

Using 100% Recycled ABS

Phase 2 Prototype Development and

Testing

## APPENDIX II



**Materials Strategy for BT plc**

**Materials Comparison Testing**

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## 1. Background

The De Montfort University Design Unit has recently completed a risk assessment relating to the use of %100 recycled plastic in their products, typically DECT phones

This has been part of BT's Better Future initiative to help deliver on BT's strategic aim to be a responsible and sustainable business leader.

The assessment will contribute to BT's 'North Star Goals' to be part of the wider, Better Future programme structure, achievable within 5 to 15 years. One of these North Star Goals is 'Net Good' where BT's products will achieve three times the carbon saving for their customers than they emit over their lifetime. An enabler of Net Good is implementation of the Circular Economy (CE) principles.

BT's goal is to make good quality, inclusively-designed products that exceed BT customers' expectations, while minimising the environmental impacts inherent in their manufacture and use. This is going far beyond 'compliance'.

## 2. Evaluation of ABS, rABS and Recycled Polycarbonate/ABS Mix

A number of test methods were used to compare identical injection moulded samples of Acrylonitrile Butadiene Styrene (ABS), 100% post-consumer recycled Acrylonitrile Butadiene Styrene (rABS) and 100% post-consumer recycled Polycarbonate/ABS mix (PC/ABS) against each other to evaluate their suitability for use in consumer products (fig 1).



*Fig.1 (left to right) rABS, rPC/ABS and ABS mouldings from the Materials Prototype tooling of a DECT handset.*

## 2.1 Screw Torque Tests

A calibrated 'dial indicating screwdriver' (Gedore TT500 FH, fig.2) was used to tighten a M3 thread forming screw in a moulded boss (fig. 3). The screw was then over-torqued until the plastic boss had stripped; meaning the screw no longer gripped the plastic material. The force at which the boss stripped was recorded for samples of ABS, rABS and PC/ABS (see figures 4 to 7).



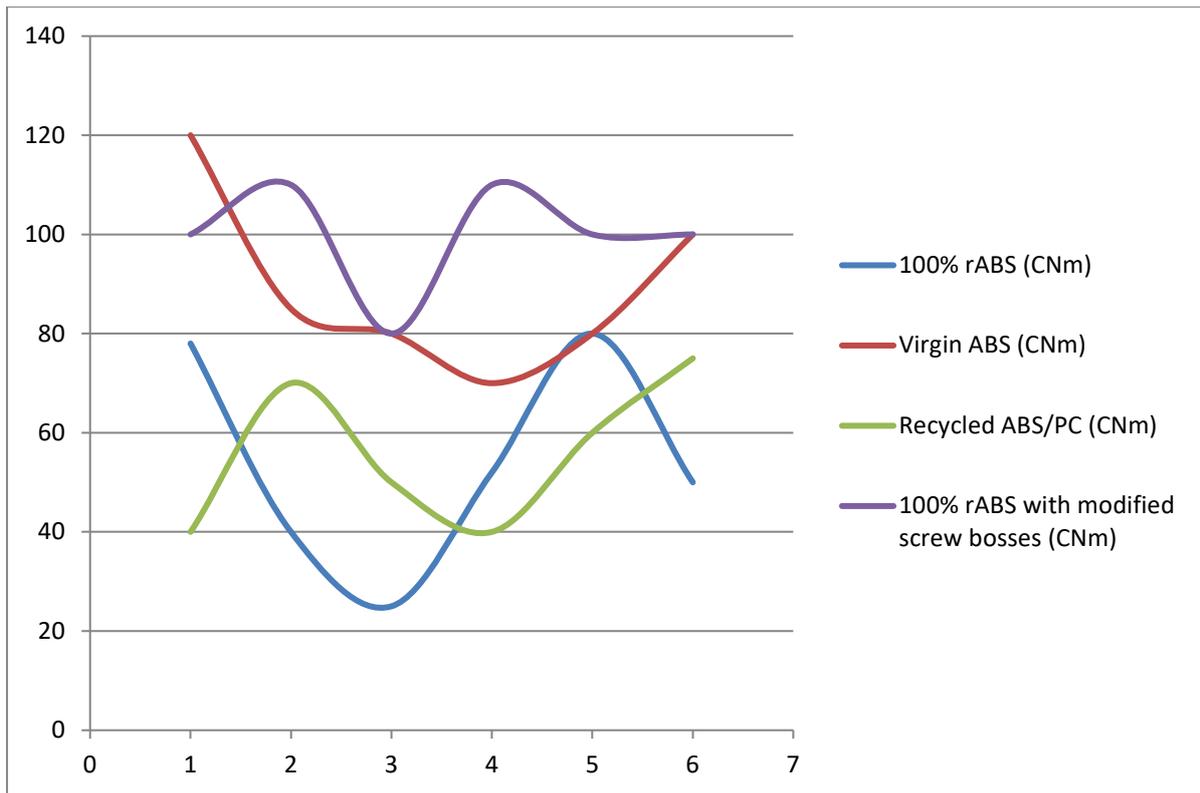
*Fig.2 Gedore TT500 FH dial indicating screwdriver*



*Fig.3 Dial indicating screwdriver and material sample*

100% rABS (CNm)	Virgin ABS (CNm)	Recycled ABS PC (CNm)	100% rABS with modified screw boss (CNm)
78	<b>120</b>	<b>40</b>	100
40	85	70	110
<b>25</b>	80	50	<b>80</b>
52	<b>70</b>	40	<b>110</b>
<b>80</b>	80	60	100
50	100	<b>75</b>	100

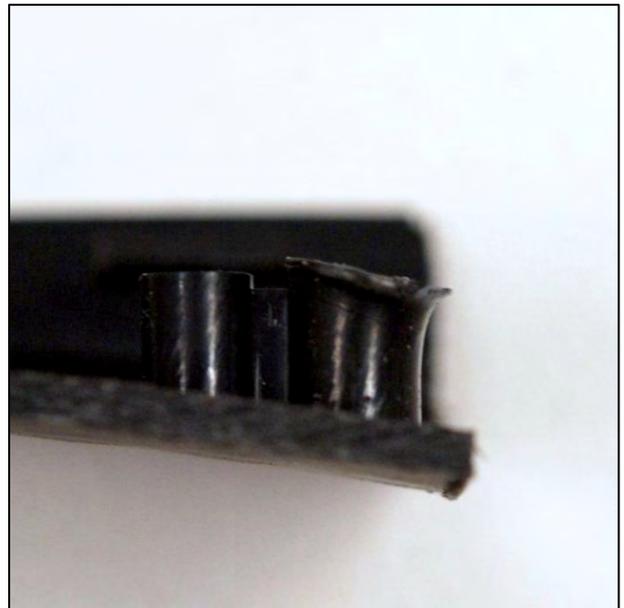
*Fig.4 Results of screw torque tests*



**Fig.5 Results of screw torque tests**



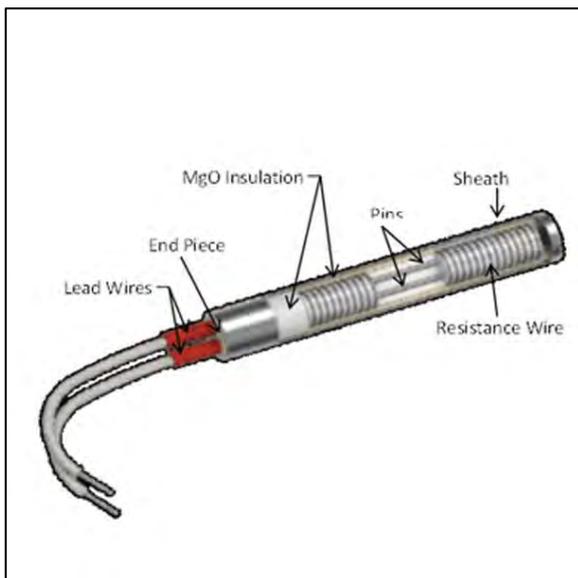
**Fig.6 Moulded screw bosses post test**



**Fig.7 Moulded screw bosses post test**

## 2.2 Heat Tests

Testing was conducted on the handset mouldings to examine the effect of heat on the different polymers, simulating an overheated/faulty battery (for example). The testing was carried out using a 200Watt “AAA battery-sized” cartridge heater (figure 8). The heater was placed inside an assembled set of DECT handset mouldings in place of a triple-A battery. A sintered Nylon component was produced and used in place of the handset’s front lens and a Nylon handset holder was produced to ensure all the samples were positioned in the same way throughout the tests. The cartridge heater was connected to a power supply unit to heat up for one hour.



**Fig.8 Cartridge heater**



**Fig.9 Heat testing**

The external temperature of the assembly was monitored periodically throughout the tests using an infrared thermometer (see figure 9) and examined for signs of cosmetic and structural damage (see figures 10 to 13).



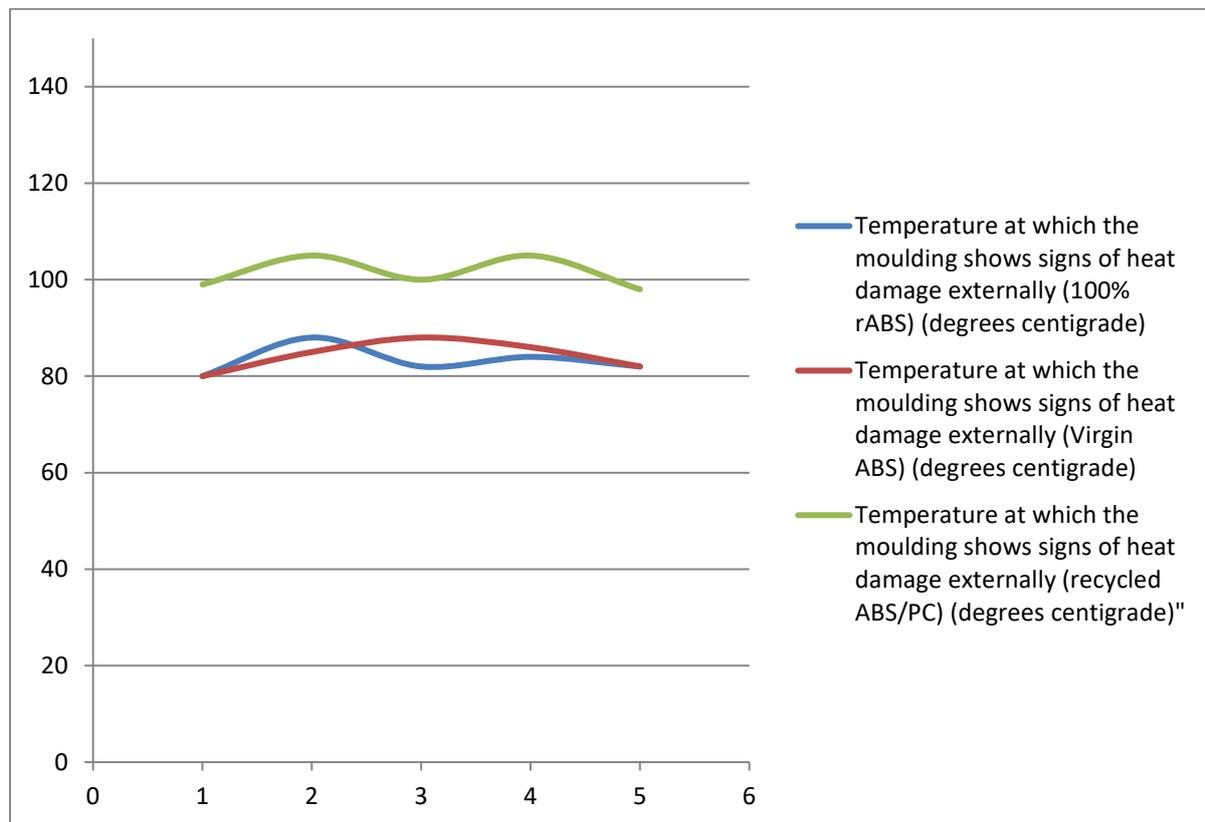
**Fig.10 Sample with signs of heat damage**



**Fig.11 Sample after one hour**

Temperature at which the moulding shows signs of heat damage externally (100% rABS) (degrees centigrade)	Temperature at which the moulding shows signs of heat damage externally (Virgin ABS) (degrees centigrade)	Temperature at which the moulding shows signs of heat damage externally (recycled ABS PC) (degrees centigrade)
80	80	99
88	85	105
82	88	100
84	86	105
82	82	98

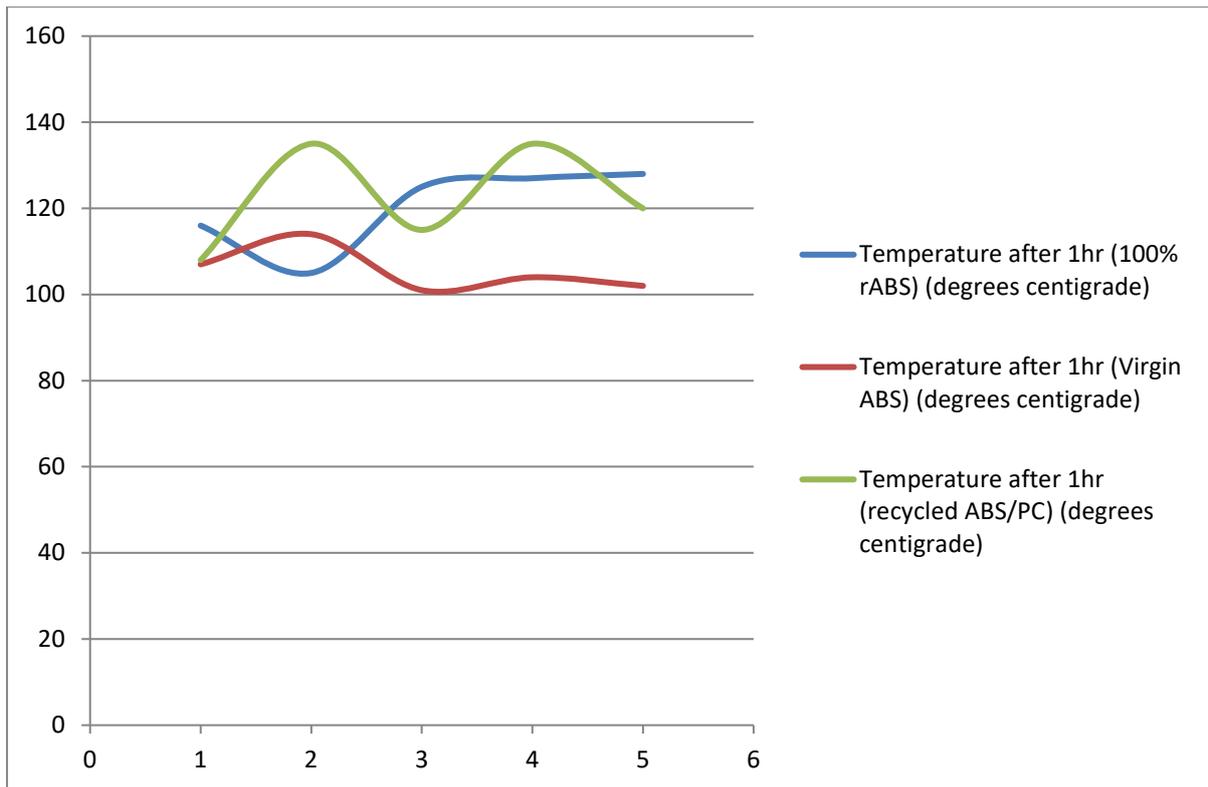
**Fig.12 Results of heat test**



**Fig.13 Results of heat test**

Temperature after 1hr (100% rABS) (degrees centigrade)	Temperature after 1hr (Virgin ABS) (degrees centigrade)	Temperature after 1hr (recycled ABS PC) (degrees centigrade)
116	107	108
105	114	135
125	101	115
127	104	135
128	102	120

**Fig.14 Results of heat test**



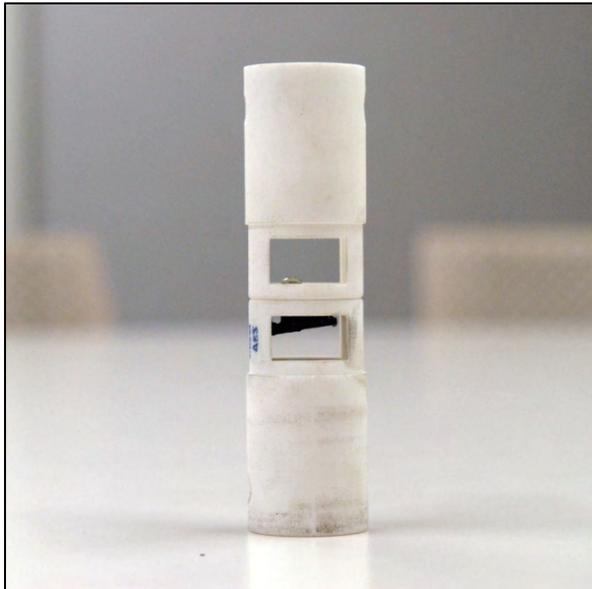
**Fig.15 Results of heat test**



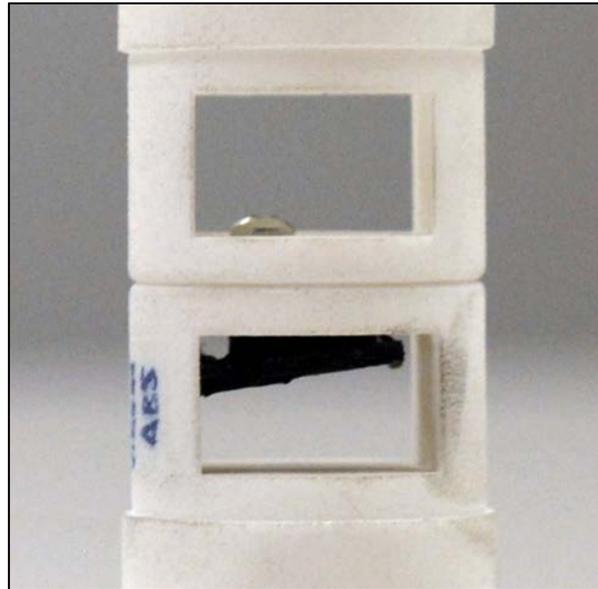
**Fig.16 Material samples showing cosmetic damage after heat testing**

### 2.3 Screw Pull-out Tests

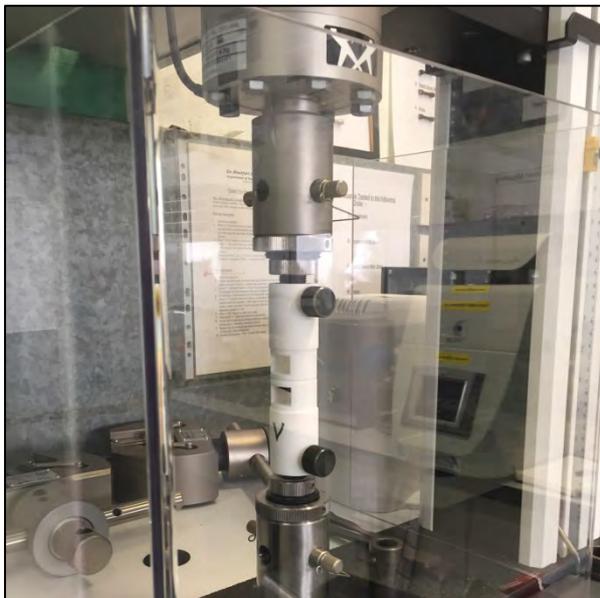
Screw pull-out tests were conducted on the moulded screw bosses using an Instron 3367 Dual Column Testing System to pull an M3 thread forming screw from the mouldings. Custom sample holders were produced in sintered Nylon (figures 17 and 18) allowing a screw to be pulled from mouldings which were trimmed down to the area surrounding the bosses. The results are documented in figures 21 – 24.



**Fig.17 Sample holders**



**Fig.18 Sample holders**



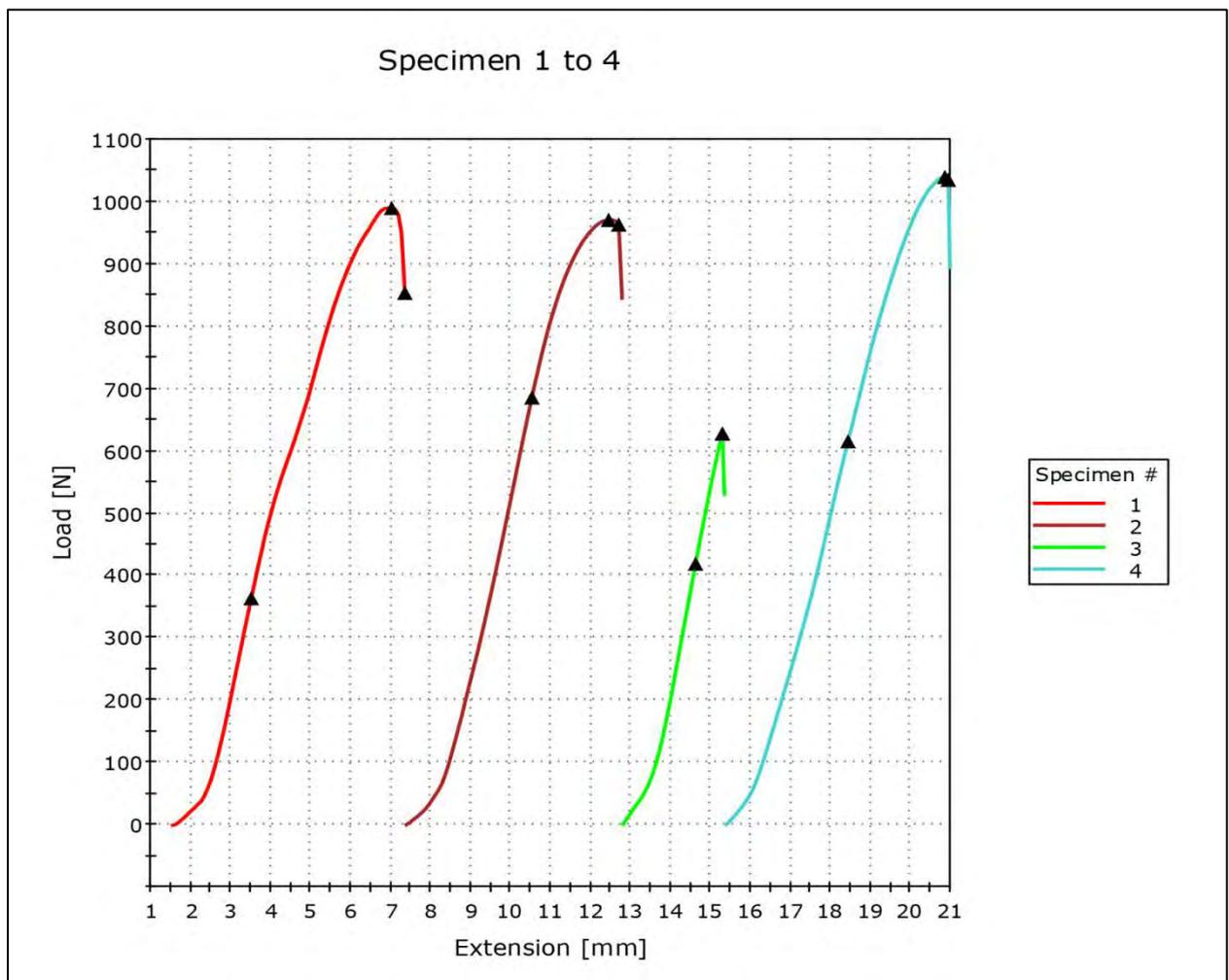
**Fig.19 Instron 3367 Testing System**



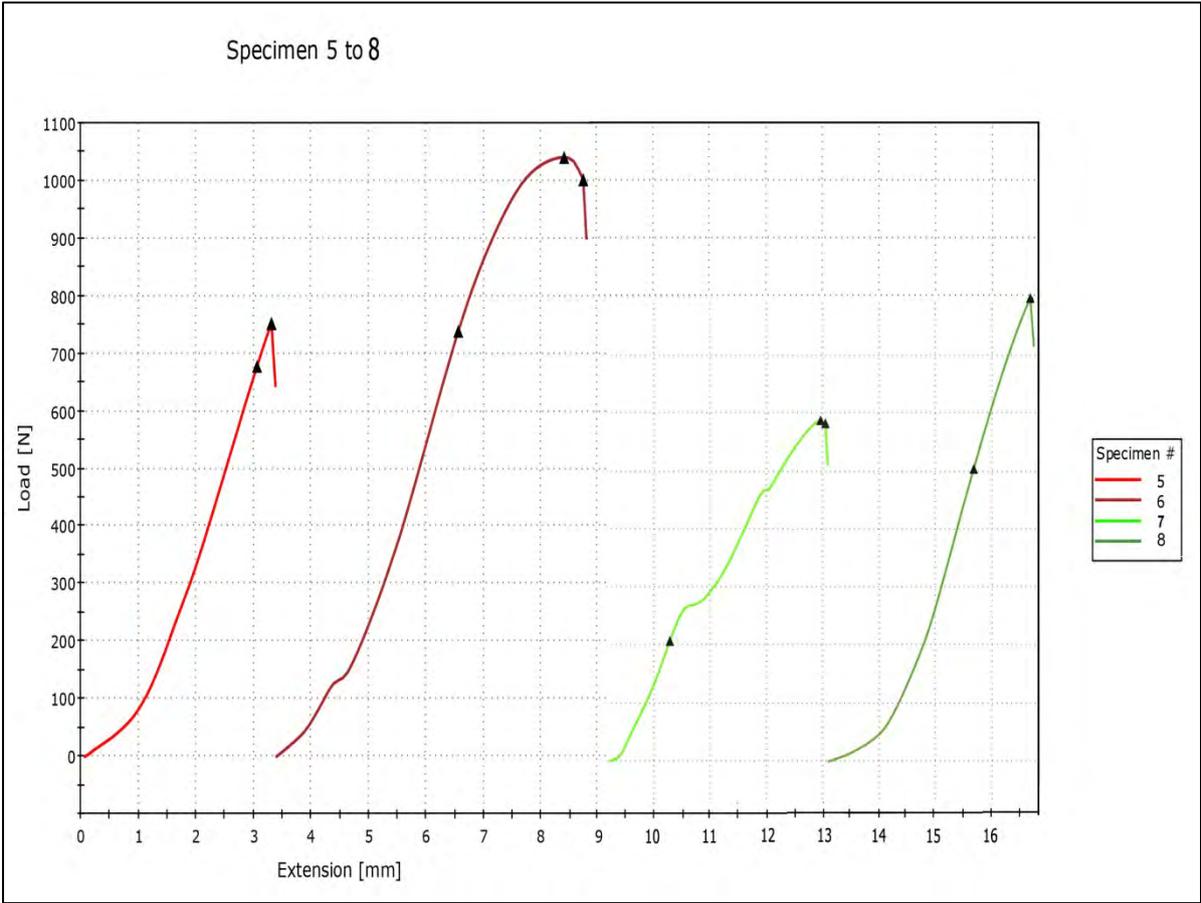
**Fig.20 Instron 3367 Testing System**

	Material	Maximum Load (N)	Break (Load 0 N)	Extension at Break (Load 0 N) mm
1	ABS	989	853	7.361
2	Recycled ABS	970	963	5.43
3	ABS	628	628	2.532
4	Recycled ABS	1039	1034	5.697
5	ABS	752	752	3.313
6	Recycled PC/ABS	1040	1001	5.377
7	Recycled PC/ABS	588	583	4.043
8	Recycled PC/ABS	799	799	3.756

**Fig.21 Screw pull-out test results**



**Fig.22 Screw pull-out test results – (left to right) ABS, rABS, ABS, rABS**



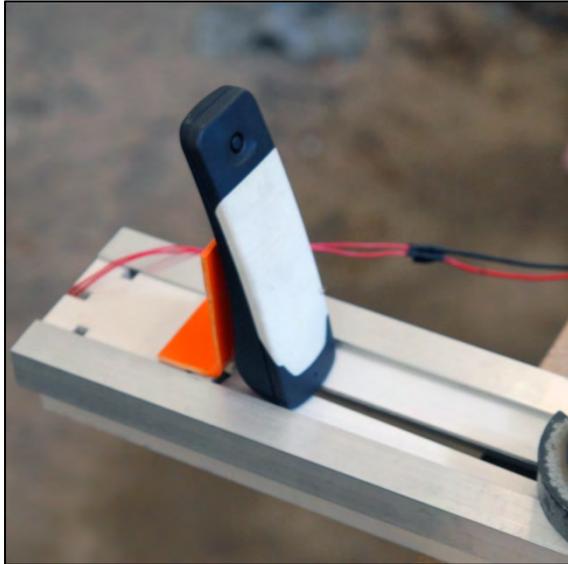
**Fig.23 Screw pull-out test results – (left to right) ABS, rPC/ABS, rPC/ABS, rPC/ABS**



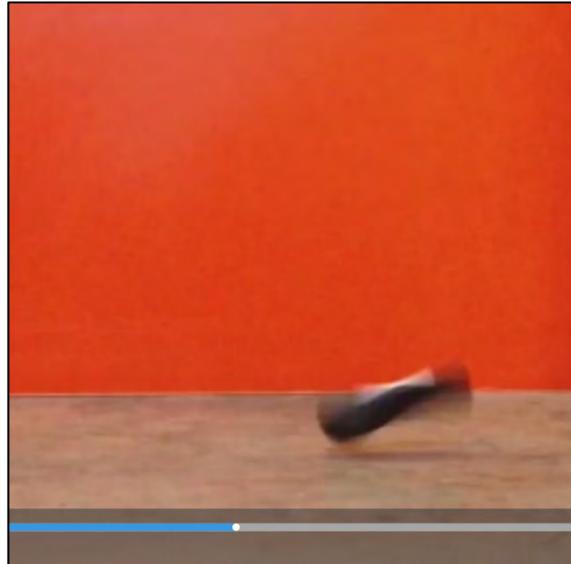
**Fig.24 Screw pull-out test results ABS (left) rABS (right)**

## 2.4 Drop Tests

Drop tests were carried out on the samples in accordance to S4002 v14 “*Dynamic, Environmental & Ageing Test Requirements for Consumer Devices*”, test method ‘IEC 60068-2-31’; with the handset being dropped from a rig onto its upper and lower faces from a height of 1.5 metres onto a concrete surface. The tests were video recorded (figure 26) and the test samples were examined for cosmetic and structural damage.



**Fig.25** Drop test rig



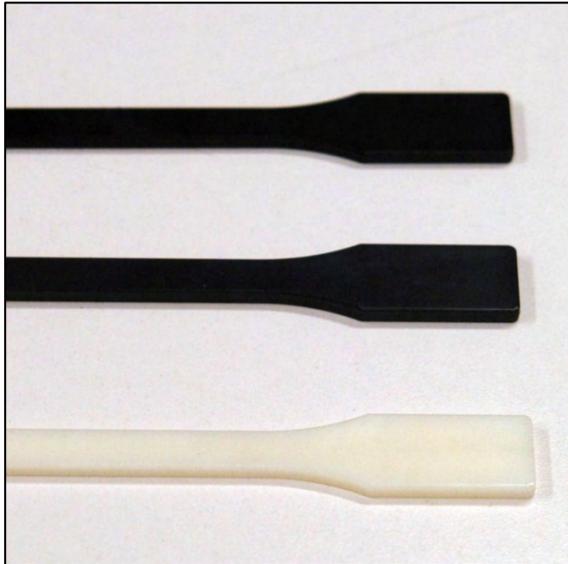
**Fig.26** Still from a drop test video recording



**Fig.27** Drop test sample examination (left to right) ABS, rPC/ABS

## 2.5 Tensile Tests

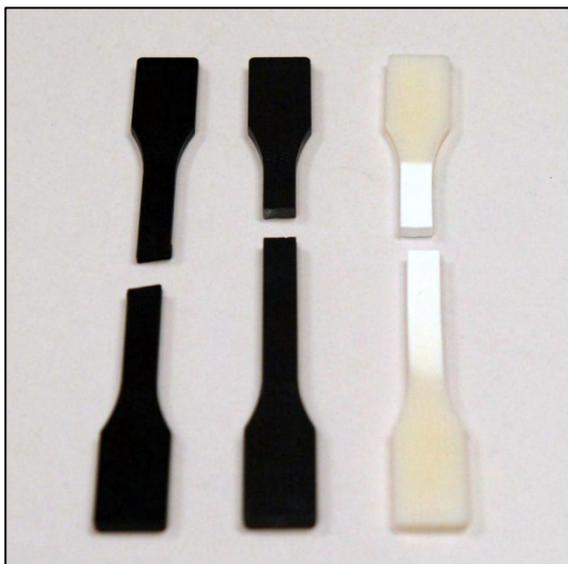
Tensile tests were conducted on moulded material sample plaques using an Instron 3367 Dual Column Testing System (see figure 30).



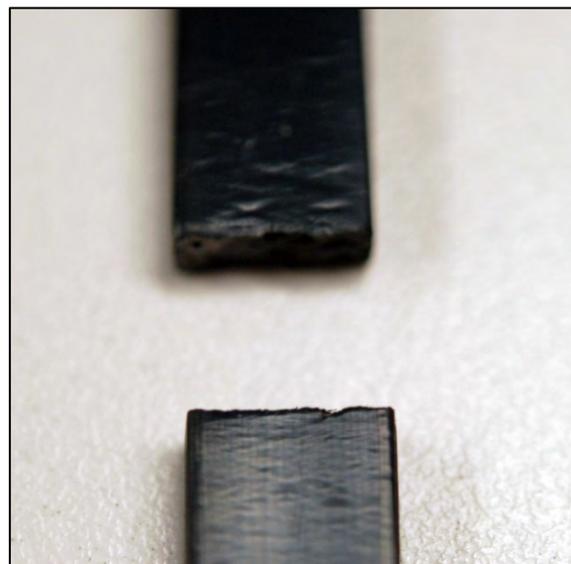
**Fig.29 Material sample plaques**  
(top to bottom) rABS/PC, rABS, ABS



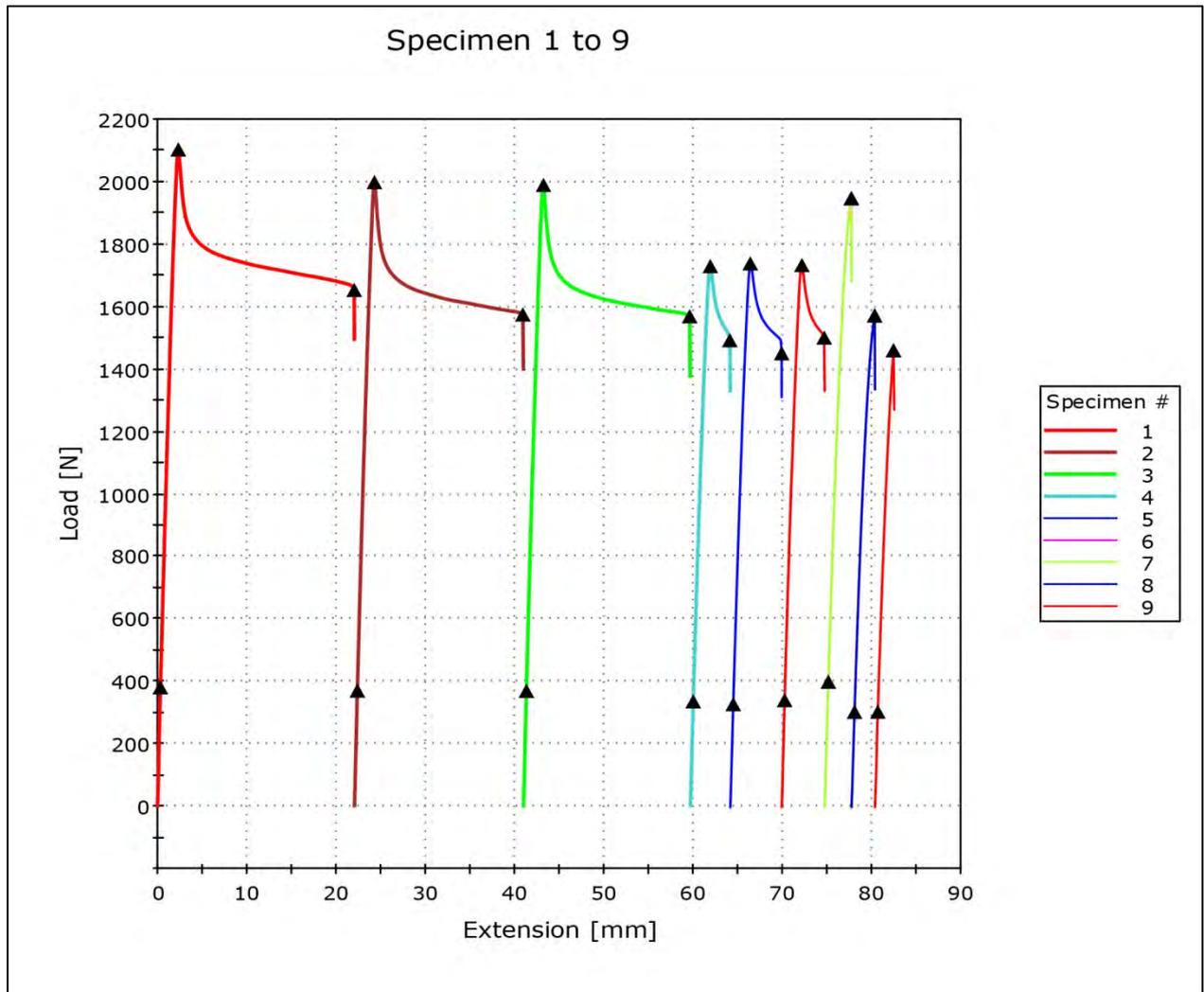
**Fig.30 Instron 3367 Tensile Testing System**



**Fig.31 Material sample plaques post-test**  
(left to right) rABS/PC, rABS, ABS



**Fig.32 rABS material sample plaque post-test**



**Fig.33 Tensile test results – ABS (specimens 1-3), rABS (specimens 4-6) & PC/ABS (specimens 7-9)**

	Material	Maximum Load (N)	Break (Load 0 N)	Extension at Break (Load 0 N) mm
1	ABS	2103	1654	22.007
2	ABS	1999	1575	18.841
3	ABS	1989	1570	18.591
4	Recycled ABS	1730	1493	4.424
5	Recycled ABS	1739	1452	5.758
6	Recycled ABS	1733	1501	4.758
7	Recycled PC/ABS	1947	1947	3.008
8	Recycled PC/ABS	1572	1572	2.591
9	Recycled PC/ABS	1461	1461	2.092

**Fig.34 Tensile test results**

### 3.0 Conclusions

Overall, these tests indicate that there is very little mechanical difference between moulded virgin ABS polymer and moulded 100% post- consumer recycled ABS polymer. The main differences seem to be cosmetic. 100% recycled ABS lost mechanical properties when coloured master-batch was added during moulding; the absence of master-batch colouring leaves the parts with a charcoal grey colour rather than a more desirable black colour. In comparison, the post-consumer recycled Polycarbonate/ABS mix mouldings were closer to the black colour of the virgin ABS mouldings.

The standard tightening torque for M3 screw thread is 1.1 Nm. The screw torque tests undertaken show a maximum stripping force of 120 CNm (1.2 Nm) for virgin material and 110 CNm (1.1 Nm) for recycled material with modified screw bosses; with a range of 40 CNm (0.4 Nm) between the two. This is a relatively small difference. The PC/ABS samples stripped at a slightly lower force, with a minimum stripping force of 40 CNm (0.4 Nm) and a maximum of 75 CNm (0.7 Nm), a range of 35 CNm (0.35 Nm). This suggests that PC/ABS mix is slightly more brittle than the other material samples.

The tensile tests show that all three materials have a similar break load. However, the recycled materials are less flexible with a considerably shorter extension at break than the virgin material, with the PC/ABS mix being more brittle than the rABS.

All three materials fared well in the drop tests, with no internal clip geometry cracking or breaking.....