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Mechanical demining

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Foreword

International standards for humanitarian mine clearance programmes were first proposed by working groups at an international technical conference in Denmark, in July 1996. Criteria were prescribed for all aspects of mine clearance, standards were recommended and a new universal definition of 'clearance' was agreed. In late 1996, the principles proposed in Denmark were developed by a UN-led working group and the *International Standards for Humanitarian Mine Clearance Operations* were developed. A first edition was issued by the UN Mine Action Service (UNMAS) in March 1997.

The scope of these original standards has since been expanded to include the other components of mine action and to reflect changes to operational procedures, practices and norms. The standards were re-developed and renamed as *International Mine Action Standards* (IMAS).

The United Nations has a general responsibility for enabling and encouraging the effective management of mine action programmes, including the development and maintenance of standards. UNMAS, therefore, is the office within the United Nations responsible for the development and maintenance of IMAS. IMAS are produced with the assistance of the Geneva International Centre for Humanitarian Demining.

The work of preparing, reviewing and revising IMAS is conducted by technical committees, with the support of international, governmental and non-governmental organisations. The latest version of each standard, together with information on the work of the technical committees, can be found at <http://www.mineactionstandards.org/>. Individual IMAS are reviewed at least every three years to reflect developing mine action norms and practices and to incorporate changes to international regulations and requirements.

Introduction

In the international effort against landmines and Explosive Remnants of War (ERW) there is a constant need to improve efficiency and safety. Machines have been used on demining operations for many years now and have already demonstrated their potential in several areas for significantly increasing output and for making demining a safer activity. However, the full potential of machines has not yet been reached. There are still opportunities to improve the use of machines and to encourage their development and application.

This standard has been produced to provide guidelines and specifications that promote the safe, efficient and effective use of machines in demining operations. It forms the introductory “standard” to a series of IMAS that relate to mechanical demining.

Mechanical demining

1. Scope

This standard provides specifications and guidelines for mechanical demining operations.

2. References

A list of normative references is given in Annex A. Normative references are important documents to which reference is made in this standard and which form part of the provisions of this standard.

3. Terms, definitions and abbreviations

A list of terms, definitions and abbreviations used in this standard is given in Annex B. A complete glossary of all the terms, definitions and abbreviations used in the IMAS series of standards is given in IMAS 04.10.

In the IMAS series of standards, the words 'shall', 'should' and 'may' are used to indicate the intended degree of compliance. This use is consistent with the language used in ISO standards and guidelines:

- a) 'shall' is used to indicate requirements, methods or specifications that are to be applied in order to conform to the standard.
- b) 'should' is used to indicate the preferred requirements, methods or specifications.
- c) 'may' is used to indicate a possible method or course of action.

The term 'National Mine Action Authority' (NMAA) refers to the government department(s), organisation(s) or institution(s) in each mine-affected country charged with the regulation, management and co-ordination of mine action. In most cases the national Mine Action Centre (MAC) or its equivalent will act as, or on behalf of, the NMAA. In certain situations and at certain times it may be necessary and appropriate for the UN, or some other recognised international body, to assume some or all of the responsibilities, and fulfil some or all of the functions, of a NMAA.

The term 'mechanical demining operations' refers to the use of machines on demining operations and may involve a single machine employing one mechanical tool, a single machine employing a variety of tools or a number of machines employing a variety of tools.

The term 'machine' refers to a unit of mechanical equipment used on demining operations.

The term 'mechanical demining unit' may refer to a single machine or it may refer to more than one machine that works as part of a system for example, a front end loader and a screening plant.

The term 'mechanical tool' refers to the working component(s) attached to a machine, such as flails, tillers, sifters, rollers, excavators, ploughs, magnets etc. A single machine may utilise a number of different tools, which may be fixed or interchangeable.

The term 'intrusive machine' refers to those machines that are designed to work inside a hazardous area, while the term 'non-intrusive machine' refers to those designed to operate from a cleared or known safe area, with its mechanical tool working in the hazardous area.

In this IMAS the term 'residual risk' relates to the hazard remaining from landmines or ERW following mechanical demining in a particular hazardous area.

4. Use of machines on demining operations

Machines used on demining operations can be divided into three general categories; mine clearance machines, ground preparation machines, and Mine Protected Vehicles (MPV) when used in detection and survey operations.

4.1. Mine clearance machines

Mine clearance machines are those machines whose stated purpose is the detonation, destruction or removal of landmines. A consequence of their use is that the necessity for post-mechanical follow-up clearance is reduced to the minimum possible, or in certain cases, eliminated i.e. where the perceived hazard was non-existent, where the machines removed the hazard or where the remaining hazard forms a tolerable residual risk.

4.2. Ground preparation machines

Ground preparation machines are primarily designed to improve the efficiency of demining operations by reducing or removing obstacles¹.

Ground preparation tasks may include:

- a) vegetation cutting and clearing;
- b) removal of tripwires;
- c) loosening the soil;
- d) removal of metal contamination;
- e) removal of building debris, boulders, rubble, defensive wire obstacles etc; and
- f) sifting of soil and debris.

Ground preparation may or may not involve the detonation, destruction or removal of landmines.

4.3. Mine Protected Vehicles (MPV) used in detection and survey operations

MPV are vehicles specifically designed to protect the occupants and equipment from the effects of a mine detonation. MPV are commonly used during detection and survey operations, where they may carry equipment such as detector arrays, vapour sampling devices or in some cases push or pull a roller.

While these operations are not strictly mechanical demining operations involving 'machines' and 'mechanical tools' some of the work carried out by MPV falls into the category of mechanical demining. For example:

- a) heavy MPV using their wheel tracks to provide an access path for manual sampling teams (a ground preparation role); and
- b) MPV pushing or towing rollers (a mechanical mine clearance role).

When used on demining operations, the requirements of MPV are similar to those for mechanical demining. Accordingly, the requirements of this standard shall apply equally to the use of MPV on detection and survey operations.

1. See A Study of Mechanical Application in Demining, GICHD 2004, chapter 4 page 103.

4.4. Operational requirements

When machines are used for mine clearance, and the machine has been assessed as potentially leaving hazards which pose an intolerable risk to the end users of the land, follow-up demining operations shall be carried out before the area is considered cleared.

When machines are used for ground preparation, they shall always be followed-up by other demining operations such as manual, Mine Detection Dog (MDD) or mechanical mine clearance.

When machines are used for detection and survey operations, the information that they provide shall be followed up as appropriate and determined by an information management process, e.g. leading to a decision to clear the area, mark the area or classify the area as non-hazardous.

4.5. Mechanical area reduction

Mechanical area reduction can be a part of a technical survey process or a part of a clearance operation. Mechanical area reduction involves a machine being used to indicate or confirm the presence or absence of landmines and/or ERW within a hazardous area. The aim is to enable the deployment of other demining assets only in areas that are proven to contain landmines and/or ERW.

The scope and extent of mechanical area reduction operations depends on factors such as the accuracy and completeness of existing information, terrain, vegetation, machine and tool type, mine and ERW types and area reduction procedures used. Generally, the less information available about a hazardous area, the more investigation is required by a machine in order to be able to confirm the location of landmines and subsequently reduce the hazardous area.

4.6. Other operations

Machines may also be used for other functions in support of demining operations. Such functions may include preparing tracks to permit access into areas for demining operations, excavation in support of deep search operations and the removal of debris to enable access to suspected hazards (e.g. under collapsed buildings etc.).

5. Systems approach to mechanical demining

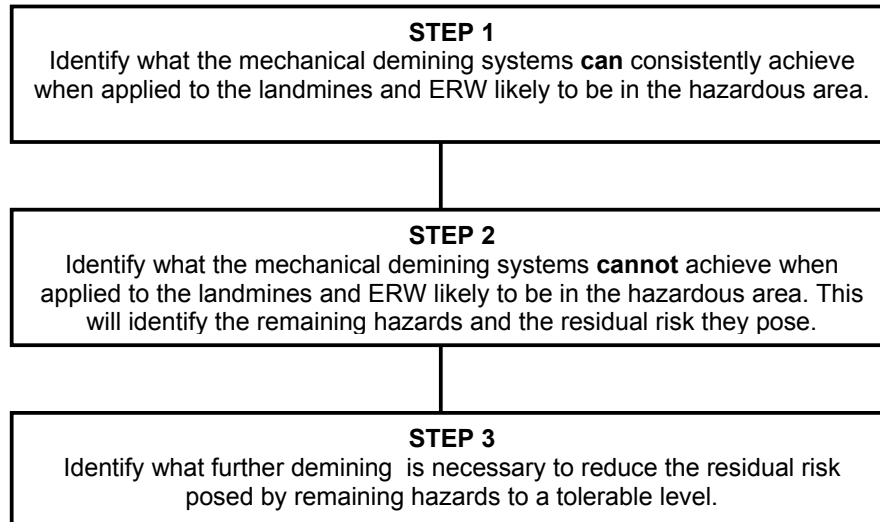
While there are many varieties of machines and tools available for use in mechanical demining, machines alone are rarely able to defeat all mine types and are unlikely to detonate all ERW².

This has led to a need for a '**systems approach**' to mechanical demining whereby machines with a combination of tools, or a combination of machines with different tools, are applied at different stages during the demining process to reduce the hazard to the greatest extent possible. Both ground preparation and mine clearance machines may be used in a systems approach.

The systems approach is about mechanical demining being integrated with other demining assets (manual or MDD) to ensure that the most effective outcome is achieved.

On the next page is an example of the steps involved in a systems approach leading to the selection of an appropriate method to deal with a hazardous area.

2. "Machines are fairly ineffectual at detonating or breaking up all UXO" GICHD, A Study of Mechanical Application in Demining, May 2004, p.65.



5.1. Tolerable risk

The identification of tolerable risk to the end user is an important component of any demining operation, as it implies how thorough the demining process has to be to reach the required level of tolerance. After mechanical mine clearance has been completed, an assessment of the residual risk posed by remaining hazards may show that the risk is already tolerable and no further demining is required. National mine action standards should provide guidance for the process of determining tolerable risk

More information on tolerable risk can be found in the section on risk management included in IMAS 01.10.

6. Mechanical demining operations - general requirements

Machines used in demining operations shall conform to certain general requirements:

- a) each machine shall be Tested and Evaluated (T&E) to determine its suitability for the task(s) it is expected to carry out in the conditions in which it will work. Further guidance on T&E is provided in clause 7 of this standard;
- b) the operation of each machine shall be assessed and confirmed as safe for the operator and any other person on the worksite. The protection level for machines shall be established through a risk assessment; and
- c) Standing Operating Procedures (SOPs) shall be developed for each machine. These SOPs should include general mechanical operating procedures, procedures specific to the machine, and where necessary, procedures for the integration of the machine with other machines or demining operations.

Operational accreditation of a machine in accordance with the requirements of IMAS 07.30, should also be based in part on fulfilling the requirements of this clause of this standard.

Machines should not be used with tools, or on tasks, or in conditions for which they do not have operational accreditation.

Prior to the deployment of any machine to a programme an assessment should be made of the in-country infrastructure and support systems to ensure that a machine can be operationally maintained in the areas where it will be used.

7. Testing and Evaluation (T&E)

T&E of machines is carried out to ensure that a machine is suitable for its intended use in the environment in which it will operate. .

7.1. Scope of T&E

T&E for machines should be designed to:

- a) identify the operational limitations of the machine;
- b) identify the optimal operating conditions for the machine in its intended operating environments;
- c) [for mine clearance machines], identify the effectiveness in disrupting, destroying, detonating or otherwise removing different types of landmines or ERW from hazardous areas in different operating environments. This should only occur for landmines or ERW that a machine has been designed and developed to combat in accordance with the manufacturer's specifications;
- d) [for individual mine clearance machines, or a number of machines or tools to be used as part of a systems approach], identify the residual risk remaining from each landmine or ERW type to be targeted in the operating environments in which the machine(s) will work;
- e) identify any limitations in the employment of a machine (e.g. environmental conditions such as inclines, wet soil, hard ground, temperatures etc, or certain explosive hazards);
- f) assess and confirm the safety of the machine for the operator and any other person on a mechanical demining worksite; and
- g) identify the operating procedures required to ensure that a machine is able to achieve the specified standards.
- h) Identify any potential environmental damage caused through the use of demining machines e.g. soil erosion.

Where a machine has been through T&E or has proven to be effective in other comparable locations, additional formal T&E may not be necessary.

This should only be permitted if continued performance monitoring is carried out by the demining organisation concerned, and that the operating procedures for the machine are such that the NMAA is confident that the standards required of the machine, and any required follow-up demining, will be achieved.

Where such operational performance monitoring is undertaken, records shall be maintained by the demining organisations. The records shall be sufficient to justify any changes to the operating procedures of the machine. See IMAS 03.40 for further guidance on the T&E of mine action equipment.

7.2. CWA 15044:2004 for demining machines

The European Committee for Standardisation (CEN) has developed a CEN Workshop Agreement (CWA) for the T&E of demining machines (CWA 15044:2004). This CWA provides standardised methodology for T&E of demining machines. It gives technical criteria for the following:

- a) performance test. A test to establish whether the machine and its tool(s) is capable of performing the role for which it is intended under comparable and repeatable conditions and to evaluate the manufacturer's specifications;
- b) survivability test. A test to verify that the machine survives the explosive forces used as design criteria; and
- c) acceptance test. A test to ensure that a machine is able to work in the environment where it is intended to be used.

The CWA also establishes the requirements for the test targets to be used in the performance and acceptance tests. Further information can be found at www.mineactionstandards.org or at www.itep.ws

7.3. Mechanical records

The NMAA should require demining organisations to maintain detailed records of their mechanical and follow-up operations to establish a statistical database of information that can be used for operational decision making. This information may for example, permit NMAAs to release land after mechanical mine clearance without follow-up activities if statistical data proves sufficiently that the residual risk posed by remaining hazards is tolerable.

Reporting on operational performance indicators, such as hours worked, land cleared and landmines and ERW found, is essential in order to maintain sufficient statistical records. Reporting on non-operational time, such as mechanical breakdowns, transport between sites and logistical delays, may help understanding the operational constraints and/or visualising performance trends of particular machines, which subsequently may help organisations to improve the efficiency of their mechanical operations. See Annex C for an example of a weekly report format for a mechanical demining unit.

8. Mechanical procedures

Demining organisations shall ensure that operating procedures developed for mechanical operations include the following topics.

8.1. General

Machines are only employed within the limits of their operational accreditation as established during T&E and as documented in SOPs.

Soil expansion (the increase in volume of soil as a result of mechanical processing) is to be taken into consideration when planning follow-up demining. Depth of processing shall be referenced to the original undisturbed ground surface.

8.2. Landmines, ERW and other hazards

If during operations, a hazard is identified which a machine was not designed or approved to be used against, the mechanical operation shall cease and a review of the task shall be carried out.

Machines shall be checked prior to moving from hazardous to safe areas to ensure that no landmines, ERW or hazardous components remain in the working or moving parts of the machine or are attached to the machine.

8.3. Management of mechanical demining operations

Management of mechanical demining operations shall be carried out in a manner that ensures that adequate control is exercised over the operation and that it is possible to provide emergency support in accordance with accident response and equipment recovery plans.

8.4. Medical

See IMAS 10.20 'Safety & occupational health - Demining worksite safety' for demining response plans. In addition, accident response plans for mechanical operations involving crewed machines shall include procedures for the extraction of a casualty from the inside of a machine.

8.5. Communications

Communications between the site supervisor and the mechanical operator shall be in place at all times while a machine is working in a hazardous area.

8.6. Personnel requirements

Mechanical demining worksites shall have sufficient qualified personnel on site while operations are ongoing; to ensure that:

- a) standards for operations are maintained;
- b) where applicable, the effective integration with other demining operations is achieved; and
- c) the necessary support is provided in an emergency.

9. Machine support

9.1. Maintenance and servicing

Demining organisations should make provisions for the maintenance and servicing of machines. Such provisions should ensure that:

- a) machines are maintained and serviced in accordance with the manufacturers' recommendations;
- b) maintenance and servicing is carried out by qualified personnel and authorised agencies;
- c) routine checks are made on the working components of machines and where working components critical to the effective operation of a machine are damaged or lost, these components are repaired or replaced before further work continues;
- d) routine inspections of safety features on machines are carried out and where damage is identified, the damage is repaired before further work continues; and
- e) whenever a machine is subject to a detonation that may have affected the safety of the operation, the machine is immediately withdrawn from the hazardous area and inspected. Where damage to a machine may place personnel in danger from subsequent detonations, the machine should not return to work until the damage is repaired.

A key component of good machine maintenance is the way that a machine is operated. Mechanical operators should be qualified and experienced in the operation and maintenance of their machines.

9.2. Recovery requirements

Operating procedures for mechanical demining operations shall include provisions for the recovery of the machine and operator in the event of a machine becoming stranded in a hazardous area. Such procedure shall ensure the safe extraction of the operator as quickly as possible, and the safe recovery of the machine in a reasonable time.

9.3. Fire precautions and drills

Demining organisations employing machines shall develop procedures to be followed in the event of a fire on a machine. These procedures shall cover the immediate actions to be taken and ensure the safe extraction of an operator from a hazardous area. Where an onboard operator is present, machines shall be fitted with fire extinguisher or fire suppressing systems. On no account shall any person be permitted to enter an uncleared area to fight a fire on a burning machine.

Fire fighting equipment shall be available at all places where refuelling of machines is carried out.

10. Environmental considerations

10.1. General

The ground over which mechanical operations are carried out shall be left in a state whereby the land is suitable for its intended use when handed over.

Where mechanical operations involve the removal of vegetation, or occur on ground that may be subject to erosion, demining organisations shall ensure that measures are taken to limit such erosion.

The operation, repair, maintenance and servicing of demining machines shall be carried out in an environmentally acceptable manner e.g. by preventing ground or watercourse contamination from fuel, oil and lubricants.

10.2. Protection of property and infrastructure

Planning for mechanical operations shall take into account any possible damage to property or infrastructure. Where damage to property or infrastructure is possible, the property owners or local authorities should be consulted prior to the operations.

11. Responsibilities

11.1. National Mine Action Authority (NMAA)

The NMAA shall:

- a) operationally accredit machines in accordance with the requirements of this standard;
- b) develop and implement national standards for the employment of machines on demining operations;
- c) implement QM systems to ensure the safe, effective and efficient use of machines on demining operations;
- d) develop an environmental policy for the use and maintenance of demining machines;
and
- e) provide advice to prospective machine users.

In addition the NMAA should:

- a) establish procedures to ensure the proper T&E of machines prior to their deployment on demining operations;
- b) establish reporting systems and procedures for the gathering of data on mechanical and follow-up demining operations. Such data should be made available to all stakeholders; and
- c) provide advice and assistance to demining organisations in establishing tolerable risk for demining operations.

11.2. Demining organisation

The demining organisation shall:

- a) support the NMAA with the T&E of machines to be used on demining operations;
- b) obtain (from the NMAA) the operational accreditation for each different machine (model, make, type) to be used in demining operations;
- c) comply with the national standards for the employment of machines on demining operations. In the absence of national standards, the demining organisation shall apply the IMAS standards, or such standards as are specified in their contract or agreement;
- d) apply management practices and operational procedures which aim to clear land to the requirements specified in national standards or contracts and agreements;
- e) establish and maintain reporting systems and make the information available on mechanical and follow-up demining operations as specified by the NMAA; and
- f) establish systems and procedures to ensure that machines used on mechanical demining operations operate effectively, are properly maintained and serviced and remain safe for the operator and support staff.

In the absence of a NMAA, the demining organisation should assume additional responsibilities. These include, but are not restricted to:

- a) agreeing common mechanical standards with other demining organisations operating in the same programme; and
- b) assisting the host nation, during the establishment of an NMAA, in developing national standards for mechanical demining.

Annex A (Normative) References

The following normative documents contain provisions, which, through reference in this text, constitute provisions of this part of the standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of the standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid ISO or EN:

- a) IMAS 01.10 Guide to the application of International Mine Action Standards (IMAS);
- b) IMAS 03.40 Test and evaluation of mine action equipment;
- c) IMAS 04.10 Glossary of mine action terms, definitions and abbreviations;
- d) IMAS 07.30 Accreditation of demining organisations;
- e) IMAS 10.20 Safety & occupational health - Demining worksite safety; and
- f) CEN 15044:2004 – CWA for demining machines.

The latest version/edition of these references should be used. GICHD hold copies of all references used in this standard. A register of the latest version/edition of the IMAS standards, guides and references is maintained by GICHD, and can be read on the IMAS website (www.mineactionstandards.org). NMAA, employers and other interested bodies and organisations should obtain copies before commencing mine action programmes.

Annex B (Informative) Terms, definitions and abbreviations

B.1. accreditation

the procedure by which a **demining organisation** is formally recognised as competent and able to plan, manage and operationally conduct **mine action** activities safely, effectively and efficiently.

Note: For most mine action programmes, the **NMAA** will be the body which provides accreditation. International organisations such as the United Nations or regional bodies may also introduce accreditation schemes.

Note: ISO 9000 usage is that an '**Accreditation**' **body** accredits the 'Certification or Registration' bodies that award ISO 9000 certificates to organisations. The usage in IMAS is completely different to this, and is based on the main definition above, which is well understood in the mine action community.

B.2. area reduction

the process through which the initial area indicated as contaminated (during any information gathering activities or surveys which form part of the **GMAA** process) is reduced to a smaller area.

Note: Area reduction may involve some limited clearance, such as the opening of access routes and the destruction of landmines and ERW which represent an immediate and unacceptable risk, but it will mainly be as a consequence of collecting more reliable information on the extent of the hazardous area. Usually it will be appropriate to mark the remaining hazardous area(s) with permanent or temporary marking systems.

Note: Likewise, area reduction is sometimes done as part of the clearance operation.

B.3. cancelled area

an area previously recorded as a **hazardous area** which subsequently is considered, as a result of actions other than **clearance**, not to represent a **risk** from **landmines** and **ERW**.

Note: This change in status will be the result of more accurate and reliable information, for example from technical survey, and will normally only be authorised by the **NMAA**, in accordance with national **policy**. The documentation of all **cancelled areas** shall be retained together with a detailed explanation of the reasons for the change in status.

B.4. CEN (Committee European Normalisation)

CEN is the European Committee for Standardisation.

Note: The mission of CEN is to promote voluntary technical harmonisation in Europe in conjunction with worldwide bodies and its European partners. European standards (referred to as EN (Europe Normalisation)) form a collection which ensures its own continuity for the benefit of users.

B.5. demining organisation

any organisation (government, NGO or commercial entity) responsible for implementing demining projects or tasks. The demining organisation may be a prime contractor, subcontractor, consultant or agent.

B.6.

ground preparation

preparing of ground in a **minefield** or **hazardous area** by mechanical means by reducing or removing obstacles to clearance e.g. tripwires, vegetation, metal contamination and hard soil to make subsequent **clearance** operations more efficient. Ground preparation may or may not involve the detonation, destruction or removal of landmines.

B.7.

hazard

potential source of harm. [ISO Guide 51:1999(E)]

B.8.

hazardous area

contaminated area

a generic term for an area not in productive use due to the perceived or actual presence of landmines, UXO or other explosive devices.

B.9.

mine clearance machines

those machines whose stated purpose is the detonation, destruction or removal of landmines as part of the overall clearance process.

B.10

minefield

an area of ground containing **landmines** laid with or without a pattern. [AAP-6]

B.11

residual risk

in the context of humanitarian demining, the term refers to the risk remaining following the application of all reasonable efforts to remove and/or destroy all **mine** or **UXO hazards** from a **specified area** to a **specified depth**. [Modified from ISO Guide 51:1999]

B.12

risk

combination of the probability of occurrence of **harm** and the severity of that **harm**. [ISO Guide 51:1999(E)]

B.13

risk analysis

systematic use of available information to identify **hazards** and to estimate the **risk**. [ISO Guide 51:1999(E)]

B.14

soil expansion

the increase in volume of soil caused by being mechanically processed.

Annex C
(Informative)
Example of weekly report format for a mechanical demining unit

Organisation						Reporting Period Start:			
Machine ID						Reporting Period End:			
Supervisor									
	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Total	Remarks
Area cleared/prepared (m ²)									
AP blast mines detonated (qty)									
AP frag mines detonated (qty)									
AT mines detonated (qty)									
ERW detonated (qty)									
Working depth (cm)									
Fuel consumption (L)									
Machine hrs meter reading									
Operational time (hrs)									
Maintenance time (hrs)									
Inactive time	Transport to site (hrs)								
	Breakdown, repairs (hrs)								
	Breakdown, no spares (hrs)								
	Waiting for task (hrs)								
	Waiting for transport (hrs)								
	No operator/mechanic (hrs)								
	No support personnel (hrs)								
	No fuel, oil, lubricants (hrs)								
	Weather constraints (hrs)								
	Security constraints (hrs)								
Other – specify (hrs)									
Total (hrs)									

