# ergonomic aspects

# cabins of mobile cranes

A joint publication by:

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# Working Group on the ergonomic aspects of Mobile Cranes

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## Foreword

The "Stichting Bedrijfsgezondheidsdienst voor de Bouwnijverheid" (Foundation Occupational Health in the Building and Construction Industry), BGBouw, protects and promotes industrial health care for all employees in the building trade and associated industry.
Individual services, in the form of industrial medical assistance are provided by the more than forty affiliated regional industrial health services. In addition scientific research, aimed at practical circumstances, is conducted with the purpose of analyzing labour conditions in the building trade and, where necessary, to point the way to improvement.
With the latter task in mind, BGBouw instituted i.a. a Steering Committee Ergonomics which was given the responsibility of setting up ergonomic research projects, and to have these carried out.
When, at the end of 1979, the survey into tower crane cabins was completed, it was decided to request the Netherlands Institute for Preventive Health Care-TNO (NIPG) to conduct a similar survey into cabins of mobile cranes. To assist in this survey, a working group was again constituted, the composition of which is shown on next page. Research consisted of an inventory of national and international directives and instructions in respect of the layout of cabins of mobile cranes, an ergonomic assessment of existing equipment, and interviews with some twenty cranedrivers, whereby particular attention was paid to health-, safety- and comfort aspects.
The results of this survey are presented in a report "Towards ergonomically correct cabins of mobile cranes in the Building Industry", which is published by the NIPG (in Dutch).
New technologies, such as remotely controlled machines are putting in an appearance, but these are still in an experimental stage. Although these developments can contribute to improvement of labour conditions, it was decided to direct this survey exclusively at cabins of mobile cranes, based on the manner in which these are used at the present.
This booklet presents a brief, clear summary of the recommendations which were formulated on the basis of this survey.

**Descriptions are given of how cabins of mobile cranes will probably look in future. This, on the one hand is important in the designing of new machines, while on the other hand these recommendations have their use when existing equipment is being adapted.**
**The data presented in this booklet generally go farther than the minimum conditions applicable in the Netherlands, and which are laid down in Standards and Publications.**
**Among designers and builders of cranes an increased interest in the ergonomic aspects of cabins has been noted in recent years. This booklet, provided active support by purchasers and users of cranes is obtained, can help in channelling the intentions that are present. Hence this booklet should be seen, not as a subject of discussions, but as a working paper!**

**August 1981**
**BGBouw**

# 1. Introduction

There is noticeable increase in the interest paid to the endeavour to improve the quality of labour, also termed the humanization of labour. In addition to improvements regarding conditions of labour and labour relations, this endeavour is also concerned with the work, and with the place of work itself. On the one hand the point is the nature of the work itself, and on the other hand the means, by which, and the physical conditions under which such work is performed. The ergonomic approach, which strives for adaptation of work, work-place and equipment, to the human being, occupies an important position within this framework.

An earlier survey in respect of the cabins of tower cranes has shown that regarding appliances in the building trade there is an obvious need for a more ergonomic trend of thought in terms of the design of places of work[1]. In general terms the problems that arise concerning ergonomic aspects of mobile cranes, are of the same origine[2] as those that were found earlier in the case of tower cranes. The cabin from which the crane is operated is still frequently given a low priority, as the cabin in many cases forms an assembly of many components, that are hardly attuned to each other. Where virtually all mobile cranes in the Netherlands are imported, and where exporting countries frequently employ their own method of approach, standardization of these machines, and hence also of their operation, is still a long way off. Another complicating factor is introduced by the fact that some cabins of mobile cranes must be suitable for both driving and crane operation. Finally, the requirement that both loads at considerable heights and loads at ground level must be able to be handled, brings with it, that great demands are posed in respect of the positioning of the operator in the cabin, in order to enable him to always watch the load, without engaging in acrobatics.

It has been noted that existing cabins in many respects do not meet the requirements of a justifiable place of work. This booklet is intended to make recommendations, which designers may be able to employ for the benefit of all concerned.

The common denominator "mobile cranes" comprises a large number of different types of machines, all of

1. Ergonomic aspects of tower crane cabins A publication by BGBouw/Netherlands Institute for Preventive Health Care-TNO Amsterdam 1979

2. Pasmooij C.K. and M.P. van der Grinten. "Towards ergonomically correct cabins of mobile cranes in the building trade" (in Dutch) Netherlands Institute for Preventive Health Care - TNO, Leiden 1981.

which have in common that they are hoisting appliances, which are self-propelled. The standard NEN 2026 states: "A mobile hoisting crane, the movement of which is not confined to a fixed track". In this booklet the complete range of mobile cranes is subdivided in three main groups, as follows:

1. **Truck-mounted cranes with telescopic jib**
   This group consists of cranes which are capable of independent movement over great distances on public roads, from one job to another. This type of crane is on the road a good proportion of total time, and is seldom located permanently at one building site. These cranes are suitable for this type of work on account of the good driving characteristics and the speed at which the crane can be put into operation. This type of crane has two cabins: a driving and a hoisting cabin.

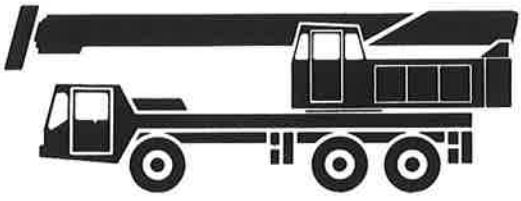


*Fig. 1: Truck-mounted crane with telescopic jib.*

2. **Crawler-mounted cranes with detachable jib**
   This type of crane is mounted on a crawler chassis or on a wheeled chassis. It is not suitable for covering long distances. This means that it is usually found at sites where the presence of a crane is required virtually permanently. This type of crane has a combined driving and hoisting cabin.

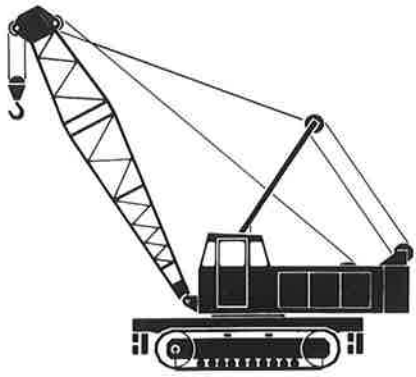


*Fig. 2: Crawler-mounted crane with detachable jib.*

3. **Rough-terrain cranes with telescopic jib.**
   These cranes are mounted on a four-wheeled chassis and can propel themselves across rough ground. Under certain circumstances these cranes may be driving on public roads. This type of crane has a combined driving and hoisting cabin.

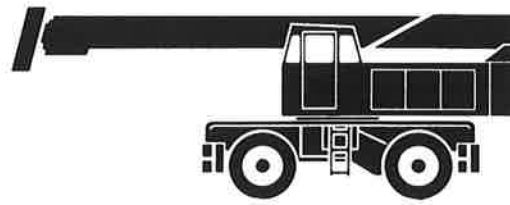


*Fig. 3: Rough-terrain crane with telescopic jib.*

In this booklet recommendations are made regarding the ergonomically correct layout of hoisting cabins of truck-mounted cranes, and of the combined driving/hoisting cabins of crawler or wheeled cranes and of those of rough-terrain cranes. Where necessary, this distinction between the three main groups of mobile cranes is made in each chapter. The driving cabins of truck-mounted cranes are not discussed here. The contents of this booklet are limited to cranes of which the hoisting cabin, or the combined driving/hoisting cabin slews with the jib.

The further arrangement of this booklet is as follows:

chapters 2 u/i 11 further explore the recommendations given for ten different aspects of these cabins:

**Chapter 2:** Accessibility (hand- and footrests, platforms, opening of door, emergency exit possibilities).

„ **3:** Visibility (window area, reflections, windshield, wiper, angles of visibility).

„ **4:** Seating accomodation in the cabin (dimensions of seat, adjustability, material, vibration damping, position of seat in respect of controls).

„ **5:** Dimensions of cabin (operation, freedom of movement, personal comfort).

„ **6:** Operating controls in cabin (location, uniformity of operation, control forces, priorities).

„ **7:** Presentation of data (instruments, presenting information regarding crane operation, readability, location, completeness, priorities).

„ **8:** Communication (radio system, standardized hand signals).

„ **9:** Climate control/ventilation (temperature, humidity, sun shading, heating, insulation).

„ **10:** Noise and vibration (with open and closed door, damping by construction of seat and cabin).

„ **11:** Lighting (of cabin, of work area).

Taken together, these recommendations indicate what a mobile crane cabin should look like from the ergonomic point of view. It was attempted to formulate these recommendations in such a manner, that practically feasible constructions can be designed. These recommendations however are definitely not "the last word" in this area. Small changes and additions are conceivable. In practice these should come from constructors and from users. The authors of this booklet will be pleased to receive any suggestions.

# 2. Accessibility

At various positions of the superstructure, good accessibility of the slewing crane cabin must be assured in order to prevent accidents when entering and leaving the cabin, and also to permit the cranedriver to leave the cabin quickly and easily in case of necessity. It is advisable to design good horizontal routes on the chassis, with stairs or ladders at various locations (see fig. 4). The following recommendations are important:

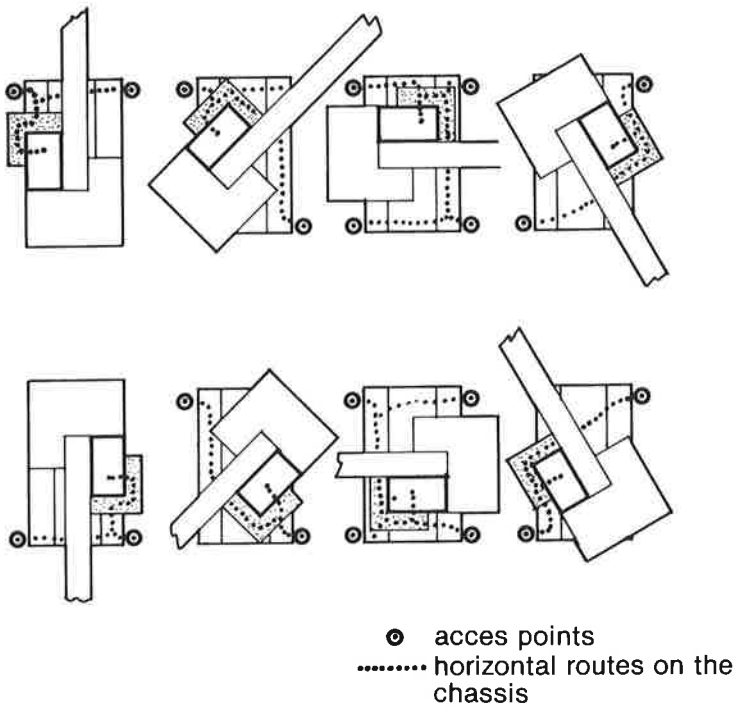
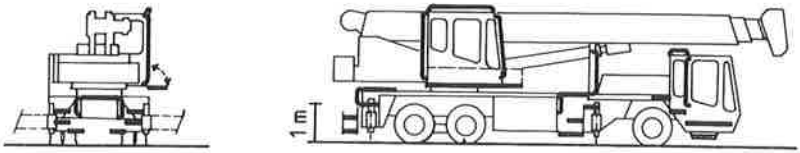
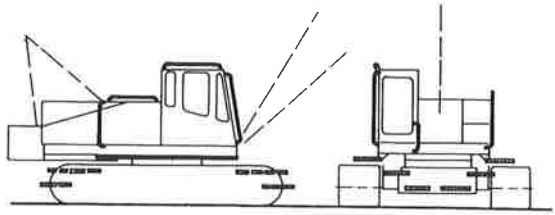


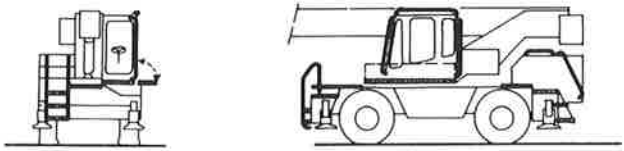

*Fig. 4: Access routes at various positions of the superstructure.*



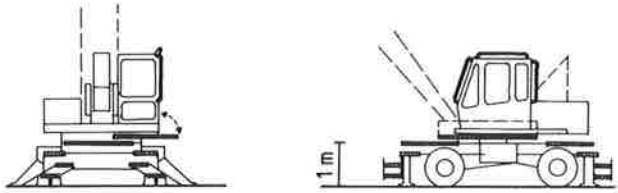
*Accessibility at truck-mounted crane with telescopic jib*



*Accessibility at crawler-mounted crane*



*Accessibility at rough-terrain crane with telescopic jib*



*Accessibility at rough-terrain crane with detachable jib*

*foot-board*

*grip or hand-rail*

*Fig. 5: Hand-rails and foot-boards on chassis and superstructure*

- To promote good accessibility at various positions of the superstructure, a co-slewing platform with a width of at least 300 mm must be fitted on the door side at the front of the cabin. This platform shall make it possible to stand up when leaving the operator's seat, and to turn around when going to the exit ladders.
  The platform on the door side must be detachable when necessary during transport of the crane. From a safety point of view the construction should be such, that the cabin door cannot be opened, until the platform has been lowered or slid out.
  As many vertical access points as possible must be provided on the chassis, to enable personnel to enter or leave the crane cabin in all positions of the superstructure - preferably at no less than four locations of the underworks (see fig. 5). In connection with quick, comfortable and safe entering and leaving of the crane, stairs at as small an angle as possible are to be prefered to ladders.

- If it is necessary to have movable entries - preferably not as a loose component - it should be possible to move these simply and quickly. Good locking and resistance against wear and tear are also required.

- Footrests - where possible - should be of the self-cleaning type, as mud and clay, and sometimes also oils and grease, will attach to shoes.
  The lowest rung of the vertical entry should be as low as possible. If the height of this rung above the ground is greater than 400 mm, handholds should be fitted at convenient locations.

- On the chassis, or on the enclosed wheel arches, good horizontal walkways should be projected, that are sufficiently wide (600 mm) for free and safe passage without having to use railings.
  Where possible the walkways should have self-cleaning grids to be mounted slightly above the cladding of the chassis and the wheel boxes, in order to enhance the self-cleaning effect.

**Doors**

- The shape of the cabin door opening should be such, that free passage is possible without the risk of injury from protruding corners. The width of the door opening should be 600-800 mm.

- Entry doors must never be blocked - in any position of the superstructure - by objects on the chassis, and these doors should move freely, even after years of use.
- Doorhandles of sliding doors should have a vertical handhold, and it should be possible to operate these while standing on the platform.
- An open door, in the wide open position, should have a smoothly working automatic locking system, which can be unlocked from a seated position.
- On the inside of hinged doors a handle should be fitted at the hinged side, enabling the operator to close a door that is open 180°.
- The doorhandle, and the handhold, if any, on the inside of the door, shall be placed in such a manner that they do not offer a risk of injury, and that hands cannot be injured by the closing and locking mechanism.
- In the event that a cabin is so high, that the door can only be opened while standing on a rung of a ladder, hinged doors should be avoided.
- In cabins with a low seat, a handhold in the roof or on the wall is necessary in order to pull oneself up.
- For details of the design of stairs, ladders and railings, reference is made to draft - NEN 2027.
- The front window or the roof window should be designed as emergency exit: dimensions laterally at least 560 mm, longitudinally at least 310 mm.

# 3. Visibility

**Crane operation**
Visibility by the cranedriver from the cabin during crane operation plays an important part in the design of cabin and seat. In addition to a good view of the load handler, the load, the hook and the top of the jib, a good view to the sides is also of importance. While slewing, one should be able to see persons in the vicinity of the crane. Where possible, the operator should be able to see the attachments of the most heavily loaded struts.

**Locomotion**
When the crane is driven from the cabin (crawler- and wheeled cranes, rough-terrain cranes), it is important that obstacles on the site and routes, which are in front of, next to, or behind the chassis, can be watched closely. In this context the different tracks caused by front-wheel or rear-wheel steering, should be taken into account.
When being driven on public thoroughfares, the design of the cabin in terms of visibility should adhere to the demands of Road Traffic Ordinances. This may result in the addition of a second cabin (driving cabin).
The following recommendations and remarks should be noted:

- Cranedrivers should have a comfortable and unrestricted view (primary field of vision) of the site from their seat in the cabin. The primary field of vision covers a pyramid-shaped area forward. The top of the pyramid coincides with the reference point of the operator's eyes.* The pyramid is flanked by planes, the position of which are shown in fig. 6 and 7.

* The point between the two eyes. The location of the reference point in the cabin depends on the height of the cranedriver (and on his seated position).

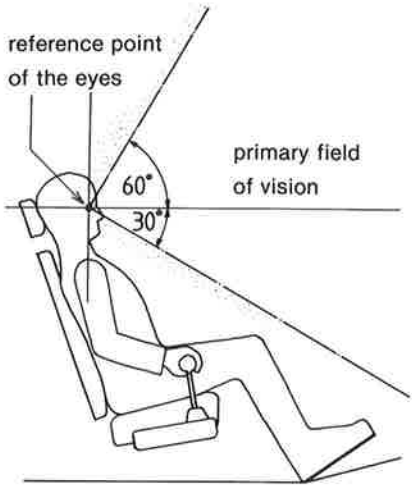



*Fig. 6: Primary field of vision in a vertical plane.*

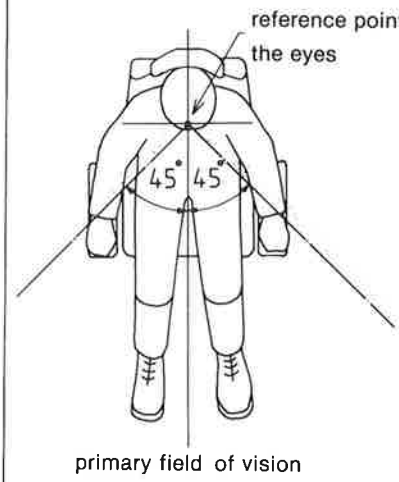



*Fig. 7: Primary field of vision in the horizontal plane.*

It does not appear possible to cover this whole field with single point eye- and/or head positions, which may cause tiredness in the long run. Hence a different position of the torso is also considered necessary when hoisting at greater heights (see chapter 4, seating accomodation).

- In the primary field of vision as few components of the cabin and of panels as possible, should obstruct the view. Possible solutions in this respect are: a roof window that continues far back, limiting the number and thickness of girders and cabin frames in the direction of vision, and restriction of the dimensions of consoles directly in front of the cranedriver.
- The cranedriver should, in addition to the primary field of vision, be able to see from his seat several points in connection with safety while driving, jacking or slewing. These points are the extreme corners of the superstructure and the chassis and the places where the jacks rest on the ground. Here the various positions of the superstructure play a part.
- The field of vision to the sides and to the rear from the cabin with raised jib, must be obstructed as little as possible by components of the superstructure and of the cabin. Measures that improve visibility are:
  - — the hinge point of the jib in relation to the cabin should be as far to the rear as possible.
  - — the engine housing should be as low as possible and in any case lower than the cranedriver's shoulder.
  - — glass areas to the sides and the rear should be as large as possible.
- Blind angles should be avoided by the placing of mirrors.
- Mirrors must be free from vibration and adjustable and they should be able to resist operating conditions in the building trade (e.g. hinged and fitted with a return spring).
  All adjusting devices of mirrors that cannot be adjusted from the operator's seat, should have a position indicator fitted, so that they can be returned to the correct position without assistance, when the setting has been disturbed.
- The roof window and the front window (upper part) should have mechanically driven windshield wipers,

which wipe the greatest possible area of these windows (parallel operation), covering in any event the areas within the primary field of vision.

- Transparent sun visors should be fitted in such a manner, that these can be lowered in front of both the front window (above the horizon) and the roof window.
  These visors may not be mounted against parts of the window that open, and they must be non-reflective, in order to prevent parts of the cabin or the panels being mirrored.
  It is also preferred to have the cabin interior covered in matt- and dark-coloured materials.
- At least the front window and the roof window must be blown by warm air for demisting purposes.
- It must not be possible for water to gather on roof windows.
- The windows must be made of scratchproof security glass.
  The roof window glass must be extra strong, making a protective grid superfluous (see draft standard-NEN 2027).

# 4. Seating accomodation in cabins

Both in order to avoid unnecessary tiring, and to improve control accuracy, it is important that the seating accommodation of the cabin is designed in such a way, that the cranedriver can look up comfortably during long periods. At the same time comfortable operation of the crane, both with hands and feet, should be guaranteed. This can be realized by tilting cabins, or by being able to change the seated position. The seating of the cabin must be able to accomodate both tall and short cranedrivers. Cabins are frequently limited in width and height as the crane dimensions are subjected to certain maximum dimensions by traffic regulations. The degrees of freedom in the longitudinal direction of the cabin are greater. The recommendations are limited to the possibility of being able to alter the seating position.

It is recommended to select a lower seating arrangement than is usual for many types of cranes, earthmoving machines and trucks. These recommendations are closely related to those of chapter 3 "Visibility".

The following comments should be noted particularly:

- Two reference points are important. There is a seat reference point SP, which can be defined as the intersection of two lines through the middle of the seat, where back and thighs touch respectively the backrest and the seat bottom. The back of the heel, resting on the pedal or on the floor, is called the heel reference point HP (see fig. 8).

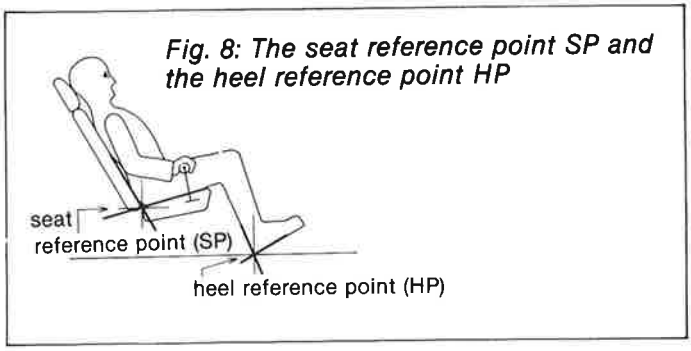



*Fig. 8: The seat reference point SP and the heel reference point HP*

- The seating accommodation should be designed in such a manner, that it is suitable for operators having a small build (5th percentile) and those having a large build (95th percentile); these dimensions to agree with those of standard ISO-3411 (see fig. 9 and fig. 10).

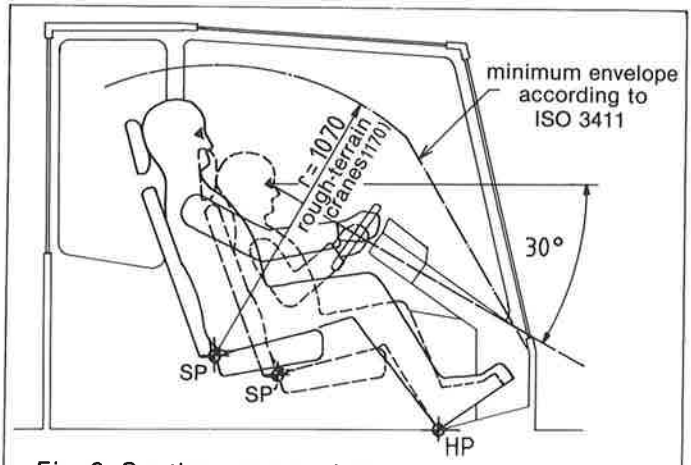



*Fig. 9: Seating accomodation while driving for tall and small cranedrivers.*

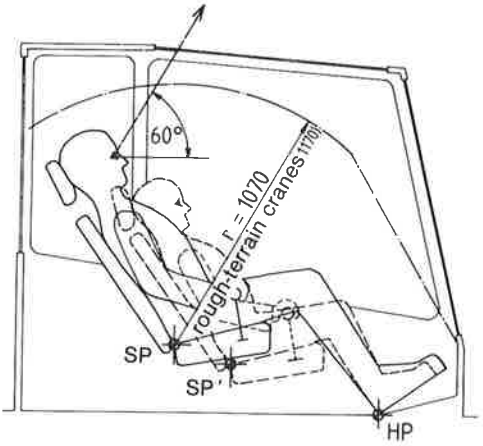



*Fig. 10: Seating accomodation while hoisting for tall and small cranedrivers.*

- In order to effect visibility at a 60° angle upwards comfortably, it is necessary to design the seat bottom inclining backwards at an angle of 15° (see fig. 11). The angle between the backrest and the seat bottom must be adjustable from 95° to 110°.

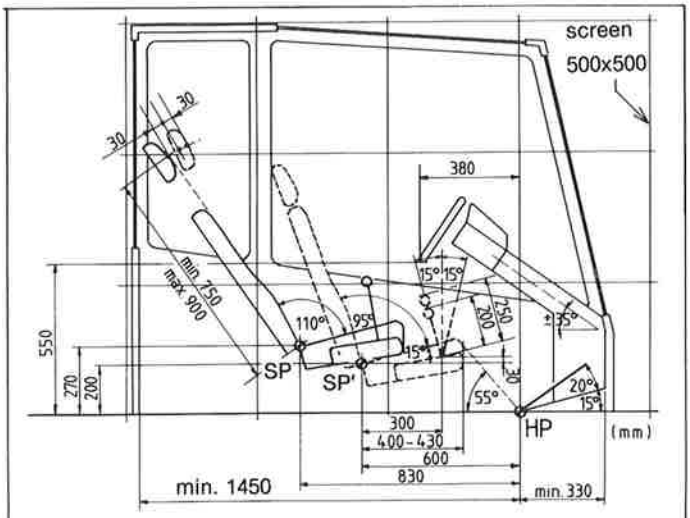



*fig. 11: The dimensions of the seating accomodation; side view.*

- The adjusting lever of the backrest should be within hand's reach on the side of the door of the cabin. Operation should be quick, and should not require great force. The backrest must be able to be locked in all positions and it must return to the vertical position, when the torso is moved forward during adjustment.
- On account of the limitations imposed by the height of the cabin and the required damping or spring devices and the adjusting provisions of the seat, this should not be designed either too high, or too low. As a basis, an angle of 55° between lower leg and the horizontal is recommended. A height adjustment, measured from the seat reference point SP to the horizontal, through the heel reference point HP, of 200-270 mm, and a length adjustment measured from the heel reference point HP to the seat reference point SP of 600-830 mm, is preferred.

- If the operator's seat is sprung or damped against vertical shocks and vibration, the height measurements of the upper sprung position of the seat must be applied, in order to prevent the foot leaving the pedal. The vertical stroke of the springing should not exceed 70 mm.
- On the backrest a headrest - adjustable in height and angle - should be present. The distance between the point of contact of the head with the headrest and the seat reference point SP must be adjustable between 750 and 900 mm. The headrest must be adjustable forwards and backwards in such a way, that the head position can vary and rest against the headrest 30 mm forward in respect of the torso, and 30 mm backwards. The headrest should allow for a slight sideways movement of the head (approx. 50 mm).
- The depth of the seat must be between 400 and 430 mm, the width between 430 and 480 mm (see fig. 12). The height of the backrest must be between 650 and 700 mm, to provide good support in the tilt-back position. The width of the backrest shall be between 400 and 420 mm.

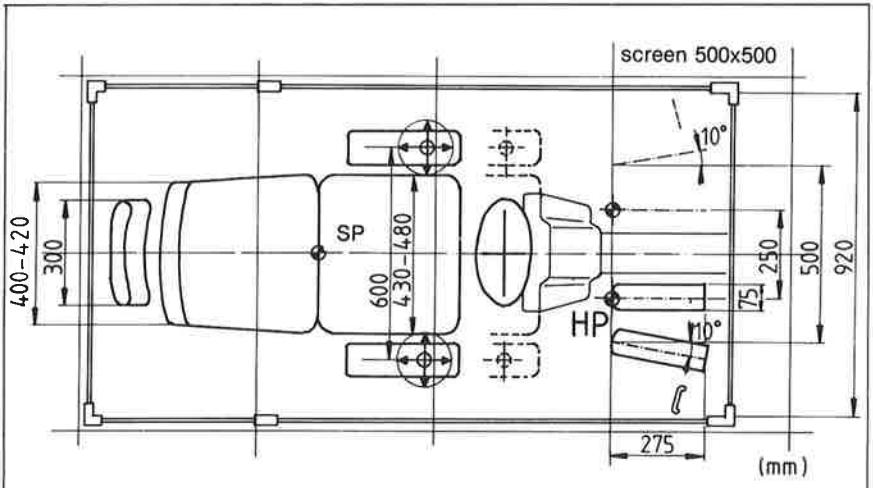



*Fig. 12: Dimensions of the seating accommodation; view from above.*

- The seat must have a well-designed seat bottom, incorporating a vibration-free, fairly firm cushion, with heat-insulating, wear-resistant and ventilating covering. The backrest and the seat cushion must be shaped anatomically, and they must provide adequate support of the lower back.
- In the event that the mobile crane is driven from the cabin, the seat should offer adequate lateral support against heavy swaying or shocks while driving. In addition good springing and shock absorbing of the seat must be provided, which can be adjusted to suit the weight of the cranedriver (500-1100 N). Furthermore a safety belt, attached the the upper structure of the seat, is recommended.
- All adjustments of the seat must be able to be effected comfortably, without the aid of tools, and while being seated.
- Operating controls for hoisting operations must be fitted on the structure of the seat, so that these can be adjusted together with the seat. The control on the side of the door must be able to be hinged out of the way, to provide easy access.

# 5. Dimensions of cabin

The basic dimensions for the free space which the cranedriver must have in the cabin, are based on the standard ISO 3411-1975 (E). This refers to the required free space for operators of earthmoving equipment.

- The free width of the interior of the cabin shall be at least 920 mm in the plane where both hands operate the cross-control levers. This also applies to the plane of the elbows, when the hands are on the steering wheel.
- The height shall be such, that a tall cranedriver wearing a helmet, still has free space above his head in the highest seat position. The height shall be a minimum of 1070 mm above the seat reference point SP. For rough-terrain cranes this shall be 1170 mm in the extreme sprung position of the seat (see fig. 9 and 10).
- The front of the cabin wall shall be sufficiently far away, to permit a tall cranedriver to stretch his legs. The distance from the front of the cabin, at the height of point HP, shall be a minimum of 330 mm at this point. The distance from the rear wall to the seat reference point SP shall be a minimum of 550 mm, allowing the seat in its rearmost position to be tilted back, when the backrest and the headrest are adjusted rearwards as far as possible (see fig. 11).
- It is preferable to have some storage space for the cranedriver behind the seat, for tools, fire extinguisher, first-aid kit, and for the hanging of clothing.
- There shall also be a lockable storage cabinet for documents, instruction manuals, the crane manual, personal effects etc.
- Next to, or between the pedals anti-slip surfaces shall be fitted, inclining upwards and forwards from the cabin floor, at an angle of 15° with the horizontal, so as to provide the feet with a comfortable rest.
- The finish of the cabin shall be such, that an operator will not bump into steering wheel, panels, handrests etc. Pointed protruding components, such as door locks and bolts, shall also be avoided.

# 6. Operating controls in the cabin

In addition to the requirements for control equipment, as formulated in draft-NEN 2027 in connection with safety, the following recommendations are important:

## 6.1 Operating controls in crane cabins while driving

These guidelines only apply to crawler cranes, rough-terrain cranes and other cranes on wheels, in which the operating controls for driving are located in the crane cabin.
The operation of these controls should be seen in conjunction with those for jacking and hoisting.
The following remarks and conclusions should be noted:

- The steering column should be angled 35° to 40° from the horizontal, towards the driver. The knees of the "tallest cranedriver", in the straight position of the seat, should be able to pass easily under the steering column, in connection with accessibility of the seat.
- The diameter of the steering wheel should not be greater than 350 mm and not smaller than 300 mm.
- The selector lever of the steering column mounted gearchange must be fitted on the right-hand side of the steering column, within easy reach of the right hand. The neutral position must be horizontal.
- When the superstructure is at an angle of 90° to the chassis, an indicator must show that the operation of the selector lever has changed in relation to the direction of movement, or the control system should reverse automatically. The controls of the steering system should also reverse in this slewed position.
- The throttle pedal and the brake pedal should be located to the right of the steering column.
- It must be possible for the throttle pedal to be operated only by a foot movement, whereby the heel is supported by a raised edge on the throttle pedal, lightly and within comfortable movement of the ankle joint. The angle between the instep and the shinbone may not become less than 90°, and not greater than 110°.

- The clutch should be of the automatic type; the force needed to operate the pedals should be a minimum of 30 N, and a maximum of 50 N.
- The control for the crawler tracks may be a simple short lever with cross-control, in which the directions of movement correspond with the movement of the chassis (see fig. 13). The lever can be fitted on a small console on a slender column, for which the same conditions apply as for the steering column (for cross-control levers see paragraph 6.3).

## 6.2 Operating controls for positioning the crane

- In cranes where jacking takes place from the turning cabin, a number or a colour code must be placed at the control, that corresponds with a number or colour code on the leg of stabilizing jack concerned. This must be visible from the cabin, in connection with the changing of the relative position of the operating controls on the one hand, and the jack movement on the other hand, when the superstructure is turned.
- Operating controls for jacking and for locking of the axles should be housed in a logical manner in a panel, together with any corresponding signal lamps and symbols.
  The panel should be within hand's reach. A good location is the co-moving panel no. 4, on the right-hand side of the cranedriver's seat (see fig. 14 and 15, chapter 7).
- A level gauge should be fitted in each cabin, which can be read in a horizontal line (see chapter 7).

# 6.3 Operating controls for crane operation

The four major movements of cranes with a telescopic jib must be achieved with two cross-control levers, according to the following patterns:

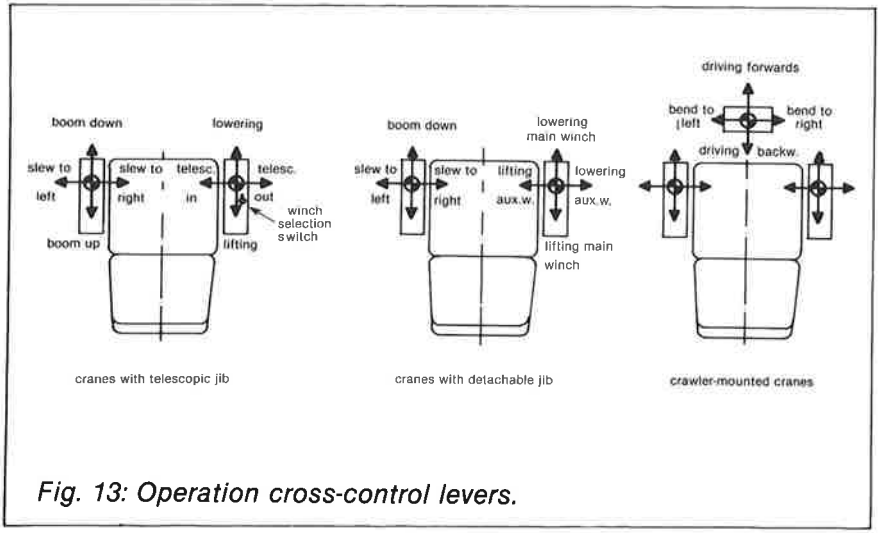



*Fig. 13: Operation cross-control levers.*

**A. the right hand:**

1. fore - aft = lowering - lifting
2. left - right = telescope in - out

**B. the left hand:**

3. fore - aft = jib down - up
4. left - right = slewing left - right

If in exceptional cases a second auxiliary winch is required, this must be operated by means of cross-control levers by the right hand, whereby the main- or the auxiliary winch can be selected with a selector switch. If this is not possible, the second auxiliary winch must be operated by a pedal for the left foot.

- For lattice-work jib cranes telescoping does not apply (function A2) but for cranes with a second winch A2 would be able to take over this function as follows (see fig. 13):

**A. the right hand:**

| | |
|---|---|
| 1. fore - aft | = lowering - lifting |
| 2. left - right | = lifting - lowering auxiliary winch |

- The cross-control levers must be mounted on either side of the seat in panels that are attached to the adjustable upper part of the operator's seat (no. 4, 5 fig. 14, 15).
- The hinge point of the levers should have a horizontal distance from point SP of 300 mm, and a vertical distance of 30 mm (see fig. 11).
- The length of the levers must be adjustable between 200 and 250 mm (see fig. 11).
- The left and the right-hand levers should be at the same distance from the centre of the seat; the distance between both levers must be 600 mm.
- The levers should consist of a rod, topped by a ball with a diameter of 40 to 50 mm.
- The maximum stroke of the levers should be approximately 75 mm in both directions, and the neutral (zero) position should be in between. When released, the levers should automatically return to the neutral position.
- The lever control design must be such, that a compounded movement can be achieved (e.g. 100% hoisting velocity, combined with 50% slewing velocity). It is advisable to adjust the engine rpm automatically to the required power of one or more hydraulic systems, so that throttle operation during crane operation becomes superfluous.
- The force to operate the levers should be a miminum of 5 N (artificial feel) and a maximum of 20 N.
- The construction of the levers must be such, that a hand resting on one, does not cause activation, both in the case of the seat being straight or tilted back. Unintentional touching of a lever should not result in crane movement.

- The lever on the side of the door must be arranged so as to be able to be folded down, in connection with accessibility. Crane movement must be switched off automatically when the lever is folded down.
- On the slewing lever a switch should be fitted for a separate hoisting horn.
  In cases where a foot-operated slewing brake is required, this shall be placed immediately to the left of the steering column.
- The pedals should operate in such a manner, as to only be activated by a foot movement. Attention should be paid to a comfortable angle between the lower leg and the instep. The force required to operate the pedal should be a minimum of 30 N, and a maximum of 50 N.
- Next to, or between the pedals, there should be adequate room to allow the feet to rest comfortably.
- The remaining levers, such as those for the hand brake, superstructure locking, and the adjusting lever of the seat backrest, must be fitted on the door-side of the seat, in such a manner, however that one cannot trip over them when entering or leaving the cabin.
- The function of all controls should be indicated in the language of the country where the crane will be used and/or by clearly recognizable symbols.

# 7. Presentation of data

In addition to the presentation of data, the control facilities that have been incorporated in the instrument panels and the safety features on the operation controls in the crane cabin, should also be detailed. Further to the directives that have been laid down in connection with safety (draft-NEN 2027 and draft-NEN 2028), several other recommendations are worthly of consideration. The basic principle therein is the complex situation, viz. a crane cabin from where all operations, such as driving, hoisting and monitoring of the condition of the engine, propulsion and energy generating systems, can be operated or checked. If the controls for jacking etc. have been fitted elsewhere on the underworks, such as an instruction panel - or part thereof - is omitted from the cabin.
In crane cabins functional space must also be reserved for non-standard equipment (accessories).

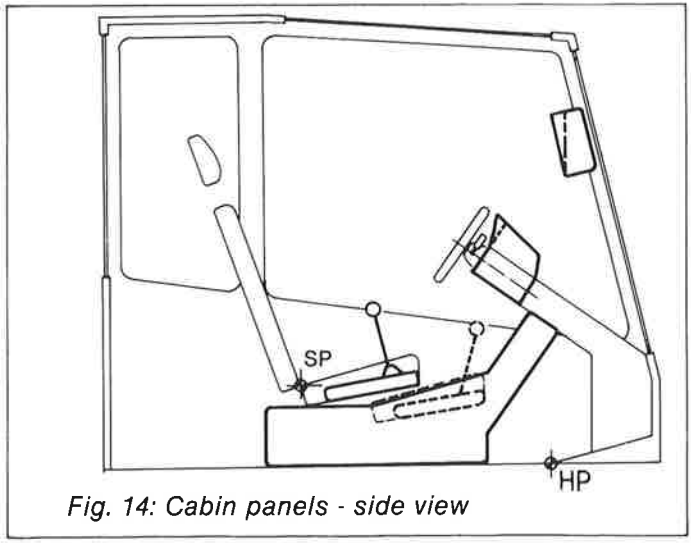



*Fig. 14: Cabin panels - side view*

**Driving**

- A small console should be fitted to the column of the steering wheel, or of the crawler track lever (e.g. immediately behind the steering wheel), on which all instruments, switches and levers for driving - also over rough terrain - are located (see fig 14, 15, panel no. 1).

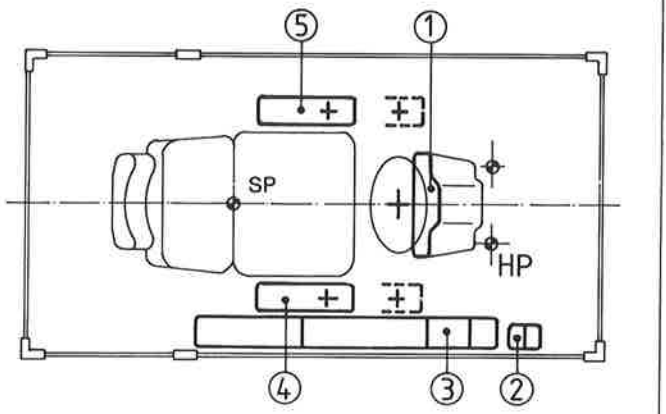



*Fig. 15: Cabin panels - view from above*

This panel should interfere as little as possible with the primary field of vision. Underneath the steering column there should be adequate space for knees during operation.

- The instruments, such as rpm counter, speedometer and indicator lamps, should be at right angles to the line of vision, and these should remain visible when the hands are on the steering wheel. The panel finish should be matt black and it should be recessed slightly, in order to avoid reflections on the panel and in the window panes. Switches etc. may be placed outside the direct field of vision (e.g. above or below the instrument panel), provided the corresponding symbols remain visible, and these switches can be located by touch and are accessible from a seated position (straight backrest).
- On the right-hand side of the console the operating controls and instruments must be located for the operation of the engine and the transmission (such as starter, lever for forward- and reverse gears, low- and highspeed slewing switches etc.). On the left-hand side the heading or the heading indication, road illumination and signals for road users (such as switches for "doglegging", "counter steering" or normal turning circle, and a lever with three functions: turning indications, road lighting and horn).

- In the centre a panel can be placed, on which the engine rpm and/or the road speed are shown, and on which also the principal non-audio alarm indications of the engine, the transmission and the battery have been included. Sofar as instrument indications are also desirable for these functions, these can be fitted outside the primary field of vision (e.g. to the side of the seat in panel no 3), provided visual alarms are located in the field of vision.

**Jacking and hoisting**

- One should distinguish between "type 1 data", which should be observed continuously, while in the primary field of vision the hook and the load are being watched (information of an indicative value), and "type 2 data", which is used to read certain values, or for operation on instruments (data of a absolute significance).
- "Type 1 data" is understood to mean information regarding the remaining lift capacity of the crane and the velocity at which this changes, the speed of the hoist winch and a representation of the horizontal position of the crane (level gauge, or a signal derived therefrom). "Type 2 information" comprises quantitative data regarding jib angle, jib length (outreach) and load.
- "Type 1 information" must be presented in a slender console along the front window frame on the side of the jib (panel 2, fig. 14, 15), at about eye level and at right angles to the horizontal line of vision, so that this information remains visible in the primary field of vision in the straight and tilted position of the seat (for further requirements refer to panel driving data).
- "Type 2 information" must be presented and combined in a panel obliquely in front of the cranedriver (panel 3, fig. 14, 15). This panel should be mounted as low as possible, on the jib side of the cabin, but it must be visible past, or above the hand on the control lever, and at right angles to the line of vision.
- Within hand's reach, on the panel circumference, switches for the operation of the safety system can be placed (programming pushbutton or cassette holder, test button, by-pass key etc.).
- In the case of deviation from the horizontal an optical yellow flashing signal must be given.

**The condition of engine, propulsion and energy supply systems.**

- Finally, next to the seat bottom, on the right-hand side, the remaining switches and instruments can be fitted in the rear portion of the console (panel 3, fig. 14, 15). These control heating, the ventilator, the hoist light, oil pressure and oil temperature gauges, and possibly a radio.
- For the layout of these instruments reference is made to ISO-6011.

**Other recommendations**

- All indicators, gauges or switches must have obvious indications or symbols which indicate their function.
- The instruments must be illuminated and the luminance must be adjustable in such a manner, that symbols are legible both in the daytime and at night. They must be designed and located in such a way, that annoying reflections in the windows are avoided.
  Panels must be made of matt materials, also preventing reflections.
- Numerical data can best be presented by lighted numerals.
- For load moment protection and other limiting systems, reference is made to the relevant guidelines (see draft-NEN 2028: Automatic limiting devices).

# 8. Communication

Efficient communication between the cranedriver and persons on the ground is essential. With this in mind, the following comments are made:

- In those situations where the distance between the cranedriver and the load handler becomes too great, or where the load is beyond the field of vision, an efficient and interference-free radio communication system must be available in the cabin, allowing the operator to talk to one or more persons on the building site.
- The system in the cabin may consist of a microphone which can be used from any seated position, and a loudspeaker in an upper corner behind the cranedriver.
- Another possibility is the application of a headset, which could fulfil a double function. On the one hand this reduces noise for the cranedriver (see chapter 10), and on the other hand the communication equipment can be built into the headset.
- The microphone should have an automatic on/off arrangement.
- Standardized hand signals (see NEN-2025) should be considered a necessary supplement to the communication system described above (see fig. 16). Both the cranedriver and the load handler should be fully conversant with these hand signals.
- It is recommended to attach a plasticized chart showing the standardized hand and arm signals (available from the NNI, Netherlands Standardization Institute) permanently and visibly outside the cabin.
- Particularly in situations in which the crane for a long periods is held in one position, an acoustic attention signal for the cranedriver is advisable.

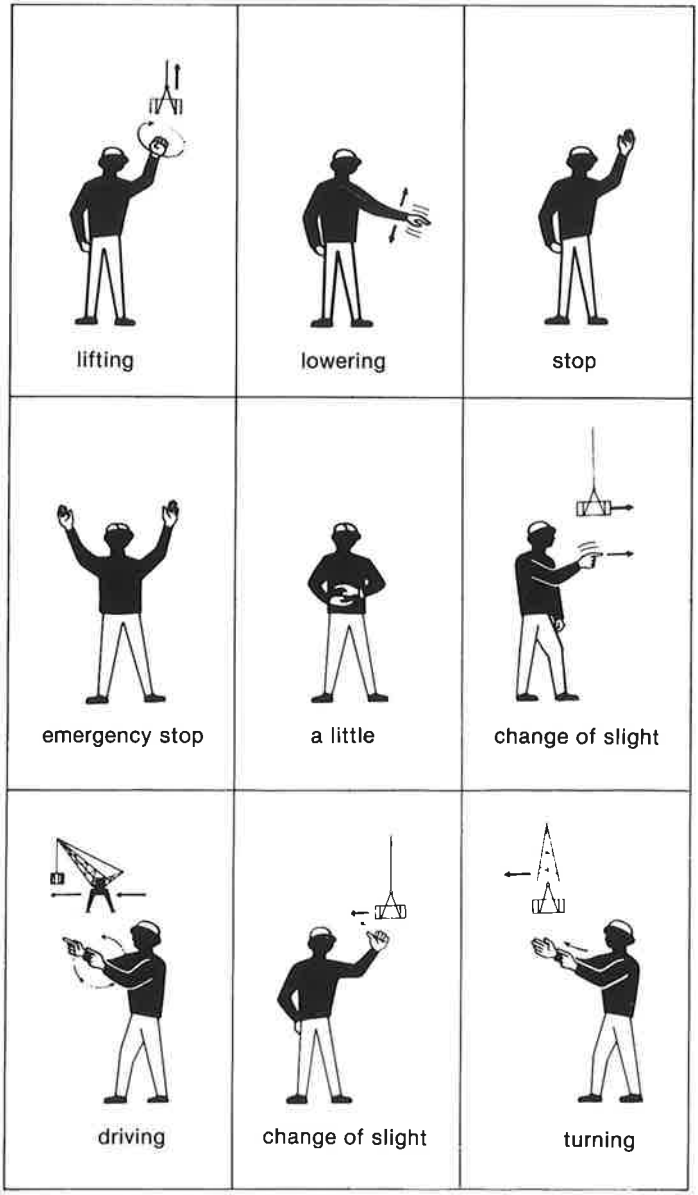



*Fig. 16: Examples of hand and arm signals according to NEN-2025 (The complete standard is available from NNI (Nederlands Normalisatie Instituut), Kalfjeslaan 2, 2623 AA Delft, The Netherlands).*

# 9. Climate and ventilation

Climatic and ventilation aspects in the cabin require necessary attention. As a result of the necessarily large window areas of the cabin, during the summer extreme heat can occur, and during winter great heat loss. Hence a climate control system for the cabin should be considered. The following conditions must be met.

- A fan heater should be fitted in the cabin in a fixed location. In the case of mild frost (to -5°C) an average temperature of 18°C should be achieved in the cabin. In such a case the difference between the air-temperature at the floor and at the roof should not be greater than 5°C.
- The fan heater should draw in cold outside air, and discharge warm air. Air velocities within the cabin should not exceed 0.25m/s. Combustion gas must not be permitted to enter the cabin.
- The heater should have adequate capacity to keep windows free of condensation, and in the case of frost, free of ice.
- Wall panels, roof and floor must be provided with heat insulating materials.
- Special attention should be paid to draught-free closures and to the possibility of keeping door, windows and hatches, if any, closed for longer periods. In the event that no airconditioning system is available, the cabin must have at least one opening window, in addition to the front window. It must be possible to lock this window in various positions, by means of a locking device.
- There must be a facility in the crane cabin to aim a cool flow air directly at the operator's head, at a controllable velocity.

# 10. Noise and vibration

**Noise**

- Over the years an operator may be subjected to noise for 8 hours per day or more. The safe equivalent noise level is Leq = 80 dB(A). This should be taken into account regarding noise levels in cabins during driving and hoisting.
- In terms of the communication by the cranedriver with others on the building site, the lowest possible noise levels should be achieved.
- In an attempt to achieve soundproofing, one should start at the source (low-noise engines, the greatest possible distance between engine and cabin, engine housing of soundproofing material). The engine housing should be constructed in such a way, that fitting and removal is not too difficult.
- Dominating "pure tones" should be avoided.

**Vibration**

- If there is a chance that engine vibrations penetrate the cabin, the latter should be mounted on good vibration dampers.
- In terms of driving comfort - in the case of cranes which are frequently driven on roads - good springing and shock-absorbing of both front and rear axles should be achieved, without affecting the stability of the crane. If this is not possible, a sprung driving cabin is recommended.

# 11. Lighting

- Effective lighting of the work site, of the jib and of the load is required.
- The cabin should have glare-free cabin lighting, with a luminance of approx. 100 lux. Reflecting surfaces in the cabin must be avoided.
- Instrument and control panels should be illuminated. The luminance level must be adjustable. The cabin should permanently have an emergency battery lamp of adequate capacity.
- The cabin should moreover have a socket for an inspection lamp (for repair activities etc.).

## Notes