24 MAR 2015

LEGISLATIVE COUNCIL
Question on notice

See tabled paper.

Tuesday, 24 February 2015

2718. Hon Ken Travers to the Parliamentary Secretary representing the Minister for Transport.

(1) Has the investigation into the snapped power line at the Daglish Train Station on 24 March 2014 been completed?
(2) If yes to (1), will the Minister table the report into the investigation and, if not, why not?
(3) If no to (1), will the report be made public when it is completed and, if not, why not?
(4) Have the reasons for the incident been identified?
(5) If yes to (4), what were the reasons?

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(1) Yes.

(2) The Public Transport Authority (PTA) has no objection to the Minister tabling the report, noting (3) below. [see tabled paper no.].

(3) The report has been issued to the Office of Rail Safety and had not been made public.

(4) Yes.

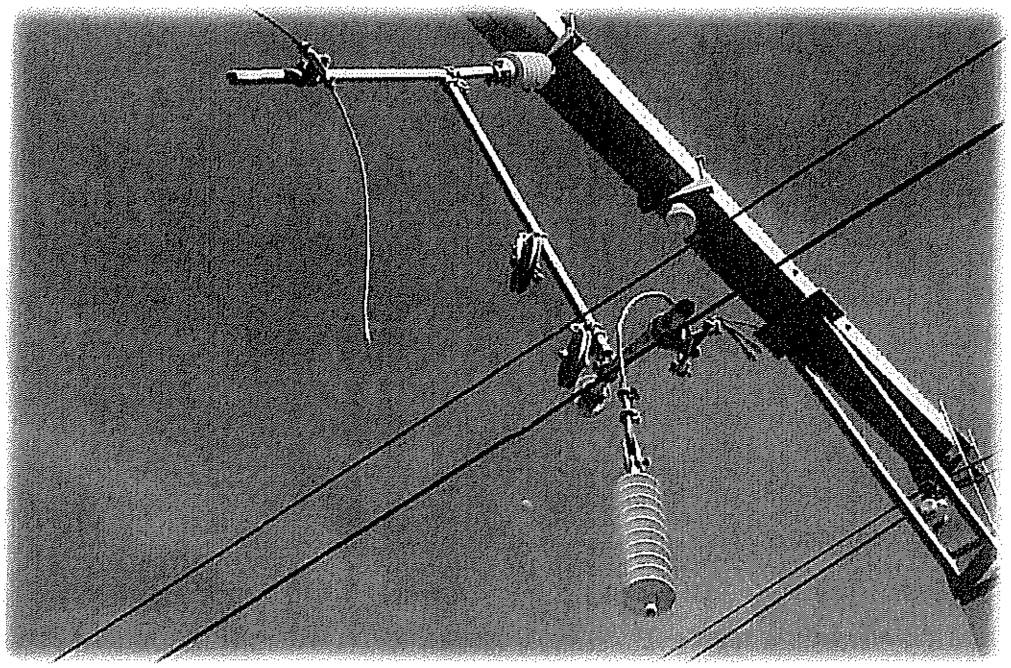
(5) The incident was directly caused by a tree branch which had blown down across the overhead traction wiring equipment (OHTWE). However, the investigation established that the OHTWE at this location had been installed incorrectly which subjected the equipment to minor mechanical wear over a sustained period of time. This contributed to the failure of the OHTWE.

All similar locations across the network were reviewed for compliance with the system design as part of the corrective actions in response to this incident with no other locations found to have the same issue.

Public Transport Authority	INVESTIGATION REPORT
	FINAL REPORT

Dewirement of Overhead Line Daglish Station

24 March 2014



File: PTA1181/14

Incident Date: 24 March 2014

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EXECUTIVE SUMMARY

At 0756 hours on Monday 24 March 2014 a Public Transport Authority train service operating between Fremantle and Perth City on the Fremantle line collided with, and became entangled with the Overhead Traction Wiring Equipment (OHTWE).

The incident occurred west of Daglish Station on the Down Main line. The Daglish Station is located seven kilometres from the Perth Station.

The investigation established that the Catenary Wire was installed incorrectly. The Catenary Wire was fed through and supported by the pulleys at structure No 7.278DU. It was not supported by stainless steel Bridle arrangements that normally support the Catenary Wire at the pulleys.

Due to the absence of the stainless steel support Bridles, the Catenary Wire was subjected to minor mechanical wear at the pulley, and given it is an insulated overlap it would have been subjected to minor arcing over a sustained period of time.

High winds recorded the previous day gave rise to a branch landing on the overlap prior to the dewirement. The branch had blackened scorching on it which indicated that the branch had been resting on the OHTWE causing arcing to the overlap span over a period of time.

The Driver reacted to the entanglement in the OHTWE by applying the emergency brake, stopping the four car set with the front railcar coming to rest on the Daglish Station platform.

As a result of the dewirement and entanglement the train pulled down approximately 300 metres of the OHTWE. Emergency services were not required to attend the site.

The root causes of the incident were:

- A tree branch had blown down across the OHTWE causing arcing on the overlap span;
- The portal pulleys were installed and the Catenary Wires were not fitted with the stainless steel Bridles as required by the system design drawings introducing a latent or inherent defect into the system; and
- The Catenary Wire failed as a result of arcing and wear due to the non-installation of the stainless steel Bridles.

Post incident corrective actions on all similar locations that have portals on the network were reviewed for compliance with the system design with no other locations having the same issue.

TERMS OF REFERENCE

The Objective/Purpose of the investigation

The objective of the investigation was to gather evidence and undertake research to determine the causal factors that led to the dewirement of the OHTWE at the Daglish Station at 0756 hours on Monday 24 March 2014.

The investigation team comprised of the Manager Safeworking and the Electrical Engineering Manager.

Scope of the Investigation

The scope of the investigation included but was not limited to the following:

- Undertake a systemic investigation into events surrounding the occurrence and prepare a final report in accordance with PTA's Investigating Health, Safety and Environmental Incidents procedure 9110-000-015.
- Take immediate steps to preserve and record evidence including the condition and location of OHTWE (including overhead wire, insulators and other associated items) and railcars involved in the occurrence.
- Map/record the location of damaged overhead and rollingstock equipment for further analysis.
- Preserve data from the Supervisory Control and Data Acquisition system (SCADA), voice transcripts between the Driver, train control and the downloads from railcar data loggers leading up to and immediately following the occurrence.
- Conduct interviews with relevant affected parties including railcar Drivers, witnesses and maintenance staff.
- Review the condition, height and stagger of the overhead contact wire and supporting equipment in the affected section of line and prior to the impacted section of line to establish specification tolerance parameters.
- Review the inspection regime and maintenance schedule of the railcar Pantograph System.
- Review detail of the latest inspection report for the Pantograph System on the affected railcars.

- Arrange for metallurgical examination of the Contact Wire/Catenary Wire and other components of the OHTWE (where identified) in the area of the wire break to determine the reasons for the failure.
- Examine whether any prevailing environmental conditions and the associated engineering controls contributed to the occurrence.
- Examine the contributing factors associated with the occurrence and identify engineering and procedural changes required to prevent a recurrence of the event.
- Examine the design of the systems and processes which were in place prior to the occurrence and establish if appropriate controls were in place to minimise the risk of such an event occurring.
- Review of recent line section inspection reports, associated recommendations and corrective actions arising from the inspections and the timeliness for closing out corrective actions.
- Identify the safety actions to be implemented to prevent, or reduce the risk of a recurrence of a similar event.
- Compare the circumstances of this event and other dewirement events on the PTA network for similarities.

Conduct of the Investigation

The investigation conducted into the events surrounding the occurrence was in accordance PTA's Investigating Health, Safety and Environmental Incidents procedure 9110-000-015.

The methodology of the investigation included:

- An interview with the Driver of the affected train service.
- Interviewed members of the overhead management and supervisory and maintenance team.
- Collection and review of SCADA data.
- Collection and review of forward and reverse facing camera data from railcars in the vicinity of the incident.
- Collection and analysis of the Automatic Train Protection (ATP) data from the railcars in the vicinity of the incident.
- Review of telephone and radio communications.

- Metallurgical examination of the damaged Catenary Wire.

GLOSSARY OF TERMS

Arcing: Flow of current through an air gap between a contact strip and a contact wire usually indicated by the emission of intense light.

Bridle: Stainless steel wire rope attached to the Catenary Wire to assist in supporting the wire when used in conjunction with pulleys at portals.

Catenary Wire: A bare stranded conductor, being the uppermost of the two overhead wires mounted directly above the track centre line and supporting the contact wire.

Conductor: A substance which permits the flow of current.

Contact Wire: The bare solid conductor, being the lowest of the two overhead wires mounted directly above the track centreline.

Down direction (Down Main): On the Fremantle line this is the line that leads away from Fremantle station towards Perth.

Earth wire: A conductor electrically connecting together the steelwork of two or more structures and in turn connected to the traction earth system.

Overhead Traction Wiring Equipment: An arrangement of conductors, suspended over or adjacent to the railway line, for supplying electricity to electric trains, together with the associated foundations, structures, fittings, insulators and other attachments by means of which the conductors are suspended or registered in position.

Pantograph: A retractable frame, mounted on insulators on the roof of an electric train, which presses against the underside of the contact wire and through which the current is collected from the Overhead Traction Wiring Equipment.

Return Conductor: A conductor attached to the Overhead Traction Wiring Equipment structures that carries traction return current.

Up direction (Up Main): On the Fremantle line this is the line that leads from Perth towards Fremantle station.

REPORTING

The PTA has prepared a report consistent with PTA's Investigating Health, Safety and Environmental Incidents procedure 9110-000-015 which has been approved by the PTA Incident Evaluation Committee.

The report was compiled by the Manager Safeworking, and outlines the investigation, analysis, findings, conclusions, and the agreed safety actions that arose from the investigation.

The report from Exceed Consulting with regard to Metallurgist testing of Catenary Wire is appended in this report.

1.0 FACTUAL INFORMATION

1.1 The Incident

At 0746 hours on Monday 24 March 2014 train service 7541B reported that the service had experienced a loss of power at Subiaco; the Electrical Control Officer (ECO) reset the power with no further incidents of power tripping recorded at that time. At 0746 hours Daglish Station CCTV footage shows the wires violently moving for a short time.

At 0756 hours, train service 7543AS (a four car "A" series set) was traveling express from Claremont Station to Subiaco Station. On the approach to Daglish Station, the train had just passed the 85km/h speed board and the Driver was in the process of accelerating from 80Km/h to track speed of 85km/h when he heard a very loud bang.

The Driver immediately applied a full brake application and as he did, he saw and heard a wire hitting the windscreen of the railcar. The wire left a mark on the glass but did not do any significant damage to the glass.

At the same time the ATP recorder went into fault mode with a code H2 appearing on the fault screen. The Driver then pushed the emergency power isolation button and applied the emergency brake.

The train came to a stop with the lead railcar (four car set) on the platform at Daglish Station. The Driver contacted Train Control stating that he suspected that the Overhead Wires were down. The Driver opened the external cab doors in an attempt to gain a better view of the incident, however, he remained in his railcar at that stage as he thought that there was a possibility there could be live power lines in contact with the railcars. [1]

As service No 7543AS approached Daglish Station the railcar's forward facing camera shows a loss of tension in the Catenary System at 0757 hours. The balance weights were on the ground, which corresponds with the second SCADA event trip. As shown from *Figure 1* the three disc glass insulators can be seen hanging down because of the loss of tension. This confirms that further damage and loss of tension occurred during passage of service 7543AS.

Figure 1: Still shot from forward facing camera of train service 7543AS

On inspection of the incident site a scorched branch was found in the middle of the Down Main in the overlap takeover span. This branch had clear evidence of blackened scorching on it. It is suspected that this was sustained over a period of time, indicating further arcing to the overlap span had occurred. High winds were recorded in the days leading up to the dewirement.

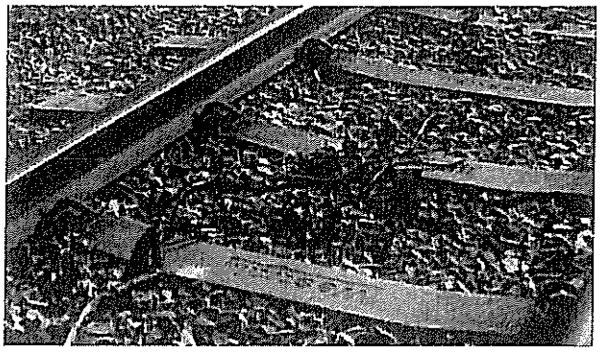

Figure 2: photo of the location of the branch after the incident.

A closer inspection of the branch found in the overlap span found that the leaves on the branch were fresh. This indicates that the branch had recently fallen from a tree in close proximity to the perway

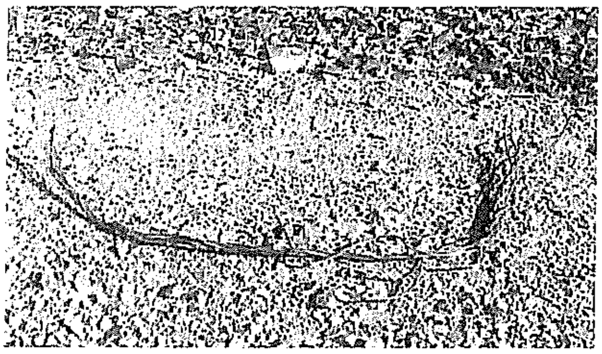

Figure 3: photo of the section of Catenary Wire found

A one metre section of the Catenary Conductor was found several metres into the overlap span. This section of the Catenary shows evidence of sustained arcing over a period of time *[figure 3]*. This has caused annealing which confirms that the parting of the Catenary was due to heat rather than mechanical failure.

1.2 Background to Work Leading Up to the Incident

There was no work occurring or scheduled to occur on the OHTWE in the vicinity of the dewirement incident.

1.3 Injuries

There were no reported injuries as a result of this incident.

1.4 Railcars

"A" series railcars are a class of Electric Multiple Units (EMU) operated by Transperth Train Operations. They were introduced into the suburban rail network in 1991.

Each "A" series train set comprises of two semi-permanently coupled railcars, designated AEA and AEB. Both have a Drivers cab and powered bogies. Each of the two car sets has a Pantograph designed to collect power from the OHTWE. Their operation (raising and lowering) is effected by the Railcar Driver from the operating cab of the railcar.

The railcars are fitted with Automatic Train Protection (ATP) to ensure the observance of approved track speed. The system monitors train speed and brake operation and provides a reminder to the Driver of current line speed information. A warning is received by the Driver if an over speed situation is detected. The system will apply the brake if the Driver takes no action to reduce the train speed.

The A series ATP system accuracy is +/- 4%, it is important to note that the Drivers speedometer utilises the same axle probe speed signal. This will not provide the exact same signal as recorded by the ATP system because it converts the signal using different hardware.

After the incident the railcars involved were checked by the mechanical engineering staff who determined that at the time of the incident that they were in a satisfactory operating condition.

1.5 Railcar maintenance

The railcars involved in the incident underwent an A Service in March 2104.

- Railcars AEB 307 and AEA 207 on 17 March 2014.
- Railcars AEB 302 and AEA 202 on 5 March 2014.

There were no significance issues raised during the maintenance inspection, with the railcars released for service and fit for purpose. [3]

1.6 Pantographs

The Pantographs fitted to the "A" railcars are Schunk Model WBR 23L (refer Figure 4) have no secondary suspension or Automatic Dropping Device (ADD).

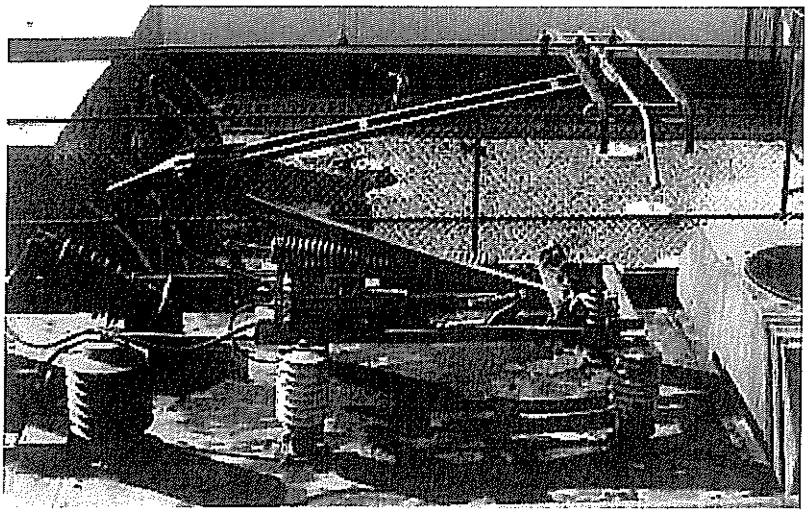

Figure 4: SINGLE ARM PANTOGRAPH Model WBR23LK.

Electrical current collection by the railcars is obtained by means of a segmented carbon Pantograph sitting on top of the EMU and underside of the Contact Wire. There could be one or two Pantographs on one EMU at the same time, depending on how the railcars are coupled together.

On the day of the incident the affected train was being operated as a four car set with AEB 307 operating as the lead railcar and AEB 302 operating as the trailing railcar, with its Pantograph knuckle leading.

Both Pantograph heads were severely damaged as a result of the dewirement.

1.7 The PTA Overhead Traction Wiring Equipment

The OHTWE operates at a nominal 25,000 volts, 50 Hertz, and alternating current (AC). This system was installed and commissioned on the Fremantle line in the 1990's. In 2007 the Daglish Station turnback siding was built to assist in the stowing of railcars. This enabled the PTA to move large crowds from Subiaco and West Leederville Stations after special events. The design and construction of the turnback siding required the PTA to make alterations to the OHTWE at the Daglish Station. The concrete masts supporting the overhead wires were changed to steel portal structures. (Refer to Figure 5).

The portal registration support frames at Daglish Station on the Down Main at Location F 7.278DU have pulleys attached that support the Catenary Wire. The Catenary Wire was run across the top of, and through, the pulley and not in accordance with the system design specifications for this type of arrangement. (Refer to Figure 5 and Figures 6 to 8 on subsequent pages).

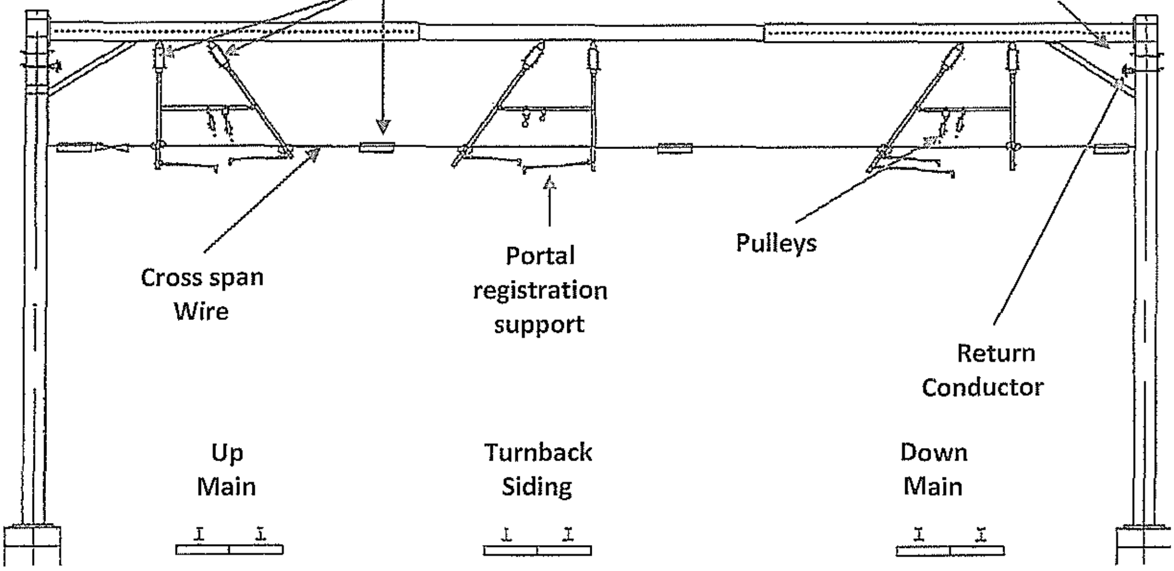

Figure 5: Diagram showing Location F 7.278DU.

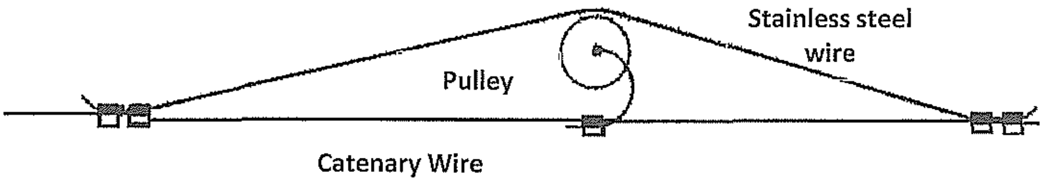

Figure 6: Diagram showing pulley assembly support in accordance with System drawing ES-HG-1757.

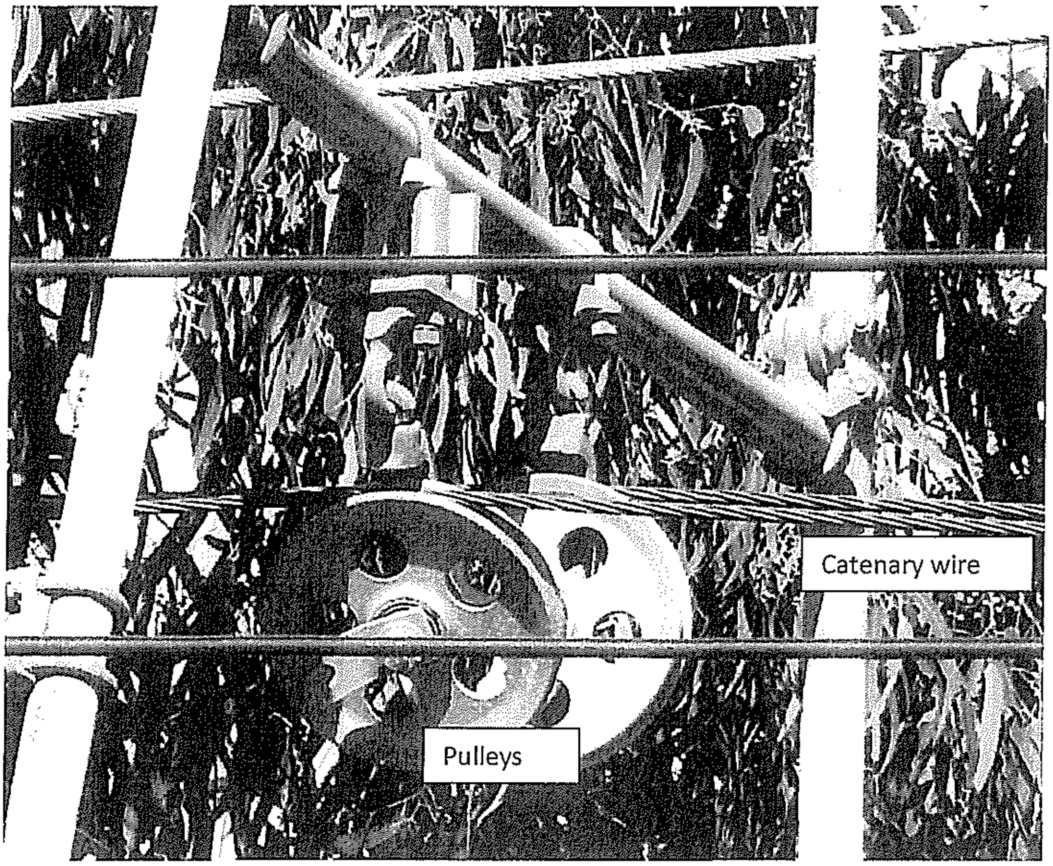

Figure 7: photo showing how the Catenary Wire was run through the pulley assembly support.

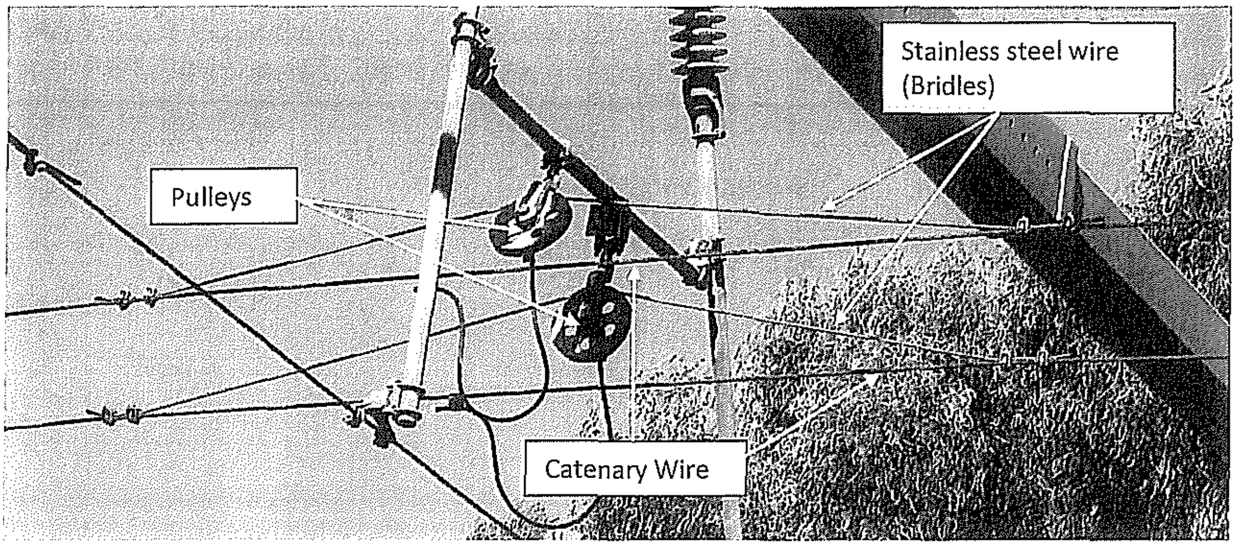

Figure 8: photo showing how the Catenary Wire is supported in accordance with the system design.

Tension lengths for each Catenary Wire run are a maximum of 1.6km in length. They have balance weights at each end providing constant tension to compensate for any temperature variation. Balance weights are composed of a number of small cast iron round discs, or concrete weights.

The design incorporates the use of stainless steel wire Bridles that run through the pulley system. Stainless steel is a much stronger and harder wearing metal than the seven strand copper Catenary Wire. Running copper Catenary Wire through pulley wheels is a not recommended because the pulley wheels can be different in their mechanical makeup and composed from different alloys, they are not bimetallic.

1.8 Commissioning of the Daglish Station turnback siding

The drawings of the overhead structures [4] provided for the investigation show some anomalies in that they:

- Have no drawing number, the drawings show xx-x-xx-xxx;
- Show the designed, checked and approved blocks are signed by the same person;
- Show the original issue, the redesign and the as built document blocks are also signed by the same person; and
- Have the incorrect Public Transport Authority logo.

The "as-built" documents show that pulleys are required to be installed for the portal configuration. Drawing ES-HG-1757 [5] shows that when pulleys are installed a stainless steel "Bridle" is required.

The Bridle is used to ensure that the Catenary Wire is not in contact with the alloy pulley wheel to prevent arcing and undue wear on the Catenary Wire. (See figures 6, 7 and 8)

At the time of writing this report the inspection and testing documents for the commissioning of the Daglish Station turnback siding could not be located.

The investigation process highlighted that the issue of the missing Bridles on the Daglish project was raised, verbally, several times by overhead personnel prior to the event, however there is no documented evidence of this. The outstanding defects were not tracked and therefore they were not rectified by the project.

1.9 Maintenance of the Overhead Traction wiring system at the affected location

Cab patrols are run along the Fremantle line monthly, they look for generic problems with the OHTWE. They specifically target broken droppers, wind stay dropper, nose dropper issues, excessive wire vibration or swinging and unsafe work activities near the 3m OHTWE zone. The cab patrols travel (in the train) at line speed, this inspection process is limiting due to the speed that the trains travel through the sections and concentrates on issues such as broken droppers, excessive swing or vibration of the overhead lines as the rail care travels through the section. However it is seen as a valid form of intervention in the overall asset management of OHTWE. [12]

Routine visual line patrols are conducted by Line Walkers on the Fremantle line every three months. A full list of the items to be checked by the Line Walkers is provided in appendix. [6]

One of the items written on the Line Walkers check sheet is; "are the conductor connections in good order?", this question relates to the checking of the conductor connections it does not specifically request an inspection of the pulley supports.

The maintenance record dated 13 December 2012 relating to the Contact Wire height and stagger of wire runs 122 & 122A around the Daglish Station incident area, was assessed in compliance with the Code of Practice 8190-800-001, *The Design, Supply, Construction and Commissioning of 25KV A.C. Traction Overhead Catenary Equipment Part A. General System Specifications.*

The following criteria are considered as per the Code of Practice: [7]

- Staggers are within criterion;
- Mid-span offsets are within the criterion;
- Stagger sweeps are within the criterion; and

- Wire heights are within the limit of gradient.

1.10 Drivers record of the incident

The Driver of service No 7543AS stated that when he was at Mosman Park Station he overheard a radio communication between the service that was directly in front of him and service No. 7541B and Train Control. The Driver of 7541B stated that he had no overhead power. The Driver of service No 7543AS then heard Train Control report to the Driver of 7541B communicating information that the ECO was performing switching and that power should be restored shortly. Service no 7543AS did not lose power, the service was in a different electrical section which was unaffected by the trip.

On the approach to Daglish Station the Driver of service No. 7543AS stated that he had just passed the 85Km/h speed board. He was in the process of accelerating from 80Km/H to track speed of 85Km/h when he heard a very loud bang. His immediate action was to apply a full brake application. He then saw and heard wire hitting his windscreen which left a mark on the glass but did not do any damage. He pushed the emergency power isolation button and applied the emergency brakes.

The train came to a stand with the front half of the first two car set on the platform at Daglish Station. The Driver contacted Train Control stating that he suspected that the overheads were down. The Driver opened the external cab doors in an attempt to gain a better view of the incident however, remained in the railcar as he thought there was a possibility that the train had live power lines in contact with it.

At the time of the bang the Driver noted that the ATP recorder went into fault mode with a code H2 appearing on the fault screen.

Due to the loss of overhead power there was no air-conditioning on the train, knowing that the train was full of passengers, the Driver made the first of many calls to the passengers using the PA, informing the passages of the situation. The Driver contacted Train Control to gain permission to detrain the passengers from the lead set via the Drivers cab door. Train Control denied the request until the ECO had given permission.

The Driver made several safety announcements to the passengers telling them not to open the doors. He gave them progress updates and let them know that they would be detrained as soon as possible.

When the Operations Manager arrived on site and received confirmation that it was safe to detrain the passengers, he detrained the passengers from the front two cars onto the platform. Passengers on the rear two cars were evacuated via the Drivers door via the perway onto the platform.

Once all of the passengers were off the railcars and clear of the perway the Driver isolated and shut down the train and awaited further instructions.

After a period of time the Driver was relieved by another Driver and taken back to Claisebrook Depot by road vehicle.

The Driver of 7543AS did not see and was not made aware of any passengers whom had any ill effects as a result of being on the train or whilst evacuating. [1]

1.11 Damage to Equipment

Both railcars received extensive damage to their Pantographs however it is anticipated that the repairer should be able to restore each of the Pantographs back to full operational condition for less than the cost of a new Pantograph.

The leading railcar also received:

- A high voltage flashover to the body of the railcar near the R16 window.
- Damage to the RHS green stripe.
- A cracked AEB cab quarter window.
- Flashover damage to the cab quarter window's frame. [3]

300m of Catenary Wire, between mast numbers F07046 and F07339, was replaced in addition to the following:

- Droppers between F06861D and F7389D.
- 3 sets of drapes.
- Isolator feeds.
- 7 steady arms.
- 3 sets of stand-off insulators.
- LDV tube & insulator.
- numerous clamps/clips/components.[8]

1.12 Metallurgists Report

In their report, Exceed Consulting identified the presence of thermal damage on sections of Catenary Wire provided from the incident site.

Failure of the conductor strands was identified as a ductile overload failure, however, this was not considered to have occurred due to the conductor being overloaded. This occurred as a result of the thermal damage at the location of failure reducing the tensile strength of the conductor in that region. The reduction in the tensile strength therefore reduced the loads that the conductor could withstand and therefore initiated an overload failure.

Findings from Exceed Consulting concluded that the Catenary Wire failed as a result of the conductor having experienced arcing and thermal damage resulting in a reduction in strength.[9]

1.13 Engineering Assessment

High winds were recorded in the days prior to the dewirement and a blackened branch was found in the takeover overlap span which had clear evidence of scorching that had been sustained over a period of time. This indicates that further arcing to the insulated overlap occurred. Further inspection of the branch revealed that the leaves on the branch were fresh, indicating that the branch had recently fallen from a tree in close proximity to the perway.

A one metre section of Catenary Wire was found several meters into the overlap span. All strand ends show typical evidence of annealing, which confirm that the parting of the Catenary Wire was due to heat rather than mechanical failure. Some strands are worn from the pulley wheel but not sufficiently to have caused a dewirement. Hard drawn copper conductor can have 3 strands broken and still maintain full mainline tension.

The copper Catenary Wire being placed on aluminium pulley wheels gave rise to localised minor arcing over a sustained period.

The absence of stainless steel Bridle arrangements (not installed by the enhancement project) has given rise to localised minor arcing over a sustained length of time. Although the Catenary Wire does show minor wear on the strands from passing through the pulley wheel, it is the tree branch that led to the final catastrophic failure of the Catenary Wire. [10]

1.14 Location Description

Daglish Station is located seven kilometres from Perth on the Perth to Fremantle railway. The railway is designated as double line with exclusive up and down uni – directional main lines to facilitate train operations in each direction. The incident occurred on the western side of Daglish Station adjacent to the turnback siding.

The turnback siding at Daglish Station is located between the Up and Down Mains on the western side of the station platforms. The turnback siding was constructed in 2007 to move large crowds from Subiaco and West Leederville Stations after special events. All rail traffic movements are controlled from the Train Control Centre on the second floor of the Public Transport Centre (PTC).

Communications on this line are by means of the PTA two way radio network and commercial mobile phone carriers.

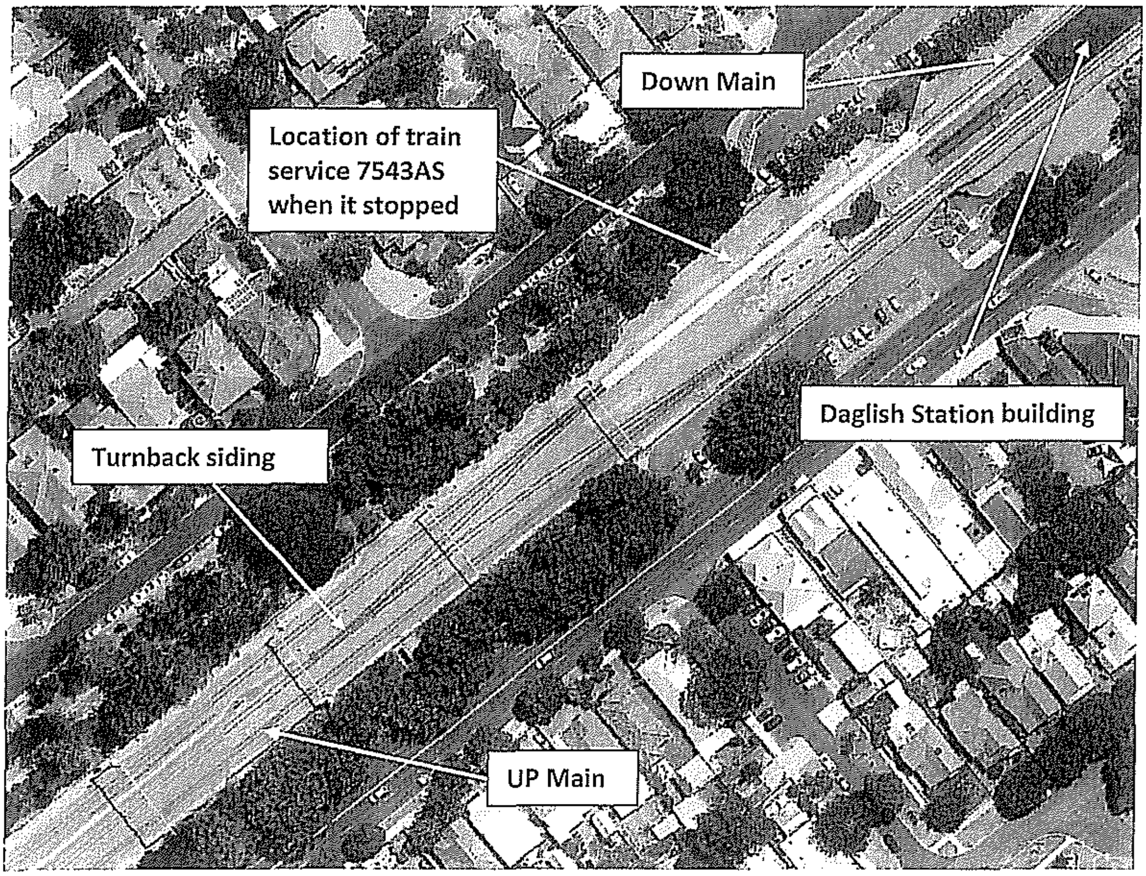

Figure 9: Near map view of incident location.

1.15 Lighting Conditions

This incident occurred at 0756 hours as the train was traveling in a westerly direction, the sun was rising from the East.

1.16 Weather Information

Weather information for the previous 10 days has been drawn from the Australian Government Bureau of Meteorology and is a combination of observations from the Mount Lawley and Perth Airport Stations. (Refer Table 2, below) [11]

Observations from these locations confirm that there were high winds on the preceding 10 days prior to the incident which may have resulted in the branch being blown down onto the overhead lines.

Table 1: Weather events 10 days prior to the incident.

Date	Minimum Temperature	Maximum Temperature	Rainfall	Maximum Wind Speed Km/h
15/03/2014	10.3	24.0	0	S 35
16/03/2014	13.7	26.8	0	SSW 35
17/03/2014	15.6	28.5	0	SSW 30
18/03/2014	16.1	30.0	0	SSW 31
19/03/2014	17.3	31.9	0	SSW 31
20/03/2014	18.9	31.6	0	ESE 50
21/03/2014	16.2	28.1	1.0	SE 43
22/03/2014	18.7	31.7	0	ENE 44
23/03/2014	20.7	33.9	0	ENE 41
24/03/2014	22.3	34.2	0	SW 31

1.17 Drug and Alcohol Testing

There was no alcohol or other drug testing undertaken as a result of this incident. There is no suggestion that either alcohol or other drugs played a part in the incident.

1.18 Railcar DriverTraining

The Driver of service 7543AS on the 24 March 2014 had a current Track Access Permit WTO 11 and has completed training and awareness sessions applicable to the position. He was deemed competent to operate as a railcar Driver at the time of the incident.

1.19 Previous Dewirement Events at the PTA

The following three previous dewirements were considered in relation to this incident;

- Cockburn on 31 December 2012;
- Warnbro on 11 January 2014; and
- Currambine 28 February 2014.

All have the same common thread; being they were not constructed as designed.

1.20 Functioning of Rolling Stock and Technical Installations

The Train Control and Electric Control Officer (ECO) SCADA functions and voice loggers were downloaded following the incident. The Train Control System replay did not provide evidence that was of value to the investigation.

Evaluation of the ECO SCADA data validated the timeline and provided insight into the initial occurrence involving train service 7541 and 7543 the train that was involved in the dewirement.

The power fault reported by the previous service 7541 as it passed Daglish Station which led the ECO to reclose the circuit breaker. There was no further fault detected by the system; no actions to find the cause of the fault were initiated.[2]

Analysis of the automatic data registration supported the Drivers's version of events with the operation of the railcars, and verifies that the brakes were working satisfactorily at the time of the incident. There were no issues of concern or discrepancies identified in terms of the safe operation of the train. [3]

1.21 Summarised Sequence of Events

The summary of the sequence of events was compiled using data from the voice logger, the forward facing camera of the railcar and the ATP together with the statements of the Railcar Driver and the Operations Manager.

Table 2: Summarised sequence of events.

Time	Who by	Action
0746	Drivers 7541	Advised Train Control (TC) of loss of power, TC informs that ECO is restoring. The Drivers replied that he has power once again.
0757	Drivers 7543	Reported that the overhead has come down on the approach into Daglish Station. Once the railcars had stopped the Drivers reported that he had the cab on the platform and asked if he should detrain. TC advises not to detrain until it has been determined that it is safe to do so.
0802	Drivers 7543	Reported that Transit Officers are on site and requests to detrain passengers. TC refuses and want overhead staff on site first.
0815	Drivers 7543	Reported that the Transit Officer had walked around the railcars and confirmed that wires are over the rear set and requests permission to detrain the front set. TC refused as he was waiting for qualified staff to arrive.
0830 to 0840	Operations Manager	Arrived on site and confirmed with the Transit Officers and the Driver of 7543. Waiting for approval from the ECO to evacuate the railcars. Approval to evacuate the railcars was given at approximately 0837 by the ECO.
0840 To 0900	Operations Manager	Oversaw the evacuation of the railcars. The passengers in the front set were moved to the doors that were opened onto the platform. Passenger in the rear set were evacuated through the Drivers cab onto the perway and then walked to Daglish Station platform.
0915	Operations Manager	Passengers were being loaded onto the busses to continue their journey.
10:35	Operations Manager	Left the site after conferring with the Manager Safety Investigations and the Electrical Engineering Manager that the site was closed.
1834	Train Control	The Up and Down Mains were opened to rail traffic.
1840	ECO	Overhead power was restored.
1926	Relief Train	Service 7545 was used to remove service 7543 from Daglish Station to Claisebrook Railcar Depot.
1852		Normal services resumed.

2.0 ANALYSIS

The contributing factors of this incident were analysed using the Incident Cause Analysis Method (ICAM).

Organisational factors	Task / environmental conditions	Individual/team actions	Absent or failed defences	Non contributory factors
Overhead inspections do not consider design vs. as constructed requirements.	High winds the days of the day and days before the incident caused a small branch to fall onto the overhead.	Driver heard a loud bang and immediately applied a full break application, followed by emergency power isolation then emergency brake.	Quality of commissioning on overhead line did not detect design shortfall.	
Commissioning of overhead line equipment was not thorough enough to detect missing Bridles.		Train Control placed Emergency blocking on signals placed at stop, all trains warned of issue, ECO applied an emergency de-energisation.	Regular inspections and maintenance did not detect the missing Bridles.	
Recording and tracking of defects was not thorough enough to ensure that the defect was corrected.		ECO issued Permit to work with the Nominated Person in the Field.	No special arrangements in place to ensure the system was constructed as designed.	

2.1 Investigation Methodology

ICAM is an analysis tool that sorts the findings of an investigation into a structured framework, with the contributing factors classified into the following four categories:

2.2 Absent or Failed Defences

Defences are those measures designed to prevent the consequences of a human act or component failure producing an incident. Defences include equipment or procedures for detection, warning, recovery, containment, escape and evacuation, as well as individual awareness and protective equipment.

These contributing factors result from inadequate or absent defences that failed to detect and protect the system against technical and human failures. These are the control measures which did not prevent the incident or limit its consequences. The absent and failed defences identified in this incident are briefly described below:

- Design assurance and associated verification;
- Project installation verification was not adequately carried out;
- Quality of commissioning on overhead line equipment did not detect design shortfall; and
- No special arrangements were in place to ensure the system was constructed as designed in terms of detailed post commissioning inspection or maintenance arrangements.

2.3 Individual or Team Actions

The Driver heard a loud bang and immediately applied a full break application, followed by emergency power isolation then emergency brake.

2.4 Task and Environmental Conditions

These are the conditions in existence immediately prior or at the time of the incident that directly influences human and equipment performance in the workplace. These are the circumstances under which the errors and violations took place and can be embedded in task demands, the work environment, individual capabilities and human factors.

Deficiencies in these conditions can promote the incident of errors and violations. They may also stem from an organisational factor type such as risk management, training, incompatible goals, or procedures, when the system tolerates their long term existence.

The Task / Environmental Conditions are listed below:

- High winds the weekend before caused a small branch to be blown onto the overhead insulated overlap equipment.

2.5 Organisational Factors

Organisational Factors are the underlying organisational factors that produce the conditions that affect performance in the workplace. They may lie dormant or undetected for a long time within an organisation and only become apparent when they combine with other contributing factors that led to the incident.

The Organisational Factors identified in this incident are listed below.

A short description of what each organisational factor entails precedes a summary of issues (in no specific or weighted order) that were identified in relation to this incident.

- Commissioning of OHTWE was not thorough enough to detect the lack of Bridle arrangements, Design (DE).
- Existing OHTWE inspections do not consider design vs. as constructed requirements as part of the inspection regime, Organisation (OR).

  Note: In relation to the second dot point it may not be practicable for overhead line patrollers to carry vast amounts of design documentation.
- Recording and tracking of defects was not thorough enough to ensure that the defect was corrected, Organisation (OR).

3.0 FINDINGS

The absence of stainless steel Bridle ropes that were not installed by the original project resulted in minor arcing over a sustained period of time. The tree branch that fell onto the OHTWE was the catalyst that led to the final failure of the Catenary Wire.

The failed Catenary Wire was hanging down within track gauge on the Down Main and collided with the train as the train was travelling toward Perth.

The Catenary Wire caught and dislodged the Pantograph head of one railcar and severely damaged the head of the second railcar.

300 metres of the OHTWE was pulled down with further damage to the OHTWE on the portal.

3.1 Root Causes

The root causes of the incident were:

- The tree branch which had blown down across the overhead caused arcing on the overlap span.
- The portal pulleys were installed and the Catenary Wires were not fitted with the stainless steel Bridles as required by the system design drawings introducing a latent or inherent defect into the system.
- The Catenary Wire failed as a result of arcing and wear due to the non-installation of the stainless steel Bridles.

3.2 Underlying Causes

The underlying causes were:

- Commissioning of the Daglish Station set back siding did not detect the anomaly.
- Worksite inspections undertaken since commissioning of the railway were not adequately scoped to detect anomalies of this type.
- Inadequate design assurance and verification.
- Inadequate project installation and associated verification controls.
- Inadequate reporting, tracking and rectification of identified issues, the lack of Bridles.
- The absence of stainless steel Bridle ropes that were not installed by the original project resulted in minor arcing over a sustained period of time.
- The tree branch that fell onto the OHTWE was the catalyst that led to the final failure of the Catenary Wire.
- The failed Catenary Wire was hanging down within track gauge on the Down Main and collided with the train as the train was travelling toward Perth.
- The Catenary Wire caught and dislodged the Pantograph head of one railcar and severely damaged the head of the second railcar.
- 300 metres of the OHTWE was pulled down with further damage to the OHTWE on the portal.

4.0 ACTIONS ALREADY UNDERTAKEN

- All similar locations that included portals on the network were reviewed for compliance with the system design; no other locations were identified with the same issue.
- The overhead team has been fully briefed on the importance of stainless steel Bridles at pulley wheels, especially at insulated overlaps.
- A maintenance alert regarding midpoint and catenary suspension pulleys has been issued to the overhead maintenance team.
- Key engineering roles have been identified to ensure that there is full ownership across all of the areas of design, installation and commissioning.
- New Procedure for Engineering Assurance for Projects.

5.0 RECOMMENDED SAFETY ACTIONS

- Briefings and Tool box talks with all staff.
- Long term implement a new linesmen course for all staff.

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13. Code of Practice 8190-800-001, The Design, Supply, Construction and Commissioning of 25KV A.C. Traction Overhead Catenary Equipment Part A. General System Specifications.