Guide 5, 2003

Guide for Visual Identification of Deterioration & Damages on Suspension Composite Insulators

Notice to users

Neither STRI nor any other persons, employees, consultants and contractors acting on their behalf makes any warranty, express or implied, or assumes any legal responsibility for the accuracy of any information, data or photographs contained herein, or for the completeness or usefulness of any information or data or photographs contained herein, or accepts liability for the use, or damages resulting from the use, thereof. STRI does not represent that its use would not infringe upon privately owned rights.

Any reference in this report to any specific commercial product, guidelines, recommendations, process or service by tradename, trademark, manufacturer or otherwise does NOT constitute or imply its endorsement or recommendation by STRI or any of its members or any of its employees or any of its consultants or contractors. Although the intended aim is stated in the guide, it is important to note that it is the responsibility of the user of this guide to judge its suitability for his intended application.

Solicitation for Suggestions

This guide is subject to periodic review and suggestions for improvement. Thus, STRI respectfully requests that users of this guide feel free to contact STRI with suggestions and pictures that they feel would enhance and complement it. All such suggestions are requested to be forwarded to: STRI AB at PO Box 707, S-771 80, Ludvika, Sweden or nci.damage.guide@stri.se.

Acknowledgements

STRI would like to thank the many Parties who have permitted the use of their photographs for this guide. These include in alphabetical order:
- Arizona State University; Ravi Gorur [9]
- ESKOM Technology Group; Wallace Vosloo [8]
- Florida Power & Light Co.; Jeffery Burnham [10]
- T&D High Voltage Consulting Ltd; Erich Gnandt [11]
- Mace Technologies, Roy Macey [14]

Abbreviations

Abbreviations used in this guide include:

FRP = Fibre reinforced plastic
IEC = International Electrotechnical Commission
CSA = Canadian Standards Association
ANSI = American National Standards Institute
IEEE = Institute of Electrical & Electronic Engineers

Definitions

The terms and definitions listed below have been adopted from international standards [1]-[2], [4]-[5] and/or application guides [3], those that are **not**, have been formulated by STRI.
In the definitions below and in table 1, photographs of each specific type of damage and deterioration are referenced in red text. By clicking on the words in red text in the .pdf document the reader can utilize hypertext links to go to the appropriate photographs.

Definition for Different Types of Deterioration

Deterioration

Deterioration is defined as cosmetic or superficial ageing that has occurred on the composite insulator as a direct result of exposure to the service environment, electrical stress, mechanical loading or careless handling. *This ageing is **not** expected to cause a significant reduction in the insulator's performance and/or longevity.* Deterioration does **not** significantly reduce the thickness of the polymer housing that prevents moisture ingress to the core rod, or reduce the leakage distance by more than about 10%.

Chalking

Appearance a rough or powdery surface due to the exposure of filler particles from the housing material [1][12]. See fig. 12.

Colour Changes

Change in the colour of the housing material of the composite insulator. See fig. 13(a).

Crazing

Consists of surface micro-fractures of depths approximately 0.01 to 0.1 mm [1][12]. See fig. 13(b).

Flange Corrosion

Deterioration due to a chemical reaction with the environment (rusting), see fig. 1.

Grease Leakage

Escape of grease from shed/sheath or sheath/sheath (e.g. joiner ring) interface onto the sheath or shed surface. See fig. 16 (b).

Light erosion

Superficial, irreversible and non-conducting degradation of the surface of the insulator that occurs by loss of material[1], which does not penetrate deeper than 1 mm. This can be uniform or localised. See fig. 6.

Minor debonding

Debonding occurring between different components of the insulator which can be regarded as deterioration[1] rather than damage. See fig. 16(a).

Minor Splitting/Cutting

Minor break, tear or crack in polymer housing (e.g. shed, sheath) which may have resulted in removal of material, and can be regarded as deterioration[1] rather than damage. See fig. 3, fig. 7, and fig. 14.

Definition for Different Types of Damages

Damage

Damage is defined as changes to the composite insulator that have occurred as a consequence or progression of deterioration and/or external influences, including careless handling. *Damages may be expected to have a negative impact on the insulator's performance and/or longevity.*

Core Exposure

Uncovering of the core to the environment (e.g. due to erosion, tracking, splitting, puncture or careless handling). See fig. 4(a) and fig. 8(a).

Debonding

Separation of different parts of a composite insulator which significantly reduces the creepage distance (i.e. by more than about 10%), or the thickness of material that prevents moisture ingress to the core rod (i.e. by more than 1mm). See fig. 8(b).

Erosion

Irreversible and non-conducting degradation of the surface of the insulator that occurs by major loss of material[1], which significantly reduces the thickness of the polymer sheath that prevents moisture ingress to the core rod (i.e. by more than 1mm). This can be uniform or localised. See fig. 4(b) and fig. 9.

Peeling

Loss of adhesion of the seal from the metal fitting[2]. See fig. 5(a).

Power Arc Damage

Damage sustained from a high current and temperature concentration at the metal fitting caused by an electrical flashover. See fig. 2.

---

1. Deterioration does not significantly reduce the creepage distance (i.e. by more than about 10%), or reduce the thickness of the polymer sheath that prevents moisture ingress to the core rod by more than 1 mm.
2. Peeling is not regarded as damage for insulators where the bottom shed is moulded over the flange, unless the seal has opened to a depth of more than 1cm.

Puncture

Hole in the insulator sheath/shank or shed. See fig. 5(b) and fig. 10(b).

Splitting/cutting

Break, tear or crack in polymer housing (e.g. shed, sheath) which may have resulted in removal of material, and which significantly reduces the creepage distance (i.e. by more than about 10%), or the thickness of the polymer sheath blocking moisture ingress to the core rod (i.e. by more than 1mm). See fig. 4(a), fig. 8(a), fig. 11, and fig. 15(a).

Tracking/Carbonising

Irreversible degradation by formation of conductive paths starting and developing on the surface of an insulating material [1]. These tracks have the appearance of carbon tracks which cannot be easily removed and are conductive even when dry. See fig. 10(a) and fig. 15(b) [8][9].

Definition of types of insulator failure

Mechanical Failure

Breakage of an insulators core rod so that the mechanical load can no longer be supported. See fig. 17 for a photograph of a mechanical failure **not** due to Brittle Fracture (see below).

Brittle Fracture (Mechanical Failure) A type of mechanical failure of the fibre reinforced plastic (FRP) core rod characterized by one or more of the following [7]:

- smooth fracture surfaces mostly running perpendicular to the rod axis
- sometimes stepwise formations of smooth surfaces
- fibres and resin break on the same plane
- clean fracture surface (no fine glass and/or resin particles), or normally a small residual fracture section which is generally fibrous.

See fig. 18 for a photograph of a brittle fracture failure.

Electrical Failure

A flashover has occurred across the insulator, and a permanent reduction in the dielectric strength has occurred so that the insulator can no longer sustain the system voltage.

Table of Contents

1 Background

The life expectancy of composite insulators is still the most important yet uncertain parameter facing both users and manufacturers. Third generation composite insulator (late 1980's to 1990's) designs in use today are expected to perform superior to the first and second generation designs initially used in the 1970's and 1980's respectively. It is important to note that all polymers used in the manufacturing of composite insulators will age over time but what is important is that they do not drop the line or permit an electrical flashover. The ageing and service condition of composite insulators can be expected to vary with respect to polymer material formulations, filler type and percentages, vintage, manufacturing quality, insulator profile design, operating electrical stress, service environmental conditions, installation and handling, etc.

2 Introduction

The aim of this guide is to simplify in-service inspection for utility field personnel by providing a representative set of photographs and definitions of known types of deterioration and damages that have occurred with earlier and modern generations of composite insulators. It is not intended to target or attack the integrity or capabilities of certain past or modern day composite insulator manufacturers.

It should be noted that the photographs of composite insulator deterioration and damages used in the guide may have resulted from a number of causes which include inferior polymer formulations and insulator designs, inadequate manufacturing process and/or quality control, abnormal operating electrical and/or mechanical stresses, severe environmental stresses, acts of god (i.e. hurricanes, tornadoes, earthquakes, lightning, etc.), improper maintenance practices, misapplication and mishandling by users, etc.

It is important to note that it is the responsibility of the user of this guide to judge its suitability for the intended application and restrict its unregulated distribution among other electric power utilities and especially manufacturers of composite, porcelain and glass suspension insulators. Interested electric power suppliers are encouraged to contact STRI for a copy of the guide.

3 How to use the Guide

For the purposes of this guide, the following definitions for deterioration and damages apply:

We ask the users of the guide to follow these steps:

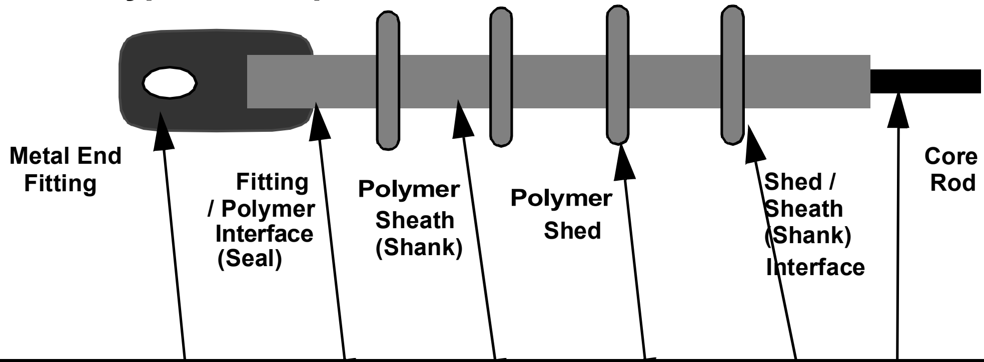
1. Familiarize oneself with the insulator diagram (table 1) which lists typical composite insulator deterioration and damages. View the composite insulator diagram and determine the section of interest. The arrow should be traced to the reference table column and locate the corresponding section that lists the location of the photograph(s) and definition of deterioration and damages.

2. a) Utility personnel that are familiar with the many types of deterioration and damages may then locate the corresponding figure in table 1 and review the photograph(s) and definition(s) in Chapter 4.

   b) Utility personnel that are unfamiliar with such details may wish to read the complete chapter section corresponding to the insulator section of interest to familiarize themselves with the specific types of deterioration and damages.

Clickable hypertext links to figures and definitions are indicated in Red

Typical Composite Line Insulator Profile



		End Fitting	Fitting-polymer interface	Sheath (Shank)	Shed	Shed-Sheath interface	Core Rod
	Deterioration or Damages	**Section 4.1 Page 10**	**Section 4.2 Page 11**	**Section 4.3 Page 12**	**Section 4.4 Page 15**	**Section 4.5 Page 17**	**Section 4.6 Page 18**
Deterioration	**Chalking**		*(fig. 12)*	*(fig. 12)*	fig. 12		
	Colour Changes		*(fig. 13(a))*	*(fig. 13(a))*	*fig. 13*(a)	*(fig. 13(a))*	
	Crazing		*(fig. 13(b))*	*(fig. 13(b))*	fig. 13(*b*)	*(fig. 13(b))*	
	Flange Corrosion	fig. 1					
	Grease Leakage					fig. 16(b)	
	Light Erosion		*(fig. 6)*	fig. 6	*(fig. 6)*	*(fig. 6)*	
	Minor debonding		-	*(fig. 16(a))*	*(fig. 16(a))*	fig. 16(a)	
	Minor Splitting/Cutting		fig. 3	fig. 7	fig. 14	-	
Damage	**Core Exposure**		fig. 4(a)	fig. 8(a)		*(fig. 8(a))*	
	Debonding			fig. 8(b)		*fig. 8(b)*	
	Erosion		fig. 4(b)	fig. 9	*(fig. 9)*	-	fig. 17
	Peeling		fig. 5(a)				
	Power Arc Damage	fig. 2	(fig. 2)	(fig. 2)	-	-	
	Puncture		fig. 5(b)	*(fig. 10(b))*	fig. 10(b)	*(fig. 10(b))*	
	Splitting/Cutting		fig. 4(a)	fig. 11	fig. 15(a)	-	
	Tracking/Carbonising		*(fig. 10(a))*	fig. 10(a)	fig. 15(b)		fig. 17
Mechanical Failure	**Non-brittle fracture Mechanical failure**						fig. 17
	Brittle fracture						fig. 18

table 1: Reference table for composite line insulator components and their respective deterioration & damages.

a) **Shaded cell** indicates that the specific type of **deterioration** or **damage** described is **not** applicable to this section of composite insulator.

b) "-" indicates that there is **no** photograph available at this time for this type of **deterioration** or **damage.**

c) "*(fig#)*" indicates that a representative photograph from another part of the guide is identified.

4 Photographic Guide to Deterioration & Damage for Typical Sections of a Composite Insulator

In the caption for each photograph, the specific composite insulator deterioration and/or damage is identified in **bold** letters. By clicking on the words in **bold** letters in the .pdf document the reader can utilize hypertext links to go to the appropriate definitions.

4.1 Metal End-Fitting

Photographs of damage and deterioration affecting the metal end-fitting are given in this section.

4.1.1 Deterioration affecting the metal end-fitting

.

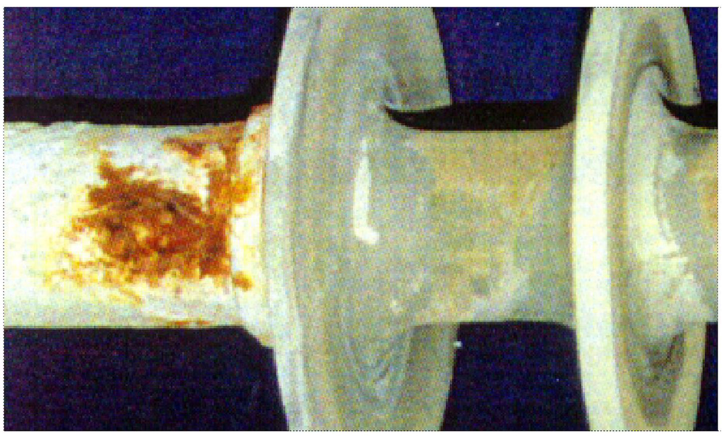


fig 1 Example of deterioration affecting the metal end-fitting: ***Flange Corrosion****[11].*

4.1.2 Damages affecting the metal end-fitting

fig 2 Examples of damage occurring on the metal fitting: ***Power Arc Damage****. Right photo [11].*

4.2 Polymer housing/End-fitting Interface (Seal)

Photographs of damage and deterioration at the polymer housing/end-fitting transition are given in this section.

4.2.1 Deterioration at the polymer housing/end-fitting transition (Seal)

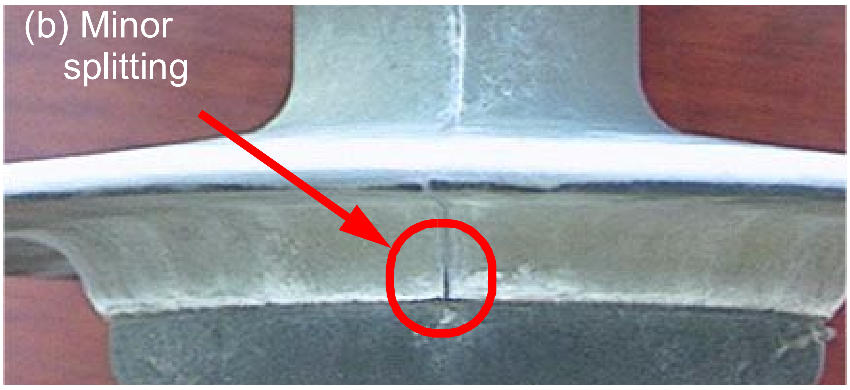


fig 3 *Example of* ***Minor Splitting/Cutting*** *(deterioration) at the polymer housing/end-fitting interface (seal).*

4.2.2 Damage at the polymer housing/end-fitting transition (Seal)

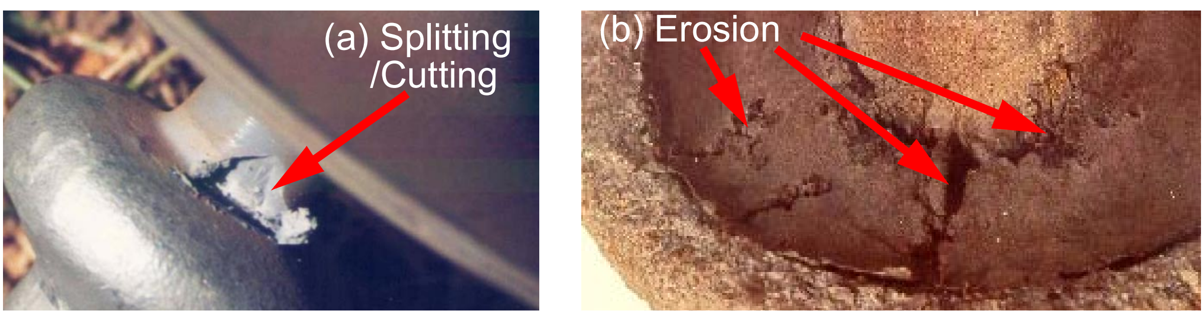
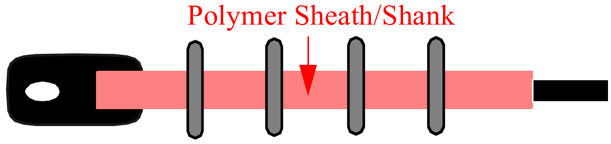


fig 4 *Examples of damage at the polymer/fitting interface (seal):(a)* ***Core Exposure*** *due to* ***Splitting/Cutting****[14], and (b)* ***Erosion****[8].*

fig 5 *Examples of damage at the polymer sheath/fitting interface (seal):***(a)** ***Peeling****, and (b)* ***Picture*** *of the seal [8].*



4.3 Polymer Sheath/Shank

The sheath/shank is the polymeric covering that protects the fibreglass core from the environment and is typically bonded or vulcanized onto the core.

4.3.1 Deterioration affecting the sheath/shank

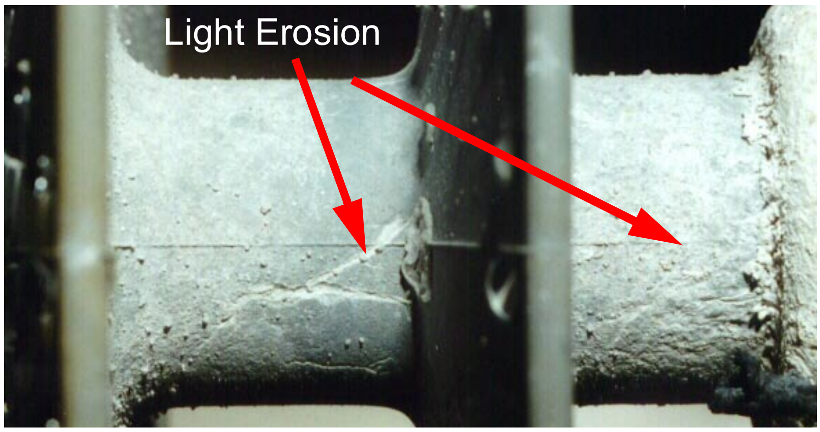


fig 6 Example of deterioration on the sheath/shank: ***Light Erosion*****.**

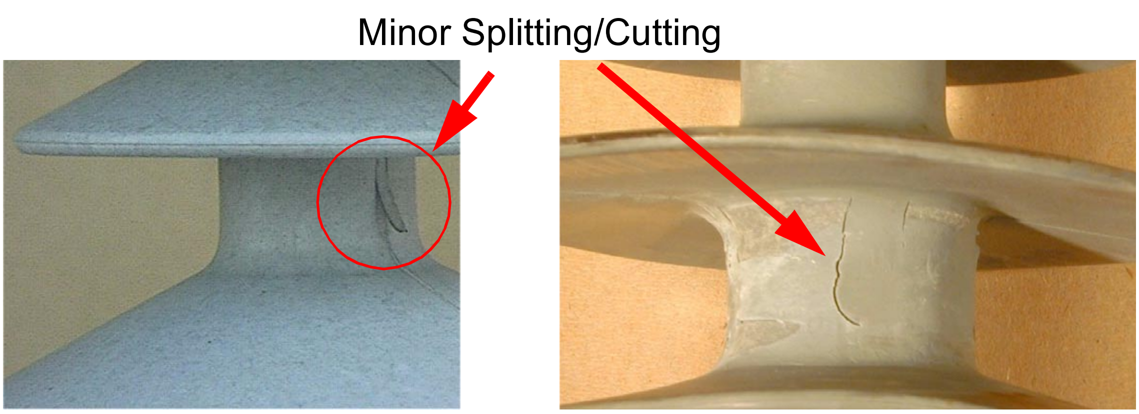


fig 7 Examples of deterioration on the sheath/shank: ***Minor Splitting/Cutting.***

4.3.2 Damage affecting the sheath/shank

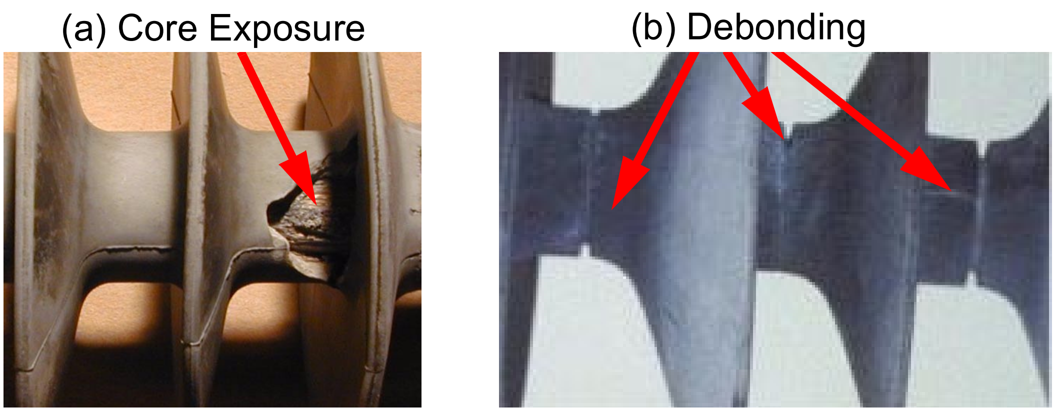


fig 8 *Examples of damage on the polymer sheath/shank:* ***(a) Core Exposure*** *due to* ***Splitting/ Cutting****, (b)* ***Debonding*****.**

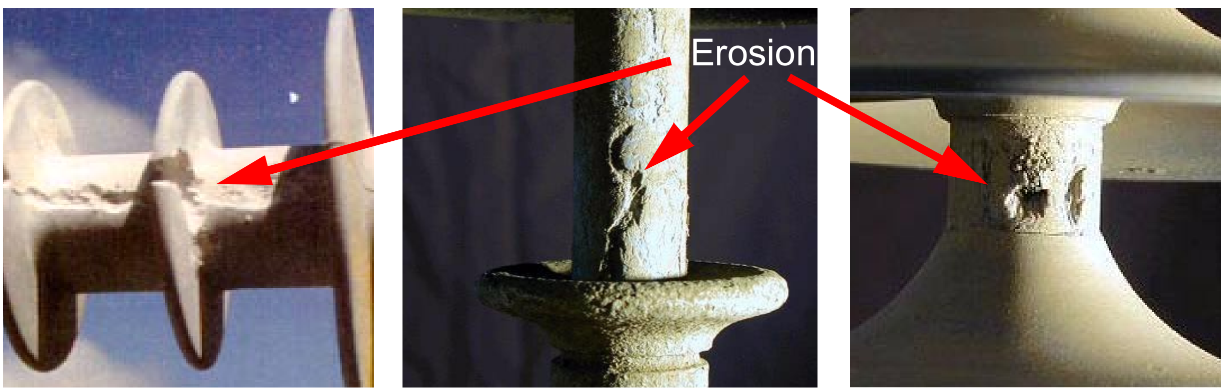


fig 9 *Examples of damage on the sheath/shank:* ***Erosion*** *(Left hand photo [9]).*

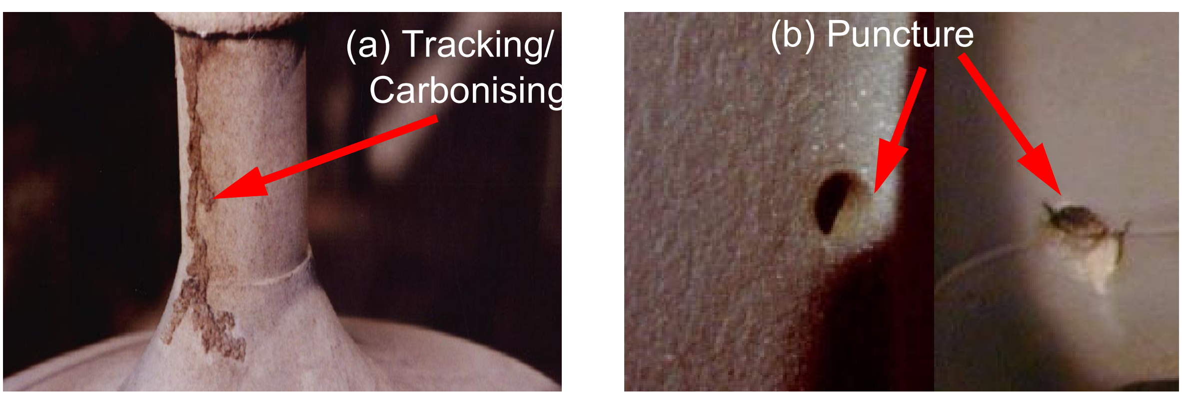


fig 10 *Examples of damage on sheath/shank: (a)* ***Tracking/Carbonising****[8]***,** *(b)* ***Puncture****[11].*

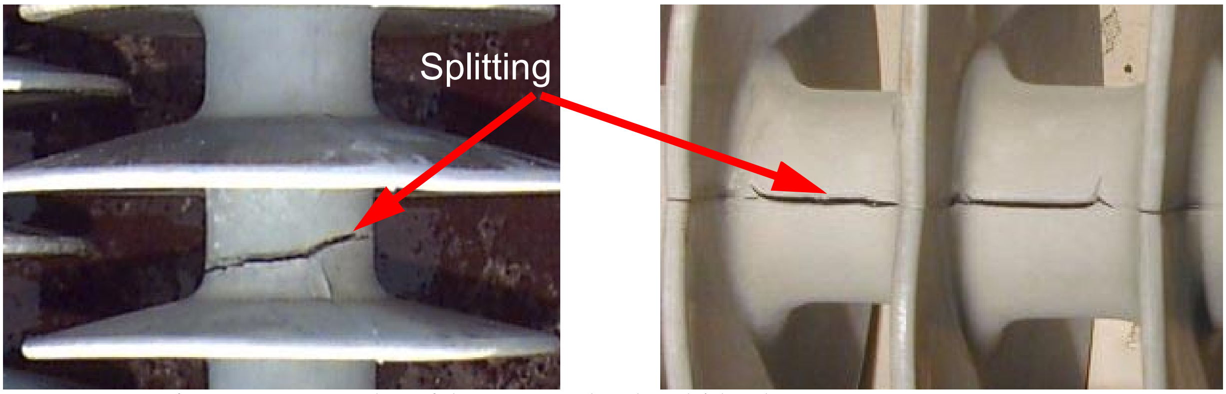
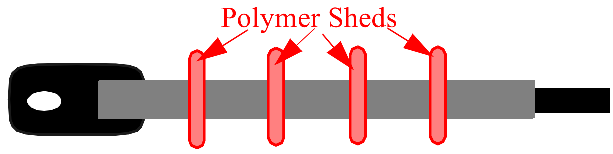


fig 11 Examples of damage on the sheath/shank: ***Splitting/Cutting*****.**



4.4 Polymer Shed

Polymer sheds are the external projected part of the insulator intended to provide the wet electrical strength and leakage distance. Depending on the design of the composite insulator, the weathersheds may comprise a separate or integral sheath [3] [8].

4.4.1 Deterioration affecting the sheds

*fig 12 Examples of deterioration affecting the sheds, **Chalking**; Right picture [11].*

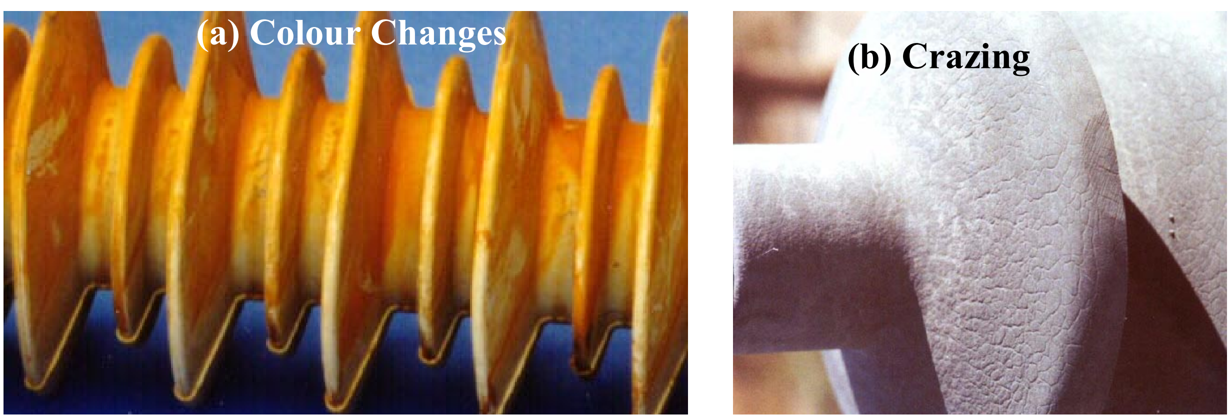
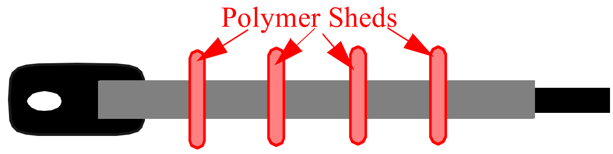


*fig 13 Examples of deterioration of the sheds, (a)**Colour Changes** [11], & (b) **Crazing**[8].*



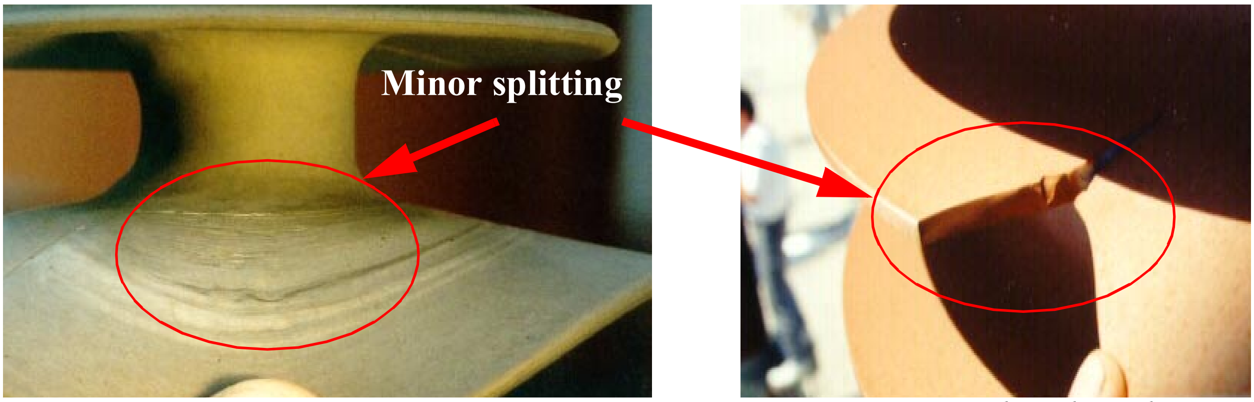
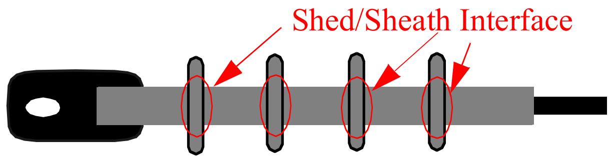


fig 14 *Examples of deterioration affecting the sheds:* ***Minor Splitting/Cutting****. N.b in the right hand picture only one shed of 10 is affected so that the observed changes can be regarded as deterioration, i.e. not reducing the creepage distance by more than 10%.*

4.4.2 Damage affecting the sheds

fig 15 *Examples of damage to sheds: (a)* ***Splitting/Cutting*** *which reduces the creepage distance by >10%[14], and (b)* ***Tracking/Carbonising*** *on insulator sheds.*



4.5 Shed/Sheath Interface

4.5.1 Deterioration affecting the shed/sheath interface

(a) Minor Debonding **(b) Grease Leakage**

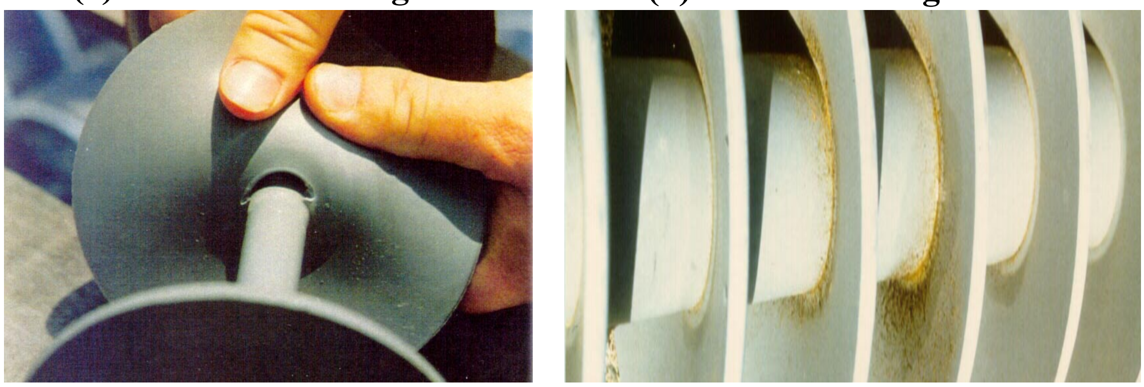
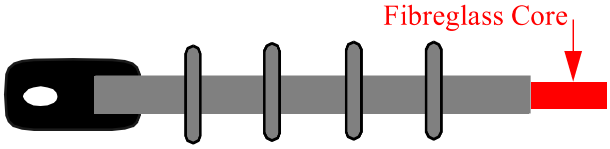


fig 16 Deterioration at the shed/sheath interface (a) ***Minor Debonding****, & (b)* ***Grease Leakage****.*



4.6 Core Rod (Fibreglass Core)

The core rod (fibreglass core) is the internal insulating part of the composite insulator, designed to provide the mechanical strength required.

4.6.1 Damage and failures

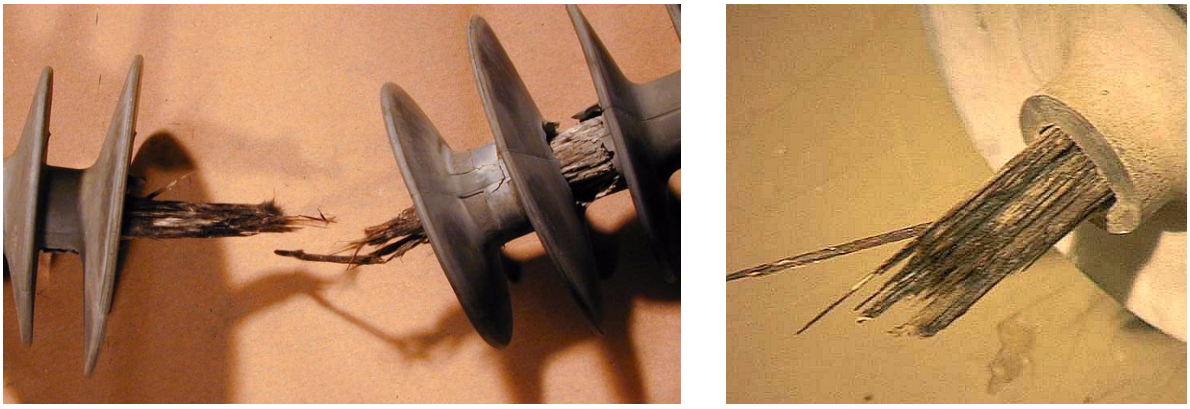


fig 17 Examples of ***Mechanical Failure*** *of the fibreglass core which is* ***not*** *due to brittle fracture, but rather resulting from erosion and tracking damage to the core.*

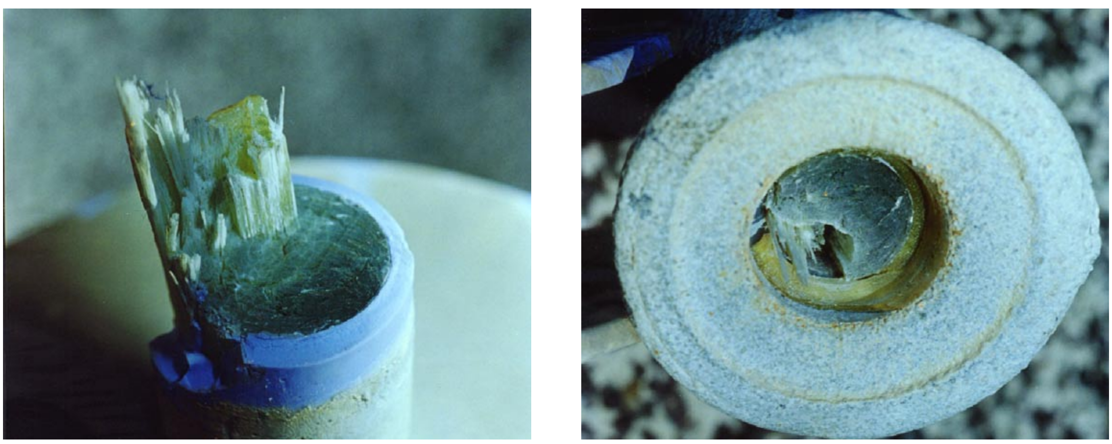


fig 18 ***Brittle Fracture*** - ***Mechanical Failure*** *of the fibreglass core; photos [8].*

5 References

[1] IEC Standard: "Composite Insulators for A.C. Overhead Lines with Nominal Voltage Greater than 1,000 V - Definitions, Test Methods and Acceptance Criteria", IEC 1109, First Edition, 1992-03, Reference # CEI/IEC 1109: Page 15,1992.
[2] IEEE Standard: "Standard For Specifying Distribution Composite Insulators (Suspension and Dead-end Type)", Final Draft version of the IEEE 1024 (P1024 Upgrade), Pages 8-9, March 1998.
[3] IEEE Application Guide: "IEEE Guide for Application of Composite Line Post Insulators", Draft #7, Pages 4-5, Feb. 1998.
[4] ANSI/IEEE Standard: "IEEE Guide for Application of Composite Insulators", ANSI/IEEE Standard 987 - 1998, Final Draft Version, Pages 7, March 1998.
[5] CSA Standard: "Composite Suspension Insulators for Transmission Applications", CSA 411.4-M96 Draft No. 5 Standard, April 1996.
[6] STRI Guide: "Composite Insulator Status Program: Field inspection of composite line insulators", STRI Guide 3, 2002/1, 2002.
[7] CIGRE Guide: "Guide for the Identification of Brittle Fracture of Composite Insulator FRP Rod", CIGRE WG 22.03, Electra No. 143, August 1992.
[8] Photographs by kind permission from Vosloo, W.L., TSI Eskom
[9] Gorur, R.; Cherney, E.; Burnham, J.: "Outdoor Insulators - #8208 Short Course Notes", Arizona State University, 8-11 March, 1998.
[10] Photographs by kind permission from Burnham, J., Florida Power & Light Company.
[11] Photographs by kind permission from Gnandt, E.P., T&D High Voltage Consulting.
[12] CEA Purchase Specification: "Dead-end/Suspension Composite Insulator for Overhead Distribution Lines", CEA LWIWG-01, Pages 5-8. November 1996.
[13] STRI Guide: "STRI Hydrophobicity Classification Guide 1", Guide 1, 92/1, 1992.
[14] Photograph by kind permission from Mace Technologies.