AD-A020 818

CONCRETE DOOR. PROOF TEST FOR AIR BLAST

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Norwegian Defence Construction Service
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May 1975

FORTIFIKATORISK

NOTAT NR. 105 / 75

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FORSVARETS BYGNINGSTJENESTE

NORWEGIAN DEFENCE CONSTRUCTION SERVICE
Office of Test and Development

Fortifikatorisk notat nr 105/75

Concrete door. Proof test for air blast.

by
Anton Rinnan

May 1975

SUMMARY

A reinforced door 140 x 220 cm, concrete quality 250 kg/cm^2, designed by "Fortifikasjon A/S" was tested with gradually increasing air blast until max load according to the latest consideration of the NATO, AC/258 Storage Sub-Group [Head wall of acceptor igloo facing back wall of donor igloo at a scaled distance 0,8 $Q^{\frac{1}{3}}$]

	NATO AC/258	Test
Pressure	14 bar *(proposed)*	14 bar
Positive duration $[t=1 \cdot Q^{\frac{1}{3}}]$	40 ms [Q=64 tonn]	90 ms [Q=729 tonn
Positive impulse $[i=2 \cdot Q^{\frac{1}{3}}]$	80 bar.ms [Q=64 tonn]	240 bar.ms [Q=17500 tonn

After the test which totaled 10 shots the

- max plastic deformation of the door was 2 cm, and the only visible damage was a small crack in the concrete.
- Full protection would have been afforded to the interior of a magazine or shelter.

C O N T E N T S

1. Introduction.

The object of the test was to load a door according to drawing in appendix 2 with a side on air blast according to the latest consideration of the NATO AC/258 Storage Sub-Group (Head wall of acceptor igloo facing back wall of donor igloo at a scaled distance of $0,8 \cdot Q^{1/3}$, (m, $kg^{1/3}$)

Pressure	14 bar
Positive duration $[t=1 \cdot Q^{1/3}]$	40 ms
Positive impulse $[i=2 \cdot Q^{1/3}]$	80 bar.ms

As may be seen the duration and impulse is determined by the amount of net explosives in the donor igloo. In the test was also another door and a polycarbonat window with higher priority than the concrete door. The charge weights in the first 9 shots were therefore chosen with respect to these two objects.

2. Test arrangement.

The test was carried out in the NDCS's test tunnel at Raufoss in March 1975. The tunnel has a cross section of about 4 m^2, and the door was placed horizontally. Fig 2.a and appendix 3 show the arrangement in detail.

The charges were detonated at a distance 14 m from measuring point 2 and 17,5 m from measuring point 4 close to the door.

In table 4.a the charge weights are listed.

3. Measurements.

The measuring chain is presented in fig 3.a and the measuring points in fig 3.1.a. During each shot the following quanties were measured:

- Pressure-time history.

  Only one and partly two pressure transducers operate satisfactory during shot 6-10. There is however, good correspondence between these two. The pressure-time history is also known from previons tests.

- Strain of the door.

- Deflection of the door

Both the deflection - and straingauges were fastened to a thin steel plate on the on the rear side of the door. The plate was nessesary for the casting of the test door, but normally it will not be a part of the door-scaffolding will be removed after casting. For the test door, therefore, strain- and deflection are measured for the plate and not for the concrete. For shot 6-9 the plate is supposed to indicate the response of the concrete, but during shot 10 the plate loosened from the concrete and therefore the measurements has no value.

After shot 10 the door was controlled for plastic deformations. A metal ruler, supported at the door frame, was placed accross the door in its longitudinal direction. See table 4.b.

3.1. Location of the measuring points.

Fig 3.1.a and 2.a show the location of the measuring points.

- The pressure-transducers (mp 1-8 fig 2.a) was placed in the same horizontal plane as the floor. Only mp 2 an 4 operated satisfactory during shot 6-10.

- The strain-gauges mp 17, 18 and 19 were mounted on a steel plate on the rear side of the door. The strain was measured normal to the longitudinal direction of the door.
- The deflection gauges mp 15 and 16 were mounted in the steel plate on the rear side of the door and fixed to the concrete floor below.
- The controll points for plastic deformation are shown with results in table 4.b.

4. Results.

Table 4.a gives pressure, strain and dynamic deflection from each shot, and appendix 1 presents the recordings from each shot and measuring point. Table 4.b gives the plastic deformation after shot 10. This can also seen from the pictures in fig 5.4.

Table 4.a indicates that the natural vibration period of the door is 20-30 ms. There is not enough suitable recordings to determine the vibration period more accurately.

5. Discussion of the results.

5.1. Pressure measurements.

Only the pressure transducers in mp 2 and partly in mp 4 are expected to give a fairly correct pressure time history ($\pm$ 20 %). There is usually a larger scatter in positive duration and impulse than in pressure, between different measuring points. Therefore, the uncertainity of positive duration an impulse is estimated to be $\pm$ 30 %.

- The recordings from mp 4 show a pressure peak short after the arrival of the shock front. This is the reflected shock front from the concrete door. The reading of the max pressure is done on the first shock and not on the reflected shock.
- The calculation of the positive impulse is done by a rude fitting of simple geometric figures to the recordings. The accuracy of the calculations is estimated to ± 30 %.

5.2. Strain measurements.

In fig 5.2.a and 5.2.b strain is plottet versus side on pressure and impulse, respectively. Since the plate loosened from the concrete during shot 10, the last point on the curves may be wrong. The max strain was recorded approximated 10 ms after the door started to deflect.

5.3. Deflection measurements.

There is very little information to get from the deflection measurements except that for a load of 0,85 bar and 11 bar.ms the max deflection is 2 mm which is not very much. Unfortunately, the gauges was not in operation during shot 9 and in shot 10 the plate loosened as already mentioned.

5.4. Visual observations.

The only visible damage of the door was a max 2 cm deflection and a crack along its longitudinal direction. See fig 5.4.a. The fact that the steelplate loosened is not important since it will normally be removed after casting.

6. Conclusions.

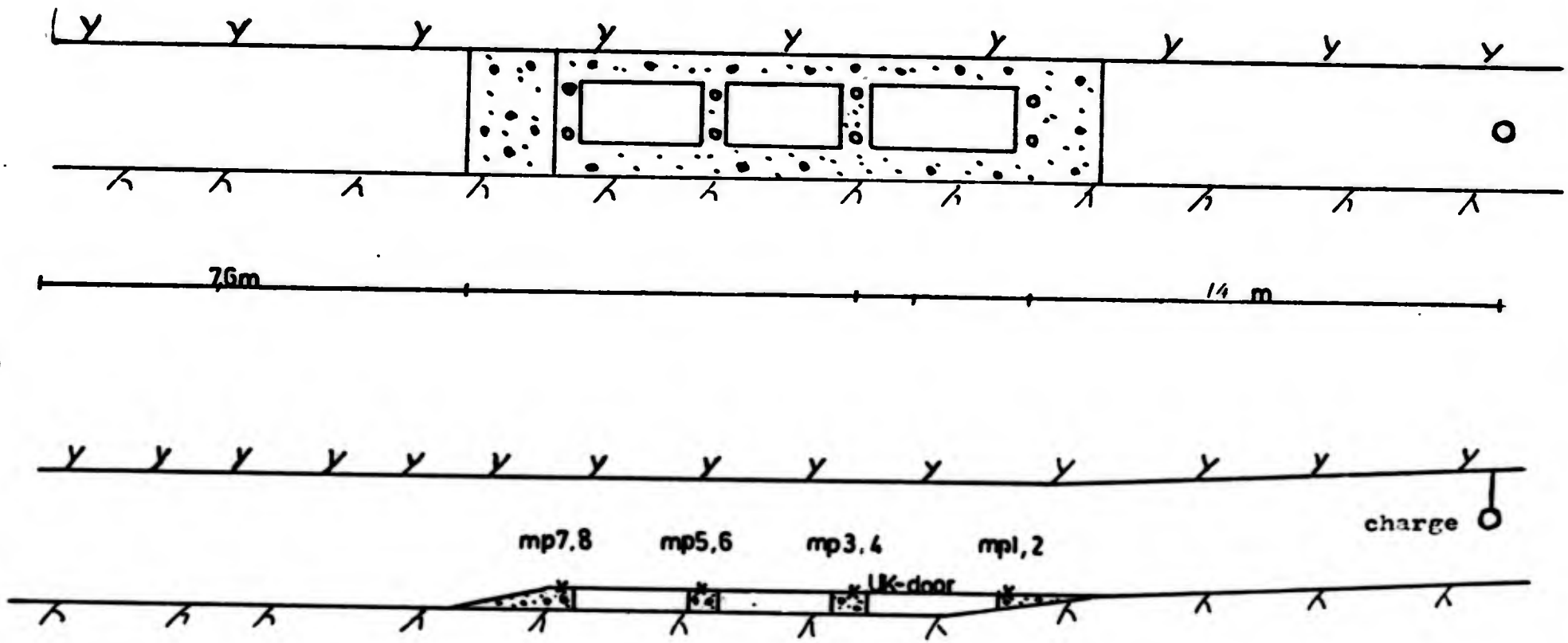
The door withstood the following load:

Pressure	14 bar
Positive duration	90 ms
Positive impulse	240 bar.ms

with a max deformation of 2 cm.

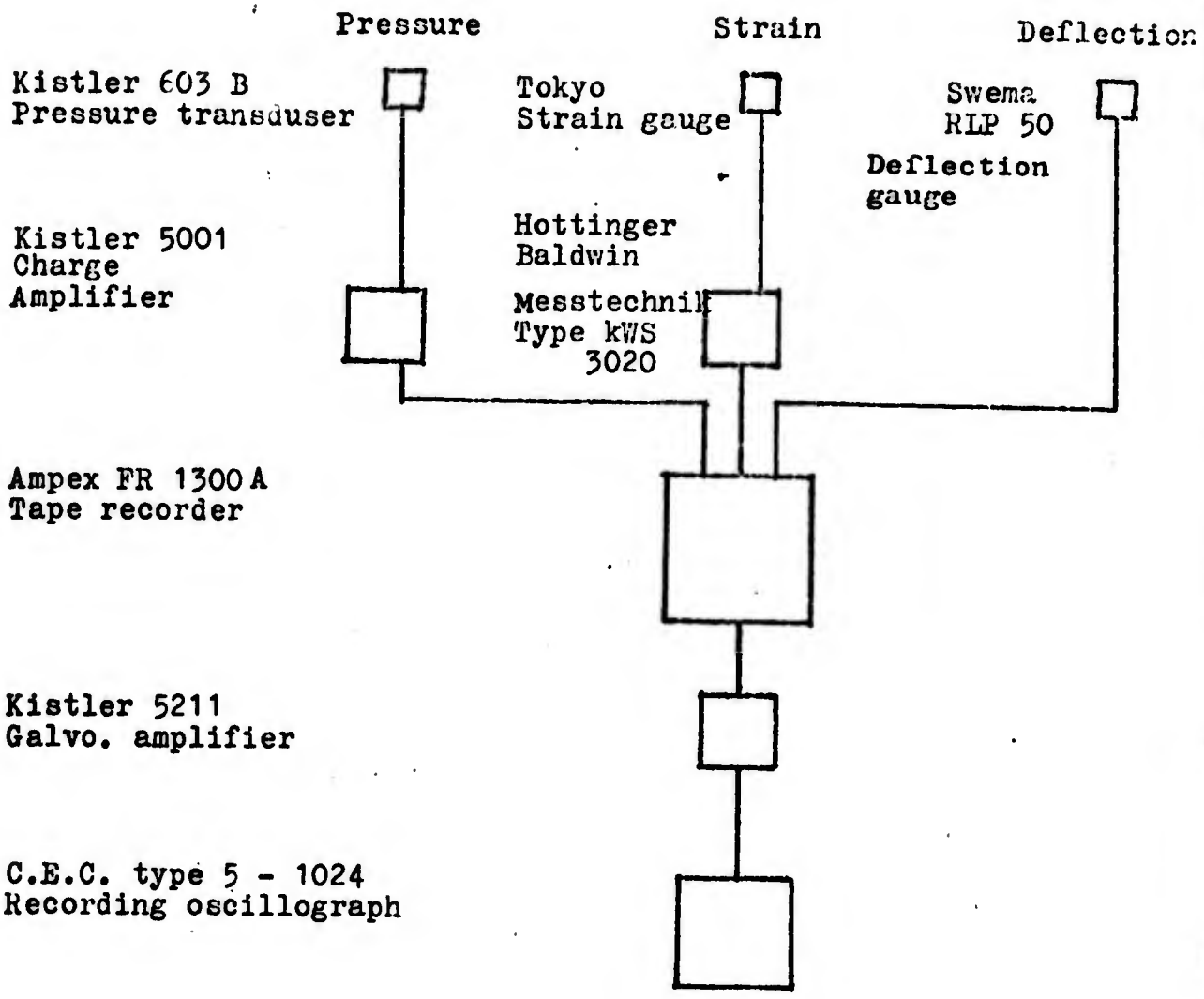
Full protection would have been afforded to the interior of a magazin or shelter.

The door is considered to be designed for the load considered by the NATO AC/258- Storage Sub-Group for the head wall of an acceptor igloo facing the back of an acceptor igloo at a scaled distance of $0,8 \cdot Q^{1/3}$ $\left(m, kg^{1/3}\right)$



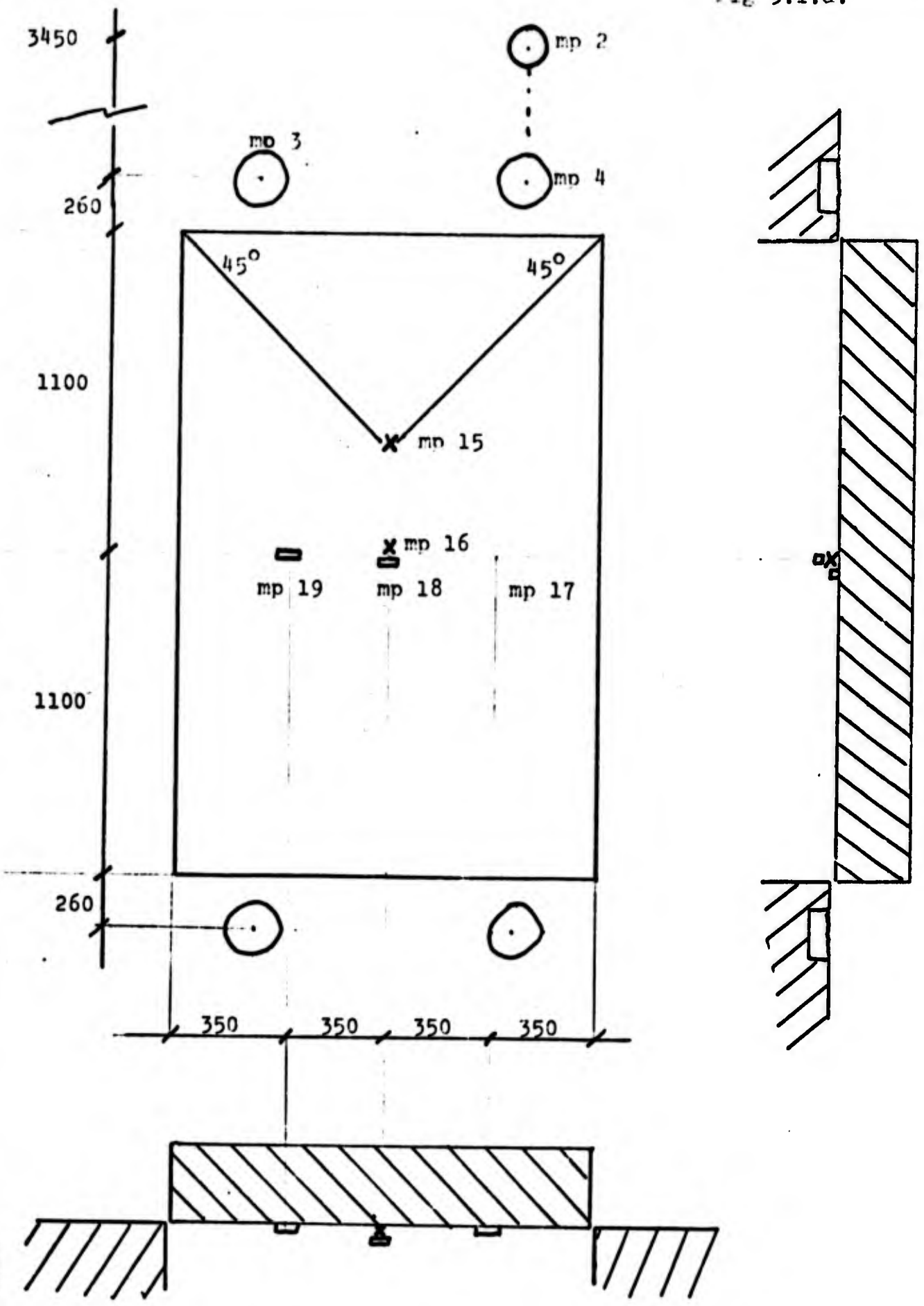
Sketch of tunnel. Not in scale.

Fig 2 a



The measuring chain.

Fig 3.1.a.



X Deflection gauge

⊏⊐ Strain gauge

Shot no	6	7	8	9	10
Charge weight (kg)	1,0	1,5	3,0	30	100
2.					
Pressure (bar	0,35	0,56	0,85	4	13
.Duration (ms)	17	22	39	80	103
Impulse (bar.ms)	3	6	11	80	240
4. Pressure (bar)			0,96		14,5
Duration (ms)			43		80
Impulse (bar.ms)			14,5		230
15.Deflection (mm)	< 2	< 2	2	-	> 25
16.Deflection (mm)	-	< 2	2	-	> 25
17.Strain (μs)	< 50	< 50	40	280	1000
18.Strain (μs)	< 50	< 50	50	530	720
19.Strain (μs)	< 50	< 50	40	160	1700

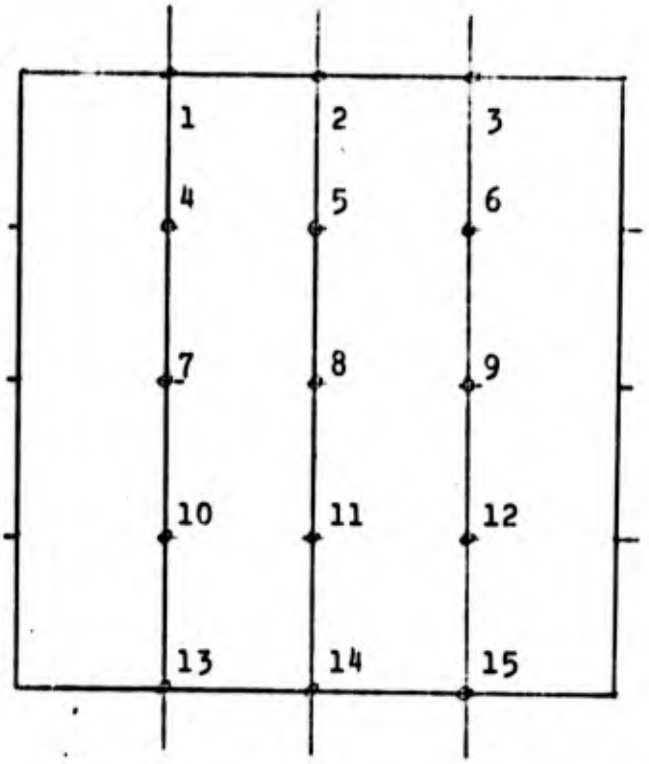
Nu

1) Numbers indicates measuring point.

Table 4.b.

Plastic deformation after shot 10.

The ruler placed across the door in its length direction and supported on the door frame.



MP	1	2	3	4	5	6	7	8	9	10	11
Deformation (cm)	0,5	0,8	0,7	0,6	1,2	1	1,2	1,7	1,0	1,2	1,9

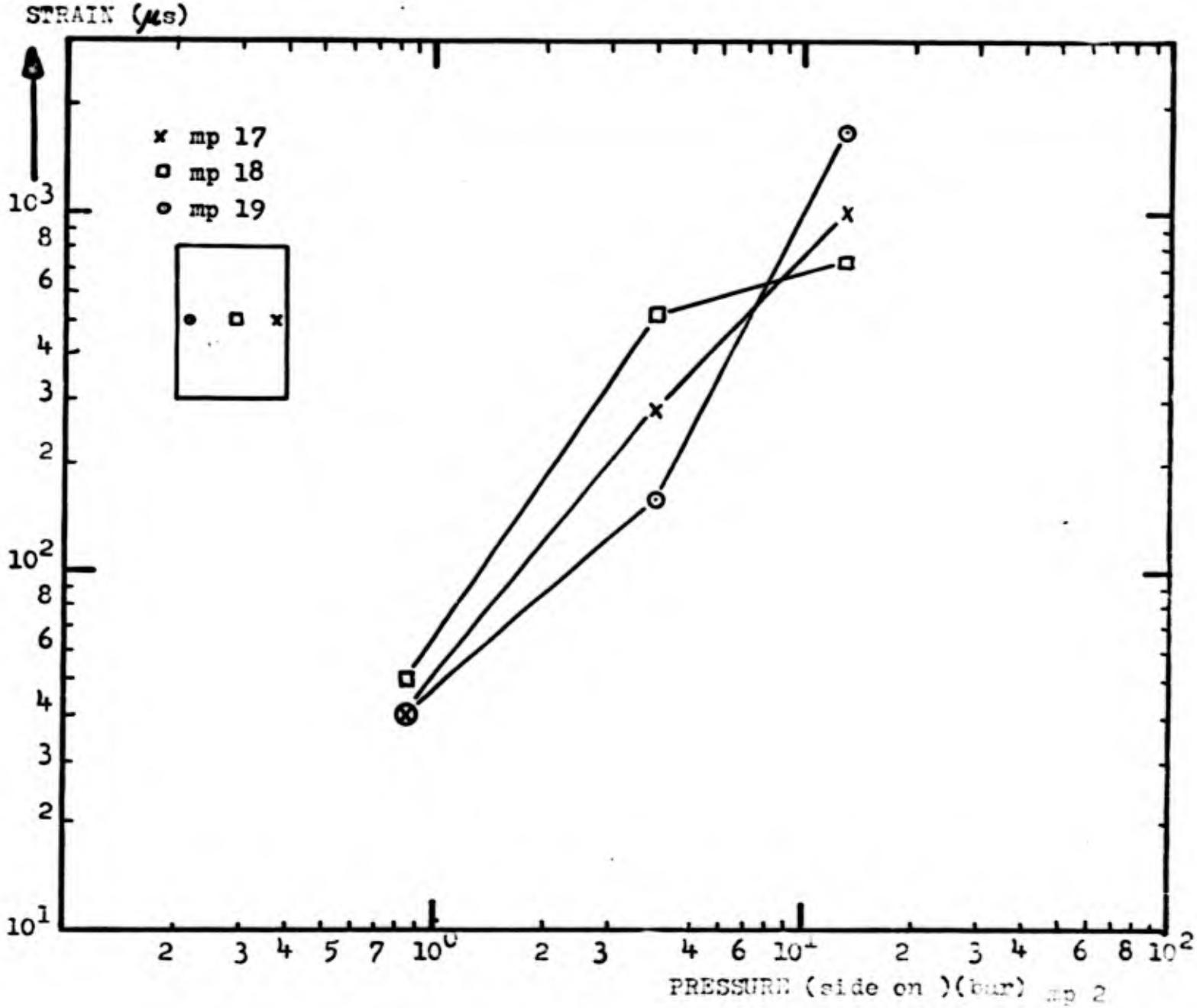
12	13	14	15
1,2	1,8	2,5	1,2

Table 4.c.

Natural vibration period.

Shot no	8	9
MP 15	32 ms	
16	32 ms	
17		25 ms
18		
19		21 ms

Natural vibration period $\approx$ 20-30 ms.


STRAIN (μs)
x mp 17
□ mp 18
○ mp 19
10^3
8
6
4
3
2
10^2
8
6
4
3
2
10^1
2 3 4 5 7 10^0 2 3 4 6 10^1 2 3 4 6 8 10^2
PRESSURE (side on)(bar)
mp 2

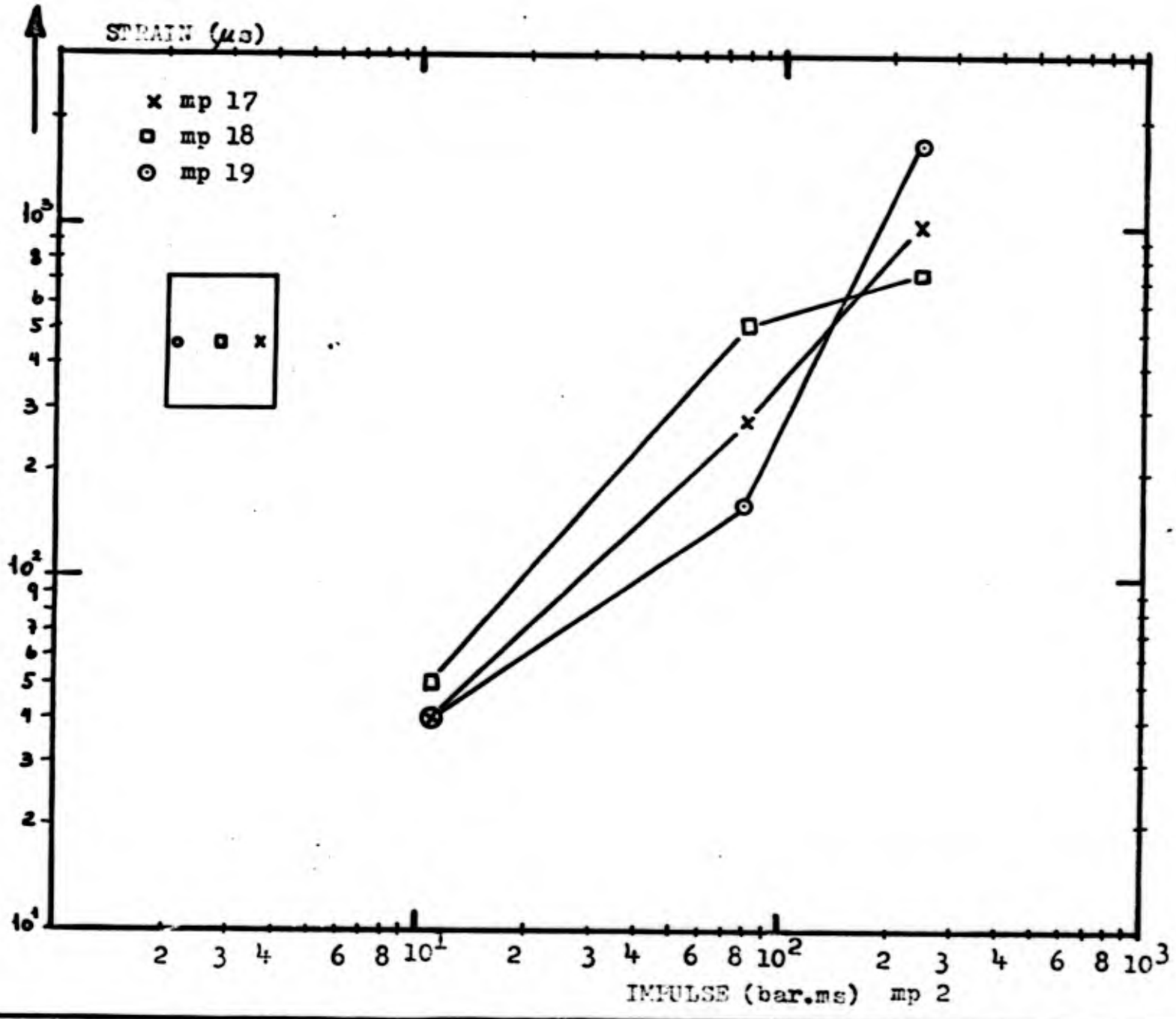

STRAIN (μs)
× mp 17
□ mp 18
⊙ mp 19
10^3
10^2
2 3 4 6 8 10^1 2 3 4 6 8 10^2 2 3 4 6 8 10^3
IMPULSE (bar.ms) mp 2

Fig. 5.2.b

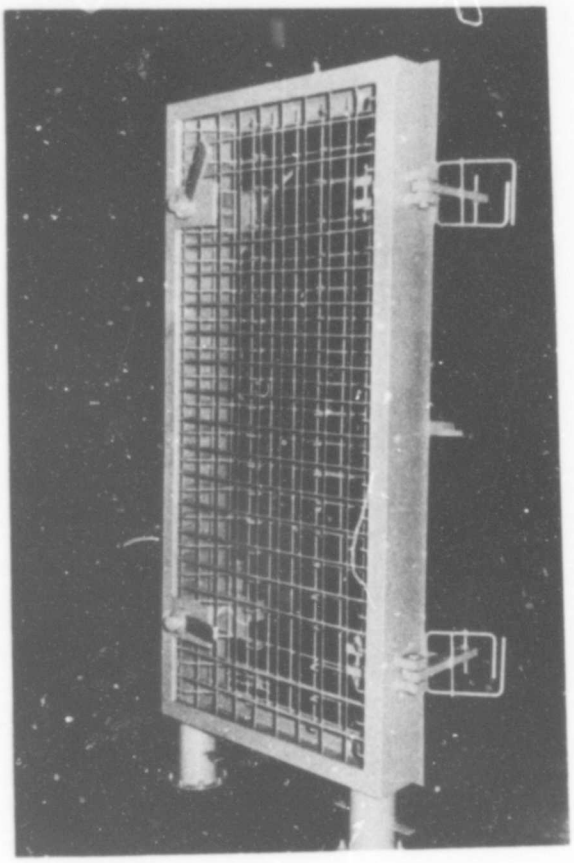


Plate 1.

The reinforcement of the door.

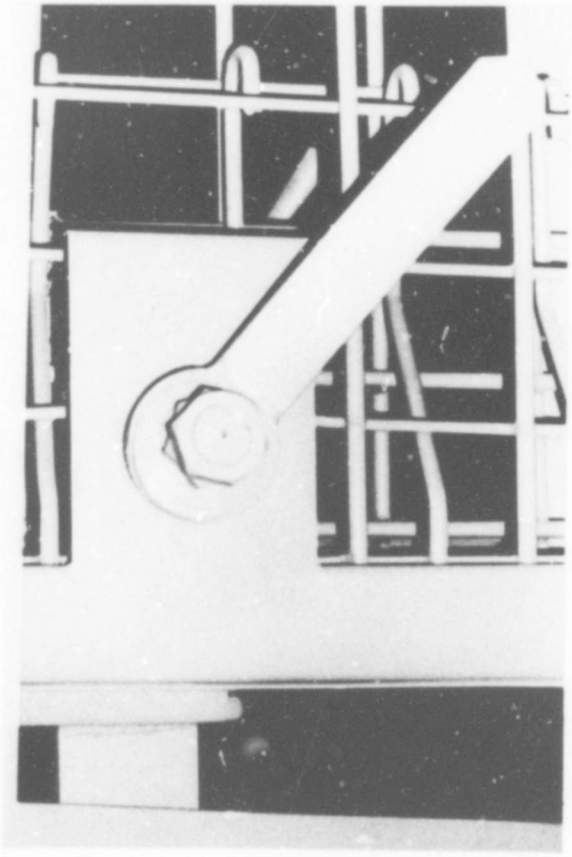


Plate 2.

Detail of the locking mechanism.

Plate 3. The door before the test.

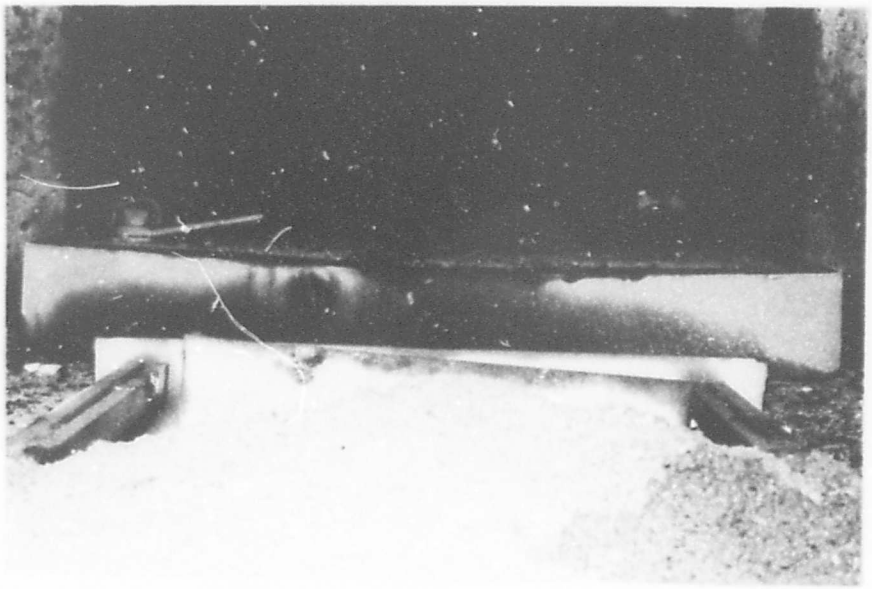


Plate 4. The door after the test.

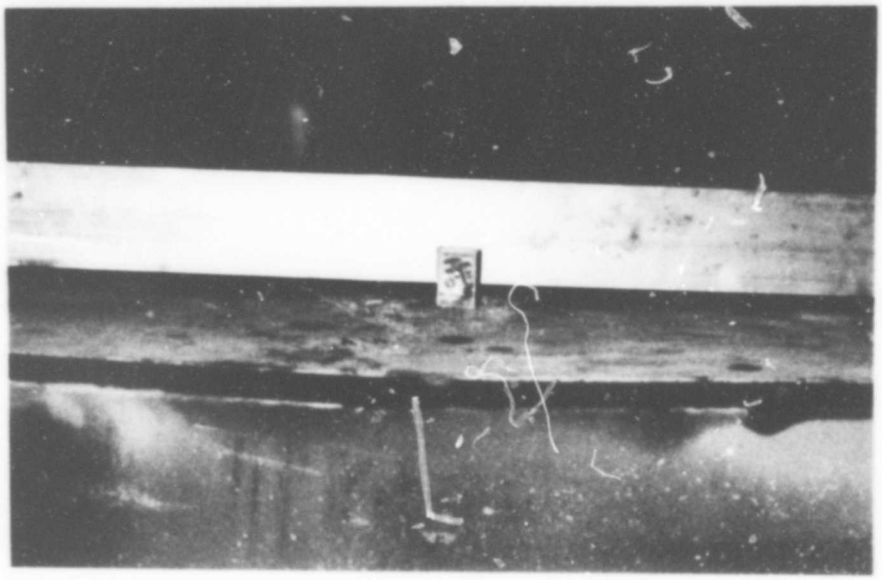


Plate 5. Permanent deformation after the test.

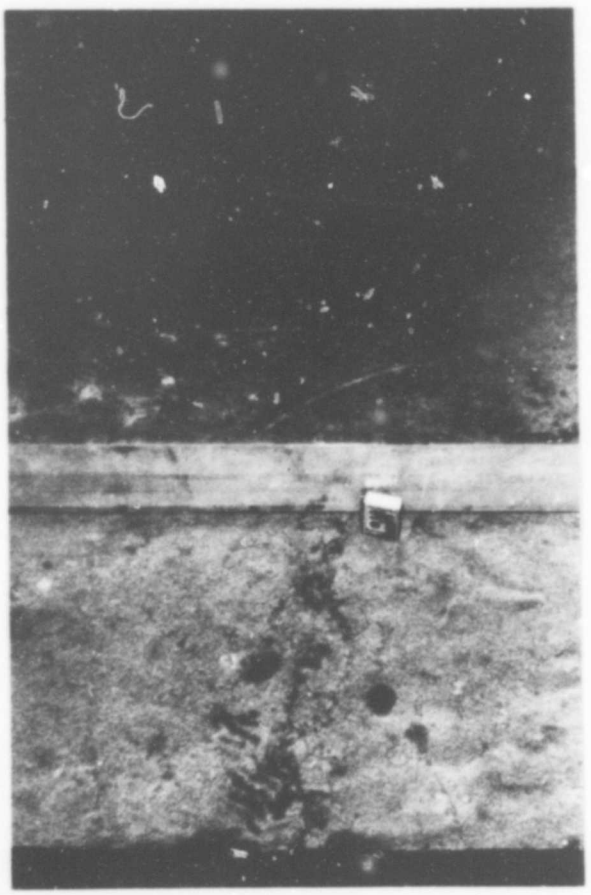
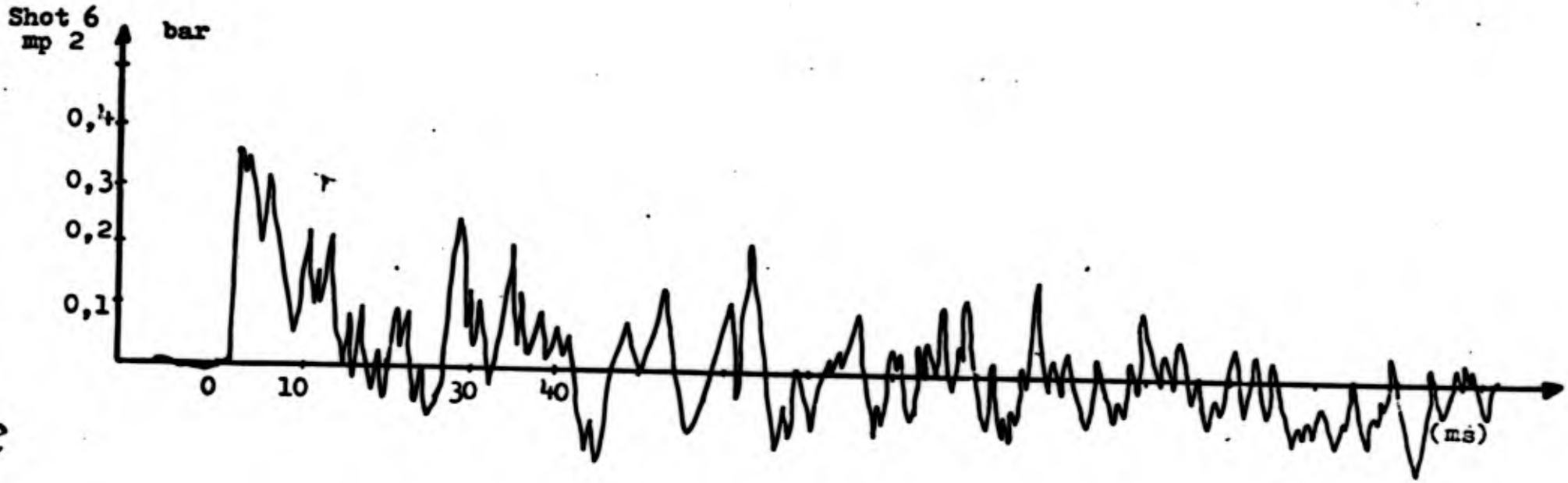
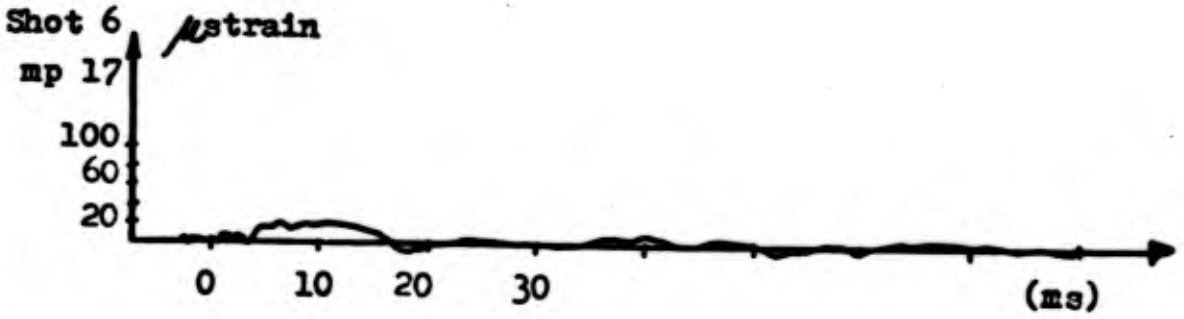


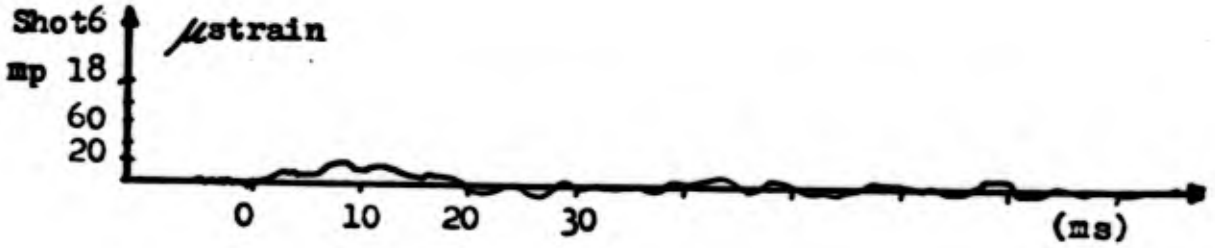
Plate 6.

Crack in the conrete after the test.

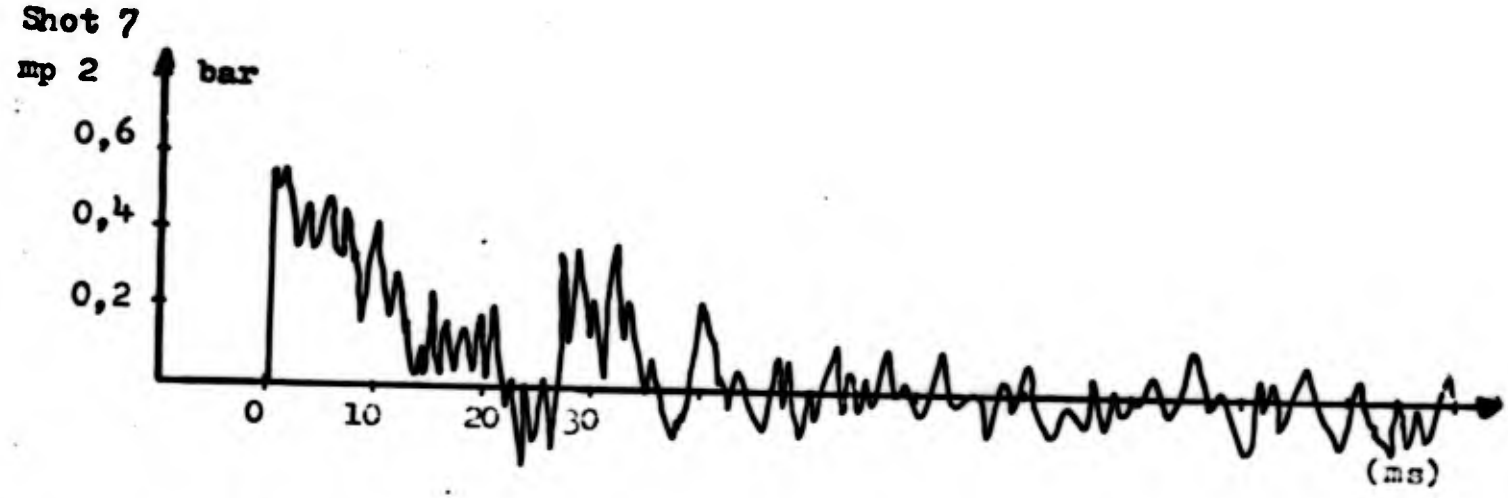

Shot 6
mp 2
bar
0,4
0,3
0,2
0,1
0
10
30
40
(ms)

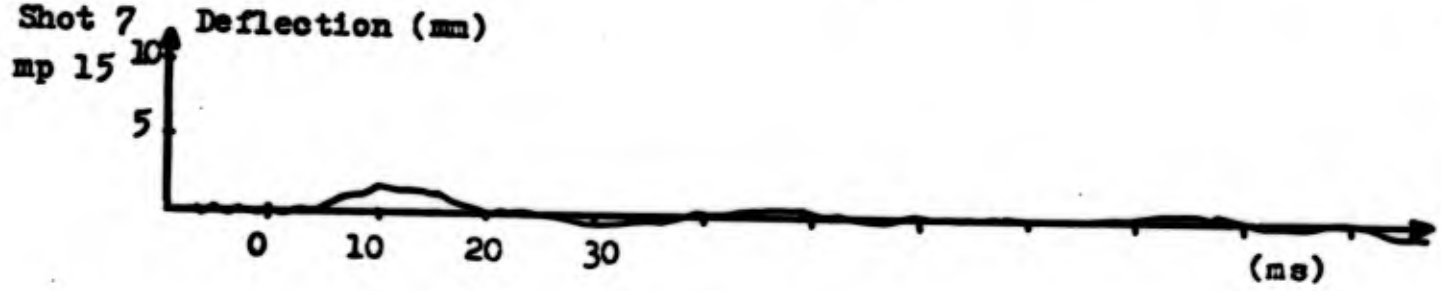

Shot 6
mp 15
Deflection (mm)
0
10
20
30
(ms)


Shot 6
μstrain
mp 17
100
60
20
0
10
20
30
(ms)

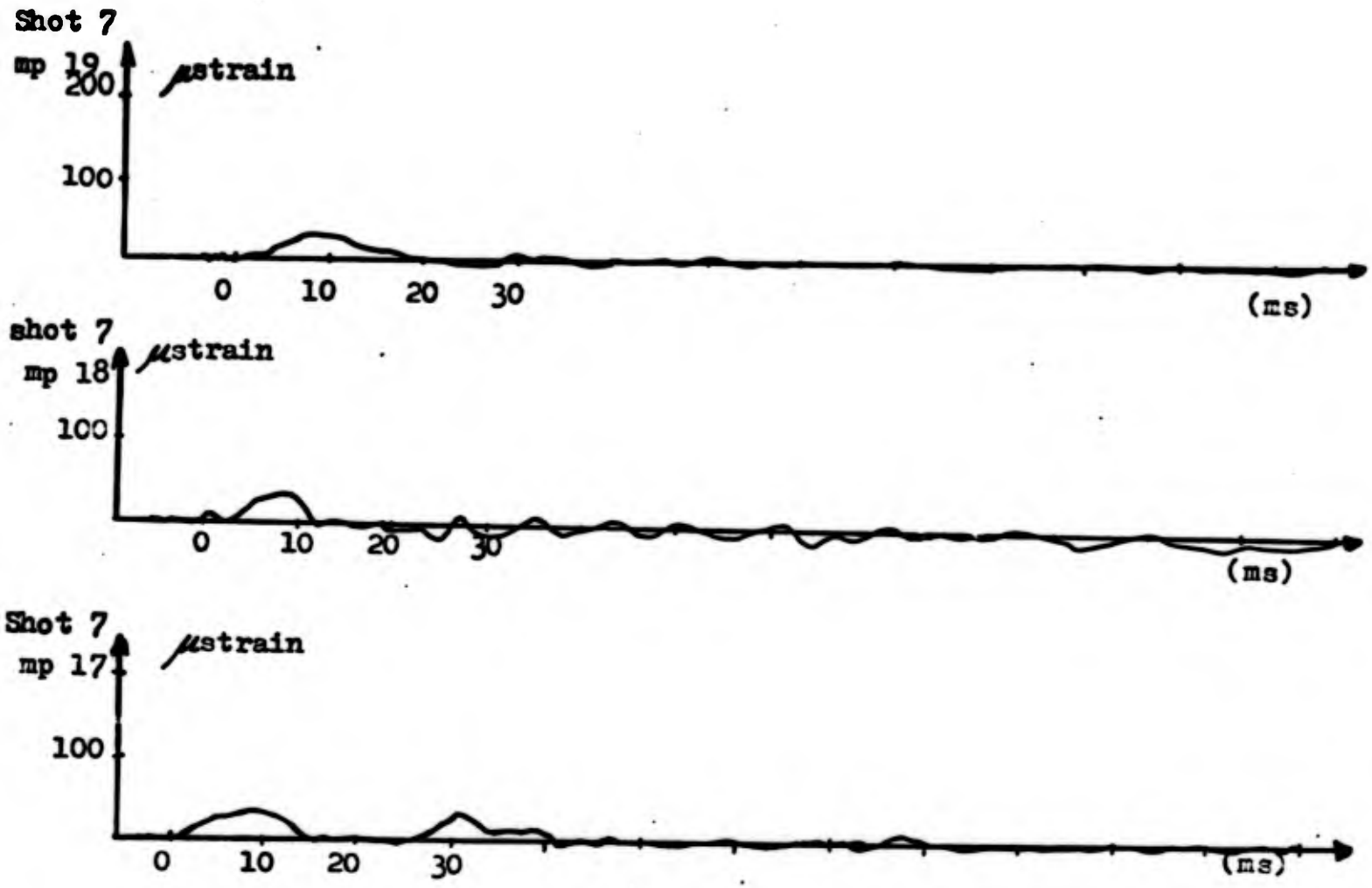

Shot6
μstrain
mp 18
60
20
0
10
20
30
(ms)

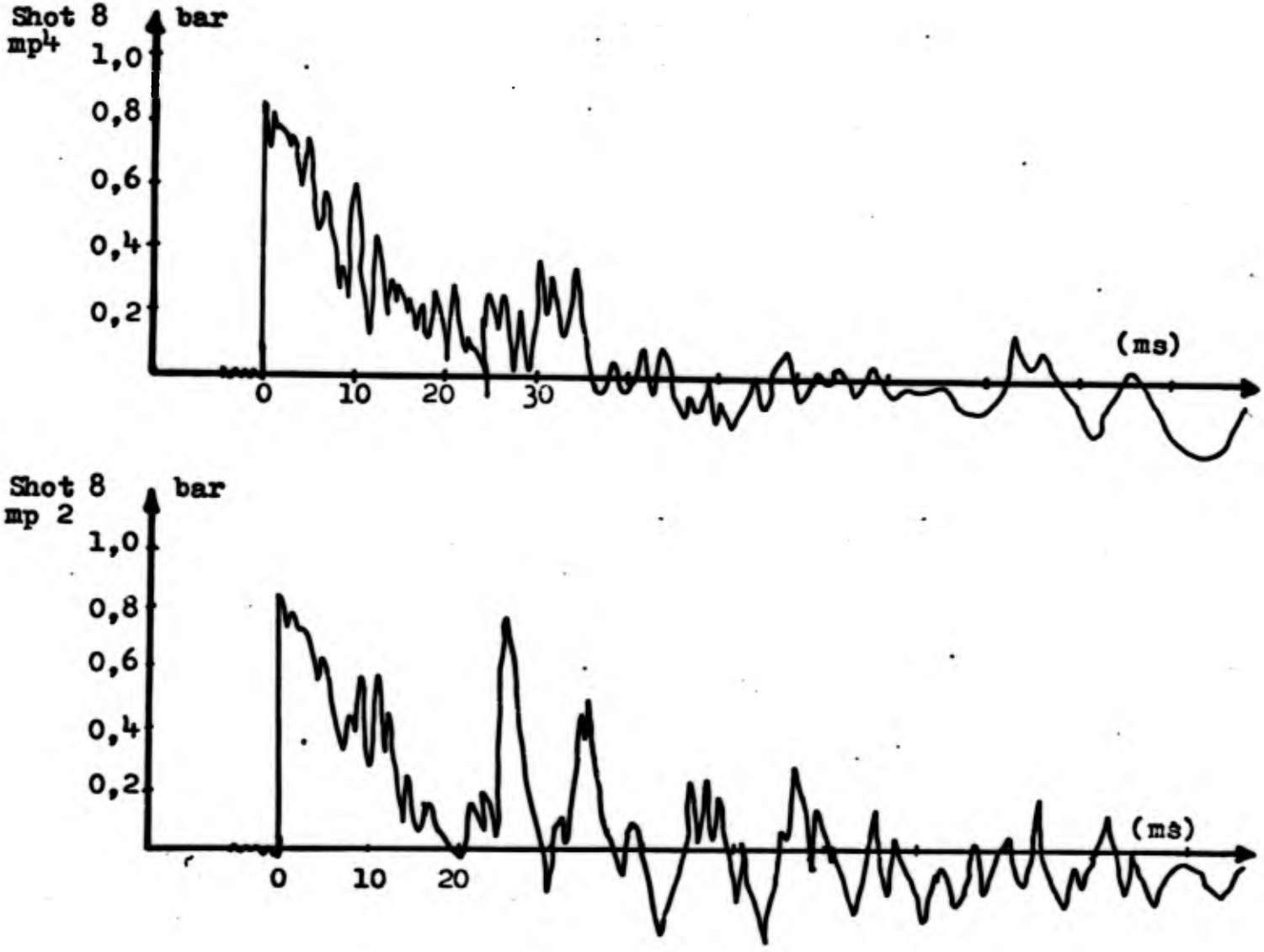

Shot 6
μstrain
mp 19
100
60
20
0
10
20
30
(ms)


Shot 7
mp 2
bar
0,6
0,4
0,2
0
10
20
30
(ms)


Shot 7
Deflection (mm)
mp 15
10
5
0
10
20
30
(ms)


Shot 7
Deflection (mm)
mp 16
10
5
0
10
20
30
(ms)

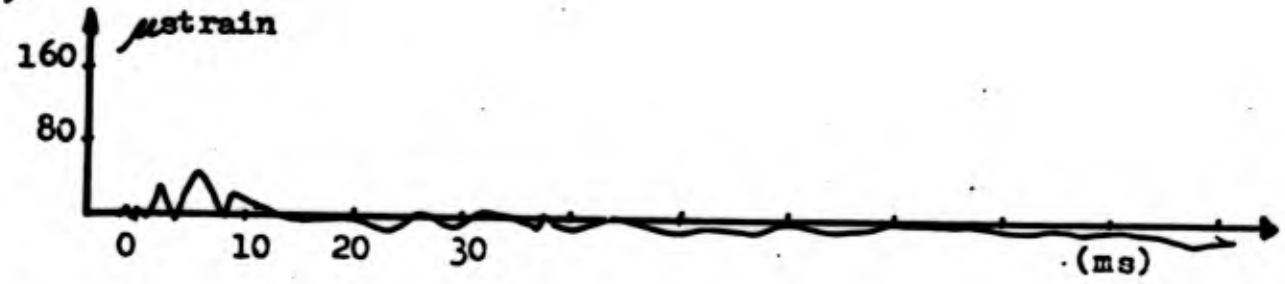

Shot 7
mp 19
μstrain
200
100
0
10
20
30
(ms)
shot 7
mp 18
μstrain
100
0
10
20
30
(ms)
Shot 7
mp 17
μstrain
100
0
10
20
30
(ms)


Shot 8
mp4
bar
1,0
0,8
0,6
0,4
0,2
0
10
20
30
(ms)
Shot 8
mp 2
bar
1,0
0,8
0,6
0,4
0,2
0
10
20
(ms)

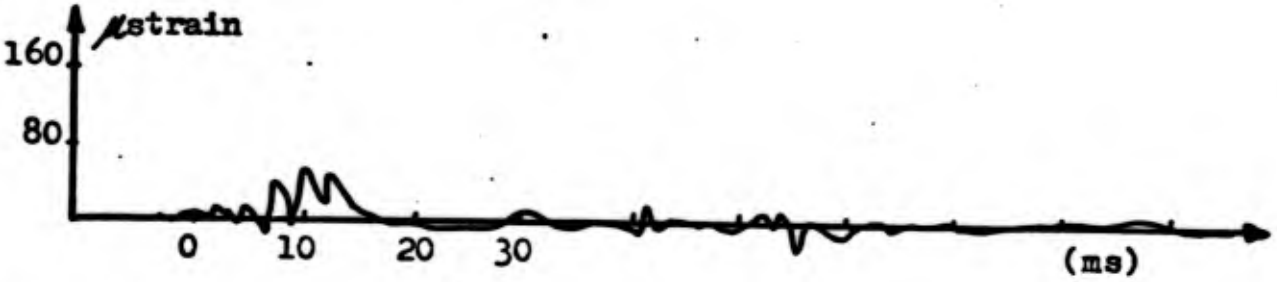

Shot 8
mp 15
Deflection (mm)
10
5
0
10
20
30
(ms)


Shot 8
mp 16
Deflection (mm)
10
5
0
10
20
30
(ms)

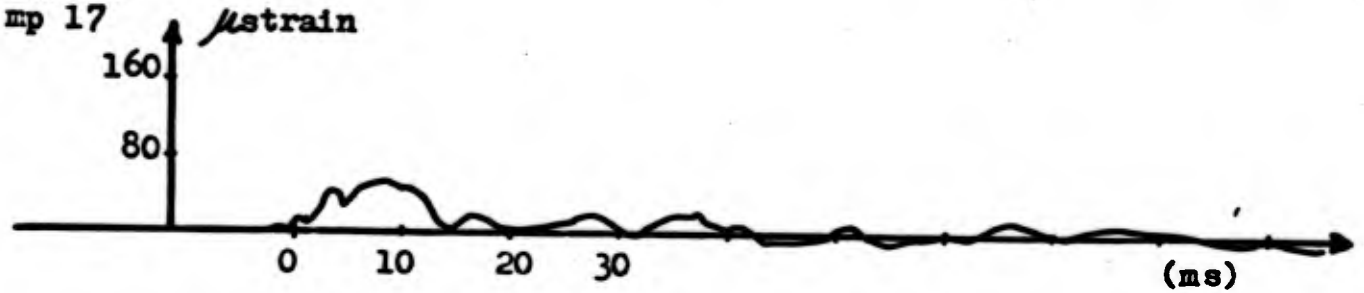
Shot 8
mp 19

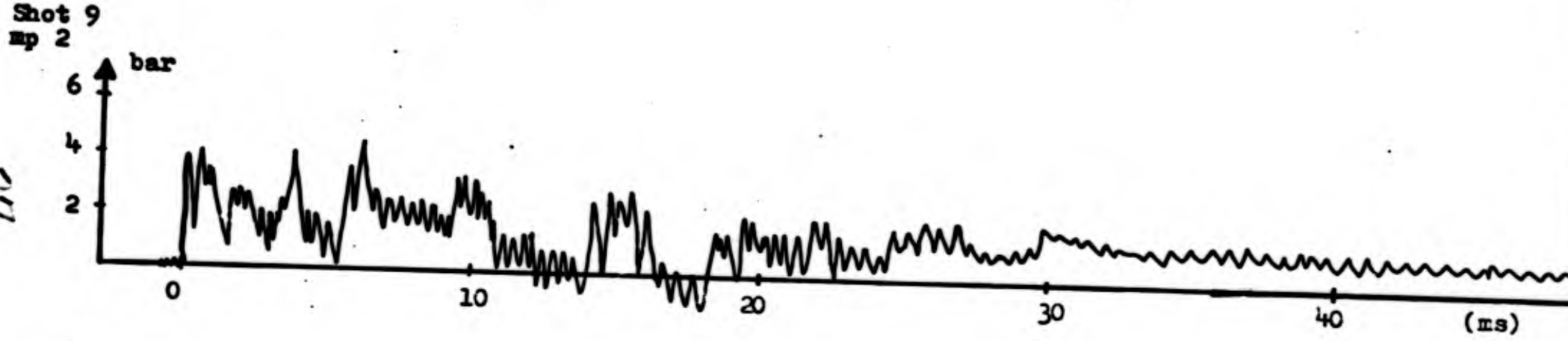


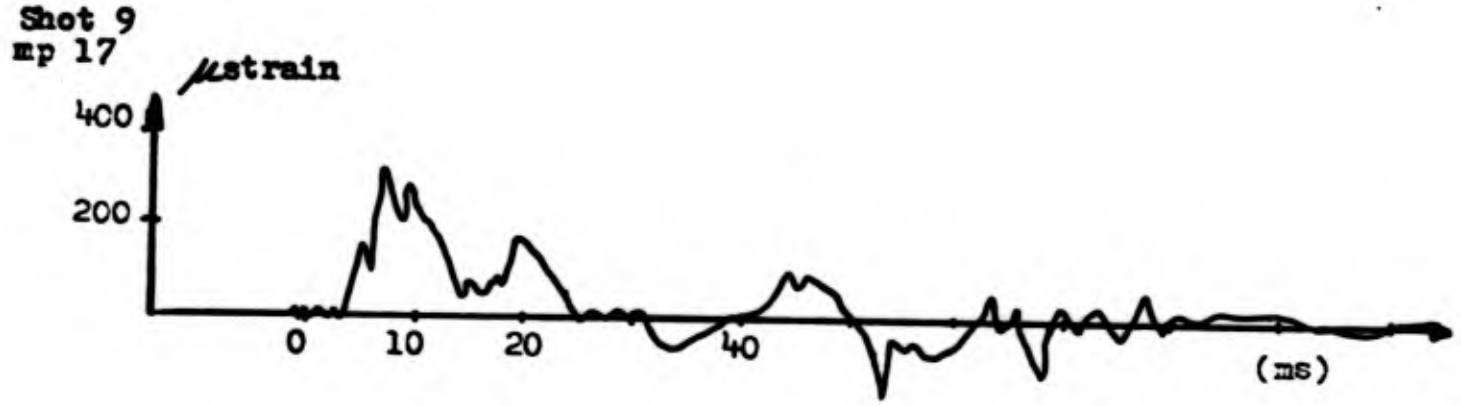
Shot 8
mp 18



Shot 8
mp 17

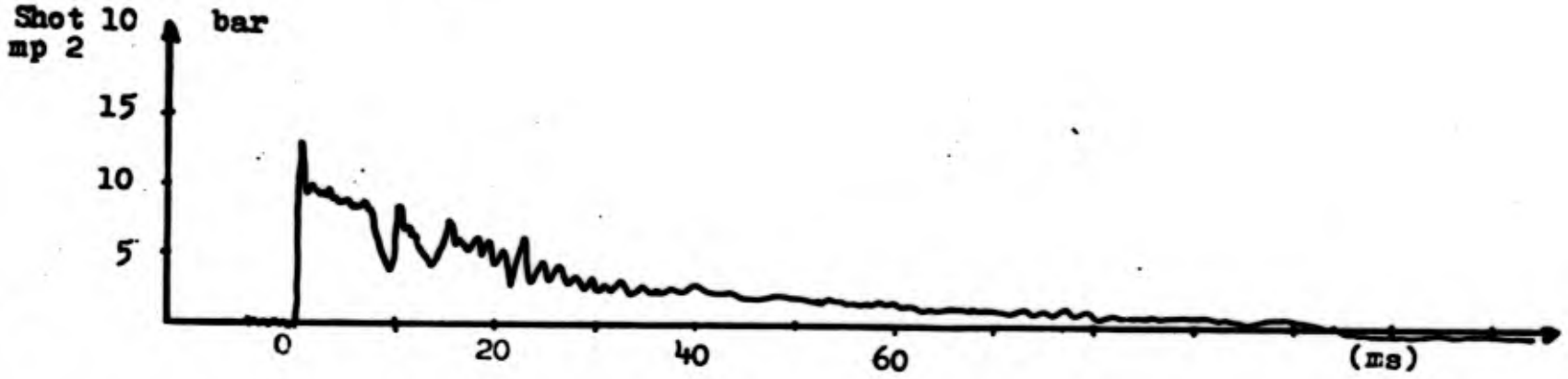


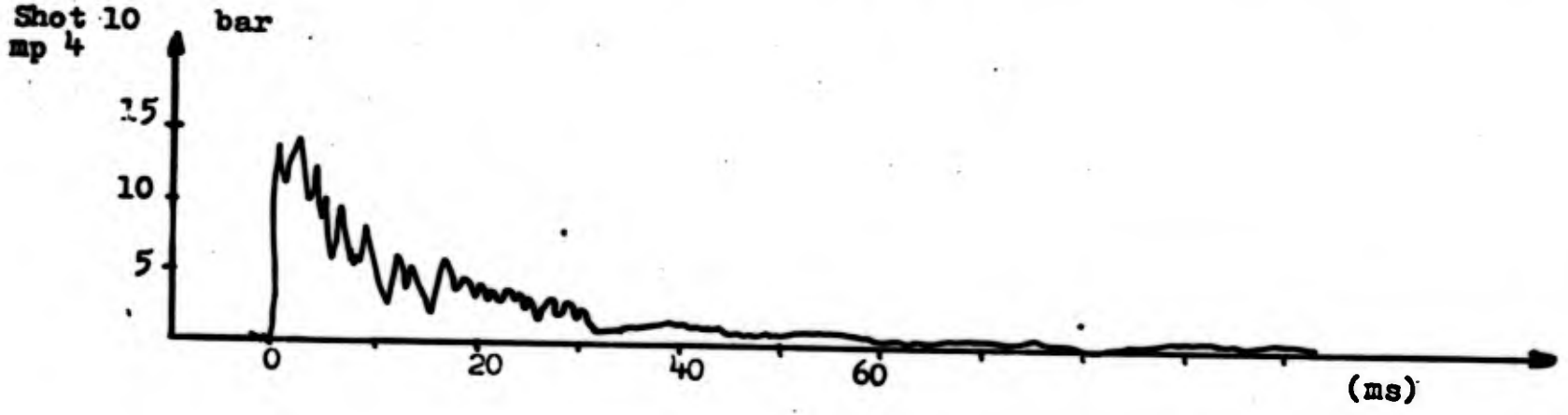

Shot 9
mp 2
bar
6
4
2
0
10
20
30
40
(ms)

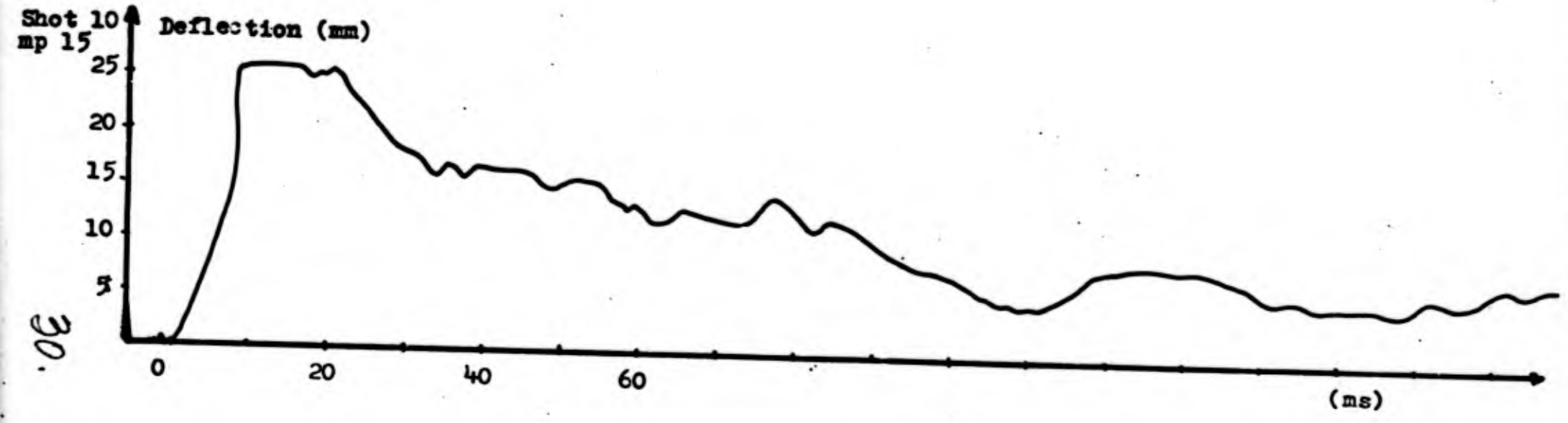

Shot 9
mp 17
μstrain
400
200
0
10
20
40
(ms)

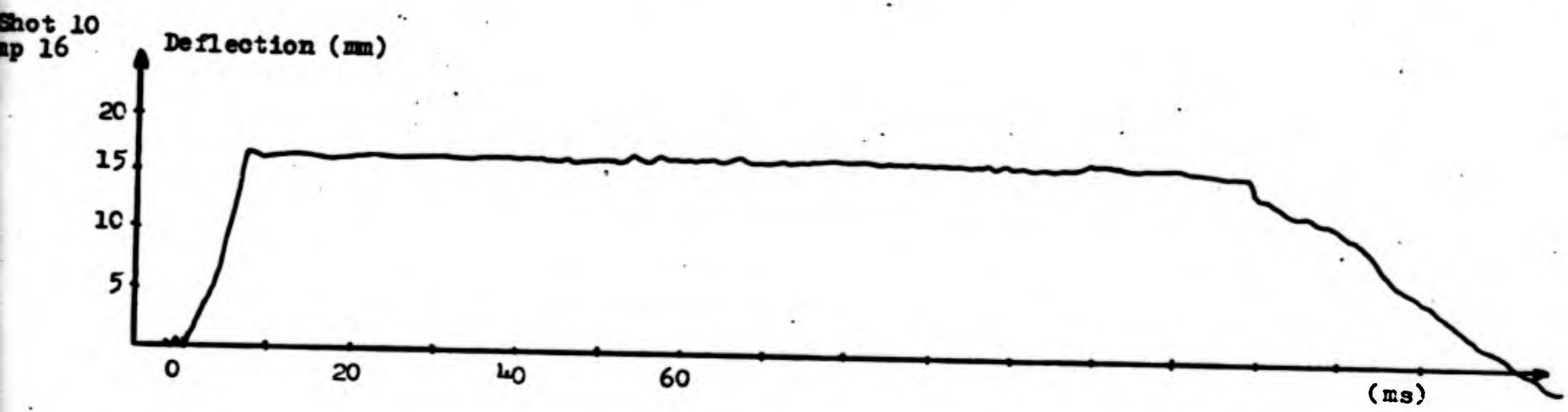

Shot 9
mp 18
μstrain
600
400
200
0
10
20
(ms)

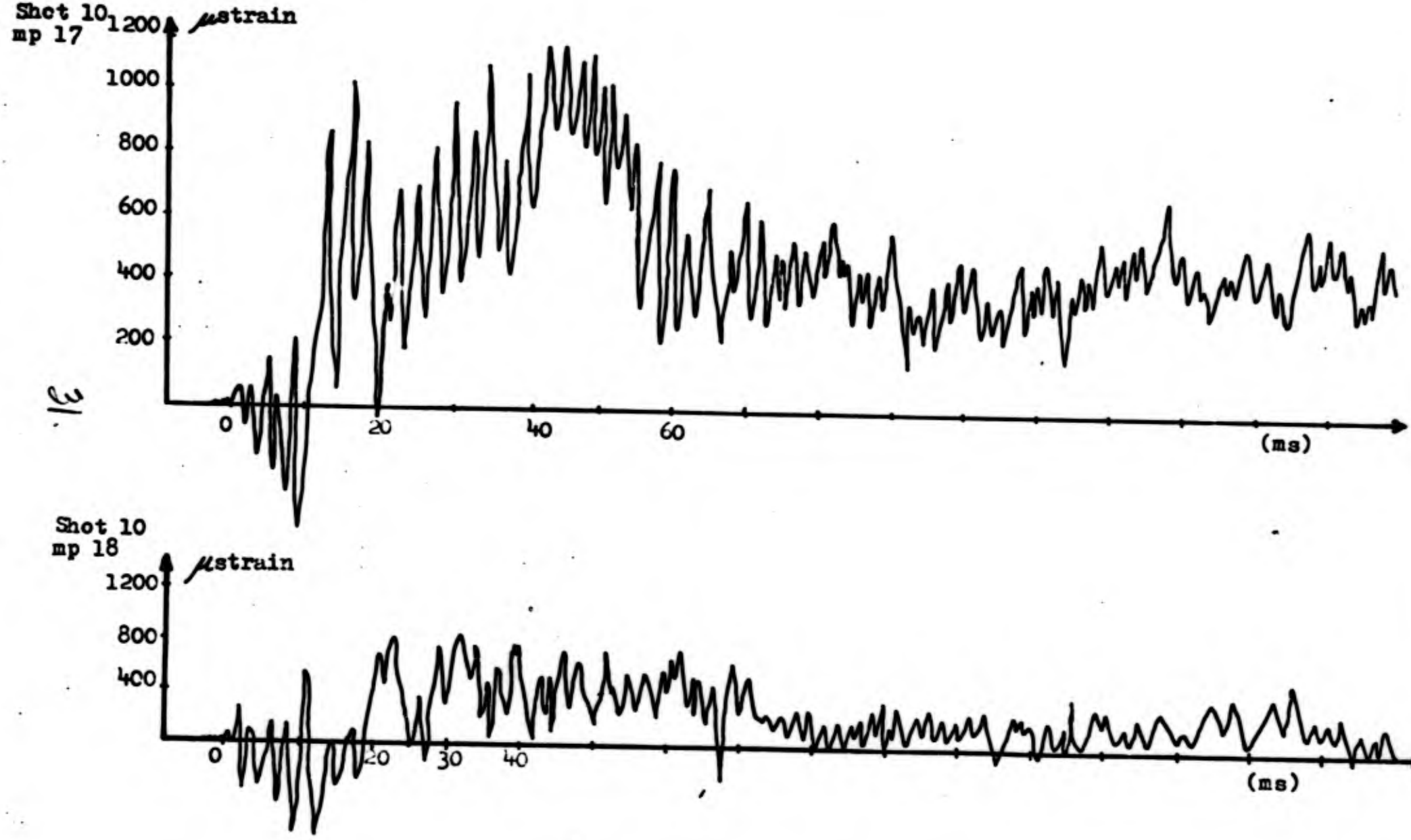

Shot 9
mp 19
μstrain
200
0
0
10
20
(ms)


Shot 10
mp 2
bar
15
10
5
0
20
40
60
(ms)

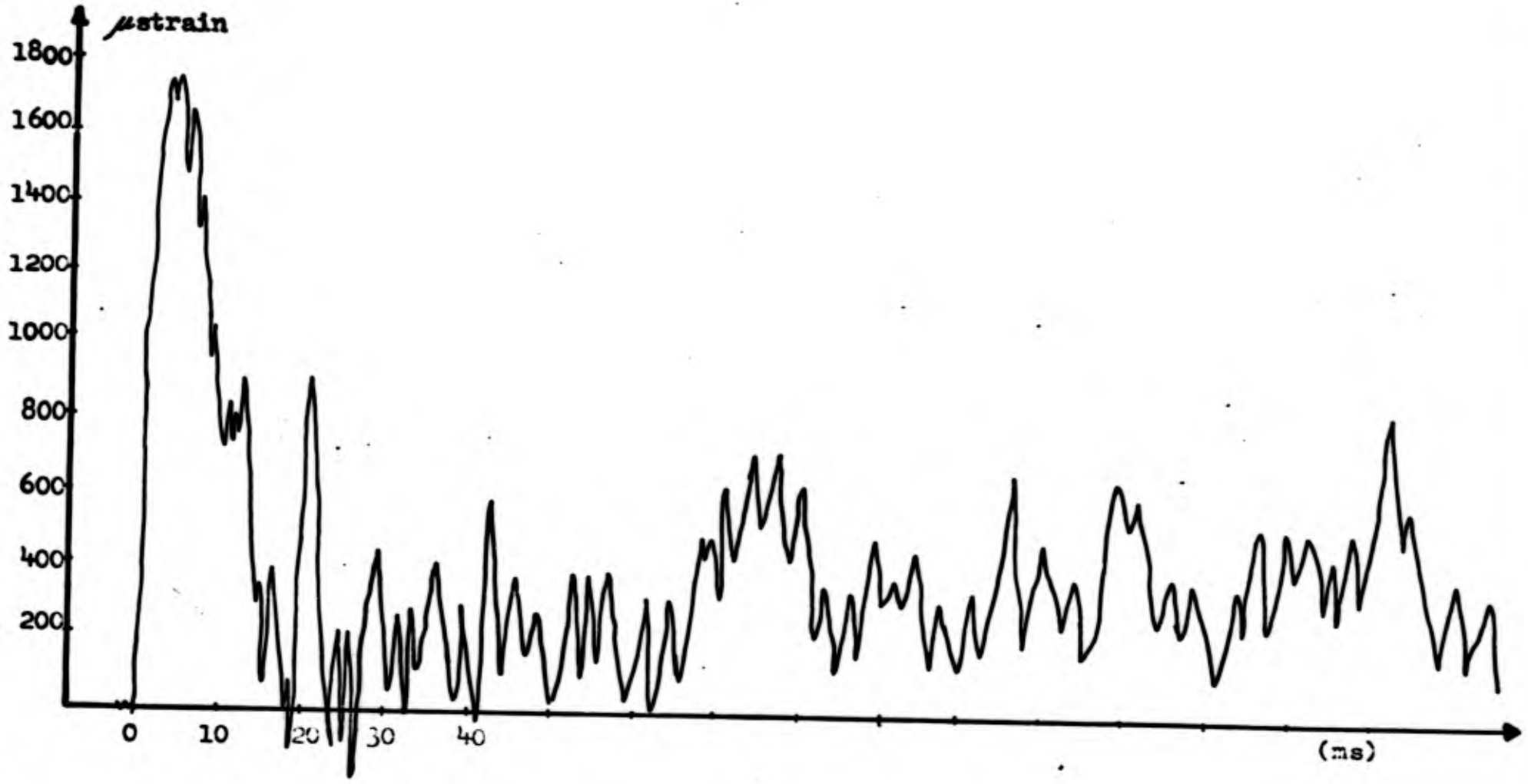

Shot 10
mp 4
bar
15
10
5
0
20
40
60
(ms)


Shot 10
mp 15
Deflection (mm)
25
20
15
10
5
0
20
40
60
(ms)


Shot 10
mp 16
Deflection (mm)
20
15
10
5
0
20
40
60
(ms)


Shot 10
mp 17
μstrain
1200
1000
800
600
400
200
0
20
40
60
(ms)
Shot 10
mp 18
μstrain
1200
800
400
0
20
30
40
(ms)

hot 10
p 19


μstrain
1800
1600
1400
1200
1000
800
600
400
200
0
10
20
30
40
(ms)

SUMMARY

A reinforced door 140 x 220 cm, concrete quality 250 kg/cm^2, designed by "Fortifikasjon A/S" was tested with gradually increasing air blast until max load according to the latest consideration of the NATO. AC/258 Storage Sub-Group [Head wall of acceptor igloo facing back wall of donor igloo at a scaled distance 0,8 $Q^{\frac{1}{3}}$]

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- Full protection would have been afforded to the interior of a magazine or shelter.