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Air-blown Micro Cables

Lin Fei

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1. Structural Requirements of Micro Air-blown Cables

1.1 Terminology and Definition

1.1.1 Air-blown Micro Cable

Air-blown micro cable is the optical cable simultaneously meeting the following three conditions:

(1) Must be applicable to laying in micro tube by air-blowing method;

(2) Dimension must be small enough; diameter range: 3.0`10.5mm;

(3) Outer diameter range of micro tube suitable for its air-blowing installation: 7.0`16.0mm.

1.1.2 High-performance Optical Fibre Unit

High-performance optical fibre unit is the optical cable simultaneously meeting the following four conditions:

(1) One integral part consisting of one or more optical fibre (ribbon) after coating and curing, with few non-metal reinforcing parts in coating layer if necessary;

(2) Must be applicable to laying in micro tube by air-blowing method;

(3) Dimension shall be small enough; diameter range: 0.4`3.0mm;

(4) Outer diameter range of micro tube suitable for its air-blowing installation: 3.5`8.0mm.

1.1.3 Micro Tube Bundle

Micro tube bundle is a bundle of micro tube consisting of certain quantity of micro tubes tied together.

1.1.4 Tube Cable

Tube cable is the cable consisting of certain quantity of micro tubes; it is provided with outer protective layer and certain protection measures (e.g., damp-proof layer).

1.2 Structure and Material

1.2.1 Chromatography for Cable Identification

When there are not more than 12 fibre cores inside one tube, optical fibre inside the tube are identified by full chromatography; the colors shall be selected as per the sequence specified in Table 1; and the natural color is allowed provided that the identification is not affected. When there are more than 12 fibre cores inside one tube, surface of optical fibre shall be provided with color ring or wrapped by colored yarn, for easier identification. The color of color ring or wrapping yarn shall be selected from Table 1.

Table 1 Full Chromatography for Identification

S/N	1	2	3	4	5	6	7	8	9	10	11	12
Color	Blue	Orange	Green	Brown	Gray	White	Red	Black	Yellow	Purple	Pink	Aqua

1.2.2 Small Tube (Outer Protective Tube)

Outer protective tube can be high-density polyethylene silicon core tube, mother-son type corrugated rib wall cable conduit, high-density polyethylene plastic tube, etc.

Outer protective tube shall be able to resist

the pressure and variation thereof generated during air-blowing installation process. Full-length cross section of outer protective tube shall be round and uniform; the inner surface of the tube shall be of fairly low friction coefficient.

Luster of outer protective tube shall be uniform; the color is generally black. When outer protective tubes are installed in other large tube, each outer protective tube shall be identifiable along the full length. To guarantee the identification of pipes from pipe ends during construction, surface of outer protective tube shall be identified by full panchromatic method; the color shall be blue, orange, green, brown, gray, white, red, black, yellow, purple, pink or dark green as specified in GB6995.2-1986. Upon agreement between the manufacturer and the user, other colors easy to identify can also be used. The color shall be identifiable within the life cycle. On condition that the identification from end is guaranteed, color strips can also be used for identification. Color of the color strip shall be selected from Table 1.

1.2.3 Micro Tube

Micro tube shall be small, flexible and light-weight tube; and its outer diameter shall not exceed 16mm.

Micro tube must be flexible, light-weight, durable and easy to process.

Micro tube material shall be high-density or medium-density polyethylene. When flame retardance is required, other suitable materials can be used.

Single piece of micro tube shall be used by air blowing in outer protective tube. When micro tubes are installed in outer protective tube, each micro tube shall be identifiable along the full length. To guarantee the identification of pipes from pipe ends during construction, outer surface of micro tube shall be identified by panchromatic method; and the color shall be blue, orange, green, brown, gray, white, red, black, yellow, purple, pink or dark green as specified in GB6995.2-1986. Upon agreement between the manufacturer and the user, other colors easy to identify can also be used. The color shall be identifiable within the life cycle. On condition that the identification from end is guaranteed, color strips can also be used for identification. Color of the color strip shall be selected from Table 1.

1.2.4 Micro Tube Bundle and Tube Cable

Each micro tube inside micro tube bundle and tube cable shall be identifiable along the full length. To guarantee the identification of pipes from pipe ends during construction, outer surface of micro tube shall be identified by panchromatic method; and the color shall be blue, orange, green, brown, gray, white, red, black, yellow, purple, pink or dark green as specified in GB6995.2-1986. The color shall be identifiable within the life cycle. On condition that the identification is not affected, color strips can also be used for identification. Color of the color strip shall be selected from Table 1.

When mechanical performance is met and damp-proof measures are taken, tube cable can be used along, without being put into the outer protective tube.

1.2.5 Micro Optical Cable

Structure of micro optical cable can be divided into all-dielectric stranding type, all-dielectric central tube type, central steel tube type, etc. Other similar structural forms are allowed.

Sheath material of micro optical cable shall be high-density or medium-density polyethylene. When flame retardance is required, other suitable materials can be used.

Micro optical cable shall be free of optical fibre splicing within one delivery section.

Each optical fibre in micro cable shall be identifiable along the full length.

Water blocking requirement of micro cable structure: micro cable structure shall be waterproof in whole cross section; water shall not be able to seep vertically in cable core and sheath. When micro cable is used indoor, waterproof is not required.

1.2.6 Loose Tube

Loose tube shall be made of thermoplastic

or metallic materials; thermoplastic loose tube can be of single-layer structure or double-layer structure. Plastic material for loose tube can be polybutylene terephthalate (PBT) plastic, polypropylene plastic or other suitable plastic; the performance of polybutylene terephthalate (PBT) plastic and polypropylene plastic shall conform to specifications of YD/T 1118.1-2001.and Y/D1118.2-2001. Metallic material for loose tube can be stainless steel or other suitable materials; the performance of stainless steels shall conform to specifications of GB/T 4239-1991.

Outer diameter and wall thickness of loose tube varies along with the number of cores inside the tube. The nominal outer diameter thereof is 1.2~6.0mm, with allowance of ±0.1mm.

1.2.7 Thickness of Polyethylene Sheath

Polyethylene sheath is a layer of polyethylene extruded outside cable cores; its average thickness shall not be less than 0.35mm, with a minimum value of not less than 0.30mm.

1.2.8 Special Surface Structure

To promote the air-blowing efficiency, outer surfaces of micro cable and fibre unit or inner surface of micro tube can be changed to increase the air-blowing performance, in order to get a longer air-blowing distance. For examples, use surface spiral or parallel slot structure, or increase the surface roughness, use silicon coating or longitudinal guide slot on inner wall of micro tube; where there are special requirements, spherical grains with low friction coefficient can be added to the surface of air-blown fibre unit.

2. Air-blown Construction Method

2.1 Installation Method

Air-aid installation is realized by using an air source to drive the optical cable in continuous high-speed air flow. The moving air flow pushes the optical cable forward at the typical speed provided by the equipment.

Air-blown installation method may have or not have a piston, or have a leaking piston at the front end of cable. The installation method shall be selected according to several factors: cable type (diameter, weight, hardness, friction coefficient), pipe diameter, routing shape (number of bends, and position, gradient, thereof), equipment type, etc. Installation length and speed rely on all factors above.

2.1.1 Installation Method With Piston At Front End of Cable:

This method has a piston attached to the front end of cable, which gives a large fixed towing force to the cable; but the towing force shall not exceed the allowable load of cable (depending on structural design). The towing force provides only a portion of the allowable tension of cable.

If the piston enters an elliptical pipe, blockage may occur. To avoid such problem, the piston must be flexible.

A piston with diameter smaller than inner diameter of pipe can also be used (leaking piston). It is similar to an open shuttle, allowing air to runs through its center. In such case, the extent of leakage will also affect the tension on the optical cable.

2.1.2 Installation Method Without Piston At Front End of Cable:

For the method without piston, there is no towing force at the front end of cable; the pushing force provided by the air flow is distributed on the full length of optical cable. In such case, the cable enters the pipe freely by the pull force of the high-speed air flow. Compressor shall be able to provide sufficient air for installation.

And it is unnecessary to connect a towrope at the front end of optical cable.

2.2 Operating Procedure

Once preparation works are done and the air blower is set in place, operation shall be carried out in the following steps:

(1) Prepare front end of optical cable. If piston is not used, a light-weight cable guiding head well fitted with the cable shall be used, such that the cable can pass through bend or micro tube joints easily. If piston is used, attention shall be paid to its fastening with the

cable.

(2) Prepare pipe, make it adapt to air blower.

(3) When necessary, adjust the cable pushing machine to adapt to the cable outer diameter.

(4) Clean the cable before inserting it into machine.

(5) Tuck the optical cable in air blower.

(6) Guide the cable into the pipe.

(7) Fix the cable on the air blower inserting machine.

(8) Fix the pipe on the air blower by suitable connector, in order to avoid losing pressure during installation.

(9) Start the machine. Tow the cable into the pipe by the high-speed air flow produced by the compressor.

(10) Receive optical cable at the far end. The receiving end shall be watched by specially assigned person, as the optical cable comes out very fast. If installation ends here, optical cable shall be reserved for future splice.

(11) For micro optical cable covered in plastic tube, the lightning protection device connected with the laid lightning protection wire shall be disconnected from the metallic component at the optical cable joint.

(12) When several air blowers are used for cascaded blowing, the first air blower shall be stopped when the cable reaches the second blowing point; the cable shall be led into the second air blower and pipe, and then fixed, according to the procedure mentioned above; and the first air blower shall be started again, then the second blower shall be started. If there are more air blowers, all blowers shall be operated according to this procedure.

(13) When necessary, cable can be laid from the middle two both sides. In such case, after the first section of cable is installed in one direction, other cable shall be coiled in "8" shape or blown into special coiling device by air blower. Special attention shall be paid to prevent the optical cable from contamination. Air blower shall be rearranged, such that the cable can be laid in opposite direction; then the cable laying can be resumed with the same method.

(14) In the whole air-blowing process, the maximum pressure that can be supported by the tube shall not be exceeded.

(15) When blowing micro tube bundle into outer protective tube at one time by using micro tube air blower, attention shall be paid to leave certain clearance between micro tube and outer protective tube; it is better to fill half of the outer protective tube; such that the micro tube still has strong impact resistance; and the loose space is convenient for making Y-shaped bifurcation and handling failures, and for blowing micro tube.

3. Evaluation of Main Factors on Air-blowing Efficiency

3.1 Main Factors on Air-blowing Efficiency

(1) Terrain, topography complexity, pipe straightness: the greater bend amplitude, the smaller cycle, and the more frequent bending of pipe will result in shorter cable laying distance by air-blowing method, and the poorer air-blowing efficiency.

(2) Inner surface static friction coefficient of outer protective tube, micro tube, micro tube bundle and tube cable, as well as outer surface static friction coefficient of micro tube, micro cable and fibre unit; the greater friction coefficient results in poorer air-blowing efficiency.

(3) Inner surface dynamic friction coefficient of outer protective tube, micro tube, micro tube bundle and tube cable, as well as outer surface dynamic friction coefficient of micro tube, micro cable and fibre unit; greater friction coefficient results in poorer air-blowing efficiency.

(4) Cable hardness and weight of unit length: greater cable hardness and heavier weight of unit length bring in poorer air-blowing efficiency.

3.2 Evaluation Method

(1) Through test of micro tube on tray: evaluate the air-blowing performance of micro cable by measuring the air-blown distance, air-blowing speed and air pressure of micro cable corresponding to each time point. In general, for micro optical cable, the average blowing speed shall not be less than 25m/min, and the installation distance within 20min shall not be less than 500m; for fibre unit, the average blowing speed shall not be less than 20m/min, and the installation distance within 25min shall not be less than 500m.

(2) Through test of micro tube on site: evaluate the air-blowing performance of micro cable by measuring the air-blown distance, air-blowing speed and air pressure of micro cable corresponding to each time point. In general, for micro optical cable, the average blowing speed shall not be less than 35m/min, and the installation distance within 30min shall not be less than 1000m; and for fibre unit, the average blowing speed shall not be less than 25m/min, and the installation distance within 20min shall not be less than 500m.

(3) Additional Attenuation of Optical Fibre After Air-blowing

Measure the attenuation coefficient of optical fibre in micro cable respectively before and after the air-blowing performance test, in order to figure out the additional attenuation of optical fibre after air-blowing. The index requirements are given in Table 2.

Attenuation monitoring: during test, the uncertainty of monitoring result caused by repeatability of monitoring instruments shall be better than 0.02dB/km. When the absolute value of fibre attenuation variation during the test is not more than 0.02dB/km, it can be considered that the attenuation has no significant change. When attenuation is allowed to change at certain value, it should be understood that such value has included the uncertainty. The attenuation change monitoring of single-mode fibre shall be implemented on 1550nm wavelength (or the service wavelength specified by the user).

Table 2 Allowable Additional Attenuation for Air-blown Installation

Purpose	Type of micro cable	Allowable addition attenuation of optical fibre (dB/km)				
		Class B1.1	Class B1.3	Class B4	Class A1a	Class A1b
For long-distance or core network	Micro optical cable	≤0.02			≤0.15	
	Optical fibre unit	≤0.05			≤0.30	
For short-distance (1km), access network or short-distance metropolitan area network	Micro optical cable	≤0.05			≤0.30	
	Optical fibre unit	≤0.1			≤0.60	

Notes: (1) Air-blown additional attenuation is the attenuation different of optical fibre before and after the air-blown installation.

(2) The allowable additional attenuation for air-blown installation does not include the fibre splice attenuation.

(3) When the distance is not greater than 1km, the allowable additional attenuation for optical fibre shall be required as 1km.

4. Matching of Tube and Optical Cable (See Table 3)

Table 3 Main Specifications of Tubes

Tube			Example of micro tube or micro cable to be contained therein at most	Remarks
Category	Outer/inner diameter (mm)	Material		
Big tube	110/100	PVC, PE	3 pieces of 40/33 small tubes, 4 pieces of 34/28 small tubes	Exit tube or trunk pipe
	100/90	PVC, PE	2 pieces of 40/33 small tubes, 3 pieces of 34/28 or 32/26 small tubes	Trunk pipe
	75/65	PVC, PE	2 pieces of 32/26 small tubes	Branch pipe to splice box or feed pipe to bulk user
Small tube (outer protective tube)	63/54	HDPE	10 pieces of 10/8 micro tubes, 20 pieces of 7/5 micro tubes	Arranged in big tube, or used alone. In general, a layer of permanent solid lubricant is mold pressed on the inner wall as lining layer (e.g., silicon core)
	50/41	HDPE	7 pieces of 10/8 micro tubes, 14 pieces of 7/5 micro tubes	
	46/38	HDPE	6 pieces of 10/8 micro tubes, 12 pieces of 7/5 micro tubes	
	40/33	HDPE	5 pieces of 10/8 micro tubes, 7 pieces of 8/6 micro tubes, 10 pieces of 7/5 micro tubes, 4 sets of 4/3 micro tube bundles	
	34/28	HDPE	3 pieces of 10/8 micro tubes, 7 pieces of 7/5 micro tubes	
	32/26	HDPE	3 pieces of 10/8 micro tubes, 6 pieces of 7/5 micro tubes	
Micro tube	16.0/13.5	HDPE	Maximum Φ10.5 micro cable	Arranged in small tube. In general, a layer of permanent solid lubricant is mold pressed on the inner wall as lining layer (e.g., silicon core)
	14.0/11.5	HDPE	Maximum Φ8.9 micro cable	
	12.0/10.0*	HDPE	Maximum Φ7.8 micro cable	
	10.0/8.0*	HDPE	Maximum Φ6.2 micro cable	
	8.0/6.0	HDPE	Maximum Φ4.6 micro cable; also available for blowing fibre unit	
	7.0/5.5*	HDPE	Maximum Φ4.2 micro cable; also available for blowing fibre unit	
	5.0/3.5*	HDPE	Maximum Φ2.7 micro cable	
	4.0/3.0	HDPE	Maximum Φ2.3 micro cable	
	3.5/2.5	HDPE	Maximum Φ1.9 micro cable	
Micro tube bundle and tube cable	Specifications include 1, 2, 4, 7, 12, 19, 24 ports, etc			Arranged in small tube or big pipe

Notes: (1) Those marked with * are commonly used micro tubes.
(2) Examples of micro cables that can be contained are figured out as per 60% duty ratio, and only applicable to the case of blowing single cable or fibre unit.
(3) Selection of tube aperture shall be based on the most common specification, as well as the advantage for reducing aperture and increasing wire containing ratio in tube.
(4) For outdoor use, small tube shall be provided with damp-proof layer.

5. Air-blown Micro Cables of YOFC (See Table 4)

Table 4 Air-blown Micro Cables of YOFC

Micro cable	Number of fibre unit	Sleeve diameter (mm)	Sleeve Quantity	Quantity of filling rope	Outer diameter (mm)	Unit cable weight (kg/km)	Maximum tensile strength (N)	Maximum compression strength (N/100mm)
GCYFTY-4~12Xn*	4~12	1.7	1	4	5.6	27	300	450
GCYFTY-14~24Xn	14~24	1.7	2	3	5.6	27	300	450
GCYFTY-26~36Xn	26~36	1.7	3	2	5.6	27	300	450
GCYFTY-38~48Xn	38~48	1.7	4	1	5.6	27	300	450
GCYFTY-50~60Xn	50~60	1.7	5	0	5.6	27	300	450
GCYFTY-62~72Xn	62~72	1.7	6	0	6.2	33	400	450
GCYFTY-74~84Xn	74~84	1.7	7	1	7.3	44	500	450
GCYFTY-86~96Xn	86~96	1.7	8	0	7.3	44	500	450
GCYFTY-98~108Xn	98~108	1.7	9	3	9.5	76	500	450
GCYFTY-110~120Xn	110~120	1.7	10	2	9.5	76	500	450
GCYFTY-122~132Xn	122~132	1.7	11	1	9.5	76	500	450
GCYFTY-134~144Xn	134~144	1.7	12	0	9.5	76	500	450

Note: *Xn refers to the type of optical fibre.

References

[1] YD/T 1460.1 (2006) Telecommunication Micro Duct Optical Fibre Cables and Fibre Units for Installation by Blowing Part 1: General

[2] YD/T 1460.4 (2006) Telecommunication Micro Duct Optical Fibre Cables and Fibre Units for Installation by Blowing Part 4: Microduct Optical Fibre Cables

[3] YD/T 1460.5 (2006) Telecommunication Micro Duct Optical Fibre Cables and Fibre Units for Installation by Blowing Part 5: Enhanced Performance Fibre Units

Yangtze Optical Fibre and Cable Joint Stock Limited Company

Stock code: 601869.SH 06869.HK

Address: No. 9 Optics Valley Avenue, Wuhan, China (postcode: 430073)

Tel: 027-67887650

Email: sales_spu@yofc.com

Web: www.yofc.com