Table of Contents

Chapter 1

Knowledge of Cranes

Chapter 2

Operation and Inspection of Pendant-Controlled Cranes

Chapter 3

Knowledge of Prime Mover and Electricity

The figure number, table number, and page number in the parenthesis refer to the separate textbook (Japanese version).

Chapter 4

Knowledge of Dynamics Necessary for Crane Operation

Chapter 5

Signaling Methods

Chapter 6

Relevant Laws and Regulations

Chapter 1

Knowledge of Cranes

1 Qualifications of Crane Operator (p.1)

The qualifications of crane operators are classified according to the type of operation and the lifting load, as in Table 1-1.

Table 1-1 Qualifications of Crane Operator

Lifting load and type of operation		**5 tons or more**				**Less than 5 tons**
		Crane (including wireless)	Floor operated crane	Floor operated crane (moves along with load)	Telpher	
Certification types	Crane/derrick operator's license (no limitations)	○	○	○	○	○
	Floor operated crane operator's license (limited)		○	○	○	○
	Skill training course for floor operated crane			○	○	○
	Special education for crane operation				○	○

As indicated in the table, the cranes to be operated by qualified persons who have finished the skill training course of floor operated crane prescribed under the applicable legislation are "in a lifting-load range of not less than 5 tons and operated by an operator on the floor who has to move with the movement of the load carried by the crane".

Fig. 1-1 shows a part of an overhead traveling crane as an example to explain those cranes which, as stated above, are operated by an operator on the floor or ground who moves with the movement of the load carried by the crane. This type of crane has a push-button assembly (known as a "pendant switch") suspended directly from the trolley.

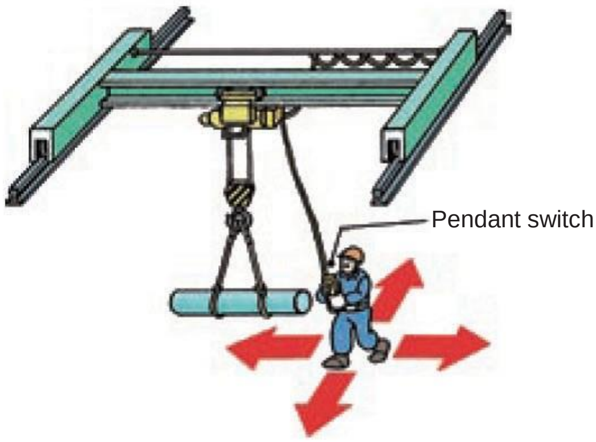


Fig. 1-1 Pendant Switch Suspended from Hoist

None of the crane operators who have completed the skill training course prescribed herein but have not finish the skill training course or special education in sling works are not permitted to sling goods for conveyance by crane or any other hoisting equipment.

Fig. 1-2, or have a push-button switch suspended from the fixed place of the girder, as shown in Fig. 1-3. In operating any of these cranes, the operator has to move with the movement of the lifted load while the crane is traveling, but during its traversing, the operator can operate the crane without shifting the operator's position, wherever the load may move. These cranes are not to be included among those which require the operators to move with the movement of the lifted loads. The operator of any of these cranes, even though it is operated from the floor, is required to have a crane operator's license if its specified lifting load is not less than 5 tons.

In addition, when operating the crane from the floor, a crane operator's license is also required as in the normal cabin operation (on-board operation type).

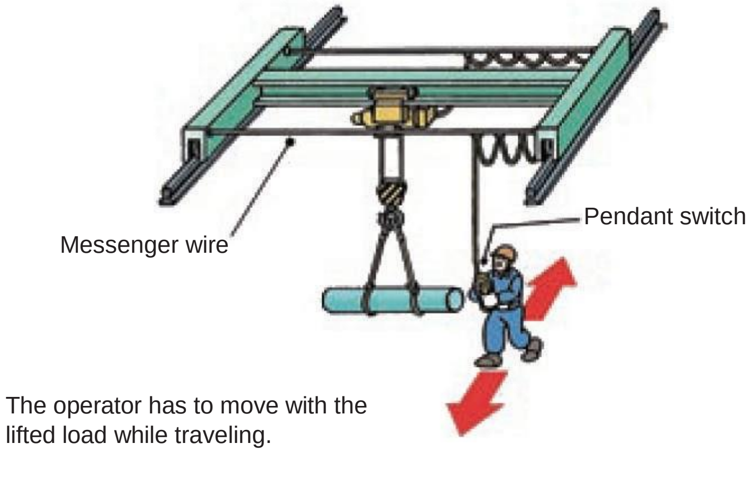


Fig. 1-2 Pendant Switch Suspended from Messenger Wire

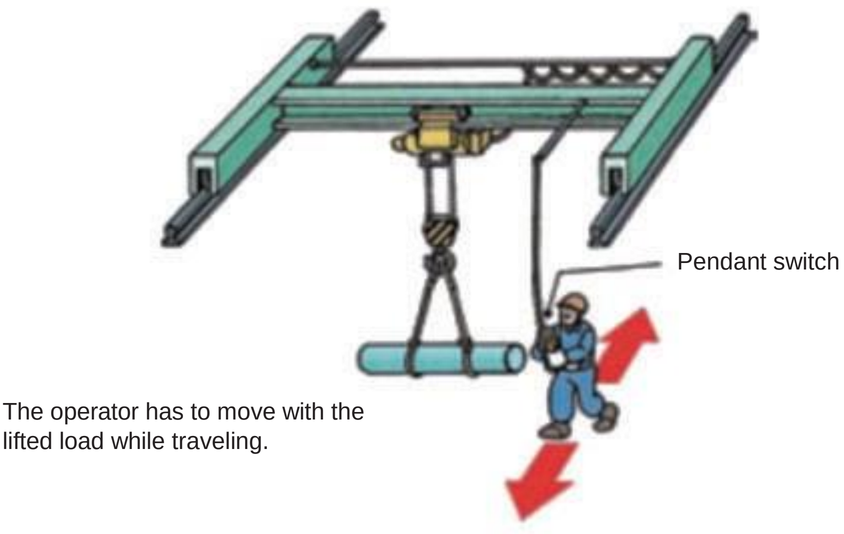


Fig. 1-3 Pendant Switch Suspended from Fixed Place of Girder

2 Definition of Cranes (p.3)

The term “crane” means any of the mechanical devices, other than mobile cranes and derricks (described in Fig. 1-4), which are designed to lift loads by power (excluding human power) and carry the lifted loads horizontally.

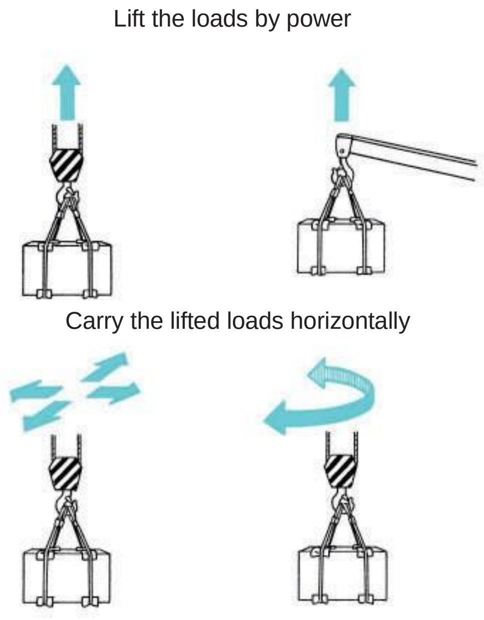


Fig. 1-4 Definition of Cranes

Accordingly, the crane does not include any of the mechanical devices which lift goods by human power using a manual chain block as a hoisting unit even if they carry the lifted goods horizontally by power. (See Fig. 1-5, p.3) On the other hand, the crane includes those mechanical devices which lift goods by a power even if they rely on human power for the horizontal conveyance of the lifted goods.

The machines defined below have similar functions, but cannot be operated with the qualification of floor-operated cranes.

2.1 Mobile Cranes

“Mobile crane” means any of those cranes which have built-in motors to move themselves to unspecified place. (See Fig. 1-6, 1-7, 1-8, p.4)

2.2 Derricks

Derricks are those mechanical devices which are designed to lift goods by motive power, have a mast or a boom and are operated by wire ropes with motors installed separately. Generally, derricks are classified structurally into guy derricks, stiff-leg derricks, twin-pillar derricks and gin-pole derricks. (See Fig. 1-9, 1-10, p.5)

3 Technical Terms Relating to Cranes (p.5)

3.1 Lifting Load

The term “lifting load” means the maximum load that may be laid on a crane according to its construction or configuration and materials used. The lifting load includes the weight of the crane’s hoisting accessory.

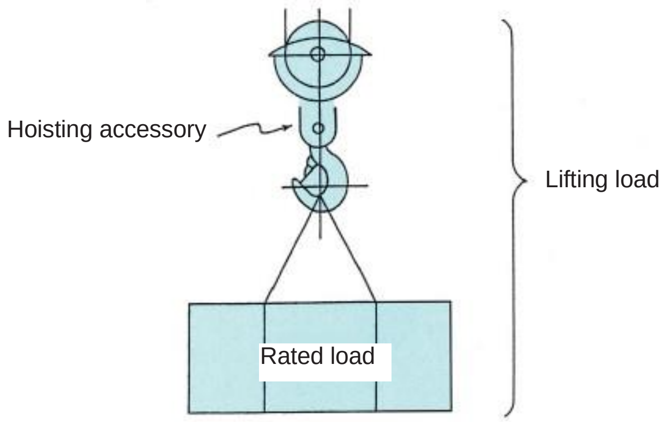


Fig. 1-5 Lifting Load, Rated Load

3.2 Rated Load

The term “rated load” means the remainder after deduction of the weight of the hook, grab bucket or any other hoisting accessory from the lifting load. To put it concisely, the rated load can be defined as the maximum net load that can be hung on the crane’s hook; usually the rated load is labeled on the crane or its hook block.

The point to be noted here is that the rated load does not represent a single fixed value with some types of cranes which are so designed that their maximum allowable net load varies according to such factors as the location of the trolley or the angle of the jib. Before working any crane, therefore, you have to check the rated load and operating range.

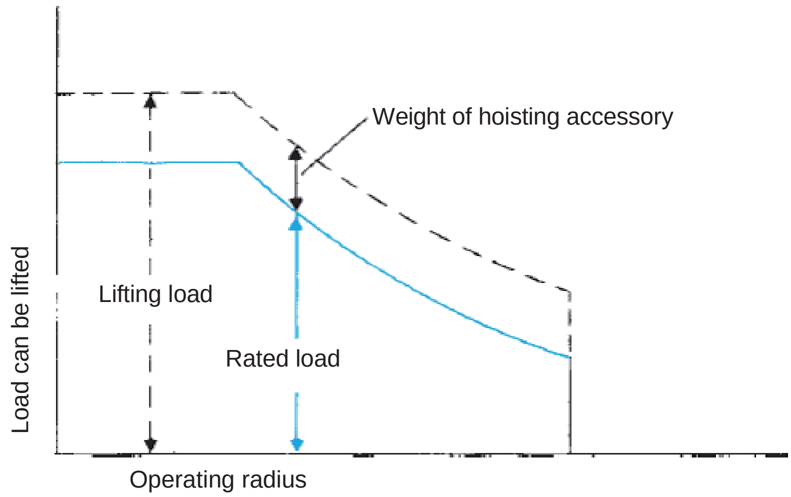


Fig. 1-6 Rated Load

3.3 Rated Speed

The “rated speed” means the maximum speed at which a crane, mobile crane or derrick may perform such a motion as lifting, traversing, traveling or slewing with the rated load on its hoisting accessory.

3.4 Trolley (or Hoist)

The term “trolley” means a machinery unit that carries a load and moves horizontally along the crane girder. Among trolleys, a hoisting and traversing device installed one is called “Club trolley” or “Clubs” for short, and “Hoist” is a compactly integrated trolley. Some hoists have only a lifting function.

3.5 Span

The term “span” means the horizontal distance between centers of the traveling rails.

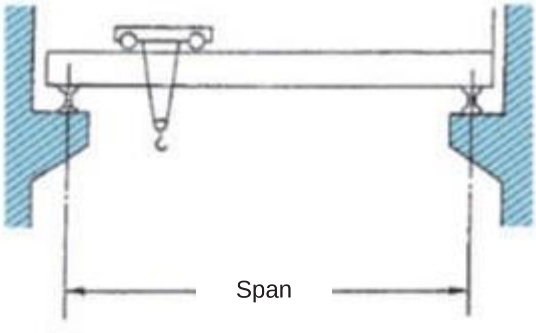


Fig. 1-7 Span

3.6 Lift

The term “lift” means the effective distance between the upper and lower limits within which hoisting accessories such as hooks and buckets can be lifted or lowered. (See Fig. 1-8.)

3.7 Outreach

The term “outreach” means the horizontal distance between the outermost end of the hook and the center of the traveling rail. (See Fig. 1-8.)

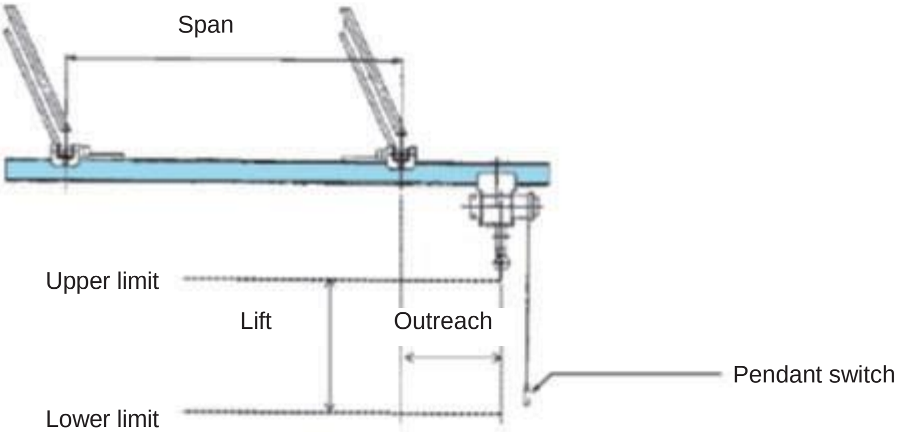


Fig. 1-8 Span, Lift and Outreach

3.8 Operating Radius

The “operating radius” means the horizontal distance between the center of rotation of a jib crane and the center of its hoisting accessory. The operating radius is also known as the “slewing radius”, of which the largest limit is called the “maximum operating (or slewing) radius” and the smallest limit is called the “minimum operating (or slewing) radius”.

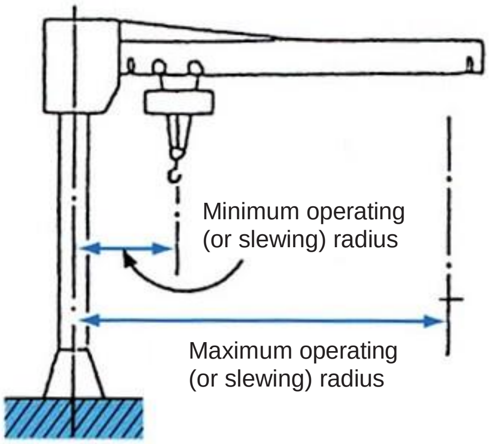


Fig. 1-9 Operating Radius

3.9 Inching

“Inching” means an operating method to move the lifted load by inches by starting and stopping the crane repeatedly by the push buttons on the pendant switch.

3.10 Slinging (Fig. 1-16, p.8)

“Slinging” means securing a load to or removing it from the hoisting accessory of a crane with wire rope, chain and/or other sling gear.

3.11 Lifting off the ground

This means the motion of lifting the load slightly away from the bearer blocks. Stop once the load has been lifted off the ground, and confirm the stability of the load and the safety of the sling gear.

4 Motions of Crane (p.8)

The following are the motions of a crane in lifting a load and carrying it to the desired place:

4.1 Lifting and Lowering

These are upward and downward movements of a load. Lifting means a motion of the crane to move up a load by winding up the wire rope on the drum and lowering is the reverse motion to bring the load down by unwinding the wire rope from the drum.

4.2 Traversing

Traversing is a motion of the crane to move its trolley along the girder, usually in a direction perpendicular to the traveling path of the crane itself.

This term also refers to the movement of the hoist of a wall crane (a variety of jib crane) along its horizontal jib.

4.3 Traveling

Traveling is the movement of the whole crane on its path. In the case of an overhead traveling crane or a portal bridge crane, the term refers to the movement of the crane on its rail or runway. Movement of a traveling wall crane along the wall surface and that of a telpher along its rail are also called “traveling”.

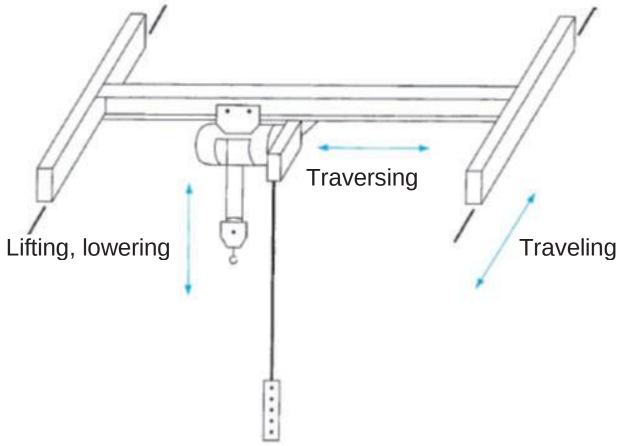


Fig. 1-10 Lifting, Lowering, Traversing and Traveling

4.4 Derricking and Jib Angle

The motion of the jib in the direction that increases the jib angle (the angle between the centerline of the jib and the horizontal plane) is called the “lifting or raising of the jib”, while its motion toward a smaller jib angle is called the “lowering of the jib”.

4.5 Slewing

Slewing means the rotation of the jib, boom or some other similar component of the crane with its fixed end or center of rotation as the axis.

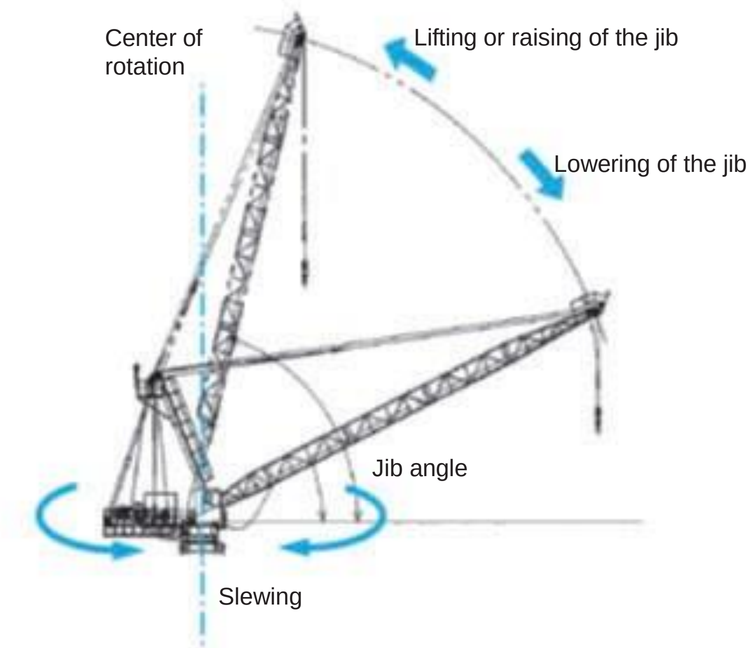


Fig. 1-11 Derricking and Slewing

4.6 Operating Range (p.32)

The “operating range” means the space within which the crane or any other hoisting device can move cargo by each of the available combinations of motions (traversing, traveling, slewing, etc.).

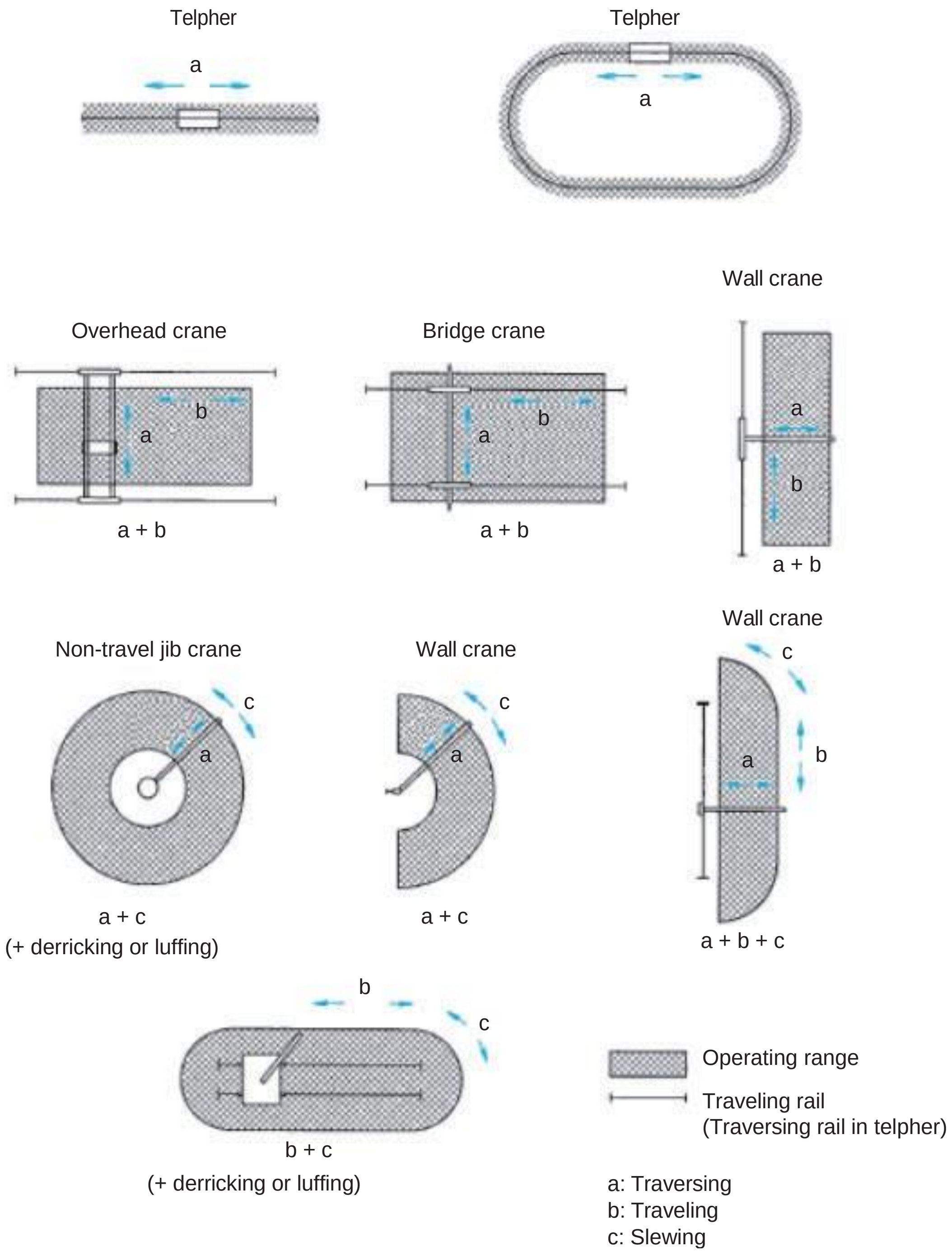


Fig. 1-12 Motions of Crane and Operating Range

5 Safety and Alarm Devices for Cranes (p.32)

When operating the crane, perform safe and reliable operation all the time. For that, have sufficient knowledge of the capabilities stipulated in the specifications (rated load, lifting height, etc.), pay attention to surrounding conditions, and operate the crane in a way that is appropriate for its capabilities. Cranes are provided with not only various safety devices but also alarms and accessories that are necessary to ensure safe operation. These safety and alarm devices should be examined usually to make sure that they will work infallibly, whenever necessary. The operator of a crane must, before starting the crane, carefully checkup and test all safety devices of the crane to ensure that they will work infallibly, whenever necessary.

5.1 Over-winding Preventive Device (p.33)

The over-winding preventive device automatically stops the hoisting motion whenever it reaches the specified upper limit of lifting, in order to preclude such mishaps as a collision between the hoisting accessory and a mechanical or structural component of the crane or a broken wire rope that may result from over winding, This device comes in two types, of which one is a direct driven type that switches on or off the control circuit of the electromagnetic contactor and the other (indirect/semi indirect driven type etc.) is a direct-shutoff device that directly switches on or off the motor circuit.

It is required under the applicable legislation that when the hook block stops by the actuation of the limit switch, the clearance between the top of the hook block and the bottom of any of such crane components as the drum, sheave and trolley frame be not less than 50 mm, if the limit switch is a direct driven device, and not less than 250 mm, if the switch is other than a direct driven device. If a sufficient clearance is not left between the crane components noted above, the hook block may hit the drum or some other component, resulting in such accidents as a broken wire rope, damaged trolley frame or fallen load.

Direct Driven Type Over-winding Preventive Device (Fig. 1-68, 1-69, p.34)

The drawback of this device is that the lowering position cannot be controlled because the system is operated directly by the hook block. For this reason, it is necessary to prepare a separate limit switch to control the lower limit.

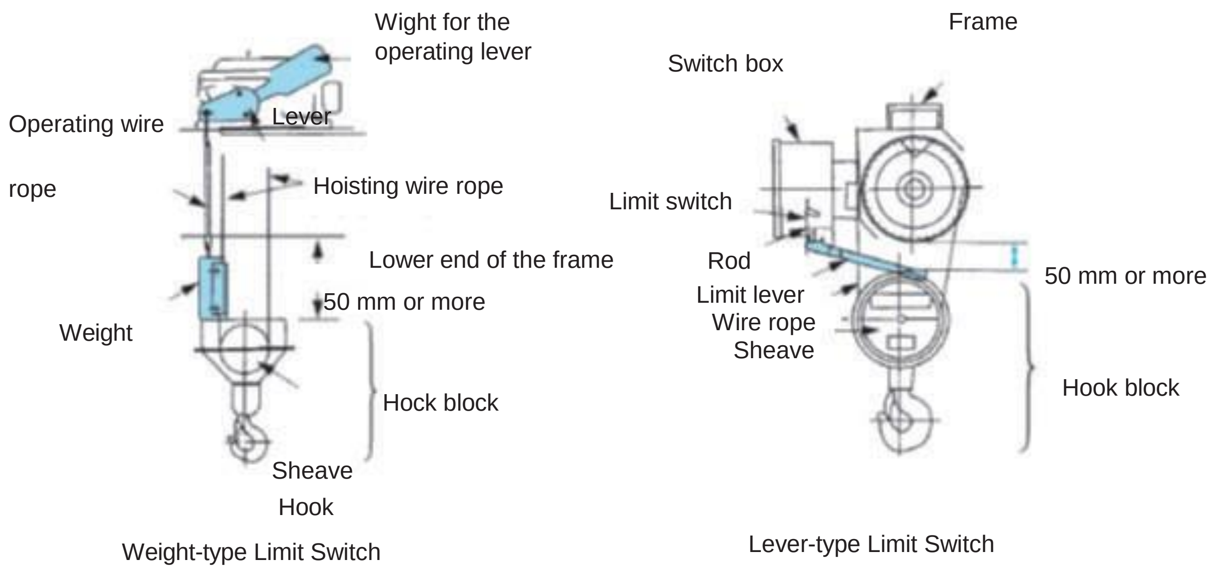


Fig. 1-13 Limit Switch

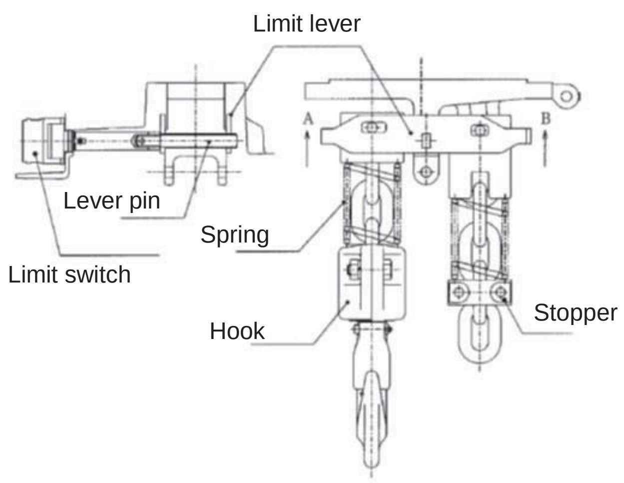


Fig. 1-14 Mechanism of Upper-Lower Limit Switch of Electric Chain Block

5.2 Overload Preventive Devices (p.35)

However, for jib cranes with a lifting load of less than 3 t, a fixed jib angle and jib length, or a rated load that does not change, it is stipulated that a device that prevents overload, such as a device that detects the weight of the load (with a function that displays the load or sounds an alarm), is sufficient, rather than an overload preventive device with a stop function.

5.3 Alarm Devices (p.36)

Buzzers, beepers, bells or some other devices, whichever appropriate, are stipulated as alarm units for cranes. In particular, when a plurality of units are installed on the same traveling rail, an alarm device is often attached to prevent collision.

There are two ways to use the alarm device:

- A pendant switch with an alarm button is adopted, and the driver can issue an alarm at any location as needed (e.g. starting the crane traverse or travel). (See Fig. 1-75, p.37)
- A method of automatically sounding an alarm by separating a specific operation and time of a series of cycles, such as hoisting, moving, traveling and lowering (e.g. alarming only in traversing)

5.4 Safety Catch Devices (Fig 1-76, 1-77, p.37)

“Safety catch” means a device for preventing sling wire ropes from slipping off from the hook, and it must be used when lifting a load. There are two types of the “safety catch”, one is spring type and the other is weight type.

5.5 Shock Absorber of the Traversing Rail Edge (p.37)

It is required that shock absorbers or wheel stoppers be installed at both ends of traversing rails or a similar place to prevent cranes from overrunning their rails.

5.6 Shock Absorber of the Traveling Rail Edge (p.38)

In order to prevent the crane body running off from the traveling rail end, shock absorbing devices, shock absorbing materials or wheel stoppers is stipulated by the Safety Ordinance

5.7 Safety-against-Wind Devices (p.39)

It is required that any crane, used for outdoor service and is likely to be exposed to a wind with a maximum instantaneous velocity of over 30 meters per second, be provided with a safety-against-wind device or some other effective measure to prevent it from moving inadvertently by the force of a strong wind, especially during a storm. In addition to such a safety-against-wind device, which is generally known as an “anchor”, another device called a “rail clamp” is often installed to preclude the crane from being moved by a sudden gust of wind during work. If the travel operations are performed while the crane is secured by a rail clamp or anchor, a large load is applied on the motor. Some cranes include an electrical interlock that operates while the crane is secured and prevents travel operations.

Rail Clamp

This device prevents runaway against gusts of wind while the crane is operating. The crane is prevented from escaping by the frictional force by sandwiching the head side surface of the traveling rail at an arbitrary position on the traveling path or pressing against the top surface of the traveling rail head. Therefore, when there is a possibility that a strong wind may blow, it is necessary to move the crane to a mooring position provided on the traveling path and moor the crane with an anchor. (See Fig. 1-84, p.40)

Anchor

This is a device that prevents runaway of an outdoor crane when there is a possibility that the crane may run away due to a storm or the like when the crane stops working. Dropping the strip-shaped bracket (anchor plate) at the fixed mooring position of the traveling path on the ground foundation prevents the crane from escaping. (See Fig. 1-85, p.40)

5.8 Other Safety Devices (p.40)

The applicable legislation requires that where two or more cranes are installed on the same runway, shock absorbers or buffers be provided on the end of each crane which faces another. In addition to these protections, some cranes are equipped with a special device to prevent collisions as follows. (See Fig. 1-86, 1-87, 1-88, p.41)

6 Brakes of Cranes (p.42)

The brake is an essential crane component that stops the motor and holds the load at the desired place by means of friction.

The brake of the hoisting device has 1.5 times braking force of the hoisting force. Traversing and traveling brakes generally do not have 100% braking force with respect to motor torque.

From the viewpoint of ensuring safety, cranes must be so designed that they always have their brakes on when they are at a standstill. In other words, they are released from the brakes only while their motors are revolving.

6.1 Brakes of Cranes with Crab Trolleys (p.42)

Usually a crane with a crab trolley is equipped with an electromagnetic brake for stopping its hoist motion and with an electrohydraulic brake for speed control. Either of these brakes is also used widely for traverse or travel motion if it is provided with a brake at all.

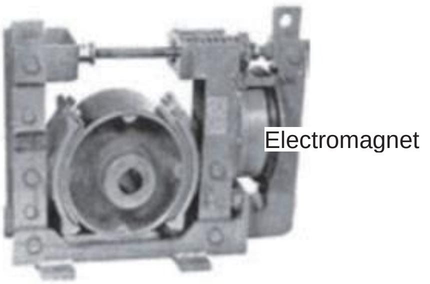


Fig. 1-15 Electromagnetic Brake

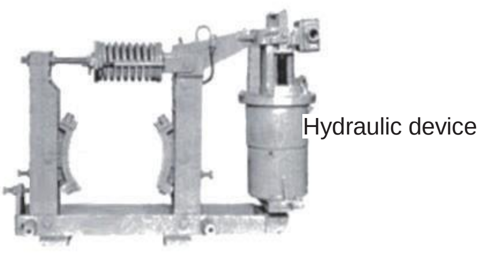


Fig. 1-16 Electrohydraulic Brake

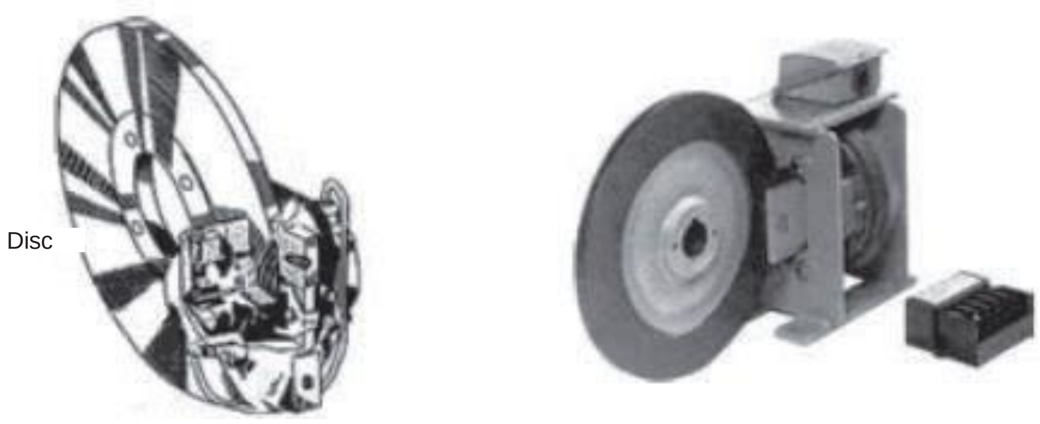


Fig. 1-17 Disc brake

6.2 Brakes of Cranes with Hoists (p.44)

Brakes for the lifting gears of cranes with hoists are built in the electric motors. The types of brakes generally used for this purpose include:

- Hinged electromagnetic brake

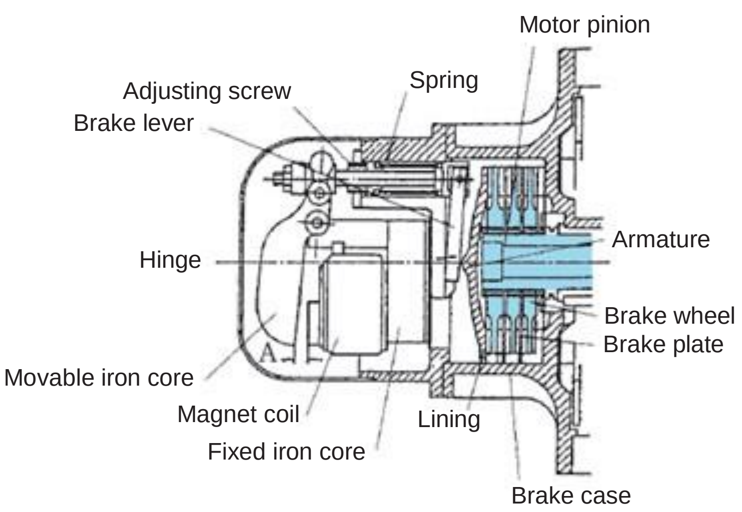


Fig. 1-18 Hinged electromagnetic brake

- Electromagnetic brake

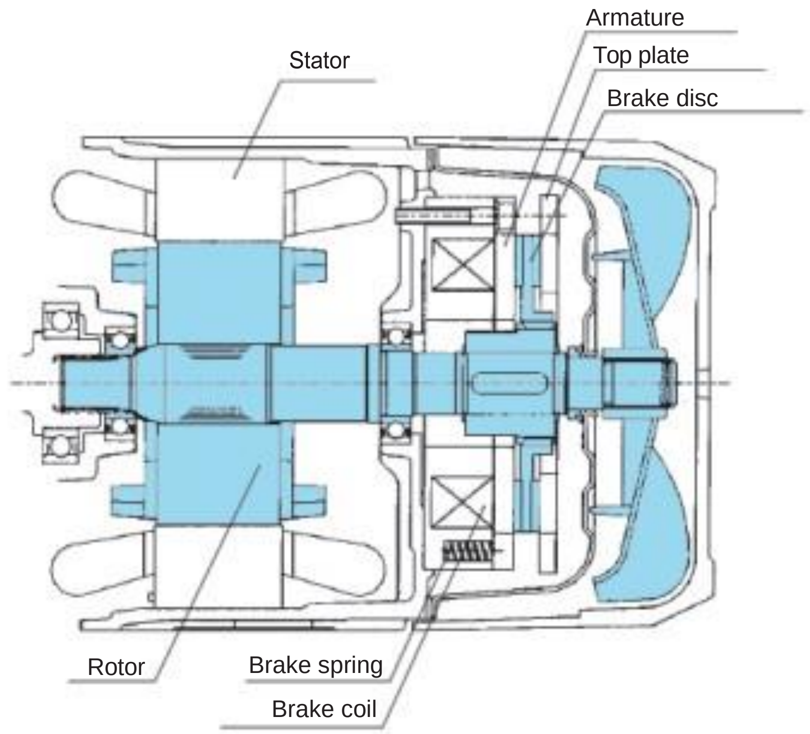


Fig. 1-19 Electromagnetic brake

- Cone brake

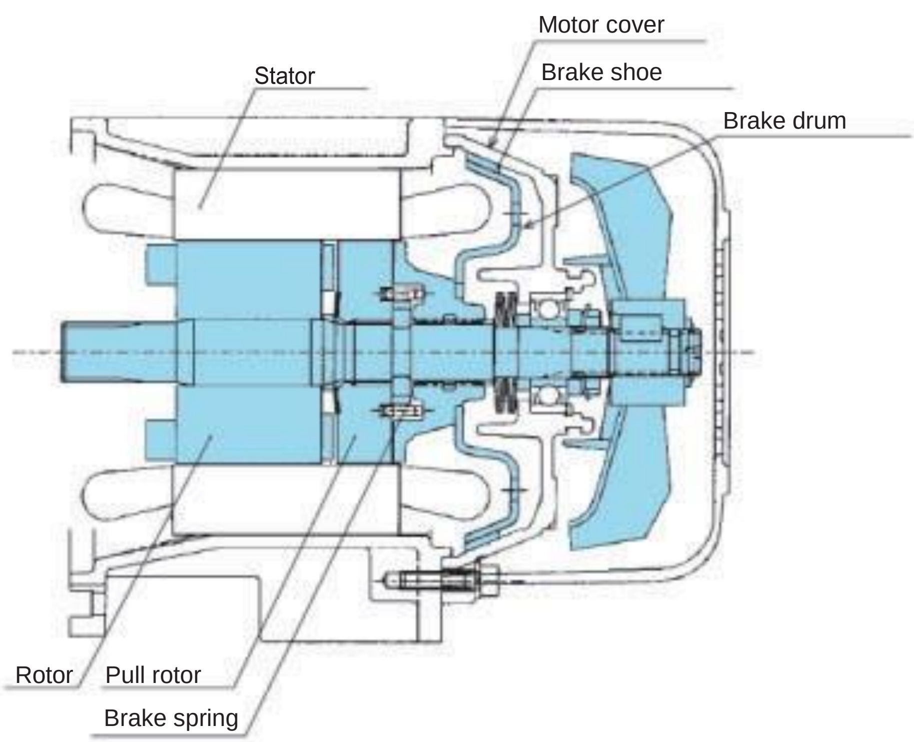


Fig. 1-20 Cone brake

Chapter 2

Operation and Inspection of Pendant-Controlled Cranes

1 Major Features of Pendant-Controlled Cranes (P.47)

Pendant-controlled cranes make lifting, traversing, traveling and other motions by a push-button switch assembly, known as a "pendant," suspended from the hoist or crab trolley. Compared with cab-controlled cranes which are controlled from the operator cabs, pendant-controlled cranes have special features described as follows.

- Pendant-controlled cranes are easy to operate.
- The operator can control it from the floor, so their positioning can be done easily.
- The operator can keep satisfactory communication with the slingers by signals, etc.
- The operator can do other tasks as well.

a:	Easy to operate
b:	Positioning can be done easily
c:	Satisfactory communication can be done with the others
d:	Other tasks can be done as well

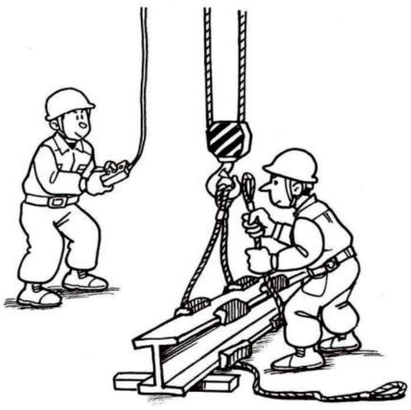


Fig. 2-1 Special Features of Pendant-Controlled Cranes (Compared with Cab-Controlled Cranes)

The high incidence of industrial accidents with pendant-controlled cranes can be attributed mainly to an increasing number of these cranes in service. Other major factors are summarized below:

- These cranes are mostly installed in such a working environment that the operator can be operated readily and easily. (See Fig. 2-2, p.48)
  - Unqualified operators can easily operate cranes against the rules.
  - It is easy to leave the task of handling malfunctions to others since the cranes are used by many operators.
  - It is easy to suffer an accident since operators are close to the load.
- The operator is sometimes assigned to sling loads to be lifted as well as to operate the crane.
  - Operators may push the push button switch accidentally.
- The operator is often assigned to operate the crane and sling its loads as a subsidiary job while performing his or her principal task (e.g., welding, assembling or machining).
  - It is difficult to become skilled in operating cranes.
- Safety and maintenance services for these cranes are liable to errors or oversights because, in many instances, responsible persons in charge of these jobs are not clearly specified.

2 How to Operate Pendant-Controlled Cranes Safely (p.48)

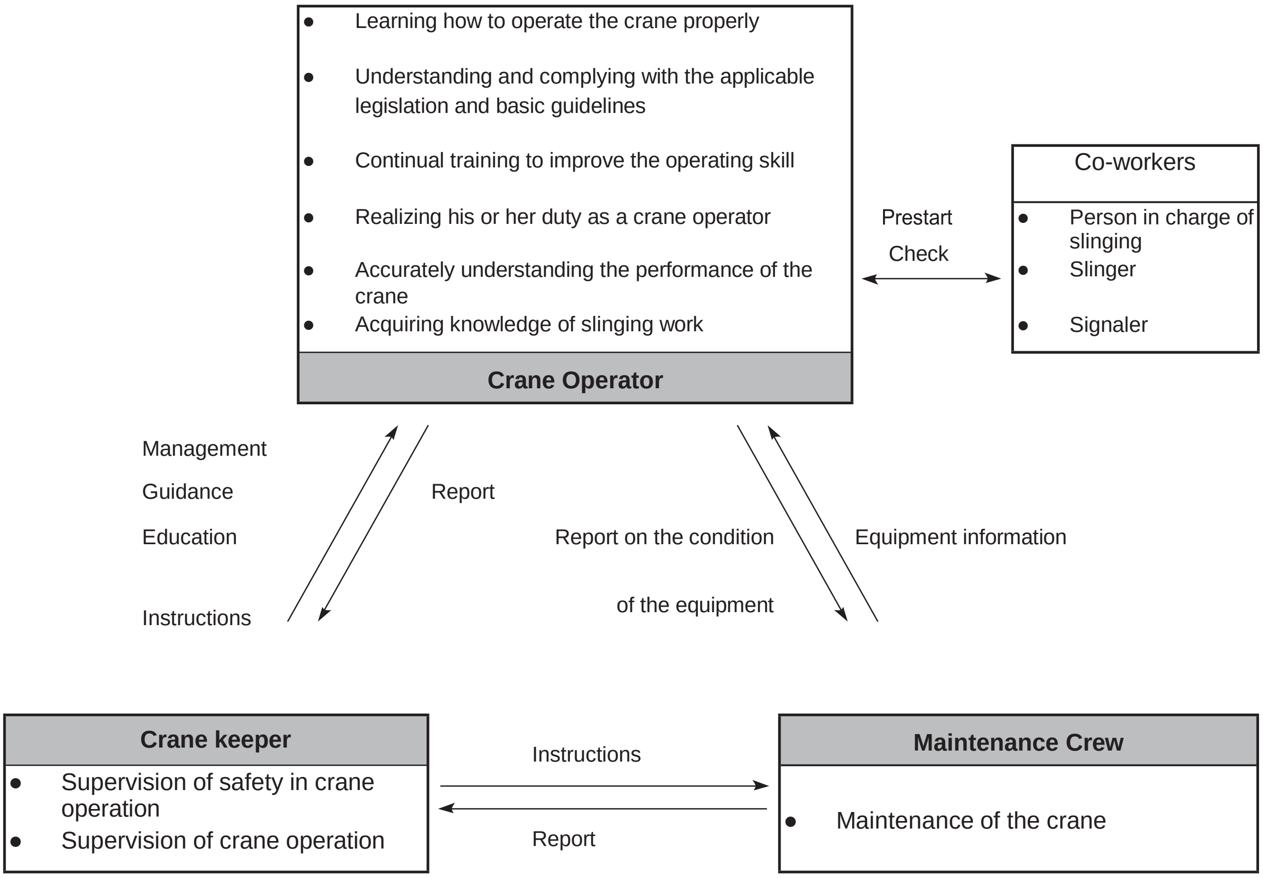


Fig. 2-2 Duties of each person in charge

The operation of the crane is generally a collaborative work with the slinging operation, and the slinger and the signaler are often damaged when occupational accidents occur. Causes of the accidents are mainly due to insufficient safety measures in slinging work such as inappropriate slinging procedure and sling gears in damaged condition. For this reason, the crane operators also should have sufficient knowledge of slinging work and sufficient meetings with related workers such as slingers and signalers about safety slinging conditions in order to prevent the industrial injuries during crane work.

3 Basic Work Rules for Crane Operators (p.50)

(1) Be sure to properly operate the crane based on a full understanding of its performance and functions.

- Fully understand instructions manual and operating instructions by manufacturers'.
- Obey the operation standard if it has been established.

(2) Continually check the state of things at your job site to ensure safety in crane operation.

(3) Wear the specified working outfit

- Wear nonslip-soled, strong safety shoes.
- Fasten your pant cuffs with leggings, gaiters or some other coverings.
- Wear a long-sleeved jacket and keep the cuff buttons or snap hooks fastened.
- Do not wear wet clothes, which make you liable to get an electric shock.
- Wear dry, clean working gloves.
  The gloves will protect you against an electric shock that may be caused by an electric leak from the pendant cable.
- Wear a hard hat or a helmet to protect your head against things falling from the crane.

Fig. 2-3 Working outfit

(4) Pedestrian Safety Rules

- When moving from one place to another in the factory, take the specified passage.
- Look at safety signs carefully and follow the instructions shown on them.
- When getting on the crane, use the specified stair or elevator or lift.
- Never get on the crane while it is operating.
- Do not run at any of such dangerous places as the walkway on the girder of the crane and its operating site.
- Do not walk with either of your hands in the pocket.

(5) Keeping Your Job Site in Order

- Store machines, materials, tools, and other things neatly in specified places.
- Do not leave anything on the top of the crane or any other elevated place. If you are forced to put something in such a place under unavoidable circumstances, take necessary measures to preclude it from falling.
- Care should be taken to prevent a leak of oil, grease, paint or other similar fluid onto the crane or its operating site.

4 Operation Procedure of Floor-operated Crane (p.51)

Fig. 2-4 shows the daily work flow of a general floor-operated crane. The floor-operated crane is rarely operated by a specific worker continuously, and is generally used in such a way that an unspecified number of workers alternately operate according to the progress of each work process. In such a condition, it is often unclear who performs the pre/post-operation inspection and is desirable to determine the person in charge in advance. In addition, the designated person shall inspect abnormality and report to the administrator.

(1) Prestart meeting

(2) Arrangement of work areas and driving paths (ensure safety one's step)

(3) Prestart inspection (static inspection of crane parts, refueling, etc.)

(4) Power on the main trolley wire or main power cable

(5) Power on the pendant switch

(6) Prestart inspection (confirmation of operation of crane equipment, operation of safety equipment, etc.)

(7) Crane operation work

(8) Return the crane to the predetermined standby position and turn off the power of the pendant switch

(9) Inspection after completed the work (static inspection of crane parts, refueling, etc.)

(10) Turn off the main trolley wire or main power cable

(11) Report of the operation completion, entry of the operation log, etc.

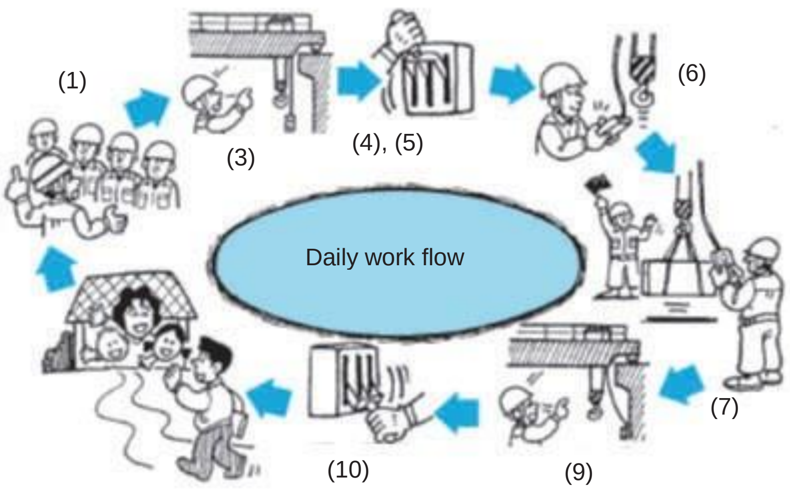


Fig. 2-4 Daily Work Flow of Floor-operated Crane

5 Prestart Check List (p.52)

Before setting about his or her work on each day, the crane operator must perform essential items of the prestart check list as follows:

- Check the details of the job to be carried out on the day (especially information on the loads to be lifted)
- Put the operating site and route in order
- Perform a prestart inspection of the crane

5.1 Checkup on Details of the Day’s Work (p.52)

Before starting work on each day, examine such papers as the job order and production drawings to get the necessary information on the goods to be carried by crane for the day.

- Check the loading and unloading places of the goods and then map out a conveyance route and other processes of the job.
- After finding the size, weight, COG (center of gravity) and other details of the goods, make necessary prearrangements for sling gear and other related tools.

According to the type of the load to be carried

all members of the team should consider

fully understand

decide on the best slinging gear method for the load

Fig. 2-5 Prestart Check

- Based on the working plans described above, put the job site, operating route and other things in order to ensure that a safe walkway will be provided for workers.
- If necessary, request the person in charge of slinging to take measures such as removing obstacles.

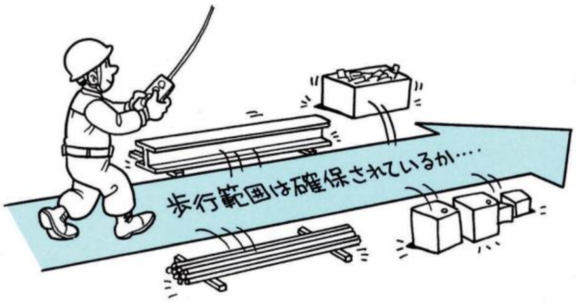


Fig. 2-6 Check whether an adequate passage is provided

5.2 Prestart Inspection (p.51)

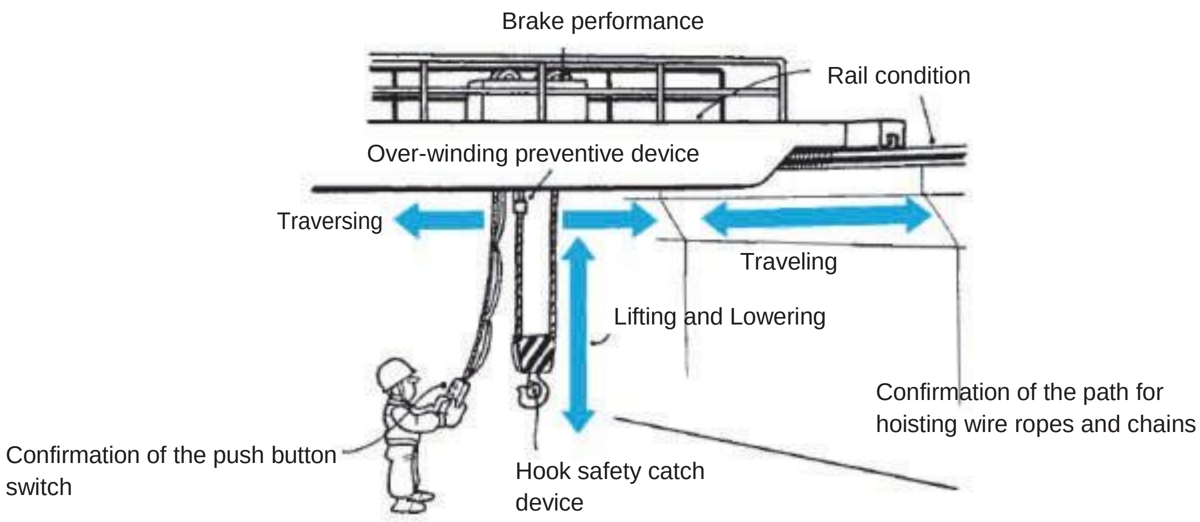


Fig. 2-7 Prestart Inspection

The following are the items, details and key points of prestart inspection for standard cranes with hoists:

It is important to sufficiently understand the details of each item so that you can accurately judge the condition of the crane.

(1) Checkups Before Switching-on of Power Supply

- Check whether there is any obstacle on the traveling or traversing rails and whether anyone is working on or near the runway or the crane girder. Also examine whether the rails are in order.

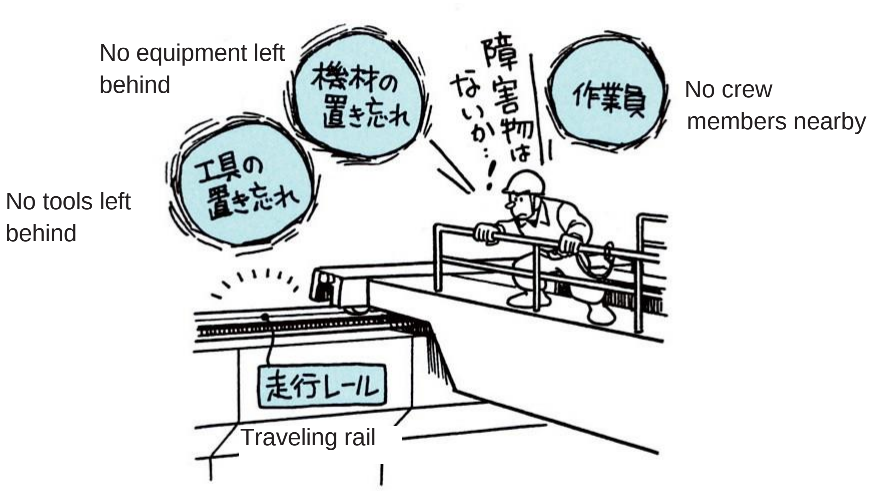


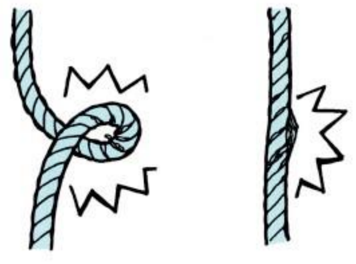
Fig. 2-8 Inspection of obstacles

- Check whether there is anything wrong with the parts where the lifting wire rope passes through.

(a) Check whether the wire rope is not slipped out of the sheave.

(b) Check whether the wire rope is not in contact with a trolley, hoist frame, or other structures.

(c) Examine the wire rope for any broken wire, wear, kink, deformation, corrosion or any other damage.



Kink Deformation

Fig. 2-9 Defective Wire Rope

- Check the condition of the push button station.

(a) Examine the cabtyre or tough-rubber sheath cable for any damage.

(b) Check whether the lifting wire rope is in order (it should be free of tension).

(c) Check the switch box for any damage.

(d) Check whether the push buttons work smoothly. Do not operate the crane if the push button remains pressed and does not return.

(e) Check whether the mechanical interlock of the push-button switches works properly.

- Inspect the lubrication of crane components (specifically the lifting wire rope, bearings and all other parts which need to be properly lubricated or greased).

- Check whether any locking or anchoring devices such as anchors or rail clamps are released.

(2) Checkups with Power Supply Switch on

Inspect how the crane operates.

Activate the crane without a load and confirm the following items.

- Check whether the crane moves in each of the directions specified on the indication plate of the push-button switch assembly.
  This inspection covers such functions as power supply switching on and off, lifting, lowering, traversing, traveling, alarm-giving and lighting.

Whether the crane works as directed.

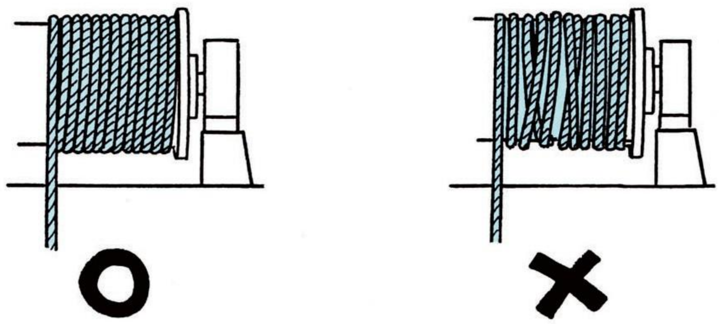
Fig. 2-10 Operation Check

- Check if the crane makes any unusual noise or vibrations during operation.
- Check whether the over-winding limit switch works properly.

(a) Test the limit switch at least two to three times under no-load condition.

(b) If the limit switch is out of order, the lifting wire rope may be wound up until it breaks. To preclude such mishap, conduct the first test by inching and, if the limit switch is found to work, then carry out the second and all subsequent tests in a normal operation mode.

- Check the hook block for any abnormalities.
  - (a) Check for wear or damage, or whether the hook opening is too wide.
  - (b) Check whether the stopper is not damaged or moves smoothly.
  - (c) Check whether the hook rotates smoothly or the hook nut is not loose.
    If the hook rotates incorrectly, the hoisting wire rope and sling wire rope are twisted by the rotation of the load, and this may cause damage.
- Operate the hoisting unit over the full range of lift to find whether there is anything wrong with the winding device or any other crane component involved.
  - (a) Check whether the lifting wire rope is properly wound on the drum.
    Check whether the hoisting wire rope is properly wound along the drum grooves. When it is not properly wound along the drum grooves, as shown in Fig. 2-11 b, this is called random winding. To fix the random winding, unwind and loosen the wire rope as shown in Fig. 2-11 a.



a: Appropriate condition   b: Inappropriate condition (random winding)

Fig. 2-11 Winding status of the drum

  - (b) Check whether the sheaves rotate properly.
    If rotation failure occurs, the winding wire rope is squeezed and generates heat, and this may cause wire breakage.
- Examine whether the brake is in good working condition.
  Examine how effectively the brake works under no-load condition.

5.3 In-Operation Check List (p.57)

Essential Items of Check List (p.57)

- Only a qualified person can operate the crane. For cranes operating from the floor, the qualification of a slinger is required separately when an operator makes the sling work by him or herself.
- Do not use a crane with a lifting load of 3t or more if there is no inspection certificate, if the validity period of the inspection certificate has expired, or if there is poor maintenance.
- Fully understand the specifications of the crane, and do not operate beyond the specifications. In particular, do not lift a load exceeding the rated load even if it is only once, or it is slightly over the rated load.

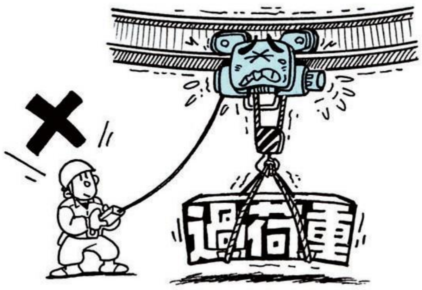


Fig. 2-12 Prohibition of overload

- Keep the safety device in effect at all times. If there is a problem with the safety device, be sure to ask a specialist to perform inspection and adjustment. Do not fully rely on the safety device for operation, as the safety device may not work properly.

- Even if the lifting height is slightly insufficient, do not turn off the over-winding prevention device limit switch or fail to operate it, and do not turn off the traverse/travel mechanism limit switch to allow for a wider operating range.

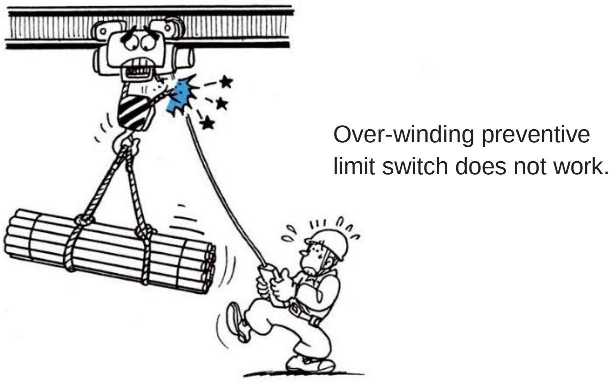


Fig. 2-13 Keeping the safety device effective (1)

- Do not fasten the hook safety catch devices with tape due to sling works being difficult.

Fig. 2-14 Keeping the safety device effective (2)

- Stop the lifting of the load by operating the switch to avoid the stop by the over-winding prevention device as much as possible.
- The stopper is intended to prevent a crane or club trolley from running off the rail end in an emergency. If a collision occurs, an impact force acts on the crane or club trolley, and this may cause failure.

Fig. 2-15 No collision to the stopper

- In joint work with the signaler, make sufficient arrangements for the signals in advance, and perform the crane operation according to the specified signals.
  Learn how to sling and signal. Be sure to stop the operation of the crane if any of the following signal failures or sling failures occurs.

  (a) When the signal is unclear or is not the prescribed signal method

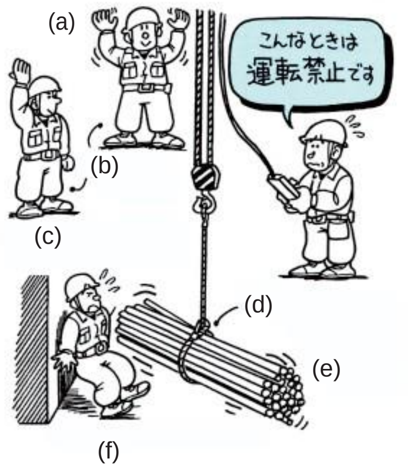
  (b) When two or more signalers signal

  (c) When a person other than an qualified person or a designated person performs signaling or slinging work

  (d) If you feel that the sling is dangerous

  (e) When the weight of the load may exceed the rated load of the crane

  (f) When you think it is a dangerous action



Stop operation in the following cases.

Fig. 2-16 Prohibited operations

- Do not use the crane to transport or lift a worker. Do not operate the crane while the operator or the slinger is on the load.

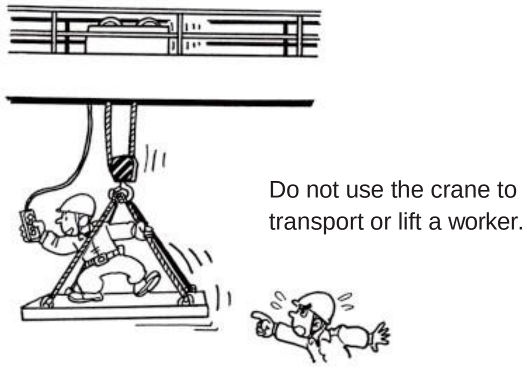


Fig. 2-17 Transportation of workers by cranes is prohibited

- Do not leave the operating position with the load lifted.
  Even if you are leaving the crane for a short time, you must lower the load and turn off the power of the crane by the pendant switch or any other power switch that is nearby.

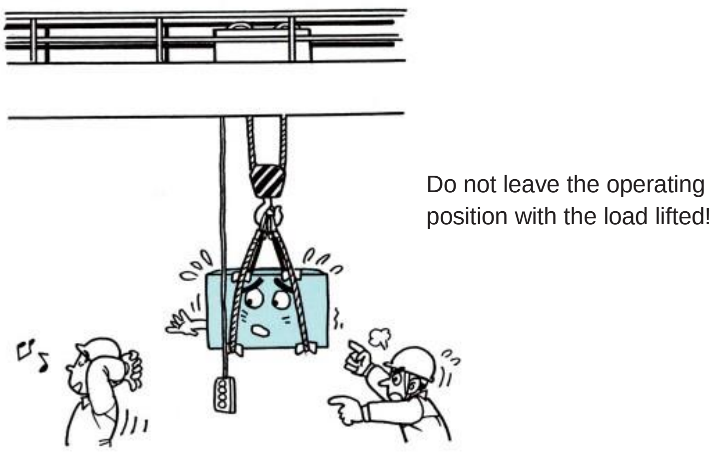
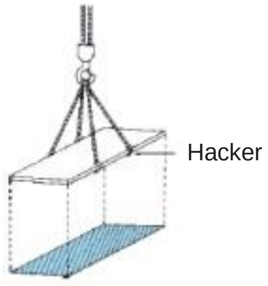
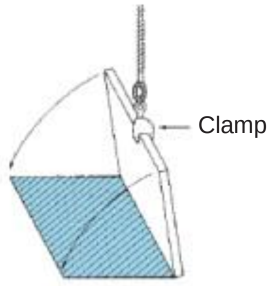


Fig. 2-18 Leaving with a load lifted is prohibited

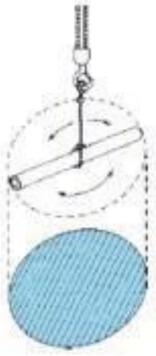
- In the following cases and even in other cases, in principle, do not step under the lifted load.



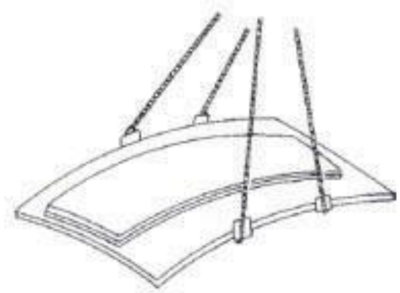
When lifting a load slung with hackers



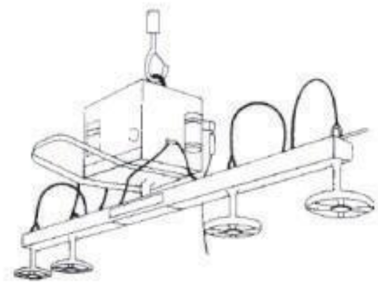
When lifting a load slung with one clamp



When lifting a load slung on a single point with a wire rope or chain



When lifting a load of multiple unbound pipes and plates slung together



When lifting a load with using a magnetic lifter or vacuum lifter

Fig. 2-19 Do not enter the area under the load

- If you perceive that the crane makes an unusual noise or vibrations or there is something wrong with its operation, stop the crane immediately and report to the maintenance supervisor.

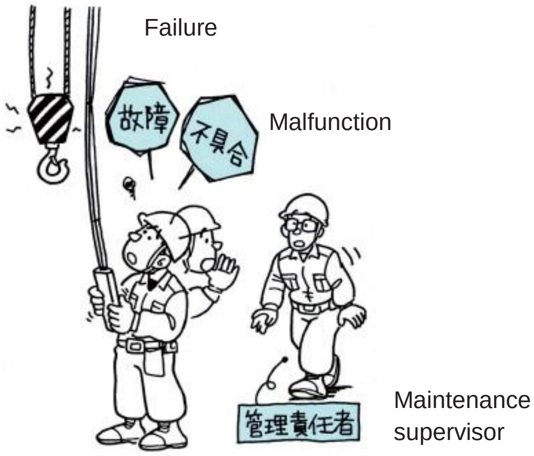


Fig. 2-20 Measures when an abnormality is found

- How to handle the push-button switches and power supply cables
  - After carefully checking the markings on the indication plate (showing the categories and directions of crane motion) to avoid making any error, press the appropriate button home (until it reaches the end of its stroke).
  - Operate the crane in such a way that the power supply cables for the push buttons, traverse and travel motions, and some other components will not come in contact with any fixed article on the floor or ground.
  - The pendant cable for the push-button switches may, if pulled too strong, suffer broken wires, resulting in an electric-shock accident.

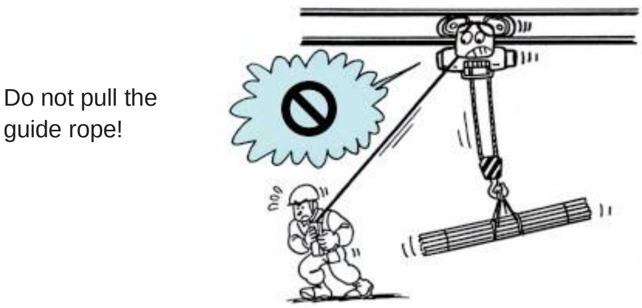


Fig. 2-21 Traction by a guide rope

- When another crane is on the same runway, be sure that both cranes are operated with sufficient care to avoid colliding, as crane collisions are extremely serious incidents. Try to avoid making traverse and travel motions simultaneously as much as possible.

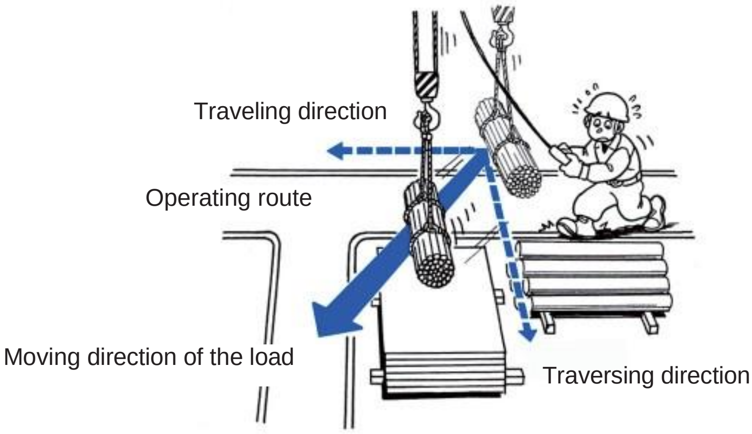


Fig. 2-22 Danger of two-way simultaneous operation

- Under the following circumstances, sound the alarm to give warning to workers around the crane:
  When starting the crane; when carrying slippery or dangerous goods; when seeing some other workers in the direction in which the lifted load is moving; when crossing a “safety” walkway or a vehicle passage; or when sensing danger.
- When another crane is on the same runway, be sure that both cranes are operated with sufficient care to avoid colliding, as crane collisions are extremely serious incidents. Naturally, when approaching a crane on the same runway, you must alert the other operator using an alarm or other methods.
- If a power failure occurs during operation, turn off the power switch of the crane, and wait for recovery. For the crane using a lifting magnet, if the operation is possible with using emergency power during a power failure, lower the load to the ground immediately.
- If you feel an earthquake during operation, you must lower the load to the ground as quickly as possible and turn off the power.

- If you have to wait for a proceed signal with a load lifted on the crane hook, stop the crane at a place other than directly above a safety walkway or a job site.

Fig. 2-23 Standing by with a load lifted

- You must not use an operating crane to push another at a standstill.
    - Because the traveling brake is applied while the crane is stopped, there is a possibility that the motor for traveling during crane operation may suffer burnout due to overload.
- If the crane does not stop after releasing the operation button, press the “OFF” button to make an emergency stop. If the assembly has no OFF button, turn off the main power supply switch.
- When the hook is swinging, do not perform lifting operation.This may cause random winding of the hoisting wire rope around the drum, as well as wire rope breakage and damage. In addition, if the swing hook comes into contact with the drum or the body frame of the hoist, it may cause damage to them.
- Do not perform unnecessary inching operation. Performing inching operations more than is necessary shortens the life of the mechanical and electromagnetic components (such as the electromagnetic contactor and electromagnetic brake), so avoid this as much as possible. However, some inching operations are necessary for safe operation. For example, to reduce the impact when lifting the load off the ground or lowering the load to the ground, or to prevent load swing when starting and stopping traverse and travel motions. Be sure to perform inching operations in as few tries as possible and at appropriate timing.

- Do not operate the crane in the opposite direction
  - The load swings widely, and this may cause the load to fall.
  - Impact force acts on the mechanical and structural parts of the crane.
  - The current of the motor increases, the contacts of the contactor deteriorate, and the temperature of the motor rises, which may shorten the life of the crane. When operating in the opposite direction, press the button of the opposite direction after the motor stops.

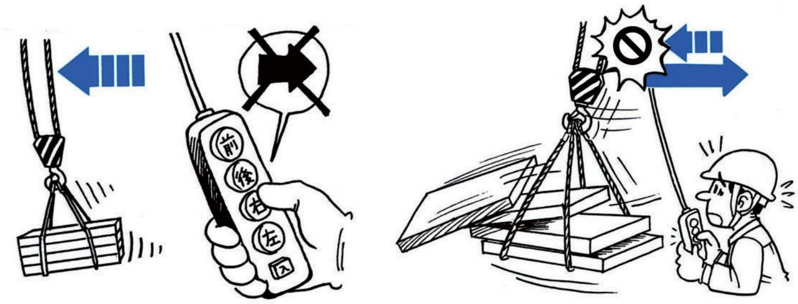


Fig. 2-24 Prohibition of opposite operation

- Do not operate the crane while workers are on the crane for the maintenance of cranes, adjacent buildings and equipment. In this case, turn off the power of the crane, and indicate that the startup of the crane is prohibited.

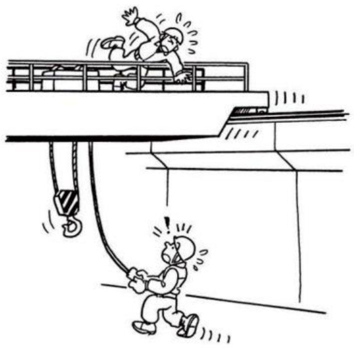


Fig. 2-25 Startup during the inspection is prohibited.

Items of Check List for Specific Operation (p.66)

Move the Crane to the Loading Place (by Traverse and Travel Motions)

- Move the crane horizontally after wind up the hook to a height at which it will not contact the adjacent buildings and equipment on the ground. Normally, wind up 2 meters or more, but do not wind up more than is necessary.
- Set traverse and travel positioning in such a way that the center of the hook will come right above the COG of the load to be lifted.

Lower the hook to a proper level for slinging the load.

Lower the hook to a proper level for slinging the load. At this time, the following problems may occur.

Operate with care so that you do not lower more than necessary.

- The hoisting wire rope becomes slack, and the wire rope comes loose from the drum grooves during hoisting. This may cause random winding.
- The hoisting wire rope is designed for two or more winds to be left on the drum of the hoisting device when the hoisting accessory is at its lowest position. Lowering it beyond this position may cause the load to be applied directly to the end of the hoisting wire rope, which may cause the hoisting wire rope to fall off the drum.
- For club trolleys and hoists without an over-winding prevention device (lowering limit switch), if lowering operations continue, the hoisting wire rope is unwound from the drum and then wound up in the reverse direction (reverse winding of the hoisting wire rope).
  Operate carefully when lowering the hook close to the lower limit, and stop operation immediately when the load starts to move in the lifting direction, even if you are performing a lowering operation.

If the hoisting wire rope is in the reverse winding state, the following problems may occur.

- Because it is being operated on the lowering circuit, even if it moves in the lifting direction, the over-winding prevention device may not work.
- This may lead to accidents such as damage to the securing bracket of the hoisting, wire rope, and frames of the club trolley and hoist.

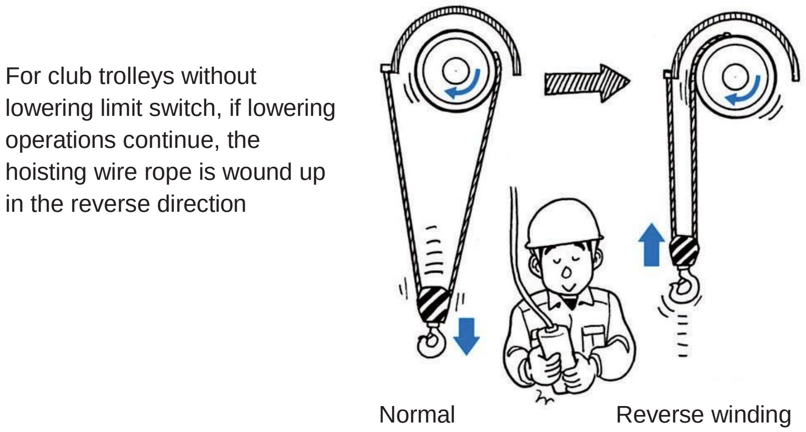


Fig. 2-26 Reverse winding of wire rope for lifting

Wait until the sling work on the load completes.

For cranes operated on the floor or ground, turn off the power switch and place the crane on standby until sling work is complete, and confirm the status of the sling during this time. Inadequate slinging is the major factor in the falling of loads, so ensure that crane operators acquire knowledge about sling work and can confirm the safety of sling work. It is preferable that operators also possess sling certification. If operators perform sling work, they must complete a sling skill training course.

Fig. 2-27 Understanding of Slinging

Fig. 2-28 Certification of Slinger

Checking the sling state before starting operation

- Check that the weight of the load does not exceed the rated load of the crane.
    - Confirm the weight of the load.
    - Confirm the weight of the load through work meetings and work instructions in advance.
    - Practice visual assessment of weight during daily tasks.

- Check that the sling gear is strong enough for the load.
- Check that there is no problem with the sling wire rope.
    - The sling wire rope should in principle have a sling angle of 90 degrees or less, and usually 60 degrees or less.
    - If the rope twists, it will become easy to snap, so correct any twisting.

Preferably within 60 degrees
(90 degrees in maximum)

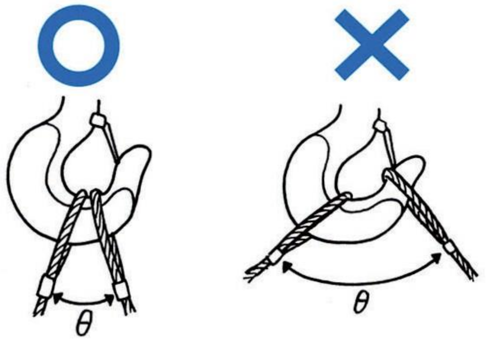


Fig. 2-29 Sling angle

Lifting

- Evacuate the workers to an area where no damage will occur even if the load swings, and then evacuate yourself as well. Do not hold the load with your hands to stop the swing, it is extremely dangerous.

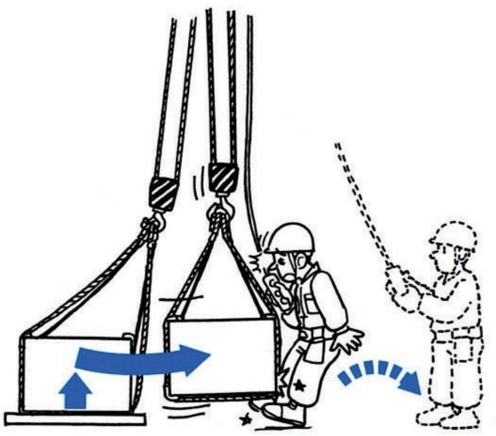


Fig. 2-30 Take enough distance to evacuate

- Do not pull the load sideways or lift it obliquely.
  - When lifting the load off the ground, movement of the load can cause sandwiching, collisions, and other accidents.
  - This may damage the club trolley or hoist frame or lead to wire rope damage.
  - Before starting lifting operations, confirm that the hook is directly above the COG of the load.

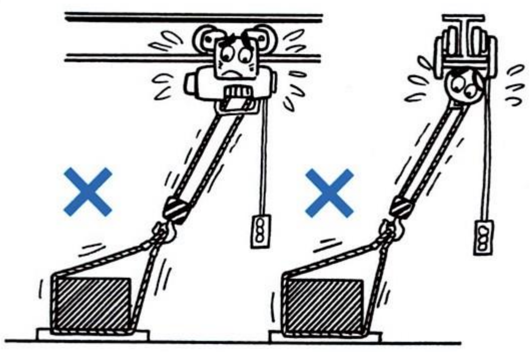
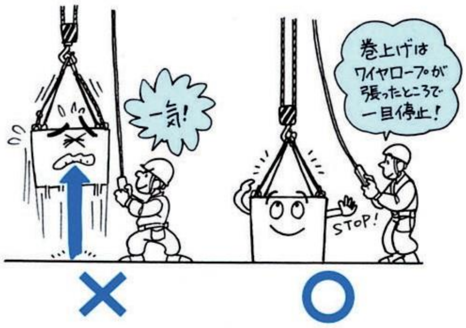


Fig. 2-31 Pulling the load sideways and lifting it obliquely are prohibited.

- Do not perform the operation for lifting the load rapidly.
  - Continue lifting until right before the sling wire rope begins to tense.
  - Right before the sling wire rope tenses and the load leaves the ground, temporarily stop lifting and reduce the impact from lifting the load off the ground.

(a) Confirm the hanging condition and tension state of the sling wire rope.

  - If the squeeze of the sling wire rope is not effectively applied, the load may collapse and an impact force acts on the crane.
  - Confirm that the load is distributed evenly across the entirety of the sling wire rope.
  - If the position of the sling wire rope deviates during lifting, this could cause the wire rope to snap, so stop lifting and fix the sling.



Stop lifting once when the sling wire ropes are taut.

Fig. 2-32 Rapid lifting of the load is prohibited.

Noosing of a sling wire rope

Load collapse

Guide rope

Fig. 2-33 Checking the rope condition

(b) Check if the pads are in their places.

- If the sling wire rope is directly hung on the sharp corner of the load, the rope may be cut.

(c) Check if the load is well-balanced in the sling.

- Confirm that the COG of the load and the hook are in a vertical line.
- When lifting a load where it is difficult to identify the COG, slowly lift the load and confirm.
- To ensure the balance of the load when lifting, assume the lifting position according to the COG of the load, and consider the installation of the hanging pieces to the load at the time of design depending on the situation.

(d) Check that the sling gears and load are not trapped by other loads, machines and structures.

- If the load or sling gear catches onto another object, a force larger than the rated load will be applied, and this could damage the hoisting wire rope and hoist.

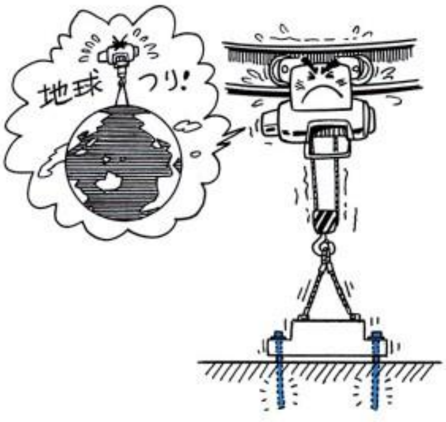


Fig. 2-34 Checking the status of the load

- Lift the load slowly by two or three rounds of inching until it begins leaving the floor or the ground. Then stop the crane for a moment.
- Reexamine Check Items (a) through (d) right after the load is lifted off.
- Following the completion of lift-off, hoist the load continuously to the desired height.
  - Lift the loads to a position higher than people's height, where they can be moved safely at all times. However, if there are no obstacles in the vicinity, stop lifting at as low a height as possible.
  - When lifting a heavy load that weighs nearly as much as the rated load of the crane, be sure to test the brake while the load is still at a low level, before proceeding to normal operation.
  - Avoid regular use of the upper limit switch to stop lifting motion.
  - Do not use the inching mode unnecessarily during load lifting.
  - If the load is swinging, do not start lifting it because, under such condition, the lifting wire rope may be irregularly wound on the hoisting drum, resulting in a damaged wire rope.

Conveyance of Load to Unloading Place

- When operating the crane, take your position behind or at the side of the load and walk along with it.
  Never take your position in front of the load (as seen from the direction of its motion) or right under it.
  If the load falls due to inadequate signaling or other cause, this could lead to someone being crushed under the load.
- Do not pass the load right above any other worker under any circumstances. Take a route over those places where there is no machinery or any other article (preferably, provide passages specially for the conveyance of goods by crane).
- Do not operate the crane inattentively. Always keep your eyes on the passage ahead while the crane is moving.
- Before crossing a safety walkway or a vehicle passage, slow down the crane and give warning to workers around there by sounding the alarm or by some other method.

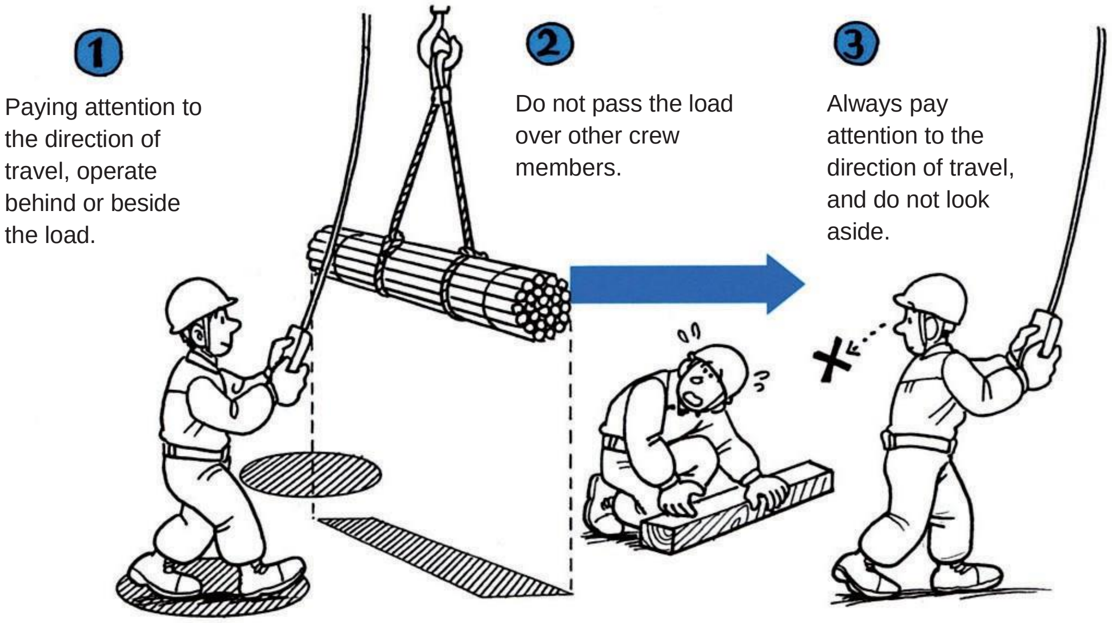


Fig. 2-35 Ensuring safety during transportation

Lowering

- Check the safety of the unloading place.
  Caution workers around the unloading place to move away from there.
  Check whether there is an obstacle at the unloading place and whether the load may, when deposited there, overturn.

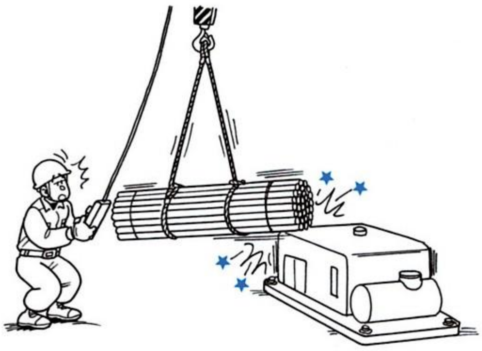


Fig. 2-36 Checking the unloading place

- Lower the load continuously until it is about to reach the floor or ground (to reduce inching).
- Just before the grounding of the load, stop the lowering motion for a moment to make sure that the surface of the unloading place is in order.
- Deposit the load on the floor or ground very carefully with the minimum inching.
- When the load reaches the floor or ground, stop the crane for a moment to check if the load rests stably.
- In slackening the sling wire ropes, lower the hook continuously and avoid unnecessary use of inching.

Unslinging

- Be sure to cut off the power supply of the crane before the slinger begins removing sling wire ropes from the load.
- Never pull out the sling wire ropes from under the load by the hoist motion of the crane.

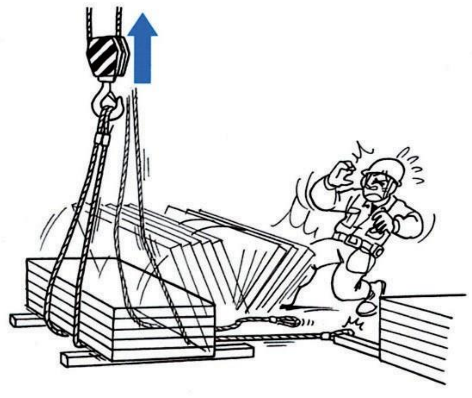


Fig. 2-37 Pulling out the sling wire ropes by the crane is prohibited.

Lifting the Crane Hook

- Lift the hook, checking if the wire rope is properly wound on the hoist drum.
- Care should be taken not to lift the hook while it is swinging.
  If the hoisting wire rope winds around the drum randomly, this could cause snapping or damage of the wire rope. Additionally, if the hook swings, it could come into contact with the drum, club trolley frame, or hoist frame and cause damage.

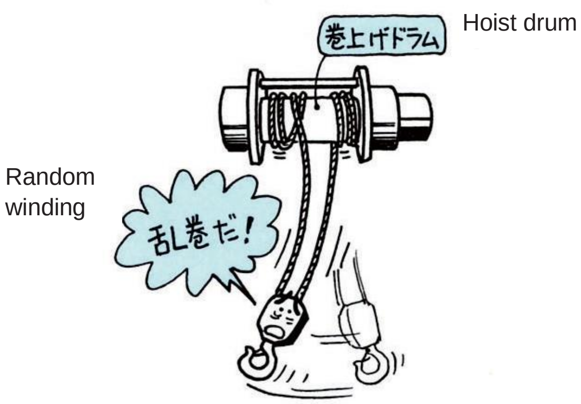


Fig. 2-38 Lifting the swinging hook is prohibited.

End of Conveyance Job

- Switch off the power supply for the crane.
- If you hold the push-button pendant aslant when you are through with it, do not let go of it from that position. This could cause collisions with workers and machinery in the vicinity and lead to worker injuries, damage to the pendant switch, accidental activation of the push-button switch, and damaged machinery.

Do not release the pendant switch while pulling it up.

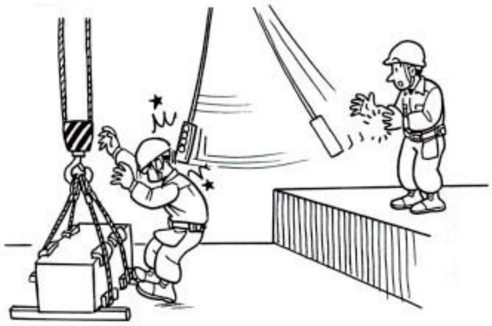


Fig. 2-39 Handling the pendant switch

Post-operation Check List (p.74)

- When using a sling gear, lower it to the specified position and make sure the hook is unloaded.
- Stop the crane at the specified position.
  If a stair or an elevator or lift is provided specially for inspection purposes, stop the crane at such installation.
- Secure the crane if there is a rail clamp or anchor.
- Hoist the snatch block to a level where it does not obstruct pedestrian and wheeled traffic.
- Turn off the power supply switches of the crane.
  If the push-button assembly is provided with a power “OFF” switch, work it to cut off power.
  Turn off the main power supply switch of the crane.
- Check crane components, particularly those which attracted your attention during operation and, if necessary, report to the maintenance supervisor.
- Lubricate or grease crane components as necessary.

- Make necessary entries in the logbook, diary or some other report to ensure that all necessary information will be given to your relief.

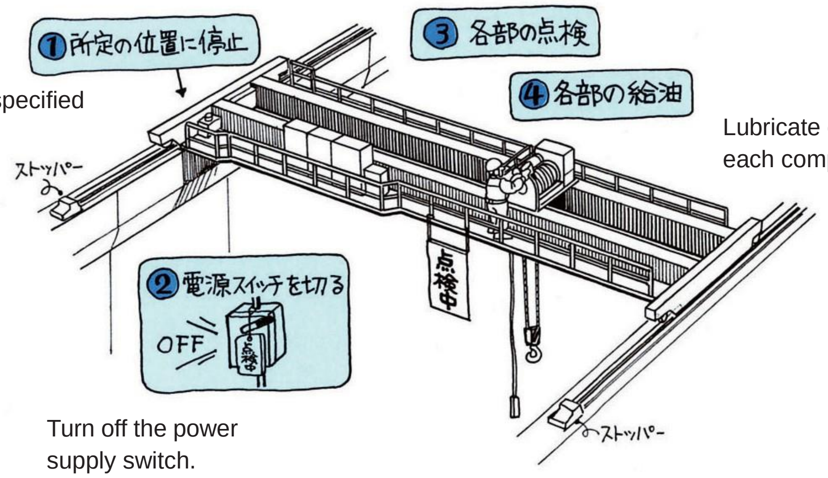


Fig. 2-40 Measures at the end of work

How to Operate Cranes with Hoists to Prevent Swing of Load (P.75)

The damage caused by the swinging load often occurs. It is important to operate the crane with care to keep the load as steady as possible.

Causes of Load Swing

The following are major causes of load swing that may occur with this type of crane:

- Lifting obliquely, ill-balanced COG
  Load swing occurs when lifting the load obliquely or when lifting the load with ill-balanced COG.
- Force of inertia at the start and stop of traversing or traveling
  In the case of cranes that have one-speed traverse and travel motions, the occurrence of load swing at the start and stop of traversing or traveling is unavoidable to a certain extent. In addition, load swing has the following properties.
  - As the load increases, it becomes more difficult to stop the swing.
  - As acceleration or deceleration increases, the load swings widely.
  - As the hoisting wire rope gets longer, the load swings widely.
  - As the hoisting wire rope gets longer, the swing cycle becomes longer.
  - The weight of the load is not related to the swing cycle.

Based on the above, the following are the basics for preventing load swinging.

- Use inching operations until the wire rope tenses and temporarily stop the wire rope at the position where it tenses, then confirm the COG of the load once more before lifting the load off of the ground.
- As the load increases, acceleration and deceleration decrease.
- Perform swing stopping operations appropriate for the length of the hoisting wire rope (the swinging cycle).

Fig. 2-41 Hook position

The above are examples of how to prevent load swinging, but loads do not swing in the same manner. It is important to master operations based on the cranes used at each workplace and the loads being handled while keeping the above fundamentals in mind. In general, cranes with hoists perform lifting, traversing, traveling, and other motions at single speeds, and there is no shock absorber for when the crane starts up. Performing operations while keeping the load swing small is more difficult than with on-board operation-type cranes, so it is important to improve operation skills by repeatedly practicing operation. In addition, cranes with hoists have lighter crane bodies compared to club trolley-type cranes, and the hoists in particular are much lighter than the rated load.

For this reason, performing traversing or traveling of the crane or hoist while a load is swinging can result in the following.

- If the load is swinging in the advancing direction, movement speed will increase.
- If the load is swinging in the direction opposite that of the advancing direction, movement speed will decrease.
- Swinging of the load will cause the crane to vibrate as it moves and not move at a fixed speed.

If the load swing is extremely large, the crane or hoist may stop temporarily as the load swings between the advancing direction and reverse direction.

Fig. 2-42 Anti-swing operation

Preventing load swing

(1) Positioning the hook directly above the COG and lifting
Position the hook directly above the COG and perform inching operations until the rope tenses, then temporarily stop the rope at the tensing position and lift the load off the ground after re-confirming the position of the COG.

(2) Preventing load swing by operations
With cranes, load swing is prevented primarily through the following two methods.

Gradual-Acceleration Method of Load Swing Prevention

This method prevents a load swing by repeating short rounds of inching until the crane reaches the rated traveling or traversing speed. Load swings can be rather easily prevented by this method, but efforts are needed to hold down the required rounds of inching.

Follow-Notch Method of Load Swing Prevention

- Prevention of Load Swing at Startup
  - If the travel switch is pressed on in State (I) described in Fig. 2-43, the crane would start moving immediately but the load would not begin moving until a moment later because of the inertia force working on it, and this will lead to State (II).
  - If the travel switch is turned off in this state, the crane would decelerate immediately while the load would gain on the crane, resulting in State (III).
  - Then if the travel switch is pressed on again just before the load comes right under the crane, as in State (III), the load would start moving forward without swinging appreciably.

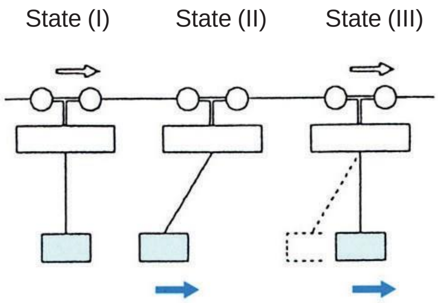


Fig. 2-43 Prevention of Load Swing at Startup

- Prevention of Load Swing in Stopping
  - If the travel switch is turned off for a moment shortly before the crane reaches the desired stop position, as in State (IV), the crane would immediately decelerate to a stop but the load would continue to move forward by the force of inertia. As a result, the State (V) would follow.
  - If the travel switch is pressed on again momentarily just before the load reaches the foremost point of its swing, as in State (V), the crane would move on a little further and then come to a stop in State (VI).

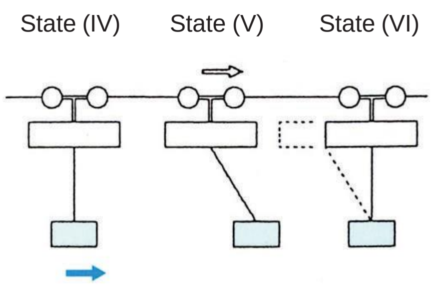


Fig. 2-44 Prevention of Load Swing in Stopping

(3) Preventing load swing by equipment
By using conventional technology such as fluid couplings and electric shock absorbers or recent technology such as inverter controlled shock absorbers, it is possible to make startup and stopping smooth and minimize load swing.

5.4 Inspection and Maintenance (p.77)

Work Rules for Operators (p.77)

The operator of a crane has to bear in mind that he or she is one of the maintenance crew members as well and, during the performance of his or her daily job, has to work the crane properly always giving careful attention to any change in the way it operates.

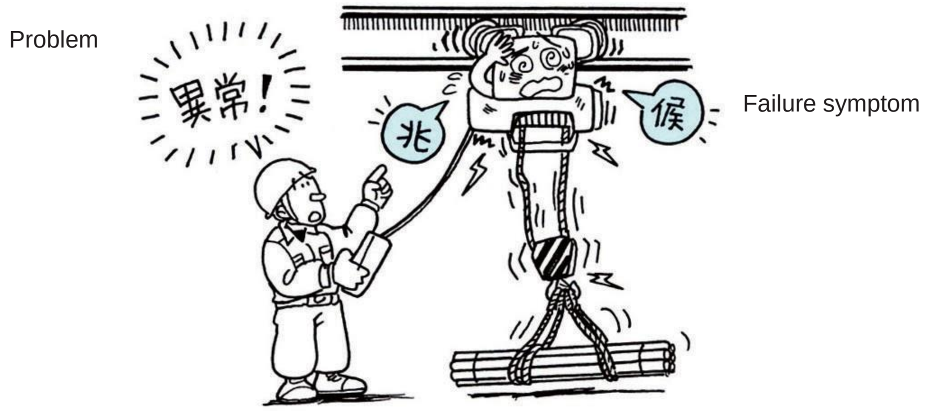


Fig. 2-45 Routine Checkup

Whenever finding any of the following troubles or malfunctions, the operator has to immediately stop the crane and report to the chief maintenance mechanic on the state of the trouble or malfunction. Information on the trouble or malfunction should also be given to all other operators of the crane.

- If the crane does not stop when the operator discontinues pressing the push button:
  A conceivable cause is the fusing of the contact in the push button assembly or in the contactor.

Fig. 2-46 Stopping when abnormal

- If, after the over-winding limit switch is actuated, the crane fails to start a lowering motion:
  The most probable cause is the actuation of the emergency limit switch due to a failure of the service limit switch.
- If a change occurs with mechanical noise, particularly the generation of an unusual noise (e.g., creaks or rumbles) or a frictional or droning sound:
  Attention should be paid not only to the crane itself but also to the conditions of and around the lifted load and traveling rails.
- If the crane vibrates unusually:
  The operator has to check whether the crane is making a rattling noise or whether the pendant cable is vibrating in his or her hand.
- The following irregularities may occur with the operation of the crane:
  - Failure to move at all
  - Decline in the quickness of motion, responsiveness, readiness to start up, smoothness of motion or operating speed below the specified level or occasional failure to work
  - Decreased performance of the brakes
  - Failure of rotary components to turn: The crane components subject to this failure include the sheave of the snatch block, traveling wheels and current collector wheel.
- If the crane sends forth any unusual heat or odor:
  - Whether any of the motors is overheated or burned
  - Whether any of the brake linings have an unusually high temperature or is burned

5.5 Implementation of Inspection and Checkup (p.79)

The crane operation is stipulated to perform the following inspections and checkups. The results of the periodic self-inspection in (2) and the inspection after a storm in (4) are set to be retained for three years, but it is desirable to retain the other inspection results.

(1) Prestart checkup (See 2.3.2, p.54)

(2) Periodical self-inspection
Regardless of whether there is a failure or abnormality, detailed inspection and overhaul of important parts are conducted to discover defective parts that cannot be found by daily inspection. It is usually performed by maintenance personnel with specialized knowledge of cranes.

- Monthly self-inspection
  This is a voluntary inspection conducted within one month.

- Annual self-inspection
  This is a voluntary inspection conducted within one year.

(3) Performance inspection
This is an inspection to be taken within the validity period (usually two years) of the certificate.

(4) Checkup after Storm
It is stipulated to conduct when carrying out the work using a Lift for Construction Work (excluding the one installed underground), after the wind having instantaneous wind velocity of exceeding 30 m/s, or after the earthquake of medium intensity or heavier, check up in advance, abnormalities in each part of the Lift for Construction Work.

5.6 Inspection Guidelines (p.80)

Directions for Crane Operators

During the inspection of a crane, do not switch on the main power supply or operate the crane.

When operating a crane near another which is being inspected, care must be taken to move it slowly and avoid bringing it closer than necessary to the other crane so that their collision will be prevented.

Notes for inspections

When inspecting a crane, perform sufficient preparations in advance to prevent accidents during the inspection and exercise proper work methods.

- Prearrangements
  Before a crane inspection, all people concerned have to be fully informed of the required time and other details of the inspection.
- Checkup on Inspection Outfit
  Before starting the inspection which is generally performed at elevated laces and involves the danger of electric shocks, all inspection crew members have to make sure that they wear a proper working outfit.

Fig. 2-47 Prearrangements

Fig. 2-48 Suitable clothing with the protective equipment

- Inspection Tools
    - Be sure to use well-maintained inspection tools.
    - Provide necessary measures to prevent any of the tools from falling.
- Signs and Markings
    - Keep “Under Inspection” and other necessary signs posted during the inspection.
    - Stretch a rope around the crane to keep unauthorized people off.
    - Put up “Do Not Switch On” and other relevant signs at the power supply switches.
- Measures to Prevent Collisions
    - If the neighboring crane is in operation, set stoppers to prevent a collision.

5.7 Inspection and maintenance of wire ropes and load chains (p.81)

Inspection and maintenance of wire ropes

The rope core of the wire rope includes rust inhibitor and oil for preventing wear due to friction between the wires. The surface of the strands and wire rope are lubricated as well, but if they are used for a long time, the oil will be squeezed out and depleted, and wear of the wires will increase, so it is important to apply oil and replenish the supply. In addition, wear and snapping occur in wire ropes for hoisting and derricking due to the repeated twisting from sheaves and drums. For this reason, focus wire rope inspections on critical points such as easily damaged sections, especially sections that pass through sheaves and are repeatedly twisted, the installation parts at the ends of the rope, and the area around the sections in contact with the equalizer sheave. If you discover the following conditions during inspections, you must exchange the parts immediately.

The criteria for determining the acceptability of wire ropes are set forth in the construction codes for the crane. According to the criteria, any of the wire ropes specified below must not be used for cranes:

- Wire ropes of which not less than 10 percent of the total number of wires (excluding filler wires) contained in any one rope lay are broken.
- Those which have decreased in diameter by more than 7 percent of the nominal diameter
- Those which have any kink
- Those which are severely deformed or corroded

When replacing the wire rope, use the one specified by the manufacturer. It is desirable to replace the wire rope as soon as possible even if the cutting or diameter reduction of the wire rope is within the following values.

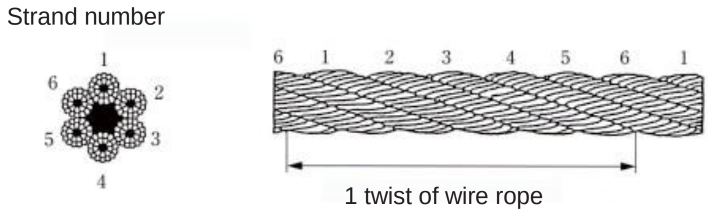


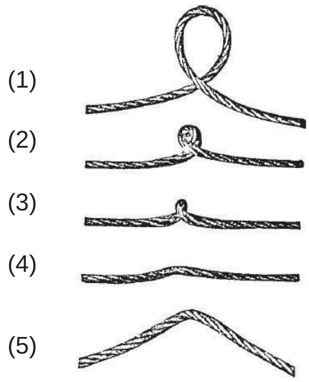
Fig. 2-49 1 twist of wire rope

Fig. 2-50 Breaking of wire

Fig. 2-51 Wear

a: Negative kink

b: Positive kink



c: Generation process of kinks

Fig. 2-52 Kink

a: Corrosion

b: Collapse

Fig. 2-53 Deformations

Inspection and maintenance of load chains (p.81)

The criteria for determining the acceptability of load chains are set forth in the construction codes for the crane. According to these criteria, any of the load chains specified below must not be used for cranes:

- Those chains which have elongated by more than 5 percent of their original length as determined at the time of production
- Those which have any link whose sectional diameter has decreased by more than 10 percent of the original size as determined at the time of production
- Those which have any crack
- Defective welded, defective forged joints, or significantly deformed

In replacing an old chain with a new one, care should be taken to use the type and grade of the chain specified by the manufacturer. Joining any additional links of chain to the existing one must be avoided as it is unsafe.

Lubrication (p.84)

Appropriate lubrication is needed for the crane bearings, gears, and wire rope. The lubricant used should be determined based on the location of use. Use grease, gear oil, and machine oil on the appropriate areas. Also, the appropriate lubricant changes depending on the usage conditions of the lubricated sections, such as the viscosity, the strength of the oil film, and the susceptibility to deterioration.

5.8 Guidelines on Operation of Cranes Installed Outdoors (p.86)

Basically, cranes installed outdoors should be handled in the same way as those installed indoors but their operation requires a full understanding of the applicable guidelines, work rules and check lists, especially those concerning precautions against bad weather.

Notes on operation

- Check weather information during a morning briefing every day.
- If the surface of the load is wet, operate the crane very carefully as the sling wire ropes are apt to slip out of their positions on the load.
- If the crane has no rainproof cover, do not operate it in wet weather.
  - Standard hoists are not waterproof, so malfunctions and electrocution may occur.
  - When not in use, place them underneath a rain shelter (roof).
  - Beware oil deflection of the wire rope or lubricated sections due to rainfall and such.
  - Beware rusting of the mechanical components and interiors of the hoist, and traveling device.
  - Beware that electrical items, wiring, and the like are susceptible to insulation deterioration.
- Stop the work if danger is expected due to strong winds (average wind speed of 10 m/s or more for 10 minutes).
- If there is a possibility of a storm (such as the instantaneous wind speed exceeding 30 meters per second), take necessary measures to prevent the crane from moving inadvertently.
- If the traversing and traveling rails are wet with rain or snow, operate the crane carefully, especially when starting or stopping it, because the wheels are liable to slip on the rails.

- Suspend crane operation during a thunderstorm, which may cause a mishap from lightning.

Strong winds are expected according to weather information

Fig. 2-54 Checking the weather information

It's starting to rain, let's stop.

Fig. 2-55 Stop operation due to rain

Administrative notes

- In addition to legal regulations, if there are on-site standards for the cessation of operations in inclement weather, be sure to adhere to them.
- Countermeasures for strong winds
  - Decide a method for obtaining information about the wind speed.
  - If there are standards for the cessation of operations during strong winds, be sure to adhere to them.
  - If there are standards for implementing countermeasures for strong winds, implement the countermeasures according to said standards.

  (a) Secure the crane using an anchor or other locking devices.

  (b) If there are any objects that may fall onto or fly at the crane, take countermeasures.
- Perform inspections after strong winds and such and confirm that there are no abnormalities.

5.9 Industrial Accidents from Crane Operation (p.87)

Cranes are used to carry heavy loads and, therefore, an accident arising from or in connection with crane operation may result in severe damage to humans and materials. An essential consideration in precluding crane accidents is to take satisfactory preventive measures based on a study on the past record of crane accidents.

The following are cases of crane accidents classified by cause:

(1) Fall of the load

- Poor slinging (e.g., using a wire rope with too large a diameter, setting the sling angle too large or slinging the load with ill-balanced COG)
- Swinging load (due to slinging the load with its COG off the center of the hoisting hook, ill-balanced slinging, rough operation of the crane, etc.)
- Broken wire rope (due to inadequate strength of the wire rope, overload, use of a damaged wire rope, etc.)
- Broken sling gear (due to overload, use of degenerated or damaged sling gear, etc.)

(2) Casualties from being hit or jammed by the load

- Operator's error (e.g., an error in estimating the distance with the eye or careless operation)
- Incorrect signaling

(3) Overturn of the load (due to poor slinging, inadequate curing of the unloading site, wrong judgment by the operator, poor working plans, etc.)

(4) Fall or overturn of things hit by the load

- Operator's error (e.g., an error in estimating the distance with the eye, careless operation or wrong judgment by the operator)
- Slinger's error (e.g., incorrect signaling or poor slinging)

(5) Casualties from being jammed by the sling gear or the hoisting accessories (due to inadequate signaling, unskilled slinging, misunderstanding of a signal, etc.)

(6) Casualties from being jammed by the crane (due to inadequate communication, the operator's misunderstanding, etc.)

(7) Casualties from being jammed by the driving gear (due to a missing or uninstalled protective cover, workers in an improper outfit or in an unstable position, inadequate communication, etc.)

(8) Overturned or damaged crane (due to an inadequate inspection, a fault in construction or engineering works, failure to take precautions against storms, etc.)

(9) Casualties from falling off the crane (due to poor scaffolding, workers in an improper outfit, the operator's misunderstanding, etc.)

(10) Falls from the crane (e.g., things inadvertently left on top of the crane or loosened crane parts)

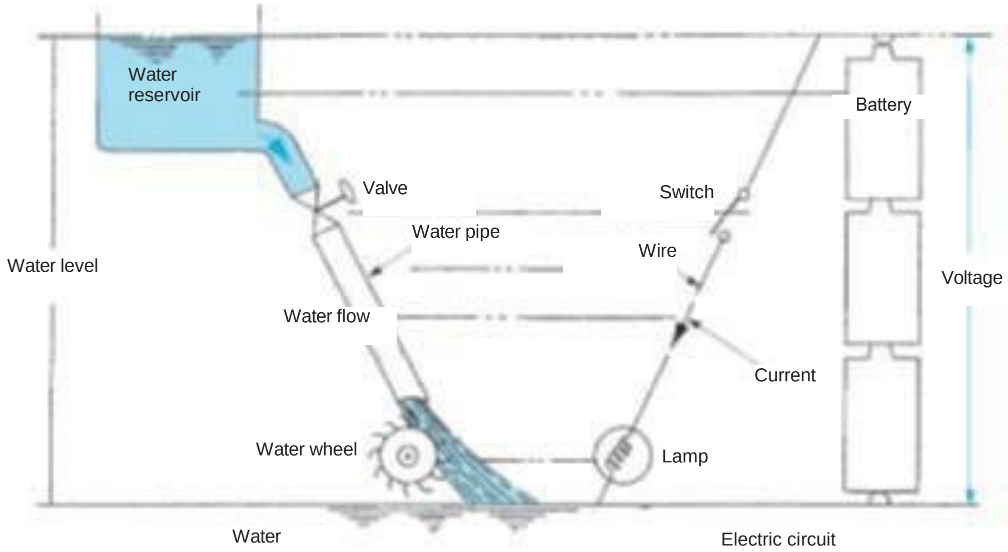
(11) Casualties from electric shocks (due to contact with a bare conductor, failure to turn off the main power supply, inadvertent switching-on of the power supply, etc.)

Chapter 3

Knowledge of Prime Mover and Electricity

1 Electricity (p.96)

1.1 Voltage, Current, and Resistance (p.96)



Water reservoir	Battery
Water wheel	Lamp
Valve	Switch
Water pipe	Wire

Fig. 3-1 Diagram of Electric Circuit Compared to Water

2 Electrical Equipment of Cranes (p.101)

2.1 Circuit breakers and magnetic contactors for wiring (p.105)

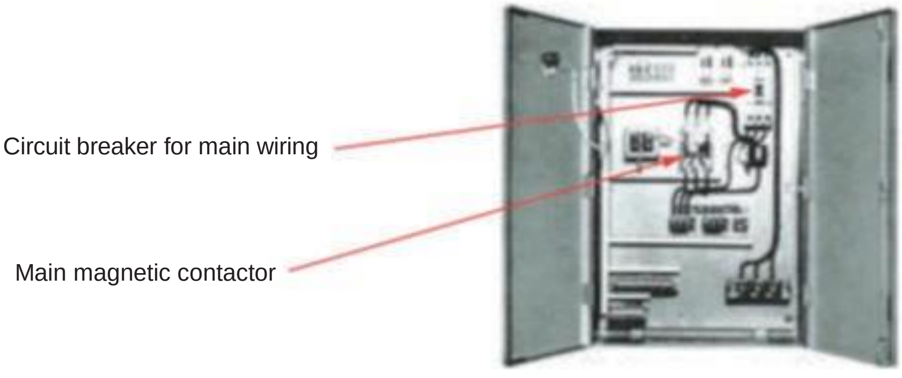


Fig. 3-2 Shared Protection Panel

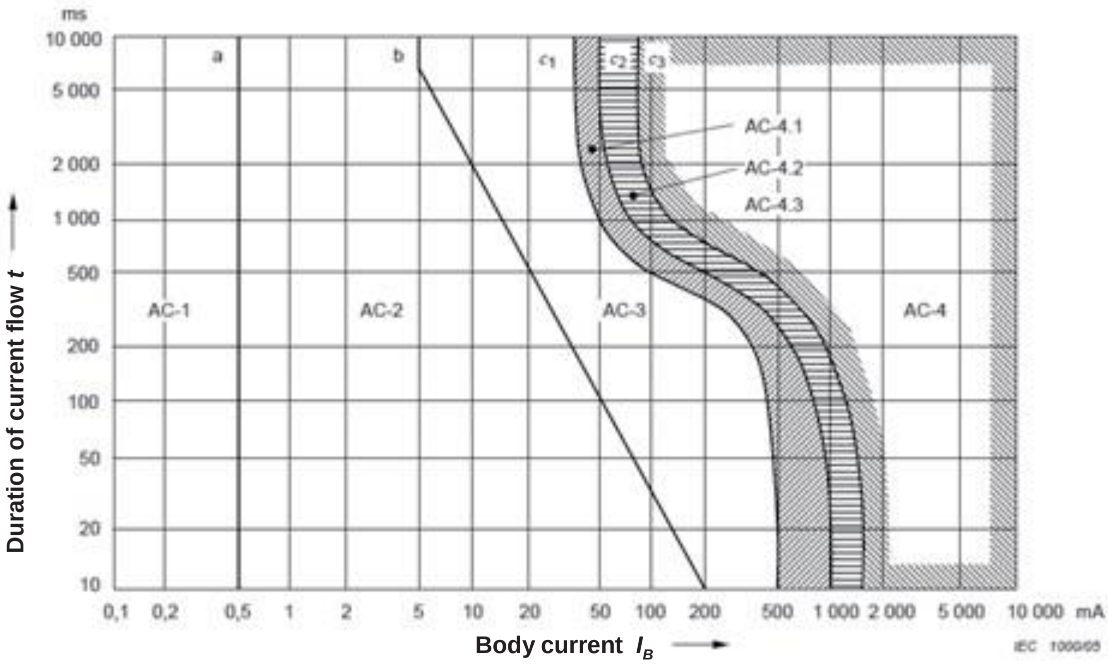
Fig. 3-3 Earth Leakage Breaker

3 Checkup and repair of electric circuit (p.116)

3.1 Danger due to Electric Shock (p.118)

Electric shock (electrical injury) is a physiological reaction with pains and other effects caused by electric current passing through the body. The degree of the effect on human body varies depending on the conditions such as magnitude of the current, conduction time, current type (AC or DC), physical constitution and health condition of the sufferer etc., the magnitude of the current and the energization time are greatly affected in particular.

In general, the criteria for estimation of the danger caused by electric shock are usually indicated only by the current value. On the other hand, International Electrotechnical Commission (IEC) evaluates by the product of current and time as given in Fig. 3-4. The figure shows the value when the current flows from the left hand to both feet, and risk of death with ventricular fibrillation may occur in 1,000 mS (millisiemens) at a current of 50 mA, in 500 mS at 100 mA and in 10 mS at 500 mA respectively. However, even if a large current flows through the human body due to contact with a high voltage, there is the case that the sufferer can escape only with burns when the conduction time is very short.



Zones	Boundaries	Physiological effects
AC-1	AC-1 Up to 0.5 mA curve a	Perception possible but usually no ‘startled ‘ reaction.
AC-2	0.5 mA up to curve b	Perception and involuntary muscular contractions likely but usually no harmful electrical physiological effects.
AC-3	Curve b and above	Strong involuntary muscular contractions. Difficulty in breathing. Reversible disturbances of heart function. Immobilization may occur. Effects increasing with current magnitude. Usually no organic damage to be expected.
AC-4 [1)]	Above curve c_1	Patho-physiological effects may occur such as cardiac arrest, breathing arrest, and burns or other cellular damage. Probability of ventricular fibrillation increasing with current magnitude and time.
	c_1 - c_2	AC-4.1 Probability of ventricular fibrillation up to about 5 %
	c_2 - c_3	AC-4.2 Probability of ventricular fibrillation up to about 50 %
	Beyond curve c_3	AC-4.3 Probability of ventricular fibrillation above 50 %
[1)] For durations of current flow below 200 ms, ventricular fibrillation is only initiated within the vulnerable period if the relevant thresholds are surpassed. As regards ventricular fibrillation, this figure relates to the effects of current which flows in the path left hand to feet. For other current paths, the heart current factor has to be considered.		

Fig. 3-4 Conventional time/current zones of effects of A.C. currents (15 Hz to 100 Hz) on persons for a current path corresponding to left hand to feet

Chapter 4

Knowledge of Dynamics Necessary for Crane Operation

1 Topics Relating to Force (p.126)

1.1 Three Elements of Force (See p.126)

1.2 Action and Reaction (See p.127)

1.3 Composition of Forces (p.127)

As shown in Fig. 4-1 a, when two people pull the stump with a rope, the stump is pulled in the direction of the arrow. Thus, when two forces are acting on an object, these two forces can be replaced with one resultant force (combined forces) having the same effect.

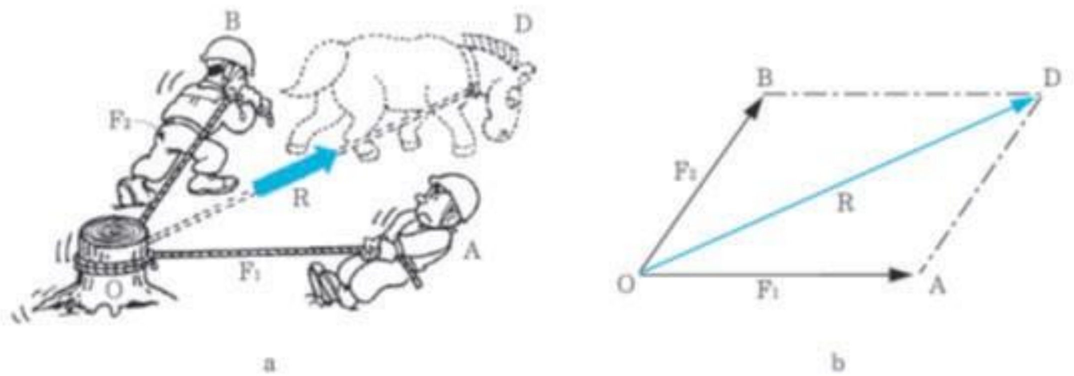


Fig. 4-1 Composition of Forces

Fig. 4-1 b explains a method of finding a resultant force. The resultant of the forces F1 and F2, which work on the point O from two different directions, can be determined by drawing a parallelogram (OADB) with these forces on its two sides. The diagonal R in the figure represents the magnitude and direction of the resultant force to be determined. This is called the parallelogram law.

1.4 Decomposition of Forces (p.128)

The “decomposition of force” is the process of dividing a force working on an object into two or more forces at an angle to one another. Each of the portions into which a force is thus divided is called a “component” or a “component force” of the original force.

To find a component of a force, the parallelogram of forces described in the “composition of forces” is used in reverse sequence to divide the force into two or more forces at an angle to one another.

Let us look at a man dragging a sled as shown in Fig. 4-2 a by way of example. Since he pulls the rope forward at an angle to the ground, i.e., somewhat upward, the sled is hauled horizontally (longitudinally) but, at the same time, vertically. So we have to find what is the magnitude of the force that actually draws the sled horizontally.

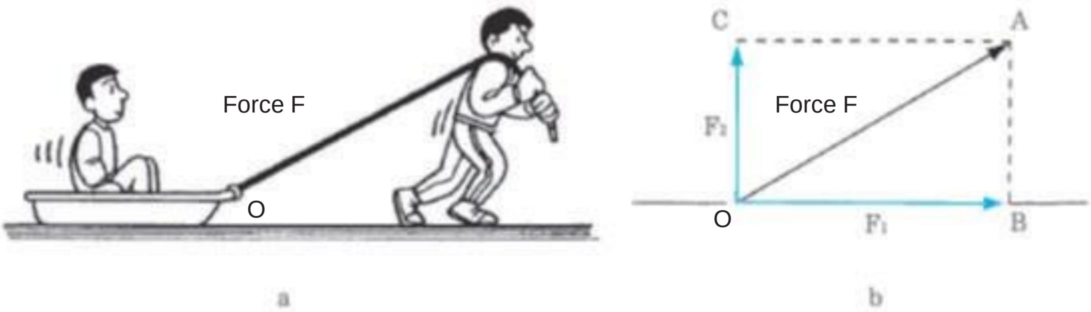


Fig. 4-2 Decomposition of Forces

As shown in Fig. 4-2 b, the force F (OA) is divided into F1 (OB) and F2 (OC) using the parallelogram law. This is the decomposition of force and it can be found that the horizontal force of the sled becomes F1 (OB).

1.5 Moment of Force (p.129)

In turning a nut with a spanner wrench, a smaller force is required when you hold the wrench near the end of the shaft than when you hold it in the middle of the shaft.

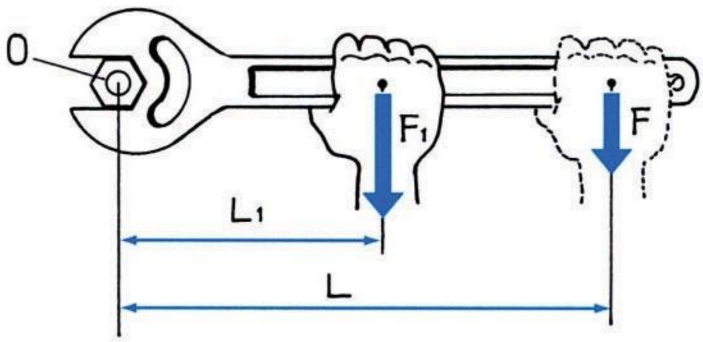


Fig. 4-3 Relationship between Magnitude and Arm of Force

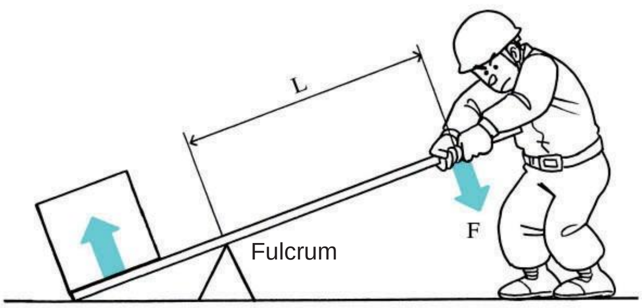


Fig. 4-4 Moment of Leverage

A quantity represented by the product of the magnitude of a force and the length of its arm, in relation with a given axis of rotation or a given fulcrum as described above, is called the “moment of a force”.

With the magnitude of a force given as F and the length of arm given as L, the moment of the force M can be written as $M = F \times L$. Where the magnitude of the force F is stated in N (newton) and the length of arm L in m (meter), then the moment of the force M can be represented in N·m (newton meter).

$M1 = 9.8 \times m \times L1$, $M2 = 9.8 \times m \times L2$

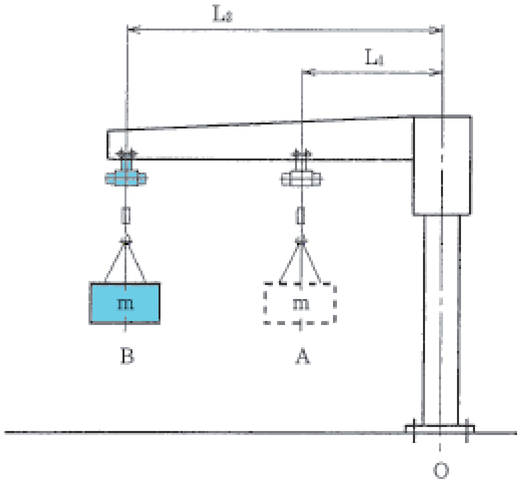


Fig. 4-5 Moment Working on Jib Crane

Usually moment works to turn an object either clockwise or counterclockwise.

To find the sum or equilibrium of two or more moments, therefore, you have to take into account the rotational direction of each of them.

1.6 Equilibrium of Parallel Forces (p.133)

Fig. 4-6 shows a worker carrying a couple of loads on the ends of a pole. To keep it level on the shoulder, the pole should be held right in the middle when the two loads are equal in weight, but when their weights differ, the pole should be held at a point nearer the heavier load. This is because of the need to equilibrate the moments of forces.

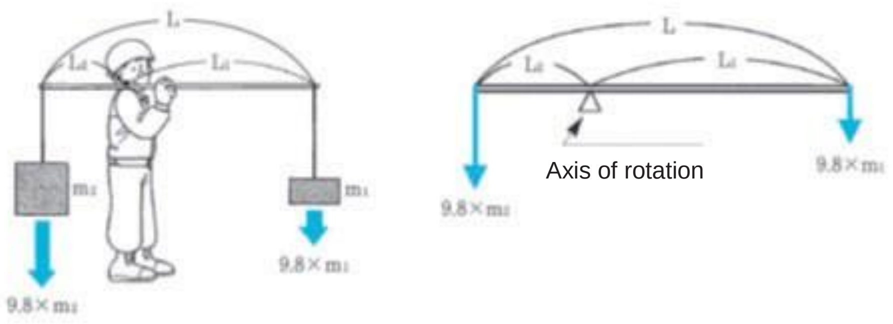


Fig. 4-6 Equilibrium of Parallel Forces

In this diagram, let us examine the moments of forces with the worker's shoulder as the axis of rotation. With the weights of the two loads given as m1 and m2 and with the load-supporting places on the pole (horizontal distances between the loads and the shoulder) given as L1 and L2

The clockwise moment: $M1 = 9.8 \times m1 \times L1$

The counterclockwise moment: $M2 = 9.8 \times m2 \times L2$

The moments around the axis of rotation are kept in equilibrium as below:

$9.8 \times m1 \times L1 = 9.8 \times m2 \times L2$ (1)

$m1 \times L1 = m2 \times L2$ (2)

$m1 \times L1 = m2 \times (L - L1)$ (3)

$m1 \times L1 = m2 \times L - m2 \times L1$ (4)

$m1 \times L1 + m2 \times L1 = m2 \times L$ (5)

$L1 \times (m1 + m2) = m2 \times L$ (6)

(Note that $L = L1 + L2$)

Needless to say, the worker's shoulder serves as the axis of rotation that supports the weight of the loads (m1 + m2).

Equation (6) can be rewritten as:

$$L1 = \frac{m2}{m1 + m2} \times L$$

Accordingly, the loads will be equilibrated if the pole is held at the point determined by internally dividing the pole in inverse proportion to the weights of the loads m1 and m2.

2 Mass and Center of Gravity (p.135)

Refer to the textbook.

3 Motion (p.140)

3.1 Velocity (p.141)

Speed is a quantity indicating how rapidly an object moves. It is represented by the distance the object moves in a unit length of time.

If an object in uniform motion moves 50 meters in 10 seconds, its speed can be expressed 5 m/s. The speed of an object in uniform motion is expressed by the result of dividing the distance the object has moved in a certain period of time by the required number of unit lengths of time, as written below:

$$\text{Velocity } (v) = \frac{\text{Distance } (L)}{\text{Time } (t)}$$

Among commonly used units of speed are meters per second (m/s), meters per minute (m/min) and kilometers per hour (km/h).

In determining the motion of an object, however, it is hardly sufficient to think of its speed alone. We have to find the direction of its motion as well, and the term “velocity” is often used as a quantity indicating both the direction and speed of motion.

3.2 Inertia (p.142)

A material body has a tendency to remain at rest if at rest, or, if moving, to continue moving in the same direction, forever in either case, unless it is affected by some external force. This tendency is known as “inertia”, and the force that works on a material body because of inertia is called the “force of inertia”.

Fig. 4-7 Inertia

3.3 Centripetal and Centrifugal Forces (p.143)

When a hammer thrower, after turning the hammer quickly to give it a circular motion, releases his hold of the ring, the hammer flies in a direction tangent to the circle at the point of the release. To make the hammer continue a circular motion, the athlete has to keep pulling it toward the center of the circle.

In order to set an object in circular motion, some force (in the above instance, the force of hand holding the hammer by the ring) has to be made to work on it. The force which thus sets an object in circular motion is called “centripetal force”. In this connection, a force that is equal in magnitude but opposite in direction to centripetal force is called “centrifugal force”.

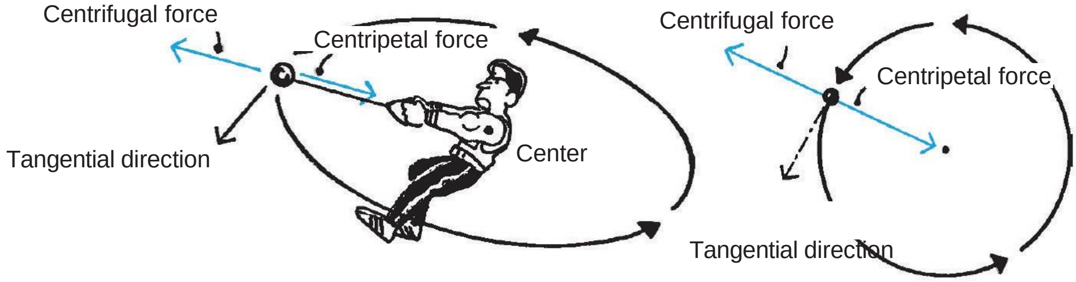


Fig. 4-8 Centripetal and Centrifugal Forces

As shown in Fig. 4-9, the faster the lifted load turns, the greater the centrifugal force becomes, resulting in the movement of the load further outward. Compared with situation where the lifted load is at rest, this condition increases the moment of a force that works to make the jib crane fail. Under some extreme conditions, it is not unlikely that the crane will fall actually.

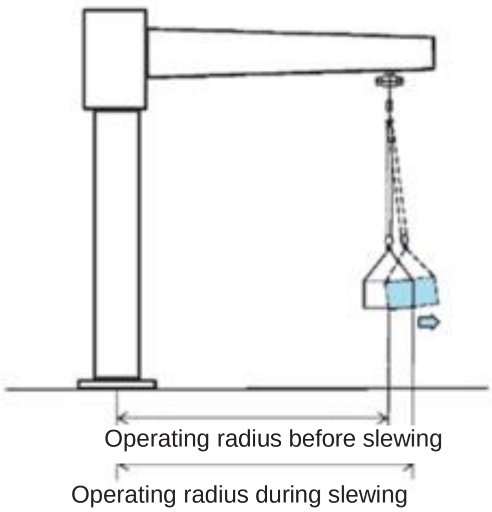


Fig. 4-9 Outward Movement of Lifted Load and Changes in Operating Radius due to Centrifugal Force

4 Pulley Blocks (p.145)

“Pulley block” is a general term for assemblies consisting of a combination of sheaves. These assemblies can be divided into the following categories:

4.1 Stationary Pulley (p.145)

This type of pulley is fixed at a specified place as shown in Fig. 4-10. All you have to do to lift a load by stationary pulley is to pull the other end of the rope downward. In other words, this device changes only the direction of inputted force, leaving its magnitude unchanged. To lift a load by 1 meter, for instance, you only have to pull down the rope by 1 meter.

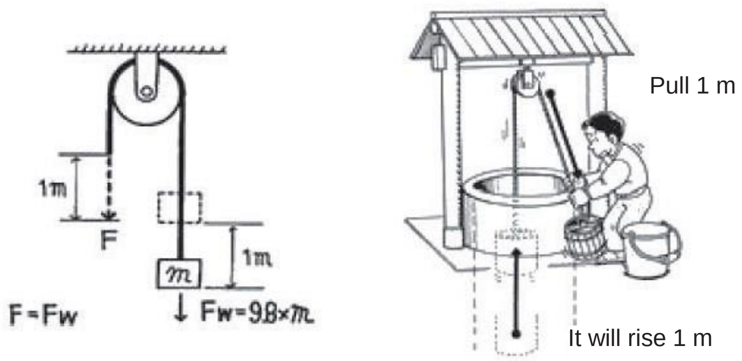


Fig. 4-10 Stationary Pulley

4.2 Movable Pulley (p.146)

This is the same type of pulley as those used for the hook blocks of cranes. As shown in Fig. 4-11, a movable pulley is operated by moving up and down one end (A in the diagram) of the rope that runs on its wheel or wheels, with the other end fixed. The pulley itself moves up and down carrying a load, according to the vertical motion of the rope end A. You can lift a load by this device with a force equivalent to half the weight of the load (assuming that the pulley is free from any friction), but when the rope is pulled 2 meter, for example, the load moves up only 1 meter - half the length by which the rope is pulled. In other words, the pulley requires a smaller input force to lift a given weight of load but so much greater length of rope has to be pulled.

Meanwhile, the direction of inputted force remains unchanged as the rope is pulled up whenever a load is to be lifted.

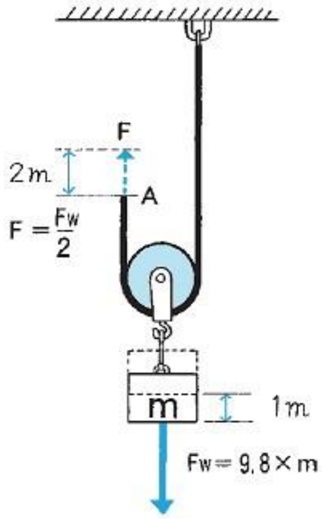


Fig. 4-11 Movable Pulley

4.3 Combination Pulley (p.147)

A combination pulley block, made by combining several movable and stationary pulleys, can lift or lower a very heavy load with a relatively small force. A combination of three movable pulleys and three stationary ones, as described in Fig. 4-12, is capable of lifting a load with a force equivalent to only one sixth of the weight of the load, assuming that the pulley system is free from any friction. However, it can lift a load only one sixth of a meter for every one-meter length of the rope pulled. This means that the velocity of a lifting or lowering load is also one sixth of that of the inputted force.

$$F = \frac{1}{2 \times n} \times Fw \qquad Vm = \frac{1}{2 \times n} \times v \qquad L = 2 \times n \times L$$

F:	Force to pull rope	Vm:	Winding speed	L:	Winding length
Fw:	Weight of load	v:	Lifting speed of load	Lm:	Lifting distance of load

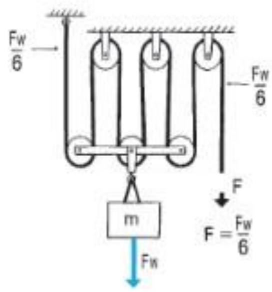


Fig. 4-12 Combination Pulley (Three Movable Pulleys)

Given in Fig. 4-13 is an example of combination pulley systems for cranes.

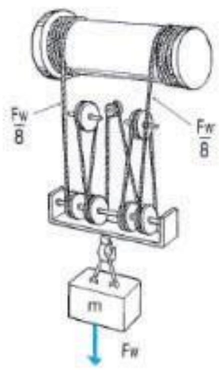


Fig. 4-13 Combination Pulley (Four Movable Pulleys for Crane)

5 Load (p.148)

Load is a force working on an object from outside (i.e., an external force). It can be categorized in different ways according to how such force works on the object involved.

5.1 Classification by Direction of Force

Tensile Load

Tensile load pulls a rod by the force F that works on the longitudinal axis of the rod. A typical example of it can be found in the load on a wire rope by which cargo is being lifted.

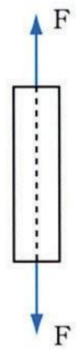


Fig. 4-14 Tensile Load

Compressive Load

Compressive load works in a direction opposite to tensile load, as indicated in Fig. 4-15, to compress the rod longitudinally with the force F. You can find a typical example of it in the force working on the ram of a jack.

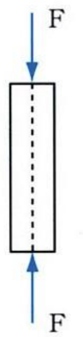


Fig. 4-15 Compressive Load

Shearing Load

A reamer bolt may, when exposed to the force F as described in Fig. 4-16, be cut along a sectional plane parallel to the direction of F if this force is very strong. Such action of force is called “shearing load”.

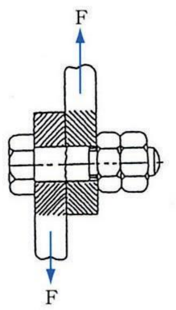


Fig. 4-16 Shearing Load

Bending Load

A beam supported at both ends may bend if the force F perpendicular to its longitudinal axis works on it as shown in Fig. 4-17. This action of force is known as “bending load”. An example of it can be found in the weight of a load or the trolley working on the girder of an overhead traveling crane.

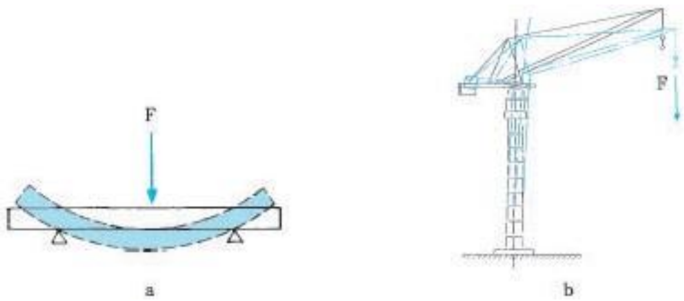


Fig. 4-17 Bending Load

Twisting Load

A shaft may be twisted if one end of it is fixed and the other is exposed to the force F working in two opposite directions on its circumference, as described in Fig. 4-18. Such work of force is called “twisting load”. You can find an example of this load in the instance where the shaft of a winch is pulled and twisted by the wire rope.

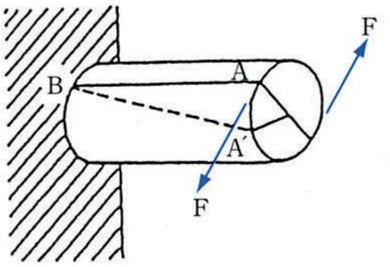


Fig. 4-18 Twisting Load

Compound Load

Mechanical components of a crane are affected more often by a combination of the loads described above rather than by their individual actions. For instance, the wire rope and hook are both subject to a combined action of tensile and bending loads, while power unit shafts in general are subject to a combination of bending and twisting loads.

5.2 Classification by speed of load

Static Load

Static load means a fixed or standing load that has invariable magnitude and direction of force like the dead weight of crane structure.

Dynamic Load

Dynamic load, which is variable in magnitude, is classed under two categories. One is repeated load that continually varies with time, and the other is impact load that suddenly applies force to an object for a very short period of time.

Repeated load can be further divided into single-acting load and double-acting load, of which the former always works in the same direction but varies in magnitude with time like the load on such crane components as the wire rope and winch bearings, while the latter varies with time both in direction and magnitude like the load on gear shafts.

Machines or structures may break under any of these dynamic loads even if its magnitude is far smaller than static load. This phenomenon is called “fatigue fracture” which, arising from the fatigue of materials, accounts for a substantial percentage of fractures that occur actually.

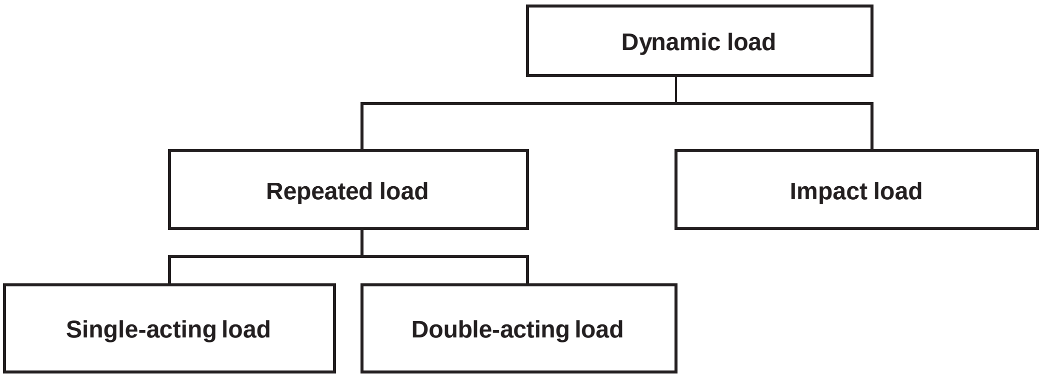


Fig. 4-19 Classification of Dynamic Load

Other Classification

Load can also be classified, according to the state of its distribution, into concentrated and distributed loads of which the former focuses on a single spot or a very small area while the latter works on a wide area.

6 Stress (p.150)

Any object, when under load, generates a force in it (internal force) that works to resist and counterbalance the applied load as shown in Fig. 4-20. This internal force is called “stress”, whose intensity is represented by the magnitude of force per unit area.

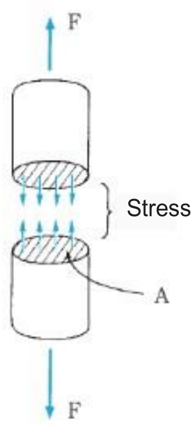


Fig. 4-20 Stress

Stress can be divided into tensile, compressive and shearing stresses, of which the first occurs under tensile load, the second under compressive load and the third under shearing load. With the sectional area of the structural member under load given as A and the tensile load working on the member given as F kg, the tensile stress can be written as:

$$\textbf{Tensile stress} = \frac{\textbf{Tensile load applied to the structural member (N)}}{\textbf{Sectional area of the structural member (mm}^2\textbf{)}} = \frac{F}{A}\,(\mathrm{N/mm^2})$$

7 Strength of Wire Rope, Chain and Other Sling Gear (p.152)

Wire ropes, chains or other sling gear may differ in strength, depending on their materials, even if they are in the same size and shape. These articles are also subject to a much greater force than the weight of the lifted load itself because such weight dynamically works on them. Taking these factors into account, steps are taken generally to set a reference standard below the load at which the selected sling gear, such as wire rope or chain, may break. Then an arrangement is made to avoid using the sling gear above the reference load and to provide an effective means of directly comparing the reference load with the actual load to be born by the sling gear, so that lifting work can be carried out safely and smoothly.

Breaking Load

The breaking load is the maximum load at which single wire rope breaks. (Unit: kN)

Safety Factor

The ratio of the breaking load of the wire ropes and chains to the maximum load applied to them is called the "safety factor".

The safety factor is defined taking the type, shape, material and using method of the sling gear into consideration. The safety factor for sling gears are stipulated as follows in the Safety Ordinance for Cranes.

- Wire rope: 6 or more
- Chain: 5 or more, or 4 or more when certain conditions are met
- Hook, shackle: 5 or more (See p.155)

Clamps and hackers are also used, and the use of fiber ropes such as belt slings and round slings has also become more common. Although the safety factors for these items are not stipulated in the regulations, the Japan Crane Association Standard has specified the safety factors indicated below.

- Clamp and hacker: 5 or more
- Belt sling, round sling: 6 or more

Standard Safe Load

The standard safe load (or standard working load) is the maximum load that can be lifted vertically using a single wire rope, taking this safety factor into consideration. The value can be calculated by the following equation.

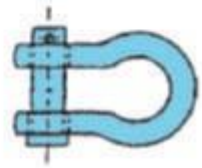
Standard Safe Load (t) = Breaking load (kN) / (9.8 x Safety Factor)

Safe Load

The safe load (or working load) is the maximum load (t) that can be lifted vertically using a wire rope or chain, according to the number of ropes and sling angle. Some sling gears indicates the safe load as a rated load or working load.

Safe Load of Sling Hooks and Sling Gears

The manufacturer indicates the safe load or working load of the sling hooks and sling gears taking the safety factor into account.



(a) Bow shackle

(b) Straight shackle

Fig. 4-21 Shackles

8 Relationship between Number of Wire Ropes and Load (p.155)

8.1 Load Applied to Wire Rope (p.155)

The load applied to the wire rope varies depending on the weight of the load, number of wire ropes and sling angle.

Number of Ropes and Sling Angle

The number of ropes are represented as One-rope slinging with two-point, Two-rope slinging with two-point, Three-rope slinging with three-point, Four-rope slinging with four-point or such depending on the number of slinging points at the load. The sling angle (angle between the sling wire ropes attached to the hook) is shown in textbook. (Fig.4-39, p.156)

When the load is lifted using two wire ropes as shown in Fig. 4-22, the force to support the weight m of the load is the resultant force (F) of the tensions (F1, F2), which are each larger than the value of F/2. For a load of a given weight, the tensions F1 and F2 increase when the sling angle is increased.

In addition, the horizontal component P of the tensions F1 and F2 also increases with the sling angle. This horizontal component P acts as a compressive force on the load, and it pulls the sling wire ropes inward. Careful attention is therefore required when the sling angle is large.

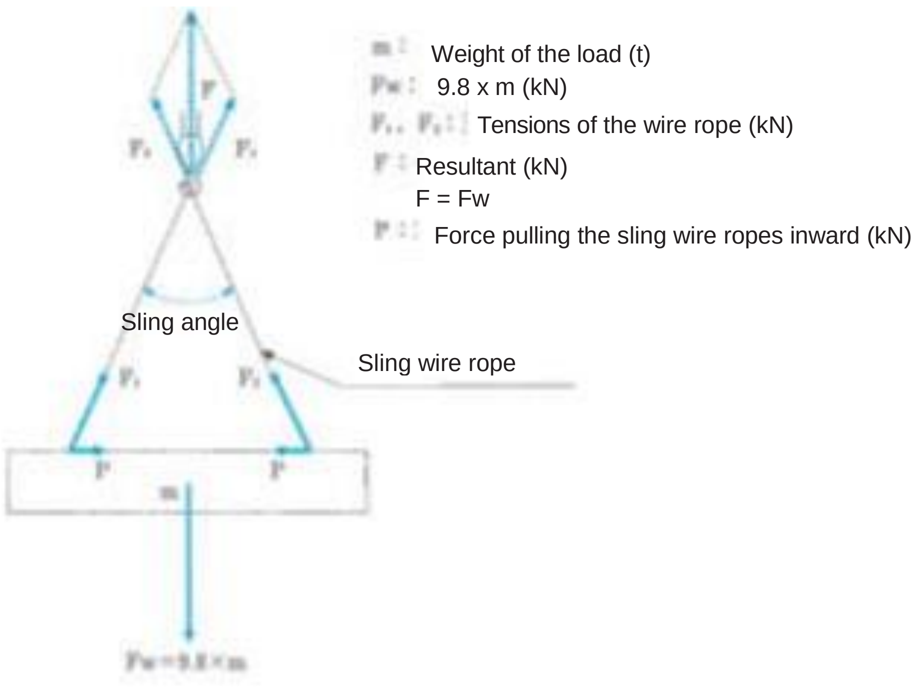


Fig. 4-22 Tension of Sling Wire Ropes

Tension Factor

Tension factor is the value to calculate the load (tension) applied to single wire rope for each sling angle. The load (tension) to the single wire rope can be calculated by finding tension factor and number of ropes even the number of the ropes is changed. For the relation between the sling angle of the wire rope and tension, refer to the textbook (Table 4-4, p.157).

Fig. 4-23 shows the relationship between the sling angle and the tension of wire ropes, indicating that as the sling angle increases, thicker wire ropes have to be used even if the weight of the load remains unchanged, since the tension applied to the wire rope increases. If the sling angle increases too much, the eye of sling wire rope may come off the hook. Accordingly, ensure that the sling angle is 60 degrees or less.

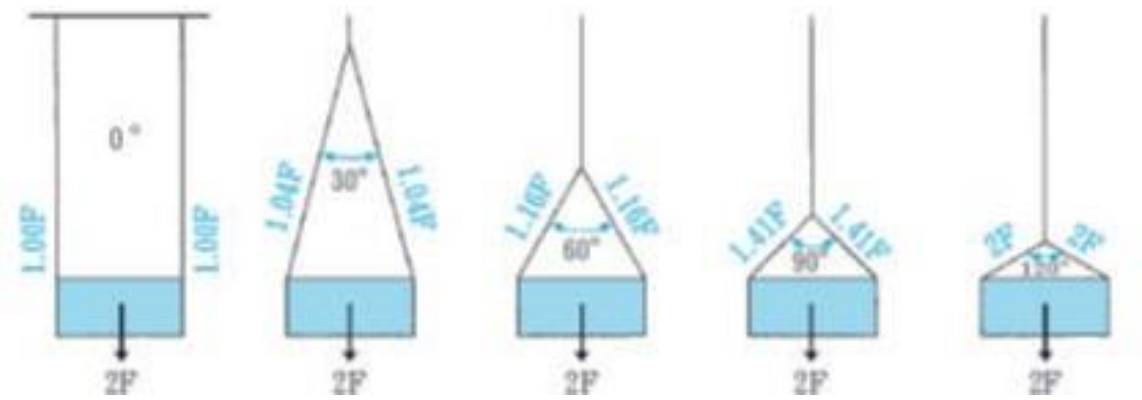


Fig. 4-23 Relationship between Sling Angle and Tension

Mode Factor

(See Table 4-5, p.157.)

8.2 Calculation for Selecting Sling Wire Ropes (p.159)

To calculate the safe load for selecting the sling wire rope, tension and mode factors are used.

Calculation by Tension Factor

The standard safe load required for single wire rope can be calculated by the following equation.

Standard safe load required for single wire rope = (Weight of Load / Number of ropes) x Tension Factor

Calculation by Mode Factor

The standard safe load required for single wire rope can be calculated by the following equation.

Standard Safe Load = Weight of Load / Mode Factor

Chapter 5

Signaling Methods

1 Signaling Methods (p.160)

Various means of signaling, including motions of the hand, flags and whistles (as supplementary signals to motions of hand or flags) are used for communication with crane operators, but in general, signaling by hand is used widely.

A primary consideration in signaling by hand is to give distinct signals by the specified motions of hand in a clear, readily discernible, unmistakable manner.

Crane operators must be conversant with all signals used, so they can readily and correctly understand signals given and accurately operate the crane accordingly.

To prevent any accident that may arise from signaling errors, the operators must suspend crane operation temporarily in the following instances:

- When the signal is unclear
- When they receive any signal, other than the specified ones
- When they receive signals from two or more signalers
- When any worker, other than the assigned signaler, gives a signal

1.1 Signaling by motions of hand (See p.161 - p.163)

1.2 Voice signaling (See p.165)

Chapter 6

Relevant Laws and Regulations

1 Industrial Safety and Health Law

Law No. 57 of June 8, 1972

(Issue of Inspection Certificate, etc.) p.171

Article 39

2. The Chief of the Labor Standards Office shall, as provided for by the Ordinance of the Ministry of Health, Labour and Welfare, issue the inspection certificate for the specified machines, etc., which have passed the inspection concerning the installation of the specified machines, etc., in that set forth in paragraph (3) of the preceding article.
3. The Chief of the Labor Standards Office shall, as provided for by the Ordinance of the Ministry of Health, Labour and Welfare, endorse the inspection certificate of the specified machines, etc., which have passed the inspection concerning the partial alteration or the resumption of the use of the specified machines, etc. in the inspection set forth in paragraph (3) of the preceding article.

(Restriction on Engagement) p.173

Article 61

In the case that one's industry comes under one of those defined by Cabinet Order, the employer shall conduct safety and/or health education on the following matters, as provided for by the Ordinance of the Ministry of Health, Labour and Welfare, for those who are newly charged as foremen or others to directly guide or supervise workers in operations (except operations chief):

1. Matters pertaining to the decision of the method of work and the assignment of workers
2. Matters pertaining to the method of guiding or supervising workers
3. In addition to the matters listed in preceding two items, matters necessary for preventing industrial accidents, as provided for by the Ordinance of the Ministry of Health, Labour and Welfare.

2 Enforcement Order of the Industrial Safety and Health Act

Amendment of Cabinet Order No. 13 of 2012

(Specified Machines, etc.) p.170

Article 12

1. Machines, etc. specified by the Cabinet Order set forth in paragraph (1) of Article 37 of the Act (excluding the case that they are clearly not for domestic use) shall be the machines, etc. listed below:

3. Cranes with a lifting capacity of 3 tons or more (for stacker cranes, 1 ton or more)

3 Safety Ordinance for Cranes

Amendment of Ordinance of the Ministry of Health, Labour and Welfare No. 1 of 2006

(Inspection Certificate for Crane) p.178
Article 9

The Chief of the Competent Labour Standards Inspection Office, as regards the crane, which passed the completion inspection or the crane set forth in the proviso of paragraph (1) of Article 6, is to issue the crane inspection certificate (Form No. 7) to the person who submitted the application pursuant to the provisions of paragraph (6) of the same Article.

(Inspection Certificate for Crane) p.178
Article 10

The validity term of the crane inspection certificate is for two years. However, based on the results of the completion inspection, the said validity term may be restricted for less than two years.

(Inspection Certificate for Crane) p.179
Article 16

The employer must, when carrying out the work using a crane, provide the crane inspection certificate of the said crane at the place where the said work is carried out.

(Limitation on Overload) p.180-181

Article 23

The employer must not use a crane being loaded with the load exceeding its Rated Capacity.

2. Notwithstanding the provisions of the preceding paragraph, the employer may, in the case of having remarkable difficulty to conform to the provisions of the same paragraph due to the unavoidable reason and when taking the following measures, use the crane loaded over its Rated Capacity up to the load on the load test prescribed in paragraph (3) of Article 6:

(i) to submit in advance, a crane special case report (Form No. 10) to the Chief of the Competent Labour Standards Inspection Office,

(ii) to confirm in advance, that there is no abnormality by performing the load test prescribed in paragraph (3) of Article 6;

(iii) to designate a person who supervises the operation, and to operate the crane under the direct supervision by the said person.

(Limitation on Overload) p.180-181

Article 25

1. The employer must, when carrying out the work using a crane, set fixed signals for operation of the crane, designate a person who gives the said signals and have the said person give the said signals. However, this does not apply to when having only a crane operator carry out the work single-handedly.
2. The person designated pursuant to the preceding paragraph, when engaging in the work set forth in the same paragraph, must give the signals set forth in the same paragraph.
3. Workers engaging in the work set forth in paragraph (1) must follow the signals set forth in the same paragraph.

(Restriction on Riding) p. 181

Article 26

The employer must not carry workers by a crane, nor have workers work being hanged from the crane.

(Periodical Self-inspections) p.184

Article 34

1. The employer must, after installation of a crane, perform self-inspection for the said cranes periodically once every period within a year. However, this does not apply to the non-use period of the crane, which is not used for a period of exceeding one year.
2. The employer must, as regards a crane set forth in the proviso of the preceding paragraph, perform the self-inspection before resuming its use.
3. The employer must perform the load test on the self-inspection set forth in the preceding two paragraphs. However, this does not apply to the cranes falling under any of the following each item:

(i) a crane for which the load test pursuant to the provisions of paragraph (1) of the Article 40, has been performed within two months before the said self-inspection, or the validity term of the crane inspection certificate of which is to be expired within two months after the said self-inspection;

(ii) a crane installed at power plants, substations, etc. where there is remarkable difficulty to perform the load test, and the load test for which is found unnecessary by the Chief of the Competent Labour Standards Inspection Office.

4. The load test set forth in the preceding paragraph is to be done in such manners as performing motions with hoisting, travelling, slewing, trolley traverse, etc., under the Rated Speed, while suspending a load with the mass corresponding to the Rated Capacity.

(Periodical Self-inspections) p.185

Article 36

The employer must, when carrying out the work using a crane, checkup the crane as to the following matters before commencing the work for the day:

(i) the function of over-winding preventive devices, brakes, clutches and controls;

(ii) the condition on the upper part of runways and rails on which the trolley traverses;

(iii) the condition of the parts where wire ropes reeve through.

(Records of Self-inspection, etc.) p.185

Article 38

The employer must record the results of the self-inspection and the checkup, prescribed in this Section (excluding the checkup set forth in Article 36) and reserve these records for three years.

(Return of Inspection Certificate) p.186

Article 52

A person who had installed a crane must, when having disused or altered its Lifting Capacity down to less than 3 tons (for a stacker type crane, less than 1 ton), return without delay the crane inspection certificate to the Chief of the Competent Labour Standards Inspection Office.

(Safety Coefficient of Chain Sling) p.186-187

Article 213-2

1. The employer must not use a chain as the slinging equipment for a crane, a Mobile Crane or a derrick, unless its safety coefficient is more than the value listed in the following items, based on the types of chain slings.

(i) a chain falling under all of the followings: 4:

a) in the case of pulling it with the force of the half of its breaking load, the elongation is 0.5 % or less; and

b) the value of the tensile strength is 400 N/mm^2 or more and its elongation is equal to or more than the value listed in the right column of the following table corresponding to the value of tensile strength listed in left column of the same table;

Tensile strength (N/mm^2)	Elongation (%)
400 or more and less than 630	20
630 or more and less than 1000	17
More than 1000	15

(ii) a chain not falling under the preceding item: 5.

2. The safety coefficient set forth in the preceding paragraph is the value obtained from dividing the breaking load of a chain sling by the value of the maximum load applied on the said chain sling.

(Safety Coefficient of Hook, etc.) p.187

Article 214

1. The employer must not use a hook or a shackle as slinging equipment for a crane, a Mobile Crane or a derrick, unless the safety coefficient is 5 or more.
2. The safety coefficient set forth in the preceding paragraph is the value obtained from dividing the breaking load of the hook or the shackle by the value of the maximum load applied on the said hook or the said shackle.

I. Knowledge of floor-operated cranes

[Question 1] Which of the following is the correct definition of "crane"?

(1) A mechanical device designed to lift loads manually by human power and carry the lifted loads horizontally

(2) A mechanical device designed to lift loads by power

(3) Any mechanical device designed to lift loads by power and carry the lifted loads horizontally, other than mobile cranes and derricks

[Question 2] Which of the following is the correct definition of a technical term related to cranes?

(1) "Lifting height" refers to the horizontal distance between the centers of the traveling rails upon which the crane travels.

(2) "Lifting load" means the weight of the load that has been lifted by a crane.

(3) "Rated load" means the maximum load that can actually be hung on the crane's hook or grasped by the grab bucket, which varies depending on the conditions of the crane.

[Question 3] Which of the following is NOT the correct definition of a technical term related to cranes?

(1) "Span" means the horizontal distance between the centers of the traveling rails.

(2) "Slewing" means motion other than the rotation of the jib or other similar component of the jib crane with its center of rotation as the axis.

(3) "Rated load" means the maximum load that can be hung on the crane's hook.

[Question 4] Which of the following correctly describes the span of an overhead traveling crane?

(1) The distance that the trolley is able to move along the girder

(2) The distance between the centers of the axes of the outer wheels on either side of the saddle

(3) The horizontal distance between the centers of the traveling rails

[Question 5] Which of the following is the correct definition of a technical term related to cranes?

(1) "Rated speed" means the maximum speed at which a motion such as lifting, traveling, or traversing can be performed while the rated load is on the hoisting accessory.

(2) "Lifting load" means the maximum load that can actually be hung on the crane's hook or grasped by the grab bucket.

(3) "Jib angle" means the angle between the centerline of the jib and a vertical line.

[Question 6] Which of the following is NOT a correct description of the motions of a crane?

(1) "Slewing" means the rotation of the jib or other similar component of the jib crane horizontally around a particular axis of rotation.

(2) "Jib derricking" means moving the jib up and down with the end at the jib base as the axis of rotation, and "lifting or raising of the jib" refers to the motion of the jib in the direction that decreases the jib angle.

(3) "Level-luffing" means the motion in which the height of the lifted load remains at the same level when it is moved inwards and outwards relative to the jib base.

[Question 7] Which of the following is NOT a correct description of the precautions for handling cranes?

(1) When a power outage occurs, return the controller handle to the stop position, and turn off the power switch.

(2) To carry a load, first lift the load to the specified height before moving it horizontally.

(3) On an outdoor crane, unlock the device that prevents runaway when there is a possibility of strong wind.

[Question 8] Which of the following is NOT a correct description of the information related to load swing?

(1) The longer the wire rope, the shorter the period of the swing.

(2) The basic method for preventing swing is to perform operations based on the length of the wire rope (period of swing).

(3) The longer the wire rope, the greater distance that the load may swing.

[Question 9] Which of the following is NOT a correct description of the brakes?

(1) Brakes do not need to be inspected, because they do not experience problems regardless of how frequently they are used.

(2) If brakes are not adjusted properly, they may stop functioning or cause damage.

(3) The brake is a component that stops the motor and holds the load at the desired place.

[Question 10] Which of the following is NOT a correct description of the information related to crane inspection and maintenance management?

(1) When performing crane inspection, there is no need to post "Do Not Switch On" signs at the power supply switches of the crane.

(2) While performing their daily work, crane operators should always pay careful attention to any changes in the way the crane operates, and should not overlook any problems that may occur.

(3) Always wear a safety belt when performing inspection in high places.

[Question 11] Which of the following is NOT a correct description of the information related to crane inspection and maintenance management?

(1) When a load chain is not long enough, order additional links from the manufacturer and join them to the existing chain.

(2) A load chain must not be used if it has elongated by more than 5 percent of its original length as determined at the time of production.

(3) A wire rope must not be used if it has decreased in diameter by more than 7 percent of the nominal diameter.

[Question 12] Which of the following is a correct description of the information regarding prestart inspection?

(1) Make sure that there are no obstacles on the traveling rails, and no problems with the rails.

(2) It is OK to operate the crane even if the wire rope comes into contact with part of the structure.

(3) It is not a problem to operate the crane if a button switch is damaged.

[Question 13] Which of the following is NOT a correct description of the "traveling" motion of a crane?

(1) "Traveling" refers to the movement of the trolley on the main rope of a cable crane.

(2) "Traveling" refers to the movement of a wall crane along the wall surface.

(3) "Traveling" refers to the movement of a tower jib crane along the ground surface.

[Question 14] Which of the following is a correct description of the points to note for operating a floor-operated crane?

(1) Make sure to cut off the power supply to the crane before removing sling wire ropes from the load.

(2) If the crane is stopped in a position other than above the safety walkway, it is OK to lift or lower the hook to any height.

(3) When there is no load on the hook, it is OK to lift the hook to the specified height even if it is swinging widely.

[Question 15] Which of the following is a device to prevent runaway of an outdoor crane when there is strong wind?

(1) Anchor

(2) Hydraulic buffer device

(3) Overload preventive device

II. Knowledge of prime mover and electricity

[Question 1] Which of the following equations correctly describes the relationship between current (I), voltage (E), and resistance (R)?

(1) I = ER
(2) E = IR
(3) R = IE

[Question 2] Which of the following is the current in a circuit when the voltage is 200 V and the resistance is 20 Ω?

(1) 0.1 A
(2) 10 A
(3) 4,000 A

[Question 3] Which of the following is NOT a correct description of electricity?

(1) Two circuits have the same power consumption if the voltage of both circuits is the same, regardless of whether the current is different.
(2) The electrical resistance of an object is proportional to the length, and inversely proportional to the cross-sectional area.
(3) 2,000 W can also be expressed as 2 kW.

[Question 4] Which of the following is a correct description of the method for changing the rotation direction of a three-phase induction motor?

(1) Interchange any one of the three wires of the primary-side power supply.
(2) Interchange any two of the three wires of the primary-side power supply.
(3) Interchange all three wires of the primary-side power supply.

[Question 5] To calculate electric energy, which of the following is multiplied by the electric power?

(1) Time
(2) Speed
(3) Distance

[Question 6] Which of the following types of motors is most commonly used in cranes?
(1) Commutator motor
(2) Single-phase induction motor
(3) Three-phase induction motor

[Question 7] Which of the following types of electricity is used for the power supply in most cranes?
(1) Direct current (DC)
(2) Single-phase AC
(3) Three-phase AC

[Question 8] Which of the following is an insulator material?
(1) Silver
(2) Rubber
(3) Aluminum

[Question 9] Which of the following is the safe limit for the amount of current in an electric shock?
(1) 10 mAs (milliampere-seconds)
(2) 50 mAs (milliampere-seconds)
(3) 80 mAs (milliampere-seconds)

[Question 10] Which of the following is NOT a correct description of the information related to electric shock?
(1) Death will not occur if the voltage is low, because only a small amount of current passes through the body.
(2) The severity of an injury due to electric shock is related to the amount of current that flows through the body and the duration of the electric shock.
(3) The degree of electric shock is greater if the skin is wet with sweat or other liquid.

III. Knowledge of dynamics necessary for crane operation

[Question 1] Which of the following are the three elements of force?

(1) Magnitude, direction, and acting point

(2) Balance, centrifugal force, and direction

(3) Line of action, magnitude, and strength

[Question 2] Which of the following is a correct description of the moment of force?

(1) The moment of force does not change when the arm length is longer, if the magnitude of the force remains the same.

(2) The moment of force increases when the arm length is longer, even if the magnitude of the force remains the same.

(3) The moment of force increases when the arm length is shorter, even if the magnitude of the force remains the same.

[Question 3] Which of the following is NOT a correct description of the stability of an object that is placed on a level surface?

(1) The stability of an object varies depending on how it is positioned.

(2) When an object placed on a level surface is tilted slightly, the center of gravity moves down to a lower position.

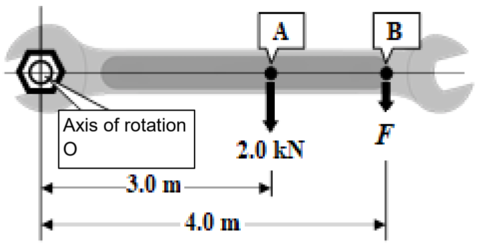
(3) Objects with a larger base area are more stable.

[Question 4] In the illustration below, which of the following is the force *F* of point B when the moment of force for point A is equal to that for point B?

(1) 1.5 kN

(2) 3.0 kN

(3) 4.5 kN

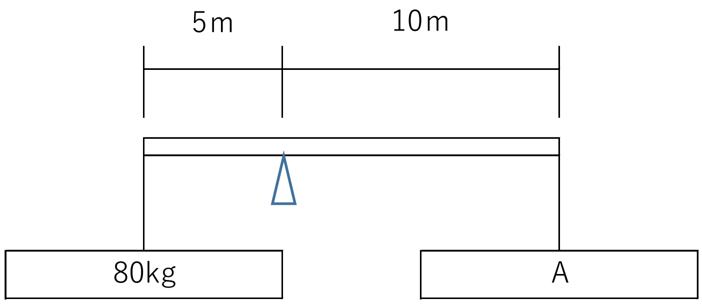


[Question 5] Which of the following is the weight A that is necessary to balance both sides of the pole shown in the illustration below? For this question, do not include the weight of the pole.

(1) 10 kg

(2) 20 kg

(3) 40 kg

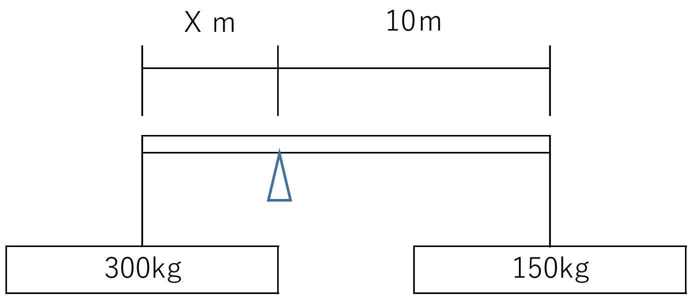


[Question 6] Which of the following is the length X that is necessary to balance both sides of the pole shown in the illustration below? For this question, do not include the weight of the pole.

(1) 1.0 m

(2) 2.5 m

(3) 5.0 m

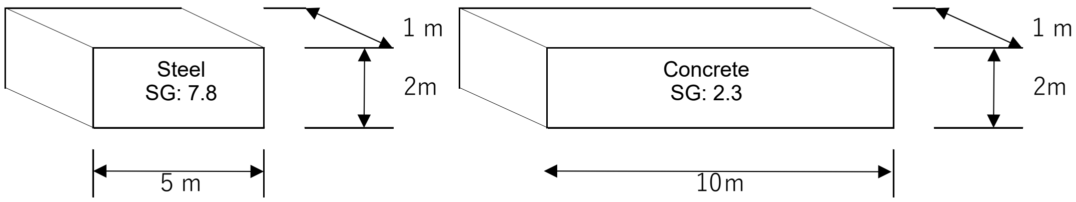


[Question 7] When comparing the mass of the steel block to that of the concrete block shown in the illustration below, which of the following is correct?

(1) The mass of the steel block is equal to that of the concrete block.

(2) The mass of the steel block is greater.

(3) The mass of the concrete block is greater.



[Question 8] Which of the following is the type of load that has an invariable magnitude and direction of force, like the dead weight of the crane structure?

(1) Static load

(2) Dynamic load

(3) Single-acting load

[Question 9] When an object is in circular motion, a force pulls the object outward from the center of the circle. Which of the following is the name of this force?

(1) Friction

(2) Centripetal force

(3) Centrifugal force

[Question 10] An object at rest tends to stay at rest and an object in motion tends to stay in motion, unless acted upon by an external force. What is this property called?

(1) Velocity

(2) Inertia

(3) Acceleration

IV. Relevant laws and regulations

[Question 1] Which of the following is NOT included in the definition of "crane" in the Safety Ordinance for Cranes?

(1) Overhead traveling crane
(2) Bridge crane
(3) Crawler crane

[Question 2] Which of the following types of cranes is NOT subject to the Safety Ordinance for Cranes?

(1) An overhead traveling crane with a lifting load of 2.5 t, which performs traveling and traversing by power, and which performs lifting by manual power
(2) A wall crane with a lifting load of 0.7 t, which performs lifting by power
(3) A jib crane with a lifting load of 0.5 t, which performs all operations by power

[Question 3] Which of the following is the period of time that self-inspection records must be kept, as stipulated in the Safety Ordinance for Cranes?

(1) For 1 year
(2) For 3 years
(3) For 5 years

[Question 4] Which of the following is the validity term of a crane inspection certificate?

(1) 1 year
(2) 2 years
(3) 3 years

[Question 5] Which of the following is a correct description of the operations performed by a person who has received skill training for floor-operated cranes?

(1) A person who has completed the skill training course for floor-operated cranes is permitted to perform slinging work.
(2) To perform slinging work that involves lifting loads of 1 t or more, the operator must complete the skill training course for slinging work.
(3) It is OK for an operator to perform slinging work when designated by the employer.

[Question 6] Which of the following is NOT stipulated in the regulations as an item to inspect before starting work each day?

(1) The strength of the jib and legs
(2) The function of the brakes
(3) The function of the over-winding preventive device

[Question 7] Which of the following may be performed only by a person who is registered with the Minister of Health, Labour and Welfare?

(1) Initial inspection
(2) Performance inspection
(3) Temporary load inspection

[Question 8] Which of the following is the lifting load of cranes other than floor-operated cranes (except telphers) that may not be operated by a person who has completed the skill training course for floor-operated cranes?

(1) 1 t or more
(2) 3 t or more
(3) 5 t or more

[Question 9] Which of the following people is permitted to perform slinging work using a floor-operated crane with a lifting load of 5 t or more?

(1) Person who completed the skill training course for floor-operated cranes

(2) Person who completed the special education course related to slinging work

(3) Person who completed the skill training course in slinging work

[Question 10] Which of the following is the weight of the load test for the self-inspection that is performed periodically at least once a year?

(1) 0.5 times the rated load

(2) 1.0 times the rated load

(3) 1.5 times the rated load

[Question 11] Which of the following is a correct description of the crane operations when there is a storm or strong wind?

(1) It is OK for the employer to perform crane operations when there is strong wind.

(2) It is not necessary for the employer to take measures such as setting devices that prevent runaway, even if the crane is expected to be exposed to wind with an instantaneous wind velocity exceeding 30 m/s.

(3) The employer must suspend work related to cranes when there is a forecast of strong wind that may pose a danger to the work.

[Question 12] Which of the following is a correct description of the laws and regulations for cranes?

(1) Operation signals must be performed by a slinging assistant.

(2) It is OK to use the crane to lift workers.

(3) The crane operator must not leave the operating position while the load is lifted.

[Question 13] Which of the following is the correct safety factor for sling wire ropes, as stipulated in the Safety Ordinance for Cranes?

(1) 2 or more

(2) 4 or more

(3) 6 or more

[Question 14] Which of the following is the correct safety factor for load chains, as stipulated in the Safety Ordinance for Cranes?

(1) 1 or more

(2) 3 or more, or 2 or more when certain conditions are met

(3) 5 or more, or 4 or more when certain conditions are met

[Question 15] Which of the following is the correct safety factor for sling hooks and shackles, as stipulated in the Safety Ordinance for Cranes?

(1) 1 or more

(2) 3 or more

(3) 5 or more

Answers

I. Knowledge of floor-operated cranes (15 questions)

[Q1] (3), [Q2] (3), [Q3] (2), [Q4] (3), [Q5] (1),
[Q6] (2), [Q7] (3), [Q8] (1), [Q9] (1), [Q10] (1),
[Q11] (1), [Q12] (1), [Q13] (1), [Q14] (1), [Q15] (1)

II. Knowledge of prime mover and electricity (10 questions)

[Q1] (2), [Q2] (2), [Q3] (1), [Q4] (2), [Q5] (1),
[Q6] (3), [Q7] (3), [Q8] (2), [Q9] (2), [Q10] (1)

III. Knowledge of dynamics necessary for crane operation (10 questions)

[Q1] (1), [Q2] (2), [Q3] (2), [Q4] (1), [Q5] (3),
[Q6] (3), [Q7] (2), [Q8] (1), [Q9] (3), [Q10] (2)

IV. Relevant laws and regulations (15 questions)

[Q1] (3), [Q2] (1), [Q3] (2), [Q4] (2), [Q5] (2),
[Q6] (1), [Q7] (2), [Q8] (3), [Q9] (3), [Q10] (2),
[Q11] (3), [Q12] (3), [Q13] (3), [Q14] (3), [Q15] (3)