66kV Salt Creek Wind Farm – Terang Transmission Line Failure

Technical investigation report

energysafe VICTORIA

Creating a safer state with electricity and gas

VICTORIA State Government

Preface

This technical investigation report has been prepared by Energy Safe Victoria (ESV) pursuant to the objectives, powers and functions conferred on it by The Electricity Safety Act 1998 (Act).

Specifically, these include, amongst other things, to investigate events or incidents, which have implications for electricity safety and to regulate, monitor and enforce the prevention and mitigation of bushfires that arise out of incidents involving electric lines or electrical installations and to monitor and enforce compliance with this Act and the regulations.

This report has been endorsed by the Director of Energy Safety in Victoria.

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On 21 March 2019 ESV was made aware of an insulator failure on a transmission line owned and operated by AusNet Services. The incident was also reported by the media.

It was reported that on 20 March 2019 a fault occurred on the Salt Creek Wind farm – Terang Transmission Line (the SCWF-TGTS line). The post insulator on the bottom phase on pole 195 in Lodrigans Lane near Noorat had broken and fallen to the ground along with a section of twin conductor.

The failed insulator was a Suzhou line post insulator drawing number 28685 (referred to as the insulator).

The SCWF – TGTS line connects the wind farm to the Terang Terminal Station via 50.5 km of 66 kV powerline. The line was placed into services on 4 June 2018.

AusNet Services engaged a consultant to provide an expert opinion regarding the damage to the insulator. ESV reviewed the consultant's report along with other evidence and subsequently decided to conduct independent testing to determine if the insulator was fit for purpose, and if the insulator had been subjected to an impact consistent with being struck by a bullet or bullets.

ESV produced a scope document for the analysis and testing of the insulator 'Salt Creek HV Insulator Testing Scope 2019 E-30167'. This document identified specific tests, including type tests from Australian Standards for insulators and fittings that the insulator must comply with.

The insulator surpassed the required mechanical failing load by more than 20%.

The bracket fitting passed the mechanical failing load test according to section 5.3.2 of AS 1154.1.

The analysis and testing of the failed insulator revealed that the damage is consistent with it being subjected to a significant impact, such as being struck by a bullet or bullets.

It is the conclusion of this report that the insulator was compliant with the standard and failed as a result of a significant impact, most likely from a bullet or bullets from a firearm.

Introduction

Scope

This report details the findings of an Energy Safe Victoria (ESV) technical investigation into the cause of, and contributing factors to the failure of an insulator on the Salt Creek to Terang 66 kV line. The investigation includes independent analysis of the failed insulator from pole 195, and the failed fittings from the two insulators installed on either side of the failed insulator from poles 194 and 196, and partial type testing of the same type of insulators and fittings to confirm they are fit for purpose.

Objectives

ESV's investigative objectives were to:

- confirm the insulator was compliant to standard
- confirm the insulator fittings were compliant to standard
- identify the cause of the insulator failure.

To meet these objectives, ESV sourced specific information and product samples that included:

- six samples of the failed Suzhou insulator including fittings, Suzhou drawing number 28685, for independent testing
- manufacturer drawings of the failed insulator
- the failed insulator
- failed fittings from the insulators on the poles on either side of the pole supporting the failed insulator
- AusNet Services' consultant report "Insulator Damage Investigation AusNet 66kV Line Salt Creek Wind Farm – Terang Transmission".

Methodology

ESV's investigative methodology involved:

1. Assessing whether or not the insulator complies with the mechanical failing load test of AS/NZS 2947.1
2. Assessing whether or not the insulator fittings comply with the failing load test of AS 1154.1
3. Using a stereomicroscope and a scanning electron microscope (SEM) equipped with semi-quantitative energy dispersive x-ray spectroscopy (EDS) to analyse and identify any deposited material on the failed insulator
4. Identify the root cause of the insulator failure and failed fittings.

Background

On 21 March 2019 ESV was made aware of an insulator failure on a transmission line owned and operated by AusNet Services. The incident was also reported by the media.

It was reported that on 20 March 2019 a fault occurred on the Salt Creek Wind Farm – Terang Transmission Line (the SCWF-TGTS line). The post insulator on the bottom phase on pole 195 in Lodrigans Lane near Noorat had broken and fallen to the ground along with a section of twin conductor.

The SCWF-TGTS line connects the wind farm to the Terang Terminal Station via 50.5 km of 66 kV powerline. The line was placed into services on 4 June 2018.

ESV requested AusNet Services to provide a report of its investigation of the incident, including causes of the failure of the insulator and the broken insulator end brackets on pole 194 and pole 196.

On 9 April 2018, ESV received a copy of the investigation report.

The investigation report from the consultant, engaged by AusNet Services to provide expert opinion regarding damage to the 66kV line post insulator, made the following conclusions:

1. The SCWF-TRTS line was designed to the current Australian Standard, AS/NZS 7000 for Overhead Line Design, and commonly used international software has been used for the line profiling and layout.
2. Loading at pole 195 is not high compared to other poles on the line.
3. The most likely cause of insulator damage is impact by an external object. This could be due to a large object with relatively low velocity, or a small object with high velocity, and may be an act of vandalism.
4. The damage is consistent with impact by a bullet or bullets from a firearm.
5. Consequential hardware failures at adjacent poles due to overload have resulted in a length of conductor on the ground.

ESV produced its own report titled ‘66kV Salt Creek Wind Farm – Terang Transmission Line Failure 20 March 2019 Technical Investigation Report’ into the insulator failure based on the AusNet Services consultant’s report, and our own testing and assessment. This report recommended that further forensic examination of the failed insulator be conducted to determine if it had been subjected to a significant impact, and if the insulator was fit for purpose.

Technical investigation

ESV engaged HRL Technology Group Pty Ltd to analyse the failed insulator and fittings to confirm that the type of insulator met the requirements of mechanical failing load tests. A scope for the testing and analysis was produced "Salt Creek HV Insulator Testing Scope 2019 E-30167" detailing the testing regime to be undertaken that included to:

- determine if there is residual evidence of a foreign object such as a bullet to be found on the primary insulator
- determine what material has created black marks on the surface of the insulator
- determine if the strength of the insulator (by testing others of the same design from the same manufacturer) meets minimum strength requirements, as per the mechanical failing load test according to section 19.1 of AS/NZS 2947.1
- determine if the strength of the insulator fittings (by testing others of the same design from the same manufacturer) meets minimum strength requirements as per the failing load test according to section 5.3.2 of AS 1154.

ESV observations

Failed insulator from Pole 195

The examination of the failed insulator identified a main fracture area between the 4th and 5th sheds (numbered from the base of the insulator) and numerous partially fractured sheds and a large slant/inclined fracture on the pole base of the insulator.

The damage is illustrated in the photographs: Figure 1 shows the two halves of the failed insulator, and Figure 3 shows a close up of the two halves of the failed insulator.

A visual examination of the fracture region revealed one impact point, and possibly a second adjacent impact point, on the outer surface of the insulator between the 4th and 5th sheds. The impact points presented as indentations and/or black marks (see Figure 3) and were located approximately at the 9 o'clock (side) position on insulator (when viewed from the front/line-end of the insulator). No similar marks were evident elsewhere on the insulator.

The fracture originated at one of the impact regions, where noticeable surface damage (spalled material) and numerous faceted fracture surface regions developed prior to a more uniform fracture surface.

The connection between the galvanised caps and porcelain was intact, and there was no noticeable cracking or upset of the cement.

Victoria Police from Western Region Division 2 confirmed that a .250 calibre shell was located approximately 20 metres from the broken insulator.

The examination cannot categorically conclude the insulator was struck by one or more than one bullets.

Figure 1: Overall view of the two main sections of the failed insulator

Figure 2: Close-up view of the two main sections of the failed insulator

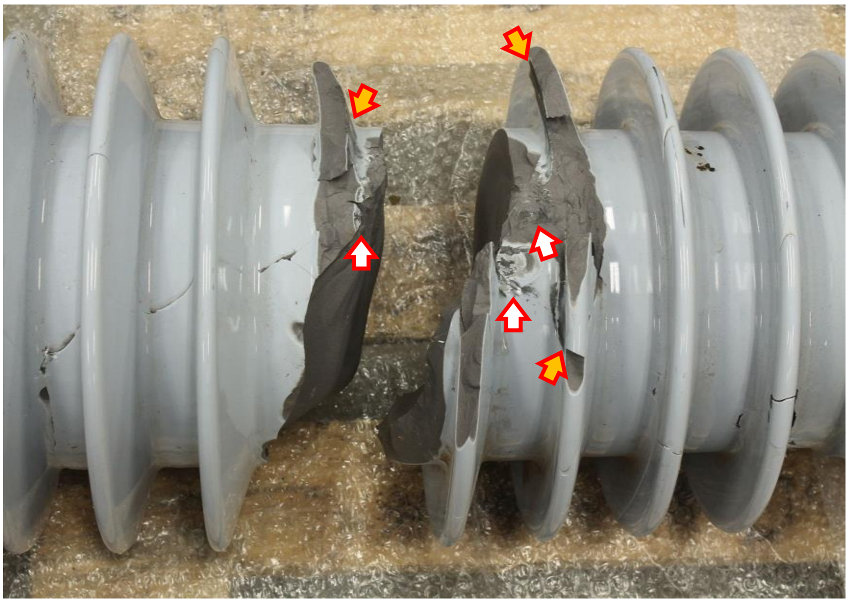


Figure 3: Views of the fractured region of partially reconstructed insulator

Note: White arrows highlight indentations, and orange arrow highlight black marks.

ESV analysis of the failed insulator

Two spalled fragments (designated as sample 1 and 2) exhibiting insulator surface regions with black marks were chosen for examination. Sample 1 was from shed 5 and sample 2 from shed 4, as shown in Figure 4 and Figure 5 below.

Examination of the insulator surfaces using a stereomicroscope revealed that the black marks were deposits of a typically dark grey material that was mostly in the form of fine aligned strips/ridges or smeared regions and occasionally as irregular, globular particles. Occasional yellow/copper-coloured regions were also observed.

Elemental analysis using a scanning electron microscope (SEM) equipped with semi-quantitative energy dispersive x-ray spectroscopy (EDS) revealed that the deposited material was rich in lead and to a lesser extent oxygen. The deposited material is considered to be metallic lead and/or lead oxide.

This is consistent with impact from a bullet or bullets striking at high velocity.

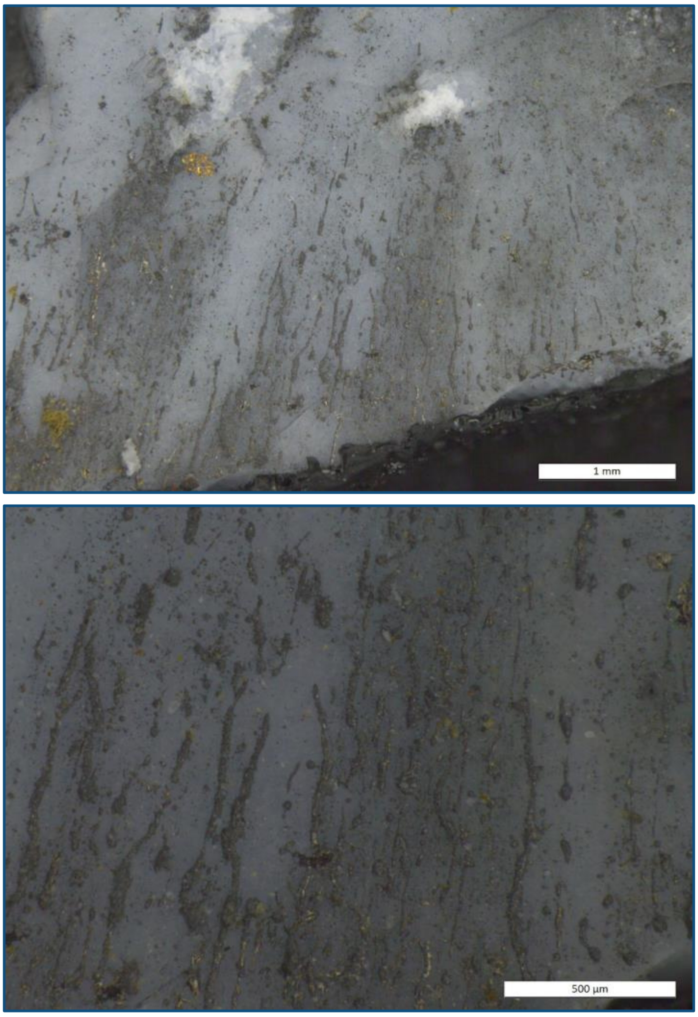


Figure 4 - Detailed views of the sample 1 insulator

Figure 4 shows the insulator surface with fine dark-grey and yellow-coloured deposits present.

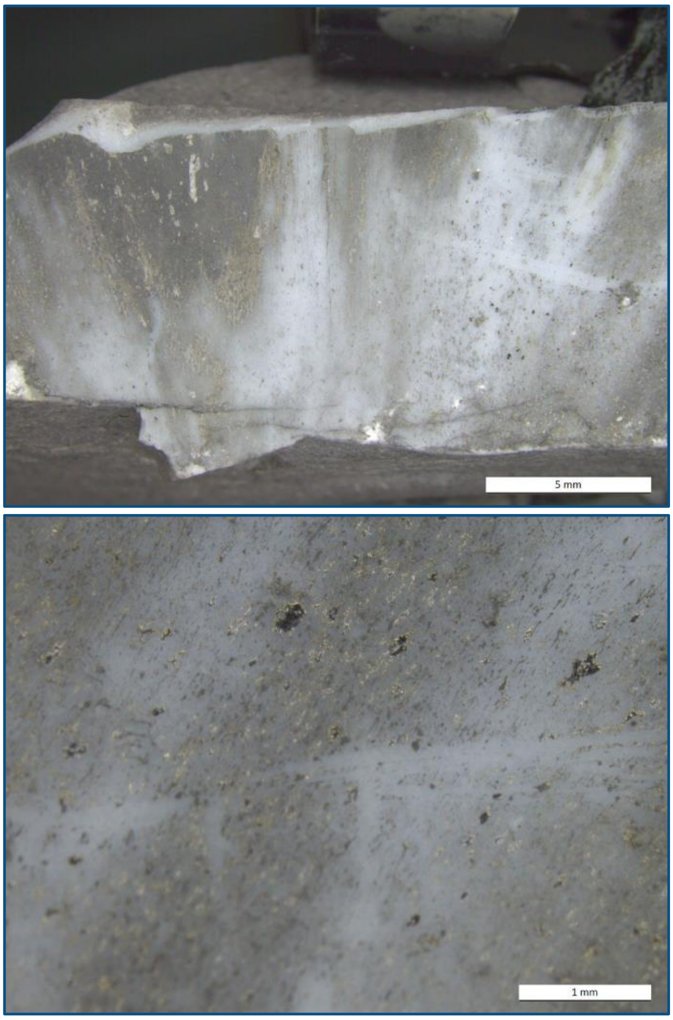


Figure 5: Detailed views of the sample 2 insulator

Figure 5 shows the insulator surface with dark-grey and yellow-coloured patches and particles present.

Energy Safe Victoria testing

Compliance testing – Insulators

HRL conducted the mechanical failing load test according to section 19.1 of AS/NZS 2947.1 on three samples of the Suzhou line post insulator, drawing number 28685. This test is designed to establish the cantilever load the insulator can withstand. The insulator is rated at 30 kN and must sustain this load to pass the test, as shown in Figure 6.

Three insulators were tested, all exceeded 30 kN under cantilever loading. One failed at 36.7 kN and testing was discontinued on the other two when they reached 40 kN. The insulator that reached a maximum of 36.7 kN could not sustain further loading as the porcelain began to separate from the cap at its base, at the securing cement line. The other two insulators tested to 40 kN also showed the early stages of this failure mode, with the cement line breaking and starting to separate, as shown in Figure 7.

It is the opinion of Energy Safe Victoria that the Suzhou insulator, drawing number 28685, complies with this test (section 19.1 of AS/NZS 2947.1).

Figure 6: Image of the insulator loading frame for the insulator mechanical failing load test, in accordance with AS/NZS 2947.1

Figure 7: Insulator 5 after completion of mechanical failing load (MFL) test.

Figure 7 shows the porcelain separating and rotating in the base cap.

Compliance testing – Insulator fittings

HRL conducted the Failing load test according to section 5.3.2 of AS 1154.1 on two samples of the insulator fittings from the Suzhou line post insulator, drawing number 28685. The test is designed to establish the load that the insulator fitting can withstand.

Two samples of the insulator bracket fitting were tested statically to 70kN and did not permanently deform. The samples were then tested to failure, with breaking loads of 129 kN and 129.5 kN as shown in Figure 8.

Figure 8: Image of a failed bracket after the mechanical failing load test

Figure 8 shows a fracture through the round hole.

Regulatory requirements

All Major Electricity Companies (MECs) operate under the Electricity Safety Act and must produce an Electricity Safety Management Scheme (ESMS) that complies with the Electricity Safety (Management) Regulations. Under this regime MECs are required to minimise, as far as practicable, hazards and risks to the safety of any person, property and bushfire danger. One method used to meet this requirement is to comply with Australian and International standards and an ESMS is required to nominate which standards the MEC complies with.

AusNet Services Transmission operates the Salt Creek Wind Farm – Terang (SCWF-TGTS) Transmission Line and in its ESMS it states compliance with the two standards used as the basis for the compliance testing:

- AS/NZS 2947.1 Insulators—Porcelain and glass for overhead power lines—Voltages greater than 1000 V a.c. Part 1: Test methods— Insulator units
- AS 1154.1 Insulator and conductor fittings for overhead power lines Part 1: Performance, material, general requirements and dimensions.

Findings and Conclusions

ESV has undertaken testing and analysis of the Suzhou line post insulator, drawing number 28685, and concludes that the insulator was compliant with the Australian/New Zealand Standard 2947.1 and failed due to a significant impact consistent with being stuck with a bullet or bullets.

Failed Insulator

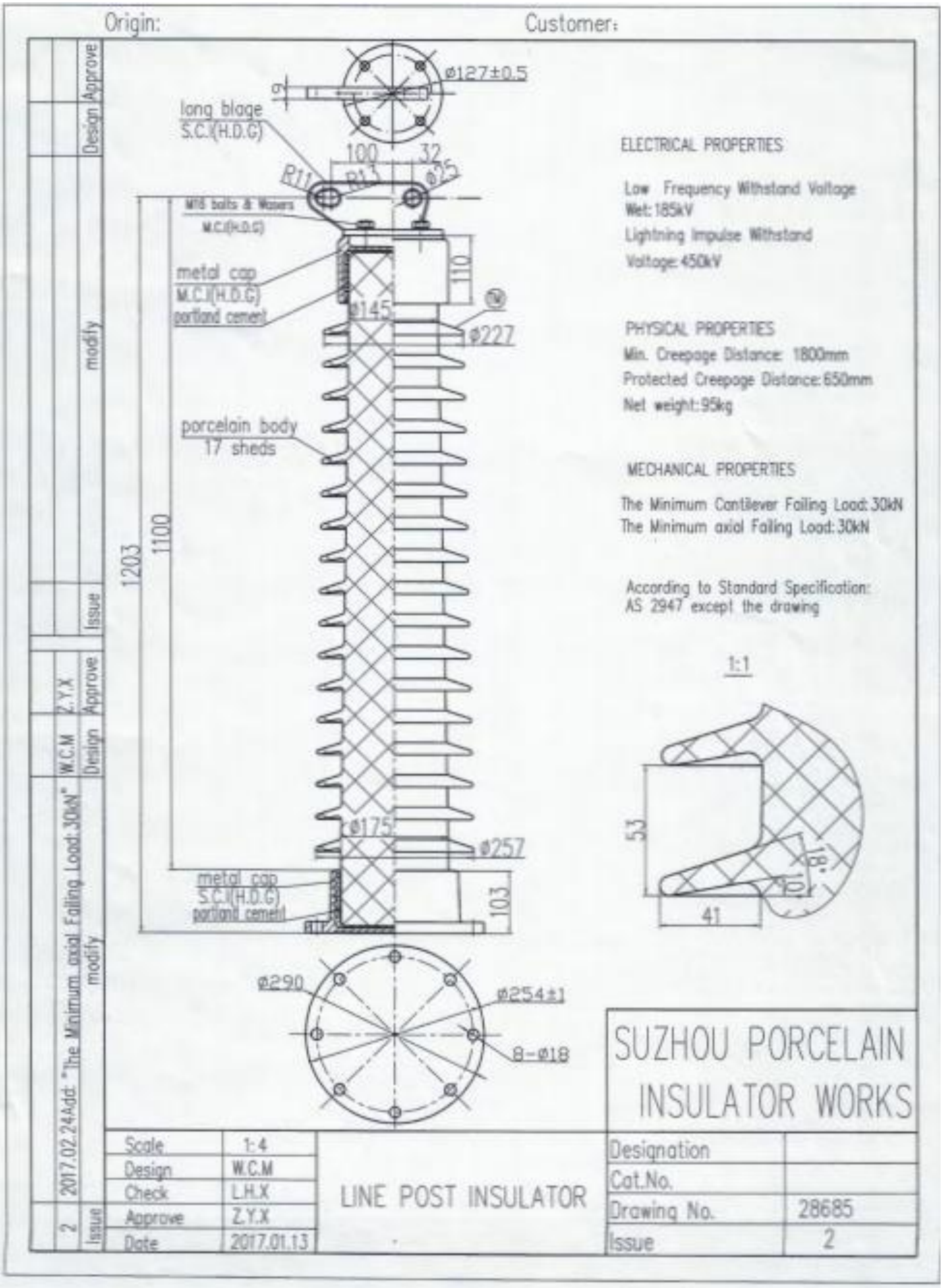
ESV concludes from its testing and analysis of the failed insulator that the insulator failed due to being subjected to a significant impact, consistent with a bullet or bullets being shot from a firearm.

ESV confirmed from its testing that the Suzhou line post insulator, drawing number 28685 complies with the mechanical failing load test according to section 19.1 of AS/NZS 2947.

Failed Insulator Fittings

ESV confirmed from its testing that the fittings from the Suzhou line post insulator, drawing number 28685 complies with the mechanical failing load test according to section 5.3.2 of AS 1154.1.

Appendix A



Suzhou Porcelain Insulator, drawing 28685.