BUNNYTHORPE–HAYWARDS CONDUCTOR RELACEMENT
Major Capex Proposal

Attachment B
CONDITION ASSESSMENT

Keeping the energy flowing




TRANSPOWER

Transpower New Zealand Limited The National Grid

1| Introduction

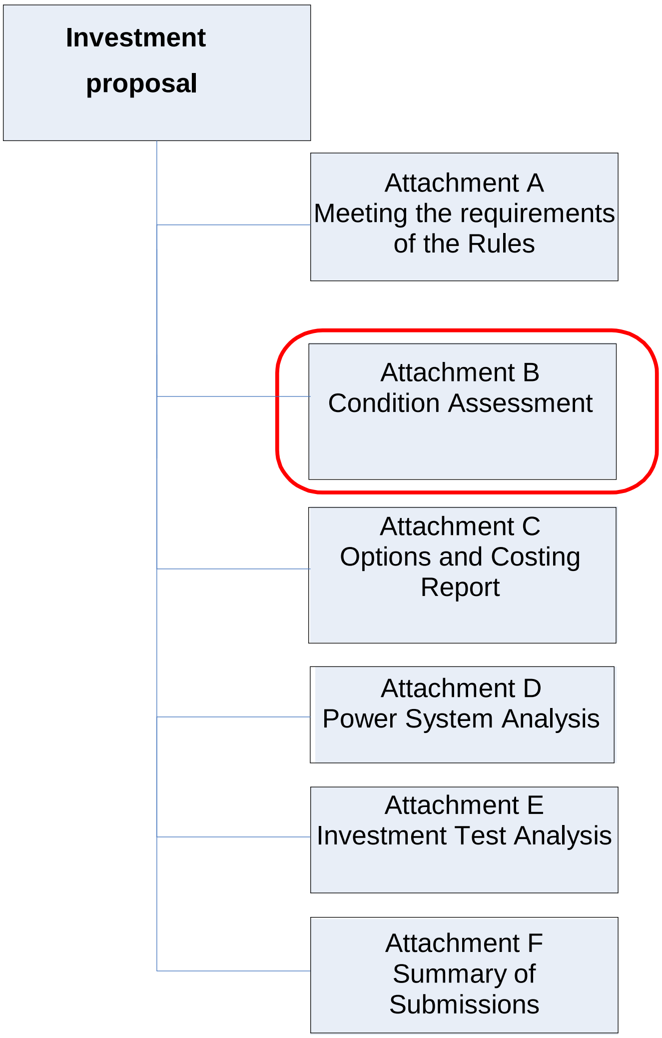
This document is a Condition Assessment report for the Bunnythorpe–Haywards A and B lines conductor replacement investment proposal.

1.1 Purpose

The purpose of this document is to outline condition assessment information which has led to the need to replace the conductor on the Bunnythorpe–Haywards A and B lines.

1.2 Document Structure

This report forms part of the Bunnythorpe-Haywards A and B lines conductor replacement investment proposal, as set out in the diagram below:



2| Condition Assessment

2.1 Why does the conductor need to be replaced?

There are two main reasons:

1. Widespread corrosion of the steel core wire and aluminium strands due to “grease holidays”; (sections that did not receive grease during manufacture); and

2. Abraded and broken aluminium strands under clamps caused by vibration fretting.

2.2 Background

The Bunnythorpe–Haywards lines were first commissioned in 1954 (B line) and 1957 (A line). Due to corrosion caused by the severe coastal climatic conditions and the specification of “non-greased” ASCR/GZ conductor, the original conductor was replaced with “greased” conductor over a 5 year period and completed in 1983. The original conductors were approximately 25 years old at that time.

2.3 ACSR conductor

Aluminum conductor steel-reinforced cable (ACSR) is a specific type of high-capacity, high-strength stranded type of conductor. The outer strands are aluminium, chosen for its excellent conductivity, low weight and low cost. The centre strand is of steel for the strength required to support the weight without stretching the aluminium due to its ductility. This gives the cable an overall high tensile strength. The tensile capacity of ACSR conductor is calculated by combining the relative strengths of the aluminium strands and the steel core wire. In the case of Goat ASCR conductor, with 30 aluminium strands and 7 steel strands, the contribution of the steel is significantly more than the aluminium. Extensive study has now found that ACSR/GZ conductors are prone to accelerated corrosion in salt laden areas as the galvanic cells are formed due to the dissimilar metals (steel, zinc and aluminium). The addition of grease between the zinc and aluminium creates a protective barrier against this.

Once the galvanised coating of the steel core has galvanically corroded it is found that the steel core wire does not corrode appreciably because the aluminium strands “sacrifice” themselves to protect the steel. Loss of strength therefore occurs from loss of aluminium section – noted by visible aluminium oxide build up, and in the worst case, bulging of the conductor. From previous conductor bulge analysis on Goat conductor we know that loss of aluminium section can be fairly well estimated by the bulge diameter.

Significant corrosion of the aluminium strands leads to a loss of the conductive cross sectional area as well as pitting of the steel core wire. Under electrical load the reduced area leads to an increase in temperature of the aluminium, which in turn accelerates the corrosion process. Conductor failure is typically caused by the steel core wire overheating and effectively burning down.

Today’s modern equivalent conductor is greased ACSR/AC – an ACSR conductor with an aluminium clad core wire. The advantage of an aluminium clad core is that it removes the galvanic cell between the previously used galvanised core (zinc) and the dissimilar aluminium strands. In addition, in areas of high corrosion Transpower now specifies a Type 2 greasing to IEC 61089 (greasing to the outer layer of the conductor). The modern greased ACSR/AC conductor has an expected life of 60 years.

2.4 Failures and condition

The expected life of greased ACSR/GZ (GZ meaning galvanised core) conductors in salt-laden environments as used in the 1980s is approximately 40 years. The points of failure being identified today appear to be where grease has not been applied, or missed, during the manufacturing process.

In 2005 one phase of the Bunnythorpe–Haywards-A line failed and fell to the ground. The cause was identified as corrosion of the aluminium strands and steel core wire, with the steel strands yielding under electrical load (burn-down). Subsequent investigations revealed widespread bulging of the conductor on both the Bunnythorpe–Haywards A and B lines. As noted, bulging occurs when galvanising on the steel core wire is depleted and the aluminium strands corrode, forming white aluminium oxide which expands within the conductor.

Experience has shown that once a conductor bulge is first detected there is only a further two years of operation before that section of conductor needs to be repaired or replaced. Once bulging occurs there is also an inherent risk with this timeframe as factors such as location, degradation rate and line load need to be also considered, i.e. the rate of degradation is not typically linear.

Repair work in 2005 included installing armour rods over observed small localised areas of damage, cutting out sections of conductor mid span using cranes, and replacing whole spans with new conductor. These repairs were targeted to reducing the risk of failure on the worst sections in an effort to ensure the majority of the line lengths were experiencing similar levels of corrosion.

Photo from 2005 showing typical conductor bulging.

Since the conductor failure in 2005, close aerial inspections of the conductor have been carried out annually over the entire length of both lines. This inspection technique entails flying a helicopter at low speed along the line, and looking at the conductor for signs of white powder or bulging. A programme of “Corman” testing has been combined with the visual inspections. The Corman is a robotic device installed on the conductor, which tracks along it and measures the amount of galvanising remaining on the steel core wire. The results of both inspections are combined to identify where sections of degraded galvanising are occurring and these are the first sections to typically show bulging on the conductor.

In all instances, the corrosion (bulging) has occurred where there is minimal or no grease on the steel core wire. These “grease holidays” are due to poor conductor manufacturing processes, ie. patches of conductor which did not have grease consistently applied. These grease holidays are wide-spread along both lines ranging from a large number in some spans to few in others.

The majority of the two lines are situated in an environment classified as high corrosion and high vibration (approx 55% of the length is high corrosion, and 80% is in a high vibration zone).

Both lines have suffered from extreme vibration caused by constant perpendicular laminar winds. Vibration dampers were installed on the lines in the early 1990s, but conductor vibration damage continues to be reported by field staff and confirmed by expert consultants where measured.

A total of 24 conductor samples have been removed from these lines for assessment since the start of 2004. Samples were found to have high levels of corrosion and some level of vibration damage, ranging from very severe on the flat terrain section to minor on the hilly section. The majority of samples confirmed that the conductor had reduced aluminium section to the point where it exceeded Transpower’s replacement criteria[1].

[1] Replacement criteria for ACSR is a 20 % reduction in Ultimate Tensile Strength (UTS), or a 15 % reduction in cross-sectional area of the aluminium

3| Conclusions

We need to replace the conductor on the Bunnythorpe–Haywards A and B lines because of poor condition. The conductor bulging and vibration damage on these lines limits our ability to achieve the full 40-year life of the conductor.

Stringent conductor monitoring and repair programmes have extended the life of the conductor but a visual survey in June 2013 has shown there are incidences of further bulging occurring.

Repair work alone is not guaranteed to mitigate the risk of conductor failure. It involves significant disruption and one fifth of the line route is through dense bush. Here it is not feasible to repair conductor defects, as crane access will be impossible in most locations.

Given the inherent risks of managing conductor corrosion and vibration damage, the coastal sections must have the conductor replaced as soon as possible and all conductor on both lines should be replaced by 2020, noting that 80% of the line is subject to high vibration due to wind.

This timing balances:

- the increasing risk of line failure; and
- minimising disruption to operation of the grid.

Condition assessment is not an exact science; however, experience with both Corman testing and visual inspection over the last 8 years has led to greater certainty on conductor life. Our requirement to replace the conductor now ensures the prudent operation of core grid assets.