

WASC 1864
WAI 459

PERME Injection
into Incident in
Beds P720 27-1-1982

RESTRICTED
IN-CONFIDENCE

WAC 192/045

PROCUREMENT EXECUTIVE
MINISTRY OF DEFENCE

REPORT OF A LOCAL COMMITTEE OF INQUIRY HELD AT
THE PROPELLANTS, EXPLOSIVES AND ROCKET MOTOR ESTABLISHMENT
WALTHAM ABBEY, ESSEX
ON FEBRUARY 2nd, 1982

By Order of the Director/PERME for the purpose of enquiring
into and reporting upon the incident which occurred in
Building P720 on January 27th, 1982. Report to Director/PERME.

RESTRICTED
IN-CONFIDENCE

CONTENTS

	<u>Page No</u>
<u>PART 1</u>	
1. Time and Place of Inquiry	1
2. Constitution of Committee	1
3. Terms of Reference and Security Aspects	1
4. Circumstances of the Accident	1
5. Description of Building, Plant and Procedure	1
6. Examination of the Scene of the Accident	2
7. Quantity of Material Involved	2
8. Casualties	2
9. Summary of Salient Facts	2
ANNEX A Schedule of Damage	3
ANNEX B Operating Instructions	4
ANNEX C Compatibility Report	5
ANNEX D List of Witnesses	6
ANNEX E Summary of Evidence Presented	7 - 11
ANNEX F Notes Provided by Mr G Smith	12
ANNEX G Photographs of the Mixer after the Accident	13

PART 1

1. Time and Place of Inquiry

The inquiry was held on February 2nd 1982 at the Propellants, Explosives and Rocket Motor Establishment, Waltham Abbey.

2. Constitution of Committee

Chairman:	Dr A Osborn	-	GC Branch
	Mr J Henderson	-	Safety Services Organisation
	Mr D Salter	-	Staff Side Representative
	Mr E Morgan	-	T.U. Representative
	Mr A Dentry	-	Engineering Facilities Branch
Secretary:	Mr D Johnson	-	Administration

3. Terms of Reference and Security Aspects

To inquire into the circumstances of the accident, to determine the cause and to make recommendations to prevent a recurrence.

The composition detailed on the Work Card (ANNEX B2) is classified as Restricted.

4. Circumstances of the Accident

At approximately 9.30 am on Wednesday, 27th January 1982 a fire occurred while the ingredients of an experimental propellant composition were being introduced into a horizontal mixer in Bay 1, Building P720. The fire was confined to the mixer and extinguished itself within a few minutes. The Fire Brigade were called and attended the incident.

5. Description of Building, Plant and Procedure

Building P720 is used for mixing, filling and pressing rubbery composite propellants and occasionally plastic propellants, and associated activities. Bay 1 contains a number of small mixers, associated tools, benches and weighing equipment.

The mixer in question has a capacity of 5 kg with provision for heating by circulation of hot fluid through a built-in jacket.

The normal sequence of operations for the mixing of propellant ingredients is detailed at Part 2 of the Operating Instructions (ANNEX B1). The procedure used on this occasion is detailed elsewhere in the report.

6. Examination of the Scene of the Accident

The Committee visited Building P720 accompanied by Mr E Cooke the Scientist in Charge of the Building and were shown the mixer and the arrangements for heating comprising Churchill water heaters (out-of-service) and a steam line, together with the facilities for weighing the ingredients and with them the Work Card (Form PB/1 Revised; Annex B2) relating to the mix in question.

7. Quantity of Material Involved

At the time of the fire the mixer contained approximately 2½ kg of propellant ingredients.

8. Casualties

No one was injured as a result of the incident.

9. Summary of Salient Facts

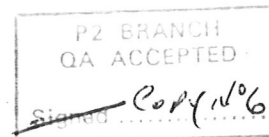
- i) Propellant ingredients in a mixer in Bay 1, Building P720 ignited.
- ii) Damage was confined to the mixer.
- iii) No one was injured.

Schedule of Damage

- i) Two plastic sightglasses normally located in the hinged cover of the mixer had been destroyed and the paintwork of the lid scorched.

Operating Instructions

1. Plastic Propellant Instruction P720/1.
2. Work Card Form PB/1 Revised.



Propellants Explosives and Rocket Motor Establishment
Waltham Abbey
Essex

Plastic Propellant Instruction P720/1

Incorporation of Propellant in the Small Scale Incorporators
in Building P720, Bay 1

1 General Safety Precautions

- 1.1 Keep all machines and ovens at temperatures specified by scientist-in-charge.
- 1.2 Check that the mantlet at the south entrance to the bay and the cubicle mantlet are both fully open before incorporator is loaded, unloaded or cleaned.
- 1.3 Do not operate any machine, whether loaded or empty, while personnel are in the same cubicle.
- 1.4 Do not operate any machine containing propellant while personnel are in the same bay.
- 1.5 Check that machine is free from solvent before use.
- 1.6 Clean up all spilt material immediately and place in the waste bucket.
- 1.7 Wear face visors when unloading or cleaning incorporators.
- 1.8 If there is any unusual occurrence, stop processing immediately and report to the scientist-in-charge.

WARNING

Mixtures of ammonium perchlorate and aluminium powders are very friction sensitive. Mixtures of ammonium perchlorate and catalyst powders will burn violently.

All ingredients other than ammonium perchlorate and ammonium picrate are to be premixed with binder before addition to the incorporator.

NEVER add aluminium or catalyst powders to ammonium perchlorate unless the ammonium perchlorate is completely wetted by the binder.

2 Mixing of Propellants

- 2.1 All requests for propellant manufacture will be made by the scientist concerned on the appropriate card. This will specify composition details (including amounts of premixes), quantity of propellant required, incorporation time and temperature, etc. This card should be returned to the scientist, after completion of the incorporation, with any details requested entered on it.

2.2 Raise the jacket to the nominated working temperature using hot water, unless otherwise specified.

2.3 TO BE CARRIED OUT BY CHARGEHAND. Inspect machine for faults. Pull down steel shutters on verandah. Leave bay, drawing mantlets across cubicle and south entrances. Run the machine empty for two minutes. Listen for any indications of malfunction. Stop machine and draw mantlets away from entrances. Re-inspect the machine.

If there is any suspicion that the machine is not in correct working order, do not proceed further and report to the scientist-in-charge.

2.4 Weigh out the ingredients in the quantities described on the manufacture card.

2.5 Add weighed ingredients to the machine in the order described on the manufacture card.

2.6 Leave bay, drawing mantlets across cubicle and south entrance.

2.7 Start the machine.

2.8 The mix should be inspected at intervals as indicated in 2.9. On each occasion, the procedure will be: (1) stop the machine, (2) draw mantlets away from entrances, (3) carry out the required operation, (4) leave the bay, drawing mantlets across cubicle and south entrance, (5) start the machine.

2.9 After 10-15 minutes incorporation, tip any powder which has passed through the trough ends into the trays, back into the incorporator. As necessary, thereafter, scrape the blades and sides of the incorporator, using the approved tools, and tip any propellant, which has passed through the trough ends into the trays, back into the incorporator.

2.10 After the nominated period of incorporation, stop the machine and draw mantlets away from entrances.

2.11 Remove propellant by hand with the aid of approved tools and place in polythene bag or other material as instructed.

2.12 The above mixing procedures may be altered only on the instructions of the scientist-in-charge.

3. Cleaning of Incorporators

It is extremely important that incorporators are maintained in an absolutely clean condition, free from propellant and powder deposits.

3.1 Remove as much as possible of the propellant by hand with the aid of the approved tools.

3.2 Fill the machine with paraffin up to the blade shaft.

3.3 Apply heat to the jacket and run the machine for 5 minutes.

3.4 Using a brush, clean thoroughly inside the incorporator and on the outside in the region of the shafts.

3.5 Empty the incorporator and then repeat operations 3.2 to 3.4.

3.6 Empty the incorporator and then repeat operations 3.2 to 3.4 using 70 : 30 acetone : water.

3.7 Empty the incorporator, inspect for cleanliness, and apply steam heat until thoroughly dry.

3.8 Pour used paraffin and acetone/water into the waste solvent container.

4. Maintenance of Incorporators

Maintenance of incorporators is primarily the responsibility of the Engineering Services, but it will be the responsibility of the Chargehand to keep certain section records.

4.1 For each incorporator there is a file containing drawings, specification and other documents of interest, and this must be kept in the Foreman's Office.

4.2 A log will be kept of all incorporations, stating composition and mixing time. At the conclusion of each 25 hours mixing, the Chargehand will report to the Foreman, who will arrange for a minor mechanical inspection by the Services Section. After each 100 hours mixing, the Foreman will arrange for a major mechanical inspection.

4.3 A duplicate copy of each maintenance inspection sheet will be supplied at the time of inspection by the Services Section to the Chargehand. The sheet must be signed by the scientist-in-charge before mixing is commenced and then placed on the file.

4.4 At the conclusion of each major inspection, a batch of inert propellant, will be made with $1\frac{1}{2}$ hours mixing time and steam heat. The machine will then be cleaned, and the clearances remeasured. These will be entered on a separate maintenance inspection sheet, and this must be signed by the scientist-in-charge before mixing is recommenced. The sheet will then be placed on the file.

These instructions are valid until _____

Scientist-in-Charge E. M. Cook Telephone Ext: 496

Section Leader B. G. Tucker Telephone Ext: 301

Propellant - Composition/Mix/Results

Composition Number HT 524 Batch T2 Date of Manufacture

Batch Size 5000g Mixer P720 Scientist: R. J. ...

Made for: High RL Sgt. No Aluminium ATD Propellant

Material	Details	Per cent	Weight g.
Ammonium Perchlorate	<u>Minced AP</u>	<u>70</u>	<u>3500</u>
Ammonium Perchlorate	<u>50000</u> ✓	<u>.4</u>	<u>700</u>
Ammonium Perchlorate	<u>-</u>		
Aluminium	<u>-</u>		
Ballistic modifier	<u>SILICA* V4</u> ✓	<u>1.0</u>	<u>50</u>
Plasticiser	<u>BINDER R2 No 11</u>	<u>14.76</u>	<u>738</u>
Prepolymer			
Crosslinker			
Bonding agent	<u>BOBWA 8</u> ✓	<u>+ 0.2</u>	<u>+ 10 g</u>
Cure Catalyst			
Antioxidant	<u>AO 2246</u> ✓	<u>+ 0.1</u>	<u>+ 5 g</u>

Mixing Procedure * get silica from K. Brown.

Mix Viscosity @ Temperature °C Weight 180/443 g Distance 25.4/50.8 mm
 Time* Fall Times, sec Viscosity poises

*From Time of addition of Crosslinker

Filling Requirements

K-rounds: Dumbbell Moulds: Strand Moulds:

Others: 6 K rounds only.

Cure/Storage in bag sealed until required

27

Res:

Ballistics

Burning Rate at $MN/m^2 =$

Specific Impulse at $MN/m^2 =$

" " $MN/m^2 =$

Pressure Exponent =

" " $MN/m^2 =$

Temperature Coefficient =

" " $MN/m^2 =$

Strand Burning Rate at $MN/m^2 =$

Tensile Results - Constant Strain

Cure Storage/Conditions	Test Temperature/Constant Strain %				

Tensile Results - Constant Rate

Cure/Storage Temperature and Conditions	Test Temp	Strain Rate	S	E ₁	E ₂	Y Mod

Compatibility Report

Compatibility of BOBBA 8 and Ammonium Perchlorate

After the fire in building P720 on 27.1.82 the compatibility and stability section were approached for information regarding the compatibility of ammonium perchlorate with BOBBA 8. We were unable to find any record of tests having been conducted and have consequently carried out the following investigation.

Short Term Compatibility Tests

In these tests 1 gr of ammonium perchlorate (S. 8000) was placed in a glass tube and approx 100 mg of test material was dropped onto it, a glass sheathed thermocouple was inserted and the tube placed either in an air bath at 50°C or a boiling water bath at approx 100°C.

Results

Temp	Test Material	Result
50°C	BOBBA 8	No measurable effects over 4 hours
100°C	BOBBA 8	Approx 3 mins after insertion into the bath the temperature rose sharply to 170°C accompanied by bubbling of the BOBBA 8. There were no visible signs of AP decomposition. At the end of the test the BOBBA 8 was a hard solid mass.
	This test repeated 3 times with same result	
100°C	BOBBA 8 alone no AP present	No effect during 10 minutes, BOBBA 8 still liquid at end of test.
100°C	BOBBA 8 dispersed in RP2 binder (1.36%)	No effect
100°C	AP + RP2 Binder 1.4 to 1 mixed together then BOBBA 8 added	No effect in 15 minutes

Differential Scanning Calorimetry

Ammonium perchlorate (1 mg) with BOBBA 8 (1.5 mg) was tested at a scan rate of 20°/min starting at ambient temperature. A broad exotherm starting at 80°C and finishing at 140°C with a maximum at 129°C was recorded, this was followed by the ammonium perchlorate melting endotherm at 243°C and two strong exotherms with maxima at 315 and 360°C thought to be due to oxidation of the BOBBA 8 by the AP.

The presence of the AP melt endotherm indicates that although the BOBBA 8 was present in excess, little if any AP has been consumed in the first exotherm starting at 80°C.

Conclusions

MAPO is known to undergo rapid acid catalysed homopolymerisation and it is likely that BOBBA 8 which is based on MAPO and contains unreacted aziridine rings would behave similarly. The results obtained above strongly suggest that AP is not consumed in any significant amount in the reaction which occurs between the two materials. It is therefore suggested that BOBBA 8 will rapidly homopolymerise in the presence of ammonium perchlorate at 100°C with liberation of heat.

M G Farey
1 February 1982

List of Witnesses

Mr G Smith - EW III, Process Worker
Mr E Cooke - SSO, Scientist in Charge of the Building
Mr A Taylor - EP'A', Chargehand
Mr R Brown - SSO, Scientist in charge of the experiment
Dr B Tucker - PSO, Section Leader

Summary of Evidence Presented

Mr G Smith, EW III

Mr Smith provided the committee with written notes (ANNEX F) detailing the sequence of operations preceding the incident and his actions which followed. In amplification of his notes he described how the ingredients in Stage 1 were weighed, without mixing, onto the same scoop and then transferred to the mixer and steam valve 'cracked' open. The weighing and transfer involved in Stage 2 was carried out similarly. While weighing the final ingredient the contents of the mixer caught fire. Mr Smith then left the Bay, rang the Fire Bell and shouted Fire and attempted to call the Emergency Services, Ext 222, only to discover that the telephone was out of order. He then went to the opposite corridor of the building to reach a second telephone which proved to be working. He then left the building by which time all other personnel had also left.

In response to further questioning the committee learned that in Mr Smith's opinion the use of steam was effective in bringing the mixer up to temperature in a few minutes whereas water heating took longer and that the amount of steam used was at the discretion of the operator. He recalled that the Churchill water heaters had been out of service for at least four months and that there was therefore no alternative to steam heating. He had no way of knowing the steam temperature at any particular time.

On the subject of the composition in question he referred to two previous similar mixes (on 10.12.81 and 21.1.82) which had been completed successfully and without incident. When asked if he could pin-point any difference between these and the one on January 27th he mentioned that the source of silica was different (BDH for first two and a sample supplied by Mr R Brown for the last).

The committee were particularly interested in the use and relevance of the operating instructions and Mr Smith emphasised that prior to the incident he was not aware of the presence of these operating instructions (ANNEX B 1) in the building and believed that they had appeared immediately after the incident. Having now seen them he stated that they were general instructions which would not necessarily apply to this particular mix.

Mr E Cooke - SSO

Mr Cooke said that he had been Scientist in Charge of Building P720 since October 1980 and was responsible in particular for planning all work for the building. Work would be initiated by scientists and submitted to him for approval. Mr R Brown was responsible for materials and compositions.

In view of the present incident he now believed that further investigations should be carried out in connection with Bobba 8. When asked about the availability of the operating instructions he was certain that these were in fact available before the incident but pointed out that they were intended as general instructions and further thought that it would be impossible to produce a comprehensive set applicable to all possible mixtures. The instructions appropriate to any specific composition should be on the Work Card (ANNEX B 2) which was in this case shown to him by Mr Brown before work commenced. He had not regarded this particular work card as indicating anything which was unusual and cause for concern. He confirmed that the list of ingredients on the card was merely a list and did not indicate the order of addition. Mr Cooke also said that operators should take instructions only from either the scientist concerned with the experiment or the P & GS grade responsible for that particular item of work.

When questioned about mixing temperatures Mr Cooke said that $80 \pm 5^{\circ}\text{C}$ was normal and he was therefore unhappy about the availability of steam, particularly as there was neither any indication of temperature nor means of control. Although he was unable to say specifically how long the Churchill heaters had been out of commission they had been giving trouble for a considerable time and as they were obsolete new heaters had been purchased. A request for their installation on a Form 51 dated 9.11.81 had been passed to the Engineering Facilities Branch. However, he mentioned that even when the water heaters were functioning satisfactorily it was common practice to use steam to speed up the initial heating.

When asked to give his opinion on the possible cause of this accident he referred to the compatibility tests carried out by Mr Farey (ANNEX C) from which he concluded that the incident was due to the admixture of Bobba 8 and ammonium perchlorate coupled with the use of steam heating. Although he was aware that

mixtures of MAPO (of which Bobba 8 is a derivative) and ammonium perchlorate were known to be hazardous under certain conditions he had no personal experience of the use of Bobba 8.

Mr A Taylor - EP 'A'

Mr Taylor had less than three months experience in Building P720 but had been a chargehand for five years.

He said that the normal procedure in mixing propellants was that he received a Work Card (PB/1) from Mr Brown via the foreman and would then obtain the ingredients and check the weighing carried out by the operator as it proceeded. On this occasion the only difference he had noticed from the previous mix of that type was the different source of silica. Any change in procedure for incorporating the mixture was, he maintained, ultimately the responsibility of the operator. On the subject of operating instructions he said that they had been removed some time in the past and that new instructions had recently appeared. He thought that the instructions should be more specific when experimental compositions were involved.

To his knowledge the Churchill heaters had not functioned over the past few months. He personally considered that the steam was available for boost heating and not as an alternative to water heating.

He confirmed that on this occasion the Fire Alarm had not been heard by everyone in the building but that Mr Smith's shout of "Fire" had.

Mr R Brown - SSO

Mr Brown was the scientist responsible for this particular composition. He explained that this was an experimental composition of an unusual nature in that it did not contain aluminium and had been requested, in connection with a specific project, by PERME, Westcott.

This was the second mix of this specific composition (the first being the one on January 21st - that on 10.12.81 referred to by Mr Smith was slightly different) and he had discussed the procedure to be followed with Mr Smith beforehand although in the event the order of addition carried out by Mr Smith differed from what he himself would have done. He agreed that this difference

would not have affected the final outcome.

The silica, added as a burning rate catalyst, was in the January 27th experiment a silane treated sample obtained from Dr Sims, PERME. Both this mix and the previous identical one contained twice the normal amount of Bobba 8 because of the greater than normal proportion of ammonium perchlorate. He had no idea why the two had differed in their final behaviour.

When asked specifically about the possibility of reaction between ammonium perchlorate and Bobba 8 he stated that he had been unaware that they could possibly interact violently and that Bobba 8 had been used in propellant compositions for about five years without incident. He had no knowledge of any tests that had been carried out on the reactivity of ammonium perchlorate with Bobba 8 prior to those detailed in ANNEX C.

He was aware that steam heating was to be used for the experiment on January 27th although it was more usual to maintain the temperature at 80°C.

In his opinion the cause of the accident was due to a violent reaction between Bobba 8 and ammonium perchlorate made worse by steam heating. He thought that the problem could be overcome by using a different order of mixing, for example by diluting the Bobba 8 with binder before addition to the other ingredients, making sure that the temperature was not above 80°C.

He did not feel that the steam should be disconnected as it was occasionally required for other purposes.

He agreed that it was certainly desirable to include more information on the Work Card but that nevertheless the operation had been discussed beforehand with Mr Smith and the working sequence agreed. He further agreed that it was possibly a good idea to have the Scientist concerned present for the first mix of a new composition but had every confidence in Mr Smith's ability to operate on his own. He felt that his presence on this occasion would probably not have made any difference.

Dr B Tucker - PSO

Dr Tucker confirmed that he was in charge of Mr Brown and allocated work to him. The requirement would then be discussed with the General Foreman, Mr T Smith, who would in turn pass the work on to Mr Taylor with the knowledge of Mr Cooke.

Dr Tucker was asked about his knowledge of reactions between Bobba 8 and ammonium perchlorate and he referred to the recent compatibility report (ANNEX C) which indicated that there could be a problem at 100°C but probably not at 70°C. Confidence in the use of Bobba 8 derived from American use of MT4 (also prepared from MAPO) and the fact that Bobba 8 itself had given no trouble in propellant mixes over approximately the past five years.

On the subject of temperature he agreed that this should be specified and concerning the operating instructions he was adamant that they were available in the building at the time of the incident although not in the Bay in question (Bay 1).

Notes Provided by Mr G Smith

27 January 1982

STAGE 1.

Weighed 400 grams SO 8000
 " 50 grams SILICA
 " 5 grams A 2246
 " 10 grams BOBBA 8

The above were then put in mixer
Steam heat turned on.

STAGE 2.

Weighed 1000 grams Micronised AP
 738 grams R.P.2. NO 11 Bender
 weighing time 4 - 5 minutes

The above were then put in mixer with STAGE 1.

STAGE 3.

Weighed 2500 grams micronised AP, this
to be put in mixer in increments, to ensure
make-up.

I had just completed weighing of micronised A.P.
when I heard a loud hissing noise.
This noise was coming from the mixer, the material
in the mixer having caught fire.

STAGE 4

Rang fire bell. Told A. TAYLOR to turn
off electric main. Staff had left building.
Dialled 222. Called Fire brigade who were
on the scene quickly.

G. Smith 795
Building 720.

Photographs of the Mixer after the Accident

