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Technical Report No. 168

The Compatibility of 'Loctite' Sealants with Explosives

N. J. Eloy
E. F. Pambridge

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(6) The Compatibility of "Loctite" Sealants with Explosives.

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(10) N. J. Blay
E. F. Pembridge

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SUMMARY

The explosives compatibility properties of a number of commercially obtainable sealants, marketed under the trade name "Loctite", are discussed and reported.

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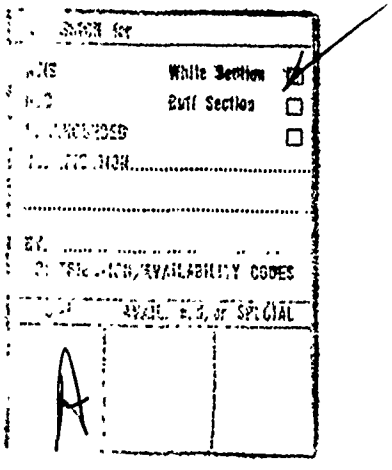
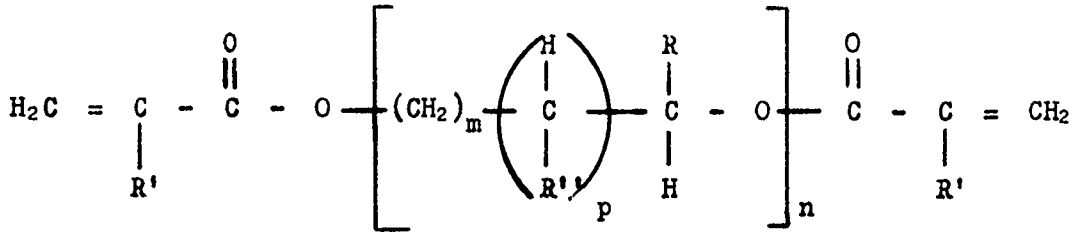


1 INTRODUCTION

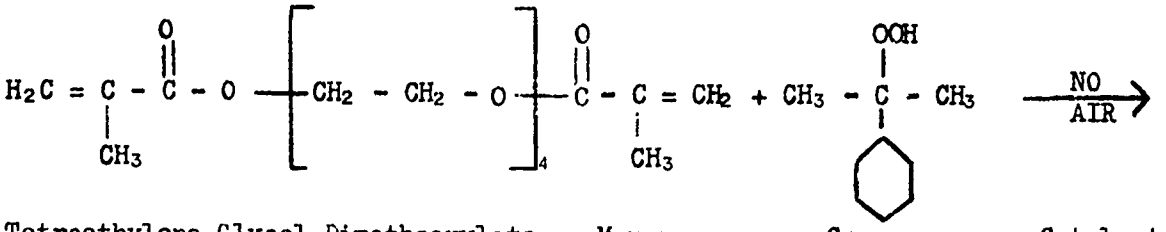
"Loctite"* sealants are anaerobic adhesives based upon acrylate acid diesters and having the general formula:



m = 1 to 8, n = 1 to 20, p = 0 or 1

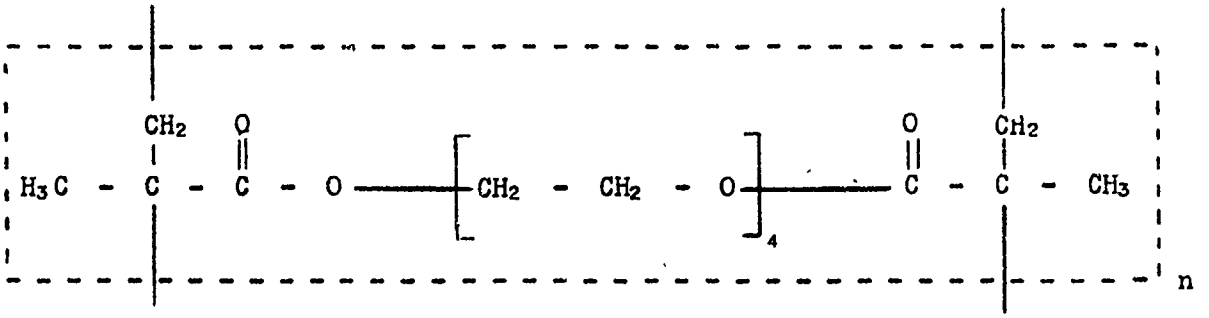
The adhesives are essentially monomeric, thin liquids, which with suitable catalysts, polymerise to form a tough plastic bond when confined between closely fitting metal parts in the absence of air. Their self hardening properties are based on two factors: (1) contact with air keeps the monomeric adhesive liquid and (2) metal surfaces accelerate the anaerobic polymerisation out of contact with air. A typical composition is tetraethylene glycol dimethacrylate monomer with catalysts such as cumene hydroperoxide (2%) and accelerators such as benzoic sulphimide (0.3%). To prevent premature gelling, benzoquinones may be added as stabilisers, and various other ingredients, such as silica to alter the viscosity and dyestuffs to aid identification, may also be included.

Polymerisation or curing of the acrylate acid diesters is essentially a free-radical type addition polymerisation, viz:[1]



Tetraethylene Glycol Dimethacrylate Monomer — Cumene Hydroperoxide — Catalyst

*"Loctite", Trademark, Loctite Corporation USA, marketed by Douglas Kane Group Ltd, Swallowfields, Welwyn Garden City, Herts.



Polymer

The presence of tetra functionality in the monomer can lead, of course, to crosslinking and a thermoset structure.

During the past decade these sealants have found increasing use in various items of ammunition where there has been need for compatibility with explosives, and as a result a large number of "Loctites" have been tested. It was the purpose of this report to collect all the results obtained and to present this information together with the judgements relating to explosives compatibility.

2 MATERIALS TESTED

In all cases materials are identified by the manufacturer's code name. Further information is available from the firms' published data sheets. In general there are no Government specifications controlling the chemical composition of these materials, although some element of control can be exercised by MQAD through Approved Firms Schedules. This is always an important consideration for materials required to be compatible with explosives, since assurance is required that the formulation of the material tested will not be changed without notification to the Inspecting Authority.

Readers are therefore advised to confirm with MQAD and/or ERDE that materials chosen on the basis of this report are still of the same composition.

3 METHODS OF COMPATIBILITY TESTING

3.1 Preparation of Samples

The tests were carried out mainly with the materials in the liquid state as received, but in some cases further tests were performed using the polymerised (solid) sample. In order to obtain the cured sample, a special procedure was devised. The liquid sealant was poured into a dish, approx 2.5 cm diameter by 2.5 cm deep, made of aluminium foil. Having added a small amount of stainless steel filings, between 0.1 - 0.2 g, the dish was placed in a small glass desiccator, the lid of which was fitted with a cork carrying two

taps. With both taps open, one was connected to a supply of nitrogen and the desiccator purged for 15 minutes. This was repeated twice a day, and after three days the sealant had cured to a hard solid disc. The foil having been peeled away, the sample was rasped to a powder for the tests.

3.2 Methods of Testing

These have already been described in a previous report on the testing of epoxy resins for compatibility with explosives.[2]

Tests with initiators were carried out either (a) in contact, ie the sample mixed with the initiator, or (b) in the vapour phase, ie the sample in proximity to, but not in contact with, the initiator. In the table of results the tests used are identified by (C) A for contact tests and (C) B for vapour phase.

4 RESULTS

The results of tests on both liquid and polymerised sealants are given in Table 1.

4.1 Compatibility with Double-Base Propellants

Only in isolated cases has incompatibility been detected by the normal methods with double-base propellants. However, as is shown by the low pH values recorded for many of these materials in Table 1, they are frequently quite strongly acidic. Because of this, approvals for their use have usually included stipulations that contact with propellants should be minimised and in some cases approval has been withheld. The materials extracted from the more acidic grades by water behave as strong acids when titrated and, because of the known catalytic action of strong acids on the decomposition reactions of nitrate esters, the compatibility of these "Loctites" must be regarded with some suspicion despite the satisfactory compatibility results which are usually obtained. Fortunately, the use of "Loctites" usually involves their application to a small component or area to be sealed and they are left enclosed between two surfaces with very little exposure where contact with propellants can occur.

Only in these circumstances, can approval for the use of many of the grades listed in Table 1 be given without question.

4.2 Compatibility with High Explosives

With the exception of amatol, high explosives usually appear satisfactorily compatible with "Loctites" although a degree of reactivity is often observed,

particularly with Torpex. However the same qualifications in regard to the high acidity and its effects on compatibility which are discussed in Section 4.1 apply equally to high explosives.

4.3 Plastic Propellants

No instance of incompatibility with the sealants has been recorded with plastic propellants typified by RD2304 and containing ammonium picrate and perchlorate. The same reservations must be made however regarding the use of those "Loctites" which are excessively acidic.

4.4 Pyrotechnics and Gunpowder

No instances of chemical incompatibility which could lead to a hazard have been recorded between pyrotechnics and the sealants. Once again however note would have to be taken of any high residual acidity in the sealants. Gunpowder has also been tested with many sealants and found to be compatible.

4.5 Initiatory Explosives

Direct contact between the sealants and most of the common initiatory explosives does not appear to introduce any serious risk of chemical action leading to explosion.

Some adverse effects should however be mentioned. Absorption of an unpolymerised liquid sealant by an initiatory explosive would be expected to cause a great reduction in sensitiveness and this combination of materials is therefore not advisable. Regard should also be taken of the acidic nature of most of these sealants. Lead azide is especially susceptible to increase in decomposition under acid conditions. This is particularly undesirable since the evolution of hydrazoic acid vapour in such circumstances is a proven cause of hazard due to the formation of sensitive azide deposits on the metal of the weapon assembly.

5 CONCLUSIONS

As a rule, "Loctite" sealants can be expected to be compatible with high explosives (except amatols), and with single-, double- and triple-base propellants, plastic propellants, pyrotechnics, gunpowder and most initiatory compositions.

Some aspects of the composition of these materials are however obscure, and clearance for compatibility with explosives cannot be assumed without confirmation that the particular grade has been tested and that its composition is

adequately guaranteed to correspond to the approved sample. The considerable acidity of some grades of "Loctite" also casts doubts on their acceptability although this is not as a rule reflected in their behaviour in compatibility tests.

6 REFERENCES

1 Twiss S B — Adhesives of the Future. Applied Polymer Symposium No 3. Interscience Publishers, NY, 1966, pp 455 - 488

2 Blay N J, Pembridge E F — The Compatibility of Epoxy Resins with Explosives. ERDE TR 110. July 1972

NOTE

LOCTITE (UK) Limited expressed concern lest the references in this report to the acidity of some grades of LOCTITE could be misconstrued as indicating that these materials could be corrosive to metals. They wish to state that LOCTITE anaerobic adhesives are in no way corrosive.

TABLE 1

Tests of "Loctite" Sealants

No	"Loctite" Sealant Code Number and Description		pH Value (aqueous extract)	Compatibilities (C = Compatible; I = Incompatible)									Clearance with Pyrotechnics, Initiators and Plastic Propellants
				High Explosives (VS Results)					Colloidal Propellants				
										Stabiliser Tests			
				CE at 100°C	Amatol at 100°C	Torpex 4A at 120°C	RDX/TNT at 120°C	Others	SV Test at 80°C	Propellant and Stabiliser Content	Trial Conditions	Increase in Stabiliser Consumption	
1	A	liquid	5.5	C (2.78 ml)	I (>10.4 ml)	C (5.03 ml)		Pentolite (C) (3.38 ml)	C (640 h)	SC 8.81 (Carbamite)	4 weeks, 80°C	C (27%)	Gunpowder G20 (C)
										FNH 1.06 (DPA)	3 weeks, 80°C	C (0%)	
		polymerised	5.4	C (0.78 ml)	I (>12.9 ml)	C (3.94 ml)		Pentolite (C) (2.47 ml)	C (760 h)	SC 8.81 (Carbamite)	4 weeks, 80°C	C (10%)	Gunpowder G20 (C)
										FNH 1.06 (DPA)	3 weeks, 80°C	C (0%)	
2	AV	liquid	6.1	C (1.79 ml)		I (10.94 ml)	C (4.52 ml)		C (888 h)	N 7.21 (Carbamite)	4 weeks, 80°C	I (55%)	Plastic Prop RD2304 (C) (0.32 ml) Lead Azide (C) A VH2 Composition (C) A 'A' Composition (C) A
		polymerised	6.4			C (4.00 ml)				"	"	C (25%)	
3	AVV	liquid	2.4	C (0.72 ml)	I (>14.1 ml)	C (5.06 ml)	C (4.61 ml)	Pentolite (C) (2.46 ml)	C (1468 h)	N 7.21 (Carbamite)	4 weeks, 80°C	I (55%)	Plastic Prop RD2304 (C) (0.53 ml) Lead Azide (C) A VH2 Composition (C) A 'A' Composition (C) A
		polymerised	3.1			C (2.41 ml)				"	"	C (28%)	
4	B	liquid	5.7	C (1.59 ml)	I (>14.2 ml)	C (5.09 ml)		Pentolite (C) (3.40 ml)	C (666 h)	SC 8.81 (Carbamite)	4 weeks, 80°C	I (33%)	Plastic Prop RD2304 (C) (0.71 ml) Gunpowder G20 (C) Lead Azide (C) A RD1303 Composition (C) A RD1651 Composition (C) A 'A' Composition (C) A
										FNH 1.06 (DPA)	3 weeks, 80°C	C (22%)	

TABLE 1 (Contd)

No	"Loctite" Sealant Code Number and Description	pH Value (aqueous extract)	Compatibilities (C = Compatible; I = Incompatible)									Clearance with Pyrotechnics, Initiators and Plastic Propellants
			High Explosives (VS Results)					Colloidal Propellants				
									Stabiliser Tests			
			CE at 100°C	Amatol at 100°C	Torpex 4A at 120°C	RDX/TNT at 120°C	Others	SV Test at 80°C	Propellant and Stabiliser Content	Trial Conditions	Increase in Stabiliser Consumption	
4	B polymerised	5.7	C (1.04 ml)	I (>14.8 ml)	C (4.57 ml)		Pentolite (C) (3.68 ml)	C (715 h)	SC 8.81 (Carbamite)	4 weeks, 80°C	C (22%)	Plastic Prop RD2304 (C) (0.48 ml) Gunpowder G20 (C) Lead Azide (C) A RD1303 Composition (C) A RD1651 Composition (C) A 'A' Composition (C) A
									FNH 1.06 (DPA)	3 weeks, 80°C	C (16%)	
5	CVV liquid	2.4	C (0.81 ml)	I (>14.1 ml)	I (7.11 ml)	C (4.86 ml)	Pentolite (C) (2.08 ml)	C (928 h)	N 7.21 (Carbamite)	4 weeks, 80°C	I (50%)	Plastic Prop RD2304 (C) (0.41 ml) Lead Azide (C) A VH2 Composition (C) A 'A' Composition (C) A
	polymerised	2.9			C (2.77 ml)				"	"	C (23%)	
6	EV liquid	3.5	C (0.71 ml)									
7	HVV liquid	2.4	C (0.39 ml)	I (>13.8 ml)	C (5.03 ml)	C (4.37 ml)	Pentolite (C) (2.73 ml)	C (1624 h)	N. 7.21 (Carbamite)	4 weeks, 80°C	I (43%)	Plastic Prop RD2304 (C) (0.33 ml) Lead Azide (C) A VH2 Composition (C) A 'A' Composition (C) A
	polymerised	2.7			C (2.62 ml)				"	"	C (26%)	
8	Screw Lock (Cat No 59) liquid	4.5	C (1.20 ml)	I (>17.4 ml)	C (4.71 ml)	C (2.50 ml)	Pentolite (C) (2.08 ml)	C (917 h)	SC 8.81 (Carbamite)	4 weeks, 80°C	C (6%)	Plastic Prop RD2304 (C) (0.37 ml)
									N 7.21 (Carbamite)	4 weeks, 80°C	C (9%)	
									FNH 1.06 (DPA)	3 weeks, 80°C	C (0%)	
									CDB 1.70 (2-NDPA)	3 days, 80°C	C (0%)	

TABLE 1 (Contd)

No	"Loctite" Sealant Code Number and Description	pH Value (aqueous extract)	Compatibilities (C = Compatible; I = Incompatible)									Clearance with Pyrotechnics, Initiators and Plastic Propellants
			High Explosives (VS Results)					Colloidal Propellants				
			CE at 100°C	Amatol at 100°C	Torpex 4A at 120°C	RDX/TNT at 120°C	Others	SV Test at 80°C	Stabiliser Tests			
									Propellant and Stabiliser Content	Trial Conditions	Increase in Stabiliser Consumption	
9	Plastic Gasket (Cat No 68) liquid	4.0	C (0.82 ml)	I (>18.4 ml)	C (3.71 ml)	C (1.79 ml)	Pentolite (C) (2.32 ml)	C (1671 h)	SC 8.81 (Carbamite)	4 weeks, 80°C	C (3%)	Plastic Prop RD2304 (C) (0.25 ml)
									N 7.21 (Carbamite)	4 weeks, 80°C	C (13%)	
									FNH 1.06 (DPA)	3 weeks, 80°C	C (0%)	
									CDB 1.70 (2-NDPA)	3 days, 80°C	C (0%)	
10	Pipe Seal (Cat No 71) liquid	3.3	C (0.67 ml)	I (>14.2 ml)	C (2.97 ml)	C (1.25 ml)	Pentolite (C) (3.80 ml)	C (1551 h)	SC 8.81 (Carbamite)	4 weeks, 80°C	C (0%)	Plastic Prop RD2304 (C) (0.31 ml)
									N 7.21 (Carbamite)	4 weeks, 80°C	C (13%)	
									FNH 1.06 (DPA)	3 weeks, 80°C	C (2%)	
									CDB 1.70 (2-NDPA)	3 days, 80°C	C (0%)	
11	Nut Lock (Cat No 74) liquid	4.5	C (1.50 ml)	I (>17.9 ml)	C (4.59 ml)	C (2.22 ml)	Pentolite (C) (2.66 ml)	C (999 h)	SC 8.81 (Carbamite)	4 weeks, 80°C	C (7%)	Plastic Prop RD2304 (C) (0.59 ml)
									N 7.21 (Carbamite)	4 weeks, 80°C	C (13%)	
									FNH 1.06 (DPA)	3 weeks, 80°C	C (2%)	
									CDB 1.70 (2-NDPA)	3 days, 80°C	C (0%)	

TABLE 1 (Contd)

No	"Loctite" Sealant Code Number and Description	pH Value (aqueous extract)	Compatibilities (C = Compatible; I = Incompatible)								Clearance with Pyrotechnics, Initiators and Plastic Propellants
			High Explosives (VS Results)					Colloidal Propellants			
									Stabiliser Tests		
			CE at 100°C	Amatol at 100°C	Torpex 4A at 120°C	RDX/TNT at 120°C	Others	3V Test at 80°C	Propellant and Stabiliser Content	Trial Conditions	Increase in Stabiliser Consumption
12	Retaining Compound (Cat No 75) liquid	3.0	C (1.21 ml)	I (>18.4 ml)	C (5.04 ml)	C (0.91 ml)	Pentolite (C) (1.68 ml)	C (1167 h)	SC 8.81 (Carbamite)	weeks, 80°C	C (11%)
									N 7.21 (Carbamite)	4 weeks, 80°C	C (4%)
									FNH 1.06 (DPA)	3 weeks, 80°C	C (6%)
									CDB 1.70 (2-NDPA)	7 days, 80°C	C (0%)
13	Instant Plastic Gasket liquid	3.4	C (0.44 ml)	I (>18.5 ml)	C (4.22 ml)	C (1.36 ml)	Pentolite (C) (2.07 ml) PETN (C) (0.51 ml)	C (1359 h)	SC 8.81 (Carbamite)	4 weeks, 80°C	C (3%)
									N 7.21 (Carbamite)	4 weeks, 80°C	C (7%)
									FNH 1.06 (DPA)	3 weeks, 80°C	C (0%)
									CDB 1.70 (2-NDPA)	3 days, 80°C	C (0%)
14	Tube Weld liquid	3.1	C (0.94 ml)	I (>16.9 ml)	C (5.03 ml)	C (2.74 ml)	Pentolite (C) (3.32 ml)	C (1359 h)	SC 8.81 (Carbamite)	4 weeks, 80°C	C (6%)
									N 7.21 (Carbamite)	4 weeks, 80°C	C (6%)
									FNH 1.06 (DPA)	3 weeks, 80°C	C (0%)
									CDB 1.70 (2-NDPA)	3 days, 80°C	C (0%)

No	Clearance with Pyrotechnics, Initiators and Plastic Propellants
12	Plastic Prop RD2304 (C) (0.69 ml)
13	Plastic Prop RD2304 (C) (0.76 ml) Composition SR548A (C)
14	Plastic Prop RD2304 (C) (0.44 ml)

TABLE 1 (Contd)

No	"Loctite" Sealant Code Number and Description	pH Value (aqueous extract)	Compatibilities (C = Compatible; I = Incompatible)									Clearance with Pyrotechnics, Initiators and Plastic Propellants
			High Explosives (VS Results)					Colloidal Propellants				
									Stabiliser Tests			
			CE at 100°C	Amatol at 100°C	Torpex 4A at 120°C	RDX/TNT at 120°C	Others	SV Test at 80°C	Propellant and Stabiliser Content	Trial Conditions	Increase in Stabiliser Consumption	
15	Weld Seal liquid	4.0	C (1.41 ml)	I (>16.3 ml)	C (4.60 ml)	C (1.89 ml)	Pentolite (C) (2.11 ml)	C (942 h)	SC 8.81 (Carbamite)	4 weeks, 80°C	C (7%)	Plastic Prop RD2304 (C) (1.04 ml)
									N 7.21 (Carbamite)	4 weeks, 80°C	C (6%)	
									FNH 1.06 (DPA)	3 weeks, 80°C	C (0%)	
									CDB 1.70 (2-NDPA)	3 days, 80°C	C (0%)	
16	Stud Lock (Cat No 41) liquid	3.3	C (0.83 ml)	I (>17.1 ml)	C (4.60 ml)	C (1.29 ml)	Pentolite (C) (1.55 ml)	C (1383 h)	SC 8.81 (Carbamite)	4 weeks, 80°C	C (6%)	Plastic Prop RD2304 (C) (0.43 ml) Lead Azide (C) B Silver Azide (?) B
									N 7.21 (Carbamite)	4 weeks, 80°C	C (12%)	
									FNH 1.06 (DPA)	3 weeks, 80°C	C (8%)	
									CDB 1.70 (2-NDPA)	3 days, 80°C	C (0%)	
17	Loctite 270 liquid	2.4	C (0.68 ml)	I (>17.6 ml)	C (4.62 ml)	C (1.88 ml)	Pentolite (C) (2.08 ml) HMX (C) (0.91 ml)	C (1272 h)	SC 8.81 (Carbamite)	4 weeks, 80°C	C (15%)	Plastic Prop RD2304 (C) (0.82 ml)
									N 7.21 (Carbamite)	4 weeks, 80°C	C (11%)	
									FNH 1.06 (DPA)	3 weeks, 80°C	C (4%)	
									CDB 1.70 (2-NDPA)	3 days, 80°C	C (0%)	

TABLE 1 (Contd)

No	"Loctite" Sealant Code Number and Description	pH Value (aqueous extract)	Compatibilities (C = Compatible; I = Incompatible)									Clearance with Pyrotechnics, Initiators and Plastic Propellants
			High Explosives (VS Results)						Colloidal Propellants			
									Stabiliser Tests			
			CE at 100°C	Amatol at 100°C	Torpex 4A at 120°C	RDX/TNT at 120°C	Others	SV Test at 80°C	Propellant and Stabiliser Content	Trial Conditions	Increase in Stabiliser Consumption	
18	Refrigerant Sealant liquid	3.4	C (0.68 ml)	I (>11.6 ml)	C (4.61 ml)	C (1.67 ml)	Pentolite (C) (2.63 ml)	C (1743 h)	SC 8.8 (Carbamite)	4 weeks, 80°C	C (15%)	Plastic Prop RD2304 (C) (0.38 ml)
									N 7.21 (Carbamite)	4 weeks, 80°C	C (4%)	
									FNH 1.06 (DPA)	3 weeks, 80°C	C (4%)	
									CDB 1.70 (2-NDPA)	3 days, 80°C	C (3%)	
19	Loctite 308 Impact Resistant Adhesive liquid	2.7	C (0.81 ml)			C (2.72 ml)						
20	Loctite 312 (Adhesive/Accelerator) cured 24 h at RT		C (1.21 ml)			C (3.08 ml)						
21	Locquic Primer T liquid	5.5	C (0.73 ml)	I (6.75 ml)	C (4.86 ml)	C (2.40 ml)	Pentolite (C) (2.49 ml) PETN (C) (0.44 ml)	I (435 h)	SC 8.81 (Carbamite)	4 weeks, 80°C	C (15%)	Plastic Prop RD2304 (C) (0.45 ml) Composition SR548A (C) Lead Azide (C) B Silver Azide (C) B
									N 7.21 (Carbamite)	4 weeks, 80°C	C (4%)	
									FNH 1.06 (DPA)	3 weeks, 80°C	C (4%)	
									CDB 1.70 (2-NDPA)	3 days, 80°C	C (4%)	

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									Stabiliser Tests		
			CE at 100°C	Amatol at 100°C	Torpex 4A at 120°C	RDX/TNT at 120°C	Others	SV Test at 80°C	Propellant and Stabiliser Content	Trial Conditions	Increase in Stabiliser Consumption
22	Locquic Activator Batch EY98 liquid (activator diluted 1 part in 20 with TCE)	6.3	C (0.86 ml)		C (2.97 ml)				SC 8.81 (Carbamite) N 7.21 (Carbamite) FNH 1.06 (DPA)	4 weeks, 80°C 4 weeks, 80°C 3 weeks, 80°C	C (7%) C (0%) C (0%)	Plastic Prop RD2304 (C) (0.27 ml)
23	Sealant AVX liquid " CVX " " D " Locquic Retaining Compound (liquid) Locquic Primer N (liquid)	2.6 3.5 4.8 3.4 5.0										Lead Azide (C) A Lead Azide (C) A

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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
Blay N J	Pembridge E F		1.1974	12	2

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(TEST)

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Abstract

The explosives compatibility properties of a number of commercially obtainable sealants, marketed under the trade name "Loctite", are discussed and reported.

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Blay N J, Pembridge E F
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