Installation guide
M-6725-9212-01-B

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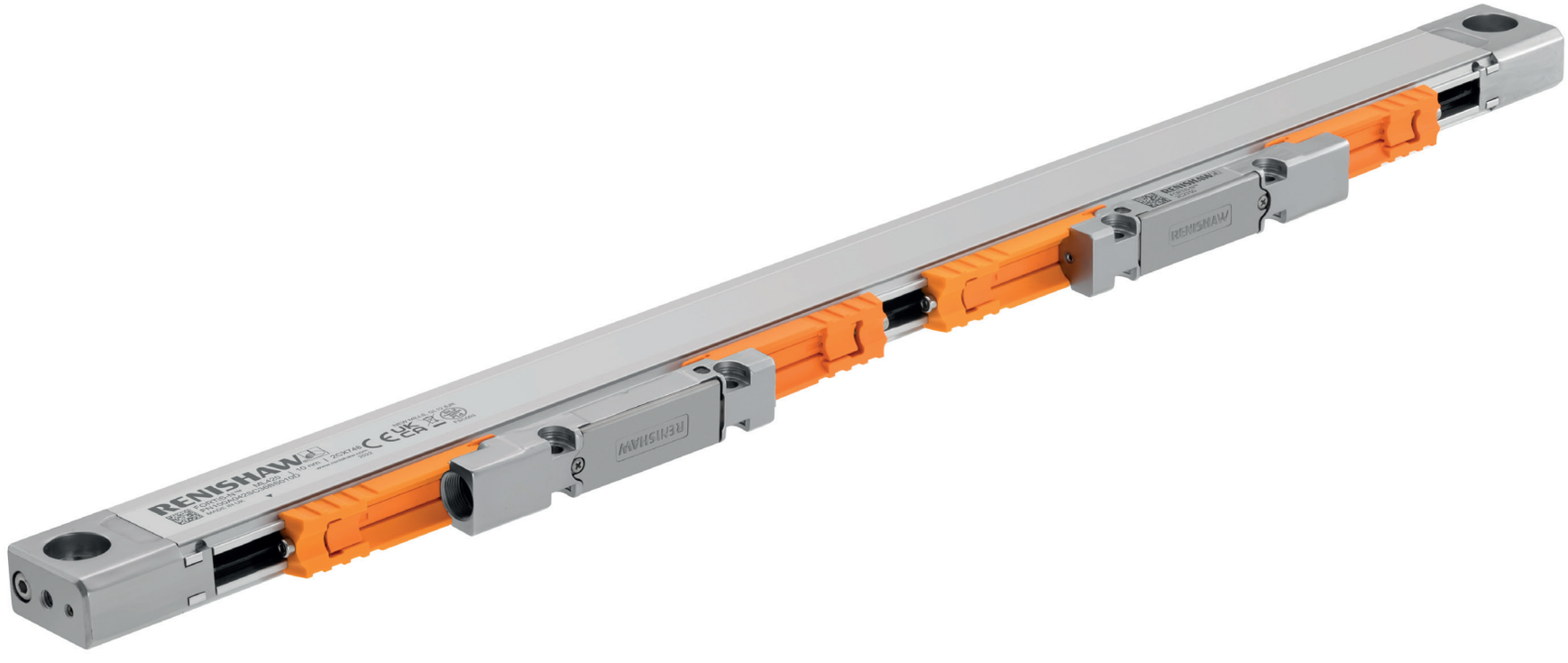
FORTiS-N™ FS enclosed encoder system with multiple readheads

Addendum to M-6725-9026



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Contents

1 Introduction to this addendum

This Functional Safety installation guide addendum details the additional information for the installation and commissioning of a Functional Safety-rated multiple readhead system.

It must be read in conjunction with the *FORTiS-N FS enclosed encoder system Functional Safety installation guide and safety manual* (Renishaw part no. M-6725-9026) for single readhead systems, which provides the following contents:

- Legal notices
- Definitions
- Information for use
- Functional Safety data declaration
- Safety function
- Certification
- Summary of EU Declaration of Conformity
- Summary of UK Declaration of Conformity
- Overview of the FORTiS-N FS encoder system
- Parts list
- Storage and handling
- Installation drawings
- Product specification
- Installation procedure – extrusion
- Installation procedure – readhead
- Cables and serial interfaces

This installation guide addendum for multiple readheads provides the following contents and revisions to the above:

- Functional Safety data declaration
- Safety function
- Certification
- Summary of EU Declaration of Conformity
- Summary of UK Declaration of Conformity
- Overview of the FORTiS-N FS encoder system with multiple readheads
- Parts list
- Additional content for the installation of a multiple readhead system
- Installation drawing

2 Functional Safety data declaration

Functional Safety data declaration for 2, 3, 4, 5, 6, 7 and 8 readheads

IEC 61508 safety data

Product identification	FORTiS-S FS and FORTiS-N FS variants with BiSS Safety and Siemens DRIVE-CLiQ serial interfaces						
Safety integrity level	2						
Failure rate data	2 readheads	3 readheads	4 readheads	5 readheads	6 readheads	7 readheads	8 readheads
Random hardware failures (per hour) – BiSS Safety serial interface	λ_S = 4.59E-07	λ_S = 6.88E-07	λ_S = 9.17E-07	λ_S = 1.15E-06	λ_S = 1.38E-06	λ_S = 1.61E-06	λ_S = 1.84E-06
	λ_D = 7.99E-07	λ_D = 1.20E-06	λ_D = 1.60E-06	λ_D = 2.00E-06	λ_D = 2.40E-06	λ_D = 2.80E-06	λ_D = 3.20E-06
	λ_{DD} = 7.19E-07	λ_{DD} = 1.08E-06	λ_{DD} = 1.44E-06	λ_{DD} = 1.80E-06	λ_{DD} = 2.16E-06	λ_{DD} = 2.52E-06	λ_{DD} = 2.88E-06
	λ_{DU} = 7.99E-08	λ_{DU} = 1.20E-07	λ_{DU} = 1.60E-07	λ_{DU} = 2.00E-07	λ_{DU} = 2.40E-07	λ_{DU} = 2.80E-07	λ_{DU} = 3.20E-07
Random hardware failures (per hour) – Siemens DRIVE-CLiQ serial interface	λ_S = 6.75E-07	λ_S = 9.94E-07	λ_S = 1.32E-06	λ_S = 1.66E-06	Not permitted	Not permitted	Not permitted
	λ_D = 1.19E-06	λ_D = 1.73E-06	λ_D = 2.31E-06	λ_D = 2.89E-06			
	λ_{DD} = 1.07E-06	λ_{DD} = 1.56E-06	λ_{DD} = 2.08E-06	λ_{DD} = 2.60E-06			
	λ_{DU} = 1.19E-07	λ_{DU} = 1.73E-07	λ_{DU} = 2.31E-07	λ_{DU} = 2.89E-07			
PFH (per hour) – BiSS Safety serial interface	λ_{DU} = 7.99E-08	λ_{DU} = 1.20E-07	λ_{DU} = 1.60E-07	λ_{DU} = 2.00E-07	λ_{DU} = 2.40E-07	λ_{DU} = 2.80E-07	λ_{DU} = 3.20E-07
PFH (per hour) – Siemens DRIVE-CLiQ serial interface	λ_{DU} = 1.19E-07	λ_{DU} = 1.73E-07	λ_{DU} = 2.31E-07	λ_{DU} = 2.89E-07	Not permitted	Not permitted	Not permitted
PFD_{avg}	Not applicable due to continuous demand mode						
Architectural constraints Type HFT SFF	B 0 95%						
Hardware safety integrity compliance	Route 1H						
Systematic safety integrity compliance	Route 1S						
Systematic capability	SC2						
Demand mode	Continuous						
Proof test interval	Not required for continuous demand mode						

ISO 13849 safety data

Failure rate data	2 readheads	3 readheads	4 readheads	5 readheads	6 readheads	7 readheads	8 readheads
$MTTF_D$ – BiSS Safety serial interface (years)	142	95	71	57	47	40	35
$MTTF_D$ – Siemens DRIVE-CLiQ serial interface (years)	96	65	49	39	Not permitted	Not permitted	Not permitted
Diagnostic coverage (DC)	Medium (90%)						
Category	3						
Performance level	d						
Lifetime/replacement limits	20 years						

The FORTiS-N FS encoder system provides safe position data that supports the following safety sub-functions defined by IEC 61800-5-2:

- Safe stop 1 (SS1) and Safe stop 2 (SS2) [1]
- Safe operating stop (SOS) [1]
- Safe limited acceleration (SLA) ≤ 200 m/s^2
- Safe acceleration range (SAR) ≤ 200 m/s^2
- Safe limited speed (SLS) ≤ 4 m/s
- Safe speed range (SSR) ≤ 4 m/s
- Safely limited position (SLP) [1]
- Safely limited increment (SLI) [1]
- Safe direction (SDI)
- Safe speed monitor (SSM) ≤ 4 m/s

[1] See the safety function restrictions for the safe position figure for each FORTiS-N FS encoder system variant.

3 Safety function

The FORTiS-N FS encoder system shall provide a safe position when requested by the evaluation unit.

The following restrictions apply to this claim:

- The system installer must perform a verified commissioning test during installation.
- The system repairer must perform a verified commissioning test following replacement of a system part.
- The maximum request rate supported is 32 kHz and 16 kHz for DRIVE-CLiQ.
- Electrical errors for the BiSS Safety serial interface are detected by the evaluation unit comparing CPW and SPW content. See the data sheet *BiSS Safety for RESOLUTE and FORTiS encoders* (Renishaw part no. L-9517-9884) for more information.
- Electrical errors for the Siemens DRIVE-CLiQ serial interface are detected by the evaluation unit comparing POS1 and POS2 content. See the relevant Siemens AG evaluation unit manual for more information.
- When installed correctly, the FORTiS-N FS encoder, with or without mounting spar, has a mechanical safe position of ±1 mm.

3.1 Fault exclusions

The following will invalidate the Functional Safety certification of the FORTiS-N FS encoder system:

- Faults caused by cutting and reconnecting the cable or the use of a non-Renishaw cable that is not approved.
- Incorrect installation.
- Dismantling.
- Operating the system outside the limits specified in this installation guide.

3.2 Failure modes effects and diagnostics analysis

All diagnosed failure modes are detected immediately except for a position discrepancy between the two measurement methods which is detected within 375 µs.

See section 2 on page 5 for a summary of the FMEDA.

NOTE: For the purposes of the FMEDA calculation the following conditions have been assumed:

Method: SN29500-2005-1 **Environment:** Ground mobile **Temperature:** 60 °C

3.3 Installation

For the safety function to be valid the instructions detailed in this installation guide must be followed.

3.4 Commissioning test

The following test MUST be performed when commissioning the FORTiS-N FS encoder system and after any repair or maintenance of the system.

Resolution check	Move each readhead by a known distance and confirm that the position changes as expected. The tolerance for raising a fault condition is relative to the safe position determined by the system manufacturer.

3.5 Evaluation unit monitoring

To achieve full system integrity the evaluation unit must continuously monitor the error condition of each readhead in the FORTiS-N FS encoder system, and in the case of fault detection place the system into a safe state within the process safety time.

NOTES:

1. The evaluation unit must have its Functional Safety functions enabled (as often it is a configuration parameter to turn on Functional Safety functionality) and must respond correctly to a FORTiS-N FS encoder system position error flag.
2. A persistent fault condition may indicate a hardware failure of the FORTiS-N FS encoder system or an installation problem.
3. The individual readheads must be treated as separate encoder sub-systems. Each readhead must be connected to a separate evaluation unit and its outputs as per the safety function and must be monitored separately. In the case of an error being reported then the appropriate action must be taken.
4. The system manufacturer and/or system installer are responsible for ensuring the safe operation of these sub-systems: for example, ensuring the readheads do not collide with each other.

3.6 Maintenance

The maintenance check intervals will be defined by the system manufacturer according to their risk assessment. There are no user-serviceable parts within the FORTiS-N FS encoder system.

The following maintenance actions are advised:

- Check the extrusion screws and readhead retaining screws are correctly tightened.
- Check for worn or damaged cables and connectors.
- Check the cable connectors are correctly tightened/located.
- Check the air supply fitting is correctly tightened and the air hose is correctly fitted.
- When the DRIVE-CLiQ interface is used check the retaining screws are correctly tightened.

3.7 Repair

- Repair of the FORTiS-N FS encoder system is only by replacement of parts.
- The replacement parts must have the same part number as the original parts.
- The repaired encoder system must be installed and commissioned in accordance with 'Commissioning test' on page 7.
- In the event of failure the affected parts should be returned to Renishaw for further analysis.
- Using damaged parts invalidates the Functional Safety certification.

3.8 Proof testing

It is the responsibility of the system manufacturer to define any proof testing of the system. Due to the diagnostic coverage (DC) and safe failure fraction (SFF) required to achieve SIL2, the encoder can only support continuous demand use.

Refer to the *FORTiS-N FS enclosed encoder system Functional Safety installation guide and safety manual* (Renishaw part no. M-6725-9026) for details of the functional safety certificate and the EU declaration of conformity.

4 Certification

FORTiS-N FS encoder system

Functional Safety Certificate No. FSC003

Under the terms of CSA SIRA Functional Safety Certificate SIRA *CASS00023/01*, for the management and self-certification of functional safety activities up to SIL3/PLd, Renishaw plc declares that the products listed by this installation guide meet the requirements of:

- IEC 61508-1:2010, IEC 61508-2:2010 and IEC 61508-3:2010
- IEC 61800-5-2:2016
- ISO 13849-1:2015 and ISO 13849-2:2012

When used as an element/subsystem in safety-related systems performing safety functions requiring up to and including:

- SIL2 with HFT = 0 (1oo1)
- Category 3, PLd.

5 Summary of EU declaration of conformity

EUD 2021-00819

EU based person authorised to compile the technical file: - Renishaw (Ireland) DAC, Swords Business Park, Swords, Co. Dublin, K67 FX67, Ireland.

This declaration of conformity is issued under the sole responsibility of the manufacturer, Renishaw plc. The object of the declaration is identified below:

Product name:	FORTiS-S™ FS and FORTiS-N™ FS enclosed encoder system	
Description:	Enclosed linear FS readhead and scale assembly	
Part no.:	Valid from:	Description:
FS1----------S----	-02	FORTiS-S™ FS standard size enclosed linear encoders
FN1----------S----	-02	FORTiS-N™ FS narrow size enclosed linear encoders

The object of the declaration described above is in conformity with all relevant EU harmonisation legislation and fulfils all the relevant provisions with EU directives:

2006/42/EC	Machinery Directive
2014/30/EU	Electromagnetic Compatibility (EMC)
2011/65/EU	On the restriction of the use of certain hazardous substances in electrical and electronic equipment – RoHS

and complies with the following technical standards:

EN ISO 12100:2010	Safety of machinery – General principles for design – Risk assessment and risk reduction
EN ISO 13849-1:2015	Safety of machinery – Safety-related parts of control systems Part 1: General principles for design (ISO 13849-1:2015)
EN ISO 13849-2:2012	Safety of machinery – Safety-related parts of control systems Part 2: Validation (ISO 13849-2:2012)
EN 61326-1:2013	Electrical equipment for measurement, control, and laboratory use. EMC requirements Part 1: General requirements
EN 62471:2008	Photobiological safety of lamps and lamp systems
EN IEC 63000:2018	Technical documentation for the assessment of electrical and electronic products with respect to the restriction of hazardous substances

For the full Declaration of Conformity EUD 2021-00819 see:
www.renishaw.com/productcompliance

6 Summary of UK declaration of conformity UKD 2021-00819

This declaration of conformity is issued under the sole responsibility of the manufacturer, Renishaw plc. The object of the declaration is identified below:

Product name:	FORTiS-S™ FS and FORTiS-N™ FS enclosed encoder system	
Description:	Enclosed linear FS readhead and scale assembly	
Part no.:	Valid from:	Description:
FS1----------S----	-02	FORTiS-S™ FS standard size enclosed linear encoders
FN1----------S----	-02	FORTiS-N™ FS narrow size enclosed linear encoders

The object of the declaration described above is in conformity with all relevant UK Statutory Instruments (and their amendments):

S.I. 2008 No. 1597	Supply of Machinery (Safety) Regulations 2008
S.I. 2016 No. 1091	Electromagnetic Compatibility Regulations 2016
S.I. 2012 No. 3032	The Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment Regulations 2012 - RoHS

and complies with the following technical standards:

EN ISO 12100:2010	Safety of machinery – General principles for design – Risk assessment and risk reduction
EN ISO 13849-1:2015	Safety of machinery – Safety-related parts of control systems Part 1: General principles for design (ISO 13849-1:2015)
EN ISO 13849-2:2012	Safety of machinery – Safety-related parts of control systems Part 2: Validation (ISO 13849-2:2012)
EN 61326-1:2013	Electrical equipment for measurement, control, and laboratory use EMC requirements Part 1: General requirements
EN 62471:2008	Photobiological safety of lamps and lamp systems
EN IEC 63000:2018	Technical documentation for the assessment of electrical and electronic products with respect to the restriction of hazardous substances

For the full declaration of conformity UKD 2021-00819 see:
www.renishaw.com/productcompliance

7 Overview of the FORTiS-N FS encoder system with multiple readheads

This system is an enclosed linear optical encoder designed for use in harsh industrial environments where high-precision feedback and metrology are required. It is suitable for applications where various slideway mechanisms are common to a particular linear axis and require multiple readheads to provide feedback.

Based upon Renishaw's award-winning absolute technology, the rugged non-contact design has no internal moving parts, such as bearings or wheeled readhead carriages, thus improving the overall reliability. Additionally, hysteresis and backlash errors associated with mechanical contact system designs are reduced.

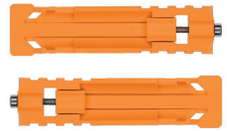
In addition to enhanced breakage resistance, the robust steel scale has a coefficient of thermal expansion similar to the base material used in the majority of machines, reducing errors due to thermal effects whilst increasing measurement certainty.

Renishaw's patented set-up LED provides instant verification of the encoder's signal strength and therefore its accurate alignment. This intuitive procedure significantly reduces the need for additional peripheral diagnostics equipment during installation. When combined with Renishaw's carefully designed installation accessories, these unique tools make installation easier and faster compared to traditional methods, whilst building confidence in a right-first-time installation.

For information regarding FORTiS FS encoder systems with single readheads please refer to the *FORTiS-N FS enclosed encoder system Functional Safety installation guide and safety manual* (Renishaw part no. M-6725-9026).

8 Parts list

8.1 Included in the box

Item		Description
	**FORTiS-N FS encoder unit**	The FORTiS-N FS enclosed encoder unit
	**18 mm readhead setting shim**	Plastic shim to be used as an installation aid
	**Air connection fitting**	To enable connection to one of the encoder air purge inlets
	**Cable connection wrench**	Used for securely connecting the encoder cable to the readhead
	**Alignment brackets**	Two brackets to secure each readhead during transit and set the correct readhead alignment during installation **IMPORTANT:** Retain until installation is complete
	**Serrated washers**	2 × M8 serrated washers for mounting an extrusion with standard end caps
	**Serrated washers**	2 × M4 serrated washers for mounting the readhead to the machine slideway
	FORTiS-N FS quality inspection certificate	Certifies specific encoder performance and provides traceability
	Yellow Functional Safety card	Shows the web address for accessing the installation guide
	**Siemens DRIVE-CLiQ interface**	Included with Siemens-only versions of FORTiS-N FS

8.2 Not included / required tools

Item		Description
	**6 mm torque wrench**	To tighten the extrusion mounting screws
	3 mm torque wrench	To tighten the readhead mounting screws
	**1.5 mm hex key**	Air bung removal (only if air purge is required)
	**3 mm hex key**	For locking the mounting aid
	**M8 screws**	2 × M8 × 1.25 screws length ≥ 20 mm for mounting the extrusion
	**M4 screws**	2 × M4 × 0.7 screws length ≥ 20 mm for mounting the readhead

9 Additional installation content for a multiple readhead system

9.1 Mounting the encoder

The encoder is available with up to eight readheads for Biss Safety systems and up to five readheads for Siemens DRIVE-CLiQ systems.

For mounting surface preparation and mounting orientations refer to the *FORTiS-N FS enclosed encoder system Functional Safety installation guide and safety manual* (Renishaw part no. M-6725-9026).

For minimum distances between readheads and permissible cable orientations refer to the system installation drawing; see section 9.3 and section 9.4 in this addendum.

NOTES:

1. It is the responsibility of the installer to ensure that readheads and their connected cable assemblies do not meet with each other or collide with end caps.
2. Typically, for applications that require multiple readheads traversing a single extrusion, the extrusion is fixed with only the readheads moving. Please contact your local Renishaw representative if your requirements are different.
3. Some of the shorter measuring lengths will not support multiple readheads, depending on number of readheads, cable configuration and cable type. Please discuss with your local Renishaw representative.

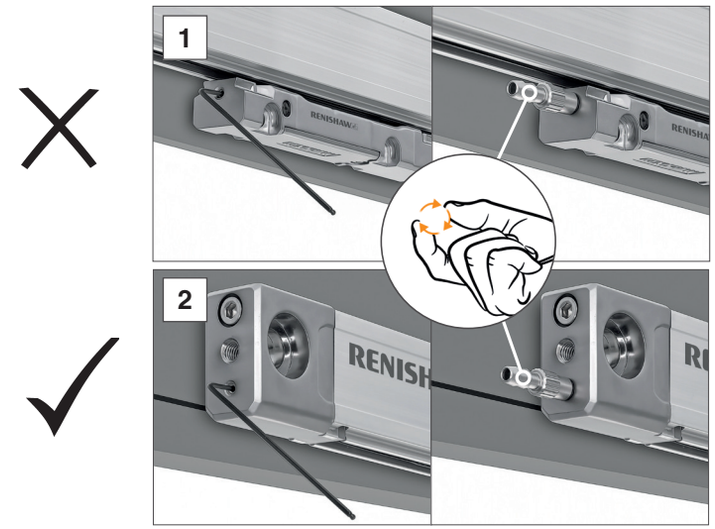
9.2 Connecting the air supply

For fixed extrusion installations as described (see note in section 9.1) the air purge supply must be connected to the extrusion only.

Air inlets are included in each end cap, at both ends of the extrusion. Use a suitable air supply hose with a 4 mm bore.

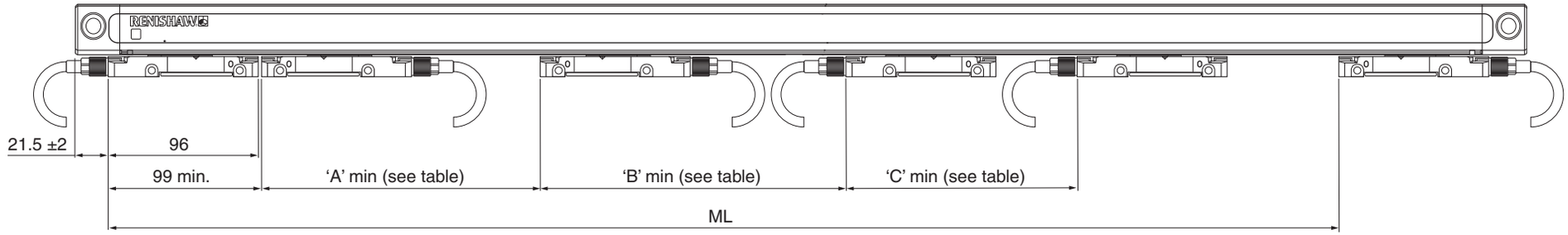
For compatible air supply components refer to the data sheet *Air filtration systems for use with FORTiS encoders* (Renishaw part number L-9517-9982).

WARNING: Remove the blanking plug only from the position at which the purge air supply is to be connected, or the sealing integrity may be compromised.



9.3 FORTiS-N FS system with multiple readheads installation drawing – standard end caps

Dimensions and tolerances in mm



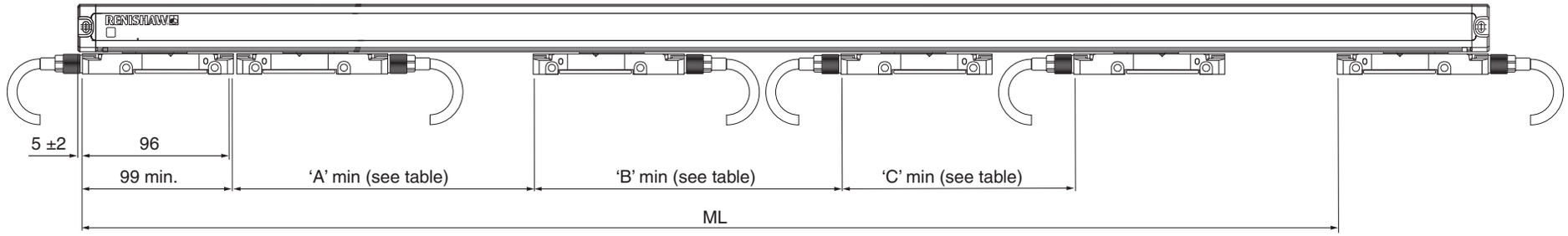
Cable type	A	B	C	Minimum static bend radius
Black	143	187	143	15
Green	160	222	160	31.5
Armoured	176	253	176	45

NOTES:

1. For required installation information see 'FORTiS-N FS system installation drawings' in the *FORTiS-N FS enclosed encoder system Functional Safety installation guide and safety manual* (Renishaw part no. M-6725-9026).
2. The arrangement of readheads shown is arbitrary and does not represent a defined sequence. It depicts the range of possible readhead and cable orientations.

9.4 FORTiS-N FS system with multiple readheads installation drawing – short end caps

Dimensions and tolerances in mm

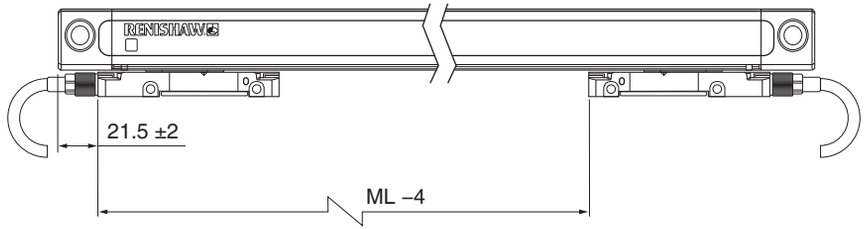


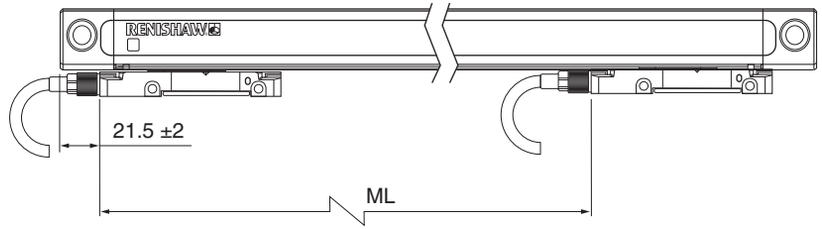
Cable type	A	B	C	Minimum static bend radius
Black	143	187	143	15
Green	160	222	160	31.5
Armoured	176	253	176	45

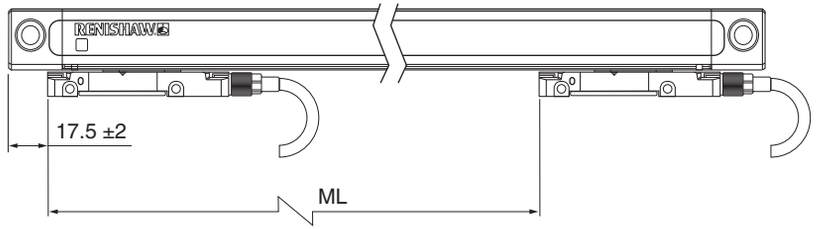
NOTES:

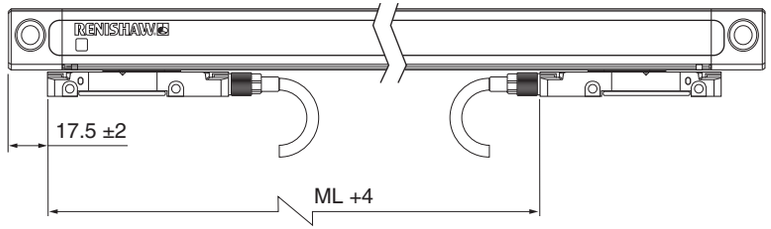
1. For required installation information see 'FORTiS-N FS system installation drawings' in the *FORTiS-N FS enclosed encoder system Functional Safety installation guide and safety manual* (Renishaw part no. M-6725-9026).
2. The arrangement of readheads shown is arbitrary and does not represent a defined sequence. It depicts the range of possible readhead and cable orientations.

9.5 Standard end caps – first and last readhead orientation

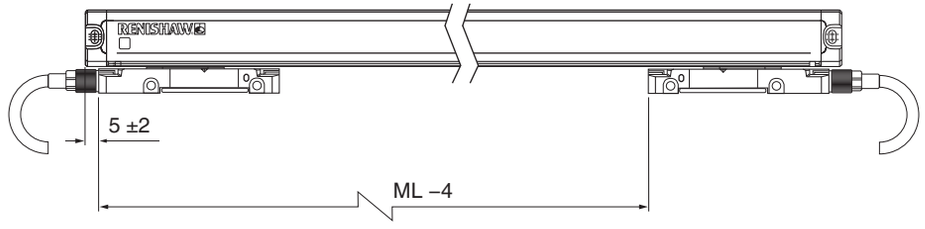


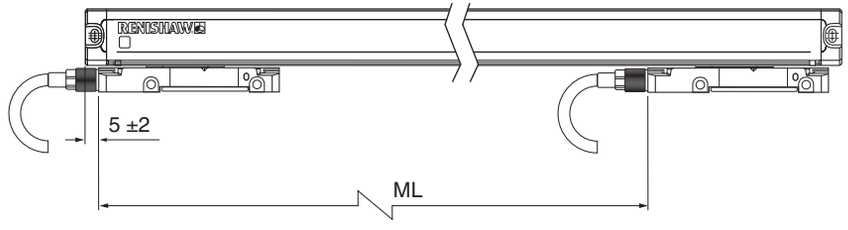


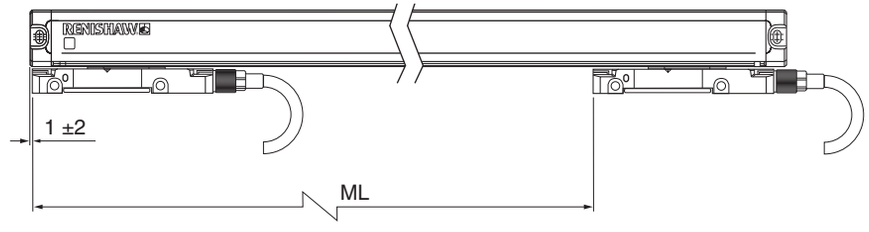


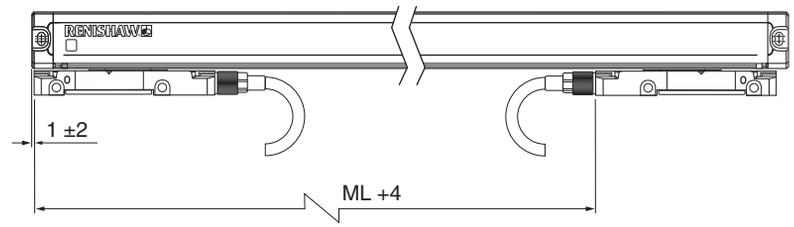


9.6 Short end caps – first and last readhead orientation









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