BioPure BioBarb Impact Testing report

Version 2, 10th November 2008

1. Purpose

To conduct tests on a range of Large Flange Biobarbs, to determine the effects of the following on the impact strength of the Biobarbs.

- New flange design against the Original flange design
- Effects of Sterilisation
- Huntsman (Bovine-tallow free) material compared with the existing Borealis material

2. Background

Runfold Medical Ltd (RML) were asked by Bio Pure Technology Ltd to undertake destructive testing of the Bio Pure Large Flange Biobarbs in the following combinations:

Batch	Ref	Description
1	BAN	Borealis Autoclaved New Generation
2	BAO	Borealis Autoclaved Original
3	BGN	Borealis Gamma New Generation
4	BGO	Borealis Gamma Original
5	BUN	Borealis Untreated New Generation
6	BUO	Borealis Untreated Original
7	HAN	Huntsman Autoclaved New Generation
8	HGN	Huntsman Gamma New Generation
9	HUN	Huntsman Untreated New Generation

3. Summary

This testing was carried out in two phases:

Phase 1

The 0.125”, 0.250” & 0.375” sizes of all of the above variants were tested by Loughborough University in all of the above combinations 1-9.

Phase 2

The 0.500”, 0.626”, 0.750” 0.875” & 1.00” sizes of the Borealis and Huntsman variants were tested by Brunel University

A series of tests designed to simulate and exceed normal operating conditions undertaken

- To compare the effects of Gamma Irradiation and Autoclaving on the performance of the Biobarbs when compared with Non Sterilised Biobarbs. The (in – use) durability and robustness of Biobarbs both before and after sterilisation by Gamma Irradiation and Steam Autoclaving will be tested.
- **To compare the strength of the original flange design with that of the new flange design.**

- To compare the strength of the Huntsman (Bovine-tallow free) material against the Borealis material in all conditions, untreated, Gamma Irradiated and Autoclaved.

4. Scope

The scope of work was to:

- Conduct impact tests on the large Flange Biobarbs listed above
- Analyse the test results.
- Report the findings.

5. References

Item #	Document	Reference
1	Loughborough University Test Report	5642/MP/RUN
2	Brunel University Test Report	2091/03/08
3	Brunel University Test Report	2091/10/08

6. Equipment and Materials

The equipment used for the Impact Testing is listed in the Test Reports (Appendix 1 & 2)

Materials used for the Biobarb Impact Testing were free issued by Biopure Technology Ltd

7. Results

Phase 1 – Loughborough University

Each batch (1 to 9) of Biobarbs were subjected to the same testing under controlled conditions.

0.125 inch Biobarb

Batch No:	Sample Ref	Peak Force (N)	Defl at Peak Force (mm)	Energy at Peak Force (J)	Defl at Failure (mm)	Energy at Failure (J)
1	BAN	172.841	17.19	1.873	24.09	2.718
2	BAO	111.740	8.75	0.561	13.91	0.969
3	BGN	184.316	17.52	1.940	21.96	2.377
4	BGO	106.873	6.98	0.374	11.34	1.212
5	BUN	178.345	19.59	2.232	27.07	3.137
6	BUO	115.429	7.74	0.461	11.08	0.691
7	HAN	170.806	15.70	1.674	19.74	2.062
8	HGN	159.276	15.22	1.504	19.79	1.862
9	HUN	173.903	17.28	1.853	23.27	2.539

Table 7.1

0.250 inch Biobarb

Batch No:	Sample Ref	Peak Force (N)	Defl at Peak Force (mm)	Energy at Peak Force (J)	Defl at Failure (mm)	Energy at Failure (J)
1	BAN	278.430	8.75	1.242	12.22	1.761
2	BAO	125.305	5.46	0.319	8.84	0.556
3	BGN	265.072	8.42	1.088	11.84	1.586
4	BGO	110.146	4.71	0.223	8.00	0.438
5	BUN	273.449	8.94	1.239	12.37	1.749
6	BUO	127.200	5.56	0.317	7.46	0.570
7	HAN	272.000	8.47	1.162	11.67	1.655
8	HGN	251.892	8.52	1.263	12.49	1.779
9	HUN	273.867	8.88	1.230	12.27	1.739

Table 7.2

0.375 inch Biobarb

Batch No:	Sample Ref	Peak Force (N)	Defl at Peak Force (mm)	Energy at Peak Force (J)	Defl at Failure (mm)	Energy at Failure (J)
1	BAN	486.084	11.59	3.025	15.38	3.957
2	BAO	238.530	4.83	0.528	8.26	0.979
3	BGN	470.279	11.01	2.693	14.53	3.549
4	BGO	198.865	4.20	0.382	7.47	0.760
5	BUN	489.771	11.77	3.115	15.17	3.990
6	BUO	213.242	4.36	0.432	7.62	0.825
7	HAN	454.356	9.71	2.276	13.08	3.114
8	HGN	432.047	9.24	2.013	12.67	2.794
9	HUN	441.715	10.11	2.319	13.71	3.136

Table 7.3

Testing was concluded by Loughborough University at the 0.375” size due to the limitations of the test machine.

From the results obtained from the testing of the 0.125”, 0.250” & 0.375” by Loughborough University, it indicated that the new flange design in all cases was stronger than the existing flange design.
Also it can be concluded that the effect of Sterilisation by either Autoclaving or Gamma Irradiation had a very minimal effect on the impact strength of the Biobarbs, and in some cases improved the impact strength.

Phase 2 – Brunel University
Each batch (1 to 9) of Biobarbs were subjected to the same testing under controlled conditions.

0.500 inch Biobarb

Batch No:	Sample Ref	Peak Force (N)	Defl at Peak Force (mm)	Energy at Peak Force (J)	Defl at Failure (mm)	Energy at Failure (J)
1	BAN	826	7.25	3.56	10.34	5.55
2	BAO	277	3.59	0.44	4.10	0.59
3	BGN	459	3.26	1.40	10.68	3.92
4	BGO	268	2.59	0.41	3.72	0.55
5	BUN	670	6.28	2.91	12.91	5.92
6	BUO	309	3.43	0.66	4.29	0.80
7	HAN	813	4.29	1.71	10.76	5.34
8	HGN	826	5.43	2.79	9.27	4.94
9	HUN	820	5.18	2.56	9.78	5.51

Table 7.4

0.625 inch Biobarb

Batch No:	Sample Ref	Peak Force (N)	Defl at Peak Force (mm)	Energy at Peak Force (J)	Defl at Failure (mm)	Energy at Failure (J)
1	BAN	848	2.61	1.72	9.74	5.64
2	BAO	240	1.92	0.25	3.52	0.38
3	BGN	859	1.25	1.26	7.75	3.49
4	BGO	187	0.72	0.18	3.24	0.37
5	BUN	767	1.44	1.29	7.19	4.90
6	BUO	189	1.84	1.26	7.75	3.49
7	HAN	838	1.91	1.07	9.75	6.42
8	HGN	1012	1.45	1.12	10.65	5.42
9	HUN	924	2.21	1.24	11.13	6.31

Table 7.5

0.750 inch Biobarb

Batch No:	Sample Ref	Peak Force (N)	Defl at Peak Force (mm)	Energy at Peak Force (J)	Defl at Failure (mm)	Energy at Failure (J)
1	BAN	862	1.79	1.11	7.14	4.05
2	BAO	182	0.85	0.12	3.50	0.40
3	BGN	867	2.48	1.19	8.61	3.25
4	BGO	180	0.82	0.13	3.04	0.48
5	BUN	807	1.29	1.87	8.62	4.20
6	BUO	205	1.56	0.23	5.43	0.70
7	HAN	740	2.36	1.25	10.29	5.74
8	HGN	768	1.69	1.94	8.15	4.41
9	HUN	793	1.98	1.33	10.94	5.51

Table 7.6

0.875 inch Biobarb

Batch No:	Sample Ref	Peak Force (N)	Defl at Peak Force (mm)	Energy at Peak Force (J)	Defl at Failure (mm)	Energy at Failure (J)
1	BAN	803	2.14	1.61	8.97	5.73
2	BAO	159	1.09	0.13	7.58	0.64
3	BGN	893	1.97	1.87	7.64	3.71
4	BGO	152	1.01	0.14	7.93	0.62
5	BUN	865	3.63	2.50	7.84	4.84
6	BUO	171	1.33	0.28	5.23	0.65
7	HAN	780	2.44	2.24	7.98	5.64
8	HGN	759	1.18	1.34	6.71	4.22
9	HUN	729	1.11	1.22	5.14	4.67

Table 7.7

1.000 inch Biobarb

Batch No:	Sample Ref	Peak Force (N)	Defl at Peak Force (mm)	Energy at Peak Force (J)	Defl at Failure (mm)	Energy at Failure (J)
1	BAN	762	1.66	1.48	9.60	4.47
2	BAO	324	3.53	0.66	4.92	0.93
3	BGN	894	1.74	1.26	8.72	3.58
4	BGO	181	1.23	0.14	4.65	0.46
5	BUN	889	8.51	4.60	10.33	5.36
6	BUO	193	1.31	0.17	3.88	0.60
7	HAN	878	1.38	2.23	10.03	6.65
8	HGN	931	1.85	1.82	11.10	3.61
9	HUN	756	2.04	1.47	11.45	5.56

Table 7.8

From the results obtained from the testing by Brunel University of the 0.500”, 0.625”, 0.750”, 0.875” and 1.000” Biobarbs, it indicated that the new flange design in all cases was stronger than the existing flange design.
Also it can be concluded that the effect of Sterilisation by either Autoclaving or Gamma Irradiation had a very minimal effect on the impact strength of the Biobarbs, and in some cases improved the impact strength.

8. Conclusions & Recommendations

From all of the testing carried out by both Loughborough and Brunel University, it may be determined that the new flange design Biobarbs can be produced in either the original Borealis or the new Huntsman (Bovine-tallow free) material, either of which will be at least 50% and in some cases 100% + stronger that the original flange designed Biobarbs.
Components produced in the Huntsman (Bovine-tallow free) material had a comparable impact strength with the original Borealis material.

Appendix 1

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Loughborough University Enterprises Limited

Unlocking business potential

Project **FALLING WEIGHT IMPACT TEST RESULTS**

Project Number **5642/MP/RUN**

Consultant Dr Carole Raymond

Department Institute of Polymer Technology and Materials Engineering

Date December 2007

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FALLING WEIGHT IMPACT TEST RESULTS

Dr C Raymond

December 2007

Introduction

A series of samples were received. These were labelled as follows:

Borealis Autoclaved New Generation (BAN)
Borealis Autoclaved Original (BAO)
Borealis Gamma New Generation (BGN)
Borealis Gamma Original (BGO)
Borealis Untreated New Generation (BUN)
Borealis Untreated Original (BUO)
Huntsman Autoclaved New Generation (HAN)
Huntsman Gamma New Generation (HGN)
Huntsman Untreated New Generation (HUN)

Each of these sets of samples came in eight different sizes:

1. 0.125 inch
2. 0.250 inch
3. 0.375 inch
4. 0.500 inch
5. 0.625 inch
6. 0.750 inch
7. 0.875 inch
8. 1.000 inch

For each different sample type and size there were 5 (in some cases 4) samples.

The objective was to subject each of the samples to a falling weight impact test, to give information on the impact characteristics of each of the types of sample, and also how the size affects this.

Test Procedure

The equipment used for this impact testing was a Rosand Instrumented Falling Weight Impacter, with associated software to control the machine and analyse and store the data.
This equipment is essentially a mass which falls freely (with guides) from a pre-set height. The mass is fitted with a striker at the bottom, and between the mass and the striker is a force transducer which measures the force experienced by the sample as the striker hits it, and the sample undergoes deflection and failure. The sample is clamped in a chamber. The point of impact was set for each set of samples to be on the parallel part of the end of the sample. Figure 1 shows this point of impact.

The mass used was 10.1kg, The striker was initially a dart shaped striker, but this was changed after testing the smaller samples to a flat circular striker of approximately 20mm diameter. The mass was dropped from a height of 0.45m.

Potential Energy = Kinetic Energy

$$mgh = 1/2mv^2$$

So a height of 0.45 m gives an impact energy of 45J impacting at 3m/s.

Results

The software takes the data measured by the transducer and produces a graph showing the force on the y –axis, and deflection on the x-axis. (The x-axis can be set to time instead of deflection.) From this trace various parameters are read:

Peak Force – this is the maximum force in Newtons experienced by the sample during the impact. It usually relates to the point at which the sample starts to fail.
Deflection at Peak Force – If the point at which the striker just touches the top of the sample is set as the zero point, then this is the distance from this zero point in mm that the striker has moved through at the point of

maximum force. It generally relates to the sample flexing in the grips, and up to this point the sample is still whole.
Energy at Peak Force – This is the energy in Joules absorbed by the sample up to the point of peak force. It is measured as the area under the force/deflection curve.
Deflection at failure – When the force/deflection curve has returned to zero (or approaching zero; bounce, signal noise, etc, account for the fact that the force rarely goes straight to zero after an impact test) the sample has failed, and this is the deflection to this point.
Energy at Failure – The energy in Joules absorbed by the sample during the entire impact test. Again it is measured as the area under the force/deflection curve.

Figure 2 shows a typical trace.

The five parameters measured by the machine are tabulated below for each of the three sizes tested, in Tables 1, 2 and 3 respectively. The values are averages of the five samples for each sample type and size.

Results for Size 1 (0.125 inch) Samples

Sample	Peak Force (N)	Defl at Peak Force (mm)	Energy at Peak Force (J)	Defl at failure (mm)	Energy at Failure (J)
BAN	172.841	17.19	1.873	24.09	2.718
BAO	111.740	8.75	0.561	13.91	0.969
BGN	184.316	17.52	1.940	21.96	2.377
BGO	106.873	6.98	0.374	11.34	1.212
BUN	178.345	19.59	2.232	27.07	3.137
BUO	115.429	7.74	0.461	11.08	0.691
HAN	170.806	15.70	1.674	19.74	2.062
HGN	159.276	15.22	1.504	19.79	1.862
HUN	173.903	17.28	1.853	23.27	2.539

For sample size 1 the results show the following trends:

The New Generation Borealis samples (BUN, BAN and BGN) and the Huntsman Untreated sample (HUN) are the strongest samples, showing highest peak force values and absorbing more energy during impact.
The Original Borealis samples (BUO, BAO, BGO) all show the lowest peak force values and impact energies and deflections. The Huntsman Autoclaved and Gamma samples (HAN, HGN) are intermediate to the above two sets, although the results for the 6 strongest sets of samples (all New Generation samples) are all fairly close.

Results for Size 2 (0.250 inch) Samples

Sample	Peak Force (N)	Defl at Peak Force (mm)	Energy at Peak Force (J)	Defl at failure (mm)	Energy at Failure (J)
BAN	278.430	8.75	1.242	12.22	1.761
BAO	125.305	5.46	0.319	8.84	0.556
BGN	265.072	8.42	1.088	11.84	1.586
BGO	110.146	4.71	0.223	8.00	0.438
BUN	273.449	8.94	1.239	12.37	1.749
BUO	127.200	5.56	0.317	7.46	0.570
HAN	272.000	8.47	1.162	11.67	1.655
HGN	251.892	8.52	1.263	12.49	1.779
HUN	273.867	8.88	1.230	12.27	1.739

For sample size 2 the results show the following trends: The three Borealis Original samples (BUO, BAO, BGO) again show the lowest impact strength. The Huntsman samples, for some parameters show better impact strength than some of the Borealis New Generation samples. Again the New Generation samples all exhibit similar results.

Results for Size 3 (0.375 inch) Samples

Sample	Peak Force (N)	Defl at Peak Force (mm)	Energy at Peak Force (J)	Defl at failure (mm)	Energy at Failure (J)
BAN	486.084	11.59	3.025	15.38	3.957
BAO	238.530	4.83	0.528	8.26	0.979
BGN	470.279	11.01	2.693	14.53	3.549
BGO	198.865	4.20	0.382	7.47	0.760
BUN	489.771	11.77	3.115	15.17	3.990
BUO	213.242	4.36	0.432	7.62	0.825
HAN	454.356	9.71	2.276	13.08	3.114
HGN	432.047	9.24	2.013	12.67	2.794
HUN	441.715	10.11	2.319	13.71	3.136

For sample size 3 the following pattern emerges: The Borealis New Generation samples (BAN, BUN, BGN) all show the highest impact strength, followed by the three Huntsman samples (HUN, HAN, HGN). The Three Borealis Original samples are lowest for all parameters. As far as treatments go, the Gamma treatment showed more brittle behaviour, but the Autoclaved and Untreated samples show no appreciable difference. Again the New Generation samples all exhibit similar results.

Table 4 gives the positions of failure for each impact. The letters A and B refer to the positions marked in Figure 1. A* refers to a failure at A which was not a complete failure, i.e., a hinge remained, holding the two parts together.

Table 4

Sample	Size 1	Size 2	Size 3
BAN	4 at A	4 at A	2 at A, 2 at B
BAO	5 at A	3 at A*, 2 at B	5 at B
BGN	5 at A	5 at A	5 at B
BGO	3 at A, 2 at B	2 at A, 3 at B	5 at B
BUN	5 at A	5 at A	5 at B
BUO	5 at A	3 at A, 2 at B	5 at B
HAN	2 at A, 2 at B	4 at A	4 at B
HGN	2 at A, 3 at B	5 at A	5 at B
HUN	4 at A, 1 at B	5 at A	5 at B

Problems Encountered

After testing the three smallest sizes, a series of problems arose. To start with, the samples of sizes 4 and 5 were not failing, rather the impacter was pushing the sample out of the clamp, and the sample remained unbroken. The clamp was not damaged in any way, the samples were just deforming enough to be removed from the clamp. During this part of the testing the dart shaped striker became bent. The trials were continued with the larger flat circular striker.
A higher drop height was attempted, to see if a higher impact energy (65J rather than the original 45J) would break the sample but this was not successful.
The larger sizes were then attempted. Sample BGO was used as this had shown relatively more brittle behaviour. Some failures were achieved but the force/deflection traces showed that the striker was hitting the anvil (on which the clamp is mounted) so the values recorded were meaningless. The samples failed at area C (on Figure 1).

Figure 3 shows an image of the BGO8 sample after the impact. The failed sample is stuck in the hole into which the striker passes. The striker has been deflected off to one side and is stuck against the anvil. The sample had to be hacksawed out, whilst the mass and striker were still wedged above, as the mass could not go up or down at this point.

The testing has therefore been suspended.

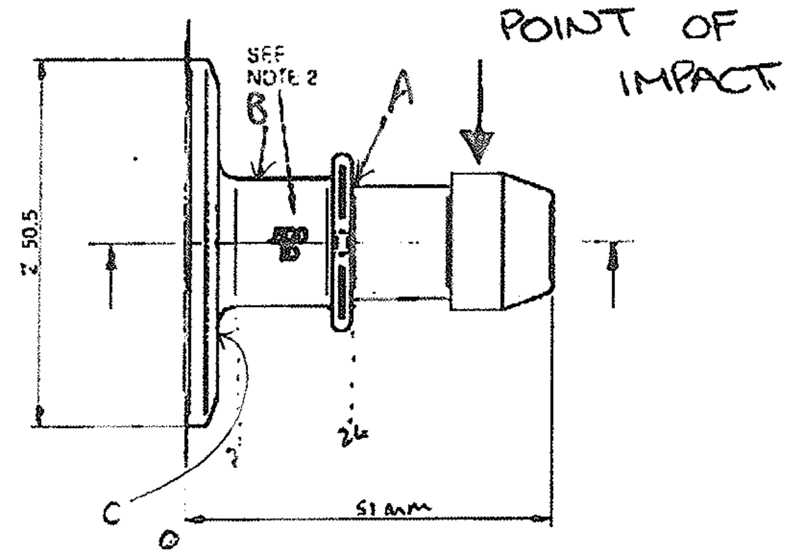
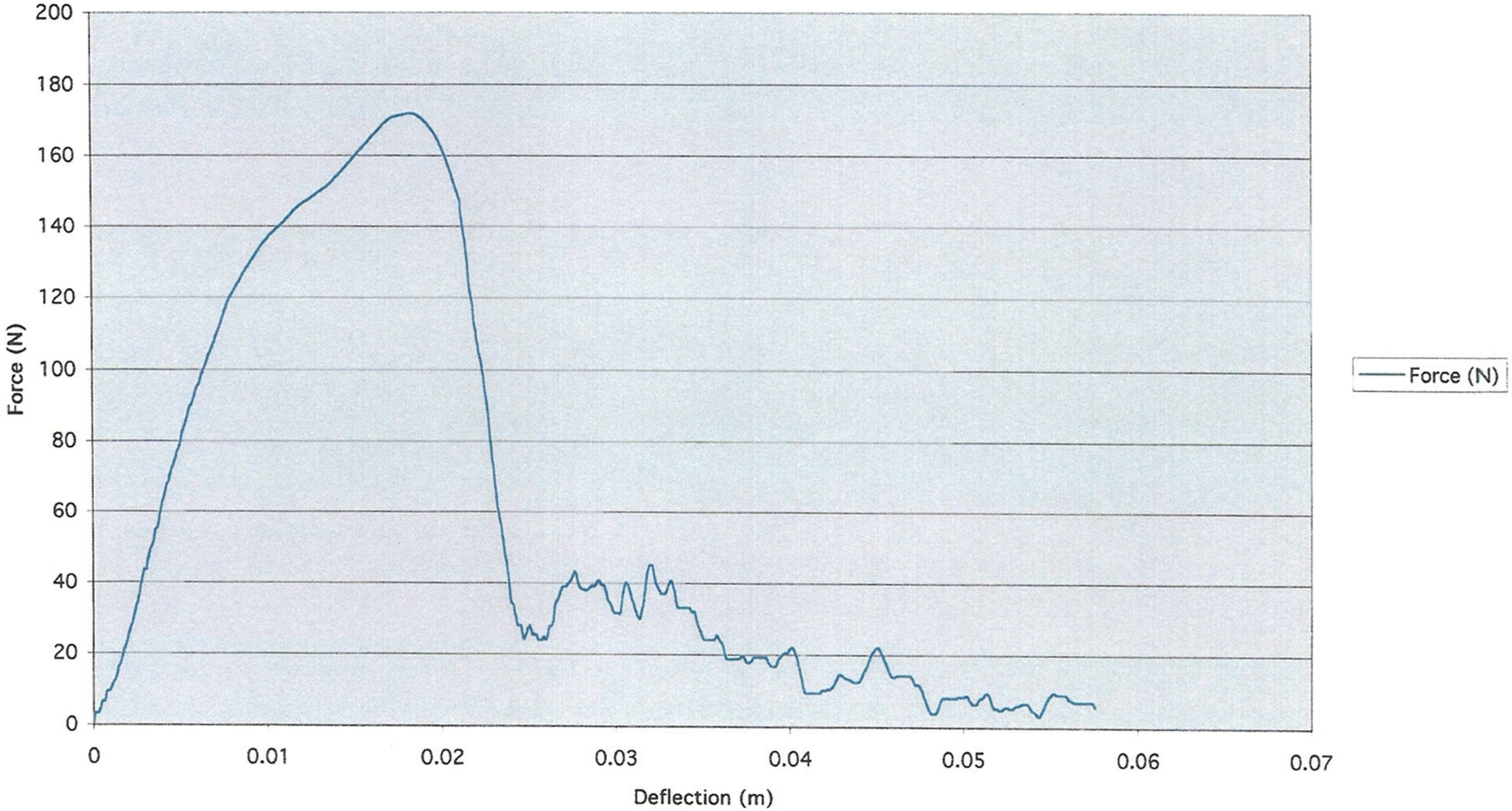


FIGURE 1

Figure 2 Impact trace for BUN15



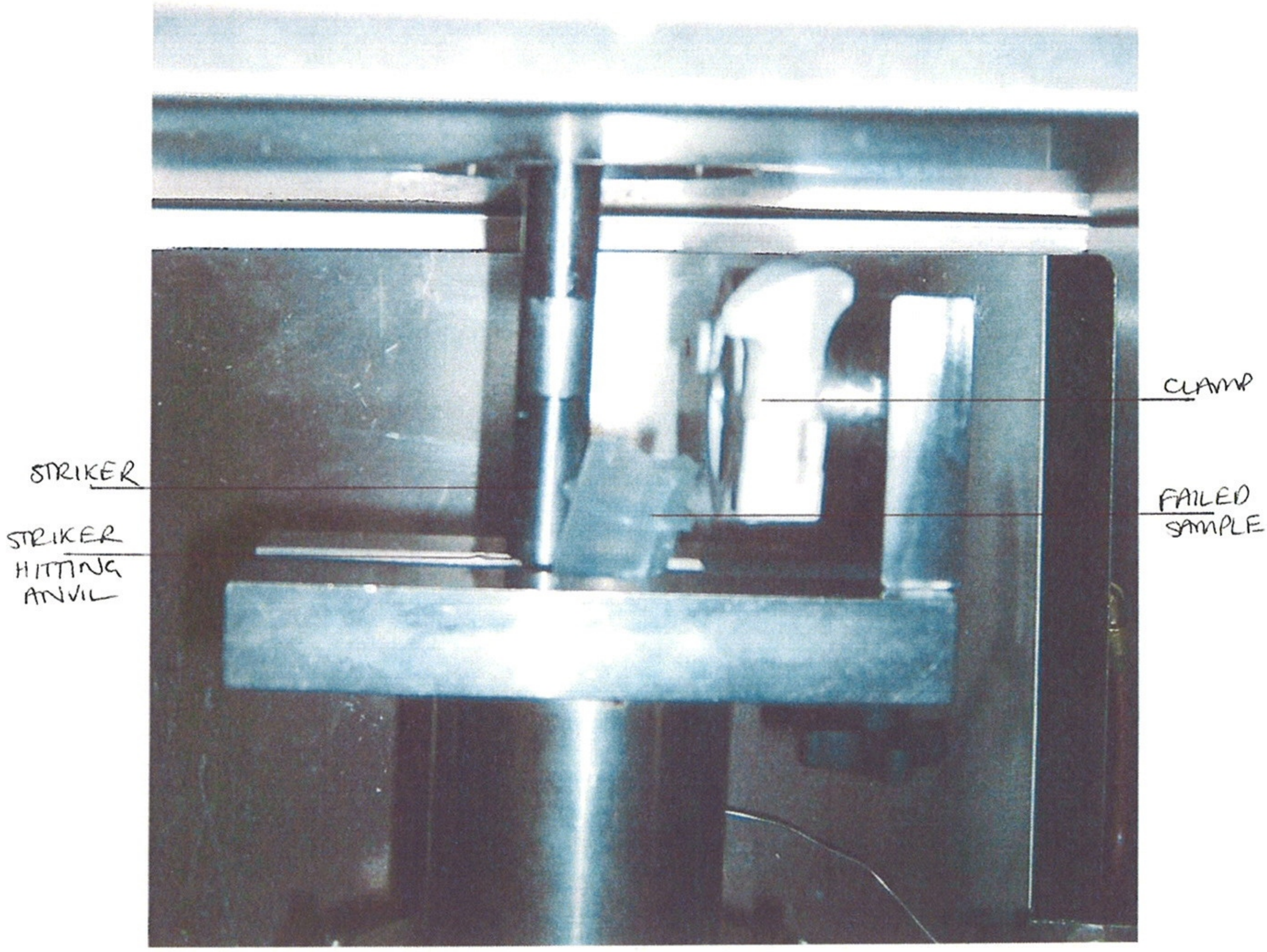


FIGURE 3

Appendix 2

Client: Runfold Medical
Consultant: Dr. Peter Allan & Ali Ahmadnia Brunel University.

Introduction

This report summarises a study performed by Brunel University on the drop weight impact properties of hose barbs. The results obtained includes nine materials in five different sizes.

Project Objective

The prime objective of the study is to obtain a set of independent impact test results on hose barbs which have been manufactured from different materials and different designs.

Materials

The materials tested in this programme were :

Borealis Autoclaved New Generation (BAN)
Borealis Autoclaved Original (BAO)
Borealis Gamma New Generation (BGN)
Borealis Gamma Original (BGO)
Borealis Untreated New Generation (BUN)
Borealis Untreated Original (BUO)
Huntsman Autoclaved New Generation (HAN)
Huntsman Gamma New Generation (HGN)
Huntsman Untreated New Generation (HUN)

A total of 25 specimens were tested for each material which came in the following diameters:

0.500 inch
0.625 inch
0.750 inch
0.875 inch
1.000 inch

Drop Weight Impact Test

A series of falling weight impact tests was performed using A CEAST FRACTOVIS PLUS impact machine (fig. 1) with a test geometry as shown in figure 2

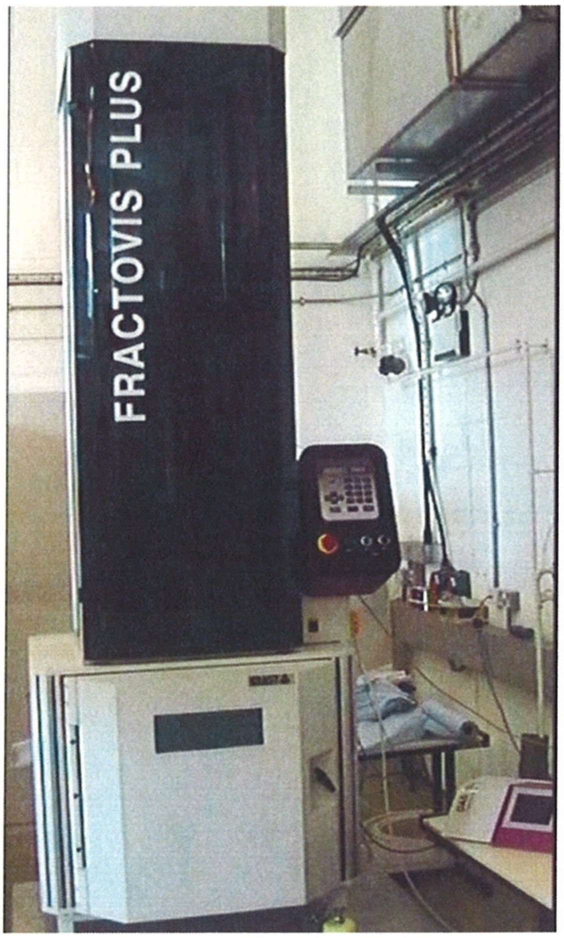


Figure 1 – CEAST Drop Weight impact machine.

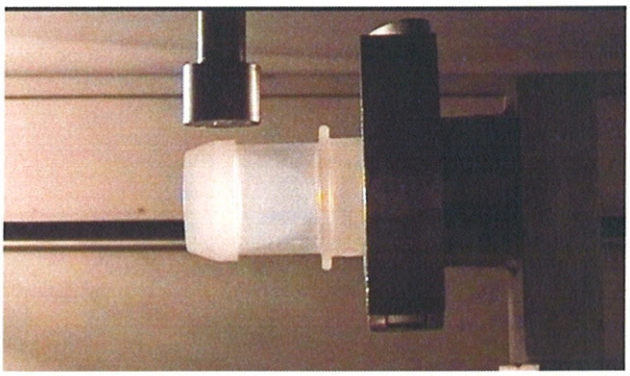


Figure 2 – Impact test geometry.

The impact machine is instrumented and the following curves can be obtained during impact:

Force – Time
Force – Deflection
Energy – Time
Velocity – Time
Displacement – Time

The area under the force - deflection curve which is an indication of the amount of energy absorbed by the hose barb and also an indication of the ductility of the material is calculated by the computer.

Impact Test Procedure

Hose barbs were restrained from the base in a clamp as shown in figure 2 and were hit on the flat section by a 5.045 kg striker with a flat circular head of 20 mm diameter. Impact speed was 4.22 m/s corresponding to 0.91 m height of the striker which gave an incident energy of 45 joules . Five specimens were tested from each size / material combination. The values of the force, energy and deflection at peak force, and the deflection and energy at failure were determined.

Impact Test Results

A typical force – deflection curve for a hose barb is shown in figure 3. A summary of the test results are shown in tables 1 to 5. The values are the average of five samples.

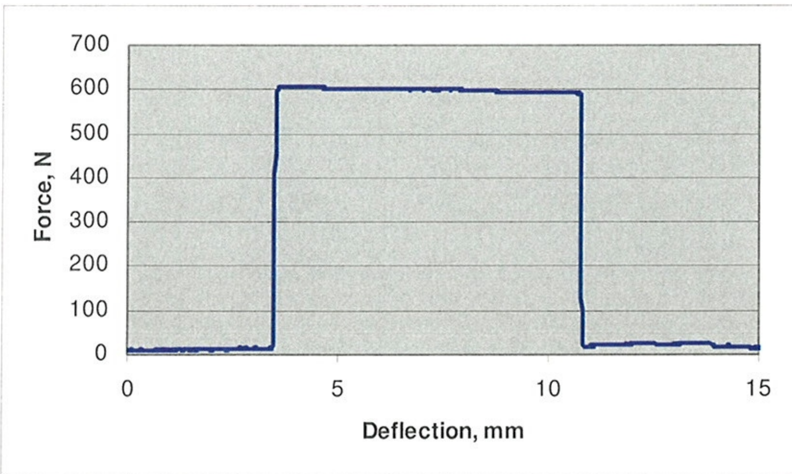


Figure 3 – Typical impact load- deflection for hose barb.

Table 1 – Impact test results for Results for 0.5 inch diameter hose barb

Sample	Peak Force N	Defl. At Peak Force mm	Energy at Peak Force J	Defl. At Failure mm	Energy at Failure J
BAN	826	7.25	3.56	10.34	5.55
BGN	459	3.26	1.40	10.68	3.92
BUN	670	6.28	2.91	12.91	5.92
HAN	813	4.29	1.71	10.76	5.34
HGN	826	5.43	2.79	9.27	4.94
HUN	820	5.18	2.56	9.78	5.51

Table 2 – Impact test results for Results for 0.625 inch diameter hose barb

Sample	Peak Force N	Defl. At Peak Force mm	Energy at Peak Force J	Defl. At Failure mm	Energy at Failure J
BAN	848	2.61	1.72	9.74	5.64
BGN	859	1.25	1.26	7.75	3.49
BUN	767	1.44	1.29	7.19	4.90
HAN	838	1.91	1.07	9.75	6.42
HGN	1012	1.45	1.12	10.65	5.42
HUN	924	2.21	1.24	11.13	6.31

Table 3 – Impact test results for Results for 0.750 inch diameter hose barb

Sample	Peak Force N	Defl. At Peak Force mm	Energy at Peak Force J	Defl. At Failure mm	Energy at Failure J
BAN	862	1.79	1.11	7.14	4.05
BGN	867	2.48	1.19	8.61	3.25
BUN	807	1.29	1.87	8.62	4.20
HAN	740	2.36	1.25	10.29	5.74
HGN	768	1.69	1.94	8.15	4.41
HUN	793	1.98	1.33	10.94	5.51

Table 4 – Impact test results for Results for 0.875 inch diameter hose barb

Sample	Peak Force N	Defl. At Peak Force mm	Energy at Peak Force J	Defl. At Failure mm	Energy at Failure J
BAN	803	2.14	1.61	8.97	5.73
BGN	893	1.97	1.87	7.64	3.71
BUN	865	3.63	2.50	7.84	4.84
HAN	780	2.44	2.24	7.98	5.64
HGN	759	1.18	1.34	6.71	4.22
HUN	729	1.11	1.22	5.14	4.67

Table 5 – Impact test results for Results for 1.0 inch diameter hose barb

Sample	Peak Force N	Defl. At Peak Force mm	Energy at Peak Force J	Defl. At Failure mm	Energy at Failure J
BAN	762	1.66	1.48	9.60	4.47
BGN	894	1.74	1.26	8.72	3.58
BUN	889	8.51	4.60	10.33	5.36
HAN	878	1.38	2.23	10.03	6.65
HGN	931	1.85	1.82	11.10	3.61
HUN	756	2.04	1.47	11.45	5.56

The same test conditions were applied to the BAO, BGO and BUO samples. No measurable impact energy was recorded for all these samples. This was due to the set impact conditions. These samples clearly had an impact energy at least two orders of magnitude lower than the samples that gave measurable results (shown above). The failure energy is an indication of the impact strength of the samples. The above results shows that gamma radiation reduces the impact strength and makes the samples less ductile. Most of the failure of the tested samples were from the base of the hose barbs.

Appendix 3

Investigation of Impact Properties
of
Hose Barbs

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Client: Runfold Medical
Consultant: Dr. Peter Allan & Ali Ahmadnia Brunel University.

Introduction

This report summarises a study performed by Brunel University on the drop weight impact properties of hose barbs. The results obtained includes nine materials in five different sizes.

Project Objective

The prime objective of the study is to obtain a set of independent impact test results on hose barbs which have been manufactured from different materials and different designs.

Materials

The materials tested in this programme were:

Polypropylene Untreated
Polypropylene Gamma eradiated
Polypropylene Autoclaved

A total of 25 specimens were tested for each material which came in the following diameters:

0.500 inch
0.625 inch
0.750 inch
0.875 inch
1.000 inch

Drop Weight Impact Test

A series of falling weight impact tests was performed using A CEAST FRACTOVIS PLUS impact machine (fig. 1) with a test geometry as shown in figure 2

Figure 1 – CEAST Drop Weight impact machine.

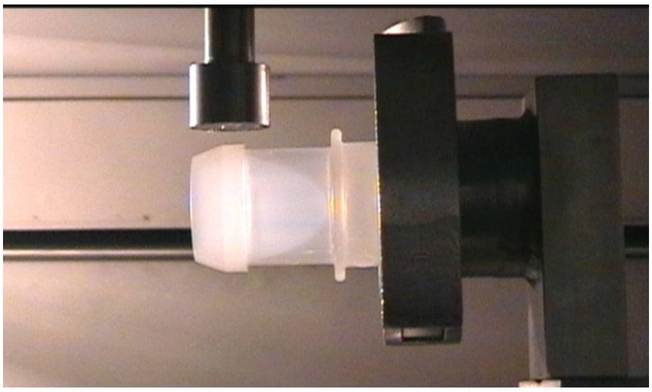

Figure 2 – Impact test geometry.

The impact machine is instrumented and the following curves can be obtained during impact:

Force – Time
Force – Deflection
Energy – Time
Velocity – Time
Displacement – Time

The area under the force - deflection curve which is an indication of the amount of energy absorbed by the hose barb and also an indication of the ductility of the material is calculated by the computer.

Impact Test Procedure

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Hose barbs were restrained from the base in a clamp as shown in figure 2 and were hit on the flat section by a 5.045 kg striker with a flat circular head of 20 mm diameter. Impact speed was 4.22 m/s corresponding to 0.91 m height of the striker which gave an incident energy of 45 joules . Five specimens were tested from each size / material combination. The values of the force, energy and deflection at peak force, and the deflection and energy at failure were determined.

Impact Test Results

A summary of the test results are shown in tables 1 to 5. The values are the average of five samples.

Table 1 – Impact test results for Results for 0.5 inch diameter hose barb

Sample	Peak Force N	Defl. At Peak Force mm	Energy at Peak Force J	Defl. At Failure mm	Energy at Failure J
Autoclaved	277	3.59	0.44	4.10	0.59
Untreated	309	3.43	0.66	4.29	0.80
Gamma	268	2.59	0.41	3.72	0.55

Table 2 – Impact test results for Results for 0.625 inch diameter hose barb

Sample	Peak Force N	Defl. At Peak Force mm	Energy at Peak Force J	Defl. At Failure mm	Energy at Failure J
Autoclaved	240	1.92	0.25	3.52	0.38
Untreated	189	1.84	1.26	7.75	3.49
Gamma	187	0.72	0.18	3.24	0.37

Table 3 – Impact test results for Results for 0.750 inch diameter hose barb

Sample	Peak Force N	Defl. At Peak Force mm	Energy at Peak Force J	Defl. At Failure mm	Energy at Failure J
Autoclaved	182	0.85	0.12	3.50	0.40
Untreated	205	1.56	0.23	5.43	0.70
Gamma	180	0.82	0.13	3.04	0.48

Table 4 – Impact test results for Results for 0.875 inch diameter hose barb

Sample	Peak Force N	Defl. At Peak Force mm	Energy at Peak Force J	Defl. At Failure mm	Energy at Failure J
Autoclaved	159	1.09	0.13	7.58	0.64
Untreated	171	1.33	0.28	5.23	0.65
Gamma	152	1.01	0.14	7.93	0.62

Table 5 – Impact test results for Results for 1.0 inch diameter hose barb

Sample	Peak Force N	Defl. At Peak Force mm	Energy at Peak Force J	Defl. At Failure mm	Energy at Failure J
Autoclaved	324	3.53	0.66	4.92	0.93
Untreated	193	1.31	0.17	3.88	0.60
Gamma	181	1.23	0.14	4.65	0.46

The failure energy is an indication of the impact strength of the samples. The above results shows that gamma radiation reduces the impact strength and makes the samples less ductile. Most of the failure of the tested samples were from the base of the hose barbs.