UNIT-11

Equipment Management

Learning Outcomes

By the end of this unit the learner will be able to:

- ✓ Explain equipment management organisation and equipment management information services
- ✓ Discuss the various aspects of spare parts inventory
- ✓ Describe ABC analysis of stock planning
- ✓ Explain the importance of inspection and maintenance programmes.

Unit 11

Equipment Management

Introduction

Equipment management is a highly critical function undertaken by construction firms. It involves planning, managing spare parts, inventories, stock planning, repairs and maintenance, and any other activity that is performed to ensure that the equipment functions as expected. This unit will look at the steps construction companies can take to manage their equipment more productively when undertaking projects.

Equipment Management Organisation

An experienced and skilled team is normally required to ensure a successful equipment management programme. The size of the project usually defines the number of personnel to employ. For small projects, the owner or operator is responsible for the management of equipment. Larger projects attract a large workforce consisting of specialised personnel whose roles are well-defined in managing equipment.

Factors to consider, when setting up an equipment management department, include the size of the project, the types of equipment available, and the type of work to be undertaken. The success of any equipment management programme, be it large or small, rests on defining and assigning responsibilities to each functional unit.

Smaller projects tend to have teams consisting of multi-skilled employees working in collaboration with an accountant or book-keeper to ensure that operations are analysed and activities consequently designed to maximise economic benefits. Due to funding constraints, smaller projects have to rely on outside help for spare parts and significant repair works.

Unlike smaller projects, larger jobs require each role to be well-defined in terms of functions and responsibilities. Larger projects normally have their own workshops to service or repair equipment. However, the company may seek outside assistance if necessary. Under such circumstances, the number of the mechanics has to be reduced, as fewer employees will be required to repair a reduced amount of equipment.

The equipment manager is responsible for managing a number of employees in administrative positions who are tasked with maintaining equipment records.

Spare Parts Inventory

The ability to secure a temporary storage facility for spare parts and servicing will significantly reduce the need for the equipment owner to construct one when undertaking a large project. Only a minimal parts inventory should be held, except on occasions when the work site is located in a remote region where accessibility of parts may be interrupted or the supplier is not very reliable. It is normal to keep a 10-day supply of parts inventory.

Filters, lubricants, bulk cable, hoses, and other consumables can be bought in bulk and stored at the workplace or workshop. For safety and economic reasons, it is advisable to avoid storing excess fuel. It is important to procure the right amount of spare parts rather than acquiring excessive quantities because some may soon become obsolete with the emergence of improved parts.
Large items such as buckets, tracks and chains can be stored outside in a designated area surrounded by fencing to protect against theft and accidents. All parts must be protected from rain, moisture, chemicals, and any other contaminants using racks, boxes, shelters or bins. It is important to have a book-keeping system to account for all parts in order to avoid future shortages.

Availability of Spare Parts

Having a good maintenance programme means sourcing a suitable number of parts on time and keeping an efficient inventory of the parts at the lowest cost possible. Inventory size depends on the number of machines, their ages, conditions of operation, storage capacity, supplies, and delivery periods, as well as the efficiency of the purchasing department.

A proper record of consumption of all machines is invaluable for estimating the rate of demand for spare components. It is good practice to consider the interchangeability of spare parts when choosing equipment for projects.

The three types of spare parts required for machines are:

- Consumable parts
- Fast-moving parts
- Slow-moving parts

Consumable spare parts can be determined quite easily. Equipment life is determined by the working conditions, which are a measure of how many critical fast-moving parts will be required from the spare parts inventory. Harsh working conditions will wear the equipment out faster than mild conditions. The inventory of slow-moving parts is determined based on a comparison of their holding cost with the likely effect on the product if they were not readily available. Inventory stocks of slow-moving spare parts are usually lower than the fast-moving parts. Inventories of spare parts can range from 100s to 1000s in a typical large-scale project. Standard and non-standard parts should be stocked separately. Standard parts include seals, bolts and nuts, belts and bearings. Non-standard parts include pistons, crankshafts, and liners. Overstocking may result in losses if parts remain unused. Reasons why parts may become available in excess include the following:

- Purchasing excess spare parts due to fear of being unable to obtain supplies for imported equipment locally
- Using several makes and models of equipment
- Purchasing a large number of spare parts based on manufacturers' recommendations to counter obsolescence

- Lack of proper equipment planning can result in the purchasing of larger quantities of parts than is necessary

In situations where excess spare parts are identified, a coordinating agency may be able to help transfer extra equipment and spare parts to other users who may be interested. This would require an effective publicity campaign using a variety of media sources.

Interchangeability of Spare Parts

Some primary manufacturers make essential components such as hydraulic system components, axles, transmissions, and differentials for diesel engines, which are bought and assembled by equipment manufacturers. Other primary manufacturers produce spares such as bolts and nuts, belts, seals, and bearings, etc. for the equipment. It is common practice among primary manufacturers to produce identical parts that can be used in different models of equipment, thereby making them interchangeable.

A database listing interchangeable parts produced by the equipment manufacturer or by private and public agencies will help the user to reduce his spare parts inventory significantly. Sometimes manufacturers of primary components create master catalogues showing which items can be used on a list of different makes of machines. It would be possible to reduce the inventory of spare parts if parts for imported equipment can be produced in the project workshop or within the country of residence.

Inventory Management

Procurement and inventory systems should be designed to meet demand at a minimum cost. Precautions should be taken when managing spare parts to avoid any shortages of parts and the need to use substantial capital in procuring items.

An inventory model developed by the operations research department can be used to estimate procurement levels (i.e., the quantity of stock remaining at the time action for extra procurement is initiated), the quantity of items to procure and how often to initiate procurement. An example of an inventory model developed by operations research is described in the next paragraph.

The inventory model consists of variables such as demand order size, cost of procurement, holding costs, and the costs of shortages. In real procurement situations, the demand is not known with certainty and it tends to vary over time. The rate of withdrawal of an item from the stock may also vary discretely or continuously. However, in simple models, demand and supply rates are constant. Lead time becomes an important factor with regard to the rate of arrival of items to the stock at either constant or variable rates. The rates may be continuous or discrete.

If we consider a constant rate of replenishment, then:

i. Procurement cost involves processing orders and following up the process of procurement. The cost relates to each lot procured at one particular time and it usually depends on the items being procured and the size of the lot.

ii. Holding costs are calculated as cost per item per unit time for storage. This involves all costs associated with the maintenance of inventory storage, handling of items, taxes, insurance and interest rates, and the like.

iii. Delays in meeting demands from suppliers or from inventories results in shortage cost. Shortage cost can be eliminated by making it infinite, i.e. by not allowing any shortages to occur. This scenario will substantially increase the inventory cost compared to the situation that results in shortage cost.

STOCK PLANNING

ABC analysis is used for stock planning by categorising items into A, B or C lots. The cost of procuring items in group A forms about 75% of total costs. The quantity of items in group A is around 10% of the total quantity of stock procured. More planning and control is placed on items in group A due to their importance in terms of cost. Items in group B account for 16-20% of the total amount of stock and usually amount to about 15-20% of total procurement costs. Items in this group are not as important as items in category A and they do not require precise control. Items in group C make up 70% of the total quantity of stock items and account for 5-10% of total expenditure. Items in group C are purchased in large quantities to ensure the project is not interrupted due to shortages. Control of group C items is not as stringent as that exercised in groups A and B.

Economic Life

Accurate records of repairs and depreciation rates can be used to estimate the productivity and profitability of equipment. Hourly rates for equipment can be estimated based on past records of expenses. The rate of depreciation and repairs vary over time and according to productivity. For newer equipment fewer repairs are needed, but repairs will increase as the equipment ages.

Replacement Analysis

Past records should serve as a guide to the future when contemplating replacing or investing in new equipment. Generally, it is important to distinguish between replacing equipment as a result of undesirable physical state and replacing it with a new item when it becomes obsolete.

Replacement is carried out when equipment downtime becomes exceedingly high or when a significant overhaul is due. The timing for effecting replacement varies from one contractor to another. A decision can be taken to replace equipment when a contractor who has been awarded a new contract reviews the condition of his equipment and recommends a replacement when he finds the current equipment unproductive or problematic. Another contractor may review his equipment condition and initiate replacement procedures based on tax and capital that has become available. It should be borne in mind that replacement of equipment is a recurring issue that has to be reviewed frequently.

Some general rules for replacing equipment have been proposed. The first option includes making replacements when all operating, repair and maintenance, and overall costs and salvage value in the subsequent period exceed the fixed price of new equipment. A second rule advocates replacement if the cost of extending the life of the equipment by one more year exceeds the cost of the equipment.

Previous experience confirms that the cumulative cost of repair increases wherever equipment is repaired. The decision to repair equipment is based on whether the serviced machine can generate significant revenue or not. Decisions on repairing or replacing equipment can be reasonably made with the assistance of previous guidelines or by analysing specific equipments.

Guidelines may provide useful information on when to replace a particular type of equipment given certain physical or operating conditions. These records or guidelines will also show the amount of losses to expect.

Replacement analysis is based on the following factors:

i. Value of money: There is a need to consider interest rates used for calculating the cost of equipment.
ii. Inflation: The rate of inflation should be included in cost analysis.
iii. Taxes: Costs of equipment should be converted to common tax basis before comparisons are made.
iv. Salvage value: The price of equipment can be reduced by the salvage value provided the salvage value is greater than the cash value of equipment.
v. Utilisation: When comparing alternatives, the choice should be based on the productivity rather than the cost
vi. Standby uses: Alternative uses of the current equipment such as putting it on standby should be weighed against completely replacing the equipment with a new item.

Necessity of Maintenance Management

Maintenance management involves all direct and indirect labour, machinery, material storage, and tasks relating to keeping all equipment in excellent condition. It entails regular inspection, servicing, lubricating, repairing and overhauling of equipment.

Achieving success with a maintenance programme requires good organisation with well-informed operating and maintenance personnel. The programme should provide a means of effectively recording critical data such as operating hours, stoppages and costs. It should provide guidelines for preventive maintenance which reduces cost and improves profits. The ideal scenario is to develop scheduled maintenance for the bulk of items requiring servicing so that the system can be well-controlled to maintain order, achieving less downtime and regular availability of equipment for productive work.

Regular communication between workers and management will make this system successful. Workers should be informed about all aspects of the schedule including the contribution expected from each individual in keeping the system efficient. They should know the lifespan of equipment, replacement policy, the extent and cost of repair works and how data should be collected in the field.

Operatives must also keep management informed about the condition of equipment including breakdowns, continuous failures of parts and improper operations in order to improve the system. It is the responsibility of the equipment maintenance organisation to develop the schedules for equipment with the operating department being informed about the schedules. The schedules should be such that

the effect of downtime on production is minimal. In the event of scheduled maintenance not being performed, the operating department must alert the maintenance supervisor for rescheduling at the earliest opportunity.

Principal Aspects and Methods of Maintenance

Methods used for maintaining equipment include inspection, servicing and repairs. Inspection should normally be done by a different organisation. Servicing includes all activities relating to the provision of lubricants, water, air and fuel. Servicing duties are performed by the equipment operator and the servicing team. The servicing or inspection team may advise another team of maintenance staff to perform field repairs when the need arises. Regular inspection should be carried out on equipment during production in order to identify likely problems which could lead to equipment breakdown.
Methods of maintenance of field equipment include:

i. Maintenance at a central depot
ii. Maintenance at work site using mobile servicing

For small projects, equipment may be taken to a central depot provided the distance is not too significant. It is advisable to carry out servicing and maintenance during non-operating periods to avoid downtime. Large projects requiring an array of equipment scattered across a wide area will require the services of a mobile unit to service and perform maintenance on the equipment on site. Servicing is normally done after working hours or in some cases during recess of a working shift. A very skilful team may take only minutes to rectify a problem, enabling the equipment to be put back to work.
Repair works in the field can be accomplished at the field repair shop or in a mobile repair unit. The mobile option tends to save time since there is no need to move any equipment. The date for servicing equipment is finalised and all equipment is colour-coded to ensure that none is omitted during servicing. The central workshop, which is responsible for major repairs and overhauling, is not part of the maintenance organisation.

Equipment Servicing and Servicing Facilities

Mobile servicing units should have the ability to store all requisite POL (tools) to carry out work on field equipment. It should also have pumps and hoses of standard lengths. Other essentials to carry to the field include a water tanker and air compressor. Ideally, several jobs can be performed simultaneously to minimise the overall time spent on the job. Mobile units may organise themselves into two teams: one for tyres and tubes, and the other team taking care of lubricants and fuel.
The central servicing depot should be equipped with team members and identical equipment just like the mobile units. The depot should provide adequate storage for fuels and lubricants which must be protected against contamination due to leakages, dust or evaporation. Two or more tanks are required to store fuel oil, one for sedimentation (3-4 days) while the other is being used.

When storing tanks underground, care should be taken to construct a manhole with filling, breather and pump connections provided on top of the tank. The above-ground storage option involves provision for a drain plug for water as well as a tap for discharging sediments at the bottom of the tank. The above-ground tank which contains the fuel is connected to an overhead tank. Fuel is pumped from the ground-level tank to the overhead tank through filters and a metered pump. Operations involving storage and transfer of oil, fuel and lubricants must be carried out under clean conditions. All tools, pipes, hoses and caps should be cleaned before being used to fill machines.

Provision should be made for adequate lubrication of machine parts for efficient operations. Suitable lubricants in the right quantities should be used on the correct parts. Use lubricant charts and schedules provided by the manufacturer when administering lubricants.

To minimise errors, keep just a minimum number of lubricating oil brands and grades. In addition, paint grease nipples and caps based on specific colour schemes on the containers to prevent mix-ups. Suitably qualified persons working under the direction of an overall lubricating supervisor should be appointed to oversee lubricating tasks.

Clear, soft cooling water should be available during servicing. Adding a small amount of oil to unsuitable water should help reduce scaling. Sometimes, it may be necessary to carry out adjustment of individual parts of the cooling system for optimal performance. Coolant, when used appropriately, can extend the life of components of the cooling system.

Servicing of wheels and tracks must also be carried out during the maintenance schedule. The correct tyre pressure should be maintained, and when a piece of equipment is expected to sit idle for a long period, it should be jacked up and contact with lubricant avoided. Track equipment requires adjustment of tracks and greasing of idler, sprockets and rollers during servicing. Loose bolts and nuts must also be tightened whenever necessary.

Attention should also be paid to the cutting blades, transmission, clutches, and electrical and electronic systems, as well as the power control unit. Teams should be arranged to work on specialised aspects of the machine requiring the skills of a specialist.

Tools for tightening bolts and nuts include wrenches, hammers and pliers, etc. Cranes, draglines and pile drivers are suitable for dealing with clutch and brake adjustments.

Comprehensive checklists for parts being checked should be made available by the servicing supervisor to ensure no important aspect is omitted.

Field Repairs and Maintenance Facilities

Permanent site workshops for field repairs and maintenance must be well stocked with the necessary tools to cater for the wide range of equipment available. Provision for both covered and open spaces should be made for repair and maintenance-ready equipment. Field stores and tools should be located in an enclosed building. The workshop floor should be made up of concrete and supplied with water, electricity, compressed air and lighting. Vices, racks, benches, cupboards, grinders, jacks, drills, lathes, and other important tools and devices should be made available in the workshop to deal with a variety of repair work. Devices such as welding machines, lifting tackle with gantries, mobile cranes or A-frames, and a small foundry would be invaluable additions.

Mobile workshop trucks contain the following tools: a pillar-drilling machine, welding device, lathe, fitter's bench, lifting gear, and a saw. Power for the devices is derived from the engine of the truck; alternatively, a generator may be used.

All major repairs, such as overhauls, should be referred to the central workshop. Overhauls are usually performed after the equipment has been used for over 2,000 hours.

Tools and Aids for Maintenance

Tools that help with maintenance functions include pressing tools, hand tools, machine tools and handling tools. Handling tools are used to lift and carry parts from one place to another. These include forklifts, mobile A-frames, boom trucks, jacks, tractor-mounted cranes and pulley blocks. Pressing tools assist in removing parts that are tightly fitted together. These devices include hand-powered pullers for light duties and portable hydraulic presses. Parts that can be removed with these devices include sleeves, brushing, gears, bearings and shafts. Spanners, chisels, sets of wrenches, screwdrivers and tongs are examples of hand tools that must be made available to the maintenance team. Aids such as compressed air, cleaning systems, benches, platforms, water and special mount frames should be available.

It is good practice to clean parts at the least opportunity. Parts should be stored in a clean place afterwards. The site should be clear of all dust, metal scraps and cuttings, bolts and nuts and all traces of lubricants. Water and steam jet devices can be used to clean repair shops rapidly. Water jets operating at a pressure of about 42kg/cm^2 can be used to remove heavy sludge. Light grease can be removed with the help of vapour-type steam-ejecting devices while steam jets operating under hydraulic pressure can be used to remove thick layers of dirt and grease at pressures of 21-28kg/cm^2.

Lubrication Requirements of Construction Equipment

Lubrication reduces incidents of breakdown and improves the productivity of equipment. Equipment operating under adverse conditions makes lubrication a daunting task during construction projects. The complexity of modern construction equipment with high-speed and heavy-loading capabilities with minimal tolerance spaces requires efficient and effective lubrication for high performance. A high-quality lubricating schedule will require the right quantity of lubricant, proper storage and correct application to the right parts. Steps should be taken to devise a foolproof mode of application to avoid costly mistakes due to misapplication. Using a minimum number of different grades, lubricants should be properly labelled and stored in an appropriate place to reduce the chances of misapplication.

Six types of lubricants can meet all the lubrication needs of construction equipment. These include gear oils, engine oils, hydraulic oils, track roll greases, heavy-duty greases, gear oil of extreme pressure type and gear oil of adhesive type. Special lubricants are required for electric motors, generators, steel wires, pneumatic tools, water pumps and fifth wheels.

i. Engine crank case oils provide effective protection from rust, oxidation and foaming; they have anti-wear properties, stability and corrosion resistance. Replace series II oil with better detergency-straight mineral oils.
ii. Extreme pressure type gear oils prevent foaming, corrosion, oxidation and thickening. They are useful in situations where sliding contact occurs. This type is capable of absorbing shock loads.

iii. The adhesive type gear oil provides excellent resistance to water. It can provide penetrability for wire rope applications by sealing each strand of wire in a tough, viscous film, preventing rusting and corrosion and reducing friction and wear.

iv. The functions of hydraulic oils include transmission of power in hydraulic equipments, cooling and lubrication of components. Hydraulic oils' mineral oil content helps prevent rusting, wearing, foaming and sludging.

v. Heavy duty greases are designed for use on bearings and gears and must be capable of dealing with wheel-bearing loads. They should be able to resist contamination by water and shear problems. Multipurpose greases for heavy loads contain a lithium component to provide high dropping point functionality.

vi. Roller bearings require the use of track roll greases. The soft types of grease with excellent mechanical stability and anti-rusting properties are in high demand. Semi-fluid greases can be applied to plain bearings.

Storage and Handling of Lubricants

It is important to provide proper storage and handling for all lubricants. Lubricating oil and grease may become ineffective if handled carelessly. Care must be taken to prevent contamination by dust and water, high temperatures, exposure and leakages. Lubricants should be ideally stored indoors in locations free of dust and exposure to high temperatures. If you decide to store them outside, you must ensure that the barrels are stored on racks and on their sides and duly covered to protect them from dust and rain.

Use exhaust steam rather than direct heat from flames to melt frozen oil during the winter season. It is advisable to store only sufficient quantities of lubricant to be applied with 6-9 months, with older stocks being used first. Avoid storing lubricants beyond the recommended period as the quality of the lubricant decreases after longer periods of storage.

When handling lubricants, it is vital to take steps to prevent contamination, leakages and dripping. To achieve efficient transfer and dispensing of lubricants, use devices that fit standard barrels containing the lubricants. Try to avoid the use of intermediate transfer units to prevent contamination. Units such as funnels, nozzles and hoses are to be kept clean of all traces of contaminants. If equipment is spread over a large working area, use mobile lubricating and fuelling units. Transfer pumps, fuel meters, fuel tanks and hoses should be provided on fuelling equipment. The fuelling equipment has lubricating containers for different types of lubricants with pumps. Reeled hoses for lubricants, air and water should also be provided on this equipment. Finally, empty barrels or containers are provided for collecting waste. Other accessories provided on board the mobile fuelling equipment include hand-operated grease guns, a volume compressor and a small air compressor. The mobile unit should also have a 1.5kW lighting plant to providing lighting. Good record-keeping is essential for proper management of stock levels and to ensure lubricating and servicing are carried out according to correct procedures.

Inspection and Maintenance Programme

A detailed inspection and maintenance programme should be drawn up to guide maintenance personnel as well as operators to perform regular inspections to determine and record the conditions of components such as the hydraulics, transmission unit, engine, tyres, structural units, undercarriage, gears and electrical components. The maintenance programme should be designed with guidance from the equipment manufacturer's maintenance instruction manual. A detailed inspection sheet should consist of a list of equipment with corresponding dates of inspection. The sheet should contain a list of individual components that need to be checked. The equipment manager is required to work closely with the equipment supplier, maintenance personnel and operating personnel to ensure a successful maintenance programme.

The duty of the maintenance inspection personnel is to undertake only inspections and adjustments for minor incidents such as restoring power loss in equipment. Major problems such as complete failure of a unit should be dealt with by a mechanic at the behest of the equipment manager when the problem is reported.

Responsibilities of maintenance personnel include:

i. Inspection and adjustment of equipment on a regular basis
ii. Providing adequate scheduling of equipment for maintenance checks
iii. Advising equipment manager on issues relating to equipment
iv. Keeping work records

Data Bank

It is important to keep an accurate data bank of all aspects of construction projects. Distortions of data collected from equipment management should be checked and eliminated. Distortions occur for all sorts of reasons such as harassing management, laziness, covering up human errors, or justifying decisions. Data should be cross-checked by supervisors to prevent inaccurate reporting. Simple, unambiguous and clear forms should be used for collecting and recording data; the forms should be signed off by two people who have verified the data as being accurate.

Forms required for data storage include:

i. Equipment repair history
ii. Shop repair order
iii. Preventive maintenance record
iv. Service station report
v. Daily operator inspection report
vi. Operator report of equipment deficiency

Standard forms for the above list may be obtained from suppliers of business forms.

Equipment Management Information Service

To keep track of fuel consumption, replacement of parts, equipment operation and major overhauls, it is important to have an efficient equipment management information service. A manual system is useful for keeping track of inventories of 500 pieces of equipment while a computerised system is ideal for items of equipment numbering over 500.

Using the computerised system saves time and is more economical. It can also be used to perform a quick analysis before making decisions on equipment. Current trends suggest that, due to the superior advantages inherent in the computerised system, many small-scale contractors with fewer than 500 pieces of equipment are switching from manual to computerised systems.

Whichever system is adopted at the work site, it should be simple and flexible for easy and accurate data keeping and transfers. Whenever a construction site is relocated, the accompanying documents for equipment must also be transferred with the equipment. Important documents, such as preventive maintenance records, lubrication charts, parts catalogues, operating instructions, and maintenance instructions, should be kept in a convenient and accessible place as they are very important. When inventories are transferred, they should be adjusted to reflect the inventory records.

Further Reading:

- ✓ **Douglas D. Gransberg, Calin M. Popescu, Richard Ryan (2006), *Construction Equipment Management for Engineers, Estimators, and Owners***
- ✓ **John E. Schaufelberger (1998), *Construction Equipment Management***
- ✓ **S. W. Nunnally (2000), *Managing Construction Equipment***