

# P12: Discussion on the application of nylon sheath cable in anti-rodent

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## Abstract

This paper answers the question of “Whether nylon jacketed can be used for anti-rodent?” by using anti-termite nylon jacketed optic fiber cable with steel strip enhancement and comparing the advantages and disadvantages with the existing anti-rodent cables. In addition, through the laboratory experiments and the practical applications of some operators, we also discuss the possibility of nylon jacketed cable used in Anti-rodent, and finally conclude that because of the balanced performance of convenient construction, lower cost and the good effect, nylon anti-rodent cable is an ideal choice for preventing the rat.

**Key Words:** Nylon jacketed cable, Anti-rodent, Application

## 1. Introduction

With the rapid development of optical projects, such as Copper Back into the Light, Construction of Rural Informatization and Coverage of All-Optical Network, optical fiber communication has become a mainstream. However, pipeline and aerial optical fiber cables often be destructed by rats, especially in some hilly and mountainous areas. Besides, in the case of multiple species, large numbers and widely distributed, the issues of Anti-rodent become more and more serious. Despite there are continuously trying to prevent the rat-damage, the disappointing performances of the prevention effects, high producing costs and tough construction are too clear to be accepted. This article has explored the application of anti-rodent of Nylon jacketed cable.

## 2. Conception of Rat and Anti-rodent Cable

### 2.1 Rat

Rat belongs to Mammalia Rodentia, and the species of the rat are over 1600. As the characteristic of reproduction explosion, short pregnant period, high birth rate and rapid sexual maturity, the number of the rat can sharply increasing in a short term. It has a strong ability to survive, and the tracks of the rat can be easily found in every corner of the world except Antarctica. As a result, rat is really a huge disaster to agricultural production.

Rodent teeth are highly specialized. It has 1 pairs of incisors up and down in the mouth, three molars, no canines but tooth-gap left, and about 1 or 2 premolars were disappeared. The enamel exists only in its front incisors, thus the soft teeth behind depletes much faster, which leads to forming sharp chisel-shaped incisors. In addition, there is no tooth-root in incisors to removing the growth, which means that the rat has to molar constantly to keep equilibrium. If two relative incisors touch each other, rat will endure a deadly consequence. This unique molar property makes its teeth sharp and effective, which is also the reason why rodent

are addicted to biting and successful in biting optical fiber cable.

The damage to cable is mainly caused by the Sciuridae rodent, which aims at destroying the aerial cable, as well as Cricetidae and Muridae Myomorpha rodent-harmful to pipeline and part of the aerial optical fiber cable. At present, the widely distribution of rodent in China and Southeast Asia are *Rattus norvegicus* (close to SD rat and Wistar rat used in laboratory) and *Sciurus vulgaris*.

### 2.2 Comparison of the existing Anti-rodent cables

Anti-rodent cables generally work as the following three categories:

1. Improving sheath or armor layer to make the cable get the ability to hurt rat oral, which makes rodent have hurtful feelings and be fear to bite cable again. For example, glass fiber ribbon cable and glass fiber yarn cable.
2. Adding rodent repellents or spicy agent into the cable to keep the rat away.
3. Strengthening the hardness of the cable material to make it more difficult for rat to bite. The most available programs currently are taking steel tape armored and steel wire armored.

The following table discusses about the prevention principles and characteristics of the existing Anti-rodent cables.

**Table 1: comparison of common Anti-rodent**

Model	Principle	Advantage	Disadvantage
GYTS, GYTA53	Using spicy agent PE for sheathing to keep the rat fear to bite cable (Chemistry & Biology)	Low costs	1. The effect of prevention gets decrease or disappeared for spicy agent volatilizing 2. Harmful to workers' eyes and respiratory during the producing. 3. Environmentally unfriendly
GYTA33, GYTS33	Using the hardness of steel wire wrapped to prevent (Physics)	The hardness is high enough for rat to damage	1. large outer diameter of cable, heavy weight, tough construction, high costs 2. The steel wire rust easily after sheath layer got damaged, affecting mechanical properties of cable and transmission performance of optical fiber.

GYFTY73 (including glass fiber yarn cable)	The broken glass fiber yarn can hurt rat oral after cable get damage, which make rodent remind hurt and fear to bite cable again. (Physics & Biology)	Available in strong electric field for non-metal	The sheath and armor layer already got destroyed when rat biting cable, which affect the mechanical properties of cable and transmission performance of optical fiber for a long time.
Stainless steel armored cable	Using the hardness of stainless steel to prevent (Physics)	Hard to destroy for high hardness	1. high costs, inflexible, tough construction 2. Hard to dock when cable got destroyed during work.
GYXTS	Using the wrapped fine steel wire inside the cable to prevent (Physics)	Small outer diameter, Convenient construction	The max cores of cable is 12, low output and high costs
GYTS04, GYTS4	Using the properties of Nylon material (high hardness, smooth cable surface) and thickened steel strip to prevent. (Physics)	Superior performance, Available for general installation environment, Convenient construction	Cable price is slightly higher than ordinary cables

According to the comparative results from the above table, Nylon jacketed Anti-rodent cable is a balanced program between prevention and cost as well as construction presently. As for nonmetal structure Anti-rodent cable, the most mature and wide-used one is glass fiber yarn cable (like GYFTY73) nowadays. However, its outer diameter is much larger than Nylon jacketed cable under the same number of cores, and behaved worse on construction and cable surface protection (Details referring to the following comparison of experiment)

## 2.2 Conception of Nylon jacketed Anti-rodent cable

The structure of Nylon jacketed Anti-rodent is as follows:

Structure diagram of GYTS04

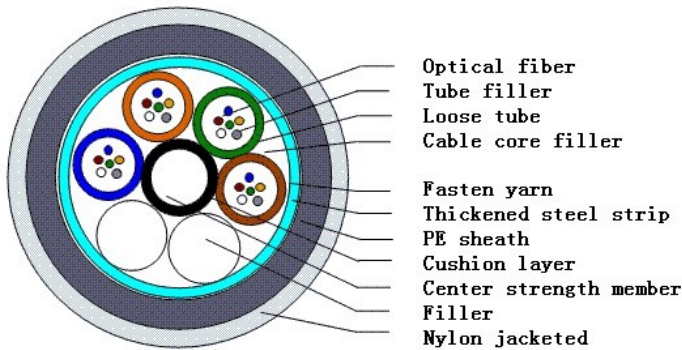


Figure 1. Structure diagram of GYTS04

From the previous comparison we can figure out that ordinary Anti-rodent cables cannot strike the right balance among diameter,

weight and prevention. However, the Nylon jacketed Anti-rodent cable almost perfectly meets the requirements due to the properties of Nylon material. As thermoplastic material, Nylon is green & environmentally friendly, nonpoisonous and tasteless, and it has relatively high intensity (shore hardness is over 70), stiffness and toughness, also it has excellent abrasion resistance, heat resistance and resistance to creep. It is difficult for rat to find a working-point to tear the cable for its smooth and solid surface after sheath formed, and the Nylon is an ideal sheath material for Anti-rodent. Besides, the thickened steel strip (thicker over 20% than common steel strip) strengthens the capacity of steel strip against bite (the maximum bite force of Wistar rat is about 9.3-44.6 N<sup>[1]</sup> under natural condition, and the bite through force of thickened steel strip is over 900N), those features can make a better protection to the cable, so as to achieve a ideal prevent effect.

## 3. Experiment and practical application

To verify the actual prevent performance of Nylon jacketed Anti-rodent cable, on the one hand, we had commissioned the Animal Laboratory Center of Sichuan University to take rat-bite comparative experiments of different types of Anti-rodent cables. On the other hand, we had collected the operation and maintenance data from communications used Nylon jacketed Anti-rodent cable.

### 3.1 Experiment

The followings are the descriptions of the experimental procedures and data analysis:

#### 1. Introduction to different types of Anti-rodent cables is as following table.

Table 2: types of Anti-rodent cables

Types	Structures of the cable
Type A	High density PE sheathed, steel tape armored cable
Type B	Middle density PE sheathed, steel tape armored cable
Type C	High density PE sheathed, nonmetal glass fiber yarn armored cable
Type D	Nylon jacketed, thickened steel tape armored cable

#### 2. The following table is about the weight data and groupings of the rats.

Table 3: weight date and groupings of the rats

Grouping	g	Condition	Category & number	Weight( g )					
				19	17	18	19	16	20
SPF	1	normal	SD,male, 6	0	7	2	0	2	4
	2	hungry	SD,male, 6	2	2	5	2	4	2
Adult	3	normal	SD,female, 6	7	9	0	6	5	8
	4	hungry	SD,female, 6	1	2	4	3	4	0
SD big rat	5	normal	SD, male/female, 3/3	21	20	16	19	21	18

SPF Adult C57 small rat	6	normal	C57,male, 6	21 .7	25 .4	26 .2	25 .4	22 .4	22 .9
	7	hungry	C57,male, 6	24 .1	25 .6	24 .9	23 .1	23 .6	23 .4
	8	normal	C57,femal e,6	13 .8	14 .9	15 .6	14 .8	15 .9	14 .9
	9	hungry	C57,femal e,6	13 .4	11 .9	15 .3	14 .5	15 .1	14
	10	normal	C57,male/ female,3/ 3	25 .5	25 .8	23 .6	13 .2	15 .8	16 .7

Note: amount of the feeding is as follows,

- 2.1 150g/6 for SD big rat under normal condition
- 2.2 90g/6 for C57 small rat under normal condition
- 2.3 100g/6 for SD big rat under hungry condition
- 2.4 60g/6 for C57 small under hungry condition

### 3. Additional description to experimental program

Keeping rats of all the group hydrated, healthy metabolism and surrounding normal, then placing one group of cables that have four types into every cat cage. The length of each cable is 20cm, every cable is naturally placed. The experimental period is calculated from the date of placing cables into cat cage for 3 weeks.

### 4. Taking photos as the recording materials during the experiment

The following is the picture of each period. Each picture is chosen as the most serious damaged one, and the type of the cable is in order of Type A, Type D, Type B and Type C from top to bottom.

4.1 Week 1, as the figure 2 shows, the rats of group 10 achieved the most serious damage compared to all the 5 groups of C57 small rats.



Figure2. The record of group 10 on week 1.

4.2 Week 1, as the figure 3 shows that the rats of group 5 achieved the most serious damage compared to all the 5 groups of SD big rats, and the Type A got severely destroyed as the steel tape armored can be easily found, Type B is also got extensively damaged as the part of steel tape armored can be seen, part of Type C got damaged to see the glass fiber yarn and Type D just got some bite marks.



Figure3. The record of group 5 on week 1.

4.3 At the end of the experiment on week 3, as the figure 4 shows, the rats of group 10 still achieved the most serious damage compared to all the 5 groups of C57 small rats. There is no obvious bite mark except Type B.



Figure4. The record of group 10 on week 3

4.4 At the end of the experiment on week 3, the figure 5 and figure 6 show that the rats of group 3 and group 5 got the most serious damage compared to all the 5 groups of SD big rats.

We can see from figure 5 that group 3 Type A got extensively destroyed as the steel tape armored can be easily found, the sheath of Type B is completely damaged as the steel tape armored got totally exposed, part of Type C got damaged to see the glass fiber yarn and just part points of Type D got some destroy.



Figure5. The record of group 3 on week 3

It is easily can be seen from figure 6 that group 5 Type A got extensively destroyed as the steel tape armored is exposing, Type B is also got extensively damaged as the steel tape armored got totally exposed, most part of Type C got damaged to see the some glass fiber yarn and just part of Type D got destroy.



Figure6. The record of group 5 on week 3

## 5. Explanation to data analysis

5.1 Examining the cable surface area damaged to evaluate the ability of the Anti-rodent, and the rate of protection is calculated as the remained undestroyed surface area of cable divided by the surface area of the original, which is shown as follows.

Table 4: the rate of protection

Grouping		Protection rate ( calculated by surface area) unit: %			
		Type A	Type B	Type C	Type D
SPF Adult SD big rat	1	20.21%	15.41%	84.29%	90.56%
	2	11.73%	15.94%	81.01%	92.20%
	3	14.41%	6.68%	75.86%	82.89%
	4	17.69%	15.28%	79.96%	92.01%
	5	7.54%	6.54%	76.63%	78.54%
SPF Adult C57 small rat	6	100.00%	99.96%	99.99%	100.00%
	7	99.99%	99.98%	100.00%	99.99%
	8	100.00%	99.96%	100.00%	100.00%
	9	99.99%	99.25%	100.00%	100.00%
	10	99.97%	98.20%	99.99%	100.00%

5.2 Examining the weight of outer sheath of each cable before the experiment, so as to the finish. The rate of protection is valued as the remained sheath weight divided by the original weight, as following shows.

Table 5: the rate of protection

Grouping		Protection rate ( calculated by sheath weight) unit: %			
		Type A	Type B	Type C	Type D
SPF Adult SD big rat	1	19.35%	11.30%	91.78%	94.24%
	2	13.50%	13.22%	91.22%	95.25%
	3	14.44%	7.47%	91.29%	94.47%
	4	22.22%	12.68%	91.22%	96.20%
	5	12.54%	7.34%	90.52%	93.13%
SPF Adult C57 small rat	6	100.00%	101.48%	100.62%	100.00%
	7	100.00%	101.51%	100.00%	100.00%
	8	100.00%	100.00%	100.62%	100.96%
	9	100.00%	99.10%	101.26%	100.95%
	10	100.00%	97.75%	101.25%	101.88%

Note: the weight of part cables increased due to the absorption to urine

From the experiment results and data, we can conclude that the main cable destroyer is SD big rat rather than C57 small one. Nylon jacketed Anti-rodent cable showed the best quality compared to all the experimental cables in prevent, and each properties is more superior than the glass fiber yarn Anti-rodent cable widely used nowadays. The surface of Nylon jacketed cable is smooth and tough, it is difficult for rat to find point to bite, besides, the thickened steel tape provides the further protection to cable in prevent, the two characteristics are the root causes bringing cable better prevention effects than ordinary ones.

## 3.2 Practical application of Nylon jacketed Anti-rodent cable

There has been lots of cables got damaged before the application of Nylon jacketed Anti-rodent cable, as the communications feedback frequently, especially on pipeline and aerial optical fiber cables. It was at least once a month that the cable got damaged by rat in some rodent areas. Communications started to use Nylon jacketed Anti-rodent cable from 2012, according to our continuously record by Mar2016, the length of Nylon jacketed Anti-rodent cable in service is over 47,000 km, and there is no report about damage feedback by communications any more. Here, we take one practical application used in Puer, Yunnan China Mobile as for discussion.

In Puer, Yunnan province, there are mostly mountains and forests (as the figure 7 shows), and lots of rodent animals like squirrel and rat live in there, as a result, the aerial cables got seriously damaged in this kind of environment. Especially from April to August, when squirrel and rat become active, the cables even got damaged within one week after construction, some loose-tube also got broken, the 2km cable got destroyed four or five times within one week in some areas, then lead to line broken, large decay after re-welding and communication interrupt ( shown as figure 8 and 9).

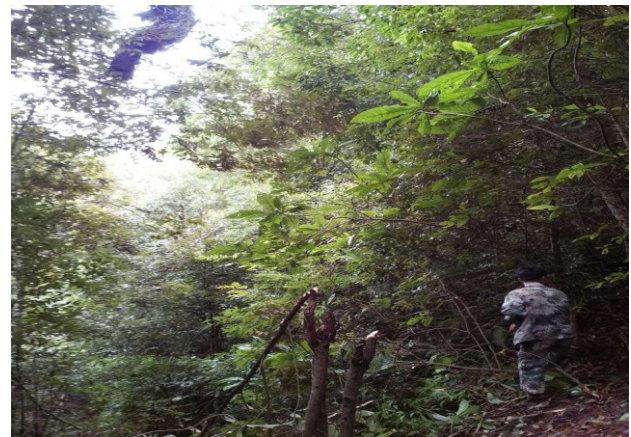


Figure7. The vegetation in Puer



Figure8. Destroyed ordinary aerial cable



Figure9. Destroyed ordinary aerial cable

Later in these serious rodent areas, aerial cables were replaced by Nylon jacketed Anti-rodent cable GYTS04, about 200 km, which was mainly used in Puer, Jinggu, Ninger, Mojiang and Tonggaa for local network and access network project. Table 6 is the actual operational data.

Table 6: the comparison of actual operational data by Puer China Mobile

program	Using period	Actual cable life (year)	Accident ratio (%)	Maintenance frequency (time/month)	Maintenance Costs (yuan)	Average time interval of an accident(day)	Direct loss (yuan)	Indirect loss (yuan)
Using ordinary cable	6.2013-05.2015	2	20%	1-2	750.00	20-30	5000/km	>5000
Using Nylon jacketed Anti-rodent cable	05.2015--	≥1	0%	0	0	0	0	0

At present, there are no traces of cable found destroyed by

squirrel or rat after the construction, cable is functioning normally. This makes communications feel satisfied and promote the application in their companies.

#### 4. Conclusion

The result of analyzing the performance of Nylon jacketed cable's actual application and comparing the comparative experimental results indicates that the application of Nylon jacketed cable to Anti-rodent is feasible and satisfying. As a new type of Anti-rodent cable, which behaves harmoniously on prevention, cost and construction, it has accepted by many national communications. However, the application of the Nylon jacketed as the professional Anti-rodent cable requires further attention of the cable industry, such as developing the corresponding industry standards or expanding the scope of its application.

#### 5. Reference

- 【1】 GBT 29199-2012,. Test methods For rodent resistance of optical fiber cable:20-21

#### 6. The author



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Mr. Yang Dong was born in 1985, graduated from Southwestern University of Finance and Economics and work in Jiangsu Hengtong Optic-electric Co., Ltd., he is engaged in research and development of optical fiber cables. Now he is a R & D Engineer of New Product Development Department.



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