



ELASTOMERIC COMPOSITIONS

5 This invention relates to elastomeric compositions particularly those compositions for use in electrical cables. Certain electrical cables require insulation covering and sheath with elastomeric compositions that are halogen free, flame retardant and resistant to fluids. Where cables are used in marine applications there are a number of standards that define the operating qualities and characteristics of both the
10 elastomeric compositions in the cables. Such standards include British Naval Engineering Standards NES 518, NES 525 and NES 526. The Australian Department of Defence (NAVY) has a comparable standard known as A014000. The elastomeric composition described hereunder has been
15 designed to preferably satisfy all of the standards referred to above.

When cables are used in a marine environment, there is an inherent necessity to withstand hostile conditions and rough usage. The cables can be exposed to
20 salt water and a variety of hydrocarbon fluids such as hydraulic fluid, diesel, fuel and lubricating oils. It is important that cables can operate for long periods and are designed to withstand damage from the hostile environment.

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do catch fire that they do not produce hazardous hydrochloric fumes or other corrosive volatiles. A further demand for cables for use in marine applications is the ability to operate satisfactorily for long periods over a wide temperature range and have a good capacity to withstand abrasive forces.

The present invention relates to materials particularly for use in the sheathing and insulation covering where applicable of cables of this kind.

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According to one aspect of the present invention there is provided a halogen free elastomeric composition comprising a combination of acrylate elastomer and fully hydrogenated butadiene/acrylonitrile copolymer, the elastomeric composition being cross-linked to meet the mechanical property characteristics required by Australian Department of Defence (Navy) Standards A014000 and British Standards NES 518.

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Preferably, the acrylate elastomer is ethyl-methyl-acrylate (EMA). However, it is understood that the acrylate elastomer may also be ethylene-ethyl-acrylate (EEA) or ethylene-butyl-acrylate (EBA).

According to a still further aspect of the present invention, a halogen free elastomeric composition comprising (in parts by weight):

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a) 50 to 80 parts of ethylene-methyl-acrylate (EMA) copolymer with acrylate content of greater than 40%;

b) 20 to 50 parts of a fully hydrogenated butadiene/acrylonitrile copolymer with acrylate content greater than 30%, the total polymer content of (a) and (b) making 100 parts;

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c) 2 to 5 parts of processing aids;
d) 100 to 170 parts of aluminium trihydrate or and with other endothermic fillers of BET surface area of

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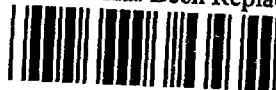
the property characteristics required by Australian Standards A014000 and British Standards NES 518.

The invention also relates to an electrical cable sheathed and insulated by the elastomeric composition described above.

10 In developing the elastomeric composition, a variety of compounds were produced essentially comprising a mixture of EMA and HNBR in a range of proportions. Compound 1 was 100% EMA, compound 2 had an EMA/HNBR ratio of 85/15, compound 3 the ratio was 50/50, compound 4 the
15 ratio was 25/75 and compound 5 the ratio of 0/100. All the compounds were tested for tensile strength and elongation properties. Compounds 1, 2 and 3 were tested for tear resistance and compounds 2 and 3 were also tested to fluid immersion with lubricating oil OX38 (Aeroshell 750) for 28
20 days at 50°C as specified in paragraph 6.2 of the specification of Australian Standard A014000. Compound 3 was also tested against the other fluid immersion types referred to in paragraph 6.2 of the Australian Standard. The EMA product used in these tests was a Du Pont product
25 sold under the trademark VAMAC N123. The material composition of this product is a copolymer ethylene, methyl acrylate and a third monomer containing carboxylic curing sites. It also contains 23 parts of compounding ingredients for each 100 parts of ethylene-acrylic
30 elastomer. The HNBR used in these tests was a Bayer product sold under the trademark THERBAN and essentially comprise hydrogenated butadiene/acrylonitrile rubber. The acrylic content of the EMA was in the order of 40% for VAMAC N123. The acrylonitrile content of HNBR was 38%
35 (Therban 1907).

Further details of the processing aids, fillers, antioxidants, colourants, curing agents and other additions

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5 Stearic Acid 2.0
TE-80 Powder 2.0

N-Octadecanoic Acid
Metal Oleates, Stearates,
hydrocarbons and
monohydroxy compounds

Fillers

10	<u>Name</u>	<u>Composition</u>	<u>Specific Surface Area (BET)</u>
	HYDRAL 710	Aluminium Hydroxide	6-8
	MISTRON Vapour Talc	Magnesium Silicate	20
	APYRAL B120	Aluminium Hydroxide	10-12
15	PERKASIL KS 404GR	Silica	-

Antioxidants

<u>Name</u>	<u>Composition</u>
SANTOWHITE	4, 4' - butylidene - Bis 6-t-butyl-m-cresol

20 Colourants (Pigments and Colour Masterbatches)

<u>Name</u>	<u>Composition</u>
LEPRUB, black, blue red, etc.	Pigments and carrier

Curing Agents

25	<u>Name</u>	<u>Composition</u>
	HVA2 (accelerator)	N,N'-m-phenylenedimaleimide
	PERKADOX 14-40MB	Bis (Tert-butylperoxy-Isopropyl) benzene
	(crosslinking agent)	

30 Other Additive - Deodourant Vanillin

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	VAMAC 1125	02
5	THERBAN 1907	50
	MISTRON Vapour Talc	20
	HYDRAL 710	150
	SANTOWHITE Powder	2
	ARMEEN 18D	0.5
10	Vanillin	0.2
	Stearic Acid	2
	HVA2	2
	PERKADOX 14-40MB	10
	LEPRUB Red	0.5

- 15 Tests were conducted on an elastomeric composition that was essentially VAMAC with evaluation of the HFS-90-R and HFS-110-R cable ratings to meet the fluid resistance tests as specified in Australian Standard A014000. It was discovered that the compound that consisted merely of VAMAC
- 20 when immersed in Fluid Type C2 (OX 38, Aeroshell 750) for 28 days at 50° failed to meet the specified criteria.

A compound that incorporated 50% HNBR and 50% VAMAC in accordance with the example listed above was then evaluated to determine its tear, heat ageing and fluid immersion

25 properties. The results of this evaluation are shown in the following table.

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<u>Test</u>	<u>Result</u>	<u>Specified (A014000)</u>
Unaged Mechanical Properties		
Tensile Strength (mPa)	7.6	6.0 minimum
Elongation (%)	185	150 minimum
Tear Resistance (Nmm ⁻¹)	6.7	5.0 minimum
Mechanical properties after ageing at 130°C for 20 days		
Tensile Strength (mPa)	12.8	6.0 minimum
% Retained	168	.
Elongation (%)	150	100 minimum
% Retained	81	.

Fluid Immersion

<u>Fluid Type</u>	<u>Test Conditions</u>	<u>Tensile (T_s) (MPa)</u>	<u>Elongation (E_B) (%)</u>	<u>Retained (%)</u>	<u>% Swell</u>	<u>Criteria Retained (%)</u> T _s
Propulsion Fuels						
15 A1 F76	24 hours at 100°C	7.9	210	104	114	60 min. 6.3
A2 F44	24 hours at 50°C	7.4	200	97	108	60 min. 5.4

Hydraulic Fluids

5	B1 0x30	28 days at 50°C	8.3	210	109	114	5.1	60 min.
	B2 HS200 X	28 days at 50°C	6.0	285	79	154	0.4	60 min.
	<u>Lubricating Oils</u>							
	C1 OMD 113	28 days at 50°C	9.8	205	129	111	0.1	60 min.
	C2 OX 38 (Aeroshell 750)	28 days at 50°C	7.3	205	96	111	10.1	60 min.
10	<u>Mineral Oil</u>							
	D1 ASTM Oil No. 2	18 hours at 120°C	9.8	220	129	119	1.6	60 min.
	<u>Water</u>							
	E1 Deionised Water	28 days at 50°C	7.8	285	103	154	1.1	80 min.
	E2 Deionised Water + 3½% Na Cl	28 days at 50°C	8.8	260	116	140	- 0.3	80 min.

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5 a halogen free elastomeric compound based on cross-linked
ethylene acrylate copolymer, suitable for up to and
including a maximum of 90°C continuous operating
temperature. HFS-110-R relates to a higher temperature
version of HFS-90-R, suitable for up to and including a
10 maximum of 110°C continuous operating temperature.

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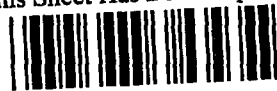
PACIFIC DUNLOP LIMITED

By Its Patent Attorneys

GRIFFITH HACK & CO.

5 Fellows Institute of Patent Attorneys
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In some individual cases cables may be subject to additional tests not included in Table 7. Such additional tests, if any, are detailed in the individual specification sheets (see Appendix D).

Attention is drawn to Appendix A in respect to safety measures when performing some of the tests specified.

Except where otherwise specified, the tests listed in Table 7 need not be performed in the order numbered.

6.2 FLUID IMMERSION

The test method, as is specified for Mineral Oil Immersion Test in AS1660, applies except that the following conditions and fluids shall be used:

Type A (Propulsion fuels)

- (i) Fuel oil, NATO F-76 to DEF (AUST) 5213, specimens immersed for 24h at $100 \pm 3^\circ\text{C}$.
- (ii) Aviation turbine fuel, F-44 AVCAT/FSII to DEF(AUST)5207, specimens immersed for 24h at $50 \pm 2^\circ\text{C}$.

Type B (Hydraulic fluids)

- (i) Hydraulic fluid (Petroleum based), OX30 to DEF STAN. 91-35/1, specimens immersed for 28 days at $50 \pm 2^\circ\text{C}$.
- (ii) Hydraulic fluid (Silicone based), HS200X, specimens immersed for 28 days at $50 \pm 2^\circ\text{C}$.

Type C (Lubricating oils)

- (i) Lubrication oil (Detergent mineral based), OMD 113 to DEF STAN 91-22/2, specimens immersed for 28 days at $50 \pm 2^\circ\text{C}$.
- (ii) Lubrication oil (synthetic ester based), OX38 to DERD 2487 (Issue 4), specimens immersed for 28 days at $50 \pm 2^\circ\text{C}$.

Type D (Mineral oil)

Mineral oil as is specified in AS1660, with the specimens subjected to the following immersion time and temperature:

- (i) HFS-90-R or HFS-110-R sheathed - for 18h at $120 \pm 3^\circ\text{C}$.
- (ii) HFS-90-TP sheathed - for 4h at $70 \pm 2^\circ\text{C}$.

Type E (Water)

- (i) Deionised water, specimens immersed for 28 days at $50 \pm 2^\circ\text{C}$.
- (ii) Deionised water + 3.5% by mass Na Cl, specimens immersed for 28 days at $50 \pm 2^\circ\text{C}$.

Any use of alternative fluids shall be subject to a written approval by the QA.

On completion of the test, the specimen shall meet the criteria specified in Table 9.

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6.4 WEATHERING

The test shall be made on six dumb-bell specimens for each material, prepared in accordance with AS1660, and shall be performed generally in accordance with ASTM D2565, using Type BH apparatus, but with the following modifications:

Xenon arc lamp of 6.0 to 8.0 kV rating;
0.48W/m² irradiance;
80 ± 1.5°C black panel temperature;
340 nm wavelength; and
Borosilicate glass inner and outer filter.

The duration of the test shall be 240 x 126 minute cycles each comprising 108 minutes light only, followed by 18 minutes light and water spray. A total of 504 hours.

On the completion of the test the specimens shall meet the criteria specified in Table 9.

6.5 SCREEN EXAMINATION, ELECTRICAL CONTINUITY AND INSULATION INTEGRITY

In addition to visual and dimensional examination, electrical continuity shall be checked by applying not more than 25 volts d.c. across the ends of the cable screen through an appropriate indicator, such as an ohmmeter, electric bulb or buzzer.

The continuity test on more than one screen component (e.g. tape insulated individual screens in multicore cables) may be performed on each screen separately or with the screens connected in series. The cable shall meet the requirements specified in Table 7.

In the case of individually insulated screens (e.g. as in tape insulated individual screens in a multicore cable) the insulation integrity shall also be checked by applying not less than 50 V r.m.s. or 100 V d.c., for 1 minute, between adjacent screens and, in the case of cable comprising two or more layers of cores, pairs or triples, between the adjacent layers.

6.6 HIGH VOLTAGE FOR 5 MINUTES AND INSULATION RESISTANCE

The requirements of AS1660 apply except that, in the case of 175/300 V rated cables, the test voltage shall be 2.0 kV a.c. or 4.0 kV d.c.

The cable shall meet the requirements specified in Table 7.

6.7 CAPACITANCE

The mutual capacitance and the capacitance unbalance tests shall be performed by the two terminal method specified in MIL-C-17, at room temperature and, unless otherwise stipulated in a particular specification sheet, at a frequency of 1 kHz.

All conductors other than those under test shall be connected to the cable screen(s) and the earth.

The cable shall meet the requirements specified in Table 7.

For cables comprising triples, the measurements shall be made on Wires A and B while Wire C is connected to the screen(s) and earth.

6.9 CHARACTERISTIC IMPEDANCE

The test shall be performed at room temperature and, unless otherwise specified in a particular specification sheet, the characteristic impedance shall be measured at 1 MHz, by the open circuit/short circuit method on a representative 10 m sample of cable.

The cable shall meet the requirements specified in Table 7.

6.10 CROSSTALK

The test shall be performed at room temperature and, unless otherwise specified in a particular specification sheet, the crosstalk measurements shall be made at 1 MHz using 100 ohm terminations, according to the method specified in AS3081.

The cable shall meet the requirements specified in Table 7.

6.11 SURFACE TRANSFER IMPEDANCE

The test shall be performed at room temperature, on a suitable sample length of the cable, in accordance with that specified in MIL-C-85485A.

The cable shall meet the requirements specified in Table 7.

6.12 WET ARC TRACK RESISTANCE

When tested in accordance with the requirements specified in Appendix E, duration of the test being 5 minutes (See Note) for all cables and the test voltage being 240V rms in the case of Power cables or 120V d.c. in the case of Data cables, the cable specimen shall meet the criteria specified in Table 7.

Note: Earlier termination of the test may be necessary, through tripping of the equipment protective circuit breaker, indicating a total failure of the test specimen.

6.13 MUTUAL INDUCTANCE

This test applies only to cables comprising a composite of one or more individually screened pairs together with two or more unscreened cores.

When tested in accordance with the requirements specified in Appendix J, the cable specimen shall meet the requirements specified in Table 7.

6.14 COMBUSTION PROPAGATION OF BUNCHED CABLES

When tested in accordance with the requirements specified in AS1660, the bunched cable specimen shall meet the criteria specified in Table 7.

6.15 SMOKE EMISSION

When tested in accordance with the requirements of AS1660 and Part 2

comprise the complete cable cross-section with only the metallic components removed and, unless otherwise directed by the accredited test establishment, the mass of a specimen shall be approximately 10g and diced into particles not greater than approx. 1 g.

The cable specimen shall meet the requirements specified in Table 7.

6.17 COLD BENDING

A 1.5 m long specimen of the cable shall be maintained straight and conditioned for a minimum of 6 h, in a cold chamber, at $-20 \pm 2^\circ\text{C}$. Immediately on removal of the specimen from the cold chamber, it shall be bent 180° around a wooden mandrel 12 times the overall diameter of the cable and secured to maintain the formed bend in the cable.

The specimen shall then be carefully dissected and a visual examination made of all its functional components (ignoring those used as optional manufacturing aids, e.g. fillers or binders).

The cable shall meet the requirements specified in Table 7.

NOTE: At the option of the cable manufacturer, smaller mandrels than that specified may be used.

6.18 BENDING ENDURANCE

This test applies to flexing service cables only.

When tested in accordance with the requirements specified in Appendix K, the cable specimen shall meet the requirements specified in Table

6.19 SHRINKAGE

The test is applicable to all types of cables, applied to conductor insulation and the overall sheath of the cable, in accordance with the test method specified in AS1660, except for the following modifications:

(a) Insulation

The air oven shall be maintained at $15 \pm 2^\circ\text{C}$ above the rated maximum continuous operating temperature of the cable, for 4 h and then allowed to cool for 24 h, prior shrinkage measurement is made.

(b) Overall sheath

The sheath shall be cut as accurately as possible at the 200 mm marks, through to the layer under the sheath (e.g. metallic screen, laid-up core assembly, as appropriate, see Note), both ends of the cut sheath discarded, the length of the remaining sheath on the specimen accurately measured, suitably marking it at both ends where the measurement was taken and the measured length recorded.

The air oven shall be maintained at $15 \pm 2^\circ\text{C}$ above the rated maximum continuous operating temperature of the cable, for 4 h and then allowed to cool for 24 h, prior shrinkage measurement is made at the marks made on the sheath.

The cable overall dimensions, determined by the method specified in AS1660, shall meet the requirements specified in Table 7.

6.20.2 Cable mass

The cable mass shall be determined by weighing not less than a 1m length of the cable subject to the test.

The cable shall meet the requirements specified in Table 7.

NOTE: For the purposes of this test the weighing of the complete despatch length of cable is acceptable, provided that proof of the mass of the packaging materials (e.g. cable drum) can be provided.

6.21 LEGIBILITY AND DURABILITY OF CORE MARKING

The durability of the printed legend on the cores shall be determined by the method specified in Appendix B of AS2276.1.

The legibility and durability of the printed legend shall meet the requirements specified in Table 7.

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1	2	3	4	5
Test No.	Test	Criteria	Category of Test	Reference for test Methods
1	All appropriate tests, with the exception of resistance, on conductors and screen wires taken from the cable.	As specified in Sections 1 and 2 of AS 1125 and Clause 5.2		
2	Insulation (a) Tests other than (b) below, performed on material representative of cable (b) Degree of cross-linking, performed on material taken from completed cable: 1 Hot set test, at 200 ± 3 deg.C and a load (initial stress) of 200kPa, applicable to R-EP-90, X-90 and R-S-150 only. or 2 Solvent extraction test, applicable to X-90 only, where the insulation is too thin for Hot set test	As specified in Table 8 for the appropriate insulation material (a) Maximum elongation under load: 175 % (b) Maximum residual elongation after cooling: R-EP-90 and X-90 15 % R-S-150-25 % Extractable matter shall not exceed 30%	Type Special	See Table 8 AS 1660 or Appendix G, as appropriate
3	Sheath (a) Tests other than (b) below performed on material representative of cable (b) Hot set test, performed on material taken from completed cable. Tested at 200 ± 3 deg.C and a load (initial stress) of 200kPa applicable to HFS-90-R and HFR-110-R only.	As specified in Table 9 for the appropriate sheath material (a) Maximum elongation under load: 175% (b) Maximum residual elongation after cooling: 20%	Type Special	See Table 9 AS 1660
4	Conductor examination and resistance.	The conductor dimensions, form, material and resistance shall comply with the appropriate requirements of Clause 5.2.	Routine	AS1660
5	Measurement of insulation thickness.	The insulation thickness shall comply with Clause 5.4	Special	AS1660
6	Measurement of thickness of sheath and extruded bedding	The sheath and extruded bedding (where applicable) thicknesses shall comply with Clauses 5.9 and 5.7 respectively.	Special	AS1660

7	Continuity and, in the case of individually insulated screens, the insulation integrity	shall comply with the appropriate requirements of Clause 5.2 and shall be electrically continuous. In the case of individually insulated screens, no breakdown of the insulation shall occur and the insulation resistance shall be not less than 0.1 M Ω .km.		Clause 6.5
8	High voltage for 5 minutes followed by: (a) Insulation resistance at room temperature and corrected to 20 deg.C (b) Insulation resistance at 90 deg.C $\pm$ 2 deg.C	No breakdown of insulation shall occur. The insulation resistance shall meet the values derived from those given below: Insulation resistance constant (ki) at 20 deg.C, minimum (G Ω .m) R-EP-90 : 400 X-90 : 3000 HFI-90-TP : 40 R-S-150 : 400 Insulation resistance constant (ki) at 90 deg.C, minimum (G Ω .m) R-EP-90 : 0.4 X-90 : 3.0 HFI-90-TP : 0.002 R-S-150 : 0.4	Routine Routine Type	AS1660 and
9	Capacitance (Data cables only) (a) Mutual (b) Unbalance	When measured at 1 kHz, the cable shall not exceed the following values:- (i) Where only collectively screened : 120 nF/km. (ii) Individually screened (with or without collective screen): 150nF/km 3 nF/km	Type	Clause 6.7
10	Attenuation (Data cables only)	When measured at 1 MHz, the cable shall not exceed the following values:- <u>Conductor size, sq. mm</u> <u>dB/100m, max.</u> 0.35 4 0.50 3 0.75 Under Consideration 1.0 Under Consideration	Type	Clause 6.8
11	Characteristic impedance (Data cables only)	When measured at 1MHz, the characteristic impedance shall be 75 $\pm$ 10 ohm	Type	Clause 6.9
12	Crosstalk (Data cables only)	When measured at 1 MHz, the cable shall not exceed the following values, dB/100 m: Where only collectively screened Individually screened (with or without collective screen) 50 60	Type	Clause 6.10

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				Methods
13	Surface transfer impedance	(Under consideration)	Type	MIL-C-8548 and Clause 6.11
14	Wet arc track resistance	Other than in the case of the intentionally damaged core (see appendix H), no electrical breakdown of the insulation shall occur and there shall be no open circuits in conductors	Type	Clause 6.12
15	Mutual inductance	The calculated value, in μH , shall not exceed that specified in the appropriate Specification Sheet.	Type	Clause 6.13
16	Combustion propagation of bunched cables: (a) Cable $\leq$ 6sq.mm conductor-Cat.C (b) Cable $>$ 6sq.mm conductor-Cat.B	The charred portion of the cable bunch shall not extend beyond 2500mm above the point of application of the burner flame and the after burning duration shall not exceed 30 minutes.	Type	AS1660 and Clause 6.14
17	Smoke emission	Unless otherwise specified in Appendix D the light transmittance during flaming and smouldering mode shall be not less than: 1 cable 70% 2 cables 60% 3 cables 60% N1 cables 50% N2 bundles 50%	Type	AS1660/IEC 1034 and Clause 6.15
18	Toxicity index	The index shall not exceed 3.0	Type	Clause 6.16
19	Cold bending, at -20 ± 2 deg.C Non-flexing service cables only)	There shall be no cracks or tears in any cable components other than fillers or optional binders.	Type	Clause 6.17
20	Bending endurance (Flexing service cables only)	There shall be no electrical failure of the insulation, no broken wires or cracks or tears in insulation and protective coverings other than fillers or optional binders.	Type	Clause 6.18
21	Shrinkage	The shrinkage of insulation and sheath shall not exceed 2%	Type	AS 1660 and Clause 6.19
22	Dimensional and mass	Except for components already covered in preceding tests - check for conformance to requirements of Appendix D	Special	AS1660 and Clause 6.20
23	Permanence of printing on cores	The printed legend shall still be legible without magnification	Type	Clause 6.21

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Test	2	3	4	5	6	7
	Criteria				Category of test	reference for test method
	R-EP-90 insulation	X-90 insulation	HFI-90-TP insulation	R-S-150 insulation		
A. Mechanical tests without ageing on conditioned specimens:					Type	AS 1660
1. Tensile strength, minimum (MPa)	5.0	12.5	10.0	5.0		
2. Elongation at rupture, minimum (percent)	200	200	100	150		
B. Mechanical tests after ageing in air oven: Duration (hrs) and temperature of ageing (deg.C)	168 h at 135 ± 3	168 h at 135 ± 3	240 h at 100 ± 2	240 h at 200 ± 3	Type	AS 1660
1. Tensile strength, minimum						
(a) Percentage of values found in the unaged specimens	70	75	-	-		
(b) Actual (MPa)	-	-	8.0	4.0		
2. Elongation at rupture, minimum					Type	AS 1660
(a) Percentage of values found in the unaged specimens	70	75	-	-		
(b) Actual percentage	-	-	80	120		
C. Acid and corrosive gas emission:					Type	AS 1660
1. pH, minimum	3.5	3.5	3.5	3.5		
2. Conductivity, maximum [micro S cm(to the minus 1)]	100	100	100	100		
D. Pressure test at high temperature					Type	AS 1660
Test temperature Centigrade	-	-	90 ± 2	-		
Indentation, maximum (percent)	-	-	50	-		

NOTES:

1. A hyphen in the Criteria column means that the test is not applicable for the given insulation.
2. The tests are to be performed on samples from flat moulded sheets 2mm ± 0.2mm thick prepared under laboratory conditions.

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Test	Criteria			Category of test	Reference for test method
	HFS-90-R	HFS-110-R	HFS-90-TP		
	SHEATH	SHEATH	SHEATH		
A. Mechanical tests without ageing on conditioned specimens:				Type	AS 1660
1. Tensile strength, minimum (MPa)	6.0	6.0	10		
2. Elongation at rupture, minimum (percent)	150	150	100		
3. Tear resistance, minimum (N/mm)	5	5	5		
B. Mechanical tests after ageing in air oven (see NOTE 2) Duration (hrs) and temperature of ageing (deg.C)	240 h at 120 ± 3	480 h at 130 ± 3	240 h at 100 ± 2	Type	AS 1660
1. Tensile strength, actual minimum (MPa)	6.0	6.0	8.0		
2. Elongation at rupture, actual minimum (percent)	100	100	80		
C. Fluid immersion: (Conditions per Clause 6.2)				Type	As in AS 1660 for Mineral oil immersion test
1. Tensile strength, minimum (percentage of values found in the unaged specimens)					
Fluid types:					
A, B, C	60	60	-		
D,	60	60	70		
E,	80	80	-		
2. Elongation at rupture, minimum (percentage of values found in the unaged specimens)					
Fluid types:					
A, B, C	60	60	-		
D,	60	60	70		
E,	80	80	-		

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	SHEATH	SHEATH	SHEATH	test	method
D. Loss of mass, maximum (see NOTE 2) (mean loss in mg/sq.cm of exposed surface of specimen)	-	-	2.0	Type	AS 1660
E. Pressure test at high temperature: Test temperature (deg.C) Indentation, maximum (percent)	- -	- -	90 ± 2 50	Type	AS 1660
F. Heat shock	-	-	The sheath shall show no sign of cracking or flaking either when initially wound on the mandrel or after the test.	Type	AS 1660
G. Limiting oxygen index, minimum	32	30	34	Type	AS 2122
H. Temperature index, minimum (deg.C)	250	250	250	Type	Clause 6.3
J. Acid and corrosive gas emission: .				Type	AS 1660
1. pH, minimum	3.5	3.5	3.5		
2. Conductivity, maximum [micro S cm(to the minus 1)]	100	100	100		
K. Durometer hardness (IRHD)			-	Type	ASTM D2240
(a) minimum	55	55			
(b) maximum	85	85			

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	HFS-90-R SHEATH	HFS-110-R SHEATH	HFS-90-TP SHEATH	of test	for test method
L. Weathering				Type	ASTM D2565 and Clause 6.6
(a) Tensile strength minimum (percentage of value found in unweathered specimen)	75	75	75		
(b) Elongtion at rupture minimum (percentage of value found in unweathered specimen)	75	75	75		
(c) Surface examination under X magnification	No cracks	No cracks	No cracks		

- NOTES :
1. A hyphen in the Criteria column means that the test is not applicable for the given sheath.
 2. For HFS-90-TP the test procedure in AS 1660 for Thermal Ageing and Loss of Mass for PVC shall be followed.
 3. The tests are to be performed on samples from flat moulded sheets $2\text{mm} \pm 0.2\text{ mm}$ thick prepared under Laboratory conditions.

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butadiene/acrylonitrile copolymer (HNBR), the elastomeric composition being cross-linked to meet the mechanical property characteristics required by Australian Department of Defence (Navy) Standards A014000.

2. The composition according to claim 1 wherein the acrylate elastomer is ethylene-methyl acrylate (EMA).

3. The composition according to claim 1 wherein the acrylate elastomer is ethylene-ethyl acrylate (EEA).

4. The composition according to claim 1 wherein the acrylate elastomer is ethylene-butyl acrylate (EBA).

5. A halogen free elastomeric composition comprising (in parts by weight):

a) 50 to 80 parts of ethylene-methyl acrylate (EMA) copolymer with acrylate content of greater than 40%;

b) 20 to 50 parts of a fully hydrogenated butadiene/acrylonitrile copolymer with acrylate content greater than 30%, the total polymer content of (a) and (b) making 100 parts;

c) 2 to 5 parts of processing aids;

d) 100 to 170 parts of aluminium hydroxide or/and with other endothermic fillers of BET surface area of between 5 and 20 m²/g;

e) 1 to 4 parts of antioxidants;

f) 1 to 10 parts of colorants;

whereby the elastomeric composition is cross-linked to meet the property characteristics required by Australian Standard A014000.

6. An electrical sheathed and insulated by the elastomeric composition according to any one of the preceding claims.

7. A halogen free elastomeric composition substantially as described herein with reference to the Example.

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TITLE

Elastomeric Compositions

FIELD AND BACKGROUND OF THE INVENTION

This invention relates to elastomeric compositions particularly those compositions for use in electrical cables. Certain electrical cables require insulation covering and sheath with elastomeric compositions that are halogen free, flame retardant and resistant to fluids. Where cables are used in marine applications there are a number of standards that define the operating qualities and characteristics of both the elastomeric compositions in the cables. Such standards include British Naval Engineering Standards NES 518, NES 525 and NES 526. The Australian Department of Defence (NAVY) has a comparable standard known as A014000. The elastomeric composition described hereunder has been designed to preferably satisfy all of the standards referred to above.

When cables are used in a marine environment, there is an inherent necessity to withstand hostile conditions and rough usage. The cables can be exposed to salt water and a variety of hydrocarbon fluids such as hydraulic fluid, diesel, fuel and lubricating oils. It is important that cables can operate for long periods and are

by flaming cables. It is also critical that if the cables do catch fire that they do not produce hazardous hydrochloric fumes or other corrosive volatiles. A further demand for cables for use in marine applications is the ability to operate satisfactorily for long periods over a wide temperature range and have a good capacity to withstand abrasive forces.

The present invention relates to materials particularly for use in the sheathing and insulation covering where applicable of cables of this kind.

SUMMARY OF THE INVENTION

According to one aspect of the present invention there is provided a halogen free elastomeric composition comprising a combination of acrylate elastomer and fully hydrogenated butadiene/acrylonitrile copolymer (HNBR), the elastomeric composition being cross-linked to meet the mechanical property characteristics required by Australian Department of Defence (Navy) Standards A014000.

Preferably, the acrylate elastomer is ethylene-methyl acrylate (EMA). However, it is understood that the acrylate elastomer may also be ethylene-ethyl acrylate (EEA) or ethylene-butyl acrylate (EBA).

According to a still further aspect of the present invention, there is provided a halogen free elastomeric composition comprising (in parts by weight):

- a) 50 to 80 parts of ethylene-methyl acrylate (EMA) copolymer with acrylate content of greater than 40%;
- b) 20 to 50 parts of a fully hydrogenated butadiene/acrylonitrile copolymer with acrylate content greater than 30%, the total polymer content of (a) and (b) making 100 parts;
- c) 2 to 5 parts of processing aids;
- d) 100 to 170 parts of aluminium hydroxide or/and

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1, 1 to 10 parts of colorants,
whereby the elastomeric composition is cross-linked to meet
the property characteristics required by Australian
Standard A014000.

The invention also relates to an electrical cable
sheathed and insulated by the elastomeric composition
described above.

DESCRIPTION OF PREFERRED EMBODIMENTS

The development of elastomeric composition for
use in cables for marine applications requires careful
consideration of applicable standards that define the
operating qualities. One such standard is Australian
Standard AO 14000.

A particularly difficult requirement of this
standard is the resistance to a range of fluids such as
aviation fuels, hydraulic fluids (both petroleum and
silicone based), lubricating oils (both detergent mineral
based and synthetic ester based), mineral oil as
represented by ASTM reference oil No. 2 and deionised
water, and deionised water with 3.5% sodium chloride.
Other requirements are that the compound is halogen free,
while achieving a flame retardance of limiting oxygen index
32 minimum, and in combination with the other cable
components, produces a cable of specified resistance to
flame propagation, be low in smoke and low in toxicity
under combustion conditions. Mechanical properties of the
compound must be maintained to tensile 6.0 MPa minimum,
elongation 125% minimum and tear 5N/mm minimum. In
addition, the compound in combination with the other cable
components must provide a low temperature flexibility of up
to -20°C.

In developing a suitable elastomeric composition,
a variety of compounds were produced essentially comprising
a mixture of Ethylene Acrylic (EA) Rubber and hydrogenated

ethylene acrylic (EA) rubbers including ethylene-methyl acrylate (EMA), ethylene-ethyl acrylate (EEA) and ethylene-butyl acrylate (EBA) the majority of four experimentation and testing was conducted on a composition including EMA. Compound 1 was 100% EMA, compound 2 had an EMA/HNBR ratio of 85/15, in compound 3 the ratio was 50/50, in compound 4 the ratio was 25/75 and compound 5 was 100% HNBR. All the compounds were tested for tensile strength and elongation properties. Compounds 1, 2 and 3 were tested for tear resistance and compounds 2 and 3 were also tested to fluid immersion with lubricating oil OX38 (Aeroshell 750) for 28 days at 50°C as specified in paragraph 6.2 of the specification of Australian Standard A014000. Compound 3 was also tested against the other fluid immersion types referred to in paragraph 6.2 of the Australian Standard. The EMA used in these tests was a Du Pont product sold under the trademark VAMAC N123. The material composition of this product is a copolymer of ethylene-methyl acrylate and a third monomer containing carboxylic curing sites. It also contains 23 parts of compounding ingredients for each 100 parts of ethylene-acrylic elastomer. The HNBR used in these tests was a Bayer product sold under the trademark THERBAN and essentially comprise hydrogenated butadiene/acrylonitrile rubber. The acrylic content of the EMA was in the order of 40% for VAMAC N123. The acrylonitrile content of HNBR was 38% (Therban 1907).

Further details of the processing aids, fillers, antioxidants, colourants, curing agents and other additions

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Stearic Acid 2.0
TE-80 Powder 2.0

N-octadecanoic acid
Metal oleates,
stearates,
hydrocarbons and
monohydroxy compound.

Fillers

<u>Name</u>	<u>Composition</u>	<u>Specific Surface Area (BET)</u>
HYDRAL 710	Aluminium Hydroxide	6-8
MISTRON Vapour Talc	Magnesium Silicate	20
APYRAL B120	Aluminium Hydroxide	10-12
PERKASIL KS 404GR	Silica	-

Antioxidants

<u>Name</u>	<u>Composition</u>
SANTOWHITE	4, 4' - butylidene - bis 6-t-butyl-1-cresol

Colourants

UV - stabilizer composition
SAF Carbon Black N110 (ASTM) Type Carbon Black Super
Abrasion Furnace Black

Curing Agents

<u>Name</u>	<u>Composition</u>
HVA2 (accelerator)	N,N'-m-phenylenedimaleimide
PERKADOX 14-40MB	Bis (Tert-butylperoxy-Isopropyl) benzene

(crosslinking agent)

Other Additive - Deodourant

Vanillin

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<u>Example</u>	phr
VAMAC N123	62
THERBAN 1907	50
MISTRON Vapour Talc	20
HYDRAL 710	150
SANTOWHITE Powder	2
ARMEEN 18D	0.5
Vanillin	0.2
Stearic Acid	2
HVA2	2
PERKADOX 14-40MB	10
SAF Black	5.0

The compound was used in the laboratory using two roll mills. It was then pressed into sheets at 160°C for sixty minutes, and the sheets were watercooled to room temperature. Samples from the prepared sheets were then tested for a series of unaged and aged physical properties. The results of these tests are shown in Table 1.

The samples prepared from the moulded sheets were then left in a constant temperature room to stabilise for 24 hours before testing. The stabilised moulded sheets were then cut into dumbbells and evaluated to determine the unaged mechanical properties including tensile strength, elongation at break and tear resistance followed by the determination of mechanical properties of heat aged samples and a wide range of fluid immersion properties. These results are shown in Table 2.

Tests were conducted on an elastomeric composition that was essentially VAMAC with evaluation of the HFS-90-R and HFS-110-R cable ratings to meet the fluid resistance tests as specified in Australian Standard

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A compound that incorporated 50% HNBR and 50% VAMAC in accordance with the example listed above was then evaluated to determine its tear, heat ageing and fluid immersion properties.

The composition was therm-chemically cross linked but it is understood that other curing techniques are envisaged such as electro-beam cross linking with appropriate compound modifications.

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TABLE 1

Test	Result	Specified A014000
Unaged Mechanical Properties		
Tensile Strength (mPA)	8.3	6.0 minimum
Elongation (%)	265	150 minimum
Tear Resistance (Nmm ⁻¹)	5.3	5.0 minimum
Mechanical properties after aging at 130°C for 20 days		
Tensile Strength (mPA)	12.8	6.0 minimum
Elongation (%)	150	100 minimum
Limiting Oxygen Index L.O.I.	40	32
Weathering		
Tensile Strength % Retained	115	75 minimum
Elongation % Retained	97	75 minimum
Surface Examination Under Magnification	No Cracks	No Cracks
Hardness IRHD	82	55 minimum, 85 maximum
Acid and Corrosive Gas Emission		
1. pH minimum	4.8	3.5 minimum
2. Conductivity μ S/cm	13	100 maximum

This Sheet Has Been Replaced



TABLE 2

<u>Fluid Immersion</u> <u>Fluid Type</u>	<u>Test Conditions</u>	<u>Retained (%)</u> <u>I_r</u>	<u>E_a</u>	<u>Specified A014000</u> <u>Retained (%)</u> <u>I_s</u>
<u>Propulsion Fuels</u> A1 F76	24 hours at 100°C	101%	83%	60 min.
A2 F44	24 hours at 50°C	98%	89%	60 min.
<u>Hydraulic Fluids</u> B1 Ox30	28 days at 50°C	122%	94%	60 min.
B2 HS200 X	28 days at 50°C	84%	119%	60 min.
<u>Lubricating Oils</u> C1 OMD 113	28 days at 50°C	124%	75%	60 min.
C2 OX 38 (Aeroshell)	28 days at 50°C	105%	79%	60 min.
<u>Mineral Oil</u> D1 ASTM Oil. No. 2	18 hours at 120°C	127%	92%	60 min.
<u>Water</u> E1 Deionised Water	28 days at 50°C	100%	87%	80 min.
E2 Deionised Water	28 days at 50°C	111%	81%	80 min.

It is considered that this particular compound passes the unaged and aged mechanical criteria tests and also the fluid immersion criteria tests for cable ratings HFS-90-R and HFS-110-R. HFS-90-R defines a sheath characteristic of a halogen free elastomeric compound based on cross-linked ethylene acrylate copolymer, suitable for up to and including a maximum of 90°C continuous operating temperature. HFS-110-R relates to a higher temperature version of HFS-90-R, suitable for up to and including a maximum of 110°C continuous operating temperature.

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specimens shall be capable of complying with the tests specified in Table 7. All tests shall be made as specified in Table 7 and Clause 9.

In some individual cases cables may be subject to additional tests not included in Table 7. Such additional tests, if any, are detailed in the individual specification sheets (see Appendix D).

Attention is drawn to Appendix A in respect to safety measures when performing some of the tests specified.

Except where otherwise specified, the tests listed in Table 7 need not be performed in the order numbered.

6.2 FLUID IMMERSION

The test method, as is specified for Mineral Oil Immersion Test in AS1660, applies except that the following conditions and fluids shall be used:

Type A (Propulsion fuels)

- (i) Fuel oil, NATO F-76 to DEF (AUST) S213, specimens immersed for 24h at $100 \pm 3^\circ\text{C}$.
- (ii) Aviation turbine fuel, F-44 AVCAT/FSII to DEF(AUST)S207, specimens immersed for 24h at $50 \pm 2^\circ\text{C}$.

Type B (Hydraulic fluids)

- (i) Hydraulic fluid (Petroleum based), OX30 to DEF STAN. 91-35/1, specimens immersed for 28 days at $50 \pm 2^\circ\text{C}$.
- (ii) Hydraulic fluid (Silicone based), HS200X, specimens immersed for 28 days at $50 \pm 2^\circ\text{C}$.

Type C (Lubricating oils)

- (i) Lubrication oil (Detergent mineral based), OMD 113 to DEF STAN 91-22/2, specimens immersed for 28 days at $50 \pm 2^\circ\text{C}$.
- (ii) Lubrication oil (synthetic ester based), OX38 to DERO 2487 (Issue 4), specimens immersed for 28 days at $50 \pm 2^\circ\text{C}$.

Type D (Mineral oil)

Mineral oil as is specified in AS1660, with the specimens subjected to the following immersion time and temperature:

- (i) EFS-90-R or EFS-110-R sheathed - for 18h at $120 \pm 3^\circ\text{C}$.
- (ii) EFS-90-TP sheathed - for 4h at $70 \pm 2^\circ\text{C}$.

Type E (Water)

- (i) Deionised water, specimens immersed for 28 days at $50 \pm 2^\circ\text{C}$.
- (ii) Deionised water + 3.5t by mass Na Cl, specimens immersed for 28 days at $50 \pm 2^\circ\text{C}$.

Any use of alternative fluids shall be subject to a written approval by the QA.

On completion of the test, the specimen shall meet the criteria specified in Table 9.

CRITERIA, CATEGORY AND REFERENCE
(See NOTES 1, 2 & 3)

1 Test	2	3	4	5	6
	Criteria			Category of test	Reference for test method
	MPS-90-R SHEATH	MPS-110-R SHEATH	MPS-90-TF SHEATH		
A. Mechanical tests without ageing on conditioned specimens:				Type	AS 1660
1. Tensile strength, minimum (MPa)	6.0	6.0	10		
2. Elongation at rupture, minimum (percent)	150	150	100		
3. Tear resistance, minimum (N/mm)	5	5	5		
B. Mechanical tests after ageing in air oven (see NOTE 2) Duration (hrs) and temperature of ageing (deg.C)	240 h at 120 ± 3	480 h at 120 ± 3	240 h at 100 ± 2	Type	AS 1660
1. Tensile strength, actual minimum (MPa)	6.0	6.0	8.0		
2. Elongation at rupture, actual minimum (percent)	100	100	80		
C. Fluid immersion: (Conditions per Clause 6.2)				Type	As in AS 1660 for Mineral oil immersion test
1. Tensile strength, minimum (percentage of values found in the unaged specimens)					
Fluid types:					
A, B, C	60	60	-		
D,	60	60	70		
E,	80	80	-		
2. Elongation at rupture, minimum (percentage of values found in the unaged specimens)					
Fluid types:					
A, B, C	60	60	-		
D,	60	60	70		
E,	80	80	-		

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Test	Criteria			Category of test	Reference for test method
	NFS-90-R	NFS-110-R	NFS-90-TP		
	SHEATH	SHEATH	SHEATH		
D. Loss of mass, maximum (see NOTE 2) (mean loss in mg/sq.cm of exposed surface of specimen)	-	-	2.0	Type	AS 1660
E. Pressure test at high temperature: Test temperature (deg.C) Indentation, maximum (percent)	- -	- -	90 ± 2 50	Type	AS 1660
F. Seat shock	-	-	The sheath shall show no sign of cracking or flaking either when initially wound on the mandrel or after the test.	Type	AS 1660
G. Limiting oxygen index, minimum	32	30	34	Type	AS 2122
H. Temperature index, minimum (deg.C)	250	250	250	Type	Clause 6.3
J. Acid and corrosive gas emission:				Type	AS 1660
1. pH, minimum	3.5	3.5	3.5		
2. Conductivity, maximum (micro S cm(to the minus 1))	100	100	100		
K. Durometer hardness (IRHD)			-	Type	ASTM D2240
(a) minimum	55	55			
(b) maximum	85	85			

This Sheet Has Been Replaced



1 Test	2	3	4	5	6
	Criteria			Category of test	Reference for test method
	MFS-90-R SHEATH	MFS-110-R SHEATH	MFS-90-TP SHEATH		
L. Weathering				Type	ASTM D2565 and Clause 6.6
(a) Tensile strength minimum (percentage of value found in unweathered specimen)	75	75	75		
(b) Elongation at rupture minimum (percentage of value found in unweathered specimen)	75	75	75		
(c) Surface examination under X magnification	No cracks	No cracks	No cracks		

NOTES : 1. A hyphen in the Criteria column means that the test is not applicable for the given sheath.

2. For MFS-90-TP the test procedure in AS 1660 for Thermal Ageing and Loss of Mass for PVC shall be followed.

3. The tests are to be performed on samples from flat moulded sheets 2mm ± 0.2 mm thick prepared under Laboratory conditions.

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butadiene/acrylonitrile copolymer (HNBR), the elastomeric composition being cross-linked to meet the mechanical property characteristics required by Australian Department of Defence (Navy) Standards A014000.

2. The composition according to claim 1 wherein the acrylate elastomer is ethylene-methyl acrylate (EMA).

3. The composition according to claim 1 wherein the acrylate elastomer is ethylene-ethyl acrylate (EEA).

4. The composition according to claim 1 wherein the acrylate elastomer is ethylene-butyl acrylate (EBA).

5. A halogen free elastomeric composition comprising (in parts by weight):

a) 50 to 80 parts of ethylene-methyl acrylate (EMA) copolymer with acrylate content of greater than 40%;

b) 20 to 50 parts of a fully hydrogenated butadiene/acrylonitrile copolymer with acrylate content greater than 30%, the total polymer content of (a) and (b) making 100 parts;

c) 2 to 5 parts of processing aids;

d) 100 to 170 parts of aluminium hydroxide or/and with other endothermic fillers of BET surface area of between 5 and 20 m²/g;

e) 1 to 4 parts of antioxidants;

f) 1 to 10 parts of colorants;

whereby the elastomeric composition is cross-linked to meet the property characteristics required by Australian Standard A014000.

6. An electrical sheathed and insulated by the elastomeric composition according to any one of the preceding claims.

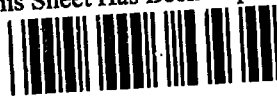
7. A halogen free elastomeric composition substantially as described herein with reference to the Example.

This Sheet Has Been Replaced



A halogen free elastomeric composition comprising a combination of acrylate elastomer and fully hydrogenated butadiene/acrylonitrile copolymer (HNBR), the elastomeric composition being cross-linked to meet the mechanical property characteristics required by Australian Department of Defence (Navy) Standards A014000.

This Sheet Has Been Replaced



2-75-000

02 APR 1997

TITLE

Elastomeric Compositions

FIELD AND BACKGROUND OF THE INVENTION

This invention relates to elastomeric compositions particularly those compositions for use in electrical cables. Certain electrical cables require insulation covering and sheath with elastomeric compositions that are halogen free, flame retardant and resistant to fluids. Where cables are used in marine applications there are a number of standards that define the operating qualities and characteristics of both the elastomeric compositions in the cables. Such standards include British Naval Engineering Standards NES 518, NES 525 and NES 526. The Australian Department of Defence (NAVY) has a comparable standard known as A014000. The elastomeric composition described hereunder has been designed to preferably satisfy all of the standards referred to above.

When cables are used in a marine environment, there is an inherent necessity to withstand hostile conditions and rough usage. The cables can be exposed to salt water and a variety of hydrocarbon fluids such as hydraulic fluid, diesel, fuel and lubricating oils. It is important that cables can operate for long periods and are

that electrical fires or action damage fires are not spread by flaming cables. It is also critical that if the cables do catch fire that they do not produce hazardous hydrochloric fumes or other corrosive volatiles. A further demand for cables for use in marine applications is the ability to operate satisfactorily for long periods over a wide temperature range and have a good capacity to withstand abrasive forces.

The present invention relates to materials particularly for use in the sheathing and insulation covering where applicable of cables of this kind.

SUMMARY OF THE INVENTION

According to one aspect of the present invention there is provided a halogen free elastomeric composition comprising a combination of acrylate elastomer and fully hydrogenated butadiene/acrylonitrile copolymer (HNBR), the elastomeric composition being cross-linked to meet the mechanical property characteristics required by Australian Department of Defence (Navy) Standards A014000.

Preferably, the acrylate elastomer is ethylene-methyl acrylate (EMA). However, it is understood that the acrylate elastomer may also be ethylene-ethyl acrylate (EEA) or ethylene-butyl acrylate (EBA).

According to a still further aspect of the present invention, there is provided a halogen free elastomeric composition comprising (in parts by weight):

- a) 50 to 80 parts of ethylene-methyl acrylate (EMA) copolymer with acrylate content of greater than 40%;
- b) 20 to 50 parts of a fully hydrogenated butadiene/acrylonitrile copolymer with acrylate content greater than 30%, the total polymer content of (a) and (b) making 100 parts;
- c) 2 to 5 parts of processing aids;
- d) 100 to 170 parts of aluminium hydroxide or/and

f) 1 to 10 parts of colorants;
whereby the elastomeric composition is cross-linked to meet the property characteristics required by Australian Standard A014000.

The invention also relates to an electrical cable sheathed and insulated by the elastomeric composition described above.

DESCRIPTION OF PREFERRED EMBODIMENTS

The development of elastomeric composition for use in cables for marine applications requires careful consideration of applicable standards that define the operating qualities. One such standard is Australian Standard AO 14000.

A particularly difficult requirement of this standard is the resistance to a range of fluids such as aviation fuels, hydraulic fluids (both petroleum and silicone based), lubricating oils (both detergent mineral based and synthetic ester based), mineral oil as represented by ASTM reference oil No. 2 and deionised water, and deionised water with 3.5% sodium chloride. Other requirements are that the compound is halogen free, while achieving a flame retardance of limiting oxygen index 32 minimum, and in combination with the other cable components, produces a cable of specified resistance to flame propagation, be low in smoke and low in toxicity under combustion conditions. Mechanical properties of the compound must be maintained to tensile 6.0 MPa minimum, elongation 125% minimum and tear 5N/mm minimum. In addition, the compound in combination with the other cable components must provide a low temperature flexibility of up to -20°C.

In developing a suitable elastomeric composition, a variety of compounds were produced essentially comprising a mixture of Ethylene Acrylic (EA) Rubber and hydrogenated

acrylate (EMA), ethylene-ethyl acrylate (EEA) and ethylene-butyl acrylate (EBA) the majority of four experimentation and testing was conducted on a composition including EMA. Compound 1 was 100% EMA, compound 2 had an EMA/HNBR ratio of 85/15, in compound 3 the ratio was 50/50, in compound 4 the ratio was 25/75 and compound 5 was 100% HNBR. All the compounds were tested for tensile strength and elongation properties. Compounds 1, 2 and 3 were tested for tear resistance and compounds 2 and 3 were also tested to fluid immersion with lubricating oil OX38 (Aeroshell 750) for 28 days at 50°C as specified in paragraph 6.2 of the specification of Australian Standard A014000. Compound 3 was also tested against the other fluid immersion types referred to in paragraph 6.2 of the Australian Standard. The EMA used in these tests was a Du Pont product sold under the trademark VAMAC N123. The material composition of this product is a copolymer of ethylene-methyl acrylate and a third monomer containing carboxylic curing sites. It also contains 23 parts of compounding ingredients for each 100 parts of ethylene-acrylic elastomer. The HNBR used in these tests was a Bayer product sold under the trademark THERBAN and essentially comprise hydrogenated butadiene/acrylonitrile rubber. The acrylic content of the EMA was in the order of 40% for VAMAC N123. The acrylonitrile content of HNBR was 38% (Therban 1907).

Further details of the processing aids, fillers, antioxidants, colourants, curing agents and other additions

ARMEEN 18D 0.5
 Stearic Acid 2.0
 TE-80 Powder 2.0

N-octadecyl amine
 N-octadecanoic acid
 Metal oleates,
 stearates,
 hydrocarbons and
 monohydroxy compounds

Fillers

<u>Name</u>	<u>Composition</u>	<u>Specific Surface Area (BET)</u>
HYDRAL 710	Aluminium Hydroxide	6-8
MISTRON Vapour Talc	Magnesium Silicate	20
APYRAL B120	Aluminium Hydroxide	10-12
PERKASIL KS 404GR	Silica	-

Antioxidants

<u>Name</u>	<u>Composition</u>
SANTOWHITE	4, 4' - butylidene - bis 6-t-butyl-m-cresol

Colourants

UV - stabilizer composition
 SAF Carbon Black N110 (ASTM) Type Carbon Black Super
 Abrasion Furnace Black

Curing Agents

<u>Name</u>	<u>Composition</u>
HVA2 (accelerator)	N,N'-m-phenylenedimaleimide
PERKADOX 14-40MB	Bis (Tert-butylperoxy-Isopropyl) benzene

(crosslinking agent)

Other Additive - Deodourant

Vanillin

hereunder:

<u>Example</u>	<u>phr</u>
VAMAC N123	62
THERBAN 1907	50
MISTRON Vapour Talc	20
HYDRAL 710	150
SANTOWHITE Powder	2
ARMEEN 18D	0.5
Vanillin	0.2
Stearic Acid	2
HVA2	2
PERKADOX 14-40MB	10
SAF Black	5.0

The compound was used in the laboratory using two roll mills. It was then pressed into sheets at 160°C for sixty minutes, and the sheets were watercooled to room temperature. Samples from the prepared sheets were then tested for a series of unaged and aged physical properties. The results of these tests are shown in Table 1.

The samples prepared from the moulded sheets were then left in a constant temperature room to stabilise for 24 hours before testing. The stabilised moulded sheets were then cut into dumbbells and evaluated to determine the unaged mechanical properties including tensile strength, elongation at break and tear resistance followed by the determination of mechanical properties of heat aged samples and a wide range of fluid immersion properties. These results are shown in Table 2.

Tests were conducted on an elastomeric composition that was essentially VAMAC with evaluation of the HFS-90-R and HFS-110-R cable ratings to meet the fluid resistance tests as specified in Australian Standard

the specified criteria.

A compound that incorporated 50% HNBR and 50% VAMAC in accordance with the example listed above was then evaluated to determine its tear, heat ageing and fluid immersion properties.

The composition was therm-chemically cross linked but it is understood that other curing techniques are envisaged such as electro-beam cross linking with appropriate compound modifications.

TABLE 1

<u>Test</u>	<u>Result</u>	<u>Specified A014000</u>
Unaged Mechanical Properties		
Tensile Strength (mPA)	8.3	6.0 minimum
Elongation (%)	265	150 minimum
Tear Resistance (Nmm ⁻¹)	5.3	5.0 minimum
Mechanical properties after ageing at 130°C for 20 days		
Tensile Strength (mPA)	12.8	6.0 minimum
Elongation (%)	150	100 minimum
Limiting Oxygen Index L.O.I.	40	32
Weathering		
Tensile Strength % Retained	115	75 minimum
Elongation % Retained	97	75 minimum
Surface Examination Under Magnification	No Cracks	No Cracks
Hardness IRHD	82	55 minimum, 85 maximum
Acid and Corrosive Gas Emission		
1. pH minimum	4.8	3.5 minimum
2. Conductivity µS.cm	13	100 maximum

TABLE 2

<u>Fluid Immersion</u>	<u>Test Conditions</u>	<u>Retained (%)</u> <u>I_L</u>	<u>E_a</u>	<u>Specified A014000</u> <u>Retained (%)</u> <u>I_s</u>
<u>Fluid Type</u>				
<u>Propulsion Fuels</u>				
A1 F76	24 hours at 100°C	101%	83%	60 min.
A2 F44	24 hours at 50°C	98%	89%	60 min.
<u>Hydraulic Fluids</u>				
B1 0x30	28 days at 50°C	122%	94%	60 min.
B2 HS200 X	28 days at 50°C	84%	119%	60 min.
<u>Lubricating Oils</u>				
C1 OMD 113	28 days at 50°C	124%	75%	60 min.
C2 OX 38 (Aeroshell)	28 days at 50°C	105%	79%	60 min.
<u>Mineral Oil</u>				
D1 ASTM Oil. No. 2	18 hours at 120°C	127%	92%	60 min.
<u>Water</u>				
E1 Deionised Water	28 days at 50°C	100%	87%	80 min.
E2 Deionised Water	28 days at 50°C	111%	81%	80 min.

HFS-90-R and HFS-110-R. HFS-90-R defines a sheath characteristic of a halogen free elastomeric compound based on cross-linked ethylene acrylate copolymer, suitable for up to and including a maximum of 90°C continuous operating temperature. HFS-110-R relates to a higher temperature version of HFS-90-R, suitable for up to and including a maximum of 110°C continuous operating temperature.

6.1 GENERAL

Cables shall be capable of complying with the tests specified in Table 7. All tests shall be made as specified in Table 7 and Clause 9.

In some individual cases cables may be subject to additional tests not included in Table 7. Such additional tests, if any, are detailed in the individual specification sheets (see Appendix D).

Attention is drawn to Appendix A in respect to safety measures when performing some of the tests specified.

Except where otherwise specified, the tests listed in Table 7 need not be performed in the order numbered.

6.2 FLUID IMMERSION

The test method, as is specified for Mineral Oil Immersion Test in AS1660, applies except that the following conditions and fluids shall be used:

Type A (Propulsion fuels)

- (i) Fuel oil, NATO F-76 to DEF (AUST) 5213, specimens immersed for 24h at $100 \pm 3^{\circ}\text{C}$.
- (ii) Aviation turbine fuel, F-44 AVCAT/FSII to DEF(AUST) 5207, specimens immersed for 24h at $50 \pm$

- OX38 to DEF STAN. 91-35/1, specimens immersed for 28 days at $50 \pm 2^{\circ}\text{C}$.
- (ii) Hydraulic fluid (Silicone based), HS200X, specimens immersed for 28 days at $50 \pm 2^{\circ}\text{C}$.

Type C (Lubricating oils)

- (i) Lubrication oil (Detergent mineral based), OMD 113 to DEF STAN 91-22/2, specimens immersed for 28 days at $50 \pm 2^{\circ}\text{C}$.
- (ii) Lubrication oil (synthetic ester based), OX38 to DERD 2487 (Issue 4), specimens immersed for 28 days at $50 \pm 2^{\circ}\text{C}$.

Type D (Mineral oil)

Mineral oil as is specified in AS1660, with the specimens subjected to the following immersion time and temperature:

- (i) HFS-90-R or HFS-110-R sheathed - for 18h at $120 \pm 3^{\circ}\text{C}$.
- (ii) HFS-90-TP sheathed - for 4h at $70 \pm 2^{\circ}\text{C}$.

Type E (Water)

- (i) Deionised water, specimens immersed for 28 days at $50 \pm 2^{\circ}\text{C}$.
- (ii) Deionised water + 3.5% by mass Na Cl, specimens immersed for 28 days at $50 \pm 2^{\circ}\text{C}$.

Any use of alternative fluids shall be subject to a written approval by the QA.

On completion of the test, the specimen shall meet the criteria specified in Table 9.

Table 9
TESTS FOR MATERIAL CHARACTERISTICS OF SHEATH
- CRITERIA, CATEGORY AND REFERENCE -
(See NOTES 1,2 & 3)

1 Test	2	3	4	5	6		
						Category of test	
							Criteria
HFS-90-R SHEATH	HFS-110-R SHEATH	HFS-90-TP SHEATH	Type	AS 1			
A. Mechanical tests without ageing on conditioned specimens:							
1. Tensile strength, minimum (MPa)	6.0	6.0	10				
2. Elongation at rupture, minimum (percent)	150	150	100				
3. Tear resistance, minimum (N/mm)	5	5	5				
B. Mechanical tests after ageing in air oven (see NOTE 2) Duration (hrs) and temperature of ageing (deg.C)							
1. Tensile strength, actual minimum (MPa)	240 h at 120 ± 3	480 h at 130 ± 3	240 h at 100 ± 2	Type	AS 1		
	6.0	6.0	8.0				
2. Elongation at rupture, actual minimum (percent)	100	100	80				

1 Test	2	3 Criteria			4 HFS-90-TP SHEATH	5 Category of test	6 Refer for met
		AS AS 1 f Mine C immer t					
		HFS-90-R SHEATH	HFS-110-R SHEATH	Type			
C. Fluid immersion: (conditions per Clause 6.2) 1. Tensile strength, minimum (percentage of values found in the unaged specimens) Fluid types: A, B, C, D, E, 2. Elongation at rupture, minimum (percentage of values found in the enaged specimens) Fluid types: A, B, C, D, E,	60	60	-		Type	AS 1	
	60	60	70				
	80	80	-				
	60	60	-				
	60	60	70				
	80	80	-				
D. Loss of mass, maximum (see NOTE 2) (mean loss in mg/sq.cm of exposed surface of specimen)	-	-	2.0		Type	AS 1	

1 Test	2	3			4	5 Category of test	Refe for met AS
		Criteria					
		HFS-90-R SHEATH	HFS-110-R SHEATH	HFS-90-TP SHEATH			
E. Pressure test at high temperature: Test temperature (deg.C) Identification, maximum (percent)	- -	- -	-	90 ± 2 50	Type	AS	
F. Heat shock	-	-	-	The sheath shall show no sign of cracking or flaking either when initially wound on the mandrel or after the test.	Type	AS	
G. Limiting oxygen index, minimum	32	30	34		Type	AS	
H. Temperature index, minimum (deg. C)	250	250	250		Type	Clas	
J. Acid and corrosive gas emission: 1. pH, minimum 2. Conductivity, maximum [(micro S cm(to the minus 1))]	3.5 100	3.5 100	3.5 100	3.5 100	Type	AS	

1 Test	2	3	4	5	Reference for method		
						Criteria	
						HPS-90-R SHEATH	HPS-110-R SHEATH
K. Durometer hardness (IRHD)							
(a) minimum	55	55	-				
(b) maximum	85	85					
L. Weathering							
(a) Tensile strength minimum (percentage of value found in unweathered specimen)	75	75	75				
(b) Elongation at rupture minimum (percentage of value found in unweathered specimen)	75	75	75				
(c) Surface examination under x magnification	No cracks	No cracks	No cracks				

NOTES: 1. A hyphen in the Criteria column means that the test is not applicable for the given sheath.

2. For HFS-90-TP the test procedure in AS 1660 for Thermal Ageing and Loss of mass for PVC shall be followed.

3. The tests are to be performed on samples from flat moulded sheets $2\text{mm} \pm 0.2\text{ mm}$ thick prepared under laboratory conditions.

composition being cross-linked to meet the mechanical property characteristics required by Australian Department of Defence (Navy) Standards A014000.

2. The composition according to claim 1 wherein the acrylate elastomer is ethylene-methyl acrylate (EMA).

3. The composition according to claim 1 wherein the acrylate elastomer is ethylene-ethyl acrylate (EEA).

4. The composition according to claim 1 wherein the acrylate elastomer is ethylene-butyl acrylate (EBA).

5. A halogen free elastomeric composition comprising (in parts by weight):

a) 50 to 80 parts of ethylene-methyl acrylate (EMA) copolymer with acrylate content of greater than 40%;

b) 20 to 50 parts of a fully hydrogenated butadiene/acrylonitrile copolymer with acrylate content greater than 30%, the total polymer content of (a) and (b) making 100 parts;

c) 2 to 5 parts of processing aids;

d) 100 to 170 parts of aluminium hydroxide or/and with other endothermic fillers of BET surface area of between 5 and 20 m²/g;

e) 1 to 4 parts of antioxidants;

f) 1 to 10 parts of colorants;

whereby the elastomeric composition is cross-linked to meet the property characteristics required by Australian Standard A014000.

6. An electrical sheathed and insulated by the elastomeric composition according to any one of the preceding claims.

7. A halogen free elastomeric composition substantially as described herein with reference to the Example.

A halogen free elastometric composition comprising a combination of acrylate elastomer and fully hydrogenated butadiene/acrylonitrile copolymer (HNBR), the elastometric composition being cross-linked to meet the mechanical property characteristics required by Australian Department of Defence (Navy) Standards AO14000