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Permanent Magnet Test and Evaluation

February 2005



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1. Introduction

During the 22-23 of February, a permanent magnet was tested at SWEDEC. The trail was requested by the Geneva International Centre for Humanitarian Demining GICHD. The Test Team was made up of the following people:

Mr Kaj Hörberg	GICHD
Mr Curt Larsson	SWEDEC
Lt Tommy T Karlsson	Gota Engineers
Maj Göran Danielsson	SWEDEC
Mr Heinz Rath	MineWolf Demining Technology (donor)

The trail called for basic tests of the effectiveness of magnets in order to pick up metal fragments from the ground and out of the ground in a more or less laboratory environment.

The request for the GICHD Magnet Study is found in Annex B



2. Trail Description

2.1 Facilities and Tools

The test was conducted by SWEDEC in an indoor environment. The test bed was made of a sand box filled with gravel of 018 size. The Magnet was hanging in a block and could be adjusted both lengthways and in height. The speed of the sweep was controlled by a winch. The sweeping speed was recorded to 180 m/hour.

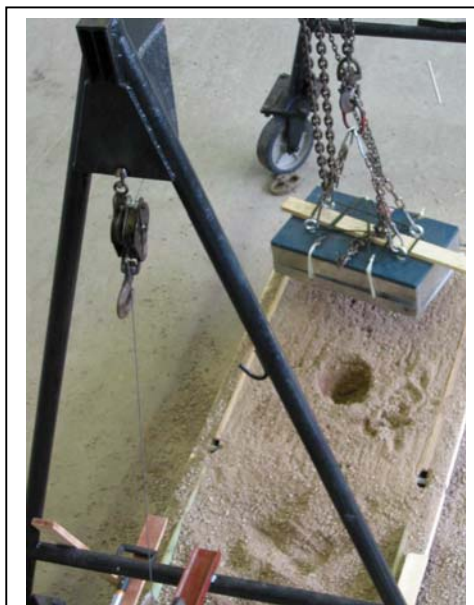


Figure 1: Test set up for magnet test



Figure 2: Winch Mechanism to maintain 180 m/h



Cardboard sheets were used in order to put out the targets in a repeatable pattern and to make sure that there were no contact between the targets. The targets were laid at a width of $\frac{1}{2}$ the full width of the magnet (310 mm)

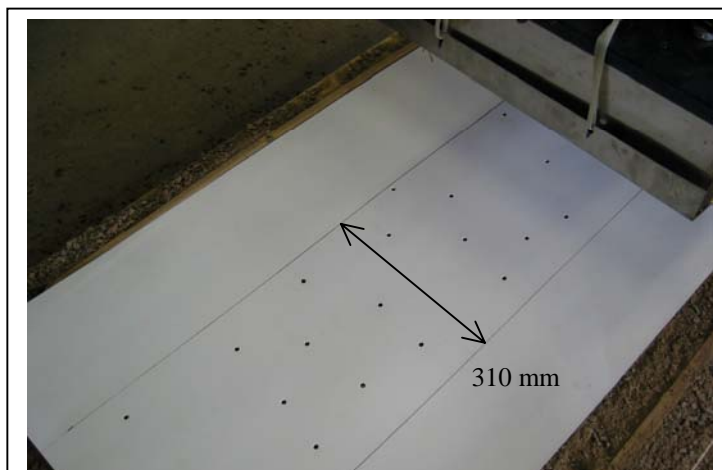


Figure 3: Guide Cardboard Sheets

2.2 Targets

The test targets that were supposed to be used during the test were steel balls in four different sizes. The # 4 steel ball target was only used in the first tests because it couldn't be detected with a metal detector.

During the test the test team decided to add some more targets to the test in order to test whether exposed area to the magnet was an important factor or not. The team decided to use metal washers in three different sizes that were similar in weight with the steel balls. We also decided to use live fragments from shells as reference objects.

The Magnets was also tested against some typical UXO like shells, AP fragmentation mine and sub-munitions

2.2.1 Steel Balls

Steel Ball # 1:

- diameter 20 mm
- weight 28 grams

Steel Ball # 2:

- diameter 10 mm
- weight 4 grams

Steel Ball # 3:

- diameter 5 mm
- weight 0,5 grams

Steel Ball # 4:

- diameter 2 mm
- weight 0,03 grams

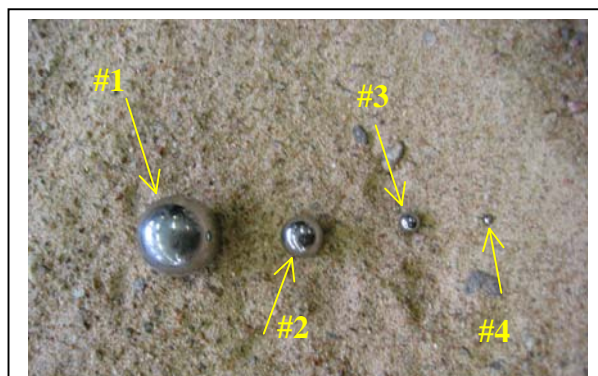


Figure 4: Steel Ball Test Targets



2.2.2 Metal Washers

Metal Washer # 1:

- diameter outer 45 mm
- diameter inner 25 mm
- thickness 4 mm
- weight 32 grams

Metal Washer # 2:

- diameter outer 22 mm
- diameter inner 10,5 mm
- thickness 2 mm
- weight 4 grams

Metal Washer # 3:

- diameter outer 10 mm
- diameter inner 5 mm
- thickness 2 mm
- weight 0,4 grams

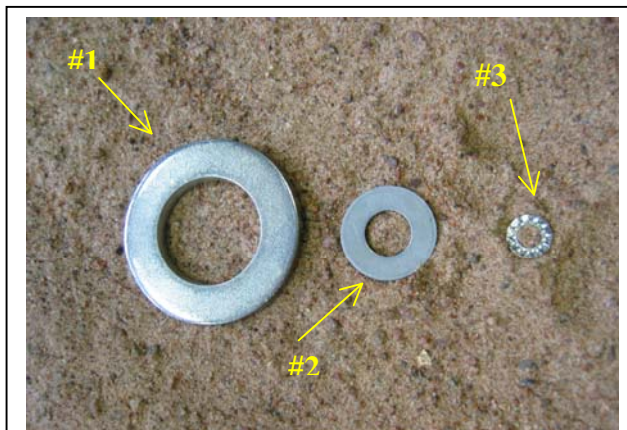


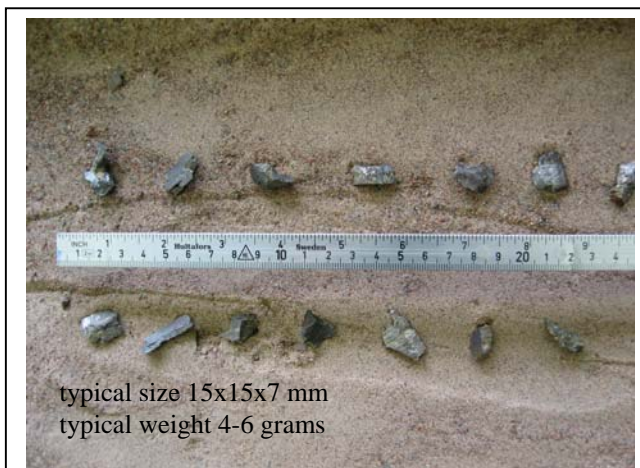
Figure 5: Metal Washer Test Targets

2.2.3 Shell Fragments



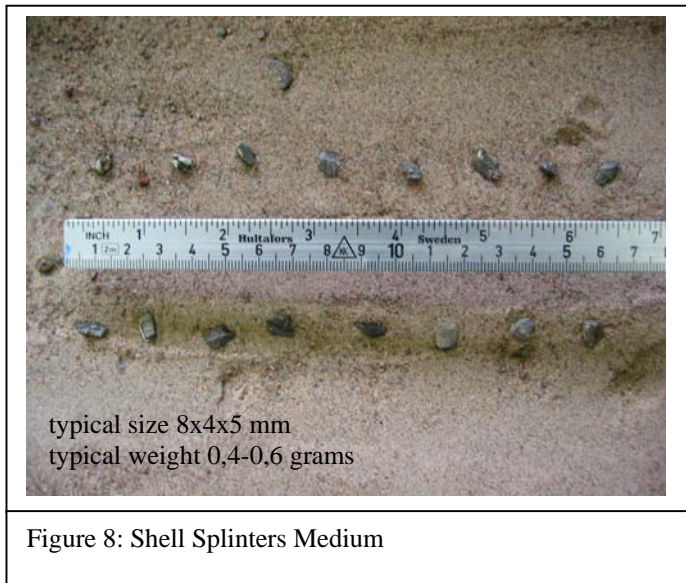
typical size 50x20x10 mm
typical weight 30-34 grams

Figure 6: Shell Splinters Large

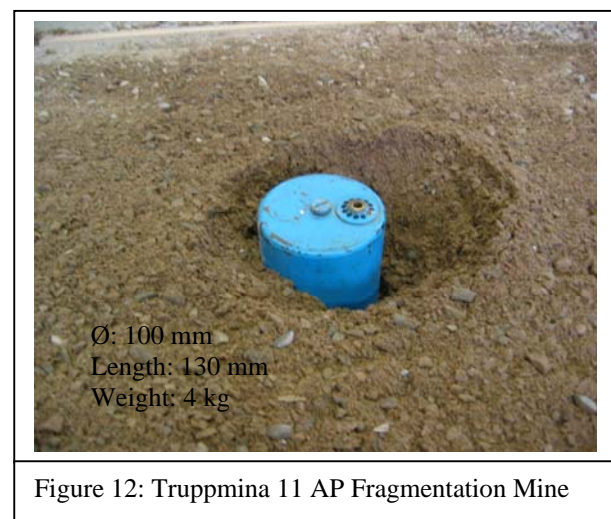
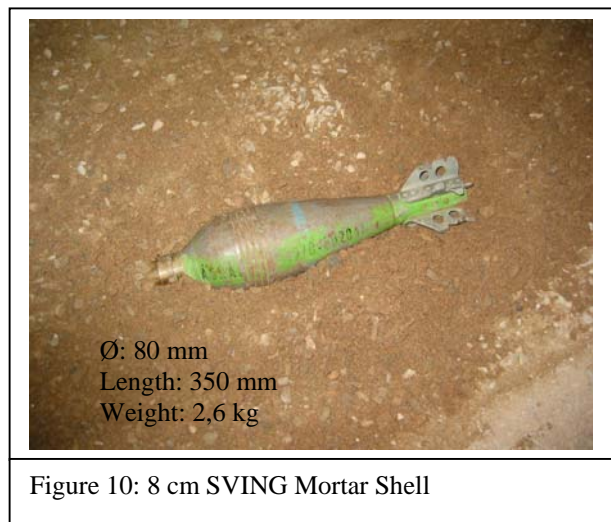
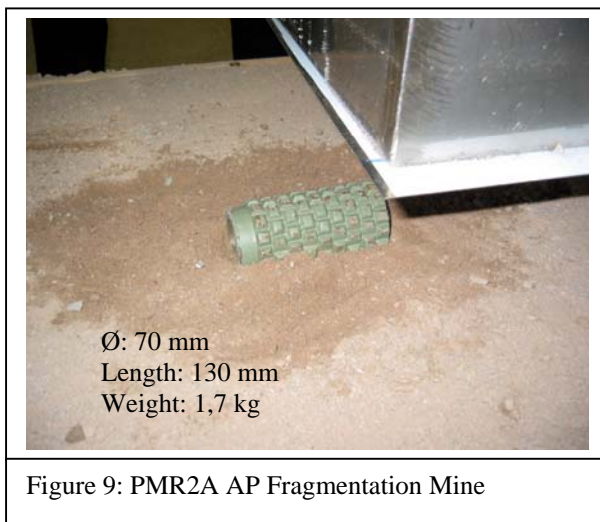


typical size 15x15x7 mm
typical weight 4-6 grams

Figure 7: Shell Splinters Medium



2.2.4 UXO





2.3 The Magnet

The Magnet was a permanent magnet from the HYAB company, provided by the Geneva International Centre for Humanitarian Demining (GICHD). The size of the magnet is 617x357x153 mm and the weight is about 180 kg. A 1 mm stainless steel plate was put under the magnet to simulate the wearing surface that magnets in the field usually are equipped with.

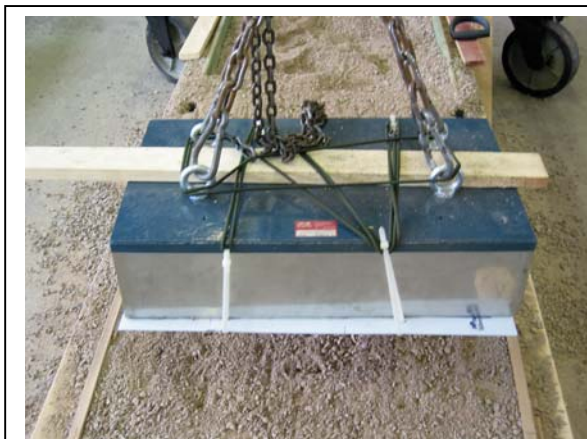
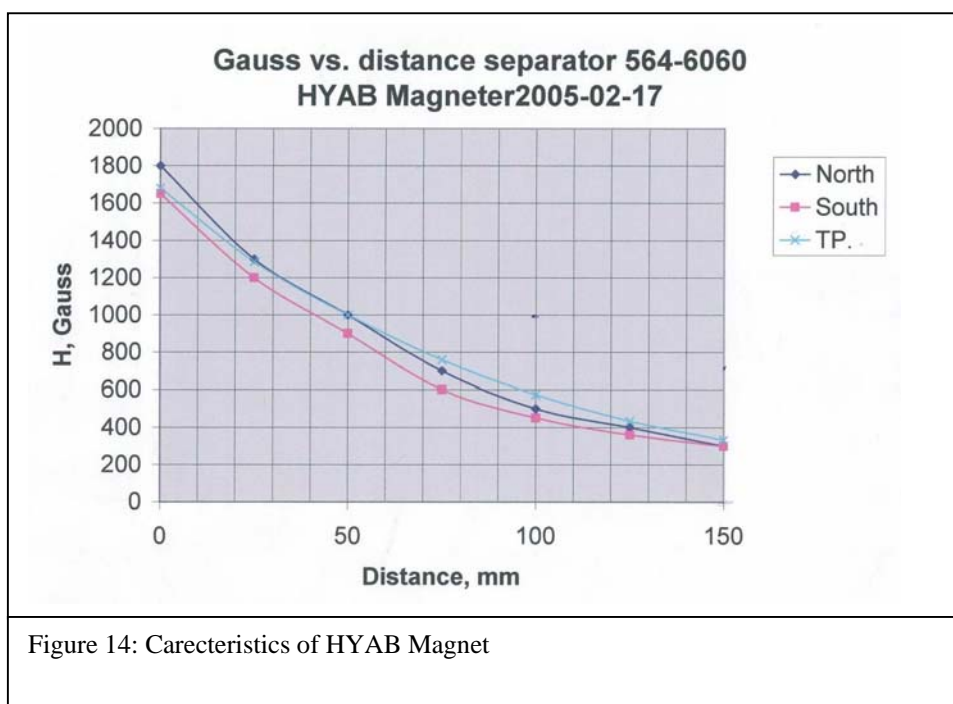


Figure 13: HYAB Permanent Magnet



Figure 14: 1 mm Stainless Steel Wearing Surface

The characteristics of the magnet is shown in the table below.





2.4 Test Method

The sand box was filled with gravel of size 018 (fraction from 0-18 mm). The surface of the soil was levelled with help of a board. The cardboard sheet guide (figure 3) was put out and the position of the targets were marked. The targets were laid on the soil either on the surface or flush to the surface. If the targets were covered, two cm gravel were put on top of the targets and levelled once again. The used method is described in the test data sheets. The UXO targets were covered with 6 cm of soil.



Figure 15: Soil Bed Leveled with board



Figure 16: Targets Covered with 2 cm of Gravel

The magnet was adjusted in height to a level where non of the targets were pulled out. It was than lowered in steps of 2 cm until all the targets were pulled out. The magnet was swept with a constant speed of 180 m/h only once at each height. The number of pulled out targets were recorded after each sweep in the Test Data Sheets. All targets were demagnetised after each test.



Figure 17: Magnet was guided during the test



3 Test Results and Other Observations

All results of the test are recorded in Annex A Test Data Sheets.

3.1 Questions for the test due to Annex C to be answered.

1. What is the practical sweeping height for a magnet?

A practical height for a magnet in the fields might be about 10 cm. A contouring system for the magnet is needed though.

2. At which magnetic flux density is all metal that is laying on the surface or close to surface of the soil picked up and is it depending of the sizes of the fragments?

Exposed area seems to be of more importance than the weight of the object.

The table below shows the height the **uncovered targets** were picked up at.

Type	Height (cm)	Comment
Steel ball 2 mm	8	on the surface
Steel ball 5 mm	8	on the surface
Steel ball 10 mm	8	on the surface
Steel ball 20 mm	10	on the surface
Steel ball 2 mm	N/A	flush to the surface
Steel ball 5 mm	10	flush to the surface
Steel ball 10 mm	10	flush to the surface
Steel ball 20 mm	8	flush to the surface
Metal Washer small	18	horizontal
Metal Washer medium	18	horizontal
Metal Washer large	20	horizontal
Metal Washer small	18	vertical
Metal Washer medium	16	vertical
Metal Washer large	14	vertical
Splinters small	14	
Splinters medium	14	
Splinters large	14	

For uncovered objects a practical height of the magnet in a pull out point of view should be 8-10 cm



- 3. Is it possible for a magnet to “pull up” fragments buried in the soil and if so,**
- from which depth**
 - is it depending of the sizes of fragments**
 - which strength of the magnet is needed**
 - does it work in loose as well as compacted soil?**

The table below shows at which height the **covered targets** were picked up at. The targets were put on the test bed and then covered with 2 cm of gravel. The top layer was only levelled and not compacted. The test plan called for even compacted soil and bigger depths, but the tested magnet failed to pull out the objects even in the easiest case. FAILED is used in the table if the magnet did not pick up all the targets at a certain depth. More details are available in the test data sheets in Annex A.

Type	Height (cm)	Comment
Steel ball 2 mm	N/A	flush to the surface
Steel ball 5 mm	FAILED	flush to the surface
Steel ball 10 mm	FAILED	flush to the surface
Steel ball 20 mm	2	flush to the surface
Metal Washer small	FAILED	horizontal
Metal Washer medium	6	horizontal
Metal Washer large	10	horizontal
Metal Washer small	FAILED	vertical
Metal Washer medium	4	vertical
Metal Washer large	6	vertical
Splinters small	FAILED	
Splinters medium	4	
Splinters large	6	

A more powerful magnet is needed if the magnet is supposed to pull out buried objects.

- 4. Is it a disadvantage if the soil has been processed prior the first sweep with the magnet? “Will dig down more than it will dig up?”**

The test with the objects buried in 2 cm loose soil was meant to simulate a processed ground. The tested magnet was not powerful enough to pull out objects. Further tests at bigger depth were not executed.



3.2 Other observations

The orientation/position, in the point of the compass, of long objects is essential. Long objects want to rotate and align into the magnetic field before they will be pulled out. If the objects can not rotate freely, it takes a more powerful magnet to pull them out. Another solution might be to use a rotating magnet or pass the area from different angles with the magnet (test number 14 PMR2A).

Electro magnets are preferred before permanent magnets because they could be shut off. This is of importance when it comes to transport, maintenance etc.

Buried targets require a very strong magnet to be able to pull out fragments from the ground. Factors that will influence the result might be:

- weight of the soil above the fragment
- friction
- distance between target and magnet
- alignment to magnetic field



Annex A

Test Data Sheets

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Testprotocol Magnet test GICHD DRAFT																						
Date: 2005-02-22	Weather conditions: Indoors	Temperature: 18° C																				
Ground conditions: Gravel mix 018	Status:	Location:																				
Test number/overview: 1: Targets laid on the surface (not covered)		Photo/video:																				
Equipment: 2, 5 ,10 and 20 mm steel balls																						
Sketch: <div style="text-align: center; margin: 10px 0;"> </div> <p>The targets (20 of each) are laid open on the surface without contact with each other. The magnet will be moved parallel to the sand box. After the magnet has passed once, the number of targets that have been stuck under the magnet were recorded</p>																						
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	2 mm	5 mm	10 mm	20 mm																		
8 cm	20(20)	20(20)	20(20)	20(20)																		
10 cm	15(20)	18(20)	19(20)	20(20)																		
12 cm	0(20)	0(20)	0(20)	6(20)																		
Personnel/test leader: Maj Danielsson		Signature: <div style="text-align: right; margin-top: 20px;">DAN</div>																				



Testprotocol Magnet test GICHD																		
Date: 2005-02-22	Weather conditions: Indoors	Temperature: 18° C																
Ground conditions: Gravel mix 018	Status:	Location:																
Test number/overview: 2: Targets laid flush to surface (not covered)		Photo/video:																
Equipment: 5 ,10 and 20 mm steel balls																		
<p>Sketch:</p> <div style="text-align: center; margin: 20px 0;"> </div> <p style="text-align: right; margin-right: 50px;">Different heights A: 8 cm B: 10 cm C: 12 cm</p> <p>The targets (20 of each) are laid open on the surface without contact with each other. The magnet will be moved parallel to the sand box. After the magnet has passed once, the number of targets that have been stuck under the magnet were recorded</p>																		
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Date: 2005-02-22	Weather conditions: Indoors	Temperature: 18° C																				
Ground conditions: Gravel mix 018	Status:	Location:																				
Test number/overview: 3: Targets laid flush to surface and covered with 2 cm of gravel		Photo/video:																				
Equipment: 5 ,10 and 20 mm steel balls																						
Sketch: <div style="text-align: center; margin: 20px 0;"> </div> <p>The targets (20 of each) are laid flush the surface without contact with each other. After that they were covered with 2 cm of loose gravel. The magnet was moved parallel to the sand box. After the magnet has passed once, the number of targets that have been stuck under the magnet were recorded</p>																						
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5 cm	0(20)	0(20)	0(20)																			
Personnel/test leader: Maj Danielsson		Signature: <div style="text-align: right; margin-top: 20px;">DAN</div>																				



Testprotocol Magnet test GICHD DRAFT																						
Date: 2005-02-22	Weather conditions: Indoors	Temperature: 18° C																				
Ground conditions: Gravel mix 018	Status:	Location:																				
Test number/overview: 4: Targets laid horizontal on the surface (not covered)		Photo/video:																				
Equipment: Metal Washers in three different sizes large medium and small																						
Sketch: <div style="text-align: center; margin: 20px 0;"> </div> <div style="float: right; margin-top: 20px;"> Different heights A: 16 cm B: 18 cm C: 20 cm D: 22 cm </div>																						
The targets (20 of each) are laid open on the surface without contact with each other with help of a guide. The magnet will be moved parallel to the sand box. After the magnet has passed once, the number of targets that have been stuck under the magnet were recorded																						
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Testprotocol Magnet test GICHD DRAFT																						
Date: 2005-02-22	Weather conditions: Indoors	Temperature: 18° C																				
Ground conditions: Gravel mix 018	Status:	Location:																				
Test number/overview: 5: Targets put into a vertical position(not covered)		Photo/video:																				
Equipment: Metal Washers in three different sizes large medium and small																						
Sketch:																						
<p>The targets (20 of each) were put into a vertical position in the test bed without contact with each other, in a random E-W, N-S pattern. The magnet was moved parallel to the sand box. After the magnet has passed once, the number of targets that have been stuck under the magnet were recorded</p>																						
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Date: 2005-02-22	Weather conditions: Indoors	Temperature: 18° C																																								
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Test number/overview: 6: Targets laid on the surface in a horizontal position and covered with 2 cm of gravel		Photo/video:																																								
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Personnel/test leader: Maj Danielsson		Signature: DAN																												



Testprotocol Magnet test GICHD DRAFT										
Date: 2005-02-22	Weather conditions: Indoors	Temperature: 18° C								
Ground conditions: Gravel mix 018	Status:	Location:								
Test number/overview: 8: Targets laid flush to the surface (not covered)		Photo/video:								
Equipment: Fragments from shells 0,4-0,6 grams										
Sketch: <div style="text-align: center; margin-top: 20px;"> </div> <p style="text-align: right; margin-right: 50px;">Different heights A: 14 cm B: 16 cm C: 18 cm</p> <p>The targets (18 of each) are laid flush to the surface without contact with each other. The magnet will be moved parallel to the sand box. After the magnet has passed once, the number of targets that have been stuck under the magnet were recorded</p>										
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	Small									
14 cm	18(18)									
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Personnel/test leader: Maj Danielsson		Signature: DAN								



Testprotocol Magnet test GICHD DRAFT																
Date: 2005-02-22	Weather conditions: Indoors	Temperature: 18° C														
Ground conditions: Gravel mix 018	Status:	Location:														
Test number/overview: 9: Targets laid flush to the surface and covered with 2 cm of gravel		Photo/video:														
Equipment: Fragments from shells 0,4-0,6 grams																
Sketch: <div style="text-align: center; margin-top: 20px;"> </div> <p>The targets (18 of each) were laid flush to the surface without contact with each other in a random position. They were then covered with 2 cm of gravel. The magnet was moved parallel to the sand box. After the magnet has passed once, the number of targets that have been stuck under the magnet were recorded</p>																
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6 cm	0(18)															
8 cm	0(18)															
10 cm	1(14)															
Personnel/test leader: Maj Danielsson		Signature: DAN														



Testprotocol Magnet test GICHD DRAFT														
Date: 2005-02-22	Weather conditions: Indoors	Temperature: 18° C												
Ground conditions: Gravel mix 018	Status:	Location:												
Test number/overview: 10: Targets laid flush to the surface (not covered)		Photo/video:												
Equipment: Fragments from shells 4-6 grams														
Sketch: <div style="text-align: center; margin-top: 20px;"> </div> <p>The targets (14 of each) are laid flush to the surface without contact with each other. The magnet will be moved parallel to the sand box. After the magnet has passed once, the number of targets that have been stuck under the magnet were recorded</p>														
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14 cm	14(14)													
16 cm	11(14)													
18 cm	4(14)													
20 cm	1(14)													
22 cm	0(14)													
Personnel/test leader: Maj Danielsson		Signature: <div style="text-align: right;">DAN</div>												



Testprotocol Magnet test GICHD DRAFT														
Date: 2005-02-22	Weather conditions: Indoors	Temperature: 18° C												
Ground conditions: Gravel mix 018	Status:	Location:												
Test number/overview: 11: Targets laid flush to the surface and covered with 2 cm of gravel		Photo/video:												
Equipment: Fragments from shells 4-6 grams														
Sketch: <div style="text-align: center; margin-top: 20px;"> </div> <p>The targets (14 of each) were laid flush to the surface without contact with each other in a random position. They were than covered with 2 cm of gravel. The magnet was moved parallel to the sand box. After the magnet has passed once, the number of targets that have been stuck under the magnet were recorded</p>														
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4 cm	14(14)													
6 cm	12(14)													
8 cm	3(14)													
10 cm	1(14)													
12 cm	0(14)													
Personnel/test leader: Maj Danielsson		Signature: DAN												

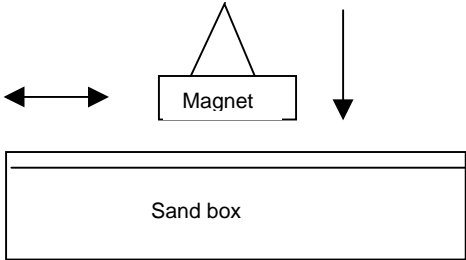



Testprotocol Magnet test GICHD DRAFT																
Date: 2005-02-22	Weather conditions: Indoors	Temperature: 18° C														
Ground conditions: Gravel mix 018	Status:	Location:														
Test number/overview: 12: Targets laid flush to the surface (not covered)		Photo/video:														
Equipment: Fragments from shells 30-34 grams																
Sketch: <div style="text-align: center; margin: 20px 0;"> </div> <p>The targets (13 of each) are laid flush to the surface without contact with each other in a random position. The magnet were moved parallel to the sand box. After the magnet has passed once, the number of targets that have been stuck under the magnet were recorded</p>																
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14 cm	13(13)															
16 cm	12(13)															
18 cm	8(13)															
20 cm	6(13)															
22 cm	4(13)															
24 cm	0(13)															
Personnel/test leader: Maj Danielsson	Signature: <div style="text-align: right; margin-top: 20px;">DAN</div>															

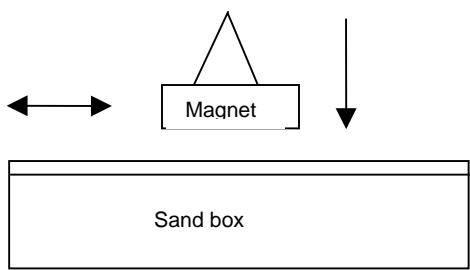



Testprotocol Magnet test GICHD DRAFT																				
Date: 2005-02-22	Weather conditions: Indoors	Temperature: 18° C																		
Ground conditions: Gravel mix 018	Status:	Location:																		
Test number/overview: 13: Targets laid flush to the surface and covered with 2 cm of gravel)		Photo/video:																		
Equipment: Fragments from shells 30-34 grams																				
Sketch: <div style="text-align: center; margin: 20px 0;"> </div> <p>The targets (13 of each) were laid flush to the surface without contact with each other in a random position. They were than covered with 2 cm of gravel. The magnet was moved parallel to the sand box. After the magnet has passed once, the number of targets that have been stuck under the magnet were recorded</p>																				
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Personnel/test leader: Maj Danielsson		Signature: DAN																		

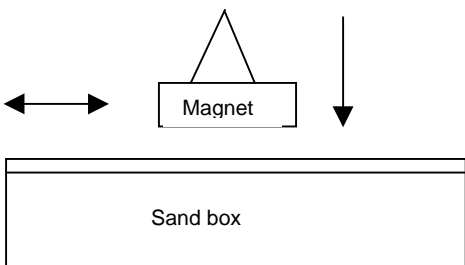



Test protocol Magnet test GICHD DRAFT														
Date: 2005-02-23	Weather conditions: Indoors	Temperature: 18° C												
Ground conditions: Gravel mix 018	Status:	Location:												
Test number/overview: 14: PMR2A metal mine body		Photo/video:												
Equipment:														
<p>Sketch:</p> <p>Test 1: Target laid on the ground (not covered) in a North-South position.</p> <p>Test 2: Target laid on the ground in an up right position</p> <p>Test 3: Target buried half ways in a North-South position</p> <p>Test 4: Target buried half ways in an East- West position</p> <p>Test 5: Target buried 6 cm in loose soil in a North-South position</p> <div style="display: flex; justify-content: space-around; align-items: center;"> <div style="text-align: center;">  <p>The diagram shows a rectangular box labeled 'Sand box' with a horizontal double-headed arrow above it. Above the box is a trapezoidal shape labeled 'Magnet' with a vertical arrow pointing down towards the box.</p> </div> <div style="text-align: center;">  <p>The photo shows a green, textured cylindrical magnet being pulled up by a metal frame over a surface of brown soil. The text 'Test # 4' is written at the bottom of the photo.</p> </div> </div> <p>The magnet was swept over and lowered until the magnet was able to pull the target up. The height of the magnet from the ground was recorded.</p>														
Comments and results:														
<table border="1" style="width: 100%; border-collapse: collapse; text-align: center;"> <thead> <tr> <th style="width: 15%;"></th> <th style="width: 15%;">Test 1</th> <th style="width: 15%;">Test 2</th> <th style="width: 15%;">Test 3</th> <th style="width: 15%;">Test 4</th> <th style="width: 15%;">Test 5</th> </tr> </thead> <tbody> <tr> <td style="text-align: left;">Height</td> <td>22 cm</td> <td>22 cm*</td> <td>18,5 cm</td> <td>14 cm</td> <td>4 cm</td> </tr> </tbody> </table> <p>*The target was flipped over to a horizontal position before it was pulled up</p>				Test 1	Test 2	Test 3	Test 4	Test 5	Height	22 cm	22 cm*	18,5 cm	14 cm	4 cm
	Test 1	Test 2	Test 3	Test 4	Test 5									
Height	22 cm	22 cm*	18,5 cm	14 cm	4 cm									
Personnel/test leader: Maj Danielsson		Signature: <div style="text-align: right; margin-top: 20px;">DAN</div>												

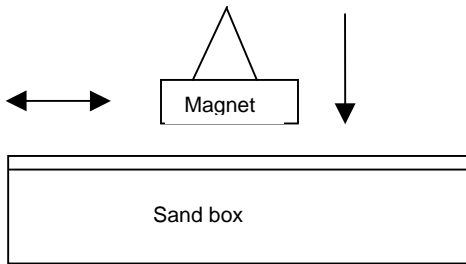



Test protocol Magnet test GICHD DRAFT						
Date: 2005-02-23	Weather conditions: Indoors	Temperature: 18° C				
Ground conditions: Gravel mix 018	Status:	Location:				
Test number/overview: 15: 8 cm SVING mortar shell		Photo/video:				
Equipment:						
Sketch:						
<p>Test : Target buried 6 cm in loose soil in a North-South position</p> <div style="display: flex; justify-content: space-around; align-items: center;"> <div style="text-align: center;">  </div> <div style="text-align: center;">  </div> </div> <p>The magnet was swept over and lowered until the magnet was able to pull it up. The height of the magnet from the ground was recorded.</p>						
Comments and results:						
<table border="1" style="margin: auto; border-collapse: collapse;"> <tr> <td style="width: 50%;"></td> <td style="width: 50%; text-align: center;">Test</td> </tr> <tr> <td style="text-align: center;">Height</td> <td style="text-align: center;">4 cm</td> </tr> </table>				Test	Height	4 cm
	Test					
Height	4 cm					
Personnel/test leader: Maj Danielsson	Signature: <div style="text-align: right; margin-top: 20px;">DAN</div>					



Test protocol Magnet test GICHD DRAFT						
Date: 2005-02-23	Weather conditions: Indoors	Temperature: 18° C				
Ground conditions: Gravel mix 018	Status:	Location:				
Test number/overview: 16: PTAB 2,5 Russian Sub-Munition		Photo/video:				
Equipment:						
Sketch: Test : Target buried 6 cm in loose soil in a North-South position <div style="display: flex; justify-content: space-around; align-items: center;"> <div style="text-align: center;">  </div> <div style="text-align: center;">  </div> </div> <p>The magnet was swept over and lowered until the magnet was able to pull it up. The height of the magnet from the ground was recorded.</p>						
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	Test					
Height	4 cm					
Personnel/test leader: Maj Danielsson		Signature: <div style="text-align: right;">DAN</div>				



Test protocol Magnet test GICHD DRAFT								
Date: 2005-02-23	Weather conditions: Indoors	Temperature: 18° C						
Ground conditions: Gravel mix 018	Status:	Location:						
Test number/overview: 17: AP fragmentation mine # 11 (Swedish)		Photo/video:						
Equipment:								
Sketch: Test 1: Target laid in the ground in an up right position with the top of the mine flush to the surface. Test 2: Target buried 6 cm in loose soil in a North-South position <div style="display: flex; justify-content: space-around; align-items: center;"> <div style="text-align: center;">  <p>The diagram shows a rectangular box labeled 'Sand box'. Above it, a triangle representing a mine is positioned on a horizontal line. A vertical line with a downward-pointing arrow indicates the magnet's path. A horizontal double-headed arrow is to the left of the mine, indicating its orientation.</p> </div> <div style="text-align: center;">  <p>The photograph shows a blue cylindrical magnet being lowered into a sand box. The magnet is positioned directly above a small, dark, cylindrical object (the mine) which is partially buried in the sand.</p> </div> </div> <p>The magnet was swept over and lowered until the magnet was able to pull it up. The height of the magnet from the ground was recorded.</p>								
Comments and results:								
<table border="1"> <thead> <tr> <th></th> <th>Test 1</th> <th>Test 2</th> </tr> </thead> <tbody> <tr> <th>Height</th> <td>7 cm</td> <td>3 cm</td> </tr> </tbody> </table>				Test 1	Test 2	Height	7 cm	3 cm
	Test 1	Test 2						
Height	7 cm	3 cm						
Personnel/test leader: Maj Danielsson		Signature: DAN						



Annex B

Request for Magnet Test

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Test with magnet as a tool to reduce the metal contamination during demining

Background

The contamination of metal fragment within the mine suspected areas is one of the main reasons that delay the manual demining. The metal comes from domestic debris as well as fragments from detonating ordnance. Very small pieces of metal will cause an alarm in a metal detector and these small fragments are more difficult and time consuming to find and remove for the deminers. The amount of metal is different from area to area but only few areas have a low metal contamination. A magnet can only collect ferromagnetic metal and it usually requires that the metal is lying on or close to the surface. Vegetation, if it is not removed, will also be an obstacle for the magnet.

Despite the limited use of magnet the Thailand Mine Action Centre has showed on incremental improvements in cost effectiveness when magnets are used.

The full potential has not yet been used. To be able to do so more knowledge about the magnets possibilities has to be built up concerning the configuration of the magnets, the optimal strength and the distribution of the magnetic field. With that knowledge available the cost for investments can be kept as low as possible. It will also enhance the possibilities to integrate magnets in to different machines or as a stand alone tool in the demining process.

Objective

One objective is to obtain what result could be achieved when using magnets to collect metal debris during demining. The strong relationship that is between the magnetic strength on one side and the price, size and weights on the other side makes it important to define the optimal strength of the magnet.

The second objective is to study some of the influences that the soil will have on the result. It will be limited to measure if a better result could be expected if the soil is processed (loosen up) prior to the magnet sweep.

Aim

The aim is to:

1. Define the optimal magnetic strength to achieve best possible result when collecting ferromagnetic metal fragments within the demining process.
2. Study the possibilities to collect buried ferromagnetic fragments and if so, down to which depth that it will be possible.
3. Study the impact that the soil compactness will have of the result and what will be the differences if the soil is processed (loosened up).
4. Investigate the relationship between the size of the fragments and the possibilities for the magnet to collect them.



Questions for the test

2. What is the practical sweeping height for a magnet?
3. At which magnetic flux density is all metal that is laying on the surface or close to surface of the soil picked up and is it depending of the sizes of the fragments?
4. Is it possible for a magnet to “pull up” fragments buried in the soil and if so,
 - a. from which depth
 - b. is it depending of the sizes of fragments
 - c. which strength of the magnet is needed
 - d. does it work in loose as well as compacted soil?
5. Is it a disadvantage if the soil has been processed prior the first sweep with the magnet? “Will dig down more than it will dig up?”

Guidelines and limitations

- As test objects (fragments) steel balls shall be used. Guidelines for the different sizes that will be used are 2, 5, 10, and 20 mm.
- The test will only be done with one type of soil preferable a type of gravel that is easy to compact.
- To loosen up and cultivate the soil a machine driven handheld cultivator will be used.
- To compact the soil a handheld vibrator will be used. (for ex Dynapac)
- The degree of compactness of the soil will not be measured with instrument.
- All trial will be made using one permanent magnet. The simulations of different magnetic strength will be made by changing the distance between the magnet and the soil.
- The trial will be made in laboratory environment.
- Depth for test targets during the test will be:
 - o On the surface and down to 1 cm
 - o 2 – 3 cm
 - o 4-5 cm
- If targets are deployed in all depth in the same time they will be distributed with 50% on top and then 30% and 20% in the deepest layer