INFORMATION ON THE EXPLOITATION OF MINES RECOVERED DURING THE IMPLEMENTATION OF ARTICLE 5 BY THE UNITED KINGDOM

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Demining Programme Office in the Falkland Islands – Exploitation 2015

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FALKLAND ISLANDS LANDMINE EXPLOITATION – MARCH 2015

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Background

The need for exploitation[1] was recognised early during the planning for mine clearance operations in the Falkland Islands. Little was known about the state of the mines some 30 years after the conflict, and it was considered important to understand the effects of ageing, along with the implications for issues such as appearance/recognition, functionality and detectability.

Exploitation was previously carried out during clearance Phases 1 and 3. This report outlines the work conducted during Phase 4a, where samples of the following mines were examined:

Type	Designation	Country of origin	Number examined/tested
Anti-personnel (AP)	P4B	Spain	50
	SB-33	Italy	16
Anti-tank (AT)	SB-81	Italy	12

Outline details of these mines are given in ***Annex A***.

A total of 78 mines and fuzes were examined or tested, with 38 mines being fully disassembled. Work was carried out by Colin King (herinafter 'CK'), technical director of Fenix Insight Ltd, from 5 – 12 March 2015.

Aim

The aim of this report is to outline the findings from the exploitation work, with particular emphasis on:

a. The general condition of the mines
b. Their ability to function, either as designed, or by other mechanisms
c. Significant changes in their characteristics that might affect detectability or sensitivity.

Preparation

Tools were fabricated in the UK to allow the machine-assembled casings of the SB-33 and SB-81 mines to be opened without inflicting unnecessary damage. A number of other specialist tools were taken to the Falklands, while others were bought or borrowed locally.

The process was mapped (see ***Annex B***) and risk assessments were performed for the disassembly of each mine type; appropriate controls were emplaced for activities considered particularly hazardous.

Recovery of Mines

AP mines were recovered by BACTEC the Land Release Contractor (LRC) during clearance operations. P4B mines were defuzed and stored, ready for exploitation, in the holding area.

Defuzing SB-33 mines was considered potentially hazardous, since the detonator is extracted perpendicular to the firing pin; this means that the mine could function if the pin were embedded in the detonator – a

[1] The process of disassembling explosive ordnance in order to accurately characterise the munition.

situation that was later found to have occurred. SB-33 mines were therefore recovered and stored fully fuzed.

AT mines were located, identified and partially uncovered by the deminers, but left in place. CK photographed each mine in position before fully uncovering and lifting. The mines were then assessed to establish that it was safe to disarm them, and were defuzed inside the minefield.

SB-81 mines were located and partially exposed by deminers, then recovered by CK

AT mines were examined and then defuzed in the minefield. The condition of detonators was noted

Disassembly and examination

Exploitation was carried out in a remote area of the quarry at Pony Pass, adjacent to the site used for the destruction of mines by burning. Access to the area was controlled to minimise the risk during the disassembly process.

The APB was established in a disused section of the quarry at Pony Pass

Explosive storage was in the left hand container, with the APB to the right

Two Iso containers were positioned side-by-side. One was used for the storage of recovered mines and fuzes (the assemblies being safely separated from one another). The other container was converted for use as an Ammunition Processing Building (APB).

Storage of recovered mines

The APB was basic but functional

The following sequence of events was then followed (***Annex B***):

a. External check of condition and photography
b. Assessment of safety to disarm, where applicable
c. Disarming by removal of the detonator
d. Disassembly of mine casing
e. Removal of internal components
f. Examination and photography throughout
g. Reassembly as a training aid, or set aside for destruction.

Explosive testing

The explosive testing of detonators was an important part of the Phase 4A exploitation work. No matter what the condition of the body, the fuze mechanism or the main charge, a mine is incapable of functioning as designed if the detonator is not serviceable.

A rig was improvised, in which a heavy steel girder could be lowered onto a mine fuze in order to actuate it. The firing pin was released onto the detonator and the outcome observed from a safe distance.

P4B fuzes, complete with detonators, were placed between two blocks for actuation. In order to test SB-33 and SB-81 detonators, SB-81 fuze mechanisms were reassembled and detonators attached; the assembly was then placed in an adapted SB-81 casing. The number of tests that could be conducted this way was limited because the fuze was destroyed each time a detonator functioned.

The explosive test rig used a rope and pulley to lower a girder onto the mine fuze

A P4B mine fuze placed on the test rig, ready for the girder to be lowered

OUTLINE OF FINDINGS

P4B

Origin

All mine bodies and fuze assemblies were produced in the same batch, namely 2-5-78 (1978 being the year of production).

There is no reason to expect any significant inconsistencies among the batch, therefore most of the differences observed are due to the effects of ageing.

Casing

A significant proportion of the fuze casings had hardened and cracked, with many partially disintegrated. The proportion of degraded fuzes recovered so far during Phase 4A is substantially greater than on previous phases.

The primary result of casing degradation is the exposure of the inner fuze cavity, leading to the ingress of water. This tends to have two significant effects:

a. Corrosion of the striker spring
b. Degradation of the detonator.

In examples where the top of the fuze casing had broken away, the striker spring and spacer were often missing altogether, leaving the mechanism incomplete. This means that the fuze could no longer function as designed.

In most instances, the lower section of the mine (containing the main charge) was in good condition.

Detectability

As in previous phases, no detection instrument has been considered reliable enough for use with buried P4B mines. Even when new, the striker spring (weighing just 0.14 g) is borderline for location using the current generation of detectors, while the foil covering the main charge is completely non-ferrous and makes little contribution to the detection signature. This has meant using primarily manual excavation to locate mines.

Any corrosion of the striker spring reduces its metallic mass and makes it even less detectable.

A range of degradation was present among P4B fuze casings

Many springs were corroded

Although it has little significance for conventional metal detection, the foil[2] which covers the explosive charge in the mine body may be significant for Ground Penetrating Radar (GPR).

GPR is now used in some instruments, combined with conventional metal detection, in order to identify anomalies in the ground. However, the fingers of broken foil - which are similar in size to the wavelength of the radar - may resonate to create a distinctive signal. GPR is an increasingly mainstream detection technique and might suitable for use against this mine type in future.

The foil is installed in the P4B body as a flat disc, but is broken when the fuze is fitted. In most cases, the foil ruptures in several places, creating ‘fingers’ that protrude into the fuze well. In some examples the foil remains virtually intact, while in others a portion is absent, but every P4B mine examined (including previous phases) has had some foil present.

Variations in the foil covering the main charge

View of the foils from the inside of the casing

Detonator functionality

Detonator function tests were performed on a number of fuzes recovered from four separate locations. Only complete fuzes, in good external condition, were selected for the test.

Of the 50 fuzes tested, only 16 (approximately one third) produced any explosive effect. The majority of these were recovered from a mine dump, where the packaging provided some measure of protection against the environment. Test results are shown in the table below:

Location	59S	59N	24	Mines dump
Number tested	10	10	10	20
Functioned	5	0	0	11
Failed	5	10	10	9

Out of those that exploded, the majority produced a weak effect that would probably fail to propagate to the main charge. In other words, actuation of mines in this category would be unlikely to cause injury.

Results from P4B detonator testing. The fuze on the left was one of the few that detonated fully; the one on the right barely had the energy to break the housing and would not have detonated the main charge

[2] The foil is an alloy of lead, tin and antimony

SB-33 and SB-81

Origin

The SB-33 (AP) and SB-81 (AT) were both produced by the former Italian manufacturer MISAR. They use similar designs and materials, and are often laid together in minefields; it therefore makes sense to consider them together.

The mines bear no significant markings, so it is not possible to confirm their date of manufacture or lot numbers. However, both types were produced in huge quantities and it is probable that all of the mines sold to Argentina, and subsequently laid in the Falkland Islands, originated from the same batches.

Casing

Almost all of the casings of the SB-33 and SB-81 mines examined were in excellent condition and showed little sign of deterioration.

As noted in previous phases, the rubber covers of the SB-33 mines were generally domed where prolonged exposure to water had caused the material to swell. Despite the rubber remaining intact, it appears that water eventually permeated, since most mines were moist inside.

Moisture was also present in most of the SB-81 mines, despite the integrity of the rubber pressure plate. The SB-81 fuze is actuated pneumatically, so the seal and flexibility of this plate are critical to its function; both aspects appeared to be unaffected in the mines examined[3]

The rubber domes on the SB-33 mines have swelled and allowed some moisture to enter

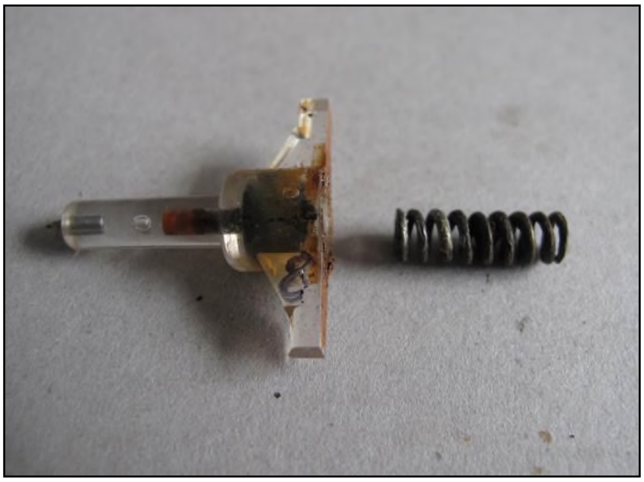
The pressure plates (right) of the SB-81 mines were in good condition; most were wet on the inside

Detectability

The primary detection signatures of the SB-33 and SB-81 come from their striker springs; these are made from magnetic steel and, when new, have masses of approximately 0.64 g and 0.86 g respectively. Other metallic components (such as stainless steel firing pins and aluminium detonator capsules) make little contribution to the signature.

Even where water had entered the mines, rusting of the striker springs was generally light and superficial. This means that the metal content of both mine types still remains well above the detection threshold.

[3] Similar mines in hotter climates often have dry, cracked pressure plates that prevent them from operating.



Even when rusted, the steel springs had lost little of their original mass (SB-33 left, SB-81 right)

Main charges

Most of the SB-33 and SB-81 explosive charges were in excellent condition; some SB-33 charges and SB-81 boosters were damp, but most were assessed to be fully functional.

Detonator condition

The same type of detonator capsule is used in the SB-33 and SB-81. In both cases, the detonator is attached to a plug that seals the underside of the mine with a synthetic rubber O-ring. If this plug has not been tightened sufficiently then water will enter the mine. The front surface of the detonator incorporates the ‘stab-receptor’, which contains a pyrotechnic composition that is susceptible to damp.

Most detonators appeared to be in good condition; however, some had white crusting (probably aluminium oxide from the detonator capsule) while others had a brown gelatinous exudation from the stab receptor.

Detonators from the SB-81 mines, some of which show signs of deterioration

Detonator functionality

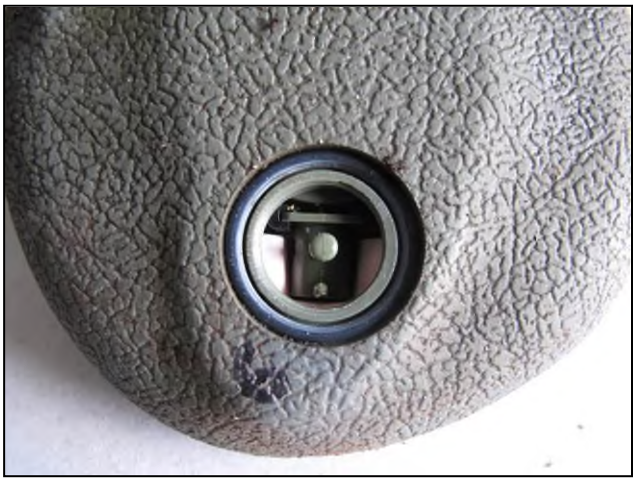
Detonators from SB-33 and SB-81 mines were tested by attaching them to a reassembled SB-81 fuze mechanism, from which the pneumatic actuation system had been removed. This assembly was then placed in an adapted SB-81 mine body, from which all explosive had been removed.

The limited number of fuzes available meant that only a relatively small number of detonators could be tested, since the fuze was destroyed if the detonator functioned. The results below have little statistical significance, but they do indicate that some detonators are fully functional and others are unserviceable, while some appear to be in a transitional state that results in incomplete detonation.

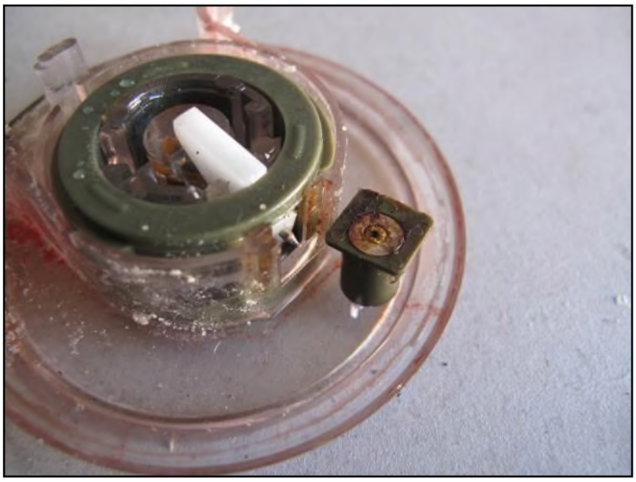
Mine type	SB-33	SB-81
Number tested	4	4
Full function	2	2
Partial function	1	1
Failed	1	1

The gradual decline of detonators within SB-33 mines was also apparent from mines that had failed to fully function when actuated. Of the 16 mines examined, 6 had the firing pin embedded in the detonator, which did not initiate.

The presence of the firing pin in the stab receptor of the detonator is a major and unexpected hazard, since further movement could cause initiation. During disarming, the detonator is withdrawn from the mine body at right angles to the firing pin, meaning that the two components scrape together. If the detonator is still active, this could initiate the mine in the hands of the deminer.



An SB-33 detonator plug removed to reveal the detonator still in position, impaled on the firing pin



An SB-33 disassembled, showing the pin in the fired position and a hole visible in the detonator

A further 4 mines were recovered with no detonator plugs present. It was initially assumed that these mines had been laid unarmed, without plugs, but examination showed that all had been actuated.

In each case, the detonator had exploded (ejecting the plug) but with insufficient force to initiate the main charge. The most likely explanation for this is deterioration of the detonators.

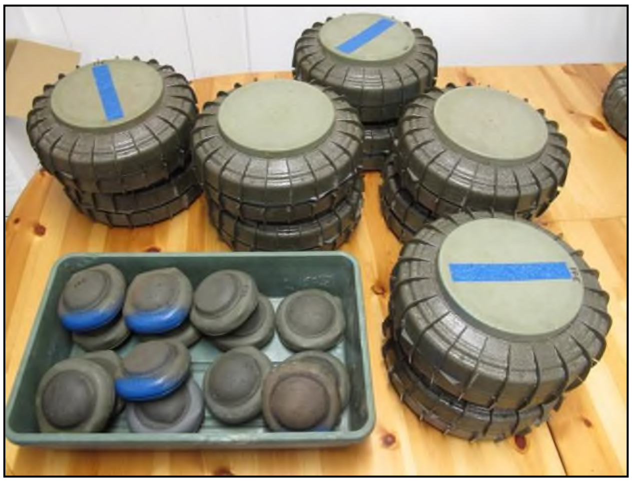
Several SB-33 mines had detonator plugs missing and were initially assumed to be unarmed

Examination revealed that the detonators had exploded, but failed to initiate the main charges

Additional tasks and deliverables

In addition to the main exploitation task, the following outcomes were achieved:

- Once disassembled, examined and tested, a number of mines were rebuilt, free from explosive (FFE). These are now available as training aids and test pieces for metal detection.
- One of each mine type was made into a sectioned model.
- The main charges extracted from the SB-81 mines were set aside for use as demolition charges.
- During clearance operations, an unknown type of AT mine was discovered. It was thought to have an inert filling but investigation showed that it contained a charge of TNT. The mine was later confirmed to be the Argentinian steel-cased copy of the US M1; this type was used in several minefields.
- The difference between the profile of an armed SB-33 and one that had been actuated was highlighted, and models made to illustrate both states.



A number of mines were reassembled, inert ('FFE')

Sectioned models were made for each mine type

SB-81 charge were retained for demolition

A 'new' mine type was identified

It is often possible to establish whether or not an SB-33 has been actuated by carefully feeling the position of the central plunger (through the rubber cover)

This inert model was produced - along with an actuated version – to illustrate the difference. The plunger is supported by a flexible ring so that it moves realistically, but cannot be actuated

Conclusions

The exploitation process was conducted successfully and without incident.

The work offered further insight into the condition of P4B, SB-33 and SB-81 mines, confirming that the samples examined showed more significant signs of deterioration than those seen on previous phases.

Specific conclusions and implications relating to the mines examined are summarised below (negative points shaded in red and positives in green):

Mine type	Conclusion	So what?
P4B	The metal content, which is close to the detection threshold when the mine is new, falls well below as the striker spring rusts	Conventional metal detection is unlikely to be reliable, regardless of enhancements to the technology
	Foil has been present in every mine examined (on this and previous phases)	Detection using GPR is a possibility
	Taking into account the number badly deteriorated or unserviceable, combined with those that produced a weak explosive effect, it is estimated that only 10 - 20% of P4B mines from these areas are still functional.	The risk of injury, should a mine be actuated accidentally, is relatively low.

SB-33	Out of 16 mines examined, 10 had been actuated but failed to detonate	This was unexpected and is currently unexplained
	It is not unusual for the mine to be found with the firing pin embedded in the detonator	It is potentially hazardous to defuze the mine in this state
SB-33 and SB-81	A proportion of detonators are non-functional or underpowered	The risks from remaining mines are declining
	Metal content remains fairly consistent, even in mines that have deteriorated	Metal detection is likely to remain a reliable option for the foreseeable future

Recommendations

It is recommended that:

- Trials are arranged to assess the feasibility of using GPR for the detection of the P4B.
- No attempt should be made to defuze SB-33 mines in the field.
- SB-33 mines should be recovered, fully fuzed, and demolished within the minefield. A special demolition procedure should be developed to ensure complete destruction.
- Scientific analysis should be conducted to investigate the changes occurring within the mine detonators, including the causes.
- The effects of ageing on recovered mines and other significant ordnance[4] continue to be monitored in future phases.
- Further data are needed on the location and circumstances of recovered mines in order to understand the factors affecting their condition. All contractors and authorities involved in demining operations should consider ways to collect such data without impeding clearance work.

CKing

Colin King

Technical Director
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March 2015

[4] Such as booby traps and BL-755 cluster munitions

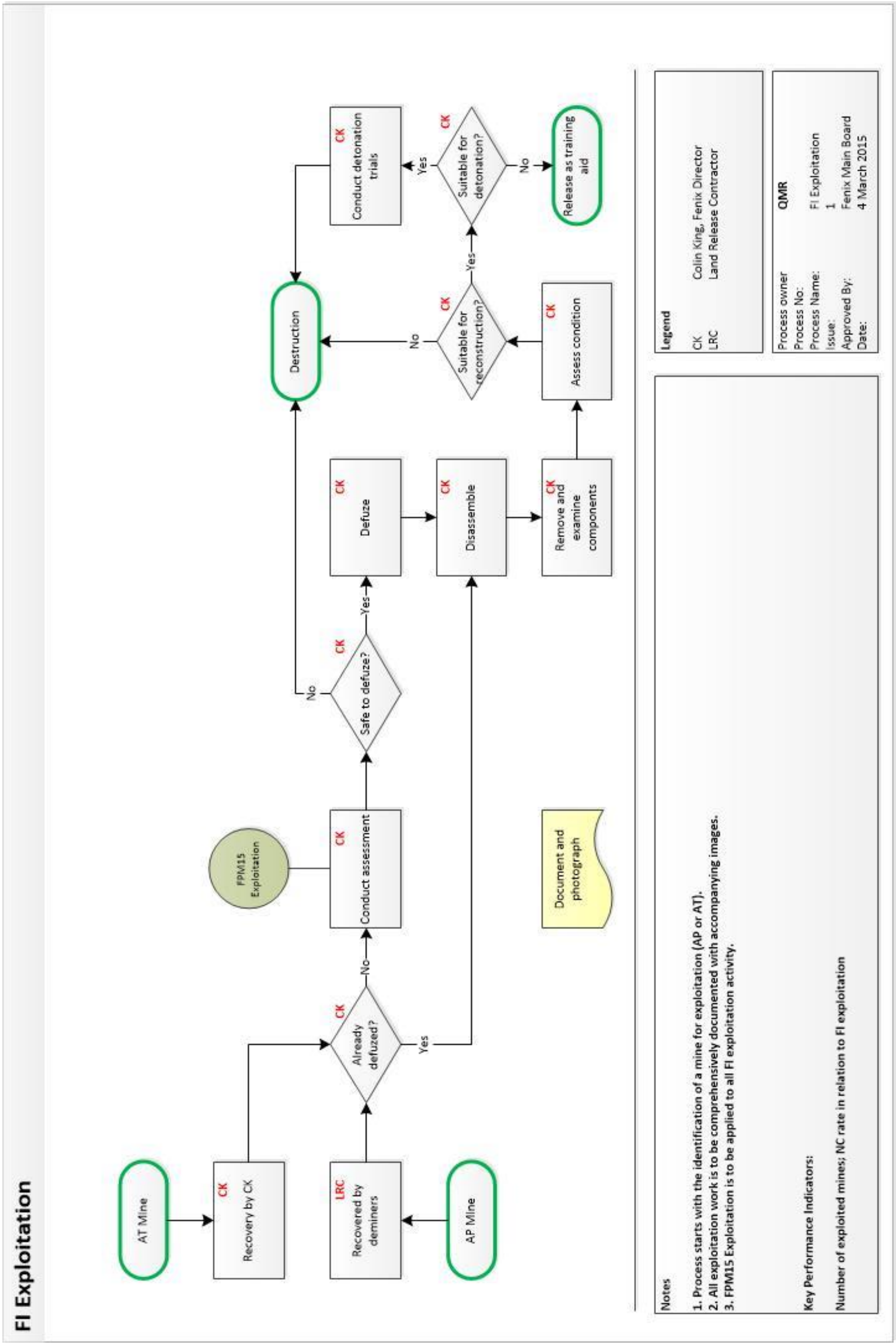
Annex A – Mine types examined during Phase 4a

Designation:	P4B
Type:	Anti-personnel
Origin:	Spain
Weight:	171 g
Diameter:	72 mm
Height:	43 mm
Explosive weight:	100 g
Explosive type:	TNT/PETN
Operating pressure:	10 kg approx

Designation:	SB-33
Type:	Anti-personnel
Origin:	Italy
Weight:	140 g
Diameter:	85 mm
Height:	30 mm
Explosive weight:	35 g
Explosive type:	RDX/HMX
Operating pressure:	8 kg approx

Designation:	SB-81
Type:	Anti-tank
Origin:	Italy
Weight:	3.3 kg
Diameter:	230 mm
Height:	90 mm
Explosive weight:	2.2 kg
Explosive type:	TNT/RDX/HMX
Operating pressure:	150-310 kg

Annex B – Exploitation Process Map



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Demining Programme Office in the Falkland Islands – Technical Support 2013

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EXPLOITATION OF ITEMS RECOVERED DURING DEMINING OPERATIONS: 2012/13

This report and the associated exploitation work was funded by the United Kingdom of Great Britain and Northern Ireland.

Background

1. Exploitation[1] work was carried out on SB-33, SB-81 and P4B mines during Phase 1 of clearance operations; findings from this work are detailed in the ***2010 Falkland Islands Demining Programme Exploitation Report***.

2. Exploitation work was conducted on the following items:

   a. C3B anti-tank mines (***Figure 1***) recovered from SA064;
   b. An SB-33 anti-personnel mine (***Figure 2***) discovered outside the mine rows of SA064;
   c. Components of booby traps recovered from SA064.

3. Work was carried out by Colin King, technical director of Fenix Insight Ltd, from 19 – 22 March 2013.

4. The findings from this work were intended to assess the conditon of the ordnance in order to:

   a. Establish the general condition of the mines;
   b. Indicate their ability to function, either as designed, or by other mechanisms;
   c. Highlight significant changes in their characteristics that might effect detectability or sensitivity.

Figure 1
The Spanish C3B anti-tank mine

Figure 2
The Italian SB-33 anti-personnel mine

Aim

5. The aim of this report is to outline the findings from exploitation work provided within the Falkland Islands demining programme during the third phase of clearance.

Mine exploitation

C3B

[1] The process of disassembling explosive ordnance in order to accurately characterise the munition.

6. Cracks were observed in the plastic casing of C3B mines recovered shortly after the 1982 conflict; it was therefore expected that mines remaining more than 30 years later would show substantial deterioration.

7. The deterioration of the plastic casing could be significant for the following reasons:

   a. Cracks might allow water into the fuze housing, causing:

      i. Rusting of the striker spring (with consequent reduction in detectability);

      ii. Degradation of the ignition composition, with consequent inability to function.

   b. The integrity of the fuze housing could be compromised, leading to a significant drop in operating pressure. This means that an affected mine might function under a load similar to that of an anti-personnel mine.

   c. The break-up of the mine body might allow the main charge to disintegrate, eventually rendering the mine ineffective.

8. Findings from the exploitation of the C3B mines are at ***Annex A***.

SB-33

9. A solitary SB-33 anti-personnel mine was discovered in SA064, but located approximately 70 m from the nearest mine row.

10. The mine had sustained external damage to the casing and the detonator plug, but it’s internal condition was unknown.

11. The mine was set aside in the hope that exploitation might offer some explanation for its location and condition.

12. Findings from the exploitation of the SB-33 mine are at ***Annex B***.

Booby trap

13. Remnants of a booby trap were discovered towards the southern end of SA064. The components included the wooden stake, main charge, safety fuse and detonator. The firing device normally associated with such booby traps had not yet been located.

14. Detailed exploitation of the booby trap remnants was not deemed to be worthwhile, but comments are at ***Annex C***.

Creation of training aids

15. The 14 C3B mines recovered for exploitation were rendered inert, with all explosive components being sent for demolition. The bases of the inert mine casings were then marked with blue paint (the NATO colour code for inert munitions). The inert mines are shown in ***Figure 3***.

Figure 3
Inert mines for use as training aids and detection samples

16. Most of the inert mines contain the original metal content and can therefore be used for detection trials. The two mines with metal content removed were clearly marked and were retained for display purposes only.

17. One of the mines was sectioned to provide a training aid (***Figure 4***).

Figure 4
One of the C3B mines was sectioned to produce this training aid

Conclusions

18. The exploitation process was conducted successfully and without incident.

19. In particular, the work offered a detailed insight into the condition of the C3B mines and confirmed the most likely explanation for the location and position of the isolated SB-33. It also provided inert samples of C3B mines for use as detection samples and training aids.

20. Detailed conclusions relating to the items examined are included in the relevant annexes.

Recommendations

21. The provision of technical support services, including the exploitation of target mine types and the creation of inert samples, is recommended as a component of all future clearance contracts.

22. Exploitation activity may offer important information for future programmes on issues such as the overall condition, viability and detectability of target mines. This type of technical intelligence should be taken into account during the planning phases in order to allocate appropriate resources over a suitable

period; it is therefore recommended that exploitation work is considered prior to the detailed planning of clearance operations.

23. It is further recommended that there is a provision for additional technical support during a programme, if necessary. The isolated SB-33 mine illustrated one scenario where this was worthwhile; other scenarios might include detection anomalies, munitions in a particularly dangerous condition and technical aspects of accident investigation.

Colin King

Technical Director
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April 2013

ANNEX A

EXPLOITATION OF THE C3B ANTI-TANK MINE

Background

1. The C3B (shown in ***Figure A1***) is a large and powerful anti-tank mine with the following specifcations quoted by the Spanish manufacturer, Explosivos Alavese (EXPAL) SA:

Weight	5.7 kg	Diameter	290 mm
Explosive weight	5 kg	Height	60 mm
Explosive type	TNT/RDX/Al (50/30/20)	Operating pressure	275 kg

Figure A1
The Spanish C3B anti-tank mine, shown here armed, with fuze fitted and safety cap to the left

2. The C3B uses a fuzing mechanism very similar to that of the P4B anti-personnel mine, protected by an additional plastic assembly to bring the operating pressure up to an acceptable level. Most of the components of the C3B are based on polystyrene plastic and are solvent-bonded together; this makes disassembly difficult and potentially dangerous. Components of the C3B are shown in ***Figure A2***.

3. Other than the aluminised explosive, the sole metallic content of the C3B is a steel spring weighing approximately 0.15 g. During Phase 1, it proved difficult to locate this spring reliably using any commercially-available detector.

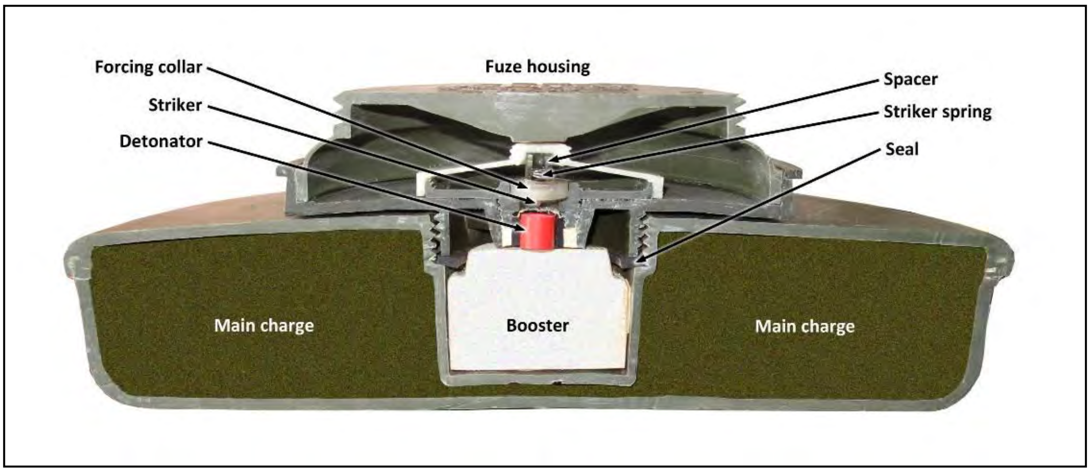

Figure A2
Components of the C3B

Methodology

4. Each of the 32 C3B mines located in SA064 was photographed in position and allocated a unique serial number. The mines were extracted from the ground and defuzed in the minefield. A sample of 14 mines were then selected and disassembled for examination.

5. All of the mines had been buried beneath peaty soil and vegetation, with depths typically around 100 mm. Mines from a variety of conditions were represented within the 14 chosen; some were extracted from firm ground while others were partially or completely submerged (see ***Figures A3 and A4***).

Figure A3

C3B in firm ground

Figure A4

Some mines were submerged

6. The mine bodies were opened and the main charge removed; the inside of the casing was then cleaned and examined for cracks.

7. The external and internal condition and constituency of the main charge was assessed before being set aside for demolition.

8. The webbing carrying handle (which is cast into the explosive) was cleaned and fastened back into position in the casing using adhesive. Previous examples had been re-assembled using metal rivets, which substantially increased the metallic signature of the mines; this means that they cannot be used as detection targets.

9. The solvent bond around the detonator was removed mechanically, the bond broken from around the thread of the detonator and the detonator unscrewed from the base of the fuze.

10. The bond around the shoulder of the external fuze housing was then broken, allowing the removal of the pressure plate and access to the fuze mechanism and striker spring. Some of the internal fuze housings could be opened by breaking the plastic bonds while others had to be cut.

11. All components were examined and photos were taken at every stage of disassembly.

12. A sample of five live fuzes, which had not been disassembled, were placed on a sandbag and subjected to pressure (well in excess of that normally required for initiation) using the bucket of an armoured excavator in order to assess the condition of the detonator.

13. The main observations from exploitation are illustrated and described below.

Exterior characteristics

Figure A5

The top surface (left) and underside (right) of the mine body with fuze removed. All of the mines recovered appeared to be in good condition superficially; however, every mine had cracks in the casing

Figure A6

Fine cracks in the casing allow the ingress of water; freezing then gradually extends the breaks

Figure A7

The top surface (left) and underside (right) of the fuze assembly. Most of the fuze bodies appeared to be undamaged and well sealed, yet almost all were wet inside

Fuze mechanism

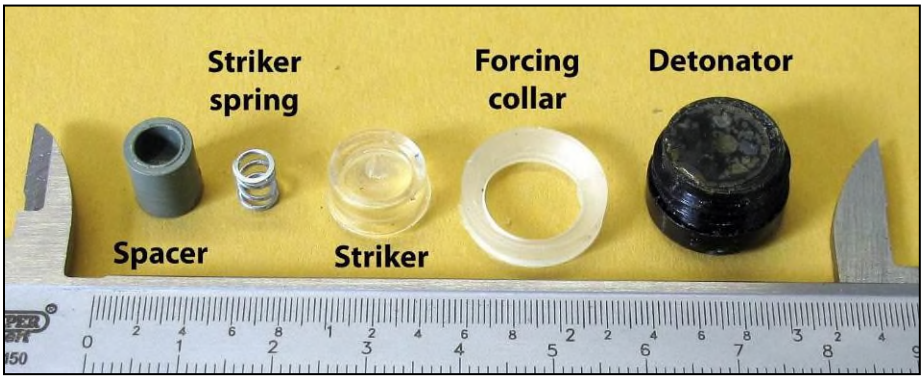

Figure A8
Components of the C3B fuze mechanism. Pressure applied to the top of the fuze forces the striker through a flexible 'forcing collar', which accelerates the striker into the detonator. The spring makes relatively little contribution to this effect

Figure A9
The sealed fuze assembly is very similar to that used in the P4B anti-personnel mine. Water was found inside almost all of these units

Figure A10
Due to corrosion, this striker Spring weighed only 0.09 g

Explosive components

Figure A11
Upper section of the casing removed to reveal the main charge; most were in good condition with little or no cracking or deterioration evident in the explosive. Although the inside of the plastic casing was wet, the cast filling contains very few voids

Figure A12
Booster pellets are composed of a pressed TNT/RDX (60/40) mixture and virtually all were in good condition. Despite the neoprene seal between the base of the fuze and the booster, all of the booster pockets contained water

Figure A13
The composition of the main charge is quoted as being TNT/RDX/aluminium (50/30/20) but, as shown here, the mixture is rarely homogenous. The aluminium content does not affect the detectability of the mine

Figure A14
The proportions of the constituents in the high explosive varied significantly; this sample contained no aluminium whatsoever. This is evidence that different material characteristics and specifications may be found within the same lot number

Figure A15
All of the C3B detonator assemblies examined were wet. The protective layer of clear plastic film over the stab receptor (right) did not provide an effective water-tight seal

Figure A16
Subjecting live fuzes to an operating load (>300 kg) using an excavator bucket did not produce any detonations. The most likely explanation is that the stab-receptive composition is no longer functional

Conclusions

14. All of the C3B mines recovered from SA064 appeared to be in good condition superficially, but all of the casings were cracked. The ingress and subsequent freezing of water is gradually causing the deterioration of the casings, but the effect is slow due to the small volumes of water and the flexibility of the plastic. The process is likely to accelerate as existing cracks enlarge and the plastic becomes more brittle.

15. The rate of deterioration has been slowed substantially by burial. Polystyrene is vulnerable to UV light and (according to observations made in the late 1980s) the casings of mines exposed to the sun had cracked badly within a year or two of exposure. Burial is also likely to reduce temperature gradients within the mines, minimising the expansion of explosive during hot weather and of water during freezing conditions.

16. There is little evidence of deterioration to the plastic of the fuze housing; it is therefore reasonable to expect that the operating pressure of most buried mines will still exceed 200 kg. However, mines that have been exposed to sunlight may be capable of functioning under far lower loads.

17. All fuze mechanisms appeared to be operational, despite the corrosion of some striker springs. Fuzes are likely to remain functional despite the deterioration of the striker spring.

18. The striker spring is the only metal component within the mine. The spring weighs less than 0.15 g when new and is positioned around 20 mm below the surface of the pressure plate; this makes its detectability marginal at best. If the striker spring is corroded, the metal content of the mine may be reduced or eliminated altogether, making it impossible to locate with a metal detector.

19. The explosive constituents of the main charge may vary, but this has little significance to the functionality of the mine. The booster and main charge remain intact while enclosed by the mine casing and solubility in ground water is low; the charges are therefore likely to remain viable for many years in buried mines.

20. Where C3B mines have been exposed to sunlight or have sustained mechanical damage to the casing, it is likely that the main charge and booster will gradually begin to crack and will eventually disintegrate.

21. Findings from the Ageing Study suggest that the primary explosive in the detonator is likely to remain viable for many years, being well protected by its plastic casing. However, the stab-receptive composition used to initiate the primary explosive is vulnerable to water and prolonged immersion appears to have rendered many of the detonator assemblies incapable of functioning as designed.

22. The ingress of water into the detonator is dependent on a number of factors and it is entirely possible that some remain capable of operating as designed. Those that cannot, but which still contain viable primary explosive, may be detonated by other influences, such as fire or impact.

ANNEX B

EXPLOITATION OF THE ISOLATED SB-33 ANTI-PERSONNEL MINE

Background

1. The SB-33 is a small anti-personnel mine with the following specifications (approximate):

Weight	140 g	Diameter	85 mm
Explosive weight	35 g	Height	30 mm
Explosive type	RDX/HMX (98/2)	Operating pressure	8 kg

2. The mine is extremely robust, with most of the components made from polycarbonate plastic; the fuzing mechanism is designed to be highly resistant to impact and shock. Some of the SB-33 mines recovered from SA064 are shown in ***Figure B1***.

Figure B1
SB-33 mines recovered from mine rows in SA064

3. The isolated mine found in SA064 (***Figure B2***) showed obvious damage, particularly to the base (***Figure B3***) where the detonator plug was cracked and a section of the mine casing had been broken away. The broken section of the base was found close to the mine body.

4. The primary purpose of exploitation was to gather evidence to support an explanation for this mine's presence outside the minefield rows, in addition to making it safe for disposal.

Figure B2
The SB-33 mine found in SA064

Figure B3
Base view of the casing

Findings

Figure B4

On initial inspection, the fuze and main charge appeared to be relatively intact. The ingress of water would not prevent the mine from functioning

Figure B5

Removal of the fuze plunger revealed that the several of the fuze components had been shattered and the striker displaced

Figure B6

Removal of the fuze components exposed the full extent of the damage

Figure B7

The detonator plug had also been shattered and could not be used to remove the detonator

Figure B8

The detonator was seized into place and surrounded by impacted explosive from the main charge

Figure B9

The main charge, normally a rigid horseshoe of pressed explosive, had been pulverised

Conclusions

5. The isolated SB-33 mine discovered in SA064 had clearly been subjected to a substantial amount of shock. This was evident in the shattering of fuze components made from polycarbonate (the plastic used in protective visors) and the pulverisation of the main charge.

6. Although the exterior of the mine casing showed no evidence of scarring from fragmentation, the internal damage is entirely consistent with the effects of a nearby detonation.

7. The damage to the mine, together with its displacement and the presence of a crater in the mine row, strongly suggest that this mine was thrown out by the detonation of an artillery shell during the conflict.

8. The mine was incapable of functioning as designed; however, the condition of the detonator means that it might have been in an unstable state.

9. The demining team and DPO were absolutely correct not to attempt to defuze or disassemble this mine.

ANNEX C

COMMENTS ON BOOBY TRAP REMNANTS

Background

1. Several booby traps (BT) were discovered during Phase 3, all being typical of the type laid by Argentinian forces during the conflict. Each consists of a simple firing device in which a spring-loaded striker is released by tension on a tripwire. The firing device is designed to initiate a percussion cap, which ignites a length of pyrotechnic fuze running to a detonator placed within the main charge. The main charge consists of TNT blocks.

2. The following booby traps have been located:

SA number	Number of BT found	Number of TNT blocks In each
064	2	31
095	2	6
095A	2	5

3. None of the firing devices associated with these booby traps have yet been located, but they are believed to be the type shown in ***Figure C1***.

4. Detailed exploitation of the booby trap remnants was not deemed to be worthwhile; however, some of the comments in the captions below are based on findings from the Landmine Ageing Study[1].

Figure C1

The firing device typically used with Argentinian booby traps. The tube contains a spring-loaded striker retained by both a pin and a shear wire; this allows for optional pull or pressure actuation. The striker initiates a percussion cap, which ignites a safety fuse link to the detonator in the main charge. The safety fuze is retained in the fuze holder by the screw on the side

Figure C2

The fuze holder with percussion cap removed. The cap unit is a standard 12 bore shotgun primer. Although robust, these are unlikely to remain functional after 30 years exposure to wet conditions

[1] Three year Landmine Ageing Study conducted by C King Associates Ltd in association with James Madison University under funding from US State Department, Office of Weapons Removal and Abatement (WRA)

Findings

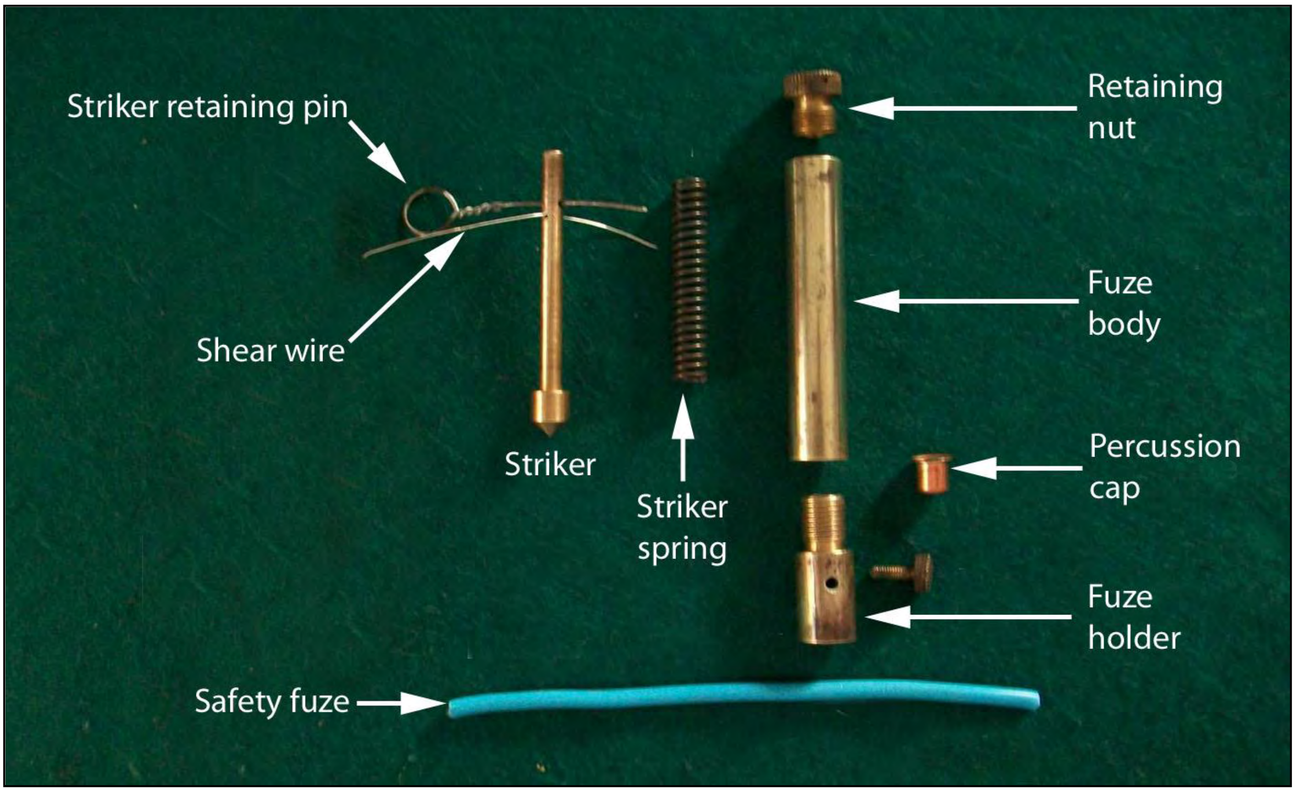

Figure C3

Components of the Argentinian firing device

Figure C4

TNT charges from a booby trap in SA064. These appear to have been 400 g blocks of pressed TNT, wrapped in waxed paper. Pressed TNT is deemed 'cap sensitive', meaning that it can be initiated directly by a No 8 strength detonator. The edges of the blocks have been eroded but the bulk of the explosive remains intact. Historical data on TNT suggests that it can remain capable of detonation for several decades

Figure C5

TNT blocks containing detonators and the remnants of safety fuzes. It is clear that any pyrotechnic composition in the fuse or detonator will be non-functional. However, findings from the Ageing Study (involving explosives of a similar type and age) suggested that the primary explosive in the detonator may be viable; this means that the explosive could be initiated by either fire or substantial impact

Conclusions

5. The booby traps found during Phase 3 were incapable of functioning as designed for the following reasons:

a. Firing devices were absent;

b. Even if firing devices had been present, data from the Ageing Study suggests that internal components (such as the steel striker spring) would be seized and incapable of functioning;

c. The shotgun primer used as the percussion cap is unlikely to remain functional after prolonged exposure to wet conditions;

d. The pyrotechnic compositions of the safety fuse and detonator flash receptor are vulnerable to water and were virtually unprotected for more than 30 years.

6. The Ageing Study suggests that the primary explosive within the detonator may still be capable of detonation. Initiation might arise from heat (such as a peat fire) or from shock (such as the impact from a flail hammer).

7. If the detonator functions, it is quite likely that TNT in contact will be initiated; this may, in turn, detonate other adjacent TNT blocks.

C King Associates Ltd

Demining Programme Office in the Falkland Islands – Technical Support 2010

Submitted by: **C King Associates Ltd**

Presented to the UK FCO

Foreign & Commonwealth Office

April 2010

TECHNICAL SUPPORT TO THE FALKLANDS DEMINING PROGRAMME

This report and the associated exploitation work was funded by the United Kingdom of Great Britain and Northern Ireland.

Aim

1. The aim of this report is to outline the technical support provided to the Falklands demining programme during the Austral summer of 2009/2010.

Technical support - general

2. The majority of the technical support provided fell into two categories:

   a. **Detection**; activities intended to enable the contractor to establish their detection capabilities against the minimum-metal mines.

   b. **Exploitation**; examination of recovered mines in order to observe the effects of aging and assess their implications.

3. A list of the main technical support activities undertaken is at ***Annex A***.

Metal detection samples

4. Technical support to detection began with an investigation into the metallic content of the mines likely to be encountered; this would enable an assessment of detectability and allow the 'worst case' to be identified.

5. Documentary research showed that the Spanish P4B anti-personnel (AP) mine and C3B anti-tank (AT) mine had the lowest metal content of those likely to be encountered. The two mines share a similar initiation system, with a small steel spring being the sole metallic fuze component. The location of this spring, which sits lower within the AT mine, suggested that the C3B would be the harder target to detect.

Figure 1: *The Spanish P4B anti-personnel mine, with safety cap to the left*

Figure 2: *The Spanish C3B anti-tank mine, with safety cap to the left*

6. The main charge of the P4B is normally covered with a foil made from lead alloy, although there was speculation that this might have been removed from some mines as they were laid[1].

7. It was not clear to what extent – if any - the presence of the foil would make the P4B more detectable. Nor was it clear whether the orientation of the mine would effect its detectability.

8. Some sample mines had previously been made inert or ‘Free From Explosives’ (FFE), however, the accuracy of their detection signatures was questionable. There was, therefore, a need for accurate surrogates.

9. Examples of inert mines held by C King Associates (CKA) were dismantled and the components accurately characterised, then compared to the documentary sources. A batch of 50 springs were then sourced from a specialist company, replicating the characteristics and specifications as accurately as possible[2].

10. Precise measurements were taken to gauge the distance from the top surface of the mine to the spring, and a test piece designed. Since the same spring is used in both the P4B and C3B mines, and the spring is symetrical around the horizontal axis, a single test piece could represent both mines. The off-set of the spring from each end of the test piece represented the location of the component within each mine. The resultant test piece is shown in ***Figure 3***.

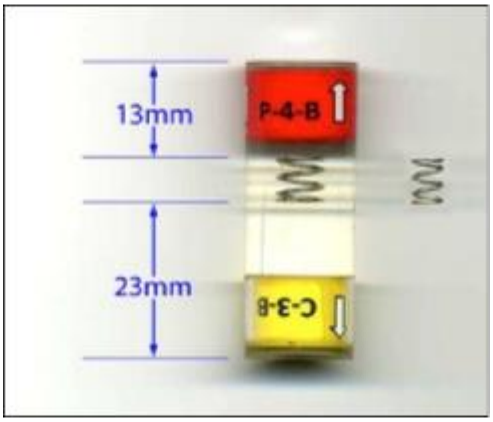

Figure 3

A detection test piece developed by CKA.

Note that in the image the spring inside the detection piece is magnified by the curve of the polymer surface making it appear larger than the free air example on the right. The two springs are actually identical

11. Eight test pieces were produced, six of which were immediately shipped to the Falklands (on 6 November 2009).

12. A number of springs were shipped direct to BACTEC UK (the clearance contractor) for incorporation into inert mines and use in their own detection testing.

13. Work on other programmes[3] had shown that corrosion could reduce – or even eliminate – the detection signature of metallic components. Samples of springs were immersed in a weak saline solution to assess their susceptibility to rusting; ***Figure 4*** shows the results.

[1] The first P4B recovered was indeed missing most of the lead foil, however, all remaining P4Bs were found with the foil still in place.

[2] Accuracy included correct steel type, spring mass to within two hundredths of a gram and all dimensions to within a tenth of a millimeter.

[3] Primarily CKA studies into the effects of aging on landmines, conducted on behalf of US State Department.

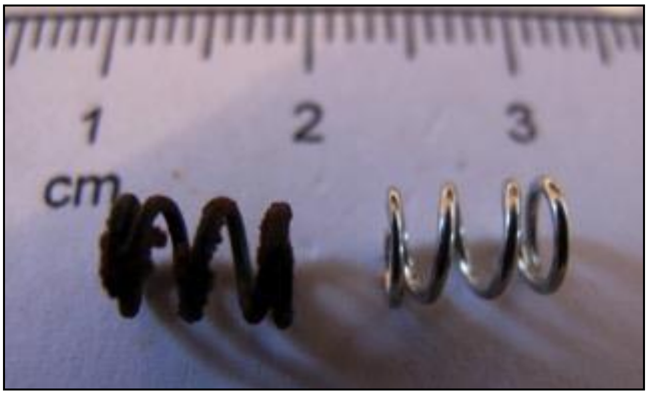

Figure 4

Corrosion testing.

Two springs of the type used in the Spanish P4B and C3B mines. The spring on the left has been immersed in weak saline solution for two weeks. The effect indicates that the spring is vulnerable to rusting, which might reduce its detectability

14. The conclusion of the corrosion test was that springs were likely to be heavily rusted if water had penetrated the fuze assembly. If so, the detection signature might be even lower, making the mine virtually undetectable[4].

Metal detection assessment

15. An in-depth assessment of detection capabilities began with a review of previous tests[5] - probably the most thorough and objective detection testing ever carried out and therefore provided a good overview of likely capabilities.

16. Early findings in the Falkland Islands matched the theoretical detection assessment reasonably well, however there were a number of variables that could not be taken into account. These included:

- The potential influence of the lead foil in the P4B;
- The performance of the Minelab 'yellow cap' enhancement;
- The effect of mines/components at different angles of incidence;
- The influence of an aluminised explosive filling on detection.

Radar detection samples

17. The clearance contractor had been asked to undertake some research on dual-sensor mine location using the Minehound detector. This would require targets with both the correct metallic content and an appropriate radar signature.

18. CKA had previously commissioned production of a microcrystalline wax specifically for this purpose. This wax has electrical and mechanical characteristics very similar to those of TNT, with a far higher melting point than normal wax and blue colouring to avoid any possibility of confusion with live explosive.

19. Several kilograms of the wax were carried to the Falklands, then moulded into the body of a C3B AT mine. The mine was then re-sealed and marked as inert for use in Minehound detection trials. The remaining wax was left with the Demining Programme Office (DPO) for filling AP mines, if required.

[4] In practice, very few fuzes had been penetrated by water; meanwhile, detection by instrument was ruled out (for this contract) due to the shallow detection depth achieved during tests.

[5] International Pilot Project for Technology Cooperation, dated October 2000

Mine exploitation

20. Samples of all three mine types recovered during clearance operations (P4B, SB-33 and SB-81) were disassembled in order to assess their condition. The examination did not encompass full exploitation, but focussed on:

a. Ability to function;
b. Detectability;
c. Trends in deterioration.

21. 14 P4B AT mines had been recovered from the Sapper Hill minefield and retained for the exploitation visit, while 17 SB-33 AP mines and 15 SB-81 AT mines were lifted from the Surf Bay minefields during the course of the analysis.

22. In addition to the points listed above, lifting the mines allowed examination of the immediate location in order to assess the effect on, or action of, the ground conditions.

23. Photos showing the recovery sequence for the Surf Bay mines (SB-33 and SB-81) are at ***Annex B***.

24. Key findings from the exploitation work are at the following annexes:

a. P4B: ***Annex C***
b. SB-33: ***Annex D***
c. SB-81: ***Annex E***

Creation of training aids

25. All of the mines recovered for exploitation were rendered inert, with all explosive components being sent for demolition. The inert mine casings were then marked with blue paint (the NATO colour code for inert munitions) and set aside as training aids for future operations.

Figure 5: *Inert Spanish P4B AP mines, with the wax-filled C3B body to the top left*

Figure 6: *Inert SB-33 and SB-81 mines awaiting final safety checks and marking*

Conclusions

26. The technical services provided by CKA covered a wide variety of functions, many of which had not been anticipated at the time of the original contract.

27. Most of the three types of mine examined appeared to be fully functional, with levels of deterioration well below those expected.

28. Examination of recovered mines will be an important component of future clearance operations, particularly since many of the remaining mines (such as those with steel cases or exposed steel components) are known to have deteriorated to a far greater extent than those encountered so far.

Recommendations

29. If possible, samples of target mines should be examined, well before clearance operations commence, in order to determine the most appropriate clearance techniques and equipment.

Colin King
Director
C King Associates Ltd

April 2010

LIST OF TECHNICAL SERVICES PROVIDED

Serial	Activity	Notes
1	Investigation of metallic content for the following mines: P4B, C3B, SB-33, SB-81	Involving documentary research and disassembly of inert mines to examine critical components
2	Sourcing of replica components	Procurement of springs and lead foil to replicate those used in the P4B and C3B
3	Corrosion testing	Investigating the vulnerability of P4B and C3B springs to rusting
4	Production of detection test pieces	Design and fabrication of double-ended test pieces to replicate the detection signatures of P4B and C3B mines
5	Provision of replica springs to the clearance contractor	Allowing the clearance contractor to complete their own surrogate test pieces
6	Investigation of detection capabilities against low-metal mines	Involving review of the Detection Pilot Project and discussions with detector manufacturers
7	Commissioning of report into detection capabilities	Locating an independent detection agency with access to the Minelab (yellow cap) and other detectors for comparison. Agreeing terms of reference and trial configurations
8	Provision of explosive substitute for C-3-B mine body (for Minehound trials)	Microcrystaline wax blocks were taken to the Falkland Islands and moulded into the body of an inert C3B
9	Exploitation of P4B, SB-33 and SB-81 mines	Involving the recovery, disarming, disassembly and examination of live mines
10	Creation of training aids	Removal of all explosive material from sample mines, followed by appropriate marking

THE MINE EXTRACTION PROCESS

Overview of the Surf Bay minefield

A clearance lane, with located mines to the right

Beginning extraction of an SB-81 AT mine

Turf was cut from above the mine

Cut turf was removed in blocks to expose the entire body of the mine

With the mine extracted, the underlying ground was photographed and examined

Extracted mines were disarmed immediately

A wet ditch containing a number of mines

An SB-33 AP mine under water

An SB-33 in relatively dry ground

The extraction process for the SB-33 was similar to that used for the SB-81

Disarming the SB-33 by unscrewing the detonator assembly from the base of the mine

EXAMINATION OF THE P4B

Figure 1

Figure 2

Most of the P4B mines examined showed little obvious sign of external degradation, with both the colour and the texture of the plastic casing appearing virtually 'as new' (Figure 1). However, the condition of some mines suggests that this initial visual impression may be misleading, and that all of the plastic casings are now beginning to deteriorate.

Many had some degree of root penetration between the underside of the fuze (Figure 2) and the mine body. This type of growth would not affect performance, although it is possible that further enlargement of the roots might eventually force the two assemblies apart, resulting in malfunction.

Figure 3

Throughout the course of the clearance operation, all but one of the P4B mines examined had the red lacquered lead foil present in fuze well. As the fuze assembly is fitted, this foil ruptures in unpredictable patterns (Figure 3). The shape of the ruptured foil is known to affect the return on short-wave radar and may also affect the signature with some metal detectors.

Figure 4

Figure 5

The P4B pressure plate shown in Figures 4 and 5 shows the type of long-term deterioration expected in ABS plastic. Increasing brittleness has caused fine cracks where the plastic is under stress; this has led to eventual failure, permitting the ingress of water. In most samples examined, cracking was not immediately visible; however, it is evident that the plastic is becoming more brittle and that all casings would eventually reach this stage. Previous studies have shown that such deterioration accelerates, since the effects (such as increasing the exposed surface area) make the material even more vulnerable to further degradation. Extensive tests would be required in order to assess the rate of degradation.

Figure 6

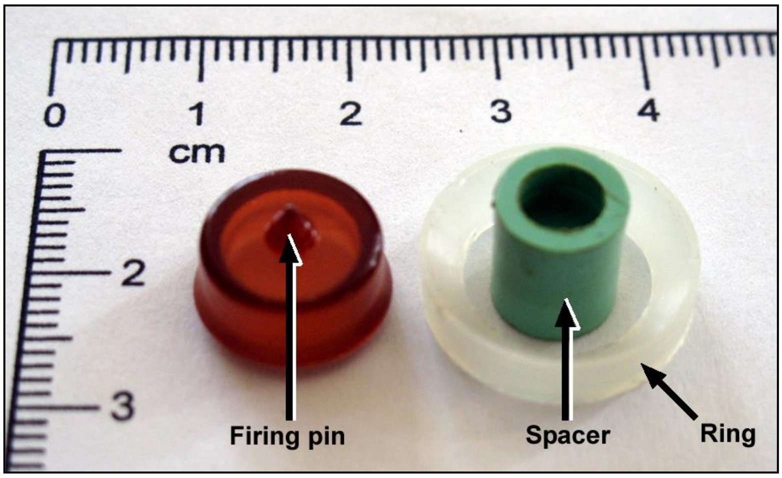

Figure 7

Even where water had penetrated the fuze assembly, the firing spring (Figure 6) was in remarkably good condition and remained fully functional. This was surprising, although, had the mines been nearer the coast, salt-water would probably have caused more extensive rusting. This would further degrade the detection signal from the small metallic mass.

It is important to note that the P4B can function regardless of the spring's condition. The firing pin is made from polymethylacrylate plastic, which is unlikely to deteriorate significantly within the foreseeable future. It is forced through a polythene ring by a spacer and this action alone may be sufficient to cause initiation without the additional impetus of the spring. These plastic components are shown in Figure 7.

Figure 8

Figure 9

The detonator assembly is bonded into the fuze body and has to be cut from the mine, as shown in Figure 8. The stab-sensitive receptor in the centre is covered by a thin plastic film (seen here having been cut using a scalpel) to keep it dry. A similar assembly, shown in Figure 9, was full of water.

Figure 10

The presence of water might prevent the stab receptor from initiating, since water-soluble compounds are used within the composition. This is likely to be the primary cause of failure for P4B mines in the near term.

As expected, the pressed TNT charges (Figure 10) were in good condition, despite many being wet. TNT is relatively stable, especially when protected from sunlight. This High Explosive (HE) content is likely to remain functional for the foreseeable future.

Conclusions

1. Most of the P4B mines examined appeared to be fully functional.
2. Deterioration of the plastic casings has begun, but – in most instances - is progressing at a far slower rate than expected. Most mines have retained their structural integrity.
3. The ingress of water into the fuze assembly has caused only minor deterioration of the striker springs. This will not significantly affect the detection signature or the mine’s ability to function.
4. The ingress of water into the detonator assembly may render the mine inoperative; this would need to be confirmed by testing.
5. The lead foil was present in all but one of the mines examined. The manner in which the foil splits (when the fuze assembly is fitted) may affect the detection characteristics of the mine. Determining this would require additional trials.
6. The TNT HE content is stable and well preserved.

EXAMINATION OF THE SB-33

Figure 1

Figure 2

Seventeen SB-33 mines were recovered from a mixture of dry and wet sites (Figures 1 and 2). None of the SB-33 mines examined showed signs of significant external degradation, other than a notable increase in the profile of the rubber pressure plate; this is clear from Figures 3 and 4.

***Figure 3**: An SB-33 recovered from the Falklands; note the domed profile of the pressure plate*

***Figure 4**: The normal appearance of the SB-33, with a relatively flat pressure plate*

The casing of the SB-33 is made from glass-reinforced polycarbonate and showed no indication of deterioration whatsoever. However, all of the recovered mines had been buried, and it is probable that the casings and rubber pressure plates would degrade more quickly after prolonged exposure to the sunlight.

Expansion of the rubber appears to be due to the material softening when wet, although it continued to be waterproof. As the rubber dried, the height of the dome reduced noticeably, but not to the original profile.

Examination of the casing and pressure plate showed that the upper sections of all of the mines had remained watertight. Where water had penetrated, this appeared to be because the detonator plug (to the left in Figure 3) had not been tightened sufficiently.

Figure 5

Figure 6

Mines were disarmed by unscrewing the detonator assembly from the base well (Figure 5); in most cases, this plug had been fitted tightly. Once disarmed, the two halves of the mine were unscrewed using a chain wrench (Figure 6) to access the internal components and main charge.

Figure 7

Figure 7 shows a recovered SB-33 disassembled. Most of the clear plastic internal fuze components are made from polycarbonate, and are therefore extremely strong.

Some casings were made from olive green plastic; others (including this one) were grey and merely painted green on the outside.

None of the internal components showed any mechanical damage. The main charge (RDX/HMX) was often cracked, but this would not affect performance.

Although the mines were generally well sealed, several were damp inside. In many cases this had caused very minor rusting of the striker spring (which is made from spring steel 'piano wire'). This superficial corrosion would have no effect on the performance of the mechanism, nor would it effect the detectability of the mine.

The firing pin is made from stainless steel and none of those examined showed any significant degree of corrosion.

Most of the aluminium detonator capsules were in good, functional condition (Figures 8 and 9), but some did show significant signs of corrosion; see Figures 10 and 11.

Figure 8*: Most detonator assemblies were in very good condition*

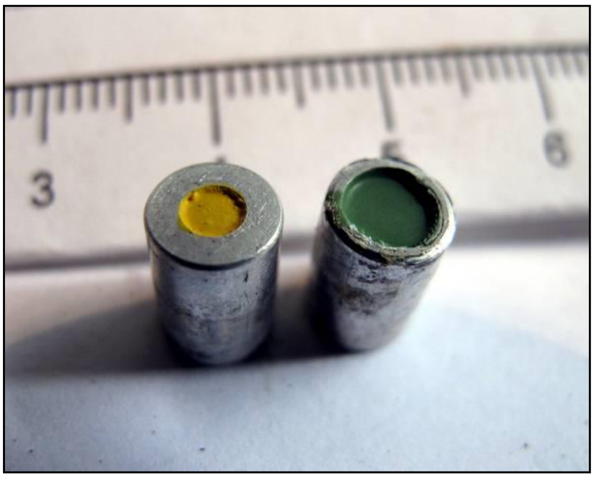

Figure 9*: The end seals of these detonator capsules show no signs of deterioration*

Figure 10*: Some detonator capsules did show significant signs of degradation*

Figure 11*: The yellow seal on the stab receptor appears to have been breached*

There was obvious degradation where detonator capsules had been exposed to water for prolonged periods. It is likely that this had breached the seals of the capsule, particularly the thin yellow membrane covering the stab receptor. This is significant because the stab-receptive composition is likely to be affected by water, which may cause the mine to malfunction.

Only one of the recovered SB-33 mines contained a significant quantity of water; this was caused by the detonator plug not being screwed into place sufficiently tightly. The most obvious result of the water ingress was the disintegration of the striker spring, which would probably prevent the mine's fuze mechanism from actuating and might also make the mine more difficult to detect. The detonator capsule was also substantially corroded and possibly non-functional.

The badly coroded mine (shown in Figure 12) demonstrates the longer-term fate of all SB-33 mines, as rubber seals gradually deteriorate and permit water to enter the mine.

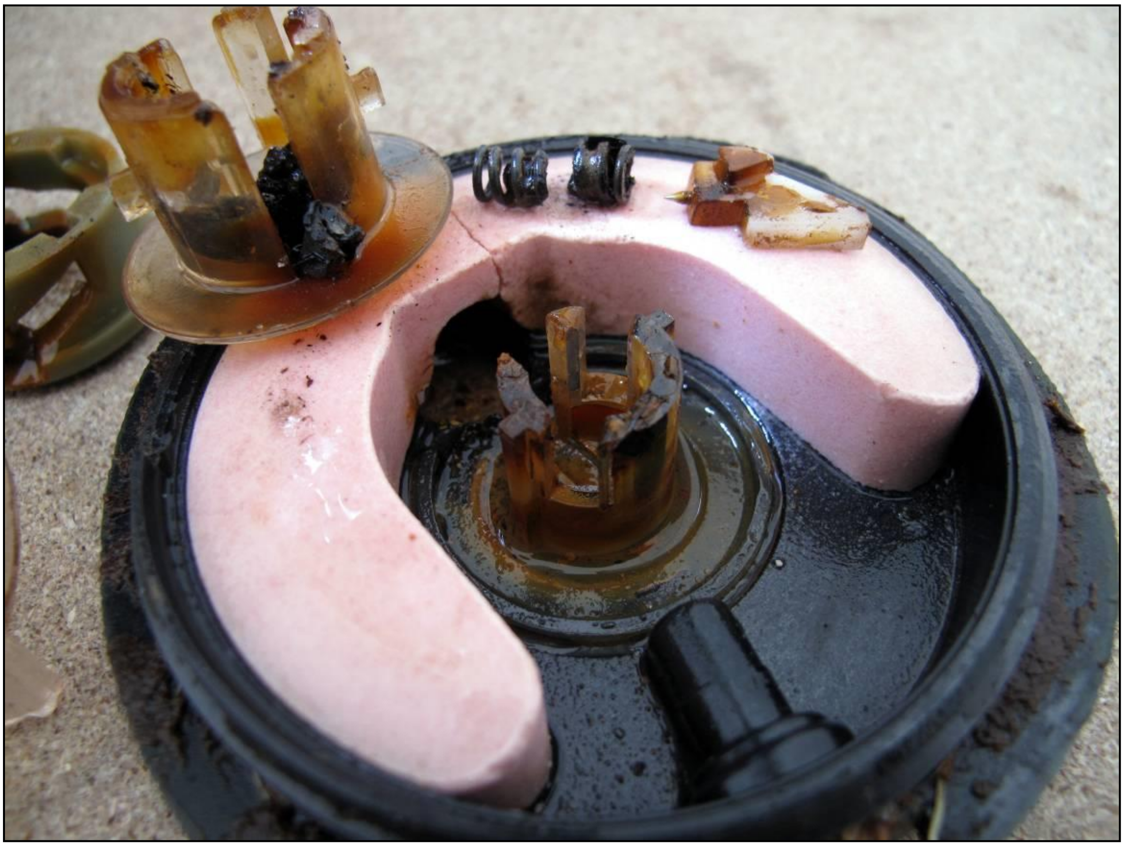

***Figure 12**: Inside an SB-33 which had been penetrated by water. The most likely cause of failure would be the disintegration of the striker spring, although degradation of the detonator capsule might also prevent the mine from operating. Note that the stainless steel firing pin is virtually unaffected*

Conclusions

1. Most of the SB-33 mines examined appeared to be fully functional.
2. The rubber pressure plates were distorted where the material appeared to have softened; this probably indicates the beginning of degradation that would eventually lead to failure.
3. Deterioration of the rigid mine casings was minimal and all of the mines examined retained their structural integrity.
4. Minor dampness inside the mines has caused only minor deterioration of the striker springs. This will not significantly affect the detection signature or the mine's ability to function.
5. Degradation of the detonator assembly, due to dampness, may render the mine inoperative; this would need to be confirmed by testing.
6. The HE charges are well preserved, despite some being cracked.
7. Where water had penetrated a mine, the striker spring and detonator capsule showed substantial deterioration; this would almost certainly have prevented it from functioning. In the long term, this is what could be expected to happen to all SB-33 mines in the Falklands.

EXAMINATION OF THE SB-81

Figure 1

Figure 2

Fifteen SB-81 Anti-Tank (AT) mines were recovered from a mixture of dry and wet sites (Figures 1 and 2). None of these mines showed signs of significant external degradation; in fact, their appearance was virtually 'as new', as shown in Figures 3 and 4.

***Figure 3**: An SB-81 recovered from the Falklands*

***Figure 4**: Base view of the SB-81*

The casing of the SB-81 is made from polycarbonate and showed no indication of deterioration whatsoever. Even the pressure plate, which is made from a polyester elastomer, appeared to be in pristine condition.

All of the mines examined had been buried in the ground and were not, therefore, exposed to sunlight. Polycarbonate is known to become brittle after prolonged exposure to sunlight, so it is probable that exposed mines would show more evidence of degradation.

Examination of the casing and pressure plate showed that all of the mines had remained watertight. Where there was evidence of moisture on the inside, as with the SB-33, this appeared to be because the detonator plug (shown in Figure 4) had not been tightened sufficiently.

Figure 5

Figure 6

With the halves of the casing separated, the internal components could be examined. Figure 5 shows upper section of the mine with the pressure plate removed to reveal the top of the fuze assembly. The seal around the edge of the pressure plate is critical to the pneumatic function of the fuze; this is a common point of failure among Italian AT mines. Although small roots were present on the outside (Figure 6) all seals were intact.

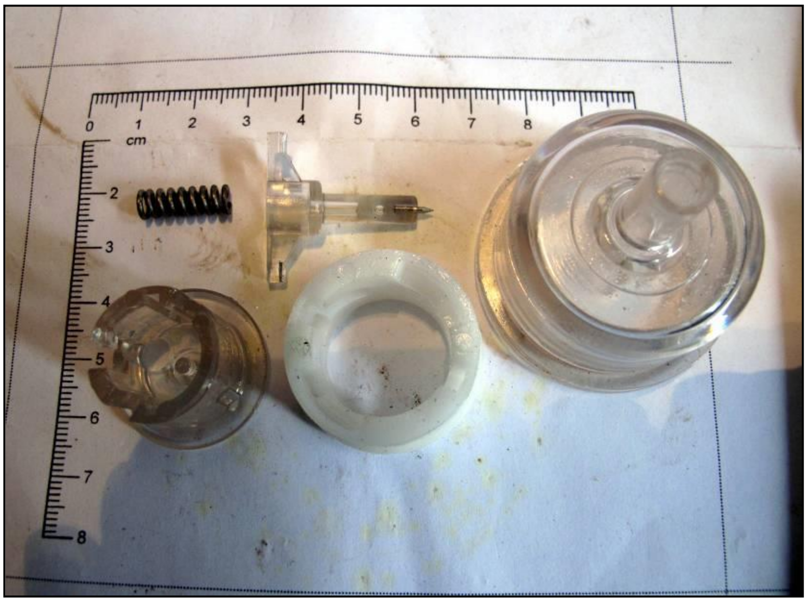

Figure 7

Figure 7shows the major components of the fuze mechanism. The fuze is similar to that used in the SB-33, with most of the clear plastic internal fuze components made from polycarbonate.

Not only were the components in perfect condition, but the thin layer of grease applied during manufacture was also present.

As with the SB-33 mines, the SB-81s were generally well sealed, but several were damp inside. In many cases this had caused very minor rusting of the striker spring (which is made from spring steel ‘piano wire’). This superficial corrosion would have no effect on the performance of the mechanism, nor would it effect the detectability of the mine. The firing pin is made from stainless steel and none of those examined showed any corrosion.

The main charge (approximately 2 kg of TNT/RDX/HMX) is encapsulated in plastic, while the booster (approximately 140 g of RDX/HMX/wax) is in the form of a pressed disc. These are shown in Figure 8. Removal of the plastic showed the main charge to be in perfect condition (Figure 9).

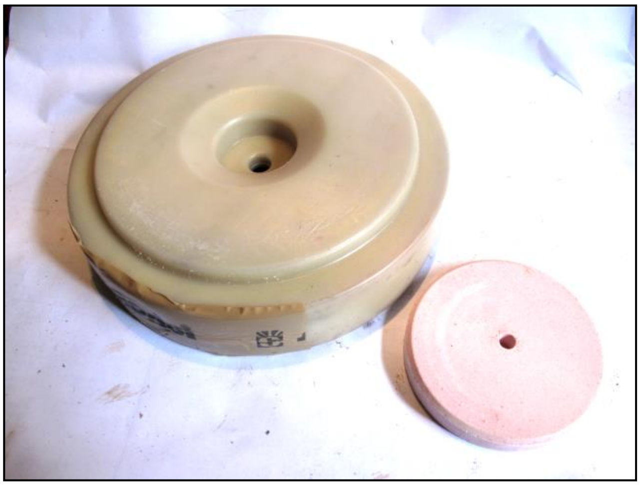

Figure 8*: The main charge and booster*

Figure 9*: The main charge casting*

Figure 10*: Some detonator capsules showed significant signs of degradation*

Figure 11*: The yellow seal on the stab receptor appears to have been breached*

The SB-81 uses the same detonator capsule as the SB-33, albeit in a different holder (Figure 10). Most were in good condition, but some, such as the one shown in Figure 11, showed obvious signs of degradation where they had bedome damp. It is possible that, in some cases, this had breached the seals of the capsule, particularly the thin yellow membrane covering the stab receptor. This is significant because the stab-receptive composition is likely to be affected by water, which may cause the mine to malfunction.

Since the casings have endured so well, the deterioration of detonator capsules represents the most likely cause of failure within the next few years. In the longer term, more water can be expected to enter the mines as rubber seals gradually deteriorate. In addition to affecting the detonators, this will also corode the striker springs and cause failure of the fuze mechanism.

Where mines are exposed to sunlight, the elastomer pressure plate is likely to become brittle, causing the seal around the shoulder to fail. When this is no longer air-tight, the pneumatic actuation system becomes incapable of operation. Deterioration of the thin diaphragm which bears on the fuze mechanism will have a similar effect, rendering the mine incapable of functioning as designed.

Conclusions

1. Most of the SB-81 mines examined appeared to be fully functional.
2. The mine casings showed no signs of deterioration; however, prolonged exposure to sunlight is likely to cause degradation that would eventually lead to failure.
3. Minor dampness inside the mines has caused only superficial rusting of the striker springs. This will not significantly affect the detection signature or the mine's ability to function.
4. Degradation of the detonator assembly, due to dampness, had occurred in some mines and might render the mine inoperative; this would need to be confirmed by testing.
5. The HE main charges and boosters were in good condition.
6. The SB-81 is one of the most resilient mines ever made, and is likely to remain a threat in the Falkland Islands for the foreseeable future.