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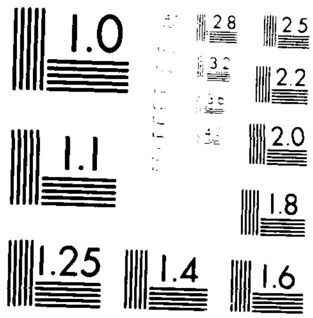


MICROCOPY RESOLUTION TEST CHART

AUSTRALIA

# DEPARTMENT OF DEFENCE

## DEFENCE SCIENCE AND TECHNOLOGY ORGANISATION

## MATERIALS RESEARCH LABORATORIES

MELBOURNE, VICTORIA

## REPORT

## MRL-R-805

# THE USE OF RECRYSTALLISED RDX IN CAST RDX/TNT COMPOSITIONS

William S. Wilson

Approved for Public Release







MARCH, 1981

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ABSTRACT

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The RDX/TNT/Beeswax compositions derived from recrystallised RDX are less sensitive to shock initiation than are those derived from milled and boiled RDX, but there are indications that they may be more sensitive to impact.

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POSTAL ADDRESS: Chief Superintendent, Materials Research Laboratories
P.O. Box 50, Ascot Vale, Victoria 3032, Australia

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The particle size of RDX recrystallised from cyclohexanone (Grade A Class 1) is much larger than that of milled and boiled RDX (Grade B Class 1), and as a consequence the recrystallised RDX is subject to a larger sedimentation during casting of RDX/TNT/Beeswax compositions. However this sedimentation occurs largely from the top of the casting, which is normally discarded, and the density and RDX distributions of pressure castings produced in the MRL experimental moulds using either recrystallised or milled and boiled RDX appear to be satisfactory.

The RDX/TNT/Beeswax compositions derived from recrystallised RDX are less sensitive to shock initiation than are those derived from milled and boiled RDX, but there are indications that they may be more sensitive to impact.

# C O N T E N T S

# THE USE OF RECRYSTALLISED RDX IN CAST RDX/TNT COMPOSITIONS

## 1. INTRODUCTION

Until recently the Australian manufacturing process for RDX has included as the penultimate stage a milling and boiling step designed to break down crystalline aggregates and to remove traces of residual acid. This grade of RDX is designated RDX Grade B Class 1. In the mid 1960's Munitions Filling Factory St Mary's experienced difficulties loading into shells Composition B (RDX/TNT 60/40 with 1% added Beeswax) prepared from this milled and boiled RDX, due to high and sometimes variable viscosity of the molten slurry [1-4]. It was found that the viscosity of this material increased with stirring, that the rate of viscosity increase was dependent on the rate of stirring, and that the viscosity increase could be partially reversed by very rapid stirring. On the other hand Composition B prepared from the coarser-grained UK Bridgwater RDX (recrystallised from cyclohexanone) showed a very much smaller increase in viscosity with stirring, and it was demonstrated that the undesirable high viscosities were associated with the presence of excessive quantities of "fines" in the RDX. It was concluded that in practice there was little MFF could do to reduce the viscosity of unpourable RDX/TNT, and that the only satisfactory method of ensuring that an RDX/TNT lot was acceptable was to control carefully the RDX particle size distribution. The only reliable method was to use recrystallised RDX. In the meantime pourable RDX/TNT compositions were obtained by reducing the content of milled and boiled RDX to 55%.

In the light of these recommendations AEF introduced a recrystallisation from cyclohexanone as the final step in the manufacture of RDX, and the material so produced was designated RDX Grade A Class 1. In 1977-78 Materials Research Laboratories commenced using RDX/TNT/Beeswax prepared from this recrystallised RDX in its experimental casting and machining programmes. Preliminary examination showed that the composition 60/40/1 had a low efflux viscosity of 8.2 s, and that this viscosity changed very little with stirring [5]. (This early batch of recrystallised RDX was subsequently shown to have a particle size somewhat lower than the norm, and a more representative efflux viscosity is 6.2 s [6].) However Stokes' Law indicates that an increase in particle size is accompanied by an increase in the rate of sedimentation, and during routine casting experiments with this composition it was noticed that a degree of segregation or sedimentation of the RDX did occur to leave a "collar" of TNT at the top of the header, an occurence which could have far-reaching implications. These observations were confirmed by similar sedimentation in experimental 105 mm shell and 81 mm mortars filled at MFF St Marys with RDX/TNT prepared from recrystallised RDX. Further misgivings were felt when it was found at MRL that experimental charges of Composition B based on recrystallised RDX could not be initiated reliably by a standard exploding bridgewire (EBW) detonator, *viz* the Scale I Gap Test Donor. A programme of work was therefore initiated to evaluate the extent of sedimentation of recrystallised RDX in RDX/TNT compositions, to evaluate changes in safety and reliability of these compositions due either to this sedimentation or to the intrinsic differences in the RDX used, and to eliminate or alleviate this sedimentation should that be deemed necessary.

## 2. RDX PARTICLE SIZE DISTRIBUTION

RDX Grade B Class 1 (milled and boiled) was, and RDX Grade A Class 1 (recrystallised from cyclohexanone) is, produced at Albion Explosives Factory by the Woolwich process (direct nitration of hexamine) and both conform to the Australian Defence Standard DEF (AUST) 5382. The characteristics which show differences between the two grades of explosive are listed in Table 1 below.

For reasons of safety RDX is normally stored in Australia as a slurry in water (ca 40% w/w). At MRL this water is removed prior to use by filtration followed by drying to constant weight at 70°C, and the dry RDX is packaged in 1 kg lots. Duplicate 25 g samples of dried recrystallised RDX were taken from five such packages using the coning and quartering technique. Each sample was slurried in water containing a little detergent and subjected to wet sieve analysis. The slurry was poured into the coarsest sieve, which was immersed in water until the solid was just covered and the wet RDX was passed through the sieve by gentle agitation by hand for ten minutes. The material retained on the sieve was transferred to a weighed Gooch crucible and dried to constant weight at 65°C. The RDX passing through the sieve was transferred to the next sieve, and the process was repeated. Sieving losses were found to be in the range 1-2%. Results of the ten sieve analyses are shown in Table 2, together with an average particle size distribution for recrystallised RDX. To aid visual assimilation, these data are shown in histogram form in Figure 1, together with data obtained by Eadie and Milne for the milled and boiled RDX [1].

## TABLE 1

### EXTRACT FROM RDX SPECIFICATION DEF (AUST) 5382

| No | Characteristic | Grade A Class 1 | Grade B Class 1 |
|---|---|---|---|
| 4 | Acidity | | |
| | (a) Total acidity as $HNO_3$, % | 0.015 max | 0.05 max |
| | (b) Occluded acidity as $HNO_3$, % | 0.01 max | 0.035 max |
| 8 | Cyclohexanone, % | 0.2 max | - |
| 11 | Particle Size Distribution | | |
| | Retained on 850 µm AS Sieve, % | Nil | Nil |
| | Retained on 500 µm AS Sieve, % | 2.0 max | 2.0 max |
| | Retained on 300 µm AS Sieve, % | 25 max | 25 max |
| | Total passing 75 µm AS Sieve, % | 12 max | 60 max |

Data from sieve analyses may be treated statistically in a number of ways to generate values descriptive of the particle size distribution.

A *weight average* is given by

$$\bar{\mu}_w = \Sigma w_i \bar{\mu}_i / \Sigma w_i$$

where $w_i$ is the weight of a sieve cut and $\bar{\mu}_i$ is the average particle diameter of that cut, while a *number average* is given by

$$\bar{\mu}_n = \Sigma n_i \bar{\mu}_i / \Sigma n_i$$

where

$$n_i = w_i / \frac{4}{3} \pi \rho (\frac{\bar{\mu}_i}{2})^3$$

### T A B L E 2

**PARTICLE SIZE DISTRIBUTION OF RDX GRADE A CLASS 1**

| RDX SAMPLE | <75 μm | 75–100 μm | 100–212 μm | 212–300 μm | 300–425 μm | 425–500 μm |
|---|---|---|---|---|---|---|
| 1A | 2.40 | 4.88 | 33.24 | 49.01 | 7.18 | 3.29 |
| 1B | 0.59 | 4.07 | 32.26 | 54.62 | 7.61 | 0.85 |
| 2A | 0.97 | 1.58 | 32.13 | 56.32 | 8.46 | 0.54 |
| 2B | 0.90 | [illegible] | 28.57 | 60.08 | [illegible] | 3.29 |
| 3A | 1.27 | 3.41 | 31.42 | 55.07 | [illegible] | [illegible] |
| 3B | 1.62 | 3.44 | 30.55 | 56.74 | 7.48 | [illegible] |
| 4A | 0.96 | [illegible] | 28.29 | 57.72 | [illegible] | [illegible] |
| 4B | 1.36 | 3.11 | 30.49 | 54.68 | 9.97 | 0.39 |
| 5A | 1.07 | 2.95 | 30.45 | 55.71 | 9.11 | [illegible] |
| 5B | 1.49 | [illegible] | 33.34 | 54.11 | 6.66 | [illegible] |
| AVERAGE | 1.26 | [illegible] | 31.07 | [illegible] | [illegible] | [illegible] |

In this treatment more importance is placed on the finer particles. Alternatively the *median* size of the sample, the mid-point in the distribution where half the weight of RDX is larger and half is smaller, can be interpolated from a plot of cumulative weight percent undersize (or oversize). These values were determined for the recrystallised RDX, and are presented in Table 3 together with the corresponding values obtained for milled and boiled RDX [1].

TABLE 3

VALUES FOR RDX PARTICLE SIZE DISTRIBUTIONS

| | Grade A Class 1 (Recrystallised) | Grade B Class 1 (Milled and Boiled) |
|---|---|---|
| Weight Average | 227 μm | 95 μm |
| Number Average | 89 μm | 45 μm |
| Median | 236 μm | 75 μm |

It is interesting to note, however, that the two grades of RDX both have bulk powder densities of about 1.18 $Mg/m^3$ (experimental values of 1.184 and 1.177 $Mg/m^3$ were obtained by the recrystallised and milled and boiled materials respectively).

Photomicrographs of the two grades of RDX using oil as dispersant are shown in Figure 2. The recrystallised RDX is seen as discrete, well-formed particles, while the milled and boiled RDX contains a large number of much smaller crystals which tend to be present as large aggregates. RDX has the same refractive index as bromoform, and photomicrographs were also prepared using that liquid as dispersant in an attempt to examine internal discontinuties in the RDX. However as Figure 3 shows, these efforts were unrewarded, as no conclusive evidence was obtained.

It has already been noted that the greater sedimentation of the larger recrystallised RDX in molten TNT follows from Stokes's Law

$$V = \frac{2g\,(\rho_2 - \rho_1).r^2}{9\eta}$$

which relates the rate of sedimentation (V) to the density of the solid and liquid phases ($\rho_2$ and $\rho_1$), the radius of the solid particles (r) and the viscosity of the liquid ($\eta$). The rate of sedimentation of a dilute suspension of a solid through a liquid can also be used to measure particle size, and one instrument used for this purpose is the Shimadzu Sedimentograph Type SA-2.

This apparatus consists of a balance beam, from one arm of which hangs a pan in a beaker containing the powder under test suspended in an appropriate liquid. The recommended concentration is 4-20 g in 400 ml. The weight of powder falling on the pan trips an electrical contact, which in turn releases a bearing ball counterweight from a ratchet wheel reservoir to fall at the other end of the beam and break the electrical contact. The ratchet wheel is connected to the pen of a drum chart recorder, whose speed is regulated by a set of gear wheels. A typical chart record is given in Figure 4.

The Shimadzu Sedimentograph SA-2 was used to estimate the particle size distribution of both recrystallised (Grade A Class 1) and milled and boiled (Grade B Class 1) RDX samples. The suspension medium was ethane-diol (ethylene glycol, specific gravity 1.11 $Mg/m^3$ and coefficient of viscosity 0.199 poise). The rates of sedimentation are illustrated in Figure 5, and the cumulative undersize/particle diameter profiles derived from them are shown in Figure 6. The curves for the milled and boiled RDX were independent of the concentration of the suspension, and the particle size distribution was indistinguishable from that obtained by sieve analysis. However the sedimentation/time curve for recrystallised RDX did vary with the concentration of the suspension, and the particle size distributions obtained were not identical with that obtained from sieve analysis, although they fell in the same general region. The significance of this variation with concentration is not entirely clear, but it is probable that the particle size of recrystallised RDX is close to the upper limit practical by this technique. However molten TNT at 85°C has a specific gravity of 1.45 $Mg/m^3$ and a coefficient of viscosity of 0.120 poise [7] so that the curves in Figure 5 should give a fair pictorial representation of the sedimentation of dilute suspensions of the two RDX grades in TNT at 85°C.

## 3. DENSITY AND RDX-CONTENT OF EXPERIMENTAL RDX/TNT CASTINGS

At MRL a pressure casting facility is normally used to prepare the good quality high density, crack-free experimental TNT based charges required for subsequent machining [8]. Two mild steel pressure moulds are available of diameters $2\frac{1}{2}$ and $3\frac{1}{2}$ inches (64 and 89 mm), requiring about 2.6 and 4.2 Kg of explosive respectively. The $2\frac{1}{2}$ inch pressure mould is shown in Figure 7. The explosive composition is melted in a jacketted kettle and held at 85°C with constant stirring. The pressure mould is assembled and water at 85°C is circulated through both jackets for 15 minutes to allow the mould temperature to reach equilibrium. The pressure mould is then filled with molten explosive to within $\frac{1}{2}$ inch (about 1 cm) of the top. The filling is stirred gently with a wooden rod to remove air bubbles adhering to the sides, and the mould is closed. Air pressure (50 psi, 340 kPa) is applied, and the temperature of the water circulating in the bottom jacket is reduced to 55°C while keeping that circulating in the top jacket at 85°C. These conditions are maintained for one hour, after which the water circulation to both jackets is stopped and the mould is allowed to cool overnight under the 50 psi (340 kPa) air pressure.

The portion maintained at 85°C in the top half of the mould (the header) is normally discarded, but in this investigation it was examined along with the lower half.

Pressure cast charges, both 2 1/2 and 3 1/2 inches (64 and 89 mm), were prepared in this manner from the RDX/TNT/Beeswax compositions 60/40/1 and 55/45/1 using both the recrystallised RDX and the milled and boiled material. These castings were then cut and faced to 5/8 inch (16 mm) thick discs, from which were machined prisms 5/8 x 3/8 x 3/8 inch (16 x 9 x 9 mm) for determination of density and RDX distributions. The disposition of the discs and prisms is illustrated in Figure 8. The densities of the prisms were measured by water displacement after first solvent-coating with a film of paraffin wax, while RDX-content was determined gravimetrically after solvent extraction of the TNT and wax with toluene. In general the porosity and fragility of the header tops made machining of these portions impossible, and the RDX-content of fingers or even whole discs was measured. The porosity and irregularity of these segments prevented density measurements being carried out. Density and RDX distributions of typical castings are given in the Appendix. It should be noted that duplicate and triplicate castings were prepared, machined and analysed for most compositions, and that consistent results were obtained.

It was apparent that two separate processes occur during casting of RDX/TNT compositions, namely sedimentation of the particulate RDX and a 10% contraction of the TNT matrix on solidification. When the finer milled and boiled RDX was used the rate of sedimentation was low and the TNT tended to drain away from the top of the header to leave a porous conical region which was deficient in TNT and rich in RDX. When the coarser recrystallised RDX was used the rate of sedimentation was much higher, and there remained a "collar" of TNT around the top of the header (30 mm for the composition 60/40/1 and 50 mm for the 55/45/1) from which the RDX had settled. Immediately below this collar a small porous conical region could be observed in the centre of the header which was slightly deficient in TNT and rich in RDX. The 55/45/1 composition prepared from milled and boiled RDX showed a narrow collar free from RDX (*ca* 8 mm), but the 60/40/1 composition showed no such visible collar, although the top of the header was slightly low in RDX.

The remainder of the recrystallised RDX/TNT/Beeswax 60/40/1 castings contained 58-66% RDX, the interior being in the range 62-66% RDX. The 55/45/1 castings contained 54-64% RDX, the major portion being 58-62%. The milled and boiled RDX/TNT/Beeswax 60/40/1 castings contained 58-63% RDX the bulk being 60-63%, while the 55/45/1 compositions contained 53-59%, the major portion being 55-59%. The densities of the compositions containing recrystallised RDX were largely in the range 1.69-1.71 $Mg/m^3$ and those containing milled and boiled RDX 1.68-1.70 $Mg/m^3$, with the exception of the conical regions from which the TNT had drained during solidification, which had a somewhat lower density. Thus, although the recrystallised RDX is subject to greater sedimentation and the charges do tend to have a slightly wider (and higher) range of RDX content than those prepared from the milled and boiled material, the adverse effects in MRL experimental pressure castings are by no means as drastic as was originally feared. It is pertinent to note that Popolato expects composition spreads of 2-4% RDX and density spreads of the order of

0.01 $Mg/m^3$ [7]. On the other hand Humphris and Thomson found RDX concentrations in the range *ca* 45-63% and densities of 1.63-1.68 $Mg/m^3$ in 105 mm shell filled at MFF St Marys with RDX/TNT/Beeswax 55/45/1 prepared from milled and boiled RDX [9]. Clearly the MRL experimental pressure castings prepared to either composition and with either grade of RDX are of significantly better quality.

It would appear then, that although the increased rate of sedimentation of the recrystallised RDX alters the processes which take place during casting of RDX/TNT/Beeswax compositions, the quality of the fillings so produced is not significatly inferior to that of fillings based on milled and boiled RDX. This is particularly true if one can disregard the top of the header, which is normally discarded from either experimental castings or production shell fillings. It was intended to examine RDX sedimentation and its effects in shell filled with recrystallised RDX/TNT/Beeswax in a normal production run. However although production of milled and boiled RDX/TNT/Beeswax has ceased the new material is not yet in use at MFF St Marys, and it is felt that this examintion would be best delayed until that time.

Some consideration has been given to possible remedial action, should the extent of sedimentation observed be deemed unacceptable. Limiting the extent of sedimentation could be achieved by limiting the *time* of sedimentation or by controlling its *rate*. The *time* of sedimentation could be reduced by reduction of the casting temperature or by increasing the cooling rate (provided, of course, that the quality of the filling - integrity, resistance to cracking, etc - is not degraded). However no change in the extent of sedimentation could be detected in a limited series of experiments in which the casting temperature (and the upper jacket temperature) was varied between 82 and 87°C, and the lower jacket temperature between 50 and 55°C. It may be pertinent to note, as shown in Figure 9, that the efflux viscosity of recrystallised RDX/TNT 60/40 varies little over the temperature range 85-95°C [6]. The *rate* of sedimentation might be controlled either by reduction of the RDX particle size or by increasing the viscosity of the RDX/TNT/Beeswax slurry. This must be achieved without re-introducing the unacceptable increase of viscosity with stirring, presumably ruling out reduction in the RDX particle size. However it has been shown that an increase in the concentration of RDX can effect a significant increase in the efflux viscosity of recrystallised RDX/TNT compositions, and that the viscosity does *not* increase further with prolonged stirring [6]. These results are illustrated in Figure 10. Such an increase in the RDX concentration would also confer a marginal improvement in the explosive performance of the composition, which may be an additional benefit. Another possible solution is the incorporation of an additive such as nitrocellulose (NC) [10] or cellulose acetyl butyrate (CAB) [11]. It has been shown that quite small quantities of these additives can increase the viscosity of RDX/TNT, without causing the unwanted side effects (see for example Figure 11 [6]).

## 4. EXPLOSIVE SENSITIVITY OF EXPERIMENTAL RDX/TNT CHARGES

The safety of an explosive filling during handling and operation and its reliable functioning on arrival at the target are, of course, of paramount importance. It is now generally accepted that the presence of cracks and other imperfections in the explosive contributes significantly to the incidence of gun-prematures in shell filled with TNT-based compositions. Such cracks may be the result of thermal stresses produced by cooling and contraction of the casting, physical stresses due to rough handling, or the setback forces imposed on the shell by the gun. The physical strength of the explosive compositions must therefore be considered. From a survey of work carried out at MRL [6], it was established that pressure cast RDX/TNT/Beeswax 60/40/1 prepared from recrystallised RDX has an ultimate compressive strength of only 11.[illegible] MPa, compared with a value of 20.7 MPa for pressure cast RDX/TNT/Beeswax 55/45/1 based on the milled and boiled RDX. This reduction in strength of an already weak and brittle composite could be critical, particularly if it is accompanied by an increase in the sensitivity of the explosive. The mechanical strength of the recrystallised RDX/TNT/Beeswax compositions will therefore be the subject of further examination.

The Rotter Impact Test is used to assess the sensitivity of a specific sample of explosive powder to initiation by impact. It has been shown that the shape and size of the granules can have a profound effect on the impact sensitivity of an explosive, and the Rotter Impact Test is therefore an inappropriate test for a cast composition. However it may be pertinent to note that RDX/polyethylene wax compositions based on the recrystallised RDX are consistently more sensitive than those containing milled and boiled RDX [12]. This is the reverse of the result anticipated simply on the basis of the particle size of the RDX, and has been attributed to the presence of occluded cyclohexanone remaining from the recrystallisation process.

There is no convenient test at MRL to assess the sensitivity of explosive charges to impact or setback. An Australian version of the Picatinny Arsenal "Setback Simulator" has been used in the past [13], but suffered from cost, a difficult and tedious process to set up the equipment before each firing, problems of experimental reproducibility due to venting of reaction products, and frequent extrusion of explosive from the test assembly. These shortcomings appear to have been overcome in the RARDE Vertical Activator [14]. In this apparatus the test assembly of the Setback Simulator was retained, but turned vertically so that the moveable punch could be driven by the impact of a falling weight rather than by a propellant charge. Sealing of air cavities of accurately reproducible size was achieved by the inclusion of dished polyethylene discs above and below the explosive. This test is to be adopted at MRL, and it will be applied to the current problem as an early priority.

The sensitivity of an explosive to initiation by shock waves is measured at MRL using an adaptation of the Gap Test described by Cachia and Whitbread [15]. Briefly, a standard detonator (normally the Scale I Gap Test Donor, comprising an exploding bridgewire to initiate a low density PETN charge which detonates a high density PETN pellet) generates a standard shock which is attenuated by a stack of laminated 0.05 mm brass shims 25 mm square. The attenuated shock strikes the test explosive, usually a pellet about 12.5 mm in diameter and 25 mm long, resting on a mild steel witness block. The thickness of laminated brass barrier is varied according to the Bruceton Staircase procedure [16] to determine the critical gap, the thickness of brass required to prevent 50% of detonations in the test explosive.

However it has already been noted that the recrystallised RDX/TNT/Beeswax compositions could not be detonated reliably by the Scale I Gap Test Donor without any barrier, and this initiating source was therefore boosted by the inclusion of a second high density PETN pellet to give the Scale II Gap Test Donor. The shock sensitivity of the four pressure cast RDX/TNT/Beeswax compositions (recrystallised and milled and boiled RDX, both 60/40/1 and 55/45/1 compositions) relative to this initiation source were measured, and the results are given in Table 4. It is noted that the compositions formulated from recrystallised RDX are much less sensitive (i.e. have a much smaller critical barrier thickness) than those including the milled and boiled RDX. These results are fully in accord with expectations on the basis of particle size and specific surface area of the RDX component. However this reduction in sensitivity is not sufficient to cause problems with reliable initiation. It is also noted that there is a small but consistent dependence of shock sensitivity on the RDX content, with the RDX/TNT/Beeswax 60/40/1 compositions being slightly more sensitive than the corresponding 55/45/1 formulations.

TABLE 4

SENSITIVITY OF PRESSURE CAST RDX/TNT/BEESWAX COMPOSITIONS TO SHOCK INITIATION BY SCALE II GAP TEST DONOR (CRITICAL BRASS BARRIER THICKNESS, MM (STANDARD DEVIATION))

| | 55/45/1 | 60/40/1 |
|---|---|---|
| Recrystallised RDX (Grade A Class 1) | 0.423 (0.012) | 0.500 (0.019) |
| Milled and Boiled RDX (Grade B Class 1) | 0.868 (0.014) | 1.032 (0.018) |

## 5. CONCLUSIONS

The particle size of recrystallised RDX (Grade A Class 1) is much larger than that of milled and boiled RDX (Grade B Class 1), and as a consequence the recrystallised RDX is subject to a larger sedimentation during casting of RDX/TNT/Beeswax compositions. However this sedimentation occurs largely from the top of the casting, which is normally discarded, and the density and RDX distributions of pressure castings produced in the MRL experimental moulds using either recrystallised or milled and boiled RDX are better than those found in 105 mm shell filled with milled and boiled RDX/TNT/Beeswax 55/45/1 during normal production at MFF St Marys. Density and RDX distributions should also be measured for stores filled with recrystallised RDX/TNT/Beeswax, but this material has not yet been used in production. However it is no longer expected that the use of this composition will cause any difficulties in this regard.

Should the sedimentation of recrystallised RDX in stores filled with Composition B still cause problems several possible remedies present themselves. Variation of casting temperatures and cooling rates do not appear to be effective, but an increase in the RDX concentration or the inclusion of additives such as nitrocellulose or cellulose acetyl butyrate seem possible solutions.

The use of recrystallised RDX in place of the milled and boiled grade in cast RDX/TNT compositions significantly reduces their ultimate compressive strengths, and further work will be directed towards measurement of mechanical properties of these materials. There are indications that the compositions based on recrystallised RDX may be more sensitive to impact, and the Vertical Activator will be used to examine these compositions in more detail. On the other hand the RDX/TNT/Beeswax compositions derived from recrystallised RDX are less sensitive to initiation by shock waves, although not sufficiently to cause problems with reliable initiation in service stores.

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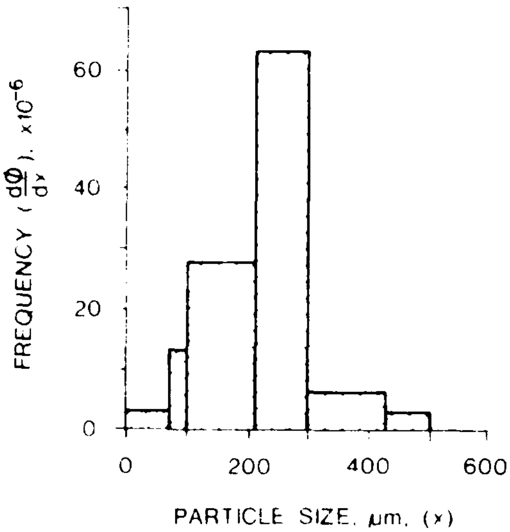
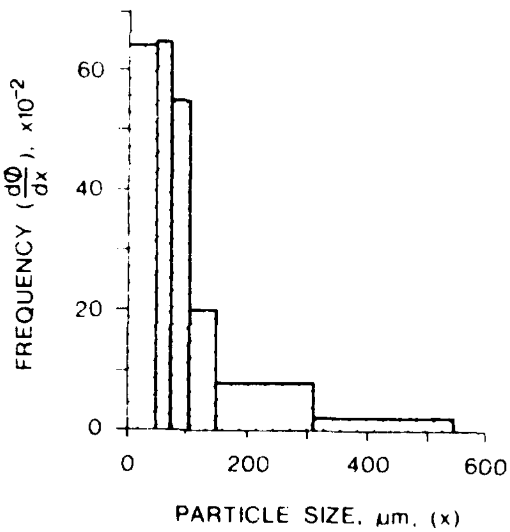
14. Hubbard, P.J., Lee, P.R. and Tisley, D.G. (1978). RARDE Technical Report 3/78.

15. Cachia, G.P. and Whitbread, E.G. (1958). *Proc. Roy. Soc.* A246, 268.

16. Dixon, W.J. and Mood, A.M. (1948). *J. Am. Stat. Ass.* 43, 109.

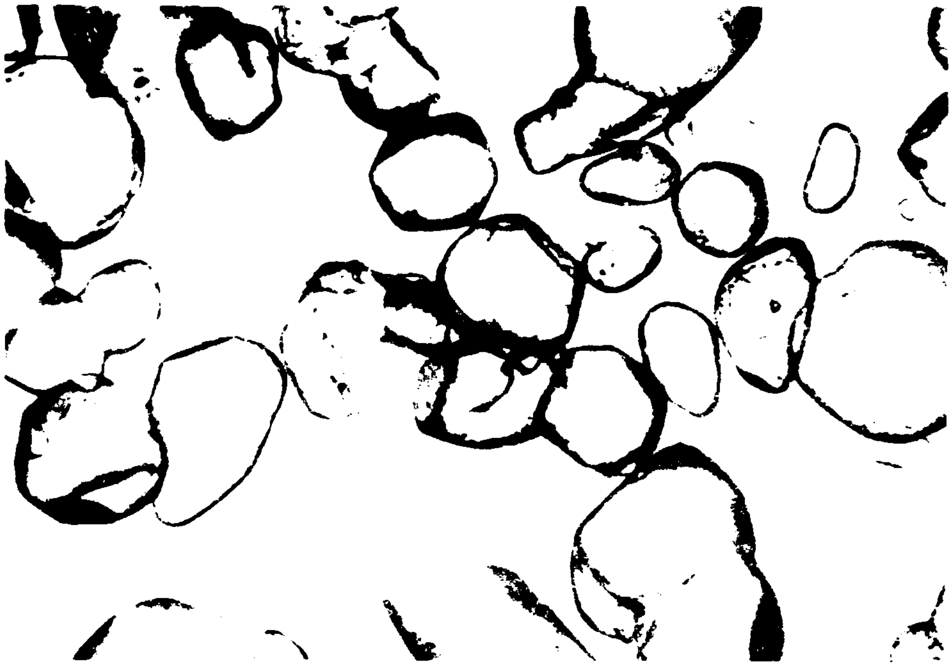



(i) RDX Grade A Class 1 (Recrystallised for Cyclohexane)

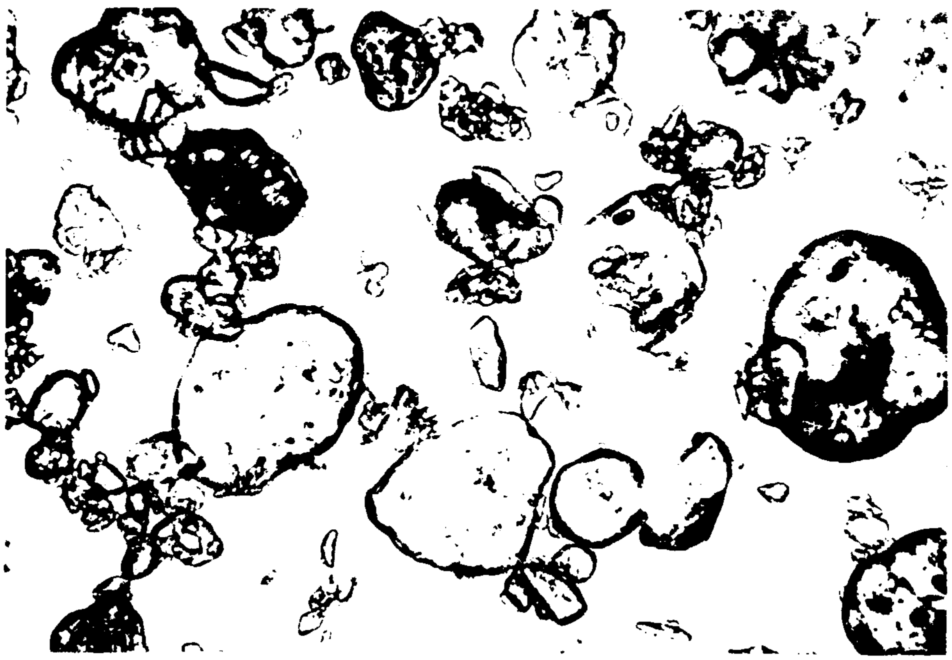



(ii) RDX Grade B Class 1 (Milled and Boiled), from Ref. 1.

FIGURE 1. RDX PARTICLE SIZE DISTRIBUTIONS



(a) RDX Grade A Class 1.



(b) RDX Grade B Class 1

FIGURE 2. PHOTOMICROGRAPHS OF RDX GRADES.

(a) RDX Grade A Class 1.

(b) RDX Grade B Class 1.

FIGURE 3. PHOTOMICROGRAPHS OF RDX GRADES DISPERSED IN BROMOFORM

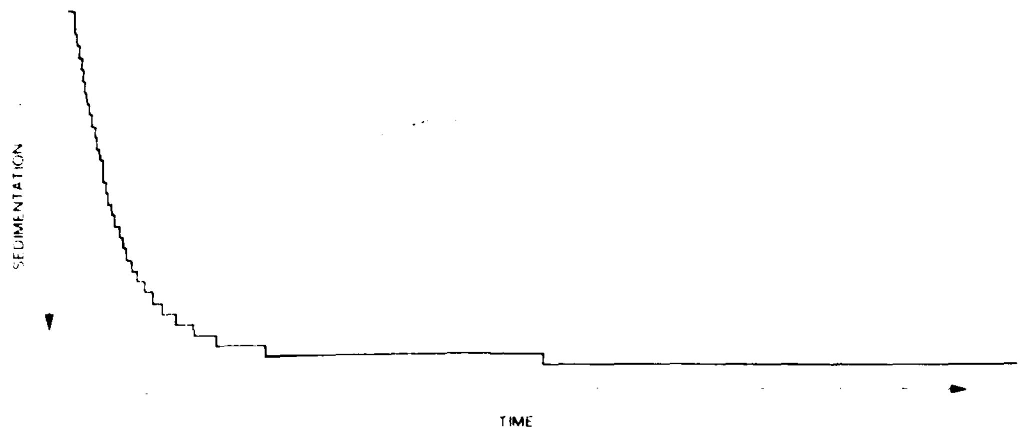



FIGURE 4. TYPICAL CHART RECORD FROM SHIMADZU SEDIMENTOGRAPH

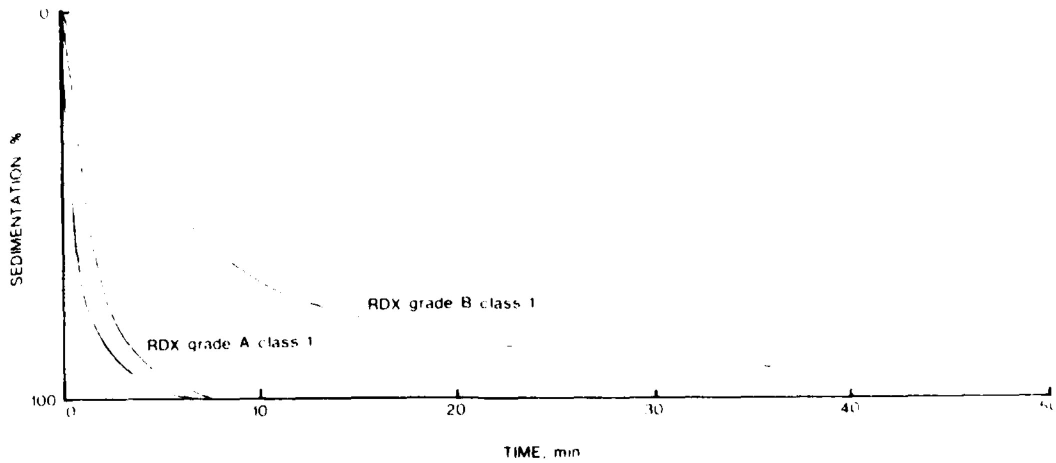



FIGURE 5. RATE OF SEDIMENTATION OF RDX SUSPENDED IN ETHANEDIOL

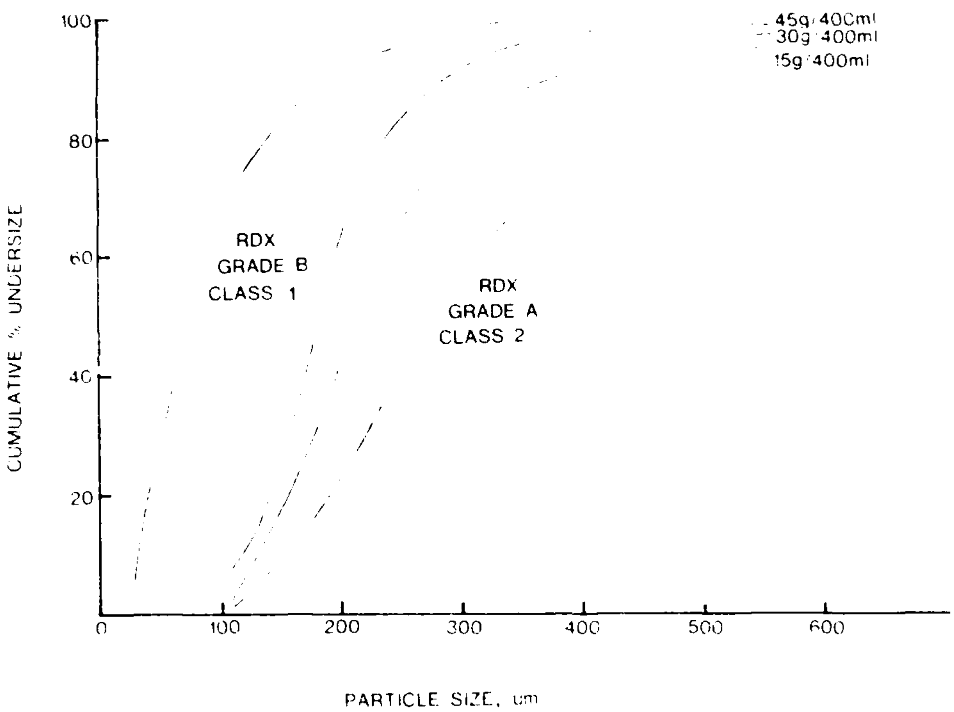



FIGURE 6. PARTICLE SIZE DISTRIBUTION OF RDX SEDIMENTOGRAPH RESULTS.

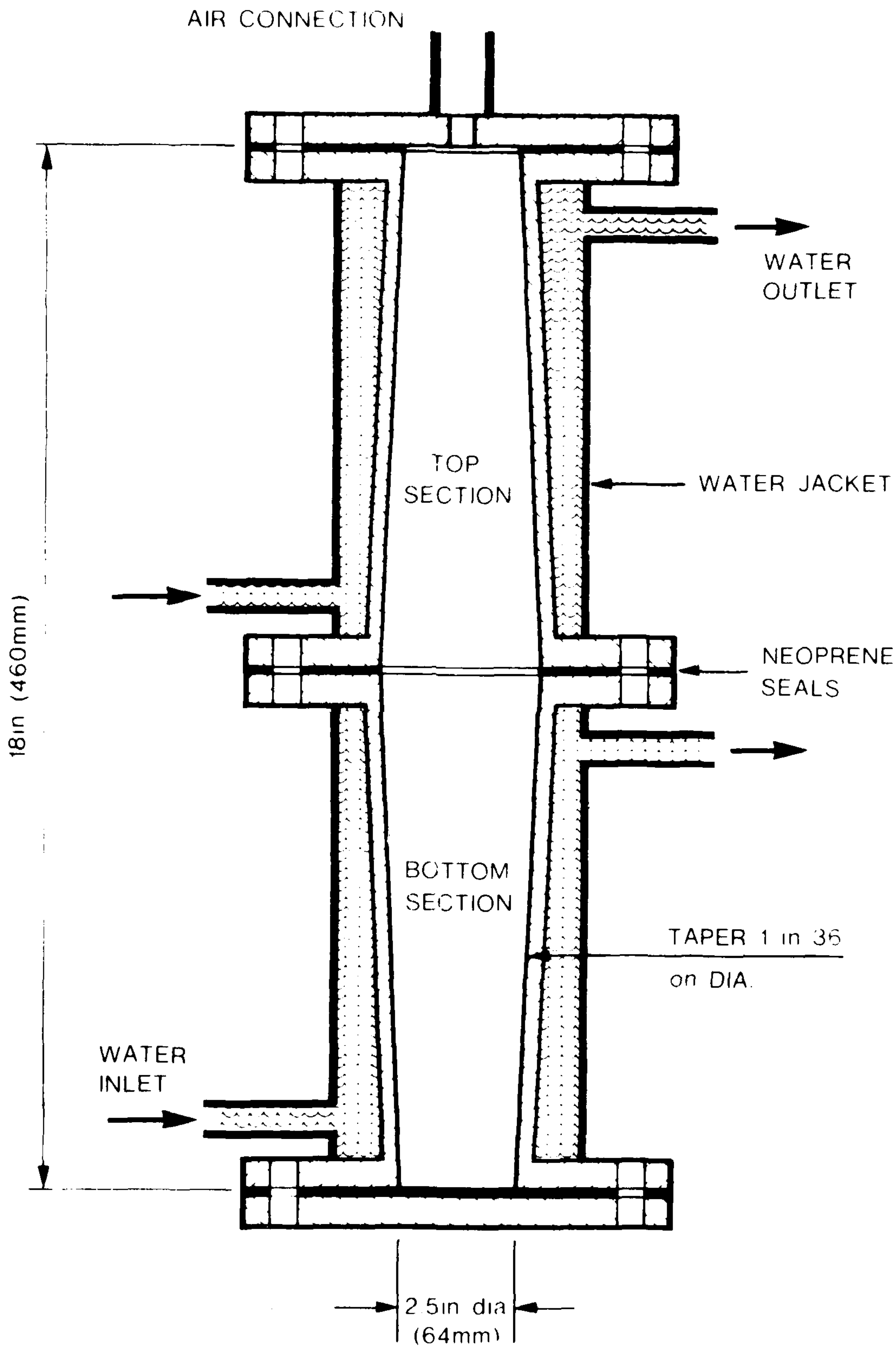



FIGURE 7. MRL 2½" PRESSURE MOULD FOR CASTING TNT-BASED EXPLOSIVES.

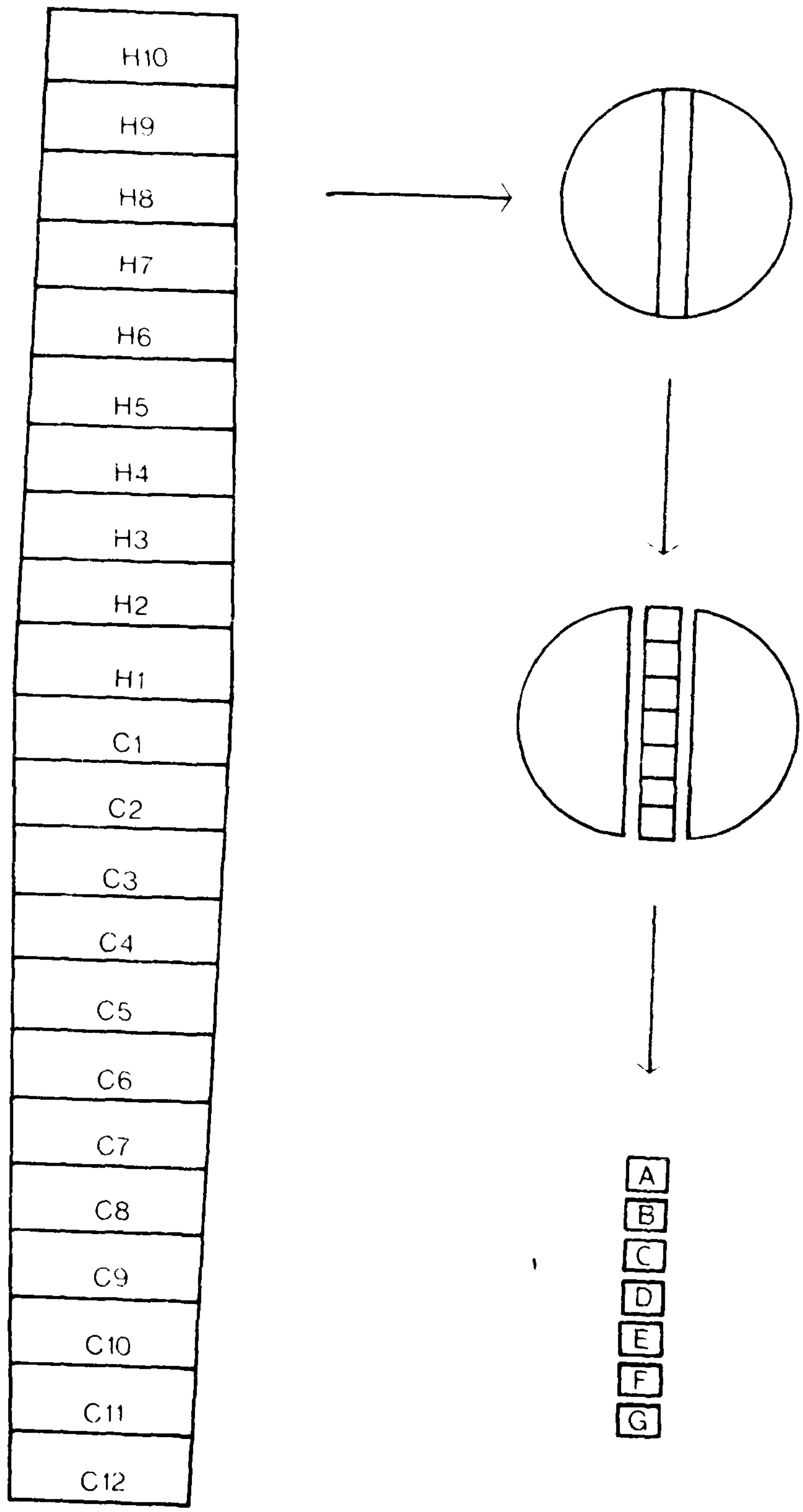



FIGURE 8. MACHINING OF SAMPLES FOR MEASUREMENT OF RDX AND DENSITY DISTRIBUTIONS.

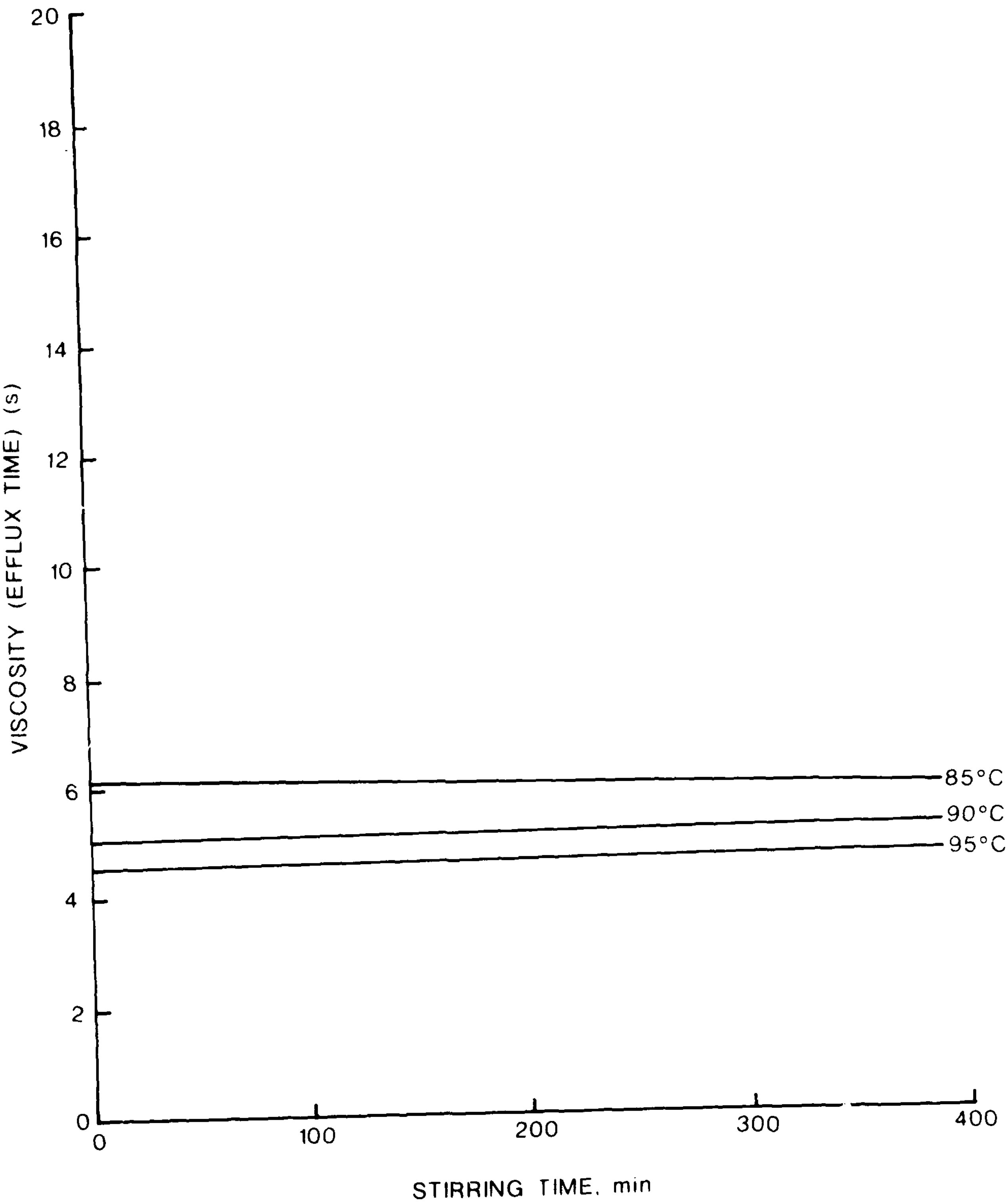



FIGURE 9. EFFECT OF TEMPERATURE ON VISCOSITY OF RDX/TNT 60/40 PREPARED FROM RECRYSTALLISED RDX.

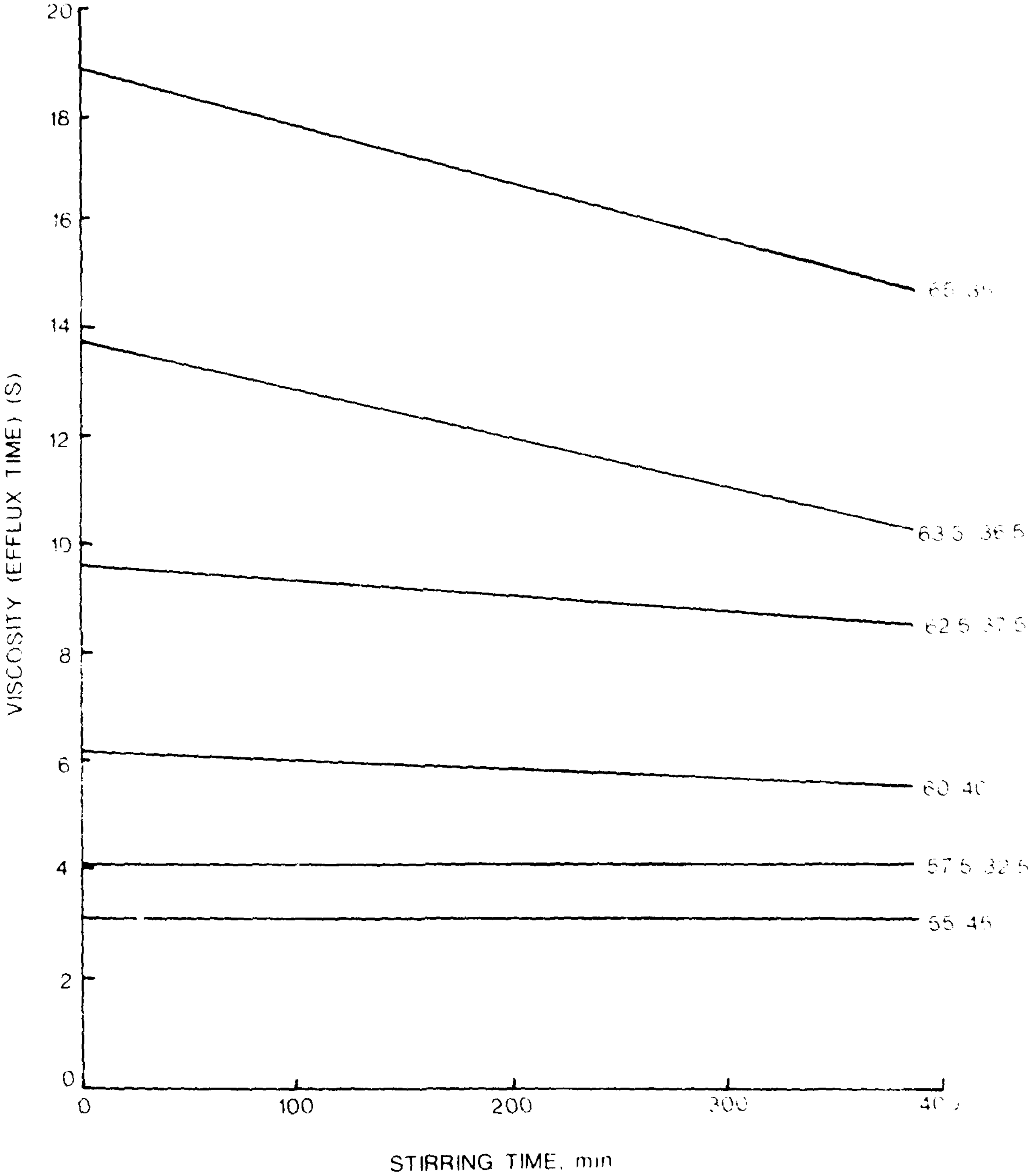



FIGURE 10. EFFECT OF COMPOSITION ON VISCOSITY OF RDX/TNT PREPARED FROM RECRYSTALLISED RDX.

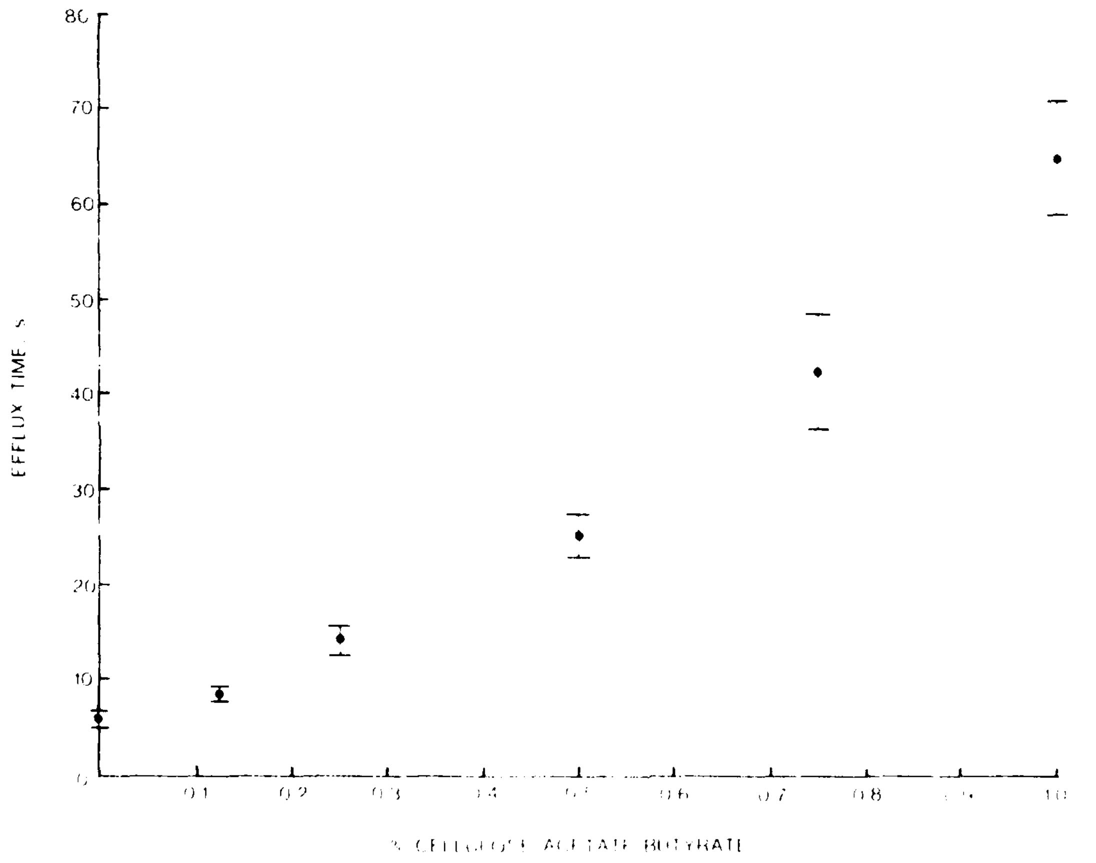



FIGURE 11. EFFECT OF CELLULOSE ACETATE BUTYLATE ON VISCOSITY OF RDX/TNT FROM RECRYSTALLISED RDX.

## APPENDIX

## DISTRIBUTION OF RDX AND DENSITY IN EXPERIMENTAL RDX/TNT/BEESWAX CASTINGS

| | | | | | | |
|---|---|---|---|---|---|---|
| ← 2.9 → | | | | | | |
| ← 2.7 → | | | | | | |
| ← 47.5 → | | | | | | |
| 62.7 | 64.2 | 65.0 | 70.6 | 65.2 | 64.5 | 6[illegible].9 |
| 63.7 | 64.6 | 65.2 | 67.8 | 65.2 | 64.4 | 63.5 |
| 64.2 | 64.9 | 65.5 | 66.3 | 65.8 | 6[illegible].2 | 64.2 |
| 64.5 | 65.1 | 65.5 | 65.6 | 65.6 | 65.3 | 64.9 |
| 65.2 | 65.4 | 65.8 | 65.8 | 66.0 | 65.6 | 65.[illegible] |
| 65.2 | 65.7 | 66.0 | 66.0 | 66.1 | 65.6 | 65.1 |
| 64.9 | 65.3 | 64.8 | 64.6 | 65.0 | 65.2 | 64.9 |
| 64.4 | 64.9 | 64.5 | 64.5 | 64.6 | 64.9 | 64.7 |
| 59.7 | 63.0 | 64.1 | 64.7 | 64.7 | 64.0 | 60.[illegible] |
| 59.6 | 62.2 | 64.1 | 64.7 | 64.3 | 63.4 | 59.5 |
| 58.8 | 62.7 | 64.6 | 65.2 | 64.6 | 63.1 | 59.5 |
| 58.6 | 62.8 | 64.7 | 65.7 | 64.8 | 63.3 | [illegible] |
| 58.6 | 62.3 | 64.7 | 65.4 | 65.0 | 63.6 | [illegible] |
| 58.8 | 63.4 | 64.7 | 65.4 | 64.6 | 63.6 | [illegible] |
| 59.3 | 63.7 | 64.8 | 65.5 | 64.6 | 63.8 | [illegible] |
| 59.6 | 63.8 | 64.9 | 65.3 | 65.0 | 64.3 | 61.[illegible] |
| 59.9 | 64.1 | 64.9 | 65.3 | 64.0 | 64.6 | 63.[illegible] |
| 62.3 | 64.4 | 64.9 | 65.1 | 65.2 | 64.7 | 63.5 |
| 63.9 | 65.0 | 65.0 | 65.1 | 65.0 | 64.9 | 64.1 |
| 64.6 | | 64.7 | 64.4 | 64.0 | 63.9 | 64.3 |

Distribution of RDX in 3 ½" diameter casting RT 979, nominal composition RDX/TNT/Beeswax 60/40/1, prepared from recrystallised RDX.

| | | | | | |
|---|---|---|---|---|---|
| ← 2.4 → | | | | | |
| ← 21.6 → | | | | | |
| 62.4 | 64.3 | 65.8 | 65.8 | 64.0 | 62.5 |
| 63.3 | 64.6 | 65.2 | 65.5 | 64.5 | 63.5 |
| 64.3 | 65.3 | 66.0 | 65.8 | 65.1 | 64.2 |
| 64.7 | 65.4 | 65.8 | 65.6 | 65.0 | 64.8 |
| 64.9 | 65.4 | 65.7 | 65.7 | 65.3 | 64.9 |
| 64.9 | 65.0 | 65.9 | 66.0 | 65.4 | 64.9 |
| 65.1 | 65.2 | 65.1 | 65.2 | [illegible] | 64.9 |
| 64.5 | 64.7 | 64.3 | 64.4 | 64.6 | 64.4 |
| 60.1 | 63.2 | 64.2 | 63.8 | 63.1 | 59.7 |
| 59.3 | 62.3 | 64.4 | 64.1 | 62.3 | 58.9 |
| 58.9 | 61.7 | 64.7 | 64.6 | 62.1 | 58.5 |
| 58.7 | 62.1 | 64.8 | 64.9 | 62.2 | 58.5 |
| 58.8 | 62.0 | 64.8 | 65.0 | 62.5 | 58.5 |
| 59.0 | 61.9 | 64.7 | 64.8 | 62.9 | 58.6 |
| 59.0 | 62.6 | 64.8 | 64.8 | 63.1 | 58.8 |
| 59.1 | 63.0 | 64.3 | 64.5 | 63.2 | 59.1 |
| 59.3 | 63.3 | 64.4 | 64.3 | 63.5 | 59.4 |
| 59.8 | 63.6 | 64.4 | 64.4 | 64.4 | 60.1 |
| 61.7 | 64.1 | 64.5 | 64.6 | 64.3 | 62.3 |
| 63.1 | 63.7 | 63.7 | 63.7 | 63.8 | 63.2 |

Distribution of RDX in 2 ½" diameter casting RT 974, nominal composition RDX/TNT/Beeswax 60/40/1, prepared from recrystallised RDX.

| | | | | | |
|---|---|---|---|---|---|
| ← NOT MEASURED → | | | | | |
| ← NOT MEASURED → | | | | | |
| 1.71 | 1.70 | 1.68 | 1.68 | 1.70 | 1.70 |
| 1.71 | 1.70 | 1.69 | 1.70 | 1.70 | 1.70 |
| 1.71 | 1.71 | 1.70 | 1.70 | 1.71 | 1.70 |
| 1.71 | 1.71 | 1.70 | 1.70 | 1.71 | 1.71 |
| 1.71 | 1.70 | 1.70 | 1.70 | 1.71 | 1.71 |
| 1.71 | 1.70 | 1.70 | 1.70 | 1.71 | 1.71 |
| 1.70 | 1.70 | 1.70 | 1.70 | 1.71 | 1.71 |
| 1.70 | 1.70 | 1.70 | 1.70 | 1.70 | 1.71 |
| 1.70 | 1.71 | 1.71 | 1.71 | 1.70 | 1.70 |
| 1.70 | 1.71 | 1.71 | 1.71 | 1.71 | 1.70 |
| 1.70 | 1.71 | 1.71 | 1.71 | 1.70 | 1.70 |
| 1.70 | 1.70 | 1.71 | 1.70 | 1.71 | 1.70 |
| 1.70 | 1.70 | 1.71 | 1.71 | 1.70 | 1.71 |
| 1.70 | 1.70 | 1.71 | 1.70 | 1.70 | 1.70 |
| 1.70 | 1.70 | 1.71 | 1.71 | 1.71 | 1.70 |
| 1.70 | 1.70 | 1.71 | 1.71 | 1.70 | 1.70 |
| 1.70 | 1.70 | 1.71 | 1.71 | 1.71 | 1.70 |
| 1.70 | 1.71 | 1.71 | 1.71 | 1.71 | 1.70 |
| 1.70 | 1.71 | 1.71 | 1.71 | 1.71 | 1.70 |
| 1.71 | 1.71 | 1.70 | 1.71 | 1.71 | 1.70 |

Distribution of Density in 2 ½" diameter casting RT 974, nominal composition RDX/TNT/Beeswax 60/40/1, prepared from recrystallised RDX.

| | | | | | | |
|---|---|---|---|---|---|---|
| ← 2.6 → | | | | | | |
| ← 2.8 → | | | | | | |
| ← 2.8 → | | | | | | |
| 44.5 | 41.7 | 39.8 | 39.8 | 40.7 | 43.6 | 48.6 |
| 60.7 | 61.1 | 62.2 | 62.7 | 62.3 | 61.7 | 60.8 |
| 61.8 | 62.4 | 62.7 | 63.2 | 62.9 | 62.8 | 61.9 |
| 62.4 | 63.2 | 63.4 | 63.7 | 63.7 | 63.4 | 63.4 |
| 63.1 | 63.6 | 63.8 | 64.2 | 64.0 | 63.9 | 62.7 |
| 63.0 | 63.9 | 63.8 | 63.7 | 64.2 | 64.1 | 63.7 |
| 63.5 | 63.7 | 63.2 | 62.0 | 62.9 | 63.7 | 63.6 |
| 63.1 | 63.5 | 62.3 | 61.9 | 63.3 | 63.2 | 63.3 |
| 57.7 | 62.3 | 61.4 | 61.8 | 61.7 | 60.8 | 56.0 |
| 57.4 | 62.1 | 62.2 | 61.9 | 62.1 | 60.3 | 54.7 |
| 57.3 | 62.2 | 62.7 | 62.7 | 63.0 | 60.2 | 54.2 |
| 57.4 | 62.5 | 63.0 | 62.8 | 62.8 | 60.2 | 54.4 |
| 58.0 | 62.7 | 63.3 | 63.3 | 63.0 | 60.6 | 54.3 |
| 59.0 | 63.0 | 63.4 | 63.6 | 63.0 | 61.2 | 54.6 |
| 60.4 | 63.0 | 63.5 | 63.8 | 63.2 | 61.8 | 55.1 |
| 60.3 | 63.3 | 63.7 | 64.2 | 63.6 | 62.6 | 56.9 |
| 61.0 | 63.4 | 64.0 | 64.4 | 64.0 | 63.2 | 59.3 |
| 62.1 | 63.8 | 64.1 | 64.5 | 64.2 | 63.6 | 61.0 |
| 62.6 | 63.7 | 64.2 | 64.1 | 64.1 | 63.7 | 62.5 |
| 63.2 | 63.2 | 63.1 | 63.0 | 63.0 | 63.0 | 62.9 |

Distribution of RDX in 3 1/2" diameter casting RT 981, nominal composition RDX/TNT/Beeswax 55/45/1, prepared from recrystallised RDX.

| | | | | | | |
|---|---|---|---|---|---|---|
| ← NOT MEASURED → | | | | | | |
| ← NOT MEASURED → | | | | | | |
| ← NOT MEASURED → | | | | | | |
| 1.68 | 1.66 | 1.65 | 1.63 | 1.64 | 1.66 | 1.67 |
| 1.70 | 1.70 | 1.69 | 1.68 | 1.69 | 1.70 | 1.70 |
| 1.70 | 1.70 | 1.70 | 1.68 | 1.70 | 1.70 | 1.70 |
| 1.70 | 1.70 | 1.70 | 1.69 | 1.70 | 1.70 | 1.70 |
| 1.70 | 1.70 | 1.70 | 1.69 | 1.70 | 1.70 | 1.70 |
| 1.71 | 1.70 | 1.69 | 1.68 | 1.69 | 1.70 | 1.71 |
| 1.70 | 1.70 | 1.70 | 1.69 | 1.69 | 1.70 | 1.70 |
| 1.71 | 1.70 | 1.70 | 1.69 | 1.70 | 1.70 | 1.70 |
| 1.70 | 1.70 | 1.70 | 1.70 | 1.70 | 1.70 | 1.69 |
| 1.70 | 1.70 | 1.70 | 1.69 | 1.70 | 1.70 | 1.69 |
| 1.70 | 1.70 | 1.70 | 1.69 | 1.70 | 1.70 | 1.69 |
| 1.70 | 1.70 | 1.70 | 1.70 | 1.70 | 1.70 | 1.69 |
| 1.70 | 1.70 | 1.70 | 1.70 | 1.70 | 1.70 | 1.69 |
| 1.70 | 1.70 | 1.70 | 1.70 | 1.70 | 1.70 | 1.69 |
| 1.70 | 1.70 | 1.70 | 1.70 | 1.70 | 1.70 | 1.70 |
| 1.70 | 1.70 | 1.70 | 1.70 | 1.70 | 1.70 | 1.69 |
| 1.70 | 1.71 | 1.70 | 1.70 | 1.70 | 1.70 | 1.70 |
| 1.71 | 1.71 | 1.70 | 1.70 | 1.70 | 1.70 | 1.70 |
| 1.70 | 1.70 | 1.70 | 1.70 | 1.70 | 1.70 | 1.70 |
| 1.70 | 1.70 | 1.70 | 1.70 | 1.70 | 1.70 | 1.70 |

Distribution of Density in 3 1/2" diameter casting RT 981, nominal composition RDX/TNT/Beeswax 55/45/1, prepared from recrystallised RDX.

| | | | | | |
|---|---|---|---|---|---|
| ← 2.2 → | | | | | |
| ← 0.7 → | | | | | |
| ← 2.7 → | | | | | |
| 57.9 | 57.6 | 57.6 | 57.6 | 58.9 | 58.0 |
| 60.8 | 62.6 | 62.9 | 62.5 | 62.1 | 61.[illegible] |
| 62.4 | 63.3 | 63.7 | 63.5 | 63.4 | 62.2 |
| 63.5 | 64.3 | 64.5 | 64.1 | 64.0 | 63.1 |
| 63.9 | 64.4 | 64.6 | 64.6 | 64.3 | 63.4 |
| 63.8 | 64.7 | 64.7 | 64.8 | 64.4 | 63.8 |
| 63.8 | 63.8 | 63.0 | 63.4 | 64.1 | 63.8 |
| 62.7 | 63.2 | 62.2 | 62.4 | 63.0 | 63.1 |
| 55.8 | 59.9 | 61.4 | 61.6 | 59.1 | 55.4 |
| 55.1 | 58.6 | 61.6 | 61.6 | 58.5 | 54.8 |
| 54.8 | 58.4 | 62.2 | 62.1 | 58.3 | 54.[illegible] |
| 54.8 | 58.2 | 62.5 | 62.3 | 58.0 | 54.2 |
| 54.2 | 59.2 | 62.5 | 62.4 | 58.5 | 5[illegible].2 |
| 54.6 | 60.4 | 62.7 | 62.3 | 59.3 | 54.[illegible] |
| 54.8 | 60.8 | 62.6 | 62.7 | 60.9 | 54.4 |
| 54.9 | 61.5 | 63.0 | 62.9 | 61.7 | 54.8 |
| 55.6 | 62.5 | 63.5 | 63.4 | 62.3 | 55.2 |
| 57.0 | 62.7 | 63.8 | 63.6 | 62.9 | 55.5 |
| 59.5 | 63.5 | 64.1 | 64.2 | 63.6 | 59.5 |
| 61.7 | 62.8 | 63.0 | 62.9 | 62.7 | 61.8 |

Distribution of RDX in 2 1/2" diameter casting RT 973, nominal composition RDX/TNT/Beeswax 55/45/1, prepared from recrystallised RDX.

| | | | | | |
|---|---|---|---|---|---|
| ← NOT MEASURED → | | | | | |
| ← NOT MEASURED → | | | | | |
| ← NOT MEASURED → | | | | | |
| 1.70 | 1.69 | 1.68 | 1.68 | 1.69 | 1.70 |
| 1.70 | 1.70 | 1.69 | 1.69 | 1.70 | 1.70 |
| 1.70 | 1.70 | 1.70 | 1.69 | 1.70 | 1.70 |
| 1.70 | 1.70 | 1.70 | 1.70 | 1.70 | 1.70 |
| 1.71 | 1.70 | 1.70 | 1.70 | 1.70 | 1.70 |
| 1.71 | 1.70 | 1.70 | 1.70 | 1.70 | 1.70 |
| 1.71 | 1.70 | 1.69 | 1.70 | 1.70 | 1.71 |
| 1.70 | 1.70 | 1.70 | 1.70 | 1.70 | 1.70 |
| 1.69 | 1.70 | 1.70 | 1.70 | 1.70 | 1.69 |
| 1.69 | 1.70 | 1.70 | 1.70 | 1.70 | 1.69 |
| 1.69 | 1.70 | 1.70 | 1.70 | 1.70 | 1.69 |
| 1.69 | 1.70 | 1.70 | 1.70 | 1.70 | 1.69 |
| 1.69 | 1.70 | 1.70 | 1.70 | 1.70 | 1.69 |
| 1.69 | 1.70 | 1.70 | 1.70 | 1.70 | 1.69 |
| 1.69 | 1.70 | 1.70 | 1.71 | 1.70 | 1.69 |
| 1.69 | 1.70 | 1.70 | 1.70 | 1.70 | 1.69 |
| 1.70 | 1.71 | 1.71 | 1.71 | 1.70 | 1.69 |
| 1.70 | 1.71 | 1.70 | 1.70 | 1.71 | 1.70 |
| 1.70 | 1.71 | 1.70 | 1.71 | 1.70 | 1.70 |
| 1.71 | 1.71 | 1.71 | 1.71 | 1.70 | 1.70 |

Distribution of Density in 2 ½" diameter casting RT 973, nominal composition RDX/TNT/Beeswax 55/45/1, prepared from recrystallised RDX.

| | | | | | | |
|---|---|---|---|---|---|---|
| ← | | | 42.35 | | | → |
| 61.1 | 68.6 | 68.1 | 67.7 | 67.6 | 67.6 | 62.3 |
| 60.7 | 69.6 | 74.7 | 80.9 | 75.5 | 67.7 | 62.0 |
| 61.4 | 64.8 | 71.8 | 79.2 | 71.1 | 64.6 | 62.4 |
| | | ← | NOT MEASURED | → | | |
| 62.1 | 63.0 | 64.0 | 70.8 | 64.5 | 64.8 | 62.3 |
| 61.7 | 62.0 | 63.4 | 65.3 | 64.2 | 64.4 | 62.5 |
| 61.4 | 62.0 | 63.1 | 63.6 | 63.4 | 64.6 | 61.8 |
| 60.5 | 61.5 | 62.7 | 63.2 | 62.9 | 62.2 | 61.0 |
| 59.6 | 61.2 | 62.4 | 63.0 | 62.5 | 61.2 | 58.9 |
| 58.9 | 60.7 | 62.0 | 62.5 | 61.9 | 60.4 | 58.2 |
| 58.6 | 60.6 | 62.1 | 62.5 | 61.7 | 60.4 | [illegible] |
| 58.6 | 60.6 | 61.9 | 62.6 | 61.7 | 60.2 | 58.1 |
| 58.6 | 60.5 | 61.7 | 62.4 | 61.8 | 60.2 | 58.1 |
| 58.1 | 60.2 | 61.4 | 62.2 | 61.6 | 60.1 | 58.3 |
| 58.2 | 60.2 | 61.4 | 62.1 | 61.4 | 60.1 | 58.3 |
| 58.4 | 60.1 | 61.4 | 62.2 | 61.4 | 60.1 | 58.4 |
| 58.6 | 60.2 | 61.2 | 61.8 | 61.2 | 60.3 | 58.6 |
| 59.2 | 60.4 | 61.1 | 61.2 | 60.9 | 60.2 | 59.0 |
| 60.0 | 60.6 | 60.8 | 60.7 | 60.7 | 60.5 | 59.6 |
| 60.3 | 60.4 | 60.0 | 59.9 | 59.9 | 60.0 | 60.0 |

Distribution of RDX in 3 1/2" diameter casting RT 994, nominal composition RDX/TNT/Beeswax 60/40/1, prepared from milled and boiled RDX.

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | | | | |
| ← | | | NOT MEASURED | | | → |
| 1.68 | 1.58 | 1.62 | 1.64 | 1.64 | 1.61 | 1.65 |
| 1.69 | 1.51 | 1.44 | 1.35 | 1.44 | 1.60 | 1.68 |
| 1.70 | 1.65 | 1.51 | 1.38 | 1.54 | 1.70 | 1.68 |
| | | ← | NOT MEASURED | → | | |
| 1.70 | 1.69 | 1.67 | 1.53 | 1.69 | 1.70 | 1.70 |
| 1.70 | 1.70 | 1.69 | 1.65 | 1.70 | 1.67 | 1.70 |
| 1.70 | 1.70 | 1.69 | 1.70 | 1.70 | 1.70 | 1.70 |
| 1.70 | 1.70 | 1.70 | 1.69 | 1.70 | 1.70 | 1.70 |
| 1.69 | 1.69 | 1.69 | 1.69 | 1.69 | 1.69 | 1.69 |
| 1.69 | 1.69 | 1.69 | 1.69 | 1.69 | 1.69 | 1.69 |
| 1.69 | 1.69 | 1.69 | 1.69 | 1.69 | 1.69 | 1.69 |
| 1.69 | 1.69 | 1.69 | 1.69 | 1.69 | 1.69 | 1.69 |
| 1.69 | 1.69 | 1.69 | 1.69 | 1.69 | 1.69 | 1.69 |
| 1.69 | 1.69 | 1.69 | 1.69 | 1.69 | 1.69 | 1.69 |
| 1.69 | 1.69 | 1.69 | 1.69 | 1.69 | 1.69 | 1.69 |
| 1.69 | 1.69 | 1.69 | 1.69 | 1.69 | 1.69 | 1.69 |
| 1.69 | 1.69 | 1.69 | 1.69 | 1.69 | 1.69 | 1.69 |
| 1.69 | 1.69 | 1.69 | 1.69 | 1.69 | 1.69 | 1.69 |
| 1.69 | 1.69 | 1.69 | 1.69 | 1.69 | 1.69 | 1.69 |
| 1.69 | 1.69 | 1.69 | 1.69 | 1.69 | 1.69 | 1.69 |

Distribution of Density in 3 1/2" diameter casting RT 994, nominal composition RDX/TNT/Beeswax 60/40/1, prepared from milled and boiled RDX.

| 40.4 | | | | | | |
|---|---|---|---|---|---|---|
| 57.1 | 70.4 | 73.8 | 76.8 | 71.6 | 64.0 | 58.0 |
| 59.5 | 66.1 | 74.6 | 80.6 | 72.8 | 62.8 | 59.1 |
| 60.1 | 63.5 | 67.4 | 78.0 | 69.7 | 62.5 | 60.4 |
| 60.7 | 63.2 | 64.8 | 74.7 | 65.8 | 62.1 | 60.9 |
| 60.9 | 62.4 | 63.2 | 70.8 | 63.4 | 62.1 | 60.8 |
| 61.6 | 63.4 | 63.6 | 66.9 | 62.5 | 62.1 | 61.4 |
| 61.8 | 62.2 | 62.6 | 65.4 | 62.4 | 61.9 | 61.5 |
| 62.0 | 62.5 | 62.4 | 62.8 | 62.5 | 62.0 | 61.4 |
| 61.7 | 59.8 | 62.4 | 62.8 | 62.5 | 61.5 | 60.8 |
| 61.4 | 61.8 | 60.8 | 62.4 | 61.8 | 60.5 | 57.5 |

| | | | | | |
|---|---|---|---|---|---|
| 58.1 | 60.5 | 61.6 | 61.7 | 60.5 | 58.0 |
| 57.6 | 59.7 | 61.1 | 61.1 | 59.9 | 57.9 |
| 57.3 | 59.7 | 61.2 | 61.0 | 60.0 | 57.7 |
| 57.0 | 59.4 | 61.0 | 61.0 | 59.8 | 57.6 |
| 57.2 | 59.5 | 60.7 | 60.9 | 59.7 | 57.3 |
| 57.2 | 59.4 | 60.8 | 60.8 | 59.4 | 57.2 |
| 57.0 | 59.4 | 60.8 | 60.6 | 59.3 | 57.3 |
| 57.0 | 59.5 | 60.8 | 60.7 | 59.2 | 57.5 |
| 57.6 | 59.4 | 60.4 | 60.3 | 59.4 | 57.7 |
| 58.3 | 59.7 | 60.1 | 60.1 | 59.1 | 58.2 |
| 59.1 | 60.1 | 60.2 | 60.0 | 60.0 | 59.2 |
| 59.8 | 59.7 | 59.6 | 59.6 | 59.4 | 59.7 |

Distribution of RDX in 2 1/2" diameter casting RT 1000, nominal composition RDX/TNT/Beeswax 60/40/1, prepared from milled and boiled RDX.

| | | | | | | |
|---|---|---|---|---|---|---|
| ← NOT MEASURED → | | | | | | |
| ← NOT MEASURED → | | | | | | |
| ← NOT MEASURED → | | | | | | |
| 1.70 | 1.69 | 1.59 | 1.37 | 1.52 | 1.70 | 1.70 |
| 1.70 | 1.68 | 1.67 | 1.43 | 1.62 | 1.70 | 1.70 |
| 1.70 | 1.69 | 1.70 | 1.51 | 1.68 | 1.70 | 1.70 |
| 1.70 | 1.70 | 1.68 | 1.59 | 1.69 | 1.69 | 1.70 |
| 1.70 | 1.70 | 1.68 | 1.62 | 1.70 | 1.70 | 1.70 |
| 1.70 | 1.70 | 1.70 | 1.69 | 1.70 | 1.70 | 1.70 |
| 1.70 | 1.70 | 1.69 | 1.68 | 1.69 | 1.69 | 1.70 |
| 1.70 | 1.70 | 1.70 | 1.69 | 1.69 | 1.69 | 1.70 |

| | | | | | |
|---|---|---|---|---|---|
| 1.69 | 1.69 | 1.70 | 1.70 | 1.70 | 1.69 |
| 1.69 | 1.69 | 1.69 | 1.69 | 1.59 | 1.69 |
| 1.69 | 1.70 | 1.70 | 1.69 | 1.69 | 1.69 |
| 1.69 | 1.69 | 1.69 | 1.69 | 1.69 | 1.69 |
| 1.69 | 1.69 | 1.69 | 1.69 | 1.69 | 1.69 |
| 1.69 | 1.69 | 1.69 | 1.69 | 1.69 | 1.69 |
| 1.68 | 1.69 | 1.69 | 1.69 | 1.69 | 1.69 |
| 1.69 | 1.69 | 1.69 | 1.69 | 1.69 | 1.69 |
| 1.69 | 1.69 | 1.69 | 1.69 | 1.69 | 1.69 |
| 1.69 | 1.69 | 1.69 | 1.69 | 1.69 | 1.69 |
| 1.69 | 1.69 | 1.69 | 1.69 | 1.69 | 1.69 |
| 1.69 | 1.69 | 1.69 | 1.69 | 1.69 | 1.69 |

Distribution of density in 2 ½" diameter casting RT 1000, nominal composition RDX/TNT/Beeswax 60/40/1, prepared from milled and boiled RDX.

| | | | | | | |
|---|---|---|---|---|---|---|
| ← | | | 1.9 | | | → |
| ← | | | 37.1 | | | → |
| 53.6 | 62.3 | 67.7 | 70.4 | 67.9 | 59.5 | 52.1 |
| 54.5 | 59.2 | 70.6 | 77.0 | 68.4 | 61.7 | 55.2 |
| 55.5 | 58.8 | 68.0 | 55.4 | 72.6 | 64.2 | 61.2 |
| | ← 57.3 | → | | ← 56.3 | → | |
| 57.3 | 59.2 | 62.0 | 71.2 | 62.5 | 60.7 | 57.4 |
| 57. | 59.0 | 61.0 | 65.6 | 62.4 | 60.8 | 58.4 |
| 58.4 | 59.1 | 60.6 | 62.2 | 62.2 | 59.6 | 58.6 |
| 57.9 | 58.8 | 59.5 | 61.8 | 62.0 | 59.2 | 58.3 |
| 57.2 | 58.1 | 58.8 | 59.8 | 59.5 | 58.7 | 57.6 |
| 54.6 | 57.6 | 58.9 | 59.7 | 58.9 | 57.7 | 54.3 |
| 53.5 | 56.8 | 58.5 | 59.7 | 58.9 | 57.7 | 53.2 |
| 53.5 | [illegible] | 58.3 | 59.2 | 58.8 | 56.5 | 53.1 |
| 53.2 | 56.3 | 58.4 | 59.3 | 58.6 | 56.3 | [illegible] |
| 53.1 | 56.1 | 58.1 | 59.6 | 58.5 | 56.4 | 53.2 |
| 53.2 | [illegible] | 58.1 | 59.7 | 58.3 | 56.6 | 53.2 |
| 53.2 | [illegible] | 58.0 | 58.9 | 58.1 | 56.4 | 53.2 |
| 53.4 | 56.2 | 57.7 | 59.0 | 57.9 | 56.4 | 53.5 |
| 53.9 | 56.7 | 58.1 | 58.4 | 57.8 | 56.9 | 54.0 |
| 54.6 | 57.1 | 58.1 | 58.5 | 58.1 | 57.5 | 54.9 |
| 56.1 | 57.6 | 58.1 | 58.1 | 58.0 | 57.8 | 56.1 |
| 56.7 | 57.0 | 56.9 | 57.0 | 57.0 | 57.2 | 56.9 |

Distribution of RDX in 3 1/2" diameter casting RT 995, nominal composition RDX/TNT/Beeswax 55/45/1, prepared from milled and boiled RDX.

| | | | | | | |
|---|---|---|---|---|---|---|
| ← | | | NOT MEASURED | | | → |
| ← | | | NOT MEASURED | | | → |
| ← | | | NOT MEASURED | | | → |
| 1.69 | 1.69 | 1.47 | 1.37 | 1.55 | 1.68 | [illegible] |
| 1.69 | 1.70 | 1.51 | 1.68 | 1.45 | 1.64 | 1.68 |
| | ← 1.69 → | | | ← 1.69 → | | |
| 1.69 | 1.69 | 1.68 | 1.47 | 1.69 | 1.68 | 1.69 |
| 1.69 | 1.69 | 1.70 | 1.60 | 1.70 | 1.68 | 1.69 |
| 1.69 | 1.69 | 1.69 | 1.69 | 1.70 | 1.68 | [illegible] |
| 1.69 | 1.69 | 1.69 | 1.69 | 1.68 | 1.69 | 1.69 |
| 1.69 | 1.69 | 1.69 | 1.69 | 1.69 | 1.69 | 1.69 |
| 1.69 | 1.69 | 1.69 | 1.68 | 1.66 | 1.69 | 1.68 |
| 1.68 | 1.69 | 1.69 | 1.68 | 1.69 | 1.69 | 1.68 |
| 1.68 | 1.69 | 1.69 | 1.68 | 1.69 | 1.69 | 1.68 |
| 1.68 | 1.69 | 1.69 | 1.68 | 1.69 | 1.69 | 1.68 |
| 1.68 | 1.69 | 1.69 | 1.69 | 1.69 | 1.69 | 1.69 |
| 1.68 | 1.68 | 1.69 | 1.69 | 1.69 | 1.68 | 1.68 |
| 1.68 | 1.69 | 1.69 | 1.69 | 1.68 | 1.69 | 1.68 |
| 1.68 | 1.68 | 1.69 | 1.68 | 1.69 | 1.69 | 1.68 |
| 1.68 | 1.69 | 1.69 | 1.68 | 1.69 | 1.69 | 1.69 |
| 1.69 | 1.69 | 1.69 | 1.68 | 1.69 | 1.69 | 1.69 |
| 1.69 | 1.69 | 1.69 | 1.69 | 1.69 | 1.69 | 1.69 |
| 1.69 | 1.69 | 1.69 | 1.69 | 1.69 | 1.69 | 1.69 |

Distribution of density in 3 1/2" diameter casting RT 995, nominal composition RDX/TNT/Beeswax 55/45/1, prepared from milled and boiled RDX.

| 1.1 | | | | | | |
|---|---|---|---|---|---|---|
| 47.9 | 51.5 | 62.0 | 63.1 | 61.8 | 48.2 | 49.[illegible] |
| 51.1 | 56.3 | 64.9 | 72.[illegible] | 68.6 | 56.0 | 51.9 |
| 53.5 | 56.2 | 61.7 | 71.6 | 64.4 | 55.5 | 53.8 |
| 55.1 | 57.0 | 61.1 | 71.6 | 62.7 | 56.7 | [illegible] |
| 56.[illegible] | 58.1 | 60.7 | 67.2 | 61.0 | 57.6 | [illegible] |
| 57.1 | 58.4 | 60.4 | 63.3 | 60.6 | 58.3 | [illegible] |
| 57.3 | 58.6 | 59.5 | 62.9 | 60.4 | 58.5 | 57.3 |
| 57.8 | 58.6 | 59.3 | 62.5 | 59.6 | 58.6 | [illegible] |
| 57.7 | 58.3 | 59.1 | 59.8 | 58.7 | 58.1 | [illegible] |
| 55.9 | 57.2 | 58.1 | 59.0 | 58.2 | 57.2 | [illegible] |

| | | | | | |
|---|---|---|---|---|---|
| 52.7 | 56.2 | 58.2 | 58.7 | 57.0 | 52.[illegible] |
| 52.5 | 56.0 | 57.6 | 58.7 | 56.6 | 52.8 |
| 52.5 | 55.6 | 57.8 | 58.6 | 56.[illegible] | 52.5 |
| 52.1 | 55.8 | 57.8 | 58.4 | 56.2 | 52.6 |
| 52.3 | 55.7 | 57.9 | 58.5 | 56.3 | 52.7 |
| 52.4 | 55.7 | 57.5 | 58.4 | 56.3 | 52.[illegible] |
| 52.6 | 55.5 | 57.5 | 58.3 | 56.1 | 52.7 |
| 52.4 | 55.6 | 57.3 | 58.2 | 56.1 | 52.8 |
| 52.7 | 55.6 | 57.4 | 58.0 | 56.0 | 52.6 |
| 53.4 | 56.0 | 57.2 | 57.4 | 56.2 | 53.5 |
| 54.2 | 56.8 | 57.3 | 57.1 | 56.6 | 54.7 |
| 56.0 | 56.2 | 56.3 | 56.5 | 56.3 | 56.1 |

Distribution of RDX in 2 1/2" diameter casting EC 1, nominal composition RDX/TNT/Beeswax 55/45/1, prepared from milled and boiled RDX.

| | | | | | | |
|---|---|---|---|---|---|---|
| ← NOT MEASURED → | | | | | | |
| ← NOT MEASURED → | | | | | | |
| ← NOT MEASURED → | | | | | | |
| 1.69 | 1.69 | 1.67 | 1.46 | 1.59 | 1.69 | 1.69 |
| 1.69 | 1.69 | 1.68 | 1.45 | 1.64 | 1.69 | 1.69 |
| 1.69 | 1.69 | 1.70 | 1.57 | 1.70 | 1.69 | 1.69 |
| 1.69 | 1.69 | 1.70 | 1.66 | 1.70 | 1.69 | 1.69 |
| 1.70 | 1.69 | 1.69 | 1.67 | 1.69 | 1.69 | 1.69 |
| 1.69 | 1.69 | 1.69 | 1.66 | 1.69 | 1.69 | 1.69 |
| 1.69 | 1.69 | 1.69 | 1.69 | 1.69 | 1.69 | 1.69 |
| 1.69 | 1.69 | 1.69 | 1.68 | 1.69 | 1.69 | 1.69 |

| | | | | | |
|---|---|---|---|---|---|
| 1.69 | 1.69 | 1.69 | 1.69 | 1.69 | 1.69 |
| 1.68 | 1.69 | 1.69 | 1.69 | 1.69 | 1.69 |
| 1.68 | 1.69 | 1.69 | 1.69 | 1.69 | 1.68 |
| 1.68 | 1.69 | 1.69 | 1.69 | 1.69 | 1.68 |
| 1.68 | 1.69 | 1.69 | 1.69 | 1.69 | 1.68 |
| 1.68 | 1.68 | 1.69 | 1.69 | 1.69 | 1.68 |
| 1.68 | 1.68 | 1.69 | 1.69 | 1.69 | 1.68 |
| 1.68 | 1.69 | 1.69 | 1.69 | 1.68 | 1.68 |
| 1.68 | 1.68 | 1.69 | 1.69 | 1.69 | 1.68 |
| 1.68 | 1.68 | 1.69 | 1.69 | 1.69 | 1.68 |
| 1.69 | 1.69 | 1.69 | 1.68 | 1.69 | 1.68 |
| 1.69 | 1.69 | 1.69 | 1.69 | 1.69 | 1.69 |

Distribution of Density in 2 ½" diameter casting EC 1, nominal composition RDX/TNT/Beeswax 55/45/1, prepared from milled and boiled RDX.

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