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## Demolition Slabs:

### Development of New Containers and Covering Materials Part 1: Effect of Binder Oils on Films

G. W. Harding

T. K. Overton

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MATERIALS RESEARCH LABORATORY, WALTHAM ABBEY, ESSEX

Demolition of Slabs:

4 Development of New Containers and Covering Materials:  
Part 1: Effect of Binder Oils on Films

by

5 (G.W. Harding and T.K. Overton)

6 (Jul 1960)

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Demolition Slabs:  
Development of New Containers and Covering Materials:  
Part 1: Effect of Binder Oils on Films

by

G.W. Harding and T.K. Overton

Reference: M(T)87/2, M(R)87/26

1. SUMMARY

Ten film materials have been examined after storage in contact with the binder oils used in plastic explosives PE.3A, DG.20 and DG.29. It has been confirmed that polyethylenes are affected whereas polar materials are generally resistant, and polyethylene terephthalate film is shown to be outstanding.

2. INTRODUCTION

Demolition slabs of plastic explosives PE.3A in bituminised board containers, with paper tissue as cover, have not been completely satisfactory and a requirement therefore exists for improved slabs. New plastic explosives have been developed and various plastics are being considered as container materials.

Although a previous report (1) indicated that polyethylenes might be adversely affected by the binder oils of these newer explosives, demolition slabs were made of explosive compositions DG.20 and DG.29 in containers of various types of polyethylene. Trials have been carried out to assess their probable life. In addition various film materials have been examined for their resistance to the binder oils.

3. OBJECT

The purpose of this work has been threefold: first to assess the performance of a range of film materials in contact with binder oils at 70°C; secondly, to assess the effect on the containers of storing slabs at 60°C; thirdly, to assess a few selected films as possible alternatives to tissue paper.

The second and third parts of the work were conducted simultaneously and are dealt with in Part 2 of this report.

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4. EXPERIMENTAL

4.1 Materials

Ten film materials were used in this work. Descriptions of them are given in Table 1.

TABLE 1

Film	Polymer Type	Thickness (Inches)
Alkathene 7	Low density polyethylene	0.005
Alkathene 2	" " "	0.005
Alkathene 2/P.I.B.	" " 2 with 10 parts of polyisobutene	0.005
Marlex 50	High density polyethylene	0.006
Cobex	Vinyl chloride/vinylidene chloride copolymer	0.006
Akulon	Nylon 6	0.0015
Supronyl	Mixed nylons, believed to be 6.6, 6, 6.10 with monomer	0.004
Melinex	Polyethylene terephthalate	0.005
Cellophane	Regenerated cellulose	0.0015
Cellulose triacetate	Cellulose triacetate	0.005 and 0.008

The binder oils are formulated in Table 2.

/TABLE 2 .....

TABLE 2

Oil	Composition	Parts by Weight
PE.3A	Shell Mex Oil	6.2
	Liquid Paraffin	4.1
	Lecithin	0.1
DG.20	Di-octyl sebacate	4.4
	Vistac polyisobutene	5.0
	Aluminium laurate	0.6
DG.29	B.P. Paraffin	

Note: The DG.29 oil normally consists of a mixture of B.P. paraffin and lithium stearate; this is solid at room temperature so paraffin only was used in this trial.

4.2 Exposure of Films to Oils

The films were immersed in oils as described below (see Fig. 1). This method minimised container space and quantity of oil required.

An aluminium block 9 inch x 3½ inch x 2 inch was slotted at ¼ inch intervals along its length the slots being 0.05 inches wide and of sufficient depth to contain the films completely. Individual test pieces, either 2 inch x 1 inch or of dumb-bell shape (to B.S.903: Part A2: 1956,) were put into separate slots with a means of easy withdrawal. The block was then placed in an aluminium container of just sufficient size to allow it to be completely covered with oil. When filled with oil the assembly was placed in an oven at 70°C. Thus each test piece was in a separate cell of a width such as to prevent sagging of soft films while still allowing maximum swelling.

4.3 Testing

Absorption measurements were carried out by weighing the test pieces both before and after immersion, periodically on the rectangular test pieces and after 90 and 180 days on the dumb-bell specimens.

After weighing, each rectangular test piece was tested for brittleness by flexing before replacing on trial. The tensile (dumb-bell) specimens were conditioned at 70°F and 65 per cent R.H. for 24 hours and then broken

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on a Baldwin Universal testing machine with rate of separation of the grips of 20 inches per minute for Alkathene 2, Marlex 50, Akulon and Supronyl, and one inch per minute for Melinex, Cobex, Cellophane and Cellulose triacetate.

Control specimens kept under the same conditions except for oil immersion were tested similarly.

5. RESULTS

The results are shown in Tables 3 - 5. Table 3 gives a qualitative assessment of the condition of the rectangular test pieces at the end of the trial, Table 4 the weight changes of these specimens, and Table 5 the effect on the physical properties of the films.

Alkathene 7. After 180 days this material had disintegrated in the DG.20 oil and was highly swollen by the PE.3A and DG.29 oils.

Alkathene 2/Polyisobutene behaved similarly to Alkathene 7 but showed rather higher swelling.

Alkathene 2. DG.20 oil had caused almost complete loss of strength in this material, while DG.20 and PE.3A oils appeared to plasticise it.

Marlex 50 had disintegrated after 180 days in DG.20 oil and was degraded to some extent by immersion in both PE.3A and DG.29 oils. It was also badly degraded in air at 70°C. This material showed less swelling than that of the less crystalline low density polyethylenes.

Cobex was little affected by contact with PE.3A and DG.29 oils while contact with DG.20 oil caused some swelling with consequential plasticising.

Cellophane showed a negative swelling effect after immersion in all the oils because of its original high moisture content, 16 per cent loss being shown after heating alone. Its tensile strength showed an increase and elongation at break a decrease after immersion in any of the oils. The brittleness shown by the rectangular test pieces after immersion in PE.3A and DG.20 oils was not confirmed by tensile tests.

Akulon exhibited little swelling after 90 days but appreciable swelling after 180 days immersion. Its degradation was not severe after contact with PE.3A and DG.29 oils but DG.20 oil caused a reduction of about 50 per cent in both its tensile strength and elongation at break.

Supronyl showed a negative swelling effect possibly because of high moisture content and solubility of monomer or low-molecular-weight material in the binder oils. It was readily degraded in air, in DG.20 oil and to a lesser extent in DG.29 oil. It was not degraded in PE.3A oil.

Melinex was unaffected by contact with the oils or in air.

Cellulose triacetate was largely unaffected by contact with the oils but was degraded to some extent when aged in air at 70°C.

/6. ....

6. DISCUSSION

The results show that polyethylene terephthalate is the outstanding film material for use in contact with the binder oils although Cobex, Akulon, Cellulose triacetate and Cellophane may also be used safely. Supronyl is not suitable because of its poor heat resistance.

Of the non-polar polyethylenes none can be considered generally suitable, but Alkathene 2 may be used in contact with PE.3A and DG.29 oils in spite of its rather high swelling. Although Marlex 50 film, as expected, shows less swelling than the low density polyethylenes, it is less heat resistant and therefore not so suitable as Alkathene 2. These findings generally confirm the results of previous work (1) but the plasticising effect on Marlex 20 shown by plastic explosive DG.29 has not been repeated here by DG.29 oil. (Note: Plastic explosive DG.29 contains lithium stearate, a soap, whereas DG.29 oil does not. The presence of this material may cause different results to be obtained on polyethylenes because of the phenomena "environmental cracking" peculiar to polyethylenes).

Previous work (1) on the comparison of the effects of plastic explosives on polyethylenes and polymethyl methacrylate suggested that polar materials would be the less affected. This is confirmed in the present work and it will be noticed that the polar materials, with the exception of Cobex in contact with DG.20, absorb very little of the oils and do not deteriorate unduly after contact with them, in fact a protective influence is shown in some cases; Akulon and Supronyl for example are less affected in oil than in air.

The swelling of Cobex is not unexpected as dioctyl sebacate (Solubility parameter ( $\delta$ ) 8.4 (1)), an ingredient of the DG.20 oil, is more polar than the hydrocarbon oils ( $\delta$  about 7.5 (1)) and is in fact currently in use as a plasticiser for polyvinyl compounds.

The degradation of polyethylene has been discussed previously (1) when it was stated that antioxidants should extend its life. Similarly, polar materials can be treated with antioxidant to extend their life, for example Supronyl and Akulon which are both degraded in air. It is known for instance that antioxidants incorporated in nylon 6 or nylon 6.6 can extend their lives several fold (2).

7. CONCLUSIONS

This work has confirmed that polyethylenes are affected by the oils used in plastic explosives and has substantiated a previous suggestion (1) that polar materials should be more resistant. It also shows that, of the materials examined, polyethylene terephthalate is the most suitable for use in contact with these oils.

8. BIBLIOGRAPHY

1. Harding, G.W., Technical Note D.M.X.R.D./PL/58/3.
2. Unpublished work.

/TABLE 3 .....

TABLE 3

Effect of Binder Oils for Plastic Explosives on Various Films after 6 Months Immersion at 70°C

Binder Oil	Condition (Qualitative Examination)		
	PE.3A	DG.20	
Film		DG.29	
Alkathene 7	Soft and weak	Disintegrating	Very soft and weak
Alkathene 2	Satisfactory	Very soft and weak	Flexible and soft
Alkathene 2/P.I.B.	Very soft and flexible	Very soft and weak	Very soft and flexible
Marlex 50	Satisfactory	Brittle (in pieces)	Satisfactory
Cobex	"	Satisfactory	"
Akulon	"	"	"
Supronyl	"	"	"
Melinex	"	"	"
Cellophane	"	"	Brittle
Cellulose triacetate	"	"	Satisfactory

/TABLE 3 •••••

Weight Changes (per cent) of Various

Film Material	Alkathene 7				Alkathene 2				Alkathene 1
	Nil	EE 3A	DG 20	DG 29	Nil	EE 3A	DG 20	DG 29	
Oil	Nil	EE 3A	DG 20	DG 29	Nil	EE 3A	DG 20	DG 29	Nil
Initial Weight (g)	0.2085	0.1795	0.2103	0.1838	0.1161	0.1189	0.1140	0.1144	0.1983
Period (days)									
1	0.19	21.1	9.0	25.4	0.10	17.7	7.7	22.3	0.20
2	0.34	19.2	8.8	30.6	0.10	16.3	6.1	21.7	0.75
3	0.24	21.7	8.8	27.2	0.20	16.5	6.8	21.9	0.40
7	0.24	23.4	8.1	27.2	0.30	18.1	6.2	21.9	0.56
14	0.4	22.1	6.7	24.7	0.30	16.9	6.4	19.8	0.60
28	0.5	22.5	8.5	22.9	0.40	17.7	7.4	20.1	0.60
90	0.8	22.7	9.1	22.1	0.60	17.7	10.1	23.1	0.50
180	1.0	24.2	D	20.5	0.90	19.7	16.6	20.6	0.80

Note: EE.3A Oil - Shell Mex Oil  
Liquid Paraffin  
Lecithin

DG.20 Oil - Dioctyl sebacate  
Vistac polyisobutylene  
Aluminium Laurate

DG.29 Oil - B.P. Paraffin  
(Mixture of B.P. Paraffin  
Lithium stearate)

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TABLE 4

t) of Varicus Films after Immersion in Oils at 70°C

	Alkathene 2/P.I.B.				Marlex 50				Cobex			
	Nil	FE 3A	DG 20	DG 29	Nil	FE 3A	DG 20	DG 29	Nil	FE 3A	DG 20	DG 29
44	0.1983	0.1970	0.1882	0.2064	0.1421	0.1778	0.1821	0.1878	0.2827	0.2885	0.2962	0.2700
3	0.20	24.8	16.8	31.0	0	6.8	4.7	7.8	-0.04	0.21	3.3	0.40
7	0.75	23.4	16.9	33.0	0.35	7.1	6.4	8.5	0.04	0.11	5.6	0.51
9	0.40	23.9	16.7	33.0	0.40	7.1	4.7	8.2	0.04	0.11	5.6	0.19
9	0.56	25.5	17.1	32.5	0.45	7.1	6.3	7.7	0.04	0.07	8.9	0.30
8	0.60	25.0	16.3	26.3	0.45	7.7	5.2	8.2	0.04	0.13	10.1	0.03
1	0.60	26.1	17.6	29.9	0.56	7.9	5.3	8.9	0.24	0.10	10.1	0.37
1	0.50	26.0	20.5	33.1	0.70	8.4	6.1	8.8	-0.11	0.07	10.3	0.11
5	0.80	29.2	D	26.3	1.0	10.6	D	10.1	0.0	1.6	12.6	0.52

1 Mex Oil 119                    6.2)  
 d Paraffin Trade 1            4.1) parts by weight  
 thin                                0.1)

tyl sebacate                    44)  
 to polyisobutene               50) parts by weight  
 nium Laurate                    6)

Paraffin only used  
 ure of B.P. Paraffin with  
 um stearate is solid.)

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2

TABLE

Film Material	Akulon				Supronyl				
Oil	Nil	FE 3A	DG 20	DG 29	Nil	FE 3A	DG 20	DG 29	Nil
Initial Weight (g)	0.0362	0.0374	0.0348	0.0340	0.2131	0.2104	0.2181	0.1461	0.1614
Period (days)									
1	-0.8	-	1.1	5.0	-1.2	-4.5	-5.3	-2.5	-0.2
2	-0.8	1.3	0.3	1.8	-0.84	-6.9	-7.5	-5.5	-0.2
3	0	1.3	1.1	1.8	-0.98	-8.2	-8.6	-6.4	-0.1
7	0	1.3	0	1.8	-1.3	-9.9	-10.0	-8.2	0
16	0.2	1.9	3.4	1.6	-1.5	-11.7	-10.7	-10.1	-
28	0.8	2.9	1.4	3.2	-	-12.3	-12.8	-11.3	-
90	0.6	2.1	1.1	3.8	-2.1	-12.3	-12.0	-11.4	-0.4
180	2.5	13.6	6.3	11.2	-4.8	-9.9	-10.4	-11.2	-0.4

Note: \* Original sample :

\*\* New sample. Numl

D Sample disintegrate

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TABLE 4 (Contd.)

DG 29	Melinex				Cellophane				Cellulose Triacetate			
	Nil	FE 3A	DG 20	DG 29	Nil	FE 3A	DG 20	DG 29	Nil	FE 3A	DG 20	DG 29
14.61	0.1614	0.2051	0.2200	0.1530	0.0661	0.0521	0.0651	0.0651	0.0680	0.0781	0.06718 0.1200	0.0785
-2.5	-0.24	-0.43	-0.04	-0.26	-4.7	-3.8	-2.4	-2.8	-0.14	-0.64	<sup>###</sup> -1.3	0
-5.5	-0.24	-0.24	-0.45	0	-5.7	-3.8	-2.3	-0.3	-0.29	-0.64	<sup>###</sup> -1.5	-0.89
-6.4	-0.12	-0.34	-0.72	-0.13	-7.4	-4.0	-2.6	-0.3	0	-0.9	<sup>###</sup> -1.7	-0.84
8.2	0	-0.54	-0.66	-0.39	-9.3	-5.6	D	-1.5	-1.4	-1.2	<sup>###</sup> (4) -1.4	-1.3
0.1	-	-0.63	-0.77	-0.52	-8.0	-6.7	-	-3.4	-	-1.3	<sup>###</sup> (13) -1.4	-1.5
1.3	-	-0.34	-0.59	-0.26	-9.3	-7.2	-	-2.0	-	-1.0	<sup>###</sup> (25) -1.3	-0.77
1.4	-0.4	-0.5	-1.8	-0.5	-17.1	-7.3	-	-8.0	-0.7	-2.0	-	-1.1
1.2	-0.4	0.2	-1.9	0.1	-15.9	D	-	-6.3	-1.2	0.9	<sup>###</sup> (177) -2.8	1.7

al sample lost after trial had been on for 3 days  
 mple. Numbers in parenthesis indicate actual period in days  
 disintegrated very brittle

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TABLE 5

Effect of Binder Oils on Various Films after Immersion at 70°C

Film Material:	Alkathene 2			Marlex 50			Cobex			Cellophane			
	Ageing Period (Days)	Tensile Strength (% of Original)	Elong. at Break (% of Original)	Weight Increase (%)	Tensile Strength (% of Original)	Elong. at Break (% of Original)	Weight Increase (%)	Tensile Strength (% of Original)	Elong. at Break (% of Original)	Weight Increase (%)	Tensile Strength (% of Original)	Elong. at Break (% of Original)	Weight Increase (%)
	0	100 (2930)	100 (420)	-	100 (3185)	100 (940)	-	100 (8120)	100 (25) <sup>#</sup>	-	100 (9300)	100 (40)	-
Nil	90	86.7	100.0	0.60	130	1.6 (29.8)	0.70	129.6	200	-0.11	181.7	25	-17.1
	180	77.8	71.4	0.90	54.6	Negligible	1.0	124.9	100	0	133.4	37.5	-15.9
PE.3A	90	81.2	100 <sup>###</sup> (550-370)	17.7	97.0	42.5 (8.5)	8.4	127.2	200 <sup>###</sup> (20-80)	0.07	194.6	12.5	-7.3
	180	73.7	126.2 <sup>###</sup> (450-700)	19.7	90.1	23.4	10.6	128.4	780	1.6	144.1	75.0	D
DG.20	90	76.5	61.9 <sup>###</sup> (120-420)	10.1	94.8 (82.3)	58.5 (5.3)	6.1	69.6	520	10.3	179.2	12.5	D
	180	0	0	16.6	0	0	D	44.1	160	12.6	130.3	62.5	D
DG.29	90	73.0	95.2 <sup>###</sup> (350-500)	23.1	101.3	33.0 <sup>###</sup>	8.8	130.5	40	0.11	145.8	12.5	-8.0
	180	56.3	171.4	20.6	87.0	33.0	10.1	126.8	100	0.52	129.2	50.0	-6.3

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TABLE 5 (Contd.)

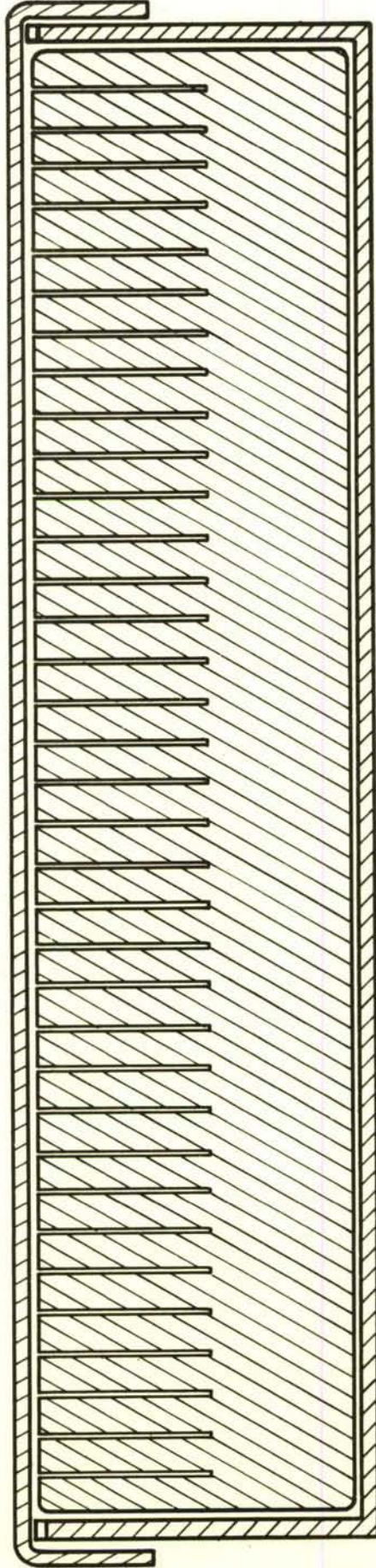
Film Material:	Akulon			Supronyl			Melinex			Cellulose Triacetate			
	Ageing Period (Days)	Tensile Strength (% of Original)	Elong. at Break (% of Original)	Weight Increase (%)	Tensile Strength (% of Original)	Elong. at Break (% of Original)	Weight Increase (%)	Tensile Strength (% of Original)	Elong. at Break (% of Original)	Weight Increase (%)	Tensile Strength (% of Original)	Elong. at Break (% of Original)	Weight Increase (%)
Oil Contact	0	100 (10500)	100 (275)	-	100 (5400)	100 (340)	-	100 (20370)	100 (20)	-	100 (10700)	100 (20)	-
	90	90.9	58.2	0.6	76.8) 46.9) 32.4)	44.1) 5.9) 5.9)	2.1	111.7	80	-0.4	97.7	60	-0.7
	180	89.1	47.3	2.5	27.6	5.9	-4.8	100.6	90	-0.4	83.2	50	-1.2
PE.3A	90	102.9	61.8	2.1	106.1	100	-12.3	111.9	80	-0.5	100.9	50	-2.0
	180	81.4	85.4	13.6	102.8	132.4	-9.9	104.3	120	0.2	92.8	150	-0.9
DG.20	90	131.7) 65.3)	74.5) 29.1)	1.1	111.1	97.1	-12.0	108.8	85	-1.8	95.6	65	-
	180	59.9	47.3	6.3	27.8	3.0	-10.4	98.7	100	-1.9	82.2	150	-2.8 [177]
DG.29	90	112.9	87.3	3.8	83.3	52.9	-11.4	109.5	80	-0.5	101.2	60	-1.1
	180	90.9	81.8	11.2	65.2	64.7	-11.2	101.7	120	0.1	87.9	125	1.7

Notes: \* - Variable results - 40, 10 and negligible elongation at break  
 \*\* - Inconsistent results. (Experience has shown that Cobex exhibits very variable elongations at break)

Figures in parenthesis ( ) actual tensile test results  
 " " brackets [ ] actual time of trial

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FIG. 1.

SLOTTED ALUMINIUM BLOCK AND CONTAINER.

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D. of A.(R. & D.)  
D.O.F.(Amm.)  
D.O.F.(F)  
D.O.F.(X)  
D.R.E.E.  
D.X.C.P.  
D.S.C.(D) (Mr. T.K. Overton)

Establishments

D.A.R.D.E.  
D.F.V.R.D.E.  
D.M.E.X.E.

ATOMIC ENERGY AUTHORITY

D.A.E.R.E.

OVERSEAS (through T.I.L.)

Australia: D. of S.  
S.R.L.O.

Canada: C.A.R.D.E.

U.S.A.: J.S. Reading Panel (18)

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D.M.X.R.D. Technical Demolition Slabs: Development of New  
Note No. PL/60/1 Containers and Covering Materials: Part 1:  
Effect of Binder Oils on Films

G.W. Harding and T.K. Overton July, 1960

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10 pp., 1 fig., 5 tables

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