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THE DEVELOPMENT OF A HIGH PRODUCTIVITY HALOGEN FREE, LOW SMOKE, FIRE RETARDANT CABLE SHEATHING COMPOUND

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Compound Design Requirements

- The market for cables is highly competitive
- There are many LSOH compounds having similar basic characteristics.
- As cable volume demand increases, there is a need for increased extrusion capacity.

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Compound Design Requirements

- This increased capacity can arise through the purchase of new additional extrusion machines, or ….
- It can be achieved through the development of compounds capable of extrusion at higher speeds.

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Compound Design Requirements

- Any such new compound must be capable of satisfying the performance requirements for the cable, typically to HD 624.7 S1 for data cables
- The finished cables must, in addition to being halogen free, pass the IEC60332 Part1 or IEC60332 Part 3 fire test.
- Eventually, the cables so produced will need to be classified according to the new Construction Product Directive (CPD) designation

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Properties of Compound S800

Mechanical Properties

Property	Result	Method
Tensile Strength	12 MPa	IEC 60811-1-1
Elongation at break	150 %	IEC 60811-1-1
After Ageing (168h at100°C)		
Tensile Strength	13.2 MPa (+10%)	IEC 60811-1-1
Elongation at break	128 % (-15%)	IEC 60811-1-1
Other Properties		
Hot Pressure (80°C)	30% penetration	IEC 60811-3-1
MFR (21.6kg, 150°C)	10 g / 10min	ISO 1133
Density	1.5	ASTM D-792

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Properties of Compound S800

Fire Test Properties

Property	Result	Method
Oxygen Index	30%	ISO 4589-2
Flammability Temperature	345°C	ISO 4589-3
Halogen Acid Evolution	0	IEC 60754-1
Acid Gas Evolution	pH = 5.5 Conductivity = 5µS.cm^{-1}	IEC 60754-2

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Comparison of Compound S800 with some existing products

COMPOUND	MFR (21.6kg, 150°C)	Method
S300	4.5 g / 10 min	ISO 1133
S500	6 g / 10 min	ISO 1133
S800	10 g / 10 min	ISO 1133

High MFR generally gives rise to easier extrusion

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Comparison of Compound S800 with some existing products

Compound	Oxygen Index	Flammability Temperature
D160/1/120	28	245 °C
S300	35	270 °C
S500	35	255 °C
S800	30	345 °C

- Compound S800 is based on different chemistry to compounds S300 and S500
- This gives rise to a different reaction to fire tests

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Comparison of Compound S800 with some existing products

- A key design parameter for a data cable is to pass IEC60332 Part 1 vertical fire test.
- The performance of any sheathing material in this test not only dependent on its fire properties, but also on the cable design and sheath thickness
- In order to try to gauge the relative performance, specimen of various thicknesses were subjected to the UL94 test, and the minimum thickness at which a V0 rating could be achieved was determined.

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Comparison of Compound S800 with some existing products

Compound	Oxygen Index	Flammability Temperature	Minimum thickness of specimen to achieve a UL94 V0 rating
D160/1/120	28	245 °C	3.90 mm
S300	35	270 °C	2.75mm
S500	35	255 °C	3.05 mm
S800	30	345 °C	3.15 mm

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Comparison of Compound S800 with some existing products

- Since both S300 and S500 are known to generally enable typical data cables to pass IEC60332 Part 1 at the sheath thicknesses common in the industry, then S800 might be expected to provide a similar performance.

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Extrusion of Compound S800

- The next stage in the development was to examine the processability of Compound S800 in comparison with existing compounds.
- This has been performed using standard industrial extrusion equipment.
- Extrusion bleed trials were performed followed by cable manufacture
- A number of parameters were recorded, allowing calculation of screw torque, specific work, normalised output etc

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Extrusion of Compound S800

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EXTRUSION TRIAL REPORT

CUSTOMER, MATERIAL & EXTRUDER		CABLE TYPE & CONSTRUCTION				TOOLS	
Date (dd/mm/yy)						Die ID (mm)	7.3
Customer						Tip OID (mm)	5.0
Material	S800	SCREW		MOTOR		Cable OID (mm)	6.2
Specific Gravity	1.53	Type	LSF	Size (kW)	90	Wall Thickness	0.6
Extruder Manufacturer		Compression	1.2:1	Max Current	218	Core OID (mm)	4.8
Diameter (mm)	75	Used for	LSF	Max Voltage	440	Draw Down Ratio	1.54
L/D	24	Max Speed	120.0	Max Speed	2600	Draw Down Balance	0.88

DATE	10/11/2005	10/11/2005	10/11/2005	10/11/2005	10/11/2005	10/11/2005	10/11/2005	10/11/2005	10/11/2005	10/11/2005	10/11/2005	10/11/2005
TIME (hh:mm)		9:33	9:35	9:37	9:40	9:45	9:48					
TEMPERATURE PROFILE												
Zone 1	130	128	130	132	131	130	129					
Zone 2	135	138	139	134	133	136	136					
Zone 3	140	142	142	141	138	138	140					
Zone 4	150	150	150	150	150	150	150					
Zone 5												
Flange	155	156	154	156	156	156	156					
Head 1	160	160	160	160	160	160	160					
Head 2	160	169	160	161	161	160	161					
Die	170	169	170	170	171	170	170					
Screw												
Screw Speed (rpm)		10.0	20.0	30.0	40.0	45.0	54.6					
Motor Current (amps)		58	77	79	75	77	86					
Line Speed (metres/minute)												
Melt Temperature (oC)		171	176	180	176	172	178					
Vacuum (ON/OFF)												
Head Pressure (psi)		4600	6030	6500	6900	7200	7700					
Instantaneous Power (kW)		2.13	5.65	8.69	11.00	12.71	17.22					
Screw Torque (Nm)		2031	2696	2766	2626	2696	3011					
Output (kg/hr)		36.5	82.8	127.4	167.0	171.0	196.2					
Output (litres/hr)		24.3	55.2	84.9	111.3	114.0	130.8					
Normalised Output (kg/hr/rev)		3.65	4.14	4.25	4.18	3.80	3.59					
Normalised Output (l/hr/rev)		2.43	2.76	2.83	2.78	2.53	2.40					
Specific Work (kWhr/kg)		0.058	0.068	0.068	0.068	0.074	0.088					
Specific Work (kWhr/lb)		0.087	0.102	0.102	0.089	0.111	0.132					
COMMENTS												

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Extrusion of Compound S800

- The extruder used was a typical 75mm, 24 L/D single screw machine fitted with an appropriate crosshead
- The machine was normally used for the industrial manufacture of data cables

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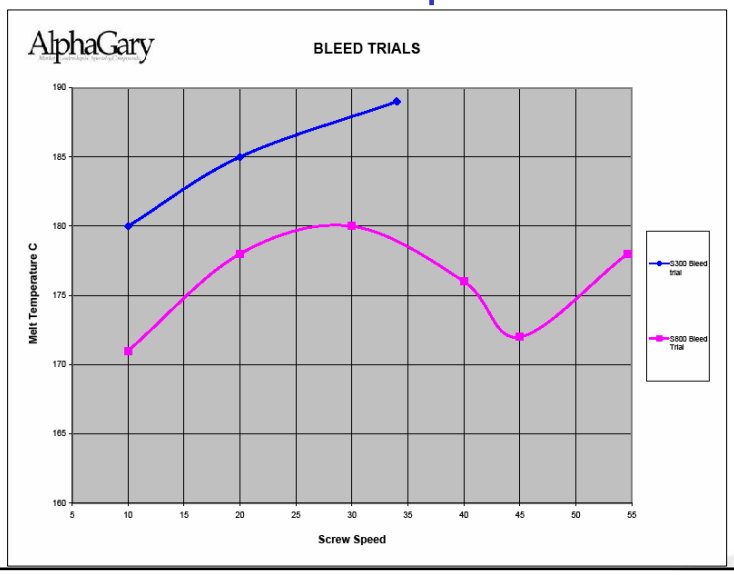
Extrusion of Compound S800



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Extrusion of Compound S800

- Compound S300 had a significantly higher melt temperature than compound S800 at all screw speeds.
- Extrusion of S300 was limited to 34rpm as the maximum melt temperature for the compound had been reached.
- The chemistry of S800 allows higher processing temperatures, but these were not reached during the bleed trial

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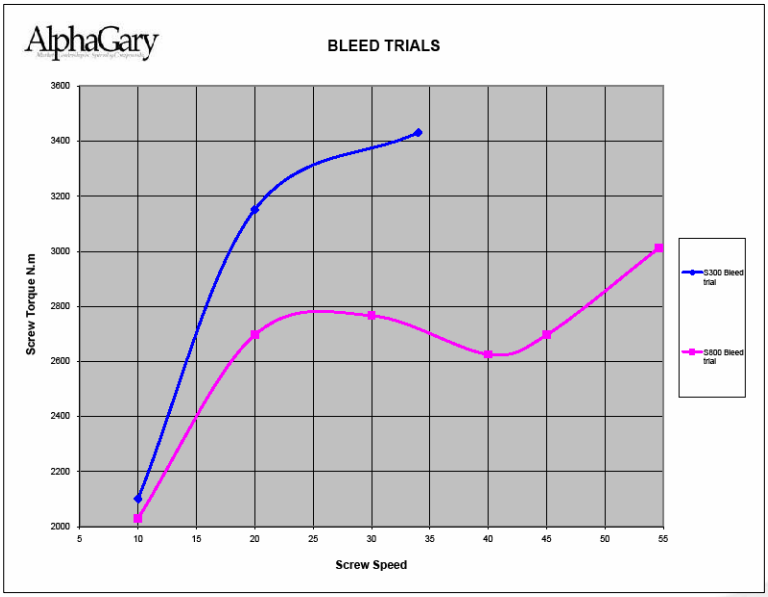
Extrusion of Compound S800



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Extrusion of Compound S800

- The extruder screw torque was much lower for Compound S800 than for Compound S300
- The motor current was much lower for Compound S800
- These observations are expected as the melt viscosity of the S800 is significantly lower than that of S300

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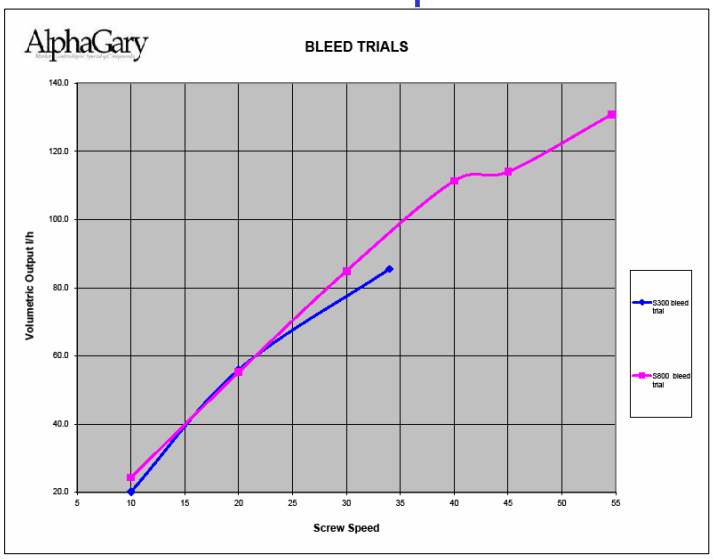
Extrusion of Compound S800



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Extrusion of Compound S800

- Since the extruder can be considered to be a volumetric pump, it would be expected that each compound should lie on approximately the same line.
- S300 volume dropped off at the higher screw speeds, probably as a result of increased back pressure.
- S300 was limited to 85 l/h output owing to a melt temperature limitation, but S800 achieved a maximum output of 130 l/h

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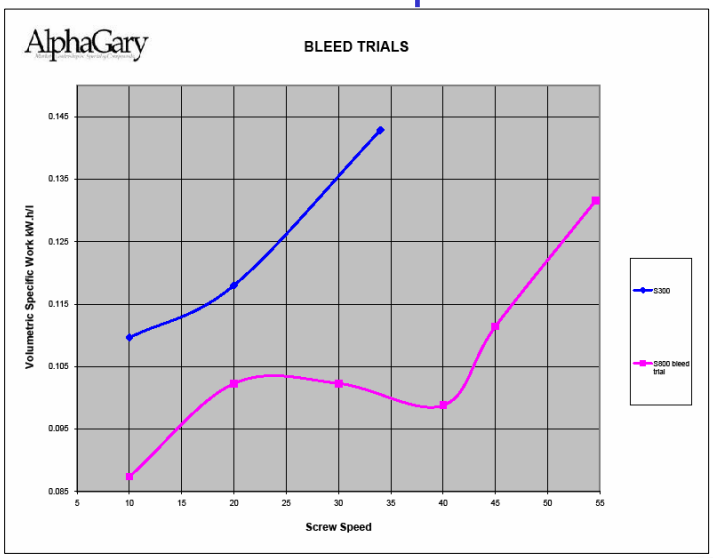
Extrusion of Compound S800



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Extrusion of Compound S800

- It is possible to calculate the amount of mechanical work performed on the compound during extrusion.
- Compound S800 requires less energy than S300 to extrude the same volume
- This in turn gives rise to lower melt temperature and screw torque as reported

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Extrusion of Compound S800

- Following these bleed trials, a data cable core was threaded through the crosshead, and a production run was undertaken.
- Obviously, it is less easy to measure the melt temperature, but it is possible to calculate the screw torque, power and work during the production run.

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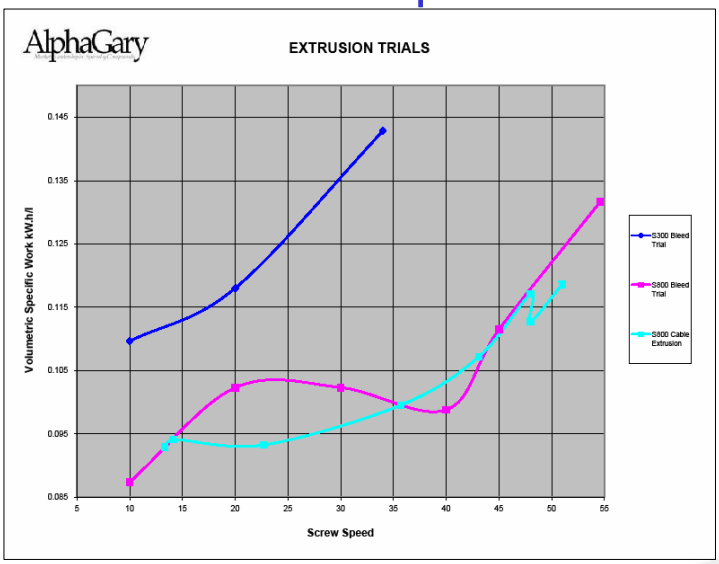
Extrusion of Compound S800



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Extrusion of Compound S800

- The extruder performed in the production run, in a similar manner to that of the bleed trials.
- The calculated volumetric work was very similar to that of the bleed trial
- The cable was produced at over 50% faster line speed than with Compound S300

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Extrusion of Compound S800

- The data cable, manufactured to standard sheath wall thickness, was tested to IEC 60332 Part 1
- And gave a '**PASS**' result

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Extrusion of Compound S800

- Compound has also been extruded on a variety of screw designs on different extruders
- These include both low compression screws, and higher compression screws that have normally been used for the extrusion of PVC compounds.

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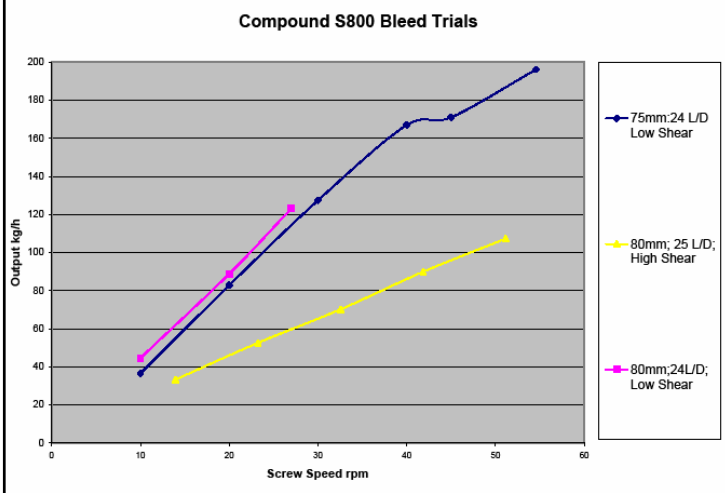
Extrusion of Compound S800



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Extrusion of Compound S800

- Low compression screws are characterised by having a relatively high volume at the metering end, and consequently can discharge a greater volume of material per screw revolution.
- The high compression screw was usually used to process PVC compounds

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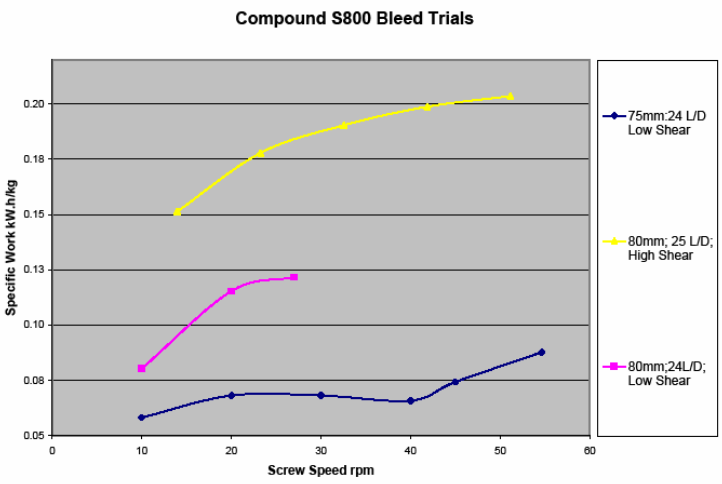
Extrusion of Compound S800



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Extrusion of Compound S800

- The high compression screw required more power to rotate and hence performed a higher level of mechanical work on the compound during extrusion.
- This increased level of work led to a higher melt temperature

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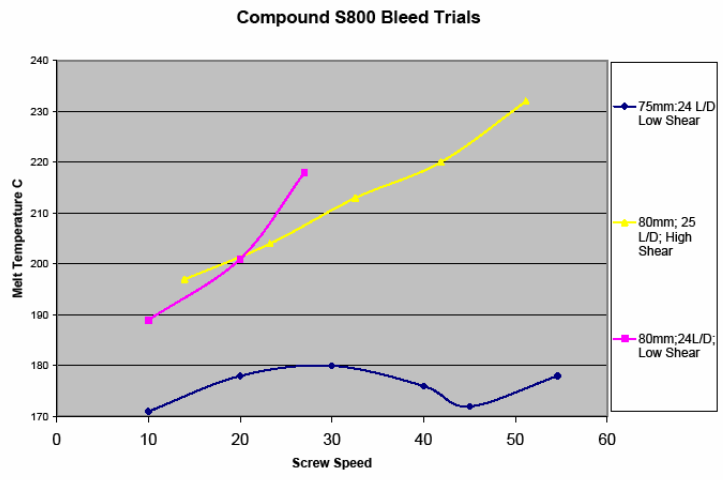
Extrusion of Compound S800



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Extrusion of Compound S800

- Despite the higher melt temperature encountered using the high shear screw, there was no evidence of porosity or gassing of the compound.
- This is achieved via the chemistry of the compound, which may be processed at temperatures above 200°C

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CONCLUSIONS

- Compound S800 can be processed at high speed relative to some existing cable sheathing compounds
- Melt temperature in excess of 200°C does not give rise to porosity
- Compound S800 may be extruded on screws that typically process PVC compounds
- Compound S800 requires lower power and energy for processing.

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CONCLUSIONS

- Low compression screws give higher outputs in combination with lower power and heat build-up
- Oxygen Index is not a good guide to cable performance in a vertical fire test

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CONCLUSIONS

- Data cables produced with Compound S800 have passed the IEC 60332 Part 1 vertical fire test
- More recently, it has been reported to us, that a steel wire armoured power cable (to BS6724:1997) jacketed with compound S800, has passed IEC 60332 Part 3C vertical fire test. This provides a solution for BS7655, Section 6.1:1997; LTS 1 sheath performance.

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CONCLUSIONS

- This new halogen free fire retardant sheathing compound complements the existing range of cable compounds available from AlphaGary.
- Depending on cable type and construction, we would expect cables would be accorded a Class D or Class C in the new CPD classification matrix, also having the low acid gas, low smoke and low drip additional characteristics

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Thank You for your attention

ANY QUESTIONS?