Polyolefins

Impact of Petroleum Jelly on the Ageing of Telephone Wire

Introduction

Over the years Borealis has devoted effort to studying the interaction between petroleum jelly (PJ) and telephone wire insulation. Although the manufacture of traditional copper multipair telephone cables is in decline, there remains a need to continue to produce these products in cases where it is more cost effective to extend an existing network rather than install new fibre optic technology. In addition, similar cable filling technology continues to be used for fibre optic cables although the current trend is to use dry filling technology in these cables. The purpose of the brochure is to provide a compendium of data generated over many years.

Petroleum Jelly Filled Telephone Wire

At its simplest, a copper multipair cable consists of a core of twisted telephone wires encompassed in a cable sheath. Any damage to the sheath leaves the cable core exposed to possible transmission degradation due to the entrance of water into the core structure. This core has a large percentage of air space (approximately *47%* of the core cross section is air).

In 1968, Bell Telephone Laboratories (1) reported a new cable design where this air space was filled with a dielectric compound, consisting of polyethylene and petroleum jelly. In the case of a rupture of the outer sheath, the jelly will prevent water ingress and thus stabilize the transmission parameters. In summary, this approach

1) prevents liquid water ingress in the presence of a sheath break,
2) stabilizes electrical transmission,
3) permits use of an economical sheath design,
4) prevents water from flowing along the cable length.

Capacitance stability on the order of 1% or less was achieved on experimental cables immersed in water for many weeks.

Experimental cable fabrication progressed from manual stranding and filling with a hot flooding tank for rather short (10-15 feet) early laboratory cable samples to the use of full scale production lines. The basic idea of drawing the insulated, twisted pairs through a hot melt tank and forming them together by means of a nozzle at the exit of the tank has remained unchanged to this day.

One negative consequence of the process is that the telephone wires are immersed in hot petroleum jelly for a significant time and during this immersion are subject to stabiliser depletion. Provided the insulations remain immersed in petroleum jelly, the stabiliser depletion is of little consequence. However cables have to be terminated which entails the removal of the protective sheath and petroleum jelly and it is at these termination points where failures due to stabiliser depletion have been reported. As a consequence, the stabilisation of telephone insulation grades has for long been an interesting and challenging topic.

The phenomenon of embrittlement and cracking of solid low density polyethylene (LDPE) insulation in pedestals was first observed in the USA in 1970 in the Bell network1. The deterioration occurred after 3-4 years after installation in the south-western United States. The insulation material was changed to high density polyethylene (HDPE)2. The recommendation from Bell, was to change the antioxidant (AO) from Santonox to a combination of primary AO, Irganox 1010, and a metal deactivator - Eastman Inhibitor OABH3. Polypropylene was initially used in these cables, but was replaced by a foam HDPE design in 1976 with an outer skin of solid HDPE (foam/skin).

Insulation cracking was also reported in Australia during mid-1970s. The initial failures occurred in exposed (i.e. non-sheathed) insulation in above ground joints. The original stabilisation package used consisted of Santonox R or Santonox R together with Nonox WSP.4,5 It was also found that the oxidation process was accelerated by the presence of titanium dioxide (TiO_2). Many colour pigments contain TiO_2.

The stabilisation package for the HDPE insulation compounds has evolved over the years to include a primary antioxidant with a metal deactivator. The current antioxidant package generally used, in USA and Europe, consists of a phenolic antioxidant, Irganox 1010 and a bi-functional (antioxidant combined with metal deactivator) stabiliser, Irganox MD 1024.6 The combination of Irganox 1010 and Eastman OABH is used in Australia.

Standards

This system vulnerability has been recognised and tests to explore the interaction of petroleum jelly with telephone wires have been standardised. Within Borealis we have focused on 3 standards:

- EN50407 which makes reference to EN50290-2-23/EN60811-4-2
- British Telecommunications BTM 142
- Bellcore TR-NWT-000421

Table 1. Interaction Petroleum Jelly with Insulated Telephone Wire

Test	BTM 142	EN50290-2-23	EN60811-4-2	Bellcore TR-NWT-000421
Pre-treatment in Petroleum Jelly (PJ)	14 days, 60°C	7*/10 days, 60/70°C**	7*/10 days, 60/70°C**	28 days, 70°C
• Weight gain	< 15%	< 15/18%	See cable spec.	na
• Mechanical properties	Retained yield stress >85%	Elongation >100%	na	na
• Pig tail sample. Age 1 day, 70°C. Visual inspection	na	No cracks	No cracks	na
Long term stability	21 days, 105°C	42days 100/105°C	42days 100/105°C	260 days, 90°C
• Visual inspection for cracking	No cracks	No cracks	No cracks	No cracks
• Weight gain	< 1mg/2m	<1mg/2m	<1mg/2m	na
• Pig tail test. Visual inspection	No cracks	No cracks	No cracks	na
• Pig tail sample Age 7days, 60°C.	No cracks	No cracks	No cracks	na
• OIT 200°C	na	Record data	>2min	na
Conditioning finished cable	na	14 days, 100°C	14 days, 100°C	na
• Tensile properties		Elongation >100(foam)/ 200(solid)%	na	
• Pig tail test. Visual inspection		No cracks	No cracks	
Fast test	na	na	na	PJ pre-treatment 14 days, 70°C
• Retained OIT 200°C, 28days				>50% of initial (>60min)
• Retained OIT 200°C, 56days				>35% of initial (>60min)

Notes * Pre-treatment temperature for long term stability test
** 60°C for PJ with drop point 50-70°C, 70°C for PJ with drop point >70°C

EN60811-4-2 refers to two ageing temperatures (100°C for conditioning complete cables and two classes of performance (100 and 105°C) for the long term stability of insulated conductors. Although the test methods differ in detail, all consist of a petroleum jelly pre-treatment at elevated temperature (to simulate the manufacturing process) followed by removal of the petroleum jelly and oven ageing of the insulated wires (to correlate with the life expectancy after installation).

Products

Over the years a number of petroleum jelly products have been evaluated in combination with Borealis' telecommunication grades (Table 2). Insojell 2332 is a very common petroleum jelly, based on mineral oil, used in telecommunication and included here as a reference. Waterguard, being a thixotrope, inherently resists flow at elevated temperatures, hence providing a drip free cable at temperatures greatly in excess of the current 80°C requirement. Waterguard P90 is designed as a waterproof copper cable filling compound.

Table 2. Filling Compounds

Producer	Trade name	Application	Type of FC
Dussek Campbell	Insojell 2332	CuMP	Mineral oils, Td = 75°C
Dussek Campbell	Insojell 5116	CuMP	Poly-isobutene, Td = 105°C
Caschem	Bufferite 117-M1	FOC	Polypropylene glycol (polar)*, Td > 343°C
Seppic	Sepigel OF300SF	FOC	Polyalphaolefin*, Td > 200°C
Waterguard	P90	CuMP	Mixture of mineral oils - synthetic*
Witco	Witcogel II / TCV 910	FOC	ETPR*, Td > 196°C
	KBELFILL 6200		

* thixotropic, Td = drop point

Bufferite 117-M1 is targeted as filling compounds for fibre optic cables (FOC) like loose tube, central tube and slotted core. The Bufferite 117 series are highly purified, non-melting, thixotropic gels which can be extruded at temperatures up to 270°C. They are claimed to be compatible with a wide range of fibre coatings, inks and tube construction materials, including PBT, PA12, PP and PP/PE copolymers. Bufferite 117 is based on a polyol fluid, stabilised with a hindered phenolic antioxidant. Sepigel OF300 SF is a filling compound specifically developed for use in FOC. It is manufactured from synthetic aliphatic hydrocarbons. Witcogel II/TCV 910 is based on extended thermoplastic rubber, ETPR

Table 3. Insulation Compounds.

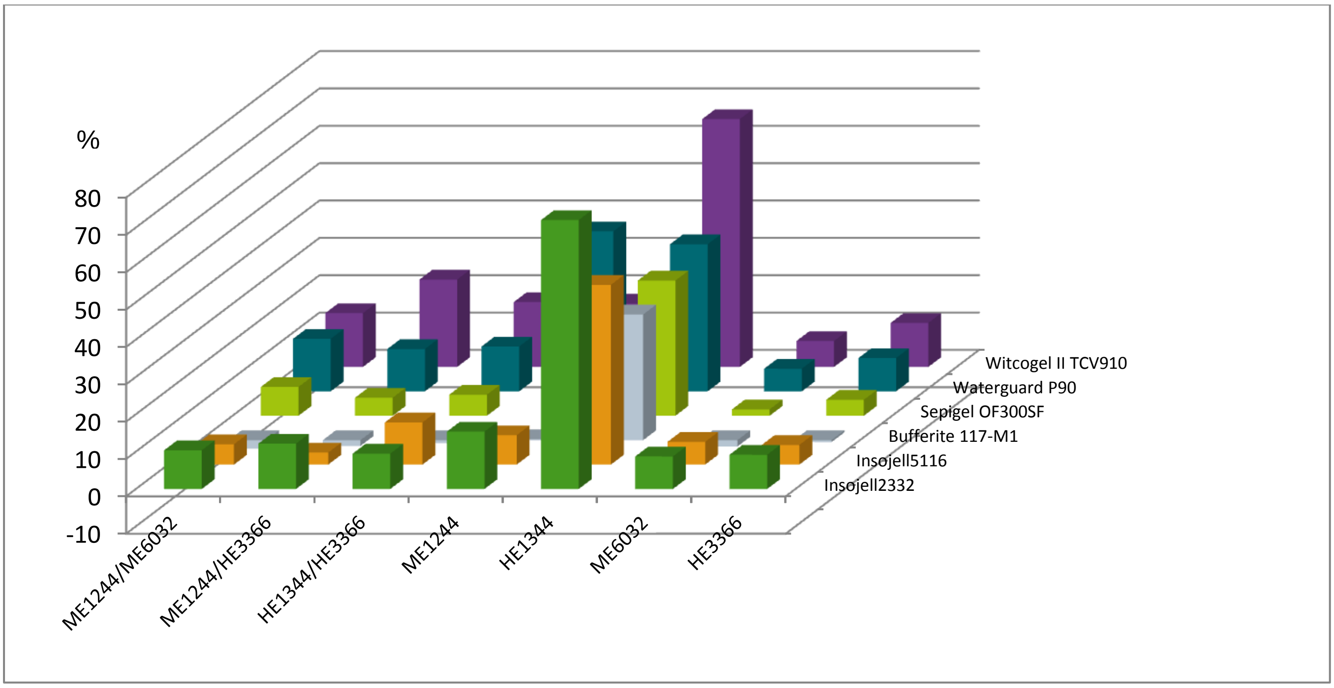
Grade	Application	Skin	Sample
ME1244	MDPE cellular	ME6032	Wire 0,5 x 0,9mm (skin 0,05mm)
ME1244	MDPE cellular	HE3366	Wire 0,5 x 0,9mm (skin 0,05mm)
HE1344	HDPE cellular	HE3366	Wire 0,5 x 0,9mm (skin 0,05mm)
ME1244	MDPE cellular	None	Wire 0,5 x 0,9mm
HE1344	HDPE cellular	None	Wire 0,5 x 0,9mm
HE1345	HDPE cellular + enhanced stabilisation	None	
ME6032	MDPE solid	None	Wire 0,5 x 0,8mm
HE3366	HDPE solid	None	Wire 0,5 x 0,8mm
HE3368	HDPE solid + enhanced stabilisation		
HE1110	HDPE slotted core (FOC)		Plaque 1,5mm

The telecommunication grades tested are shown (Table 3). As these tests have been completed over many years there may be some minor variations in the product tested. However for the grades noted, the basic properties and additive package are totally consistent.

Results

a) EN60811-4-2 test data

Table 4. Absorption of Filling Compounds (70°C, 10 days) into Wires.



	ME1244/ ME6032	ME1244/ HE3366	HE1344/ HE3366	ME1244	HE1344	ME6032	HE3366
Insojell2332	10,36	12,14	9,45	15,35	72	8,71	9,16
Insojell5116	5,44	3,22	11,28	7,86	48,13	6,08	5,26
Bufferite 117-M1	-2,27	-1,54	-0,77	0,27	33,65	-1,7	-0,5
Sepigel OF00SF	7,71	4,83	5,64	9,49	36,19	1,7	4,26
Waterguard P90	14,06	11,33	12	42,82	39,37	6,06	8,9
Witcogel II TCV910	14,4	23,4	17,36	16,96	66,35	6,94	11,78

Table 5. OIT/Pigtails after Different Treatments.

Sample	0-test OIT/min	Insojell 2332 FC 70°C/7d OIT/min	Air 105°C/42d OIT/min	Pigtails (OIT/min), vis. 60°C/ 7 d	Insojell 5116 FC70°C/7d OIT/min	105°C/42d OIT/min	Pigtails (OIT/min), vis. 60°C/ 7 d	Bufferite 117-M1 FC70°C/7d OIT/min	105°C/42d OIT/min	Pigtails (OIT/min), vis. 60°C/ 7 d
Wire										
ME1244/ME6032	138	30	12	8/OK	24	12	13/OK	114	6	degr.
ME1244/HE3366	175	54	21	8/OK	46	23	23/OK	176	13	degr.
HE1344/HE3366	164	37	12	8/OK	28	8	7/OK	162	4	degr.
ME1244	164	26	10	8/OK	27	25	18/OK	135	4	degr.
HE1344	135	4	< 1	<1/OK	28	19	21/OK	14	2	degr.
ME6032	76	<1	<1	<1/OK	<1	degr.	degr.	16	<1	degr.
HE3366	205	28	8	2/OK	47	8	8/OK	189	4	degr.
HE1110 (plaque)	>220	>220	188	-	>220	212	-	>220	197	-

Sample	0-test OIT/min	Sepigel OF300SF FC 70°C/7d OIT/min	Air 105°C/42d OIT/min	Pigtails (OIT/min), vis. 60°C/ 7 d	Waterguard P90 FC70°C/7d OIT/min	105°C/42d OIT/min	Pigtails (OIT/min), vis. 60°C/ 7 d	Witcogel II TCV910 FC70°C/7d OIT/min	105°C/42d OIT/min	Pigtails (OIT/min), vis. 60°C/ 7 d
Wire										
ME1244/ME6032	138	32	9	OK	42	52	22/OK	19	6	1/OK
ME1244/HE3366	175	50	24	OK	63	80	36/OK	27	22	9/OK
HE1344/HE3366	164	31	9	OK	52	66	13/OK	12	degr.	degr.
ME1244	164	34	15	OK	40	44	21/OK	10	4	<1/OK
HE1344	135	10	degr.	degr.	52	62/disc.	28/OK	8	1	<2/OK
ME6032	76	<2	degr.	degr.	6	6	<1/OK	2	-	degr.
HE3366	205	28	<1	degr.	49	53	20/OK	8	-	degr.
HE1110 (plaque)	>220	>220	-	-	>220	-	-	>220	215	-

b) Bellcore TR-NWT-00421 (Pedestal Test)

Seven different coloured commercially produced telephone wires insulated with HE1345 have been aged according to the Bellcore test method. The petroleum jelly used was KBELFIL 6200. For the purposes of this report, the results have been averaged.

Table 6. Fast Test.

	Initial	Pre-treated 14 days at 70°C	Aged 28 days at 90°C	Aged 56 days at 90°C
OIT 200°C	271 min	151 min (>60min)	108 min	83 min
Retained		56%	71% (>50%)	55% (>35%)

Note. Requirements shown in brackets.

Table 7. Standard Test

	Pre-treated 28days at 70°C	Aged 260days at 90°C	Aged 280days at 90°C
Cracks	NA	3/30 (max 3)	
Cracks (%)			10% (max 10%)

Note. Requirements shown in brackets.

The results indicate that the insulations met comfortably the requirements of the fast test but were marginal for the standard test.

Discussion of Results

Ageing performance is a challenging combination of material properties, cable design and manufacturing process. The results presented are indicative but cable makers must make tests on products produced in their own manufacturing facilities to ensure compliance with specific test standards.

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