ITS specification

Optical fibre supply and installation (ITS-02-03)

First edition, Amendment 3

Effective from October 2103

NZ TRANSPORT AGENCY
WAKA KOTAHI

More information …

Published October 13

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This document is available on the Waka Kotahi website at www.nzta.govt.nz.

Document management plan

1) Purpose

The purpose of this document is to specify the requirements for the ITS backbone and local optical fibre single mode supply and installation.

2) Document information

Document name	*ITS specification: Optical fibre supply and installation*		
Document number	ITS-02-03		
Document status	Provisional		
Document availability	This document is located in electronic form on the Waka Kotahi website at www.nzta.govt.nz.		
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3) Key words

ITS Optical fibre supply and installation.

Record of amendments

Amendment number	Section amended	Description of change	Updated by	Effective date
Draft R0	All	ITS Draft Specifications Issue	TLH	20/9/2010
Draft R1	All	AMA Specifications Review	JF & TLH	25/1/2011
Final R2		Updates following consultation	PTA	10/01/2012
Final R3 Final R3a	All App B	Provisional Referenced appropriate ITS Standards for Ducting and Chambers	BW & JS KF	14/02/2012 11/06/2015

Contents

1.0 General

1.1 Scope

This section sets out the requirements for the supply and installation of the ITS Communications backbone and local fibre optic cable.

The ITS sites shall be connected via the fibre backbone installed along the motorways to the Traffic Operations Centre.

The ITS roadside control cabinets shall have a local fibre connection the fibre backbone in the nearest ITS backbone jointing chamber.

1.2 Drawings

The attached standard drawings are provided for information to provide a basis for design and recording of ITS backbone and local fibre optic cable installations.

Site specific detailed design drawings for all fibre routes and jointing details shall be provided for review prior to commencement of installation.

In the fibre schematic drawings the fibre shall be drawn with increasing route position from left to right and the joint, cable and cabinet numbers recorded as set out below.

1.3 ITS fibre optic cable numbering

1.3.1 Fibre optic cable chambers

Fibre optic cable chambers shall be labelled in the format “A-BBB-CCCC-D”, Typically J-018-2020-W:

a. where “A” is P for Pull Pits and J for jointing chambers

b. where “BBB” is the state highway designation, e.g. 001, 016, 018 or 020

c. where “CCCC” is the number assigned to the jointing chamber.

d. where “D” is the direction of traffic on the carriageway on which the chamber is located, e.g.: N (northbound), S (southbound), E (eastbound) or W (westbound).

1.3.2 ITS backbone fibre optic cable

In each Jointing Chamber the ITS Backbone fibre optic cables shall be labelled, using Critchley labels, in the direction of the highway (north to south, east to west) in the format:

- “BBB-AA-FF-GGGG/CCCC” for backbone cable from previous chamber (GGGG)
- “BBB-AA-FF-CCCC/HHHH” for backbone cable to next chamber (HHHH).

  a. where “BBB” is the state highway designation, e.g. 001, 016, 018 or 020

  b. where “AA” is the local fibre optic cable number

  c. where “FF” is the number of fibre cores in the backbone fibre optic cable

  d. where “CCCC” is the number assigned to the jointing chamber.

e. where “GGGG” is the number assigned to the previous jointing chamber.

f. where “HHHH” is the number assigned to the next jointing chamber

Typically for Jointing Chamber J-018-2020-W the backbone fibre cable would be numbered 018-01-96-2010/2020 for the cable from previous pit on the left side of the fibre schematic diagram and 018-01-96-2020/2030 for the cable from previous pit on the right side of the fibre schematic diagram.

1.3.3 Roadside cabinets

Roadside control and network node equipment cabinets shall be labelled in the format “E-CCC-D” typically E-202-W:

a. where “E” is E for equipment cabinet

b. where “CCC” is the first three digits of the site number assigned to the jointing chamber.

c. where “D” is the direction of traffic on the carriageway on which the chamber is located, e.g.: N (northbound), S (southbound), E (eastbound) or W (westbound).

1.3.4 Local fibre optic cables

Local fibre optic cables to Equipment Cabinets shall be labelled in the format “BBB-AA-GG-E-EEE-E”, typically 018-01-12-E-202-W:

a. where “BBB” is the state highway designation, e.g. 001, 016, 018 or 020

b. where “AA” is the local fibre optic cable number

c. where “GG” is the number of fibre cores in the local fibre optic cable

d. where “E-EEE-E” is the destination equipment cabinet number.

1.4 Fibre change control

The method of requesting changes to the fibre configuration is dependent upon local Waka Kotahi operating practices and the correct forms should be obtained from the Waka Kotahi Fibre Change Control Manager in the region that the change is required.

The attached *Fibre optic cable change request form* (appendix A) shall be completed and submitted to the Waka Kotahi Fibre Change Control Manager at the Auckland Motorway Alliance together with the detailed design drawings for all the fibre routes and jointing details proposed.

No change or new connection to the Waka Kotahi ITS fibre optic cable network shall be made without the written confirmation that the proposed change or new connection has been approved by the Fibre Change Control Manager.

The Fibre Change Control Manager shall be informed with 48 hours of the fibre change work being completed. An updated As-Built fibre schematic drawing shall be forwarded to the Fibre Change Control Manager within two working days of the fibre change work being completed.

For users in Auckland only, the attached *Fibre optic cable change request form* (appendix A) shall be completed and submitted to Waka Kotahi.

2.0 Cable Types

2.1 General

The optical fibre network shall use high quality all dielectric loose tube optical fibre with dry or flooded water barrier that is suitable for underground installation.

The fibre shall have a minimum 10 year performance warranty.

The fibre shall meet or exceed the latest ITU-T recommendation G.652d-2000.

The following characteristics shall apply to all cable used for the network:

a. Single mode 1550 nm low dispersion fibre

b. Attenuation at 1310 nm not to exceed 0.4 dB/km

c. Attenuation at 1550 nm not to exceed 0.3 dB/km

2.2 ITS backbone fibre optic cable

The ITS Backbone fibre along the motorway shall be single mode 96 core fibre optic cable.

At each jointing chamber, 20m of optical fibre cable shall be left neatly coiled within the triangulated storage brackets inside the jointing chamber.

At each pull pit, 5m of optical fibre cable shall be left neatly coiled within pull pit.

2.3 Local fibre connection cable

Local fibre optic cable from jointing chambers to the roadside control cabinets shall, as a minimum be single mode 12 core fibre optic cable.

2.4 Peripheral equipment fibre connection cable

Multimode fibre optic cable may be only be used to connect local peripheral equipment to the roadside control cabinet ITS fibre interface Ethernet switches subject to the approval of the Waka Kotahi Fibre Change Control Manager.

3.0 Cable installation

3.1 Transport of cable drum and positioning

The cable shall be transported to site in an upright position, and lifted directly onto the cradle for installation. Rolling the cable drum shall be avoided.

The cable drum shall be set up on a cradle in such a way that the cable leaves the drum and enters the duct in a smooth continuous manner.

The drum shall be positioned so that the cable does not foul the flanges of the drum as it is hauled into the ducts.

3.2 Hauling

The hauling cable shall be attached to the optical fibre cable using correctly sized grips and shall be attached so as to minimise damage to the cable.

Bell mouths or similar shall be inserted at the entry to ducts to guide the cable and ensure the cable is not unduly strained or “creased”.

Cable guides shall be used at the point where the hauled cable exits the duct, so as to guide the haul cable and the fibre, and ensure that cables do not abrade against any surfaces.

At any time and position during hauling, the minimum bending radius of the optical fibre cable shall not be exceeded.

The hauling equipment shall be fitted with a dynanometer to monitor the tension on the hauled cable. This shall be continuously monitored to ensure that maximum tension recommended by the cable manufacturer is never exceeded.

Cable ends shall be capped with a heat shrinkable watertight cap until they can be jointed.

3.3 Cable storage coils

At each pull pit, 5m of optical fibre cable shall be left neatly coiled within the pit.

At each jointing chamber, 20m of optical fibre cable shall be left neatly coiled within the triangulated storage brackets (on the inside, not the outside of the triangle).

An elasticised band shall be stretched over the three brackets to hold the cable in place.

3.4 Splice enclosures

The splice enclosures used on the ITS backbone fibre in the jointing chambers shall be FIST-GC02 type closures.

Only one closure shall be used per backbone fibre in the same jointing chamber.

The splice enclosures shall be mounted to a bracket on the side wall of the jointing chamber so that the cables neatly exit the bottom of the enclosure and enter into the coil formation. The minimum bending radii of the cables shall not be exceeded. The mounting bracket shall allow easy removal of the enclosure without the use of tools.

The enclosures and distribution frames shall comply with section 4 of the Waka Kotahi *ITS standards and best practices: Fibre handling and management* document provided in appendix B.

3.5 Cable jointing

The optical fibre cable shall be joined with fusion splicing within jointing chambers only. Joints are not permitted elsewhere.

The fusion splicing shall be carried out in a clean environment, using the slack the 20m coil affords to move the splice location out of the jointing chamber and into a suitable area for fusion splicing.

The fusion splices shall have an attenuation no greater than 0.1dB at 1550nm and 1310nm.

Splices that fail to meet the criteria shall be removed and re-spliced until a satisfactory result is achieved.

Optical fibre handling, jointing and labelling shall comply with section 5 of the Waka Kotahi *ITS standards and best practices: Fibre handling and management* document provided in Appendix B.

3.6 Testing and documentation

Optical fibre testing shall comply with section 6 of the Waka Kotahi *ITS standards and best practices: Fibre handling and management* document provided in Appendix B.

The Contractor shall complete testing and supply test results as follows:

3.6.1 Factory test results

The Contractor shall complete testing and supply Factory Test Results shall be supplied, showing attenuation at two operating wavelengths for each fibre in each cable reel. These results shall be indexed to identify where each reel was installed in the network.

3.6.2 OTDR test results

After installation and splicing, bi-directional testing of every single mode fibre shall be completed using an Optical Time Domain Reflectometer (OTDR) at 1300nm and 1500nm from the sub-station to sub-station.

The test results shall be supplied to the Engineer in hard and soft copies. Any software required to view the OTDR traces shall also be supplied.

It is expected that the test results will match the factory tests for the cable reels that have been installed.

In the event that the test results indicate point discontinuities at locations other than splices, or that the installed fibre links do not meet the attenuation requirements defined herein, it shall be the Contractor's responsibility to correct the problem.

3.6.3 Jointing chamber documentation

For every jointing chamber in which the Contractor has accessed a splice enclosure a fibre audit sheet shall be supplied to the Engineer in hard and soft copies identifying all the fibre connections in the spice enclosure by fibre number, cable label number and cable direction in the jointing chamber. Fibre optic cables in the chamber but not spliced shall also be identified.

This fibre audit shall be accompanied by a Jointing Chamber Fibre Schematic Diagram certified as "As-Built" by the Contractor and photographs of the interior of the jointing chamber after completion of the fibre splicing and re-coiling of the ITS backbone fibre inside the chamber.

Appendices

3.7 Appendix A – Fibre optic cable audit forms

Joint pit audit form
Pull pit audit form
Cabinet audit form
Fibre optic cable change request form

Joint pit audit form

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Chamber ID		**Pit**	
Previous chamber ID		Dimensions (W x L)	
GPS coordinates		Cover type	
Location details		Cover lifter type	
Inspection date		Cover size	
Engineers present		Locking screw type	
		Was chamber buried?	Yes ☐ No ☐
Joint		**Traffic management (TM)**	
Enclosure type (FIST or FOSC)		Was TM required and adequate?	Yes ☐ No ☐
Correct type?	Yes ☐ No ☐		

Cable Colour	Cable A		Cable B		Cable C		Cable D		Fibre connection type:
Cable Type/direction (ie 48F, SM LT, North):									• continuous ☐
Previous Cable ID:									• splice, or ☐
New Cable ID (ie 001-01-48-5210-5220):									• end. ☐
	Tray #	Fibre #	Tray #	Fibre #	Tray #	Fibre #	Tray #	Fibre #	

Notes/pit drawing:

Pull pit audit form

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Chamber

Chamber ID (ie P-001-8130-E):	
Previous chamber ID:	
Inspection date:	
Engineers present:	
GPS coordinates:	
Details of location (ie road, suburb):	

Was TM required & adequate? Yes ☐ No ☐

Pit

Pit dimensions (W x L): _____ Lid dimensions: _____

Lid type: _____ Locking screw type: _____

Lid lifter type: _____ Hand sketch of pit taken? Yes ☐ No ☐

Was chamber buried? Yes ☐ No ☐ Photo of pit taken? Yes ☐ No ☐

Have bolts been replaced? Yes ☐ No ☐

Cable

Long enough to create a joint?	
Main cable labelled (ie 001-02-48-8120-8130)?	

Notes

Cabinet audit form

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Cabinet No:	
Previous cabinet ID:	
Date:	
GPS location:	
Description of location (ie road, suburb):	
Engineers:	
Patch panel type (pivot or sliding / 1.5 RU or 1 RU):	
Panel Connector type (ie SCACP, screw type):	
Patch panel has been labelled (ie 96F NORTH F85-96)?	
New cable label (ie 001-01-12-E-491-N)	
Was TM required & adequate?	Yes ☐ No ☐

Patch Panel No & ID (ie A1 of 98F North F85-96)	Equip Connection or Patching Details (Peter to fill in)

Notes

Fibre optic cable change request form

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Change requested by

Company name		Project	
Contact name		Contact number	
Expected date and duration of work		Date	
Start time		End time	

Reason for new works/changes:

PLEASE READ:

1. All new works or changes to the fibre optic network must comply with the Waka Kotahi NZ Transport Agency (Waka Kotahi) Fibre Handling and Management Standards.
2. The information requested in this form pertaining to the proposed works must be provided in full in order for Waka Kotahi to grant permission to the Company to undertake the works.
3. Waka Kotahi will contact the Company within 48 hours of receiving this form to advise on approval for the works to be undertaken.
4. Within 7 days of completing the works, the Company must complete the Waka Kotahi Change Notification Form and forward to the Fibre Change Control Manager at Waka Kotahi. The works will not be deemed to be completed until this form has been received and all relevant information and documentation provided.
5. The Company will need to supply its workers with a GPS in order to provide coordinates for the location of new works.

Forward forms to:

Please fill in only the sections below that are relevant to the work that is to be undertaken.

Details of NEW WORKS to be undertaken (tick and fill in where applicable)

New trench or overland ducting ☐

Location *From:* *To:*

Duct dimension and type

Note: *Aerial photo marking proposed trench line must be provided.*

New chamber ☐

Chamber ID: (as provided by Waka Kotahi)

Chamber type (ie aluminium)

GPS coordinates Location:

Chamber dimension:

1200 x 900 (for joint) ☐ 1200 x 600 (pull pit) ☐

Other size (specify) ☐

Cover type & rating (ie cast iron, roadway):

Locking system type (ie torque bolts):

Note: *Aerial photo marking proposed trench line must be provided.*

New cable ☐

Starting chamber ID: Ending chamber ID:

Cable size (ie 48F): Cable type (ie SM LT):

New joint ☐

Chamber ID: (as provided by Waka Kotahi)

Joint type/model (ie FIST GC02)

GPS coordinates Location:

New cabinet ☐

Cabinet ID: (as provided by Waka Kotahi)

GPS coordinates Location:

Details of purpose of cabinet and equipment to be installed:

Note: *Aerial photo marking the proposed location of new cabinet must be provided.*

New equipment external to cabinets (ie camera, VMS sign etc) ☐

Description: GPS and location:

Description: GPS and location:

Description: GPS and location:

Note: *Aerial photo marking the proposed location of new equipment must be provided.*

Details of CHANGES to existing works (tick and fill in where applicable)

Changes to cabinet ☐

Cabinet ID:

Equipment to be changed/replaced:

Changes to equipment external to cabinets (ie camera, VMS sign etc) ☐

Location:

Equipment to be changed/replaced:

Replacing of fibres in joint ☐

Chamber ID:

Destination chamber/cabinet ID:

Purpose:

End user (ie council or Waka Kotahi):

Description of proposed changes:

Specify proposed fibre changes below:

Cable ID	Cable Direction	Fibre No's	Cable ID	Cable Direction	Fibre No's
example: 001-01-48-5210-5220	*North*	*11 & 12*	*001-01-12-E-521-N*	*north to cabinet*	*7 & 8*

Any other changes ☐

Waka Kotahi internal use only:

Approved by Fibre Change Control: Fibre Change Control Manager

Name:

Signature:

Date:

3.8 Appendix B – Reference document

ITS standards and best practices: Fibre handling and management

4.0 Summary

4.1 Background

ITS equipment located in Auckland is largely attached via Fibre Optic Cable. As a direct result of this there is a need to provide a set of guidelines for the use, management and handling of Fibre Optic cable by Contractors to ensure that best practices are followed. Contractors are expected to comply with the requirements detailed in this document, and failure to do so will be considered a breach of contractual obligations.

4.2 Expected outcome

This document provides an overview for Contractors on the appropriate best practices expected by Waka Kotahi in the handling and management of Fibre Optic Cable and related peripherals. Any exceptions to the recommendations made herein must be approved by Waka Kotahi.

4.3 Scope

This best practices document covers the following elements:

- Fibre optic cable and related transmission equipment.
- Equipment location, housing and cabinetry.
- Provides recommendations for installation and maintenance.

5.0 General rules and process

5.1 Change control

Absolutely no work is to be undertaken on the Waka Kotahi fibre optic network without submitting the Waka Kotahi Fibre optic cable change request form, which must be approved by the Waka Kotahi Fibre Change Control Manager. There are a number of contracts that may be affected by any changes and this risk must be managed. Non-compliance will not be tolerated.

5.2 Temporary traffic management (TMP)

TMPs are required for all activities that vary the normal operating condition of a road, irrespective of whether the activity is on a carriageway, a footpath or a shoulder. The TMP must be approved by either Waka Kotahi, a Waka Kotahi-authorised representative or the local road controlling authority (RCA).

In the event that work will require traffic management, a traffic management plan must be submitted as part of this process. It must include the names of all the subcontractors involved, the details of relevant trained staff and their qualification levels.

All Contractors will follow the rules and processes outlined by Waka Kotahi, its representatives or the local RCA with respect to safety and traffic management principles. Please refer to the Waka Kotahi *Code of practice for temporary traffic management* (CoPTTM).

For TMP arrangements in the Auckland region, Contractors will need to contact the ITS Asset Manager at Auckland Maintenance Alliance, on 09 5399100.

5.3 Local authority permits

Contractors must obtain permission from local authorities, such as Councils, if the work to be undertaken is on their property (i.e. a road opening notice).

5.4 Change notification and as-builts

Within 7 days of the work being completed, the Waka Kotahi Fibre optic cable change request form must be completed by the Contractor and sent to the Waka Kotahi Fibre Change Control Manager. Supporting information including relevant updated as-builts and/or schematics must also be provided.

Failure to comply with this requirement will be seen as failure to deliver a working solution.

5.5 Protecting the NZTA's network

Contractors must ensure that each person engaged in the installation or servicing of equipment is competently trained and/or supervised in the work to be undertaken.

Waka Kotahi must be notified immediately of conditions or practices that have the potential to cause personal injury or property damage.

5.6 Shared trench line and chambers

It is important to note the following when identifying the Waka Kotahi cable:

- Both Waka Kotahi and Telstra share the same trench line and chambers for their respective telecommunication networks. However, each entity uses its own specifically coloured duct – Waka Kotahi usually uses two orange 100mm ducts situated in the middle of the chamber wall, and Telstra uses two purple 200mm ducts situated at the bottom of the chamber wall. The remaining black or orange ducts are usually reserved for power cables and are on the top of the wall.
- Often Waka Kotahi chamber or a chamber containing the Waka Kotahi fibre could have a coverset branded with the Telstra or Saturn logo.
- The Waka Kotahi and Telstra joint closures are generally not housed in the same chamber.

5.7 Cabinet maintenance books

Each time cabinets are accessed, the maintenance booklet must be updated. The Contractor must include his/her name, company name, the date and reason for access. If a booklet is not already available, the ITS Asset Manager at Auckland Maintenance Alliance must be notified.

If any anomalies are observed, such as insect infestation, damaged equipment etc, the ITS Asset Manager must be notified immediately.

6.0 Cabling rules and guidelines

6.1 Fibre designers/installers

The Contractor's fibre designers /installers should be consulted when designing networks.

Fibre designers /installers can provide:

- Rules of thumb for early and approximate design parameters.
- More considered calculations reflecting topographical and connection considerations when the design needs to be more tightly defined.
- An instrument-measured and exact attenuation when design precision is required.
- Knowledge of TMP and access requirements for specific sites.

This will permit network designers to select appropriate GBIC's and equipment more accurately.

6.2 Route selection

When planning the route for a cable, the following should be considered:

- Avoid unduly abrupt bends which will considerably increase cable pulling-in tensions.
- Check for any future road works that may affect the offset selected.
- Ensure the required separation from other underground plant is maintained.
- Avoid laying cables close to building/gantry/pole/bridge foundations.
- Lay cable in straight lines, as this will reduce both recording costs and maintenance costs and reduces the risk of accidental damage by other contractors.
- Avoid areas contaminated by effluent, chemical wastes or leakage of dangerous fluids, petrol, etc., or areas that are likely to be inundated by water.
- Note areas of Earth Potential Rise, and design duct networks passing through them so no joints in the cable are required in the E.P.R. zone.
- Ensure safe and easy access for workers and/or vehicles, where possible.
- When new cables are to be laid, the future excavation of swale drains over the cable route must be given consideration.

6.3 Diversity

Ideally, a fibre circuit should have full diverse path protection and automatic switching failover to a backup circuit in the event of a cable being cut or damaged. However this is not always available for cost and /or geographical reasons.

Partial diversity can be made available by means of a second cable being run in a different duct along the same route. The chances of a complete outage are reduced as both cables/duct and subducts must be hit at the same time. Even if this path has no automatic switching, the outage time is reduced considerably against the time spent repairing a damaged cable.

7.0 Physical network and equipment

7.1 Transmission

The following transmission standards are to be followed.

7.2 Fibre types

Single Mode Loose Tube: fibre transmission between nodes (referred to as the "fibre backbone") is to be over single mode loose tube fibre.

The fibre core count to be used for each project or works is to be approved by Waka Kotahi.

Multi Mode: the use of multi-mode fibre must be approved by Waka Kotahi, and may only
to be used to connect local peripheral equipment.

Single mode loose tube fibre

7.2.1 Fibre colour coding

The New Zealand colour coding is as follows (note that certain types of fibre from different countries may have a different colour code).

The following table shows fibre numbers and respective colours:

1	2	3	4	5	6	7	8	9	10	11	12
BLUE	ORANGE	GREEN	BROWN	SLATE	WHITE	RED	BLACK	YELLOW	VIOLET	ROSE	AQUA

7.2.2 Cable ties

Only stainless steel tabbed cable ties are to be used for securing *all* optical fibre cables, tubes and cords at termination points. Plastic tabbed cable ties release tension over time, and have been found to be the main cause of abnormal network events.

7.2.3 Fibre connectors

It is important to use good quality connectors, as low quality or inappropriate connectors can introduce unexpected attenuation and can throw out network design parameters.

The interface to the Waka Kotahi fibre is to be a pair of fibre pigtails spliced into the main fibre run with a pair of SC connectors.

Other connector types are acceptable where:

1. existing equipment dictates the use of a specific type, such as FC; or
2. there is a specific ATMS requirement for specialist equipment.

Any variation to this must be clearly documented on any as-built diagrams or schematics.

7.2.4 Patch cords

Patch cords used to connect the Waka Kotahi fibre to equipment should be 3mm, except when connector type dictates otherwise, such as with LC connectors.

7.3 Equipment housing

7.3.1 Cabinets

All cabinet housing fibre racks, equipment, pigtails and any other related fibre equipment should be physically secure and weatherproof to at least IP65.

In the event that a new cabinet is required for fibre equipment, it will comply with IP65 as well as be separated from its base concrete pad by a glanded, watertight pedestal.

Rack Size: the standard rack size for cabinets and equipment is 19 inches.

Maintenance booklet: a maintenance booklet must be supplied for all cabinets.

Securing of cabinets: all cabinets must be secured with locks or padlocks using the standard key approved by Waka Kotahi.

Position of cabinets: for safety reasons and where practicable, cabinets are to be positioned such that the worker accessing the front of the cabinet is facing oncoming traffic.

7.3.2 Optical fibre distribution frames (OFDFs)

Fibre is to be terminated in a 19 inch, 1 rack unit (RU) shelf pivoting optical fibre distribution frame with 24 SC simplex adaptor positions. Pivoting trays are preferred as they minimise movement of the feeder cable.

Pivoting optical fibre shelf

7.4 Joint closures

It is strictly prohibited to install more than 1 closure per backbone fibre cable in the same chamber.

7.4.1 FIST–type closures

Only FIST-GCO2 type closures are to be used for backbone joints, and the size of closure will depend on the fibre count. This type of closure is preferred due to the following functions and features:

d. Single-ended design.

e. Easily opened and closed.

f. Base and dome are sealed with a clamp and O-ring system.

FIST closure

g. 6 or 16 round entry/exit ports for drop cables and 1 oval port for coiled cable.

h. The mounting system allows for both SC (Single Circuit) and SE (Single Element) type trays.

i. Three sizes available – BC6, BD6, BE6.

The following types of splice trays are to be used for backbone and spur terminations:

Fibre Joint	Splice Tray
Backbone fibre	FIST SE (Single Element) SOSA (Splice Only Sub-Assembly) trays with 12 splices per tray
Spur fibres	FIST SC (Single Circuit) SOSA trays with 4 splices per tray

Supply Details of FIST Closures

The tables below show the supply details of standard FIST closures & accessories from Raychem, for ordering purposes. Note, however, that Waka Kotahi does not have a preferred supplier.

1. Joint Closure Kit (base, dome, 'o' ring, clamp; no cable seals; installation doc supplied):

Raychem Part #	Description	Raychem Part Name
3-1197857-3	Base closure kit, 28 unit UMS	FIST-GCO2-BC6-NV
4-1194695-8	Base closure kit, 42 unit UMS	FIST-GCO2-BD6-NV
3-1197857-4	Base closure kit, 58 unit UMS	FIST-GCO2-BE6-NV

2. Sealing Kits:

Raychem Part #	Description	Raychem Part Name
6-1190670-2	Oval port heatshrink seal kit with branch clip	FIST-GCO2-OSK-LTS
2-1195672-3	Round port heatshrink seal kit	FIST-GCO2-RSK-LTS
0-1193030-4	Multi drop cable kit with 2 tubes	FIST-GCO2-MULTI2/11
7-1191283-1	Cable seal to seal cable onto tube	FIST-GCO2-MULTI-SEAL

3. Mounting Brackets:

Raychem Part #	Description	Raychem Part Name
5-1193527-9	Mounting bracket, GCO2-BC6	FIST-MOBRAA859
4-1198941-7	Mounting bracket, GCO2-BD6	FIST-MOBRABD6-NZ
8-1190124-1	Mounting bracket, GCO2-BE6	FIST-MOBRANZ

4. Splicing Modules:

Raychem Part #	Description	Raychem Part Name
8-1193657-4	2 tray, 12 splice, single element tray	FIST-SOSA2-2SE-S

5-1194213-4	4 tray, 12 splice, single element tray	FIST-SOSA2-4SE-S
6-1190134-4	4 tray, 4 splice, single circuit tray	FIST-SOSA2-4SC-S
5-1192827-9	8 tray, 4 splice, single circuit tray	FIST SOSA2-8SC-S

7.4.2 Other closure types

The use of other types of closures, such as FOSCs, *must* be approved by Waka Kotahi. If a FOSC type closure is to be used, a storage basket must be used for uncut loose tubes.

7.4.3 Closure mounting brackets

Closure brackets and fixing bolts should be of hot dip galvanised construction, except in low-lying geographical areas where there is a possibility of exposure to sea or bracken water. In these instances stainless steel must be used because of the corrosion factor.

Closure brackets should be mounted, if possible, on the opposite side of the chamber from the duct to avoid crowding the duct and making future hauling difficult.

7.5 Ducts

Refer to ITS-02-01 Duct Supply and Installation

7.6 Chambers

Refer to ITS-02-02 Jointing Chambers and Pull-pits

7.7 Cable protection

All cable must be protected by duct - under no circumstances is cable to be left exposed.

All duct and duct formations entering a building are to be constructed in a manner that prevents the ingress of water, gas, etc from entering the building around the ducts, i.e. the ducts are permanently fixed and sealed.

Where cables are to be stored below ground level, underwater or onto a solid structure such as a rock face or bridge, the minimum ground cover required is as follows:

Cable Laying Scenario	Minimum Ground Cover (mm)
Existing communication ducts	450
New duct lines in rural areas or alongside non kerbed roads (ie where there is a possibility of road reforming or grading of the road edge)	600
New duct lines in stable well formed suburban areas	600
Direct buried copper cables in footway and berms	450
Direct buried copper cables in roadways	600
Direct buried fibre cable	1000

8.0 Fibre and equipment management guidelines

8.1 Cable handling

8.1.1 Cable hauling

Experienced fibre hauling companies must be employed to ensure fibre is correctly handled.

Cable handling methods must consider the specified minimum bending radius and maximum tensile loading of the particular optical fibre cable being installed. The maximum tensile load to be applied to standard cables is 2.5 kN (not including lead-in cable, aerial cable or subaqueous cable). This is the maximum longitudinal tension that can be placed on the cable without risking damage to the cable.

Cables should be routed from the duct to the joint or to the next duct in such a way that it is clear and not intertwined with other cables.

Factory fitted hauling eyes can be ordered with the cable. Some areas are having success with a cable sock specially designed for fibre optic cable. If the sock method is used then the first metre of cable should be removed and scrapped after the pull.

8.1.2 Cable bend radius

The maximum specified cable pulling tension and minimum cable bending radius must not be exceeded.

The allowable bending radius for the fibre cable is as follows:

Cable Status	Bending Radius
Cable under no tension	10 x cable's outside diameter
Cable under tension during installation	20 x cable's outside diameter

8.1.3 Break off couplings

Break off couplings matched with the cable manufacturer's specifications for linear strength should be used to attach hauling ropes to fibre cables to prevent stretching, which can cause irreparable damage to cables during the hauling process.

8.1.4 Locating wires

Where non-metallic strength members are incorporated in a cable, a suitable locating wire should also be hauled and the ends sealed. Locating wires and draw tapes should be sealed and neatly coiled.

8.1.5 Residual cable

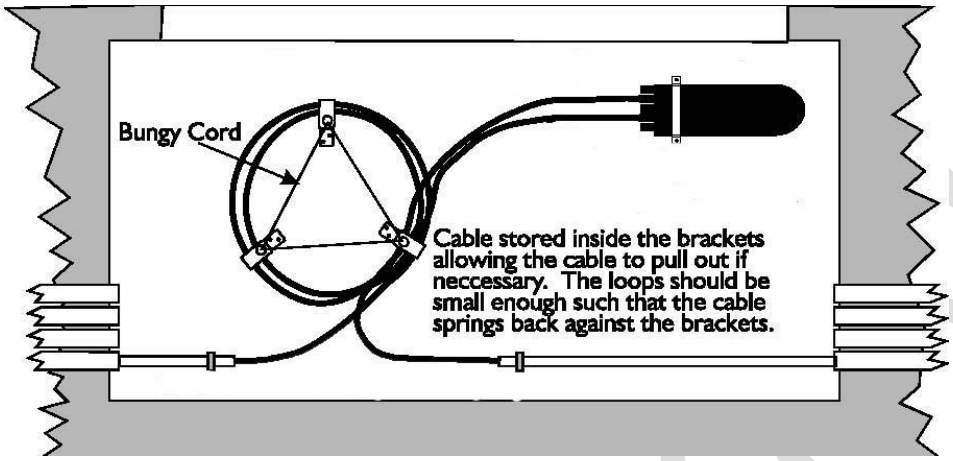
A 5m coil of cable should be left in any turning pit.

Where there is to be a joint closure installed in a pit, or the possibility of a future joint, then sufficient length of cable is to be left to allow the cable joint to be lifted into a clear workspace. A minimum of 10m end or a 20m coil should be left, and not exceed minimum bend radius requirements.

The coil of spare cable should be placed inside 3 direct fixed cable brackets, which are bolted to a chamber wall, and held there with bungy cord. The 3 brackets should form a tight enough coil that the

cable springs back into them and no weight is placed on the bungy cord. The cable needs to be able to be pulled out the brackets if necessary, and should not be tied to the brackets. The cable must not be fastened such that it cannot be pulled back down the duct, in the case of a dig-up or earthquake. The diameter of the coil should not be smaller than 600mm.

Cables should be routed from the duct to the joint in such a way that it is clear and not intertwined with other cables.



Chamber cable management

8.1.6 Tension on cable ties

All cable ties must be tensioned to ensure no movement of fibre, but the tension must not introduce macrobending.

No compression of the cable must occur.

FIST closure

8.2 Closure preparation

8.2.1 Closures

Closures are to be installed as per manufacturer's instructions.

Access point type closures (i.e. FISTs) are to be used for all backbone joints, unless otherwise approved by Waka Kotahi. For demarcation purposes, all backbone fibres are to be terminated on one side of the closure and spur fibres on the other side. Fibres from one tube should be jointed on the same tray, except when the fibres are to be connected to a spur.

Backbone fibres are to be terminated on the "O" (odd numbered ports) side of the base of the closure, using the single element trays. Spur fibres are to be terminated on the "E" (even numbered ports) side, using the single circuit trays. However, the cables can enter the closure via any port.

In the event that only 2 ports are left free on the base of a Fist-type

Underneath view of a closure base (with numbers added)

closure, a multi-drop cable kit is to be fitted on these remaining ports, to allow extra capacity at a later date.

8.2.2 Heat shrinking

Cables entering the ports of the closure should be, after heat shrinking, set straight down from the closure base without any angle or deviation.

The cables and port must be thoroughly abraded with sandpaper and cleaned with isopropyl alcohol, before heat shrinking the port seal, thus ensuring a leak free seal (as per manufacturer's instructions for the closure).

Aluminium foil should be used to protect the cable below the seal from heat during the process of shrinking. This foil should enter no more than 20mm into seal. Small cable overheat protection (SCOP) may be used to pack small cables up to the minimum shrinkage diameter of the seal to be used.

Hot air guns must be used.

8.2.3 Pressure testing

All closures should be pressure tested after preparation to ensure that they are sealed properly.

8.2.4 Oversleeve standards

In the event that the use of a FOSC type closure has been approved by Waka Kotahi, oversleeve tubing should extend to within 10mm of the butt of the cable and should not extend beyond 10mm past the cable ties on the tray, such that it encroaches into the path of the fibres.

8.2.5 Splicing tray management

Tubes should enter from the opposing sides of the splicing trays to prevent any crossover of fibre upon trays. Tubes must allow for tray movement for access to lower trays.

There should be a minimum of 1250 mm of fibre end for splicing in splicing trays.

The size of the splice protector to be used will be dictated by the type of splice tray used, i.e. a FIST-type splice tray will require a 45mm splice protector and a FOSC-type splice tray will require a 62mm splice protector. A splice protector must cover the fibre cladding by a minimum of 5mm.

8.2.6 Moisture absorbing bags

Moisture absorbing silica crystal bags must be used in closures, as moisture and water break down splices and cloud the glass, causing significant problems.

Each time a closure is accessed, the moisture bag must be replaced with a dry one.

8.2.7 Spare fibre storage

In a FIST-type closure, uncut fibres can be stored as single circuits in trays, whilst uncut tubes can be stored in the storage space between the profiles. Spare cut fibres should be stored on spare trays.

In a FOSC-type closure, uncut fibres must be stored on a tray, whilst uncut tubes must be stored in a storage basket.

8.3 Fibre verification

8.3.1 General considerations

Fibre verification (the process of positively identifying fibre to be worked using test equipment) must be undertaken before any fibre is cut, to eliminate avoidable disruption to the network and Waka Kotahi customers.

When undertaking work on the fibre network, Contractors must ensure that their employees are supplied with the appropriate test equipment. The equipment to be used must be suitable for the length of the fibre to be tested.

8.3.2 Verification equipment and techniques

There are a number of fibre verification techniques using various types of equipment, such as:

- OTDR
- Light Source & Power Meter
- Live Fibre Identifier
- Visible Light Source
- Optical Talkset.

Macrobending

Macrobending is a verification technique which should only be used as a last resort when all other positive identification is unavailable. If it has to be used, all care should be taken to ensure the microbending does not jeopardise the physical integrity of the fibre. Bending should be as close as practicable to the splice protector, or in the middle of the fibre loop so that a splice can be easily created should the fibre break.

Optical loss is cumulative so a number of small bends can accomplish the equivalent of one very sharp (and risky) bend. Where possible, use multiple small bends to create the required high loss (i.e. wrapping the fibre around a small finger several times). If the fibre is part of a working system, the macrobend(s) will trigger an alarm condition.

8.3.3 Fibre verification procedure

1. Check the details of the Waka Kotahi Fibre optic cable change request form, which will specify the cable and fibres to be used.
2. Notify Waka Kotahi and/or other affected parties of the intention to commence work.
3. Establish communication between the worksite and the test site.
4. At test site, uncap the fibre to be tested and connect to testing equipment.
5. Turn on equipment and request the worksite party to check for condition on the appropriate fibre.
6. Obtain positive identification that the fibre is the one to be worked on.
7. When the fibre has been positively identified it should be immediately cut and/or labelled to avoid confusion if it is not immediately worked on or if there are more fibres to be worked on.
8. Repeat for all subsequent fibres to be tested.
9. Upon completion of testing, restore connection of fibres or re-cap.

10. When work is completed, confirm with Waka Kotahi and/or other relevant parties that the affected systems are working properly.

8.4 Fibre cutting and splicing

8.4.1 Fibre cutting

Use only side cutters or purpose made tools (e.g. stripping tool or cleaver) for cutting optical fibres. A bare fibre (with cladding removed) should never be broken by bending, as flying splinters can easily penetrate skin and eyes. All cleaving operations should be performed using a well maintained cleaver.

8.4.2 Fibre cleaning

Fibre should be thoroughly cleaned and separated with isopropyl alcohol and/or lint free wipe before splicing. Only pharmaceutical grade isopropyl alcohol (99.8% pure or better) may be used to clean bare optical fibres and connector end faces. No other solvent should be used as this may have a detrimental effect of the cladding, turning them soft or removing the colouring.

8.4.3 Disposal of fibre off-cuts

For health and safety reasons, remove all fibre ends and waste lengths from the workplace by carefully placing in a sealable optical fibre off-cut disposal canister, and dispose of in a safe manner.

8.4.4 Fibre splicing rules

All fibre should be jointed using fusion splicing. The splices are then protected with a heat shrink splice protector and placed on a splice tray where the splice is held and spare fibre managed.

Mechanical splicing is only acceptable for temporary fault restoration.

When fibre splicing, the fusion splicer estimates the loss of the splice. This is only an estimation therefore all splices should be checked with an OTDR and any splice with an estimation of 0.05db or more should be re-spliced as a precaution. The actual splice loss verified with the OTDR should be no more than 0.1db. If the fibre is re-spliced more than four times to try to achieve this maximum loss, then the fibre should be deemed as a mismatched fibre and the best loss accepted but noted.

8.5 OFDFs and patch cord management

8.5.1 OFDFs

The following procedure is to be followed regarding OFDFs:

- Cable entering OFDFs should be mechanically fixed, and strength members should be fixed with an appropriate clamp and/or anchor device.
- Compression glands should be used together with cable ties to ensure there is no way of accidentally pulling the cable from the OFDF.
- Sufficient cable length should be left in the nearest pit to allow for easy opening or removal of OFDF for repairs or additional work.
- Velcro ties should be used on pigtails and patch cords except when securing cords to splicing trays.

- When using cable ties to secure pigtails to trays, wrapping a foam tape or a few wraps of PVC tape under the ties will prevent macrobending of the fibre inside.
- PVC tape is acceptable to use to fix cables as an alternative to Velcro.
- Flexible conduit should be used to protect pigtails and patch cords wherever they are run under floor spaces, along cable trays or cable ladder or in any area where they could potentially be harmed in any way.

8.5.2 Fibre connectors

If not properly maintained, fibre connectors can be a major source of insertion loss and reflections.

Connection and connector quality is critical, as poor jointing or splicing will introduce higher levels of attenuation and can throw out network design parameters. The high optical power of a laser can permanently damage a connector by carbonising microscopic particles of dirt on the connector end face, hence the importance of cleanliness.

The following points should be noted:

- Each time a connector is mated, it must be cleaned and dried.
- Adaptors must be cleaned and dried before attaching a connector.
- Always attach endcaps to unmated connectors or adaptors.
- Do not pull, twist, kink, or otherwise stress any optical patch cord or pigtail.
- Do not use index matching gel on any fibre connections.
- Maintain the minimum bend radius of 30mm for 3mm cord.

8.5.3 Patch cords

Patch cords should be managed in such a way that they are protected against accidental damage and from weight stress. A form of patch cord management system should be adopted to deliver patch cords to equipment from the OFDF.

Movement of sliding trays should be allowed for and this taken into consideration when running any patch cords, to allow easy opening of the OFDF after commissioning.

8.6 Chamber and cable management

The positioning of the cable and the closure will require careful consideration to minimise risk to the cable and ensure room for future provisioning.

8.6.1 Mounting of closures

Joint closures should be secured in the chamber in such a way they do not obstruct, or are likely to be affected by, any future installations.

Closures should be mounted vertically and as high as possible up the chamber wall to ensure minimum water penetration if a port seal should fail and to maximise available space within the chamber.

Closure brackets and cable loops should be mounted on a side of the chamber with no ducts to avoid obstruction of duct line.

The cable minimum bend radius must not be compromised.

8.6.2 Cable ducts

Cable ducts entering chambers should be trimmed such that they protrude no more than 100 mm from the chamber wall and sealed with Telecrete or similar to avoid water seepage.

8.6.3 Securing of chamber coversets

Over time, the locking systems of coversets can seize up or become damaged, making it difficult to open covers or to re-secure them after opening. It is important that coversets are correctly replaced and secured after accessing a chamber. In instances where locking systems are damaged, the Contractor must notify Waka Kotahi immediately to arrange for repair or replacement.

All care must be taken to avoid damaging coversets when accessing chambers and Contractors must ensure that workers have the appropriate lifting device(s) before they attend sites. Any cover damaged in the process of opening must be replaced by the Contractor at the Contractor's expense.

In the case where the bolts of a galvanised steel tread type cover have seized and need to be ground off in order to access the chamber, the bolts must be replaced with Torx-Post Buttonhead T45 stainless steel M10x40 bolts. All four bolts will need to be of the same type.

In the case of the pre-cast aluminium covers, the spring latch locking system must be replaced with the same type. The Contractor will need to contact the manufacturer of the coverset for replacement details.

When replacing covers after opening a chamber, thoroughly clean the cover and frame units before reinstallment. Failure to do this may result in a pedestrian or vehicle hazard, or the cover becoming loose (and noisy) in the frame as traffic further compresses any foreign material left in the frame.

The final tension of 65 ft-lbs must be applied using a standard torque wrench and the security torque wrench coupling. Only this tension procedure guarantees that each cover is correctly secured.

The rubber dust covers or protective caps must be replaced over locking systems on coversets.

Under no circumstances must a cover be bent. This can become a dangerous hazard for pedestrians, lawnmowers, and motorists where chambers are located in shoulders. A protruding cover corner can puncture tyres and damage mower blades. In the event that a Contractor discovers that a cover is already damaged, it must be reported to Waka Kotahi immediately.

8.7 Labelling of cables and equipment

8.7.1 Use of K-type cable marker system for cables

All cables in chambers and cabinets must be labelled using K-Type cable markers and carrier strips (i.e Critchley, Partex or similar). The carrier strips must be secured to the cable using stainless steel tab cable ties.

8.7.2 Labelling of cables

Cables entering closures must be labelled as close as possible to the ports. Cables entering cabinets must be labelled as close as possible to the OFDF and easily sighted.

Cable labels need to show the node from which the cable originates, the section ID of that cable, the fibre count and the ID of the chambers or cabinets that the cable feeds.

Cables are to be labelled in the following manner and order:

1. Site code of cable point of origin – i.e. CMJ, ATM etc
2. cable ID – i.e. "01" denoting backbone cable number between nodes

3. fibre count – i.e. “48” for a the fibre count of the cable

4. chamber IDs in ascending order – i.e. “4100-4110” indicating the current chamber ID is 4100 and the next chamber through which the cable passes is 4110; or “E-488-N” indicating the cabinet fed by this cable.

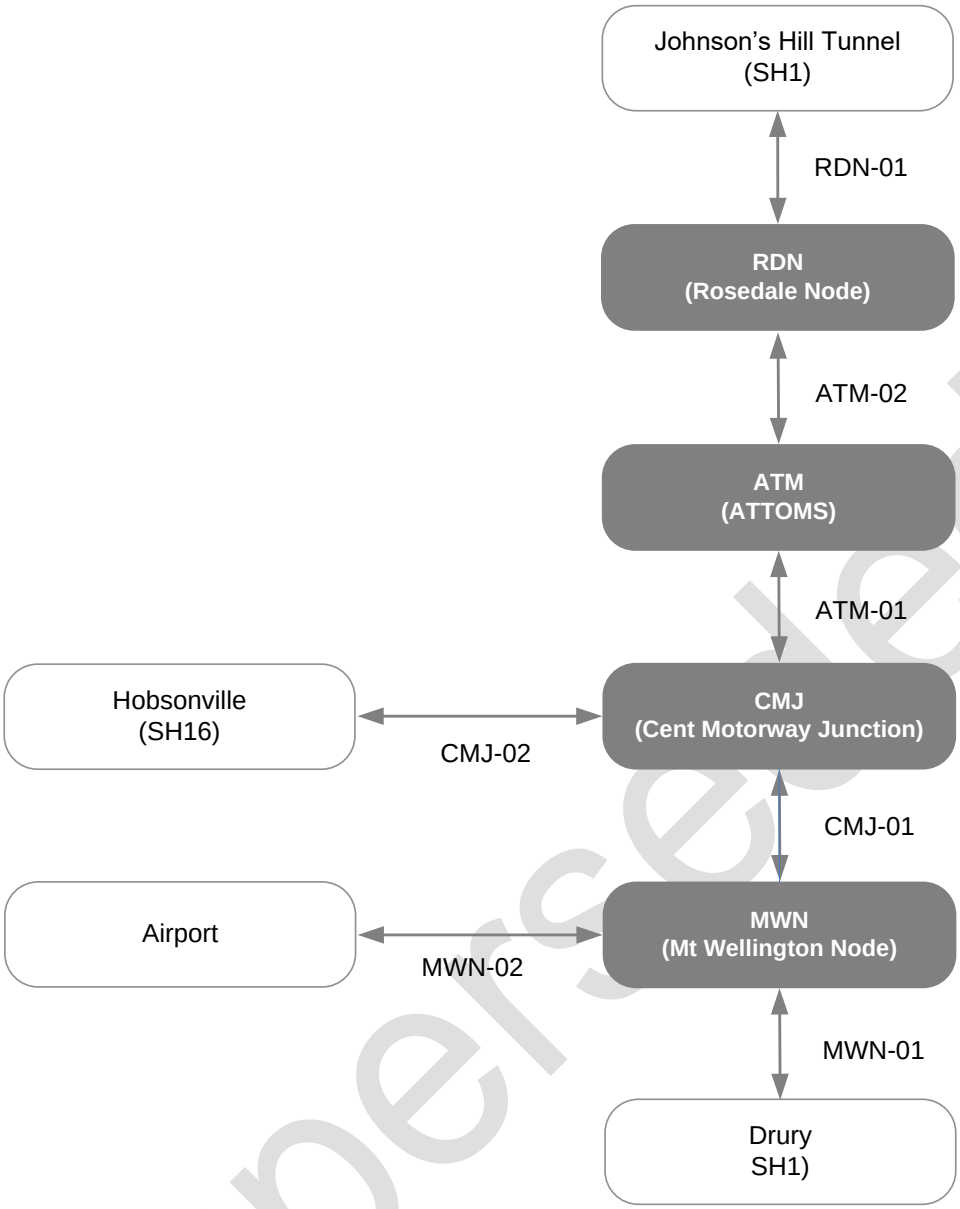
Backbone cable labelling example: CMJ-01-48-4100-4110

Spur cable labelling examples: CMJ-01-12-E-488-N

The list of site code acronyms are as follows:

Code	Site
ATM	ATTOMS – Auckland Transport Management Centre
CMJ	Central Motorway Junction Node
MWN	Mount Wellington Node
RDN	Rosedale Node
Code	Site

Below is a diagram showing the labelling of cable ID sections on the Waka Kotahi network:


Johnson's Hill Tunnel
(SH1)
RDN-01
RDN
(Rosedale Node)
ATM-02
ATM
(ATTOMS)
ATM-01
Hobsonville
(SH16)
CMJ-02
CMJ
(Cent Motorway Junction)
CMJ-01
Airport
MWN-02
MWN
(Mt Wellington Node)
MWN-01
Drury
SH1)

8.7.3 Labelling of closure domes

Closure domes should be labelled using the 3M Non-Reflective Lettering system.

The labelling of the dome must include, in the following order:

1. The letter “J” for joint
2. state highway number - “001” for SH1, “016” for SH16
3. current chamber ID
4. direction of adjacent traffic flow – North, South, East or West.

Dome labelling example: J-001-5050-S

8.7.4 Labelling of splices and splicing trays

The method for labelling splices and trays will depend on the type of closure used. However, regardless of type of trays in use, *all fibres or trays must be labelled* to allow easy identification of splices.

All trays should be numbered starting from the bottom up. Contractors are to follow the manufacturer’s instructions on labelling of trays and splices.

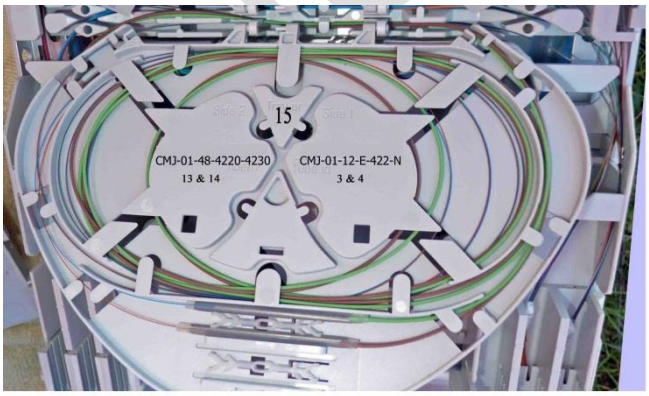
FIST Closures

The trays in Fist-type closures should be labelled with a fine permanent marker pen. If a mistake is made or the label needs to be changed at a later date, isopropyl alcohol can be used to remove the existing label.

Trays should be marked as follows (see diagram below):

1. tray position number
2. fibre section IDs
3. fibres spliced.

Note that trays should be numbered according to their position on the mounting frame, and not according to the number of trays actually used. This allows for the correct numbering of additional trays that may be inserted at a later date.



FIST tray labelling example

Tray mounting system layout

FOSC Closures

Splices in FOSC type closures should be labelled with the wrap around labels that are generally provided with this type of enclosure, and the trays should be labelled with the stickers provided, always starting in numerical order form the bottom tray working upwards.

8.7.5 Labelling of OFDFs

OFDFs and patch cords should be labelled as follows:

1. section and cable ID
2. number of the backbone fibre used
3. equipment designation.

OFDF labelling example: CMJ-01, 19 to C-001-0720-N, 20 & 21 to V-001-0650-N

The following table shows the prefixes used to identify items of equipment:

Prefix	Equipment	Prefix	Equipment
C	CCTV camera	N	Network node
D	Vehicle detection site (VDS)	OH	Over height vehicle detector
E	Equipment cabinet	P	Pull pit
F	Fixed camera	R	RMS VMS
G	Emergency access gate	SL	Ramp signal loops
J	Jointing pit	V	Variable message sign (VMS)
L	Lane control signal		

9.0 Testing

9.1 Optical time domain reflectometer (OTDR) testing

9.1.1 Introduction

OTDR testing *must be done* for all new cable installation, all section replacement (overlays, resplicing existing joints) and all changes to a link (spur, lead-in and reconfiguration).

OTDR users must be familiar with trace capture and manipulation, and be able to adjust the OTDR settings to obtain the highest resolution across the total length of the link under test.

Using the OTDR “auto function” is not always sufficient to produce a quality optical signature (trace) or allow detailed link or splice analysis.

All equipment that requires calibration must be maintained according to the manufacturer’s requirements. Connectors must be cleaned before mating, prior to testing, and every time a connector is moved. Either a fibre connector cleaner, or alcohol and a lint free wipe, can be used.

The OTDR has an inherent weakness which is normally called its “dead zone”. When looking at a fibre signature on an OTDR, the dead zone is the area from the connector on the front of the OTDR (zero distance), to the point in the trace that can be seen as a smooth line which can be interpreted for interrogation (splice measures etc). This point may be anything from 10m to 200m, and is dependent on the power and capabilities of the type and make of OTDR used. Ideally, a launch cable of should be used to observe the true launch of the connector at the near end. The length of the launch cable has to be longer than the dead zone of the OTDR, to be able to interpret the first connection. This cable must be made of fibre and connectors of a matching type to the cables to be tested.

The distance given by an OTDR is the “optical distance” which is very different from the cable sheath distance. The optical distance takes into account every optical item in the path, e.g. pigtails, patch cords, bare fibre on OFDF’s and closure trays, loops in manholes and pits and the fibre stranding back and forth within the cable sheath along its length. On average, the optical distance within a cable sheath is longer than the physical sheath distance by 0.25%. This may not seem like much, but over a 10km length that adds up to 25m, which is a significant amount when trying to pinpoint an exact location.

End to end power meter testing should be done to ensure no crossovers, as well as true attenuation levels. Test leads should be cleaned and calibrated before and after testing for an average, as environmental conditions can affect the readings.

Splice loss should be 0.1db +/- .05db.

Link loss tests for systems that require 2 fibres, e.g. fibre pairs, should be closely matched. Results for each fibre should be within 1db.

9.1.2 OTDR-set up parameters

Ensure the OTDR is set up correctly for the link under test - pulsewidth, range, resolution, wavelength, index of refraction and backscatter co-efficient are all settings that can affect the resultant trace.

- The OTDR used must have sufficient dynamic range (be powerful enough) to produce an acceptable (clear) trace over the entire fibre section under test.
- To gain the maximum OTDR launch power, the appropriate fibre connector cleaning procedure must be followed.
- Sufficient time must be taken to allow for trace averaging if an acceptable (clear) trace is to be obtained.

9.1.3 Wavelength to use

Testing should be done using both 1550nm and 1310nm, in both directions. Fibre may appear to be okay at 1310nm but may have very high losses at 1550nm.

9.1.4 OTDR traces

Trace Naming

OTDR traces must be sent to Waka Kotahi in Bellcore GR196-CORE format only.

Traces shall be saved in the following naming standard:

Item	Example
Fibre # (3 character)	015
Trace type (1 character)	B for Bellcore
Wavelength (1 character)	3 for 1310 or 5 for 1550
Trace number (3 character)	001

Trace naming examples:

- 013B5001.sor for trace from site A to site B
- 013B5002.sor for trace from site B to site A

Trace Storage

Traces need to be stored in the following manner:

- create a directory for site A (where the fibre is going from)
- create a Site B directory under site A (where the fibre is going to)
- create a Cable ID directory under Site B
- store the trace under this directory.

Both sets of traces, from site A and site B, need to be stored in the same Cable ID directory.

Trace storage example: C:\ATTOMS\E-450-N\ATM-01\013B5001.sor

Where ATTOMS is site A, E-450-N is site B cabinet number, ATM-01 is the cable ID, 013B5001.sor is the file name of the trace for fibre 13.

Specific Trace Information

Item	Header Field or Fibre Report	Project Information required in exactly this format	Example
1	Cable ID	Cable description	ATM-01
2	Fibre ID	Fibre Number	009
3	Wavelength	1310nm or 1550nm	1550
4	Origin Location	Site A Code	ATTOMS
5	Termination Location	Site B Code	E-450-N
6	Cable Code	Cable type (Loose Tube or Slotted Core) Fibre Type (Single Mode or Multimode)	Loose Tube Single Mode
7	Operator	Name of OTDR user, Company and Date	A Smith, Prime Comms,

			15-02-01
8	Comment	Project description and circuit ID	CCTV Rosedale

9.2 Light source and power meter test

Occasionally, a test requiring a light source and power meter may be requested by Waka Kotahi.

All test instrumentation used must be within calibration. All cords and connectors must be cleaned prior to use.

The loss of test cords and connectors (if used) must be accounted for as part of the link loss calculation.

9.3 Cable and splice loss

9.3.1 Attenuation

The reduction in optical power as it passes from A to B is referred to as attenuation or loss. This loss occurs from absorption, scattering and reflection along the fibre length and is generally referred to as decibels (db).

When matching lasers or equipment to fibre links or connections, if the true power loss levels are not available then a simple calculation may be done to estimate the loss on a particular section of cable. This may be used to determine the strength of laser to be used on the connection (these figures are atypical of losses in a high quality fibre).

The average attenuation for single mode fibres commonly used on the Waka Kotahi network is:

- 0.22db/km @ 1550nm.
- 0.33db/km @ 1310 nm.

For single mode loose tube cable, the acceptable maximum individual splice loss is 0.1db

9.3.2 Loss formula

The formula to use when allowing for attenuation of a circuit is as follows:

- 1550 nm allow 0.2db per km of cable.
- 1310 nm allow 0.35db per km of cable.
- Allow 0.15db per fusion splice.
- Allow 0.4db per connector.

For example, a circuit connectorised at both ends being 10km in length and having 7 splices along the length (including OFDF splices) may be calculated as having a potential loss of 3.85db @ 1550nm and 5.35db @ 1310nm.

10.0 Training and safety

10.1 Contractor responsibilities

The Contractor's responsibilities include:

- Providing a safe working environment for their staff.
- Ensuring that all staff are suitably trained in the work practises and health and safety measures to be applied during work, to protect themselves and other people.
- Ensuring that appropriate equipment is on hand to test for potential hazards.
- Ensuring that all staff are fully aware of potential worksite hazards, and that any visitors to the work site are also made aware of the hazards.
- Ensuring that a trained Site Traffic Management Supervisor (STMS) is present at all times at work sites on Level 2 and Level 3 roads (i.e. high traffic volume motorways and state highways). Refer to the Waka Kotahi *Code of practice for temporary traffic management* (CoPTTM).
- Ensuring that all staff are supplied with safety equipment and wear the appropriate Personal Protective Equipment (PPE). Work on level 2 or 3 roads requires the use of a hard hat, safety glasses, reflectorised high viz vest/jacket and safety boots (refer to CoPTTM).
- Ensuring the necessary maintenance, calibration and safe keeping of all tools, test gear, mechanical aids, vehicles etc, required to undertake the work.

10.2 General worksite hazards

Workers should take note of potential hazards that may be peculiar or specific to certain worksites, such as:

- broken glass from discarded bottles etc;
- discarded syringes;
- human and animal urine and faeces, both outside of or inside chambers;
- lighting strikes during storms;
- chambers being located close to steep embankments or walls etc;
- falling debris.

10.3 Eye safety and viewing of fibres

Treat all fibres as live.

Lasers are used as optical transmitters in single mode cables and associated test equipment. These devices emit intense invisible electromagnetic radiation which is capable of damaging the eyes. Therefore, never directly look at an optical fibre end or connector end face with the naked eye and do not point at other people. Do not attempt to view at a distance of less than 100mm.

Prior to using a direct viewing aid (e.g. video fibre inspection scope), verify that the fibre is not live by using an optical power meter or live fibre identifier.

Goggles /safety glasses should be worn when preparing and splicing fibre as fragments of fibre in the eye can blind.

When cutting fibre, make sure that you do not rub your hands into your eyes to avoid fragments getting into the eyes.

10.4 Disposal of fibre

For health and safety reasons it is required that the disposal of any glass substance must be securely managed and pose no threat to the general public, animals or to waste transfer plant personnel. Fibre off-cuts are a serious health hazard and once under the skin they are virtually impossible to locate and remove.

All fibre ends and waste lengths from the worksite must be carefully placed in a sealable optical fibre off-cut disposal canister, which is to be then securely sealed and disposed of in a safe manner (e.g. at a refuse collection bin or, if available, a hazardous substance bin).

10.5 Solvent use and disposal

Isopropyl alcohol and other solvents may be absorbed through the skin and present various health risks; they are a poison and should be treated as such. Chemicals should be kept in suitable air tight storage containers, handled as per their instructions and disposed of in the appropriate manner.

Material Safety Data Sheets: when using approved chemicals, the guidelines/requirements of material data safety sheets must be available and adhered to.

Ventilation: ensure ample ventilation of the workspace when working with isopropyl alcohol or any other chemicals.

Prohibited: the use of chemical strippers such as acetone, kerosene or petroleum-based products is prohibited.

Washing: thoroughly wash hands with soap and warm water after handling chemicals and before eating or drinking.

Smoking: smoking when using solvents is not permitted, as they are highly flammable.

Cell phones: cell phone use in the immediate vicinity of exposed flammable solvents is not advised.

10.6 Working from heights

Contractors shall, in relation to a place of work under the control of that Contractor, ensure that where a worker may fall more than 3 metres, means are provided to prevent this.

Contractors must ensure that workers are adequately trained and have the appropriate equipment, such as ladders, harnesses, cherry pickers etc, required to undertake any work that involves working from heights.

10.7 Working in confined spaces

Working in a confined space such as a manhole is a hazard in itself and must be treated accordingly.

The following outlines some of the typical hazards:

- Difficulty of access and egress.
- Poor ventilation, dangerous gasses & oxygen deficiency.

- Dangers from traffic (pedestrian and vehicular).
- Things falling into open manholes.

Contractors must ensure that employees observe the OSH requirements for identifying and managing these hazards.

10.8 Gas testing

An evaluation of the workplace atmosphere must be performed from outside a confined space, such as a chamber, before any entry occurs. As the gases may be flammable, toxic or asphyxiating (and most likely a combination), all employees are required to observe special work practices to ensure a safe working environment. An atmospheric test must be undertaken to detect the possible presence of harmful airborne contaminants or the displacement of oxygen.

- Toxic gases can render a person unconscious, or kill them.
- The amount of oxygen in the workplace may be displaced by a vapour, reducing the breathable atmosphere below safe oxygen levels causing asphyxiation.
- Flammable gases can explode if ignited by a spark or equipment use.

Refer to OSH standards for gas testing requirements.

11.0 Environmental considerations

11.1 Rubbish disposal

After the completion of work, *all* rubbish and excess materials (i.e. cable off-cuts, duct tape, blue ribbon, old cable ties, equipment packaging etc) must be removed. This includes the removal of backfill when trenches or chambers are installed. The work site is to be left in a clean and tidy condition.

11.2 Water disposal

In the event that water needs to be pumped out of a chamber before entry, or water needs to be used in the process of concrete cutting/drilling, local authority rules regarding discharge and removal must be adhered to.

11.3 Damage to landscaping & structures

Contractors must avoid damage to surrounding landscape or structures when undertaking works on the Waka Kotahi network. Any damage must be rectified as per the local road authority's standards, at the Contractor's expense.

The following are a couple examples to take note of:

- If driving on a site results in ground surface damage by the vehicle, the surface must be repaired.
- If the work requires removal of earth (i.e. during the installation of a new chamber or trench), the exposed soil must be covered with straw or similar protective layer to minimise contamination of surrounding waterways and drains.

12.0 Glossary of terms

A	
Absorption	That portion of fibre optic attenuation resulting from the conversion of optical power to heat.
Adaptor	An adaptor is a mechanical device designed to align fibre-optic connectors.
Attenuation	The reduction in optical power as it passes along a fibre, usually expressed in decibels (dB).
Attenuator	A device that reduces signal power in a fibre optic link by inducing loss.
B	
Backscatter	The scattering of light in a fibre back toward the source, used to make OTDR measurements.
Bandwidth	The range of signal frequencies or bit rate within which a fibre optic component, link or network will operate.
Bend Radius	The radius of curvature that an optical fiber can bend without sustaining damage.
Bit-error Rate (BER)	The fraction of data bits transmitted that are received in error.
Bit	An electrical or optical pulse that carries information.
Buffer	A protective coating applied directly on the fibre.
C	
Cable	One or more fibres enclosed in protective coverings and strength members.
Chamber	An enclosure used to provide space for the management of cables and associated equipment.
Cladding	The lower refractive index optical coating over the core of the fibre that "traps" light into the core.
Connector	A device that provides for a demountable connection between two fibres or a fibre and an active device and provides protection for the fibre.
Code of practice for temporary traffic management (CoPTTM)	The Waka Kotahi *Code of practice for temporary traffic management* describes best practice for the safe and efficient management and operation of temporary traffic management on all roads in New Zealand.
Core	The light-conducting centre of an optical fibre, defined by the region of high refractive index.
Coupler	An optical device that splits or combines light from more than one fibre.
Coverset	The lid and frame assembly used to cover manholes/chambers.
D	
dBm	Optical power referenced to 1 milliwatt.
Decibel (dB)	A unit of measurement of optical power which indicates relative power on a logarithmic scale, sometimes called dBr. dB=10 log (power ratio).

Detector	A photodiode that converts optical signals to electrical signals.
Digital	Signals encoded into discrete bits.
Dispersion	The temporal spreading of a pulse in an optical waveguide. May be caused by modal or chromatic effects.
Duct	Parts of a closed wiring system used to enclose cables and electrical telecommunication installations; allows cables to be drawn in or replaced.
E	
End Face	Term often used to describe the end of a ferrule. The end face is finished or polished to have a smooth end, which can minimize connector loss or backreflection. Typical polish types are PC, UPC, and APC.
F	
FC Connector	FC stands for Fixed Connection; it is fixed by way of a threaded barrel housing.
Ferrule	A precision tube which holds a fibre for alignment for interconnection or termination. A ferrule may be part of a connector or mechanical splice.
Fibre Identifier	A device that clamps onto a fibre and couples light from the fibre by bending, to identify the fibre and detect high speed traffic of an operating link or a 2 kHz tone injected by a test source.
Fibre Optics	Light transmission through flexible transmissive fibres for communications or lighting.
FIST	Fibre Infrastructure System Technology (a Raychem joint closure).
FOSC	Fibre Optic Splice Closure (from Raychem).
Fusion Splicer	An instrument that splices fibres by fusing or welding them, typically by electrical arc.
G	
GBIC	Gigabit networking, or commonly called 10-Gigabit Ethernet (10GBASE-T), is a communications technology that offers data speeds up to 10 billion bits per second.
GCO	Generic Closure Organiser.
Graded Index (GI)	A type of multimode fibre which uses a graded profile of refractive index in the core material to correct for dispersion.
I	
Index of Refraction	A measure of the speed of light in a material.
Index Matching Gel	A liquid used of refractive index similar to glass used to match the materials at the ends of two fibres to reduce loss and back reflection.
Insertion Loss	The loss caused by the insertion of a component such as a splice or connector in an optical fibre.
ITS	Intelligent Transport System.
J	
Jacket	The protective outer coating of the cable.
Jumper Cable	A short single fibre cable with connectors on both ends used for interconnecting other cables or testing.

L	
Laser Diode, ILD	A semiconductor device that emits high powered, coherent light when stimulated by an electrical current. Used in transmitters for single mode fibre links.
Launch Cable	A known good fibre optic jumper cable attached to a source and calibrated for output power used as a reference cable for loss testing.
LC Connector	LC stands for Lucent Connector. The LC is a small form-factor fiber optic connector.
Light-emitting diode, LED	A semiconductor device that emits light when stimulated by an electrical current. Used in transmitters for multimode fibre links.
Link, Fibre optic	A combination of transmitter, receiver and fibre optic cable connecting them capable of transmitting data. May be analogue or digital.
Loss, Optical	The amount of optical power lost as light is transmitted through Fibre, splices, couplers, etc.
Loss budget	The amount of power lost in the link. Often used in terms of the maximum amount of loss that can be tolerated by a given link.
M	
Macrobending	Macrobending occurs when optical fibre is bent into a visible curvature.
Margin	The additional amount of loss that can be tolerated in a link.
Mechanical Splice	A semi-permanent connection between two fibres made with an alignment device and index matching fluid or adhesive.
Microscope, Fibre Optic Inspection	A microscope used to inspect the end surface of a connector for flaws or contamination or a fibre for cleave quality.
Microbending	Sharp but microscopic curvatures in optical fibre that create local axial displacements of a few microns and spatial wavelength displacements of a few millimetres.
Mode	A single electromagnetic field pattern that travels in fibre.
Multi Mode Optical Fibre	Optical fibre with core diameter much larger than the wavelength of light transmitted that allows many modes of light to propagate. Commonly used with LED sources for lower speed, short distance links.
N	
Nanometer (nm)	A unit of measure, 10-9 m, used to measure the wavelength of light.
Network	A system of cables, hardware and equipment used for communications.
O	
Optical Amplifier	A device that amplifies light without converting it to an electrical signal.
Optical Fibre	An optical waveguide comprised of a light carrying core and cladding which traps light in the core.
Optical Fibre Distribution Frame (OFDF)	A multi-purpose mechanical shelf assembly for a fibre management system in a rack environment.
Optical Loss Test Set (OLTS)	A measurement instrument for optical loss that includes both a meter and source.

Optical Power	The amount of radiant energy per unit time, expressed in linear units of Watts or on a logarithmic scale, in dBm (where 0 dB = 1 mW) or dB* (where 0 dB*=1 microwatt).
Optical Return Loss, Back Reflection	Light reflected from the cleaved or polished end of a fibre caused by the difference of refractive indices of air and glass. Typically 4% of the incident light. Expressed in dB relative to incident power.
Optical Switch	A device that routes an optical signal from one or more input ports to one or more output ports.
Optical Time Domain Reflectometer (OTDR)	An instrument used to measure the time and intensity of the light reflected on an optical fibre.
OSH	Occupational Safety and Health regulations, as governed by the New Zealand Department of Labour.
P	
Patch Cord	A patch cord is a fibre optic cable used to attach one device to another for signal routing.
Photodiode	A semiconductor that converts light to an electrical signal, used in fibre optic receivers.
Pigtail	A short length of fibre attached to a fibre optic component such as a laser or coupler.
Power Budget	The difference (in dB) between the transmitted optical power (in dBm) and the receiver sensitivity (in dBm).
Power Meter, Fibre Optic	An instrument that measures optical power emanating from the end of a fibre.
R	
Receiver	A device containing a photodiode and signal conditioning circuitry that converts light to an electrical signal in fibre optic links.
Refractive Index:	A property of optical materials that relates to the velocity of light in the material.
Repeater, Regenerator	A device that receives a fibre optic signal and regenerates it for retransmission, used in very long Fibre optic links.
Road controlling authority (RCA)	An organisation that manages roads, i.e. Waka Kotahi for state highways and territorial authorities for other roads.
S	
Scattering	The change of direction of light after striking small particles that causes loss in optical fibres.
SC Connector	Subscriber Connector- a general purpose push/pull style connector.
Single Mode Optical Fibre	Optical fibre designed to carry a single ray of light (mode). This ray of light often contains a variety of different wavelengths. Commonly used with laser sources for high speed, long distance links.
Site Traffic Management Supervisor (STMS)	A Waka Kotahi-qualified person who has specific responsibility for documentation and management of Temporary Traffic Management (TTM).
Source	A laser diode or LED used to inject an optical signal into fibre.

OSA	Splice Only Sub-Assembly; come in both SC (Single Circuit) and SE (Single Element) type.
Splice (Fusion or Mechanical)	A device that provides for a connection between two fibres, typically intended to be permanent.
ST Connector	A bayonet style optical fibre connector.
T	
Talkset, Fibre Optic	A communication device that allows conversation over unused fibres.
Traffic Management Plan (TMP)	A document describing the design, implementation, maintenance and removal of temporary management while the associated activity is being carried out within the road service or adjacent to and affecting the road service.
Termination	Preparation of the end of a fibre to allow connection to another fibre or an active device, sometimes also called "connectorisation".
Test Cable	A short single fibre jumper cable with connectors on both ends used for testing. This cable must be made of Fibre and connectors of a matching type to the cables to be tested.
Test Source	A laser diode or LED used to inject an optical signal into fibre for testing loss of the fibre or other components.
Transmitter	A device which includes a LED or laser source and signal conditioning electronics that is used to inject a signal into fibre.
V	
Visual Fault Locator	A device that couples visible light into the fibre to allow visual tracing and testing of continuity. Some are bright enough to allow finding breaks in fibre through the cable jacket.
Visible Light Source	An instrument that couples visible light into the fibre to allow visual checking of continuity and tracing for correct connections.
W	
Waka Kotahi	Waka Kotahi NZ Transport Agency – the government agency formed on 1 August 2008 from the amalgamation of Land Transport New Zealand and Transit New Zealand.
Watts	A linear measure of optical power, usually expressed in milliwatts (mW), microwatts (*W) or nanowatts (nW).
Wavelength	A measure of the colour of light, usually expressed in nanometres (nm) or microns (*m).
Wavelength Division Multiplexing (WDM)	A technique of sending signals of several different wavelengths of light into the Fibre simultaneously.
Working Margin	The difference (in dB) between the power budget and the loss budget (i.e. the excess power margin)