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## Mechanical demining

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### **Warning**

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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) (including unexploded sub-munitions) there is a constant need to improve efficiency and safety. Demining 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 demining machines has not yet been reached. There are still opportunities to improve the use of demining 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 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; and
- c) 'may' is used to indicate a possible method or course of action.

The term 'National Mine Action Authority' (NMAA) refers to the government entity, often an inter-ministerial committee, in a mine-affected country charged with the responsibility for the regulation, management and coordination of mine action.

Note: In the absence of a NMAA, 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 the functions, of a MAC or, less frequently, an NMAA.

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

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

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

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 demining machines on demining operations**

### **4.1. General**

Machines used on demining operations can be divided into those machines designed to detonate hazards, machines designed to prepare the ground, and machines designed to detect hazards. Some machines may be designed to fulfil more than one of these purposes. Many of these machines are also designed to be Mine Protected Vehicles (MPV) and so protect the occupants and equipment from the effects of a mine detonation. All machines that are designed to be used in hazardous areas are demining machines.

### **4.2. Machines designed to detonate hazards**

Machines designed to detonate or otherwise destroy hazards may be meeting their design aims under different conditions. Their use may reduce or, in some cases, eliminate the necessity for follow-up clearance i.e. where the perceived hazard was non-existent or where the remaining hazard forms a tolerable residual risk.

### **4.3. Machines designed for ground preparation**

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

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) processing of soil and debris.

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

### **4.4. Machines designed to detect hazard**

Machines designed to detect hazards may do so physically, as with sifting machines and rollers, or by carrying a detection technology such as metal-detector array or vapour sampling devices. Some physical detection methods may involve detonating some hazards during the detection process.

### **4.5. Follow-up requirements**

When demining machines are used in clearance operations to detonate devices and the machine may leave hazards within the agreed clearance depth, follow-up demining operations shall be carried out before the area is released as cleared.

When demining machines are used for ground preparation in a Hazardous Area that will be released as cleared, they shall always be followed-up by other demining operations.

When demining machines are used for detection or in technical 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 release the land as non-hazardous. More information on follow-up after use of demining machines is given in CWA 15832:2008.

Note: when a demining machine is used in a technical survey role, follow up after the use of demining machine may not be required as the aim is to search for evidence of mines and ERW not to clear the land.

#### **4.6. Mechanical land release**

Mechanical land release can be a part of a technical survey process or a part of a clearance operation. Mechanical land release involves a machine being used to indicate or confirm the presence or absence of landmines and/or ERW within a suspected or confirmed 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 including unexploded sub-munitions.

The scope and extent of mechanical land release 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 define any hazardous areas.

#### **4.7. Other operations**

Demining machines may also be used for other functions in support of technical survey and clearance 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**

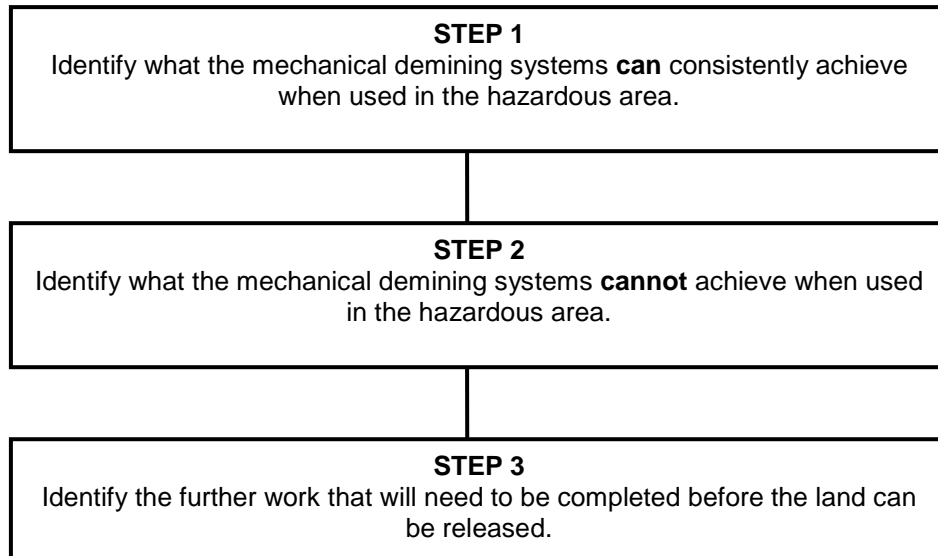
While there are many varieties of demining machines and tools designed to detonate devices available for use in mechanical demining, these are rarely able to defeat all mine types and are very unlikely to detonate all ERW.

This has led to a need for a '**systems approach**' whereby machines with a combination of tools, a combination of machines with different tools, or non-mechanical demining procedures are applied at different stages during the demining process. All demining machines may be used in a systems approach.

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

Below is an example of the steps involved in a systems approach leading to the selection of appropriate demining machines to use in a hazardous area.





### 5.1. Tolerable risk

The identification of tolerable risk to the end user is an important component of any demining operation because it determines how thorough the demining process has to be to reach the required level of tolerance. After mechanical demining 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 risk and liability is provided in IMAS 07.11 Land release. Clearance requirements are discussed in IMAS 09.10.

## 6. Mechanical demining operations - general requirements

Demining machines used in demining operations shall conform to certain general requirements:

- a) each demining machine and mechanical tool 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 demining 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) Standard Operating Procedures (SOPs) shall be developed for each demining machine or mechanical tool that is used in a hazardous area. These SOPs should include general mechanical operating procedures, procedures specific to the machine, and procedures for the integration of the machine with other machines or demining operations.

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

Demining 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 demining machine can be operationally maintained in the areas where it will be used.

## **7. Testing and Evaluation (T&E)**

T&E of demining 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 demining 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 machines designed to detonate or otherwise destroy hazards], 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 demining machines, or a number of machines or tools to be used as part of a systems approach], identify the residual risk remaining from each potential hazard 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;
- g) identify the operating procedures required to ensure that a machine is able to achieve the specified standards; and
- h) Identify any potential environmental damage caused through the use of demining machines e.g. soil erosion.

Where a demining 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 15044:2009 for T&E of demining machines**

The European Committee for Standardisation (CEN) has developed a CEN Workshop Agreement (CWA) for the T&E of demining machines (CWA 15044:2009). 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 demining machine survives the explosive forces used as design criteria; and
- c) acceptance test. A test to ensure that a demining 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](http://www.mineactionstandards.org).

## **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 demining 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 processed 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 demining 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**

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

When using ground engaging mechanical tools, 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 demining machine was not designed or approved to be used against, the mechanical demining operation shall cease and a review of the task shall be carried out.

Demining machines shall be checked prior to moving from hazardous to safe areas to ensure that no landmines, ERW or hazardous components including unexploded sub-munitions remain in the working or moving parts of the demining 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 demining machines shall include procedures for the extraction of a casualty from the inside of any machine used inside a hazardous area.

### **8.5. Communications**

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

### **8.6. Personnel requirements**

Mechanical demining worksites shall have sufficient qualified male and female personnel on site while operations are on-going; 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. Demining machine support**

### **9.1. Maintenance and servicing**

Demining organisations should make provisions for the maintenance and servicing of demining machines and mechanical tools that they use in demining. Such provisions should ensure that:

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

A key component of good demining 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 demining machine and operator in the event of a demining 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 demining machine in a reasonable time.

## **9.3. Fire precautions and drills**

Demining organisations employing demining machines in hazardous areas shall develop procedures to be followed in the event of a fire on a demining 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 on-board operator is present, demining machines shall be fitted with fire extinguisher or fire suppressing systems. On no account shall any person be permitted to enter a confirmed hazardous area to fight a fire on a burning demining machine without first clearing the access route(s). Fire fighting equipment should be available at all places where refuelling of demining 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. IMAS 10.70 provides guidance on protection of environment.

### **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.

When machines are used in clearance of residential areas or agriculture land, they may remove boundaries of the land and this may create a potential land right dispute. Measures should be taken to ensure property ownership prior to the operation.

## **11. Responsibilities**

### **11.1. National Mine Action Authority (NMAA)**

The NMAA shall:

- a) operationally accredit demining machines in accordance with the requirements of this standard;
- b) develop and implement national standards for the employment of demining 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 demining machine users.

In addition the NMAA should:

- a) establish procedures to ensure the proper T&E of demining 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 demining machines to be used on demining operations;
- b) obtain (from the NMAA) the operational accreditation for each different demining machine (model, make, type) to be used in demining operations;
- c) comply with the national standards for the employment of demining 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 demining 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 07.11 Land release;
- f) IMAS 08.20 Technical survey;
- g) IMAS 09.10 Clearance requirements;
- h) IMAS 10.20 Safety & occupational health - Demining worksite safety;
- i) IMAS 10.70 S&OH protection of environment;
- j) CWA 15044:2009 – Test and evaluation of demining machines; and
- k) CWA 15832:2008 – Follow-on after the Use of 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](http://www.mineactionstandards.org)). NMAA, employers and other interested bodies and organisations should obtain copies before commencing mine action programmes.

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

Organisation						Reporting Period Start:			
Demining machine ID						Reporting Period End:			
Supervisor									
	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Total	Remarks
Area cleared/prepared (m <sup>2</sup> )									
AP blast mines detonated (qty)									
AP frag mines detonated (qty)									
AT mines detonated (qty)									
ERW detonated (qty)									
Working depth (cm)									
Fuel consumption (L)									
Demining 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)									



## Amendment record

### Management of IMAS amendments

The IMAS series of standards are subject to formal review on a three-yearly basis, however this does not preclude amendments being made within these three-year periods for reasons of operational safety and efficiency or for editorial purposes.

As amendments are made to this IMAS they will be given a number, and the date and general details of the amendment shown in the table below. The amendment will also be shown on the cover page of the IMAS by the inclusion under the edition date of the phrase *'incorporating amendment number(s) 1 etc.'*

As the formal reviews of each IMAS are completed new editions may be issued. Amendments up to the date of the new edition will be incorporated into the new edition and the amendment record table cleared. Recording of amendments will then start again until a further review is carried out.

The most recently amended IMAS will be the versions that are posted on the IMAS website at [www.mineactionstandards.org](http://www.mineactionstandards.org).

Number	Date	Amendment Details
1	21 Dec 2009	<ol style="list-style-type: none"> <li>1. Updated definition of NMAA.</li> <li>2. Updated UNMAS address.</li> <li>3. Machine changed to demining machine throughout the IMAS.</li> <li>4. Minor changes to ensure land release and cluster munitions issues.</li> <li>5. Reviewed to ensure gender issues – minor changes to that effect.</li> <li>6. Removal of Annex B from the IMAS series and its reference in clause 3.</li> <li>7. Renaming Annex C to B.</li> <li>8. Updated reference to CWA in Annex A.</li> </ol>
2	08 Apr 2011	<ol style="list-style-type: none"> <li>1. Definition of 'mechanical demining unit' is deleted in Clause 3</li> <li>2. Significant changes to Clause 4 and its sub-clauses to reflect that demining machine are machines designed to detonate hazards, machines designed to prepare the ground, and machines designed to detect hazards.</li> <li>3. Minor changes and update throughout to include land release issues.</li> <li>4. Updating clause 7.2 on CWA 15044.2009.</li> <li>5. Annex A normative reference updated.</li> <li>6. A paragraph on land rights was added to Clause 1.2.</li> </ol>
3	01 Aug 2012	<ol style="list-style-type: none"> <li>1. Reviewed for any impact of IATG development.</li> <li>2. Minor typographical amendments.</li> </ol>
4	01 Jun 2013	<ol style="list-style-type: none"> <li>1. Reviewed for the impact of new land release IMAS.</li> <li>2. Amendment No and date included in the title and header.</li> <li>3. References updated to IMAS TS and LR in clause 5.1 and Annex A.</li> <li>4. The word Defined and DHA deleted in 4.5.</li> </ol>