PARAFIL® ROPE
Physical Properties
Technical Notes Issue 3

Linear COMPOSITES

1. PARAFIL® Types

PARAFIL® ropes consist of a closely packed core of high strength synthetic fibres lying parallel to each other, and encased in a tough and durable polymeric sheath.

The parallel fibre structure ensures that PARAFIL® ropes have high strength and modulus characteristics coupled with an excellent tension-tension fatigue performance and low creep.

There are three standard types of PARAFIL® based on the kind of fibre used. Each has a choice of three different polymeric sheaths. A flame retardant variety is also available. The product range is shown in Table 1.

Table 1 ~ PARAFIL® Types

Yarn Type	Sheath materials and Types			
	Polyethylene (LDPE)	Polyethylene Copolymer (EVA)	Polyester Elastomer (Hytrel)	Flame Retardant Cross linked Polymer
High Tenacity polyester	Type A	Type A (C)	Type A (H)	Type A (X)
Standard Modulus Aramid	Type F	Type F (C)	Type F (H)	Type F (X)
High Modulus Aramid	Type G	Type G (C)	Type G (H)	Type G (X)

The specially formulated polyethylene sheath is most commonly used and is perfectly satisfactory for most purposes, but the polyethylene-EVA copolymer sheath is more flexible. Higher resistance to heat and abrasion can be obtained from the polyester elastomer.

The standard ranges of PARAFIL® ropes are shown in table 2 and 3, other sizes are available as requested.

Table 2 ~ Basic Characteristics of Types A and A(C) PARAFIL® Ropes

Nominal Breaking Load (NBL) (Tonnes)	Nominal Diameter (mm)	Nominal Diameter of Fibre Core (mm)	CSA of Fibre in the Core (mm^2)	Approximate Weight in Air (kg/100m)	Estimated Weight * in Seawater (Core Flooded) (kg / 100m)
0.3	4	3.0	5.19	1.2	-
0.5	7	3.7	7.97	3.7	0.05
1	8.5	5.3	15.94	5.4	0.2
2	11	7.5	31.88	9.4	0.5
3.5	13.5	10	55.8	14.5	2.1
5	17	12	79.7	22	2.1
7.5	20	15	119.6	30	4.6
10	22	17	159.4	37	5.0
15	27.5	22	239.1	56	7.5
20	31	24	318.8	73	9.3
30	36	29	478.2	99	13.4
50	47	39	797	165	25
60	53	42	956	215	32
100	64	56	1594	310	77
200	90	77	3188	622	143
250	99	86	3985	763	153

TABLE 3 ~ Basic Characteristics of Type F and F(C), G and G(C), PARAFIL® Ropes

(Note Type G ropes have a higher elastic modulus than Type F ropes)

Nominal Breaking Load (NBL) (Tonnes)	Nominal Diameter (mm)	Nominal Diameter of Fibre Core (mm)	CSA of Fibre in the Core (mm^2)	Approximate Weight in Air (kg/100m)	Estimated Weight * in Seawater (Core Flooded) (kg/100m)
0.75	4	3	4.8	1.2	-
1.5	7	4	7.64	3.7	0.13
3	8.5	5.4	15.28	5.4	0.34
4.5	9.5	6.6	22.92	6.9	0.6
6	11	7.6	30.55	9.1	0.8
10.5	13.5	10	53.47	14.9	2.6
15	17	12.5	76.38	21.5	3.7
22.5	20	15	114.6	30	5.8
30	22	17	152.8	37	7.2
45	27.5	21.5	229.2	60	7.5
60	31	24	305.5	72	8.2
90	36	29	458.3	100	16
150	47	39	763.8	170	29

Note since PARAFIL® ropes consist of a closely packed core of cylindrical filaments there is always an air space amounting to 25-30% of the cross sectional area of the core. If the ropes are sealed to prevent the penetration of water then they will float. If the ropes are allowed to become completely saturated they will have this weight in sea water.

2. Tensile Properties

The load-extension curves are shown in Figure 1 and were obtained after pre-tensioning to 60% Nominal Breaking Load and then relaxing for 1 hour, using a PARAFIL® termination fitted to each end of the test length.

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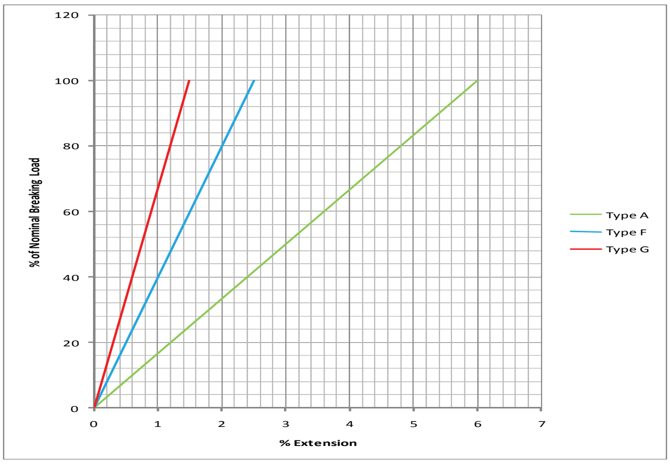
Figure 1 ~ Load Extension Curves for Type A, F and G PARAFIL®



More Detailed Load Extension curves are available from Linear Composites Ltd

The tensile properties given in Table 4 are based on the cross sectional area of fibre in the core.

The tensile properties are determined solely by the type and quantity of fibre used in the core and are independent of the sheath type.

TABLE 4 ~ Tensile Strength and Elastic Modulus of PARAFIL® Ropes

PARAFIL® Rope	Tensile Strength at NBL $kNmm^{-2}$	Elastic Modulus (Young's) $kNmm^{-2}$
Type A	0.6	9.8
Type F	1.9	77.7
Type G	1.9	125.6

Note: All Type A PARAFIL® ropes have the same core and therefore the same tensile properties. This is also true for the F and G series of PARAFIL®.

3. Effect of Temperature

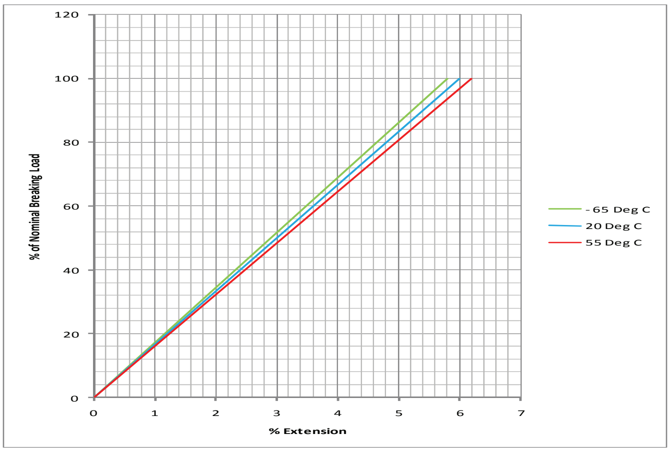
Polyester fibres melt at about 260° C. Aramid fibres do not melt but decompose at around 460° C. It is important to differentiate between 1) the effect of exposing the fibre to high temperatures and testing at that temperature, and 2) the effect of exposing to high temperatures for periods of time but testing at normal temperatures.

PARAFIL® based on aramid fibres has been tested at temperatures between –40° C and +80° C and has shown to have no detectable change in properties. Moreover aramid fibres exposed to a temperature of 150° C for long periods of time show no detectable change in residual strength when tested at normal temperatures. Aramid fibres show a strength loss of only 5% after 20 hours exposure at 200° C when tested at normal temperatures.

The Breaking Load of PARAFIL® based on Polyester has been found to be virtually unaffected when tested at temperatures between –65° C and +55° C but there are small changes in extension, as shown in Figure 2. Polyester fibres are not affected by long exposures at temperatures up to about 80°-100° C, but if tested at these temperatures they will show a small reduction in strength.

If PARAFIL® ropes are to be used at temperatures above 80° C for long periods of time it is recommended that a polyester elastomer sheath be used.

Figure 2 ~ Load Extension Curves for Type A PARAFIL® at Various Temperatures



4. Fire Resistance

Type A and A(C) and A(H) PARAFIL® will burn if exposed to a flame. However the sheathing materials can be made flame retardant if required (see separate Technical Note). Aramid fibres do not burn but decompose at around 460° C. As with Type A PARAFIL® a flame retardant sheath can be supplied.

5. Resistance to Environmental Effects

5.1 Corrosion Resistance

The ability of a rope to resist deterioration over long and continuous exposure to the environment is of prime importance. With this in mind PARAFIL® ropes have been evolved from materials which not only possess a high degree of mechanical toughness but which are extremely inert chemically. For example the core and sheath components used in PARAFIL® have outstanding resistance to the corrosive action of salt water, most inorganic salts and acids and many organic solvents. An example of this was shown when an examination of Type A ropes recovered from the sea water moorings after 10 years showed that the ropes were clean and in good condition. Tensile testing of both the rope and individual core fibres revealed no significant decrease in strength.

Resistance to marine biological attack is extremely high and the smooth sheath inhibits build up of marine growth.

5.2 Resistance to Sunlight

The black polyethylene and polyethylene copolymers used for the sheathing of PARAFIL® ropes are especially formulated for maximum resistance to Ultra Violet degradation. For instance, exposure of the black Polyethylene compounds to Florida sunlight for 29 years caused no significant degradation or embrittlement.

5.3 Icing

There is very poor adhesion between ice and the smooth water repellent surface of PARAFIL® ropes. This was clearly demonstrated in tests carried out in the British Aircraft Corporation climatic chamber.

Trials on fishing vessels in Icelandic waters have shown that PARAFIL® mast-stays freed themselves of ice when aided by the ships vibration transmitted through the rigging.

5.4 High Speed Loading

Type A PARAFIL® ropes have been tested under conditions of high speed loading by the National Engineering Laboratories in the UK. At a loading speed of 15.2m/sec (50ft/sec) on a 6m (20ft) long sample, breaking loads 10-15% below nominal were recorded. The energy absorbed was measured as 2000 joules (1500ft.lbf) per tonne of breaking load (note this was for a 6m length).