

**ORGANISATION EUROPEENNE POUR LA RECHERCHE NUCLEAIRE  
EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH**

Laboratoire Européen pour la Physique des Particules  
European Laboratory for Particle Physics

# **Market Survey**

**MS-2811/EP/CMS**

**Supply of Optical Fibre, Fibre-ribbon and Multi-ribbon Cables for the  
CMS Tracker**

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Contains:

**I. Technical Description**

**II. Qualification Criteria**

**III. Questionnaire**

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## **Abstract**

The purpose of this Market Survey is to establish a list of firms able to supply single-mode optical fibre cables in "fibre-pigtail", "ribbon-stack" and "multi-ribbon" cable form. A total of approximately 50000 optical point-to-point links will be required to readout and control the tracker-detector of the CMS experiment. Each link will be 60 to 100 meters long and will consist of 3 sections: a fibre-pigtail, a ribbon-stack and a multi-ribbon cable section.



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# **I. Technical Description**

## **1. Introduction**

The European Organisation for Nuclear Research, CERN, is an Intergovernmental Organisation with 20 European member states. CERN has its seat in the Canton of Geneva (Switzerland) but its laboratories are located on both sides of the Swiss-French border. CERN is running a number of particle accelerators, the largest being the Large Electron Positron Collider (LEP).

The Large Hadron Collider (LHC) project, a large proton-proton collider and superconducting accelerator of 27km in circumference, was approved in 1994. The LHC will be the next major research tool for world particle physics and it is expected to be commissioned in 2005.

CMS is one of the two main experiments which will be installed at this accelerator to measure hadron-hadron collisions. The CMS-tracker detector is situated closest to the proton beam collision point and is equipped with approximately 12 million micro-strip sensor channels distributed in a volume of 37 cubic meters. Analogue and digital optical links will transmit data between the detector and processing electronics situated approximately 100m away.

A total of about 50000 optical links will be required to readout and control the tracker detector. Each link will be 60 to 100 meters long. Inside the CMS detector, all components will have to withstand very harsh environmental constraints during an expected experiment-lifetime of 10 years.

## **2. Purpose and scope of the Market Survey**

The purpose of this market survey is to identify companies specialised in the manufacturing of optical cables in single-fibre pigtail, ribbon-stack and multi-ribbon form. The suppliers must be able to supply all three product types.

CERN will qualify companies in accordance with the qualification criteria set out in part II of this document. Single fibre pigtail, ribbon-stack and multi-ribbon cables are requested as evaluation samples. Based on the samples evaluation and on the supplier-responses to the questionnaire (part III of this document), CERN will then freeze the technical specification for fibre, ribbon and cables before proceeding to the tendering stage.

CERN intends to issue one or more Invitations to Tender for the optical cables production. Only companies which have thoroughly answered the questionnaire, and have been qualified by CERN in accordance with the qualification criteria, will be consulted for the forthcoming Invitation to Tender.

CERN reserves the right to split the contract between different suppliers.

## **3. Quantity and Delivery**

A total of about 50000 optical links will be required to readout and control the tracker detector of the CMS experiment. Each link will be 60 to 100 meters long and will consist of 3 sections:

- a) 0.5 to 2 meters of 9/125/900 "fibre-pigtail",
- b) 5 to 8 meters of 12-way ribbons grouped together to form "8-ribbon stacks",
- c) 60 to 90 meters of 96-way "multi-ribbon" (8x12) cable.

In terms of fibre-length, a total of approximately 5000km of single-mode optical fibre is required. About 99% of this fibre-length will be assembled into 12-way ribbon (about 400km ribbon length).

Eight of these ribbons will be grouped together into 96-way stacks and 96-way cables. The remaining 1% of the total fibre-length will be used in single-channel pigtail form.

In total, the requirements are:

- a) 25 to 100km of fibre pigtail
- b) 2.5 to 4km of ribbon-stack protected in sheath
- c) 30 to 50km of multi-ribbon cable

It is foreseen to place a contract for pre-terminated and pre-tested fibre pigtail, ribbon-stack and multi-ribbon cables between 2000 and 2001.

The cables should be available in pre-production quantities (typically 100 fibre-km/year) in 2001, and in production quantities (greater than 2000 fibre-km/year) from 2001 to 2003.

## **4. Technical requirements**

Recent evaluations by CERN of several types of single-fibre, ribbon and multi-ribbon cables have suggested that standard commercial components can satisfy the CERN requirements for analogue and digital operation in the harsh environment of the CMS experiment.

As CERN is targeting the use of commercial off-the-shelf products, no unusual environmental-compliance requirements are imposed upon the manufacturer apart from the set of features specified in this section. However, all candidate single fibre pigtail, ribbon-stack and multi-ribbon cables shall be evaluated by CERN in order to assess their compliance with the technical specifications (section 4) and with the operating environment requirements (section 5). They will be technically accepted or rejected on the basis of these evaluations. The CERN evaluation procedure is expected to last about 6 months.

### **4.1. Description**

Figure 1 shows a schematic representation of the generic optical link architecture: on the left are the laser transmitter hybrids situated on the tracker detector front-end. The transmitter pigtails are typically 0.5m to 2m long and are of the 9/125/900 $\mu$ m single fibre type.

A ribbon-stack links the distributed and in-line patch-panels. It consists of a bundle of eight 12-way ribbons protected by a thin sheath which prevents stacks from becoming disorganised and tangled. 5 to 10 stacks will be carefully routed together in cable trays over a distance of approximately 5 to 8m.

A 96-fibre cable links the in-line patch panel to the final break point of the system, which is situated on the receiver electronics. This cable crosses the concrete shield separating the detector volume from the counting room. It will be pulled manually across a cable duct and should withstand standard installation and operation conditions.

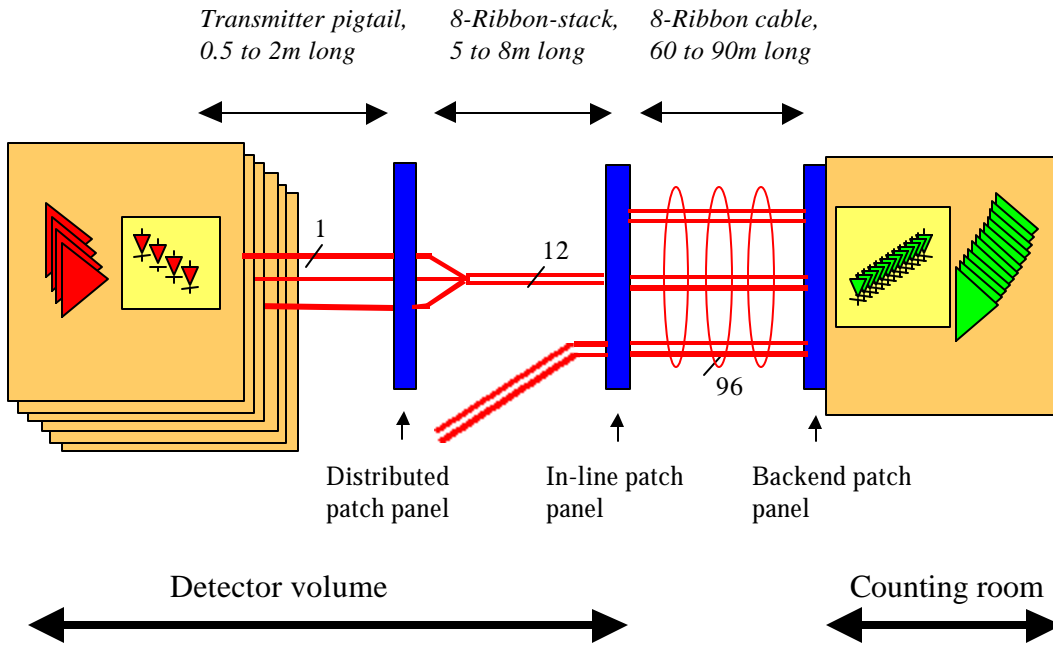


Figure 1: Generic optical link architecture.

#### 4.2. Target specification

Specifications have to be met by all channels over the full operating temperature range (section 5, specification number 7.5) unless otherwise noted.

#	Optical fibre specifications	min	typ	max	unit	note
1.1	Fibre type	Single-mode non-dispersion shifted				ITU G652
1.2	Fibre material	Phosphorus free				
1.3	Geometry	9/125			µm	
1.4	Cladding diameter	124.5	125	125.5	µm	
1.5	Mode field concentricity error			0.3	µm	
1.6	Operation wavelength	1260	1310	1330	nm	
1.7	Fibre cut-off			1260	nm	
1.8	Attenuation			0.4	dB/km	

#	Fiber-ribbon specification	min	typ	max	unit	note
2.1	Number of channels	12				
2.2	Overall dimensions	3100 x 320			µm	w x h, typical, to be discussed with manufacturer
2.3	pitch		250		µm	
2.4	Fibre to fibre skew			10	ps/m	
2.5	Bend radius	3			cm	perpendicular to ribbon plane
2.6	Torsion			5	turn/m	installation

				1	turn/m	operation
2.7	Tensile loading			10	N	installation
				1	N	operation
2.8	Compressive strength			3	N/cm	installation and operation
2.9	Impact resistance			2	J	

#	Fibre pigtail specification	min	typ	max	unit	note
3.1	Number of channels			1		
3.2	Section length		1		m	TBD
3.3	pigtail diameter		900		µm	Tight buffer, semi-tight or Loose tube; options to be discussed
3.4	Pigtail bend radius	3			cm	
3.5	Pigtail torsion			5	turn/m	installation
				1	turn/m	operation
3.6	Pigtail tensile loading			10	N	installation
				5	N	operation
3.7	Pigtail compressive strength			5	N/cm	installation and operation
3.8	Pigtail impact resistance			5	J	

#	Ribbon stack specification	min	typ	max	unit	note
4.1	Number of channels		96			
4.2	Section length		6.5		m	TBD
4.3	Stack diameter			4.9	mm	including sheath
4.4	Stack bend radius	14			cm	in any plane, no kink allowed
4.5	Stack torsion			1	turn/m	installation and operation
4.6	Stack tensile loading			10	N	installation and operation
4.7	Stack compressive strength			10	N/cm	installation and operation any axis
4.8	Stack impact resistance			5	J	

#	Multi-ribbon cable specification	min	typ	max	unit	note
5.1	Number of channels		96			
5.2	Section length		75		m	TBD
5.3	Cable diameter		8	10	mm	
5.4	Cable bend radius	8			cm	Smaller bend radius (<8cm) would be an advantage
5.5	Cable torsion			1	turn/m	installation and operation
5.6	Cable tensile loading			500	N	installation
				50	N	operation
5.7	Cable compressive strength			50	N/cm	
5.8	Cable impact resistance			15	J	
5.9	Cable water resistance	occasional radial immersion				24hrs duration

#	safety specifications		note
6.1	All materials	Low smoke Halogen-free	CERN IS23 and IS41* IEC 332-1, 332-2

\*Safety instructions are available on: [http://www.cern.ch/CERN/Divisions/TIS/safdoc/docOnLine\\_en.html](http://www.cern.ch/CERN/Divisions/TIS/safdoc/docOnLine_en.html)

## 5. Operating environment

### 5.1. Fibre pigtail and ribbon stack

#	environmental specifications	min	typ	max	unit	note
7.1	Magnetic field <sup>1</sup>			4	T	parallel to any axis
7.2	Neutron fluence <sup>1</sup>			2e14	n/cm <sup>2</sup> (1MeV)	Integrated over lifetime
7.3	Charged particles fluence <sup>1</sup>			4e14	part./cm <sup>2</sup> (0.3GeV)	“
7.4	Gamma radiation dose <sup>1</sup>			3e5	Gy(Si)	“
7.5	Temperature	-20	-10	+70	°C	
7.6	Operating humidity	dry Nitrogen flow				

<sup>1</sup>The component resistance to magnetic field and radiation will be evaluated under the responsibility of CERN. No testing, validation or qualification under these particular conditions is pre-required from the suppliers.

### 5.2. Multi-ribbon cable

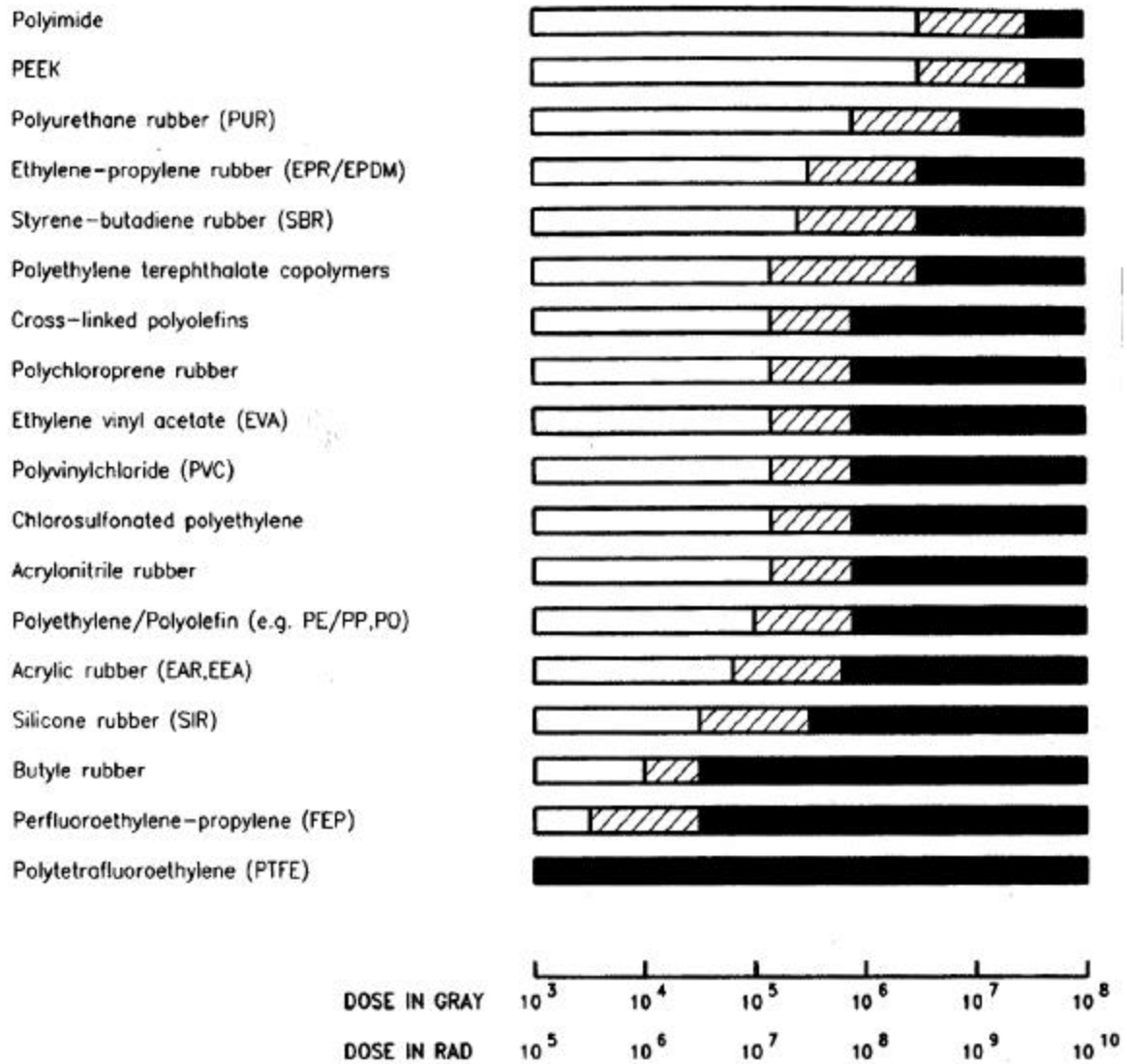
#	environmental specifications	min	typ	max	unit	note
7.1	Magnetic field <sup>1</sup>			4	T	parallel to any axis
7.2	Neutron fluence <sup>1</sup>			1e12	n/cm <sup>2</sup> (1MeV)	Integrated over lifetime
7.3	Charged particles fluence <sup>1</sup>			1e11	part./cm <sup>2</sup> (0.3GeV)	“
7.4	Gamma radiation dose <sup>1</sup>			1e3	Gy(Si)	“
7.5	Temperature	-20	-10	+70	°C	
7.6	Operating humidity			60	%RH	13°C dew point

<sup>1</sup>The component resistance to magnetic field and radiation will be evaluated under the responsibility of CERN. No testing, validation or qualification under these particular conditions is pre-required from the suppliers.



### 5.3. Radiation resistance of insulating material

Figure 2 shows the radiation resistance of a selection of materials frequently used for cable sheathing. This list can be used as a guide, or the companies can ask for information about a specific material by directly contacting CERN (see section 7).



Appreciation of Damage	Elongation	Utility	Symbol
Incipient to mild	75-100 % OF IN. VALUE	Nearly always usable	White box
Radiation index area	25-75 % OF IN. VALUE	Often satisfactory	Hatched box
Moderate to severe	< 25 % OF IN. VALUE	Not recommended	Black box

Fig. 2. Radiation resistance of cable insulating material [CERN TIS 89-12]

## **6. Evaluation samples**

Acceptance of candidate optical fibre pigtail, ribbon-stack and multi-ribbon cables is subject to testing by CERN. To this end, the manufacturer is requested to free-issue evaluation samples to CERN by June 16 2000, with a set of measured characteristics, a detailed product data-sheet and a list of materials used in the supplied components. Test-procedure details and test-reports will be made available upon request. After testing by CERN, all or part of the supplied components may be returned to the manufacturer for re-characterisation, and a short test report comparing pre- and post-evaluation performance may be requested from the company.

The following evaluation samples are requested:

1. 9/125/250 $\mu$ m fibre: Four spools of 100m length each, produced from two different pre-forms (two spools of each preform). Blank spools of approximately 5cm diameter will be supplied by CERN. Details on the fibre manufacturer, type and composition must be disclosed to CERN.
2. 9/125/250/900 $\mu$ m pigtail: 20m length section.
3. 12-way ribbon: 20m length section.
4. Ribbon-stack: 50m length section, coiled with large bending radius, or wound in an eight pattern.
5. Multi-ribbon cable: 50m length section, coiled with large bending radius, or wound in an eight pattern.

## 7. **Persons in Charge**

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## **II. Qualification criteria**

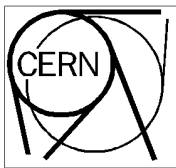
In order to be considered for the forthcoming call for tenders, the following criteria must be met:

### **Technical criteria**

1. The proposed fibre, ribbon, fibre-pigtail, ribbon-stack and multi-ribbon cables must fulfil all technical requirements, as specified in part I, section 4 of this document;
2. The supplied samples (according to part I, section 6 of this document) must be verified by CERN to meet the operating-environment requirements, as specified in part I, section 5 of this document;
3. The company must guarantee a direct technical contact with the CERN engineers;
4. The company must inform CERN, and receive CERN's authorisation prior to making any change(s) to the product and its sub-components. Modified products will be subject to re-qualification by CERN;

### **Other criteria**

5. The company must have at least 3 years of experience in the manufacture of fibre, ribbon and multi-ribbon cables. In case the company intends to subcontract part of the work, experience of all major subcontractors must also be demonstrated;
6. The company must demonstrate its ability to process over 10000 fibre-km/year in ribbon form;
7. The company must have had an average annual turnover of at least 2M Swiss Francs over the last 3 years in the field of optical fibre cables;
8. The company must have a registered Quality Assurance Plan satisfying the requests of ISO9000 or equivalent national standards;
9. In the event of being awarded a contract, the company must accept to provide detailed technical specifications, via CERN, to connector manufacturers, to allow proper termination of the fibre-pigtail, ribbon-stack and multi-ribbon cables;
10. The company shall accept a contract for either the full or part of the overall supply;
11. The company must return to CERN the enclosed questionnaire duly filled in.



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## **III. Questionnaire**

(To be returned in duplicate by the companies interested in tendering)

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Company .....

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**Company:**

Name: .....

Address: .....

.....

**Commercial Contact Person** .....

Telephone Number .....

Fax Number .....

Electronic Mail .....

***In case of absence:***

Commercial Contact Person .....

Telephone Number .....

Fax Number .....

Electronic Mail .....

**Technical Contact Person** .....

Telephone Number .....

Fax Number .....

Electronic Mail .....

***In case of absence:***

Technical Contact Person .....

Telephone Number .....

Fax Number .....

Electronic Mail .....

# 1. Questions to the company

## General Information

1. Are you interested in receiving the Invitation to Tender ?

Yes  No

2. Financial information

When established: .....  
Registered capital: .....  
Turnover in 1997 (optical cables field): .....  
Turnover in 1998 (optical cables field): .....  
Turnover in 1999 (optical cables field): .....  
Number of employees in 1999 (optical cables field): .....

3. Did you already reply to a CERN call for tender or market survey?

Yes  No

If yes, specify for which product(s):

.....  
.....  
.....

## Qualification criteria

4. Does your company comply with the qualification criteria stipulated in this market survey?

Yes  No

If not, indicate which criterion(a) is (are) not satisfied and why:

.....  
.....  
.....  
.....  
.....

5. Does your product comply with the technical requirements stipulated in this market survey?  
(Qualification criterion 1)

Yes  No

If not, indicate which requirement(s) is (are) not satisfied and why:

.....  
.....  
.....  
.....  
.....

6. Is your company in a position to communicate promptly any change(s) in the product and its sub-components? (Qualification criterion 4)

Yes  No

7. Would you sub-contract part of the work? (Qualification criterion 4)

Yes  No

If yes, please specify which part of the work would be sub-contracted, and give the name, address, person in charge and the telephone number of the potential sub-contractors. CERN reserves the right to contact the subcontractors directly.

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8. Can your company assure that identical products can be supplied for product evaluation and during volume production? (Qualification criterion 4)

Yes  No

To assure this, volume production should start after delivery of evaluation samples, within a period of:

.....

9. Please indicate major customer references: (Qualification criterion 5)

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.....  
.....



If your company has supplied optical cables to CERN before, please indicate references:

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.....  
.....

10. How many fibre-km do you produce yearly in optical cable form (please indicate type, whether single or multi-mode, whether single or multi-way, whether ribbon-based)? (Qualification criterion 6)

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.....

11. Do you have a registered Quality Assurance Plan? (Qualification criterion 8)

Yes  No

If yes, indicate which one:

.....  
.....

### Further Technical Information

12. Are the proposed cables commercial off-the-shelf products?

Yes  No

13. Does your company intend to modify the standard product(s) to meet the specifications?

Yes  No

If yes, indicate which specification(s) is (are) causing a modification and describe the changes:

.....  
.....

14. Have your products (or major parts of it) been internally qualified?

Yes  No

If yes, indicate to which standard and supply qualification reports. If no, indicate plans:

.....  
.....

15. Is the proposed "fibre-pigtail" cable low-smoke, halogen-free and flame retardant?

Yes  No

please indicate material composition and test standard:

.....

16. Is the proposed "ribbon-stack" cable low-smoke, halogen-free and flame retardant?

Yes  No

please indicate material composition and test standard:

.....

17. Is the proposed "multi-ribbon" cable low-smoke, halogen-free and flame retardant?

Yes  No

please indicate material composition and test standard:

.....

18. What suggestion does the company have to permanently label and automatically identify its cables, ribbons and fibres?

.....  
.....

19. What kind of technical support can the company provide during the pre-production and production phase?

.....  
.....  
.....

20. What kind of cable conditioning and delivery method do you suggest to use for the ribbon-stack and multi-ribbon cable?

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21. Please include engineering drawings and data-sheets for the fibre-pigtail, ribbon-stack and multi-ribbon cables you propose to supply.

**2. Questions from the company**

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*Date*

*Company seal and signature*