Greater Cambridge Partnership

CAMBOURNE TO CAMBRIDGE

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Countryside Properties

Desk Study for Potential Unexploded Ordnance Contamination

Bourn Airfield

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Countryside Properties

Desk Study for Potential Unexploded Ordnance Contamination

Bourn Airfield

Prepared by:
Rhys Pearson

Reviewed & Authorised by:
David Denman

11th September 2017

RPS Explosives Engineering Services

Riverside Court
Beaufort Park
Chepstow
Monmouthshire
NP16 5UH

Suite A, Kings Point House
5 Queens Mother Square
Poundbury
Dorset
DT1 3BW

Tel +44 (0)1291 621 821
Fax +44 (0)1291 627 827
Email denmand@rpsgroup.com

Quality Management

Prepared by:	Rhys Pearson
Proof Checked by:	Violet Storey
Reviewed & Authorised by:	David Denman
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RPS Energy

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Executive Summary

Risk Assessment

Based on the risk assessment undertaken and the factors below, it has been determined that there is a **Moderate** risk from UXO at the site.

During WWII, the site was an operational RAF airfield. Military personnel would have been present across the area with reports of defensive positions such as pillboxes known to have been present at the time. As such, it is considered the potential for infantry munitions to be present across the site.

Further to this as the airfield was occupied, it is likely it would have had some form of anti-aircraft defences. Whilst no specific locations have been identified within the bounds of the site, several batteries have been identified in the area. As such, it is considered there is the potential for unexploded projectiles to have been dropped / landed on the site.

Bombs are known to have been dropped on the airfield by enemy planes and whilst the area was occupied by military personnel, sections of the site were covered by woodland. As such, it is considered that there is the potential for air dropped weapons to have landed in areas of the site and gone unnoticed.

Bomb stores are known to have been present on the site during WWII however; it is considered highly likely these would have been removed, along with the ordnance housed therein, once the airfield became inactive.

WWI Bombing: No specific records of WWI bombs having landed within the site bounds have been identified. Given the relative quantities of these bombs having been dropped in the area, the chances of encountering such an item during works are considered highly improbable. However, due to the fact bombs were dropped on Cambridgeshire, it is prudent to maintain an awareness of this source of UXO contamination.

Military Positions: Records of defensive positions associated with the airfield have been identified although their specific locations are at this time unknown. Given the military nature of the site, it is considered these would have been occupied by personnel with live munitions who would also have been traversing the site. As such, there is the potential to encounter infantry munitions across the site.

AAA: While no evidence of AAA positions having been stationed directly on the site has been uncovered, it is possible that given the nature of the site during WWII, i.e. a military airfield, there were positions located within the bounds. Given that the airfield was attacked on several occasions, it is likely these positions were also in use. Further to this, several AAA positions are known to have been present in the vicinity. As such, it is considered that there is the potential for unexploded projectiles to have landed/been dropped within the bounds of the site.

WWII Bombing: Several bombing raids have been identified which took place in the area of the site; however, RPS has been unable to identify bomb census maps that cover the site. As such, the specific locations of bomb strikes are unknown.

Whilst it is considered that items directly associated with strikes recorded pose little or no threat to the proposed works, these records highlight the potential for further bombs to have landed within the area.

WWII Access: During WWII the site was occupied by a military airfield. As such, it is considered plausible that large disturbances caused by UXO landing on the site would have been noticed and investigated / removed at the time as a priority.

This said, smaller disturbances may have been dismissed and areas of the airfield were also wooded thus increasing the possibility of disturbances / entrance holes being missed entirely.

Further to this, as the airfield was attacked, the possibility of damage from UXO being dismissed as damage caused by UXO that functioned / said damage masking further entrance holes should be borne in mind.

Post WWII Development: Since WWII the site has seen some development with the removal of numerous WWII era buildings. The fields have reportedly been returned to agriculture although certain areas remain wooded. No large scale ground works appear to have taken place across the site since WWII.

Recommendations for Future Intrusive Works

Based on the assessed risk, the following mitigation is recommended to be implemented in support of works taking place across the site:

- Explosives Safety & Awareness Briefings / Site Safety Guidelines,
- Explosives Safety Consultancy on Call.

All Areas of Intrusive Works

- Intrusive Magnetometer Survey ahead of Piling / Boreholes if/where practical,
- Explosives Site Safety Support for Excavations,
- Safety & Awareness Briefings / Site Safety Guidelines.

1 Introduction

1.1 Instruction

RPS Explosives Engineering Services (*RPS EES*), part of RPS Energy Consultants Ltd, has been commissioned by Countryside Properties (*CPPLC*) to conduct a desktop study for potential Unexploded Ordnance (*UXO*) contamination at a site known as Bourn Airfield in Cambridgeshire.

1.2 Scope of Work

The purpose of this study is to assess the likelihood of buried historic air delivered ordnance and/or unexploded ordnance (*UXO*) related items to be present within the footprint of the site. Moreover, to then evaluate the implications of potential items during any future land use.

The site is considered to offer a potential explosives risk based on the following:

- ***Enemy Bombing:*** Great Britain sustained widespread aerial attacks during historic German air raids, and as such there is the potential for aerial delivered ordnance to have been deployed in the area local to the site,
- ***Anti-Aircraft Artillery (AAA) Shells:*** AAA Batteries were used in the defence of key strategic positions during WWII. If projectiles were fired in the surrounding area and failed to explode they could have landed in the vicinity of the site,
- ***British Military Munitions:*** The potential for the airfield to have been used by the British Military during WWII will be assessed. There is the potential for munitions originating from this source to have been left within the bounds of the site.

1.3 Definitions

The term 'site' refers to the area encompassing the extent of the works associated with the Bourn Airfield project. This report will generally focus on activities that occurred on site and its immediate surroundings. A location map is presented at *Appendix 001*, which details the extent of the site. Selected terminology referred to throughout this report is presented at *Appendix 002.*

1.4 Reporting Conditions

It must be emphasised that a Desk Study can only indicate the potential for UXO related items to be present on site, and, dependent on the information identified throughout the Desk Study Process, further UXO mitigation may be advised / recommended prior to / in support of any future redevelopment and/or works on site. Any such recommendations are discussed later in this document. It should be noted that any recommendations made may need to be altered, or further mitigation may be advised, if information outside of that already covered within the Desk Study subsequently comes to light. This desk study did not involve any non-intrusive survey or intrusive site investigation works.

Our appraisal relies on the accuracy of the information contained in the documents consulted and that RPS EES will in no circumstances be held responsible for the accuracy of such information or data supplied.

Records of air raids, bomb damage, casualties and the locations of UXB were rarely released into public domain in the interest of national security. Furthermore, details relating to these records are often difficult to locate. The records compiled were only as detailed and accurate as the availability of time, personnel and the ease of access to information would allow. Densely populated areas, such as those associated with major cities, tended to have a greater number of records than those produced for the more provincial, or rural areas. Official records were often supplemented by press reports and local information.

This source of information was sometimes discredited as being inadvertently inaccurate, or purposely made inaccurate, in order to confuse enemy intelligence. Even the accuracy of classified official records is somewhat dubious.

This stance has been borne out by the amount of unrecorded German UXO and part exploded ordnance discovered since 1945.

1.5 Objectives

The primary objective of this document is to ensure the safety of personnel and civilians in the vicinity of the site with regard to any impacts from potential UXO contamination and to identify the potential risk of uncovering either buried unexploded ordnance or explosive devices. Research into the history of the site, and its immediate surroundings, has been undertaken to establish the following:

- Frequency and intensity of WWII bombing raids,
- Bomb impacts and associated damage,
- Review of military activity in the area,
- Records of Explosive Ordnance Clearance tasks or bomb disposal activities during and after WWII,
- The potential for UXO to remain on site,
- Site-specific assessment of the penetration depths of UXO to determine the risk horizon on site.

The main sources of information consulted are presented at *Appendix 003*.

1.6 Legislation

Whilst undertaking this desk study the requirements of a number of legislations have been borne in mind, as presented at *Appendix 004*.

2 Site Details and Description

2.1 Site Location and Description

The Bourn Airfield site is located in Cambridgeshire between Highfield Caldecote and Great Cambourne. The site itself is bound to the north by the A428, the west by a road known as Broadway, the east by open ground and residential gardens and to the south by fields.

The site measures 270ha, is currently occupied by runways in various states of repair, small buildings and open fields. The surrounding area is generally rural although settlements are present.

A map indicating the location of the site is presented at *Appendix 001*.

2.2 Proposed Scheme of Work

RPS EES is currently unaware of the exact nature of the works to be undertaken on site but believes that intrusive works across the site are likely to take place. As such, there is the potential for UXO to be found during operations both above and below the surface.

2.3 Geology

One of the most important factors in assessing the maximum ordnance penetration depth is to establish the site geology. The ground conditions will predominately determine the path of ordnance. Furthermore, the consistency and thickness of any pre WWII made ground should be considered, as this would have the potential to significantly limit the penetration. The ordnance penetration calculation will be discussed later in this report.

RPS EES has not been provided with site specific geotechnical data at this point although has been informed that:

"The bedrock comprises waves of gault and chalky clays creating landscape diversity in the lowland areas around the site as acidic and alkaline materials coincide. This bedrock in the airfield area has been obscured by the actions of glacial retreat: a large deposition of boulder clay has created a total distinctive upland area."

2.4 Historical Site Conditions

RPS EES has been informed that "*the site was farmed until the Second World War when it was deemed an ideal location for a Ministry of Defence airfield, housing Bomber Command from 1940 until 1948. The last of the land was sold for farming in 1961, although a small part of the airstrips remain in use today.*

In 1950 the current landowners – the Taylor family - began to farm the land and at that time the airfield still had most of the runways, taxiways, pill boxes, hangars, barracks, air-raid shelters and ancillary buildings. Over time these have been removed, land leveled and returned to agriculture, but the standard of restoration has been haphazard and a legacy of problems exist. These centre on soil disturbance and problems of drainage."

RPS EES has reviewed aerial imagery from 1945 that covers the site. This imagery clearly shows the airfield in situ although no aircraft are apparent. Several outbuildings are present across the site with no apparent damage visible. Areas of worked fields and wooded land are present within the bounds of the site in the imagery. The image has been presented at *Appendix 005.*

3 British Military Impacts / Sources

3.1 General

The following sections present information identified relating to the various types of military positions typically found historically around areas of the UK during periods of war. Further information regarding relevant types of positions can be seen at *Appendix 006*.

3.2 WWII Defensive Positions

As outlined earlier in this report, the airfield had its own defensive pillboxes, barracks and air-raid shelters.

RPS has reviewed historical data and has found records of defensive positions situated in the wider area of the site. These positions included a Pillbox 2.9km north west and a further pillbox 6.2km north east of the site.

Due to the fact there were positions located within the bounds of the airfield, it should be considered there is the potential for UXO originating from this source to be present within the site bounds.

3.3 WWII Anti-Aircraft Artillery (*AAA*) Positions

Numerous Heavy Anti-Aircraft (*HAA*) Artillery positions have been identified in the vicinity of the site. The closest of the positions lies approximately 5.7km north east of the site north west of Cambridge. Several further positions were located in and around Cambridge to the east with a further position located at 'Sandy', 9.5km south west.

Given the military background of the site, the presence of Light Anti-Aircraft Artillery (*LAA*) cannot be ruled out as they were often placed at or near airfields. However, due their mobile nature the locations of these weapons changed regularly and weren't always logged.

Given the number of positions in the wider area, RPS considers it possible that, given the distance to the site, munitions fired from these positions may have landed unexploded within the site bounds.

At this time, no records of 'Z' rocket batteries in the direct vicinity of the site have been identified.

3.4 Military Presence / Training

Having consulted historical records, RPS has not found any evidence of historic training areas in the direct vicinity of the site.

With this in mind, RPS doesn't believe there would be a legacy of UXO arising from this source on site.

3.5 Airfields

RPS has consulted historical records and has found numerous WWII era airfields situated around the area of the site. Besides RAF Bourn, Caxton Street, Gransden Lodge, Gravely, Oakington and Cambridge were all in the vicinity.

Given that the site is located upon a WWII airfield, it should be considered that there is the potential for UXO to be present due to the nature of the activities taking place there.

3.5.1 RAF Bourn

It is unknown when the first aircraft began using Bourn but it is known that planes from Wellington and Oakington landed at the airfield in the summer of 1941.

It is recorded that bombs fell on the airfield on the 09th April 1941 and as such, it is known the airfield was in place at this time. Indeed, three bombs reportedly hit a runway during the attack.

A further attack took place on the 23rd May 1944 when an intruder bombed and strafed Bourn. Two aircraft were damaged during the attack.

The airfield was used by bombing aircraft during the war with numerous squadrons spending time at the location. It is known that the bomb stores were located on the south-east side of the airfield, in the 'Bucket Hill Plantation' section of the airfield. This location is highlighted in a 1944 sketch drawing of the airfield at *Appendix 007.* Fighter aircraft also used the airfield although later in the war.

The airfield was also used to repair aircraft and a hangar was established in the north east of the site by SEBRO Ltd. Those lightly damaged were able to fly in and fly out relatively quickly whereas those with greater damage arrived by road.

The airfield was place on maintenance in 1947 and was closed in 1948; the land was sold on in 1961. It is reported that most of the dispersals have been removed and most of the airfield is farmland. It is considered highly likely the bombs once stored on site were removed once the airfield became inactive and thus unlikely any remain at present.

3.6 Decoy Sites

In the early years of World War II there was a sophisticated system of decoy sites all over the country with the aim of diverting air attacks away from the major cities and important targets. In the event of an imminent air raid, beacons were lit at the decoy sites; these were sometimes successful in fooling the Luftwaffe bombers into thinking that it was their intended target, and they dropped their bombs harmlessly in unoccupied areas.

Several decoy sites were located around the site during WWII, the nearest being 4.1km south of the site at Great Eversden.

3.7 Munitions Production Facilities

No evidence of historic munitions production facilities has been identified at, or directly adjacent to the site. As such, it is considered unlikely that UXO from this source would be present within the site bounds.

4 German Aerial Bombing

The following sections present the relevant information that has been identified with regard to German Aerial Bombardment of the UK during historic periods of wartime. Further supplemental information regarding these periods and the sources of information consulted are presented in the relevant appendices. Basic overviews of the WWI and WWII bombing campaigns against the UK are presented at *Appendix 008*.

4.1 WWI German Bombing

Having consulted historical records, whilst it is known that Cambridgeshire was subject to bombing during WWI, no specific records of bomb strikes have been identified on, or in the direct vicinity of the site.

Given the relatively low density of WWI bombing, the chances of encountering items from this period are considered highly unlikely. However, it is prudent to maintain an awareness of this source of UXO contamination.

4.2 WWII German Bombing

4.2.1 German Bombing Targets

RPS EES has reviewed several sources, and based on the information available consider that the following may have been targeted by the Luftwaffe:

- ***Airfields:*** As shown above, there were numerous military airfields in the area during WWII. In particular, the presence of RAF Bourn attracted enemy bombers to the direct location of the site,
- ***Anti-Aircraft Defences:*** As reported above, there were AA positions located in the area in an attempt to minimise the Luftwaffe aerial threat. These AA positions would have been specifically targeted by the Luftwaffe in order to allow German bombers safe passage,
- ***Railway Infrastructure:*** Railway lines were essential for the transport of people, goods and weapons throughout WWII, and as such the Luftwaffe often targeted significant railway lines in an attempt to cause as much hindrance as possible to the war effort.

4.2.2 Details of Air Raids

Classified records, Local Government reports, Air Raid Precaution (*ARP*) reports and RPS archive documents relating to local air raids have been examined. It should be noted that air raid records in no way constitute a full account of the air raids that may have occurred during the war period. Details of identified air raids against the area of the site during WWII are presented at *Appendix 009*. These records show that the airfield itself was attached on several occasions.

4.2.3 WWII Bomb Census Mapping

Having checked sources, RPS EES has been unable to identify bomb census mapping covering the site itself. As such, whilst bombs are known to have fallen on the site, the specific locations (*beyond descriptions in text*) are unknown.

5 Potential Ordnance Details

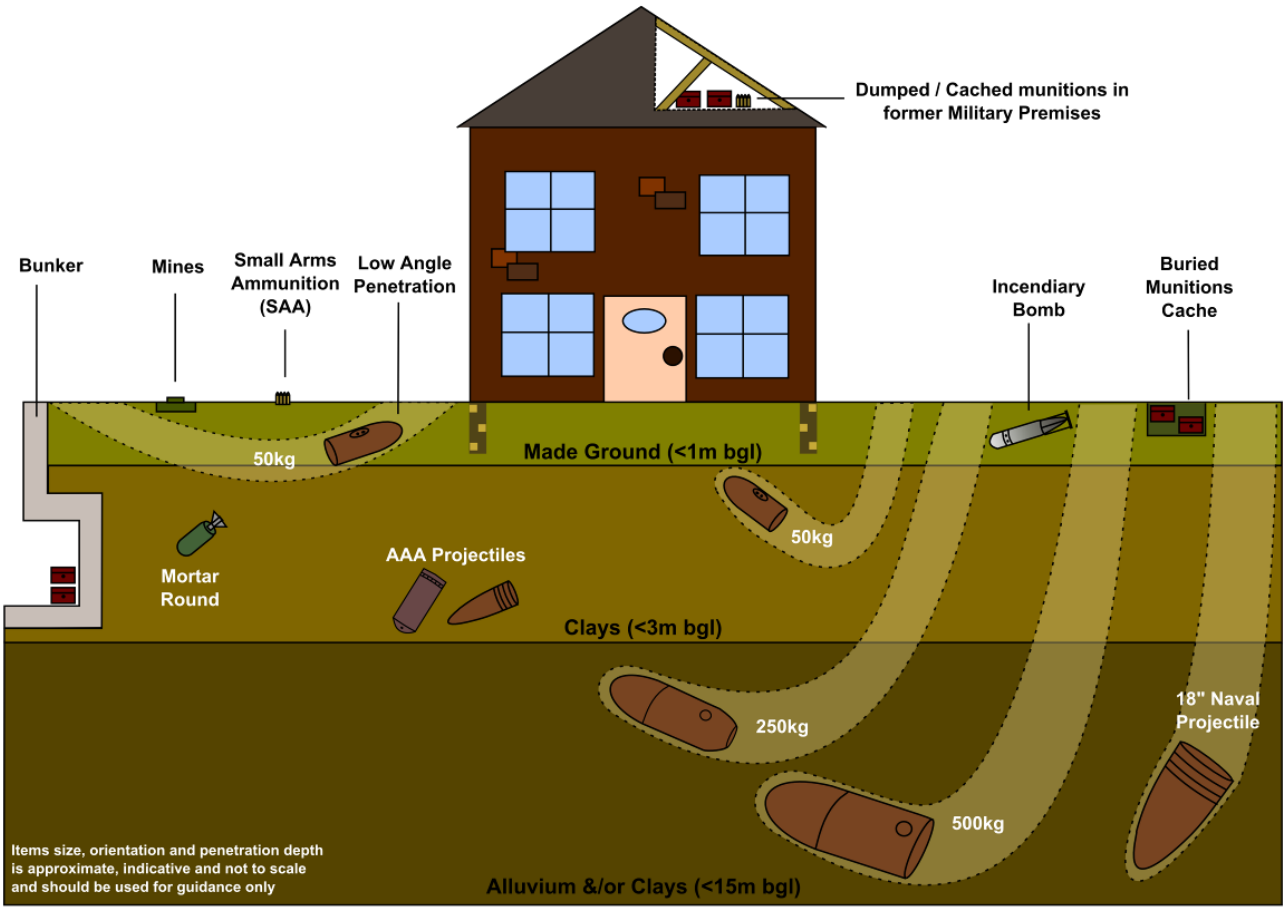
Based on the information gleaned at this juncture RPS EES considers that the following types of ordnance have the potential to have been utilised on, or in the vicinity of the site:

- ***German High Explosive Aerial Delivered Bombs*:** Description and examples are presented at *Appendix 010,*
- ***German Aerial Delivered Bomblets*:** Description and examples are presented at *Appendix 011*,
- ***British Anti-Aircraft Artillery Shells / Projectiles*:** Description and examples are presented at *Appendix 012,*
- ***British Land Service Ammunition / Small Arms Ammunition:*** Description and examples are presented at *Appendix 013.*

6 Risk Horizon

6.1 General

The risk horizon at a site will depend on the expected types of ordnance to be encountered and the manner in which they may have been deposited at the site. The following diagram provides a basic simplified overview of the 'zones' within the ground where different types of ordnance may typically be encountered at onshore sites within the UK:



6.2 Site Specific Ordnance Penetration Assessment

RPS EES typically assesses the bomb penetration for sites based on the typical penetration depths for a 500kg German SC bomb. When assessing the potential for ordnance ground penetration it is essential not to rely solely on either an empirical, statistical and arithmetical formula. Experience has shown that a realistic depth is gained by considering the above approaches supplemented by accounts of Bomb Disposal Tasks.

Background information on Bomb Penetration Depths can be found at *Appendix 014.*

It should be noted that the bomb penetration at the site would have been significantly deeper for bombs larger than this; however, comparatively, only a limited number of devices larger than 500kg were utilised during WWII bombing missions.

6.2.1 General Purpose / High Explosive Bombs

As mentioned earlier in this report, RPS EES has not currently been provided with site specific geological / geotechnical information and as such a site specific bomb penetration assessment cannot be undertaken at this juncture. However, should mitigation be required on site, where applicable and possible, the bomb penetration depth may be able to be assessed by UXO personnel in attendance, on a location by location basis, when the sub surface strata become exposed.

Penetration depths detailed relate to the depths below ground level at the time of WWII. If levels have changed significantly since WWII, this could have an effect on the likely depths that unexploded ordnance could be present relative to current ground levels in the area of the site.

7 Regulatory Authority Data

7.1 Abandoned Bomb Register

RPS has been provided with a database held by the Home Office which details abandoned bombs located throughout the UK. The list has been compiled from various sources and details items that have been abandoned but, importantly, also those that have since been removed.

Having consulted this database, it appears that no records exist within the bounds of the site or in the immediate vicinity.

This record isn't considered to pose a risk to the site itself but its presence is evidence that UXO fell in the area.

7.2 MoD Explosive Ordnance Disposal (*EOD*) Archives

RPS EES has received a response that states that the archives are no longer able to respond to requests for archive searches. RPS has been advised that an official Freedom of Information (*FOI*) request should be made in order to attain the information at this juncture.

At the time of issue, RPS has outstanding FOI requests issued to the MoD, through the overarching MOD Information Rights Team, and as such is unable to make further requests. If required by the Client, RPS can make an official FOI request upon completion of outstanding requests.

8 UXO Contamination Risk Assessment

8.1 General

Risk assessment is a formalised process for assessing the level of risk associated with a particular situation or action. It involves identifying the hazards and the potential receptor that could be affected by this hazard. The degree of risk is associated with the potential for a pathway to be present linking the hazard to the receptor. This relationship is usually summarised as the Source – Pathway – Receptor.

8.1.1 Unexploded Ordnance Detonation Characteristics

Since the end of WWII, there have been a limited number of recorded incidents in the UK where ordnance have detonated during engineering works, though a significant number of bombs have been discovered. Information and discussion pertaining to the UXO detonation characteristics can be seen at *Appendix 015*.

8.2 Sources / Hazards

Previous sections of this report have highlighted a number of activities that are known to have occurred on / around the site. The following sections will assess if they have the potential to cause significant explosive ordnance contamination.

Source of Contamination	Contaminate
German Bombing	High Explosive Bombs
	Incendiary Bomblets
British Anti-Aircraft Artillery	Primarily 3”, 3.7”, 4.5” and 6” Projectiles
British Bomb Stores	High Explosive Bombs
British Infantry Munitions	SAA, LSA

Table 8.2 Sources of Contamination

8.3 Pathway

The pathway is described as the route by which the hazard reaches the site personnel. Given the nature of the site and the proposed developments, the only pathways would be during:

- Enabling Works,
- Intrusive Site Works (*Piling etc*.),
- Demolition,
- Excavations.

8.4 Receptors

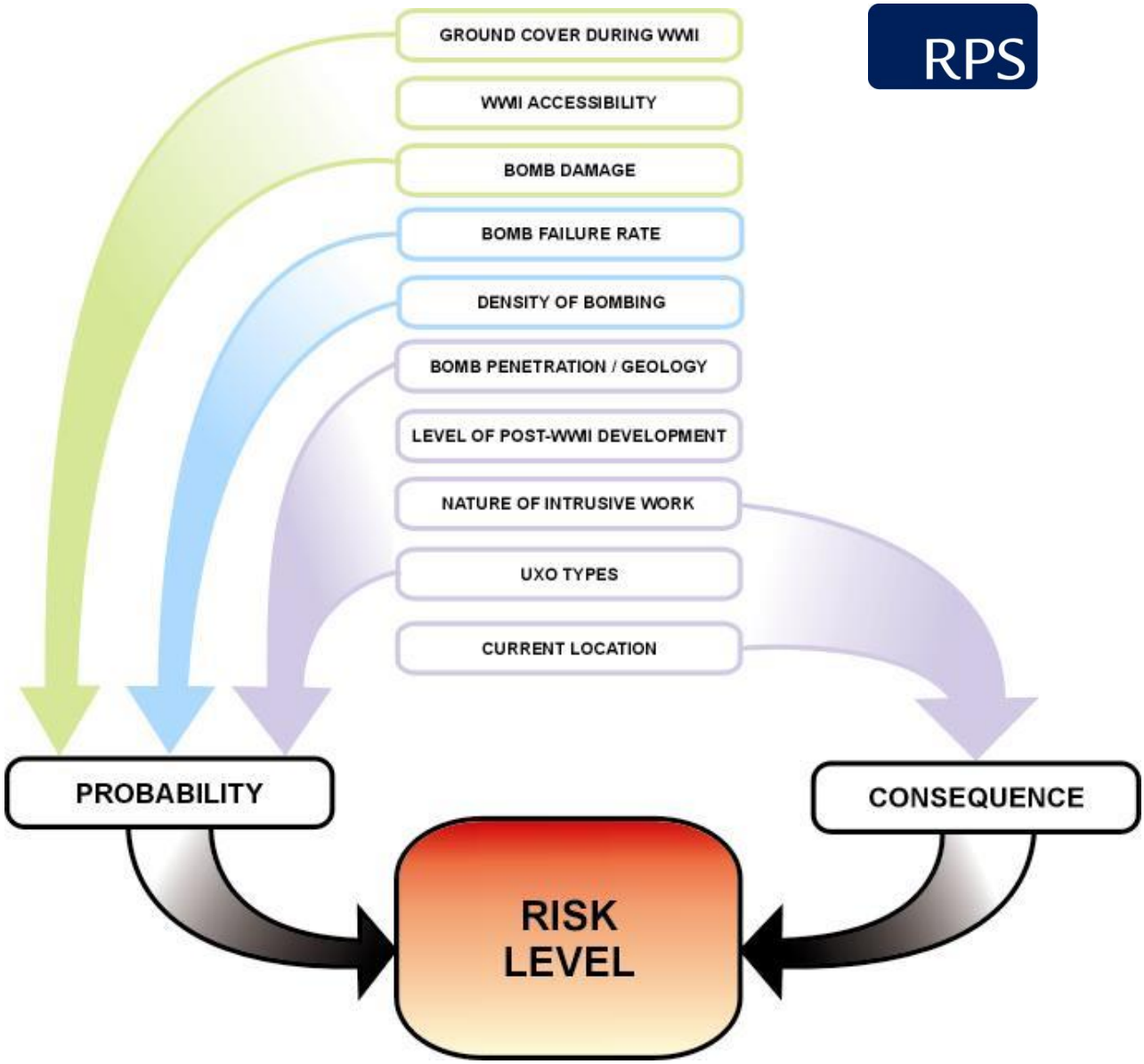
Sensitive receptors applicable to this site would be:

- People (*Site Personnel, Construction Works and General Public*),
- Plant and Equipment,
- Structures (*Including existing buildings and nearby properties*),

- Environment.

8.5 Risk Assessment

The following sections contain the risk assessment for the site, prior to the implementation of any risk mitigation measures. For the risk to be properly defined, several factors have to be taken into account, including the consequences of initiation and the probability of encountering UXO on site. The technique used to assess level of risk is detailed in the diagram below:



8.5.1 Risk Assessment Matrix

In order to identify an appropriate risk mitigation strategy for the works it is now necessary to complete a semi-quantitative assessment of the identified risks.

Once the factors detailed above have been assessed for the site, the consequence level is obtained from the table presented in *Appendix 016*, which provides a consequence rating from 1 to 5, depending upon the severity. The probability is also deduced and given a rating between 'Improbable' and 'Almost Certain'. These two ratings are then combined to determine the final risk levels to the proposed site works from the various threat items, using the risk matrix in *Appendix 016*, taking into account the potential UXO threat items as detailed earlier.

Following is the risk assessment for the site prior to the implementation of any risk mitigation measures:

Contaminate		Hazard	Potential Pathway		Potential Sensitive Receptors	Probability of Encounter*	Consequence of Initiation*	Final Risk Level
German	Incendiary Bombs (excluding 2kg with Explosive Nose)	Heat	Surface Activities	Enabling Works	Site Personnel, General Public, Engineering Equipment, Existing Buildings & Infrastructure, Environment.	1	2	N
			Intrusive Activities	Excavations		2	3	L
				Piling / Boreholes		2	3	L
	HE Bombs	Blast, Fragmentation	Surface Activities	Enabling Works	Site Personnel, General Public, Engineering Equipment, Existing Buildings & Infrastructure, Environment.	1	5	L
			Intrusive Activities	Excavations		2	4	M
				Piling / Boreholes		2	4	M
British	AAA Rounds	Blast, Fragmentation	Surface Activities	Enabling Works	Site Personnel, General Public, Engineering Equipment, Existing Buildings & Infrastructure, Environment.	1	5	L
			Intrusive Activities	Excavations		2	4	M
				Piling / Boreholes		2	4	M
	HE Bombs	Blast, Fragmentation	Surface Activities	Enabling Works	Site Personnel, General Public, Engineering Equipment, Existing Buildings & Infrastructure, Environment.	1	5	L
			Intrusive Activities	Excavations		1	4	L
				Piling / Boreholes		1	4	L

British	Infantry Munitions	Blast, Fragmentation	Surface Activities	Enabling Works	Site Personnel, General Public, Engineering Equipment, Existing Buildings & Infrastructure, Environment.	1	3	**L**
			Intrusive Activities	Excavations		3	3	**M**
				Piling / Boreholes		3	3	**M**
	Small Arms Ammunition	Blast, Fragmentation	Surface Activities	Enabling Works	Site Personnel, General Public, Engineering Equipment, Existing Buildings & Infrastructure, Environment.	1	3	**L**
			Intrusive Activities	Excavations		3	3	**M**
				Piling / Boreholes		3	3	**M**

KEY:	N: Negligible	L: Low	M: Moderate	H: High

*Table 8.5.1 Risk Assessment Matrix (*See Appendix 016 for assessment scheme)*

8.6 Risk Assessment Analysis

WWI Bombing: No specific records of WWI bombs having landed within the site bounds have been identified. Given the relative quantities of these bombs having been dropped in the area, the chances of encountering such an item during works are considered highly improbable. However, due to the fact bombs were dropped on Cambridgeshire, it is prudent to maintain an awareness of this source of UXO contamination.

Military Positions: Records of defensive positions associated with the airfield have been identified although their specific locations are at this time unknown. Given the military nature of the site, it is considered these would have been occupied by personnel with live munitions who would also have been traversing the site. As such, there is the potential to encounter infantry munitions across the site.

AAA: While no evidence of AAA positions having been stationed directly on the site has been uncovered, it is possible that given the nature of the site during WWII, i.e. a military airfield, there were positions located within the bounds. Given that the airfield was attacked on several occasions, it is likely these positions were also in use. Further to this, several AAA positions are known to have been present in the vicinity. As such, it is considered that there is the potential for unexploded projectiles to have landed/been dropped within the bounds of the site.

WWII Bombing: Several bombing raids have been identified which took place in the area of the site; however, RPS has been unable to identify bomb census maps that cover the site. As such, the specific locations of bomb strikes are unknown.

Whilst it is considered that items directly associated with strikes recorded pose little or no threat to the proposed works, these records highlight the potential for further bombs to have landed within the area.

WWII Access: During WWII the site was occupied by a military airfield. As such, it is considered plausible that large disturbances caused by UXO landing on the site would have been noticed and investigated / removed at the time as a priority.

This said, smaller disturbances may have been dismissed and areas of the airfield were also wooded thus increasing the possibility of disturbances / entrance holes being missed entirely.

Further to this, as the airfield was attacked, the possibility of damage from UXO being dismissed as damage caused by UXO that functioned/said damage masking further entrance holes should be borne in mind.

Post WWII Development: Since WWII the site has seen some development with the removal of numerous WWII era buildings. The fields have reportedly been returned to agriculture although certain areas remain wooded. No large scale ground works appear to have taken place across the site since WWII.

8.6.1 Final Risk Level(s)

Based on the aforementioned factors, and the risk assessment undertaken, it has been determined that there is a **Moderate** risk from UXO at the site.

During WWII, the site was an operational RAF airfield. Military personnel would have been present across the area with reports of defensive positions such as pillboxes known to have been present at the time. As such, it is considered the potential for infantry munitions to be present across the site.

Further to this as the airfield was occupied, it is likely it would have had some form of anti-aircraft defences. Whilst no specific locations have been identified within the bounds of the site, several batteries have been identified in the area. As such, it is considered there is the potential for unexploded projectiles to have been dropped / landed on the site.

Bombs are known to have been dropped on the airfield by enemy planes and whilst the area was occupied by military personnel, sections of the site were covered by woodland. As such, it is considered that there is the potential for air dropped weapons to have landed in areas of the site and gone unnoticed.

Bomb stores are known to have been present on the site during WWII however; it is considered highly likely these would have been removed, along with the ordnance housed therein, once the airfield became inactive.

9 Recommendations

9.1 The 'ALARP' Principle

Based on the risk assessment outlined previously, RPS EES has found there to be a **Moderate** risk from UXO during works taking place on site.

On sites where a risk from UXO has been identified, an aim must be to mitigate the UXO risk to as low as is reasonably practicable (*ALARP*); considering safety and cost vs. benefit. Further detail and diagrammatic representations of the ALARP principles are presented at *Appendix 017*.

Based on the assessed risk the following mitigation is recommended to be implemented in support of works taking place across the site:

- Explosives Safety & Awareness Briefings / Site Safety Guidelines,
- Explosives Safety Consultancy on Call.

All Areas of Intrusive Works

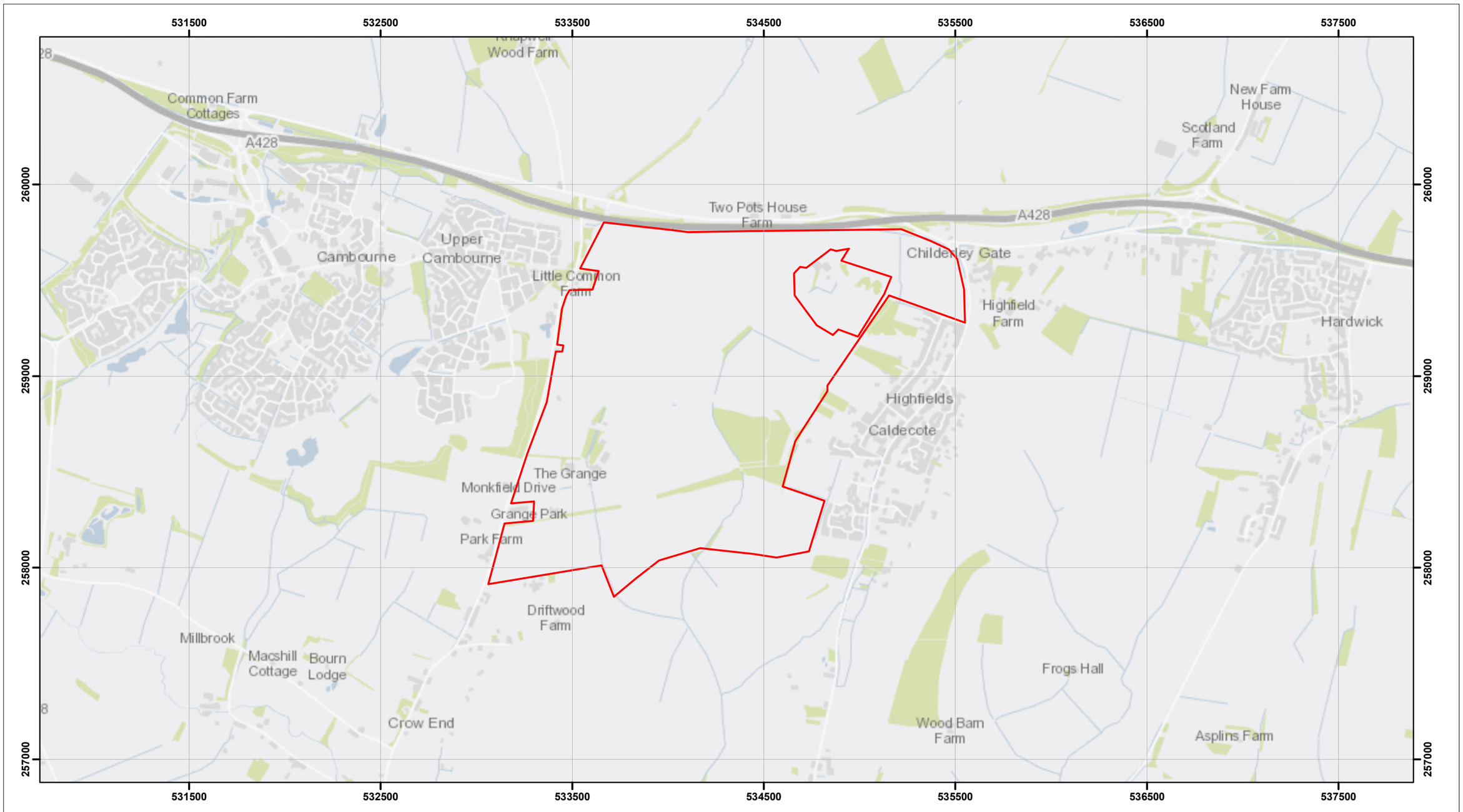
- Intrusive Magnetometer Survey ahead of Piling / Boreholes if/where practical,
- Explosives Site Safety Support for Excavations.

Full descriptions of each of the mitigation recommendations are presented at *Appendix 018*.

Appendices

Appendix 001

Site Location Map



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Certain information is digitsed based on varying resolutions and quality of historical/third party sources, upon which high accuracy cannot be guaranteed.

0 250 500 1,000 1,500 2,000 Meters

LEGEND

Approximate Site Boundary

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Drawing Number: EES0823-D-001 **Rev:** 00

Client: Countryside Properties

Project: Bourn Airfield, Cambridgeshire

Title: Site Location

Job Ref: EES0823 **Date Created:** 11-09-2017

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Scale: 1:20,000 **Paper Size:** A3

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Appendix 002

Terminology

Terminology

Explosive Ordnance Disposal (EOD) - The detection, identification, evaluation, rendering safe, recovery and disposal of UXO.

Fuze- A designed and manufactured mechanism to activate munitions. It can be designed for use by electrical, chemical or mechanical systems, by push, pull, pressure, release and time activation, singly or in combination. Usually consists of an igniter and detonator.

High Explosive (HE) - An explosive that normally detonates rather than burns; that is, the rate of detonation exceeds the velocity of sound.

Initiation - A physical process that sets in motion a cascade of chemical reactions of ever increasing energy (the explosive chain) that will eventually generate sufficient energy (the velocity of detonation) to allow the main charge to detonate in a violent, explosive chemical reaction, releasing energy in the form of heat and blast.

Unexploded Bomb (UXB) -The term UXB refers to any WWII aerial-delivered unexploded bomb, torpedo, projectile or mine consisting of a complete ferrous casing (without tailfins) weighing 50kg or greater.

Unexploded Ordnance (UXO) - Explosive Ordnance that has been primed, fuzed, armed or otherwise prepared for action, and which has been fired, dropped, launched, projected or placed in such a manner as to constitute a threat to the safety and/or security of people, animals, property or material and remains unexploded either by malfunction or design or for any other reason.

UXO Contamination - UXO that is present, within any given physical context that is considered to be an impediment to the safe on-going or intended use of a facility, including geological features. Safety in this instance is measured against an acceptable level of exposure to the potential risks that UXO present.

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Glossary

AAA	Anti-Aircraft Artillery
Allied Forces	The Allies of World War II were the countries officially opposed to the Axis powers during the Second World War
ARP	Air-raid Precautions
BD	Bomb Disposal (historic term for EOD)
BDO	Bomb Disposal Officer
bgl	Below Ground Level
EOC	Explosive Ordnance Clearance
EOD	Explosive Ordnance Disposal
FP	Fire Pot (Incendiary bomb)
HE	High Explosive
IB	Incendiary Bomb
Kg	Kilogram
LSA	Land Service Ammunition
Luftwaffe	German Air Force
mbgl	Metres Below Ground Level
MoD	Ministry of Defence
OB	Oil Bomb
PM	Parachute Mine
RAF	Royal Air Force
RPS	RPS Group Plc
SC	Sprengbombe-Cylindrisch, thin cased General Purpose Bomb
SD	Sprengbombe-Dickwandig, Semi-Armour-Piercing Fragmentation Bomb
SI	Site Investigation
Sqm	Square Metres
USAAF	United States Army Air Forces
UXB	Unexploded Bomb
UXO	Unexploded Ordnance
WWI	First World War (1914 -1918)
WWII	Second World War (1939 – 1945)

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Appendix 003

Sources of Information

Sources of Information

- RPS related site records.
- RPS Company records.
- Central and Local Government records.
- National Archives.
- Historic maps, photographs and records.
- Internet Research.

Supplemental Sources of Historical Information Consulted

The following additional sources were consulted for general background information:

- **Clark, N.J. (1996)** Adolph Hitler's Home Counties Holiday Snaps – German Aerial Reconnaissance Photography of Southern England 1939-1942. N.J.Clarke Publications: Lyme Regis.
- **Fegan, T (2002)** The 'Baby Killers' German Air Raids on Britain in the First World War. Pen & Sword Books Limited.
- **Hyde, A (2002)** The First Blitz – The German Air Campaign Against Britain 1917-1918. Leo Cooper: South Yorkshire
- **Ramsey, W.G. (1988)** The Blitz Then and Now, Volumes 1, 2 & 3. Battle of Britain Prints International Limited.
- **Fleischer, W (2003)** German Air Dropped Weapons to 1945. Midland Publishing and Stephen Thompson Associates.

Appendix 004

Legislation

Whilst undertaking this desk study the requirements of a number of legislations has been borne in mind, as presented following:

- Manufacture and Storage of Explosives Act 2005.
- Health & Safety at Work etc Act 1974.
- Construction (Design & Management) Regulations 2015.
- Control of Substances Hazardous to Health (COSHH) Regulations 2002.
- Personal Protective Equipment at Work Regulations 1992.

The Manufacture and Storage of Explosives Act 2005 does not specifically relate to UXO, but rather to the safety procedures and requirements associated with the storage and manufacturing of items containing explosive compounds. Even though this legislation is not directly applicable to site works where UXO may be encountered, there are several pertinent points which may be borne in mind when undertaking works on sites which pose a risk from encountering UXO, for example:

Disposal of explosives and decontamination of explosive-contaminated items

- Any person who disposes of explosives shall ensure, so far as is reasonably practicable, that they are disposed of safely.
- Any person who decontaminates explosive-contaminated items shall ensure, so far as is reasonably practicable, that they are decontaminated safely.
- No person shall store explosives unless he holds a licence for their storage and complies with the conditions of that licence.

These points just reinforce that when a significant risk from UXO is identified on a site, it is essential for proper procedures to be put in place and in higher risk scenarios for trained Explosives Safety Personnel to be present on site to mitigate the risks, and be on hand to handle the situation in the event of a suspicious item / UXO discovery.

The Reporting of Injuries, Diseases and Dangerous Occurrences Regulations 1995 (RIDDOR), place a legal duty on:

- employers;
- self-employed people;
- people in control of premises;

To report work-related deaths, major injuries or over-three-day injuries, work related diseases, and dangerous occurrences (near miss accidents).

These regulations do not directly apply to UXO, but under the RIDDOR legislation it is stated that as an employer, a person who is self-employed, or someone in control of work premises you must report "*dangerous occurrences - where something happens that does not result in an injury, but could have done*". As such, where a site has been shown to present a risk from UXO this legislation should be borne in mind if an eventuality occurs where an item of UXO is uncovered.

Although the Health & Safety at Work etc Act 1974 and the Construction (Design & Management) Regulations 2015 do not specifically require a search for unexploded ordnance, there is an obligation on those responsible for intrusive works to ensure that comprehensive assessment and risk mitigation measures are taken with regard to all underground hazards on site.

The Health & Safety at Work etc Act 1974 - Section 3, states:

1. *It shall be the duty of every employer to conduct his undertaking in such a way as to ensure, so far as is reasonably practicable, that persons not in his employment who may be affected thereby are not thereby exposed to risks to their health or safety.*
2. *It shall be the duty of every self-employed person to conduct his undertaking in such a way as to ensure, so far as is reasonably practicable, that he and other persons (not being his employees) who may be affected thereby are not thereby exposed to risks to their health or safety.*
3. *In such cases as may be prescribed, it shall be the duty of every employer and every self-employed person, in the prescribed circumstances and in the prescribed manner, to give to persons (not being his employees) who may be affected by the way in which he conducts his undertaking the prescribed information about such aspects of the way in which he conducts his undertaking as might affect their health or safety.*

Construction (Design & Management) Regulations 2015 - Regulation 10 states:

(2) The pre-construction information shall consist of all the information in the client's possession (or which is reasonably obtainable), including –

(a) Any information about or affecting the site or the construction works.

In addition to the above, the importance of adhering to safe systems of work should also be borne in mind, and explosives and their residues may have an implication concerning PPE requirements and COSHH.

Appendix 005

1945 Bourn Aerial Image

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Meters
0 125 250 500 750 1,000

LEGEND

Approximate Site Boundary

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Greyscale Image Source: Google Earth Pro 2017

Drawing Number: EES0823-D-002 **Rev:** 00

Geodetic Information:
CS: British National Grid
Datum: OSGB 1936

Client: Countryside Properties

Project: Bourn Airfield, Cambridgeshire

Title: Aerial Image - 1945

Job Ref: EES0823 **Date Created:** 11-09-2017

Status: INITIAL ISSUE

Drawn By: LM **Checked By:** RP

Scale: 1:14,000 **Paper Size:** A3

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Appendix 006

Examples of Military Positions

WWII Defensive Positions

The term defensive position refers to structures designed to repel invading forces, such as Anti Aircraft Artillery (AAA) positions, infantry and gun emplacements, bunkers and anti-tank positions. In addition, balloon anchorages, searchlight positions, air raid shelters and other military assets are also associated with these types of positions and were targeted by German Forces.

Examples of Pillboxes

Example of a Vickers Gun Emplacement

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Anti Aircraft Artillery

AAA batteries were often located around large towns and cities as an integral defence mechanism against the German Air Force bombers. Typically the Royal Artillery would man such defences. The AAA defence around Britain comprised mainly 4.5" Heavy AAA gun batteries and 3.7" AAA batteries.

The significance of AAA positions located close to a site is that firstly the Germans may have attempted to bomb the batteries and secondly unexploded shells or "blinds" may have landed in the general vicinity .

Example of a Light Anti-aircraft battery

Example of a Bofors Light Anti Aircraft Gun

Example of Heavy Anti Aircraft Artillery

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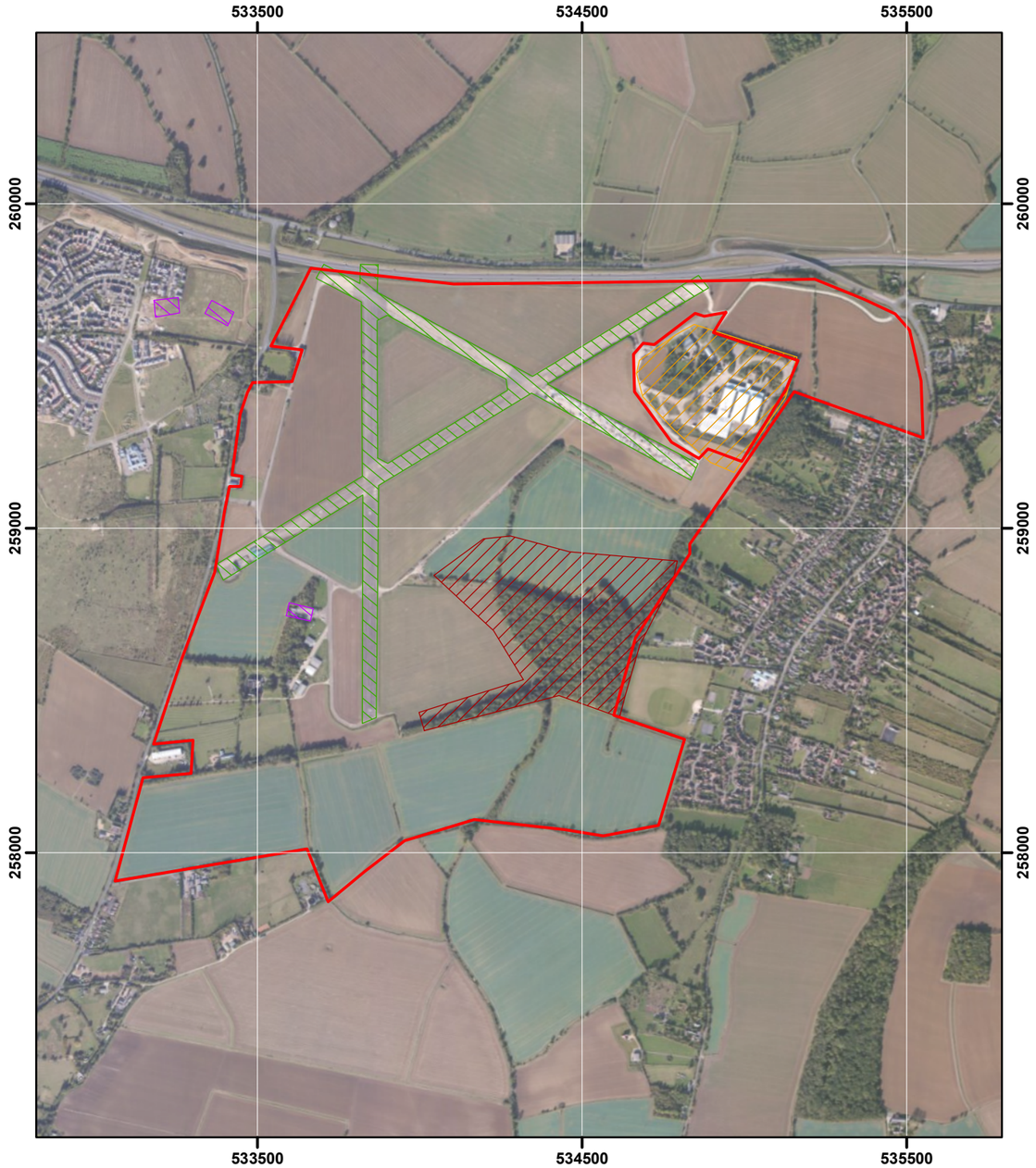
‘Z’ Batteries

In addition, to further defend against air attack, smaller more mobile batteries were also deployed using lower calibre projectiles. “Z” batteries, which fired Rockets, also known as ‘Un-rotated Projectiles’ (UP), were stationed in parts as a further form of anti aircraft artillery defence.

Appendix 007

1944 Bourn Airfield Feature Map



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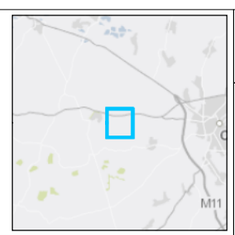
Meters
0 125 250 500 750 1,000

LEGEND

- Approximate Site Boundary

Airfield Features (Approximate)

- Bomb Stores
- Hangar
- MAP Site
- Runway



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Greyscale Image Source: Google Earth Pro 2017

Drawing Number: EES0823-D-003 **Rev:** 00

Client: Countryside Properties

Project: Bourn Airfield, Cambridgeshire

Title: 1944 Airfield Features

Job Ref: EES0823 **Date Created:** 11-09-2017

Status: INITIAL ISSUE

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Geodetic Information:
CS: British National Grid
Datum: OSGB 1936

Scale: 1:17,500 **Paper Size:** A3

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Appendix 008

German Bombing Campaigns Overview

WWII Air Raid Records	
Date	**Description**
09/04/1941	A Junkers Ju88C strafed the airfield buildings and dropped bombs successfully on the runway. Only minor damage resulted and no injuries were reported.
03/10/1942	A Stirling of 7 Squadron was shot down by a night fighter as it joined the landing circuit. Four of the crew were killed.
08/05/1944	An intruder raid was recorded
23/05/1944	An intruder raid occurred where two parked Mosquitoes were damaged.

Appendix 009

WWII Air Raid Records

WWI German Bombing

During the First World War (WWI) Zeppelin airships followed by 'Gotha' and 'Giant' bombers conducted a succession of attacks dropping high explosive (HE) and incendiary bombs on Britain. The level of enemy bombing seen during WWI does not compare to that of WWII, nevertheless bombs were dropped on Britain.

WWII German Bombing

From the onset of WWII the German Air Force's (Luftwaffe) primary goals were to destroy key military assets such as airfields, during a series of daylight bombing raids. Shortly after, their plans changed to include targets such as economic and industrial sites, railway infrastructure, power stations, weapon manufacturing plants and gas works. Eventually, the amount of daylight raids were reduced and the attacking of targets commenced under the cover of darkness. Ultimately, the Germans resorted to attacking civilian areas through the 'carpet bombing' of major towns and cities, most notably during "The Blitz", which was in retaliation to the Allied bombing campaign.

RPS records indicate that the German bombing campaign during WWII saw the extensive use of a series of High Explosive (HE) filled bombs ranging in size from the relatively small 50kg bomb through to the 250kg, 500kg, 1,000kg and 1,800kg bombs to the largest at 2,500kg. The Luftwaffe also used parachute mines, incendiary/fuel bombs and anti-personnel bomblets. In the later stages of the war, vengeance weapons namely the V1 (doodle bug) and V2 (Long Range Rockets) were used. The V2 rocket contained a 980kg high explosive filled warhead.

Available records suggest that the most numerous bombs dropped over the majority of targets during WWII were 50kg to 500kg HE bombs and incendiary devices. It is a general industry accepted rule, where no specific statistics are available, that on average, around 10% of the German HE bombs dropped during WWII failed to explode. This percentage is based on empirical data collected and collated during WWII by the ARP, and derived from bombing records. This statistic is primarily based on statistics from the London area (where the actual statistics vary widely across the region), but on average the failure rate resulted to around 10%.

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Appendix 010

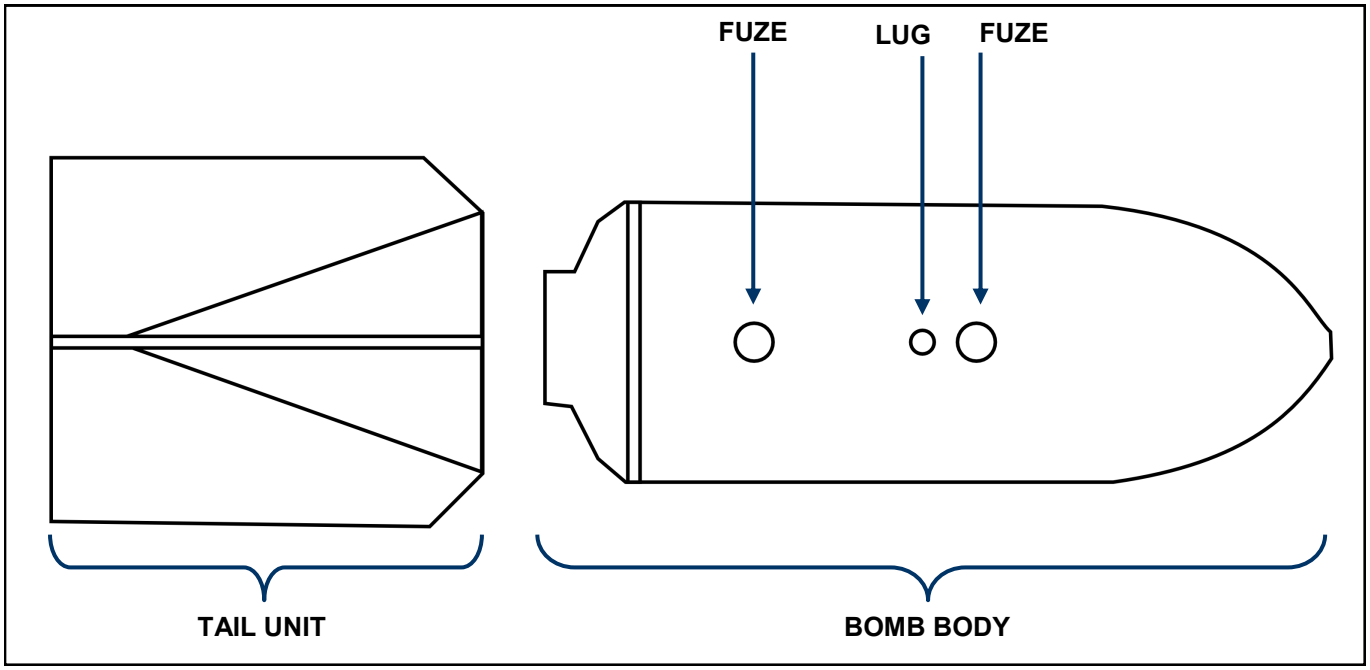
Examples of German Bombs

High Explosive / General Purpose Bombs

General-purpose bombs come in many shapes and sizes depending on the intention of the bombing mission. Generally, all these bombs are constructed the same and consist of a metal container (iron construction), a fuze (mainly transverse i.e. in the middle of the bomb), and a stabilizing device. The metal container (called the bomb body) holds the high explosive content. The body may be in one or in multiple pieces.

The main components of a bomb are:

- ***Bomb Body –*** This is the main item referred to as an Unexploded Bomb (UXB). The General Purpose bombs will have a typical bomb shape with parallel sides. Given the age and environmental conditions most bombs are found corroded. It is possible to mistake them for old gas cylinders or boiler tanks.
- ***Tail Unit –*** As the UXB enters the ground this section is removed. The presence of a tail unit may indicate that an UXB is buried at depth in the region.
- ***Fuze –*** With a German UXB it is most likely that the bomb would have a mechanical or electrical transverse fuse. In some case a bomb may contain two fuses. On a German UXB the fuzes were of an alloy construction and therefore a visual contrast from the bomb body.



TYPICAL WWII GERMAN AERIAL DELIVERED BOMB COMPONENTS

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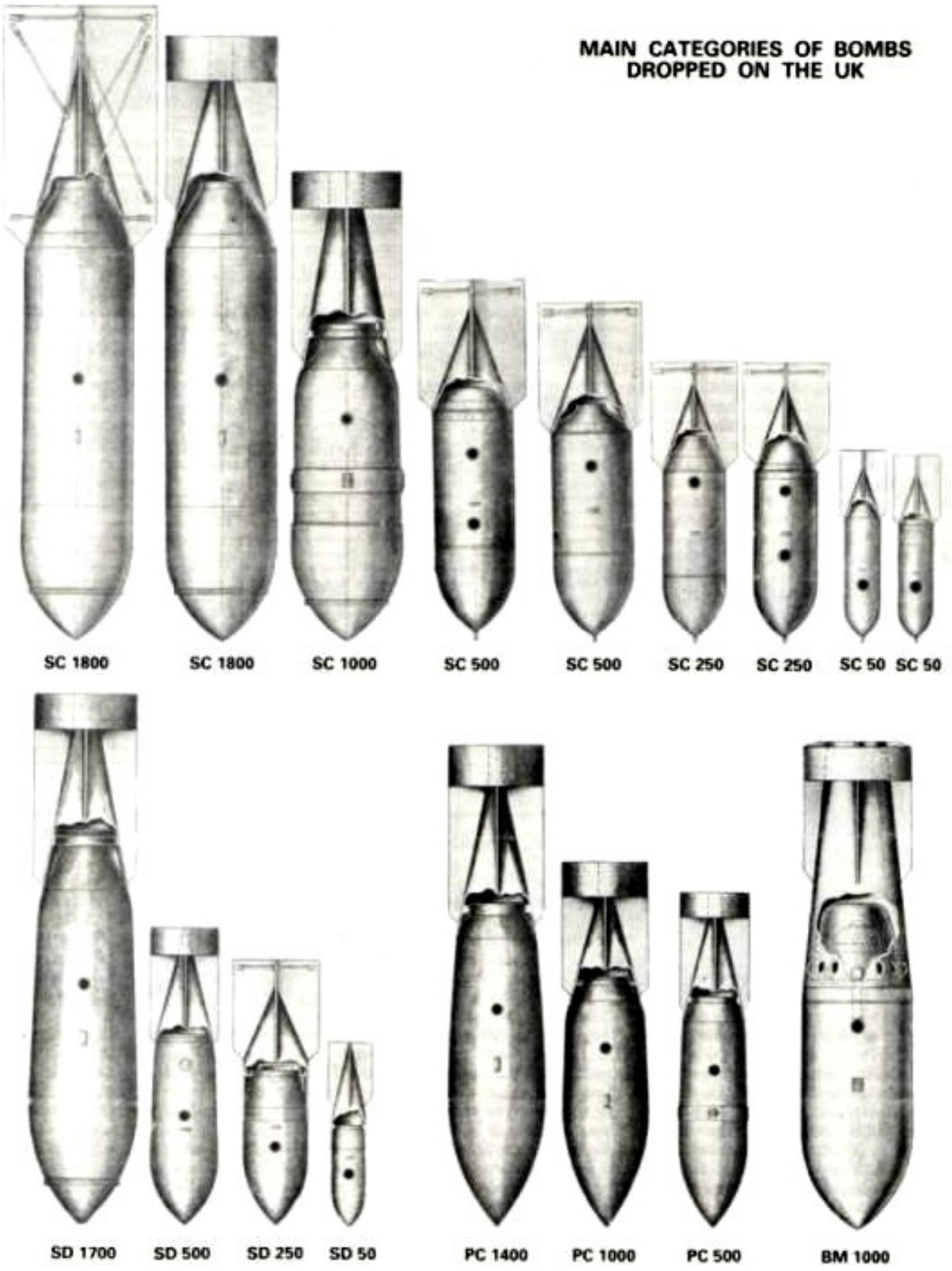

From: W. Fleishcer (2003) —German Air Dropped Weapons to 1945

Project: Bourn Airfield

Project Ref: EES0823

Appendix 010B: Examples of German WWII Aerial Delivered Bombs

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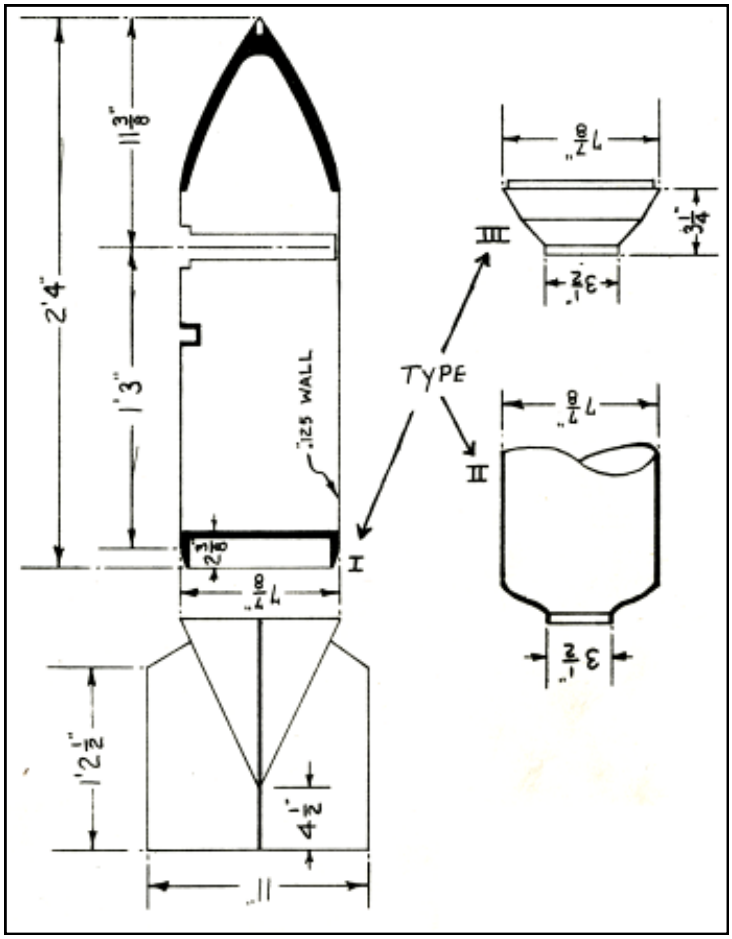
An Example of a 50kg German Bomb



50kg SC High Explosive Bomb Schematic

50kg SC HE Bomb discovered by RPS on a construction site in London (2006)

SC50 Data

Bomb Body Weight = 40-54kg

Body Length = 2' 4.5" to 2' 7"

Body Diameter = 200mm (7.87")

Explosive = TNT or Amatol

NEQ = 25kg (55lb)

Fuze = Impact Fuzing

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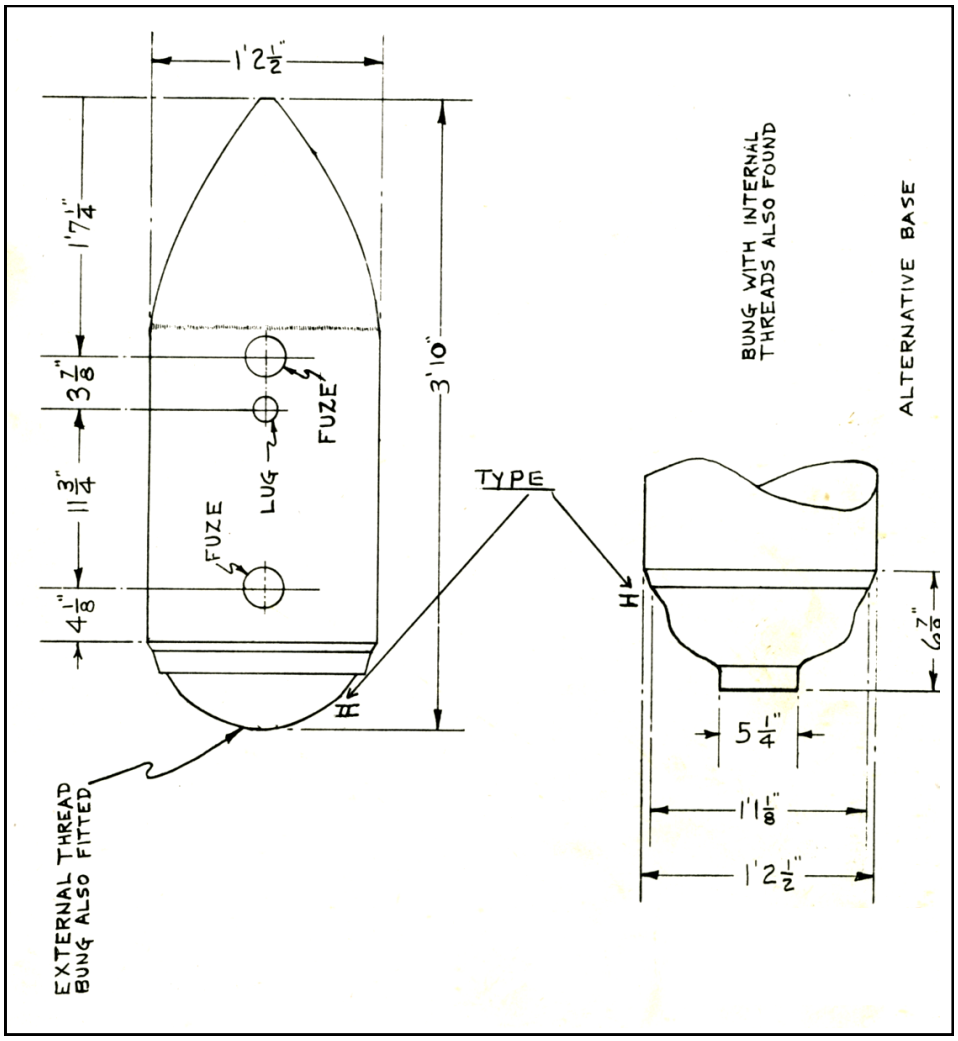


SC250 Data

Bomb Body Weight = 245-256kg

Body Length = 5' 1" to 5' 5"

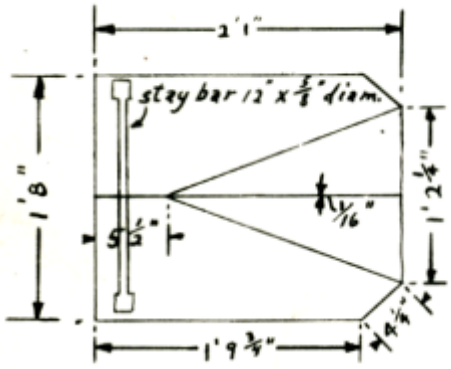
Body Diameter = 368mm (14.5")

Explosive = TNT or Amatol

NEQ = 125-130kg (276-287lb)

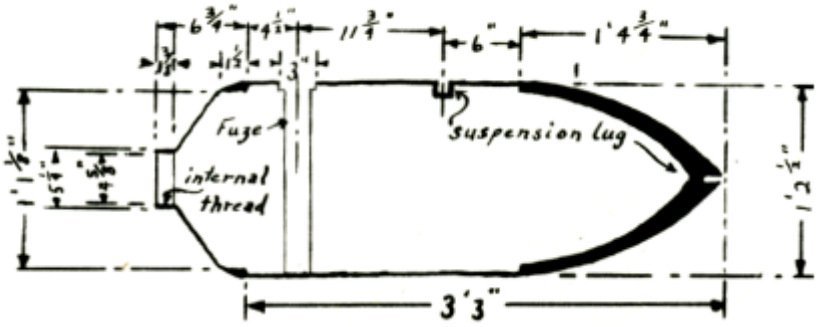
Fuze = Any (Commonly Type 7 Time Fuze)

250kg SC High Explosive Bomb Schematics



TAIL S.C. 250

SHEET METAL



S.C. 250.

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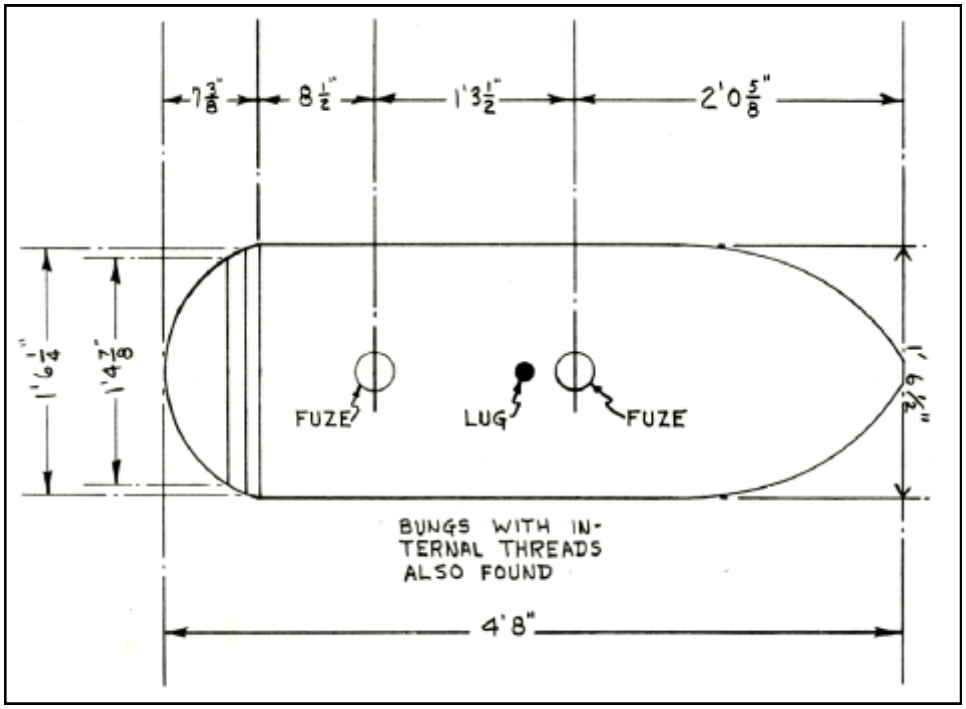
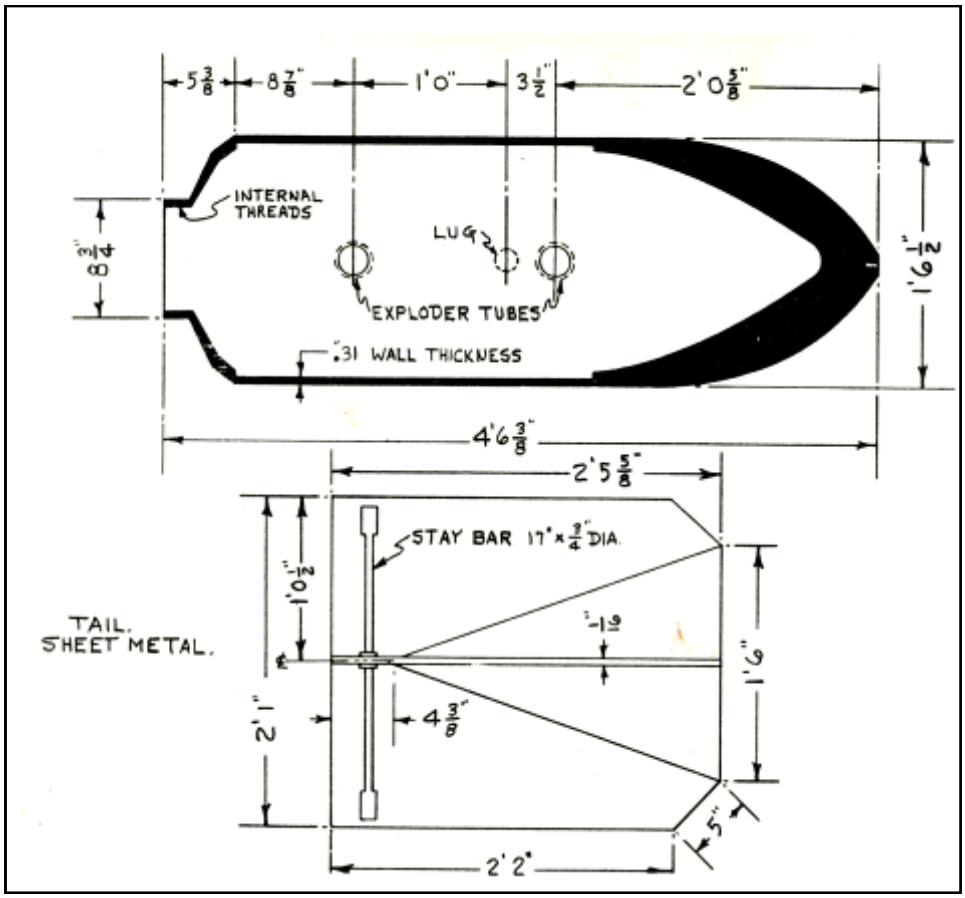
500kg SC High Explosive Bomb Schematics





SC500 Data

Bomb Body Weight = 480-520kg

Body Length = 4' 6" to 5' 0"

Body Diameter = 470mm (18.5")

Explosive = TNT or Amatol

NEQ = 125-130kg (276-287lb)

Fuze = Electrical Impact Fuzing

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Appendix 011

Examples of German Bomblets

German Bomblets & Containers

In addition to the larger individually deployed bombs, smaller HE bombs or “Bomblets” were also deployed by the Luftwaffe. The small bomblets were generally between 1-3kg or 10kg in weight and dropped in larger container bombs and most of these of these had simple impact fuzes. Many containers’ were shaped in a bomb form, with the aim of fitting into the existing bomb racks. If operating properly, they were designed to eject their cargo at predetermined height above ground level thereby spreading the bomblets over a wide area.

Some bomblets are considered the forerunners of cluster munitions which are very sensitive and considered more prone to initiate. These were used against civilians and can be considered an area denial weapon.

These weapons have been encountered in infill or rubble in larger cities and in other re-deposited contexts. They possess limited ground penetration (approximately 1-3m in a medium deposit) similar to the smaller Incendiary Bomblets discussed below. However, the small bomblets may be considered to have a greater potential to cause casualties than general incendiary bomblets based upon their fuze and explosive makeup.

German Incendiary Bomblets

In early stages of the war, the incendiary bombs dropped over the UK were of the "Oil Bomb" variation, where a flammable liquid was used with an explosive charge. The idea was to cause some blast damage with the explosive, but mainly to spray the burning liquid over a wide area and cause widespread fires. This bomb weighs approximately 50kg. The body diameter is 8 inches, and the over-all length 43.2 inches. The filling is 15 litres of a mixture of 86 per cent benzene, 10 per cent rubber, and 4 per cent phosphorus. It has a bursting charge of picric acid.

By 1942, Oil Bombs had been superseded by a smaller and more intensely burning incendiary bomblet made of magnesium. These weighed only 1kg, so could be dropped in containers carrying hundreds of individual bomblets. Some were coupled with a small High Explosive charge that went off when the magnesium was alight to spread the fire over a wider area. A corroded 1kg incendiary bomb can closely resemble a short section of scaffold tube.

- ***1kg Incendiary Bomb -*** The diameter is 2 inches, and over-all length 13.6 inches. The filling is 0.44lb of thermite.
- ***2kg Incendiary Bomb -*** The filling includes TNT or amatol in addition to thermite. The diameter is 2 inches, and the overall length is 20.7 inches.

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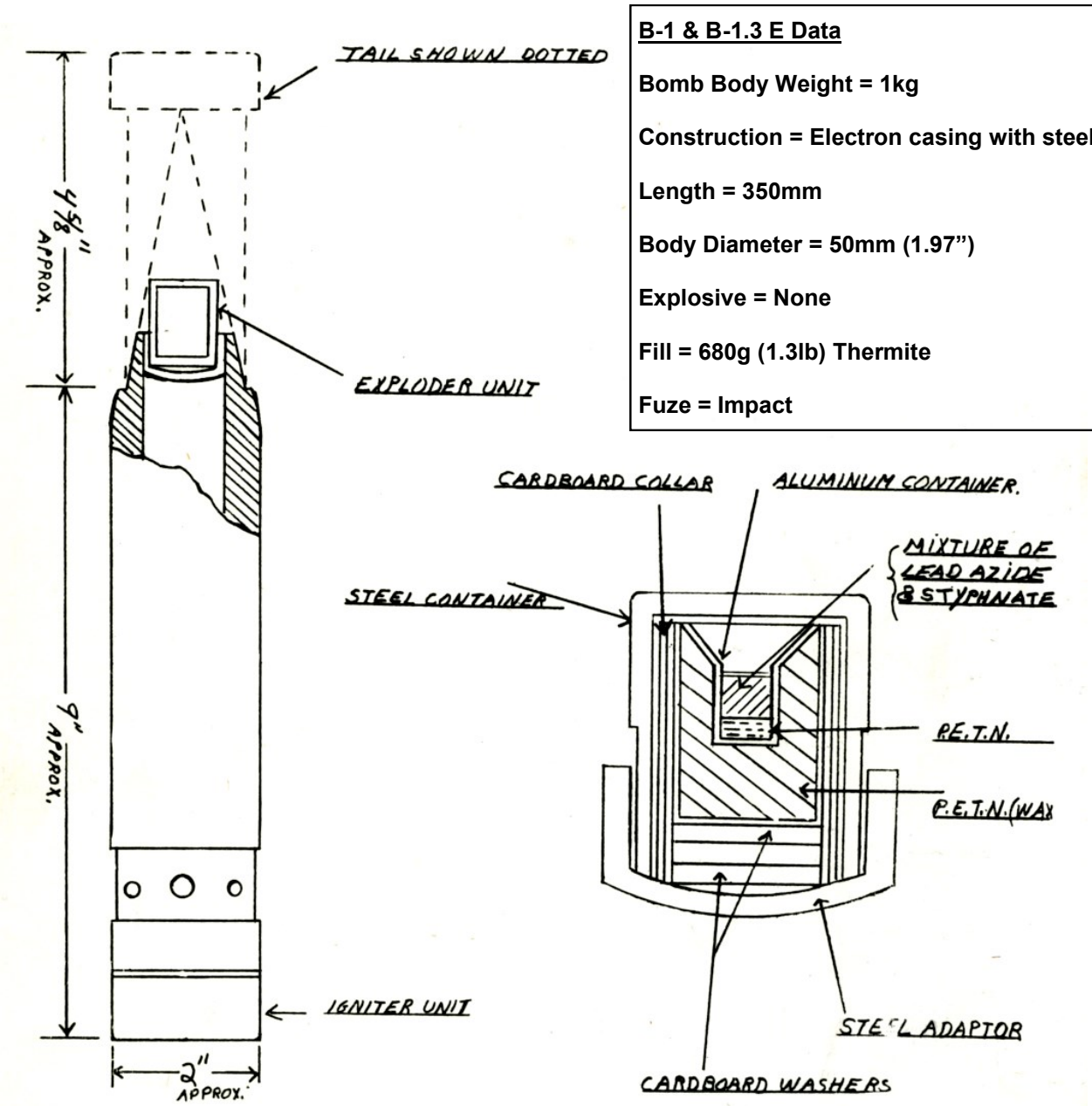


B-1 & B-1.3 E Data

Bomb Body Weight = 1kg

Construction = Electron casing with steel nosecap

Length = 350mm

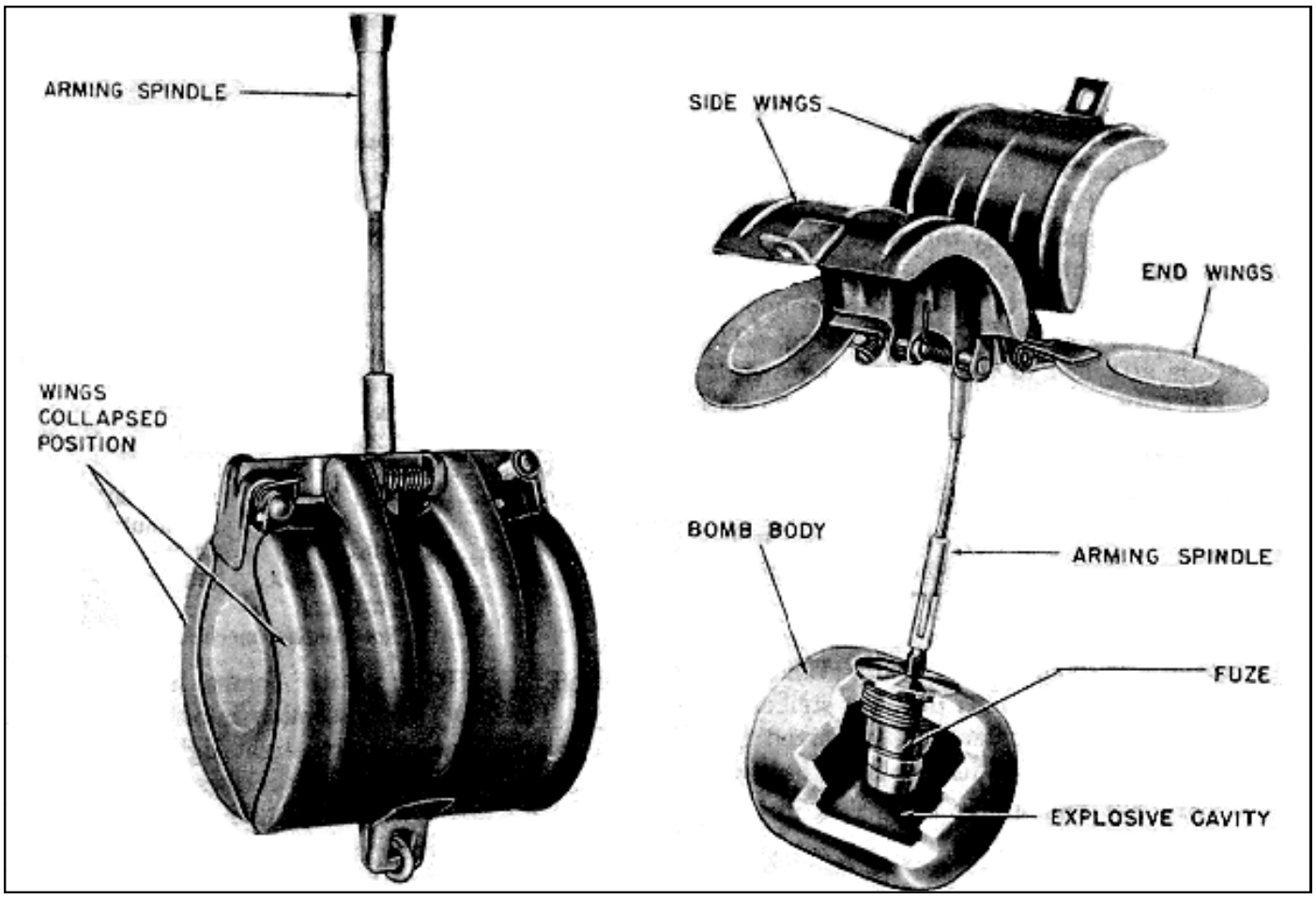
Body Diameter = 50mm (1.97")

Explosive = None

Fill = 680g (1.3lb) Thermite

Fuze = Impact

B-1 1kg Incendiary Bomblet



Butterfly Bomblet (SD2) Anti Personnel Device

SD-2 Data

Bomb Body Weight = 2kg

Length = 200mm (Including Arming Spindle)

Body Diameter = 80mm

Explosive = Fp 60/40

NEQ = 0.225kg (0.496lb)

Fuze = Mechanical Clockwork / Mechanical Time or B1/B2 Harassment

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Appendix 012

Examples of Anti-Aircraft Artillery

Anti Aircraft Artillery Projectiles

During WWII, the munitions commonly used by the British AAA were the 4.5” and 3.7” varieties. An artillery munition generally consists of four main sections:

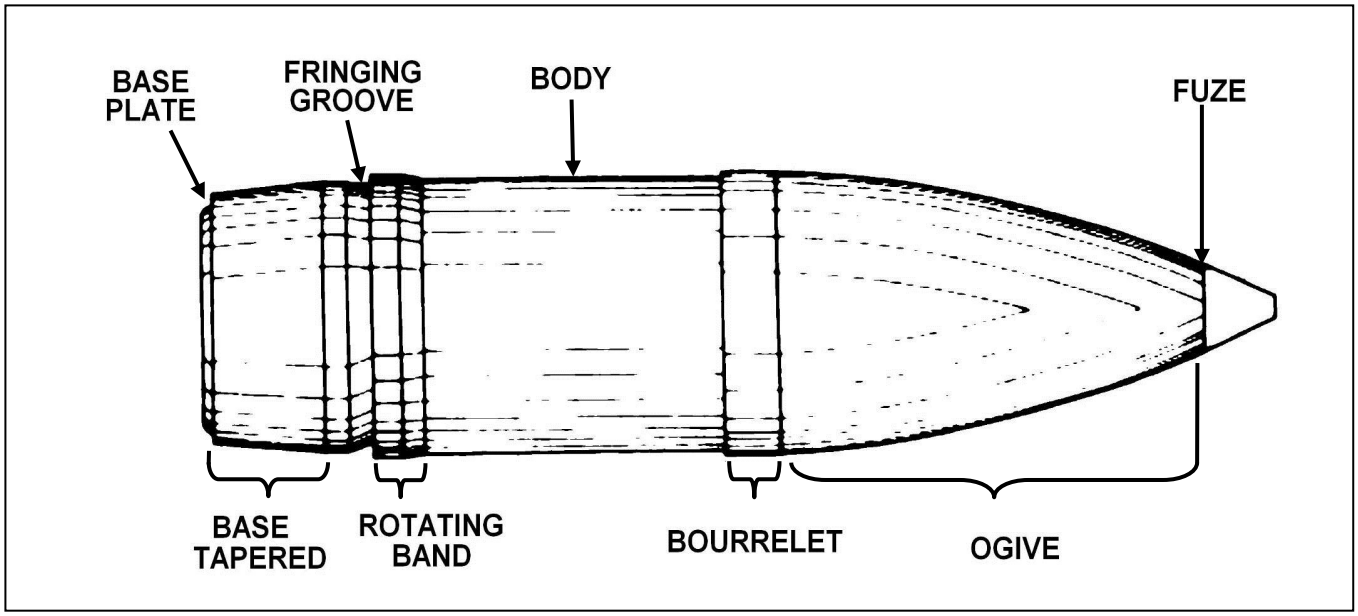
- ***Fuze –*** The part of the device which initiates the detonation of the payload. Usually artillery munitions have nose fuzes, although some do have base fuzes. When used with HE shells, ‘airburst’ fuzes usually have a combined airburst and impact function.

- ***Projectile –*** This is the part of the munition that generally contains the main payload, and will be ejected from the main munition during firing. Artillery shell projectiles can range between bursting, base ejection or nose ejection.

- ***Propellant –*** Propellant in artillery munitions is always low explosive.

- ***Primer –*** The primers purpose is to initiate the propellant upon firing.

In most cases, the part of the munition that is likely to remain as UXO, as a result of malfunction during firing, is the Projectile (potentially with fuze), as this is the part of the device that is fired through the air.



TYPICAL PROJECTILE COMPONENTS

“Z” Batteries, often manned by Home Guard units fired Rockets as part of the integrated aerial defences. These ‘projectiles’ were essentially fin stabilised rockets which contained a small propellant charge to ignite the rocket motor. Throughout WWII two variations of the rocket were utilised, the first being a 2” rocket which was later replaced by a 3” rocket after being discovered that it was far more effective.

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3.7” Anti Aircraft Artillery Projectile

NOTE: Item is a training item and does not necessarily depict the correct identification colouration and/or markings

40mm Anti Aircraft Artillery Round

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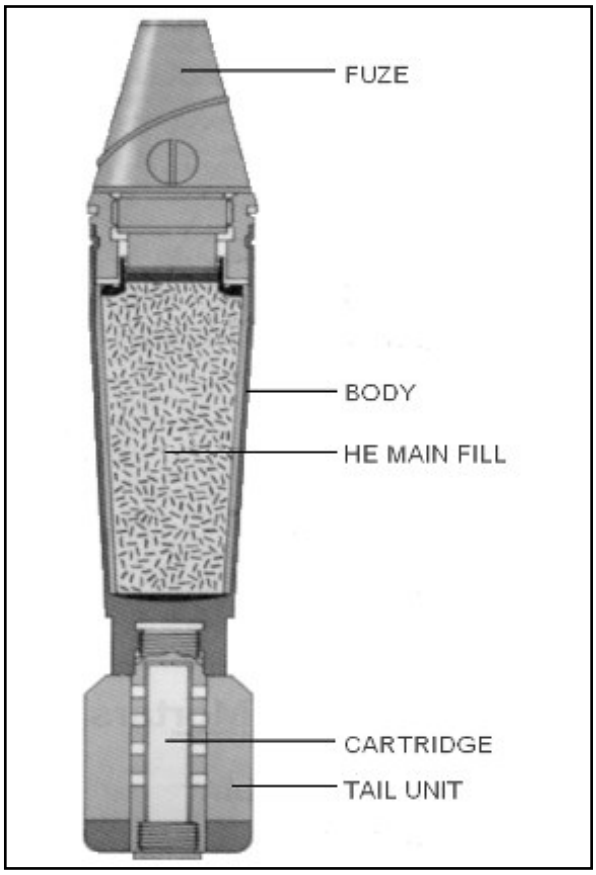
Appendix 013

Examples of British Infantry Munitions



EXAMPLES OF HIGH EXPLOSIVE MORTARS

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Project Ref: EES0823

Appendix 013A: Examples of Infantry Munitions

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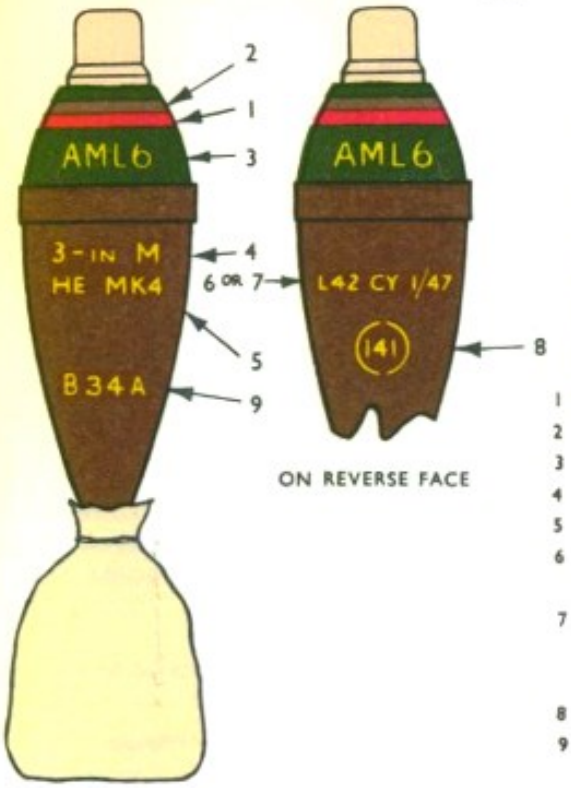
TYPICAL MARKINGS ON MORTAR BOMBS - 3 INCH

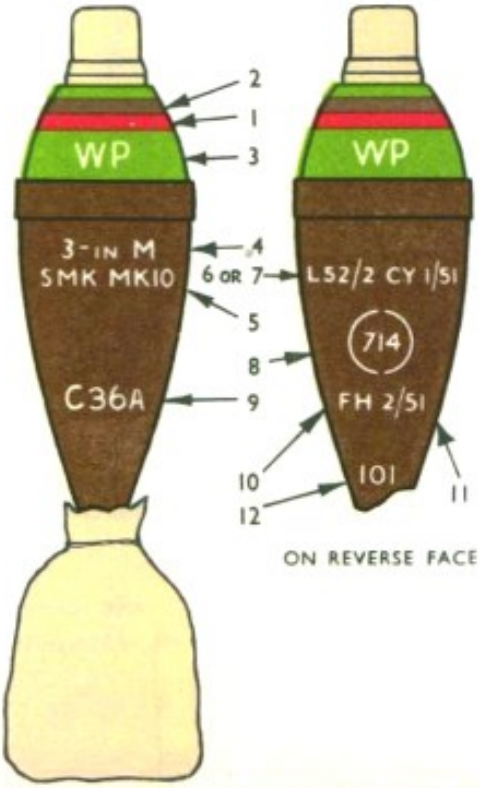
FIG.1 HE



AREAS SHOWN DARK BROWN INDICATES BODY PHOSPHATED AND VARNISHED

1 RED FILLING RING
2 BROWN RING (DENOTING CAST IRON)
3 CODE DENOTING NATURE OF FILLING
4 CALIBRE AND NATURE OF WEAPON
5 TYPE AND MARK, OR MODEL NUMBER, OF BOMB
6 ONE LINE CODE (METHOD OF FILLING) FOR BOMBS WITH MARK NUMBER
7 INITIALS OR RECOGNIZED MONOGRAM OF FILLER AND DATE OF FILLING (FOR BOMBS WITH MODEL NUMBER)
8 FILLED SERIES NUMBER
9 BATCH NUMBER, WHEN BOMBS ARE ISSUED FUZED AND CARTRIDGED

FIG.2 SMOKE BURSTING

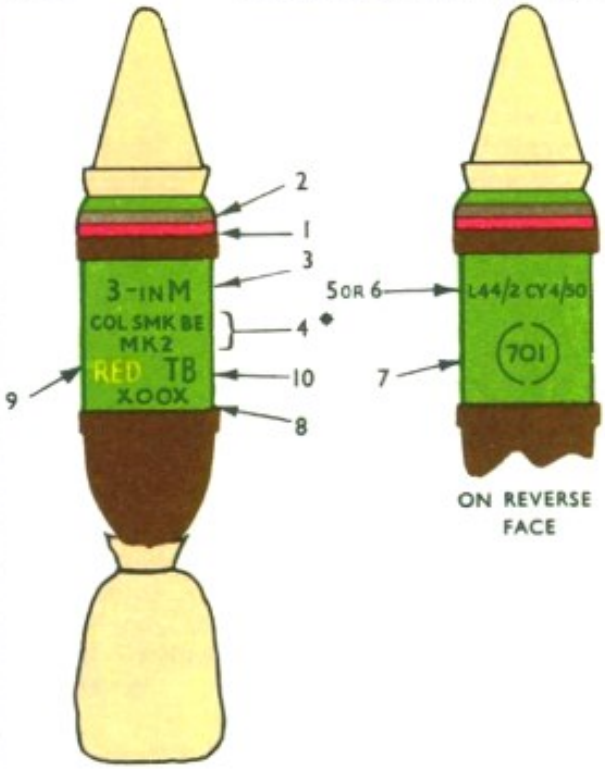


AREAS SHOWN DARK BROWN INDICATES BODY PHOSPHATED AND VARNISHED

1 RED FILLING RING
2 BROWN RING (DENOTING CAST IRON)
3 CODE DENOTING NATURE OF FILLING
4 CALIBRE AND NATURE OF WEAPON
5 TYPE AND MARK, OR MODEL NUMBER, OF BOMB
6 ONE LINE CODE (METHOD OF FILLING) FOR BOMBS WITH MARK NUMBER
7 INITIALS OR RECOGNIZED MONOGRAM OF FILLER AND DATE OF FILLING (FOR BOMBS WITH MODEL NUMBER)
8 FILLED SERIES NUMBER
9 BATCH NUMBER, WHEN BOMBS ARE ISSUED FUZED AND CARTRIDGED
10 RECOGNIZED MONOGRAM OR INITIALS OF CHARGING STATION
11 DATE OF CHARGING (MONTH & YEAR)
12 CHARGING LOT NUMBER

TYPICAL MARKINGS ON MORTAR BOMBS - 3 INCH

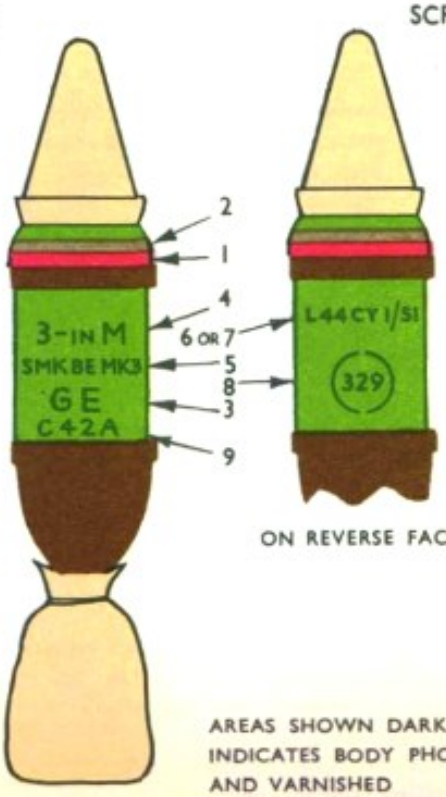
FIG.1 COLOURED SMOKE BE AND COLOURED SMOKE SKYTRAIL



AREAS SHOWN DARK BROWN INDICATES BODY PHOSPHATED AND VARNISHED

1 RED FILLING RING
2 BROWN RING (DENOTING CAST IRON)
3 CALIBRE AND NATURE OF WEAPON
4 TYPE AND MARK, OR MODEL NUMBER, OF BOMB *(SMK TRAIL BE MK 2 FOR SKYTRAIL)
5 ONE LINE CODE (METHOD OF FILLING) FOR BOMBS WITH MARK NUMBER
6 INITIALS OR RECOGNIZED MONOGRAM OF FILLER AND DATE OF FILLING (FOR BOMBS WITH MODEL NUMBER)
7 FILLED SERIES NUMBER
8 BATCH NUMBER, WHEN BOMBS ARE ISSUED FUZED AND CARTRIDGED
9 COLOUR OF SMOKE (AS APPLICABLE)
10 CODE DENOTING NATURE OF FILLING

FIG.2 SCREENING SMOKE BE



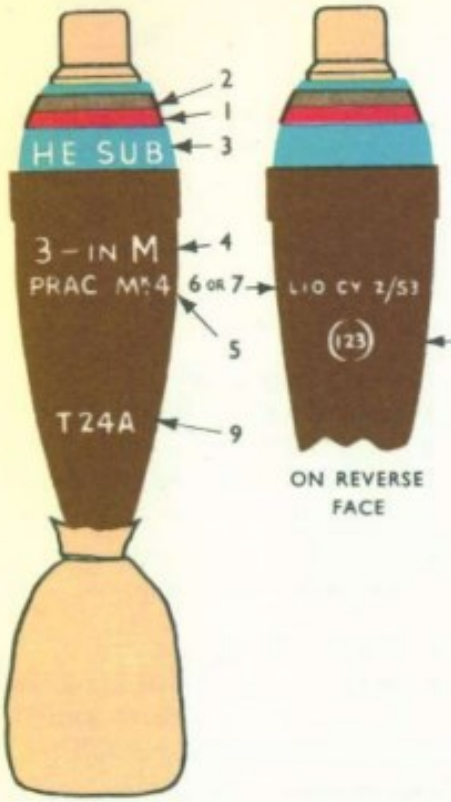
1 RED FILLING RING
2 BROWN RING (DENOTING CAST IRON)
3 CODE DENOTING NATURE OF FILLING
4 CALIBRE AND NATURE OF WEAPON
5 TYPE AND MARK, OR MODEL NUMBER, OF BOMB
6 ONE LINE CODE (METHOD OF FILLING) FOR BOMBS WITH MARK NUMBER
7 INITIALS OR RECOGNIZED MONOGRAM OF FILLER AND DATE OF FILLING (FOR BOMBS WITH MODEL NUMBER)
8 FILLED SERIES NUMBER
9 BATCH NUMBER, WHEN BOMBS ARE ISSUED FUZED AND CARTRIDGED

AREAS SHOWN DARK BROWN INDICATES BODY PHOSPHATED AND VARNISHED

TYPICAL MARKINGS ON MORTAR BOMBS - 3 INCH

FIG.1

PRACTICE

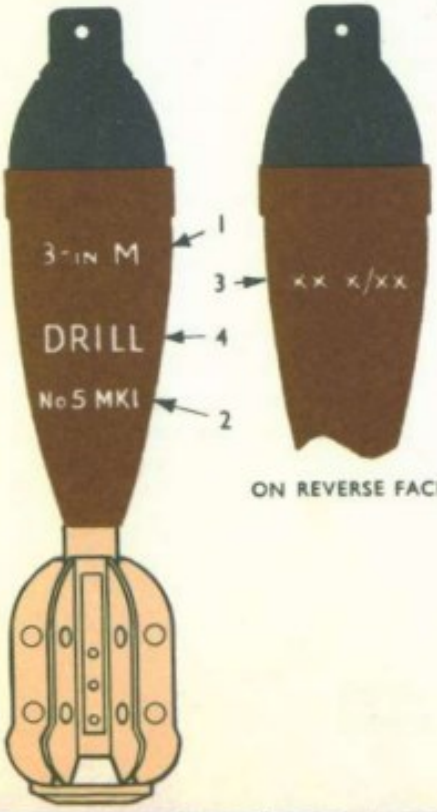


AREAS SHOWN DARK BROWN INDICATES BODY PHOSPHATED AND VARNISHED

1 RED FILLING RING (WHEN CARTRIDGE IS FITTED)
2 BROWN RING (DENOTING CAST IRON)
3 NATURE OF FILLING
4 CALIBRE AND NATURE OF WEAPON
5 TYPE AND MARK, OR MODEL NUMBER, OF BOMB
6 ONE LINE CODE (METHOD OF FILLING) FOR BOMBS WITH MARK NUMBER
7 INITIALS OR RECOGNIZED MONOGRAM OF FILLER AND DATE OF FILLING (FOR BOMBS WITH MODEL NUMBER)
8 FILLED SERIES NUMBER
9 BATCH NUMBER, WHEN BOMBS ARE ISSUED FUZED AND CARTRIDGED

FIG.2

DRILL



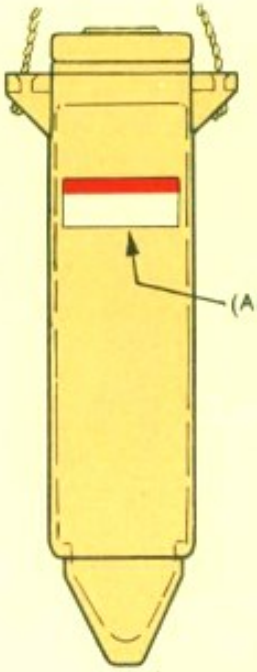
AREAS SHOWN DARK BROWN INDICATES BODY PHOSPHATED AND VARNISHED

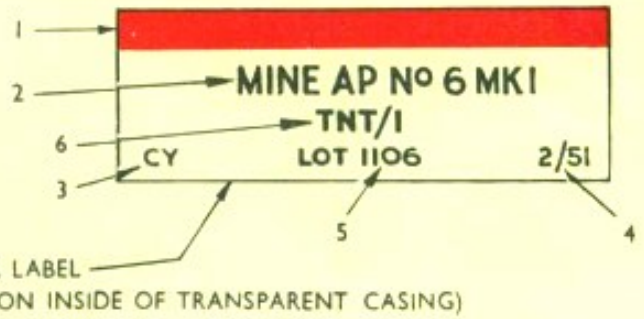
1 CALIBRE AND NATURE OF WEAPON
2 NUMBER, AND MARK, OF BOMB
3 RECOGNISED MONOGRAM OR INITIALS OF MANUFACTURER AND DATE OF MANUFACTURE (MONTH AND YEAR)
4 TYPE OF BOMB

MISCELLANEOUS (LAND SERVICE)

FIG. 1.

MINE, ANTI-PERSONNEL No. 6, MK. 1

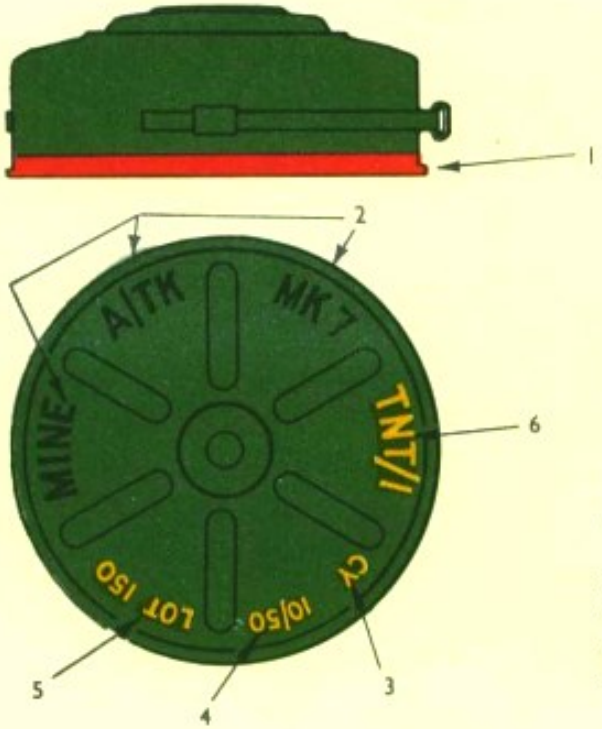




1 RED FILLING RING
2 NOMENCLATURE & MARK OF STORE
3 RECOGNISED MONOGRAM OR INITIALS OF FILLER
4 DATE OF FILLING
5 FILLED LOT NUMBER
6 CODE DENOTING FILLING COMPOSITION USED

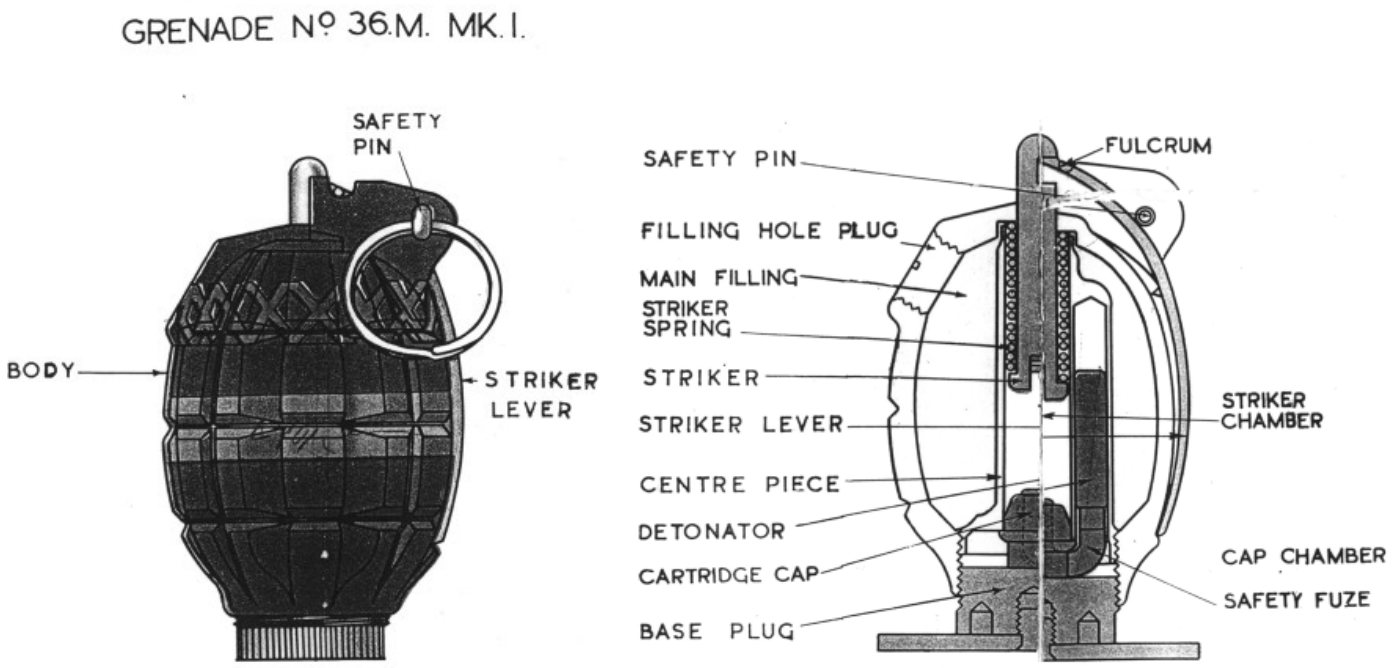
FIG. 2.

MINE, A/TK., MK. 7.



1 RED FILLING RING
2 NOMENCLATURE & MARK OF STORE (EMBOSSED)
3 RECOGNISED MONOGRAM OR INITIALS OF FILLER
4 DATE OF FILLING
5 FILLED LOT NUMBER
6 CODE DENOTING FILLING COMPOSITION USED

No 36 Mills Grenade



Project: Bourn Airfield

Project Ref: EES0823

Appendix 013G: Examples of Small Arms Ammunition

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TYPICAL IDENTIFICATION MARKINGS ON S.A.A. (SMALL ARMS AMMUNITION)

FIG.1 ·303 INCH (RIMMED CASE)

BALL

BASE STAMPINGS
ITEMS 1, 2, 4 & 5

TRACER

RED BULLET TIP SEE PARA 186

BASE STAMPINGS
ITEMS 1, 2, 4, 5 & 6

RIFLE GRENADE

FOR COLOUR IDENTIFICATION OF CASE, See para 12(d) (i) and (ii) of text

MK1Z

MK7Z

BASE STAMPINGS
ITEMS 1, 2, 4, 5 & 6

FIG.2
7·92 mm. BALL
(RIMLESS CASE)

BASE STAMPINGS
ITEMS 1, 2, 4 & 5

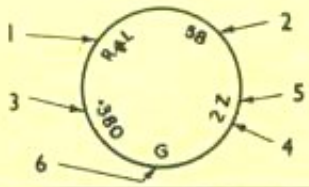
FIG.3
·380 INCH REVOLVER BALL
(RIMMED CASE)

BASE STAMPINGS
ITEMS 1, 2, 3, 4 & 5

FIG.4
9 mm BALL
(RIMLESS CASE)

BASE STAMPINGS
ITEMS 1, 2, 3, 4 & 5

FIG.5 BASE STAMPINGS



1 MANUFACTURERS RECOGNISED MONOGRAM OR INITIALS
2 YEAR OF MANUFACTURE
3 CALIBRE
4 MARK OF ROUND
5 PROPELLANT CODE (IF APPLICABLE)
6 CODE INDICATING NATURE OF ROUND

NOTES:-

1. The "Calibre" is required only to be stamped on the base of the following: .30 inch Browning, .30 inch Carbine, .310 inch Horse-killer, .380 inch Revolver, .50 inch Browning, 9 mm. and 7.62 mm. Ball L2A1, Rifle Grenade L1A1 and L1A2, Drill and Proof rounds.

2. The "Code indicating nature of round" is required only to be stamped on the base of:-

Incendiary	-	.303 inch and 7.92 mm.
Tracer	-	.303 inch, .50 inch Browning and 7.92 mm.
Blank	-	.303 inch and .380 inch.
Rifle Grenade	-	.303 inch.
Drill	-	.303 inch, .380 inch, 7.92 mm., 9 mm. and .50 inch Browning.
Observing	-	.303 inch.
Inspection	-	.303 inch, 7.92 mm., 9 mm. and .50 inch Browning.
Proof	-	.303 inch, .380 inch, 7.92 mm. and 9 mm.
AP	-	.50 inch Browning and 7.92 mm.
AP/Incendiary	-	.50 inch Browning.

TYPICAL IDENTIFICATION MARKINGS ON S.A.A. (SMALL ARMS AMMUNITION)

7·62 mm. (RIMLESS CASE)

FIG.1 ROUNDS

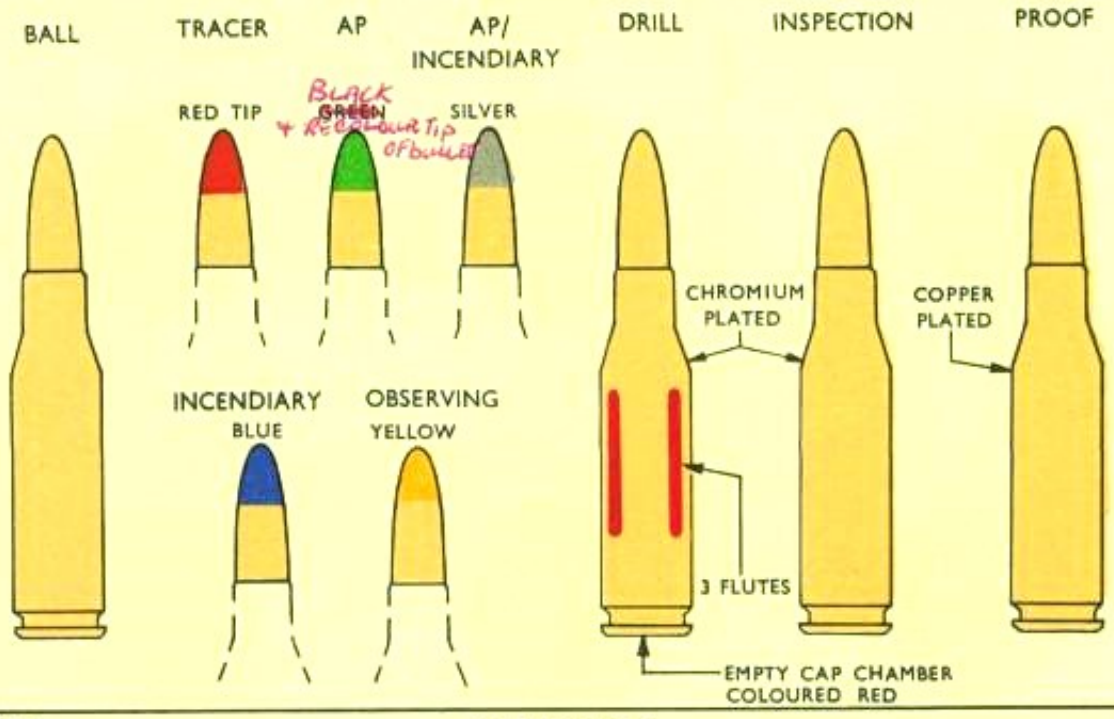
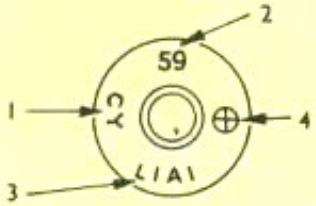


FIG.2 CARTRIDGES

RIFLE GRENADE LAUNCHING

MODELS L1A1 AND L1A2

FIG.3 BASE STAMPINGS *See also note 1 plate 2*



1 MANUFACTURERS RECOGNISED MONOGRAM OR INITIALS
2 YEAR OF MANUFACTURE
3 MARK OR MODEL NUMBER
4 NATO DESIGN SYMBOL (IF APPLICABLE)

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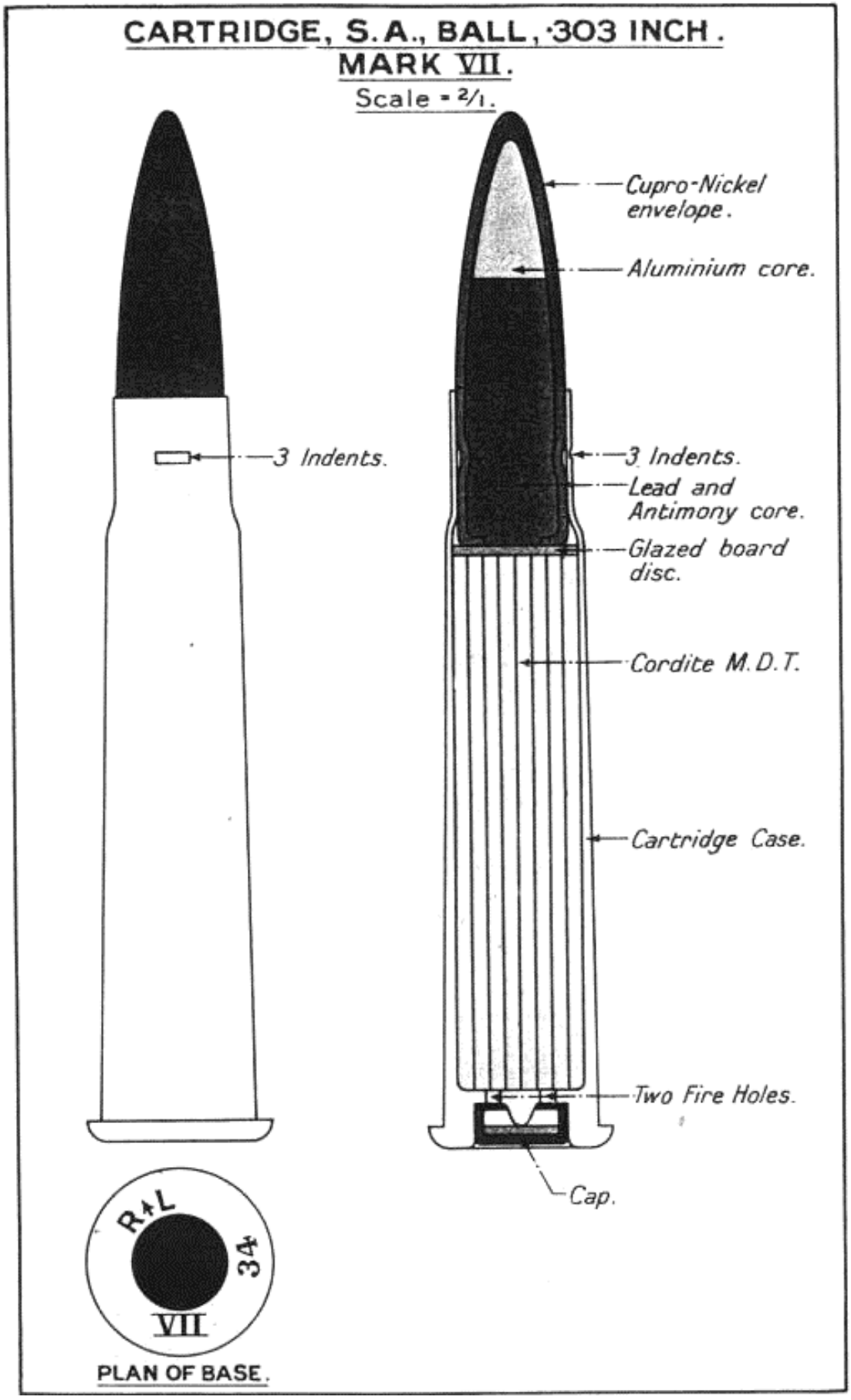

Project: Bourn Airfield

Project Ref: EES0823

Appendix 013J: Examples of Small Arms Ammunition

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Appendix 014

Penetration Depth Background Information

Background on Bomb Penetration Depths

There are a number of reasons/factors applicable to bomb penetration depths, which can lead to variations in the bomb penetration depths for aerial delivered ordnance, as follows:

- ***Shape & Weight of Ordnance –*** variations in the design of the delivered ordnance has a large impact on the depths to which it is able to penetrate. Generally speaking, the heavier the ordnance, the deeper the penetration, and when constructed in a streamlined shape this can also lead to an increased penetration depth.
- ***Geological Strata –*** variations in the composition, thickness and homogeneity of the geological strata can lead to significant variations in penetration depths.
- ***Height of delivery –*** the altitude at which the ordnance was released can lead to variations in the final penetration depth. For example, in low level attacks, or where a fleeing aircraft has had to ditch its payload, it is likely for penetration to have been much less due to any ordnance having not reached its terminal velocity and appropriate penetration angle (for maximum depth burial).
- ***Deflection –*** should an item of ordnance impacted onto an obstruction/structure prior to penetration into the ground, it may have deflected and as such behaved anomalously upon penetration, and thus the final resting position may potentially be atypical to what is normally expected.

The following table provides a guide on <u>average</u> & <u>*probable*</u> maximum penetration depths of bombs in geological conditions that are typical in most areas of the United Kingdom. This is based on a survey & calculations undertaken by the Ministry of National Security in October 1949.

The following table is based on sums conducted by the Ministry on a data set from 1,304 bombs dealt with between January 1st to May 14th, 1941 (along with 24 bombs experimentally dropped on chalk). Only incidents with a definitive soil type, without structures on the surface, were used.

Weight of Bomb Kg	Sandstone		Sand		Gravel (Mixed)		Chalk (Soft)		Clay (Wet)		Average Average Penetration	Average Probable Maximum Penetration
	Average Penetration	Probable Maximum	Average Penetration	Probable Maximum	Average Penetration	Probable Maximum	Average Penetration	Probable Maximum	Average Penetration	Probable Maximum		
	m	m	m	m	m	m	m	m	m	m	m	m
50	2.7	6.1	2.8	7.8	2.8	7.8	3.5	7.6	4.0	9.1	3.2	7.7
250	4.6	10.4	4.8	13.7	4.8	13.7	6.0	13.1	6.9	15.8	6.9	13.4
500	***5.8***	***13.1***	***6.0***	***17.4***	***6.0***	***17.4***	***7.6***	***16.5***	***8.7***	***19.8***	***8.7***	***16.8***
1000	7.3	16.5	7.6	21.9	7.6	21.9	9.6	20.7	11.0	25.0	11.0	21.2
1400	8.2	18.3	8.5	24.4	8.5	24.4	10.7	23.2	12.3	27.7	12.3	23.6
1800	9.0	20.3	9.4	27.0	9.4	27.0	11.8	25.5	13.5	30.5	13.5	26.0

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UXB 'Offset'

A typical high altitude release bomb will enter the ground at between 10º and 15º (to the vertical), and will travel on this trajectory until momentum is nearly lost. The bomb will then turn abruptly to the horizontal before coming to rest. The distance between the centre of the entry hole and the centre of the bomb at the rest is known as the 'offset'. A marked lateral movement from the original line of entry is not uncommon.

The average offset is one third of the penetration depth, i.e. an offset of some 2.0m may be expected for a 50kg bomb in clay.

Hard standing on the impact zone can result in an offset increasing by some four times. It should be noted that bombs striking buildings might be deflected to give wider variation in the impacted area.

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Appendix 015

UXO Detonation Characteristics

UXO Detonations

The major effects of partial or full detonation of a device are shock, blast, heat and shrapnel damage. It should be noted that the detonation of a 50kg buried bomb would damage brick or concrete structures up to 16m away and unprotected personnel on the surface up to 70m away. Larger ordnance is obviously more destructive, with an accepted safety distance for a 500kg HE device being 1km.

Once initiated, the effects of the detonation of explosive ordnance such as shells or bombs are usually extremely fast, often catastrophic and invariably traumatic to the personnel involved. The degradation of a shell or bomb may also offer a source of explosive contamination into the underlying soils. Although this contamination may still present an explosion hazard, it is not generally recognised that explosives offer a significant toxicological risk at concentrations well below that at which a detonation risk exists.

Unexploded ordnance does not spontaneously explode in the conditions experienced in the UK. UXBs have lain un-disturbed for some 60 years and should not detonate unless they are significantly disturbed. All HE requires significant energy to create the conditions for detonation to occur. Intense impacts in intrusive engineering such as drilling / piling and mechanical excavations could initiate a detonation. There are a number of scenarios that may occur on sites which may potentially lead to the detonation of an encountered item of UXO, as follows:

- ***Direct on the main body of the UXO*** – needs to be significant impact e.g. In the case of piling or large scale excavations.
- ***Re starting clock timer in a fuze*** – contact or vibration applied to a clock timer, in certain situations, may cause it to reinitiate. However, in the case of WWII (and pre-WWII) ordnance it is likely that such devices would be corroded and no longer able to function.
- ***Initiating Fuze Explosive*** – environmental factors, such as introduction of temperature fluctuations and water, can lead to degradation of explosives within items of UXO, which may then exude from the main body of the device and crystallise. Certain resultant compounds from such processes can be very sensitive and volatile, and through application of a small amount of movement / energy through either vibration or impact may result in detonation of the main charge.

Apart from the explosives risk, the main concerns from UXBs are threefold, these are:

- Heavy metal (Copper, Zinc etc) contamination from the bomb's casing.
- Organic aromatics (Toluene, Nitrosamines, daughter products etc) contamination from the degradation of the explosive charge.
- Heavy metal (Lead, Mercury) contamination from the degradation of the detonator charge.

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Appendix 016

Risk Assessment

CONSEQUENCE LEVEL	POTENTIAL CONSEQUENCES OF DETONATION				
	People	Environment	Assets		Reputation
			Plant and Equipment	Structures	
1	First aid injury	Minor disturbance.	No noticeable effect	No noticeable effect	No significant impact
2	Lost time injury < 3 days	Significant disturbance.	Slight superficial damage	Slight superficial damage	Slight Impact
3	Serious debilitating injury	Moderate damage to habitats.	Minor component replacement repair	Repairs - non-structural	Moderate Impact
4	Localised fatalities	Moderate damage of habitats. Some long term effects.	Significant component replacement repair	Repairs - structural	Major Impact
5	Multiple fatalities over extended area	Localised destruction of habitats. Moderate long-term effects.	Unit loss, un-repairable damage	Localised structural failure and collapse	Massive Impact

PROBABILITY OF ENCOUNTER		CONSEQUENCE LEVEL				
		1	2	3	4	5
1	**Improbable** *(Vey Low: Not likely to encounter)*	1	2	3	4	5
2	**Remote** *(Low: Slight chance of encounter)*	2	4	6	8	10
3	**Probable** *(Moderate: likely to encounter)*	3	6	9	12	15
4	**Highly Probable** *(High: highly likely to encounter)*	4	8	12	16	20
5	**Almost Certain** *(Very High: almost certain to encounter)*	5	10	15	20	25

Risk Level Key:

1 to 2	Negligible	3 to 6	Low	8 to 12	Moderate	15 to 25	High

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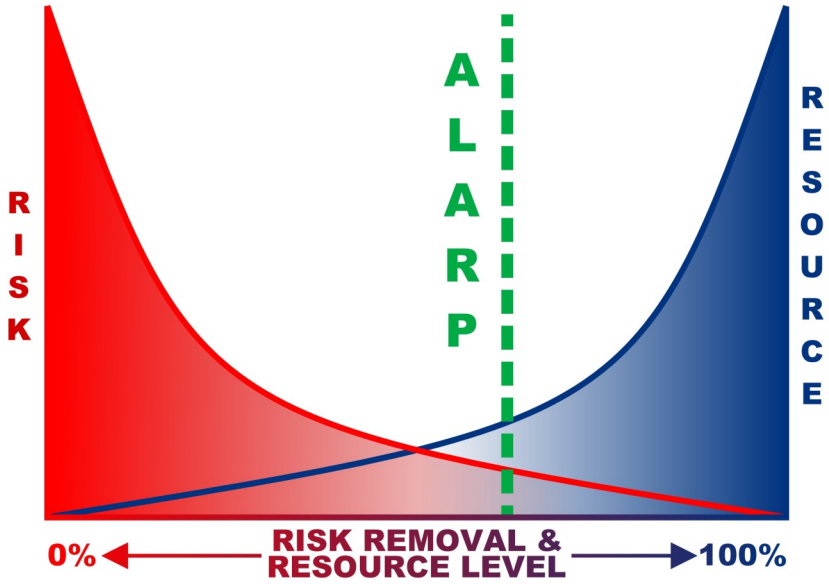
Appendix 017

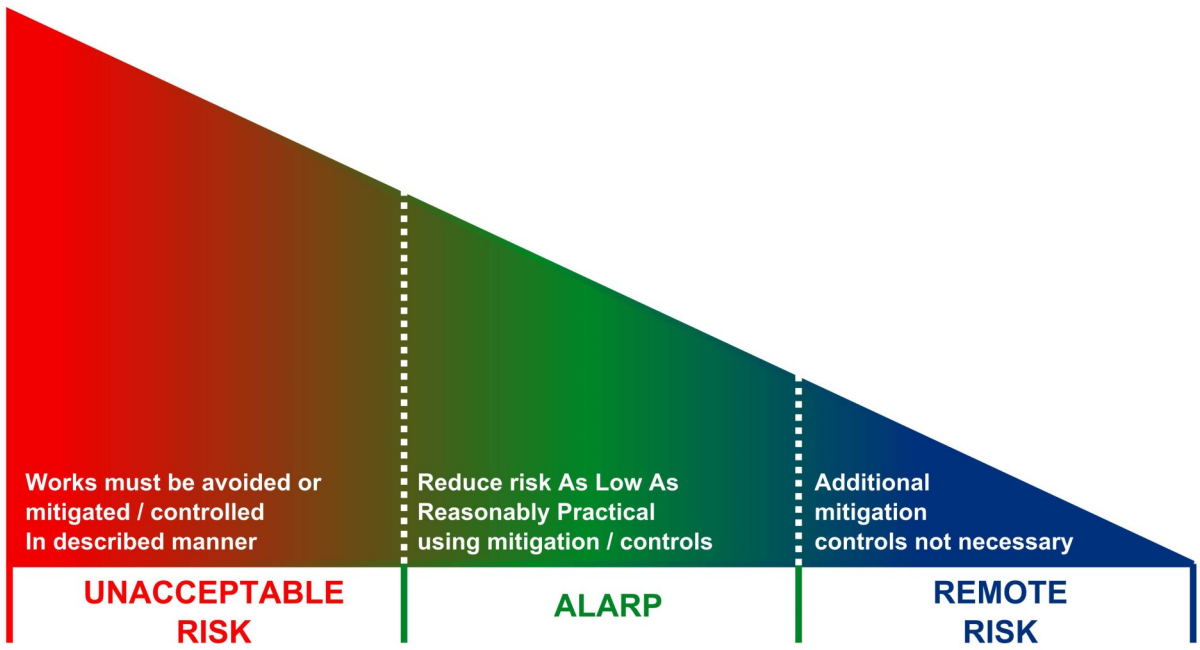
‘ALARP’ Principle

‘ALARP PRINCIPLE’

ALARP has particular connotations in UK Health and Safety law and the core concept of what is “*reasonably practicable*”. This involves weighing a risk against the effort, time and costs needed to control it. For a risk to be reduced in line with ALARP it must be possible to demonstrate that the cost involved in reducing the risk further would be “*grossly disproportionate*” to the benefit gained. The ALARP principle arises from the fact that it would be possible to spend infinite time, effort and money attempting to reduce a risk to zero. Importantly, it is not simply a quantitative measure of benefit against detriment but a common practice of “*judgment*” of the balance of risk and social benefit.



ALARP Resource Graph



ALARP Diagram Approach

Appendix 018

Recommendation Descriptions

RPS Explosives Safety & Awareness Briefings / Site Safety Guidelines

It is recommended that all personnel conducting intrusive works, in any part of the site, should attend an ***RPS Explosives Safety & Awareness Briefing***. This should comprise part of the standard site induction briefing and would form a component of the Health and Safety Plan for the site adhering to the requirements of CDM regulations 2015. All personnel working on site would be briefed on UXO recognition and made aware of the possible risks. They would be informed of the actions to take to alert the site manager and to keep people and equipment away from the hazard.

RPS feels it may be cost effective and prudent to produce a set of ***RPS Explosives Site Safety Guidelines (ESSG)***, which would be provided to the client along with training. The guidelines are designed to aid the Project Team to plan the proposed works and potentially deal with the event of a suspicious item / UXO discovery incident. The guidelines would also enable the client to incorporate the Explosives Safety & Awareness Briefings into their standard site inductions.

The guidelines would address the risk to all of the specific proposed works and will inform all personnel how to undertake the works safely, and will refer to the specific risk items/hazards that have been identified for the site.

The guidelines would typically be provided to the client in the form of a 'Guidelines Document' along with a supporting PowerPoint slideshow.

However, it should be noted that if a significant/elevated risk is subsequently identified then a fully qualified Explosives Engineer should manage the situation on behalf of the client.

RPS Energy

Explosives Engineering Services

☎ +44 (0) 845 638 4760

www.rpsuxo.com

Explosives Safety Consultancy On-Call

To provide our client's with further confidence & support, RPS EES operates an on-call service, whereby in the situation where a suspicious item is encountered / uncovered on a **Low** risk site during excavation works, RPS can be contacted for further support.

Further to this, based on the information gleaned from site, and if required a fully qualified Explosives Safety Engineer would be able to be mobilised to attend site if necessary

Typically, the on-call procedure would be as follows:

- Site representative to telephone RPS EES and describe/discuss the situation over the phone.
- Site representative to send digital photographs of the incident/item (where appropriate) to RPS EES for assessment of the situation and to advise accordingly.
- Explosives Safety Engineer to be mobilised to visit site as soon as required/practical if necessary.

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Intrusive Magnetometer Survey

RPS consider it would be prudent to conduct an intrusive Magnetometer survey ahead of any proposed boreholes and/or potential pile locations across the site to reduce the risk of encountering deep buried UXBs. The type of survey methodology required would be dependent upon ground conditions and the works taking place.

Non-Intrusive Magnetometer Survey

As an alternative to *Explosives Safety Engineer Supervision*, and considering the specific conditions on site, it may be feasible, and potentially cost effective, to carry out a Non-Intrusive Magnetometer survey ahead of shallow excavations / works over the site.

Non-intrusive magnetometer surveys have the capability to detect shallow buried items of UXO. The actual performance of the equipment is dependent on ground conditions and the sizes of potential ordnance present. It should be appreciated that the success of the proposed methods will be dependent upon the geophysical contrast between the target and the background material.

Explosives Engineer Supervision

It is recommended that, an ***Explosives Engineer*** should be present during relevant excavations taking place at the site. The Engineer will confirm if the identity of any suspicious object is ordnance related. If the item is ordnance related then the Engineer will aid with the incident management, until the appropriate authorities have control of the site.

The role of the Explosives Engineer would include:

- The monitoring of works using visual recognition and instrumentation, where practical and advising staff of the need to modify working practices to take into account the ordnance risk.
- Using a magnetometer, clear in advance of the excavator to ensure no buried ordnance is encountered.
- Providing an immediate response to reports of suspicious objects or suspected items of ordnance that have been recovered by the ground workers on site.
- Aid in incident management, including liaison with the Local Authorities and Police, should ordnance be identified and present an explosive hazard.

62-64 Hills Road
Cambridge
CB2 1LA

wsp.com