

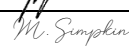
Back Turner Street / Manchester Metrolink

Design Commentary

Back Turner Street Building Fixings

POD-RPT-002107

Summary: This design commentary looks at the proposed design to support the OLE for Manchester Metrolink from the new development at Back Turner Street.

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Contents

1.	Introduction	6
1.1	The Manchester Metrolink System	6
1.2	Back Turner Street Development	6
1.3	Purpose	6
1.4	Terms and Abbreviations.....	6
1.4.1.	Terms.....	6
1.4.2.	Abbreviations	7
1.5	References.....	7
1.6	Associated Drawings and Documents.....	7
1.7	Void & Assumptions	7
2.	Scope	8
3.	Existing Arrangements	9
3.1	Pole CC51	9
3.2	Pole CC53	9
4.	Design Principles	10
4.1	Equipment	10
4.2	Overhead Line Performance Specification	10
4.2.1.	Electrical Rating	10
4.2.2.	Design Life	10
4.2.3.	Wire Heights.....	10
4.2.4.	Wire Gradients	10
4.2.5.	Environmental Data.....	10
4.2.6.	Electrical Clearances.....	10
4.2.7.	Mechanical Clearances (Structure Gauge)	11
4.3	Structural and Mechanical Loadings.....	11
4.3.1.	Static Weights of Equipment	11
4.3.2.	Radial component of wire tension.....	11
4.3.3.	Ice Layer	12
4.3.4.	Wind Loading.....	12
4.4	Electro-magnetic Compatibility	12
4.5	Safe by Design	12
4.5.1.	Designers Risk Assessment.....	12
4.5.2.	Hazard Identification of drawings.....	12
5.	Proposed Design	13

5.1	Proposed design CC53A (POD-DRG-002104).....	13
5.2	Proposed design CC53B (POD-DRG-002105).....	13
6.	Interfaces.....	15
6.1	Primary Interfaces	15
6.1.1.	Existing Metrolink System	15
6.1.2.	Permanent Way.....	15
6.1.3.	Pantograph Interface.....	15
6.1.4.	Traction Power	15
6.1.5.	Proposed Building Fixing.....	16
6.2	Secondary Interfaces	16
6.2.1.	Existing Wall Fixings.....	16
6.2.2.	Existing civil structures	16
6.2.3.	Ducting	16
6.2.4.	Drainage	16
6.2.5.	Highways and Junctions.....	16
6.2.6.	Local Authority	17
6.2.7.	Stops.....	17
6.2.8.	Lighting.....	17
6.2.9.	Landscaping and Urban environment.....	18
6.2.10.	Earthing and Bonding	18
7.	Proposed OLE equipment	19
7.1	2T Insulator.....	19
7.1.1.	Pfisterer 2T Inline Insulator	19
7.1.2.	Brecknell Willis 2T Insulator	19
7.2	Strong Registration Arm	20
7.3	8mm and 10mm Quick Links	20
7.4	10mm Delta Link.....	21
7.5	6mm Wire Rope Assembly	21
7.6	Pole Straps.....	22
8.	Designers Risk Assessment	23
8.1	Introduction.....	23
8.1.1.	Occurrence Probability	23
8.1.2.	Severity Rating.....	23
8.1.3.	Risk Significance.....	24
8.2	Summary	25

8.3	Conclusions.....	25
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Table of Figures

Figure 1 Site location and OLE poles.....	8
Figure 2 Drawing of the existing OLE Layout	8
Figure 3 Pole CC51 Existing Arrangement.....	9
Figure 4 Pole CC53 Existing Arrangement.....	9
Figure 5 Minimum clearances to accessible live parts of the OCS from a standing surface in public areas (from EN 50122 ^(Ref 2))	11
Figure 6 CC53A Proposed Design	13
Figure 7 CC53B Proposed Design	14
Figure 8 Primary Interfaces	15
Figure 9 Proposed OLE Building Fixing (from BTS-REN-B-1101-SK-S-01001).....	16
Figure 10 Street signage attached to CC53.....	17
Figure 11 Illuminated stop sign Pole CC53.....	18
Figure 12 Pfisterer 2T insulator.....	19
Figure 13 Brecknell Willis 2T insulator.....	19
Figure 14 Brecknell Willis strong registration arm.....	20
Figure 15 Quick Link	20
Figure 16 10mm Delta Link	21
Figure 17 6mm Wire rope stranding arrangement.....	21
Figure 18 Pole strap	22

Table of Tables

Table 1 Occurrence Probability.....	23
Table 2 Severity Rating.....	23
Table 3 Risk Significance	24
Table 4 Actions to be applied against risk categorisation	24
Table 5 Identified Risks	26

1. Introduction

This document is a design commentary to explain the design for the transfer of support for the overhead line from poles onto wall fixings. The locations are near a new building being constructed at Back Turner Street in Manchester. The effected poles are part of the Manchester Metrolink light rail system.

1.1 The Manchester Metrolink System

The Manchester Metrolink is a 65 mile (105km) light rail system based around the city of Manchester.

The system has been expanded multiple times from it first phase in 1992 and now features 99 stops along its route. It ranges from Manchester Airport in the south to Rochdale in the north. The latest line opened is the Trafford Park Line which started operating in March 2020.

The OLE system is a 750v D.C. double insulated system. There are a wide range of OLE supporting equipment and arrangements used throughout the system, include contact/catenary, auto-tensioned trolley wire and fixed termination trolley wire.

1.2 Back Turner Street Development

Back Turner Street development is a redevelopment of a site in Manchester. The development is for a new modern office building. It will retain the existing facia of the building on Back Turner Street.

1.3 Purpose

The purpose of the document is to explain the design methodology and equipment to support the OLE from a proposed permanent fixing on the Back Turner Street Development.

1.4 Terms and Abbreviations

Below are terms and abbreviations that are used throughout this document.

1.4.1. Terms

Term	Definition
Overhead Line Equipment	The system to support the contact wire above the track to allow the trams pantograph to collect power.
Double Insulated	A type of OLE system that uses two levels of insulation (primary and secondary) to give reinforced insulation.
Transport for Greater Manchester	Public body responsible for co-ordinating transport services throughout Greater Manchester including Manchester Metrolink
KeolisAmey	Consortium responsible for the operation and maintenance of the Manchester Metrolink system.

1.4.2. Abbreviations

Abbreviation	Definition
OLE	Overhead Line Equipment
DC	Direct Current
CW	Contact Wire
CAT	Catenary Wire
H&S	Height and Stagger
TfGM	Transport for Greater Manchester
SI	Section Insulator

1.5 References

Reference	Doc No.	Title
1	BS EN 50119:2020	Railway applications. Fixed installations. Electric traction overhead contact lines
2	BS EN 50122-1:2011+A4:2017	Railway applications. Fixed installations. Electrical safety, earthing and the return circuit. Protective provisions against electric shock
3	RSP2	Guidance on Tramways
4	ADV-RPT-002100	Feasibility Study – Back Turner Street Building Fixings

1.6 Associated Drawings and Documents

Number	Title
POD-DRG-002101	Back Turner Street - Overhead Line equipment – OLE Layout
POD-DRG-002104	Back Turner Street - Overhead Line equipment – Cross Section CC53A
POD-DRG-002105	Back Turner Street - Overhead Line equipment – Cross Section CC53B
POD-DRG-002106	Back Turner Street - Overhead Line equipment – Building Fixing Locations
POD-DRG-002107	Design Commentary – Back Turner Street Building Fixings
POD-CAL-002120	Wall Fixing Loading Calculation CC53B
POD-CAL-002121	Wall Fixing Loading Calculation CC53A

1.7 Voids & Assumptions

Ref	Void	Mitigation
1	Pole Diameter CC53	To enable the completion of the design for the bridles between at these locations, the pole sizes are required to allow allocation of the correct pole strap.

2. Scope

The scope of the project is proposed to replace the existing pole CC53 with a wall fixing supported from the new building development on Back Turner Street. The removal of the pole will enable the removal of an OLE pole and reduce the overall street clutter improving the visual landscape.

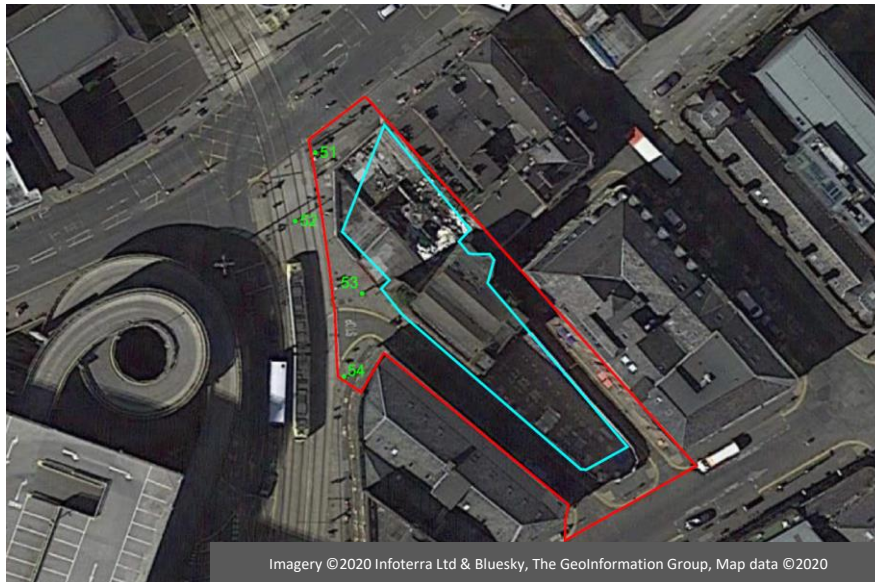


Figure 1 Site location and OLE poles

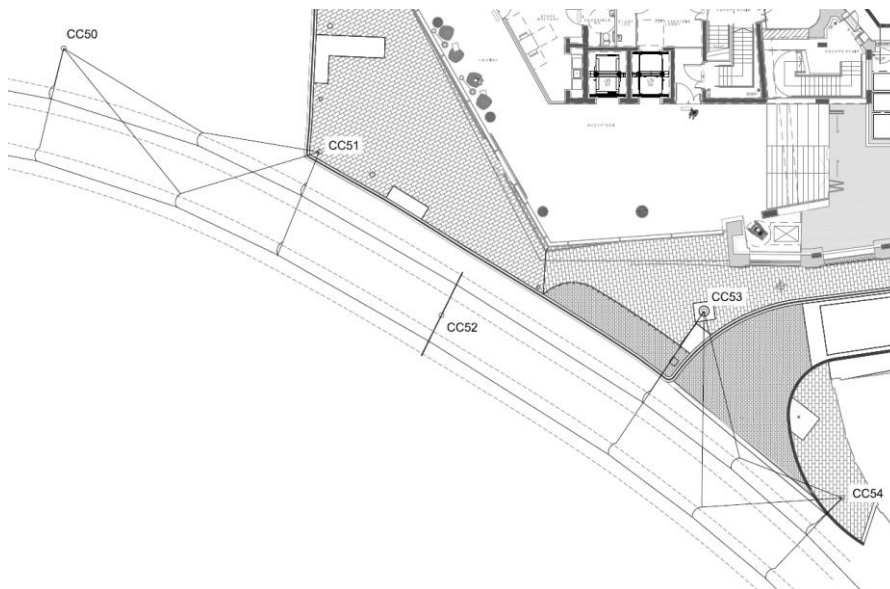


Figure 2 Drawing of the existing OLE Layout

3. Existing Arrangements

3.1 Pole CC51

During the OLE preliminary design phase CC51 was identified as being possible to change to a building fixing with agreement of the developer. This however has not been possible as the connection locations are on parts of the building that are fully glazed. Therefore, it is not possible to install attachment locations at these points and so pole CC51 will remain.



Figure 3 Pole CC51 Existing Arrangement

3.2 Pole CC53

Pole CC53 is a large, single diameter pole from which the OLE is registered. It uses two pull offs to register the inbound and outbound track. There are also two bridles between this location and CC54, that also provide registration. As with CC51 there is no vertical support for the contact wire, only registration.

The construction of the pull-offs and bridles use non-insulated registration arms and Parafil rope is used for mechanical registration and electrical insulation.

There is also a stop sign and associated lighting mounted on this pole.

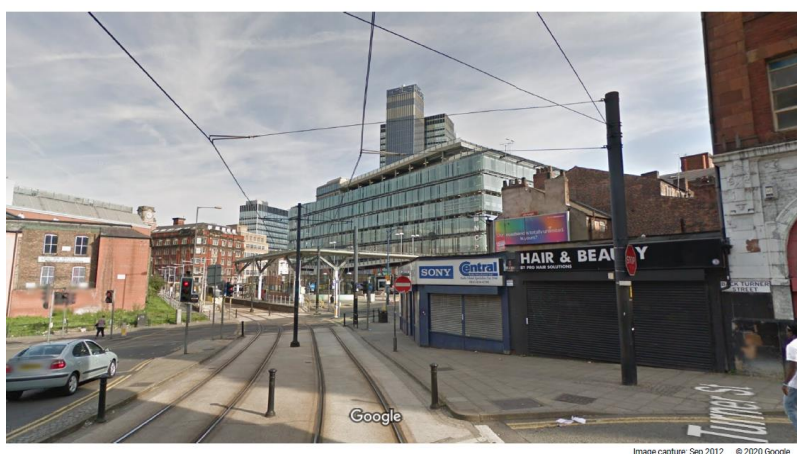


Figure 4 Pole CC53 Existing Arrangement

4.1 Equipment

Phase 3 type equipment does not use Parafil to provide support and insulation but relies on stainless steel wire rope and discreet inline insulators.

4.2.1. Electrical Rating

4.2.2. Design Life

4.2.3. Wire Heights

The nominal values for wire heights and staggers will be as follows:

Where an existing wire is under the minimum height as specified above or stagger exceeds the maximum the newly installed equipment will be installed to the existing value or better and the non-conformance reported to TfGM and KeolisAmey.

Wire gradients are not envisaged to be changed and will be as per the existing system.

Design Minimum temperature	-20°C
Wind maximum operational speed	30m/s
Max survival gust	45m/s
Radial ice	10mm

Minimum static electrical clearance between earthed and live parts will be 100mm static and 50mm dynamic (from EN 50119^(ref 1)). If there are existing locations where the clearances are below these values, the new installation shall not make them worse, and the locations shall be highlighted to TfGM & KeolisAmey.

In case of OCS failure, the design shall try, as far as reasonably practicable, to keep any live componentry above 3m from a standing surface (See Fig 13). This may mean the positioning of inline insulation in the middle of tie ropes and span work.

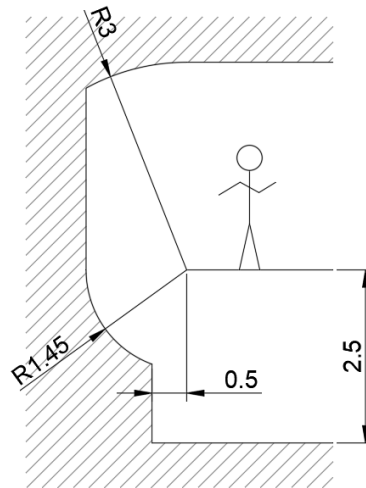


Figure 5 Minimum clearances to accessible live parts of the OCS from a standing surface in public areas (from EN 50122^(Ref 2))

Where possible the distance between two levels of insulation shall be at least 2m to reduce the risk of both levels of insulation being bridged by an incident. Where this is not possible the distance shall be maximised as far as reasonably practicable.

4.2.7. Mechanical Clearances (Structure Gauge)

There are no new poles or trackside equipment so there will be no change in clearances to the structure gauge.

4.3 Structural and Mechanical Loadings

The changes to structural and mechanical loadings to existing structures are envisaged to be minimal and therefore will not be individually calculated unless there is to be a major change in the supporting arrangement during the design phase, such as additional span wires or pull offs connecting to the poles. If such a case exists, it will be highlighted to TfGM & KeolisAmey prior to commencement of the work.

The working loads applied to the fixings will be calculated and supplied to the building developer to allow the design of suitable attachments for the OLE.

Below are listed the applicable loadings that would need to be considered in any loading calculations.

4.3.1. Static Weights of Equipment

The equipment and structures have self-weight and these create static stress in the supporting structures.

4.3.2. Radial component of wire tension

The contact wires contribute to the radial forces onto supports due to curvature of the track and/or stagger.

4.3.3. Ice Layer

In severe weather conditions all supporting wires and steelwork are liable to collect a layer of ice. This ice contributes extra mass to the system and extra wind resistance. The maximum thickness of the layer of ice considered is 10mm.

4.3.4. Wind Loading

The wind loading is considered to act at a right angle to track centreline.

BS EN 50119^(Ref 1) states that two wind loading cases should be considered:

- Operational wind speed with 10mm ice on all components except contact wire
- Maximum gust speed with no ice.

4.4 Electro-magnetic Compatibility

There is to be no change in the system feeding and contact arrangement therefore the EMC will remain as per the existing system.

4.5 Safe by Design

The principles of Safe by Design are the integration of hazard identification and risk assessment methods early in the design process. With early identification the hazards can be controlled through the design process, construction, operation, and maintenance.

4.5.1. Designers Risk Assessment

The designer's risk assessment aims to identify hazards and risk during the design process and to mitigate them where possible, through the design process.

More detail on the Designers risk assessment can be found in Section 0.

4.5.2. Hazard Identification of drawings

One of the methods for mitigation may require that the hazard be identified on the layout and cross section for that location. Therefore, the hazards will be identified on the drawings using the following format.

 OCS-000

The yellow caution triangle will highlight that there is a risk at this location. The characters next to the triangle is the risk identifier and will reference back to the Designers Risk Assessment. An outline of the hazard will also be referenced on the layout or cross section.

5. Proposed Design

5.1 Proposed design CC53A (POD-DRG-002104)

The proposed design for CC53A is as per the others using a combination of 6mm stainless steel rope and inline insulators. Brecknell Willis strong registrations arms are used to provide contact wire registration.

A single wall fixing is used for both pull-offs with a delta link connecting into the fixing to allow the attachment of both pull-offs.

The attachment for the bridles for CC53B is to be on a wall fixing situated above CC53A. Both fixings are into the existing facia of the building, which is being retained. The arrangement and connections will need to be examined and approved by the building designer and developer.

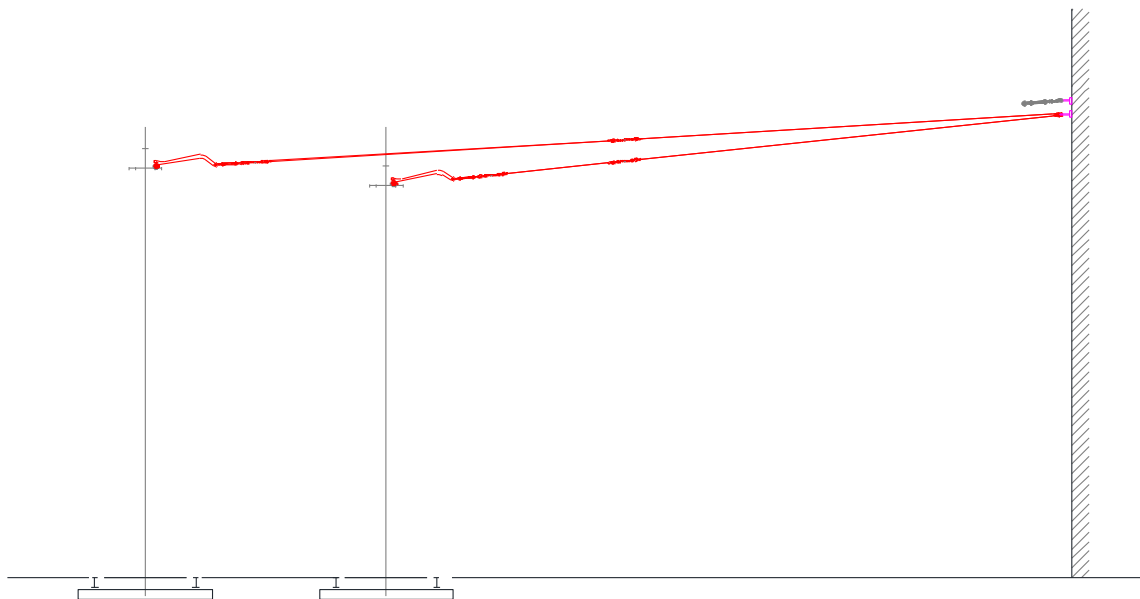


Figure 6 CC53A Proposed Design

5.2 Proposed design CC53B (POD-DRG-002105)

The bridle to register the wire between CC53B and CC54 will be constructed from 6mm Stainless Steel wire and 2T insulators. The registration arm will be a Brecknell Willis strong registration arm.

Where the far bridle crosses the near contact wire, 2T insulators will be positioned 2 m from the contact wire to try and minimise the risk of a live wire being in touching distance in a failure condition.

The connection to Pole CC54 will be via new pole straps. The size of pole CC54 will need to be advised to allow the correct allocation of the pole strap.

CC53B wall fixing will be installed approximately 250 mm above CC53A. A single fixing will be used to register both bridle legs via a delta link onto the wall fixing.

As with CC53A this is into the existing building facia, which is being retained as part of the development. The arrangement and connections will need to be examined and approved by the building designer and developer.

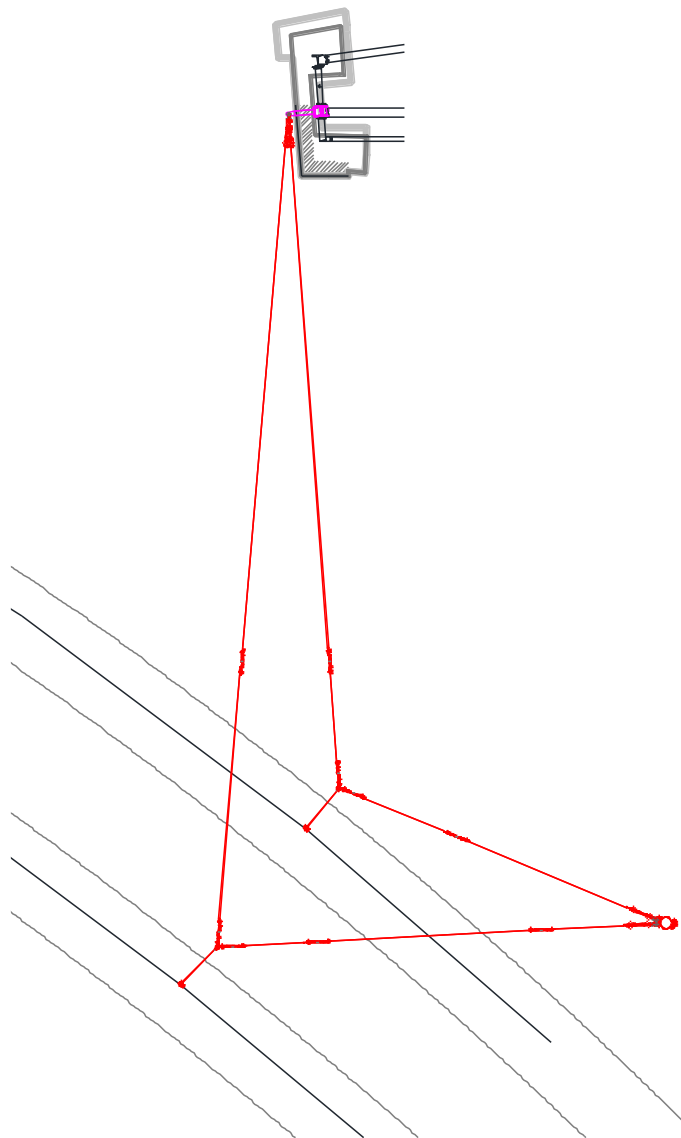


Figure 7 CC53B Proposed Design

6. Interfaces

6.1 Primary Interfaces

There are three primary interfaces with the Overhead Line Equipment – the pantograph interface, the civil interface, and the electric traction interface. The arrangement of these interfaces is shown below in Figure 8.

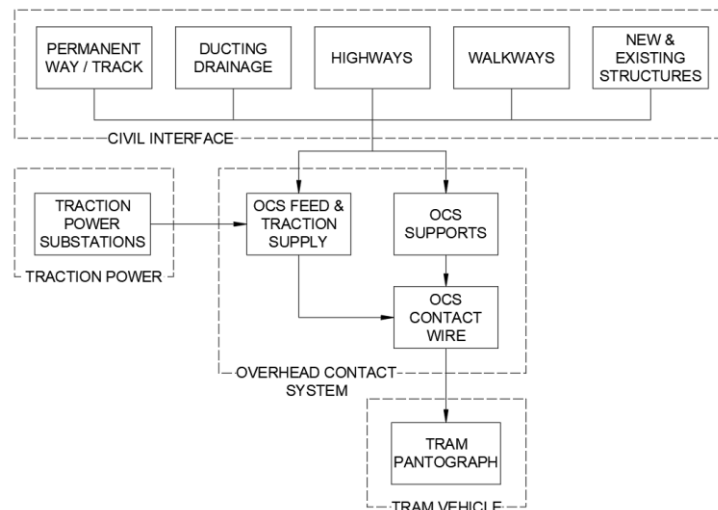


Figure 8 Primary Interfaces

6.1.1. Existing Metrolink System

The main interface is with the existing Metrolink system which is currently maintained and operated by KeolisAmey Metrolink Ltd. The design is developed to try and minimise the impact on the existing system.

Heights and Stagers will be taken prior to installation and checked post installation to ensure that the system is returned in the same or better state, prior to installation.

It is assumed that all existing equipment, that is not being replaced, is still fit for purpose. During installation if equipment is discovered to be damaged or need of replacement it will be highlighted to TfGM & KeolisAmey

6.1.2. Permanent Way

This work is not affecting the permanent way, only the OLE system. Therefore, there will be no effect on this interface.

6.1.3. Pantograph Interface

This impact on this interface can be mitigated by taking heights and staggers prior and post installation. Heel setting and clearances can be checked post installation with a MEWP using an integrated checking Pan.

6.1.4. Traction Power

There are no OLE feeds at this location and therefore there will be no effect on the traction power.

6.1.5. Proposed Building Fixing

The proposed fixing for the building is a stainless-steel square hollow section bolted directly to the internal building steel work. There is an eyelet to allow connection of the OLE to the fixing.

There will need to be two connections, one to allow the connection of the cross span and another to allow the connection of the bridle. These will; need to be approximately 200mm vertically apart.

The centre of the connection eye on the bracket will need to be at least 150 mm from the front of the fascia to allow the bridle legs to clear the corner of the building.

Further details of the proposed location and applied working loads can be found on drawing POD-DRG-002106.

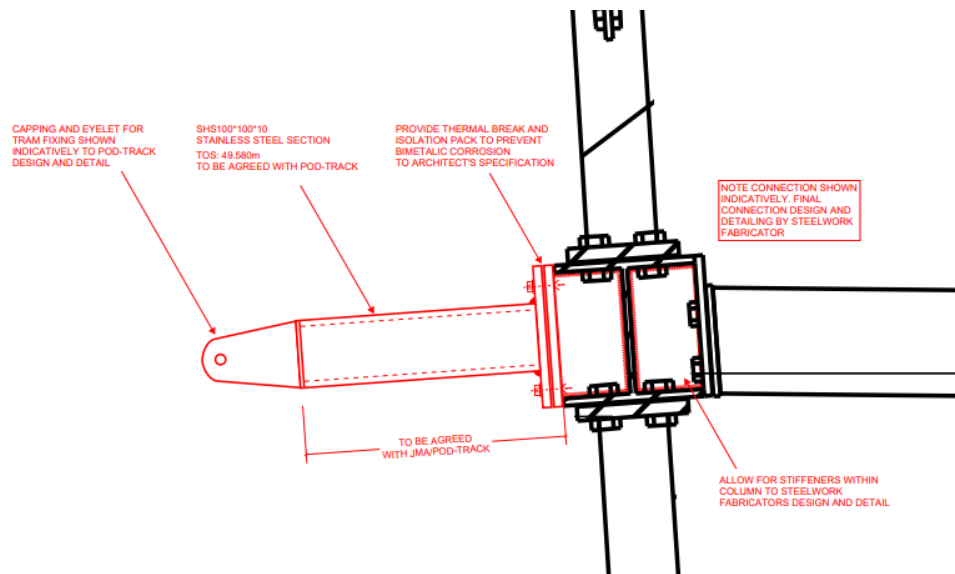


Figure 9 Proposed OLE Building Fixing (from BTS-REN-B-1101-SK-S-01001)

6.2 Secondary Interfaces

6.2.1. Existing Wall Fixings

There are no existing wall fixings that will be affected by this works.

6.2.2. Existing civil structures

The scoped works are not affecting any existing civil structures such as bridges or tunnels.

6.2.3. Ducting

The design and works have no foreseeable effect on the existing ducting.

6.2.4. Drainage

The design and works have no foreseeable effect on the existing drainage.

6.2.5. Highways and Junctions

There are road signs and tramway signage that are attached to the existing poles that are to be removed. These will need to be re-sited on new highway poles or other attachments.



Figure 10 Street signage attached to CC53

6.2.6. Local Authority

The movement of the signage from the existing poles may require an interface with Manchester City Council.

6.2.7. Stops

The nearest stop to the works is Shudehill to the north, however the works will not affect the stop.

6.2.8. Lighting

The pole is not combined with street lighting and will have no effect on the street lighting arrangement.

Pole CC53 does have an illuminated stop sign mounted onto the pole. This will need to be decommissioned and moved prior to the pole removal.



Figure 11 Illuminated stop sign Pole CC53

6.2.9. Landscaping and Urban environment

The change from pole to wall fixing will help reduce the street clutter in the area. While new street signs maybe required for the signs removed from the pole, these will be smaller in diameter and less visually intrusive.

6.2.10. Earthing and Bonding

The design does not require any changes to the earthing and bonding system, so there is not expected to be any effect.

7. Proposed OLE equipment

7.1 2T Insulator

There are 2 types of insulators that are proposed for the works. They are interchangeable between each other with equivalent minimum breaking loads and a 360mm pin to pin dimension.

7.1.1. Pfisterer 2T Inline Insulator

The Pfisterer component and has been designed to provide a single level of insulation. It can be used as either primary or the secondary level of insulation.

The ends are constructed from galvanised steel which is crimped to a glass fibre rod and a silicone over mould jacket applied. The insulator has a minimum breaking load of 20kN.

This insulator is being widely used on the Dublin Luas system as an approved alternative to the Brecknell Willis 2T insulator.

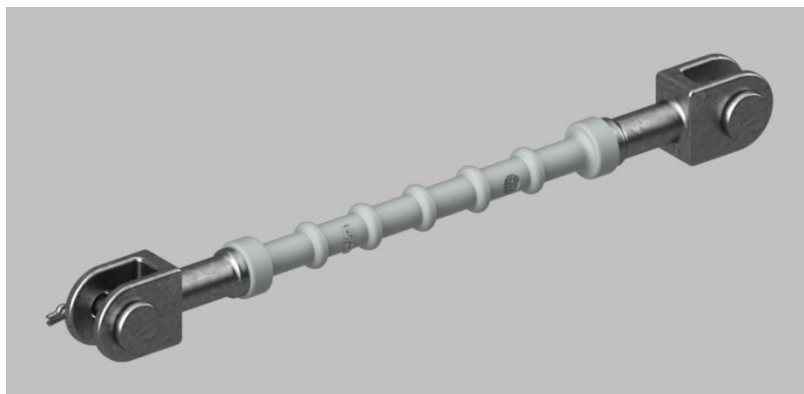


Figure 12 Pfisterer 2T insulator

7.1.2. Brecknell Willis 2T Insulator

The Brecknell Willis 2T insulator is constructed from a glass fibre rod which stainless steel ends are crimped on to. The rod then has a silicon over mould covering applied to the rod to provide protection. The insulator has a minimum breaking load of 20kN

The insulator has been widely used throughout Manchester extensions since Phase 3A.

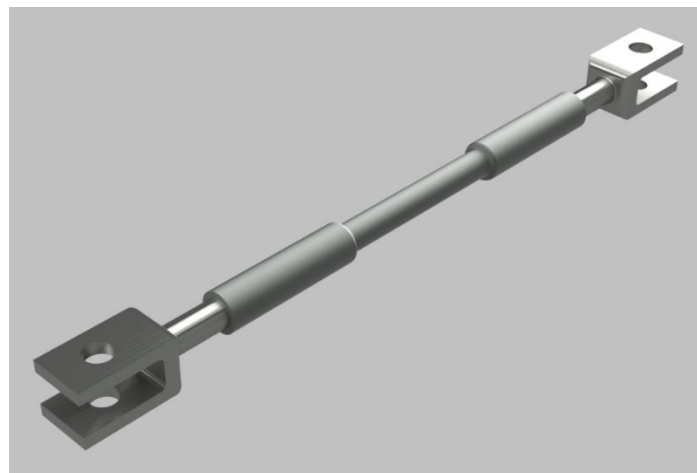


Figure 13 Brecknell Willis 2T insulator

7.2 Strong Registration Arm

The Brecknell Willis strong registration arm provides registration to contact wires where the loads would exceed the capacity of the insulated registration arm.

The arm is constructed from mild steel and a galvanised coating applied for protection. As the arm is uninsulated it will require insulation, usually from a inline insulator attached to the heel of the arm. The typical maximum registration load for the arm is 3kN.

The strong registration arm has been used throughout the Manchester system since phase 3A.

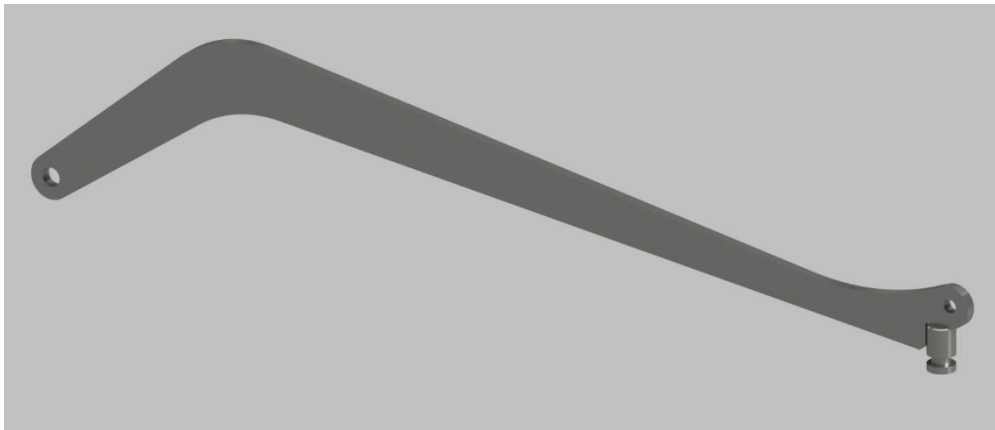


Figure 14 Brecknell Willis strong registration arm

7.3 8mm and 10mm Quick Links

The 8mm and 10mm quick links are rated stainless steel components. The 8mm Quick link has a max working load of 19.2 kN and the 10mm is 31.4kN.

They have been used widely throughout the Manchester Metrolink system.

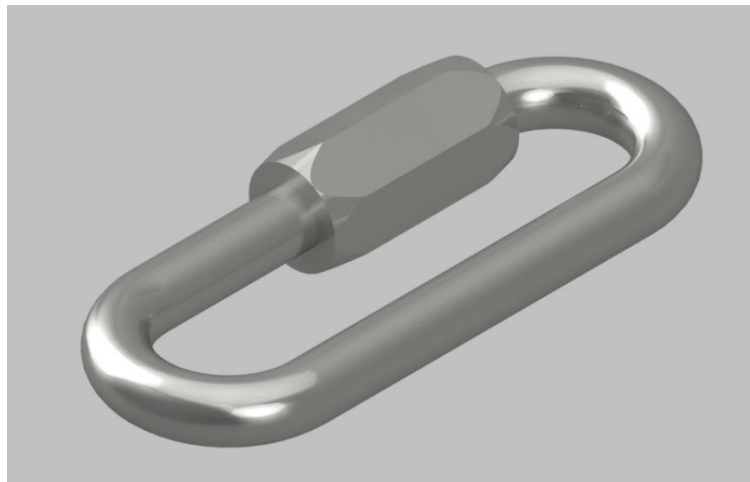


Figure 15 Quick Link

7.4 10mm Delta Link

The 10mm delta link is a rated stainless component that is widely used on the Manchester Metrolink system. It has a max working load of 24.5 kN.

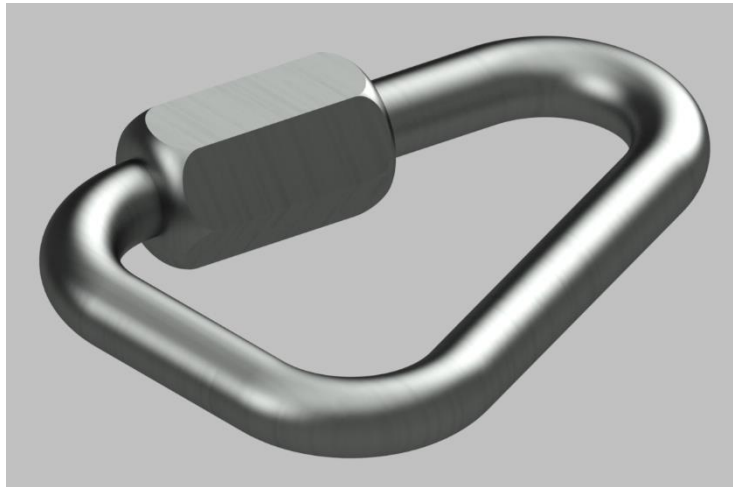


Figure 16 10mm Delta Link

7.5 6mm Wire Rope Assembly

The 6mm stainless steel wire rope is 7x19 rope with a minimum breaking load of 20.4kN. It has been used throughout the existing Manchester system. Stainless steel thimbles and copper ferrules are used to terminate the ropes at either end.

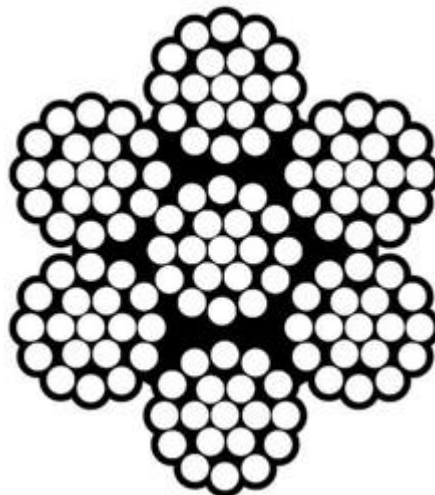


Figure 17 6mm Wire rope stranding arrangement

7.6 Pole Straps

Pole straps are mild steel and galvanised fabrications. They have been widely used on the Manchester system and allow for easy adjustment of the overhead compared to band-it strap.

The size of the pole straps required for the works need to be confirmed.

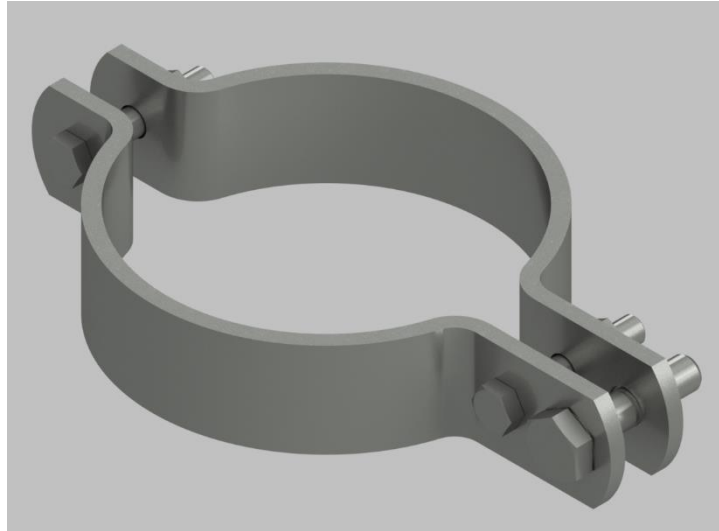


Figure 18 Pole strap

8. Designers Risk Assessment

8.1 Introduction

This section looks to identify potential hazards highlighted through the design and apply a Risk Categorisation along with mitigation.

8.1.1. Occurrence Probability

Occurrence probability was assessed based on the perceived likelihood of occurrence using the five-point system described below:

Rating	Description
1	Highly Unlikely
2	Unlikely
2	Likely
4	Highly Likely
5	Certain

Table 1 Occurrence Probability

8.1.2. Severity Rating

A Severity Rating was calculated based on the perceived relation to the likely seriousness of the injury, damage, or loss. The severity rating score was assessed using the five-point system below:

Rating	Consequences	Description
1	Very low	- Very minor health damage, injury not requiring first aid - Very minor equipment/property damage, - Very minor environmental damage, or - Very minor loss.
2	Low	- Minor health damage or a lost time injury / requiring first aid (less than three days away from work), - Minor equipment/property damage, - Minor environmental damage (no lasting effects), or - Minor loss.
3	Medium	- Moderate health damage or a reportable injury (more than three days away from work), - Moderate equipment/property damage, - Moderate environmental damage - Moderate loss.
4	High	- Significant health damage or Major injury, - Significant equipment/property damage, - Significant environmental damage, or - Significant loss /damage to company image.
5	Very High	- One or more fatalities, - Very significant equipment/property damage, - Very significant environmental damage, or - Very significant loss / damage to company image.

Table 2 Severity Rating

8.1.3. Risk Significance

The significance of the uncontrolled risk was found by multiplying the occurrence probability by the severity rating of each identified risk without considering any design mitigation measures.

Before design mitigation measures are taken the uncontrolled risk rating can lie between 1 and 25. If the calculated risk rating was 4 or below the risk was deemed to be acceptable providing it is managed, if the calculated risk rating was 5 or above then design mitigation measures need to be introduced in order to reduce the risk.

The significance was calculated again for the residual risk for each identified risk after design mitigation measures are taken. The calculated significance after design mitigation measures being taken was categorised High, Medium, or Low as follows:

Risk Category		Actions to be applied against each category
L	1 to 4	The calculated risk rating was deemed to be acceptable and no design mitigation measures need be taken provided the risk is managed. However, simple modifications that will reduce the risk further should be considered in the design.
M	5 to 14	Further investigation is required. The risk to be either reduced and re-assessed, or justified as being as low as is reasonably practicable (ALARP).
H	15 to 25	The calculated risk rating was deemed to be unacceptable and further reduction and risk re-assessment is mandatory.

Table 3 Risk Significance

			Occurrence Probability				
			Highly unlikely	Unlikely	Likely	Highly Likely	Certain
			1	2	3	4	5
Severity	Very High	5	M	M	H	H	H
	High	4	L	M	M	H	H
	Medium	3	L	M	M	M	H
	Low	2	L	L	M	M	M
	Very Low	1	L	L	L	L	M

Table 4 Actions to be applied against risk categorisation

8.2 Summary

The initial analysis highlights that there are 15 hazards of which 9 are medium and 6 are high. Through design and mitigation this is reduced to 7 medium hazards.

Some of the mitigation measures require that the installer has safe practices in place, for example test before touch. It is therefore paramount for the installer to ensure a safe system of work is in place prior to commencement of work to ensure these risks are as low as reasonably practicable.

8.3 Conclusions

The remaining 7 medium hazards are still medium due to severity rating being very high due to the risk of fatalities. In these cases, it is due to the severity not changing, even if the occurrence is highly unlikely. This is unlikely to be reduced any further as it is an inherent risk with all transportation electrification systems.

Ref No.	Design Hazard	Risk	Risk Level Before Mitigation			Design Mitigation Measure Taken	Risk Level After Mitigation		
			Occurrence Probability	Severity Rating	Risk Rating		Occurrence Probability	Severity Rating	Risk Rating
OLE-001	OLE Structure – fixing fails	Fixing failure causing equipment to fall into the street.	2	5	10	Calculations will be carried out to BS EN 50119 to ensure pole loadings given are suitable. Pole size has been selected to be suitable for the loadings applied.	1	5	5
OLE-002	OLE Structure – Span failure on modification of the equipment	While modifying the span the equipment breaks falling into the street.	2	5	10	To minimise the risk, new equipment is to be installed where modifications to the OLE is taking place. Installation staff are all trained and experienced with OLE equipment.	1	5	5
OLE-003	OLE Equipment – Component Failure	Equipment fails causes de-wirement and OLE rip down	3	4	12	Equipment specified is suitable for the loads being imparted reduce the probability of the occurrence.	1	4	4
OLE-004	OLE Equipment -Incorrect Installation	Equipment incorrectly installed causing hook up and OLE rip down	3	4	12	Competent contractor used for installation. Mechanical clearance and Height & stagger checks to be completed prior to handback.	1	4	4
OLE-005	OLE Equipment – Wire rope crimp failure	Wire rope is crimped incorrectly causing rope to come free and fall into the street	2	4	8	Competent contractor used for installation. Correct tooling and crimping method to be followed.	1	4	4
OLE-006	OLE System – Insufficient Insulation	Single level or no insulation fitted to live components risking electrocution.	3	5	15	Design has been developed to ensure that locations will have at least two levels of insulation to earth.	1	5	5
OLE-007	OLE System – Insufficient Electrical Clearance	Insufficient clearance between live components and earthed components risking electrocution.	3	5	10	The OLE has been designed to achieve the electrical clearance requirements within BS EN 50119:2020	1	5	5
OLE-008	OLE System – Live componentry within touching distance	Live components are within touching distance of staff or public risking electrocution	3	5	15	The design will ensure that the minimum wire height in public area is 5.2m. Also, the design will, as far as reasonably practicable, ensure that live components are 3m above a standing surface if a failure of the OLE system occurs.	1	5	5
OLE-009	OLE Design – Incorrect Allocation	Wrong equipment allocated causing failure and equipment falling into the street.	3	4	12	All allocated equipment will have an equivalent loading capacity to meet the envisaged loads imparted in line with loading calculations in BS EN 50119.	1	4	4
OLE-010	OLE Design – High Radial Loads	Operative releases equipment on high radial loads causing the wire and/or equipment to suddenly move under high force risking injury/death.	3	5	15	High radial load locations to be identified on the cross section and layout. Operatives to work on the opposite side of the contact wire to the expected movement.	1	5	5
OLE-011	OLE Design – Low OLE, High side vehicle strike	Low overhead line installation causes rip down by high sided vehicle.	2	4	8	Heights and Staggers to be taken prior to installation and checked post installation.	1	4	4
OLE-012	OLE – Construction – Electrocution	Operative accesses system before isolation and earth causing electrocution of operative.	3	5	15	Installer to ensure proper isolation and earth permits and procedures are followed. Overhead line to be tested before touch.	1	5	5
OLE-013	OLE – Construction – Road vehicles	Public road vehicles moving around work area, possibly collision with RRV and/or operatives.	3	4	12	Traffic management and/or road closures to be implemented to lower the risk	1	4	4
OLE-014	OLE – Construction - Working at heights	Working at heights on the OLE has a risk of falling from height.	3	5	15	MEWPS to be used and operatives to wear appropriate harnesses and fall arrestors. Operative to be "Clipped-on" at all times when at height.	1	3	3
OLE-015	OLE – Construction - Pedestrians	Members of the public walking in and around works area.	3	4	12	Exclusion zones around the working areas to be implemented. Divert pedestrians away from working area.	1	4	4

Table 5 Identified Risks