Equipment Management

Learning Outcomes

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

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

Equipment Management

Introduction

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

Equipment Management Organisation

An experienced and skilled team is normally required to ensure a successful equipment management program. The size of the project usually defines the number of personnel to employ. For small size projects, the owner or an operator is responsible for the management of equipments. Larger projects attract a large workforce, which consists of specialised personnel, whose roles are well-defined in managing equipments. 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 program, whether large or small, rests on defining and assigning responsibilities to each functional unit.

For smaller projects, a team consisting of multi-skilled employees who work in collaboration with an accountant or bookkeeper to ensure that operations are analysed and activities consequently designed to maximize 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 they consider this necessary. Under such circumstances, the size of the mechanics has to be reduced; less number of employees is required to repair a small number of equipments.

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 would significantly reduce the need for the equipment owner to construct one when undertaking a large project. Only minimum 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 work place or the work shop. For safety and economic reasons, it is best to avoid storing excess fuel. It is important to procure the right amount of spare parts and not excessive quantities because some may soon become obsolete with the emergence of more improved parts.
Large items like buckets, tracks, and chains can be stored outside in a designated area surrounded by fence 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 bookkeeping system to account for all parts in order to avoid future shortages.

Availability of Spare Parts

Having a good maintenance program means sourcing a suitable amount 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, condition 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 to estimating the rate of demand of spare components. It is a good practice to consider the interchangeability of spare parts when choosing equipments 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 is a measure of how much critical fast-moving parts will be required from the spare parts inventory. A harsh working condition will wear the equipment down faster than a mild condition. The inventory of slow-moving parts is determined based on comparison of their holding cost with the effect of they would have 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. Some reasons why parts may be become available in excess include the following:

- Purchasing excess spare parts due to fear of not being able to get supplies for imported equipments locally
- Using several makes and models of equipments
- Purchasing large number of spare parts based on manufacturers recommendation to counter obsolesce

- Lack of proper equipment planning can result in over-purchasing large quantities of parts than is necessary

In situations where excess spare parts are identified, a coordinating agency may be useful to assist in transferring extra equipments and spare parts to users who may be interested. This would require an effective publication 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 are concerned with producing spares such as bolts and nuts, belts, seals, and bearings, etc. for the equipment. It is common practice of primary manufacturers to produce identical parts which could 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 assist 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 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. Precaution should be taken when managing spare parts to avoid any shortage of parts and also, to avoid using substantial capital in procuring items.

An inventory model developed by 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 inventory model developed by operations research is described in the next paragraph.

The inventory model consists of variable such as demand order size, cost of procurement, holding costs, and the costs of shortage. For real procurement situations, the demand is not known with certainty and it tends to vary with 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 regards 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 the processing of 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. It 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 eliminated, by making it infinite; that is, by not allowing any shortage to occur. This scenario will substantially increase the inventory cost compared to the situation which 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 item A forms about 75% of total costs. The quantity of item A is around 10% of total quantity of stock procured. More planning and control is placed on item A due to its importance in terms of cost. Item B takes up 16-20% of the total amount of stock and usually cost 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. Item C makes up 70% of total quantity of stock items and costs 5-10% of total expenditure. Items under 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 those of A an B.

Economic Life

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

Replacement Analysis

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

Replacement is done when equipment downtime becomes exceedingly high or when a significant overhaul is due. The timing for effecting replacement varies from one contractor to the other. Decisions for replacement of equipment can be based on a contractor who has been awarded a new contract undertaking a review of his equipment conditions and recommending a replacement when he finds the current equipments unproductive or problematic. Another contractor may review his equipment condition and initiate placement procedures based on tax and capital which has become available. It should be borne in mind that replacement of equipments is a recurring issue that has to be reviewed frequently.

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

Previous experience show that the cumulative cost for repair increases wherever equipment is repaired. Repairing equipment is based on whether the serviced machine can generate significant revenue or not. Decisions on repairing or replacement of equipment could 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 the 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: Conversion of costs of equipment to common tax basis before comparing should be done
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. Utilization: When comparing alternatives, the choice should be based on the productivity instead of 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 one.

Necessity of Maintenance Management

Maintenance management involves all direct and indirect labour, machinery, material storage, and tasks relating to keeping all equipment in excellent conditions. It entails regular inspection, servicing, lubricating, repairing and overhauling of equipment.
Achieving success with a maintenance program requires orderly organisation with well-informed operating and maintenance personnel. The program 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 improve 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, making for 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 what contribution is 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 on the field.
Operatives must also keep management informed about the conditions of equipments including breakdown, continuous failures of parts and improper operations in order to improve on the system. It is the responsibility of 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 cases where scheduled maintenance is not performed, the operating deparment 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 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 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 best to do servicing and maintenance during non-operating periods to avoid downtime. Large projects requiring an array of equipments scattered across a wide area would require the services of a mobile unit to service and perform maintenance on the equipments 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 minutes to rectify a problem for the equipment to get 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 equipments are colour-coded to ensure 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 equipments. It should also have pumps and hoses of standard length. Other essentials to carry to the field include a water tanker and air compressor. Ideally, several jobs can be performed simultaneously to minimize overall time spent on the job. Mobile units may organise themselves into two teams; one for tyres and tubes with the other team taking care of lubricants and fuel.
Central servicing depot should be equipped with identical equipment and team members just like the mobile units. 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 having filling, breather and pump connections provided on top of the tank. Over ground storage option involves provision for drain plug for water as well as a tap for discharging sediments at the bottom of the tank. The over ground tank

which contains the fuel is connected to an overhead tank. Fuel is pumped from the over ground tank to the overhead tank through filters and metered pump. Operations involving storage and transfer of oil, fuel and lubricants must be done under clean conditions. All tools, pipes, hoses, and caps should be cleaned before using them 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 part. Use lubricant chars and schedules provided by the manufacturer when administering lubricants.

To minimise errors, only keep a minimum number of lubricating oil brands and grades. Also 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 right tyre pressure should be maintained and when an 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, greasing of idler, sprockets, and rollers during servicing. Tightening of loose bolts and nuts is also required 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 skill of a specialist.

Tools for tightening bolts and nuts include wrenches, hammer, 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 left out.

Field Repair 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 equipments. 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, cupboard, grinders, jacks, drills, lathes, and other important tools and devices should be made available in the workshop to deal with varieties of repair work. Devices such as welding machines, lifting tackles with gantry, 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 or a generator may be used instead.

All major repairs, such as overhauls, should be referred to the central workshop. Overhauls are usually performed after using the equipments for over 2000 hours.

Tools and Aids for Maintenance

Tools that help in performing 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 forklift, mobile A-frames, boom truck, jack and tractor mounted cranes an pulley block. Pressing tools assist in removing parts which are tightly fitted together. These devices include hand-powered pullers for light duties and portable hydraulic press. Parts that can be removed with these devices include sleeves, brushing, gears, bearing and shafts. Spanners, chisels, sets of wrenches, screw drivers and tongs are examples of hand tools which have to be made available to the maintenance team. Aids such as compressed air, cleaning system, benches, platforms, water and special mounts frames should be available.

It is a 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 could be used to clean repair shops in record time. Water jet operating at 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 device while steam jets operating with 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 equipments. Equipments operating under adverse conditions make lubrication a daunting task during construction projects. The complexity of modern construction equipments with high speed and heavy loading capabilities with minimal tolerance spaces require efficient and effective lubrication for high performance. A high quality lubricating schedule will require choosing the right quantity of lubricant, the proper storage and correct application to the right parts. Steps should be taken to device 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 appropriate place to reduce chances of misapplications.

Six types of lubricants can meet all 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 are good for providing protection from rust, anti-wear properties, oxidation, stability, foaming, and corrosion resistance. Replace series II oil with better detergency straight mineral oils
ii. Extreme pressure type gear oil prevents 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, 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 in preventing 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 load. They should be able to resist contamination by water and shear problems. Multipurpose greases for heavy load contain lithium component to provide high dropping point functionality

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

Storage and Handling of Lubricant

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

Use exhaust steam and not direct heat from flame 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 because 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 equipments are spread over a large working area, then 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 these equipments. Finally, empty barrels or containers are provided for collecting waste. Other accessories provided on board the mobile fuelling equipment include hand-operated grease guns, 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 to proper management of stock level and ensure lubricating and servicing are done according to procedures.

Inspection and Maintenance Programme

Detailed inspection and maintenance programmed should be drawn up to guide maintenance personnel as well as operators to perform regular inspection 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. Detailed inspection sheet should consist of a list of equipments with corresponding date 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 as well as the operating personnel to ensure a successful maintenance program.
The duty of the maintenance inspection personnel is to undertake only inspections and adjustments for minor incidents such as restoring power loss in equipments. 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 equipments on regular basis
ii. Providing adequate scheduling of equipment for maintenance check
iii. Advising equipment manager on issues relating to equipments
iv. Keeping work records

Data Bank

It is important to keep accurate data bank of all aspects of construction projects. Distort ion of data collected from equipment management should be checked and eliminated. Distortions occur for all sorts of reasons such as to harass management, laziness, cover up of human errors or mistakes, or to justify decisions. Crosschecking of data should be done by supervisors to prevent inaccurate reporting. Simple, unambiguous and clear forms should be used for collecting and recording data and signed off by tow 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 equipments while a computerised system is ideal for equipments numbering over 500.

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

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