AD-A058 811 PROPELLANTS EXPLOSIVES AND ROCKET MOTOR ESTABLISHMENT--ETC F/G 11/4
GLASS FILLED POLYSTYRENES - PROCESSING VERSUS PROPERTIES. (U)
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PROPELLANTS, EXPLOSIVES AND ROCKET MOTOR ESTABLISHMENT

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6 GLASS FILLED POLYSTYRENES - PROCESSING VERSUS PROPERTIES.

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by


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SUMMARY


The effects of injection moulding on two types of glass filled polystyrene have been considered using an instrumented moulding machine. Certain machine parameters have been shown to be important in determining the properties of specimens cut from long glass polystyrene moulded discs but rather less important with short glass polystyrene. The importance of avoiding cut edges on moulded samples has been confirmed. No obvious correlations have been found between moulding pressures and mechanical properties but a relationship exists between cavity pressure and moulding weight and size.


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CONTENTS

## 1 INTRODUCTION

Polymeric materials are processed by the application of heat and pressure followed usually by rapid cooling. These parameters cause changes to occur in the material. Heat can cause chemical degradation which is normally detectable. Pressure applied to make the material flow in the moulding machine and into the mould cavity causes more subtle but, in many materials, more important changes. These include orientation leading to anisotropy, molecular scission and in the case of fibre filled materials, fibre degradation. High rates of cooling of mouldings also produce physical effects on mouldings such as amorphous skins or anisotropy throughout the thickness of the mouldings.

A considerable amount of effort has been directed towards examining and understanding the effects produced in both thermoplastics[1-6] and thermosets.[7,8]

Some of the moulding machine variables affecting the properties of direct blended polymer/glass strand have previously been examined.[9,10] In this present work an instrumented moulding machine has been used to examine some processing effects on two commercially available glass filled polystyrenes. This work completed in 1972 was the first work within the MOD on this topic. Lessons learnt from this report have been incorporated in the present research programme. The results have been published as a guide to others engaged in this work.

## 2 EXPERIMENTAL

### 2.1 Materials

Two types of polystyrene were chosen. One of these, Fiberfil G30SL, contains long glass fibres since the material is produced by a patented process whereby a continuous glass roving is impregnated with polymer and then chopped into a granule, thus the initial glass length is the length of the granule. The other material, LNP CF Series CF1008, is produced by the more normal compounding of glass strand and polymer in an extruder and pelletising. Properties claimed for these materials differ considerably and they are expected to depend also on the conditions employed during the moulding process.

### 2.2 Moulding Machine

An Ankerwerke V17/65 reciprocating screw injection moulding machine was used throughout this work working on a normal two stage injection cycle. The moulding cycle followed the sequence mould close, boost pressure, hold pressure (packing pressure), screw return, mould open. This type of cycle, although not the best for experimentation, was adopted since this is the way machines are normally run. The change, boost pressure to hold pressure, is governed on the Ankerwerke by a cam on the volume slide. Although the boost pressure is not controlled as such, the ram forward movement (speed of fill) can be altered by a needle valve. At all filling speeds, the attainable boost pressure is governed by the balance between the polymer being injected into the cavity from the moulding cylinder and the capacity of the high pressure hydraulic pump to pump oil via the needle valve to the ram. In consequence the boost pressure can be quite low when using large runners and gates in the mould. The hold pressure is regulated by a diaphragm valve and can be set from zero to 93 MPa. One further feature of the design of the hydraulics is that the hydraulic line pressure drops to zero on change from boost to hold pressure. This feature can be seen as a drop in the nozzle pressure/time trace at change over.

The moulding machine was instrumented by fitting pressure transducers (Kistler type 601H) in the hydraulic line and in the nozzle. In addition an unsheathed thermocouple was inserted into the nozzle adjacent to the pressure transducer (Fig 1A). The mould contained two disc cavities of 100 x 3 and 100 x 6 mm respectively, only the thinner cavity being used for this work. The mould (Fig 2) could be fitted with interchangeable gate blocks (Fig 1B). Pressure transducers in the mould were located in the fixed half just before and after the gate and at the far side of the cavity. A linear transducer was fitted to the moulding machine screw slide to indicate screw position. Signals from the pressure transducers were fed via Kistler charge amplifiers together with the thermocouple signal to a UV recorder (Bell & Howell 5-127).

The parameters which were varied during the investigation were injection rate, gate size, screw speed and back pressure. Other moulding conditions are given in Appendix A.

### 2.3 Moulding Properties

Properties measured on some or all specimens included dimensions, weight, tensile strength, flexural strength and modulus and impact strength. Tensile strengths were measured on miniature dumb-bells (for design see Fig 3) cut from moulded discs as described in Appendix B, on a Tensometer testing machine at a crosshead separation rate of 10 mm/min. Flexural strengths and moduli were similarly measured on bars cut from moulded discs. Impact strengths were determined on bars cut from the discs.

## 3 RESULTS AND DISCUSSION

### 3.1 Instrumental Results

A typical trace of the pressure/temperature/time relationship for the melt passing into the mould during a cycle is given in Figs 4 and 5 for the two types of polystyrene under different moulding conditions. It can be seen how the pressures vary in a complex manner during the cycle. Certain points, however, can readily be identified. At A the shut-off nozzle opens, at A1 the melt reaches the gate, at B the change from high pressure to hold pressure occurs. Between B and C the cavity is pressurised but at C the gate freezes and the cavity pressures begin to fall. At D the hold pressure is released and the screw returns. At E the clamp opens and the moulding is ejected.

The measured temperature rise in the nozzle as the material is injected is quite small ($\approx 5^{o}$C). The pressure/time curves can be used to set up the moulding machine to give a correct cycle. Fig 6 show how different moulding faults show up on the pressure/time curve.

Pressure values taken from the recorder records are listed in Tables 1 and 2. However it is rather difficult to decide which values to compare. In Figs 7 and 8 the peak pressures attained at various points in the system are plotted against injection speed and gate size for the long and short glass polystyrenes. Apart from a slightly higher level of pressures with the short glass material the effects are similar for both materials and can be discussed together.

It can readily be seen that as the injection speed increases the peak nozzle pressure rises rapidly. This is not reflected in the runner and cavity pressures because at this point the cavity is not full and little pressure is shown by the sensors. The recorded maximum cavity pressures reflect the hold or packing pressure applied. The effect of gate size can also be examined. For both materials and at all injection speeds the cavity pressure falls as the gate size is decreased. In addition the cavity pressure falls as the speed of injection falls. The weight of the mouldings (Table 3) shows the same trend with heaviest mouldings from fast injection, large gated shots. This effect is expected and has previously been shown with thermoset mouldings.[5]

In the static system after the mould is full there are still considerable pressure falls throughout the polymer melt system. Most surprising is the fall in pressure of approximately 3 MPa across the cavity, a distance of only 80 mm. This effect is even more marked with the short glass filled polystyrene material, the pressure drop being of the order of 6 MPa over the same distance. Also of interest is the comparatively low nozzle pressures required to fill the cavity at the fastest injection speeds compared with the maximum available on the moulding machine (117 MPa).

An alternative way of examining the results is to record the instantaneous values of the cavity pressures at different nozzle pressures. This can only be done in certain cases because the boost pressure has often cut off before the cavity sensor records any value. These results are summarised for short glass polystyrene in Table 4, as the fall in pressure between nozzle and runner and runner and cavity near transducers at various nozzle pressures. The conclusions from this table are that the major pressure loss in this moulding system is between the nozzle and runner, ie through the nozzle. The drop in pressure through the nozzle is almost independent of gate size but is of course dependent on filling speed, being approximately 50% of the total pressure loss at the fastest injection speeds. The pressure drop from runner to cavity, ie across the gate, depends on gate size as expected but appears to be independent of filling speed. This suggests that any increased pressure loss at increased filling speed is offset by the reduction in apparent viscosity with shear rate.

### 3.2 Effect of Processing on Material Properties

Properties were measured on specimens cut from the moulded discs in two directions at right angles to each other as described in Appendix B.

Results for the two types of polystyrene are given in Tables 5 and 6. In all cases, the strength values obtained from the cut specimens were much lower than the values given by the material manufacturer and also the values determined by ourselves on moulded specimens having an unbroken moulded skin. This lowering of strength, in some cases 50% of the published value, must be a consequence of the cut edges of the specimens and shows that post moulding machining should be avoided at all costs with these types of material.

### 3.2.1 Long Glass Polystyrene

The tensile properties of dumb-bells cut from long glass polystyrene moulded discs in the two directions are given in Table 5 and show that different gate sizes and rates of fill produce totally different orientations within these disc specimens.

The specimens moulded with a large gate are the most uniform as judged by tensile strength measurements, followed by those moulded using the small gate which appear to be oriented in the other direction. Those moulded using the medium sized gate show the greatest difference in strength on specimens cut in the two different directions. The highest overall tensile strength, ie the sum of the strengths in the two directions, is obtained with a large gate and a slow speed of injection. This is exactly in line with expectation since the glass fibres in these samples should be the least damaged mechanically by the moulding process.

Flexural bars cut from similar discs show the same general trends in strength values as the tensile specimens with the highest strength value, again obtained from discs moulded using a large gate and slow injection speed. There was a marked effect of back pressure on flexural strength but the effect of changing from 52 to 127 r/min screw speed was minimal. This is in line with previous results for polypropylene/glass.[10]

Unnotched impact strengths measured on cut bars were higher in a direction perpendicular to flow as expected, since fibres tend to align with the flow thus increasing impact strength of samples cut in the flow direction. There was an effect of gate size noticeable with impact strengths with the highest strengths being produced using large gates. The effect of back pressure was very pronounced with the impact strength being reduced to one quarter of the value when back pressure was not used.

The effects of different moulding conditions could be seen in a visual examination of the moulded discs (Fig 9). Gate size altered the filling characteristics and produced different orientations, whereas back pressure completely dispersed the fibres within the mouldings. This dispersion and associated fibre degradation is responsible for the lower impact and flexural strengths observed.

### 3.2.2 Short Glass Polystyrene

The highest overall tensile strength, parallel and perpendicular, is shown when using the large gate and slow injection speed (Table 6). The strength values are about 15% less than those for long glass polystyrene. The strength in the direction denoted as parallel to the flow direction was much larger in some cases than that perpendicular to flow, particularly when using the large gate. Samples moulded with back pressure showed a reversal in the direction of maximum strength. Both these effects differ from those in the long glass polystyrene. The most uniform samples produced in the short glass material, as judged by equivalence of strength in the two directions, were those produced when using a small gate with fast injection; the most highly oriented those samples produced with a large gate.

Flexural strength values on cut bars showed no general pattern, except that the strength measured on bars cut in a direction parallel to flow was about 50% larger than that of bars cut perpendicular to flow.

Impact strength values were considerably less than those for long glass materials even when this latter material was moulded under the most severe conditions. This illustrates the energy absorbing capability of long glass reinforced materials.

For both long and short glass polystyrenes there is no observable relationship between cavity pressures and properties. However this does not preclude the existence of such a relationship since the effects may well be smaller in magnitude than those of fill speed and gate size on orientation, distribution and breakage of the glass fibres. As already noted cavity pressures do affect the moulding weights and dimensions (Table 3).

## 4 CONCLUSIONS

The measurement of pressures through a moulding system have shown how the pressures vary during the moulding cycle. These values have enabled pressure losses to be calculated at various points in the system with short glass polystyrene. The major dynamic pressure loss occurs at the nozzle in this mould system.

Certain machine parameters have been shown to be important in determining the properties of specimens cut from mouldings in long glass polystyrene but to be much less important with short glass polystyrene. No obvious correlations between measured pressures and mechanical properties are apparent, but a relationship exists between maximum cavity pressure and moulding weight and size. The importance of avoiding cut edges on mouldings cannot be over emphasised.

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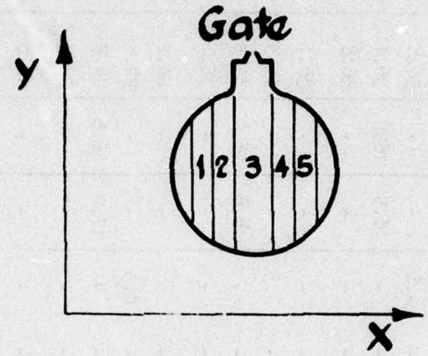
APPENDIX A

## Moulding Conditions

| | | |
|---|---|---|
| Cylinder temperatures | Zone 1 | Setting 190°C |
| | " 2 | " 225°C |
| | " 3 | " 235°C |
| | " 4 | " 225°C |
| | Mould | " 65°C |
| | Injection time | 25 s |
| | Cooling time | 15 s |
| | Interval | 15 s |
| | Volume | 3.0 cm |
| | Boost cut off | 0.7 |
| | Cushion | 0.2 |
| | Injection speed | Various |
| | Hold pressure (line) | 250 psi (1.72 MPa) |
| | Back pressure (line) | 0 or 400 psi (2.76 MPa) |
| | Screw speed | 52 or 127 r/min |

Moulding Properties - Experimental

Discs were moulded with a tab as below




Samples cut in direction Y were designated cut down the disc; those in direction X, across the disc.

Five sample bars were cut from each disc by using a set of slitting saws and suitable spacers. Those cut 12 mm wide were used without further treatment for flexural specimens. Similarly those cut at 6 mm (7) were used as impact bars.

All specimens from one disc were tested and the average of the 5 results quoted (7 for impact specimens). This compensates to some extent the variation of properties across the disc.

Dumb-bells were produced from bars by using a profiled horizontal milling wheel to give the required dumb-bell form on one edge of a set of 5 bars. The bars were then inverted and the profile cut into the other long edge to form the dumb-bell. Water only was used as a lubricating fluid during all the milling processes.

## TABLE 1

### Collected Data from Recorder Charts

| Description | Times for | | Far Cavity Pressure (MPa) | | | | Near Cavity Pressure (MPa) | | | | Runner Pressure (MPa) | | Nozzle Pressure (MPa) | | Back Pressure (MPa) | Back Pressure from Line (MPa) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Injection (s) | Screw Back (s) | A | B | C | D | A | B | C | D | B | D | B | C | | |
| **RUN A1** | 0.3 | 6 | 3.8 | 10.0 | - | 7.0 | - | - | - | - | - | - | 37.6 | 17.3 | 1.0 | - |
| **Small gate, fast injection** | 0.3 | 6 | - | - | - | - | 6.6 | 12.4 | - | 4.8 | - | - | 36.8 | 17.3 | 1.0 | - |
| **Screw speed 52 r/min. No set back** | 0.3 | 6 | - | - | - | - | - | - | - | - | 16.5 | 16.5 | 36.1 | 16.6 | 1.0 | - |
| **pressure.** | 0.3 | 6 | - | - | - | - | - | - | - | - | - | - | 36.8 | 16.6 | 1.0 | 0.3 |
| **RUN A2** | 0.3 | 6 | 4.1 | 9.7 | - | 4.5 | - | - | - | - | - | - | 36.1 | 15.0 | 1.0 | - |
| **As run 1** | 0.3 | 6 | - | - | - | - | 6.6 | 12.4 | - | 4.5 | - | - | 35.3 | 16.6 | 1.0 | - |
| | 0.3 | 6 | - | - | - | - | - | - | - | - | 18.6 | 16.0 | 35.3 | 16.6 | 1.4 | - |
| | 0.3 | 6 | - | - | - | - | - | - | - | - | - | - | 36.1 | 16.6 | 1.4 | 0.3 |
| **RUN A3** | 1.3 | 6 | 0.7 | 8.0 | - | 1.7 | - | - | - | - | - | - | 26.2 | 16.6 | 1.4 | - |
| **Small gate, medium injection** | 1.3 | 6 | - | - | - | - | 5.5 | 11.0 | - | 0.3 | - | - | 24.8 | 15.0 | 1.2 | - |
| **Screw speed 52 r/min. No set back** | 1.3 | 6 | - | - | - | - | - | - | - | - | 17.2 | 16.5 | 24.8 | 16.6 | 1.2 | - |
| **pressure.** | 1.3 | 6 | - | - | - | - | - | - | - | - | - | - | 24.8 | 16.6 | 1.2 | 0.3 |
| **RUN A4** | 4.3 | 6 | 0.3 | 5.9 | - | 4.5 | - | - | - | - | - | - | 18.0 | 16.6 | 1.2 | - |
| **Small gate, slow injection** | 4.3 | 6 | - | - | - | - | 4.8 | 9.0 | - | | - | - | 18.7 | 15.8 | 1.2 | - |
| **Screw speed 52 r/min. No set back** | 4.2 | 6 | - | - | - | - | - | - | - | - | 16.0 | 16.0 | 19.5 | 15.8 | 1.2 | - |
| **pressure.** | 4.3 | 6 | - | - | - | - | - | - | - | - | - | - | 20.3 | 15.8 | 1.2 | 0.3 |
| **RUN A5** | 4.5 | 6 | 0.7 | 5.5 | 3.5 | 1.0 | - | - | - | - | - | - | 19.6 | 15.3 | 1.2 | - |
| **Medium gate, slow injection** | 4.3 | 6 | - | - | - | - | 5.5 | 9.0 | - | | - | - | 19.6 | 15.3 | 1.2 | - |
| **Screw speed 52 r/min. No set back** | 4.4 | 6 | - | - | - | - | - | - | - | - | 16.0 | 16.0 | 19.6 | 15.3 | 1.2 | - |
| **pressure.** | 4.3 | 6 | - | - | - | - | - | - | - | - | - | - | 19.6 | 14.1 | 1.2 | 0.3 |
| **RUN A6** | 1.3 | 7 | 1.0 | 8.6 | - | 2.4 | - | - | - | - | - | - | 24.0 | 15.8 | 1.0 | - |
| **Medium gate, medium injection** | 1.3 | 7 | - | - | - | - | 5.5 | 9.7 | - | | - | - | 24.0 | 14.3 | 1.0 | - |
| **Screw speed 52 r/min. No set back** | 1.3 | 7 | - | - | - | - | - | - | - | - | 14.5 | 13.1 | 24.0 | 14.3 | 1.0 | - |
| **pressure.** | 1.3 | 7 | - | - | - | - | - | - | - | - | - | - | 24.0 | 14.3 | 1.0 | 0.3 |

TABLE 1 (Contd)

| Description | Times for | | Far Cavity Pressure (MPa) | | | | Near Cavity Pressure (MPa) | | | | Runner Pressure (MPa) | | Nozzle Pressure (MPa) | | Back Pressure (MPa) | Back Pressure from Line (MPa) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Injection (s) | Screw Back (s) | A | B | C | D | A | B | C | D | B | D | B | C | | |
| **RUN A7** | 0.3 | 7 | 8.3 | 10.0 | - | | - | - | - | - | - | - | 34.5 | 15.0 | 1.0 | - |
| **Medium gate, fast injection** | 0.3 | 7 | - | - | - | - | 10.0 | 11.0 | - | - | - | - | 34.5 | 15.0 | 1.0 | - |
| **Screw speed 52 r/min. No set back** | 0.3 | 7 | - | - | - | - | - | - | - | - | 16.2 | 14.8 | 34.5 | 15.8 | 1.0 | - |
| **pressure.** | 0.3 | 7 | - | - | - | - | - | - | - | - | - | - | 33.8 | 14.3 | 1.0 | 0.3 |
| **RUN A8** | 0.3 | 6 | - | 14.8 | - | 10.3 | - | - | - | - | - | - | 30.8 | 20.2 | 1.2 | - |
| **Angled gate, fast injection** | 0.3 | 6 | - | - | - | - | 9.0 | 17.2 | - | 8.3 | - | - | 30.8 | 19.5 | 1.2 | - |
| **Screw speed 52 r/min. No set back** | 0.3 | 6 | - | - | - | - | - | - | - | - | 5.5 | - | 30.8 | 19.5 | 1.2 | - |
| **pressure.** | 0.3 | 6 | - | - | - | - | - | - | - | - | - | - | 30.8 | 19.5 | 1.2 | 0.3 |
| **RUN A9** | 1.3 | 6 | 6.2 | 14.1 | 10.0 | 10.0 | - | - | - | - | - | - | 21.0 | 19.5 | 1.2 | - |
| **Angled gate, medium injection** | 1.3 | 6 | - | - | - | - | 5.17 | 16.5 | - | 9.0 | - | - | 21.0 | 19.5 | 1.2 | - |
| **Screw speed 52 r/min. No set back** | 1.3 | 6 | - | - | - | - | - | - | - | - | 6.6 | | 21.8 | 18.2 | 1.2 | - |
| **pressure.** | 1.3 | 6 | - | - | - | - | - | - | - | - | - | - | 21.8 | 18.0 | 1.2 | 0.3 |
| **RUN A10** | 3.8 | 6 | 0.3 | 11.4 | - | 9.0 | - | - | - | - | - | - | 19.5 | 19.5 | 1.2 | - |
| **Angled gate, slow injection** | 3.8 | 6 | - | - | - | - | 3.5 | 15.2 | - | 6.6 | - | - | 18.7 | 18.2 | 1.2 | - |
| **Screw speed 52 r/min. No set back** | 3.8 | 6 | - | - | - | - | - | - | - | - | 6.6 | - | 18.7 | 19.5 | 1.2 | - |
| **pressure.** | 3.8 | 6 | - | - | - | - | - | - | - | - | - | - | 18.7 | 18.2 | 1.2 | 0.3 |
| **RUN A11** | 3.8 | 6 | 0.3 | 10.3 | 9.7 | 9.7 | - | - | - | - | - | - | 18.7 | 18.2 | 1.2 | - |
| **Large gate, slow injection** | 3.8 | 6 | - | - | - | - | 5.5 | 16.2 | - | 9.3 | - | - | 19.5 | 19.5 | 1.2 | - |
| **Screw speed 52 r/min. No set back** | 3.8 | 6.5 | - | - | - | - | - | - | - | - | 19.3 | 19.3 | 19.5 | 19.5 | 1.2 | - |
| **pressure.** | 3.8 | 6.5 | - | - | - | - | - | - | - | - | - | - | 19.5 | 19.5 | 1.2 | 0.3 |
| **RUN A12** | 1.3 | 7 | 6.2 | 13.1 | 10.3 | 10.3 | - | - | - | - | - | - | 21.0 | 19.5 | 1.2 | - |
| **Large gate, medium injection** | 1.3 | 7 | - | - | - | - | 5.5 | 17.2 | - | 11.0 | - | - | 20.2 | 19.5 | 1.2 | - |
| **Screw speed 52 r/min. No set back** | 1.3 | 7 | - | - | - | - | - | - | - | - | 18.6 | 18.6 | 19.5 | 19.5 | 1.2 | - |
| **pressure.** | 1.3 | 7 | - | - | - | - | - | - | - | - | - | - | 20.2 | 18.5 | 1.2 | 0.3 |
| **RUN A13** | 0.3 | 6 | 5.5 | 15.2 | 11.7 | 11.7 | - | - | - | - | - | - | 29.3 | 18.2 | 1.2 | - |
| **Large gate, fast injection** | 0.3 | 6 | - | - | - | - | 6.9 | 16.8 | - | 11.3 | - | - | 28.5 | 18.2 | 1.2 | - |
| **Screw speed 52 r/min. No set back** | 0.3 | 6 | - | - | - | - | - | - | - | - | 18.6 | 17.9 | 28.5 | 18.2 | 1.2 | - |
| **pressure.** | 0.3 | 6 | - | - | - | - | - | - | - | - | - | - | 28.5 | 18.2 | 1.2 | 0.3 |

## TABLE 1 (Contd)

| Description | Times for | | Far Cavity Pressure (MPa) | | | | Near Cavity Pressure (MPa) | | | | Runner Pressure (MPa) | | Nozzle Pressure (MPa) | | Back Pressure (MPa) | Back Pressure from Line (MPa) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Injection (s) | Screw Back (s) | A | B | C | D | A | B | C | D | B | D | B | C | | |
| **RUN A14** | 1.3 | 6.5 | 0.3 | 14.1 | 10.3 | 10.3 | - | - | - | - | - | - | 19.5 | 18.2 | 3.5 | - |
| **Large gate, medium injection** | 1.3 | 6.5 | - | - | - | - | 5.5 | 16.5 | - | 10.3 | - | - | 19.5 | 18.2 | 3.5 | - |
| **Screw speed 127 r/min. No set back pressure.** | 1.3 | 6.5 | - | - | - | - | - | - | - | - | 18.6 | 18.6 | 19.5 | 18.2 | 3.5 | - |
| | 1.3 | 6.5 | - | - | - | - | - | - | - | - | - | - | 20.2 | 18.2 | 3.5 | 0.7 |
| **RUN A15** | 1.0 | 13.0 | 0.3 | 16.2 | 12.4 | 12.4 | - | - | - | - | - | - | 22.5 | 22.5 | 20.7 | - |
| **Large gate, medium injection** | 1.0 | 10.0 | - | - | - | - | 4.8 | 18.6 | - | 13.8 | - | - | 22.5 | 22.5 | 20.7 | - |
| **Screw speed 127 r/min** | 1.1 | 10.0 | - | - | - | - | - | - | - | - | 25.3 | 24.8 | 22.5 | 22.5 | 20.7 | - |
| **2.8 MPa set back pressure** | 1.1 | 9.0 | - | - | - | - | - | - | - | - | - | - | 22.5 | 22.5 | 20.7 | 2.1 |
| **RUN A16** | 0.3 | 9.0 | 10.3 | 18.6 | - | 7.6 | - | - | - | - | - | - | 28.3 | 28.3 | 20.7 | - |
| **Large gate, fast injection** | 0.3 | 9.0 | - | - | - | - | 11.7 | 18.6 | 13.4 | 13.4 | - | - | 28.3 | 28.3 | 20.7 | - |
| **Screw speed 127 r/min** | 0.3 | 14.0 | - | - | - | - | - | - | - | - | 24.8 | 24.8 | 28.3 | 28.3 | 20.7 | - |
| **2.8 MPa set back pressure** | 0.3 | 15.0 | - | - | - | - | - | - | - | - | - | - | 28.3 | 28.3 | 20.7 | 1.7 |
| **RUN A17** | 1.1 | 17.0 | 0.3 | 15.9 | 12.0 | 12.0 | - | - | - | - | - | - | 23.3 | 23.3 | 20.7 | - |
| **Large gate, medium injection** | 1.0 | 16.0 | - | - | - | - | 4.8 | 18.2 | - | 12.4 | - | - | 24.1 | 24.1 | 20.7 | - |
| **Screw speed 52 r/min** | 1.1 | 17.5 | - | - | - | - | - | - | - | - | 23.7 | 23.7 | 23.3 | 23.3 | 20.7 | - |
| **2.8 MPa set back pressure** | 1.0 | 17.5 | - | - | - | - | - | - | - | - | - | - | 24.1 | 24.1 | 20.7 | 1.7 |
| **RUN A18** | 1.3 | 7.5 | 0.3 | 10.6 | - | 3.1 | - | - | - | - | - | - | 21.8 | 18.0 | 1.2 | - |
| **Large gate, medium injection** | 1.3 | 7.5 | - | - | - | - | 5.5 | 15.9 | - | 0.7 | - | - | 21.8 | 18.0 | 1.2 | - |
| **Screw speed 52 r/min. No set back pressure.** | 1.3 | 7.0 | - | - | - | - | - | - | - | - | 18.2 | 14.5 | 21.8 | 18.0 | 1.2 | - |
| **Low mould temperature** | 1.3 | 7.0 | - | - | - | - | - | - | - | - | - | - | 21.8 | 18.0 | 1.2 | 0.3 |

**A = Pressure at cut off**
**B = Peak pressure**
**C = Steady pressure (if any)**
**D = Final pressure on mould opening**

## TABLE 2

Data from Recorder Records, Short Glass Polystyrene

| Serial No | Injection Time (s) | Nozzle: Peak Injection Pressure (MPa) | Nozzle: Hold Pressure (MPa) | Nozzle: Steady Peak Temperature (°C) | | Far Cavity Pressures (MPa): At Cut-off A | Far Cavity: Peak B | Far Cavity: Steady C | Far Cavity: Final D | Near Cavity Pressures (MPa): At Cut-off A | Near Cavity: Peak B | Near Cavity: Steady C | Near Cavity: Final D | Runners Pressures (MPa): Peak B | Runners: Final D | Screw Back Time (s) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| B1 | 0.36 | 46.6 | 24.0 | 244 | 248 | 9.0 | 13.8 | - | 8.3 | - | - | - | - | - | - | 6.2 |
| Small gate, fast injection. Screw | 0.36 | 46.6 | 24.0 | 244 | 249 | - | - | - | - | 12.4 | 17.3 | - | 6.2 | - | - | 6.5 |
| speed 52 r/min. No back pressure. | 0.36 | 46.6 | 24.0 | 244 | 248 | - | - | - | - | - | - | - | - | 23.5 | 7.6 | 6.5 |
| | 0.36 | 46.6 | 24.0 | 243 | 247 | - | - | - | - | - | - | - | - | - | - | 7.0 |
| B3 | 1.43 | 28.5 | 24.0 | 246 | 249 | 2.1 | 12.4 | - | 4.8 | - | - | - | - | - | - | 6.2 |
| Small gate, medium injection. Screw | 1.43 | 28.5 | 24.0 | 245 | 248 | - | - | - | - | 9.0 | 16.8 | - | - | - | - | 6.3 |
| speed 52 r/min. No back pressure. | 1.43 | 28.5 | 24.0 | 241 | 244 | - | - | - | - | - | - | - | - | 22.3 | 6.2 | 6.2 |
| | 1.43 | 28.5 | 24.0 | 241 | 244 | - | - | - | - | - | - | - | - | - | - | 6.2 |
| B4 | 4.0 | 24.8 | 24.0 | 237 | 239 | 2.8 | 9.7 | - | 3.5 | - | - | - | - | - | - | 6.2 |
| Small gate, slow injection. Screw | 4.0 | 24.8 | 24.0 | 235 | 236 | - | - | - | - | 9.7 | 15.9 | - | Nil | - | - | 6.0 |
| speed 52 r/min. No back pressure. | 4.0 | 24.8 | 24.0 | 237 | 239 | - | - | - | - | - | - | - | - | 22.[illegible] | 6.9 | 6.0 |
| | 4.0 | 24.8 | 24.0 | 237 | 240 | - | - | - | - | - | - | - | - | - | - | 6.0 |
| B5 | 3.84 | 22.6 | 24.0 | 244 | 247 | 1.4 | 10.3 | - | 4.5 | - | - | - | - | - | - | 6.1 |
| Medium gate, slow injection. Screw | 3.84 | 22.6 | 24.0 | 244 | 247 | - | - | - | - | 9.3 | 16.8 | - | 2.1 | - | - | 6.0 |
| speed 52 r/min. No back pressure. | 3.84 | 22.6 | 24.0 | 245 | 247 | - | - | - | - | - | - | - | - | 23.4 | 5.5 | 6.0 |
| | 3.93 | 22.6 | 24.0 | 243 | 246 | - | - | - | - | - | - | - | - | - | - | 6.1 |
| B6 | 1.35 | 24.8 | 24.0 | 245 | 250 | 1.3 | 11.7 | - | 4.1 | - | - | - | - | - | - | 6.5 |
| Medium gate, medium injection. Screw | 1.35 | 24.8 | 24.0 | 242 | 248 | - | - | - | - | 9.7 | 17.3 | - | 4.1 | - | - | 6.2 |
| speed 52 r/min. No back pressure. | 1.35 | 24.8 | 24.0 | 241 | 244 | - | - | - | - | -- | - | - | - | 23.3 | 4.8 | 6.5 |
| | 1.35 | 24.8 | 24.0 | 238 | 242 | - | - | - | - | - | - | - | - | - | - | 6.5 |
| B7 | 0.4 | 24.8 | 24.0 | 236 | 240 | 9.7 | 15.2 | - | 10.4 | - | - | - | - | - | - | 6.0 |
| Medium gate, fast injection. Screw | 0.4 | 24.8 | 24.0 | 235 | 238 | - | - | - | - | 11.7 | 17.9 | - | 5.5 | - | - | 6.0 |
| speed 52 r/min. No back pressure. | 0.4 | 24.8 | 24.0 | 236 | 240 | - | - | - | - | - | - | - | - | 26.2 | 6.9 | 6.0 |
| | 0.4 | 24.8 | 24.0 | 237 | 241 | - | - | - | - | - | - | - | - | - | - | 6.0 |
| B11 | 4.0 | 24.8 | 24.0 | 240 | 242 | 1.4 | 11.7 | - | 8.3 | - | - | - | - | - | - | 6.0 |
| Large gate, slow injection. Screw | 4.0 | 24.8 | 24.0 | 240 | 243 | - | - | - | - | 11.0 | 20.7 | - | 9.0 | - | - | 6.0 |
| speed 52 r/min. No back pressure. | 4.0 | 24.8 | 24.0 | 241 | 244 | - | - | - | - | - | - | - | - | 22.8 | 4.14 | 6.0 |
| | 4.0 | 24.8 | 24.0 | 242 | 245 | - | - | - | - | - | - | - | - | - | - | 6.0 |

TABLE 2 (Contd)

| Serial No | Injection Time (s) | Nozzle | | | | Far Cavity Pressures (MPa) | | | | Near Cavity Pressures (MPa) | | | | Runners Pressuress (MPa) | | Screw Back Time (s) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Peak Injection Pressure (MPa) | Hold Pressure (MPa) | Steady Peak Temperature ($^{o}C$) | | At Cut-off A | Peak B | Steady C | Final D | At Cut-off A | Peak B | Steady C | Final D | Peak B | Final D | |
| B12 | 1.3 | 20.3 | 21.0 | 247 | 249 | 2.1 | 14.5 | - | 9.0 | - | - | - | - | - | - | 6.5 |
| Large gate, medium injection. Screw | 1.3 | 20.3 | 21.0 | 240 | 242 | - | - | - | - | 10.4 | 21.4 | - | 13.1 | - | - | 6.5 |
| speed 52 r/min. No back pressure. | 1.3 | 20.3 | 21.0 | 237 | 239 | - | - | - | - | - | - | - | - | 23.5 | 6.90 | 6.5 |
| | 1.3 | 20.3 | 21.0 | 237 | 239 | - | - | - | - | - | - | - | - | - | - | 6.5 |
| B13 | 0.4 | 20.3 | 21.0 | 239 | 241 | 11.0 | 16.6 | - | 11.0 | - | - | - | - | - | - | 6.5 |
| Large gate, fast injection. Screw | 0.4 | 20.3 | 21.0 | 240 | 244 | - | - | - | - | 14.5 | 20.7 | - | 13.8 | - | - | 6.5 |
| speed 52 r/min. No back pressure. | 0.4 | 20.3 | 21.0 | 240 | 244 | - | - | - | - | - | - | - | - | 23.5 | 6.90 | 6.5 |
| | 0.4 | 20.3 | 21.0 | 241 | 245 | - | - | - | - | - | - | - | - | - | - | 6.5 |
| B14 | 1.25 | 20.3 | 21.0 | 241 | 244 | 1.0 | 11.0 | - | 3.5 | - | - | - | - | - | - | 2.5 |
| Large gate, medium injection. Screw | 1.25 | 20.3 | 21.0 | 238 | 241 | - | - | - | - | 8.3 | 15.2 | 1.38 | 1.4 | - | - | 2.5 |
| speed 127 r/min. No back pressure. | 1.25 | 20.3 | 21.0 | 239 | 242 | - | - | - | - | - | - | - | - | 20.7 | 1.73 | 2.5 |
| | 1.25 | 20.3 | 21.0 | 238 | 242 | - | - | - | - | - | - | - | - | - | - | 2.5 |
| B16 | 0.32 | 20.3 | 21.0 | 235 | 239 | 1.4 | 13.1 | 7.28 | 7.3 | - | - | - | - | - | - | 4.5 |
| Large gate, fast injection. Screw | 0.32 | 20.3 | 21.0 | 236 | 239 | - | - | - | - | 15.2 | 19.3 | 3.45 | 3.5 | - | - | 4.5 |
| speed 127 r/min and back pressure. | 0.32 | 20.3 | 21.0 | 238 | 241 | - | - | - | - | - | - | - | - | 21.4 | 8.64 | 4.5 |
| | 0.32 | 20.3 | 21.0 | 240 | 244 | - | - | - | - | - | - | - | - | - | - | 4.5 |
| B19 | 0.45 | 20.3 | 21.0 | 218 | 223 | 12.4 | 13.1 | - | Nil | - | - | - | - | - | - | 7.5 |
| Large gate, fast injection. Screw | 0.45 | 20.3 | 21.0 | 219 | 224 | - | - | - | - | 17.21 | 16.6 | - | 6.9 | - | - | 9.0 |
| speed 52 r/min. Low barrel T. | 0.45 | 20.3 | 21.0 | 220 | 225 | - | - | - | - | - | - | - | - | 18.6 | 10.3 | 8.0 |
| | 0.45 | 20.3 | 21.0 | 219 | 224 | - | - | - | - | - | - | - | - | - | - | 7.0 |
| B20 | 1.3 | 20.3 | 21.0 | 219 | 222 | 2.1 | 8.3 | - | 1.4 | - | - | - | - | - | - | 6.5 |
| Large gate, medium injection. Screw | 1.3 | 20.3 | 21.0 | 216 | 219 | - | - | - | - | 11.0 | 14.5 | - | 1.4 | - | - | 6.5 |
| speed 52 r/min. Low barrel T. | 1.3 | 20.3 | 21.0 | 214 | 217 | - | - | - | - | - | - | - | - | 18.0 | 5.5 | 6.5 |
| | 1.3 | 20.3 | 21.0 | 216 | 219 | - | - | - | - | - | - | - | - | - | - | 6.5 |
| B21 | 3.8 | 20.3 | 21.0 | 216 | 218 | 1.4 | 7.6 | - | 2.1 | - | - | - | - | - | - | 7.0 |
| Large gate, slow injection. Screw | 4.0 | 20.3 | 21.0 | 216 | 218 | - | - | - | - | 11.7 | 18.6 | - | 6.9 | - | - | 7.0 |
| speed 52 r/min. Low barrel T. | 4.0 | 20.3 | 21.0 | 216 | 218 | - | - | - | - | - | - | - | - | 22.1 | 6.9 | 7.0 |
| | 4.0 | 20.3 | 21.0 | 218 | 218 | - | - | - | - | - | - | - | - | - | - | 7.0 |

## TABLE 3

**Weight of Short Glass Polystyrene Discs as a Function of Injection Speed/Gate Size**

| | Slow Injection (g) | Medium Injection (g) | Fast Injection (g) |
|---|---|---|---|
| Large gate | 38.2 | 39.1 | 39.9 |
| Medium " | 37.4 | 37.9 | 38.6 |
| Small " | 37.0 | 37.6 | 38.3 |

All values average weight of five mouldings.

TABLE 4

Pressure Falls in System for Short Glass Polystyrene

| Gate Size | Injection Speed | Nozzle/Runner Pressure Drop (MPa) at Nozzle Pressure of | | | Runner/Cavity near Pressure Drop (MPa) at Nozzle Pressure of | | |
|---|---|---|---|---|---|---|---|
| | | 2000 psi (12.8 MPa) | 3000 psi (20.7 MPa) | 4000 psi (27.6 MPa) | 12.8 MPa | 20.7 MPa | 27.6 MPa |
| Large Gate | Fast injection | + | 16.6 | 15.9 | + | 2.8 | 3.5 |
| | Medium " | 9.7 | 9.7 | + | 2.8 | 2.8 | + |
| | Slow " | 5.5 | 6.9 | + | 2.8 | 2.8 | + |
| Medium Gate | Fast Injection | + | + | 15.9 | + | + | 9.0 |
| | Medium " | 9.0 | 8.3 | + (7.6) | + | 6.2 | + (6.9) |
| | Slow " | 5.5 | 5.5 | + | 6.2 | 5.5 | + |
| Small Gate | Fast Injection | + | 12.8 | 17.3 | + | 6.9 | 9.0 |
| | Medium " | 7.6 | 6.9 | 9.0 | + | 8.3 | 9.0 |
| | Slow " | 6.2 | 5.5 | + | 6.2 | 7.6 | + |

+ No reading possible

TABLE 5

Mechanical Properties of Cut Discs

(Long glass Polystyrene)

| Run No | Tensile Strength (MPa) | | Flexural Strength (MPa) Crosswise | Modulus (GPa) | Impact Strength (Charpy) (J) | |
|---|---|---|---|---|---|---|
| | Crosswise | Downwards | | | Crosswise | Downwards |
| A 1 | 37.3 | 37.8 | 90.8 | 4.1 | 0.39 | 0.39 |
| A 2 | 38.7 | 36.1 | 93.7 | 3.5 | 0.36 | 0.26 |
| A 3 | 39.9 | 45.4 | 89.3 | 4.6 | 0.36 | 0.30 |
| A 4 | 38.9 | 43.0 | 93.1 | 4.2 | 0.36 | 0.31 |
| A 5 | 36.6 | 47.4 | 94.4 | 4.1 | 0.40 | 0.32 |
| A 6 | 30.4 | 41.8 | 98.6 | 4.1 | 0.47 | 0.27 |
| A 7 | 37.6 | 46.1 | 96.5 | 4.4 | 0.41 | 0.29 |
| A 8 | 38.6 | 40.4 | 90.7 | 4.7 | 0.48 | 0.34 |
| A 9 | 40.2 | 42.7 | 96.7 | 4.3 | 0.56 | 0.33 |
| A10 | 38.9 | 40.5 | 92.5 | 4.9 | 0.61 | 0.38 |
| A11 | 46.9 | 43.4 | 110 | 5.3 | 0.62 | 0.39 |
| A12 | 42.4 | 39.5 | 107 | 5.0 | 0.48 | 0.38 |
| A13 | 39.4 | 37.7 | 97.0 | 4.6 | 0.47 | 0.36 |
| A14 | 42.7 | 43.0 | 105 | 5.2 | 0.44 | 0.34 |
| A15 | 37.6 | 37.0 | 75.8 | 4.6 | 0.15 | 0.12 |
| A16 | 36.8 | 37.6 | 75.8 | 4.5 | 0.11 | 0.10 |
| A17 | 38.3 | 42.1 | 78.2 | 4.2 | 0.27 | - |
| A18 | 47.6 | 44.6 | 98.4 | 4.5 | 0.60 | 0.55 |

## TABLE 6

### Mechanical Properties of Cut Discs

### (Short Glass Polystyrene)

| Run No | Tensile Strength (MPa) | | Flexural Strength (MPa) | | Flexural Modulus (GPa) | | Impact Strength (J) | |
|---|---|---|---|---|---|---|---|---|
| | Crosswise | Downwards | Crosswise | Downwards | Crosswise | Downwards | Crosswise | Downwards |
| B 1 | 30.8 | 29.0 | 64.6 | 88.9 | 465 | 508 | 099 | 100 |
| B 3 | 27.7 | 35.4 | 59.3 | 96.7 | 391 | 500 | 100 | 095 |
| B 4 | 24.9 | 33.2 | 52.2 | 94.2 | 355 | 516 | 085 | 096 |
| B 5 | 24.9 | 31.5 | 56.0 | 99.4 | 400 | 756 | 091 | 115 |
| B 6 | 28.7 | 32.1 | 57.6 | 85.6 | 476 | 501 | 102 | 111 |
| B 7 | 29.6 | 26.2 | 64.1 | 87.8 | 476 | 501 | 110 | 100 |
| B11 | 28.0 | 48.1 | 55.1 | 82.3 | 408 | 428 | 099 | 120 |
| B12 | 26.3 | 34.6 | 63.5 | 98.6 | 348 | 743 | 089 | 111 |
| B13 | 27.8 | 39.2 | 66.9 | 89.5 | 456 | 568 | 108 | 108 |
| B14 | 31.5 | 28.4 | 56.6 | 90.8 | - | 582 | 87 | 122 |
| B16 | 32.2 | 29.2 | 68.5 | 98.5 | 431 | 625 | 96 | 92 |
| B19 | 29.2 | 31.1 | 69.8 | 102 | 426 | 609 | 97 | 108 |
| B20 | 35.1 | 35.1 | 56.8 | 87.9 | 388 | 526 | 93 | 119 |
| B21 | 44.3 | 44.3 | 55.4 | 97.1 | 426 | 572 | 88 | 112 |

NOTE: B1 compares with A1

B7 with A7 etc

TABLE 7

Summary Table of Comparable Results for Cut Discs

| Run | Long Glass Polystyrene | | | | | Short Glass Polystyrene | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Tensile (MPa) | | Flexure (MPa) | Impact (J) | | Tensile (MPa) | | Flexure (MPa) | Impact (J) | |
| | c | d | d | c | d | c | d | d | c | d |
| 2 Small gate fast | 38.7 (74.8) | 36.1 | 93.7 | 0.36 (0.62) | 0.26 | 30.8 (59.8) | 29.0 | 64.6 | 0.099 (0.209) | 0.110 |
| 3 Small gate medium | 39.9 (84.3) | 45.4 | 89.3 | 0.36 (0.66) | 0.30 | 27.7 (63.1) | 35.4 | 59.3 | .100 (.195) | .095 |
| 4 Small gate slow | 38.9 (80.9) | 43.0 | 93.1 | 0.36 (0.67) | 0.31 | 24.9 (58.1) | 33.2 | 52.2 | .085 (.191) | .096 |
| 5 Medium gate slow | 36.6 (84.0) | 47.4 | 94.4 | 0.40 (0.72) | 0.32 | 24.9 (56.4) | 31.5 | 56.0 | .091 (.206) | .115 |
| 6 Medium gate medium | 30.4 (72.2) | 44.8 | 98.6 | 0.47 (0.74) | 0.27 | 28.7 (60.9) | 32.1 | 57.6 | .102 (.212) | .111 |
| 7 Medium gate fast | 37.6 (82.7) | 46.0 | 96.5 | 0.41 (0.71) | 0.29 | 29.6 (55.6) | 26.2 | 64.1 | .110 (.210) | .100 |
| 11 Large gate slow | 46.9 (89.3) | 43.4 | 110 | 0.62 (1.01) | 0.39 | 28.0 (76.1) | 48.1 | 55.1 | .099 (.219) | .120 |
| 12 Large gate medium | 42.4 (82.9) | 39.5 | 107 | 0.48 (0.86) | 0.38 | 26.3 (70.9) | 34.6 | 63.5 | .089 (.200) | .111 |
| 13 Large gate fast | 39.4 (77.1) | 37.7 | 97 | 0.47 (0.83) | 0.36 | 27.8 (67.0) | 39.2 | 66.9 | .108 (.216) | .108 |
| 14 Large gate medium (127 r/min) | 42.7 (85.7) | 43.0 | 105 | 0.44 (0.78) | 0.34 | 31.5 (58.9) | 28.4 | 56.6 | .087 (.209) | .122 |
| 16 Large gate fast (127 + back P) | 36.8 (75.8) | 37.6 | 75.8 | 0.15 (0.27) | 0.10 | 32.2 (61.4) | 29.2 | 68.5 | .096 (.188) | .092 |

NOTE: Sum of values for samples cut Crosswise (c) and Downwards (d) in brackets.

TR 6
Fig. 1

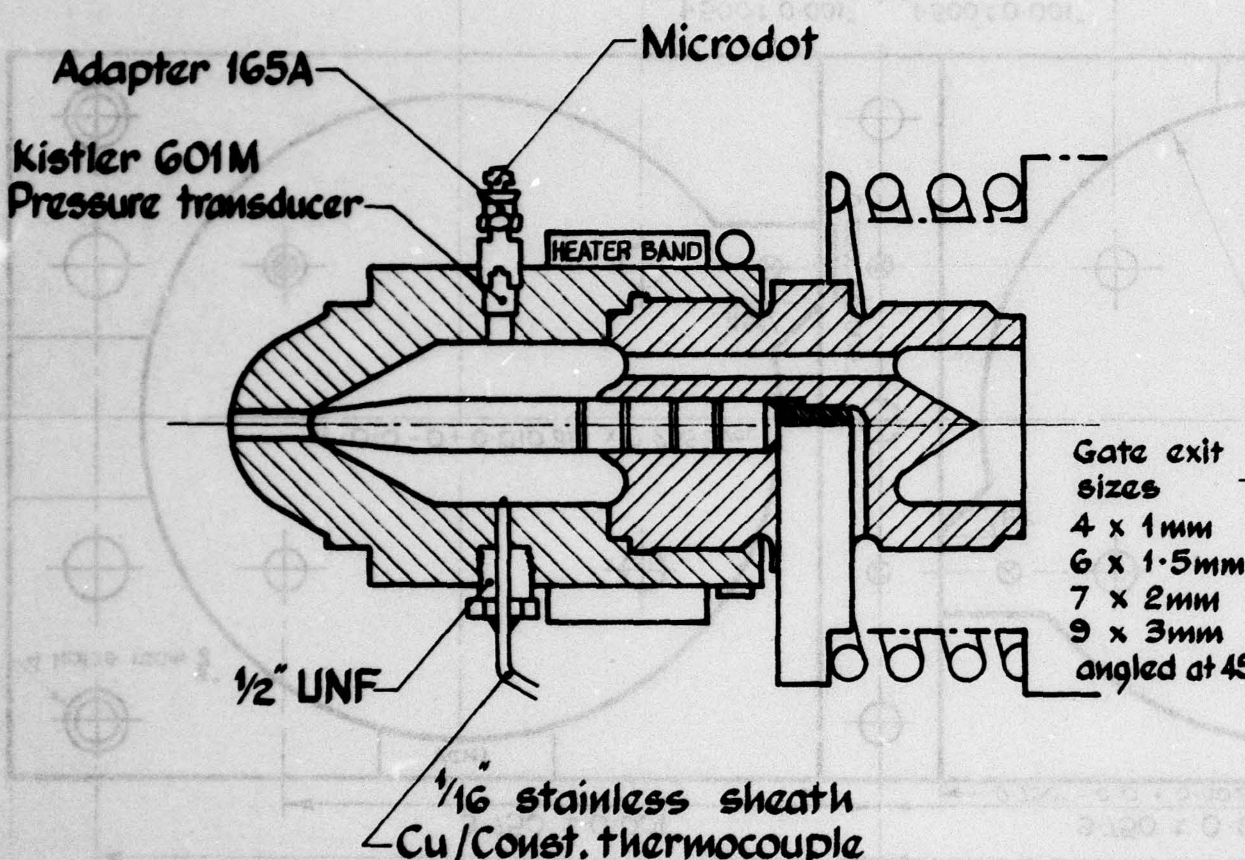



FIG. 1A ANKERWERKE NOZZLE LAYOUT

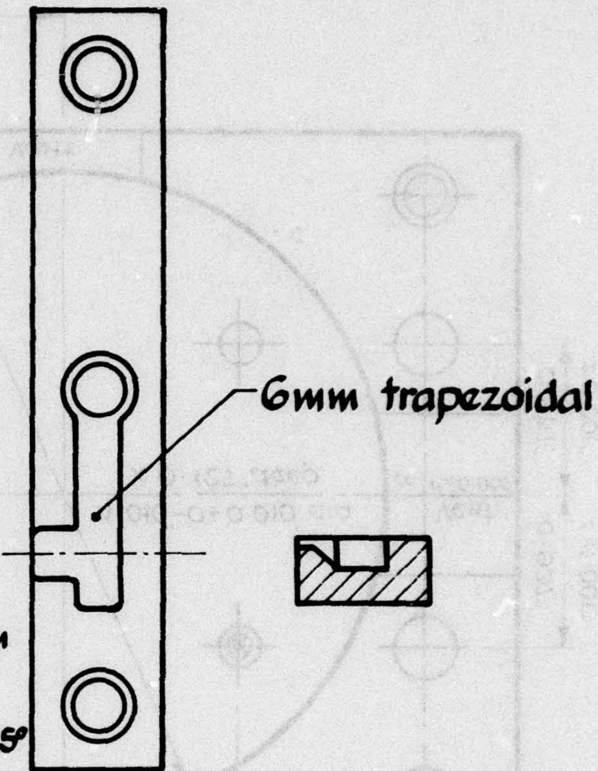



FIG. 1B GATE DESIGN

TR 6
Fig.2

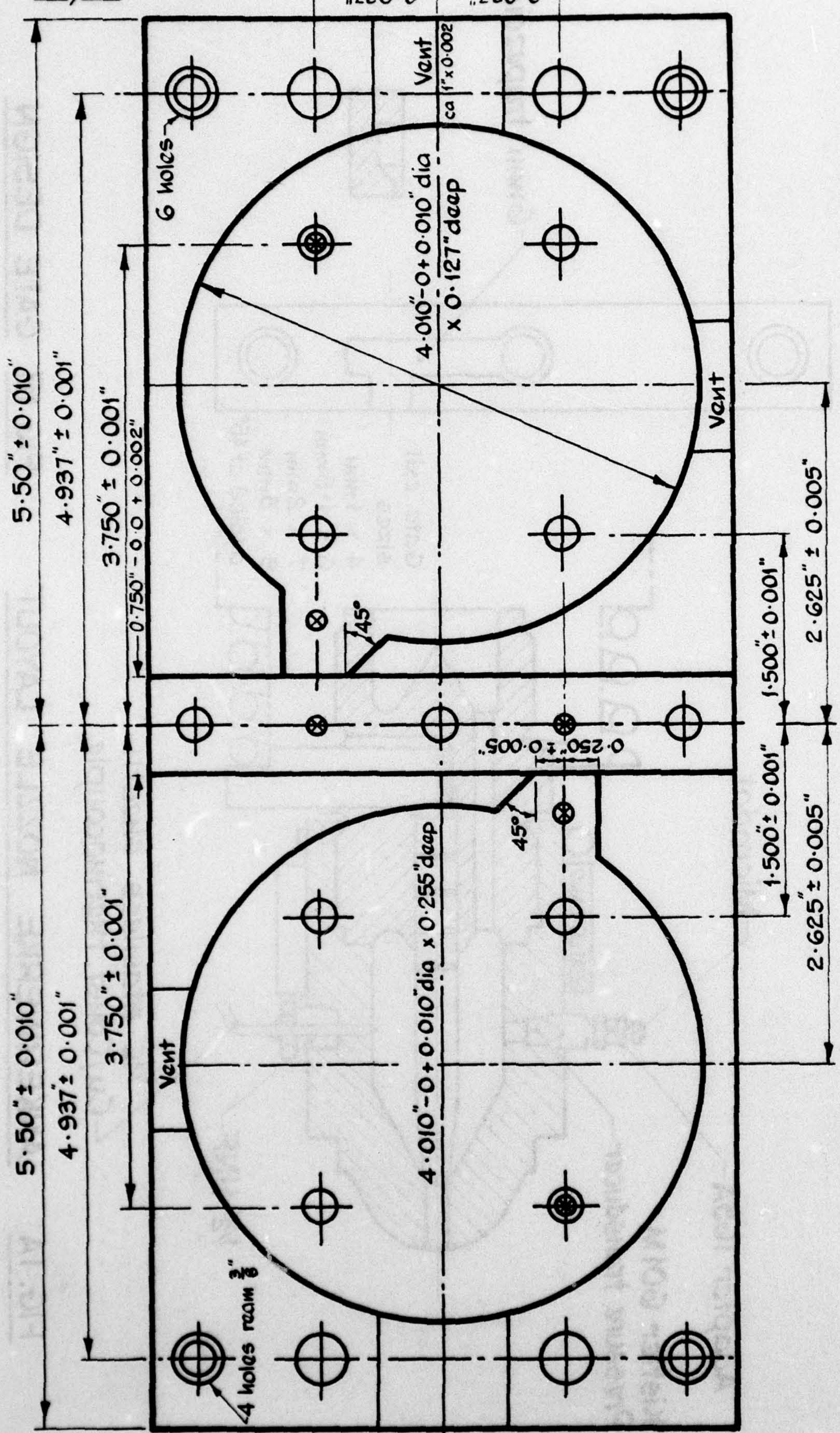
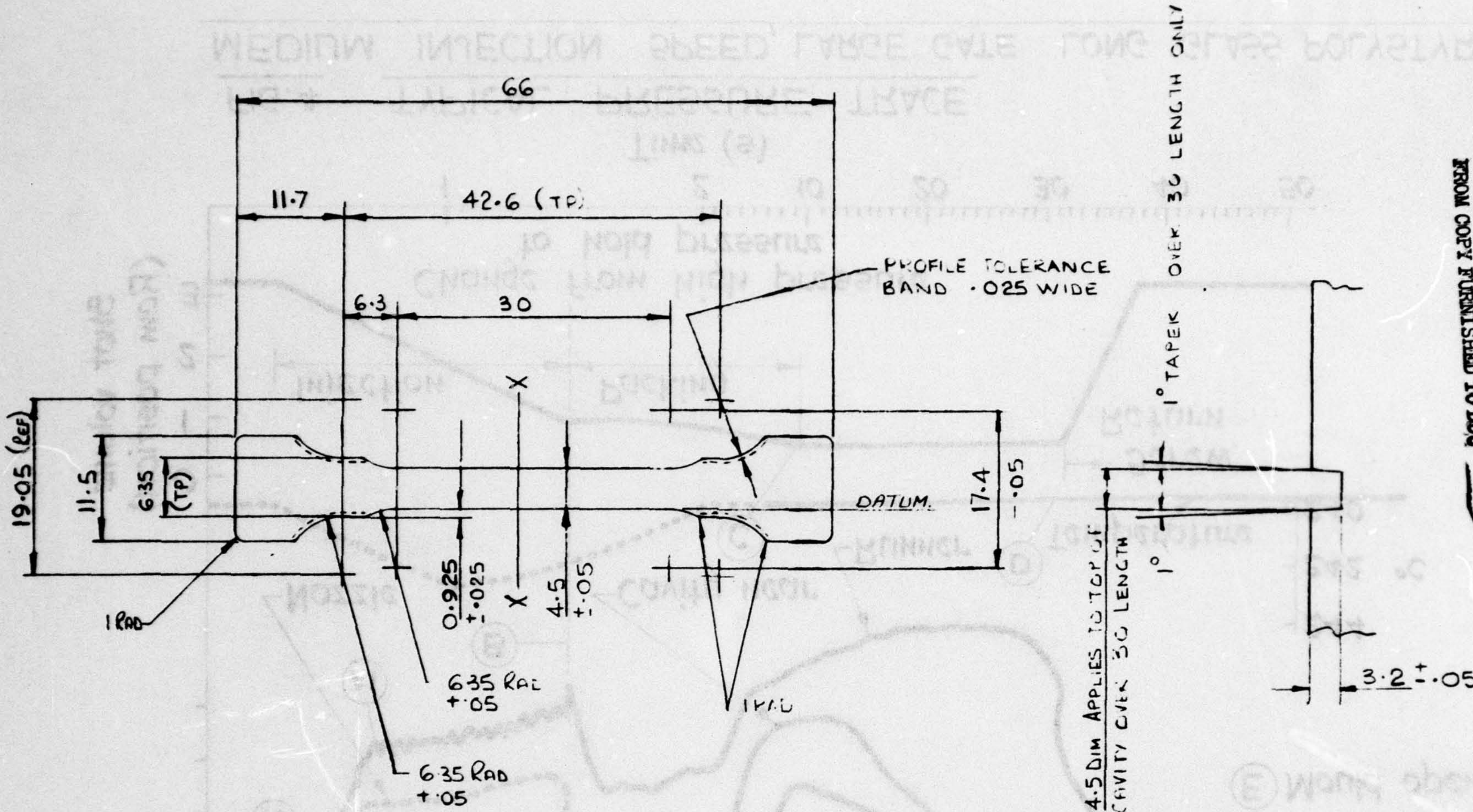



FIG.2 MOULD PLATE LAYOUT




NOTES:
1. DIMENSIONS IN mm
2. TOLERANCES ±·1 UNLESS OTHERWISE STATED.

**FIG.3** **STANDARD CAVITY FORM FOR PLASTIC DUMB-BELL SPECIMEN**

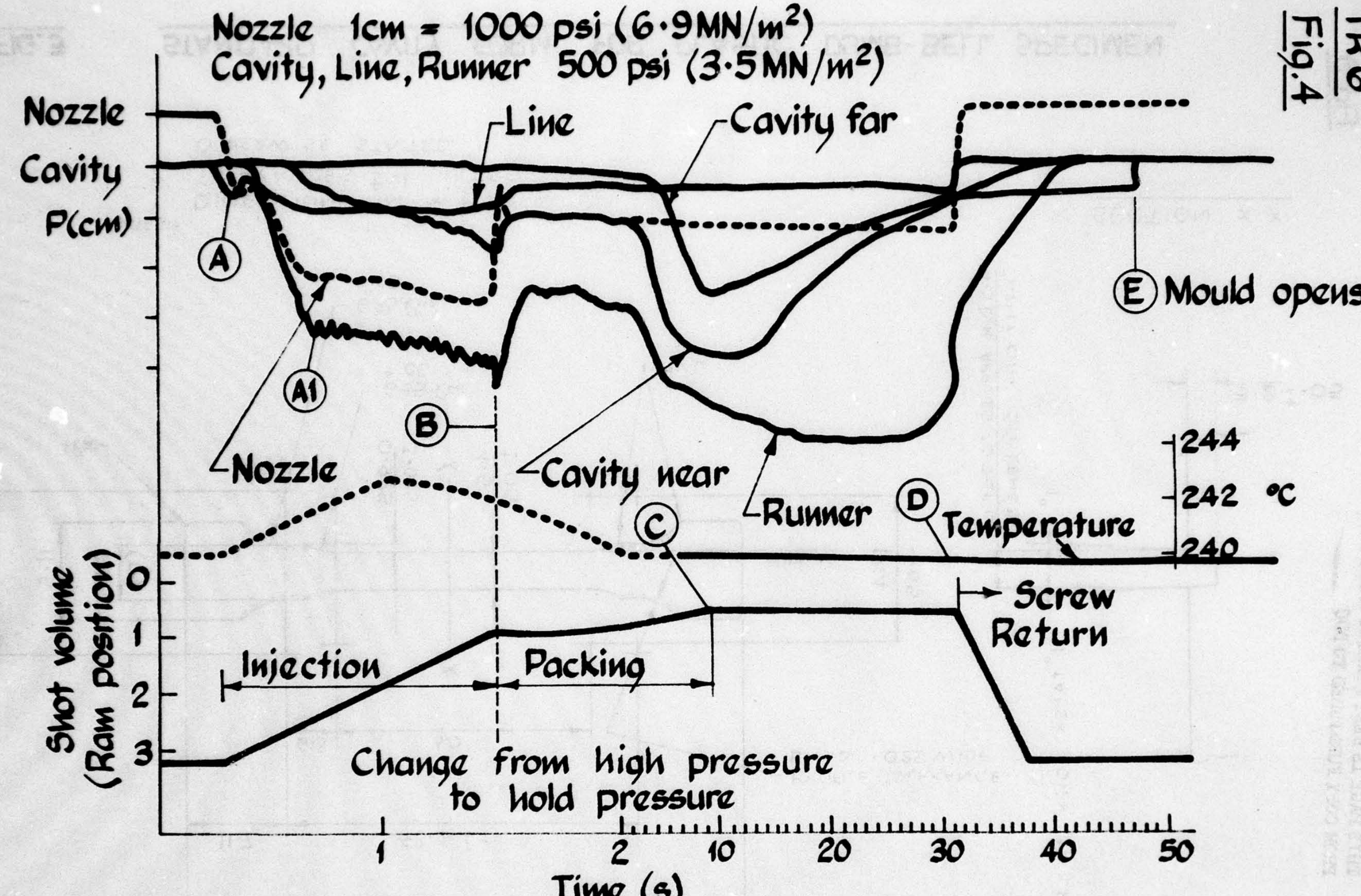



FIG.4 TYPICAL PRESSURE TRACE

MEDIUM INJECTION SPEED, LARGE GATE LONG GLASS POLYSTYRENE

TR 6
Fig. 5



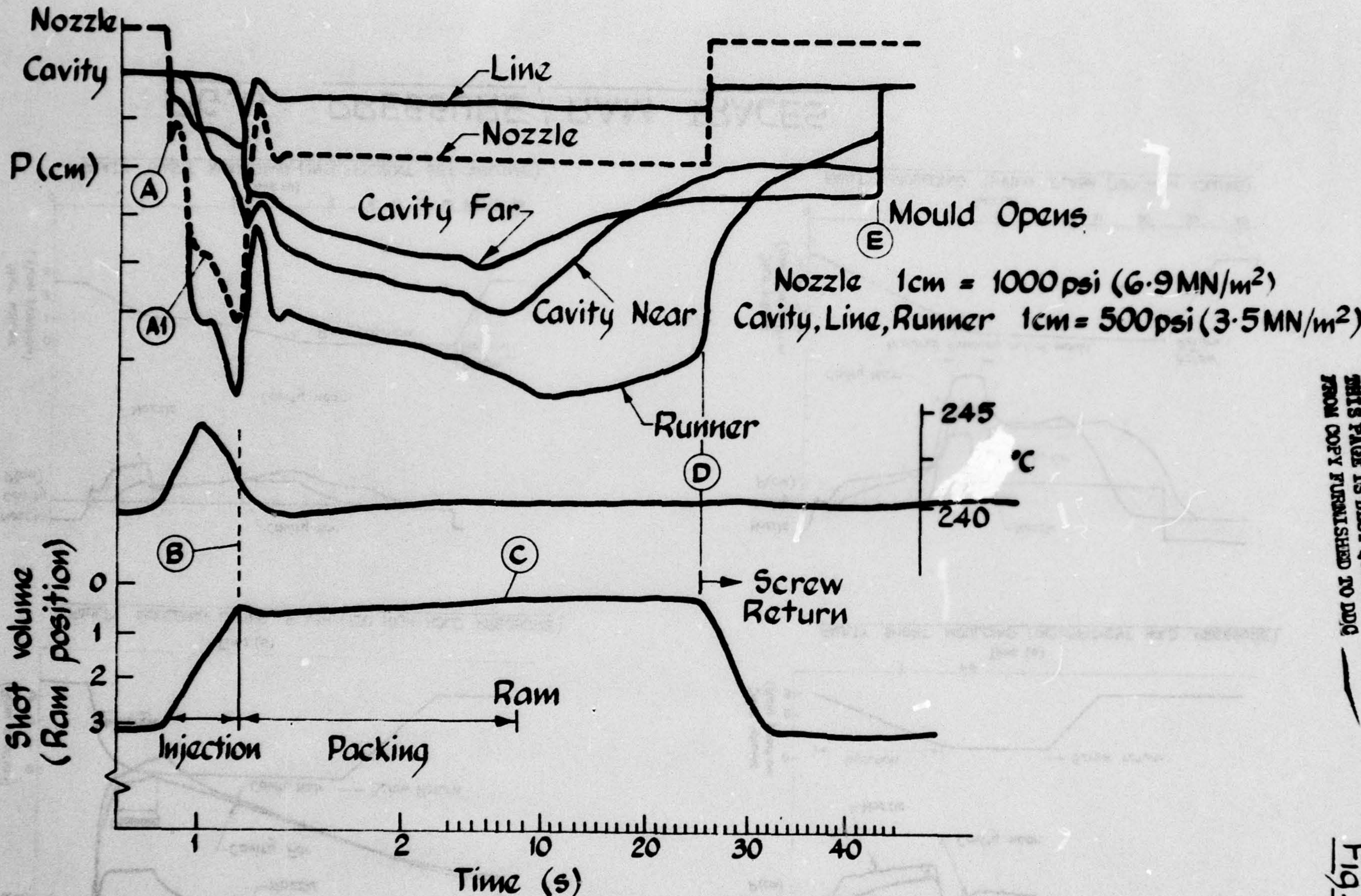



FIG. 5 TYPICAL PRESSURE TRACE

FAST INJECTION, SMALL GATE SHORT GLASS POLYSTYRENE

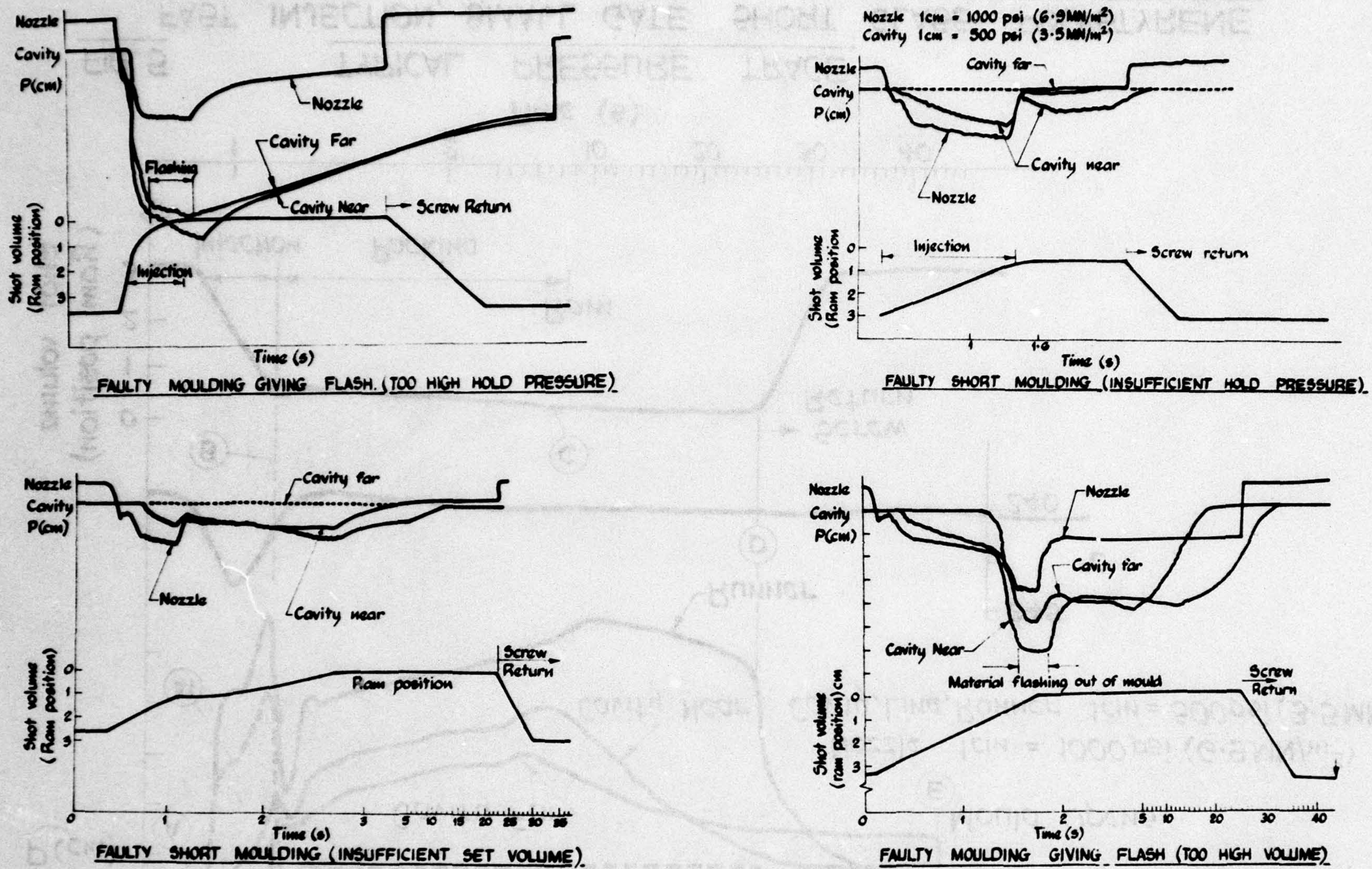



FIG. 6 PRESSURE / RAM TRACES

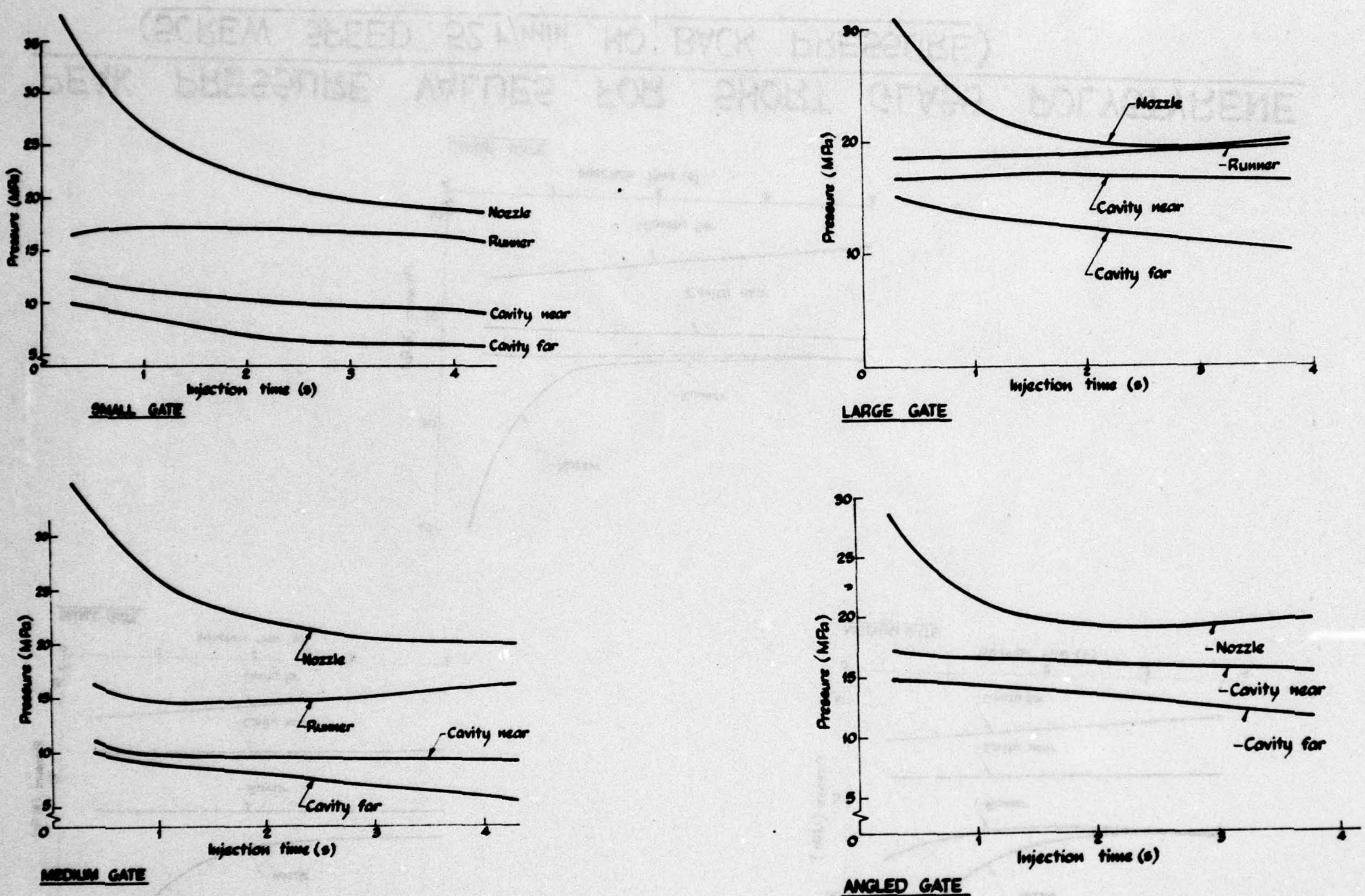



FIG.7 PEAK PRESSURE VALUES FOR LONG GLASS POLYSTYRENE
(SCREW SPEED 52 r/min. NO BACK PRESSURE)

TR 6
Fig.7

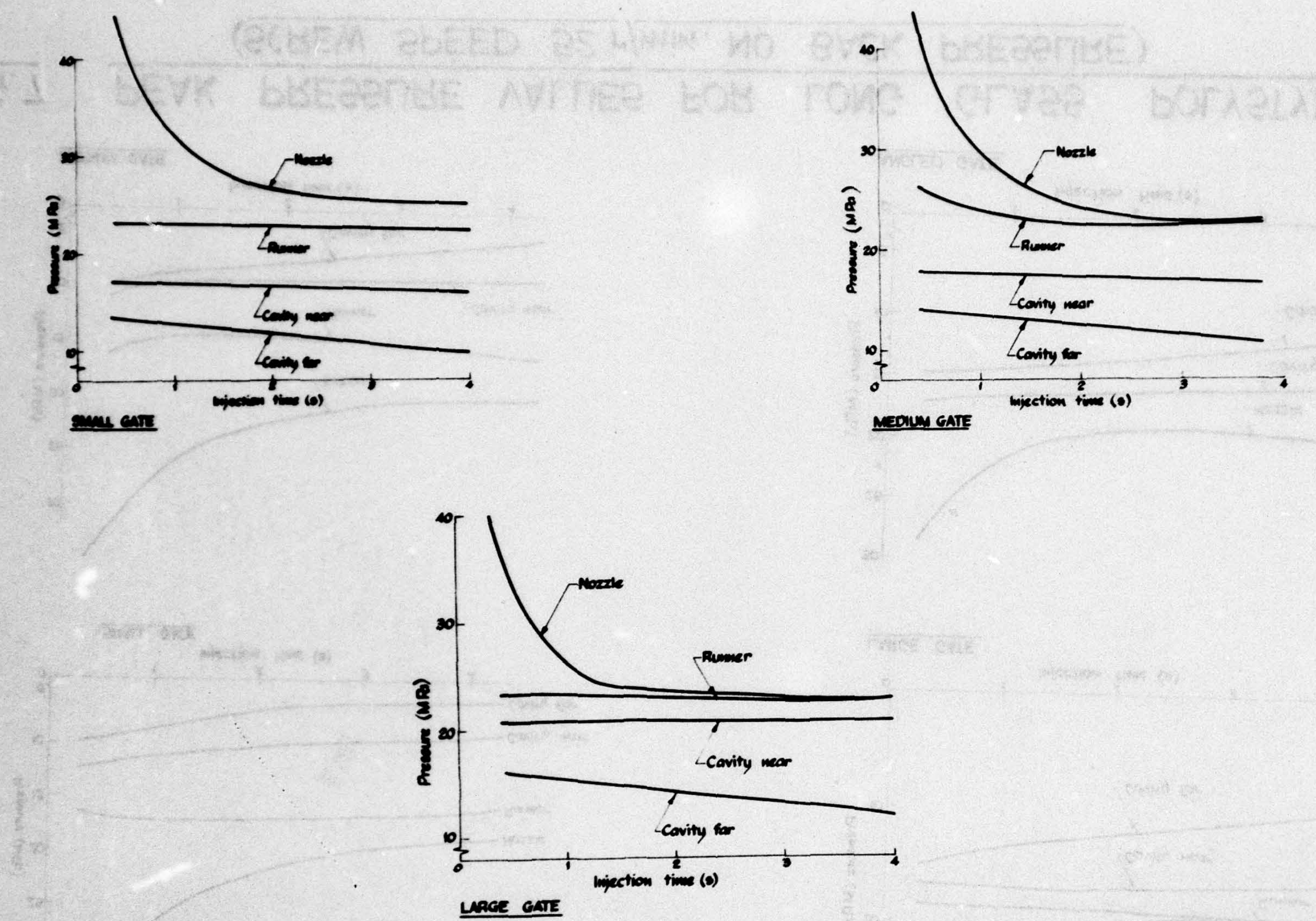
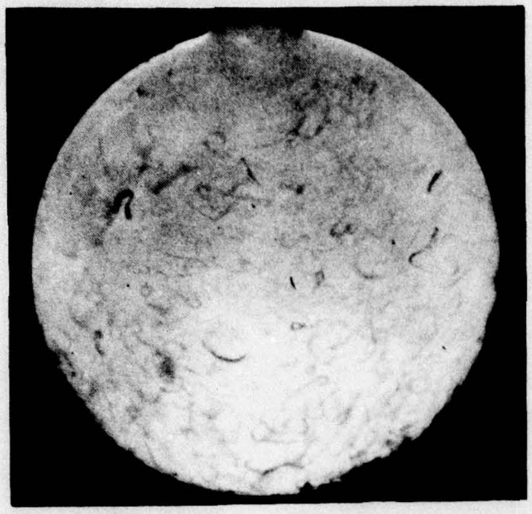
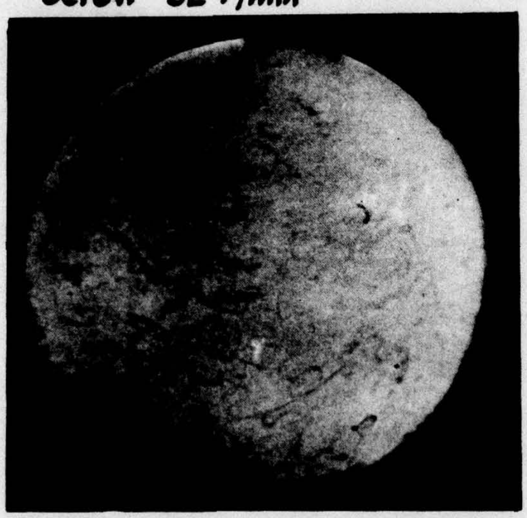



FIG.8 PEAK PRESSURE VALUES FOR SHORT GLASS POLYSTYRENE
(SCREW SPEED 52 r/min. NO BACK PRESSURE)

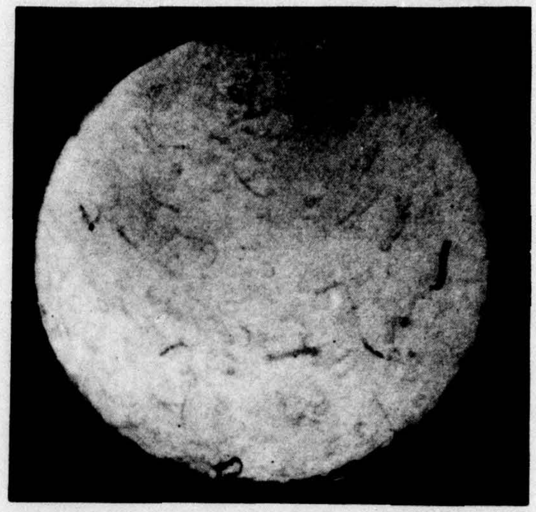


A. Large gate, medium speed. Screw 52 r/min



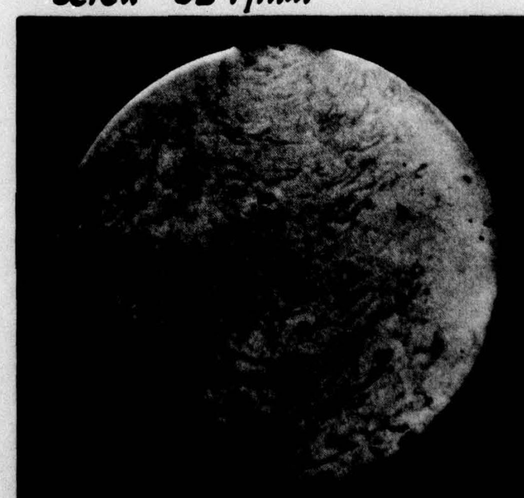
B. Large gate, medium speed. Screw 127 r/min

C. Large gate, medium speed. Screw 52 r/min, with back pressure



D. Large gate, medium speed, cold mould. Screw 52 r/min

E. Large gate, slow speed. Screw 52 r/min



F. Small gate, fast speed. Screw 52 r/min

FIG. 9 FIBRE DISTRIBUTION OF MOULDED PLAQUES

REPORT DOCUMENTATION PAGE

(Notes on completion overleaf)

Overall security classification of sheet ..........................................................................

(As far as possible this sheet should contain only unclassified information. If is is necessary to enter classified information, the box concerned must be marked to indicate the classification eg (R),(C) or (S)).

| 1. DRIC Reference (if known) | 2. Originator's Reference | 3. Agency Reference | 4. Report Security Classification |
|---|---|---|---|
| | PERME TR 6 | | UNLIMITED |

| 5. Originator's Code (if known) | 6. Originator (Corporate Author) Name and Location |
|---|---|
| 7281400E | Propellant, Explosives and Rocket Motor Establishment<br>Waltham Abbey<br>Essex EN9 1BP |
| 5a. Sponsoring Agency's Code (if known) | 6a. Sponsoring Agency (Contract Authority) Name and Location |
| | |

7. Title GLASS FILLED POLYSTYRENES - PROCESSING VERSUS PROPERTIES

7a. Title in Foreign Language (in the case of translations)

7b. Presented at (for conference papers). Title, place and date of conference

| 8. Author 1. Surname, initials | 9a Author 2 | 9b Authors 3, 4... | 10. Date | pp | ref |
|---|---|---|---|---|---|
| Richards R W | Sims D | | 5.1978 | 28 | 10 |

| 11. Contract Number | 12. Period | 13. Project | 14. Other References |
|---|---|---|---|
| | | | |

15. Distribution statement

Descriptors (or keywords)

Polystyrene, Filled molding materials, Glass, Injection molding

(TEST)


Abstract The effects of injection moulding on two types of glass filled polystyrene have been considered using an instrumented moulding machine. Certain machine parameters have been shown to be important in determining the properties of specimens cut from long glass polystyrene moulded discs but rather less important with short glass polystyrene. The importance of avoiding cut edges on moulded samples has been confirmed. No obvious correlations have been found between moulding pressures and mechanical properties but a relationship exists between cavity pressure and moulding weight and size.