	LANDMINE CLEARANCE TEST FACILITY	WTD 51

Koblenz: 15.01.2001

Summary report

Planned object:	Mechanical Mine Clearance device
Identification Nr.:	2350-14390
Manufacturer:	Fa. MaK
Model:	RHINO
Project Nr.:	E/K43A/00059/Q5204
Task:	Establishment of mine test lanes in two distinctly different types of soils and execution of clearance trials.

Report:		Pages:	62	Pictures:	24	Tables:	41
Author:	TRAR Theimer	Dept:	230	Phone:	19 73		

Main Outcome: Since the RHINO did not maintain a constant clearance penetration depth of 30 cm, an ATM was run over without being touched. In clayey soil the tiller efficiency is much reduced.

(Signature)

Remarks:

Mailing List:
BWB - KG IV 3 3x
WTD 51 - 230 1x

Translation into English: M. Garotta, ITEP Secretariat

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1. Task definition

The army requires a mine clearance device that is able to clear in a fast and safe way known minefields or areas suspected as mine-affected, in environments requested to be used as water treatment areas, airfields, and camps.

In the context of a trial the clearance efficiency (and safety) of COTS (commercial of the shelf) mine clearance devices from different types and manufacturers under equal conditions shall be compared.

In principle, the following works will be conducted:

- Definition of a test program for the assessment of the clearance efficiency
- Development of a plan for the placement of mines and the supply of surrogate mines.
- Execution of terrain survey
- Execution of a soil analysis
- Marking of the area for pre-trials and clearance trials
- Placement of surrogate mines according to the mine distribution plan
- Execution of the pre-trials and clearance trials in two distinctly different types of soil.
- Establishment of technical data
- Measurements of the vibration
- Transportability of the device
- Assessment of the results and evaluation of the destruction capacity of the mines
- Documentation of the results

- The definition of assessment criteria including the formulation of a proposal for the development and purchase of a device, which was discussed among the purchaser, the manufacturer, and WTD 51, will not be object of this report.

2. Test fields and time frame of trials

2.1. Test fields:

1. Test field: WTD 91, Meppen (Hufeisenwall) (Military Technical Centre)

2. Test field: Standortübungsplatz Schmidtenhöhe (StOÜbPl), Koblenz (Military Training Area)

2.2. Time frame:

Preparation for the trial:	25. -39. week 2000
Execution of the trial:	see Annex 1 (Work Plan status as of 26.09.2000)
Clearance results:	42. - 52. week 2000

3. Brief description of the Rhino

(see Annex 15 picture 1 to 6)

The mine clearance device RHINO consists of an unmanned tracked vehicle, a specific tiller device and a mobile control station. The system operates by remote control and has two cameras mounted at the front and one at the rear of it. A Caterpillar Diesel engine powers the tracked vehicle.

The tiller unit consists of two hydraulically-driven tiller drums turning in opposite directions. The tiller drums are equipped with changeable Wolfram-Carbide chisels.

The excavated soil is carried through the drum between a loop of about 3 cm, so that all the mines get detonated or mechanically broken.

Picture 1

Manufacturer: Fa. MaK
Falckensteiner Str. 2
24159 Kiel

4. Execution of the trials

4.1. General

Since commercially available mine clearance devices were being tested in order to compare their clearance efficiency, almost equal test conditions for all the devices had to be created.

The following requirements were satisfied:

- Nearly equal soil types
- Nearly equal terrain slopes
- Equal pre-trial test lanes and mine test fields

The trials were conducted in comparable weather conditions.

Since the trials had to be executed in two completely different soil types, they were conducted on soil with a very high sand content in the WTD 91 in Meppen and on soil with high clay content on the StOÜbPl in Koblenz.

The results of the detailed soil surveys, showing almost equal soil conditions, are attached as Annex 2.

On both soil types, pre-trials and clearance trials were conducted. The RHINO was operated by staff from the manufacturer. During the pre-trials it was remotely controlled by the operator walking in front of the machine, whereas during the clearance trials it was remotely controlled through the control station.

During the trial the following security distances given by the manufacturer had to be kept:

Nr.	Mine clearance device	Side	Front	back
1.	RHINO	5m	25m	25m

4.2. Pre-trials

During the pre-trials the mine clearance device in object covered a distance of 150m. The installed ground penetration depth that the tiller system had to maintain had to be at least 30cm.

Next to the needed time, the clearance width and depth were determined.

The pre-trials were conducted in the same way on the WTD 91 and on the StOÜbPl Schmidtenhöhe in Koblenz.

The area of WTD 91 is almost plain with grass and moss-rose vegetation.

The grass area of the StOÜbPl Schmidtenhöhe shows limited changes in terrain topography along and across the test lanes. Annex 3 (diagram) shows a representation of the test field topography along the test lane.

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4.3. Clearance trials

4.3.1. General

At the clearance trials a test lane was given to the manufacturer. The test lane was composed of a starting track, the mine test fields I to III, and an ending track. The device was positioned at the beginning of the starting track and had to work all through the test lane. The clearance process was always conducted in one direction. As the test lane had been covered, the vehicle drove back in the same lane, placed itself in front of the test lane and cleared the next part of the test lane overlapping with the already cleared track and then cleared the next track. In doing so, the company chose an overlapping of about 50 cm.

The device had to reach at least a flailing depth of 30 cm. The prepared clearance lane at WTD 91 is provided in Annex 4, whereas the one at StOÜbPl Schmidtenhöhe in Annex 5.

The topography along the test lane on the StOÜbPl Schmidtenhöhe is visible in Annex 6 and the crosswise slope in the context of the mine test fields amounts to:

Field 1	RHINO, Fa. MaK	4,7° to 5,2°

4.3.2. Mines

On the test field of WTD 91 the mines were distributed according to the distribution plan as in Annex 7, and on the StOÜbPl Schmidtenhöhe according to the mine distribution plan as in see Annex 8.

In the following table the mines distributed in the test field of WTD 91, in Meppen and in the one of StOÜbPl Schmidtenhöhe are listed.

Name	Type	Quantity		Comments
		WTD 91 Meppen	Schmidtenhöhe Koblenz	
Anti-personnel blast mines	DM 11	20	0	
	DM 18	0	14	
	PPM-2	15	14	
Mine fuse	DM 56 A1 B1	5	3	With trip wire
Anti-personnel fragmentation mines	DM 31	5	5	
Anti-tank mines	DM 21	5	5	
	TM 62P3	5	5	

See Annex 15 picture 13 and 14

For the clearance trials blast surrogate mines were used. In the weapons arsenal of WTD 91 the explosive content was taken out of the mines and was replaced by non-explosive material.

(see Annex 16).

In order to understand if the mines' fuses were initiated by the clearance vehicles, the mines in the WTD test field were prepared as follows:

- Anti-Tank blast mines surrogate — DM 21 with blast indicating (black powder) TM 62P3 with fuse chain
- Anti-personnel blast mines — DM 11 with detonator PPM-2 with detonator
- Anti-personnel fragmentation mines — DM 31 with propelling charge
- Fuse for tripwires — DM 56 A1B1 with additional detonator

For the trials on the StOÜbPl Schmidtenhöhe test field, inert mines were employed.

The tripwires used for the trials at StOÜbPl Schmidtenhöhe were connected to live fuses, which produced small amounts of smoke at initiation.

5. Results

5.1. Technical data

The most important technical information about the machine and the clearance device are listed here after:

Data on the machine:

	RHINO Fa. Mak
Measurements working position	
Length	10110 mm
Width	4100 mm
Height	3150 mm
Weight	58 t
Transportation details	
Length	10110
Width	3500
Height	3150
Velocity	3,8 km/h
Dismantling for Transport	Not needed
Engine capacity	650 kW

Technical clearance data

The technical clearance data of the mine clearance device are listed in Annex 9.

5.2. Pre-trials

WTD 91 Meppen

The vehicle took the following listed time to cover a distance of 150m:

RHINO, Fa. MaK: 15 min

The clearance width corresponds to the data given by the manufacturer.

The trials of the clearance depth (see Annex 15 picture 18), tested by carrying out spot checks, showed the following results:

RHINO, Fa. MaK: 30, 21 and 27 cm

The presented device had no traction problems.

Due to damage at the track of the RHINO vehicle the direction of the moving track had to be corrected various times.

Schmidtenhöhe Koblenz

The vehicle took the following listed times to cover a distance of about 160 m:

RHINO, Fa. MaK: Lane 1 = 19 min
Lane 2 = 16 min

The clearance width corresponds to the data given by the manufacturer.

The clearance depths are represented in the sketch of Annex 10 .

The RHINO, Fa. MaK had traction problems. Its tracks slipped repeatedly during the trial. During the pre-trials the vehicle drifted down on the slight crosswise slope, so corrections were repeatedly needed.

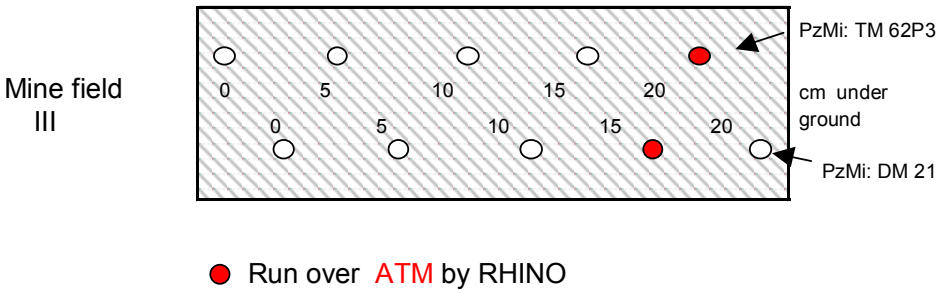
5.3. Clearance trials

The needed clearance time frame and conditions for the trials at WDT 91 and for the trials at StOÜbPl Schmidtenhöhe, Koblenz are attached as Annex 12 and Annex 13 respectively.

Mine search

After the end of each clearance trial all remaining on-surface mines and mine fragments were collected.

During the search for AT-mines, an intact TM 62P3 and an almost intact DM 21 were found inside the mine test field.



Picture 1

In order to search for remaining mine fragments, a rock collector to sieve the ground was used.

The description of the mine collection process using a rock collector (see Annex 15 picture 31 and 32) and the evaluation of the remaining mines and components after the clearance trials done by WDT 91 – 360, are attached: Annex 16.

In the context of the trial the critical mines found are represented in Annex 15 picture 19 and 20..

In order to assess the clearance depths, the mine fields were surveyed. The results are represented in Annex 14.

5.4. General observations:

Depending on the soil composition the RHINO carries small to large amounts of soil (see Annex 15 picture 21, 22 and 23) in front of it, leaving it behind in a bank at the end of the test lanes. Since not initiated mines may be hidden in this part of the soil, the soil bank must be tilled afterwards, perpendicular to the test lane (see Annex 15 picture 24).

The clayey soil of the Schmidtenhöhe stuck to the lower tiller drum so that the teeth heads were visible only for 2 to 3 cm This limited the clearance efficiency. The upper tiller was because of the higher rotating velocity free of soil (see Annex 15 picture 13 to 15). The tiller condition after the trial on the WTD 91 in Meppen is shown in Annex 15 pictures 10 to 12.

During the clearance process, soil parts are pushed to the side of the tiller system. Since undetonated mines may be found in these parts of soil, it is needed to clear these parts twice by overlapping. Moreover, the soil parts left to the side cause errors in the measurements obtained with the depth feelers. The feelers, present at each side of the unit, capture through pre-programming always the most negative value. As a consequence of the excavated soil from the two tiller drums, left at the sides, and by simultaneously passing with the feelers, a higher clearance depth may be indicated than the one that was really obtained. . As a result, deeper buried mines may be missed (see Annex 15 picture 25).

Shifting the vehicle during the clearance process is not possible. If the vehicle drives off the track (see Annex 15 picture 26), it has to be stopped, the tiller unit has to be lifted from the ground and it has to be moved back in order to restart the clearance process.

Operation: The operating of the RHINO is done without any problems through remote control at close distances (see Annex 15 picture 27), whereas the operation through monitors from the armoured control station needs lots of experience. The sun can limit the view of the monitor severely (see Annex 15 picture 28 and 29).

5.5. Test lanes after the clearance process

The conditions of the test lanes and of the moving tracks after the clearance trials are shown in the pictures hereafter:

RHINO (see Annex 15 picture 7 to 9)

5.6. Transport

The transportation between work sites: WDT 91, Meppen to StOÜbPl Schmidtenhöhe, Koblenz was done by a civilian transport company (see Annex 15 picture 30). Because of the dimensions and the heavy weight of the RHINO, its transportation on the Heavy Load Truck, used in the Bundeswehr is not possible. The transportation is only possible by specific civilian heavy load trailers.

5.7. Preparation for clearance

After the transportation of the vehicle, the following arrangements have to be completed, in order to have the machine ready for clearance.

Mounting of the depth feelers on both side of the tiller unit.

Opening of the radome on the upper part of the vehicle

Mounting the transmitter - / receiver unit in the neighbourhood of the mobile control station.

Time needed about: ca. 2,00 h

6. Summary

The mine clearance device RHINO, Fa. Mak was able to cope very well with the given clearance objectives in sandy soil.

The RHINO destroyed surface laid as well as buried mines with the tiller and detonated them by contact.

In clayey soil the machine's lower tiller drum clogged so that the teeth heads were merely visible. As a consequence the soil was pushed forward in front of the vehicle and not treated. This caused an AP-fragmentation mine DM 31 to be missed.

The required clearance depth of 30 cm was not maintained, neither in sandy nor in clayey soil. In clayey soil, an AP-mine DM 21 buried at 15 cm depth, was only slightly damaged at its upper part and a Russian AP-mine TM 62P3 buried at 20 cm depth was left untouched.

The operating of the system from the control station needs lots of experience.

Annex 1

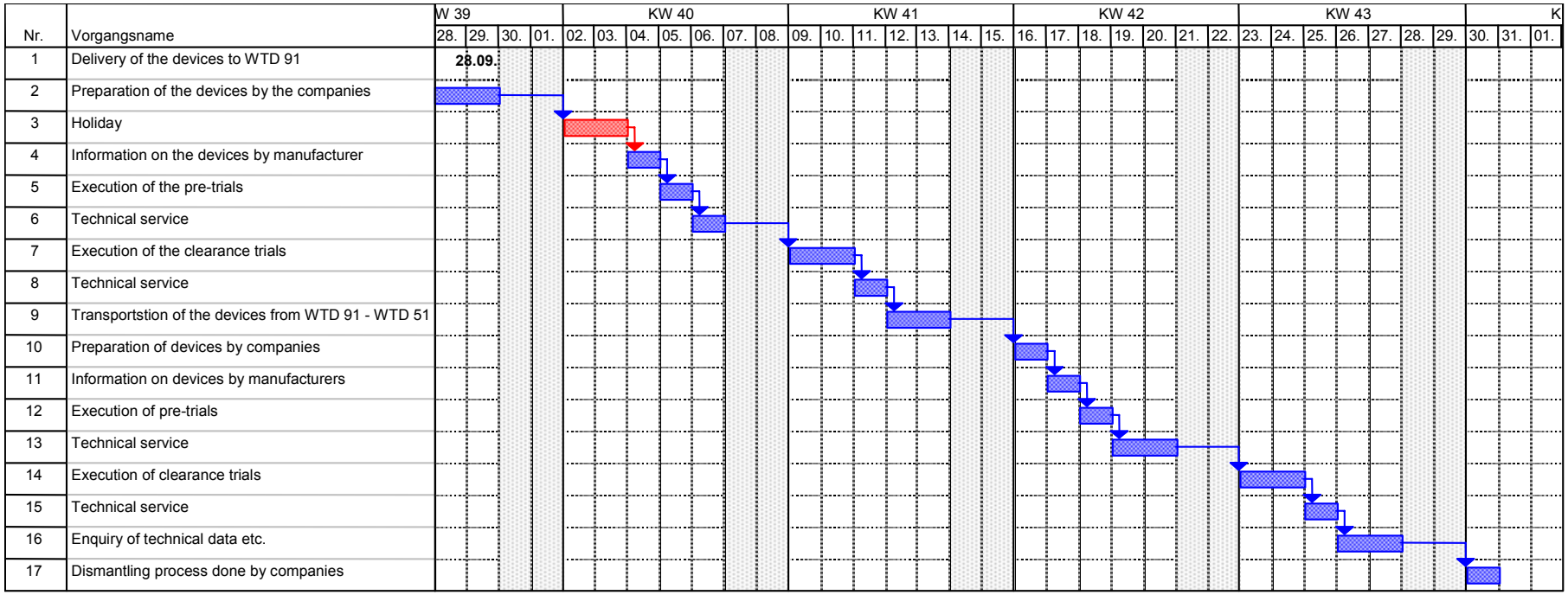
WTD 51 - 230

Koblenz, 26.09.2000

Trial of mine clearance device

Schedule from 28.09. to 30.10.2000

Legend: Nr. 1, 9 and 17 Transportations
Nr. 2 to 8 Trials at WTD 91 in Meppen



Nr. 10 to 16 Trials at Schmidtenhöhe in Koblenz

	WEHRTECHNISCHE DIENSTSTELLE FÜR PIONIER- UND TRUPPENGERÄT - LABOR FÜR BODENMECHANIK -	WTD 51

Koblenz, den 04.12.2000

Laborbericht

Berichts-Nr. : 12/00

Vorhaben : Bodenuntersuchungen Minenräumgerät

Auftrag : WTA - Nr.: Q/K43A/00059/Q5204
WTD 51 - 230

Aufgabe : Untersuchung von 16 Testbahnen auf ihre Kornverteilung
(Siebung und Schlämmung) und bodenmechanischen Eigenschaften

Bearbeiter : TROS Schlemmer **Org.-Einheit:** Dez 230

Telefon

Öffentliches Netz : (0261) 400-1999/1981

AllFspWN Bw : 4424-1999/1981

Berichtsumfang Seiten : 246

Im Auftrag

Schlemmer

Bemerkungen:

Verteiler:
WTD 51-230 2x

1 Work description

Assessment of soil characteristics of 2x8 test lanes on two mechanically different soil types.

Assessment of the test lanes on their grain size distribution and mechanical soil characteristics. The scope of these analyses was the creation of 2x8 homogenous test lanes for the choice of four mine clearance devices on two mechanically different soil types.

2 Execution of the trials

The trials were executed in the test field (WTD 91, Meppen and StOÜbPl Schmidtenhöhe, Koblenz) and in the laboratory of the WTD 51.

In the field the following trials were executed:

Survey according to DIN 4094,

Soil drilling according to DIN 4021,

Determination of the soil compactness according to DIN 18125 part 2

Laboratory tests:

Determination of the grain size distribution according to DIN 18123,

Determination of the flow and rolling borders according to DIN 18122,

Determination of the water content according to DIN 18121 part 1

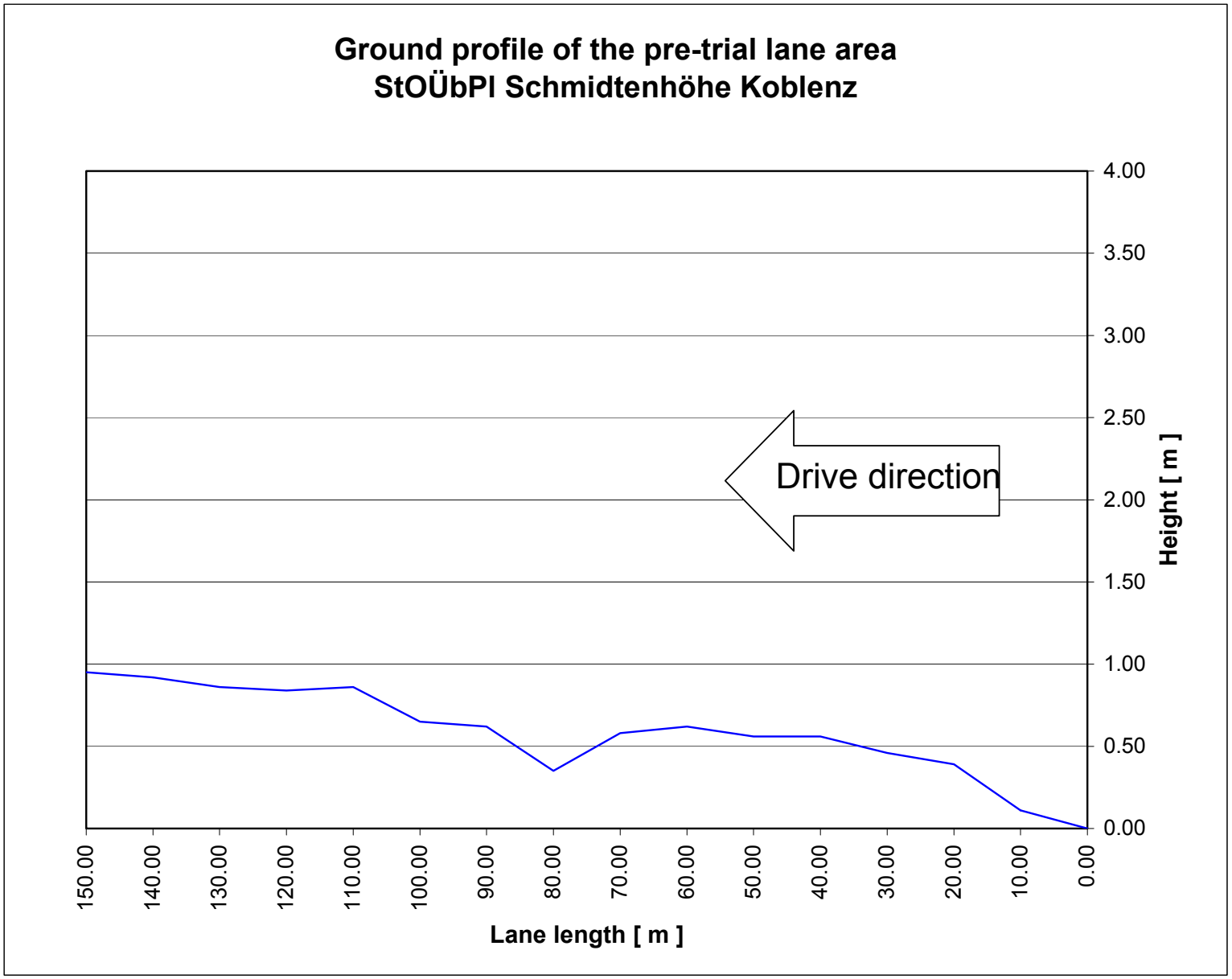
3 Summary of the results

The analysed soil of the 4 test lanes (for the clearance trials) and of 4 test lanes at WTD 91 in Meppen (for the pre-trials) can be described as a homogenous sand having silt and clay content. The silt and clay contents are very little and therefore irrelevant. The soil compactness and the soil water content were almost on all test lanes identical.

The analysed soil of the 4 test lanes (for the clearance trials) of the StOÜbPl Schmidtenhöhe, Koblenz can be described as a homogenous soil having clay, sandy and gravelly characteristics. The soil compactness and its soil water content were almost on all 4 test lanes (for the clearance trials) the same. The soil of the 4 test lanes for the pre-trials was sandier and more gravelly, with from time to time stony clay.

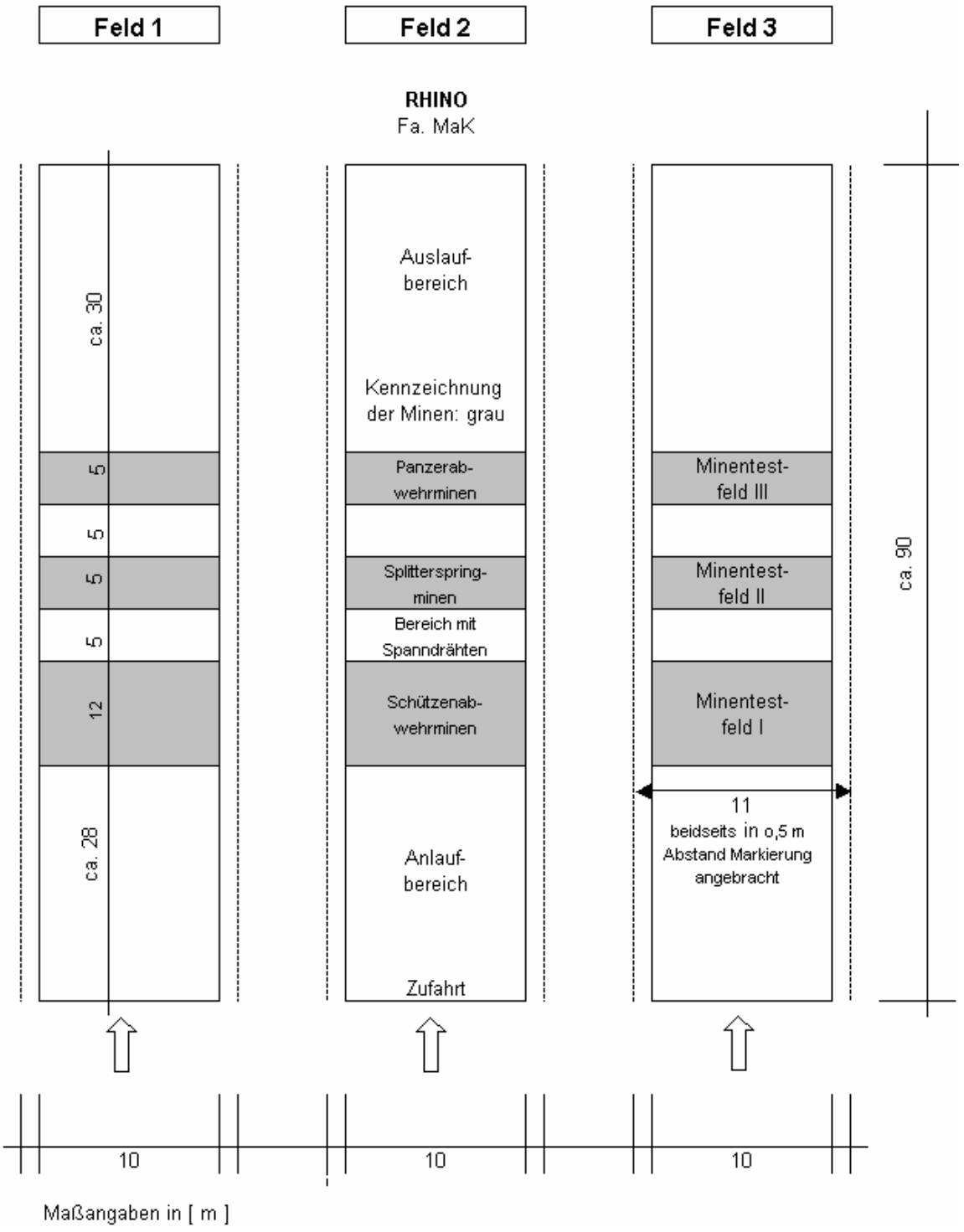
Summarising, the results clearly show that the soil properties, grain size distribution as well as mechanical characteristics, on both test fields WTD 91 Meppen and StOÜbPl Schmidtenhöhe, Koblenz, were for all 4 devices identical, so that from the soil mechanics point of view, the devices were tested under the same operating conditions.

Annex 3


Ground profile of the pre-trial lane area
StOÜbPl Schmidtenhöhe Koblenz
Drive direction
Height [m]
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
150.00
140.00
130.00
120.00
110.00
100.00
90.00
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
Lane length [m]

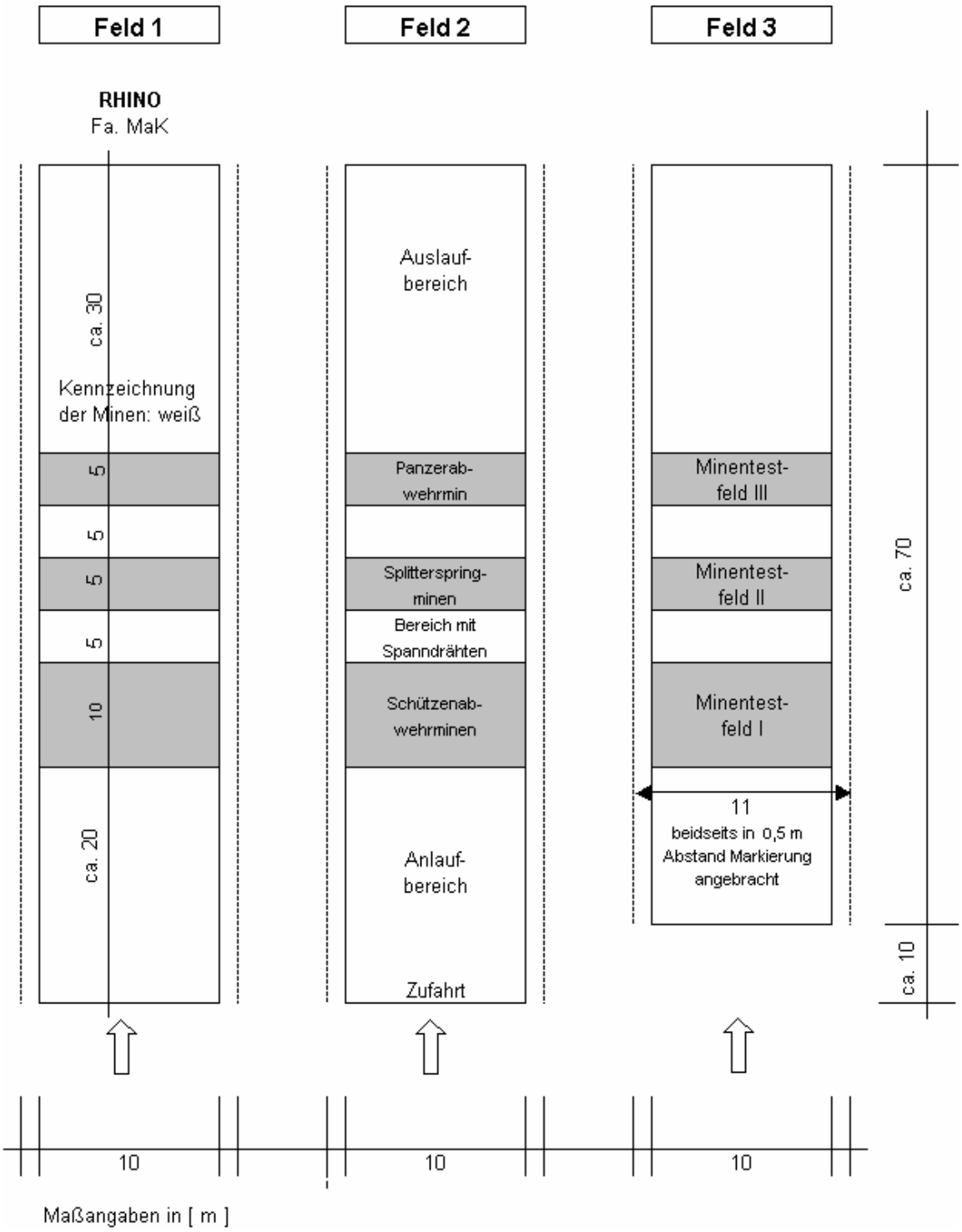
WTD 51-230 Koblenz, 26.09.2000

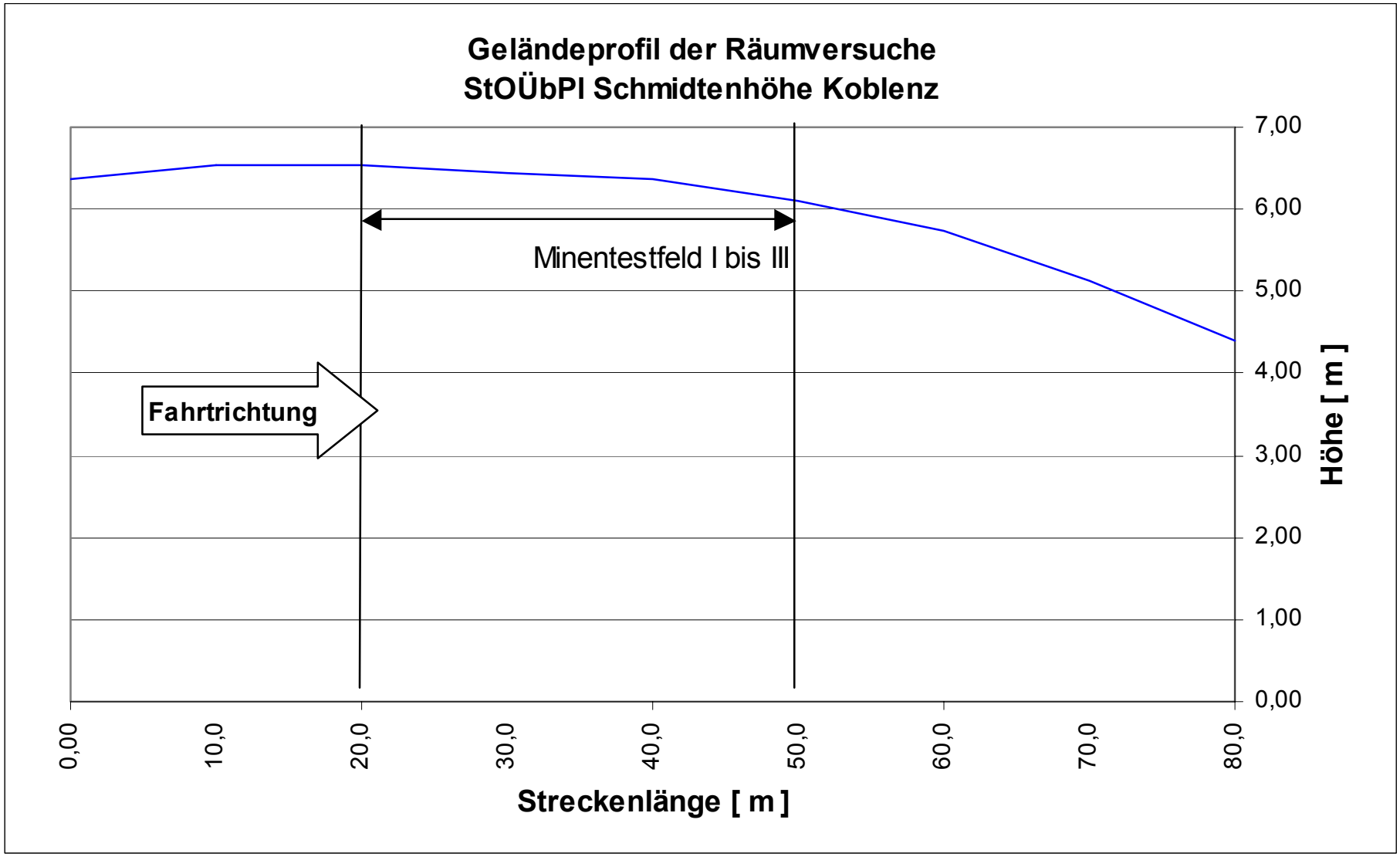
Teststrecke für Räumversuche
WTD 91, Meppen



WTD 51-230 Koblenz, 26.09.2000

Teststrecke für Räumversuche
StOÜbPl Schmidtenhöhe, Koblenz



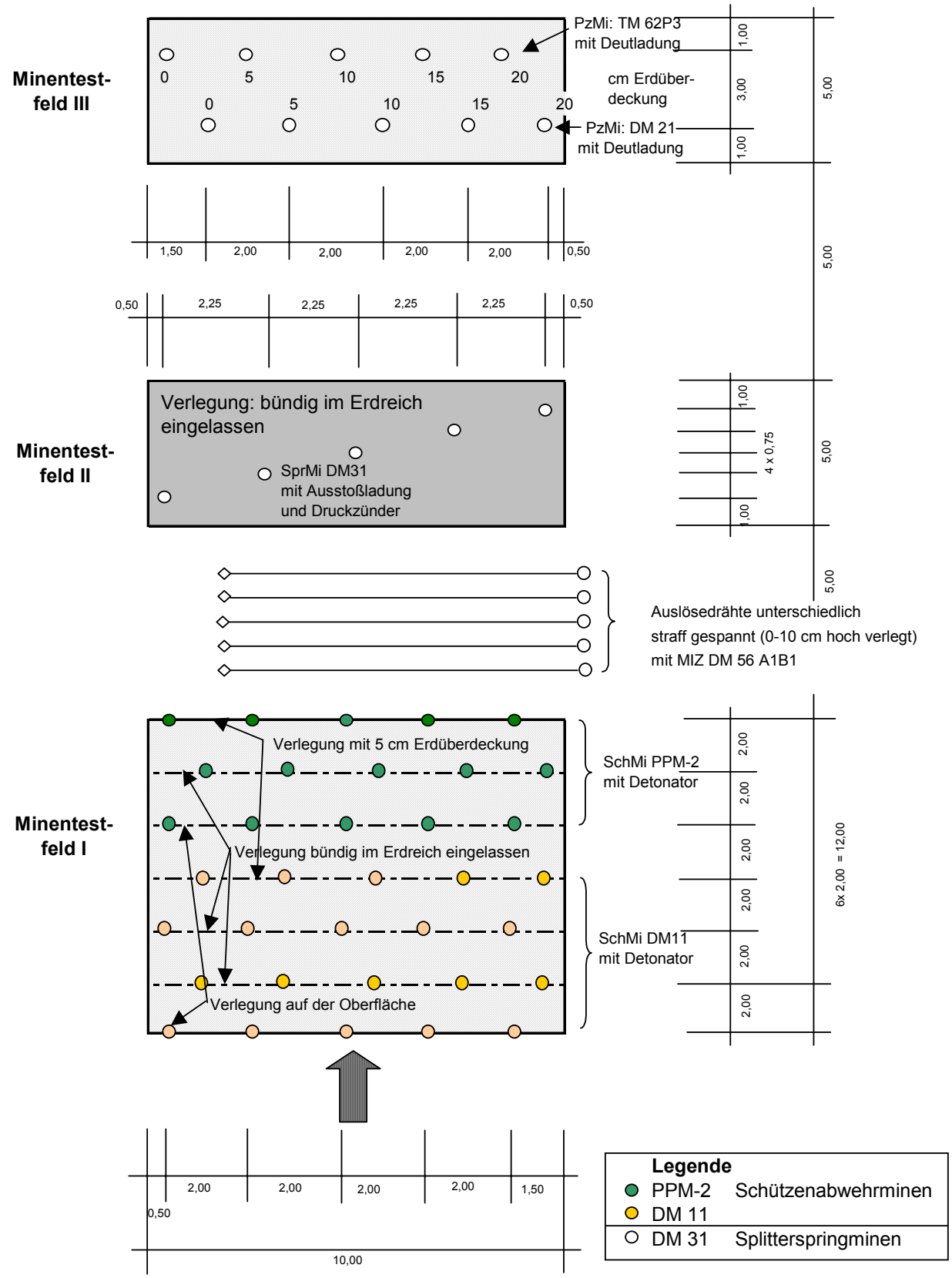

Geländeprofil der Räumversuche
StOÜbPl Schmidtenhöhe Koblenz
Minentestfeld I bis III
Fahrtrichtung
7,00
6,00
5,00
4,00
3,00
2,00
1,00
0,00
Höhe [m]
0,00
10,0
20,0
30,0
40,0
50,0
60,0
70,0
80,0
Streckenlänge [m]

Annex 7

WTD 51-230 Koblenz, 09.10.2000

Minenverlegeplan

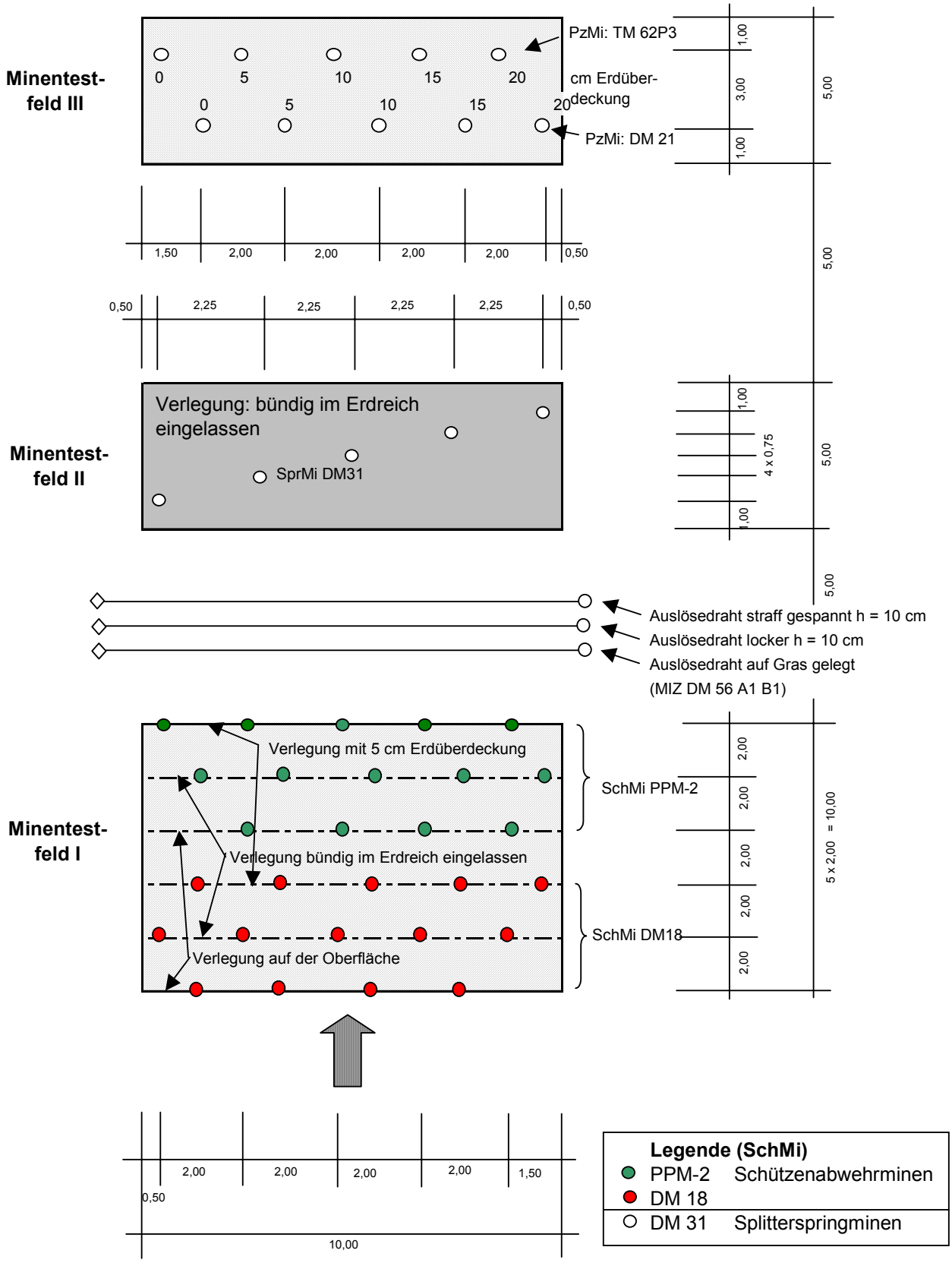
WTD 91, Meppen



WTD 51-230 **Koblenz, 26.09.2000**

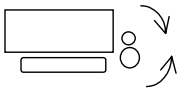
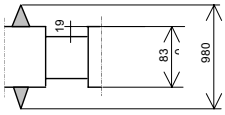
Minenverlegeplan

StOÜPl Schmidtenhöhe, Koblenz



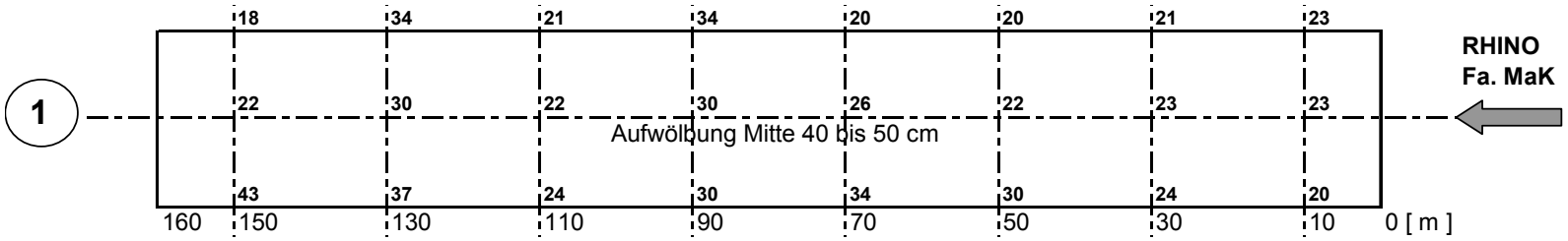
230 **Koblenz, 27.10.2000**

Technische Räumdaten

	RHINO **Fa. MaK**
Räumprinzip	Fräsen 2 Walzen
Bedienung	über Funkfern- steuerung
Reichweite Funkfernsteuerung	ca. 1000 m
Drehrichtung	
Walzen-durchmesser	980 mm untere W. 830 mm (mit Steg) -19 mm  500 mm obere W. 357 mm (mit Steg) -19 mm
U/min	30 - 120 untere W. 400 - 600 obere W.
Anzahl Fräsköpfe/ Schlegel	180 obere Walze 360 untere Walze
	RHINO **Fa. MaK**
Räumbreite	3,50 m
Räumtiefe	10 - 50 cm
Räumgeschwindig-keit/Räumleistung	4550 m²/h theoretisch 2000 m²/h in Kroatien
dynamischer Spalt	ca. 3 cm

230 **Koblenz, 20.10.2000**

Vergleichserprobung Minenräumgeräte Schmidtenhöhe Koblenz
Vorversuche: Frästiefen in cm



Measurements of the vibration

No vibration measurements were conducted for the RHINO, since the vehicle clears mines through remote control.

230 **Koblenz, 30.10.200**

Räumzeiten/Randbedingungen bei WTD 91, Meppen

	Fa. MaK RHINO
Datum	09.10.00
Beginn Uhrzeit	13.50
Räumzeit für 1. Spur [min]	11
Gesamtzeit [min]	85
Räumstrecke Länge/Breite [m]	90/10
Wetter-bedingungen	sonnig, trocken
Temperatur [°C]	12 - 13
Farbe der Minen	rot

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Picture 1

RHINO

Overall view, front left

Picture 2

RHINO

Overall view, rear left

Picture 3

RHINO

Control station

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Picture 4

RHINO

During the clearance process

Picture 5

RHINO

During the clearance process

Picture 6

RHINO

During the clearance process

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Picture 7

Moving tracks of RHINO

Picture 8

Moving tracks of RHINO

Picture 9

Moving tracks of RHINO

Picture 10

RHINO

Condition of the tiller drums after the trials on WTD 91

Picture 11

RHINO

Condition of the tiller drums after the trials on WTD 91

Picture 12

RHINO

Condition of the tiller drums after the trials on WTD 91

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Picture 13

RHINO

Condition of the tiller drums after the trials on Schmidtenhöhe

Picture 14

RHINO

Condition of the tiller drums after the trials on Schmidtenhöhe

Picture 15

RHINO

Condition of the tiller drums after the trials on Schmidtenhöhe

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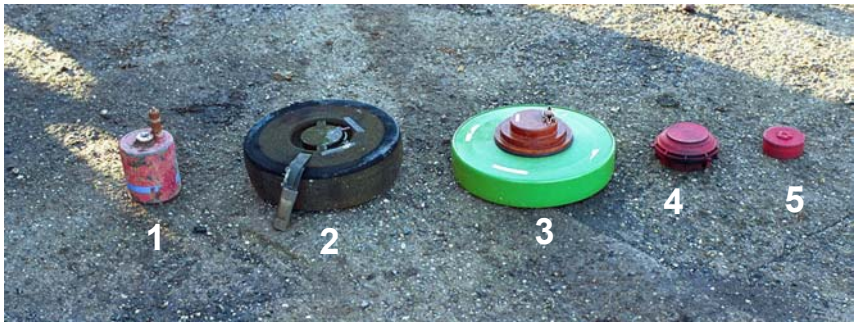
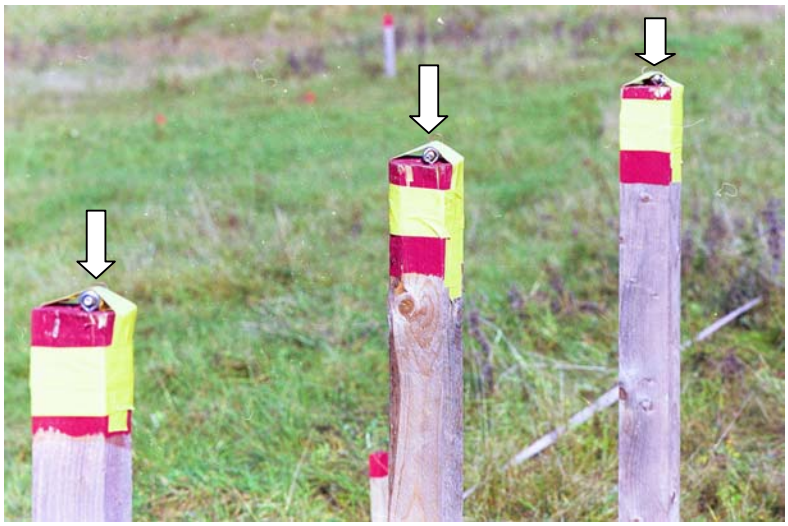


Picture 16

Used mines

1	DM 31	Splitterspringmine
2	DM 21	Panzerabwehrmine
3	TM 62P3	Panzerabwehrmine
4	PPM-2	Schützenabwehrmine
5	DM 18	Schützenabwehrmine



Picture 17

Mine fuses
MIZ DM 56 A1B1

Picture 18

Measurement of
Clearance depth

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Picture 19

Schmidtenhöhe
DM 21 run over by
RHINO

Picture 20

Schmidtenhöhe
TM 62P3 run over
by RHINO

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Picture 21

RHINO

Small soil bank in front of the tiller drum (WTD 91)

Picture 22

RHINO

Larger soil bank in front of the tiller drum (Schmidtenhöhe)

Picture 23

RHINO

Larger soil bank in front of the tiller drum (Schmidtenhöhe)

Picture 24

RHINO

Tilling of the soil bank, perpendicular to the test lane

Picture 25

RHINO

Passing over the soil with the depth feeler

Picture 26

RHINO

Driving off the lane during the clearance process on crosswise slope.

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Picture 27

RHINO

Remotely controlled operation of the vehicle at close distance

Picture 28

RHINO

Remote Control operation system at the control station

Picture 29

RHINO

Monitors inside the control station

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Picture 30

RHINO

Transportation with semi-trailers

Picture 31

Searching of the ground for remaining mines with rock collector

Picture 32

Searching of the ground for remaining mines with rock collector

WEHRTECHNISCHE DIENSTSTELLE
FÜR WAFFEN UND MUNITION
WTD 91

Dezernat 360

Anhang 16

49716 Meppen; den 11.01.2001
Tel. (05931) 43 - 2360
App.:

Ausfertigung	Verteiler
1. - 8.	WTD 51 - 230
9. - 10.	WTD 91 - 360

Bericht Nr.: 34/00/91-360

WTA-Nr.: E/E510/00672/Q5204

Protokoll Nr.:

Prüfgegenstand: Vergleichserprobung von Minenräumfräsen

Aufgabe: Vorbereitung und Bewertung der Räumergebnisse an Panzer- und Schützenminen

Result (summarised version):

The large AT-mines were cleared in Meppen by the mine clearance device in object at 100%.

Most of them initiated during the clearance process.

The AP fragmentation mines with tripwires were all initiated, whereas through the pressure fuse only half of them were initiated. The remaining mines were made harmless through the destruction of the fuse.

For the small AP-mines the proof could not be made completely, but we can assume that the clearance success was almost 100%.

In Koblenz the soil was a lot more clayey. With the RHINO two major failures in the clearance process occurred. Not taking into account this failure the evidence of clearance success for the AP-mines was much better.

Keywords: Mine clearance devices, AT-mines, AP-mines, blast surrogate mines, clearance success.

Königstein

Königstein

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Annexes: Measurement paper 1 - 9 single results in Meppen for Fa. MaK

Measurement paper 10 - 13 single results in Koblenz for Fa. MaK

1 Background:

The WTD 51 – 230 had the task to execute comparative trials of up to 5 different mine clearance devices at two different places with different soil characteristics.

WTD 91- 410 was supposed to choose the terrain in Meppen, to prepare it, to measure it and to follow up the trial.

WTD 91 – 360 had to make available in Meppen partially loaded blast surrogate mines, to prepare them and to evaluate the clearance success on the basis of the uncleared mines and mine fragments found.

For Koblenz inert mines should be prepared to be used in the same mine fields and to be evaluated later on.

2 Preparation of the test fields:

The distribution plan of the AP-mines and the AT-mines was re-elaborated several times and finally used according to the WTD 51 – 230 report.

After the start-up section, 2 different AP-mines were encountered. In Meppen 20 DM11 and 15 PPM-2 mines were deployed. These mines contained only the detonators. (In Koblenz due to restricted availability only 14 + 14 AP-mines could be used).

After that 5 MIZ DM56 A1B1 of the AP-fragmentation mine DM31 followed, which were fixed to wooden sticks and connected with tripwires. All the wooden sticks and the tripwires were collected after the first clearance action. (In Koblenz, only 3 MIZ from each were bound to wooden sticks.)

The 5 AP-fragmentation mines DM31 were buried at slightly varying depths. Their MIZ DM56 A1B1 had to be set off without tripwires, as pressure fuses. These mines contained only the initiation charge.

Later on, 2 series of AT-mines followed, 5 DM21 and 5 TM-62 P3, which had been buried at varying depths up to 20 cm. The DM21 contained the fuse and 100g of black powder explosive charge. The TM-62 P3 contained the whole fuse with about 10g of extra charge.

3 Preparation of the mines:

3.1 Blast surrogate mines used for Meppen:

	prepared	used	remaining
AP-mines DM11 Lot DN-113 Explosive body replaced by wax Detonator about 0,1 g screwed in	79	60	19
AP-mines PPM-2 Lot 06-06-76 and 06-30-77 Explosive body taken out	60	45	15

Detonator, about 1 g employed			
AP-fragmentation mines DM31 Explosive body inert filled S.P.-propelling charge (about 100g) MIZ DM56 A1B1 lot RM-3-81 A	20	15	5
AT-mine DM21 No explosive body S.P.-explosive black powder charge (about 100g) MIZ DM1001 with fuse chain from the lot DIN 1-4 lot	20	15	5
AT-mine TM 62 P3 Lot 06-26-89 No explosive body MIZ MWD-62 loaded (about 10g)	20	15	5

3.2 Inert mines used in Koblenz:

	prepared	used	remaining
AP-mines (EX) DM18 Without smoke charge	59	42	17
AP-mines PPM-2 Completely emptied	59	42	17
AP-fragmentation mines DM31 No explosive charge With inert MIZ DM56 A1B1	20	15	5
AT-mine DM21 No explosive charge With inert MIZ DM1001	20	15	5
AT-mine TM 62 P3 No explosive charge With inert MIX MWD-62	20	15	5

4 Schedule of trials:

10.05.02	Discussion with WTD 51 – 230 with the Meppen WTD 91 – 410 contractor.
12.07.00	Selection of the Russian mines according to their availabilities.
21.07.00	Assignment of partial contract 00672/703.
14.08.00	Start of work with the blast surrogate DM21 mines.
05.09.00	Discussion with WTD 51 –230 and demonstration of the 5 different blast surrogate mines.
13.09.00	Test of the unlocking time of the SchMi PPM-2.
04.10.00	Distribution of the blast surrogate mines in Meppen.
09.10.00	Clearance process with RHINO, Fa. MaK
18.10.00	Search of the sandy, grass-moss and mixed soil with wheeled loader and rock collector.
01.11.00	Photographing mine fragments of the 3 mine fields of Meppen.
07.11.00	Survey and assessment together with a representative of the army.
28.09.00	Transportation of the inert mines to Koblenz.
13.10.00	Distribution of the inert mines on Schmidtenhöhe in Koblenz.
23.10.00	First clearance process done with RHINO, Fa. MaK.
23.11.00	Mission to Koblenz-Rübenach for the survey of the mine fragments from the three mine test fields from Koblenz-Schmidtenhöhe.
24.11.00	Assessment and photographing of the mine fragments in the presence of a representative of the army.

5 Mine clearance trials in Meppen:

5.1 Preparation of the mine test fields:

The test fields had been measured and marked in September 2000 on the grass-moss ground in front of the horseshoe bank.

On 04.10.00, blast surrogate mines were distributed by the Dept. 360 in the mine field, more precisely, 35 small AP-mines, 5 AP-fragmentation mines and 10 AT-mines. These mines were all armed at the moment of deployment due to the time needed for activation, especially the AP-mines PPM-2.

On 09.10.00 5 MIZ DM 56 A1B1 mines were mounted on wooden sticks with tripwires.

These 5 fuses and the 5 MIZ, which had been installed as pressure fuses on DM31 mines, were armed immediately before the clearance trial.

5.2 Clearance process by Fa. MaK

On 09.10.00, in the afternoon the RHINO of the Fa. MaK cleared the 2nd mine field (red colour). The vehicle was controlled remotely, which caused a less controlled moving style, so that the vehicle needed 6 runs. Due to the large amount of soil that was lifted through the different rotating directions of the tiller drums, few initiations of the smaller AP-mines were heard. For details see Measurement Paper 1 + 2. Out of the AP-mines DM31, only 5 initiations were heard.

Out of the 10 AT-mines, 9 initiations were heard.

The deepest buried TM-62 P3 mine was dug out afterwards. It had not been initiated, but had been destroyed by the tiller drum. The fuse cover had been pulled out without being initiated and then the mine had been crushed without producing further reactions. Also this mine has to be considered as a clearance success.

5.3 Searching with mine prodders and spade:

On 16.10.00, the mine field (RHINO) was searched for mine fragments with mine prodders and spade, whereby the ejected body of an APM DM31 and totally destroyed parts of 3 bodies were found (in different places).

The undetonated ATM TM-62 was dug out. It had been tilled without being initiated.

On 17.10.00 a long prodder, instead of the rock collector, was used to search for AP-fragmentation and AT-mines. Nothing was found.

After deployment of the rock collector, all the soil that had been moved and taken away was levelled. By doing so, fragments of PPM-2 and TM-62 P3, together with 1 whole ring case of a PPM-2 (red) were found.

5.4 Sieving with the rock collector:

On 16.10.00 the company Hoogen came with a field tractor and rock collector Grimme CS1700. In the beginning the system seemed to work fine, but a large amount of sand was generated in front of the vehicle very soon, which did not allow the sieving part to work and which made the tractor stop several times. Apparently, the problem was that the penetrated grass-moss branches prevented the sand from circulating. The vehicle was anyway able to detect a DM31 with broken fuse and a deactivated MIZ DM56 A1B1.

The attempt to increase the traction force of the tractor using a tank recovery vehicle ended up in a larger amount of sand, and did not solve the problem.

In the end a wheeled loader to excavate the sand and pour it into the operating rock collector was employed. After 4 half filled shovels, the rock collector emptied its bucket and moved forward over the sand heap for about 5 m to restart the loading process. The output was finally combed with the fingers.

During the sieving process in the second mine field, only one detonator of an AP mine D11, one needle, and 2 DM11-bodies with broken detonator were found, therefore at least 3 DM11 mines without fuse had been crushed.

Sieving the transversally tilled section of lane no. 6, only 4 green plastic cases of the AT Mine TM-62 P3 were found.

5.5 Single results:

Comments on the initiations heard, the recovered mine parts and the mine fragments found by the rock collector in the Meppen mine field follow in:

Measurement paper 1 – 9 for Field 2 „Rhino“ of Fa. MaK

The first two measurement papers show the visible and heard results during the clearance process. After that, 3 measurement papers on the outcome of the results in the single sections of the mine fields follow, that is in the AP-mines, AP-fragmentation mines and AT-mines sections.

4 pictures are included providing an overview of the field and of the single field sections, that is, the AP-mines, AP-fragmentation mines and AT-mines sections, and a zoom of some specific parts (especially of AP mine D11) follow.

5.6 Overview of the clearance results:

On 09.10.00, in Meppen on a mine field prepared with blast surrogate mines with the Rhino.

Vehicle / Mine	Field 2 Fa. MaK Rhino
TM-62	4 initiated 1 broken (5 x break)
DM21	5 initiated (all were tilled) (not many fragments)
DM31	5 x initiated (3 body parts were tilled) (2 body parts remained intact)
MIZ	5 initiated
PPM-2	11 heard 8 Rings found (a lot of fragments)
DM11	9 heard 11 cases found 2 bodies without detonators. 1 needle 1 detonator (few fragments)

5.7 Results for the single mines:

ATM TM-62	5 x clearance success = 100 %
ATM DM 21	5 x clearance success = 100 %
AP-fragmentation mine DM31	5 x clearance success = 100 %
MIZ DM56 A1B1	5 x clearance success = 100 %
APM PPM-2	Presumably all initiated, but due to the large amount of sand they were not heard and during the sieving process very few pieces were found (a lot of case fragments were found).
APM DM11	Almost all were found in an almost complete condition (only few case fragments were found).

The AP-fragmentation mines were also cleared up to 100%. Through the tripwire initiated fuse all initiated, whereas through the pressure fuse half of them were made harmless, since their fuse was broken off.

The small AP-mines are the most difficult to assess.

For the RHINO, depending on the amount of soil lifted by the tiller, the initiations were not heard very well. During the soil sieving process, fewer PPM-2 case rings were found than explosions had been heard. Whereas, for the DM11, having a weaker detonator, more fragments were found than explosions heard. Furthermore, broken mine bodies, needles and detonators were found. A 100% proof of all the deployed parts was not possible. On grounds of the condition of the fragments and because no AP-mine parts were found in the field, a clearance success of nearly 100% can be assumed.

6 Mine clearance trials in Koblenz:

6.1 Preparation of the test fields:

In week 40/41 in 2000 the mine field was measured, marked and inert mines were placed, in order to test the mine clearance device of WTD 51-230 on the StOÜbPl Schmidtenhöhe in Koblenz.

Different from Meppen, in Koblenz only 14 +14 = 28 small AP-mines were distributed. The APM (EX) DM18 was still equipped with a dummy. The APM PPM-2 had been armed before deployment.

The AP-fragmentation mines were used with activated MIZ DM56 A1B1. The AT-mines and TM-62 P3 were buried in the ground without the safety catch.

6.2 Execution of the trials:

On 23.10.00, the “RHINO” of MaK Cie. cleared the first mine field (with the white coloured mines), whereby the vehicle was operated through the remote control system. This caused an uneven and not precise movement of the machine. Furthermore, its tiller got often lifted too high, because the terrain feelers failed to function correctly because of earth accumulating sideways of the machine. As a consequence an AP fragmentation mine DM 31 was pushed to the side of the lane and would probably not have been initiated.

Because an intact ATM was found in the tilled lane, all spots where AT-mines had been buried were searched for mines. One other mine was found.

1 ATM DM21 buried at a depth of 15 cm was missed by the machine and remained buried at its initial location. However, it had been hit by the drum and was found with a 10 mm wide and 30 mm long dent at the edge of the mine cover. It would probably have initiated, so that the clearance success could have been reached.

1 ATM TM-62 P3 buried at a depth of 20 cm was left untouched by the tiller and was therefore not cleared.

For the surface of 10 x 80 m, 1 h and 32 min was needed.

6.3 Sieving with the rock collector:

In week 45-46in 2000 the mine field on the Schmidtenhöhe was searched with the rock collector Grimme CS 1700 pulled by a tractor CASE III MX 135.

The rock collector needs, while moving forward, an inclined surface. The ground is reduced to small pieces, i.e. sieved through the 7 rotating star-shaped rubber rollers. The pieces with a diameter larger than 2,5 cm are collected in a special container.

Because the rock collector only reaches a ground penetration depth of max. 25 cm (the clearance depth of the mine clearance device amounts to 25 to 50 cm) and the traction force of the tractor was insufficient due to the soil conditions, i.e. a lot of natural vegetation (WTD 91) and high clay content, the following procedure was followed in the Schmidtenhöhe test fields.

With the tracked multi-purpose excavator, the soil was directly removed and deposited on the unflailed soil in about1,50 m wide and 0,50 m high strips next to the mine fields. After that the soil was sieved 3 to 4 times with the rock collector. During the sieving process the container was opened and the sieved soil dropped out. Two persons, standing each at one side of the container, took out the mines and the remaining pieces. Another person walking directly in front of the rock collector sorted out the visible pieces beforehand. Due to continuous rain while working with the rock collector, the sieving part of the rock collector was constrained as a consequence of the water-logged soil. The soil would agglutinate and bigger soil lumps had to be reduced by hand. It cannot be disregarded that mine pieces were completely covered by the soil and were therefore not found.

The following surfaces were searched for mine fragments:

For the Fa. MaK, the distance included 5 m before the beginning of the mine field to the end of the tilled area, whereby at the beginning of the mine field no mines or mine parts were found. In the area behind the mine field to the end of the tilled surface, parts of AT-mines were found.

WTD 51-230 put a lot of efforts in the search for mine fragments and very good results were achieved.

The clearance result of inert mines in the clayey soil of the Schmidtenhöhe was completely different from the clearance result in the sandy soil of Meppen.

6.4 Single results:

Details about the fragments of the inert mines found in the Koblenz mine field using the rock collector are shown in:

Measurement paper 10 – 13 for field 1 „Rhino“ of Fa. MaK

The measurement papers contain an overview of the mine fragments found. After that, 3 pictures are showing a complete overview of the field, of the AT-mines and of the AP-mines.

The results of the “RHINO” of Fa. Mak were assessed negatively, due to the non-uniform depth calibration.

1 APM DM31 was not cleared (-).

1 ATM DM21 was almost missed by the tiller, but it would presumably have initiated. .

1 ATM TM-62 was not touched at all (-).

1 ATM TM-62 seemed to be missed. Since the area in which the mine had been buried was searched carefully, it can be assumed that this mine had been completely destroyed, but no fragments could be found.

6.5 Overview of the clearance results:

The mine field prepared with inert mines during the clearance trial with the RHINO in Koblenz on the 23.10.00.

Vehicle Mine	Field 1 MaK Cie. Rhino
TM-62	4 tilled 1 missed (-)
DM21	4 tilled 1 initiated (?)
DM31	4 tilled 1 intact (-)
MIZ	3 initiated
PPM-2	14 tilled
DM18	6 distributed 4 bodies without detonator. 3 had presumably been initiated

6.6 Results for the single mines:

ATM TM-62	4 x tilled 1 x not cleared
ATM DM 21	5 x clearance success = 100 %
Fragmentation APM DM31	4 x tilled 1 x not cleared
MIZ DM56 A1B1	3 x detonated Clearance success = 100 %
APM PPM-2	14 x clearance success = 100 %
APM (EX) DM18	14 x clearance success ≈ 100 %

The “RHINO” of MaK Cie. missed an ATM TM-62, buried at 20 cm depth.

The “RHINO” of MaK Cie. could presumably not have initiated an APM DM31.

For the small AP-mines, the PPM-2, 100% of clearance success was reached. Following the experiences in Meppen, also in Koblenz all the PPM-2 should have exploded. For the smallest AP-mines DM18, 100% of clearance success could not be reached, but based on the mine fragments found it can be estimated that also for this AP-mines the clearance success amounts almost to 100%.

7 Clearance results for the mine clearance device:

The mine clearance device “RHINO” of Mak Cie.could not move in straight lines in the Meppen test lanes, due to the remote control operating system.This caused a bad impression for the vehicle. Most of the mines were initiated, whereas the rest of them were crushed.

In Koblenz, an APM DM 31 did presumably not initiate and an ATM TM-62 was run over and missed, because of being buried at a 20 cm depth.This was a consequence of the amount of soil pushed sideways, which falsified the depth calibration of the tiller.

The clearance result of the presented machine shows that a final selection is only possible following further criteria:

- Capability to maintain working performance in difficult, rocky terrain,
- Capability to withstand 10 AP-mines initiated in the same tool position and 5 AT-mines distributed over the tool width,
- Time and costs of repairing after setting-off AT-mines,
- Purchase and maintenance costs of the machine,
- Transportation costs and possibilities.

Office	Dept	Editor	Date
WTD 91	360	Königstein	09.10.00

	Measurement paper		Page Nr. 1	Page total

Clearance trial in field 2 with „Rhino“ of Fa. MaK with blast surrogate mines (red)

Distributed mines:	Observed ignitions during the clearance process: 1.	2.	3.	4.	5.	6.	Total
APM DM 11: 20	4 x	1 x	3 x		1 x		9x
APM PPM-2: 15	5x	1 x	4 x		1 x		11 x
MIZ DM 56: 5 with tripwire	5 x						5 x
APM DM 31: 5 with pressure fuse	1 x	1 x	2 x	1 x			5 x
	⇧ (once through the guide) (* here 1 APM was initiated)						
ATM DM 21: 5	1 x	2 x	1 x	1 x			5 x
ATM TM -62: 5	2 x		2 x				4 x
	⇧ (one only after being dragged with the earth bank for 25 m)						

Office	Dept	Editor	Date
WTD 91	360	Königstein	09.10.00

☐ Measurement Paper ☐		Page Nr. 2	Page total

Clearance trial in field 2 in Meppen with „Rhino“ of Fa. MaK with blast surrogate mines (red)

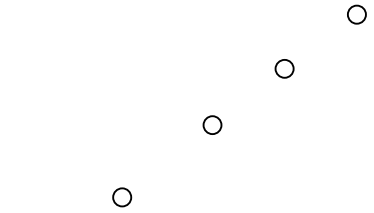
The RHINO was operated through remote control via phone and therefore, without having visibility, it was difficult to have it move in straight lines.
For this reason, a fourth run was necessary to fill the gap between the first and the second lane. A fifth run was done next to the third track.
The sixth run served to till transversally the excavated amount of earth lifted from the mine field. No more initiations were observed.
Due to the large amount of earth lifted in front of the double tiller drums, the AP-mines with their weak detonators, were difficult to detect.
Due to different direction of tiller rotation the initiated APM DM 31 could not be caught by the tiller but remained in front of it. Therefore the initiation could be heard with a delay of 2 seconds only.

Office	Mine distribution Plan	Date	
WTD 91	AP-mines	09.10.00	
Dept		Page Nr	Page total
360		3	
Editor	☐ Measurement Paper ☐	Field 2 „Rhino“ Fa. MaK	
Königstein			

09.10. 18.10.	- 11 initiations were heard - 8 case rings and many mine fragments were found	
	(11 x clearance success)	
	⊗ ⊗ ⊗ ⊗ ⊗	5 cm deep
	⊗ ⊗ ⊗ ⊗ ⊗	0 cm deep
	⊗ ⊗ ⊗ ⊗ ⊗	on top ! PPM-2
	○ ○ ○ ○ ○	5 cm deep
	○ ○ ○ ○ ○	0 cm deep
	○ ○ ○ ○ ○	0 cm deep
	○ ○ ○ ○ ○	on top ! DM 11
09.10. 18.10.	- Initiations heard - 11 rubber cases of initiated mines, + 2 cases with broken detonator + 1 detonator + 1 needle. At least 3 mines were crushed without being initiated. **(14 x clearance success)**	

Annex 16

Office	Mine distribution Plan	Date	
WTD 91	AP-mines	09.10.00	
Dept		Page Nr	Page total
360		4	
Editor			
Königstein	☐ Measurement paper ☐	Field 2 „Rhino“ Fa. MaK	

09.10. 16.10	<u>5 initiations</u> heard. 2 ejected bodies, 1 mine head and mine fragments of the 3 missing bodies were found at their original places (even buried).  DM 31 With pressure fuse
09.10.	 <u>MIZ DM 56 A1</u> With tripwire bound to wooden stick 5 MIZ were initiated at the edge of the mine clearance device over the tightly bound trip, wire after the given time delay of 2 seconds.

Office	Mine distribution Plan	Date	
WTD 91	AP-mines	09.10.00	
Dept		Page Nr	Page total
360		5	
Editor	☐ Measurement Paper ☐	Field 2 „Rhino“ Fa. MaK	
Königstein			

09.10.	4 initiations were heard.
16.10.	[5] The mines buried at a depth of 20 cm were dug out. They had been crushed by the tiller but had not been initiated. The fuse cover had been pulled off. The firing pin and detonator case were found separately. This was also considered to be a clearance success. [5] ⊗ 0 ⊗ 5 ⊗ 10 ⊗ 15 ⊗ 20 cm deep TM-62 P3
	○ 0 ○ 5 ○ 10 ○ 15 ○ 20 cm deep DM 21
09.10.	5 initiations were heard and seen.


Feld 2
Fa. MaK
09.10.2000

Annex 16

Paper 7


Feld 2
Fa. MaK
09.10.2000

Annex 16
Paper 9

Office	Dept	Edior	Date
WTD 51	230	Theimer	23.10.00

Measurement Paper		Page Nr. 10	Page total

Clearance trial in Koblenz-Schmidtenhöhe with „Rhino“ of Fa. MaK with inert mines in field 1 (white)

Distributed:	Mine fragments found:	Proof:
APM (EX) DM 18: 14	13 rubber cases, of which: 6 mines found (+) 4 without sealing plug (+) 3 still with dummy plug (?)	(13 x) (?)
APM PPM-2: 14	12 upper rings 12 ripped cases 14 case fragments this means 100 % destroyed	14 x
MIZ DM 56: 3 with tripwire	3 x detonated through tripwire, this means 100 % initiated.	3 x
APM DM 31: 5 with pressure fuse	4 mines completely destroyed 1 mine was found intact and was collected this means only 80 % clearance success.	(5 x)
ATM DM 21: 5	4 mines completely destroyed:: 4 cover parts + 3 detonators parts 1 mine found intact. (?) with only a big dent in the cover.	(5 x)
ATM TM-62: 5	3 mines completely destroyed, from them: 3 red rubber + 3 cases + 3 Detonators 1 (mine missing!) (not proved) 1 mine was found intact ⊖	(4 x)


RHINO
Fa. MaK

Annex 16

Paper 12


RHINO
Fa. MaK