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ITEP 2005 Collaborative Test and Evaluation of Mechanical Demining Equipment for Humanitarian Demining

C. Weickert¹, G. Coley², F. Borry³

Introduction

The International Test and Evaluation Program (ITEP) was established to strengthen worldwide humanitarian demining efforts by providing the efficient generation, collection, and distribution of objective, independent, scientifically-based test and evaluation data and information on equipment, systems, and methods for use in humanitarian demining. The current participants are Belgium, Canada, Germany, The Netherlands, Sweden, United Kingdom, United States, and European Commission. The ITEP principles and objectives are as follows:

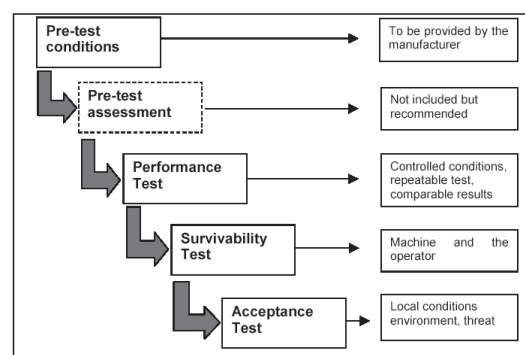
- Establish Test and Evaluation (T&E) capabilities for measuring performance and evaluating the effectiveness and suitability of all forms of equipment, systems, and methods for use in humanitarian demining.
- Conduct T&E of existing equipment, systems under development, and of promising technologies, processes, and algorithms.
- Establish and employ standards, protocols, and methodologies for cooperative T&E.
- Collect, generate, assess, evaluate, and distribute robust, scientifically objective data and information on the performance and effectiveness of such equipment, processes, and methods under a variety of environmental, physical, technical, and operational conditions.

The ITEP Work Plan 2005 endorsed by all ITEP Participants, is now available on the ITEP website (www.itep.ws) and provides an overview of national and collaborative T&E projects, executed under the ITEP umbrella. The Work Plan clearly shows that during 2005 two major collaboration efforts will take place, focusing on dual-sensor mine detectors and mechanical demining equipment. This paper aims at providing an overview of the ITEP collaborative T&E efforts of mechanical demining equipment only.

ITEP Mechanical Equipment Workgroup

The main ITEP Participants involved in the mechanical activity are Canada, Sweden, UK and US. Other ITEP Participants contribute on a case by case basis. Each of the above mentioned countries have their own T&E program that they coordinate amongst each other, i.e. they contribute test engineers and test facilities to each others programs as and when required, and they have accepted the test protocol CEN Workshop Agreement, Test and Evaluation of Demining Machines (CWA15044). The scope of the CWA is to provide standardized methodology for testing and evaluation of demining machines. It provides technical criteria for the following:

- **Performance Testing** – establish if a machine and tools can perform the intended role under comparable repeatable conditions and to evaluate the manufacture's specifications
- **Survivability Testing** – evaluate the effects of explosive forces on the machine and operator
- **Acceptance Testing** – evaluation of the machine in the environment where it is intended to be used
- **Test Targets**



Pre-Test Assessment Examples

¹ ITEP Working Group „Test and Evaluation of Mechanical Assistance Clearance Equipment“, Canadian Centre for Mine Action Technologies (CCMAT), E-mail: chris.weickert@drdc-rddc.gc.ca,

² ITEP Working Group „Test and Evaluation of Mechanical Assistance Clearance Equipment, E-mail: geoff.coley@drdc-rddc.gc.ca

³ ITEP Secretariat, E-mail: Franciska.borry@itep.ws

Qualitative examinations looking for form, fit, function, suitability, etc. Also confirm some basic operating parameters, capabilities, and manufacturer specifications. "Is it suitable for continued testing?"



Non-Explosive Targets (Performance Test)

WORM – Wirelessly Operated Reproduction Mines. Designed around CWA 15044 requirements. Signal on trigger. Data is virtually identical to Swedish live-fuze data. Wireless signal automatically logged to computer on trigger. Tested using Aardvark to ensure capability when evaluating flails/tillers.

Performance Test Examples

Ability to kill mines, extract mines, cut vegetation, etc, as applicable to that machine. Quantitative evaluation including 450 AP mine targets at 3 different depths in 3 different soils. Also fibreboards to check for skip zones. Typically have used Swedish targets (inert bodies with live fuzes) or Canadian Mechanical Reproduction Mines (all inert).

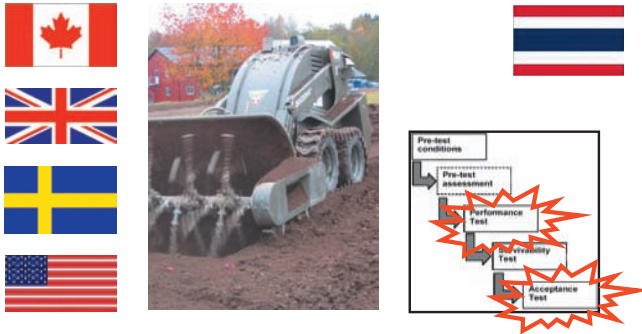


Survivability Test Examples

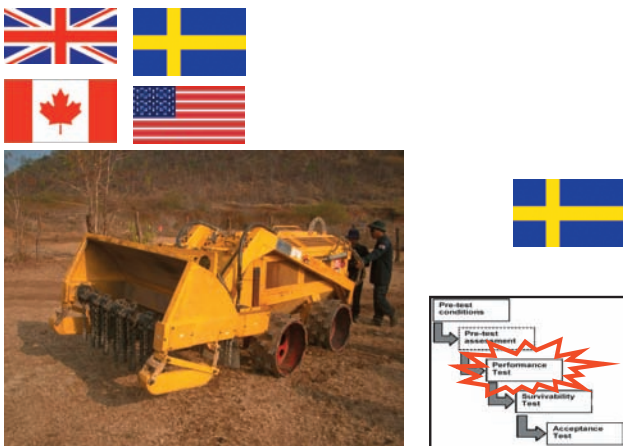
Machine survivability & repairability against AP mines. Some machines also against AT mines. Also operator protection for machines which have a human operator on-board.

ITEP Mechanical Projects - 2005

Bozena-4: Acceptance Test in Thailand. Repeat of Performance Test in Thailand – checking relocation of performance test from lab to field. Also verifying WORM targets for performance tests.



Tempest Mk 5: Repeat of performance test in Sweden using both Swedish targets and WORM. Will verify performance tests done in Cambodia against performance test done in Sweden. Also verify MRM/Swedish-target/WORM.



Vegetation Cutting: Planned to evaluate different vegetation cutters and techniques against themselves. Focus on bunching-saw forestry attachment for cutting and removing vegetation whole, and in one step instead of shredding & raking.



Mine Clearing Survivable Vehicle & Tools: The current status of the MCSV is it is in Nicaragua under a field Evaluation with the Nicaraguan Army (NA) demining units. The NA are developing their Standard Operating Procedure (SOP) for the system to QA areas behind their current clearance operations.



Conclusions

International collaboration on T&E of mechanical equipment saves significant resources. By testing in accordance with international T&E standards, direct comparisons of different mechanical equipment (manufacturer or machine type) are possible. In-country acceptance testing is important to determine suitability for a particular country/area/project. Finally, it is critical to have the direct involvement of NGOs and MACs in performance, survivability & acceptance tests.

Contact: ITEP Secretariat

“Picking the Right Tool for the Right Task” - Mine Clearance with the MineWolf Machine

Christoph Frehsee⁴

Abstract

The MineWolf is a German mine clearance concept which combines the advantages of both tiller and flail systems. It is designed as a multi-purpose toolbox to provide maximum flexibility for the user.

The patented open tiller design compensates for limitations of existing systems and shows unprecedented results when used against both AP and AT-mines. The basket-type segment structure allows the mine blast to expand through the tiller to avoid or reduce damage. Deployment of the tiller allows for ground processing results unmatched by common flail systems, particularly with respect to vegetation and ground penetration. Depending on project requirements, a standard flail can be attached alternatively. The use of quick couplings facilitates rapid replacement of the demining tool attachments in less than 30 minutes. In accordance to visibility and layout of the field the machine can either be remote-controlled or operated directly from a certified safety cabin. The built-in monitoring and control system ensures a continuous ground penetration of a depth up to 30 cm and, consequently, minimises operator mistakes. The system allows for transportation via road, rail, ship and air. During current operations in Serbia and Montenegro, Bosnia and Herzegovina and in Croatia a standard low-loader is used for transportation between work sites.

In a recent issue of the Journal of Mine Action A. Griffiths (GICHD) stated: “Demining should be about reducing the extent of the world’s mined areas in as short a term as possible. Machines are here to do just that.”

MineWolf Systems is committed to put this statement into practice.

Introduction

The MineWolf Mine clearing machine is a German mine clearance concept which combines the advantages of both tiller and flail systems. It is designed as a multi-purpose toolbox to provide maximum flexibility for the user in the field. The purpose of this article is to give the reader an introduction to the use of the MineWolf demining machine and its features.



The Company

MineWolf Systems is a leading provider of state-of-the-art demining technologies and services. Based on its flagship product, the mechanical mine clearance machine “MineWolf”, the company offers a wide range of demining solutions to its customers

worldwide. MineWolf Systems is the patent holder and owner of the worldwide distribution rights of the MineWolf demining technology. Manufacturing is done in partnership with renowned manufacturer AHWI Maschinenbau GmbH.

Headquartered in Koblenz, Germany, MineWolf Systems has operations running in Bosnia and Herzegovina, Croatia and Sudan and is building up further capacities in Africa and the Middle East. It is therefore the company’s mission to provide safe, reliable, fast and cost effective mine clearance solutions to our customers worldwide.

The Technology

The patented MineWolf toolbox system, combining both flail and tiller operations, overcomes the limitations of existing demining techniques and is bound to set new standards in the industry. The MineWolf machine is designed in order



⁴MineWolf Systems GmbH, E-mail: c.frehsee@MineWolf.com

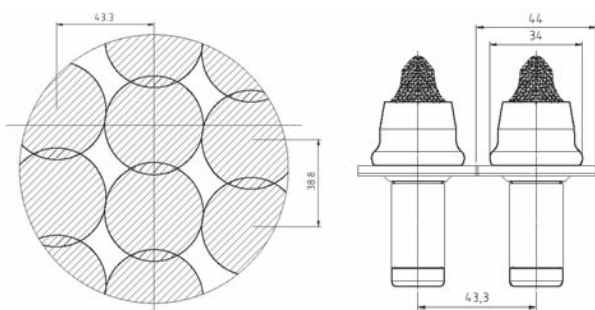


to achieve reliable and fast clearing results and to allow for cost-effective recultivation of mine-contaminated areas.

Depending on ground conditions and mine threat the user has the choice to either operate the MineWolf with the open tiller or a standard flail. The use of quick couplings facilitates rapid replacement of the demining tool attachments in less than 30 minutes. Both tools are equipped with a proven depth control unit for quality control.

MineWolf Basket Tiller

The patented open tiller design compensates for limitations of existing systems and shows unprecedented results when used against both AP and AT-mines. The basket-type segment structure allows the mine blast to expand through the tiller to avoid or reduce damage.



Nevertheless the tiller is designed in such a way that every 43.4mm a chisel with a diameter of 44mm hits the ground, ensuring that every piece of soil is processed. This guarantees that even the smallest AP mines like the M14 or the PMA2 will be hit.

Furthermore a tiller has the advantage of continuously penetrating the ground to the imposed depth since, in contrast to a flail, the rotor is a solid piece mulching the ground. Consequently, the deployment of the tiller allows for ground processing results unmatched by common flail systems, particularly with respect to vegetation and ground penetration.

MineWolf Flail

Depending on project requirements, a standard flail can be attached alternatively.

The use of the flail is recommended in rocky areas. Furthermore the flail will be the right tool when heavy AT Mines with more than 7,5 kg explosive have to be expected in order to limit costs of damage.

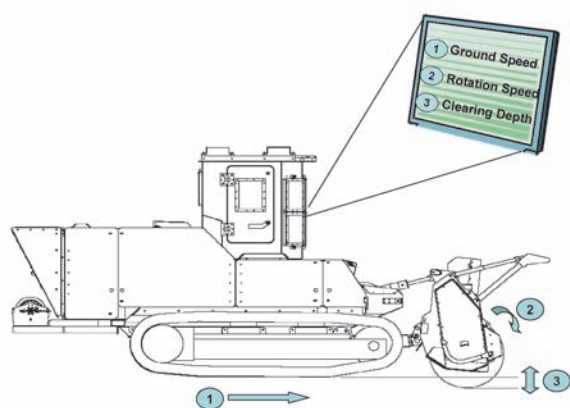
It is important to mention that flail operations have much higher running costs than tiller operations due to hammer and chain replacements.



MineWolf Quality Control

The MineWolf was built to withstand the enormous forces occurring during demining operations. All parts are designed to maximize the output as well as the vehicle's lifetime. Besides, the machine is equipped with all features necessary to give the operator full control and put safety at first priority during the working process.

MineWolf Systems has developed an automatic quality control mechanism which ensures that rotating speed of tiller and flail as well as clearing depth and ground speed are always aligned. This is important to guarantee a reliable demining process.



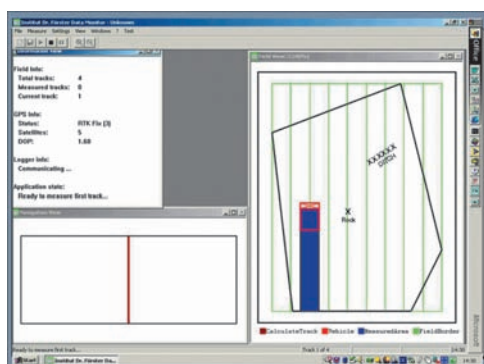
Remote Control

In accordance to visibility and layout of the field the machine can either be remote-controlled or operated directly from a certified safety cabin. Depending on UXO-threat and terrain characteristics the MineWolf can also be manoeuvred in the field by remote control. The remote-control option ensures safe operations under all circumstances and eases manoeuvring during transport.



GPS Instrument Panel

Optionally, the MineWolf can be equipped with a GPS System for directional control. Together with renowned company Foerster, MineWolf Systems has developed a GPS directional control



and recording system for additional quality control. This proves to be very helpful when operating on large and remote fields and it produces reliable data of the hourly and daily work.

Transport

During operations in Serbia and Montenegro, Bosnia and Herzegovina and in Croatia a standard low-loader is used for transportation between work sites. Due to the modular design the whole system can also be shipped in three standard sea containers and reassembled within a day at the place of delivery.



Use of MineWolf

Next to providing a mature product, MineWolf Systems takes great care in setting up a functioning support infrastructure. The company contributes its expertise to enable efficient demining operations anywhere with a strong focus on sustainability. Hereby, a key priority is the build-up of local capacities. MineWolf Systems has installed an infrastructure that ensures competent training of drivers and mechanics as well as a just-in-time procurement of spare parts. This leads to an optimized use of resources and greatly enhances the results achieved by operating the MineWolf. Service and maintenance requirements are fulfilled in order to exploit the maximum lifetime of the basic machine and all equipment coming along.



Clearing Results

No minefield is the same and it needs experience to evaluate the area that can be effectively cleared by machines. Topographic characteristics and soil conditions influence the performance and need to be taken into account when planning the project. MineWolf Systems provides a careful analysis, trains their personnel accordingly and oversees the project setup to minimize downtimes and repair works.

The MineWolf has proven in the field a capacity of up to 2.800m² per hour. The clearing result of the MineWolf allows for safe and fast manual quality control as well as for MDD follow-up.



Technical data

Technical data		
Engine type	Deutz Diesel Engine	
Engine performance	KW/PS	270/367
Speed (max.)	km/h	5
Fuel capacity	l	ca. 500
Average consumption	l	42
Length crawler tractor	mm	5940
Length with tiller	mm	7420
Length with flail	mm	7820
Width (max.)	mm	3610
Height (with cabin)	mm	3795
Weight (with cabin)	kg	21800
Weight tiller	kg	4500
Weight flail	kg	4800

Clearing data		
Clearing width tiller	mm	2800
Diameter tiller	mm	1100
Clearing depth tiller	mm	0 – 350
Clearing width flail	mm	2800
Diameter flail	mm	2420
Clearing depth flail	mm	0 – 150
Clearing speed	km/h	0,8 – 1,5
Clearing performance (max.)	m ² /h	2800
Vegetation cutting (max. diameter)	cm	15

Conclusion

We believe that only through advanced technology, we can take control of the continuous threat caused by landmines. That is why we are continuously striving for improvement and we highly welcome everybody's feedback and suggestions.

Demining Machine RM-KA-02 - Technical Description

Darko Grbac⁵



RM-KA-02 is a radio-controlled demining machine designed for mechanical clearing mine contaminated areas by removing all types of vegetation (low, medium-sized and tall plants), treating the soil categories II–V (by splitting, digging and grinding) and destroying all kinds of antipersonnel and antitank mines (by detonating, splitting and grinding).

Manufacturer

ĐĐ SPECIAL VEHICLES
Dr. M. Budaka 1
HR-35000 SLAVONSKI BROD
CROATIA

Vehicle

▪ application	midi flail machine
▪ chassis	self supporting
▪ armour	all vital components armour protected
▪ length, overall	5.215 mm
▪ length, without attachment	3.880 mm
▪ width, total	2.500 mm
▪ width, chassis	2.000 mm
▪ height, total	1.700 mm
▪ tumbler distance	2.705 mm
▪ track width	400 mm
▪ ground pressure	0,58 kg/cm ²
▪ weight, total	up to 12,5 t

Driving properties

▪ travel speed	up to 5 km/h
▪ working speed	0,3 to 0,9 km/h
▪ max. working speed	up to 1,2 km/h
▪ max. gradient	35°
▪ max. grade slope	25°
▪ turning	0 m

Clearing performance

▪ ground clearing speed	500 to 2.000 m ² /h
▪ clearance depth, up to max	300 mm
▪ mine types	all types of AP and AT land mines

Clearing system

▪ type	flail
▪ clearing width	2.000 mm
▪ diameter	900 mm
▪ number of hammers	36
▪ chain length	400 mm
▪ chain placement	two spirals
▪ hammers overlay width	6,5 mm
▪ type of hammers	"mushroom", mass 1 kg
▪ rotating speed	up to 600 rpm
▪ rotating direction	both
▪ drive	two hydraulic motors

Engine

▪ type	PERKINS, 1306-9T
▪ power	168 kW (225 HP) at 2.200 rpm
▪ fuel	diesel, D-2
▪ fuel consumption	35 to 40 l/h
▪ cooling	water
▪ air cleaning	two-stage high efficiency, heavy-duty air filter
▪ fuel tank	420 l

Transmission

▪ type	hydraulically adjusted tracks
▪ drive	hydrostatic with two-speed motors
▪ track width	400 mm

Hydraulic system

▪ type	closed
▪ manufacturer	REXROTH
▪ controls	remote controlled
▪ functions	vehicle drive, clearing appliance drive, clearing appliance lifting

⁵ „Đuro Đaković“ Special Vehicles, Croatia, E-mail: dgrbac@ddsv.hr

- oil tank volume 260 l
- working pressure 250 bar
- cooling high efficiency, heavy duty oil cooler

Remote system

- type radio-remote control
- control unit portable
- functions all engine, drive and clearing controls
- range, maximal up to 800 m

Protection

- chassis plates 20 mm
- armour plates 10 mm, ARMOX
- active automatic fire extinguisher

Standard equipment

- refuelling pump
- rotating warning light

Optional equipment

- GPS
- video-control
- cable winch
- tiller unit
- inspection vehicle



Experience from Over 10 Square Kilometers of Mechanical Mine Clearing

Davor Družijanić⁶

ABSTRACT:

1. Introduction

Mine clearing is a dangerous, labor-intensive and costly process. The question is how can a perfect safety record be achieved while the overall cost of the demining operation is reduced at the same time. Demining with machines and deminers or dogs after machines is the answer.

2. Quality

Maximum quality of mine clearing can be achieved with using machines as first check and deminers or dogs as second check of demining area. Quality records of Rhino 02 is shown in Table 1 - Quality records.

3. Safety

Maximum safety of mine clearing can be achieved with using machines. An underlying precept of successful demining operation is a perfect safety record for personal in demining, users of cleared area and environment. Safety records of Rhino 02 is shown in Table 2 - Safety records.

4. Costs

The overall cost of the demining operation with using of machines is reduced to 2/3 in compare to manual demining. Based on Rhino 02 records from June 1998 till December 2004.

5. Conclusion

Demining with machines and deminers or dogs after machines is the best way of demining concerning quality, safety and costs.

Annex A - Chart - Rhino 02 clearing records

Key words: machines, demining, mine clearing, quality, safety

1. Introduction

Mine clearing is a dangerous, labor-intensive and thus costly process. The question is how can a perfect safety record be achieved while the overall cost of the demining operation has to be reduced at the same time. Demining with machines and a control check by deminers or dogs after the machines is the answer.

According to experience, machines crash over 90 % of all cleared mines. Detonations of mines are not so often, unlike UXO's and especially caliber over 100 mm. The clearing rate of the used machines depends on the field conditions (vegetation, wet, dry, stones), our average rate was between 95 and 100 %. To reduce that gap of approx. 5 % and its risk it is important to have a control check by mine detectors and/or dogs. Also, the job of a mine detector is much faster, easier and of course safer, if he works in an already cleared area with no vegetation on it. Mine clearance by machines is the safest tool for preparation of mine clearing areas for after machine safe/control check for metal parts of mines by metal detectors and for parts of explosive by dogs.



2. Quality

Maximum quality of mine clearing can be achieved by using machines as first check and deminers or dogs for second check of demining area.

As a result of clearing over 10 square kilometers with machines, we destroyed all kind AP mines, like PROM-1, the most dangerous AP mine on safe way for the deminer, even without damage on the machine.

Only AT mines could cause some damages that can be repaired on the field at the same day in a short time. In general AT-Mine Damages hap-

⁶ E-mail: DavorDr@index.hr

pen not very often, because a part of the mines will be crashed and the operator with the help of a color video equipped and remote controlled system can see the remaining parts. For the maximum quality, it is essential to have a clearing system with adjustable automatic depth control. Clearing depth can be set up to 0.5 m in soil without rocks and trees, while the typical and most used clearing depth is 20-30 cm, this is unachievable result for demining with a prodder and/or a metal detector.

Compared to manual demining, machines work also fast on rocky areas, areas with dense vegetation with grass, bushes and small trees. Furthermore, this ensures that trip wires and most of mines are removed for a much safer second check for metal and explosive parts of mines. Another advantage of machine clearing is that the cleared areas are excellent prepared for agricultural purposes.

There are machines like RHINO, that can work with larger and denser vegetation, like bigger trees and woods, but that is not a practice because it is slowing down the clearance and makes it more expensive.

Quality records of Rhino 02 are shown in Table 1 - Quality records.

Year	Cleared (m ²)	Quality
1998 (since June)	613 872	100%
1999	1 727 402	100%
2000	1 075 967	100%
2001	1 736 623	100%
2002	1 649 252	100%
2003	1 732 000	100%
2004	997 000	100%
Total	9 532 116	100%

3. Safety

Maximum safety of mine clearing can be also achieved by using machines.

An underlying precept of successful demining operation is a perfect safety record for demining personal and the users of cleared areas.

- Safety for operators of machine means radio control with audio and video surveillance or alternatively an excellent protection for the driver cab. Radio controlled equipment is the better solution, especially because of unpleas-

ant feeling of driver in the protected cab and possibility of PTSD.

- Safety for deminers means much easier and safer using of metal detector or prodder or dog after the area is cleared by a machine. Possibility of accident and PTSD is reduced.
- Safety for users of cleared area is ensured through quality of mine clearing.
- Safety for environment means careful usage of machine and smart choice of consumables like lubricants which are bio degradable

Safety records of Rhino 02 are shown in Table 2 - Safety records.

Year	Cleared (m ²)	Safety
1998 (since June)	613 872	100%
1999	1 727 402	100%
2000	1 075 967	100%
2001	1 736 623	100%
2002	1 649 252	100%
2003	1 732 000	100%
2004	997 000	100%
Total	9 532 116	100%

4. Costs

Based on Rhino 02 records from June 1998 till December 2004, the overall cost of the demining in operation was reduced to 2/3 in comparison to pure manual demining.

For example, if we plan to clear area of 200 ha in a year (this is equivalent to an area of more than 400 football fields), it is more cost efficient to use the combination of machines and a reduced amount of deminers compared to the pure manual demining:

- it lowers all costs by 1/3,
- it reduces personal by 1/3,
- we achieve maximum safety level and
- maximum quality level.

Personal for demining with machines:

• Deminers	8
• Medics	2
• Mechanics	8
• Dog handlers (x 2 dogs)	4
• Others	4
Total:	26

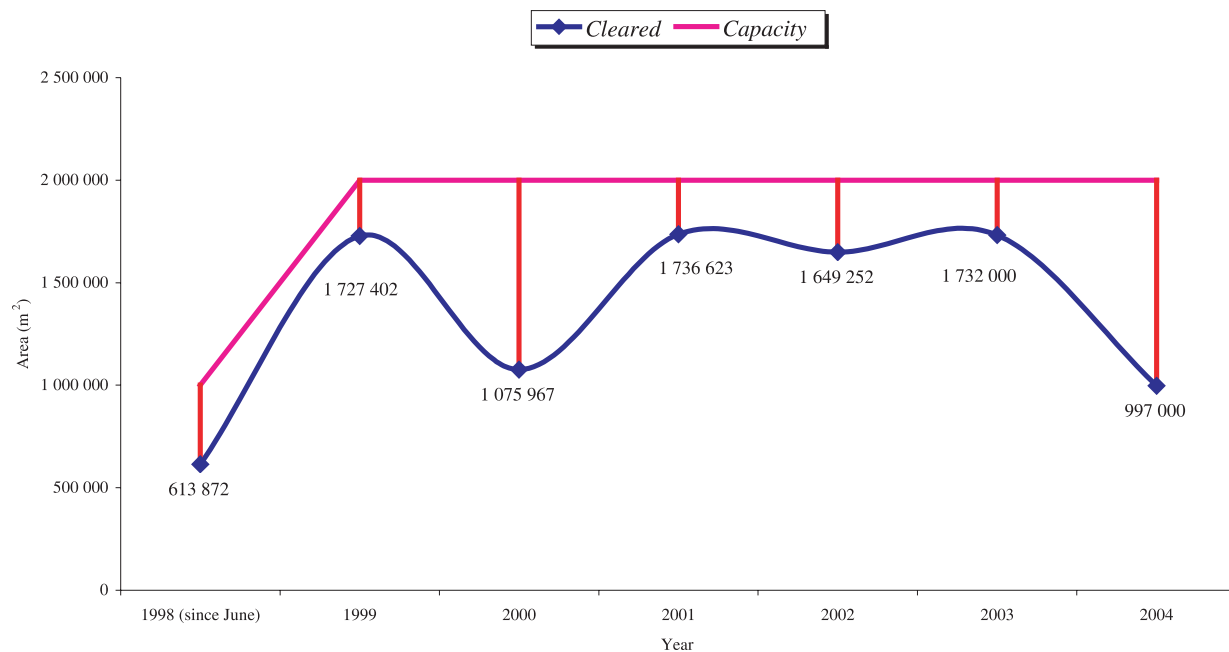
Personal for manual demining:

• Deminers	35
• Medics	2
• Others	3
Total:	40

5. Conclusion

The combination of demining with machines and an additional second check by deminers with metal detectors or dogs after machines, is the best way of demining concerning quality, safety and costs.

Cleared & Capacity of Rhino, 1998 - 2004



Annex A - Chart - Rhino 02 clearing records

Mechanics of Flail for Soil Digging and Demining

Dinko Mikulić⁷, Vjekoslav Stojković⁸, Vladimir Koroman⁹

Abstract

The phenomenon of hammer impact on the soil made of variable characteristics is not defined, as well as many impact processes. Two ways of determining energy balance of the flails are a simulation and an empirical tracking of driving power in soil digging. What is allowed is the presumption of modelling through coefficient of resistance, which can be directly connected with the category of soil digging. By using a resistance coefficient, various situations regarding working tools can be described as well as how much energy is lost during the impact of hammer on the soil.

The outcome of hammer hitting the soil is that hammer speed declines. During that it is not possible to fastly reach the desired hammer speed because of the friction during flail's dragging on the ground, which comes with hammer acceleration. In practice hammer dragging is causing additional accelerated wearing out and outstretching of the chain. With the growth of resistance of rotor turns the coefficient of resistance is declining. In these conditions this means that more power is needed in the flail's rotor. For this a stronger motor engine is needed, that is, a higher reserve of available engine power.

Introduction

Demining machine operation is based on force impact of the flail (striking chain hammer) that hits and digs the soil. Depending on soil humidity, soil is cut by hammer strikes and is moved to machine shields. If the soil is dry and hard, soil is crushed and scattered. Two theories of soil digging apply: theory of soil cutting and theory of soil hardness/crushing. So we are talking about two tool types that are usually used. For soft soil cutting blade of lower mass is preferable, and for hard soil and cutting a rectangular shape of bigger mass is advantage. Because of practicality, universal hammer shape of a "mushroom" is used. Soil that is coherent and soft can be cut. Soil that is non-coherent, dry and hard can be crushed. For the soft coherent soil, calculation from equation of cutting soil theory is applied, and for the hard non-coherent soil a criteria of soil hardness limit " σ " is applied. Hammer working principle is based force impulse of overcoming the resistance at soil digging (force impulse = change in momentum). In order to achieve cutting, hammer force impulse has to be bigger than resistance $F_i > R_{kr}$, i.e. for soil crushing condition of $F_i > R_{\sigma i}$ has to be fulfilled. Phase shift between flails that are fixed on rotor's spiral $n \times 180^\circ$ from the centre to each side, decreasing the digging resistance, removing the influence of axial forces and unbalance of the flail.

Total resistance moment to flail rotation includes static and dynamic moments of rotation of flail's parts, until hammer hits the soil, when kinetic energy is lost, angle speed is changed and number of flail rotation is decreased. Since this exchange of energy is not well known in practice, each flail cyclical operation is assumed: hammer acceleration and stopping at cutting the soil layer.

Flail consists of chains and digging hammers at the end of a chain. Hitting hammer is of "mushroom" shape having the cutting blade.

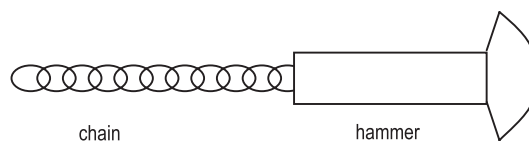


Fig. 1 - Flail

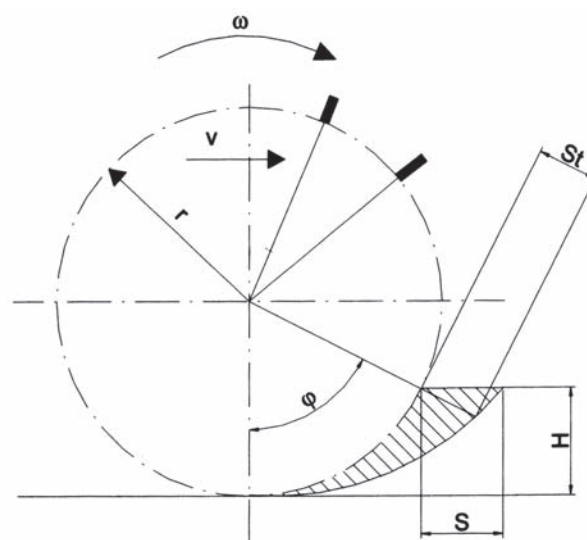


Fig. 2 – Soil layer's profile

⁷ MoD - Directorate for Development and Modernization, Croatia, E-mail: dinko.mikulic@morh.hr, dinko.mikulic@fsb.hr

⁸ Mine Action Academy, Croatia, E-mail: vjekoslav.stojkovic@vvg.hr

⁹ Brodarski institut d.o.o. Croatia, E-mail: koroman@hrbi.hr

Hammer impact on the soil

Hammer strikes to the soil can be viewed through two analysis of two body collision. It is necessary to determine the hammer force impulse. One method of determining this force assumes that force is acting in finite time interval, in which hammer is using part of its momentum it had before impact. It can be assumed that hammer behaviour during impact with soil can be described with collision coefficient " k ", i.e. coefficient of restitution:

$$k = \frac{u}{v}$$

v – hammer velocity before impact

u – hammer velocity after impact

Introducing the collision coefficient k enables that problem of hammer hitting the obstacle is studied from the classic mechanic point of view, not using the assumption of absolutely firm obstacle.

Collision coefficient in within interval:

$$0 \leq k \leq 1$$

$k = 0$ impact is ideally plastic

$k = 1$ impact is ideally elastic

Based on Law on momentum preservation:

$$m_h v_o - m_h u = F_i \Delta t \cos \varphi$$

Relation between velocity before and after collision is provided through coefficient k , which leads to equation for force impulse in time interval, Δt : $F_i = m_h v_o (1-k) / \Delta t \cos \varphi$

F_i (N) - single hammer force impulse

F_{in} (N) - grasping hammers force impulse

m_h (kg) - hammer mass

v_o (m/s) - circumferential hammer speed ($r \pi n / 30$)

Δt (s) - force impulse time interval of hammer grasping of soil

Hammer force impulse analysis

Example: digging depth $H_1 = 0.1$ m, striking hammer mass, $m = 1.2$ kg, $\varphi = 35^\circ$ (0.61 rad), $n = 900$ rpm

Assumption:

- restitution coefficient k for 3 different collision conditions; $k = 0,3 ; 0,5 ; 0,7$
- time interval of force impulse impact in interval up to $\Delta t = 10^{-4}$ s

Using coefficient k different situations for working tool can be described, from hitting the obstacle, i.e. how much energy is lost because of it, to situations when hammer hits the mine and changes the coefficient k sign. Accordingly, calculation of force impulse that influence the hammer when hitting the soil can be made, depending on soil type or obstacle k , digging depth H and flail rotation n .

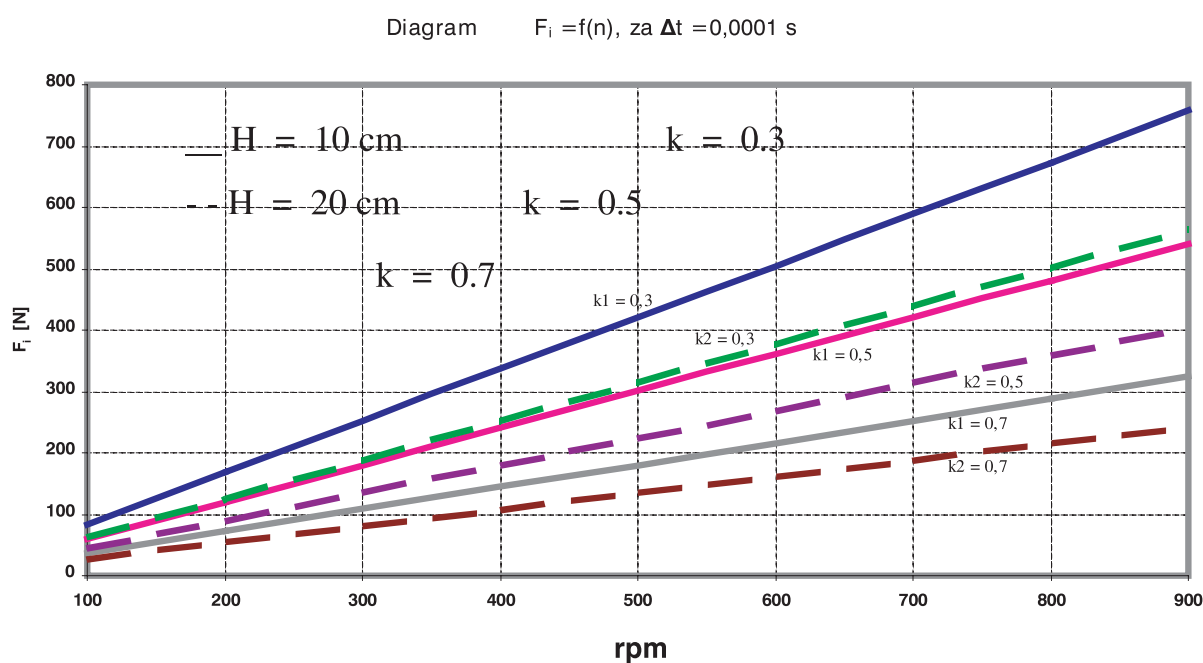


Fig. 4 – Hammer force impulse in restitution conditions k , in function of rpm $F_i = f(n)$

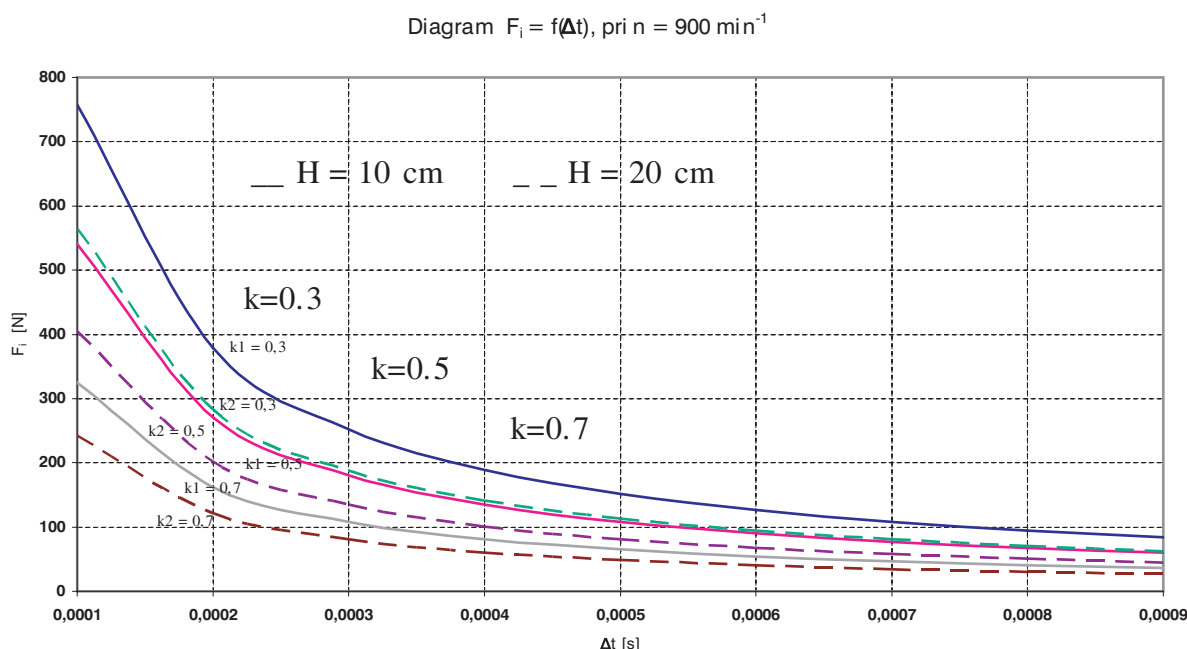


Fig. 5 – Hammer force impulse in restitution conditions k , in time interval $F_i = f(\Delta t)$

Restitution coefficient k can be brought into relation with soil category, i.e. soil hardness, in order to determine the differences between them. Restitution coefficient k can be simulated as well as digging depth H , under the assumption that $k = 0.7$ for soil category III, $k = 0.5$ for soil category IV and $k = 0.3$ for soil category V. Hammer force impulse of one hammer F_i for specific digging depth is multiplied with number of hammers that are grasping the soil.

Increasing the hammer's rpm for the same restitution coefficient k , force impulse $F_i = f(n)$ is increased linearly. From diagram $F_i = f(\Delta t)$ can be concluded that force impulse is decreasing approximately per time square when hammer hits the soil. Force is the biggest when hitting the soil and decreasing when removing the digged soil layer. Three referent rotation speed are assumed, $n = 200 \text{ min}^{-1}$, $n = 500 \text{ min}^{-1}$ and $n = 900 \text{ min}^{-1}$.

It can be assumed that with decreasing of restitution coefficient k on the flail's rotor shaft additional power will be required for acceleration of the lagged flail. Theoretically, hammer rotation speed can decrease to zero value. Hammer working speed is not possible to establish quickly because of friction resistance due to flail idle that appears at hammer's reacceleration. Practice shows that such hammer lagging causes fast wearing and elongation (in practice – at hammer replacement caused by wearing, chain extension is 10%). Finally, with restitution coefficient k decrement, rotor's rotation resistance increase. It means that flail rotor needs more power.

Digging depth H [m]		$H_1 = 0,1$ m ($z = 6$) $\varphi_1 = 35,10^\circ$	$H_2 = 0,2$ m ($z = 8$) $\varphi_2 = 50,48^\circ$
rpm n [min^{-1}]	k		
$n = 200$	0,3	1009,75	1003,50
	0,5	721,25	716,79
	0,7	432,75	430,07
$n = 500$	0,3	2524,38	2508,75
	0,5	1803,13	1791,96
	0,7	1081,88	1075,18
$n = 900$	0,3	4543,88	4515,75
	0,5	3245,63	3225,53
	0,7	1947,38	1935,32

Table 1 – Grasping hammers force impulse at soil digging F_{in} [N]

Conclusion

When digging the soil at demining, a phenomenon of hammer collision with the soil of different characteristics is not studies nor defined, as well as many collision processes. Simulation and empiric observation of drive power consumption when digging is one way to determine the flail's energetic balance. As every phenomenon, modeling assumption is allowed through restitution coefficient that can be brought in relation to soil digging category, i.e. soil hardness, in order to observe the differences between them (category I, II, III, IV). With restitution coefficient k different situations that working tool can be put into can be described, i.e. how much energy

is lost when hammer hits the soil.

This results in decrement of hammer speed. Hammer working speed is not possible to establish quickly because of friction resistance due to flail idle that appears at hammer's reacceleration. Practice shows that such hammer lagging causes fast wearing and elongation. Increase of rotor's rotation resistance introduces decrement of restitution coefficient. It means that under such conditions more power has to be added to the flail's rotor. This requires more powerful machine engine, i.e. higher power reserve in order to compensate the loss of energy.

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Development of Mine Protected Vehicles

Dinko Mikulić¹⁰, Tomislav Gašparić¹¹, Muhamed Sućeska¹²

Abstract

Mine protected vehicles are escort vehicles in machine demining. These vehicles have to be resistant to mines that can be found in mine suspected areas. As Republic of Croatia is the leading country in machine demining, it also has the priority in designing and creating mineprotected and ballistic-protected vehicles. Their purpose is that from inside of these escort vehicles demining machines are remotely controlled. Requests were made for designing the vehicle in two variants, as a transporter and as a citadel. Between the ground and the bottom of the vehicle, the blast pressure coming from the AT mine, affecting the bottom and lateral sides of the vehicle, reaches a very high level which has to be amortized. In this work, one can find vehicle design and calculation of blast pressure on vehicle bottom and lateral sides.

Introduction

All protected vehicles (APV) were designed to provide a safe and secure multi-purpose vehicle for peacekeeping operations and humanitarian operation. Mine protected vehicles (MPV) are specially designed to protect the crew from mine threats in humanitarian demining. This paper provides principle of Mine protected vehicles calculation and design based on high mobility terrain vehicle 4x4 in accordance with NATO requirements for countermine crew protection in logistics vehicles. Protected vehicles are integral part of demining mechanization. They are used as supporting/escort vehicles in machine demining, but primarily are used for deminer's crew transportation to the demining site. From this vehicle later on, demining vehicle is remotely controlled. Such vehicle has to be resistant to mines that could appear on suspiciously mined area. Republic of Croatia is leading country in machine demining, and priority task of protected vehicles design in machine demining is being set up, available as transporter or citadel.

1. Basic requirements

Basic requirements posed to MPV 220 designers are:

- Total vehicle mass 10 t,
- Maximal speed of 130 km/h,
- Possibility to transport 10 people (transporter),
- Modular variant – citadel,
- High vehicle clearance,

- Countermine protection in accordance with NATO standard,
- Possibility to upgrade the weapon station,
- Fast crew entry and exit,
- Air transported – C-130

Standard level of crew's protection against weapons and mines / Standard STANAG 4569

- Level 1 protection / option: level 2 /level 3, peace-keeping operations, intensity conflicts
- Countermine protection: level 2 counter mine vehicle protection - 6 kg TNT / level 3 - 8 kg TNT

STANAG 4569 is basic document for protection levels for occupants of logistic and light armoured vehicles, as stated in Annexes A and B. List of protection levels is based on 90% probability of providing protection for crewmembers at certain threat/danger. For countermine vehicles in humanitarian demining second level of countermine protection is applied and first ballistic protection level from ammunition and mine fragments.

2. Vehicle design



Fig. 1 - Transporter/carrier, countermine and ballistic protection

¹⁰ MoD - Directorate for development and modernization, Croatia, E-mail: dinko.mikulic@fsb.hr, dinko.mikulic@morh.hr

¹¹ Faculty of Mechanical Engineering and Naval Architecture, Croatia, E-mail: tomislav.gasparic@fsb.hr,

¹² Brodarski institut d.o.o., Croatia, E-mail: msuceska@hrbi.hr

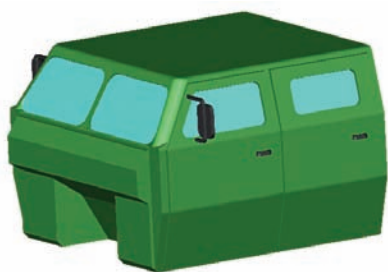


Fig. 2 - Citadel, All protection

3. AT mine blast calculation

In calculation theory of explosion effects on vehicles the goal is to transform physical features of mine detonation into engineering models, in shape of load spectre primarily of overpressure and blast impulse from the centre of explosion toward vehicle as well as other parameters of blast in characteristic intervals. At floorboard and sides of vehicle construction, a load spectre on exposed surfaces and vehicle is determined in the moment when mine detonates under the middle surface of vehicle, wheels and at its sides. It provides basis for countermine vehicles calculation that provide protection to crew from fragments, noise and blast vibrations.

Mine protected vehicles have to pass an experimental testing for AT mines explosions. It is necessary to determine the parameters of vehicle load variations on the basic AT mines of 6 kg mass of TNT for 2a and 2b protection level. In addition, it is very important to be familiar with load spectre and other mine threats for man and vehicle, for example basic AP mine of 200 g mass of TNT, AP and PROM-1 spring-blasting mines.

Blast pressure under the vehicle

Basic data for blasting wave calculations:

Name/type of explosive, TNT, 6 kg of explosive, ratio $Q_e/Q_e(\text{TNT}) = 1$

Explosion conditions: detonation at the surface /calculation by Sadovski equation/ M. Suceska, Brodarski institut, Zagreb/

R – distance from the explosion centre (radius effect)

p_u – shock wave pressure

p_d – detonation products pressure

Calculation results of shock wave under the vehicle and wheels are given in Table 1 and diagram on dependency of pressure to distance of explosion centre, Fig. 3.

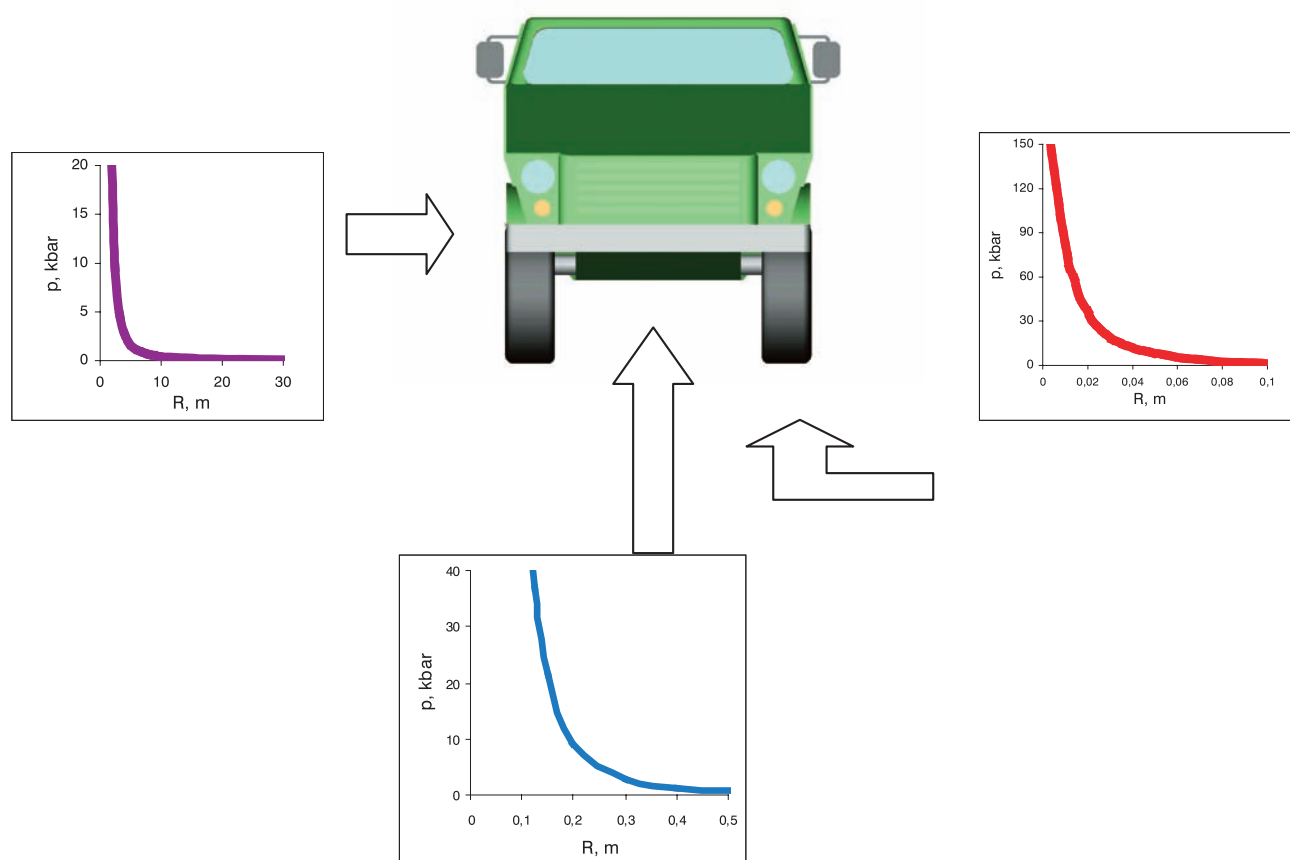


Fig. 3 - Protection valuation of MPV from shock wave pressure of AT mine under the vehicle, wheels and at vehicle's sides

Table 1 – Pressure dependence on distance of explosion centre

R (m)	p_u (kbar)	R (m)	p_d (kbar)
0.09	97.59	0	196.58
0.1	71.27	0.01	82.31
0.125	36.66	0.02	36.75
0.15	21.31	0.039	12.41
0.2	9.07	0.054	7.17
0.3	2.74	0.069	3.86
0.4	1.18	0.106	0.92
0.5	0.61	0.177	0.23
0.6	0.36	0.244	0.10
0.7	0.23	0.577	0.01

Under the vehicle at 50 cm from the ground to the floorboard, pressure of the shock wave generated by an AT mine with 6 kg of TNT is approximately 600 bars. Spheric effects of shock wave are expected from the detonation centre to periphery at radius of $R/\sim 15^\circ$. To shock wave pressure height and chassis surface a shock force is formed that should be absorbed. Because of that, a spheric chassis form is considered for protection at safe distance R and V-shape of vehicle's sides. Solution is usually provided as double floorboard or false bottom.

If the wheel activates AT mine of 6 kg mass of TNT, it is destroyed by detonation products pressure. On radius of 1 cm, pressure of those effects is approximately 80000 bars; by increasing the radius up to 50 cm, its effects are completely lost. Wheels are run-flat equipped that should allow V-shape directing of detonation products in order to lower the wheels' impact on the vehicle. If wheels are not equipped with run-flat option, vehicle will suffer major damage from AT mine explosion. Under the wheels there is dominant detonation products pressure p_d , and under the vehicle, for the floorboard construction, shock wave pressure p_u is dominant.

4. Safety Compartment, citadel

The safety compartment / citadel are protected against mine attack through a multi-layered undercarriage structure. This consists of a sandwich construction, which is designed to absorb fragmenting mine blasts and can be enhanced to protect against anti-tank mines through the fitting of a blast shield. The key to surviving mine blast is the effective absorption or dissipation of energy. The complete mine protection subsys-

tem consists of the following elements: deflector system, crew safety compartment with false floors, blast mounting for deflector and crew compartment, damping elements for the seats, 4-point safety belts. The **mine deflector system** is also specially developed to significantly increase mine protection of light, wheeled vehicles. The deflector consists of a structure of materials as well as a special blast mounting to the chassis. It serves to absorb a significant amount of the blast energy by mechanical deformation.

Instead of the original driver's cab, APV and MPV should have a citadel / safety compartment. Citadel can be especially designed and is produced in a special technology, called "Thin-plate-bending", eliminating most of weldings. The compartment should have a large, armoured front window providing an outstanding field of view for the driver, also equipped with armoured glass (one or two parts). The resistant roof on the hardtop version provides protection against grenade fragments affecting directly on it. Most of the armour protection should be modular being adapted to the basic structure of the safety compartment.

Seats that are built in into countermine vehicle should protect man from blast vibrations (at least 10g). In addition, seat has to provide stabile position and has to be designed according to ergonomics principles; seats have to reduce vibration as much as possible. Seat design has to endure all stretching that can emerge in its exploitation, as well as in case of overturning.

5. Protection from impulse noise and vibrations

When countermine vehicles and demining machines are designed, crew safety is the most important factor. When mine explodes under the vehicle, or very close to the vehicle, shock wave is created and is spread in all directions faster than speed of sound. This wave surrounds the machine cabin creating floor, roof and overall coating vibrations, which creates overpressure inside the cabin.

Intensity of explosion blast (impulse noise in) is determined based on sound pressure (overpressure). Highest noise level should not exceed allowed values for the hearing organs. At overpressure higher than 200 Pa (140 dB) safety measures should apply (ear protectors, protective helmet). Outer machine parts influence the noise level, thickness of armoured plate provides diminu-

tion of the noise level within the cabin. Length of impulse noise of one AT mine explosion close to the vehicle is 14ms, and noise burst rate is 160 dB. In addition, ear protectors lower the noise for 25 dB, which can be considered as protected. This blast can damage unprotected ears but also internal organs that are filled with air.

Shock effects on vehicle's body creates vibrations and sudden changes of personnel position which can result with complex injuries of foot and ankle, if feet are placed on the floor and injuries of spine because of vertical seat motion. High exposure to vibrations increases the risk of spine injuries and pain in its lumbar part. Extremely high blast values, such as driving through rough terrains or mine explosion under the vehicle, can cause spine fracture. In addition, long exposure to lower blast values can cause degeneration of spine discus, which leads to constant pain.

Limitations to vibration exposure:

A) spine: Average acceleration value $< 15 \text{ g}$ or max value of velocity change $< 4.5 \text{ m/s}$ or VDV $< 10 \text{ m/s}$ (DRI < 16)

B) foot/ankle: Average acceleration value $< 20 \text{ g}$ or max value of velocity change $< 3 \text{ m/s}^{1.75}$

Conclusion

Vehicles should be more and more of countermine and ballistic design. Such vehicles should be procured according to safety standards. For humanitarian demining as well as for military vehicles requirements, the same protection level from AT mines can be defined. Although there is regulation for countermine protection levels for military vehicles - STANAG 4569 – there is no so far an International Standards for Mine Protected Vehicle Testing and Evaluation. That is why is so important do develop Technical criteria for Survivability and Acceptance, and Repeatable conditions.

MPV Project emphasizes the need for transporter type vehicle and for citadel type vehicle. On these types total vehicle mass will depend on. The most important parameters in MPV design to AT mine threats are vehicle's clearance height, double floor, deflectors, independent wheel suspension, run-flat tyres, countermine seat, impulse noise protection. To chassis design, the most important is shock wave pressure; for the wheels, the most important is detonation products pressure. This paper provides more blasting wave parameters in order to be able to evaluate possible vehicle protection.

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Development of a Heavy Demining Machine

Dinko Mikulić¹³, Ivan Šteker¹⁴, Vjekoslav Majetić¹⁵

Abstract

The heavy demining machine is intended for machine demining of larger mine-suspected areas in humanitarian mine clearing. What was considered for tools were two variants: a variant of working tool with two flails, as well as a variant with one flail and one tiller, having in mind the functions of these variants. Some time ago, it was unimaginable to combine flail and tiller, mostly because power demands for this were too high. Nonetheless, by allocating the power to working tools a realistic option was designed, which would allow feasible solutions even for smaller sized machines. In order to destroy AP and AT mines, the primary role is on flail of high diameter, and secondary on tiller with a two times lower diameter which ensures that digging depth is good enough, thus enabling high quality of mine clearance. A high reliability of mine destruction is thereby ensured, because with these two independent and different tools the density of hammer strikes is immediately adapting to the conditions of mine density. The independence of tool adaptation together with remote control is improving the speed of mine clearing. The required force of the hammer impulse has been determined in order to be able to overcome the resistance from digging the soil resistance. The results of machine testing show high graded performance regarding mine clearance quality.

1. Introduction

Development goal of heavy demining machines is to achieve better machine efficiency in demining operations. At least, double working efficiency is required in relation with medium demining machines. Using two working tools and wider soil digging should achieve higher digging velocity (e.g. up to 3.5 m). That is why heavy demining machines are using more tools for demining operations. Swedish demining Scanjack 3500 machine is using two flails. Combination of flail and tiller is used on Croatian demining MV-20 machine, whose development survey is given in this paper.

Problem of destroying AP mines by activation or destruction with double tool is a problem

of determining technological working speed of first and second tool, i.e. optimum machine movement speed and rotation speed of working tools. These parameters are adjusted so that the mines of particular size are destroyed by soil digging regardless to the relative position of mine in relation to the hammer. Position of hammers and rotation speed of first and second flail should be adjusted, i.e. required density of soil digging should be achieved. For the soil digging depth with two flails working speed could be doubled and working efficiency increased. In practise, machine user will determine technological working speed according to the estimated digging depth and mine threat.

2. The concept with flail and tiller



Fig.1 - Humanitarian MV-20 demining machine / mineclearing machine

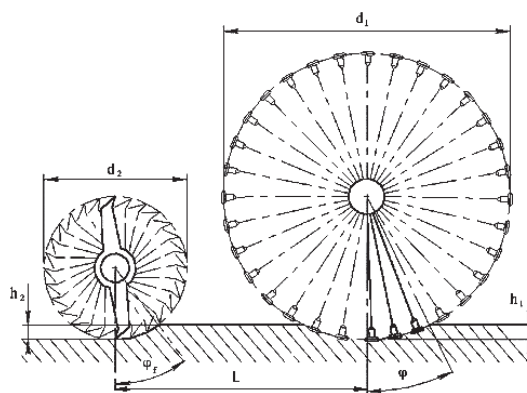


Fig. 2 – Flail and tiller

Working tool with independent positioning of flail and tiller is innovative concept, where it is possible to have different technological speed of flail and tiller, as well as different digging depths.

¹³ MoD - Directorate for development and modernization, Croatia, E-mail: dinko.mikulic@morh.hr, dinko.mikulic@fsb.hr

¹⁴ HCR-CTRO d.o.o. Croatia, E-mail: ivan.steker@ctro.hr

¹⁵ DOK-ING d.o.o., Croatia, E-mail: majetic@dok-ing.hr

For destruction of mine threats primary role is given to the first tool – flail.

Independent position and movement (in relation to digging depth) of flails is providing higher efficiency in relation to classic fixed relative positions of flails. With this combination of flail and tiller certain advantages in digging of different types of soil can be achieved. According to demining requirements digging depth and number of rpm are adjusted in order to achieve higher technological speed for better working effectiveness. Each segment of tiller rotor can have multiple heads positioned at relative angle of 120°. Segments are phase shifted in such a way that segment cutting heads are forming three spirals. Spirals are starting from the rotor centre and are spreading symmetrically to each side.

To destroy AT mines, primary role is given to high radius flail; second role is given to the tiller that insures digging depth and soil mine clearance quality. Smaller radius of tiller in relation with flail radius is better, because it provides lower mass of machine. This insures lower machine mass and insures engine power. Removal of mine threats of great destruction power has to be performed with primary tool – high radius flail – that will not be damaged. Tiller unit, as secondary tool, is adequate for demining depth adjustment according to SOP. This way high reliability in mine destruction is achieved because

with two independent and different tools hammer impact density could be quickly adjusted for different mine threat density conditions, so probability of hammer hitting the mine is high. Reliability of mine destruction is evaluated through two events:

$$P = p_1 p_2 (p_3)$$

p_1 – probability that flail hammer will hit the mine in the minefield,

p_2 – probability of mine activation

p_3 – probability of mine crashing
(p_2 and p_3 – circumstances that exclude one another)

Benefits of primary and secondary tool combination, flail and tiller

- in different working conditions is better to operate with two independent working tools
- two tools / tiller and flail can provide double efficiency according to demining SOP
- two demining tools provide high reliability of mine destruction
- the most destructive AT mines are destroyed by flail (no significant damage of machine)
- possibility to adjust digging depth and tiller's and flail's rpm; adjustment to real demining conditions

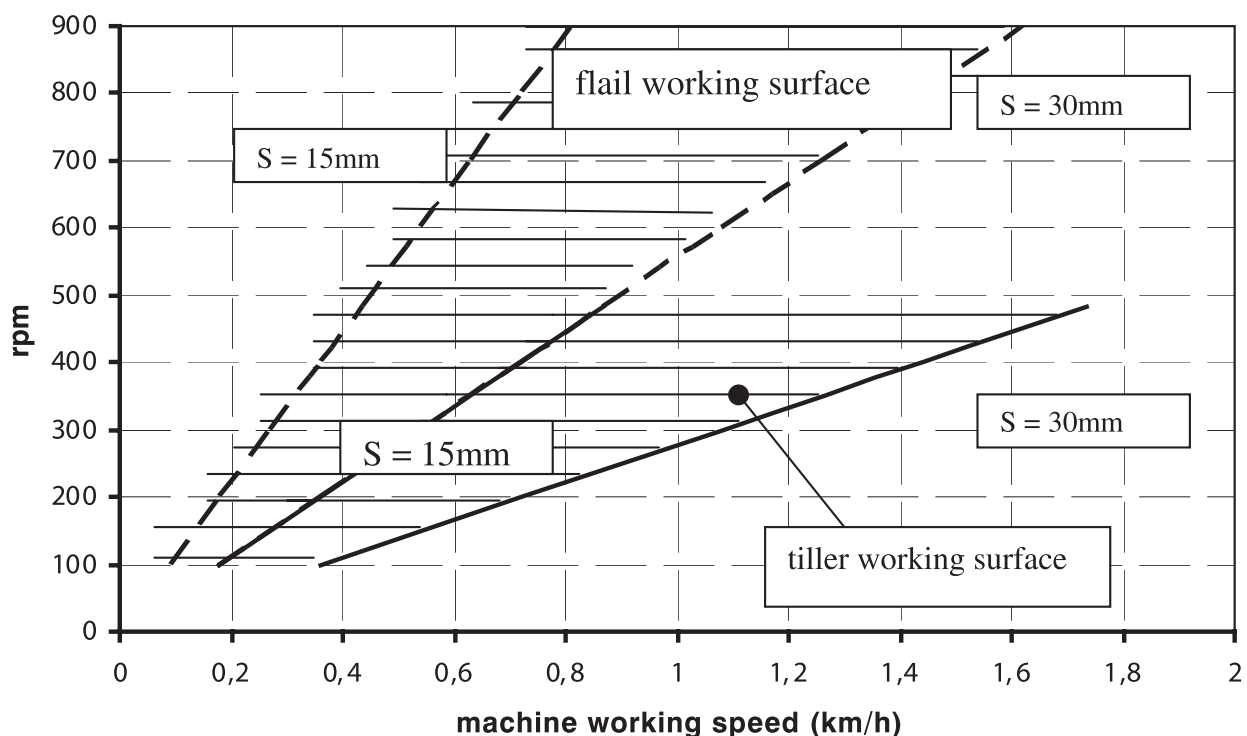


Fig. 3 - Diagram of technological machine speed and different tiller's and flail's rpm

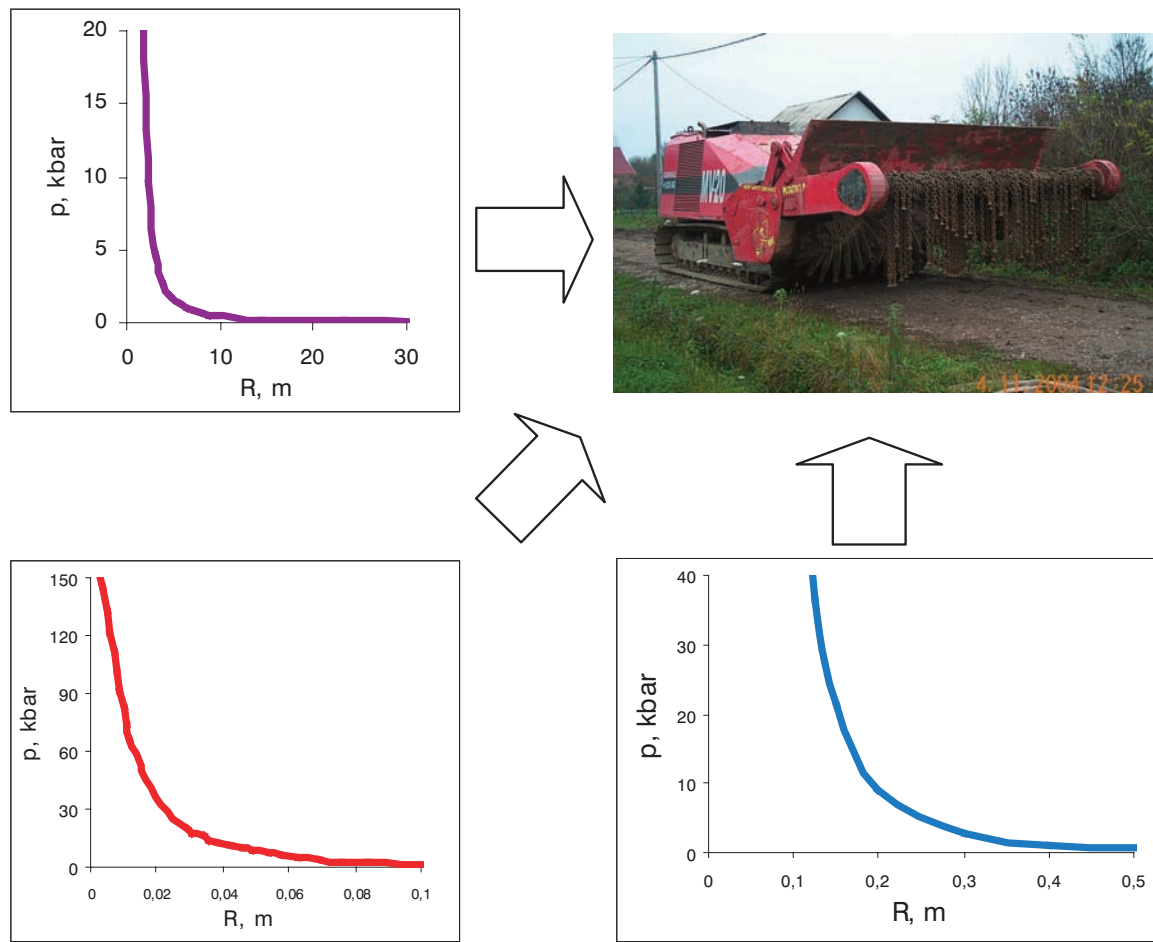


Fig. 4 - Protection valuation of MV-20 from shock wave pressure of AT mine under the machine, tracks and at machine's sides

- tiller is not heavy – small tiller, materiel and engine power savings
- tiller destroys the smallest parts
- tiller determines the final soil digging depth
- tiller protects the machine's vital parts in case of explosion under the flail

3. Blast pressure under and around the machine

Basic data for blasting wave calculations:

Name/type of explosive, TNT, 6 kg of explosive

Explosion conditions: detonation at the surface
 R – distance from the explosion centre (radius effect)

p_u – shock wave pressure

p_d – detonation products pressure

4. First machine MV-20 testing results

Machine testing according to CEN WA, International Standards for Demining Machine, Testing and Evaluation, Polygon Cerovac, CTRO, 18-19 October 2004, Croatia.

- Anti personnel mines

AP mine types: PMA-1A, PMA-2, PMA-3, PMR-2A, PROM-1

At 5, 10, 15 and 20 cm digging depth, 55% of mines were activated, 45 % crashed

All mines were destroyed, machine without damages

- Antitank mines

AT mine types and results:

TMM-1 / activated, TMA-3 / activated, TMA-4 / activated,

TMRP-6 / crashed, TMRP-6 / crashed

Example: TMA-3 mine is placed in front of the machine working tool (left third) at 3 m distance, depth of 10 cm and armed with fuses. Machine and tools activate (flail and tiller) the mine. On tools and machine, there were no damages. TMRP-6 mine is placed in front of middle axis of working tool at distance of 3 m, depth of 10 cm and armed with fuse for activation by stepping on. Machine and tool movement (flail and tiller) crash the mine. On tools and machine, there were no damages.

MV-20 technical data, DOK-ING

Machine mass	35 t	Flail type	AM-020
Machine length	8.0 m	Flail diameter	2.00 m
Machine length, no tools	6.0 m	No of "mushroom" diggers	82 pcs
Machine width /	4.0 m	Tiller type	AF-020
Machine height	2.50 m	Tiller diggers position	spiral
Engine power	663 kW	No of tiller diggers	82 pcs
Working tools	flail, tiller	Soil clearance density	15-30 mm
Working tool drive	hydrostatic	Machine speed:	6 km/h
Machine steering	tracks	Soil digging depth	up to 40 cm
Tracks width	600 mm	Machine steering	remote control
Working width	3.40 m	Machine rotation radius	in place
Working speed	2 km/h	Longitudinal inclination	37°
Working capacity	2-3ha/6h	Transversal inclination	25°



Fig. 5 – Detonation of AT mine under the flail

5. Conclusion

In heavy demining machine project, two versions were considered: version of working tool with two flails and version of working tool with flail and tiller, as well as function of each working tool. The goal was to achieve higher efficiency and independency of each tool regarding different working and demining conditions. Not so long ago, combination and use of different demining tools, such as flail and tiller, was unimaginable, due to high requirements for power balance that was not even started to be considered. Nevertheless, with certain allocation of power, realistic option, which allows perspectiveness of combined solutions, was established, except for heavy and middle machine categories. Independency of two working tool adjustment and remote control speeds up machine demining and can influence on SOP. Machine testing according to Draft CEN WA Standard that includes Performance, Survivability and Acceptance, provides high demining reliability, high quality of soil mineclearing from all mine types, simultaneously providing insensibility to damages from AT mine explosions. Moreover, required goal is

achieved – double working efficiency in demining of big surfaces in relation to middle demining machines.

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The RHINO Demining System Type II

Eugen Winschel¹⁶

ABSTRACT:

System Introduction

The Mine Clearing System Rhino is remote-controlled tiller system, based on the commercially-available components. A Caterpillar engine powers the traced, hydraulically driven machine. Due to operator's safety, the system operates by remote control. Five cameras are mounted around the vehicle, providing colour images to monitor screens for the remote operator. The Rhino is designed to clear anti-personnel and anti-tank mines, even for areas with dense vegetation. A newly developed flail unit can be attached to the vehicle for use against anti-tank mines.

Experience from Trails and Operations

Experience from trails and operations with the RHINO in Croatia, Cambodia, Israel and Korea.

Key words: mine clearance, machines, demining, mine clearing, quality, safety, mechanical demining, anti-tank mines, anti-personnel mines



Introduction

Rheinmetall Landsysteme GmbH (RLS), a whole owned subsidiary of Rheinmetall DeTec AG, is one of the leading companies for the development and production of different types of tracked and wheeled armoured vehicles such as the new Armoured Engineer Vehicle 3 "KODIAK" based on Leopard 2, the Armoured Recovery Vehicle 3 "Buffalo", the unique Mine Clearing Vehicle "KEILER" for Mine Breaching or the Demining System RHINO Type II to clear mainly Anti-Personal Mines (AP) on areas greater then 50.000-100.000 m². Alternatively, with an additional tool (Flail Unit) it is possible to clear mine-fields contaminated with AT and AP mines.

In the global effort against landmines and unexpected ordnance (UXO) RLS was constantly striving to improve the safety, the efficiency and cost-



Pict. 1: Left: Basis Vehicle with the Demining unit – Right: The Video based Remote Control Unit

¹⁶ Rheinmetall Landsysteme GmbH, Germany,
E-mail: eugen.winschel@rheinmetall-ls.com

effectiveness of our Anti-Mine-Equipment. The result of this efforts was the development of the Tiller Demining System RHINO Type I in 1997. Up to now the system was used in many mine clearing projects in different countries, on different soils and in different conditions; for example in Croatia, Korea, Jordan, Israel and Cambodia. Thus we had the opportunity to collect many ideas directly from the field users and engineers how to improve the system. The redesigned Tiller Demining System RHINO Type II is short to be released.

Technical Description

General Aspects

The Rheinmetall RHINO Demining System is a 58-tonne, remote controlled tiller system, based on commercially available of the shelf parts and welded steel. The whole system consists of:

- a) the basic vehicle with
- b) the demining unit (for AP-Mines) or alternatively a flail unit (for AT-Mines) and
- c) a remote control system.

The system is protected against normal mine fragments/splinters and is operated by a wireless remote control with colour cameras and monitors. The RHINO is designed to clear anti-personnel mines in areas even with dense vegetation. The cleared areas are excellent prepared for agricultural purposes.

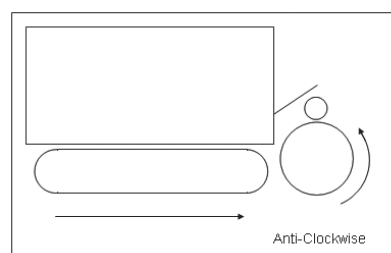
The Basic Vehicle

The basic vehicle is equipped with a hydrostatic drive and standard tracks as are commonly used on bull dozers and similar construction equipment. The energy of the main Caterpillar engine is diverted via a power split gear box into three hydraulic pump groups. All hydraulic pumps and motors as well as the main engine are electronically controlled. The electronic controller also supervises the maximum load of the main engine in order to prevent stoppages and thus damages caused by overload.

The Demining Unit and Clearance Methodology

The demining unit is designed for the destruction of anti-personnel (AP) mines. The demining unit, which is connected by a quick-connect-system to the vehicle, consists of a steel frame with integrated two hydraulically driven tiller drums. The drums are equipped with replaceable tungsten carbide chisels to simplify handling and changing.

The larger, lower drum rotates anti-clockwise in order to prevent compaction of soil and mines. The smaller, upper tiller drum rotates in the opposite direction. The lower drum cuts the soil and carries the excavated soil (soil, stones, vegetation, mines etc.) to the upper drum, where any objects among the spoil larger then 5cm x 5cm is crushed. Mines either detonated e.g. on contact with the lower drum or are crushed between the both tillers. The demining standard of 99.6 % required by the UN for mechanical demining is aspired. The demining unit has been designed to withstand explosions of typical AP mines without any harm and to survive explosions of anti-tank (AT) mines up to 8 kg TNT without severe damages.



The system allows a maximum working depth of 50 cm, while the typical and most used clearing depth being 20-30 cm.

As the control of the correct working depth is more difficult task when the vehicle is operated by remote control the demining unit is equipped with special electro-mechanical sensors on each side of the demining unit. These sensors especially designed for the RHINO system provide input signals to the vehicle controller for the automatic depth adjustments. This ensures that the pre-set working depth is kept at a constant level under normal conditions. The operator can always override this function.

Due to the working principle of the Demining unit it is neither necessary to know the number of AP mines of the infested area nor their working principle nor their exact location.

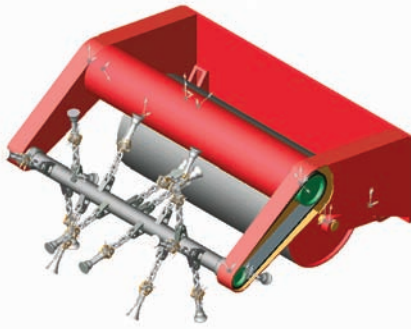
The Flail Unit

Based on components of the famous KEILER Mine Breaching system the Flail unit for the RHINO is designed. The unique, heavy flail elements are fixed by chains at the clearing shaft, which is working parallel to the front of the basic vehicle and rotates towards the ground, so that complete areas could be cleared. The flail

elements will trigger or mechanically crush the mines.

The working depth of the flail unit will be measured by level feelers and controlled by the system electronic.

For mine fields which are composed out of AT mines and a great number of AP mines it might be useful to reduce the size of the residuals by using the basic vehicle together with the Demining unit in a second clearing step.



Pict. 2: Picture of the basic design for the Flail Unit

Dozer Blade

The demining unit can be replaced by a dozer blade by a quick-connect-system. This enables the vehicle RHINO to prepare its own path, e. g. the banks of a small river if a bridge is not available or has to be bypassed.



The Video monitored Remote Control Unit – User Safety

This system allows the vehicle to be operated from a safe distance of up to 1,000 m. In this case visual control of the movements of the vehicle as well as the working process is enabled by the five (in total) colour video cameras at the front, back and the sides of the vehicle. For more detailed information during the demining processes an

additional colour camera with zoom function is installed on a pan and tilting head behind the safety glass of the protection cap. The video signals are transmitted to the two monitors by two separate video radio links with a range of up to 1.000 m. The rear camera is installed in order to enable the operator to observe the rear area especially when driving backwards. The side cameras allow the operator a good view to the sides of the vehicle to prevent damages during turn moves, like the turn on spot.

The semi-mobile control desk consists of two monitors and the remote control incl. two joysticks; it allows the operator to control all vehicle movements with only one joystick. The second one is used to operate the Demining unit. For safety reasons, a time based switch (dead man) has to be pressed by the operator periodically. Otherwise, all movements of the RHINO system including the rotations of the tiller drum will stop automatically.

The remote control unit is installed in a 10 feet mobile container with heating and air conditioning system. An external and mobile power generator provides the necessary electric supply.

In order to clean the Deming Unit e.g. when blocking up, the direction of rotation of the tiller drums can be changed by pressing a button on one of the joy sticks.

Operating and Service Personnel

The demining system RHINO is an easy to operate vehicle. One of the main guidelines for the development of the RHINO system was to use as much commercially available off-the-shelf components as possible in order to achieve easy maintenance and handling as well as to reduce live time costs.

The wear and tear parts such as the tungsten carbide chisels of the RHINO Demining unit can be replaced easily.

In order to achieve maximum efficiency it is necessary for operating personnel to take part in a special training in order to prepare them for the job optimally. It is helpful, if these people have already gathered experience in driving heavy earth moving equipment such as bulldozers or similar vehicles.

The service personnel should be of skilled workers who have practical and theoretical know-how in one or more of the following fields: mechanics, hydraulics, welding, electric and basic electronics.

Operational Costs

The average fuel consumption depending on the environment (ground, soil type, stones, vegetation etc.) is about 60 to 110 l/h. Hydraulic and engine oil has to be changed according to the guide lines of the respective manufacturer (e.g. for the Caterpillar engine after every 250 operating hours). For commercial planning purposes we recommend to calculate 5 to 10 % of the system's price per 2.000 operation hours for spare parts and maintenance service.

Short Overview – Advantages of the RHINO

- The demining standard of 99.6 % required by the UN for mechanical demining is aspired
- Full operator protect due to remote control
- Approx. 6.000-20.000,00 m² clearance capability per 8 hours
- High clearance performance up to 50 cm depth, excellent to operate on wet ground due to the low ground pressure
- Ability to cut even dense vegetation as well as individual trees up to 15 cm in diameter, the machine could be used in rocky areas
- High survivability proven, the system was field repairable even after a double-anti tank mine explosion under the track
- Powerful engine
- Self-recovery possible

Experience from trials and operations

The RHINO was very successful in different areas, swamps, areas with dense bush vegetation incl. bamboos in and trees up to Ø 30 cm (specified Ø 10 cm). Even Booby Traps, e.g. double AT Mines detonating under the tracks could not harm the operators (thanks to the remote controlled operation). Damages from AT-Mine detonations even between the tiller drums were limited and field repairable.

The RHINO system could be transported even in remote areas of developing countries e.g. Cambodia. The transportation has been done so far by railway, aircraft, tractors & semi trailers and on own tracks. To ease the transport the Demining/ Flail Unit could be dismounted. The shipping can be prepared with the dozer blade, which could be mounted to prepare the path e.g. slopes etc.

Technical Specs

General Environment Conditions

- Temperature range for operation - 20°C to + 50° C
- Air humidity up to 95 %

The Technical Values of the Vehicle are (approx.)

- Engine output 656 kW
- Fuel consumption 60-110 l/h
- Maximum speed 3.8 km/h
- Working speed (up to) 1.3 km/h
- Overall length incl. tiller unit 9,600 mm
- Vehicle width 3,000 mm
- Vehicle height 3,150 mm
- Weight incl. the Demining unit 58 t
- Dust emission protection corresponding to conditions under desert climate

Technical Data of the Remote Control Unit

- Antenna characteristic 360°
- Range, free line of sight 1,000 m

Technical values of the Demining Unit (approx.)

- Clearing depth, maximum 500 mm
- Typical clearing depth 300 mm
- Width (with level feelers) 3.800 mm
- Working width 3.450 mm

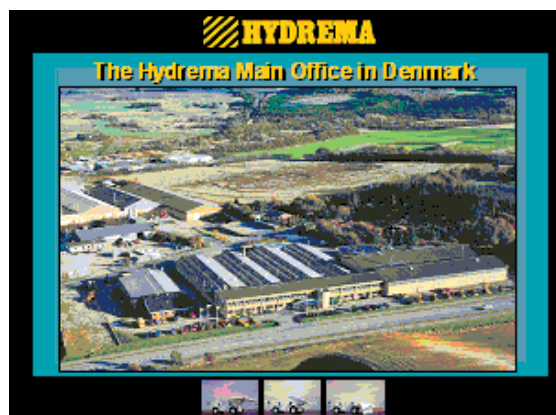
Technical data of the Flail unit (approx.):

- Clearing width 3,000 mm
- Total width incl. level feeler 4,400 mm
- Total length (clearing mode) 3,750 mm
- Weight 6-8 t
- Rotation speed 300- 400 rpm
- Clearing depth, up to 250 mm

Weapon Effects on the MCV 910 and the Nature of Mine Explosions

Gert P. Dugaard¹⁷

Ladies, Gentlemen



It is an honour for me to face an audience like you, which ranges from users, designers of equipment to scientists all interested in the same problem, dealing with a facet of the mine-problem.

If you have the impression that I am going to make an impressive sales talk, with glittering videos etc. I am sorry to disappoint you. At least most of my speed will be related very much to fragments and blast effects from landmines in general and weapon effects from mines, as we see it.

One can argue that from a scientific point of view, based on statistic evaluation, those results, or rather observations, that we have made, do not create any physical laws or represent the whole truth, but they shall be seen more as indicators to what really happens.

To introduce myself, I am now a sales manager in the Hydrema Company. And before that I, as many others, served in the Danish Army where my latest assignment was at Army Technical Command as responsible for Soft Armour Protection, flack jackets, soft armoured tents etc. and project leader of the Danish Army Mechanical Mine Clearance Project, which included among other things, the development and introduction of the MCV 910 in cooperation with Hydrema, a company which I will shortly describe here.

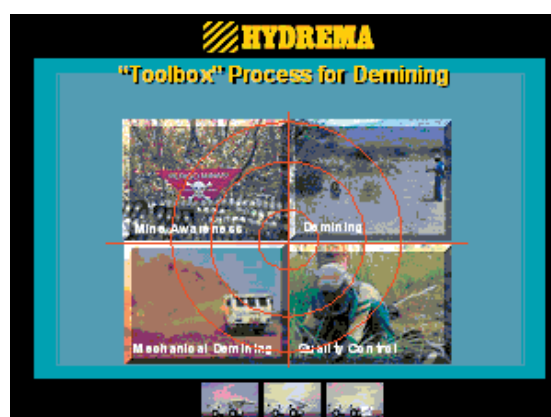
Our main office, which you see here, is situated in Denmark, near Aalborg, and our main business areas are civilian constructors' machinery, and lately mine clearing material.

Furthermore, in 1996 we bought a factory in Germany, situated in Weimar, which has been totally reconstructed and is in line with the other production which is known to make not cheap, but very high quality products. Here we see the German factory:



I could talk about half an hour just about the company and its products, but I would rather shortly describe our approach to the problem in concern – MINES.

The approach from us, concerning Military Demining as well as Humanitarian mine action, is that we believe in the toolbox approach at all levels.



The toolbox consists of several elements, some of which are mentioned here, and we have chosen to concentrate on the element that we know something about, Mechanical Mine Clearance, and the effect that mine blasts have on vehicles and how to prevent them.

¹⁷ Hydrema Export; Denmark, E-mail: hydrema@hydrema.com



Our toolbox approach on the mechanical side is not trying to find the silver bullet solution, as it does not exist – many have tried but none succeeded. Interestingly enough, this fact many times also count for protection against mines, as the explosions differs in effect and nature nearly each time.

What then, what do we do? First for the toolbox machines, mix protection etc.

As I see it, you have to consider a lot of factors and to examine them closely. Just to mention a couple of elements:

How can I get to the minefield? Do I have to fill up ditches, repair roads or even reconstruct bridges? Can I airlift the machinery inland or what?

What type of terrain is it, can you use large machines, or shall I operate in bombed/mined houses?

What is the actual mine threat?

From my point of view, those questions lead you to have several tools each designed for a specific task in order to have the flexibility you need, and those tools in fact need different protection.

This was in the main our approach, and later on, I will return to the sub-toolbox, based on either armoured excavators or armoured loader excavators.



I could talk for hours about the MCV 910 of which 64 are in service, among else four which are assisting the forces in Afghanistan, but as many of you already know the machine – and the rest of you have seen the brochures, I will concentrate on mines, and the characteristics of mine detonations.

I will try to concentrate on the many trials that we have made with blast effect/fragments directly exposing the machine to damage, rather than spending my time on technical details. The reason for doing this is that very few have tried to explode AT mines directly on the wheels or tracks of the vehicles, but many have tried right under the cabin, which they consider to be the worst problem; sorry, I totally disagree.

The stand of distance to the explosion does not seem to be especially large before one can deal with it. However, here we are not dealing with directional mines, so the main problem is when you have direct contact with the mine. A wheel, a track etc., where you have direct transfer of energy from the mine to the vehicle, or if you for example are in an MBT or APC where the distance between the belly and the ground is relatively low, and the energy can slip away to the sides.

Now I know the next question – what is the distance? If I could give you an exact answer to that question, I would be a rich man today. It seems that factors such as ground conditions, hardness of the soil in which the mine is buried, and depth of the mine below the surface, give very different results from explosion to explosion, and furthermore of course the type of mine, casing and explosive, are essential to those questions. Those views cover blast mines, and factor two is then hollow charge mines, which are another chapter in the book of mine effects. Though, it shall be said that smart mines are not yet very common, and of the approximately 100 million landmines, which are already in the ground, very few are 'smart mines'.

Again, to split up elements I have chosen to split up igniters in the following categories:

- Pressure activated
- Air pressure activated
- Magnetic fuse
- Antenna activated
- Radar fuses
- Signature imaging (Side effect mines or sea mines)
- Combined fuses

To go into detail with igniters is not the purpose of this speech, and the list is only intended as orientation to those of you that might now have been directly involved in mine warfare or countermine warfare, so I will go directly to how we look at a mine detonation.

The way I consider a mine detonation, it consists of different factors that you have to split when you design countermeasures and then - in the end - put all the countermeasures together to see if they in cooperation can prevent damage to the personnel, and, secondarily, to the equipment.

As an example, you will see this video a couple of times, where I will shortly illustrate the difference between a mine of approx 5.4kg TNT in metal casing, and a mine of pressed explosive of approximately 10kg TNT. Pictures are taken by interval of 1000/sec. Please note the difference in detonation pattern of the two mine types.

As for those of you that are not familiar with explosions from mines, I hope that this can be an eye-opener to what is really happening when mines detonate, but back to the video in details.

As we have seen from the video, we can start to split up the explosion in a kind of attack/counterattack scenario.

First element: Initial fireball

Second element: Fragment

Third element: Blast

Fourth element: Vacuum



First element

Placing an AT mine under the front and rear wheels of the MCV 910, we found out that the initial fireball is more or less harmless to the machine and does not harm the structure unless you get really close, not even the paint. This was shown in 4 tests (including 1 winter test) and was also supplemented by other trials made in Karup earlier.

So the weapon's effect from this fireball relates to burns on an unprotected body, and does not in fact interest us any more from a damage control point of view.

Second element

As you see from the video, the fragments are up to a temperature where they are almost fluid pieces. It is a phenomenon, which we have seen several times, and on a machine from the Norwegian Army, which cleared 60 AT mines without any repair, we saw that the flail axles were full of scars from the fragments, which had practically burned into the axle.

As you can see, the fragments mainly come from the mine casing though we cannot exclude the possibility that some comes from the chain and solders, which are thrown off at the explosion. Later we will see later on the video of the 10kg explosion, that in this there are nearly no fragments, so everything points in the direction that we are dealing with fragments from the mine casing.

During the trials in Karup we found fragments from fragmentation mines 5 cm inside the armoured window, and in the shield (10 mm ARMOX) of one of our flails in Angola we also found some holes. Therefore, to secure a margin security, we decided to go up to DIN C5 NATO 7.62x51mm AP protection level. Why? - because it looks as if the ballistics, for example a pre-fragmented AP mine or the thick parts of the casing from an AT mine, come close to the ballistic of the AP level.

I am very well aware, that one cannot directly compare fragment with bullets and vice versa, but at that time, that was the best assumption that we had to judge the actual protection level for our vehicle.

The reasons why we cannot compare fragments directly with projectiles obviously lies in the fact that shape, temperature and speed differ, and even though it sounds strange, we have even seen fragments spinning, not in straight lines but in curves, or in a more popular language, we shot around corners.

This has later on been confirmed by several trials in Croatia where we have detonated mines close to our protection on the armoured excavator, and the fragments were really "flying around the corner". Furthermore, we found out that the foam in the foamed wheels absorbed most of the fragments, which meant that we did not get any fragments from the casing into the hydraulic pipes, which were situated only 50 cm from the explosion. We found the broken foam wheel approx 0 metres from the vehicle, and most of the fragments seems to have been absorbed in this ring. This is very interesting, and though we have made 8 trials, this should further explored, due to protection of other vehicles; land rovers, MERC 240 or other trucks. Countermeasures: Level DIN C 5 NATO 7.62x51mm AP is chosen. That means 14mm ARMOX and 7 cm thick windows. All tyres on mine-clearing vehicles will be foamed.



Third element

Blast/ground reflection of blast.

This is one of the elements which is really difficult to deal with as we are not talking of normal energy but about impulse load. This does for instance mean that strings to a sudden extend become stiff when the pressure time is so short, and it can even have the effect that it extends the period. I will later show you that this can be dangerous, and the only philosophy that we can recommend is that: something must either break or deform to absorb the energy without transferring it to the personnel.

The results from the tests show that detonating a 10 kg mine, or even up to 15 kg, behind the flail system does not seem to cause the trouble, the trouble arises when you detonate a mine underneath the wheel. The experiences from Karup are that wheels with foam filled tyres are

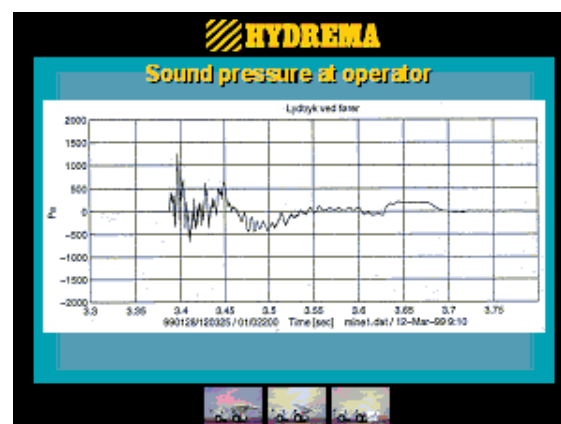
surprisingly good for absorbing the blast and fragments, and together with the fact that something shall break, this seems to be one of the key points in absorbing the blast.



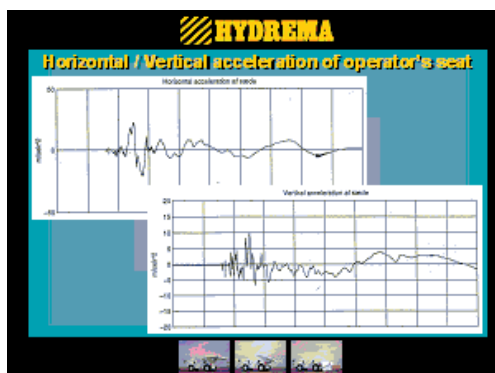
As for the acceptable acceleration level that one can expose the driver to, there only seems to be experiences from the injection seats and car industry to rely on, and those figures, or special figures from crash tests, show up to be too slow to measure what is really happening.

The cool fact is that it has been proven that the MCV 910 has acceptable levels of acceleration. This has been proven by trials with accelerometers as well as by one real accident, where the driver actually was exposed to an AT mine under the front wheel. Here we are not talking about explosives behind the flail but about worst case accidents.

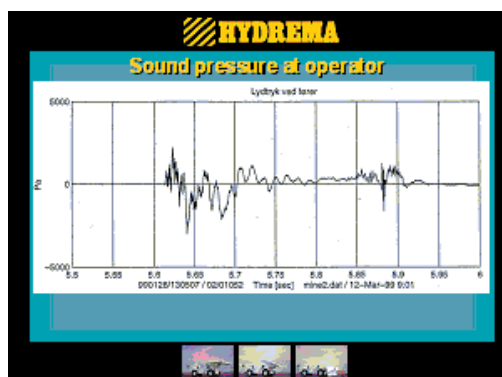
Instead of going into details and further discussion about the acceleration levels, let us have a look at some actual curves, or, as you can say it, raw data.



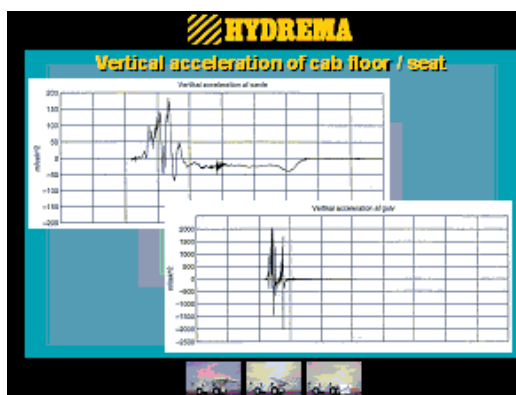
The first set of curves derive from a 6.2 kg AT mine under the rear wheel. As you can see, the sound pressure is about 1200-1300 Pascal, which is on an acceptable level, especially when wearing ear plugs.



These curves show the same explosion as on the sound pressure curve, and you will see some very interesting patterns in the curves. We are not talking simply about a peak but about a kind of amplitude fluctuation in a very short period after the explosion. And as we know that the medical effects of taking Gs is based on speed/time/amplitude, one shall be careful not to increase the time factor where the human body is exposed to the Gs. I am not a medical, but it seems that this, you can call it body exposed time, has to be as short as possible, and the amplitude as small as possible.

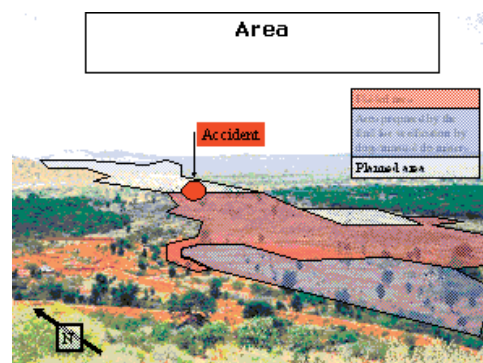


These curves represent the value under the front wheel, and you can see the same picture but of course with higher values. Still it is sufficient, if the driver wears ear protection.



This looks a little bit different as we have two peaks, but we still see the amplitude pattern. One explanation for the two peaks could be that the first peak is when the blast hits the deflection plate, deforming it, whereas the later is when the blast hits the bottom of the floor. However, this is only speculation. Important is that the medicals have evaluated the result, and they are assessed as acceptable levels. These were all trials, but is it then similar when you go into practice, having a live incident? To illustrate the blast effect, I will go through the accident in Eritrea.

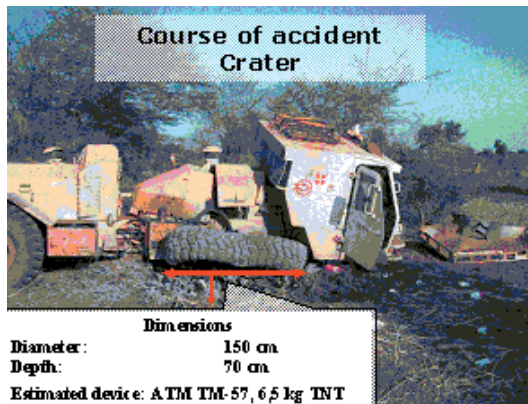
First to set the scene of the accident.



As you can see, the machine has already flailed a large area, and as you can see, the place of the accident is marked with a red dot. It was declared that there were no AT mines in the area, and the task was to verify for Prom 2, surface flailing to a depth of 5-10 cm.

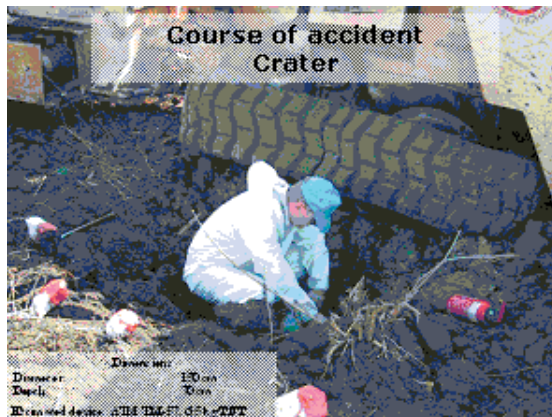


The actual mine that caused the accident was a Soviet produced AT TM 57, and the mine detonated under the wheel closest to the driver. The assumption about the mine type is based on an analysis of the remaining parts of the mine body, and as no explosive canals or body trapping was discovered, it seems to have been a pressure activated mine.



A crater Analysis was performed in good co-operation with UNMEE BOI. It indicated the use of a TM 57, with 6,5 kg TNT, buried in the normal depth of app. 20 cm.

Here we see a picture of the machine after the mine explosion with the actual dimensions of the crater. As you can see, the patterns of the damage look exactly as on the trial vehicle explosion in Karup, so the turn out was as it should be



A crater analysis done by Danish EOD experts shows that the mine was buried with the pressure plate of the mine in 20 cm depth, so as the flail system was set to 5-10 cm working depth, it did not activate the mine. Danish Army procedures normally prescribe a flailing depth of 20 cm, which means that if the procedures had been followed, the accident might not have happened. However, failures occur, and this could just as well have happened for any driver choosing the wrong settings in the computer or any other EOD team not following for example the prodding procedure. In this lecture I will only deal with damages on the machine and the driver, not the management level, but I can state that report shows that the machine reacted the way it was designed to, and the damages on the machine are as you could expect.



No damage of importance was found on the left side.



As you can see from the pictures, the damage looks very much as after the tests.

At the time when the evaluation team was in Eritrea, they had to be careful because the area nearby the flail was not demined yet.

As for the blast, it bent up a plate in the bottom of the cabin, which made a fracture in the driver's heel on line with what you for example expect from a parachuter landing in a wrong way. This is not to play down the damage for any damage shall be avoided if possible, but the driver was back again two months later, ready to drive Hydrema again.

The flail was specified to take 10 kg under the flail, so 10 kg under the wheel is extreme. However, we are always looking to optimise the security, so now the bottom plate has been reinforced to 20mm HARDUX, a solution which has been approved by the Danish and Norwegian Defence. The damage on the left side comprised, not surprisingly, a damaged wheel and rim. Furthermore, the fuel tank was dented, and the batteries with holder were blown off to be found 30 metres in front of the MCV.



As one can see here, the blast shield has been thrown away and demolished in the explosion. This was also the original intention as it was designed to protect against fragments and should take the peak of the blast by being disrupted by the blast.

All in all, the damages were as foreseen, and the machines reacted to the blast as we expected.

Countermeasures: Blast shield, deflection of the explosion and deformation. Damped seat. No loose parts in the cabin when in mined areas. The less you can have over the wheel the better, things shall be able to break or deform without transferring energy to the body of the machine.



Picture - Bagram

Fourth element. Vacuum

As we can see from this video, we see a very strong vacuum after the blast wave and explosion. As we can see on the video, it can even take

up poles from the ground, throwing them high up into the air, and we have also seen it opening doors on the vehicles.

After the accident in Eritrea, some stated that it was due up to pressure building in the cabin that the door was open, but this would be the same as filling up the swimming pool with a normal water pipe within 1/1000 of a second.

Trials made with bomblets on tanks have shown that the pressure building up inside the vehicle is limited when it burns through (small bomblets). This supports that pressure building up inside the vehicle in Eritrea was hardly the case. The fact was also that the driver's hearing was not damaged, which would have been the case if such a pressure had occurred.

This shows that the vacuum behind the explosion, combined with the pressure wave, might create a kind of amplitude on the door which means that the door handle can break.

Countermeasures: Stronger doorlocker, BUT?

Why this question mark? No literature can support this, and from my point of view those amplitudes that we saw in the curves earlier on might be of considerable interest concerning material structures etc.

Conclusion

I would like to have shown you much more material, but the time is limited. All the mentioned reports are more or less available, and I will stress that all explosive tests were made by either the Danish, Norwegian or Swedish Defence, as I know very well that factory tests many times do not express the full truth. Some in his audience can even confirm that as they have met the persons who actually did the tests.

To an inexperienced demolition person, it might look as if the machine is badly damaged, but after returning to Denmark, we have examined the vehicles, and the damages were far below the limit criteria from the Danish Army, requiring that the vehicle must be repairable even when 50 % damaged. The front frame had to be exchanged together with the axle, but the driver compartment, the back of the machines, the engines etc, are still alright.

If you want to discuss specific results, curves, pressure in the cabin, acceleration etc. please come directly to us and confront us with your questions so we can either answer you right away or take the question back home, consider it, and then give you the answer.

HYDREMA 910 MCV series 2 - MINE CLEARING VEHICLE

Gert P. Daugaard¹⁸, Christina H. Nielsen

Resume

Hydrema's 910MCV series 2 mine clearing vehicle offers high mobility and safety. It benefits from the experiences made by the users of the more than 60 units of 910MCVs that have been sold over the last decade for use all over the world and from the constant technical further development that takes place at Hydrema. The experiences from the 910MCV-1 have resulted in a 910MCV-2 vehicle, which takes a confident lead in clearing safety in tests made by SWEDEC.



Methodology

The 910MCV-2 consists of a two-part chassis with pendulum steering, an armoured blast shield and a flail mounted at the rear end of the vehicle. During clearing the 910MCV drives in the reverse direction, meaning that the driver in the cabin is furthest possible away from the explosions under the flail.

With its 72 chains, the flail either destroys the mines or causes them to explode under the flail in a 3.5 metres wide belt. The shield ensures that mines do not slip under the vehicle and protects the cabin from the blasts that take place under the flail unit. The basic vehicle's rear and front mainframe are made of welded high-strength steel box-profiles for maximum strength and rigidity. The frames are connected at the articulation joint at the middle of the vehicle by means of three ball bearings making a steering and pendulum movement between the frame parts possible. As the pivot steer is placed between the two axles, the wheels will always drive in the same track, leaving only one set of tracks. This results in better passage and minimal ground damage. Furthermore, it gives improved safety as a missed mine will detonate under the rear wheel, before it reaches the cabin.

Finally, the pendulum steering has been used to develop the 910MCV-2's unique "yaw control". It means that the usual track of piles is avoided in the cleared lane, thereby further increasing the clearing safety.

Description

The 910MCV-2 has been designed based on five keywords: safety, mobility, efficiency, comfort, and technology, and below they are used to describe the vehicle.

Safety

- Both the front and the rear frame are made of high tensile steel giving maximum protection against damage.
- The cabin is built up as a one-piece welded construction in armoured steel and gives protection against firing, mine fragments, stones, debris etc. equivalent to protection against calibre 7.62 AP (DIN 52290-2 class C5).
- All 8 windows in the cabin are equipped with large area armoured glass, offering a similar protection degree.
- The choice of the high level of protection is based on experiences with mine blasts; both

¹⁸Hydrema Export; Denmark, E-mail: hydrema@hydrema.com

live and from tests.

- The 910MCV has been tested against 10 kg live TNT.
- A blast deflection plate mounted under the cab offers improved safety in case of explosions under the cab.
- Two separate, interchangeable engines and two separate fuel tanks increase the safety. Together the two engines offer 272 kW engine power for the flail. However, if one engine should fail, the other can take over all the hydraulic functions, so the vehicle can be returned to transport position and driven out of the minefield in emergency driving.
- Hydrema's unique pivot-steering includes an anti-roll system which is particularly useful in rough terrain.
- The front and rear wheels always drive in the same track due to the pivot steering.

Mobility

- The 910MCV-2 has extremely fine cross-country qualities.
- The size and weight allows driving on the same roads as normal trucks.
- When driving on roads, the vehicle is categorised as earth moving equipment with a maximum speed of 40 km/h.
- In case of long distance transportation the vehicle may be transported by railway or by a Hercules C 130 transport aircraft.
- The complete mine clearing unit with flail and deflector plate is suspended on a turn able console, so the whole unit for transportation can be stowed lengthways over the vehicle. The change for the transport position is done from within the cabin, without any tools and in less than 10 minutes.
- Due to its construction, the 910MCV-2 is repairable with 50 % damage.

Efficiency

- Excellent clearing results for the 910MCV-2 in an official test made by SWEDEC in 2004.
- The clearing rates have been improved significantly for the 910MCV-2.
- 910MCV-2 took a clear lead position compared to the Scanjack and the Mine-Guzzler in SWEDEC's tests. Appendix 1 shows a comparison for the max depth in SWEDEC's tests (20cm), but the full test results can be found on www.itep.ws.

- The flail can rotate in both directions and thus also be used for sweeping roads or runways without damaging them.
- Tool-free preparation for mine clearing in few minutes

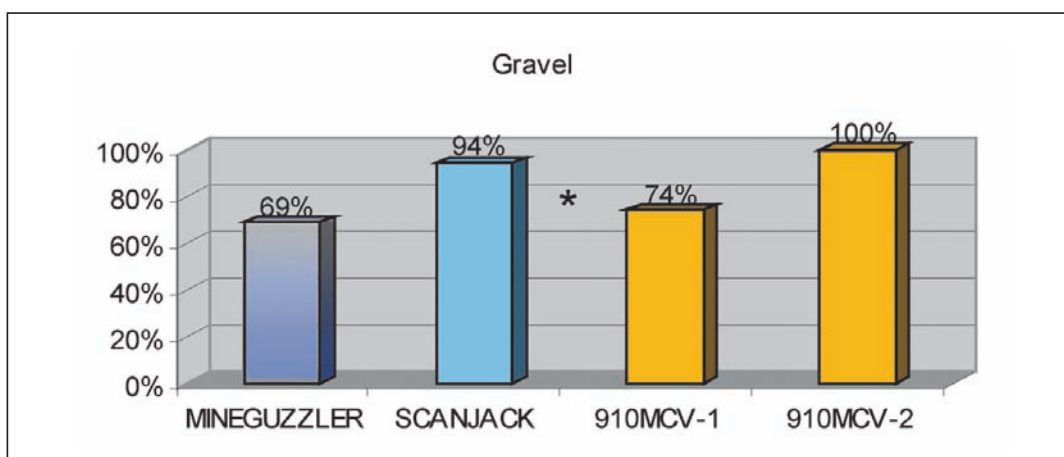
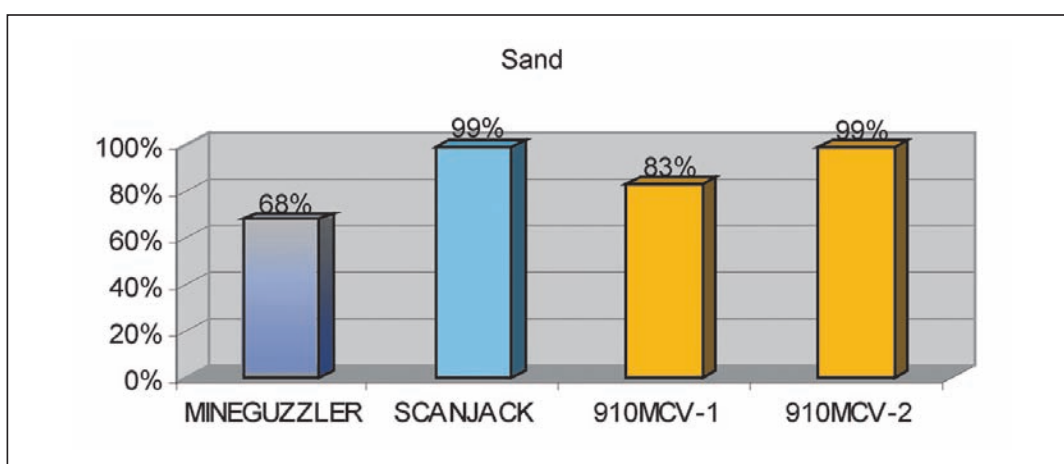
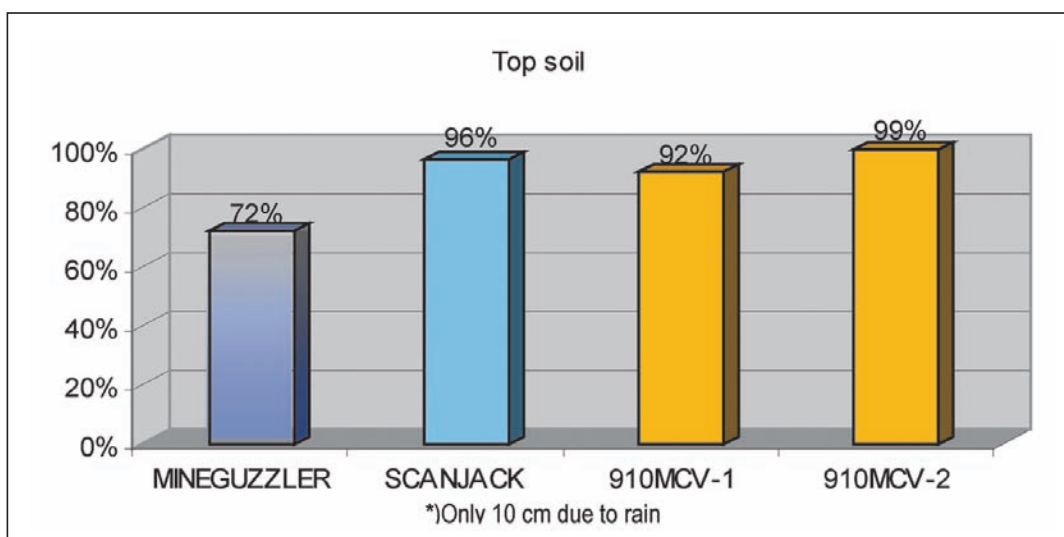
Comfort

- The driver experiences only minor disturbances at detonations.
- There is a low noise level in the cabin.
- The cabin is equipped with heating and A/C system.
- There can be up to three individually adjusted comfort seats in the cabin.
- The cabin is mounted on rubber elements and the seats are suspended and damped with arm and neck rests as well as safety belts. The seats are fitted with rotating consoles that can be turned to the rear during clearing.
- All functions - except flail rotation and driving speed with hydrostat - are adjusted by two joysticks fitted into the armrests.

Technology

- A state-of-the-art remote control system is now available
- A computer-controlled system is used for supervision and control during mine clearing in order to give the operator user-friendly information regarding adjustment as well as monitoring information.
- The system is used for flail depth adjustment, shield height, pressure adjustment and automatic steering yaw control. The system provides information about the settings and furthermore allows automatic clearing.
- In automatic clearing mode, the machine has an automatic steering yaw control, giving a completely clean clearing lane without the "tracks" normally known from flail systems. The joystick steering will overrule the automatic system, so the driver always has the full control of the vehicle.
- The electronic supervision of the main parameters maximises the ease and stability of the driving and thus the safety.
- A GPS navigation system is optional

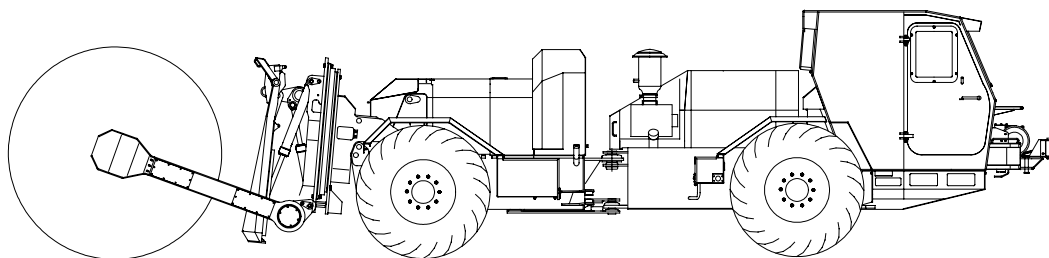
More than 60 units of the 910MCV have been sold and are in use all over the world. Therefore, Hydrema has been able to gather information about use in different ground conditions and



Appendix 1 – Graphical overview of clearing results at 20 cm in tests by SWEDEC

climates as well as specific knowledge about the effect of different types of mines. The pieces of information from controlled tests as well as from real life users have provided an excellent background for developing the 910MCV-2, a development that will continue as knowledge increases and technologies improve. Moreover, our expe-

riences enable us to advise our customers about how best to use the 910MCV-2 and other means in the important fight against mines. Controlled tests have shown excellent results but the 910MCV has also passed the hardest test – real-life use under unpredictable conditions and with the factor of human mistakes!



Appendix 2- Specifications for HYDREMA 910 MCV-2 (Mine Clearing Vehicle)

Engine:	Main engine:	136 kW
	Power pack:	136 kW
Length:	Transport position:	9.18 m
	Mine clearing:	9.97 m
	Axle distance:	3.86 m
Width:	Transport position:	2.50 m
	Hercules:	2.80 m
	Mine clearing:	4.69 m
	Standard tyres:	2.42 m
Height:	Transport position :	2.70 m
Weight:	Total: (ready for working)	18.000 kg
Driving speed:	Road transport:	0-42 km/h
	Mine clearing; (terrain):	0-1.4 km/h
	(firm surface):	0-12 km/h
Flail:	Rotation speed:	0-440 omdr/min
	Diameter:	2.20 m
	Elements:	900-1100 g
Clearing width:	Mine clearing :	3.50 m
Turning radius:	Road transport :	8.1 m
	Mine clearing :	18.0 (9.2) m

Proces and Organization of Testing of Demining Machines in the Republic of Croatia

Ivan Steker¹⁹

ABSTRACT

The Paper "Process and Organization of Testing of Demining Machines in the Republic of Croatia" describes the organization and content of testing of demining machines, from the application for testing to the issuance of the conformity assessment. The intention of the Paper is to present the whole process, in order to show the complexity and gradualness of the testing process. In addition to the testing process itself, the content of each of its components is described.

Testing of demining machines is an important element in developing and establishing demining resources. The testing quality directly influences the following:

- *development of quality solutions of machine tests*
- *searching for the new technical and technological solutions of the machines*
- *application of high quality and reliable machines in demining*

Testing of demining machines in the Republic of Croatia is based on the previous experience of machine tests, application of machines in demining to date, and collaboration with machine designers and international factors. In the future, with creation of new designer and technological solutions, we expect development of the elements of the process and content of tests of demining machines.

1. History of testing of demining machines in Croatia

During the war in Croatia and immediately after the war, machines of the Croatian army were used for demining. These were tanks with additional mine clearing discs. In 1998. AKD Mungos Company acquired the first machine called RHINO 2. The next year a Swedish company SCANJACK brought a SCANJACK 3500 demining machine to Croatia, and this is when testing of machines started. In those times there were nor documents nor Regulations, but there was a huge need for mechanical clearance, because we knew that using only manual demining would be time consuming. The same year CROMAC organized a symposium on the subject of mechanical clearance, where scientists, designers and entrepreneurs were invited with the aim of establishing the use of machines in demining. Soon new demining machines appeared on the market (MV, ORACLE, MINE GUZZLER) and organization of systematic testing of demining machines became a necessity in order to establish criteria and ensure quality and reliability of machines.

In our work we are assisted by international community, knowledge and experience are shared, and today we may talk about „industry demining“, where machines have a leading role. Criteria in testing and use of machines are established.

These criteria are more and more demanding, and efficiency of machines is constantly improving. Special attention has been given to the testing and use of demining machines in Croatia. The use of demining machines has contributed to the following:

- Accelerated demining process
- Mine suspected area survey
- Significant decrease of risk for deminers
- Lowering of the demining price
- In the work of deminers after mechanical treatment of land there have been no demining accidents.

The above stated facts oblige us to further develop and improve the testing and use of demining machines.

2. Current situation with machines in Croatia

From 1999 to 2005, 29 machines were tested in Croatia in accordance with relevant program documents.

MACHINE	NUMBER
Heavy	5
Medium	7
Light	5
Excavators	12
TOTAL	29

HCR – CTRO d.o.o., Croatia, Email: ivan.steker@ctro.hr

Some machines have left Croatia after the testing, some have been out of use, and some are being used. All the machines used in Croatia have been tested last year, they have been given a registration plate and awarded the conformity assessment which is valid for one year.

MACHINE TYPE	NAME	QUANTITY	TOTAL
heavy	RHINO 2	1	7
heavy	ZEUS 1	2	
heavy	ORACLE	1	
heavy	SCANJACK 3500	3	
medium	RM - KA 01	1	7
medium	RM - KA 02	2	
medium	SAMSON	1	
medium	SAMSON 300	1	
medium	HYDREMA 910 MCV	2	
light	MV - 4	17	29
light	BOŽENA-1	1	
light	BOŽENA-2	1	
light	BOŽENA-3	5	
light	BOŽENA-4	5	
excavators		12	12
TOTAL			55

This year the Annual conformity assessment is planned of above 55 machines, on the basis of the existing legislature. The machines will be awarded usability assessment for the period of one year. New machines will be subject to the testing in line with the current Rules and Regulations. To date, 7 new machines have been announced for testing, two of them are excavators.

3. Content and organization of testing of demining machines

Testing of demining machines is twofold:

- New machines – subject to complete testing – polygon and field testing
- Machine in use – subject to annual conformity assessment

Testing of demining machines is a complex and phased process, set out by the Program of Testing and Evaluation of Machines Used in Humanitarian Demining, which is an integral part of the Rules and Regulations on Performing Demining Works, based on the Law on Demining, and it consists of the following:

- a) Preparation of documents
- b) Polygon testing of the machine

- c) Testing on live AP mines
- d) Testing on live AT mines
- e) Measuring of noise in the cab and of machine acceleration
- f) Field testing
- g) Testing of excavators
- h) Annual conformity assessment of demining machines

Each of these testing elements is a separate part, but they are interlinked and influence each other, depending on a specific machine, technical characteristics of the machine and the testing order of the ordering party.

a) Preparation of documents

Testing of a demining machine may be ordered by an authorized legal person (demining company, a company which designed and manufactured the machine or a company which modified and adjusted a machine for the use in demining). Application for testing is submitted to HCR-CTRO in a written form, together with the required documents:

- Technical data about the machine
- Certificate of the quality of material used for the armor and glass of the cab
- Report on the measurement of noise inside the cab
- Documents on the developmental and polygon testing of the machine
- Documents on the use of the machine outside Croatia

On the basis of the documents submitted and the inspection of the machine, in accordance with the Program of Testing and Evaluation of Machines Used in Humanitarian Demining, a testing manager will develop a proposal of a Testing Plan. The Testing Plan will be adjusted to the basic characteristics of the machine (machine type, intended use, type of working tool, weight, way of operation, position of the machine operator, etc.) and with provisions of the Program.

The testing manager submits and presents the prepared Testing Plan Proposal to the Testing Committee of CROMAC, he informs them about the existing documents and give answers to their questions. The Committee may adopt the proposed Plan, but it can also ask for some elements or the whole Testing Plan to be changed. Upon adoption of the Testing Plan, the preparation and implementation of the testing is performed.

b) Polygon testing of demining machines

The polygon testing is performed at the Cerovac military range (near the town of Karlovac), at a specifically prepared area.

There are three test lanes 50 m long, 4.5 m wide and 0.5 m deep. The first lane contains local soil (the existing topsoil was dug out and removed), cleared of stone and old objects, in layers around 15 cm deep, compacted, in the overall depth of 50 cm.

The second lane contains sand with particles ranging from 0.075 to 20 mm with 85% smaller than 0.6 mm, distributed evenly. The sand has been laid in layers of around 15 cm, compacted to the desired compactness level, in the overall depth of 50 cm.

The third lane contains gravel of particles ranging from 0.075 to 45 mm, 10% smaller than 0.4 mm, linearly distributed. Gravel is laid in layers of around 15 cm, compacted to the desired compactness level, in the overall depth of 50 cm.

Three fiberboards are placed at each lane (at the first third of length, in the middle of the lane and at the last third of length) vertically to the direction of machine movement. Fiberboards are 5 mm thick, 4.00 m long. They are used for measuring the clearance depth in different types of soil. The depth at which the fiberboard has been damaged in an adequate way implies the depth of treatment in the specific soil type.

All machine types (light, medium and heavy) are tested at the test lanes and the following parameters are tested:

- Soil treatment depth
- Working capacity

Soil treatment depth is calculated measuring the damage on the three fiberboards at each test lane. It often happens that these fiberboards are not damaged at the same depth and in continuity, and in such a case average value is taken. In this way we obtain the soil treatment depth in all three testing lanes.

Efficiency of the machine at test lanes is obtained from the data about the machine speed and width of the working tool. On the basis of these parameters, possible efficiency of the working tool is obtained in the unit of time (m^2/h). Efficiency of the machine varies on various types of soil in the test lanes, depending on the type of machine, engine power, operation mode, type of working tool, way of operation, etc.

The speed of machine movement and soil treatment depth are interdependent. Up to a specific depth, depending on the machine and engine power, soil treatment depth does not influence

the speed of the movement of the machine and vice-versa. Nevertheless, as the soil treatment depth increases, the speed is decreasing and vice-versa. In this way the efficiency of the machine may be calculated very accurately.

The testing results obtained at test lanes are optimal, since the conditions are ideal, we may call them "laboratory conditions". There is no vegetation on testing lanes, there are no mine targets, the machine is moving in a linear direction (without turning) and the lanes are of comparatively short length (50 m).

The results obtained on testing lanes have the following values:

- Equal conditions have been achieved for all machines
- The procedure is repeatable for each machine and for all machines
- Results obtained are maximum (in relation to real conditions of a mine affected area)
- The procedure is simple and relatively short (around 2 hours)
- Results may be compared and statistically analyzed

c) Testing on live antipersonnel mines

Testing on live antipersonnel mines is conducted at the Cerovac military range, on a separate, specially prepared area. The following mines are used:

MINE TYPE	quantity
PMA-1A	5
PMA-2	5
PMA-3	5
PMR-2A	2
PROM-1	2
TOTAL	19

Antipersonnel pressure activated mines (PMA-1A, PMA-2 and PMA-3) are placed in a linear order, with a distance of 4 m between them and at the depth of 5, 10, 15 and 20 cm. The goal is for the machine to destroy all the mines in one run. The mine is destroyed if it has been activated or broken (ground). Due to a comparatively low quantity of explosive in the above mines, no damage to the working tool or the machine is expected.

Antipersonnel tripwire (fragmentation) mines (PMR-2A and PROM-1) are placed individually. One PMR-2A mine is placed some 25 m in front of the working tool, and the trip wire is pulled to

the side contrary to the direction of the machine movement. The tripwire of the second PMR-2A mine is pulled vertically to the direction of the machine. One PROM-1 mine is prepared for pressure activation, and the other one for tripwire activation, and the tripwire is pulled in the direction of the machine movement.

When antipersonnel fragmentation mines are activated, due to higher explosive quantity and due to their activation, smaller damage to the machine might be expected, especially on the working tool.

During the testing on antipersonnel mines, the following results must be obtained:

- All the mines have to be destroyed (either by activation or grinding)
- No vital parts of the working tool or machine must be damaged and the machine and the working tool have to be able to continue working.

If a mine remains undamaged after a machine has passed the lane, the testing procedure is repeated with the full number of mines of the same type foreseen for the testing. After the procedure has been repeated, if a mine still remains undamaged, a detailed analysis of the work of the machine and the working tool must be made, and some changes in the machine design are due in order to obtain required results.

d) Testing on live antitank mines

Testing on live antitank mines is conducted at the Cerovac military range, on a separate, specially prepared area, in safe environment. The following mines are used, depending on the machine type:

- Light machines and excavators are not tested on antitank mines
- Medium size and heavy machines are tested on live antitank mines

MINE TYPE	HEAVY MACHINE	MEDIUM MACHINE
TMM-1	1	1
TMA-3	1	(1)
TMA-4	1	
TMRP-6	2	2
TOTAL	5	3 (4)

The mines are placed individually, 5 m in front of the working tool and are buried 10

cm in the ground and armed with fuses. The task is for the machine to destroy the mine, either by activation or breaking (grinding). After activation of an antitank mine, no damage to the vital parts of the machine or working tool must occur, but the damage must be such that it allows repair on site. If a mine remained undamaged or the damage on the machine and working tool may not be repaired on site, the procedure should be repeated, but previously the machine design or material of which certain vital parts of the amour of the machine and working tool are made must be changed.

Two key results are achieved in the testing on live antitank mines:

- Impact of the machine on a mine
 - Impact of the activated mine on the machine
- Impact of a machine and working tool on an antitank mine is seen through the way and reliability of destroying the mine. An antitank mine may be activated or broken by the working tool, which are the two positive ways of destroying the mine. The antitank mine must not be missed or thrown away, i.e. it must not remain undamaged.

In the moment of activating the antitank mine by the working tool, full or partial detonation may happen. Full detonation happens in the case of activation of the entire explosive content inside the mine. Partial detonation will happen if, during the work of the working tool some parts of the mine containing the fuse are broken and separated, and then the fuse and the remaining quantity of explosive are activated. Partial detonation may occur with antitank mines which do not have a body (e.g. TMA-3) or where the mine body is made of plastic. Partial detonation cannot happen on antitank mines with metal bodies (e.g. TMM-1).

The results of the testing with live antitank mines show the following:

- Expected way of destroying antitank mines
- Expected impact on mechanically treated land containing antitank mines
- Expected impact on the machine and working tool
- Safety of the machine operator (inside the cab and outside the cab)
- Position of the machine operator
- Assessment of the need for spare parts on the working tool and machine

e) Measuring of noise inside the cab and machine acceleration

According to established standards, light demining machines must be operated remotely. Medium size and heavy machines can have a cab for the operator and may be operated both from the cab and by remote controls. If there is a cab on the machine and direct operation from the cab is possible, measuring of noise inside the cab and of acceleration of the machine in the moment of activation of TMA-3 antitank mine is performed.

The procedure of measuring the noise inside the cab and machine acceleration is conducted at Cerovac military range. The machine is brought to the test site, TMA-3 antitank mine is placed in front of the machine/below the working tool and is prepared for electrical activation. Noise measuring instruments and acceleration measuring instruments are placed in the cab. The TMA-3 mine is electrically activated from the safe distance. When the mine is activated, certain intensity of noise is created in the cab, and the detonation wave hits the working tool and the working tool moves, which is registered by the instruments in the cab.

The noise in the cab may be up to 120 dB, and impulse, momentary noise may be slightly higher. If the noise in the cab is higher than permitted, it may be ordered that the cab isolation be improved and that ear protection is mandatory during the machine operation.

Acceleration due to the shock wave in the moment of detonation (measured inside the cab) must not exceed the limit of 18,000 Pa. Higher shock waves endanger health and safety of the machine operator.

f) Field tests

Upon the polygon testing on test lanes and with live antipersonnel and antitank mines, if all results achieved are within boundaries of acceptability, a so called field testing of a demining machine is performed in realistic minefield conditions.

Depending on the type and intended use of the machine, and on the current demining projects, the most appropriate testing area is chosen. In the field testing, the machine has to treat the following project area:

• light machines	30.000 m ²
• medium machines	50.000 m ²
• heavy machines	80.000 m ²
• excavators	30.000 m ²

The ground foreseen for the testing should:

- contain mines appropriate to the machine type
- contain flat terrain, as well as horizontal and vertical slopes
- contain low, medium and high vegetation

The machine is operated in a way a designer has foreseen, directly from the cab or with remote controls, observing the safety measures and approved organization of work at the work site. The work of the machine is monitored daily, and at the end of each day achieved results are verified:

- a) working conditions
 - ground conditions
 - mine conditions
 - vegetation conditions, weather conditions
- b) machine efficiency
 - number of working hours
 - surface area treated
 - standstills and their causes
 - average treatment depth (at least 20 samples a day)

The following results may be seen from the field testing:

- operation in realistic conditions
- continued prolonged work (8-10 days)
- operation within the work site organization
- failures
- reparability and maintainability
- work capacity
- soil treatment depth in realistic conditions

It is interesting to compare results of the polygon and field testing and to look at the possibility of improving the machine and work tool design.

g) Testing of excavators

Testing of excavators used in humanitarian demining depends on their intended use, taking into account its specific characteristics.

Excavators are machines used in demining for mechanical treatment of slopes of canals, rivers, ditches and embankments. Excavators move on surveyed and safe ground and they treat the slope with their working tool mounted on the arm.

Excavators are tested on antipersonnel mines and field tested on a demining work site on the area of 30,000 m², in the same way as other demining machines.

h) Annual conformity assessment

In accordance with Article 7.14 of the Program of Testing and Evaluating the Use of Demining Machines Used in Humanitarian Demining, we have to make the annual conformity assessment of all the machines used in Croatia (of those that have undergone polygon and field testing).

The aim of the annual assessment is to:

- Examine technical characteristics of the machine
- Examine the treating depth and capacity of the machine (in comparison to the results of the basic polygon testing)

During the time the machine wears out and some parts of the machine or working tool which are important for the quality of work may be replaced, which may influence the overall results and quality of machine work.

If significant changes of the construction and working quality have been done to the machine or its working tool, the machine has to undergo the complete testing.

The annual conformity assessment of light and medium demining machines is conducted at the Cerovac test site, and heavy machines and excavators are tested at the work site where they are currently used.

The conformity assessment consists of the following:

- Examination of technical characteristics of the machine
- Examination on test lanes – soil treatment depth and machine capacity
- Examination of vegetation cutting capability

The usability assessment has direct influence on the possibility of use in mechanical treatment on different mine clearance projects.

4. Conclusion

Testing of demining machines is a continuous process which have to keep pace with the development of technology and design of machines, and growing requirements for quality in the use

of demining machines. The following results have been achieved in the testing of machines to date:

- high quality machines are used in demining
- extensive and systematized data base on machines is available to users
- use of the machines which may achieve optimum results on a specific demining site is enabled
- some 90-92% of ground is mechanically treated in Croatia
- there have been no demining accidents after mechanical treatment
- demining process has been sped up
- demining price has decreased
- risk for deminers has been reduced

We expect that in line with the development of new machine designs, development of testing conditions will follow. It is necessary to continue with the establishment of test sites, procurement of modern instruments, so that the parameters of the machine work may be measured in a more quality and reliable way, and in this way directly influence the quality of the use of machines in demining.

MINEMILL MC2004 Demining Machine – a Machine for Mechanical Ground Preparation for the Demining and Destruction of Anti-personnel Landmines and Unexploded Ordnance

Milenko Cvetković²⁰

Abstract:

Minemill MC2004 is a heavy duty tracked vehicle with low ground pressure. It possesses extreme climbing and manoeuvre abilities, including turning on the spot. The machine demonstrates excellent efficiency and reliability in difficult ground condition.

Minemill MC2004 has two independent engines for securing of optimal ground penetration. the costs of operating and maintaining the machine are low. Machine is operated from cabin, remote control with video control system is optional possibility. Cabin is air conditioned. and equipped with rear and front view cameras. Non contact flail-to-ground distance control enables permanent ground penetration without mechanical distance control.

Minemill MC2004 has been field proven and accredited for technical survey

Introduction and technical description

Minemill MC2004 is a chain flail system based on heavy duty track-driven prime mover chassis. Prime mover 90 HP engine is water-cooled and equipped with special air filtration system for heavy dust conditions. Gearbox with 16+16 gears and additional super reduction gear enables exact maneuver and climbing abilities in all ground conditions. Easy drive hydrostatic steering system enable one-hand steering, precise direction control and simultaneous hydraulic lift control. Flail unit is powered by additional 170 HP Iveco turbo diesel engine with electronic speed control. This feature enable optimal and permanent ground penetration even on the most difficult soil and vegetation independent to speed of prime mover. Flail unit powering engine is also equipped with special air filtration system for heavy dusty environment. Flail unit is equipped with 67 strengthened 13mm chains with swing-weights (hammers). Bell-shaped strengthened replaceable hammers are intended to either detonate or break anti-personnel mines. Ground penetration is defined either with mechanical distance control skis and when skis are dismounted with non-contact hydraulic ground penetration control with digital torque and pressure measuring instruments in operators cabin. Flail is chain-driven and powered by hydraulic motor. Chain drive is used to absorb unexpected shocks from flail. Chain drive is powered by hydraulic motor. Hydraulic system is compulsory

cooled with radiator and two ventilating fans. Operator cabin is fully protected with 5+5mm Armox ballistic-steel plates, 52 mm thick safety glass windows, additional 10 mm steel plate over front window, and 12 mm thick steel protection plate mounted on flail unit intended to prevent mine fragments to reach cabin armor. Flail rotation speed is up to 500 r.p.m. Clockwise and counter-clockwise rotation are enabled. Operators cabin is equipped with air conditioning device to secure optimal working conditions for operators even at high outside temperatures. Both engine compartments are protected with Pyrogen® Fire suppression systems which can be activated from operators cabin. Additional fire extinguisher is mounted in operators cabin. Two rear view mirrors are mounted on side windows. Rear and front video cameras with in-cabin mounted monitor allow operator to observe surroundings and operate the machine also when frontal steel protection plate is lowered over the



²⁰ Trademill Mejač & Co. d.o.o., Slovenia,
E-mail: info@trademill-mejac.si, www.demining.si

window. Self-recovery winch is mounted under the rear engine and is controlled from operators cabin. Minemill MC machines mechanically prepares terrain for demining and are also accredited for technical survey. They can be widely used in a multitude of different terrains and are very reliable also on very soft because of its low weight. Minemill's dimensions and drive make it very maneuverable. It can perform in populated areas and on difficult terrains like hillsides, railway embankments, riverbanks, pipelines, powerlines, telephone lines, and more. Machine can also be used on terrains with bunkers and trench systems. The steering system design with hydrostatic clutches and a super-reducing gears make Minemill MC2004 extremely agile enabling the operator to position the machine on prepared ground and to maintain the correct alignment and overlap during ground preparation or technical survey.

Previous model Minemill MC2002 was the first machine accredited for technical survey in Bosnia by BHMACH. Further models MC2003 and MC2004 was improved and modified machines based on MC2002 basic machine. During development of Minemill machines all deficiencies of previous MC2002 machines was eliminated and newest MC2004 models have excellent ground penetration (up to 25cm depth) and more than 100% better productivity as previous models (1400 m²-2000 m² per hour in mechanical ground preparation, from 1000 m² up to 1500 m² per hour in technical survey). Special hydraulic cooling system enable use of Minemill machines also at high outer temperatures up to 45°C, proven in heavy Middle-East conditions.

Minemill MC2004 machine is due its dimensions easy to transport with ordinary truck trailer.

Technical characteristics:

- Heavy-duty tracked vehicle chassis propelled by an 90 HP water-cooled diesel engine
- Track width 360 mm;
- Easy-drive hydrostatic steering
- Diesel engine 170 HP for hydraulic drive system, with electronic speed control
- A fully protective 5 + 5 mm ballistic steel armour with a separately protected operator cabin with 52 mm thick safety glass windows, accredited by Ministry of internal affairs R. Slovenia, additional 10mm steel window protection;
- Hydraulic system with 400 l oil capacity with additional cooling system;
- Flail (effective width 2000 mm) with a capacity of 67 chains with swing-weights;
- Frontal protection of the vehicle, 12 mm thick, immediately behind the flail and in front of the vehicle with additional metal 10 mm thick plates;
- Mechanical ground penetration control and non-contact hydraulic ground penetration control with torque and pressure meters;
- An additional emergency exit from the cabin;
- Rear view mirrors;
- Rear view camera;
- Additional front view camera;
- Air conditioner;
- Double »sahara« engine air filtration (prime mover and flail powering unit)
- Self-recovery winch;
- Fire extinguisher;
- Fire suppression system Pyrogen (2 pcs) – engine compartments
- Wiring and power supply for optional communications equipment;
- Wiring and power supply for optional GPS receiver
- Basic maintenance tool set
- Dimensions: l x w x h: 6,700 mm x 2,700 mm x 2,400 mm;
- Weight: 9.600 kg;

Options:

- Video control system;
- Video control system with transmitter and recorder;
- Remote operation with video control system with transmitter and recorder.



Handheld GPR and MD Sensor (ALIS) for Landmine Detection

Motoyuki Sato²¹, Xuan Feng, and Jun Fujiwara²²

Abstract

ALIS (Advanced Landmine Imaging System), which is a novel landmine detection sensor system combined with a metal detector and GPR, was developed. This is a hand-held equipment, which has a sensor position tracking system, and can visualize the sensor output in real time on a head-mounted PC display. Field evaluation test of ALIS was conducted in Afghanistan, and we demonstrated that it can detect buried antipersonnel landmines, and can also discriminate metal fragments from landmines.

Introduction

Humanitarian Demining is gathering interest all over the world. Detection of antipersonnel (AP) landmines, whose casing are made of plastic, is the principle task of humanitarian demining. Even in a plastic AP-landmine, normally very small metallic part is included, and it can be detected by a metal detector (MD). Therefore, MD is widely used for humanitarian demining operation. However, the problem of MD is its very high false alarm rate. Ground Penetrating Radar (GPR) is a useful sensor for detection of buried antipersonnel landmines, and we think it can be used for identification of AP-landmines, if it is used together with MD



Fig.1 ALIS system under test at the CDS site in Afghanistan

The combination of GPR and MD has been employed in some landmine detection systems. However, the method of combining two sensors must still be developed. We have introduced a novel technique of tracking the sensor position into a combined MD and GPR sensors, in order to use it as a hand-held system. In this paper,

we introduce the Advanced Landmine Imaging System (ALIS), which we have developed, and show the evaluation test results, which we have carried out in December 2004, in landmine fields in Afghanistan.

ALIS system

A conventional MD sensor outputs audio signal, and an operator has to estimate the position of the buried objects only from the sound. If the sensor signal can be visualized, detection of objects can be much easier. Visualization of the sensor is possible, if we can obtain the sensor position together with the sensor signal. However, most of the conventional hand-held sensor could not provide the sensor position. In order to obtain the sensor position, we can use a stereo-vision system, which needs at least two camera set around the sensing position. Sensors mounted on a robotic arm can track the sensor position, but the size of the sensor becomes larger and is not suitable for a hand-held sensor.

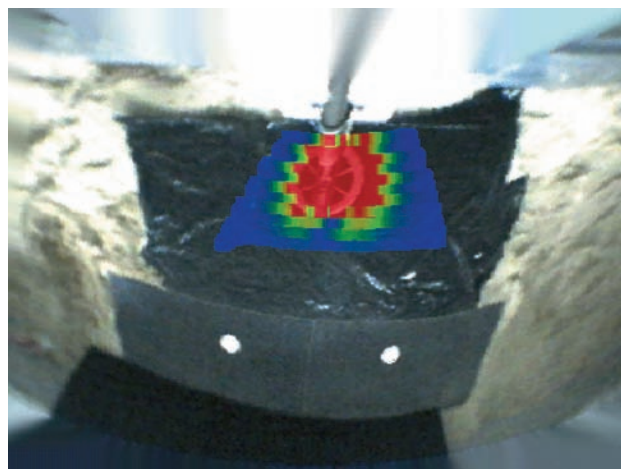
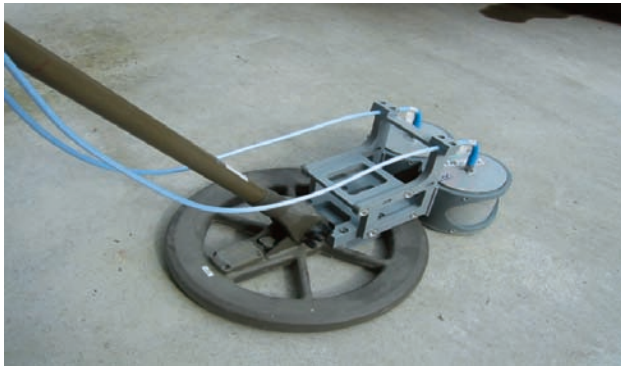


Fig.2 Visualized metal detector data.

In order to solve these problems, we developed a sensor tracking system by using a CCD camera mounted on the sensor itself and attached it to the MD and GPR sensors. Fig.1 shows the ALIS sys-

²¹ Tohoku University, Japan, E-mail: sato@cneas.tohoku.ac.jp

²² Tokyo Gas, Co. Ltd., Japan,



(a) Cavity back spiral antenna



(b) Vivaldi antenna

Fig.3 GPR antennas and metal detector sensor

tem which we have developed. ALIS is equipped with a metal detector (CEIA MIL-D1) and an impulse GPR system. GPR antennas are mounted in front of the MD sensor coil. A CCD camera is mounted on the handle of the metal detector and the image around the MD sensor coil and GPR antennas is captured. Two white disks are placed near the scanning area and its position is traced in the CCD captured image. Compared to the location of the plastic discs, the sensor position can be tracked in real time. The output signals of MD and GPR are stored in a PC together with the sensor position information. The operator scans the ALIS in the same manner as he scans a conventional MD sensor. The MD signal is visualized on the CCD captured image and they are projected on a head-mounted PC display of the operator. Fig.2 shows the visualized MD signal superimposed on the CCD image.

ALIS uses an impulse GPR system which operates at the frequency range of 1GHz-3GHz. Two orthogonal polarization cavity back spiral antennas are used, and they are mounted in front of the MD coil as shown in Fig.3(a). We are also

developing a stepped frequency GPR system, which uses a Vivaldi-type antenna as shown in Fig.3(b)[1]. Interferences between MD and GPR can be minimized by sensor calibration.

The GPR data acquired with the sensor position information is processed after the scanning the ALIS sensor over the area of about 1m by 1m. 3-D GPR image is reconstructed by diffraction stacking[2]. In this signal processing, the vertical inhomogeneity of the soil is considered. Data acquisition takes about several minutes, which is almost equivalent to the time required for normal scanning operation of a conventional MD, and the signal processing needs about two minutes after the data acquisition. Wireless LAN sends sensor data to a handheld PC display for judging the image by multiple operators.

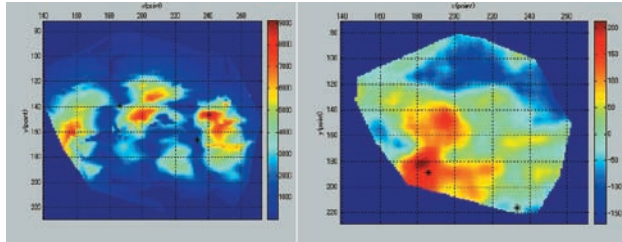
Evaluation test in Afghanistan

After laboratory tests, we have conducted field evaluation test of ALIS in Kabul city, Afghanistan in December 2004. Field test was conducted at two locations. The first site (CDS site) was a controlled flat test site, prepared for the evaluation of landmine sensors. The second site (Bibi Mahro Hill) is a small hill inside Kabul city, which is a real landmine field, where demining operation was being carried out.

At the CDS site, we could validate the operation of the ALIS for known targets in various conditions. The climate when we conducted the field tests was partly rainy, and water content of the soil at CDS site was about 10% , correspond to the dielectric constant of 5.3. Real PMN-2 and Type 72 landmines without booster were buried at the CDS site at different depths between 0 and 20cm, and we could find that the metal detector can detect landmines buried shallower than 15cm, and GPR can show clear images of landmines, which are buried up to 20cm in depth. We also found that the metal fragments, which are included in the soil does not show clear GPR image, therefore we could discriminate metal fragments from landmines by ALIS.

Bibi Mahro Hill is a real landmine field, and we buried a PMN-2 plastic shell model filled with TNT explosive and put a small metal pin in it imitating the metallic part of a booster of the real landmine. In addition, we buried a small metal fragment about 15cm apart from the landmine model. Fig.4 shows the ALIS visualization output at Bibi Mahro Hill. Fig.4(a) is the MD image, and we can find two separated metal objects in

the figure. CEIA MIL-D1 has a differential signal output, and a single metal object shows symmetric response, having a null point at the center. Fig.4(b) shows the GPR image, and we can find only one clear image, which correspond to the landmine model. Note that the center of the two sensors differs by 20cm, then the images in Fig4 has 20cm offset.



(a) Metal detector image

(b) GPR image

Fig.4 ALIS visualization output at Bibi Mahro Hill, Kabul city, Afghanistan.

Conclusion

We developed ALIS, which has high efficiency with better reliability for landmine detection by MD-GPR sensor fusion. The developed ALIS can visualize the signal, although it is a hand-held sensor. ALIS was evaluated in real mine field in Afghanistan and we could demonstrate its high

ability. We are planning to replace the GPR by stepped frequency system, and it will increase the flexibility of the system, because we can select operation frequency range on site.

Acknowledgements

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Sampling for Daily/Weekly Control of Soil Treating Depth at Mechanically Searched Mine Suspected Areas

Nikola Gambiroža²³

Summary

The procedures and methods of sampling and monitoring whole-day effect of demining machines used during technical survey works by applying the procedure of mine suspected area (MSA) search as an independent machine method are presented in this paper.

Required quality levels of machine MSA treatment are set regarding the soil type, present vegetation, soil treating depth, in accordance with the project, i.e. contractual responsibilities.

The term "acceptable quality level – AQL" used in ISO 2859, CRS ISO 2859-1 and IMAS 09.20 refers to the objective mathematical possibility of achieving required level of soil treating depth during technical survey by applying mine search procedure using demining machine as an independent method.

Subjective confidence that includes human factors such as perception, evaluation and opinion is not specially elaborated in this paper.

Non-conformity-deviation from quality characteristics (soil treating depth) is classified into three groups: A, B and C.

Efficiency and validity of expert monitoring by sampling for the purpose of checking the soil treating depth requires the mine search to be "complete and controlled". "Complete" process implies that each entity to be surveyed includes land area searched by demining machine under the same conditions (daily treated surface area), in the same way using the same tools.

In order to avoid excessive rejection of daily searched area it is expected that the average of soil treating depth (meeting the average of search depth) should be less than AQL or equal to that value.

Acceptable quality level (AQL) which should be used is defined by the contract or mine search pilot project.

Key words: *The quality of mechanical mine search and demining, procedures of inspection by attributes, ISO 2859, IMAS 09.20, sampling plan, acceptance criteria, size of entity, sample size*

Introduction

Final beneficiaries of the humanitarian demining programme have to be sure that searched and demined area is completely safe for usage. It requires high management level and detailed operating procedures providing the highest quality control over searched and demined mine suspected area.

Based on Rules and Regulations on Methods of Demining in the Republic of Croatia, technical survey of bigger mine suspected area entities can be carried out by using tested demining machines as an independent method with quality assurance performed by the company that conducts demining works. Quality assurance covers at least 15% of daily treated MSA using the manual mine detection method. The precondition for demining machines engagement on technical survey projects is to achieve the soil treating depth agreed or defined by the project.

The International Organisation for Standardiza-

tion (ISO) has developed general principles and procedures for survey and sampling and these principles and procedures accepted are published in ISO 2859. ISO procedures applied at quality assurance and sampling (based on statistic analysis) provide the rules by which it is easier to decide on product quality. When humanitarian demining is about, "product" means searched and/or demined area.

The way the soil sample is selected influences a great deal the results of searched and/or demined area sampling. Strict procedures for representative sample selection are also required. If the procedures are not regulated and abided, the Quality control can be influenced by subjective opinion of the QA Monitor and QA Officer.

One of the methods of monitoring the depth of mechanically treated MSA and that is the survey of treated soil by attributes (right-wrong) is presented in this paper. Sampling is performed using the random sampling method based on ISO 2859-1, i.e. HRN ISO 2859-1: «**Sampling procedures for the inspection by attributes**».

Sampling plans are indexed according to acceptable quality level (AQL) for the lot by lot survey.

²³ Croatian Mine Action Centre, Croatia,
E-mail: nikola.gambiroza@hcr.hr

1 General requirements and quality level (AQL)

Monitoring and quality control are an important part of humanitarian demining management process whose aim is to verify the quality of mine search on mine search projects and establish required AQL according to the Rules and Regulations on Methods of Demining and contractual obligations.

Non-conformity on mine search projects is presented as the number of non-conformed soil treating depths at mechanical treatment of the MSA as an independent method regarding the soil type and vegetation. In the table (see Supplement D, Table 3-A, 3-B and 3-C) that will be applied for one-time sampling, it is assumed that non-conformities appear accidentally and statistically independently.

The term "acceptable quality level – AQL" that is used in ISO 2859-1, HRN ISO 2859-1 and in this paper refers to the objective mathematical possibility of achieving required level of medium soil treating depth during the mine search activities. Subjective confidence that includes human factors such as perception, evaluation and opinion is not specially elaborated in this paper.

Acceptable quality level (AQL) is used for indexing sampling plans and schemes stated in ISO 2859 and HRN ISO 2859-1 together with the code letter (see Supplement B, Table 1) taking also into consideration the data from the Table 2 (see Supplement C).

AQL is the code representing the percentage value of non-conformed units (or the number of nonconformities on 100 units – it could be 50, 100 or 200 m² of searched MSA, see Supplement B, Table 1) that will, using the sampling scheme required to be used, be accepted the largest number of times. At mine search projects, AQL term represents achieving required level of soil treating depth – the depth defined by the project that makes the border value of mine search acceptable average. Sampling plans given are prepared in a way that the acceptance probability for marked AQL value for AQL given depends on the sample size.

AQL value for non-conformity of the class A will in most cases be 0.1, for non-conformity of the class B from 1.0 to 6.5 and for the non-conformity of the class C from 4.0 to 15 (see Supplement A, Point A-3).

Efficiency and value of expert monitoring by sampling for the purpose of checking the soil treating depth requires mine search to be "complete and controlled". "Complete" process im-

plies that every entity to be surveyed includes the land treated/searched using demining machine under the same conditions (daily treated area), in the same way, using the same tools. In order to avoid excessive rejection of daily searched area it is expected that the average of soil treating depth will be less than AQL or equal to that value.

That means, for applying the sampling procedures for surveying previously searched MSA by attributes (ISO 2859-1) it is required to fulfil the following requirements:

- integrality
- the fact of control
- forming the MSA lots (lot size)
- sampling system – sampling scheme linked to the AQL value
- inspection by attributes
- treated MSA unit is m²
- setting the quality level acceptance criteria

Acceptable quality level to be used is defined by the contract or area reduction project.

2 General terms and definitions

General terms and definitions used in this paper are in accordance with the standard ISO 3534, IMAS 09.20, ISO 28-59-1 (HRN ISO 2859-1) and are given in the Supplement A.

3 Sampling plan

There is a number of sampling methodologies possible to be applied. For the needs of monitoring over technical survey executed using demining machines, statistically valid sampling system is described in this paper.

Minimal overall area to be surveyed upon MSA treatment will be calculated using the numbers arising from ISO 2859-1, that is, HRN ISO 2859-1 (see Supplement B: Table 1). Certain parts of treated soil to be surveyed will be selected by QC Monitor using the random selection method.

The positions of measuring soil treating depth in the sample are selected in a way to cover the entire sample surface.

3.1 Lot formation mode

Daily or weekly MSA treatment (search) using demining machine as an independent method is formed into recognizable lot, sub-lot or in some other adequate form. Every lot should be treated approximately under the same conditions as much as possible (similar soil and climate conditions, the same machine type and working tools).

3.2 Lot acceptance

Lot acceptance is determined by using sampling plan or sampling plans joined to the marked AQL or marked AQLs (see Supplement D, Table 3-A).

The term "non – acceptance" is used instead of "rejection" when it relates to the result that ensues from the procedure.

QC Monitor decides how to treat non-accepted lots. Such lots can be searched once again using demining machines by treating the soil up to the depth determined by the project or by manual mine detection as a second method or perform the evaluation according to specific usability criteria once again.

3.3 Non-conformed units – entities

QC Monitor has the right to reject every daily entity for which it is determined to be non-conformed during the survey, no matter whether the entity is a part of weekly sample or not, even when the lot as an entity is accepted (totally weekly mechanically searched area has the average soil treating depth equal or bigger than the one determined by the project.) Rejected entities can be remedied and surveyed all over again with the approval and in a way specified by QC Monitor.

3.4 Sampling

When it is appropriate, the number of entities in a sample is selected in proportion to the size of daily or weekly treated MSA established according to the Table 1.

Samples can be determined upon weekly or daily work (treating/searching) or during daily/weekly search when the works interruption is in progress for whatever reasons. In any case, the samples are selected in a random way.

3.4.1 Types of inspection

At the beginning of inspection, if not decided differently, the QC Monitor conducts the usual inspection (see Supplement D). The usual stricter or more benign inspection is executed on the following lots without any change except in cases where transfer procedures require change of survey type.

3.5 Methods of monitoring and quality control

Authorized national body approves the procedures and the equipment used by the QC Monitor for checking the samples of searched soil and they will be coordinated with authorized demining companies. Any bigger change in the process of sampling, monitoring or quality control should be verified by authorized national body and authorized demining companies should be informed on these changes in time, prior to the commencement of monitoring and quality control.

3.5.1 Quality level acceptance criteria

"The entity" will be considered as "quality-treated/searched" only if the average value of measured sample is equal or bigger than soil treating depth determined by the project. If any sample of the entity comprises one or more average measured depths smaller than the one determined by the project, that will make the "critical non-conformity" (non-acceptance/unallowed defect), the entity that comprises this sample will not pass the final inspection/quality control.

Searched soil can comprise single (soil treating depths) non-conformities classified into three groups: A, B and C. Such cases would indicate the possible defect and create the critical defect once again. Terms for acceptance or non-acceptance of all non-conformity categories are given in Supplement D.

At defining non-conformities, especially critical defects (malfunctions) it should take into consideration the machine type in relation to the machine mass (light, medium, heavy), machine working tool and soil conditions.

3.5.2 Inspection level

QC Monitor defines required quality level for each special application regarding the usability assessment and efficiency evaluation according to SOP CROMAC 03.06-1 (Efficiency evaluation of technical survey and demining). That provides the QC Monitor the possibility to demand bigger differentiation for some purposes and smaller for the other.

For the selection of sample size code letters (Supplement B: Table 1) the Table 2 (Level of confidence regarding the machine type and soil conditions on the project) should also be used (Supplement C).

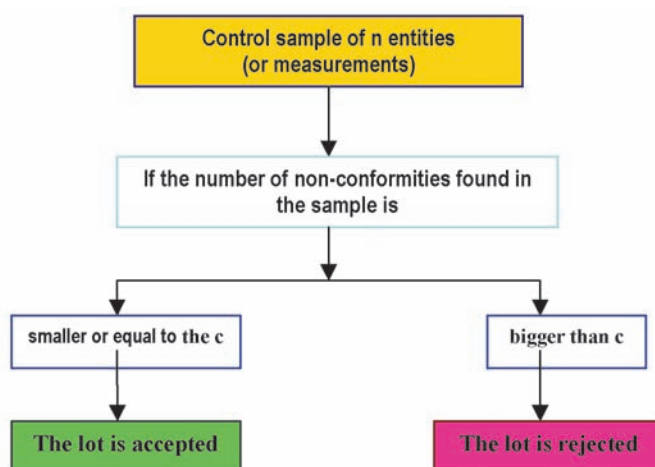


Figure 1. One-time sampling scheme

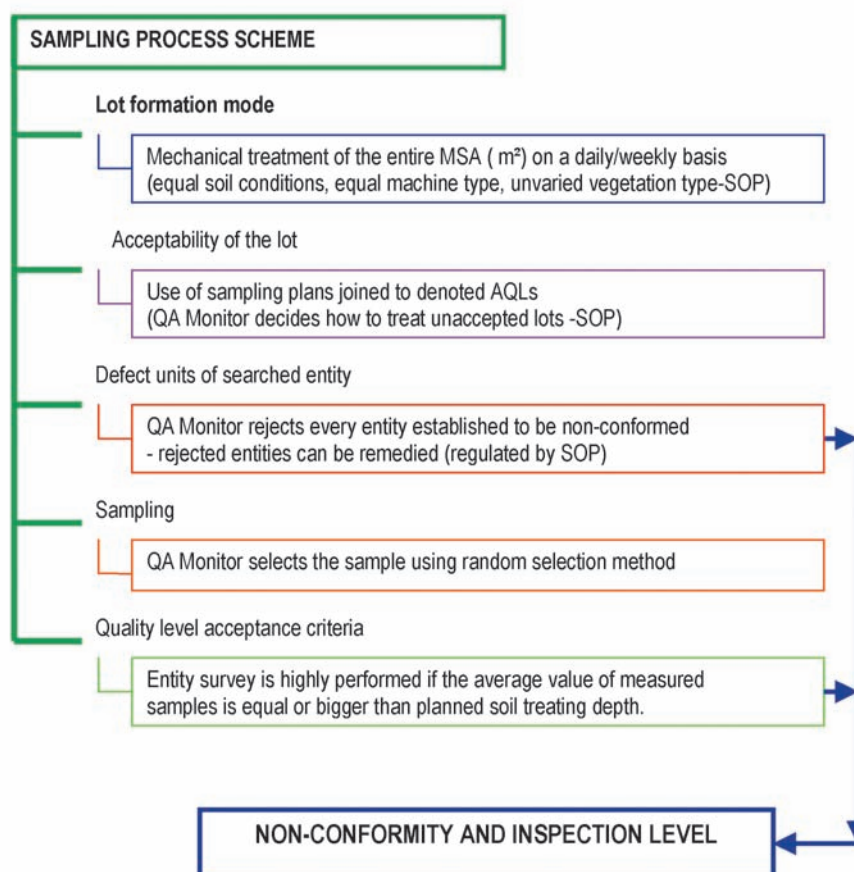
3.5.3 Defining the acceptance of treated entity

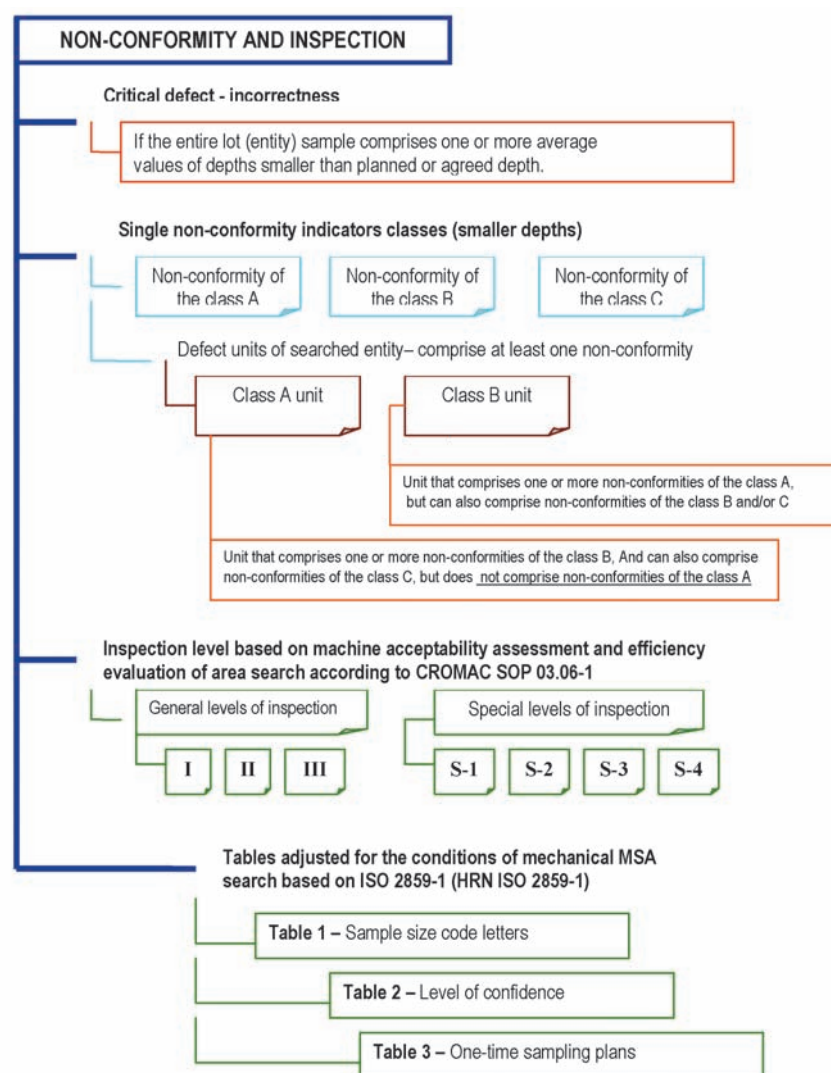
In order to determine the lot (entity) acceptance according to the number of non-conformed units, the plan of one-time sampling is used (see Supplement D: The scheme of one-time sampling and the Table 3-A). At single sampling plan the number of units inspected is equal to the sample size defined by plan. If the number of non-conformed units found in the sample is equal or smaller than the number of acceptances, entity (lot) is considered to be acceptable. If

the number of non-conformed units is equal or bigger than the number of rejections, the entity (lot) is considered to be unacceptable.

4 The scheme of proposed sampling procedure

The special sampling plan that defines the number of treated MSA entities to be surveyed (sample size) is prepared with joined criteria for acceptance definition of daily/weekly treated (searched) area.





5 The example of sampling during technical survey using demining machine as an independent method

Planned average depth of treating the soil in MSA using demining machine as an independent method is 20 cm minimum in the I category (a) and 10 cm

minimum in II and III soil category (b) (see The categorization of soil, Point 4.1.1 and 4.1.2, SOP CROMAC 04.09).

Selected MSA lot size is daily processed-treated area from 1 201 to 3 200 m² (see Supplement B). Sample size is 50 m² and number of measurements of depths in the sample is 10. The general level of second degree inspection (code letter «D» in the table 1) is selected.

For the code letter «D» from the table 3-A for the usual inspection (see Supplement D) the sample size is 5. The QA Monitor selects 5 samples of 50 m² in the lot using the random selection method. **If the average depth in the sample is smaller**

than the one determined by the project, the lot is incorrect and it is rejected. Also, non-conformities of the class A represent the incorrectness and are defined in the following way:

- If the single depth in the sample is smaller than 12 cm in the I soil category, the AQL value is 0.1. From the table 3-A the lot acceptance number is $A_c=0$ and the rejection number is $Re=1$.
- If the single depth in the sample is smaller than 6 cm in the II and III soil category, AQL value is 0.1. From the Table 3-A the lot acceptance number is $A_c=0$ and the rejection number is $Re=1$.

Non-conformity class B is:

- If the single depth in the sample is smaller than 17 cm and bigger than 12 cm in the I soil category, AQL value is 2.5. From the table 3-A the lot acceptance number is $A_c=2$ and lot rejection number is $Re=3$.

- b) If the single depth in the sample is smaller than 20 cm and bigger than 6 cm in the II and III soil category, AQL value is 2.5. From the table 3-A the lot acceptance number is $Ac=2$ and lot rejection number is $Re=3$.

Non-conformity class C is:

- a) If the single depth in the sample is smaller than 20 cm and bigger than 17 cm in the I soil category, AQL value is 4.5. From the table 3-A the lot acceptance number is $Ac=3$ and lot rejection number is $Re=4$.
- b) If the single depth in the sample is smaller than 10 cm and bigger than 8 cm in the II and III soil category, AQL value is 4.5. From the table 3-A the lot acceptance number is $Ac=3$ and lot rejection number is $Re=4$.

CONCLUSION

1. The lot is rejected if measured average depth in the sample is smaller than the one determined by the project.
2. Singly measured depths classified in the class A, AQL very small, are not allowed in the samples.
3. Depending on the machine type, its quality of soil treatment, single non-conformities are allowed by defining the classes B and C using the general different levels of inspection (I, II, III) and special levels of inspection (S-1, S-2, S-3, S-4). Their number is defined by the selection of AQL values for acceptable average of planned depth.

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- (3) ISO 2859
- (4) ISO 2859-1 (HRN ISO 2859-1)

SUPPLEMENT A

Basic terms and definitions

Basic terms and definitions used in this paper are in accordance with ISO 3534, IMAS 09.20, ISO 2859-1 (HRN ISO 2859-1) and are given in Supplement A.

A-1 INCORRECTNESS: Deviation from the quality characteristics (soil treating depth determined by the project). The consequence of such deviation is that searched mine suspected areas do not meet the requirements defined by the pilot project or the contract.

A-2 NON-CONFORMITY: Deviation from the quality characteristic when mechanically treated mine suspected areas do not meet the requirements set. Example: If the required soil treating depth is 20 cm in the first soil category, that is 10 cm in the second and third soil category (see SOP CROMAC 04.09 and SOP CROMAC 03.06-1) non-conformities are classified into three classes:

Non-conformity of the class A - single measured soil treating depth is smaller than 12 cm in the first soil category and in the second and third category it is smaller than 6 cm. AQL value is very small, mostly 0.1. The measurement with the value smaller than the stated ones is not allowed in selected sample. Critical defect – the sample is not accepted.

Non-conformity of the class B – single measured soil treating depth is smaller than 17 cm and bigger than 12 cm in the first soil category. In the second and third soil category it is smaller than 8 cm and bigger than 6 cm. AQL value is bigger than in the class A and smaller than in the class C (mostly from 1.0 to 6.5).

Non-conformity of the class C – single measured soil treating depth is smaller than 20 cm and bigger than 17 cm in the first soil category. In the second and third soil category it is smaller than 10 cm and bigger than 8 cm. AQL value is bigger than in the class B (from 4.0 to 15).

A-3 NON-CONFORMED UNIT: The unit of searched area with one non-conformity at least. Non-conformed units are classified into two classes:

Class A unit – unit with one or more non-conformities of the class A, but it can comprise the non-conformity of the class B and/or class C.

Class B unit – unit with one or more non-conformities of the class B, it can also comprise the non-conformities of the class C but it can not comprise the non-conformity of the class A.

A-4 Acceptable Quality Level (AQL): when continuously daily or weekly treated area is concerned, the quality level (the average soil treating depth) that, in terms of daily or weekly quality inspection by sampling, makes the border value of acceptable process average.

A-5 The percentage of non-conformed units: the percentage of non-conformed units (soil treating depth smaller than required) in any given quantity of product units (for example, 15 measurements in searched surface area of the size 5 m × 10 m) is equal to the ratio of the number of non-conformed units and total number of product units (measurement of the depth) multiplied by 100.

A-6 Sampling plan: special plan that demonstrates the number of units (selected entities) from every daily or weekly treated area should be checked (sample size or a number of sample sizes) and joined criteria for defining acceptance of daily or weekly treated (searched) area (numbers of acceptances and rejections).

A-7 Sampling scheme: the combination of plans and transfer procedures.

A-8 Sampling system: A collection of sampling plans or schemes. This is a part of ISO 2859 sampling system, indexed by ranges of the lot size (daily or weekly treated area), inspection levels and AQL values. Sampling system for LQ plans is given in ISO 2859-2 standard.

A-9 Inspection: The process of soil treating depth measurement, verification, inspection, or different comparison of product units (searched area) with applicable requirements.

A-10 Original inspection: the first inspection of treated area of special quality unlike the inspection of treated area that is being surveyed again upon the original non-acceptance.

A-11 Inspection by attributes: inspection during which the product unit (treated entity) is evaluated simply as conformed or non-conformed or the non-conformities are counted per product unit regarding the requirement or group of requirements given.

A-12 The unit of treated MSA (product): The unit (the depth of mechanically treated weekly or daily area) that is being surveyed in order to be classified in class of conformed or non-conformed units or in order to count the number of non-conformities on the selected area.

A-13 The lot of treated MSA: The collection of treated MSA units (m²) – daily or weekly mechanically treated surface area from which the sample should be taken and surveyed in order to determine the conformity with acceptance criteria.

A-14 Lot size: The number of product units in the lot (the number of selected treated-searched entities in weekly or daily treated area using a demining machine).

A-15 The sample: The sample consists of one or more units of treated MSA taken from daily or weekly treated area (lot); sample units are chosen at random no matter what their quality is like. The sample size is equal to the number of product units in the sample.

A-16 Critical incorrectness: The average value of the soil treating depth in selected sample is smaller than the one required in the project.

SUPPLEMENT B

Table 1- Sample Size Code Letters

No.	Lot size (m ²)	Sample area (m ²)	No. of depth measurements	Special levels of inspection				General levels of inspection		
				S-1	S-2	S-3	S-4	I	II	III
1	200-500	50	10	A	A	A	A	A	B	C
2	501-1-200	50	10	A	A	B	B	B	C	D
3	1-201-3200	50	10	B	B	C	C	C	D	E
4	3 201-5 000	100	15	B	C	C	D	D	D	E
5	5 001-8 000	100	15	C	C	D	D	D	E	F
6	8 001-15 000	100	15	C	D	D	E	E	F	F
7	15 001-35 001	200	20	D	E	E	E	E	F	G
8	35 001-150 000	200	20	D	E	E	F	F	G	H
9	150 001 and over	200	20	E	E	F	F	G	H	J

SUPPLEMENT C

Table 2 – Level of confidence

No.	Soil conditions	Level of confidence/machine type		
		Small degree	Normal degree	Large degree
		Light machine	Medium machine	Heavy machine
1	Favourable soil conditions (SC1)	91%	95%	99%
2	Aggravated soil conditions (SC2)	81%	85%	89%
3	Heavy soil conditions (SC3)	71%	75%	79%

SUPPLEMENT D

Table 3-A - One-time sampling plans for regular inspection

Lot size code letters	Sample size	Acceptable Quality Level, AQL (regular inspection)																											
		0,01	0,015	0,025	0,04	0,065	0,1	0,15	0,25	0,4	0,65	1,0	1,5	2,5	4,0	6,5	10	15	25	40	65	100	150	250	400	650	1000		
		Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re	Ac Re
A	1	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
B	2	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
C	3	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
D	5	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
E	8	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
F	13	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
G	36	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
H	85	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
J	135	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓

↓ = use the first sampling plan below the arrow

↑ = use the first sampling plan above the arrow

Ac = acceptance number

Re = rejection number

Mine Action Information Center - Resource Guide

Timothy White²⁴

Global Mine Action Registry

The Global Mine Action Registry is MAIC's resource database of most recent up-to-date contact information, available online for our website customers 24 hours a day.

The Global Mine Action Registry is a tool for organizations working directly in mine action. We allow customers to go online and search for virtually any type of organization, in any field, and in every country around the world, quickly and with the most up-to-date information available. In addition to having organizations register their contact information, we also encourage them to keep us informed of their current activities and fieldwork. And to be sure that we have the most current information available, we contact all of the organizations several times a year and ask them to review and correct their information and update anything that has changed since the last review. To make searching and browsing the Global Mine Action Registry easy and powerful, we allow customers to browse and search by multiple criteria such as organization type, activity details, country of operation, and even by keywords that may be found in the organizations mission statement. To visit the Global Mine Action Registry, point your web browser to its homepage at <http://maic.jmu.edu/gmar>.



Global Mine Action Registry (Cont')

- **Search Registry:** To search the registry by clicking on "Search Registry" the blue menu bar on the left side of the web page. This will give you a small form to fill out where you can click on the drop-down boxes to select the different organization types, activities, and countries, as well as type in keywords to search by.

- **Browse Registry:** To browse the registry's contacts by their name, click on "Browse Registry" in the blue menu bar on the left.
- **Add Your Organization:** To add your organization or field office of an existing organization, click on "Add Your Organization" in the blue menu bar.

If your field office does not exist in any of the alphabetic sets of registered organizations, you can click **Register Organization** and fill out the form to register a new organization. To register a field office, find your organization in the list and then click on **Register Field Office**.

Journal of Mine Action

The *Journal of Mine Action* is an international publication that has established a clear reputation and acceptance within the global landmine community as a valuable and effective journal for disseminating landmine, mine action and demining information from around the world.

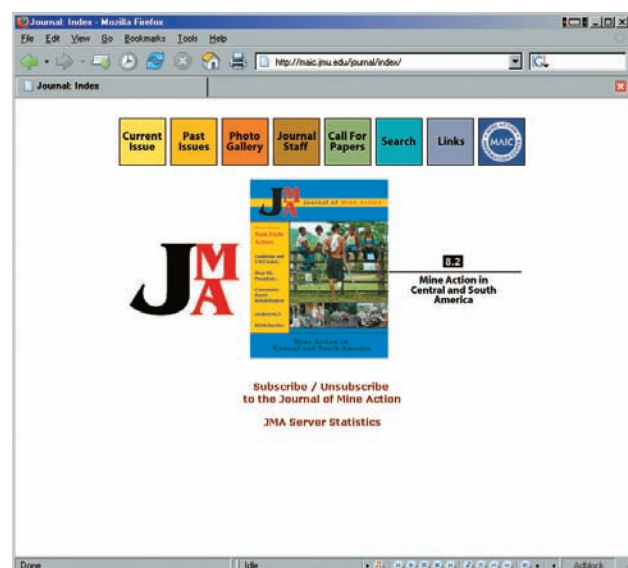
²⁴ MAIC, James Madison University, USA, E-mail: whitetj@jmu.edu

The journal is and will continue to be a forum for the mine action community to explore current practices, procedures, lessons learned and news worthy information that is of importance to the international mine action community. Through editorials, articles, reports, news, and profiles, the *Journal of Mine Action* strives to bring current and valuable information to its readers. The Journal is published twice a year both online and in print and is funded by a contract from the United States Department of State and the Canadian Centre for Mine Action Technologies.

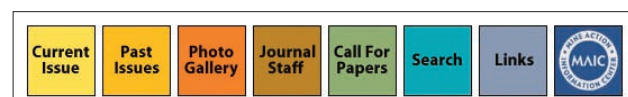
The Journal of Mine Action provides:

- Research on all topics of mine action and humanitarian demining.
- An outlet for highlighting your organization's work.
- Current articles and news pertinent to individuals and organizations involved in mine action.
- Highlights of current research and technology.
- Current news and events effecting mine action and humanitarian demining.

To visit the Journal of Mine Action, point your web browser to its homepage at <http://maic.jmu.edu/journal>



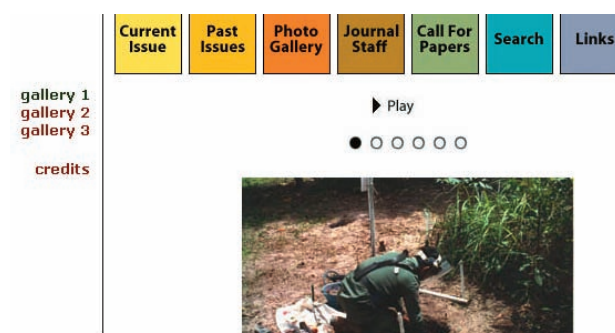
Journal of Mine Action (Cont')



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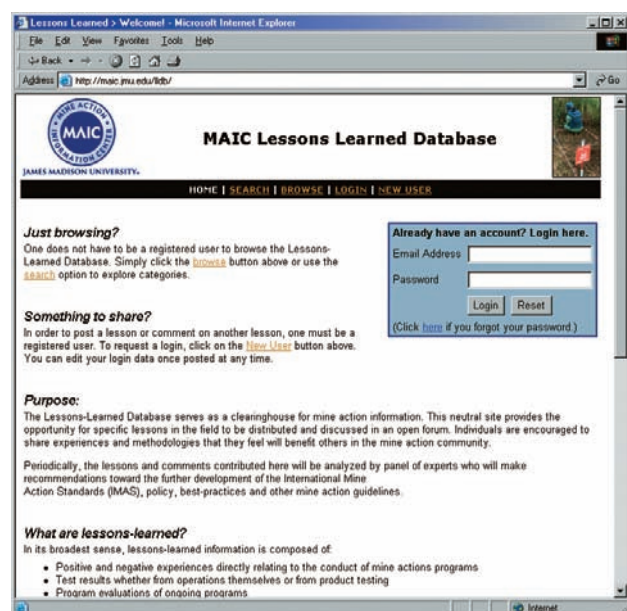
Lessons Learned Database

The Lessons Learned Database is designed to serve the entire mine action community by providing a method and forum for distributing experiences and methodologies that may be of benefit to others.

A completely open forum, The Lessons Learned Database allows anyone to view all the lessons that have been posted for research purposes or just to gain a better understanding of the topic and catch up on new ideas and concepts.

Topics range from 'Medical' to 'Mine Dogs', with the ability for registered users to comment on previously written lessons or create new subject categories to more accurately describe new lessons. Users also represent the wide spectrum of areas mine action and are identified with their posts to enable the most responsible and usable interchange of ideas and to maintain perspective.

To visit the Lessons Learned Registry Database, point your web browser to its homepage at <http://maic.jmu.edu/ldb>



Lessons Learned Database (Cont')

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- **Search Registry:** To search the database by clicking on "Search" the menu bar at the top of the page. Here you will be able to search by available categories, author, keyword, and even comments posted in response to lessons.
- **Browse:** To search the database by clicking on "Browse" the menu bar at the top of the page. The Browse view offers sorting by different criteria such as 'Category', 'Subject', 'Date', and 'Author'.

- **Add Lesson:** Registered users to the Lessons Learned Database website have the added ability to post lessons and comment on previously posted lessons, as well as edit their own lessons or comments after they have been posted.

Next 30 Lessons						
Category [sort]	Subject [sort]	Date added [sort]	Author [sort]	Views	Replies	Last Post [sort]
Victim Assistance	OAS/Rehabilitation program in Nicaragua	7/31/2003	Jaime Perales (Organization of American States)	15	0	
Mine Detecting Dogs	Mine Detection dogs in Central America	7/31/2003	Jaime Perales	19	0	
Inter-Regional Cooperation	Regional Support for Landmine Stockpile Destruction (The OAS Experience in the Americas)	7/22/2003	Jaime Perales (Organization of American States)	24	0	
Equipment	Accidental explosion due to mine activation during a mine sweeping operation	7/21/2003	Abdul Basit (Samad Rubber Works (Pvt) Ltd.)	39	0	
Equipment	Mini-Flail in Afghanistan	7/17/2003	Guy Piskulic	38	0	
Equipment	Mini-Flail	7/17/2003	Guy Piskulic	46	0	
Area Clearance Tracking	Mini-Flail in Afghanistan	7/17/2003	Guy Piskulic	35	0	
Interpreters	Interpreting for Humanitarian and Military Operations in Thailand by Hon. Smith of S-3 Services	7/9/2003	MAIC Administration	70	0	
Establishing demining programs	Start up lessons from Kosovo	7/1/2003	MAIC Administration	71	0	
Equipment	Norwegian M113 Mine Roller in Afghanistan	6/26/2003	MAIC Administration	75	0	
Equipment	US Military comment on weight dispersion boots	6/26/2003	MAIC Administration	69	0	
Equipment	US observance of the Norwegian Flail-Hydra in Afghanistan	6/26/2003	MAIC Administration	71	0	
Area Clearance	US Military mineflayer	6/26/2003	MAIC	67	0	

Add Lesson

Category

< Select a category > or < Suggest a new one below >

Suggested category (only if you don't find a match above)

Subject

Situation

Recommendation/Comment

Reveal identity

Your name will appear with this Lesson

Reveal organization

☐ If checked, your organization's name will appear with this Lesson

Submit Lesson

Reset Form

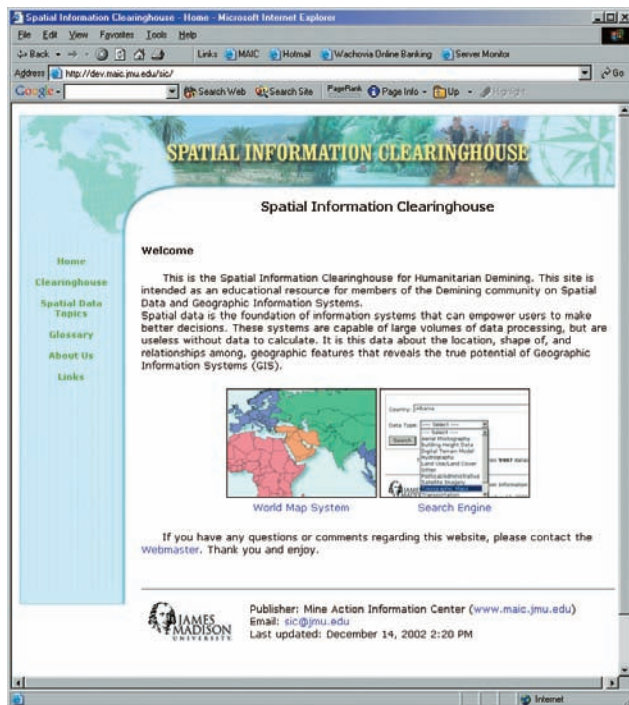
Spatial Information Clearinghouse

This is the Spatial Information Clearinghouse for Humanitarian Demining. This site is intended as an educational resource for members of the Demining community on Spatial Data and Geographic Information Systems.

The website is devoted to the understanding and obtaining of spatial data. Spatial data is the foundation of information systems that can empower users to make better decisions based on location, shape, and relationships among geographic features.

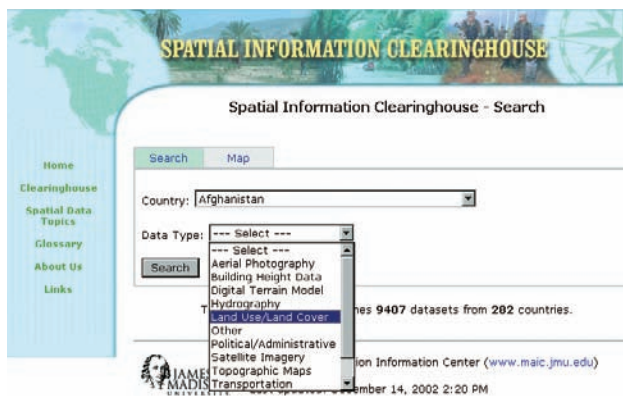
The purpose of such a clearinghouse is to aid demining organizations in understanding, acquiring,

ing and using geo-spatial data to streamline their respective operations. This site is the current evolution of that project. It focuses on the practical and theoretical aspects of geospatial data. To visit the Spatial Information Clearinghouse, point your web browser to its homepage at <http://maic.jmu.edu/sic>



Spatial Information Clearinghouse (Cont')

- **Clearinghouse:** The Clearinghouse portion of the website is divided up into countries and geospatial data types (Aerial Photography, Hydration, Political/Administrative, etc). The information can be accessed by searching for a specific data type in a country, or by a graphic map where users can view all the available information on a specific country.



Viewing Clearinghouse information by using the "Search"

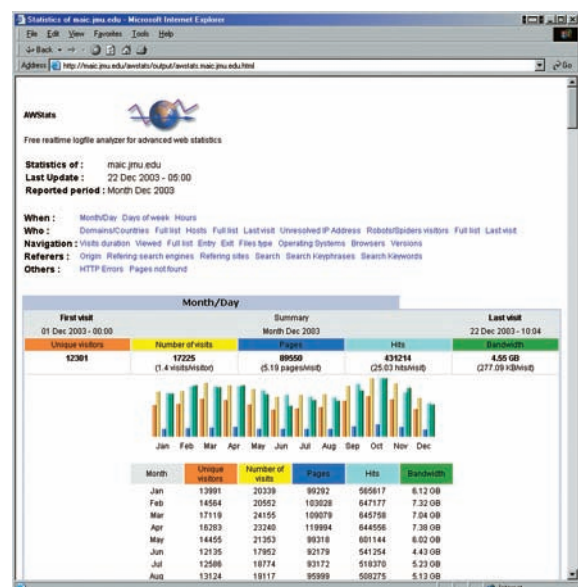


Viewing Clearinghouse information by the "Map" view

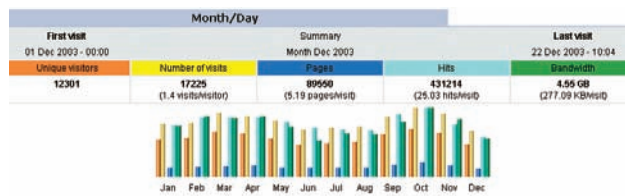
- **Spatial Data Topics:** To learn more about the many facets of spatial data, the Spatial Data Topics section is available with very descriptive and informing topic definitions using pictures and graphics, as well as pointing to other sources of information including standards and links to websites. There is also a section on spatial data standards, Global Positioning Systems (GPS) and copyright information.
- **Links:** This section includes links to information about GIS, spatial databases, metadata, spatial database clearinghouses, and demining organizations.

MAIC Website Statistics

The MAIC website is supported by number of various tools and programs, one being the statistics tracking software. This allows us to monitor the websites traffic month to month, recording such things as the number of "hits" or visits, the country from which the viewer is from, as well as the most popular sections of the website. To visit the Spatial Information Clearinghouse, point your web browser to its homepage at <http://maic.jmu.edu/sic>

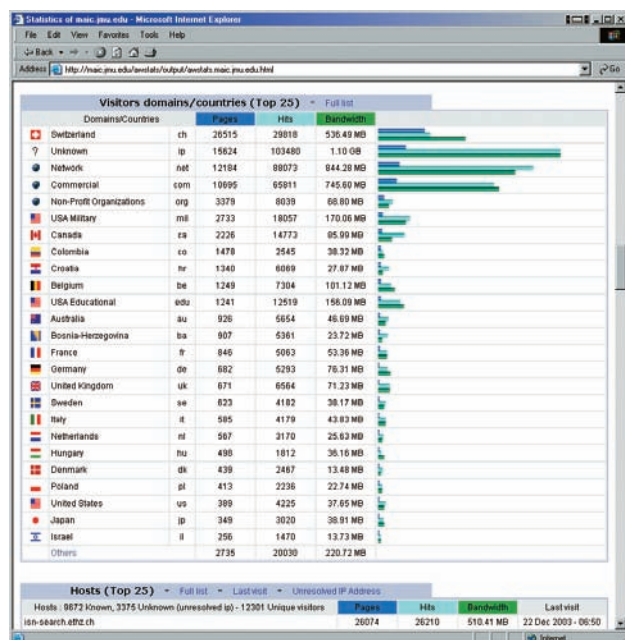


MAIC Website Statistics (Cont')



- Unique Visitors – This is the number of individual visitors to the website that have never been to the site before.
- Number of Visits – This is the number of visitors for that particular month.
- Pages – Number of pages viewed in total
- Hits – How many elements a viewer viewed on every web page (pages, images, applications)
- Bandwidth – The amount of data that all viewers have seen

Visitors Domains / Countries



This section tells us where our site is being viewed from by looking at their computers location and if they are at a company, government office or school or university. It tells us how many pages they've viewed (pages) and how busy they keep the server (hits).

Efficiency Analysis of Demining Machines Executing Humanitarian Demining Works"

Tomislav Ban²⁵

INTRODUCTION

In order to make the complete efficiency analysis of demining machines executing humanitarian demining works in the Republic of Croatia, prior to all, it is required to define the basic terms; what demining machines are, their classification, usage terms and mode, capacities and efficiency in different soil conditions as well as the influence of demining machines on safety and humanitarian demining price decrease.

Humanitarian demining works are defined by the Law on Demining and Rules and Regulations of Methods of Demining. The Enclosure 2 is an integral part of Rules and Regulations. The program of demining machines testing regulates, among other, the conditions demining machines should meet, testing methodology, usability assessment and finally the annual verification of machine characteristics. In order to be used during humanitarian demining works in the Republic of Croatia the machines have to be tested by the Croatian Mine Action Centre (CROMAC). The operative part of testing is carried out by CROMAC-CTDT (CROMAC-Centre for Testing, Development and Training Ltd.) Based on stated legislation, authorized legal entities prepare the Standard Operating Procedures (SOP) for every machine. SOP describes in details the machine usage mode, safety measures and S&OH.

DEMINING MACHINES

Demining machines are the machines that mechanically treat mined area, remove the vegetation (by cutting and/or grinding) and destroy the mines (by activating and/or smashing) in the depth of soil.

CLASSIFICATION OF DEMINING MACHINES

The machines used during demining works execution are classified into two groups: demining machines and supporting machines. The basic difference is that supporting machines can be used in a way to always move around the previously manually searched area and that area, upon the use of supporting machines, has to be searched using manual mine detection. Demining machines differ according to the soil treating depth in relation to the depth determined by the project. In this way, manual mine detection and mine detection dogs can be used upon the machines that reach the soil treating depth determined by the project. Upon the machines that do not reach the soil treating depth determined by the project only manual mine detection can be used, as with supporting machines.

1. Demining machines

- in relation to the machine mass there are:
 - light machines, mass up to 5 t
 - medium machines, mass from 5 to 20 t
 - heavy machines, over 20 t

- in relation to the working tools:
 - mill;
 - flail;
 - vegetation cutters.

Certain demining machines have two types of easily replaceable tools (MINEWOLF), that is, with double tools of the same type such as double flail (Scanjack 3 500) or double mill (RHINO-02).

- in relation to the operation mode:
 - directly from the cab
 - remotely (video surveillance)

Operation directly from the cab is applicable mostly to heavy demining machines while light and medium demining machines are operated remotely and video surveillance is applied at RHINO-02.

The most frequent problems of operating remotely are the safe distance of the operator in relation to the possibility of machine control and quality soil treatment regarding the visibility and terrain being crisscrossed.

2. Supporting machines

- excavators
- supporting vehicles
- vegetation cutters

SOIL TREATING DEPTH STANDARD:

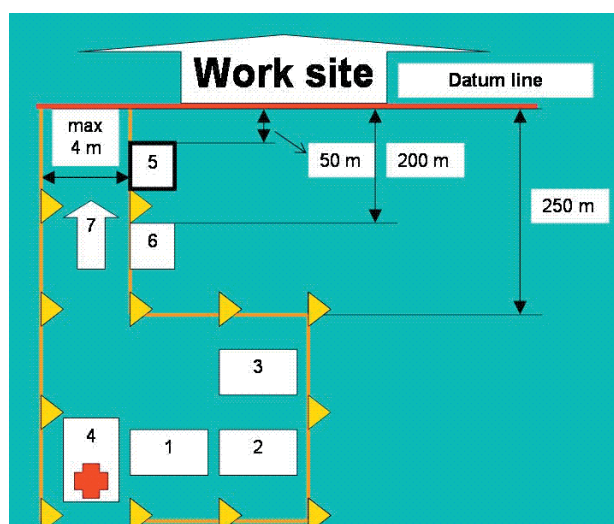
- 20 cm II and III category (favourable and aggravated conditions)

²⁵ CROMAC, Croatia, E-mail: tban@hcr.hr

- 10 cm IV and V category (difficult and specific conditions)
Soil treating depth standard is defined by the project and it depends on the soil conditions stated in the Enclosure 2 of the Rules and Regulations on Methods of Demining.

WORK SITE ORGANIZATION

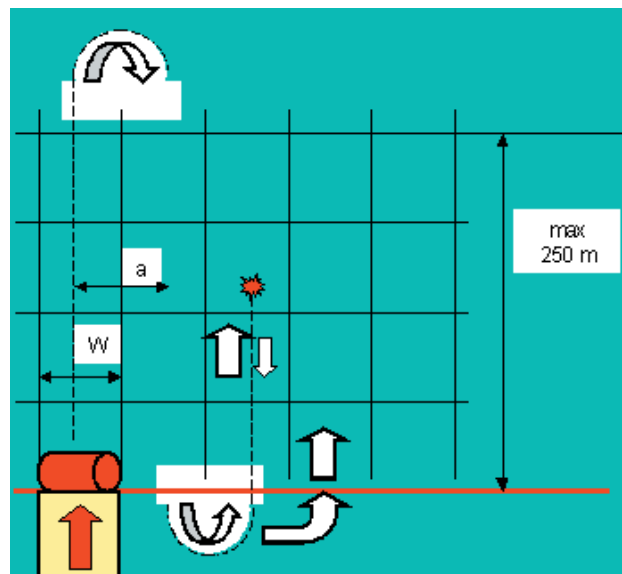
The important factor for safe and high quality execution of demining works is the proper work site organization, meaning, in terms of safety aspect, abiding the safe distances between the positions at the work site considering the possibility of non-controlled explosion during demining machines operation as well as high quality and organized conducting of technical survey and demining works.



1. Control point-command spot
2. Parking area
3. Equipment disposal area
4. Ambulance position
5. Remote control – armoured
6. Remote control – non-armoured
7. Access road

Stated scheme represents the way the work site of the humanitarian demining works execution should look like and the positions that are important during the work site organization with the special reference to the distance during machine operation using the remote control from an armoured vehicle when the distance between the operator and the machine is 50 m and ensures quality machine operating or without armoured vehicle from the distance of 200 m, what is usual-

ly the case, when it is very difficult to follow the machine and reach the required quality of work.



The figure presents one of the demining machine operation methods that reach the work systematism and, at the same time, it is possible to adequately follow the area overlapping. It is recommendable that, considering the work site dimensions, demining machine enters the depth of 200 m and only upon the area treated in this way the datum line is being moved using the second method and the machine continues operating in depth for the following 200 m. In this way, the quality of work is obtained as well as the safety of all participants.

HUMANITARIAN DEMINING WORKS EXECUTION METHOD

Humanitarian demining works execution methods are regulated by the Rules and Regulations on Methods of Demining. When the methods of humanitarian demining works execution are concerned, it is important to point out that they need to ensure the work site clearance from mines, UXO and their parts up to the depth determined by the project. This part of the paper will go into the methods demining machines participate in. It is well-known that humanitarian demining works are classified into the mine search (technical survey) and demining.

Mine search

During the mine search demining machines can be used as a combined method regarding the capacity of soil treating depth. These are:

- The machines that reach the depth determined by the project can be used as an independent method along with mandatory quality assurance using the manual mine detection on a minimum of 15 % of mechanically treated area. By quality assurance, using the manual mine detection, the authorized legal entity is required to establish the existence or non-existence of area contamination with mines and/or UXO or their parts up to the depth determined by the project. It is carried out by preparing the passages – work paths 1 m wide horizontally and vertically crating the so called net, and upon that, the remaining part is being visually observed from the areas previously inspected with the purpose of observing mines and/or UXO ejected to the surface.
- The machines that do not reach the depth determined by the project are used at the work site but upon those machines, the manual mine detection is mandatory on the entire mechanically treated area. When it comes to the supporting machines, it is required to search the area where the machine starts its operation using the manual mine detection.

Demining works

During demining works execution the demining machines can be used as a combined method regarding the soil treating depth. These are:

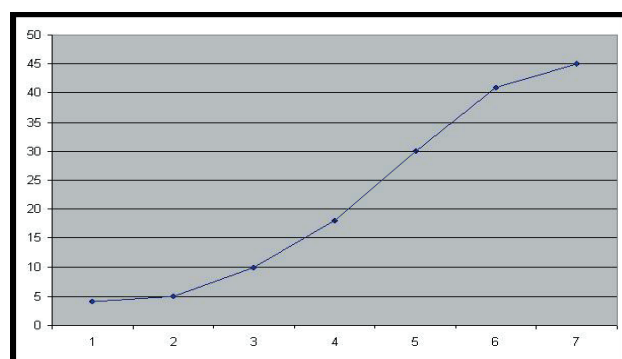
- The machines that reach the depth determined by the project can be used in combination with manual mine detection and in combination with mine detection dogs under the condition of preparing the field using the manual mine detection prior to all that.
- The machines that do not reach the depth determined by the project and the supporting machines are used in the same way as while conducting the mine search.

DEVELOPMENT OF MACHINE CAPACITIES

The beginnings of demining machines usage are in the period of Homeland war when the Croatian army for the needs of military actions used the tanks-mine sweepers with sections for making passages and later on, the removal of mine threat around the military facilities. That way

of using the tanks-mine sweepers was not very reliable and efficient because the disposition of sections provided the possibility of remaining the undamaged small antipersonnel mines (AP mines). With the first Law on Demining in 1996 and the commencement of the humanitarian demining the entrepreneurial spirit is being developed and at the end of 1996, the first machine of the MV-1 type appeared. It was the product of DOK-ING Ltd. owned by Vjekoslav Majetić who worked for AKD Mungos – the only company at that time. During operating on the work sites, as all prototypes, the MV-1 showed its advantages and disadvantages and its positive experiences were built into all forthcoming machines. Upon the Law on Demining in 1998 and market development other subjects start producing demining as well as supporting machines such as «Đuro Đaković». Authorized legal entities procure the machines from other manufacturers in the world so at the end of 2004, the total of 45 demining machines had been executing humanitarian demining works.

YEAR	No. OF DEMINING MACHINES
1998	4
1999	5
2000	10
2001	18
2002	30
2003	41
2004	45



The table and the graph present the demining machines capacity increase since 1998, that is, since the market introduction and the opening of new demining companies.

MACHINES USED IN 2004

1 LIGHT MACHINES



MV-4, DOK-ING Ltd.



BOŽENA-1, 2, 3 and 4

All light demining machines are equipped with working tool - flail and are operated remotely. They can be used during technical survey and demining works and they reach the best results in favourable and aggravated soil conditions. They have the capacity of soil treating depth up to the depth over 20 cm and Božena – 1,2 and 3 reach the depth smaller than 20 cm so they can not be used as an independent method in conducting the mine search²

2 MEDIUM MACHINES



RM-KA 02 «Đuro Đaković»



SAMSON 160,300

Medium demining machines are equipped with working tool - flail, are operated by RM-KA and SAMSON remote control, and Hydrema 910 is operated directly from the cab.

They can be used on technical survey and demining works, all reach the soil treating depth of and over 20 cm. They achieve the best results in favourable and aggravated but can also be used in difficult soil conditions.



HYDREMA 910

3 HEAVY MACHINES

Heavy demining machines used during humanitarian demining works are constructed on understructure of the construction machines, forest tractors or they are the product of military industry and equipped with working tools that have the capacity of soil treating depth and destruction of all types of mines.

Heavy demining machines are equipped with the following working tools – double flail Scan-jack 3500, mill Oraclo and Zeus with double flail Rhino-02, are operated by Rhino-02 remote control - video surveillance, and Scan-jack, Zeus and Oraclo are operated directly from the cab.



ORACLE



ZEUS



SCANJACK 3



RHINO 02

They can be used during technical survey and demining works and they all reach the soil treating depth of and over 20 cm. Best results are achieved in favourable, aggravated but can also be used in difficult soil conditions.

SUPPORTING MACHINES

Supporting machines used during humanitarian demining works are the machines constructed by adapting the classical construction machines – excavators – in a way that the impenetrable cab and working tool meant for vegetation cutting were made or various types of flails were adapted.



All supporting machines are operated directly from the cab and during the operation the operator has to wear regulated safety equipment. They can be used during technical survey and demining works under the condition of mandatory terrain search upon mechanical area treatment using manual mine detection. It is also important to emphasize that supporting machines while operating can move only around previously searched area using the manual mine detection.

WORK SITE CONDITIONS

Work site conditions important for mechanical soil treatment, that is the ones representing the adequate limiting factors for the operation and use of machines are:

- soil conditions and
- mine situation

- Soil conditions

Conditions defined by the type and category of soil, terrain configuration and vegetation situation are called soil conditions. There are:

- a) favourable soil conditions,
- b) aggravated soil conditions,
- c) difficult soil conditions,
- d) special specific conditions.

a. Favourable soil conditions

Favourable soil conditions are characterized by the flat terrain with possible transversal and longitudinal slopes from 0-5°.



The soil is mostly humus, loam or sand of normal (medium) hardness and low level of humidity, covered in short vegetation.

The short vegetation consists of fresh or dry grass, of bigger or smaller density, weeds, rare and low underbrush up to 0.5 m.

The soil is easily cultivated using the manual tools (shovel and pickaxe) and the regulated use of prodger is possible (penetration to the soil up to the soil treating depth determined by the project) and metal-detector.

There is no mineralization of soil or soil contamination with metal.

b. Aggravated soil conditions

Aggravated soil conditions are characterized by rolling terrain with possible transversal and longitudinal slopes from 6 to 20°.



The soil is mostly humus, loam or sand of increased hardness (very dry) or increased level of humidity, the earth is mixed with rocks, dirt prevails with rare low vegetation.

The stone is limestone – schist, soft, easy to be crushed by the machine working tool.

Low vegetation is up to 1 m high and medium up to 2 m. There are some rare single trees of the 10 cm in diameter. The soil is difficult to be cultivated using the manual tools for the reason of increased soil hardness (by shovel or pickaxe) and the regulated use of prodger is also aggravated (it is difficult to achieve penetration up to the depth determined by the project) and the metal-detector because of the presence of soil and metal mineralization. The soils with increased level of humidity and underwater soils are also counted among aggravated soil conditions. The use of demining machines is also aggravated.

c. Difficult soil conditions

Difficult soil conditions are characterized by the soil with steep inclinations-slopes of canals, ditches, dams and bigger hills.



The soil is mostly stony, stony sheets with a bit of dirt in between, possible vegetation existence.

The stone is of medium hardness, possible use of machine working tool on decreased depths (up to 10 cm).

Present vegetation is underbrush, bushes of high density, over 2m high. The existence of single trees over 20 cm in diameter.

Forest areas crisscrossed with ditches and water-worn ravines, trees over 3 m high and over 20 cm in diameter.

The soil is difficult to be cultivated by manual tools for the reason of increased soil hardness and presence of stone, regulated use of prodger is possible only on certain places. There are some signs referring to the high mineralization of soil and soil contamination with metal.

Swampy land areas with and without vegetation are also counted among difficult soil conditions. If it comes to extremely underwater and swampy terrain the use of demining machine is limited.

d. Special specific conditions

Special specific conditions are characterized by the soil that is difficult to be described by previously described conditions. These are very steep mountain chains, river canyons with big, impassable slopes, thick and impassable woods, impassable rocky ground covered in thick underbrush or single small thick forests with trees over 3 m and over 20 cm in diameter.

The soil is of such kind that it is very difficult or impossible to work with a demining machine with acceptable results.

The soil is not possible to be cultivated with the manual tool for the reasons of considerable soil hardness and presence of stone, regulated use of prodger is not possible in an adequate manner. There are rubbles and devastated storage facilities with ERW on the land area, ravines and wells with ERW, scattered rubble etc.

MINE SITUATION

MSA contamination as well as soil contamination with different explosive ordnance and ERW represents the mine situation. The mine situation is distinguished according to the type of explosive ordnance and their placement on the ground and the established authenticity in accordance with the UN Demining Guidelines (SOP CROMAC 03.05. Point 2.2.1, markings: M1, M2, M3 and M4). There are three levels within the efficiency assessment of technical survey and demining:

- 1 established existence of minefields:** there are some authentic documents and data registered in CROMAC MIS that confirm the existence of minefield, groups of mines or single mines (M1 – physically confirmed existence of mines, information on mines is confirmed and source of information is reliable).
- 2 assumed existence of minefields:** there are no authentic documents and data registered in CROMAC MIS that confirm the existence of minefield, groups of mines or single mines but there were some mine incidents and detonations on the areas burned down were confirmed. General survey confirmed the locations of mine incidents and indicators of mine contamination were found (M2 – evidence on existence of mines was observed, information on mines is not confirmed, source of information is reliable and M3 – evidence on existence

of mines was observed, information on mines is not confirmed, source of information is unreliable).

- 3 no signs of minefield existence:** there are no minefield records on mine contamination or authentic data registered in CROMAC MIS that refer to the existence of minefield, groups of mines or single mines. The area is located in the MSA and used to be the area of intensive war activities. General survey found no indicators of mine contamination, only the vestiges of UXO (M4 – it is considered to be mined but there is no evidence or indicators on mines, information is not confirmed and source of information unreliable).

There could be the following explosive ordnance on the ground:

- anti-personnel mines,
- anti-tank mines,
- ammunition,
- other explosive ordnance.

According to the typical placement of explosive ordnance on mine suspected and mine contaminated area there are:

- a) minefields:
 - anti-tank minefields,
 - anti-personnel minefields,
 - mixed (combined) minefields.
- b) groups of mines:
 - anti-personnel groups of mines,
 - anti-tank groups of mines,
 - mixed (combined) groups of mines.
- c) single mines:
 - single anti-personnel mines,
 - single anti-tank mines,
 - single UXO.
- d) ammunition – it can be of different type and calibre, separately rejected, unexploded or in its original container,
- e) improvised explosive ordnance and booby-traps,
- f) various fragments caused by the explosion (parts of mines and UXO).

ANALYSIS OF DEMINING MACHINE OPERATION IN 2004

In 2004, the total of 33.648.932 m² were treated during humanitarian demining works, out of which 23.083.734 m² using the mine search method and 10.601.198 m² using demining method.

REALIZED	m ²
DEMINED	10.601.198
SURVEYED	23.083.734
TOTAL	33.684.932

Stated realization is realized by engaging available capacities of authorized legal entities by engaging cca 60% of available capacities. There were no funds available for higher realization level.

Thanks to the project structure and the possibility of demining machine usage, demining and supporting machines participated a great deal in the total number of m² of realized area.

METHOD	REALIZATION %
MACHINES	76
MANUAL	24

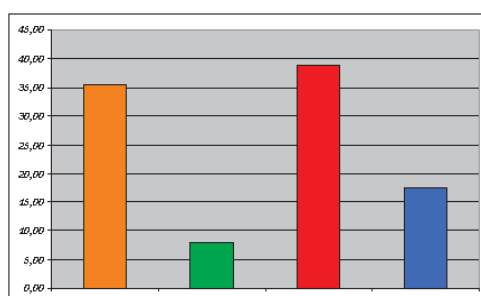
In this way, the share of the machines on technical survey and demining projects was on 76% of areas and of manual mine detection on 24% of areas. It should be emphasized that manual mine detection or MDD had to be used upon demining machines.

MACHINE SHARE IN %

Demining and supporting machines participated in the realization stated above according to the types.

DEMINING MACHINES	PIECES
HEAVY	7
MEDIUM	6
LIGHT	20
EXCAVATORS	12

The most important place among heavy machines belongs to the three machines of the Scanjack 3 500 type that reached the highest level of efficiency. At medium machines, the RM-KA had the highest level of efficiency and when it comes to light machines that were the machines of MV-4 type.



Regarding the number of machines the light machines had the biggest share in total mechanically treated area with 38,93% and then heavy machines with 35,70%.

THE CONDITION OF MINES UPON MECHANICALLY TREATED AREA

Upon use of demining machines mines and UXO can be in different conditions regarding the level of damage. Mine condition upon mechanical soil treatment depends on the machine quality that is, the quality of working tool and the quality and training of operators as well as the work site organization and continuous quality assurance by authorized persons. Mine condition depends a great deal on the quality of mechanical soil treatment so in most cases the mines should have been destroyed i.e. in such condition that they represent no threat.

Upon mechanical treatment the mines can be:

- smashed
- destroyed
- rejected
- omitted
- crammed into the ground

a. Smashed

Smashed mines are usually in such condition that there is no threat from their fragmented parts during their identification. The problem is collecting all tiny scattered parts. Mine is being smashed mostly because of high speed of flail while hitting the mine and the angle under which the mine is being hit.



b. Destroyed



When during the operation the machine destroys the mine and in this way defines the position of the mine it makes locating of other mines a lot easier. In these conditions it is required to pull the machine out and protect it from serious damage, especially if it comes to anti-tank mines, and remaining mines should be detected using the manual mine detection. In this way, the possibility for difficulties while detecting other remaining mines, cramming the mines into the ground, in bigger depths or not finding the mines at all is significantly decreased.

c. Rejected



During the machine operation the mine is rejected mostly because of low-quality work i.e. insufficient soil treating depth i.e. too small working tool operation speed. Rejected mines represent a great danger because they are very dangerous for the reason of being in unnatural position and it is unknown what happened with the fuse. Such mines should be destroyed in situ. They can also be rejected on the areas outside the project and be left there what represents a great danger for the local population.

d. Omitted



Omitted mines are the ones that machine did not hit during the operation and they stayed in their deposits. Omitting happens in cases of low-quality machine operation i.e. not reaching the regulated soil treating depth. Such mines are

easy to detect but when the low-quality machine operation is established it is required to re-do the mechanical soil treatment.

e. Crammed into the ground

Mines crammed into the ground are difficult to detect because they are usually placed in the depths of 20 cm and are out of reach to the mine search device. Mines are crammed into the ground when the mechanical soil treatment is performed in inappropriate conditions such as big soil humidity i.e. part of surface is underwater and mechanical soil treatment is performed using the big machines that, at the same time, push a large quantity of the earth in front of them and make deep track marks.

PERCENTAGE OF DESTROYED AND DAMAGED MINE

During technical survey and demining works execution in 2004, 6.158 anti-personnel and anti-tank mines were found and destroyed.

MINES				
FOUND AND DESTROYED	MECHAN. DESTROYED	MECHAN. DAMAGED	% OF DESTROYED	% OF DAMAGED
6.158	134	16		
HEAVY	81		60,45	0,00
MEDIUM	1	12	0,75	75,00
LIGHT	45	3	33,58	18,75
EXCAVATORS	7	1	5,22	6,25

According to data reported and available, during the operation demining machines destroyed 134 mines and damaged 16 mines.

The largest number of mines was destroyed by heavy demining machines during their operation i.e. out of the total number 60, 45% of destroyed mines that is, and 100% if we speak about heavy machines. Medium machines have the smallest percentage of destroyed mines but, on the other hand, they have big percentage of smashed ones. Regarding the highest share in realization of mechanically treated area light machines have the high reliability level that is the level of destroyed mines. Regarding their allocation and type of activated mines (PROM-1) supporting machines have the high reliability level regardless the soil treating depth.

DESTRUCTION OF DAMAGED MINES AND UXO

As previously stated, every mine and/or UXO left upon mechanical soil treatment represents a great danger because it is unknown what happened with the fuse i.e. if the machine working tool was active over them and in this way put them in a state of high sensitivity. In such cases when ordnance is found in this way using one of the methods, prior to all, it is required to visually establish the level of damage without moving and estimate the risk for further activities. As a rule, explosive ordnance found should not be moved and it is necessary to start with "DESTRUCTION IN SITU" bearing in mind that by using certain tools, explosive charge is put next to the dangerous ordnance without moving it.

DAMAGE ON THE MACHINES

Demining machines are not meant for destruction of mines but for their locating on the terrain since the minefield records are often very unreliable and for certain impediments even inaccessible. That is why demining machines should ensure the detection of the first mine by destroying it and after that remove the mines using manual mine detection.

But in such cases as well, during the separate destruction of mines, the working tool is being damaged. The damage can be more or less serious and it depends on the mine type and the moment of activating the mine in relation to the working tool. At serious damage, machine work-

ing tool is completely destroyed and needs to be replaced with the new one.

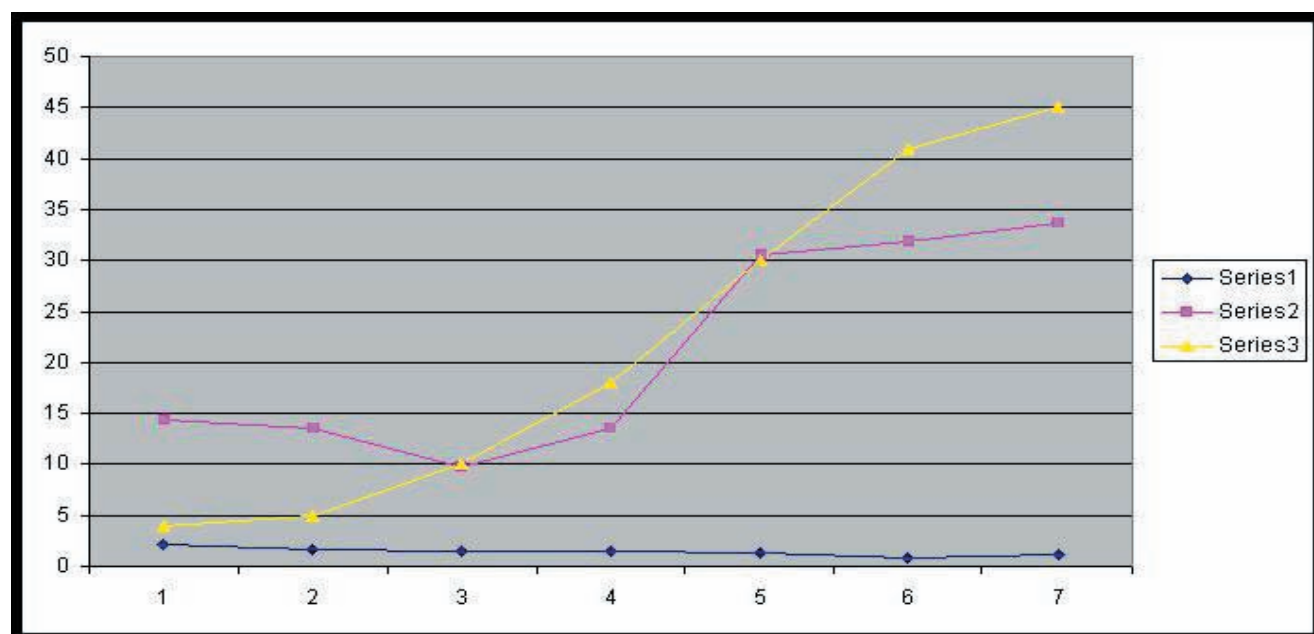


When it comes to minor machine damage, few chains are usually ejected and need to be replaced.



RECAPITULATION

We will use the following diagram to take a closer look into the importance of demining machines for the realization and their impact on realization increase, price decrease, safety and quality of works.

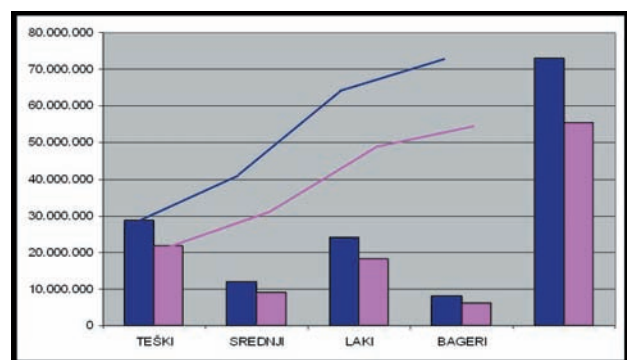


The table shows the trends of demining price, realization and increase of machine capacities per years while the graph presents their correlation. When we speak about the price it is important to emphasize that the price has been continuously dropping and in 2004 it was stabilized on the level that enables the quality and on the other hand, by increasing the capacities of demining machines, the annual realization of the total area handed over to the community for use has also been increasing. Critical period was 2002/2003 when the capacities reached the realization that was obstructed by financial means. After that, and particularly in 2004, the financial means did not follow the capacities. That is why a part of capacities did not accomplish the potential realization.

CURRENT MACHINE CAPACITIES

Analyzing the needs, the situation and quality of capacities equipment, CROMAC started preparing the Program – Croatia without mines until 2009. The most important place for its realization belongs to demining machines and their capacities.

No.	DEMINEING MACHINES	PIECES	ESTIMATED EFFICIENCY UP TO m ²		
			MONTHLY	OPTIMALLY ANNUALLY	EFFECTIVELY ANNUALLY
1	HEAVY	7	2.395.008	28.740.096	21.772.800
2	MEDIUM	6	1.001.986	12.023.837	9.108.960
3	LIGHT	20	2.006.189	24.074.266	18.238.080
4	EXCAVATORS	12	685.115	8.221.382	6.228.320
	TOTAL	45	6.088.298	73.059.571	55.348.160



Besides, other factors such as deminers and mine detection dogs that need to verify mechanically treated areas should not be ignored. In order to get the possible size of mechanically treated area, the factors such as daily machine realization (75% of the size achieved during testing), number of working days in the year and current number of demining machines) are calculated. The result of this calculation showed that 45 demining machines can monthly realize

approximately 6 km² i.e. on the annual level approximately 55 km², by optimal usage and project merging even up to the 73 km².

CONCLUSION

Demining machines increase the safety for all actors in humanitarian demining process, create the trust of deminers and final beneficiaries of the area upon humanitarian demining works completion. Demining machines enable the realization and quality increase. Besides, they make the work of deminers a lot easier for they can be used in all specific work site conditions. Highly-educated staff and quality-equipment are the guarantee for safe and high-quality execution of humanitarian demining works. Available capacities and sufficient financial means will enable Croatia to become free of mines and upon that, entrance to the world market.

Bozena 4 - Mini-Flail Mine Clearance System

Valer Repko²⁶



BOZENA 4 mini-flail system is tracked mechanical mine clearance machine remotely controlled by a transmitter with a range of 2 000 m, designed for disposal of AP mines both pressure and tripwire fused and for AT mines up to 9 kg of TNT charge. The system is suitable for clearing between buildings, along paths, plantations, around solid obstacles and where the ground cannot carry heavy weights. It will mainly be road transported on trailer between working areas. The BOZENA 4 is controlled from an armored, air-conditioned cabin by an operator with line-of-sight visibility (on request, the

producer can provide protected camera system operating in conjunction with the remote control device). BOZENA 4 is protected with an armored shield situated in front of the prime mover, directly behind the flail working tool. In addition, the whole machine is protected with an armored metal covering, giving sufficient protection against damage from detonations. BOZENA 4 has already passed NATO codification process with all respective NSN and RN. BOZENA 4 fulfills respective STANAG standards including STANAG 2895.

BOZENA 4 has been tested and fulfills Climatic Environmental Requirements AETCP 300 and Mechanical Environmental Requirements AETCP 400.

BOZENA 4 has successfully passed EMC (Electro-Magnetic Compatibility) test on methods RS-105, CE-03, CE 102, CS 114, 115, 116.

The Manufacturer follows AQAP 2110:2003, ISO 9001 and is holder of NCAGE 1001M.

BOZENA 4 has passed many survivability and performance tests on many kinds of AP mines as well as AT mines:



Review of Tests performed on BOZENA 4

Country / period	Type of used AP mines	Type of used AT mines
Croatia / Oct 2002	PMA 1, PMA 2, PMA 3, PROM 1, PMR-2A	TMM 1 (5,6 kg of TNT)
Poland / Dec 2002		PM-62P (7kg of TNT)
Ethiopia / May 2003	PMD-6, PMN	PRB-M3
Turkey / Sept 2003	M-14, M-16	DM-11, B Turkish type
Sweden / October 2004	M-49	M-47B (5,5 kg of TNT)
Slovakia / within Oct 2002 – March 2005	PP Mi-Sr II	PT Mi-Ba III (8-9 kg of TNT)

²⁶ WAY INDUSTRY, a.s., Slovakia,
www.bozena.sk, bozena@windustry.sk

Basic technical specifications of BOZENA 4			
Dimensions (LxWxH) mm	6 052 x 2 716 x 2 145	Width of cleared lane	2 225 mm
Weight	5960 kg	Depth of clearance	up to 250 mm
Engine	DEUTZ BF 4L913	Working speed (dep. on terrain)	520 – 2 500 sqm
Engine power	78 kW / 106 HP	Operating rpm of the flail	350 - 400 min ⁻¹
Hydraulics	Bosh Rexroth	Maximum transmitter range	2 000 m

Additional equipment that can be provided with BOZENA 4

Transport trailer

The trailer SPP 6 is intended for the transport of B4 or other sized and weight similar machines. The nominal load of the trailer is 6000 kg and max. travel speed is 80 km/h. The trailer is towed by a truck with a coupling system meeting requirements for vertical static load and connection of pneumatic and electric installation according to the EHK regulations.



SPP6 is equipped with pneumatic breaking system with ABS.

Trailer design allows automatic self-propelled loading of the B4 Mini-Flail with hydraulically controlled tilting of loading platform. No additional loading equipment is needed. All actions that have to be done for loading and unloading of B4 can be done by only one operator. Possibility of easy detach of loading platform plates enable to create temporary service ramp for B4 or other vehicles with similar size and weight in field conditions.

Operator's monitoring cabin



BOZENA 4 can be controlled from an armored, air-conditioned cabin (optional) by one operator with line-of-sight visibility. Armored operator's cabin is a separate part of BOZENA 4. It is fully air-conditioned and provides comfortable and maximum safety operation of the remotely controlled BOZENA 4 for the operator. The operator is in the cabin located on the truck bed at a safe distance from the minefield. The cabin is welded from steel plates of the class 11. The mine resistance of the cabin against the Anti-personnel and Anti-tank mines was proved on several mine tests. The inner walls of the cabin are lined with the sound insulating materials. The cabin is equipped with the following:

- Built in table, anatomical chair with arm supports
- Air-Condition
- Electric generator (220 V – 230 V/ 50 Hz with maximum output 4,5 kW)
- Electric Hot – Air Fan

Armored rake-shovel



The armored rake-shovel is BOZENA 4 special attachment designed for recovering and remov-

al of a surface or close-to-surface laid anti-tank and anti-personnel mines as well as different kinds of unexploded ordnance (UXO) such as artillery, mortar and aircraft ammunition, hand-grenades, RPGs and home made explosive devices. Remotely controlled B4 using the camera system can approach found UXO/mine and remove it to the safe point where EOD teams can do their job.

Additional standard working tools:



In addition to mechanical demining, BOZENA 4 can also be used for various engineering tasks by using various attachments instead of the flail.

Some of them like Fork with holder or Shovels can be used for removal of the concrete pieces or other obstacles laid on the ground before subsequent mine clearing operation with use of the flail again.

All the above-mentioned attachments can be easily and quickly installed on the prime mover B4-L1203 RC using a quick-acting fixture, an integral part of the prime mover. Replacement of attachments takes about 2 minutes.

Manufacturer has succeeded to sold and deliver 97 BOZENA flail machines up to date.

48 units of them are model BOZENA 4 which was delivered to following countries:

Afghanistan, Angola, Azerbaijan, Canada, Croatia, Eritrea, Ethiopia, Iraq, Netherlands, Poland, Slovakia, Sri lanka, Thailand.

Former models of BOZENA 3,2 and 1 has been successfully delivered to Albania, Bosnia & Herzegovina, Canada, Croatia, Czech republic, Eritrea, Iraq, Kosovo, Lebanon, Slovakia.

Bozena 5 - Midi-Flail Mine Clearance System

Valer Repko²⁷



Medium mine clearance system BOZENA 5 (hereinafter referred as BOZENA 5) is fresh new model in the category of Midi-Flail machines. BOZENA 5 is tracked mechanical mine clearing machine remotely controlled by a transmitter with a range of 2000 m, meant for clearing AP mines both pressure and tripwire fused and for AT mines. The system shall be suitable for clearing large mine affected areas. It will mainly be road transported on trailer between working areas. BOZENA 5 is controlled from an armored,

air-conditioned cabin by an operator with line-of-sight visibility.

BOZENA 5 is protected from detonations by an armored shield situated at the front of the vehicle, directly behind the flail. In addition, the whole machine is protected with an armored metal covering, giving protection against damage from detonations.

BOZENA 5, as the new model which production has been completed in November 2004 is already deployed in Azerbaijan since May 2005.



Basic technical characteristics of BOZENA 5			
Dimensions (LxWxH) mm	6 755 x 3 510 x 2 070	Width of cleared lane	2 810 mm
Weight	11 430 kg	Depth of clearance	up to 300 mm
Engine	TATRA T3A-928-30	Working speed (dep. on terrain)	1050 – 4 900 sqm
Engine power	170 kW / 231 HP	Operating rpm of the flail	350 - 500 min ⁻¹
Hydraulics	Bosh Rexroth	Maximum transmitter range	2 000 m

²⁷ WAY INDUSTRY, a.s., Slovakia,
www.bozena.sk, bozena@windustry.sk

DOK-ING MV-4 Mini Mine Clearing System

Vjekoslav Majetić²⁸, Damir Štimac²⁹



MV-4 Mini Mine Clearing System

The MV-4 Mini-Flail is designed to clear various types of terrain containing anti-personnel (AP) mines. Because of its dimensions and maneuverability, it is suitable for demining of house yards, woods, forest paths, river banks and other types of terrain that are inaccessible to larger machines.

The operating tool for digging and mine clearance consists of a flail and roller mounted in front of the machine that destroy even the smallest anti-personnel mines and the most dangerous types of jumping/bouncing anti-personnel mines. Upon client's request, the roller is replaced by two supporting wheels. The system features high performance and provides safety for the deminers and dog teams that follow the mechanical clearance. The system is light at 5.31 metric tons, has excellent crosscountry performance and is operated by remote control.

The force of the flail hammers is calculated to enable cutting through dense vegetation and digging into soil to a depth of more than 20 cm. The combination of speed of movement of the machine and velocity of the flail determines the soil processing density. The density of hammer impacts is an important factor for ensuring the safe destruction and elimination of mines. Original hydrostatic transmissions were designed for the track movement and for the movement and operation of the flail device. The MV-4 has a low center of gravity, and its low profile and aerodynamic shape minimize damage from explosions. The MV-4 Mini-Flail was designed based on

the development of the previous DOK-ING demining systems: MV-1, MV-2 and MV-3. All of DOK-ING's extensive field experience has been incorporated into the design of the MV-4. Strict requirements have been set in the development of this light machine, such as: safe clearance of antipersonnel mines, intensive use in the most severe working conditions, ability to work on soil with a hardness rating in the first to fourth category, ability to work in extremely high temperatures, high performance, modular design, lowest possible maintenance requirements, and environmental protection.

The operator easily operates the vehicle using a remote-control unit while being safely situated in an accompanying mine protected vehicle, shelter or some other location, where he is not exposed to injuries caused by activated mines.

Antipersonnel mines are destroyed by the force of impact of tools that are suitably shaped – hammers at the ends of flail chains. By flail rotation and hammer hitting, the loose soil layer of up to 20cm deep is dug up and mines are broken up or activated. Ground digging is based on the impact force of the flail hammers each with 0.6 – 0.9 kg of mass.

The machine has been developed exclusively according to real demonstrated demining requirements for maximum performance and resistance to mine detonations, and not by adapting an existing construction machine, loader type, or forestry machine. The self-supporting hull is constructed of armor plate of 8-10 mm thickness. The impact hammers are made of steel highly resistant to wear and detonations. The chains and hammers can be replaced quickly in case of damage.

²⁸ DOK-ING Ltd., Croatia; www.dok-ing.hr;
E mail: majetic@dok-ing.hr

²⁹ DOK-ING Ltd., Croatia, E-mail: d.stimac@dok-ing.hr

TECHNICAL CHARACTERISTICS OF THE DOK-ING MV-4	
1. Dimensions (L x W x H) mm	
Prime Mover (minimum length L1)	3005 x 1530 x 1470 mm
With clearing arms pulled in (medium length L2)	3005 (+1450) x 1530 (+485) x 1470 =
	4455 x 2015 x 1470 mm
With clearing arms extended (maximum length L3)	4455 (+690) x 2015 x 1470 =
	5145 x 2015 x 1470 mm
2. MV-4 Clearance	
Minimum (ground level to drive gearbox protection)	145 mm
Maximum (up to bottom armor protection)	260 mm
3. Weight	5.31 metric tons (dry weight)
	5.56 metric tons (w/ fuel & lubricants)
4. Engine	6-cylinder, in-line, turbo-charged diesel
	4-stroke, direct injection, water cooled
Engine Designation	Perkins 1106C-E60 TA modified
Power rating	129 kW (173.82HP) at 2200 rpm
Direction of rotation	Clockwise
Torque	628Nm at 1400 rpm
Engine weight	505 kg net (dry), 535 kg (wet)
Coolant	33 liters
Oil	15 liters
Oil pressure	276 – 414 kN-mP ^{2P}
Min. oil pressure at max. RPM, piston cooled	207 (280) kN/mP ^{2P}
Fuel capacity	70 liters (D2)
Fuel consumption (depends upon terrain)	15 - 25 liters/hour
5. Power Transmission	Hydrostatic System
To tracks and flail	Independent drives for propulsion and
	flail operation
Hydraulic Fluid	200 liters
Track gearbox oil	2 x 0.6 liters
Working speed	0.5 - 2 km/hour
Maximum speed	5 km/hour
Flail rotation velocity	0 - 900 RPM
Flail diameter	820 mm
Mine clearing width	1725 mm
Digging depth	More than 20 cm
Protection	Steel armor plate
6. Gearbox (multiplying)	Stiebel 4362, I=0.697
Gearbox oil	2.6 liters
7. Mine clearing capacity	500 – 2000 m ² /hour, depending on terrain

DESIGN

The MV-4 was designed to perform one task only – demining. It is not a modified construction machine or tank. In addition to machine building, DOK-ING is also the largest private commercial demining company in the South-East European region. The MV-4 is the 5Pth model in the MV series of demining machines. All of DOK-ING's demining experience in the Republic of Croatia following the recent war has been incorporated into the design of the MV-4. To date, over 20 million m² of terrain has been mechanically demined by DOK-ING machines.

PRODUCTIVITY

Because of its small dimensions, very good maneuverability, high engine power, and low track-ground pressure, the DOK-ING MV-4 can work year round in almost all conditions. The clearing productivity is up to 2000 m² per hour.

MAINTENANCE

The majority of repairs can be carried out by the operator/mechanic in the field. The entire working tool (flail with supporting wheels or flail

with roller and shield) can be replaced within few hours. Because DOK-ING's demining experience has been incorporated into the design of the MV-4, all sections of the machine that are susceptible to explosion damage can be changed quickly and easily. MV-4's low profile reduces its susceptibility to shrapnel damage.

ECONOMY

The MV-4 has a low fuel consumption compared to powerful engine and high productivity rate. Only one operator/mechanic is required for transport, operation and repairs/maintenance. The low cost of the MV-4 and low operating and maintenance costs ensure a quick return on investment. Our experience in commercial demining in Croatia is that the period for return on investment is about one year.

Because of the short training period for personnel, education costs for MV-4 operators are extremely low.

MOBILITY AND MANEUVERABILITY



The MV-4's small dimensions and low track-ground pressure allow the machine to pass over difficult terrain such as ditches, urban areas, canals, etc. MV-4 can drive and work on highly inclined terrain both transversely and longitudinally: clearing of transverse slopes of 35° up and down, driving on transversal slopes of 45° up and down, clearing longitudinal slopes of 20°, and driving on longitudinal slopes of 35°.



MV-4 can clear very close to obstacles such as buildings and other structures both when moving in parallel (25 cm) and perpendicular direction (75 cm).



The working tool can be raised, lowered, extended and retracted to enable the machine to navigate over difficult terrain such as ditches, obstacles, canals etc. MV-4 can drive through water to a depth of 45 cm and can turn 360° on a single point.

MV-4 machine is also able to pass over a ditch 0.5 m wide and 0.3 m deep, and vertical obstacles of about 0.3 m in height. MV-4 easily wades through a depth of at least 0.45 m of water without any special actions taken by the operator. MV-4 drives both in transversal and lateral inclinations. It is also able to perform self-recovery from a ditch/channel by using its hydraulic arms (extend/retract positions).



EFFECTIVENESS

The MV-4 normally uses one tool – a rotating flail designed to activate or shatter AP mines. Testing has demonstrated that MV-4 has a rate of effectiveness of about 98.5% thus greatly increasing the safety and speed of subsequent manual/dog-team demining. A number of practical tests have also proved the effectiveness of two big supporting wheels attached at the back of the clearing tool set to reduce a ground resistance and get easier through while operating in soft, wet or muddy soil. If a client requests, one more additional clearing tool – a steel roller might be installed instead of supporting wheels. Under such circumstances, the roller is designed to destroy any remaining explosive material. MV-4 is designed for destruction of anti-personnel mines, our experience has shown that, when working properly, in the event an anti-tank mine is detonated, damage is limited to the working tool which can be replaced within a period of few hours.

DURABILITY

The durability of the MV-4 Mini-Flail is assessed to be about 3-5 years depending on the operational conditions in which machine is used, intensity of operation (number of operational hours per month and annually, number of detonations made, etc.) and professionalism and knowledge of the personnel responsible for operating and maintaining the MV-4 mini-flail. All of the MV-3 machines (MV-4's predecessor introduced in 2000) and MV-4 machines are still in operation today.

PROTECTION

The MV-4 Mini-Flail is provided with the special Swedish HARDOX 400 armor plates. The MV-4 is highly resistant to the fragmentation of landmines and standard 7.62 mm NATO ball ammunition.

MV-4's low profile reduces its susceptibility to shrapnel damage.

ABILITY TO WITHSTAND AT MINE DETONATION

Although the MV-4 Mini-Flail is primarily designed for clearance of anti-personnel mines, there is always a possibility of encountering

anti-tank mines during its operation. On several occasions we actually did encounter various anti-tank mines and smashed them without detonation due to the high velocity of the tools rotation.

In all instances, the damage to the MV-3 and MV-4 machines was within the limits of expectations. If the entire flail tool needs to be replaced because of an accidental AT mine detonation, the approximate down time is about 1 hour assuming that all parts and tools are available on-site (i.e. 2 x 14 bolts M14 have to be unfastened to remove a damaged flail unit).

The MV-4 strongest ability to withstand AT mine detonations has been proved at the Swedish EOD and Demining Center (SWEDEC) in Eksjö during July 2004.



During AT mine detonation After detonation

REPARABILITY

MV-4 is not intended for anti-tank mine clearance, however, in practice in mine clearance projects, anti-tank mines were destroyed by the MV-4 both with and without detonation. After detonation of anti-tank mines, the working device of the flail might be extensively damaged but the driving mechanism always remains in good working order. In this case, the working part of the flail needs to be replaced with a spare one.

The MV-4 is easily accessible for inspection, maintenance, trouble-shooting, repair and/or replacement. Damage repair can be carried out on the location of the mine detonation incident.

The tools required for flail tool replacement are standard wrenches and some specially modified tools. A spare flail unit will be supplied as an extra. If the entire flail unit needs to be replaced because of an accidental AT mine detonation, the repair time is approximately 1 hour assuming that all parts and tools are available on-site.

In the case of an A/P mine detonation, normally either no damage or minimal damage will occur. Spare chains with hammers and standard

wrenches are sufficient. Damage resulting from AP mine detonations is usually minor in nature and can be corrected with a minimum expenditure of time and materials.

The majority of repairs can be carried out by the operator/mechanic in the field. All sections of the machine that are susceptible to explosion damage can be changed quickly and easily.

PARTS AND SERVICE

The major components not produced by DOK-ING such as motor and hydraulics are produced by large, international firms thus ensuring long-term availability of spare parts. We have our own in-house service capabilities and can send a team at short notice to any location in the world. We maintain adequate stocks of parts on our premises – both those produced by DOK-ING and outsourced ones.

SAFETY

The MV-4 is operated by remote-control from a safe distance, from the protection of the armoured support vehicle, or behind solid structures. In over 6 years of operation with MV machines, no injuries have ever been suffered by either DOK-ING operators or other personnel, or by any other persons in areas cleared by our machines.

OPERATION

The MV-4 is extremely simple to operate by remote control. Our experience has shown that most people can learn within a period of several hours to operate the machine.

TRANSPORT



Transport of the MV-4 is simple and inexpensive. The machine can be loaded onto an ordinary truck or tractor-trailer and transported without the need for any special permits or police escort. The approximate time for unloading and preparing MV-4 for work is 6 minutes. For

transport over large distances and internationally, the machine and all necessary spare parts and accessories can be packed into a standard 20' shipping container. Therefore, it does not have any extraordinary logistic or infrastructure requirements. The MV-4 machine also is fitted with 4 eye-hook lifting points.

SHORT STATISTICS

To date more than 60 mini flails of MV-family have been produced: 1 MV-1 prototype, 4 MV-2, 5 MV-3 and more than 50 MV-4 machines. 57 of them were purchased by various organizations/demining companies including:

ARMED FORCES:

- US Army - 21 units
- Swedish Army – 5 units
- Croatian Army – 2 units
- Irish Army – 2 units

NATIONAL MINE ACTION AUTHORITIES:

- Croatian Mine Action Centre (CROMAC)
- 4 units
- Iraqi National Mine Action Authority (NMAA)
- 4 units

HUMANITARIAN NONGOVERNMENTAL ORGANIZATIONS (NGO)

- Norwegian People's Aid (NPA) – 3 units
- Swiss Foundation for Mine Action (FSD) - 5 units

COMMERCIAL COMPANIES:

- Mechem Consultants - 1 unit (MV-3)
- Maavarim-Civil Engineering - 1 unit
- REASeuro Worldwide – 1 unit
- RU-RU – 1 unit
- AVANGARD – 1 unit
- CENTURION – 1 unit
- ARKA-SERVIS – 1 unit
- ENIGMA – 1 unit
- TT-KA – 1 unit
- DOK-ING DEMINING – 2 units

ING" have been tested by the Croatian Mine Action Center (CROMAC). This makes them automatically certified for operation in all other countries of the South-East Europe including the Republic of Slovenia, the Federation of Bosnia and Herzegovina, the Republic of Macedonia, Serbia and Montenegro and the Republic of Albania. The MV-4 mini flail has been also rigorously tested and evaluated by SWEDEC (Swedish EOD and Demining Center) and the US Army.

It should be mentioned that all MV-type mini flails and excavators in the possession of "DOK-

DOK-ING MV-10 Midi Double Flail-Tiller Mine Clearing System

Vjekoslav Majetić³⁰, Damir Štimac³¹

The MV-10 Midi Double Flail-Tiller Mine Clearing System is design to clear various types of terrain containing antipersonnel (AP) mines, antitank (AT) mines, and unexploded ordnance (UXO). Because of its huge power and excellent clearance rate, it is suitable for mine clearance of huge areas contaminated with all types of mines and UXO.

The operating tools for digging and mine clearance are consisted of a flail unit and tiller unit in front of machine that destroy all types of antipersonnel and antitank mines and unexploded ordnance. MV-10 system features high performance rate and provides safety for the deminers and EOD teams that follow the mechanical clearance.

The MV-10 system weights around 18 tons, but its weight is not causing any difficulties in the crosscountry performance, and is operated by single machine operator through remote control. The system has a capacity for penetrating the soil in depth of 35 cm depending on the type of soil.



MV-10 Midi Double Flail-Tiller Mine Clearing System

The MV-10 Midi Double Flail-Tiller Mine Clearing System was designed based on the development of the previous DOK-ING demining systems: MV-1, MV-2, MV-3, MV-4, and MV-20. All of DOK-ING's extensive mine clearance experience has been incorporated into the design of the MV-10 system.

Strict requirements have been set in the development of this double tool machine, such as:

safe clearance of antipersonnel and antitank mines, intensive use in the most severe working conditions, ability to work on soil with a hardness rating in the first to fourth category, ability to work in extremely high temperatures, high performance, modular design, lowest possible maintenance requirements, and environmental protection.

The machine operator easily operates the vehicle using a remote-control unit while being safely situated in an accompanying mine protected vehicle (MPV), shelter or some other location, where he is not exposed to injuries caused by activated and destroyed mines.

- Transport of MV-10 is done using a flat-bed trailer.
- The MV-10 can endure climactic conditions of -19°C and +54°C.
- The MV-10 can function in up to 100% relative humidity.
- The MV-10 is not susceptible to damage by rain, snow or hail.
- The MV-10 is a system introduced in April 2005.

The machine has been developed exclusively according to real demonstrated demining requirements for maximum performance and resistance to all types of mine detonations, and not by adapting an existing construction machine, loader type, or forestry machine. The impact hammers are made of steel highly resistant to wear and detonations. The chains and hammers can be replaced quickly in case of damage.

Basic technical characteristics of MV-10

Dimensions (L x W x H) mm	6860 x 2792 x 1900
MV-20 clearance	390 mm
Weight	18,000 kg
Fuel consumption (depends on terrain)	30 - 70 l/hour
Working speed	0 - 3 km/h
Digging depth	350 mm

³⁰ DOK-ING Ltd., Croatia, E-mail: majetic@dok-ing.hr

³¹ DOK-ING Ltd., Croatia, E-mail: d.stimac@dok-ing.hr

DESIGN

The MV-10 is designed to perform one task only – mine clearance. It is not a modified construction machine or tank. In addition to machine building, DOK-ING is also the largest private commercial demining company in the South-East European region. The MV-10 is the 7th model in the MV series of demining machines. All of DOK-ING's demining experience in the Republic of Croatia following the recent war has been incorporated into the design of the MV-10. To date, over 20 million m² of terrain has been mechanically demined by DOK-ING machines.



PRODUCTIVITY

Because of its dimensions, excellent maneuverability, high engine power, and low track-ground pressure, the DOK-ING MV-10 can work year round in almost all conditions.

MAINTENANCE

The majority of basic maintenance can be carried out by the operator/mechanics in the field. Because DOK-ING's demining experience has been incorporated into the design of the MV-10, all sections of the machine that are susceptible to explosion damage can be changed quickly and easily. MV-10's low profile reduces its susceptibility to shrapnel damage.

ECONOMY

Only one operator and two mechanics are required for transport, operation and repairs/maintenance. The low cost of the MV-10 and low operating and maintenance costs ensure a quick return on investment. Our experience in commercial demining in Croatia is that the period for return on investment is about one to two years.

Because of the short training period for personnel, education costs for MV-10 operators are extremely low.

EFFECTIVENESS

The MV-10 normally uses both tools – a rotating flail, designed to activate or shatter AP and AT mines, and rotating tiller, designed to be as a second method and in the same time to keep the digging depth constant. A flail and tiller unit can also work one at a time and rotation of tools is forward and backward.



MV-10 is designed for destruction of antipersonnel and antitank mines, and our experience has shown that, when working properly, in the event an anti-tank mine is detonated, there is no damage to the working tools.

PROTECTION

The MV-10 Midi Double Flail-Tiller Mine Clearing System is provided with the special Swedish HARDOX armor plates. The MV-10 is highly resistant to the fragmentation of landmines.

REPARABILITY

The MV-10 is easily accessible for inspection, maintenance, trouble-shooting, repair and/or replacement. Maintenance and repairs can be carried out on the field or in workshop conditions. The tools required for repairs and maintenance are standard wrenches and some specially modified tools.

In the case of an AP or AT mine detonation, normally either no damage or minimal damage to the flail unit will occur. Spare chains with hammers and standard wrenches are sufficient. Damage resulting from AP or AT mine detonations is usually minor in nature and can be corrected with a minimum expenditure of time and materials.



PARTS AND SERVICE

The major components not produced by DOK-ING such as engine and hydraulics are produced by large, international firms thus ensuring long-term availability of spare parts. We have our own in-house service capabilities and can send a team at short notice to any location in the world. We maintain adequate stocks of parts on our premises – both those produced by DOK-ING and outsourced ones.

SAFETY

The MV-10 is operated by remote-control from a safe distance, from the protection of the armoured support vehicle, or behind solid structures. In over 8 years of operation with MV machines, no injuries have ever been suffered by either DOK-ING operators or other personnel, or by any other persons in areas cleared by our machines.

OPERATION

The MV-10 is extremely simple to operate by remote control. Our experience has shown that most people can learn within a period of several days to operate the machine.



Portable Console



Control Console

TRANSPORT

The MV-10 can be loaded onto a flat-bed trailer and transported without the need for any special permits or police escort. MV-10 system can also be transported with the C-130 Hercules.

DOK-ING MV-20 Heavy Double Flail-Tiller Mine Clearing System

Vjekoslav Majetić³², Damir Štimac³³

The MV-20 Heavy Double Flail-Tiller Mine Clearing System is design to clear various types of terrain containing antipersonnel (AP) mines, antitank (AT) mines, and unexploded ordnance (UXO). Because of its huge power and excellent clearance rate, it is suitable for mine clearance of huge areas contaminated with all types of mines and UXO.

The operating tools for digging and mine clearance are consisted of a flail unit and tiller unit in front of machine that destroy all types of anti-personnel and antitank mines and unexploded ordnance. MV-20 system features high performance rate and provides safety for the deminers and EOD teams that follow the mechanical clearance.

The MV-20 system weights around 33.5 tons, but its weight is not causing any difficulties in the crosscountry performance, and is operated by single machine operator through remote control. The system has a capacity for penetrating the soil in depth of 40-50 cm depending on the type of soil.

The MV-20 Heavy Double Flail-Tiller Mine Clearing System was designed based on the development of the previous DOK-ING demining systems: MV-1, MV-2, MV-3, and MV-4. All of DOK-ING's extensive mine clearance experience has been incorporated into the design of the MV-20 system.

Strict requirements have been set in the development of this heavy double tool machine, such as: safe clearance of antipersonnel and antitank mines, intensive use in the most severe working conditions, ability to work on soil with a hardness rating in the first to fourth category, ability to work in extremely high temperatures, high performance, modular design, lowest possible maintenance requirements, and environmental protection.

The machine operator easily operates the vehicle using a remote-control unit while being safely situated in an accompanying mine protected vehicle (MPV), shelter or some other location, where he is not exposed to injuries caused by activated and destroyed mines.

Transport of MV-20 is done using a flat-bed trailer.

- The MV-20 can endure climactic conditions of -19°C and +54°C.
- The MV-20 can function in up to 100% relative humidity.
- The MV-20 is not susceptible to damage by rain, snow or hail.
- The MV-20 is a completely developed system introduced in September 2004.

The machine has been developed exclusively according to real demonstrated demining requirements for maximum performance and resistance to all types of mine detonations, and not by adapting an existing construction machine, loader type, or forestry machine. The self-supporting hull is constructed of armor plates of 10 to 20 mm thickness. The impact hammers are made of steel highly resistant to wear and detonations. The chains and hammers can be replaced quickly in case of damage.



MV-20 Heavy Double Flail-Tiller Mine Clearing System
Basic technical characteristics of MV-20

Dimensions (L x W x H) mm	8500 x 4000 x 2600
MV-20 clearance	300 mm
Weight	33,500 kg
Engine	PERKINS 3000 SERIES DIESEL 3012-26TA3
Power rating	663 kW
Torque	3520 Nm
Fuel capacity	860 l
Fuel consumption (depends on terrain)	40 - 80 l/hour
Working speed	0 - 3 km/h
Maximum speed	5 km/h
Mine clearing width	3400 mm
Digging depth	400 mm
Clearance capacity	5,000 m ² /h

³² DOK-ING Ltd., Croatia, E-mail: majetic@dok-ing.hr

³³ DOK-ING Ltd., Croatia, E-mail: d.stimac@dok-ing.hr

DESIGN

The MV-20 is designed to perform one task only – mine clearance. It is not a modified construction machine or tank. In addition to machine building, DOK-ING is also the largest private commercial demining company in the South-East European region. The MV-20 is the 6th model in the MV series of demining machines. All of DOK-ING's demining experience in the Republic of Croatia following the recent war has been incorporated into the design of the MV-20. To date, over 20 million m² of terrain has been mechanically demined by DOK-ING machines.

PRODUCTIVITY

Because of its dimensions, very good maneuverability, high engine power, and low track-ground pressure, the DOK-ING MV-20 can work year round in almost all conditions. The clearing productivity is up to 5000 m² per hour.

MAINTENANCE

The majority of basic maintenance can be carried out by the operator/mechanics in the field. Because DOK-ING's demining experience has been incorporated into the design of the MV-20, all sections of the machine that are susceptible to explosion damage can be changed quickly and easily. MV-20's profile reduces its susceptibility to shrapnel damage.

ECONOMY

Only one operator and two mechanics are required for transport, operation and repairs/maintenance. The low cost of the MV-20 and low operating and maintenance costs ensure a quick return on investment. Our experience in commercial demining in Croatia is that the period for return on investment is about one to two years.

Because of the short training period for personnel, education costs for MV-20 operators are extremely low.

EFFECTIVENESS

The MV-20 normally uses both tools – a rotating flail, designed to activate or shatter AP and AT mines, and rotating tiller, designed to be as a

second method and in the same time to keep the digging depth constant. A flail and tiller unit can also work one at a time and rotation of tools is forward and backward.



MV-20 - Testing against AT mines

MV-20 is designed for destruction of antipersonnel and antitank mines, and our experience has shown that, when working properly, in the event an anti-tank mine is detonated, there is no damage to the working tools.

PROTECTION

The MV-20 Heavy Double Flail-Tiller Mine Clearing System is provided with the special Swedish HARDOX armor plates. The MV-20 is highly resistant to the fragmentation of landmines.



REPARABILITY

The MV-20 is easily accessible for inspection, maintenance, trouble-shooting, repair and/or replacement. Maintenance and repairs can be carried out on the field or in workshop conditions. The tools required for repairs and maintenance are standard wrenches and some specially modified tools.

In the case of an AP or AT mine detonation, normally either no damage or minimal damage to the flail unit will occur. Spare chains with hammers and standard wrenches are sufficient. Damage resulting from AP or AT mine detonations is usually minor in nature and can be corrected with a minimum expenditure of time and materials.

The majority of repairs can be carried out by the operator/mechanics in the field or in workshop conditions.

PARTS AND SERVICE

The major components not produced by DOK-ING such as engine and hydraulics are produced by large, international firms thus ensuring long-term availability of spare parts. We have our own in-house service capabilities and can send a team at short notice to any location in the world. We maintain adequate stocks of parts on our premises – both those produced by DOK-ING and outsourced ones.

SAFETY

The MV-20 is operated by remote-control from a safe distance, from the protection of the armoured support vehicle, or behind solid structures. In over 7 years of operation with MV machines, no injuries have ever been suffered by either DOK-ING operators or other personnel, or by any other persons in areas cleared by our machines.

OPERATION

The MV-20 is extremely simple to operate by remote control. Our experience has shown that most people can learn within a period of several days to operate the machine.



Control Console

TRANSPORT

The MV-20 can be loaded onto a flat-bed trailer and transported without the need for any special permits or police escort.



Portable Console

DOK-ING MVD Mini Dozer

Vjekoslav Majetić³⁴, Damir Štimac³⁵

The MVD Mini Dozer is designed as a very low profile remote controlled machine for multiple use such as; underground mining application, building and construction industry, military and defence missions. Because of its low profile, and remote controlled operation it is suitable for multi purpose tasks and missions.

Based on the South African mining sector expressed need for a small machine, it was initially designed for operations of cleaning slopes after blasting. The operating tool for digging and pushing in front of machine was designed as a dozer blade. It is controlled by a single operator using a simple and convenient hand controller.



MVD Mini Dozer

The MVD Mini Dozer system weights around 4 tons, and the tests and evaluations in South African mines have showed that the machine is capable of handling a 20 tons of ore per hour, which means that the productivity has been increased by seven times, and in the same time it is greatly increasing the safety of mineworkers.

Strict requirements have been set in the development of this machine, such as: intensive use in the most severe working conditions, ability to work in extremely high temperatures, high performance, modular design, lowest possible maintenance requirements, and environmental protection.

The machine has been developed exclusively according to real demonstrated requirements and user needs for maximum performance and versatility. Because of its dimensions, very good maneuverability, high engine power, and low track-ground pressure, the MVD Mini Dozer

can work year round in almost all conditions. The MVD Mini Dozer is easily accessible for inspection, maintenance, trouble-shooting, repair and/or replacement. Maintenance and repairs can be carried out on the field or in workshop conditions. The tools required for repairs and maintenance are standard wrenches and some specially modified tools.

The major components not produced by DOK-ING such as motor and hydraulics are produced by large, international firms thus ensuring long-term availability of spare parts. We have our own in-house service capabilities and can send a team at short notice to any location in the world. We maintain adequate stocks of parts on our premises – both those produced by DOK-ING and outsourced ones.

The MVD Mini Dozer is extremely simple to operate by remote control. Our experience has shown that most people can learn within a period of several days to operate the machine.

The main functional characteristics of MVD Mini Dozer:

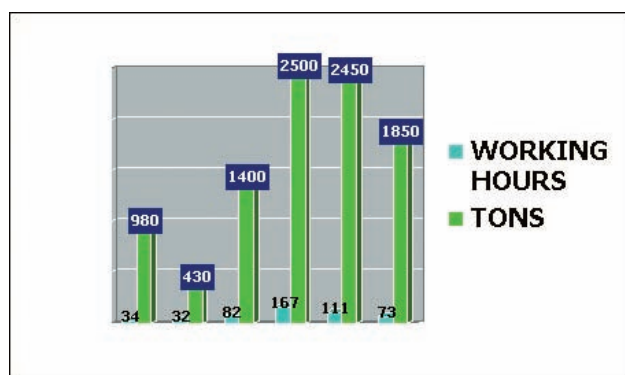
- Original design & construction based on extensive experience and study of user needs,
- Sound technology based on an integral approach,
- High mobility and flexibility,
- Safety of personnel,
- Cost-effectiveness and rationalism,
- Excellent efficiency and productivity,
- Low operating and maintenance cost



Townland Anglo Platinum Mine – 500 m bellow ground level

³⁴ DOK-ING Ltd., Croatia, E-mail: majetic@dok-ing.hr

³⁵ DOK-ING Ltd., Croatia, E-mail: d.stimac@dok-ing.hr



Test and evaluation program conducted at the Townlands Anglo Platinum Mines in South Africa during 2004 have resulted in 9,610 tons of ore pushed in 500 working hours, while the MVD Mini Dozer was working just in one shift, and with 40 – 50% of it's capabilities.

Basic technical characteristics of MVD Mini Dozer

1.	Dimensions Prime Mover (L x W x H) mm	2600 x 1380 x 830
2.	Dimensions with tool	3480 x 1600 x 830
3.	Weight with tool	4150 kg
4.	Engine	DEUTZ DIESEL 3100 ccm, 4 cylinder
5.	Power rating	88 HP at 2800 rpm
6.	Electrical system	24 V head lamps, tail lamps
7.	Fuel capacity	45 l
8.	Fuel consumption	6 - 12 l/hour
9.	Hydraulic oil	110 l
10.	Propulsion	Hydro static
11.	Drive train	Track driven
12.	Travelling speed	0 - 3 km/h
13.	Working speed	0.3 – 1.2 km/h
14.	Clearance	13 cm
15.	Productivity	20 t/h
16.	Chassis	20 mm steel plate
17.	Armor	10 mm shrapnel resistant plate
18.	Crew	1 operator via remote control
19.	Data communication	FSK – 433 MHz
20.	Lights	34 LED – 7000 mcd

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SWEDEN

Tel: +46/225-537-42
Fax: +46/225-526-60
Mobile: +46/70/6453-742

lennart.berglund@scanjack.com



Mandaličina 21, 10109 Zagreb,
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Tel: +385/1/3756-795
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Dr. Mile Budaka 1
HR-35000 SLAVONSKI BROD
Republic of Croatia

tel: +385.35 / 218.219
fax: +385.35 / 218.824
e-mail: dgrbac@ddsv.hr



Zaštitni prsluk protiv krhotina model BOROVO B-1

Zaštitni prsluk protiv krhotina, model BOROVO B-1, projektiran je da putem aramidskih paketa zaštićenih poliamidnom gumiranom tkaninom od utjecaja vlage i sunčeve svjetlosti te smještenih u vanjski nosač, pruži zaštitu od krhotina gornjem dijelu torza, bočnim stranama tijela i vrata. Zaštitni prsluk je ispitan u ovlaštenom ispitivaštu u SR Njemačkoj po NATO normi STANAG 2920, pri brzini simulacijskih krhotina od $V 50 = 480 \text{ m/s}$ za što posjeduje valjani certifikat. Zaštitni prsluk se izrađuje u pet standardnih veličina S, M, L, XL, XXL.

Prosječna težina prsluka iznosi 3,4 kg. Zaštitni prsluk namijenjen za korištenje u vojnim postrojbama kao i za razminiranje miniranih površina. Prsluk se lagano oblači i skida zahvaljujući Velero vezama.

Shrapnel-proof jacket model BOROVO B-1

Flak jacket model BOROVO B-1 is designed to protect the upper part of the body, flanks and neck against shrapnel via aramide packages, situated in exterior brace and protected with polyamide rubberised fabric against damp and sunlight. A protective vest has been tested in the registered facility in the FR of Germany in compliance with NATO standard STANAG 2920, under the speed of simulation shrapnel of $V 50 = 480 \text{ m/s}$ for which it was given the valid certificate. The jacket is made in five standard sizes S, M, L, XL and XXL. Its average weight is 3,4 kg. The vest is intended to be used by armed forces and to be worn during mine clearance. Thanks to Velcro fastenings it can easily be put on and taken off.

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Borovo

Ulica dr. A. Starčevića b.b.,
32010 VUKOVAR-CROATIA
Tel: ++385/32/422-600, 422-630
Fax: ++385/32/422-630
e-mail: borovo@zg.tel.hr
www.borovo.hr

Ulica dr. A. Starčevića b.b.
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Zaštitni balistički prsluk model BOROVO B-2

Zaštitni balistički prsluk, model BOROVO B-2, projektiran je da putem aramidskih paketa zaštićenim poliamidnom gumiranom tkaninom od utjecaja vlage i sunčeve svjetlosti te smještenih u vanjski nosač, pruži balističku zaštitu razine III A (prema normi NIJ 0101.03) za gornji dio torza, bočne strane tijela, vrat i genitalije.

Prsluk se može brzo navući i svući zahvaljujući Velero vezama preko bokova i ramena. Na prednjoj i stražnjoj strani prsluka izrađeni su džepovi za smještaj keramičkih ploča čijim se umetanjem diže balistička otpornost tako zaštićene površine na razinu III i IV prema normi NIJ 0101.03. Zaštitni prsluk se izrađuje u pet standardnih veličina S, M, L, XL, XXL. Prosječna težina prsluka (bez keramičkih pločica) iznosi 5,2 kg. Zaštitni prsluk je ispitan u ovlaštenom ispitivaštu u SR Njemačkoj i ima valjani certifikat. Prsluk je namijenjen za korištenje u policijskim i vojnim postrojbama te u zaštitarskim tvrtkama.

Bullet-proof vest model BOROVO B-2

A bullet-proof vest, model BOROVO B-2 is designed to protect the upper part of the body, flanks, neck and genitals, against ballistic impact of III A grade (according to NIJ 0101.03 standard) via aramide packages, situated in exterior brace, and protected with polyamide rubberised fabric against damp and sunlight. The vest can easily be put on and taken off, thanks to Velcro fastenings that go over hips and shoulders. On the front and back side of the vest there are pockets for ceramic plates the insertion of which raises the ballistic resistance of the area protected in such manner to the III or IV level according to the standard NIJ 0101.03. The bullet-proof vest is made in five standard sizes S, M, L, XL and XXL. The average weight of the vest (without ceramic plates) is 5,2 kg.

The protective vest has been tested in the registered facility in the FR of Germany and has a valid certificate. It is Intended to be used by the police, armed forces and security agencies.



Sisak-44000, A. Kovacica 10, CROATIA
Phone: ++385 44 554 132, Fax. ++385 44 554 132
e-mail: npavkovic@hcr.hr

With its testing capacity (test sites and equipment) and highly professional staff, the Center offers the following services:

- testing and accreditation of demining machines
- testing and accreditation of mine detection dogs
- testing of metal detectors
- testing of demining methodologies, technologies and equipment
- training of work site managers, demining teams, project developers and quality assurance officers
- training and issuing certificates for the use of Minelab and Ebinger metal detectors
- organizing workshops, conferences and other gatherings on the subject of mine action
- preparation for introducing quality management in demining companies as per ISO 9001:2000
- lease of test sites
- implementation of research and development projects in the field of mine action
- field testing and evaluation of technologies used for mine contaminated area detection and mine suspected area reduction
- scientific and professional cooperation with national and international institutions.