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Guide to

Training of mechanics concerned with the operation and maintenance of earth-moving machinery

[ISO title: Earth-moving machinery — Operation and maintenance — Training of mechanics]

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Committees responsible for this British Standard

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Construction Industry Training Board

Construction Plant-hire Association

Department of Trade and Industry (Mechanical and Electrical Engineering Division)

Federation of Civil Engineering Contractors

Federation of Manufacturers of Construction Equipment and Cranes

Health and Safety Executive

Institution of Civil Engineers

Institution of Highways and Transportation

Ministry of Defence

National Coal Board

Coopted members

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Contents

National foreword

This British Standard has been prepared under the direction of the Road Engineering Standards Committee and is identical with ISO 8152:1984 "*Earth-moving machinery — Operation and maintenance — Training of mechanics*" published by the International Organization for Standardization (ISO).

Terminology and conventions. The text of the International Standard has been approved as suitable for publication as a British Standard without deviation. Some terminology and certain conventions are not identical with those used in British Standards; attention is drawn especially to the following.

Wherever the words "International Standard" appear, referring to this standard, they should be read as "British Standard".

Cross-references

International Standards	Corresponding British Standards
ISO 4510:1976	BS 5485:1977 *Specification for maintenance and adjustment tools for earth-moving machinery* (Identical)
ISO 6012:1982	BS 5635:1982 *Recommendations for service instrumentation of earth-moving machinery* (Identical)
ISO 6165:1978	BS 5718:1979 *Glossary of terms for basic types of earth-moving machinery* (Identical)
ISO 6750:1984	BS 6228:1985 *Guide to format and content of manuals on operation and maintenance for earth-moving machinery* (Identical)

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Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 8, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

0 Introduction

This International Standard is intended as a guide to the training of mechanics. It has been assumed that candidates for training possess a sufficiently sound general education with suitable bias towards workshop practice and the use of tools, and that they are sufficiently mature to benefit from the training.

In selecting potential trainees account needs to be taken not only of ability, but also of physical and mental toughness, since the maintenance of machinery is arduous and skilful work, which, particularly when carried out in poor site conditions, can require a high degree of medical fitness.

1 Scope and field of application

This International Standard describes the training of mechanics appropriate for earth-moving machinery. It does not specify any procedure for assessing proficiency or competence, since these factors are usually covered by local and national practices and regulations.

This International Standard is not intended to override any applicable national regulations or standards.

It applies to all earth-moving machinery as defined in ISO 6165.

2 References

ISO 4510, *Earth-moving machinery — Maintenance and adjustment tools.*

ISO 6012, *Earth-moving machinery — Service instrumentation.*

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

ISO 6750, *Earth-moving machinery — Operation and maintenance — Format and content of manuals.*

3 Structure of training programmes

3.1 General

The minimum normal training period should be relevant to national practice and local conditions, but preferably should not be less than three years, with an optional fourth year when appropriate for more advanced or specialized training. It is often an advantage, in deciding the training for an individual trainee or group of trainees, if the length of the course can be decided before training commences, particularly relative to the nature and content if a fourth year of training is contemplated.

3.2 Safety

Throughout training, it must continually be emphasized that one of the **most important** aspects of machine operation and servicing is **safety**. Safety precautions must be integrated into every aspect of the training course and should include

— the understanding and application of local and national safety regulations;

— responsibilities in connection with safety measures, accident prevention, fire hazards and personal hygiene, together with the necessity of using machinery guards and shields, and personal protective equipment and safety clothing for eyes, head, ears and feet;

— precautions to be observed when operating earth-moving equipment and attachments, and the safe and proper handling of all hydraulic tools, air tools, special tools and equipment;

— safe methods of lifting by hand and the use of mechanical and hydraulic handling equipment;

— safe handling and storage of liquids and solvents (particularly those which are flammable), including oils, fuels, and acids;

— location of master switches and methods of immobilizing machinery, including all types of earth-moving base machines and equipment;

— dangers associated with high pressure systems;

— safe method of dismantling wheels and the use of a protective cage during inflation of tyres and hydro-inflation, etc.

3.3 Periods of training

In accordance with **3.1**, the periods of training described below should be regarded only as typical, and the actual durations should be chosen to conform to national practice and local conditions.

3.3.1 *Selection and probationary period*

Selection should be made from candidates who have received a sound general education, including a practical background in the elementary use of hand tools. Theoretical attainment during their education should be adequate to enable them to undertake the technical instruction inherent in the training course. The initial three months of the first year of training should, wherever possible, be regarded as a probationary period.

3.3.2 *Basic training — (suggested duration: one year)* (see clause **4**)

Basic training should include use of hand tools and simple machine tools as applied to maintenance and servicing requirements, elementary metrology and the interpretation of simple drawings.

3.3.3 ***General training — (suggested duration: two years)*** (see clause **5**)

This period provides the main general training and should include the necessary more advanced instruction in machine operation, scheduled servicing, routine repairs and maintenance on sites, for the common groups of earth-moving machinery. Instruction in simple report writing, sketching, etc., should be given.

3.3.4 ***Optional advanced training — (suggested duration: one year)*** (see clause **6**)

This optional further period of training should only be undertaken following successful completion of the basic and general periods of training. It should cover more detailed and advanced instruction on one or more groups of machines to improve the trainee's ability and level of knowledge, so that he may be capable of carrying out major site and workshop repairs and overhauls. Where it is known that a trainee undertaking a general period of training intends, and is capable of, undertaking an advanced period of training, it may be appropriate to bias his general training accordingly.

3.3.5 ***Further career development and refresher courses*** (see clause **7**)

The further development of maintenance abilities can only be achieved from the experience gained by working under normal site conditions and under adequate supervision. This is a continuing process and most training experience must, of necessity, fall within this activity. No specific programme is included in this International Standard, since it must depend upon local conditions and requirements. In addition, specialized courses on a "module" basis (see clause **7**) should be made available for attendance by maintenance personnel throughout their working life.

3.4 Method of training and location

The categories of workshop referred to in this International Standard are as follows:

a) training workshop, devoted solely to basic training in initial skills to enable the trainee to gain maximum benefit while working in a normal operational workshop;

b) depot (or repair) workshop, permanently established to carry out major repairs and servicing on machinery, as a support base for any number of independent sites;

c) site maintenance workshop (or field workshop), established on an operational site to provide local servicing and first aid repair facilities appropriate to the scale of operations on that site. On large, long-term sites, these workshop facilities may approach the scale of a depot workshop.

Wherever possible, all, or a proportion of, the first year training syllabus should be carried out in a recognized training workshop. Where this is not possible, the training should be undertaken in a depot or suitable site maintenance workshop under the direct control of recognized training supervisors.

Training beyond the first year should normally be carried out on site or in a repair workshop.

Technical training should be coordinated with, and given at, a recognized technical college or school, by attendance equivalent to preferably not less than 40 working days per year during each year of the course (but not necessarily during the optional fourth year).

4 Basic training — First year (or as appropriate)

The scope of training during the first year is intended to introduce the candidate to the industry, with particular reference to mechanical machinery to familiarize him with the basic aspects and develop his interest to continue with benefit the subsequent years of instruction. The training content should be suitably balanced between lectures/demonstrations and practical work which may be carried out in a training establishment or, under suitable supervision, in a depot or site maintenance workshop. The actual training methods or training aids to be used are not specified in this International Standard, due to variation in local conditions and availability of equipment.

The initial three months of training (and where possible a longer period) should normally be regarded as a probationary period to establish the candidate's aptitude for employment in the maintenance of earth-moving machinery.

The content should, typically, include the following aspects, which are not listed in any sequential order of importance or timing.

4.1 Safety during maintenance

Safe practices and accident prevention must be a constant feature during all instruction. This instruction should emphasize the concept of safety not only during the actual maintenance operation, but also the importance of that maintenance operation being carried out to a high standard, to ensure that the machine is safe during actual production operation. Particular care must be taken to discourage the adoption of unsafe habits during the initial training. Emphasis should be given to the various machine manuals, particularly those relative to maintenance and operation, regarding safety messages and data, and attention should be drawn to safety signs on the machine, especially where recognized International Standards and/or symbols are used. The importance of maintenance of all safety devices, and visual and audible alarms, in a high state of operational efficiency at all times, should be fully explained.

4.2 Familiarization with machinery

The trainee should gain a general knowledge of as wide a range of types of machinery as possible, including their use and limitations (see ISO 6165). He should also become acquainted with operation of machinery relative to maintenance requirements and should watch skilled operators at work. He should also be introduced to the operator manual (see ISO 6750).

4.3 Principles of basic mechanisms

Elementary instruction in the working of basic mechanisms such as engine, transmission, gears, cooling and hydraulic systems, etc., should be given as soon as practicable, to enable the trainee to appreciate the significance of the maintenance and servicing instruction which he will be given during the first year of training.

4.4 Servicing machinery

Full instruction should be given and appropriate experience gained in general servicing of machinery with particular reference to the use of common types of lubricating devices and tools (see ISO 4510), and the manufacturer's special tools or aids.

The trainee should become fully familiar with the following aspects:

— servicing procedures and practices;

— machine operation;

— maintenance schedules and records;

— lubrication charts;

— use of maintenance and lubrication manuals (see ISO 6750);

— correct and safe practices during maintenance and to ensure subsequent accident-free operation, for example, the necessity to exercise care when using flammable solvents such as cleaning fluids, etc., and the danger of welding on or near oil containers and pipes or greasy surfaces.

Particular examples of the results of bad or inadequate servicing should be given.

4.5 Basic knowledge of materials

Instruction should be given in the properties of common materials used in earth-moving machinery, such as composition and density.

4.6 Basic fitting and welding

Instruction should be given in the use of any common hand tools with which a trainee is not familiar, including, for example, files, hammers, chisels, saws, scrapers, drills, reamers, taps and dies (see also ISO 4510 for some common maintenance tools).

Elementary instruction in the principles and practice of gas and electric welding of mild steel and soldering and brazing should be covered, including the carrying out of simple welding repairs under supervision. Safe working procedures should be indicated, stressing, for example, the danger of explosion when welding fuel tanks, and the necessity to disconnect batteries or other power supplies before any welding work commences.

4.7 Dimensions and use of measuring instruments

Initial instruction in the interpretation of working drawings should be given and this should be at least as sufficient as necessary to enable the trainee to learn the use of common workshop measuring instruments quickly and accurately, with particular reference to the following:

— micrometers;

— internal, external and depth gauges;

— calipers and verniers;

— feeler gauges;

— cylinder compression gauges;

— torque wrenches;

— hydrometers for checking battery and coolant;

— other appropriate instruments, including those listed in ISO 6012.

4.8 Use of simple machine tools

While it would probably be impractical to develop a high level of dexterity in the operation of machine tools during the first year of training, sufficient instruction should be given in the use of simple drilling machines, lathes, millers, etc., as related to the requirements of machine maintenance.

4.9 Identification and procurement of spares

Introduction to the manufacturer's parts manual (see ISO 6750) should be given to the extent required to enable the trainee to identify and order spare parts as required. The importance of recognizing whether a worn part should be refurbished or replaced should be indicated, with particular attention to tolerances. Data related to parts and components should be made available for the personal use of the trainee to further his training.

4.10 Introduction to repair of machinery

Initial elementary instruction, generally under supervision, should be given in the repair of machinery. The following is typical of the content of such instruction:

— elementary assessment of reasons for repair and whether due to abuse, overload or wear;

— removal and repair of tyres and wheels, including the use of a protective cage;

— replacement of minor accessories, for example, lamp bulbs, horns, spark plugs, injectors, etc.;

— clearing blocked fuel lines and filters;

— inspection, adjustment and replacement, where necessary, of hoses, belts and cables;

— repair of paint work.

In addition, wherever practical, the trainee should work as an assistant to an experienced mechanic in dismantling, cleaning and replacing parts in assemblies such as engines, gearboxes and transmission units, etc.

5 General training — Second and third years (or as appropriate)

The general training should be phased to develop the initial skills obtained in the first year to the level of practical application on operational machines by the end of the third year of training. For trainees undertaking a fourth year of instruction, the content may, with advantage, be biased to include the subjects indicated in **5.3.2**. The content should, typically, include the following aspects, which are not listed in any sequential order of importance or timing.

5.1 Safety

Throughout the general training period, and in subsequent training, it is essential that instruction in general safety, with particular reference to safety in maintenance and servicing procedures continues.

5.2 Second year training

5.2.1 The typical content would be as follows:

— maintenance and repair of simple fuel systems;

— engine maintenance, for example, removal of cylinder head, re-grinding valves, replacing piston rings, etc.;

— removing, cleaning and replacing parts without supervision;

— attachment and removal of equipment;

— minor repairs to bodywork, cab, etc., including the use of welding and brazing techniques, etc.;

— simple fault finding and correction of electrical, air and hydraulic systems.

5.2.2 In addition to the above practical tasks, the trainee should be introduced to procedures for inspection of machinery to check

— the extent and nature of external damage or defects, with particular reference to structural and load-bearing members;

— the correct functioning of systems (for example electric, hydraulic, air, etc.);

— the condition of tyres, hoses, cables, ropes, brakes, clutches, etc.;

— the steering wheel alignment;

— the cause of failure (for example bearings, etc.) by the appearance of the failed part;

— the dimensions of parts by comparison with a drawing or specification.

5.2.3 Every endeavour should be made to give the trainee instruction and experience in:

— safety regulations, particularly in respect to workshop tasks, such as the correct jacking of machinery, the supporting of heavy assemblies, and fire precautions when welding, etc.;

— reading and interpretation of drawings;

— simple report writing, sketching and photography of components;

— assisting in the recovery of damaged machines;

— fault diagnosis using test devices;

— simple repair costing exercises, with particular reference to the relative advantages of repair by part replacement and re-build, compared with fitting a manufacturer's service exchange unit;

— elementary structural properties of materials.

5.3 Third year training

The aim during the third year of training should be to convince the trainee of the necessity for correct routine and planned preventive maintenance, and should include instruction in the use of diagnostic techniques to determine the cause of failures and performance problems. The emphasis should be on preventive, rather than remedial, maintenance. The individual should be instructed to recognize the vital part that he needs to play. For much of this year, he should be working on routine production alongside experienced mechanics, and his work should be monitored appropriately. His training should be planned to enable him to work unsupervised at the end of the 3 year training period, within the context of the standard laid down in the programme. At the end of the third year, a trainee should be competent to operate machines to enable him to confirm (or otherwise) the effectiveness of any repair. He should also be able to advise on procedures to prevent possible misuse of machines on site.

5.3.1 *Training for trainees who do not contemplate a fourth year*

For trainees not contemplating a fourth year, the typical content during the third year should be as follows:

— removal and replacement of selected major assemblies, for example gearbox, engine, hydraulic motor or pump ("selected" in this context means that extensive stripping is not required to reach the assemblies to be replaced);

— overhaul of a fuel system, including complete dismantling from carburettor or injector through the pump and filters to tank, and re-assembling and testing;

— overhaul of an engine cooling system;

— overhaul of a machine braking system;

— removal and re-fitting of winch cables, pulley systems, etc.;

— method of keeping maintenance/servicing records and overseeing operator servicing;

— repair to machine structure.

5.3.2 *Training for trainees contemplating a fourth year*

Training should include the items listed in **5.3.1**, but the level of training should normally be to a higher standard with, in particular, the addition of the following typical content:

— dismantling, inspection, re-building and testing of major assemblies, including engines, gearboxes, tracks, etc.;

— complete inspection of equipment, checking safety aspects;

— mechanism quality assessment and report writing;

— the manufacture by fabrication of minor components;

— preparation of dimensioned sketches and the manufacture of items to these sketches and to other drawings;

— the machining of simple parts, for example skimming out brake drums, etc.

6 Optional advanced training — Fourth year (or as appropriate)

Training during this period is intended to equip the trainee to work unsupervised on more complex and sophisticated machines. In addition, the ability to carry out inspections and prepare brief reports should be further developed.

6.1 Safety

Instruction already received in safety matters (see **3.2**, **4.1**, **5.1**, etc.) should be re-emphasized and, in addition, training should be concentrated on the further development of skills in inspecting and evaluating the working conditions relative to safety of all machines and appliances (including earth-moving machinery and machine tools) which the trainee is likely to encounter during his future activities.

6.2 Training programme

During this period, the trainee may be expected to undertake work unsupervised, but with performance monitored, although the more complex and unfamiliar tasks will require some supervision. The following is typical of such training:

— the testing and repair of the more complex mechanisms, such as epicyclic or multi-clutch gearboxes, provided that the necessary specialist test rigs, etc., are available;

— general machine fault diagnosis using the most developed equipment and techniques;

— the use of all forms of test equipment and apparatus to determine the physical condition of machinery;

— in-service inspection methods and techniques;

— planned systems of preventive maintenance, including the operation of maintenance programmes and records;

— accident damage and defect investigation;

— report writing and development of skills in producing work sketches;

— improvisation, including the reclamation methods of repair;

— machine recovery following accident or breakdown;

— general safety and use of machines in day-to-day operations as specified elsewhere in this International Standard;

— the use of solid-state and other electronic equipment as appropriate, including fault diagnosis and rectification.

7 Further career development and refresher courses

To enable all maintenance mechanics to remain up-to-date in developing techniques, the overall training spectrum should include the availability of relatively short courses which can be taken at any period during working life. The courses should be of two categories, the first in the nature of refresher courses designed to revitalize existing activity, and the second designed to acquaint mechanics with new methods and new machinery as developed.

The exact nature and direction of such courses is not specified directly in this International Standard, since it would depend upon local facilities, but it is recommended that a standard syllabus be drawn up for each subject on a "module" basis, such that the course can be embarked upon at any convenient time. A "module" course in this context could consist of a course (say, of duration between one week and six months) with a standard syllabus which has been prepared on a modular basis to integrate past training with that which may be taken in the future.

The content of these courses can be laid down regionally or nationally in such a way that they can be adopted by any organization with the appropriate resources, or, alternatively, such courses may be drafted by individual agencies. Instruction in this type of course will frequently be given by individual manufacturers and other commercial organizations in addition to the more normal training establishments.

8 Certification of completion of training course

On completion of a course, a certificate should, wherever practical, be issued.

Since, in some countries, statutory forms of certificates may already exist, this International Standard does not specify a layout, but it is suggested that the following information should be included:

— certificate registration serial number (and identification of the training organization), where applicable;

— trainee's name and other identification;

— nature and content of course;

— duration of course, including dates of commencement and completion;

— authorization signature.

9 Training monitoring record chart

Where required, and in accordance with national practice, the use of a training monitoring record chart, within the training establishment, may be appropriate. A typical training monitoring record chart is shown in the Annex A.

Annex A Typical training monitoring record chart — Power train skills inventory (wheeled machines)

A.1 Introduction

The training monitoring record chart serves as a record of the operations an individual can perform without supervision.

The supervisor should

a) identify skills needed for the individual's job description by circling the desired skill blocks (rectangle on chart);

b) with the cooperation of the individual, enter the year date (for example 79 for 1979) in the circled blocks for skills in which he is already satisfactorily qualified;

c) plan training for the individual based on needs identified by blocks circled but not dated, adding the date when qualified.

Shaded blocks indicate operations that do not apply.

A.2 Explanations

The operations shown on the chart, and which an individual can perform without supervision, are defined in the following table.

Operation code	Definition
A	Maintenance/visual inspection: Use the procedure shown in the lubrication and maintenance manual. Also look for leaks and broken parts at the same time.
B	Clean: Remove dirt or other materials from a part.
C	Remove/install/replace: Disconnect and take off. Put on and connect. Install new parts as necessary.
D	Disassemble/assemble/evaluate: Take apart and put together, including an analysis of parts for use again.
E	Recondition: Repair or put parts in a "like new" condition.
F	Measure/adjust/set: Make necessary measurements for evaluation or adjustments. To make any stationary adjustments or adjustments during operation.
G	Diagnostic test/performance test: Make a test for correct performance, including the use of instruments and tools for diagnosis (where necessary) to see if operation is correct.
H	Troubleshoot: Make analysis of a part or system to find the cause of failure.

Training monitoring record chart

Part or assembly		A Maintenance/ visual inspection	B Clean	C Remove/install/replace	D Disassemble/assemble/ evaluate	E Recondition	F Measure/adjust/set	G Diagnostic test/ performance test	H Troubleshoot
Drive line/drive axle	1								
Universal joint	2					▨	▨	▨	
Flexible coupling	3					▨		▨	
Drive line/shaft	4					▨	▨	▨	
Pinion	5					▨		▨	
Bevel gearshaft	6							▨	
Differential (standard)	7							▨	
Axle housing assembly	8					▨	▨	▨	
Torque proportioning differential	9							▨	
Differential lock	10							▨	
No-spin differential	11							▨	
Constant velocity universal joint	12					▨		▨	
Drive line brake	13								
Final drive (wheel type)	14								
Drive axle hub/gear assembly	15							▨	
Tandem drive	16							▨	
Tandem drive, bevel gear, final drive	17							▨	
Trunnion, housing, sprocket, axle	18							▨	
Rim and tyre	19					▨		▨	
Spindle assembly	20					▨		▨	
Compactor wheels	21							▨	
Wheel assembly	22					▨		▨	
Wheel brakes	23								
Brake drum	24							▨	
Brake shoes	25							▨	
Parking brake	26								
Brake linkage	27					▨		▨	
Steering system	28								
Steering gear	29					▨			
Steering cylinder	30					▨	▨		
Steering linkage	31					▨			
Steering valve	32					▨			
Follow-up linkage	33					▨			
Steering gear and valve	34					▨			
Tie rods	35					▨			

Publications referred to

See national foreword.

BSI — British Standards Institution

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