The Advantages of Fortified Skin

Application on the insulation and sheath of the Cables

Tools provided by:
Allianze Corporation

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Introduction

* Application of a **skin** layer of colorants on an insulation surface is a procedure that is practiced by many cable manufactures .

* Two different **extruders** are used, one to produce the insulation core and the other the outer skin surface layer

* Besides colorants, other **additives** can be added to this skin layer to enhance the overall properties of the cable

* The **overall thickness** of the cable remains the same

Reasons

- Reduction in the use of expensive colour or additive masterbatches: Because expensive materials are added only to the skin and not the whole insulation
- Reduction in down time for cleaning: cleaning the main extruder which runs only a homogenous product is easier vs cleaning the smaller skin extruder which runs a variety of products.
- The waste generated in purging: the large volume of unused extrudate in the main extruder is purged in order to get rid of any remaining colorant or additives vs the smaller amount of waste generated from a smaller extruder. This is especially true during colour change activities, which is a common occurrence
- Keeping the insulation clean: it is ironically that stringent steps are taken to maintain cleanliness before and during extrusion, then “contaminants” are added to the insulation
- Customization: the core and the skin can be made of the same polymer but using different grades to improve the overall performance of the cable. It is important to use the same polymer for the skin and the core

Headlines of Skin Application

The advantages of Skin application on Insulation and Sheath of the Cables can be categorized in 3 major sections :

1- Colored Insulation Skin of LV Cables

2- Black Skin of ABC cables Insulation

3- Anti-Termite/Rodent Skin of Cable Sheath

Extrusion tools

Essential tools and machinery for Skin application

Cross head for double layer extrusion

Co-Extruders

Vertical

Horizontal

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Cross-Head tools and accessories

For precise application of Skin , we need precise tools :

Die and Nipple

Cartridges (main distributer) and Collet (front distributer) for PE/PVC/XLPE/HFFR/PA ….

All cost savings are highly dependent to precise tools and workmanship !

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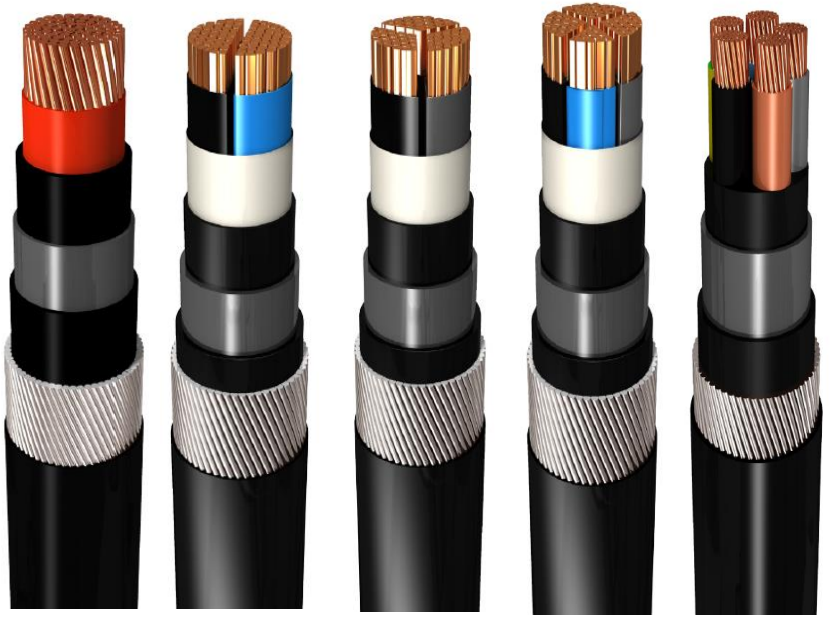
Colored Skin of LV cable's Insulation

6 month record of Kavian Cable Factory Production

Conductor Xsection Area	Insulation Total Thickness mm	(According to Kavian Cable Records)		Master-batch saving on Skin
		Production over half a year (meter)	Number of Productions	
mm2	(IEC 60502-1)	meter	No.s	kg/kM
16	0.7	447,767	135	0.19
25	0.9	231,593	118	0.22
35	0.9	160,583	100	0.24
50	1.0	146,151	145	0.32
70	1.1	100,940	110	0.43
95	1.1	71,391	84	0.49
120	1.2	99,937	81	0.62
150	1.4	61,742	50	0.83
185	1.6	55,115	38	1.08
240	1.7	62,162	49	1.32
300	1.8	89,968	46	1.56
400	2.0	3,797	4	1.97
500	2.2	400	1	2.48



The major Savings are concentrated on :

1- Reduction of used color masterbatch
2- Reduction of waste material due to color exchange
3- Reduction of electricity consumption on color change
4- Reduction of over consumption by using more precise extrusion tooling's.

Cost Saving on Colored Insulation

Details of Saved Material and Energy

Conductor section Area	Skin (0.2mm) Weight	Insulation Total Weight (Core+Skin)	Insulation Overall Diameter	Sub total of Master batch	x2 For 3 Cores different colors waist	x2 For 3 Cores different colors waist
mm2	kg/kM	kg/kM	mm	KG	kG	KWH
16	3.6	16.1	6.5	84	675	3,375
25	4.6	19.3	8.22	51	590	2,950
35	4.9	20.8	8.8	38	500	2,500
50	5.7	26.9	10.2	46	725	3,625
70	6.8	35.4	12.1	43	550	2,750
95	7.8	40.5	13.7	35	420	2,100
120	8.8	49.8	15.4	61	405	2,025
150	9.9	65.0	17.3	51	250	1,250
185	11.0	82.7	19.3	59	190	950
240	12.6	100.3	21.9	82	245	1,225
300	13.9	117.8	24.2	140	230	1,150
400	15.7	147.3	27.2	7	20	100
500	17.7	183.2	30.7	1	5	25

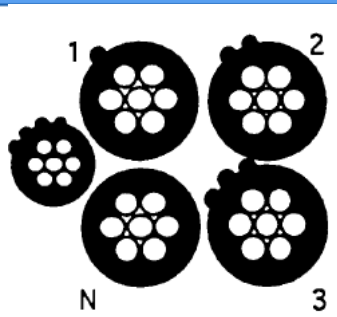
1- Saved master batch 1400 Kg/year making 6300 USD/year

2- Saved XLPE due to color change in smaller extruder about 10 tone/year , making 24,000 USD/year

3- Saved electrical energy in quicker way and in smaller extruder 22000 KWH/year , making 4300 USD/year

4- Not using extra material by thicker insulation in using more precise tooling (hidden and not included in this calculation)

Outstanding Points In ABC Overhead CABLES:



Ultra Violet radiation from direct sunshine is the major cause in deteriorating on ABC crosslinked cables, with respect to poor dispersion and improper particle size and insufficient amount of carbon black.

SOLUTION: addition of higher levels of carbon black especially in areas where year round sunshine is prevalent

PROBLEMS associated in adding more Carbon Black

- **Reduction in production speed**
- **Dull surface**
- **Higher levels of pre-crosslinking**

The purpose of the study

- We studied the results obtained by applying the same amount of the related masterbatch to the whole insulation vs only to the insulation skin layer was compared .

- We will also report our investigation on the effects of the electrical properties obtained when 2.5 % of carbon black was added to the whole insulation as compared to the electrical properties of the cable when the same level of masterbatch is confined only to the skin layer.

Important Note !

* The base materials for the core and the skin are made using PE polymer each having different melt flow Indexes and density

Because they are both **PE** based the cable is fully bonded to each other and the skin and core cannot be physically separated

* The core consist of a PE polymer that would impart excellent mechanical and chemical properties

The skin is made of a fast flowing PE polymer

HD 626 – Insulation type TIX-5

Superior Mechanical/Thermal characteristics of **TIX-5** as the best choice for insulation

	TIX-5	Normal XLPE
Tensile Strength (before aging) N/mm2	**14.5**	12.5
Aging Condition (temperature / time)	**150 'C / 240 h**	135 'C / 168 h
Hot set test , Mechanical load	**0.3 Mpa**	0.2 Mpa

AlchemiX

Siloxane XLPE Production Line

This grade covers all other Standards :

- ASTM D.1248 , Type III , category 4
- NFC 33209 (and so called Facade cables)
- AS 3560 , 3675
- ANSI/ICEA S 66-524 , S 70-547
- HD 603 S1 , HD 626 (TIX 1 ,3 , 5 , 7 , 8)
- NP 3528
- SFS 5701
- SS 424 14 63 and UNE 210302R

Introducing Skin/Core XLPE

Alchemix **XLPE-130K** (Natural) as Core

We preserve:

* Mechanical
* Thermal
* Dielectric Strength

Alchemix **XLPE-135K** (Black) as Skin

We preserve :

* Better processing in extrusion
* Smooth and Shiny surface
* Weather and environmental resistancy

Mechanical / Thermal tests

Comparisons of test results by referencing TIX-5

	Black Skin / Natural Core	Whole Black
Tensile Strength (before aging) N/mm2	**20.1**	17.9
Tensile Strength (after aging) N/mm2	**17.6**	15
Tensile Strength Variation (after aging)	**12%**	16%
Elongation at Break (before aging) %	**592**	440
Elongation at Break(after aging) %	**508**	370
Elongation at Break Variation (after aging)	**14%**	17%

The resulting cable has a superior surface finish with excellent thermal and mechanical properties that can be processed at extremely high productions speeds.

	Black Skin / Natural Core	Whole Black
Hot set test - Elongation Under Load	**85%**	95%
Hot set test - Permanent Elongation	**3.5 %**	7.5 %
Shrinkage test	**1.5%**	2.0%

Black Skin Calculation for ABC cable

Insulated Conductors and Dimensions according to **HD 626 S1:1996/A2:2002 Part1,2 , 6-E**

Section mm2	Conductor Diameter (mm)	XLPE Insulation thickness (mm)	Total XLPE Weight (gr/m)	**Carbon black (gr/m)**	Skin Weight t=0.2 mm (gr/m)	**Required M.B in Skin**
16	4.8	1.2	21.0	**0.17**	4.1	**10%**
25	5.8	1.4	29.4	**0.24**	4.9	**12%**
35	7.0	1.6	40.2	**0.32**	5.8	**14%**
50	8.2	1.6	45.8	**0.37**	6.5	**14%**
70	9.9	1.8	61.5	**0.49**	7.8	**16%**
95	11.5	1.8	69.9	**0.56**	8.7	**16%**
120	13.0	1.8	77.8	**0.62**	9.6	**16%**

- Following assumptions are made :

1- Insulation thickness acc HD 626-1

2- Skin thickness = 0.2 mm

3- Carbon black content of M.B ; 40%

4- Minimum required C.B ; 2 %

- **Conclusion :**

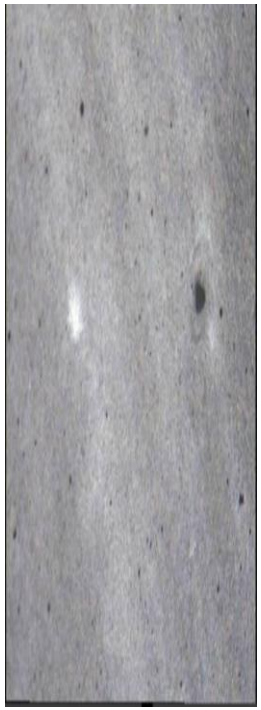
We need in average 16% of Black M.B in skin , to cover standard requirements .

So, we take **20%** in our tests .

Higher concentration of Black M.B.

Dispersion and Concentration of

5% M.B (2% C.B) vs. **20% M.B** (8% C.B)



* IEC 60811-607 (2012)
Tests for the assessment of carbon black dispersion
* ISO 18553 (2002)
Figures of Grade of dispersion assessment

- Normally Carbone black particle size is requested to be **lower than 20 nm** (for having better dispersion)
- By having higher concentration of carbon black in average ; we will achieve :

1- Higher protection against UV , by more C.B

we applied 4 times more C.B.

2- Lower risk of damage against UV with bigger C.B particle size (and poor dispersion)

Advantage of Skin in Surface

Black Skin vs. Whole Black

1-Although we have used 20% black M.B in skin (comparing to normal whole black insulation that has 5% black M.B) ;
Skin surface is more

SMOOTH and SHINY

2-Following above matter , we experienced

Easier process and
Higher Speed of Extrusion

3- Smoother surface practically leads to

HIGHER Abrasion resistance

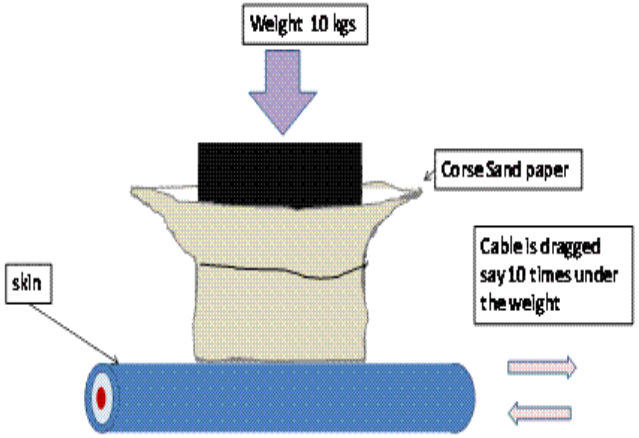
Weather Resistant test results

HD 626-2 section 2.5.1 test is done is 3 different conditions :

1- Whole Black insulation

2- Black Skin / Core insulation (un-scratched)

3- Black Skin / Core insulation **(scratched)**



Evaluation of results (Tensile strength (R) and Elongation at Break changes (A)) :

1) $\left|\frac{A_2 - A_0}{A_0}\right| \times 100 \leq 30$ $\left|\frac{R_2 - R_0}{R_0}\right| \times 100 \leq 30$

2) $\left|\frac{A_2 - A_1}{A_0}\right| \times 100 \leq 15$ $\left|\frac{R_2 - R_1}{R_0}\right| \times 100 \leq 15$

Reference batch : A0 , R0

1st batch : A1 , R1

2nd batch : A2 , R2

All 3 samples passed above tests (specially scratched one)

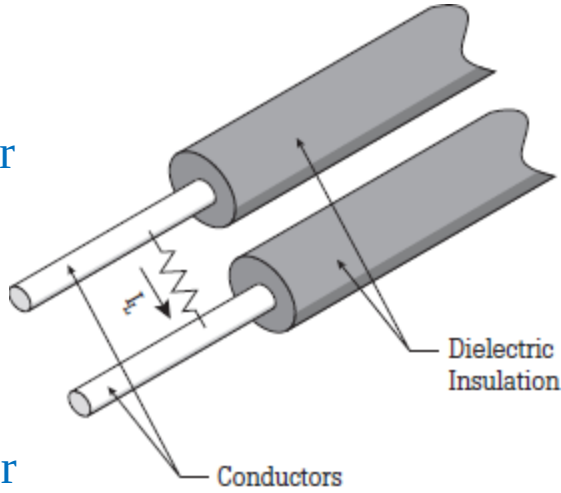
Insulation Resistance

We have applied 500 V D.C for Megger test in following conditions

A) Cores in Water – Voltage applied between Conductor and water

Black Skin / Natural Core R > 20 x 10^6 MOhms.KM

Whole Black Core R > 13 x 10^6 MOhms.KM



B) Bunched cable – Voltage applied between Conductors in the air

Black Skin / Natural Core R > 13 x 10^6 MOhms.KM

Whole Black Core R > 9 x 10^6 MOhms.KM

- **Conclusion :**

Insulation resistance in Black Skin / Natural Core is about 50 % more than Whole Black core . Meaning higher Dielectric Strength and more Cable life cycle.

Suitable Additives Comply Standard

Anti-Rodent , Anti-Termite Masterbatch :

* Non-toxic ingredients (Environmentally friendly, heavy metal free ….)

* Product based on EVA as carrier (to be used both for PVC , PE , HFFR , …) compounds

AEGIS AR B-3251 Anti-Rodent

AEGIS AT P-3151 Anti-Termite

* It causes an extremely unpleasant sensation when rodents tried to bite the finished products. Such intense and unpleasant sensation deters rodents from further attempts to attacks.

Being Unpleasant and not to be beaten more is the Key Point !

Application of Anti-Rodent in Skin

A list of Different cable size (from 10 mm to 100 mm)

Row	Cable Name	Cable Size	Jacket Thickness (mm)	Overall Diameter (mm)	Jacket Weight (gr/m)	Skin Thickness (mm)	Skin Weight (gr/m)	Ratio of Skin to Jacket (%)
1	N2XY	1x4 rm	1.4	6.8	34.7	0.4	11.7	34%
2	N2XY-O	2x1.5 rm	1.8	10.8	74.3	0.4	19.1	26%
3	N2XY-O	2x6 rm	1.8	14.2	102.4	0.4	25.3	25%
4	N2XY-O	2x16 rm	1.8	18.6	138.7	0.4	33.4	24%
5	N2XY-O	2x70 sm	1.8	23.7	180.8	0.4	42.7	24%
6	N2XY-O	2x120 sm	2.1	30.7	275.5	0.4	55.6	20%
7	N2XY-O	2x185 sm	2.3	36.7	362.9	0.4	66.6	18%
8	N2XY-O	2x240 sm	2.5	41.4	446.0	0.5	93.8	21%
9	N2XY-O	2x400 sm	2.9	52.3	657.1	0.5	118.7	18%
10	N2XSEYKYRY-O	3x25/16 8.7/15KV	2.8	61.1	748.7	0.5	138.9	19%
11	N2XSEYKYRY-O	3x50/16 8.7/15KV	3.0	67.2	883.4	0.5	152.9	17%
12	N2XSEYKYRY-O	3x70/16 8.7/15KV	3.2	73.4	1030.3	0.5	167.1	16%
13	N2XSEYKYRY-O	3x120/16 8.7/15KV	3.5	81.2	1247.3	0.6	221.7	18%
14	N2XSEYKYRY-O	3x185/25 8.7/15KV	3.8	90.6	1512.8	0.7	288.5	19%
15	N2XSEYKYRY-O	3x240/25 12/20KV	4.1	102.9	1857.9	0.8	374.5	20%

* We have considered jacket thickness from 1.4 to 4.1 mm

* Skin (having Anti-Rodent M.B) having thickness of 0.4 to 0.8 mm .

* Weight of Skin , is about 20% of whole sheath

Saving of Anti-Rodent Ordinary protection

Fortified Anti-Rodent SKIN Calculation and Savings using **3% M.B in Skin**

Row	Cable Name	Cable Size	Anti Rodent Weight in Whole sheath (gr/m)	Anti Rodent Weight in Skin (gr/m)	Saving of Anti Rodent Master batch
1	N2XY	1x4 rm	1.0	0.4	195%
2	N2XY-O	2x1.5 rm	2.2	0.6	290%
3	N2XY-O	2x6 rm	3.1	0.8	305%
4	N2XY-O	2x16 rm	4.2	1.0	316%
5	N2XY-O	2x70 sm	5.4	1.3	323%
6	N2XY-O	2x120 sm	8.3	1.7	396%
7	N2XY-O	2x185 sm	10.9	2.0	445%
8	N2XY-O	2x240 sm	13.4	2.8	376%
9	N2XY-O	2x400 sm	19.7	3.6	453%
10	N2XSEYKYRY-O	3x25/16 8.7/15KV	22.5	4.2	439%
11	N2XSEYKYRY-O	3x50/16 8.7/15KV	26.5	4.6	478%
12	N2XSEYKYRY-O	3x70/16 8.7/15KV	30.9	5.0	517%
13	N2XSEYKYRY-O	3x120/16 8.7/15KV	37.4	6.7	463%
14	N2XSEYKYRY-O	3x185/25 8.7/15KV	45.4	8.7	424%
15	N2XSEYKYRY-O	3x240/25 12/20KV	55.7	11.2	396%

- Normally it's recommended to use 2 ~ 3 % Anti-Rodent M.B in the outer Sheath
- By application of Anti-Rodent M.B. limited to Skin , we can save in average 400% meaning **1/5 of Whole Jacket having M.B**.

Saving of Anti-Rodent Extra-Ordinary protection

Fortified Anti-Rodent SKIN Calculation and Savings **using 7% M.B**

Row	Cable Name	Cable Size	Anti Rodent Weight in Whole sheath (gr/m)	Anti Rodent Weight in Skin (gr/m)	Saving of Anti Rodent Master batch
1	N2XY	1x4 rm	1.0	0.8	27%
2	N2XY-O	2x1.5 rm	2.2	1.3	67%
3	N2XY-O	2x6 rm	3.1	1.8	73%
4	N2XY-O	2x16 rm	4.2	2.3	78%
5	N2XY-O	2x70 sm	5.4	3.0	81%
6	N2XY-O	2x120 sm	8.3	3.9	112%
7	N2XY-O	2x185 sm	10.9	4.7	134%
8	N2XY-O	2x240 sm	13.4	6.6	104%
9	N2XY-O	2x400 sm	19.7	8.3	137%
10	N2XSEYKYRY-O	3x25/16 8.7/15KV	22.5	9.7	131%
11	N2XSEYKYRY-O	3x50/16 8.7/15KV	26.5	10.7	148%
12	N2XSEYKYRY-O	3x70/16 8.7/15KV	30.9	11.7	164%
13	N2XSEYKYRY-O	3x120/16 8.7/15KV	37.4	15.5	141%
14	N2XSEYKYRY-O	3x185/25 8.7/15KV	45.4	20.2	125%
15	N2XSEYKYRY-O	3x240/25 12/20KV	55.7	26.2	113%

- For some extra-ordinary application and usage of Anti-Rodent outer sheath We have considered 7% M.B

- In this case we have made stronger outer sheath of cables against Rodent attack **at least 2 times** more than normal.

- And we have saved in average 110 % of Anti-Rodent meaning , we used **1/2 M.B comparing to whole sheath** .

Verification according to IEC 60502

All sheath are tested according to IEC 60502-1 & 2 grade **ST2**

Test Item	Sheath Type	Standard Requirement	Test Result
Tensile Strength before aging	Anti Termite	MIN 12.5N/mm2	16.8 N/mm^2
	Anti Rodent		17.5 N/mm^2
	Normal		13.3 N/mm^2
Tensile Strength aged	Anti Termite	MIN 12.5N/mm2	16.9 N/mm^2
	Anti Rodent		17.7 N/mm^2
	Normal		13.7 N/mm^2
Variation	Anti Termite	MAX 25%	0.60%
	Anti Rodent		1.10%
	Normal		3.00%
Elongation at Break before aging	Anti Termite	MIN 150 %	275%
	Anti Rodent		221%
	Normal		255%
Elongation at break of aged	Anti Termite	MIN 150 %	251%
	Anti Rodent		266%
	Normal		230%
Variation	Anti Termite	MAX 25%	-9%
	Anti Rodent		20%
	Normal		-10%

Test Item	Sheath Type	Standard Requirement	Test Result
Cold impact	Anti Termite	No Crack	OK
	Anti Rodent		OK
	Normal		OK
Cold elongation	Anti Termite	MIN 20 %	110%
	Anti Rodent		115%
	Normal		115%
Hot pressure	Anti Termite	MAX 50%	11%
	Anti Rodent		10%
	Normal		17%
Heat Shock	Anti Termite	No Crack	OK
	Anti Rodent		OK
	Normal		OK
Loss of mass	Anti Termite	Max 1.5 mg/cm2	0.89 mg/cm^2
	Anti Rodent		0.7 mg/cm2
	Normal		0.9 mg/cm2

* Conclusion : No mechanical/thermal properties is compromised with high dosage of additives

Anti-Rodent/Termite – Test

We have tested 3 identical cables NYY-O 3x2.5 mm2 rm

Sample A : having ordinary jacket

Sample B : having 7% anti-rodent on skin

Sample C : having 7% anti-termite on skin

* We have selected non-armoured and small cable for test in order to show ultimate reliability of used method (in bigger cables and other cable design having metallic layers the damage of termite/rodent attack will be considerably less !!!

* Test method is adapted by Indian and Chinese test laboratories .
For evaluation of test results , comparisons of number of bites and reduced weight of cable's non-metallic parts is used .

* **Conclusion**

We believe that in using a fortified skin layer, a cable company will not only save money but also allows for the production of a cable that has superior mechanical, thermal and electrical properties, without comprising in production speeds and surface finishes.