接入網光纜的性能及改進

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接入網的建設費用在整個通信信息網的總建設費用佔三分一以上，有的資料統計，接入網線路和設備的投資約佔總投資的49%，因此引起人們的關注。我國通信核心網建設，包括八縱八橫的光纜骨幹網絡及程控交換已取得成就，因此，接入網的瓶頸問題就顯得十分突出。

按照ITU-T 1995年通過的建議G.902對接入網的定義為：接入網由業務節點接口(SNI)和用戶網絡接口(UNI)之間的一系列傳送實體(如線路設施和傳輸設施)組成，為供給電信業務而提供所需傳送承載能力的實施系統，可經由管理接口(Q3)配置和管理。

接入網用光纜和電纜線路指在有線接入(光纖接入、電纜接入)時傳送實體中的線路設施，包括接入網內交換局之間的中繼光纜及局與用戶之間的饋線光纜、配線光纜和引入光纜、配線和用戶用同軸電纜、數字通信用對絞電纜及大量採用的市內通信電纜等。

接入網線路發展的目標是光纖到用戶（FTTH）以實現全光纖化線路接入，幾乎所有國家都認為解決寬帶接入的根本辦法是實現接入網的全光纖化，但如何實現這個目標，具體安排及認識都存在很大差異。歐美國家注意挖掘已敷設的金屬電纜的潛力，同時開發一些新型電纜結構以適應向寬帶過渡的需要。日本NTT特別熱衷把光纖引到家家戶戶，據報道截至到1996年已實現了13%，預計到 2000年實現20%，到2010年全部完成。

我國的接入網，目前是一個以電話業務為主的銅電纜用戶線引入的窄帶電信接入網，很多省、市、區和公司開展寬帶接入的計劃和工作，在大城市和沿海發達地區，FTTC、FTTB已成為近幾年的主要發展方式，光纖已逐步向用戶靠近。由於經濟和技術原因，在中、西部及較落後地區，今後一段時間內光纖、電纜混合接入將會是接入的主要建設模式，即一部分饋線區和配線區採用光纜實現光纖到小區（FTTZ），光電交接後利用數字同軸電纜和/或數字通信用對絞電纜為用戶提供寬帶業務。

為使在接入網線路建設中採用的光纜、同軸電纜和數字通信用對絞電纜有標準可遵循，ITU-T正積極收集資料，制定相關的國際線路標準，預計在1998年底陸續發表。我國通信行業主管部門和相關單位已經制定了一系列的接入網線路標準以規範建設，並正不斷完善、現簡介如下。

一、光纖接入網對光纖光纜的要求

1、接入網光纜與幹線光纜使用的環境和條件不同，接入網光纖要考慮的因素可能比其他光纜更多更複雜。

2、接入網光纖操作頻繁，要求接入網光纜中的光纖具有優良的強度，較好的耐磨性和耐疲勞性、抗扭轉性能。

3、接入網傳輸的距離較短，對傳輸最大衰減的值略有放鬆，通常敷設後光纜的衰減不大於0.5dB/km即可。

4、接入網絡用光纜應具有較好的韌性，尤其對架空使用的光纜，要求有較好的環境性能。

5、對於引入室內使用的光纜要求具有阻燃性能。

6、光纜中的光纖芯數應根據業務需求種類和用戶多少來決定，光纜應採用大芯數束管式光纜，芯數應有一定的發展餘地，有條件應採用光纖帶光纜，以便於施工和接續。

二、接入網光纜的光纖性能

參考BELLCORE GR-20 (1994)等標準，我國相應部門也制定了一些規定，以下給出一些典型的數據。

1、光纖接入網用單模光纖特性均應符合ITU-T相關建議的規定。

2、光纖帶

- 光纖帶為多根單模光纖用UV固化材料將其平行地粘結而成。
- 在整個光纖帶長度上，所有光纖應平行且互相之間不得交叉。
- 光纖帶的幾何尺寸應符合表提出的要求。

圖一表示光纖帶的典型幾何尺寸的關係。我們的規定比 IEC 794-3相應的規定嚴格得多，特別是光纖帶的平整度 P，IEC的規定是 50mm，光纖帶有包封式(encapsulated)和粘邊式(edge-bonded)兩種結構兩種典型的光纖帶。粘邊式只是在光纖之間有涂料粘結，又稱薄型光纖帶；包封式每根光纖的四周都用涂料包複，又稱厚型光纖帶[1]。粘邊式尺寸小，工藝簡單，一般套管中應用較多，而包封式成本較高，工藝較複雜，但由於涂層的保護作用好，光纖帶的抗側壓性能及抗扭轉性能均較好，對骨架式光

纜，要求光纖帶有較高抗側壓性能時亦有好處。

• 光纖帶以37.5mm半徑繞繞100圈時，在1550nm波長上測得的任一光纖的宏彎附加衰減應不超過 0.5dB。

• 光纖帶經過 ± 180° 扭轉20次後，光纖不應從光纖帶中分離出來。光纖帶中的每根光纖加負載 1N，扭轉速度為每分鐘 30次。

• 光纖帶不用專門的工具或裝置應能撕開，撕開時所需要的力宜不超過13.4N；光纖帶撕開過程中不應損壞光纖的光學特性和機械性能及光學涂層；從光纖帶中撕出的任一根光纖在任一25mm長度上，應能識別出光纖的顏色。

三、對接入網光纜的機械及環境性能的要求

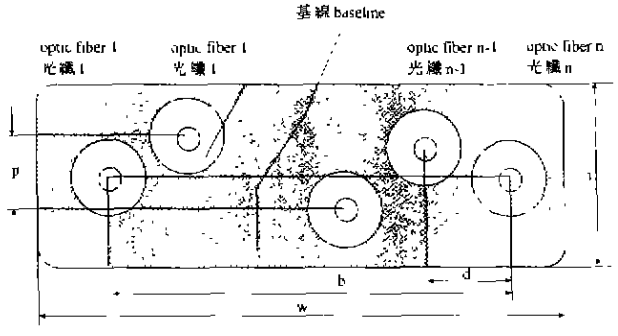
1、機械性能

光纜的機械性能包括拉伸、壓扁、衝擊、反複彎曲、扭轉、卷繞等項目。機械性能試驗中光纖衰減變化的監測宜按 YD/T 629.1規定在

光纖數 n number of optic fiber	帶子寬度 width of ribbon w (um)	帶子厚度 thickness of ribbon t (um)	首末光纖間距 gap between beginning and end b (um)	平整度 planarity p (um)
4	≤1115	≤320	≤795	≤25
6	≤1645	≤320	≤1325	≤25
8	≤2175	≤320	≤1855	≤25
12	≤3235	≤320	≤2915	≤30

表一　光纖帶的幾何尺寸要求

Table 1　Geometric size required by optic fiber ribbon



圖一　光纖帶的典型幾何尺寸

Figure 1　Typical geometric size of optic fiber ribbon

Access Network Migrates to Optic Technology

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China's current access network is a narrowband telecom access network with copper cable subscriber lines mainly for telephone service. Many provinces, metropolises and corporations are now implementing plans on broadband access network. FTTC and FTTB have become major development modes in big cities and well-off coastal areas in recent years. Optic fiber is gradually getting closer to customers. Hybrid access mode of optic fiber and cable will mainly be in mid-western China and relatively backward regions owing to economic and technical reasons. That is to say, some feeder line areas and distribution line areas will accomplish FTTZ by laying optic cable. And after optic and electric conversion, broadband services will be rendered to customers via a digital coaxial cable and/or twisted pair cable for digital communications.

ITU-T is actively collecting relevant data to formulate international line standards for optic cable, coaxial cable and twisted pair cable for publication at the end of 1998. Managements of the industry have already laid down and are perfecting the standards for a series of access network lines. The following is a brief introduction.

I. Demand of Optic Fiber Access Network (OFAN) for Optic Fiber and Optic Cable

1. An even greater number of factors have to be taken into account in choosing the right optic cable type for access network because of the difference in application environments and conditions between the access network cable and the backbone cable.

2. Heavy traffic on access network requires optic fiber of excellent intensity, better abrasive resistance, fatigue resistance and torsion resistance.

3. The shorter transmission distance in access network decreases the maximum transmission attenuation. The normal attenn-

1550nm波長上進行。光纜經各項機械性能試驗後應符合下列要求：

- 光纜中全部光纖都下應斷裂；
- 護套應無目力可見的裂紋；
- 光纜內的金屬元件應保持電氣導通；
- 護套內纜芯的各個元件應無目力可見的損壞；
- 試驗後的光纖應無明顯的殘餘附加衰減。

2、光纜的環境性能

・光纜衰減溫度特性

光纜中的光纖相對於 20°C時的允許溫度附加衰減應下超過：一級0.10dB/2km，二級0.20dB/2km，監測波長應為1310和1550nm。

・滲水性能 在20±5°C的溫度下，1M高水頭加到光纜試樣的全部截面上二十四小時後，驗視端應無水滲出，試驗應採用U型水套。

・填空複合物的滴流性能

光纜中的填充複合物應通過70°C的滴流性能的試驗。

四、對發展接入網光纜傳輸線路的幾點看法

1、根據我國郵電通信發展戰略目標及「九五」規劃，接入網建設應實現多種新業務的綜合接入能力，按照數字化、寬帶化的接入網實現電話、電視、計算機接入網絡三網合一目標，光纖光纜是最適合寬帶業務發展的傳輸線路。隨着光纖和無源光器件價格降低，特別是大城市和經濟發達地區，光纖光纜接入在技術、經濟各方面都存在優勢，應積極發展光纖光纜線路作為接入網的饋線和配線，光纜要盡量靠近用戶，如剩下100m至200m用電纜接入，既符合目前通信的要求，也便於今後逐步過渡到光纖用戶。

2、饋線和配線應盡量採用大芯數和光纖帶光纜，光纖帶光纜能提高光纜中光纖的集裝程度，且有利於集體接續，節省光纜的接續時間，在我國光纖帶中心管光纜和光纖帶套管層絞式光纜已在下少城市使用，反映良好。光纖帶骨架式光纜亦正在設計生

ation is less than 0.5dB/km after installation.

4. Optic cable in access network should have greater elasticity. Overhead optic cable, in particular, should have better performance.

5. Optic cable leading indoor should have fire-retartant capability.

6. The number of optic fiber cores in an optic cable depends on the type of service required and the number of customer involved. Optic cable should adopt binding tube optic cable with more cores which should have a room for development. Fiber optic ribbon cable is better used to facilitate installation and splicing work.

II. Performance of Optic Fiber in Access Network Optic Cable

Relevant departments in China have made some stipulations referring to Bellcore GR-20 (1994) standard. Some data are given as follows.

1. OFAN with single moder optic fiber should meet ITU-T specifications.

2. Optic fiber ribbon

- Optic fiber ribbon consists of many single moder optic fiber sticked in parallel by use of UV solidifying material.
- All fibers should be in parallel and must not cross each other.
- The geometric sizes of optic fiber ribbon should conform with the requirements shown in Table 1. Figure 1 indicates the relationships of typical geometric sizes. Our specification is stricter than that of IEC 794-3, especially the planarity of optic fiber ribbon. IEC's specification is 50mm. Two typical types of optic fiber ribbons are of encapsulated and edge-bonded structures respectively. Edge-bonded optic fiber ribbon is also called thin optic fiber ribbon with sticking coating between fibers. Encapsulated optic fiber ribbon (thick optic fiber ribbon) has

ACCESS NETWORK

According to G.902 recommendation approved by ITU-T in 1995, access network is composed of a series of transport entities (e.g. line and transmission facilities) between service node interface (SNI) and user network interface (UNI). It provides bearer capability for telecom services. It can be configured and managed via a manager interface (Q3).

Optic cable and copper cable used in access network refer to line facilities for entity transmission when adopting wireline access (optic fiber access, cable access), including junction optic cable between exchanges in the access network, optic feeder cable between an exchange and subscribers, distribution optic cable and lead-in optic cable, distribution line and subscriber coaxial cable, twisted pair cable for digital communications as well as local communications cable.

The ultimate target of access network is FTTH (fibre to the home) to implement full fiber optic line access. Most countries regard fiber optic access network as the solution to broadband access, but there is a big divergence on concrete arrangement. European and North American countries pay much attention to tapping the potential of metallic cable, and meanwhile explore new types of cable structure for broadband transition. NTT in Japan is especially keen on laying optic fiber to every home. It was reported that 13% of this target has been attained by 1996 and 20% will be achieved by 2000. It is expected to complete by 2010.

Access network gets much attention because its construction cost represents over one third of total communications and information network construction expenses. Investment in access network line and equipment roughly accounts for 49% of the total investment in the whole network.

產，按照「大容量、少局所」的思路，大容量的交換局可通過大芯數的光纜和接入設備替代很多中小容量的局所，這為網絡優化創造了條件。在接入用的饋線和配線建設中適近結合、適度超前，可避免重複建設，為了便於施工，應大力發展光纖帶光纜，替代大對數銅芯電纜的建設。

3、大力開發研究適合接入網特點的新光纜材料。根據接入網光纜使用的特點，如採用更柔軟、更穩定的套塑新材料。不少公司已進行了這種嘗試，如Accstel公司和Siecor公司開發的新套管材料，據介紹都比現在廣泛使用的PBT、PE材料具有更好的穩定性、柔軟性、抗彎折性、抗壓扁性，可大大改善接入網光纜的環境特性及可操作性。此外，阻燃、防鼠及嚙齒動物損壞的保護材料在室內光纜應用中也十分重要，當需加速開發。

4、積極發展新型光纜結構，配合接入網光纜化的建設，傳統的石油膏填充光纜在接入網中使用，在安裝、重新開頭維修等方面碰到許多不便，油膏還可能滲入接頭處引起接頭極大損耗增加。油膏的填入不僅增加了光纜重量，且會使光纜中的加強紗與護套粘接不良，使牽引時安裝光纜中會發生護套撕裂等問題。油膏雖然起到了防潮作用，但也帶來不少的問題，特別是在操作上帶來不少麻煩，近年來，隨着接入網光纜的推廣使用，一些國家忙着開發研究非填充纜芯，或稱為「幹式光纜」，利用一些親水性的不含油脂的阻水材料來代替油膏，堵塞纜芯中的空隙，如聚丙烯酸脂就是已經採用的一種，測試表明可以起到很好的填充作用，將為接入網光纜的新結構提供一些新的材料，從而改進其操作及環境性能。

室內光纜的情況較複雜，應按照室內總配線部分、樓層配線部分、終端部分各自的要求，根據下列因素，設計和發展高性能的系列室內光纜結構保証光纖進家庭的三窩使用。

接入網的光纖化長遠是世界潮流，要盡快從現有的銅導線網絡過渡到光纖化，主要是解決經濟和維護技術等方面的問題。近年來據一

each fiber encapsulated by coating. Edge-bonded optic fiber ribbon is small in size and technologically simple, normally applicable in loose tubes. Encapsulated optic fiber ribbon requires higher cost and complex technique but with better coating protection, lateral pressure resistance and torsion resistance. This type is more applicable in skeleton optic cable.

- When an optic fiber ribbon has 100 loose windings in 37.5mm radius, any macro bending attached attenuation of optic fiber measured at 1550nm wavelength should not exceed 0.5dB.
- After twisting at ±180° for 20 times, optic fibers should not come out of the optic fiber ribbon. Each fiber is added with 1N load with 20 times per minute twisting speed.
- Optic fiber ribbon can be ripped without using any special device. The force needed should not exceed 13.4N. Optical and mechanical properties and coating of optic fiber should not be damaged. The color of any optic fiber ripped should be able identifiable at a length of 25mm.

III. Requirement of Mechanical and Environmental Properties

1. Mechanical properties

Mechanical properties involve drawing, flattening, punching, repeated bending, twisting and winding. During a mechanic performance test, supervision of optic fiber attenuation variation should be carried out at 1550nm wavelength according to specifications of YD/T 629.1. Optic cable after testing should meet the following requirements:

- All optic fibers within an optic cable should not break.
- There should not be any visible crack in the sheath.
- Metal components within optic cable should maintain electrical conductivity.
- Every element of cable cores beneath sheath should not have any visible damage.
- Optic fibers should not be of any obvious additional residual attenuation.

2.Environmental performance of optic cable

- Temperature characteristics of optic cable attenuation

The additional attenuation at 20° C should not exceed: 0.10dB/2km in class A and 0.20dB/2km in class B. Monitoring wavelength should be 1310nm and 1550nm.

- Percolation performance

Under 20 ±5° C, no leakage is allowed at the viewing check up end after adding 1 meter high water-head to the entire section of optic cable specimen for 24 hours. This test should use U shape water jacket.

- Drip performance of filling composite. The filling composite within optic cable should pass the test of 70° C drip performance.

IV. Opinions on Access Network Optic Cable Transmission Line

1. According to the Ninth Five Year Plan and PT strategic target, China's access network construction should have access capability for new services, and should combine telephone, TV and computer access networks through digitalized and broadband-oriented access network. Optic fiber and optic cable are most suitable for broadband transmission. With the price cut of optic fiber and optic devices, optic cable access has technical and economic advantages especially in large cities. Optic fiber and optic cable should be actively developed as feeder line and distribution line of access networks. The last 100 to 200 meters' access network adopting optic cable access technology does not only meet current communication needs, but also facilitate the gradual transition to full fiber optic customer network.

2. Feeder line and distribution line should adopt optic cable with many cores. This kind of optic cable can raise fix density of optic fibers within an optic cable and fa-

些報告指出，在一定的距離和規模條件下，有源光網絡綜合成本已與銅網絡成本相當。隨着無源光網絡技術的發展，特別是無源光器件價格降低，有文獻預測到1998年底，無源光網絡綜合成本可能會與銅導線網絡的成本持平，如果如此，光纖接入網一定會發展得更迅速，再過十年或15年實現具有光纖入戶的接入能力將會是有希望的。 CTC

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cilitate time-saving collective splicing work. Ribbon central tube optic cable and ribbon sleeve central tube twisted layer optic cable are in good use in many cities throughout China. Optic fiber ribbon skeleton optic cable is under the process of design and trial production.

A large capacity exchange can replace many small and medium sized exchanges by utilizing optic cable with many cores and access equipment, creating a condition for upgrading networks. For the construction of feeder line and distribution line of access network, appropriate planning can avoid redundant work. Optic fiber ribbon optic cable can replace big pair-numbered copper core cable for easy construction.

3. R&D about new cable materials suitable for access network should be carried out. Those produced by Acestel and Stecor are better in stability, softness, anti-bending strength and crushing resistance in comparison with existing PET and PE plastic materials. They can greatly improve environmental characteristics and operability of access network optic cable. It is needed to produce protective materials applicable to indoor optic cable to guard against damages caused by fire, rats and rodents.

4. To explore new optic cable structure to suit the construction process of optic cable access network. Usage of petroleum jelly-filled optical cable in access network causes inconvenience in installation and repair. And petroleum jelly may seep into the splice, resulting in greater loss of the splice. Jelly filling not only increases the weight of an optic cable, but also causes bad sticking of strengthened yarns and cable sheath. Installing tracting head into an optic cable would induce some problems such as tear in sheath. In short, jelly brings many problems, especially in operation in spite of its moisturizing function. Some countries now research on non-filling cable core or "T type optic cable" adopting non-greasy watertight material to fill the gap in cable core. Polyacrylate is a successful example.

Indoor optic cable is more complicated. High performance indoor optic cable structure is designed according to different requirements and factors of main distribution part, storey distribution part and terminal part to ensure FTTH.

Full fiber optic access network is a global trend. Economical and maintenance problems have to be solved before transition from existing copper wireline network to full fiber optic network can be carried out. Some reports point out that comprehensive cost of active optic network is close to that of copper cable network under a certain distance and scale.

And that of passive optical network is predicted to equal to that of copper wireline network by the end of 1998. If this forecast comes true, optic fiber access network may realize in the next ten to 15 years' time. CTC

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