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THE UNIVERSITY OF NEW SOUTH WALES

WATER RESEARCH LABORATORY

REPORT No. 56

Seepage Control with Plastic Membranes

Part 5 - Physical Properties of Australian Plastic Films Suitable for Dam Lining

by

T. R. Fietz

JANUARY, 1962

The University of New South Wales

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SEEPAGE CONTROL WITH PLASTIC MEMBRANES - PART 5: PHYSICAL PROPERTIES OF AUSTRALIAN PLASTIC FILMS SUITABLE FOR DAM LINING

by

T.R. Fietz

January 1962

A Report to the Water Research Foundation of Australia Limited.

PREFACE

This is the fifth of a series of reports to the Water Research Foundation of Australia Limited on an investigation into the use of plastic films for seepage control in farm dams and small reservoirs.

This research programme was commenced early in 1957 and was substantially completed in 1961. Some handling tests and long-term durability trials are continuing.

The investigation was supported by grants from the Water Research Foundation of Australia Limited, which were made possible through the generosity of Imperial Chemical Industries of Australia and New Zealand Limited. It was initiated by Professor J.P. Baxter, Vice-Chancellor of the University of New South Wales.

Valuable assistance in this study of the properties of plastic films was provided by officers of I.C.I.A.N.Z. Limited, Moulded Products (A'asia) Limited, Plastalon Limited and Freydis Limited, who made samples of film and welds available. The co-operation of Professor M. Chaiken of the School of Textile Technology, University of New South Wales, who lent the facilities of his testing laboratory, is gratefully acknowledged.

Laboratory studies in connection with the plastic membrane research programme were made at the Water Research Laboratory, Manly Vale, N.S.W. The programme is under the direction of Mr. J.R. Burton of the Laboratory Research staff. The mechanical tests reported in this paper were conducted by Mr. T.R. Fietz, who was then a Research Fellow. Mr. Fietz is now a member of the Laboratory Research staff.

H.R. Vallentine
Assoc. Professor of Civil Engineering
Officer in Charge of the Water
Research Laboratory.

January, 1962.

SEEPAGE CONTROL WITH PLASTIC MEMBRANES:

REPORT No.5 - PHYSICAL PROPERTIES OF AUSTRALIAN PLASTIC FILMS SUITABLE FOR DAM LINING.

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SEEPAGE CONTROL WITH PLASTIC MEMBRANES:

REPORT No. 5

PHYSICAL PROPERTIES OF AUSTRALIAN PLASTIC FILMS SUITABLE FOR DAM LINING.

Summary: This report describes the results of physical testing carried out on Australian-made polythene and polyvinyl chloride films to determine their suitability for use as dam liners. Tests included tensile, tear and bursting strength tests on new materials and materials exposed to sunlight for varying periods up to 2 years. Tensile and tear tests were conducted on a variety of seams and welds. The report also describes a simulated handling damage test and weather ageing tests.

Tentative working stresses are given for the materials tested.

1. INTRODUCTION

The object of the investigation was to examine the relevant physical properties of Australian-made plastic films likely to be used for lining farm dams and irrigation canals in order to ascertain:-

(i) Working stresses for design purposes
(ii) Variation of physical properties when exposed to weathering agents
(iii) The efficiency of various jointing techniques before and after weathering
(iv) Resistance to injury when subjected to a soil covering test

The following properties were investigated:-

(i) A.S.T.M. tensile strength, B.S. tear strength, Elmendorf tear resistance, bursting pressure of new and weathered specimens.
(ii) A.S.T.M. tensile strength and B.S. tear strength on edge of weld for various welds and seams for both new and weathered material.
(iii) Behaviour of new material and various seams when subjected to accelerated wetting and drying conditions.
(iv) Resistance to injury when subjected to simulated soil covering test.

2. METHODS OF TESTING

The following testing techniques were employed:-

2.1 <u>A.S.T.M. Tensile Test</u>:- All tensile strength and % maximum elongation at break tests were carried out according to A.S.T.M. designation D882-56T "Tensile Properties of Thin Plastic Sheets and Films", Method B. (Ref.I), with the following deviations from the code:-

(a) Laboratory conditions were 70°F and 65% Rel. Humidity cf. 73.4°F and 50% Rel. humidity required.

(b) No suitable apparatus was available for measuring the elongation of the gauge length under load and hence the grip separation was taken as the gauge length.

All specimens were cut using a brass template and lino knife (See Fig.1), (specimen size 5" long x 1" wide) and tested in a "Baer" textile testing machine. Most specimens failed within the 0-20lb. range on the machine which read directly to 0.2 lb.

whilst a few had to be tested in the 0-100 bls. range which read directly to 1 lb. As the max. elongation at break was 100% for all cases an initial grip separation of 1½" or 2" and a loading rate of 20" per minute was used. A recording load deformation device fitted to the machine was used to obtain typical curves for various materials.

2.2 B.S. Tear Test:- Tear tests were carried out according to British Standard 1763, 1956. "Thin P.V.C. Sheeting (Flexible Unsupported)" (Ref.2). The following deviations from the standard were necessary:-

(a) The conditioning and testing temperature was 70° F, not 73.4°F as specified.

(b) Specimens were cut using a brass template and lino knife, not a die as specified. The 90° notch produced using a template and a sharp knife was found to be quite sharp, however.

The "Baer" textile testing machine used for tensile testing above was also used for tear strength tests. The loading rate was 11" per minute. A sample of polythene under test is shown in Fig. 2.

2.3 Elmendorf Tear Resistance:- This test was carried out according to A.S.T.M. designation D.689-44 "Internal Tearing Resistance of Paper" (Ref.1), using the "Baer-Elmendorf" machine. The following deviations from the code were necessary:-

(a) The conditioning and testing temperature was 70°F.
(b) The work scale on the machine was graduated in gm. cm. x 10^3, not in units of 1/16th of work done as specified. The Elmendorf machine is shown in Figs. (3) and (4).

2.4 Bursting Test:- The b sting strength and height of dilation at failure were determined using a "Frank" textile testing machine with an orifice area of 10 sq.cms. and a loading rate of 1. A photo of the machine is shown on Fig. (5).

2.5 A.S.T.M. Tensile Test of Seams and Welds:- Specimens with the weld or seam running normal to the direction of pull and situated equidistant from the two grips were tested according to method (1) above. See Figs. (6) and (9) showing various welds and seams under test.

2.6 B.S. Tear test on Edge of Weld:- These were carried out in a similar manner to (2) above with the 90° notch placed on the edge of the weld.

2.7 Accelerated Weathering Test:- A concrete weathering machine used at the Concrete Technology section of the University of New South Wales was employed to test the relative durability of film specimens of various thickness and several types of joints. The following cycle of wetting and drying was being used in the machine at the time of test:-

Samples flooded with tap water	27 mins.
Tank empties	5 mins.
Time lapse for drainage	1 min.
Heating by infra red lamp @ 112°F.	26 mins.
Time lapse before flooding	1 min.
	60 mins.

A few samples of various membranes were also exposed to infra red lamps @ 240°F. for 5 minutes and the effect noted.

2.8 Test to Simulate Covering of Films with Soil in the Field:- This test was carried out using the apparatus shown in Fig. (10) where one cubic foot of soil consisting of 75% of river sand and 25% of $\frac{3}{4}$" crushed basalt was dropped from a height of 4 ft. onto a sample of plastic membrane resting on 3" of sand. A pinhole test according to B.S. 1763: 1956 (Ref.1) was then carried out to detect any puncturing.

2.9 Microscopic Examination:- Several specimens were examined under a low power (6x) microscope using both reflected and transmitted light.

3. DETAILS OF MATERIALS TESTED

Material	Test Used
(1) I.C.I. 'Visqueen' Polythene, colour Black,(contains 2% carbon black) thickness .0015", .002", .006" & .008". New material. (2)Moulded Products 'Nylex' Polyvinyl-chloride (P.V.C.) Thickness .008", new material (3) I.C.I. Black Visqueen .004, exposed at dam at Horrox' farm, North Richmond, N.S.W. on sides and bottom of dam for 4 months. Not covered with soil.	A.S.T.M. Tensile B.S. Tear Elmendorf tear. Bursting. Pinhole examination after soil covering test. Microscopic examination. Behaviour at elevated temperature and accelerated weathering (for (1) and (2)

Material	Test Used
(4) As above, used at Ouyen, Vic. exposed for 12 months. Not covered with soil.	
(5) Black 'Visqueen' .008" thick used for sides and bottom of dam at Charlton, Vic. originally covered with soil but had been uncovered when sample was taken. Exposure time 23 months.	A.S.T.M. Tensile. B.S. Tear Microscopic examination.
(6) Plastalon heat weld on black Visqueen polythene, Thicknesses .002", .004", .006" and .008". New material	A.S.T.M. Tensile.
(7) Moulded Products electronic weld on Nylex P.V.C. Thickness .008", new material.	A.S.T.M. Tensile on a specimen parallel and adjacent to weld. B.S. tear with 90° notch on edge of weld.
(8) Plastalon heat weld on black Visqueen Polythene, thickness .004" ex Harrox' dam.	
(9) Freydis heat weld on black Visqueen polythene, Thicknesses .004", .006" and .008", new material.	A.S.T.M. Tensile
(10) Freydis tape seam on black Visqueen polythene, thicknesses .004", .006" and .008", new material.	

4. TEST RESULTS:

4.1 A.S.T.M. Tensile Strength and % Max. Elongation at Break.

Sample		Longitudinal U.T.S.	Longitudinal % Elong'n	Transverse U.T.S.	Transverse % Elong'n	Remarks
A. New Material						
Polythene black	.002"	2270psi.	135%	2603psi	456%	
" "	.004"	1850psi.	220%			
" "	.006"	1690psi.	330%	1640psi	537%	
" "	.008"	1820psi	336%	1660psi	537%	
P.V.E. green	.008"	2210psi.	360%	2040psi	458%	
B. Weathered Material						
Ex. Horrox dam	.004"	1830psi.	120%	1960psi	190%	
" Ouyen dam	.004"	1950psi.	114%			Direction doubtful
"Charlton "	.008"	1680psi.	280%			

4.2 B.S. Tear Strength and 4.3 Elmendorf Tear Resistance

Sample		B.S. Tear Strength		Elmendorf Tear Resist	Remarks
A. New Material					
Polythene black	.0015"	468 lb/in	482 lb/in		
	.002"	441 "	353 "	187 gms	
	.004"	394 "	340 "	666 "	
	.006"	433 "	383 "	656 "	
	.008"	455 "	372 "	980 "	
P.V.C. Green	.008"	256 "	275 "	1399 "	
B. Weathered Material					
Ex. Horrox dam	.004"	434 "	455 "	310 "	
" Ouyen "	.004"	416 "			Direction
" Charlton "	.008"	386 "			Doubtful

4.4 Bursting Strength and Height of Dilation at Break

Sample		Bursting Pressure on 10 sq.cm. orfice		Height of Dilation at Failure	Remarks
A. New Material					
Polythene black	.002"	0.24	kg/cm^2	6.65 mm.	
	.004"	1.13	"	8.3 "	
	.006"	1.64	"	8.75 "	
	.008"	2.265	"	10 "	
P.V.C. green	.008"	3.42	"	29 "	
B. Weathered Material					
Ex Horrox Dam	.004"	0.82	"	5.4	Small cut opened.

NOTE:- Valve setting of 1 (one) for all bursting tests.

4.5 A.S.T.M. Tensile Strength of Welds and Seams

Sample	U.T.S.	% Elong'n.	Remarks
A. New Material			
Plastalon .004" black P.	1895 psi.	298%	Failed on Edge of weld.
Spec. parallel to "	1805 psi.	316%	
Plastalon .006" Black P.	1626 psi.	273%	Failed when necking reached weld.
Spec.parallel to "	1715 psi.	411%	
Plastalon .008" black P	1550 psi.	224%	Failed when necking reach weld.
Spec.parallel to "	1670 psi.	259%	
P.V.C. .008" Electronic	2090 psi.	288%	Failed on edge of weld.
Spec. parallel to "	3220 psi.	179%	
Freydis .004" tape seam, Black P	2040 psi.	179%	
Spec. parallel to above	2020 psi.	311%	
Freydis .006" Tape	1770 psi.	146%	
Spec. parallel to above	1680 psi.	505%	
Freydis .008" Tape	1630 psi.	158%	
Spec. parallel to above	1495 psi.	310%	
Freydis .004" weld,Black P	1740 psi.	29%	Failed on edge of weld.
Spec. parallel to above	1850 psi.	238%	
Freydis .008" weld	976 psi.	30%	"
Spec. parallel to above	1510 psi.	359%	"
Freydis .008" clear weld	966 psi.	30%	"
Spec. parallel to above	1548 psi.	425	
B. Weathered Material			
Plastalon .004" ex Horrox	1880 psi	154%	Failed when necking reached weld.

4.6 B.S. Tear Strength on Edge of Weld

Sample	B.S. Tear Strength	Remarks
A. New Material		
Plastalon .004" Black P.	326 lb/in	
.006" "	342 "	
.008" "	362 "	
P.V.C. .008" Electronic	295 "	
B. Weathered Material		
Plastalon .004" ex Horrox	333 "	

4.7 Accelerated Weathering tests, A. Using Weathering Machine

Sample	Exposure: Hours Submerged	Hours Heated	Remarks
Black Visqueen .002" .004", .006" and .008" thick	115	110	No visible change.
Also P.V.C. Nylex .008" thick	70	65	No visible change.
Plastalon and Freydis tape seams.			

The above tests will be continued until some change is apparent.

B. Tests at Elevated Temperatures.

The appearance of Polythene and P.V.C. samples after exposure to infra red lamps at 240°F for 5 minutes is shown in Fig. (II).

The P.V.C. was unaffected while the polythene was rendered useless for any sealing purposes. The thinner the polythene sheet the more holes produced by the elevated temperature.

4.8 Test to Simulate Covering of Films with Soil in the Field.

Sample		No. of drops from 4'	% Elong'n at time of pin-hole Examination.	Pinholes /ft^2/drop	Remarks
Black Visqueen	.002"	1		39	
	.004"	1	0	21	
	.006"	2	20	3 to 4	
	.008"	2	20	3	
Nylex P.V.C.	.008"	2	20	1	

4.9 Microscopic Examination

The light source available was not bright enough to penetrate black polythene of thickness .004" and above. Some light was transmitted thus the black polythene .002" thick, however, and streaks and spots of carbon black were clearly visible. Some light was also transmitted through the green P.V.C. .008" thick, and the material appeared to be homogeneous.

section. Figs. (12) and (13).

5. DISCUSSION OF TEST RESULTS

5.1 Derivation of Working Stresses for Design Purposes

5.11 Lining farm ponds and irrigation canals

Typical load deformation curves indicate an ultimate extension of about 350% in the longitudinal direction and about 500% in the transverse direction for both polythene and P.V.C. (at normal room temperature.) For polythene most of this elongation occurs at creep after the U.T.L. is reached, whereas a more linear load-deformation curve is produced by P.V.C.

It is conceivable that cracking due to drying shrinkage could occur under some dam liners, in which case the liner would be forced, by the hydrostalic pressure above, into the crack. Polythene, due to its initial stiffness, would be more suitable than P.V.C. in resisting such deformation, but both materials would be capable of considerable distortion before failure and subsequent loss of water from the dam.

5.12 Flexible dam walls, flexible water tanks and other structural applications.

Kinney (Ref.4) states that "In general, creep considerations eliminate plastics from consideration as material carrying primary stresses and restrict their application to those in which

(1) The materials carry secondary stresses only, or
(2) the materials need only to be self supporting." As plastic films have already been used structurally in this country (e.g. in conjunction with A.R.C. mesh to form silo walls and floors) it is considered that further research is needed before the above quotation is taken as read.

In the absence of comprehensive creep tests at normal and elevated temperatures, the creep detected in the A.S.T.M. tension test (especially that of polythene) would indicate that a conservative factor of safety is necessary if the materials are to be used for primary stress applications.

A tentative factor of safety of 3 is suggested on the U.T.S. derived from the A.S.T.M. tension test and this would yield a working stress, f_D of :-

Material	Working Stress f_D Longitudinal	Working Stress f_D Transverse	Remarks
Black Visqueen Thickness .002" to .008" inclusive	560 psi	550 psi	1/3rd of lowest U.T.S. in range .002" to .008"
Nylex P.V.C. .008"	740 psi	680 psi	

When the above stresses are used then all of the weld and seam types tested are satisfactory, with the possible exception of the Freydis heat weld for thicker films.

5.2 Variation of Physical Properties of Polythene with Age.

Sample	Exposure Time	Variation of Property W.R.T. New Matl. U.T.S.	% Max Elong'n	B.S. Tear	Bursting Press
.004" ex Horrox	4 months	-1.1%	-45%	+10%	-27%
.004" ex Ouyen	12 months	+5.4%	-48%	+ 5%	
.008" ex Charlton	23 months	-7.7%	-17%	-15.2	

It is important to note that the above variation figures are based on test results from batches manufactured at a later date. Keeping this in mind, the obvious variations are the reduction in % elongation at break for all specimens and the reduction in bursting pressure for the sample from Horrox' dam (due to many small razor like cuts which reduce the thickness of the film).

5.3 Efficiency of Various Jointing Techniques

	Variation of Property W.R.T. New Matl. U.T.S.	% Max.Elong'n.	B.S. Tear on edge of weld	Remarks
Plastalon .004" Weld new	+5%	-5.7%	-4.1%	
" .006" " "	-1%	-47.3%	-11%	
" .008" " "	-6.6%	-58.3%	-2.7%	
Plastalon .004" ex Horrox	-4%	-19%	-26.8%	
P.V.C. Electronic .088" new	+2.5%	-37%	+7.3%	
Freydis tape .004" new	+10.3%	-18.6%		
" .006" "	+ 7.9%	-73%		
" .008" "	-1.8%	-70.5%		
Freydis weld .004" new	-6%	-87%		
" " .008" "	-41.2%	-94.5%		

The values of U.T.S, % max. elongation and B.S. tear strength for new material were obtained from different batches to those used for making the weld and tape samples. Comparisons between samples from different batches are of doubtful value, hence the above figures should not be taken as conclusive.

5.4 Comparison of Properties of Polythene and P.V.C. of Similar Normal Thickness

Property	.008" Black Polythene	.008" P.V.C.
U.T.S. Longitudinal	1820 psi.	2210 psi
U.T.S. Transverse	1660 psi.	2040 "
% max. elong'n long	336%	360%
" " trans.	537%	458%
B.S. Tear strength long.	455 lb/in	256 lb/in
" " " trans.	372 lb/in	275 lb/in
Elmendorf tear Strength	980 gms.	1399 gms.
Bursting strength	2.27 kg/cm^2	3.42 kg/cms
Ht. of dilation at break	10 mm	29 mm
B.S. Tear on edge of weld	362 lb/in	295 lb/in
No. of pinholes after drop	3/ft^2/drop	1/ft^2/drop
Resistance to infra-red test lamps @ 240°F.	Melts, holes appear.	Softens but will not run.

Difference in the properties of P.V.C. and polythene of similar nominal thickness were not great. P.V.C. was superior in U.T.S., Elmendorf tear resistance, bursting strength and dilation while Polythene was superior in % max. Elongation, initial stiffness and B.S. Tear strength.

P.V.C. is more flexible than polythene and hence would be more easily installed and less likely to damage when covered by soil. The possibility of migration of the plasticiser in P.V.C. when exposed to natural weathering agents should not be overlooked, and some investigation on this is necessary.

6. CONCLUSIONS

6.1 Working Stresses for Design Purposes.

a. The maximum elongation at break for the polythene and P.V.C. films tested indicates that they would be suitable for lining farm ponds and irrigation canals when small earth movements are to be expected.

b. A significant property of the films tested was their anisotropy. In general a higher U.T.S. and B.S. tear strength was evident for the longitudinal direction, while a higher % elong'n was observed in the transverse direction.

The properties tested were also found to vary from batch to batch.

c. The figures quoted for structural design in the 'Results' section are tentative only and should not be used where there is any possibility that failure of the structure would cause life and property loss. A series of creep tests at normal and elevated (say about $150^{\circ}F$) temperatures at about 1/3rd U.T.S. would be necessary before such films could be confidently used structurally.

d. As there is no machine available locally for testing film at elevated temperatures, the manufacture of the inexpensive bench mounted tension testing machine shown in Fig. 14 is recommended. When used in conjunction with a hot air blower the machine would be capable of testing the properties required.

6.2 Variation of Physical Properties when Exposed to Weathering

6.21 Natural Weathering

As the properties of the exposed samples were compared with those derived from new material of later manufacture it is difficult to arrive at a confident conclusion. The following changes following exposure in the field were indicated, however:-

(a) The % max. elongation at failure was considerably reduced.

(b) Very small razor like cuts in the exposed membrane from Horrox' Dam reduced the bursting strength by about ⅓rd. These cuts were probable caused by the flaky rock particles on which part of the liner rested. It follows that it is essential to cover the bottom and sides of a dam to be lined with sand or some other material which can be readily smoothed. Some tests using sawdust for this purpose would be worthwhile. As there are few material weathering test results available, it is recommended that exposure racks for both exposed and buried samples be set up at the following places in New South Wales:-

(i) Manly Hydraulic Laboratory:- This would represent the County of Cumberland.
(ii) Armidale or Alstonville:- New England or North Coast.
(iii) Orange: Central west
(iv) Griffith: M.I.A.
(v) Broken Hill: Far West.

A suggested design for exposure racks is shown in figs.(15) and (16). Control samples would also have to be stored at standard conditions and tested simultaneously with the exposed samples.

6.22 Accelerated Weathering:-

No apparent changes were detected by visual examination of the samples placed in the wetting and drying machine. These tests will be continued until some change is obvious.

6.3 The Efficiency of Jointing Techniques before and after Weathering.

The plastalon weld, freydis tape seam and freydis weld for polythene and the electronic weld for P.V.C. were all of adequate efficiency for dam sealing work. The % max. elongation at break was considerably reduced for most cases, particularly the Freydis heat weld. This means that extreme care would have to be exercised in installing a liner fabricated with Freydis welds - it may not be economical to take such care.

The B.S. tear strength on the edge of most welds was not appreciably reduced, except those welds taken from Horrox' dam (exposed 4 months), where the tear strength was reduced by about ⅓rd. This was probably due to the many stress reversals caused by wind action. The 3 to 4 inch overlap left by some fabricators when assembling a membrane appears to have a detrimental effect in practice as it tends to flap in the wind and eventually tears away along the edge of the weld. An overlap of 2" or less would appear adequate.

There was no apparent change in the weld and seam samples exposed to accelerated weathering conditions in the wetting and drying machine.

6.4 <u>Resistance of Materials to Injury when subjected to a soil Covering Test.</u>

These tests demonstrated that thin plastic films are very prone to damage by the impact of soil. P.V.C. was more suitable than polythene of equivalent nominal thickness (being more flexible and hence able to assume the shape of the underlying surface) but even this material would be punctured if soil were dumped on it from a tipping truck. Polythene below .006" thickness should not be used where it is intended to dump soil on it from a height of 4ft. or more.

6.5 <u>Items for further investigation</u>

The following research would aid the evaluation of thin plastic films as dan liners:-

(a) Long term tests on exposed and buried samples

(b) Trials to indicate resistance to root penetration, marine organisms, eels, yabbies and fish, likely to be found in farm dams and canals.

(c) Trials to indicate chemical resistance to soil sterilizers if it is decided to eliminate plant growth in the vicinity of the liner.

(d) Investigation of the effect of dumping and spreading of covering soil on membranes. Covering of the membranes initially with a crust of cold emulsion and sand may permit a fairly vigorous soil covering operation.

(e) Some tensile and tear tests at elevated temperatures (likely to occur under an exposed membrane in western regions) are necessary. Also a fatigue test of various joints at elevated temperatures when exposed to a wind which causes them to flap is necessary. This appeared to be one of the contributing causes to the failure of the liner at Horrex' dam.

(f) Testing of newer materials such as P.V.C. Laminated with terylene cloth and Teflon (Polytetrafluoroethylene) should be attempted. The latter is extremely chemically inert and very strong. Membranes of extreme thinness may be practicable using teflon.

(g) Some tests to determine the optimum batter required on a dam wall to enable a thin plastic film to remain covered with sand are required.

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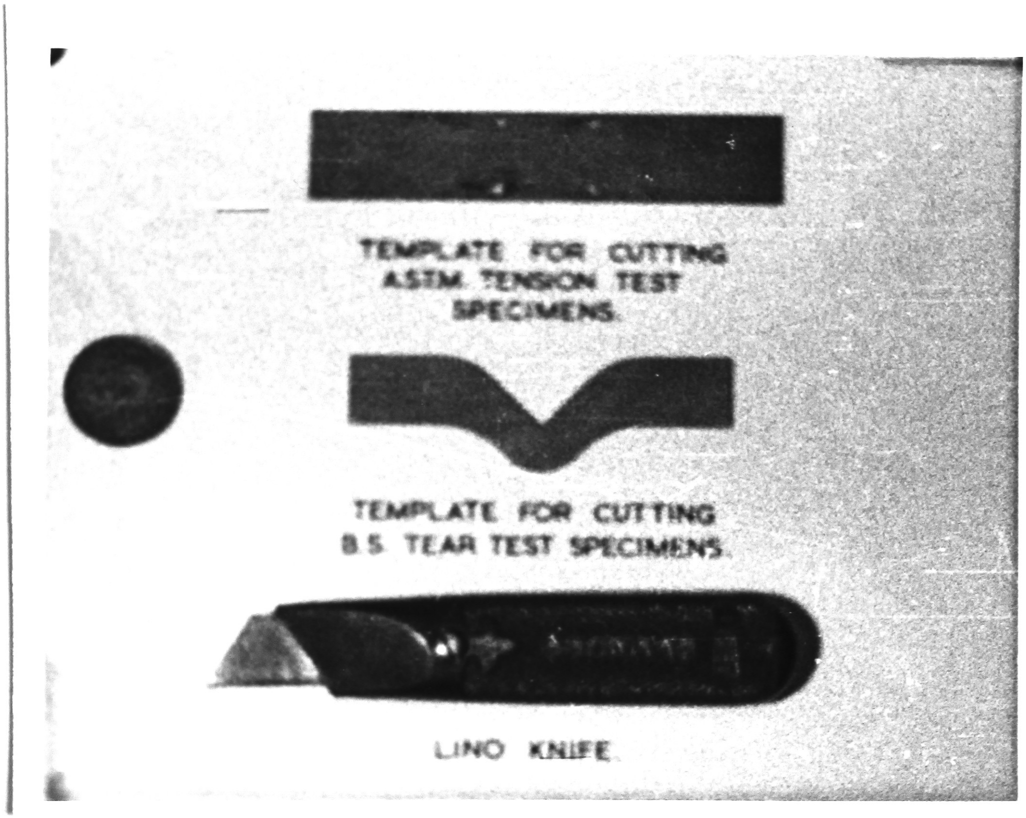


Fig. 1. Templates used for cutting test specimens.

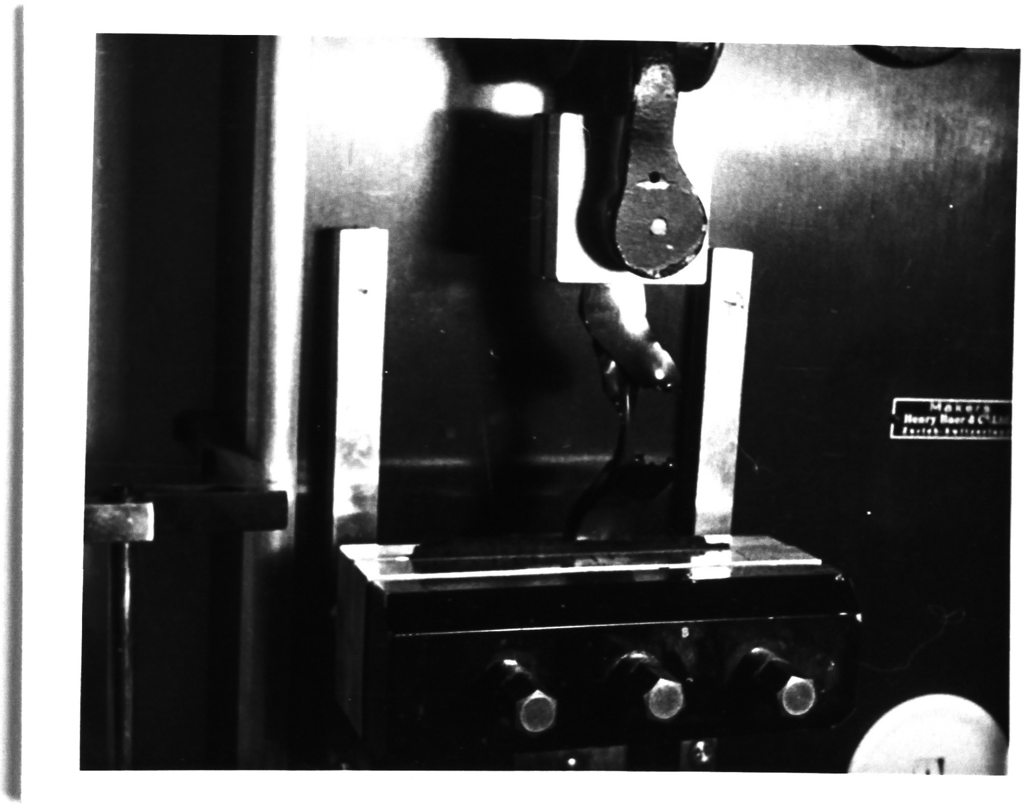


Fig.2. B.S. tear test on Polythene.

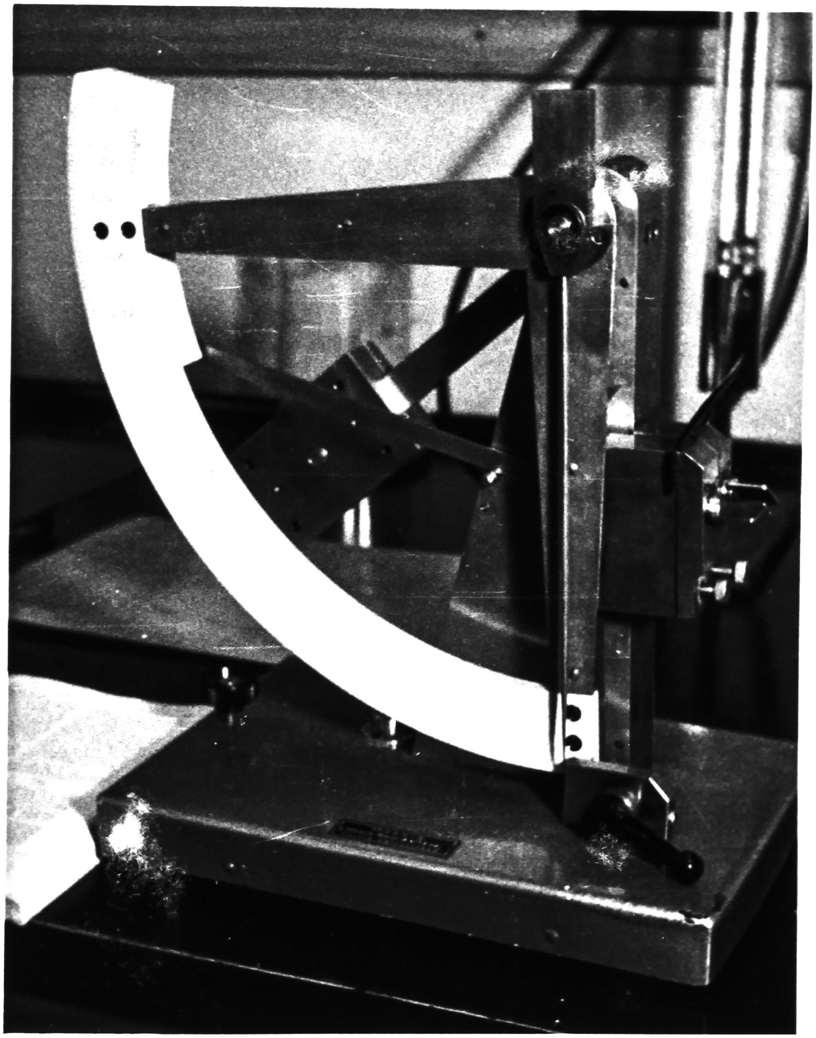


Fig. 3. Elmendorf Tear Testing Machine set up ready for testing.

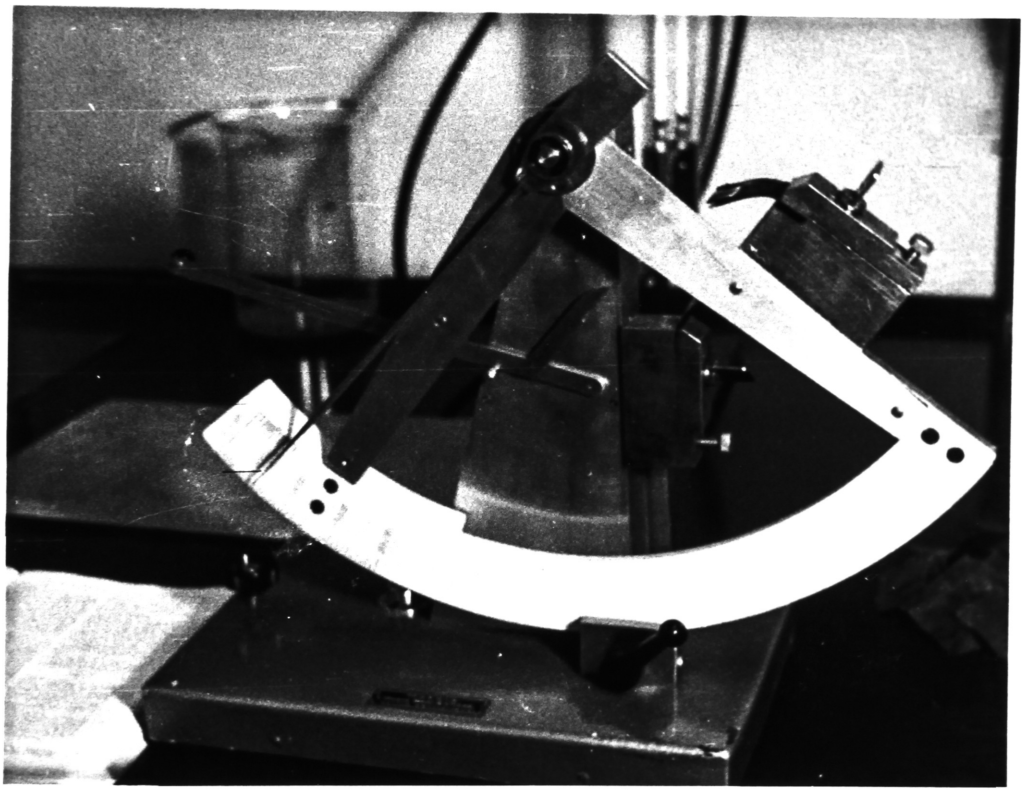


Fig.4. Elmendorf Tear Test Completed.

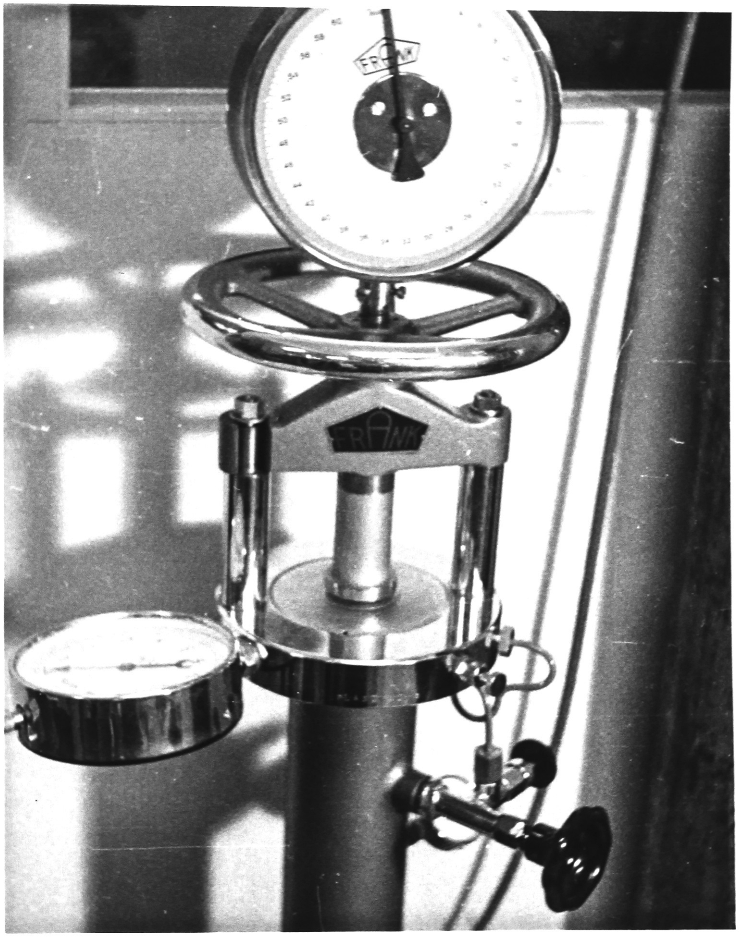


Fig.5. The "Frank" bursting strength testing Machine.

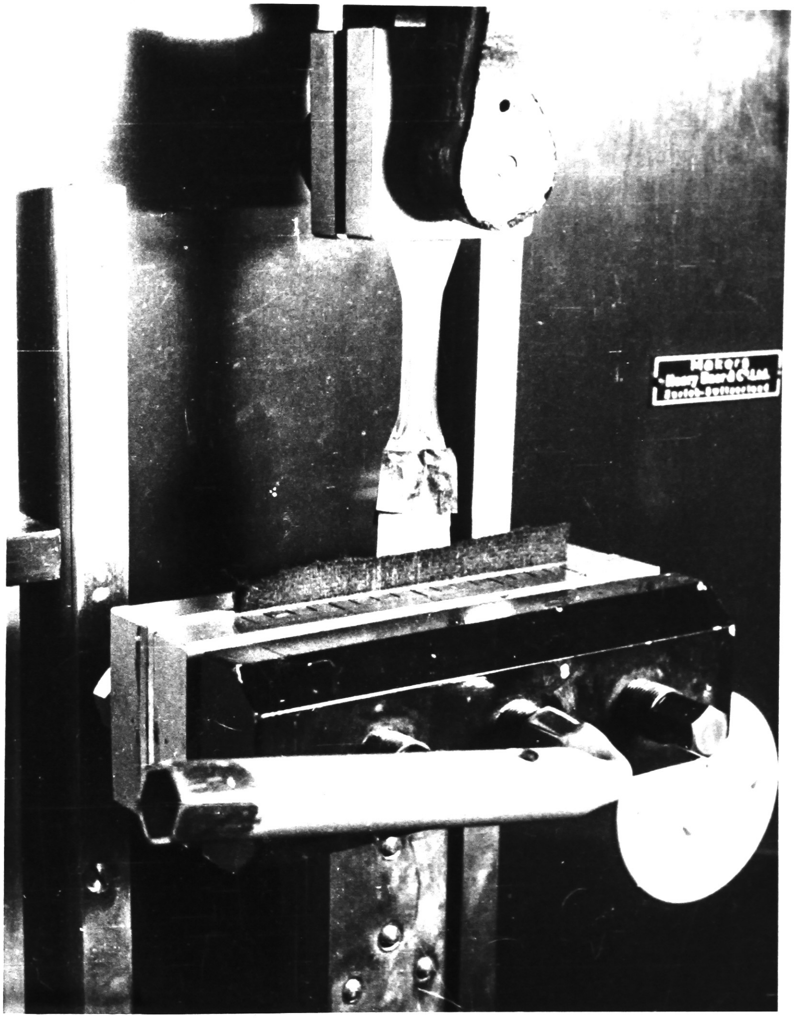


Fig.6. Plastalon weld under A.S.T.M. tension test.

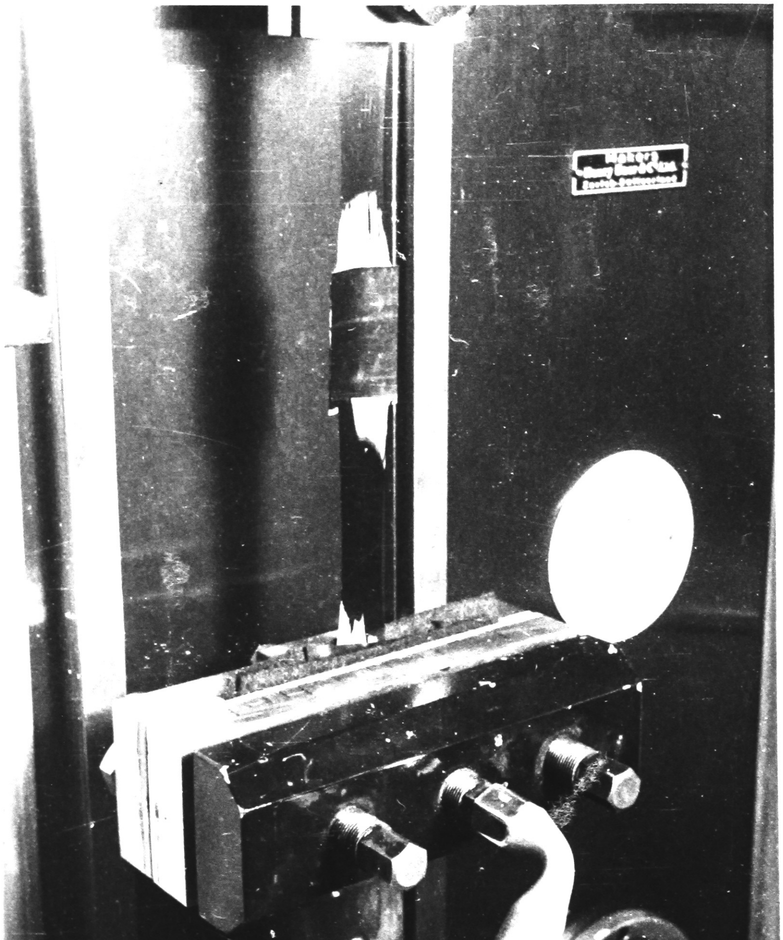


Fig.7. Freydis tape seam under A.S.T.M. tension test.

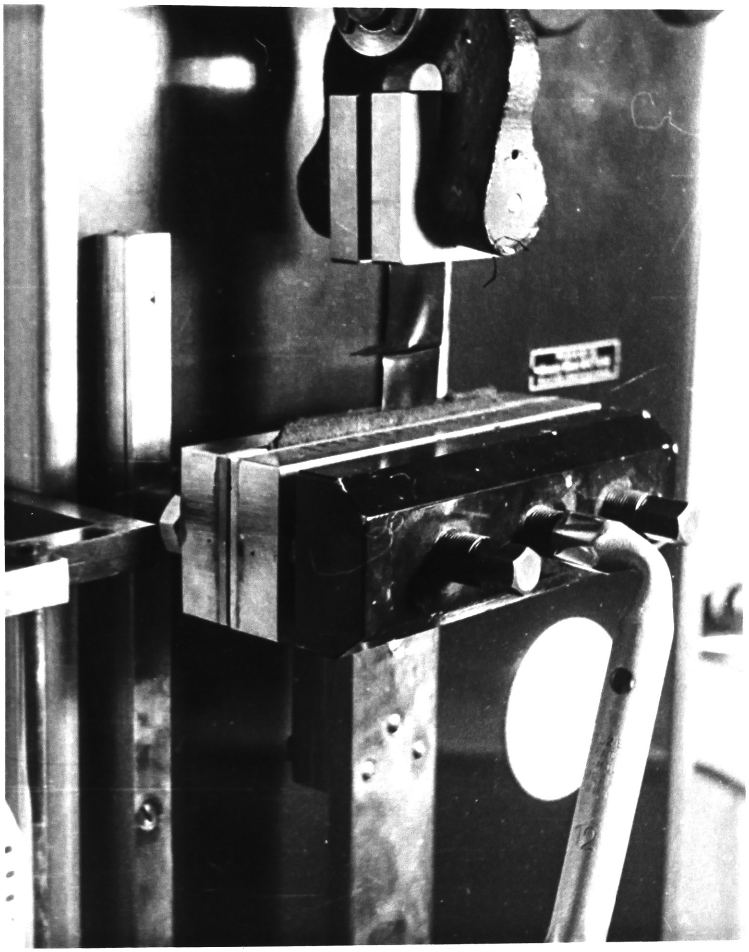


Fig.8. Freydis weld under A.S.T.M. Tension Test.

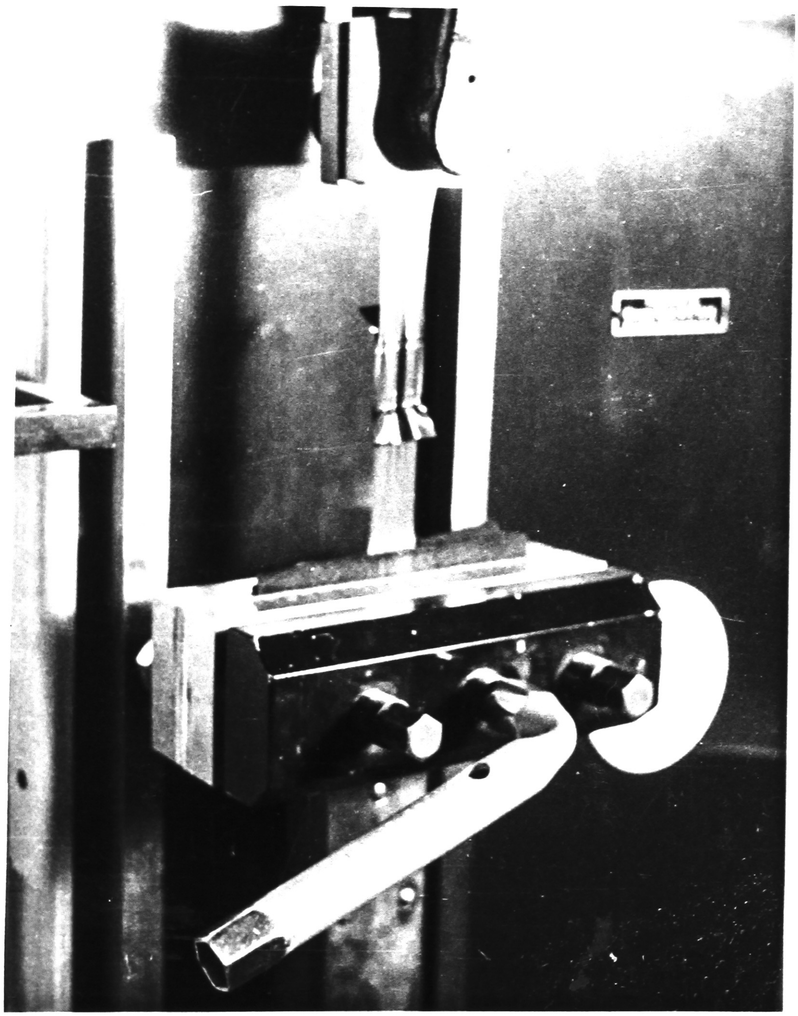


Fig.9. P.V.C. Electronic weld under A.S.T.M. tension test.

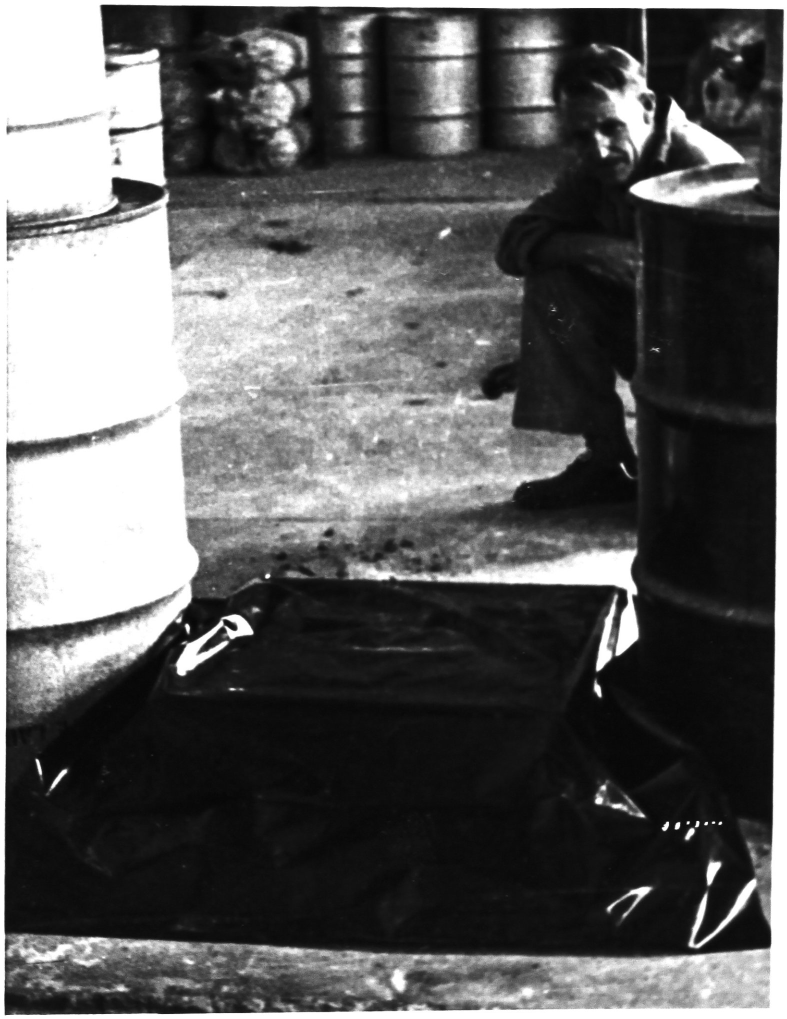


Fig.10. Drop box apparatus used for soil covering test.

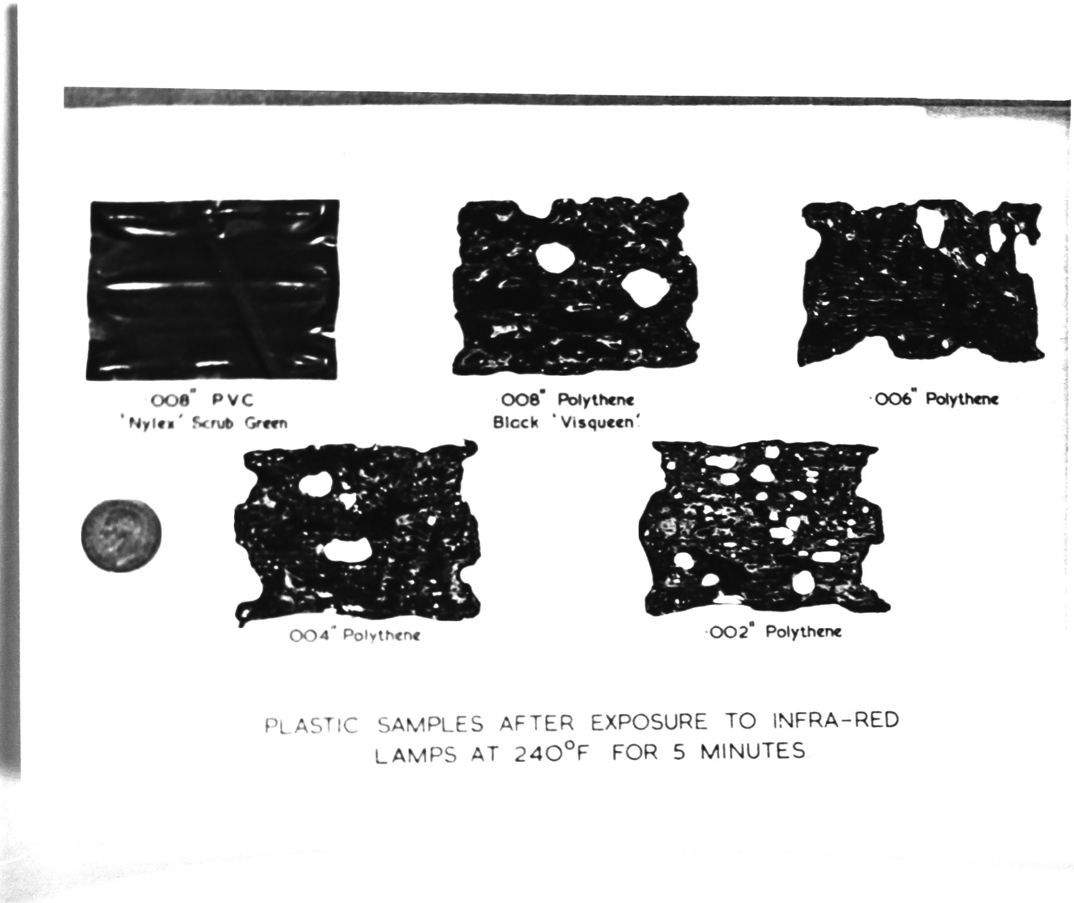
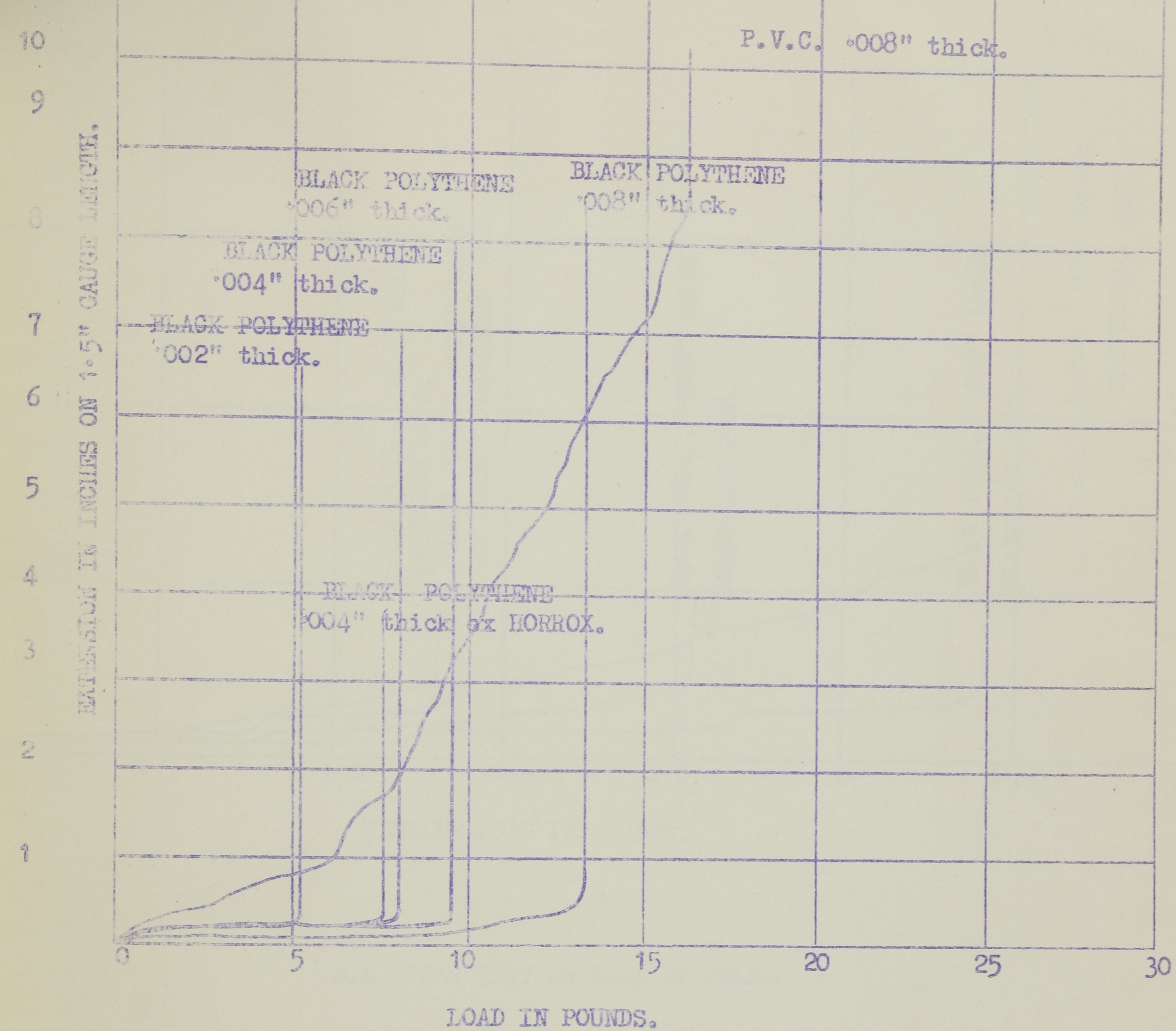


Fig. 11

Plastic samples after exposure to
infra-red lamps.



TYPICAL LOAD DEFORMATION CURVES FOR SOME THIN PLASTIC MEMBRANES A.S.T.M.

TENSION TEST.

NOTES:

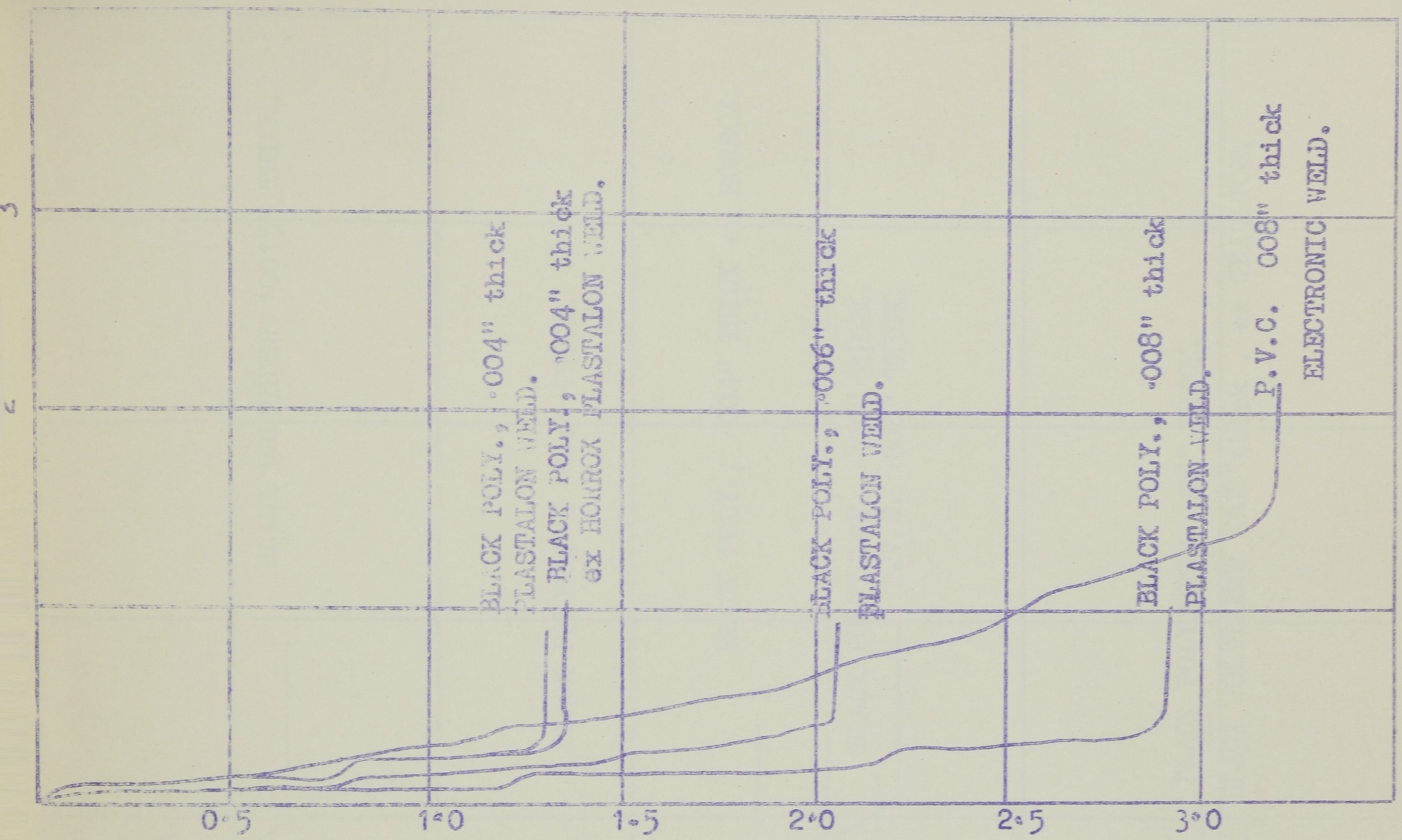
1: Specimen size 5" long x 1" wide.

2: Initial grip separation : 1·5".

3: Rate of motion of powered grip: 20" per minute.

4: Specimen tested according to A.S.T.M. designation D882-56T.

FIG: 12.



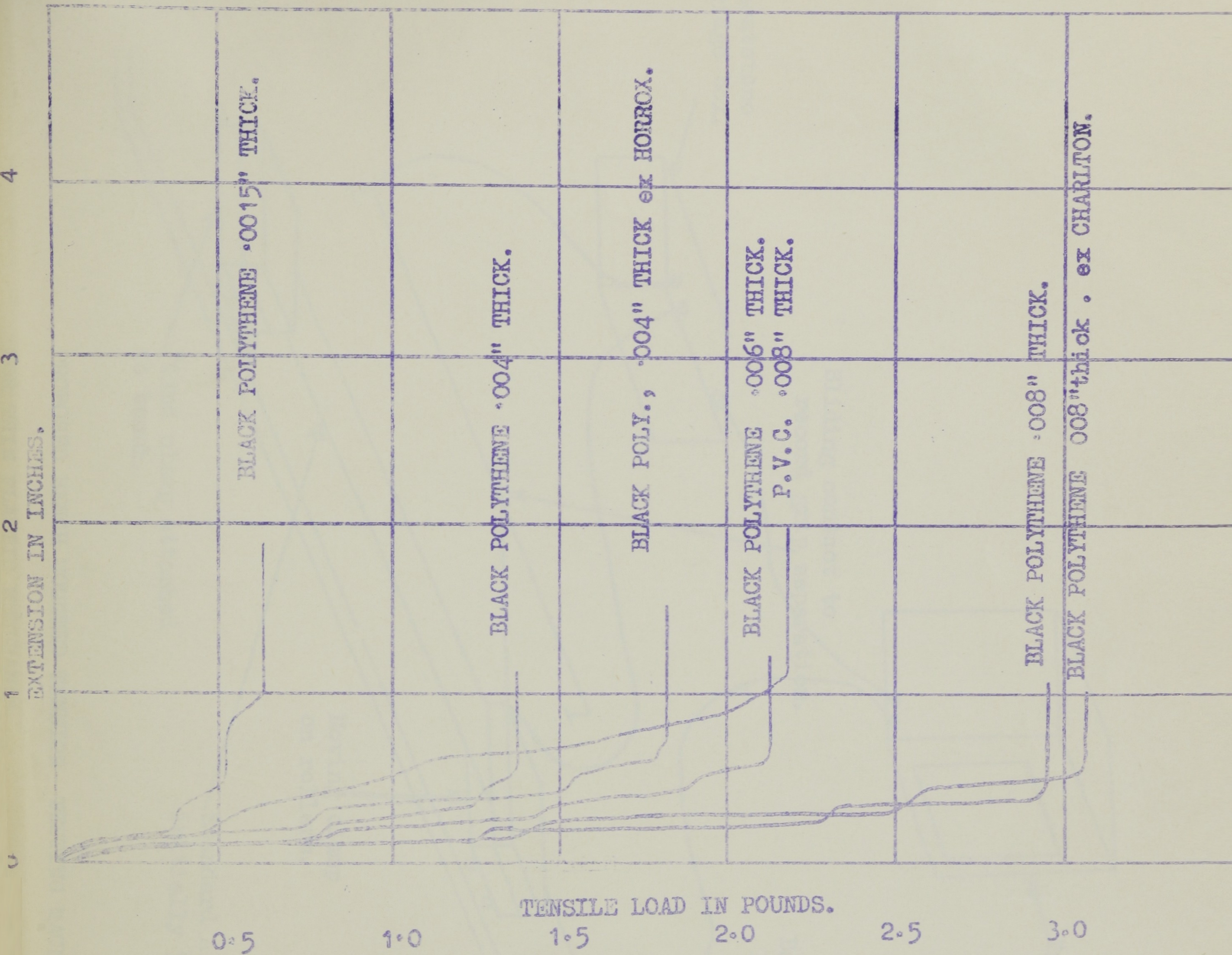
TENSILE LOAD IN POUNDS.

B.S. TEAR TEST ON EDGE OF WELD.

TYPICAL LOAD DEFORMATION CURVES FOR SOME THIN PLASTIC MEMBRANES

B.S. TEAR TEST.

FIG: 13a.

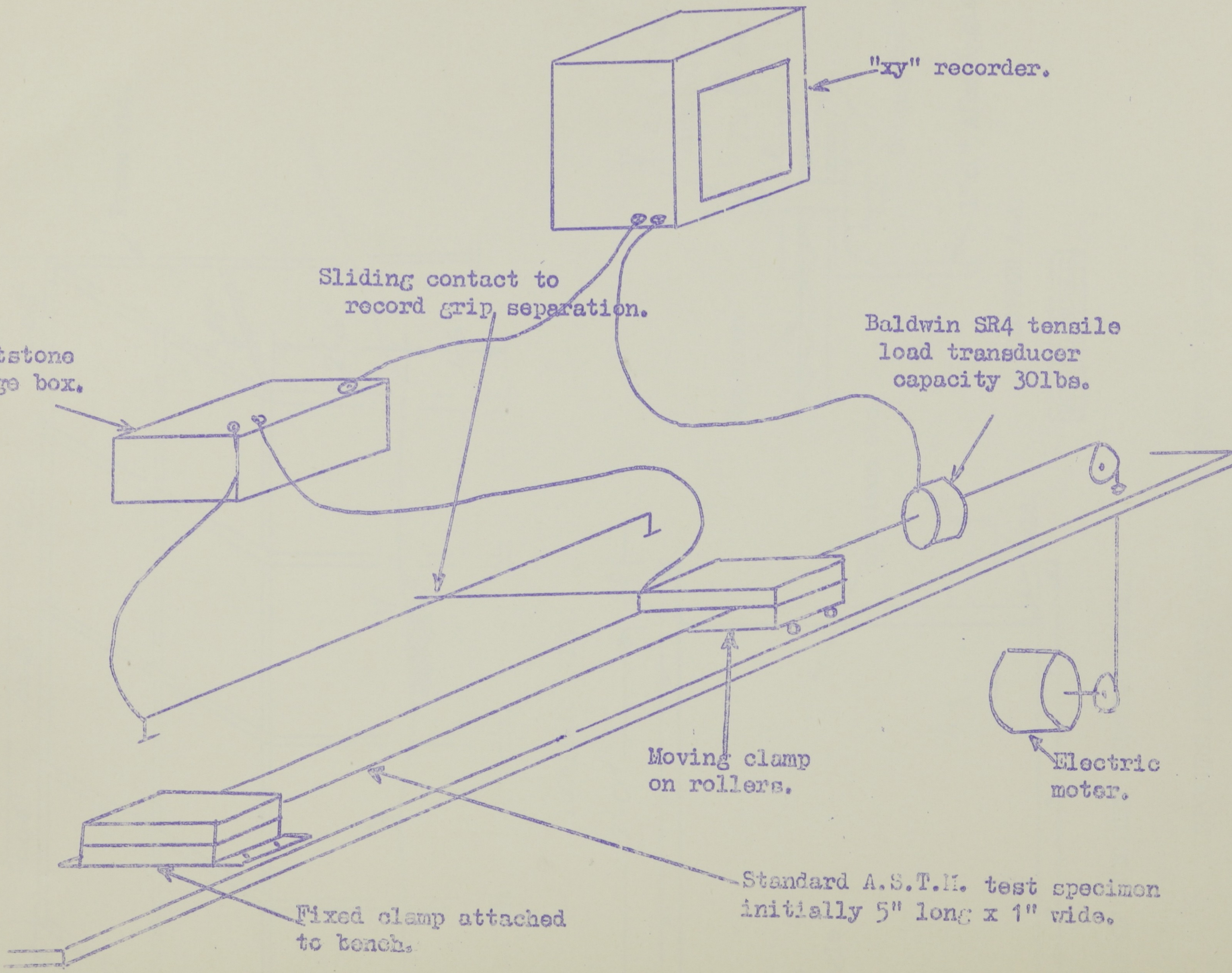


B.S. TEAR TEST ON NEW MATERIAL.

TYPICAL LOAD DEFORMATION CURVES FOR SOME THIN PLASTIC MEMBRANES

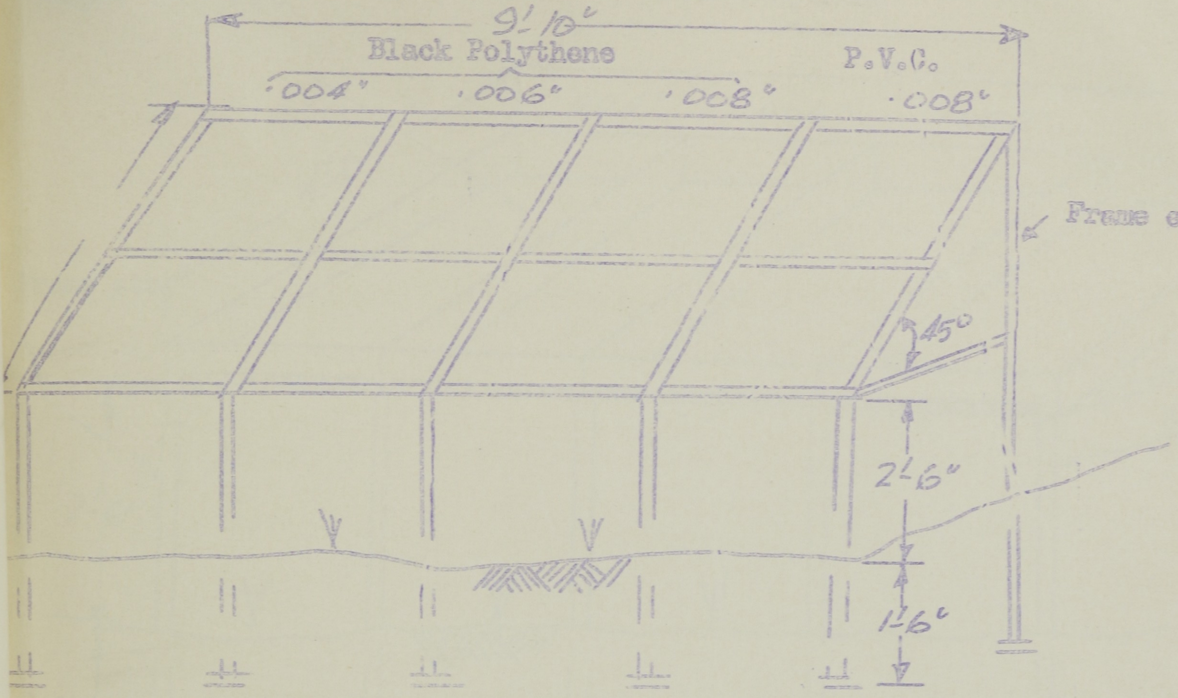
B.S. TEAR TEST.

FIG:13b.

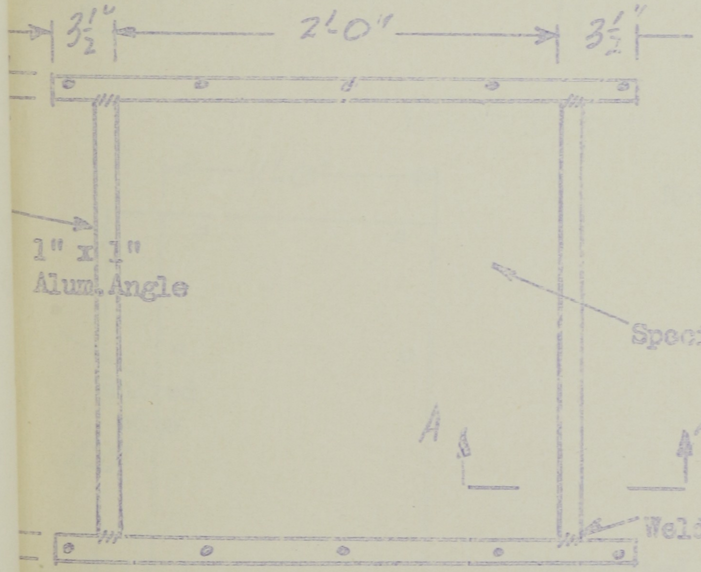


PROPOSED BENCH MOUNTED TENSION TESTING MACHINE

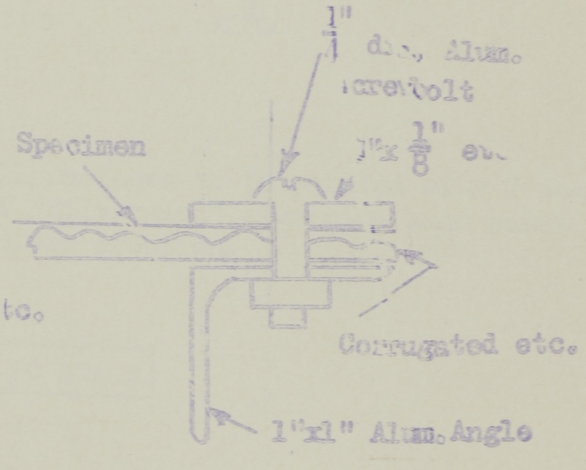
FOR THIN PLASTIC MEMBRANES.



ISOMETRIC VIEW.



PLAN OF SPECIMEN MOUNTING PANEL.

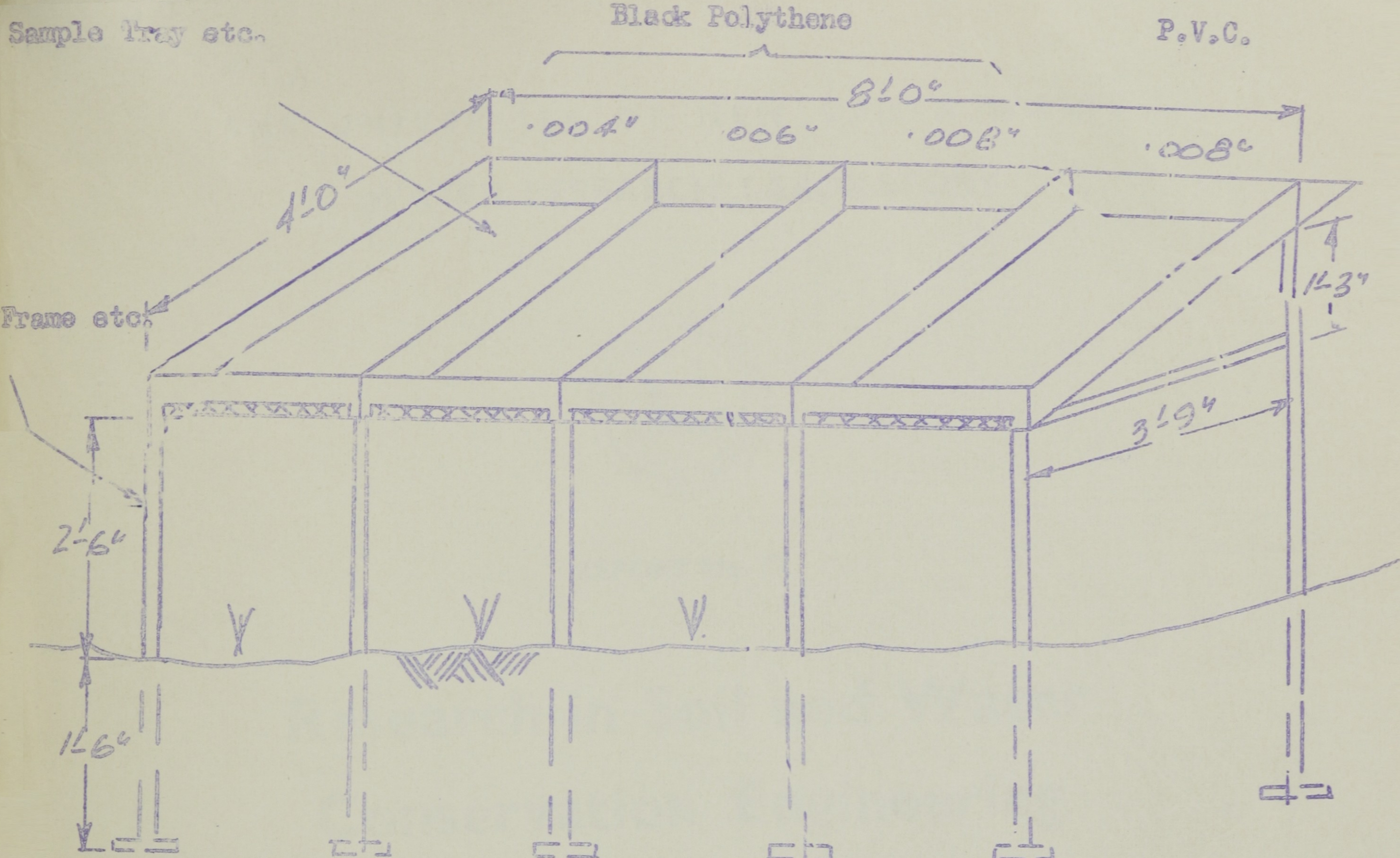


SECTION A-A.

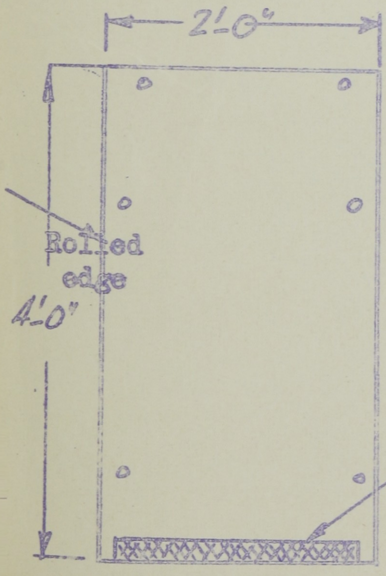
NOT TO SCALE

EXPOSURE RACK FOR WEATHERING TESTS ON PLASTIC FILMS.

FIG: 15.



ISOMETRIC VIEW.



PLAN OF TRAY.

Note:- All surfaces to be painted with 1 coat of "Silverglow" aluminium base paint before erection.

NOT TO SCALE.

EXPOSURE RACK FOR BURIED WEATHERING TESTS ON THIN PLASTIC MEMBRANES.

FIG:16.