Overhead line Equipment Inspection Maintenance and Renewal

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Electric Traction Infrastructure

• The traction infrastructure consists of many parts
• Large national grid transformers feed 25kV supplies for the railway
• Cables bring that power under roads and through fields from those transformers
• Switchgear along the railway protects and controls the traction supply
• Supervisory control systems allow the Electrical Control Operator to monitor and control the electrified line
• Rails and return cables connect the return circuit (equivalent of house neutral)
• But of course most obvious is the Overhead line Equipment
This Presentation

• All of those constituent parts require maintenance interventions
• Each has its own lifecycle
• Each will ultimately present the need for renewal
• Transformers, insulated cables and high voltage switchgear each have their own specialist nuanced inspection, test and maintenance needs
• All of those assets can be accessed without track access
• The OLE presents some specific and unique challenges
• This presentation focusses on the OLE and how we might best understand the ageing and dilapidation processes
The challenges

• All access to the OLE is difficult and disruptive
• Most OLE is only accessed at high level every 4 to 6 years
• Even then, a high percentage will not be touched
• A good deal will remain untouched across its whole life
• Ultimately renewal is highly disruptive and costly
Overhead Line

• First, I would like to define what I mean by overhead line
• The catenary wire
• The contact wire
• The registration assemblies and supports
• Other wires (feeder, return and earth wires)
• The main steel work
• The structure foundations
Catenary

- Catenary cable
- 19 strands bronze, copper or steel reinforced aluminium wire
Contact wire

- 120 sq mm solid copper alloy
- Parallel grooves allow clips to support clear of commutation surface
- Red line roughly indicates worn out profile
Registration assemblies

• Insulator(s), tubes, swivels and arms
• Moving parts, hinges and clevises
Life Cycle

• Contact wire wears (renewal usually between 35 – 40 years)
• Catenary fatigues and work hardens (generally always renewed with the contact wire)
• Moving parts of the OLE registrations wear and age (50 – 60 years)
• High fault currents and load currents heat cycle the conductors (heavily loaded wire will anneal and fatigue more quickly)
• Wiring and registration assemblies are set in motion each time a pantograph passes
• Expansion and contraction of the wires with temperature moves the assembly along track
• Main steelwork targets a minimum 80 year life
• Foundations should last 120 years
• Renewal cycles are generally time, not condition based
How does OLE age

• Contact wire wears due to pantograph passage, particularly at locations of high force

• Catenary fatigue results from work hardening at circumflex
  • Wear between strands due to differential movement and attrition between strands
  • Annealing of metal by temperature

• Registration assemblies wear and corrode
  • Excessive movement due to poor adjustment increases the rate of wear

• Main steel corrodes

• Foundations in embankments and cutting slopes move
How do we make decisions

- Disassembly and removal of components for inspection
- Removal of sections of cable and wires for forensic metallurgy
- Micrometer measurements

- All this requires access and isolation
- Can only be applied on sample basis
- Requires a great deal of applied judgement
- Nowhere near enough data
How to prolong the catenary and contact

• The OLE is a mechanically dynamic system
• If it will not or cannot move as it should it will suffer increased wear and fatigue
• If the geometry to the pantograph is not right higher forces and energies will result
• Left uncorrected, the wires, cables and mechanical supports will wear and fatigue more quickly
• If we knew what to correct, we could manage aging and dilapidation
Measure Frequently

• Our knowledge is only as good as the information we have
• If we measure the OLE only every 4 years (the classic maintenance cycle) the picture will be grainy
• Measurement every 6 months by the new measurement train helps, but our insight is still hardly HD clarity
• What if we could measure from every train?
The Future (it’s not so far away)

• To measure from every train will need:
  1. Instrumentation which is cheap, reliable and needs no maintenance
  2. Data collection on each train accurately tagged (the system needs to know where it is)
  3. A way to get the data from all trains and process it

• Some of that is a tall order now, but 1&2 already exist, and the digital railway will put in place 3 within our grasp.
Dynamic Testing

• City University and Brecknell Willis are working with Network Rail on a research and development project.
• Fibre optic strain gauges glued to the pantograph carbons provide stable and reliable data measurement.
• Data capture and processing software on the train allows analysis of the forces and wire geometry in real time.
• Post processing and comparison with previous data sets illustrates the detects change and trends.
• I estimate that this will all be available for widespread roll out within 3 years.
The Pantograph Unit
The Instrumentation

- Fiber optic strain gauges weigh less than 5 grams
- Strain gauges are epoxy resin fixed to underside of carbons
- Optical fiber connection passes through the roof to the data capture equipment on the train
Wizard and OLE StAT

• Wizard captures a data cloud (system provided by Dr Wehrhahn)
  • Acoustic, non-contact system measures contact and catenary wire position
  • Fitted to an MPV, can operate in traffic with wire live

• OLE-StAT processes the data cloud (software tool provided by Atkins)
  • This is the deep analysis tool
  • Output confirms contact wire position (XYZ) and detailed accurate dropper accuracy
Wizard Unit
How are we using these systems

- Dynamic testing shows hard spots, high forces and bad geometry
  - We are testing from an MPV (60mph max)
  - Using that data we are simulating line speed (125mph)

- OLE-StAT determines what is wrong
  - Processed data shows how the wire is profiled
  - Gives detail unobtainable by manual measurement
Summary

• We are still feeling our way
• The power of the algorithm will unlock more educated decision making
• Systems that measure frequently and compare results across time will provide insight that today we don’t have
• Less guesswork and more science will improve our ability to intervene and maintain
• That will allow us to work the assets longer and delay expensive renewal