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Earth-moving machinery — Operation and maintenance — Maintainability guidelines

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National foreword

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Foreword

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ISO 12510 was prepared by Technical Committee ISO/TC 127, *Earth-moving machinery*, Subcommittee SC 3, *Operation and maintenance*.

INTERNATIONAL STANDARD **ISO 12510:2004(E)**

Earth-moving machinery — Operation and maintenance — Maintainability guidelines

1 Scope

This International Standard establishes guidelines for the incorporation of design features that promote safety, efficiency, reliability and ease of maintenance and service operations on earth-moving machinery as defined in ISO 6165.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 6165, *Earth-moving machinery — Basic types — Vocabulary*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
test points
points which provide access to information about the status of the machine, either for routine checking of correct operation or for isolating malfunctions

3.2
service points
points which provide access for lubrication, filling, draining or similar servicing operations

4 General

Machines should be designed and built so that routine maintenance operations can be carried out safely, whenever possible with the engine stopped. Where it is only possible to undertake inspection or maintenance with the engine running, arrangements should be made to minimize the risk of contact with moving or hot parts.

Annex A gives examples of matrixes of maintainability for different categories of components and from different perspectives.

5 Location of items

5.1 Components

5.1.1 Where the visual inspection of, for example, oil levels and gauges is required, the test points should be located so that personnel can see them without the removal of panels or other components.

5.1.2 Components requiring routine servicing should be located away from parts of the machine which may have high temperatures.

5.1.3 Components needing frequent servicing or replacement should be located in accessible locations where no other components need to be removed to give access to them.

5.1.4 For those maintenance tasks which have a critical visual requirement, components should be located so that they can be easily seen and easily illuminated with a lamp.

5.1.5 Components should be designed and located so that they can be installed and removed along a straight or slightly curved path, rather than through an angled path.

5.1.6 Easily damaged components should be located away from areas where frequent or heavy maintenance work is necessary or have protective guards.

5.1.7 Components intended to be manually lifted out of position should be located where they can be pulled out. Where high levels of pulling force are required, provision should be made above the component and within its recess for bracing with one hand while the other is used for pulling. In this situation, a handle for pulling the component should be considered.

5.1.8 Where components cannot be located for direct accessibility, pull-out drawers or racks should be considered. For heavy components, these should be provided with limit stops which are easily released so as to prevent components being dropped.

5.1.9 Components normally maintained by the same maintenance operative (i.e. fitter, electrician, engineer) should be grouped together whenever possible.

5.1.10 If applicable, fuses should be grouped together in a single, readily accessible location so that they can be seen and replaced without the removal of parts or sub-assemblies. It should be possible to replace fuses without the use of tools. Spare fuses should be located adjacent to the fuse holder and labelled for fuse value. The fuses may be covered by a guard, provided that it can be removed without tools.

5.2 Test and service points

5.2.1 Accessible test points should be provided for checking for correct operation and for fault diagnosis.

5.2.2 Where possible, test points should be grouped together in a layout which reflects the layout of the units being tested.

5.2.3 Test points should be located close to the controls and displays used in the checking operation, so that personnel can operate the controls and observe the displays simultaneously.

5.2.4 Test and service points should be located on those parts of the equipment which will be most accessible when the equipment is assembled and installed on the machine.

5.2.5 Where possible, test and service points should be located where they do not require the removal of any components or items in order to gain access.

5.2.6 Test and service points should be located so that all points in a given procedure can be accessed through one opening.

5.2.7 Test and service points should be located away or shielded from unshielded moving parts or other dangerous areas.

5.2.8 Lubrication points should be located so that they are easily accessible using guide tubes or extended fittings if necessary. Grouped lubrication points are preferable.

5.2.9 Where possible, access to lubrication points should not require the removal of covers.

5.2.10 Lubrication fittings should conform to the requirements of ISO 6392-1.

5.2.11 Dipsticks and other such level indicators should be located in an accessible position and should be capable of being fully withdrawn without touching other pieces of equipment.

5.2.12 Fluid replenishing points should be located to minimize the consequence of spillage that results in damaged equipment.

5.2.13 Drain points should be visible and accessible to operate, and be located within reach of personnel and at such a place where mud or other debris will not clog them.

5.2.14 Drain points should be placed where they will not drain on personnel or sensitive equipment.

5.2.15 Drain points should be located to permit fluid drainage directly into a waste container.

5.2.16 Drain, fill and level plugs should conform to the requirements of ISO 6302.

6 Access system

Adequate access systems conforming to the requirements of ISO 2867 should be provided to the maintenance areas.

7 Access apertures

7.1 Location

7.1.1 Access should be provided to all components, test and service points and other items which require routine testing, servicing, adjusting, replacement or repair.

7.1.2 Wherever possible, access apertures should be located so that only one cover needs to be removed to replace or service any single component.

7.1.3 Apertures should be designed and located to minimize the occasions when it becomes necessary to remove components or cables in order to reach any item requiring servicing or replacement.

7.1.4 Apertures should align with the components being maintained (see 5.1.4 and 5.1.5).

7.1.5 Apertures should be located to permit to access to the related displays, controls and test points.

7.2 Size and shape

7.2.1 The size and shape of an aperture should be that which provides the passage of components, allows the specified method of grasping of components during removal and refit, and provides sufficient clearance for the use of hand and powered tools.

7.2.2 Minimum aperture dimensions should be in accordance with ISO 2860.

8 Covers

8.1 Hinged covers should open sufficiently to provide enough space for all maintenance tasks.

8.2 Wherever possible, all cover fasteners should be of the same size and type.

8.3 The number of fasteners holding a hatch cover should be minimized and, whenever possible, hinges and quick-release fasteners should be used.

8.4 Where handles can cause a safety hazard, they should be recessed or hinged.

8.5 Wherever possible, handles should be located relative to the centre of gravity of the cover to prevent it swinging or tilting when lifted.

8.6 Handle location should take into consideration the postures which need to be adopted during lifting so that, for example, excessive reach can be prevented.

8.7 Handles or covers should have no sharp edges or protrusions.

9 Tools

9.1 Where possible, machinery should be designed so that on-site, routine maintenance and adjustment work can be carried out using tools in accordance with ISO 4510-1.

9.2 Provision should be made on the machine for secure and accessible storage of the hand tools required for routine maintenance.

10 Service instrumentation

10.1 Machinery should be designed to facilitate the use of service instrumentation in accordance with ISO 6012.

10.2 Diagnostic ports should conform to the requirements of ISO 8925.

11 Labelling

11.1 General

11.1.1 Adequate labels should be provided to assist maintenance activities for identification and instruction.

11.1.2 Labels should be located where they will not be obliterated, for example, by grease or dirt.

11.1.3 Labels should be located so they can be read while performing the tasks to which they pertain.

11.1.4 Labels which read horizontally are preferable to those which read vertically.

11.1.5 The choice of colour should optimize contrast to enhance legibility for information or instructional type labels.

11.1.6 Materials should be used which will minimize the risk of loss of label information.

11.1.7 Labels should be placed in such locations as to minimize risk of damage during machine operation or from the environment.

11.1.8 Electrical wires and cables should be identified and marked in accordance with the requirements of ISO 9247.

11.1.9 When circumstances at the operating position make the provision of individual labels difficult, individual labels may be replaced by a composite label.

11.2 Component identification

11.2.1 Component serial number labels should be located in such a manner as to maximize visibility.

11.2.2 Labels should be located on a permanent structure of the component not normally considered a replaceable item and which does not readily lend itself to substitution.

11.3 Instructions

11.3.1 Instructions as to the task procedures and the requirements should be presented on a label when the task consists of a series of steps which may be confused if left to memory and where it is not possible for the operator to refer to the maintenance manual or the required speed of operation precludes its use.

11.3.2 When instructions applicable to the maintenance of a covered unit are labelled on the inside of a hinged cover, the lettering should be orientated so that it is readable when the cover is opened.

11.4 Warnings

Warning labels should be provided which comply with ISO 9244.

11.5 Maintenance information

Labels should use symbols conforming with ISO 6405-1 and ISO 6405-2.

12 Accompanying documentation

12.1 General

There should be three sets of written instructions, which should comply with ISO 6750:1984 as and when appropriate:

— an operator's manual (including a lubrication chart);

— a maintenance manual;

— a spare parts list.

12.2 Operator's manual

The operator's manual should contain at least the following items:

— a description of the machine, with sketches;

— instructions for use of the machine, presented in an unambiguous manner;

— instructions for routine (e.g. daily) maintenance checks which could be made by the operator;

— instructions for transporting, handling and storage of the machine, and the equipment and attachments with which it is supplied.

12.3 Maintenance manual

The maintenance manual should contain the lists of operations (and their frequency) to be carried out on the machine other than those routine maintenance checks (see 12.2) necessary to maintain the machine in a safe and operable condition. The maintenance manual should include electrical, hydraulic and pneumatic circuit diagrams, whenever applicable.

12.4 Spare parts list

The spare parts list should contain all the related spare parts, together with unambiguous identification and information on the location of the part to be replaced.

12.5 Storage of documentation

The operator's manual and lubrication chart should be stored on the machine.

Annex A
(informative)

Matrixes of maintainability

A.1 Components to be maintained

Components may be classified into two categories for maintenance purposes:

a) **liquids (oil, fuel and water) and vapours:** fuel, coolant, lubricant oil (engine, torque converter, transmission, axle, final drive, swing device), hydraulic tank, air intake system, brake reservoir, window washer, cab ventilation system (filter), air conditioner (refrigerant, filter);

b) **mechanical devices:** fan belt, cylinder/valve, chassis spring/shock absorber, tire/wheel, track roller/link and sprocket, recoil steering/ spring wheel, steering cylinder/linkage, steering (crawler), cutting edge/tooth, belts for air conditioner/ compressor/ condenser.

A.2 Definition of levels at each perspective

The components to be maintained (see A.1) may be taken into account at different levels, and from different perspectives, for example:

a) **working position:**

- level 1: standing or sitting above or alongside machine
- level 2: standing or sitting below machine
- level 3: lying down above or alongside machine
- level 4: looking up from below machine

b) **type of work:**

- level 1: maintained without removing a cover or a cap
- level 2: maintained by removing a cover or a cap without using any tool
- level 3: maintained by using only ISO 4510-1 and ISO 4510-2 tools
- level 4: maintained by using other special tool or device

c) **safety:**

- level 1: maintenance without a moving part and with no danger
- level 2: maintenance within a moving part and protected by a safety device (working e.g. under “boom” and on “track shoes”)
- level 3: maintenance without a safety device and risking injury if an indicated instruction is not followed correctly (e.g. maintenance of internal pressure, high temperature)
- level 4: maintenance without a safety device and risking serious injury or death if an indicated instruction is not followed correctly.

A.3 Matrixes of maintainability

Matrixes of maintainability can be established for the different categories of components to be maintained from different perspectives. See Tables A.1 and A.2.

Table A.1 — Matrix of maintainability for liquids and vapours

Perspective	Components to be maintained													
			Lubricant oil										Air conditioner	
	Fuel	Coolant	Engine	Torque converter	Transmission	Axle	Final drive	Swing device	Hydraulic tank [a]	Air intake system	Brake reservoir [b]	Window washer	Refrigerant	Filter
A.1.1 Inspection														
A.1.1.1 Working position	1	1	1	1	1	2	2	1	1	1	1	1	1	1
A.1.1.2 Type of work	1	2	2	2	2	3	3	2	1	2	2	2	2	2
A.1.1.3 Safety	1	3	2	2	2	2	2	2	2	2	2	2	2	2
A.1.1.4 Prevention of working errors — checking port should be covered to prevent dirt or sand from entering during checking	–	–	–	–	–	+	+	–	–	+	–	–	–	–
A.1.2 Draining														
A.1.2.1 Working position	2	2	2	2	2	2	2	2	2	–	–	–	–	–
A.1.2.2 Type of work	3	3	3	3	3	3	3	3	3	–	–	–	–	–
A.1.2.3 Safety	2	3	3	3	3	3	3	3	3					
A.1.2.4 Ease of work — Drain plug should be so protected as to prevent it from being worn or deformed by rock and sand.	+	+	–	–	–	+	+	–	–	–	–	–	–	–
A.1.2.5 Prevention of working errors — Only one drain port should be provided for each hydraulic unit.	+	+	+	+	+	+	+	+	+	–	–	–	–	–
— All oil should drain from under the machine when inclined at 10° max. angle in all directions.	–	–	+	+	+	+	+	+	+	–	–	–	–	–
A.1.2.6 Environmental protection — Draining portion should be designed to drain all oil to a receptacle without spilling to surroundings.	+	+	+	+	+	+	+	+	+	–	–	–	–	–
— There should be enough space under the drain port to place a receptacle having capacity to contain all drained oil.	–	+	+	+	+	+	+	–	+	–	–	–	–	–
A.1.2.7 Drain system should be so constructed as to control the drain flow.	+	–	+	+	+	+	–	+	–	–	–	–	–	–

Table A.1 (*continued*)

Perspective	Components to be maintained													
			Lubricant oil										Air conditioner	
	Fuel	Coolant	Engine	Torque converter	Transmission	Axle	Final drive	Swing device	Hydraulic tank [a]	Air intake system	Brake reservoir [b]	Window washer	Refrigerant	Filter
A.1.3 Refilling														
A.1.3.1 Working position	1	1	1	1	1	2	2	1	1	–	1	1	–	–
A.1.3.2 Type of work	2	2	2	2	2	3	3	3	2	–	1	1	–	–
A.1.3.3 Safety	2	2	2	2	2	3	3	2	2	–	2	2	–	–
A.1.3.4 Prevention of working errors — Refilling port should be covered to prevent dirt or sand from entering during replenishing.	–	–	–	–	–	–	+	+	–	–	–	–	–	–
A.1.4 Replacement of filter														
A.1.4.1 Working position	1	–	1	3	3	–	–	–	1	1	–	–	–	1
A.1.4.2 Type of work	3	–	3	3	3	–	–	–	3	3	–	–	–	2
A.1.4.3 Safety	2	–	2	2	2	–	–	–	2	2	–	–	–	2

\+ Maintenance is required or should be considered, but the degree of difficulty is undefined.

– Maintenance is not required.

1 Lowest degree of difficulty.

2 Medium degree of difficulty

3 Highest degree of difficulty.

NOTE 1 This table applies to an “average” type of earth-moving machine, therefore, there could be some differences between different models, sizes and types.

NOTE 2 The values 1, 2 and 3 used represent the degree of difficulty of maintenance work, taking account of the “average” type machine.

[a] Alternatively, it shall be so constructed as to control the drain flow.

[b] Type and level of liquid shall be indicated. The warning light shall be located in front of the operator's seat.

Table A.2 — Matrix of maintainability for mechanical devices

Perspective	Components to be maintained											
			Wheel type		Crawler type						Air conditioner	
	Fan belt	Cylinder valve	Chassis spring	Tyre	Track roller link	Recoil spring	Steering (Wheel)	Steering cylinder Linkage	Steering (Crawler)	Tooth cutting edge	Compressor belt	Condenser
A.2.1 Inspection												
A.2.1.1 Working position	1	–	2	1	1	1	1	2	1	1	1	1
A.2.1.2 Type of work	4	–	1	3	1	1	1	3	3	1	4	2
A.2.1.3 Safety	2	–	2	4	1	1	1	2	1	1	2	1
A.2.2 Adjustment												
A.2.2.1 Working position	1	–	–	1	–	1	–	–	–	–	1	–
A.2.2.2 Type of work	3	–	–	3	–	4	–	–	–	–	3	–
A.2.2.3 Safety	2	–	–	4	–	4	–	–	–	–	2	–
A.2.3 Replacement												
A.2.3.1 Working position	1	–	–	–	–	–	–	–	–	1	1	–
A.2.3.2 Type of work	3	–	–	–	–	–	–	–	–	4	3	–
A.2.3.3 Safety	2	–	–	–	–	–	–	–	–	3	2	–
A.2.4 Greasing												
A.2.4.1 Working position	–	3	2	–	–	1	–	2	1	–	–	–
A.2.4.2 Type of work	–	3	3	–	–	2	–	1	3	–	–	–
A.2.4.3 Safety	–	3	2	–	–	1	–	2	1	–	–	–
A.2.4.4 Ease of work — It should be so designed as to prevent rocks and dirt from hitting the grease point.	–	+	–	+	–	–	–	–	–	–	–	–
A.2.5 Cleaning												
A.2.5.1 Working position	–	–	2	1	1	1	1	2	1	–	–	1
A.2.5.2 Type of work	–	–	1	1	1	1	1	1	3	–	–	2
A.2.5.3 Safety	–	–	2	1	1	1	1	2	1	–	–	1

\+ Maintenance is required or should be considered, but the degree of difficulty is undefined.

– Maintenance is not required.

1 Lowest degree of difficulty.

2 Medium degree of difficulty

3 Highest degree of difficulty.

NOTE 1 This table applies to an “average” type of earth-moving machine, therefore, there could be some differences between different models, sizes and types.

NOTE 2 The values 1, 2 and 3 used represent the degree of difficulty of maintenance work, taking account of the “average” type machine.

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BSI Group Headquarters

389 Chiswick High Road London W4 4AL UK

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