J. ALLCOCK & SONS LTD.

Are an old-established company, with customers and suppliers not only throughout the United Kingdom, but overseas also. Some facts about us are:

- Were established in 1924
- Are a privately owned, independent company.
- Have long lasting relationships with suppliers and customers
- Offer good technical and commercial support
- Very experienced sales staff
- Hold Quality Certification ISO 9001: 2015
- Committed to high Health & Safety standards
- Environmentally conscious
- Have good, complementary product range

INTRODUCTION

For many years, the advantages, both economic and technical, of the use of cured rubber crumb have been known. Crumbs made from tyre tread material, right down to the cheapest commercial grades, and most of the speciality polymers, have been used to good advantage.

J. Allcock & Sons Ltd. have been involved in this business for many years, and have developed and improved the grinding process to the point where we think we have the most up-to-date, ambient grinding plant in the UK, if not Europe.

Although we offer a wide range of 'standard' crumb grades, we have developed the idea of 'Closed Loop' waste management.

We identify possible customers who have a cured rubber waste problem, and we arrange to collect that waste and convert it into crumb that can then be returned to the same customer for incorporation into the virgin compound.

Attempts have been made by others to turn the cured waste from expensive Fluoroelastomer compound into re-usable crumb by using the cryogenic grinding method. This results in a very fine, but expensive material. Tests have shown that the crumb made by this process is technically not very good. It is our opinion that the process gives small, even, smooth-surfaced particles that do not 'bond' well into the matrix when incorporated into new compound.

The Allcock process produces a 'tearing' action that results in small, but very irregularly shaped particles, having 'feather' edges, that DO bond well into new compound, and so are not overly detrimental to the finished physical properties.

A great deal of effort has been put into developing the plant to ensure that we can offer a clean, controlled technical product that, for the first time, makes the idea of 'closed loop' re-use of Fluoro scrap a viable proposition.

Black and coloured material can be processed, and it can be pre-post cured, or post cured.

TECHNICAL INFORMATION

FIGURE 1.

Shows the Rheometer curves at 170ºC, comparing control with **FKM Crumb** at 10, 30 &50 phr loading.

All the additions show an increase in plasticity (i.e. Minimum value) over the control & this would be expected. All of the crumb loadings show lower rates of cure (i.e. increased safety) and higher ultimate modulus (i.e. higher states of cure).

It is unlikely that loadings of crumb as high as 50phr would ever be tried in practice.

FIGURE 2

Mooney values at 100ºC, again comparing control compound with addition of **FKM Crumb**.

At 10phr addition, the crumb shows values very similar to the control. As the level of addition rises, FKM Crumb containing compounds show increased Mooney values, as would be expected.

TECHNICAL INFORMATION

FIGURE 3.

Shows a comparison of a number of properties of a Co-Polymer based compound, using 10phr loading of **FKM Crumb**.

FIGURES 4 & 4.A

Show, both in graph and tabular forms, further comparisons between the control and **FKM Crumb** containing compounds at various additions.

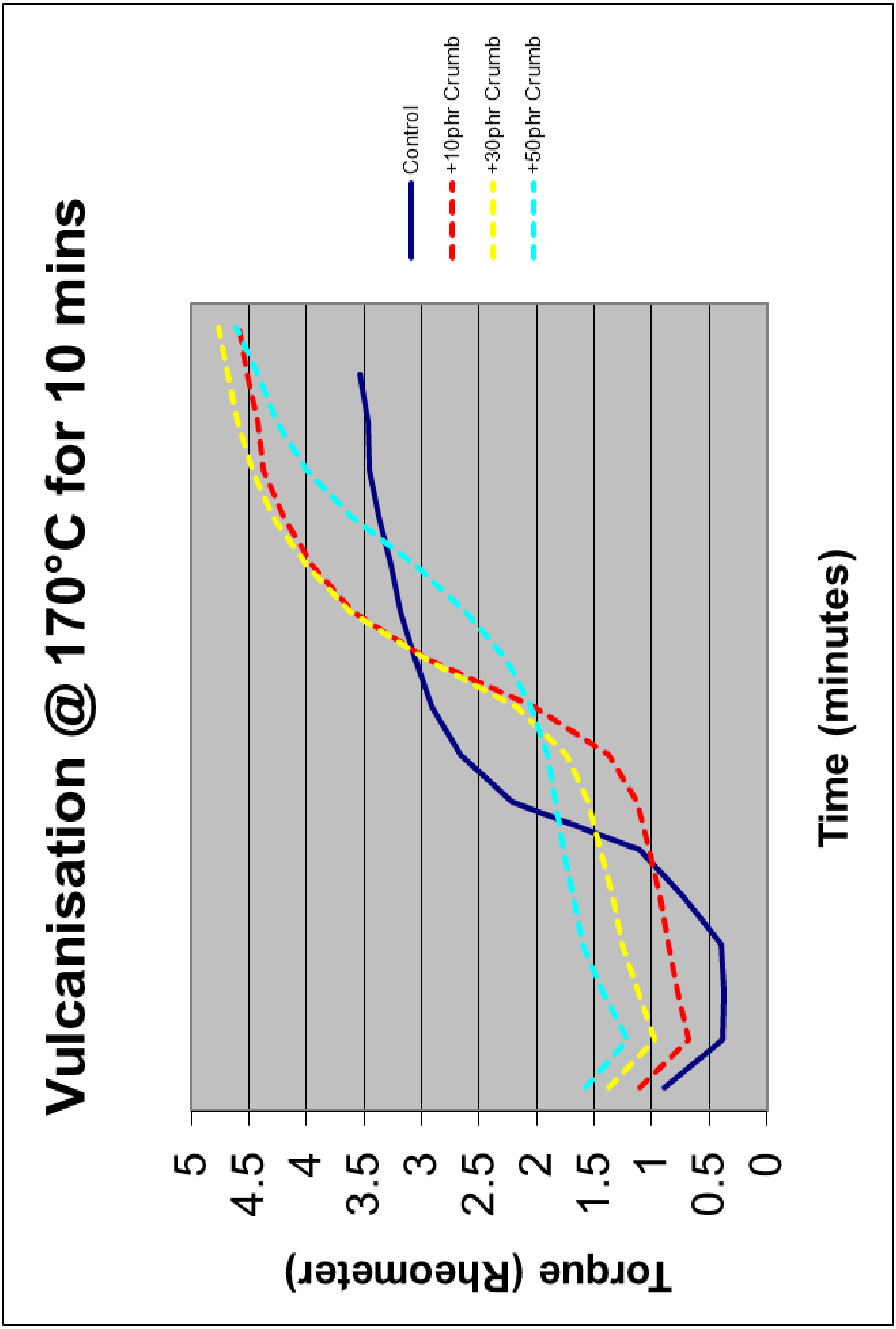
FIGURES 5 & 6

Show, both in graph and tabular form, the particle size distribution information on the factory production of **FKM Crumb**. The information is given in both B.S. Mesh and m.m size.

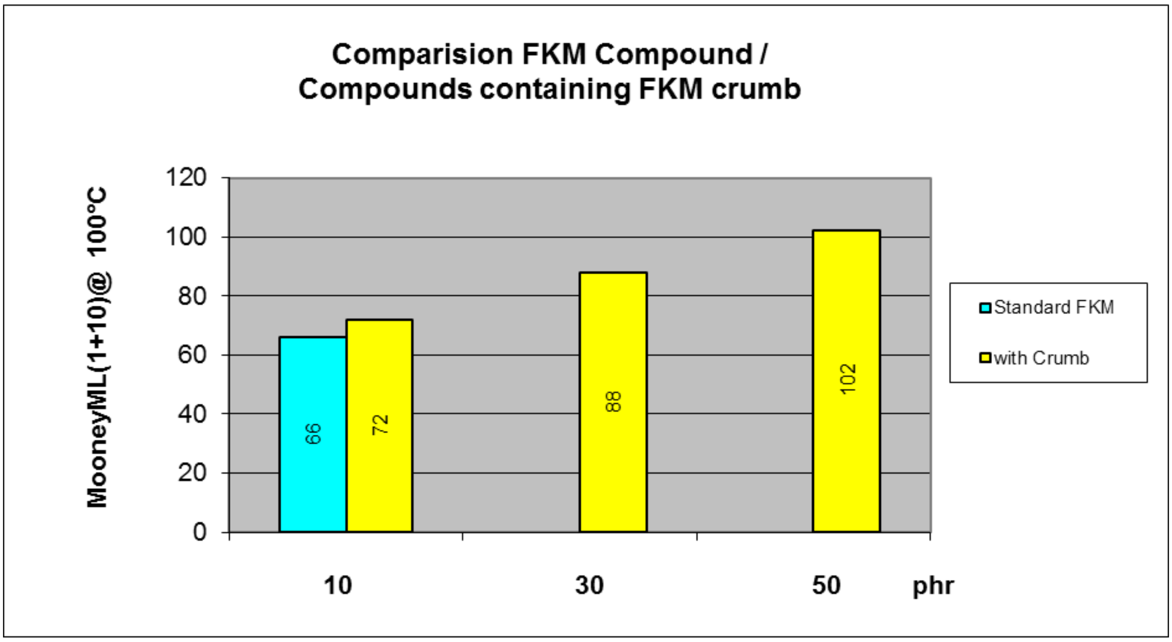
Although we describe the material as being nominally to 40's mesh (i.e. 2% over allowance on 40's BS mesh), the graph clearly shows that the peak occurs at nearer to 100's mesh. It also shows that there is some material finer that 200's mesh present.

FIGURES 7, 8 & 9

These collate, in tabular form, the information so far.



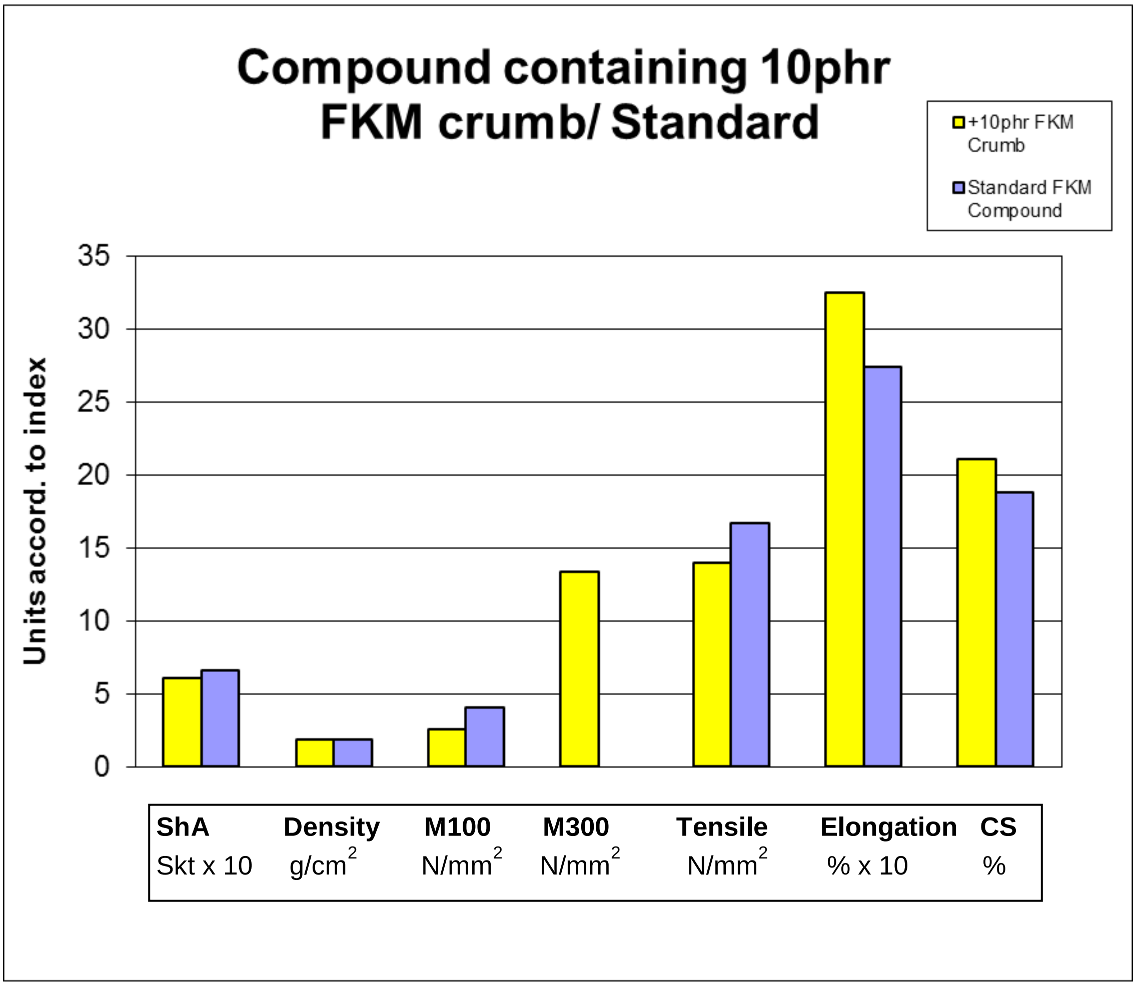
Vulcanisation @ 170°C for 10 mins
Torque (Rheometer)
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
Time (minutes)
Control
+10phr Crumb
+30phr Crumb
+50phr Crumb



Comparision FKM Compound /
Compounds containing FKM crumb
MooneyML(1+10)@ 100°C
120
100
80
60
40
20
0
66
72
88
102
Standard FKM
with Crumb
10
30
50
phr

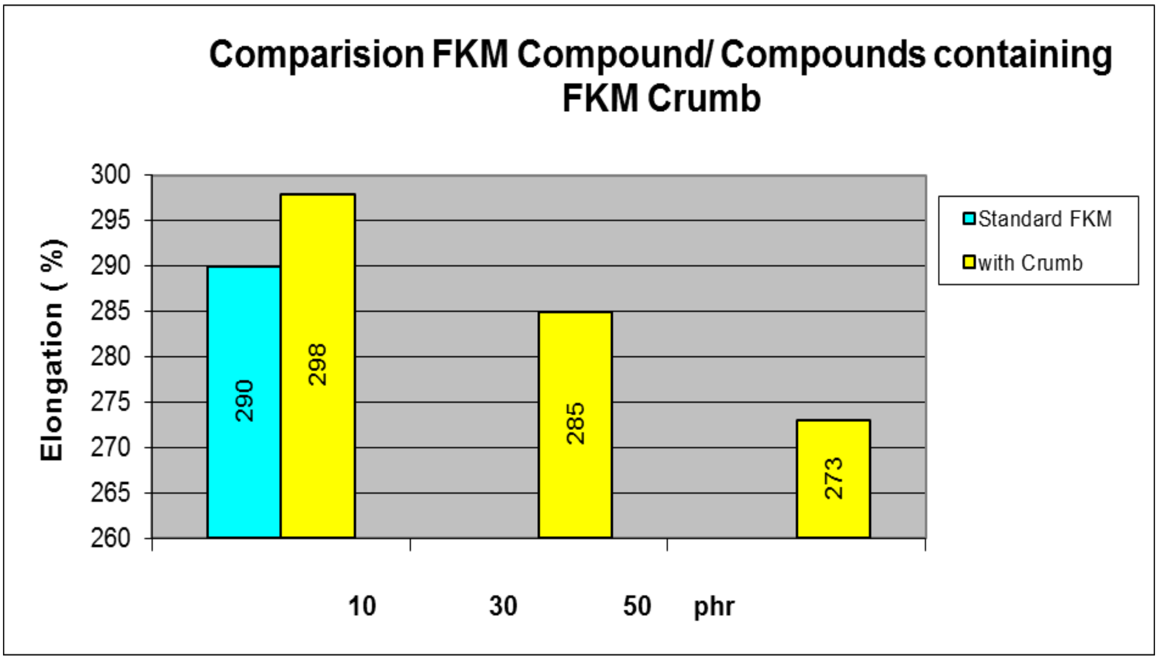
Copolymer

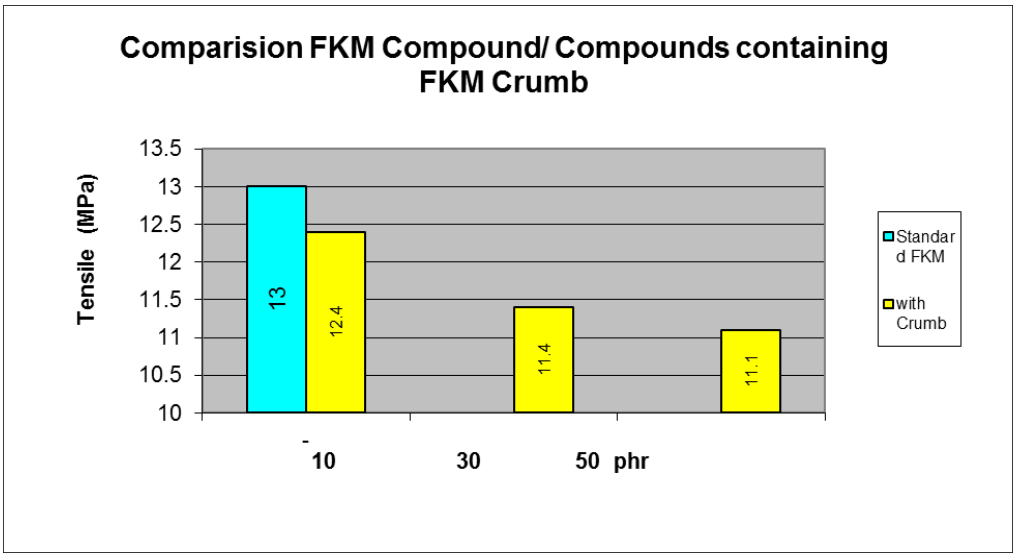
Formulation - No.:	1507/ 12	1507/13
Dai El G 763	100.-	100.-
FKM Crumb Black		10.-
MT Black	20.-	20.-
Fluorox E	6.-	6.-
Elastomag 170	3.-	3.-
Hardness (Shore A)	6.6	6.1
Density g/cm³	1.85	1.86
Modulus at 100%	4.1	2.6
Modulus at 300%		13.4
Tensile Strength (N/mm²)	16.7	14
Elongation at Break %	27.4	32.5
C.S. (72h@ 200°C)	18.8	21.1

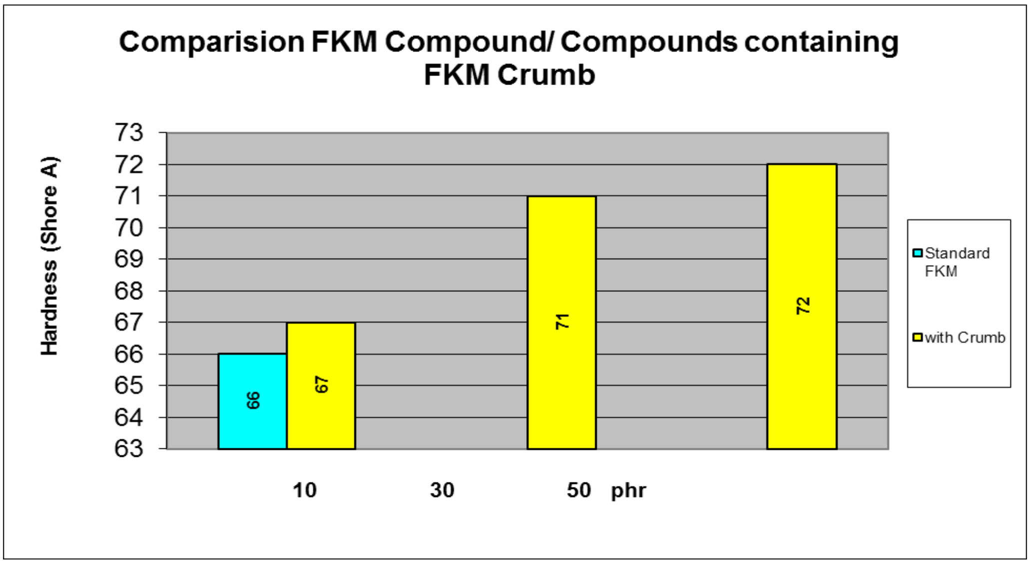


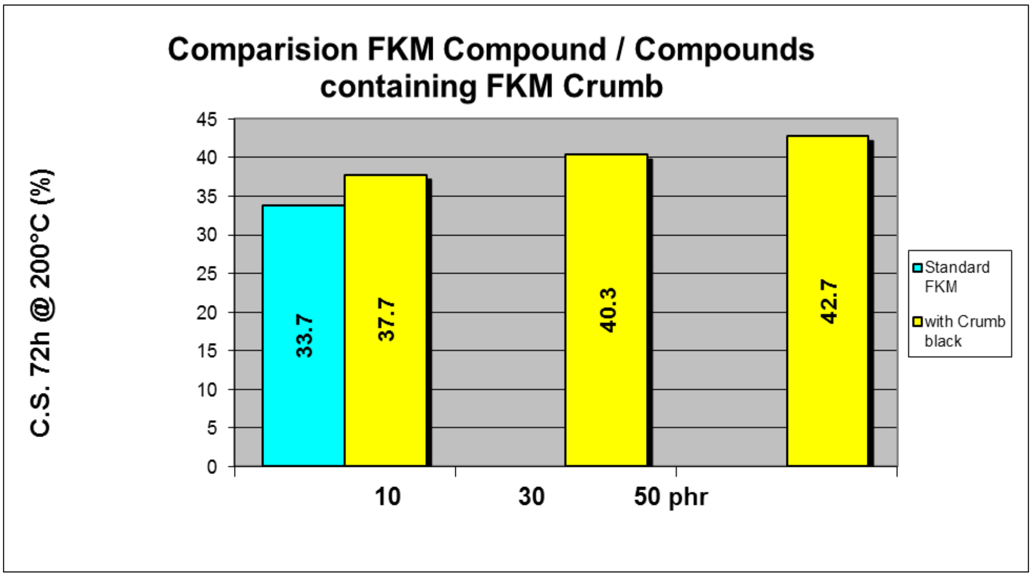
Formulation	phR	phR	phR	phR
Dai El G621	30.-	30.-	30.-	30.-
Dai El G555	70.-	70.-	70.-	70.-
FKM crumb black		10.-	30.-	50.-
MT-Black	20.-	20.-	20.-	20.-
Fluorox E	6.-	6.-	6.-	6.-
Elastomag 170	3.-	3.-	3.-	3.-

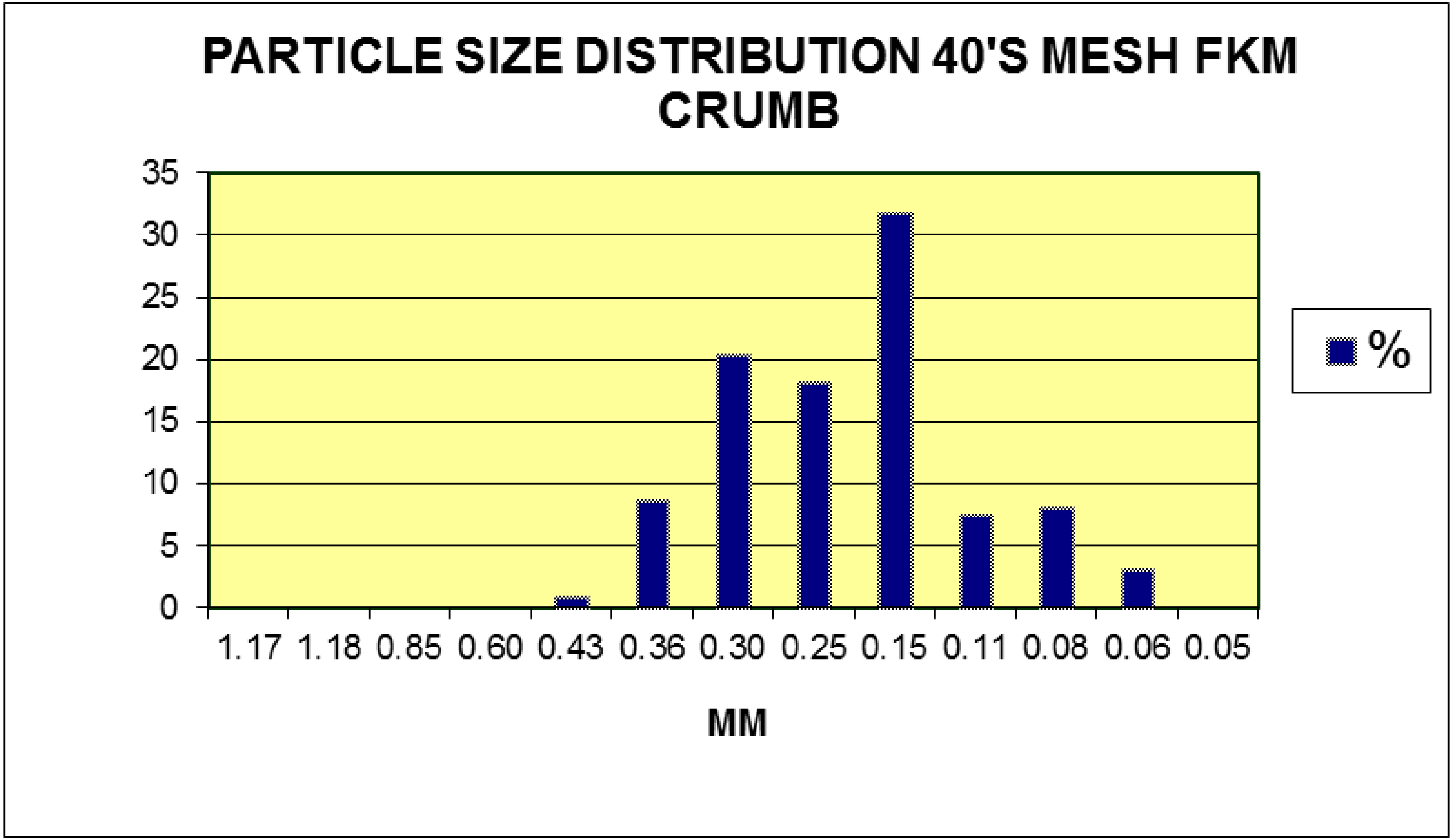
Mooney ML(1+100) 100°C	66	72	88	102
Shore A				
Hardness g/cm^2	66	67	71	72
Density	1.9	1.91	1.92	1.93
Modulus 100%	3.8	3.8	4	4.5
Tensile Strength	13	12.4	11.4	11.1
Elongation at Break(%)	290	298	285	273
C.S. 72h at 200°C(%)	33.7	37.7	40.3	42.7

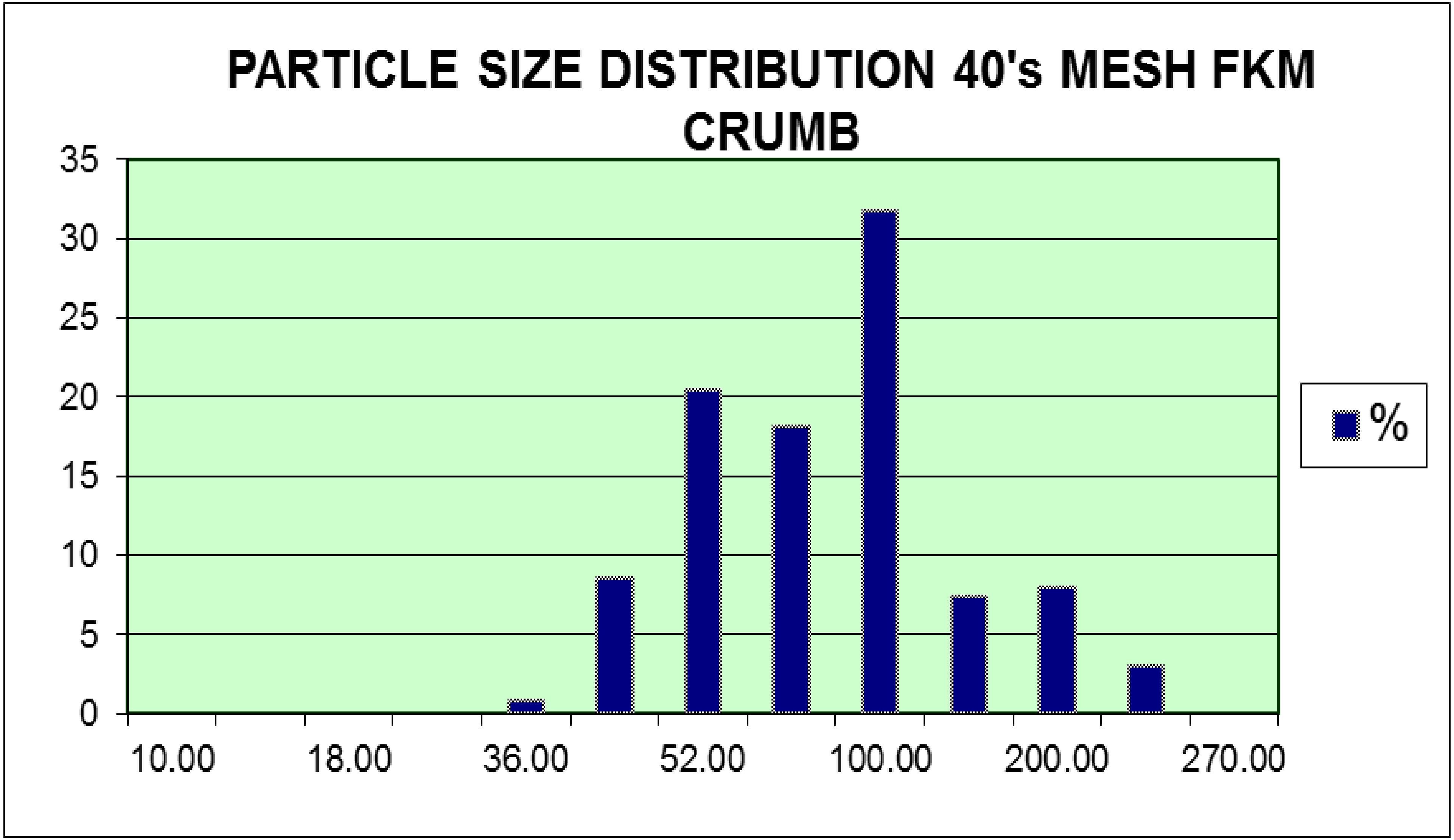



Comparision FKM Compound/ Compounds containing FKM Crumb
Tensile (MPa)
13.5
13
12.5
12
11.5
11
10.5
10
13
12.4
11.4
11.1
Standard FKM
with Crumb
-
10
30
50 phr


Comparision FKM Compound/ Compounds containing FKM Crumb
Hardness (Shore A)
73
72
71
70
69
68
67
66
65
64
63
66
67
71
72
Standard FKM
with Crumb
10
30
50 phr


Comparision FKM Compound / Compounds containing FKM Crumb
C.S. 72h @ 200°C (%)
45
40
35
30
25
20
15
10
5
0
33.7
37.7
40.3
42.7
Standard FKM
with Crumb black
10
30
50 phr

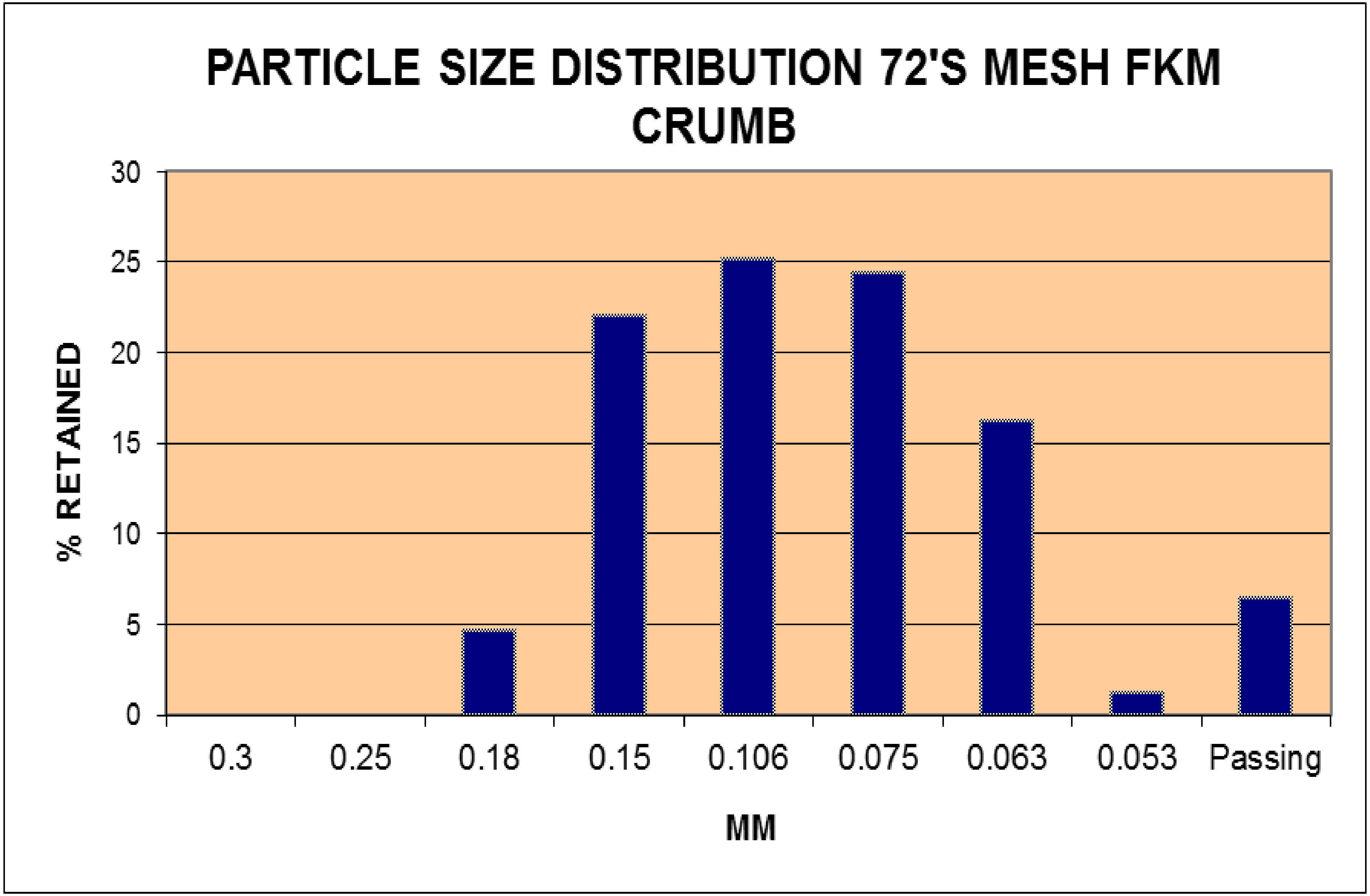

PARTICLE SIZE DISTRIBUTION 40'S MESH FKM CRUMB
35
30
25
20
15
10
5
0
1.17 1.18 0.85 0.60 0.43 0.36 0.30 0.25 0.15 0.11 0.08 0.06 0.05
MM
%

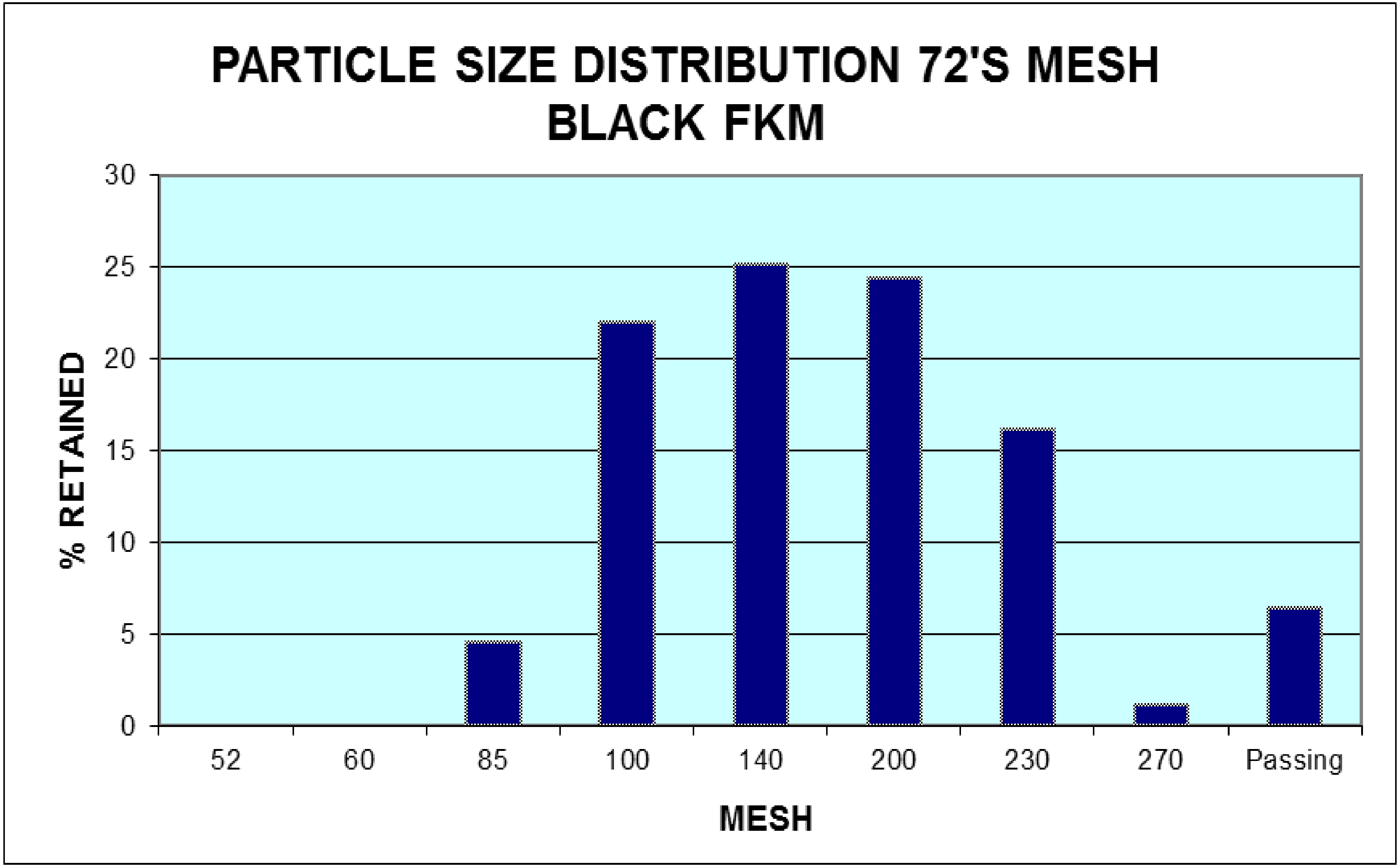


PARTICLE SIZE DISTRIBUTION 40's MESH FKM CRUMB
35
30
25
20
15
10
5
0
10.00
18.00
36.00
52.00
100.00
200.00
270.00
%

PARTICLE SIZE DISTRIBUTION FOR FKM CRUMB

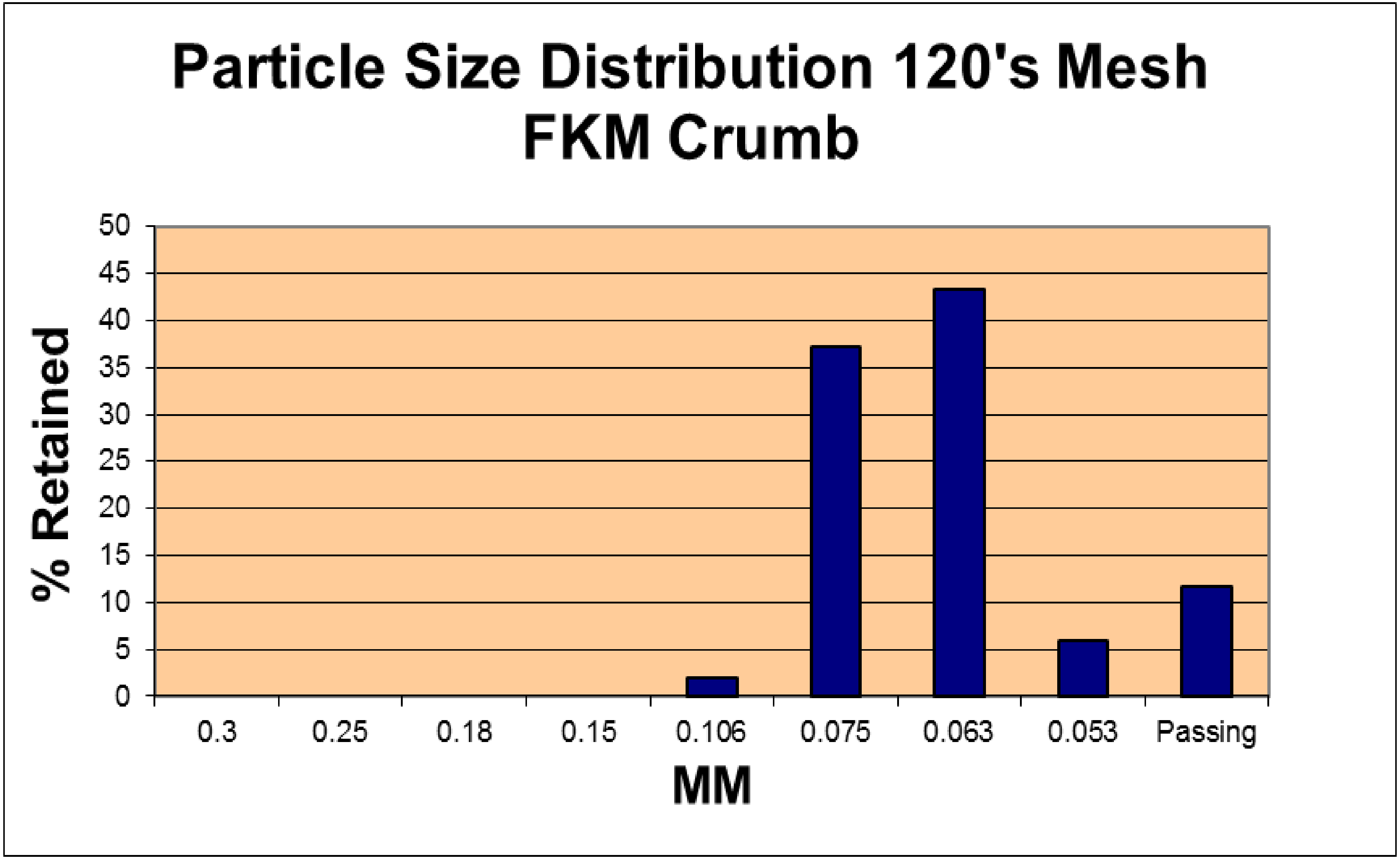
MESH	mm	%
10	1.7	0
14	1.18	0
18	0.85	0
25	0.6	0
36	0.425	0.8
44	0.355	8.6
52	0.3	20.4
60	0.25	18.2
100	0.15	31.8
140	0.106	7.4
200	0.075	8
230	0.063	3
270	0.053	0

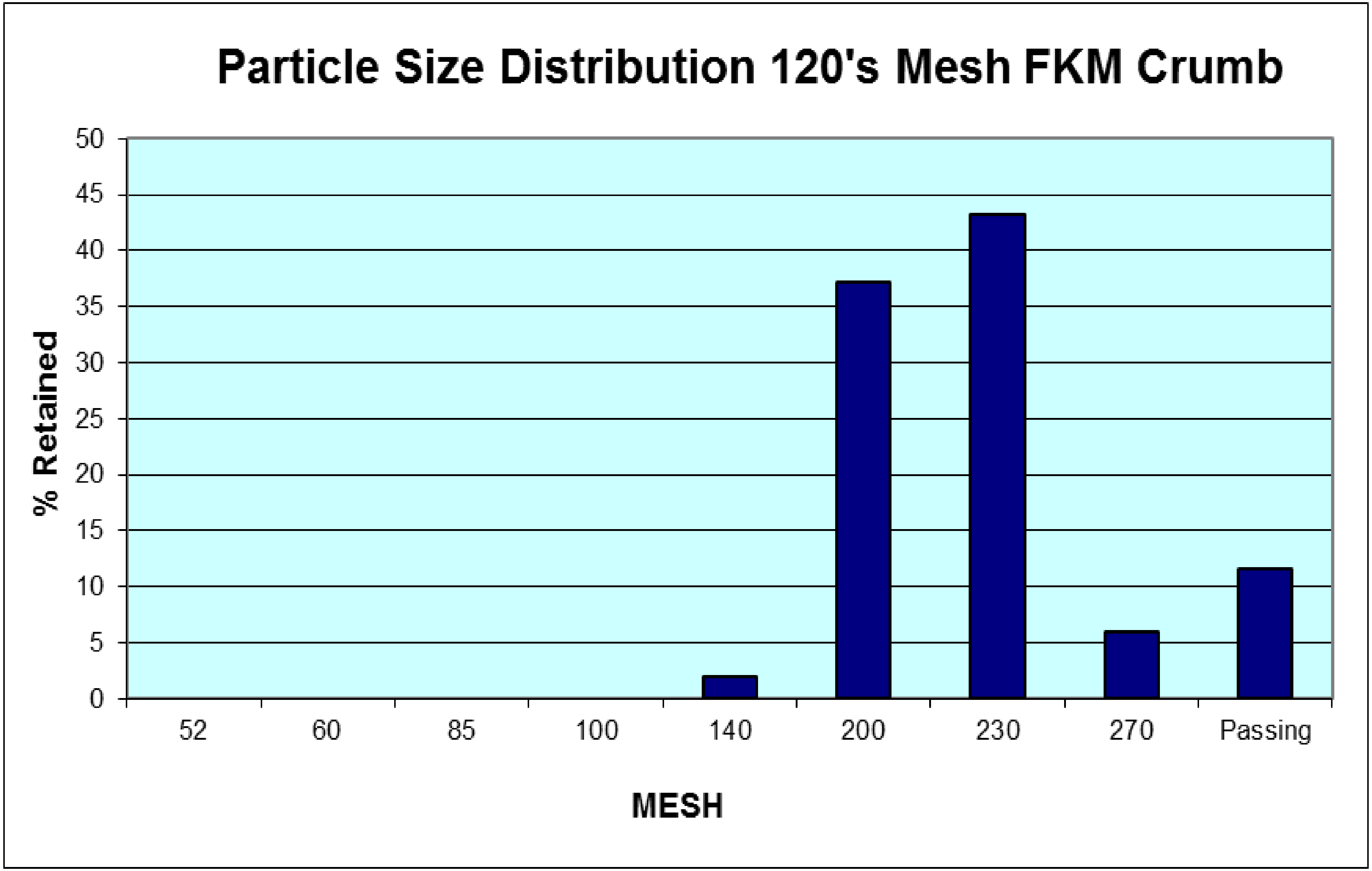

PARTICLE SIZE DISTRIBUTION 72'S MESH FKM CRUMB
% RETAINED
30
25
20
15
10
5
0
0.3
0.25
0.18
0.15
0.106
0.075
0.063
0.053
Passing
MM


PARTICLE SIZE DISTRIBUTION 72'S MESH
BLACK FKM
% RETAINED
30
25
20
15
10
5
0
52
60
85
100
140
200
230
270
Passing
MESH

PARTICLE SIZE DISTRIBUTION FOR 72'S MESH FKM CRUMB

		Retained	Passing
Mesh	**MM**	**%**	**%**
52	0.3	0	**100**
60	0.25	0	**100**
85	0.18	4.6	**95.4**
100	0.15	22	**73.4**
140	0.106	25.2	**48.2**
200	0.075	24.4	**23.8**
230	0.063	16.2	**7.6**
270	0.053	1.2	**6.4**
Passing	**Passing**	6.4	


Particle Size Distribution 120's Mesh
FKM Crumb
% Retained
50
45
40
35
30
25
20
15
10
5
0
0.3
0.25
0.18
0.15
0.106
0.075
0.063
0.053
Passing
MM


Particle Size Distribution 120's Mesh FKM Crumb
% Retained
50
45
40
35
30
25
20
15
10
5
0
52
60
85
100
140
200
230
270
Passing
MESH

PARTICLE SIZE DISTRIBUTION FOR 120'S MESH FKM CRUMB

		Retained	Passing
Mesh	**MM**	**%**	**%**
52	0.3	0	**100**
60	0.25	0	**100**
85	0.18	0	**100**
100	0.15	0	**100**
140	0.106	1.9	**98.1**
200	0.075	37.2	**60.9**
230	0.063	43.3	**17.6**
270	0.053	5.9	**11.7**
Passing	**Passing**	11.6	

DEVELOPMENT RECIPE

BLEND DESIGNATION	COMPARISON FKM CRUMB BLACK IN DAI-EL			
REFERENCE NUMBER	**1507/1**	**1507/5**	**1507/6**	**1507/7**
DATE 30/11/99				
RAW MATERIALS	**PHR**	**PHR**	**PHR**	**PHR**
DAI EL G.621	30	30	30	30
DAI EL G.555	70	70	70	70
FKM CRUMB - BLACK		10	30	50
MT. BLACK	20	20	20	20
$Ca(OH)_2$	6	6	6	6
ELASTOMAG 170	3	3	3	3
TOTAL	129	139	159	179

MOONEY ML(1+10) 100^0C	66	72	88	102
VULCANISATION ^{0}C	170	170	170	170
Min	10	10	10	10
TEMPERATURE ^{0}C	230	230	230	230
Std	24	24	24	24
HARDNESS SHORE^{0}A	66	67	71	72
S.G.	1.9	1.91	1.92	1.93
MODULUS 100% N/mm2	3.8	3.8	4	4.5
MODULUS 300% N/mm2				
MODULUS 500% N/mm2				
TENSILE STRENGTH N/mm2	13	12.4	11.4	11.1
ELONG @ BREAK %	290	298	285	273
COMPRESSION SET % @	33.7	37.7	40.3	41.7
72hrs @ 200C				

DEVELOPMENT RECIPE

BLEND DESIGNATION	FKM CRUMB GREEN IN DAI-EL			
REFERENCE NUMBER	1507/8	1507/9	1507/10	1507/11
DATE 30/11/99				
RAW MATERIALS	PHR	PHR	PHR	PHR
DAI EL G.621	30	30	30	30
DAI EL G.555	70	70	70	70
FKM CRUMB GREEN		10	30	50
BLANC FIXE	30	30	30	30
CHROME GREEN	5	5	5	5
$Ca(OH)_2$	6	6	6	6
ELASTOMAG 170	3	3	3	3
TOTAL	144	154	174	194

MOONEY ML(1+10)100^0 C	68	75	86	95
VULCANISATION ^{0}C	170	170	170	170
Min	10	10	10	10
TEMPERATURE ^{0}C	230	230	230	230
Std	24	24	24	24
HARDNESS SHORE^0 A	60	63	67	70
S.G.	2.22	2.22	2.22	2.22
MODULUS 100% N/mm2	2.8	3.2	3.5	3.7
MODULUS 300% N/mm2	11.3			
MODULUS 500% N/mm2				
TENSILE STRENGTH N/mm2	11.6	9.2	8.9	8.8
ELONG @ BREAK %	332	277	272	248
COMPRESSION SET % @	31.3	32.8	35.1	37.1
72hrs @ 200C				

DEVELOPMENT RECIPE

BLEND DESIGNATION	FKM CRUMB BLACK IN DAI G.763			
REFERENCE NUMBER		1507/13		
DATE 30/11/99				
RAW MATERIALS	PHR	PHR	PHR	PHR
DAI EL G.763		100		
FKM CRUMB BLACK		10		
MT. BLACK		20		
$Ca(OH)_2$		6		
ELASTOMAG 170		3		
TOTAL		139	0	0

MOONEY ML(1+10) 100^{0}C		84		
VULCANISATION ^{0}C		170		
Min		10		
TEMPERATURE ^{0}C		230		
Std		24		
HARDNESS SHORE^0 A		60-61		
S.G.		1.86		
MODULUS 100% N/mm2		2.6		
MODULUS 300% N/mm2		13.4		
MODULUS 500% N/mm2				
TENSILE STRENGTH N/mm2		14		
ELONG @ BREAK %		325		
COMPRESSION SET % @		21.1		
72hrs @ 200C				

SUMMARY

The above results clearly show that the **FKM Crumb** we produce can be added in economic amounts, back into Virgin Fluoro compounds.

Basic properties such as hardness and density are hardly changed. Indeed, the difference in results is within the normally allowed batch to batch spread. Although tensile strength is reduced a little, it is rarely the main criteria for use. In the case of flat gasket or compression jointing type applications, the critical property – compression set – is actually increased. Temperature, chemical and fluid resistance should be little affected, because all that is being added is 100% cured Fluoro compound. There are NO extra additions in the form of process aids etc, as there would be with reclaim.

The use of the materials can be considered in two distinct ways: -

- As an additional raw material that can be used to noticeably reduce cost, whilst not seriously affecting properties. The cost of the crumb is considerably lower than polymer or compound, and as the S.G. is the same, there is NO effect on volume cost.

- Although the above will show considerable advantage in cost, the real economic advantage will be derived by the company making product from scratch and producing cured waste. Normally, this would have to be disposed of, at a cost that gives no return. With our input, that waste could be collected, turned into crumb, and then re-used, at a percentage, back into virgin compound.

- Typically, the waste will be less than 10%, and the results quoted show that such amounts can be incorporated into new compound with little adverse effect.

Advantages are:

- No skip or removal charges.
- No problems with future anti-tipping/landfill legislation
- Cost of producing the crumb is offset by reduction in compound cost.
- Environmentally sound, ‘closed loop’ system
- Technical advantages of reduced problem from air trapping and improved compression set.
- Advantageous with regards to ISO 14001:
- Will boost a company’s “green” credentials.
- Indirectly; zero waste can be achieved.