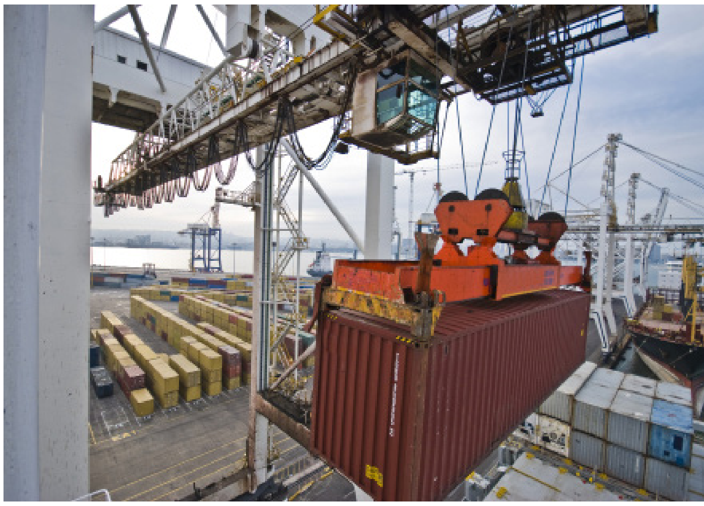
Crane Operator Health & Safety

A PEMA Information Paper



This information paper provides a brief overview of the challenges faced by ports and terminals attempting to improve the working conditions of crane operators in terms of crane cabin ergonomics.

PEMA
PORT EQUIPMENT MANUFACTURERS ASSOCIATION

www.pema.org

CONTENTS

This document is designated IP14 Crane Operator Health & Safety in the PEMA series of Information Papers.
PEMA would like to thank Bridea Cabins for kindly providing images.

First published March 2018

INTRODUCTION

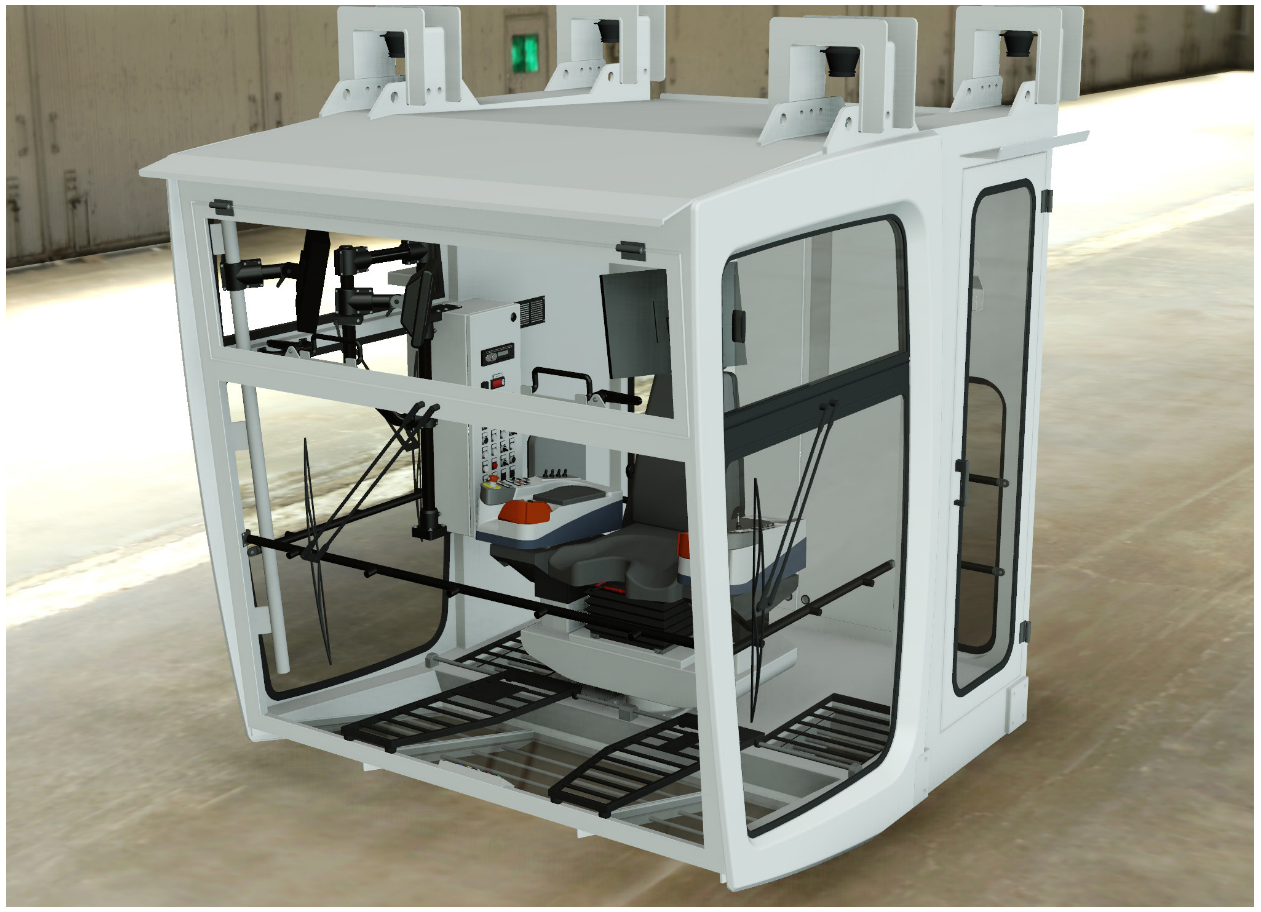


Fig. 1 Example of Gantry Cabin

DOCUMENT PURPOSE

This information paper provides a brief overview of the challenges faced by ports and terminals attempting to improve the working conditions of crane operators in terms of crane cabin ergonomics.

The paper describes how many of these concerns, despite considerable improvements in crane cabin design, remain unaddressed at container handling applications at ports and terminals.

The paper considers the benefits of introducing a common set of specifications with a view to mitigating the health risks associated with crane cabins.

ABOUT THIS DOCUMENT

This document has been produced by the Safety & Environment Committee of the Port Equipment Manufacturers Association (PEMA). It does not constitute professional advice, nor is it an exhaustive summary of the information available on the subject matter to which it refers.

Every effort has been made to ensure the accuracy of the information contained in this report. However, neither the authors of this paper, PEMA, nor any member company may be held responsible for any loss, damage, costs or expenses incurred, whether in negligence, arising from reliance on or interpretation of the contents of this paper.

Further Information Papers, Surveys and Recommendations from PEMA and partner organisations can be downloaded free of charge in PDF format at: www.pema.org/publications

1 | EXECUTIVE SUMMARY

The rise of containerisation has brought new challenges for ports and terminals concerned about the health of their operators. Despite a growing degree of focus on crane cabin and work station design, ergonomic issues such as awkward posture, and environmental factors including inadequate heating, ventilation, noise, and vibration, continue to impact crane operators' wellbeing. Beyond its personal cost, poor employee health also has detrimental effects on wider operational safety and productivity.

However, the global ports and terminals industry currently lacks a basic, comprehensive list of cabin characteristics that could be used to mitigate the health risks associated with crane cabins and work stations. The aim of this paper is to provide baseline specifications for work stations and crane cabins in relation to ergonomic and safety features.

To make such moves effective, this paper suggests that these recommendations should be included in design tenders requested by crane customers, and furthermore that they should also be included as standard features in suppliers' initial quotations, rather than being optional extras.

Although critics may raise concerns that such recommendations encroach upon the functioning of the crane cabin market, if all equipment suppliers were to adopt these features as standard, it is not anticipated that competitiveness would be affected, nor should it significantly affect cranes' base prices.

Furthermore, the likely improvement in safety would reduce staff injuries and equipment damage costs over the lifetime of equipment, and improve the reputation of the container terminal industry and equipment manufacturers in general through an increased focus on safety.

Fig. 2 Wrong postures adopted by crane operators

2 | BACKGROUND

For many years, crane cab and work station design focused almost entirely on mechanical structures and basic control layout, with little reference to their human operators.

As early as the 1970s, industry studies highlighted concerns over the impact of poor cab design on musculoskeletal disorder (MSD) and other conditions. A study by Wicks et al., published in 1975, suggested that tower crane operators would often leave their jobs before they reached the age of 50 due to ill health.

A study by Zondervan, (1989), showed that 64 per cent of the crane operators it surveyed were suffering from back complaints; and 42 per cent from neck complaints. Burdorf et al., (1993), found that 50 per cent of crane drivers were prone to back problems.

In 2001, Ariens concluded that there is some evidence to suggest a clear relationship between neck pain and resultant work-related risk factors: neck flexion, arm force, arm posture, duration of sitting, twisting or bending of the trunk, hand-arm vibration, and workplace design. A study published in 2002 showed that between 44 and 77 per cent of crane drivers surveyed suffered neck complaints, and between 67 and 86 per cent complained of lower back pain. Further, Eger et al. (2008) analysed video recordings of container crane operations, finding that operators spent significant amounts of time with their necks and trunks rotated or unnaturally bent.

An ergonomics study on grab unloaders by Courtney and Chan, (1999), demonstrated that to look downward through the central lower front window – a necessity for around half of a typical shift of the cranes surveyed – operators' main body parts were in awkward postures involving the neck, (81 per cent), the lower back (88 per cent), the mid-back (50 per cent), and shoulders (50 per cent). This resulted in static loading of the neck and back, with the trunk flexed 30 to 40 degrees' forwards and the neck fixed about 60 to 70 degrees' forwards from the vertical to ensure a proper view of directly below the cab.

A more recent research paper, based on European Standards EN 1005-3/4/5 and focused on biomechanical analysis by the EPM Research unit – Ergonomics of the body posture and movement and the Biomedical Technology Department of the University of Milan (2007-2008), in collaboration with PEMA member Brieda Cabins, used electrodes to accurately measure stressors on trunk, neck and limbs with the use of the electromyography.

These tests clearly showed that the awkward postures adopted by crane operators is the result of improper cabin design, and went further in demonstrating that a good ergonomic control station's configuration and control layout will alleviate poor posture and resulting injury.

International Standard ISO 11226, Ergonomics – Evaluation of Static Working Postures, establishes ergonomic recommendations for different work tasks. This standard provides information to those involved in the design and redesign, of work, jobs and products that incorporate basic concepts of ergonomics and working postures in particular. Recommendations contained in the standard related to trunk inclination and head posture, in combination with the studies mentioned above, appear to support the need for specific equipment for crane drivers. This report provides a brief overview of the ISO recommendations.

Design also has an overall impact on safety, as it can improve the poor visibility typically associated with crane cabins, mitigate the forces required to operate joysticks, buttons and levers and, by helping to reduce fatigue, also help operators to remain alert.

Finally, in addition to the cost of chronic conditions among the workforce caused by poor crane cabin design, the detrimental effect of employees' poor health on relationships between operators and port management should also be considered.

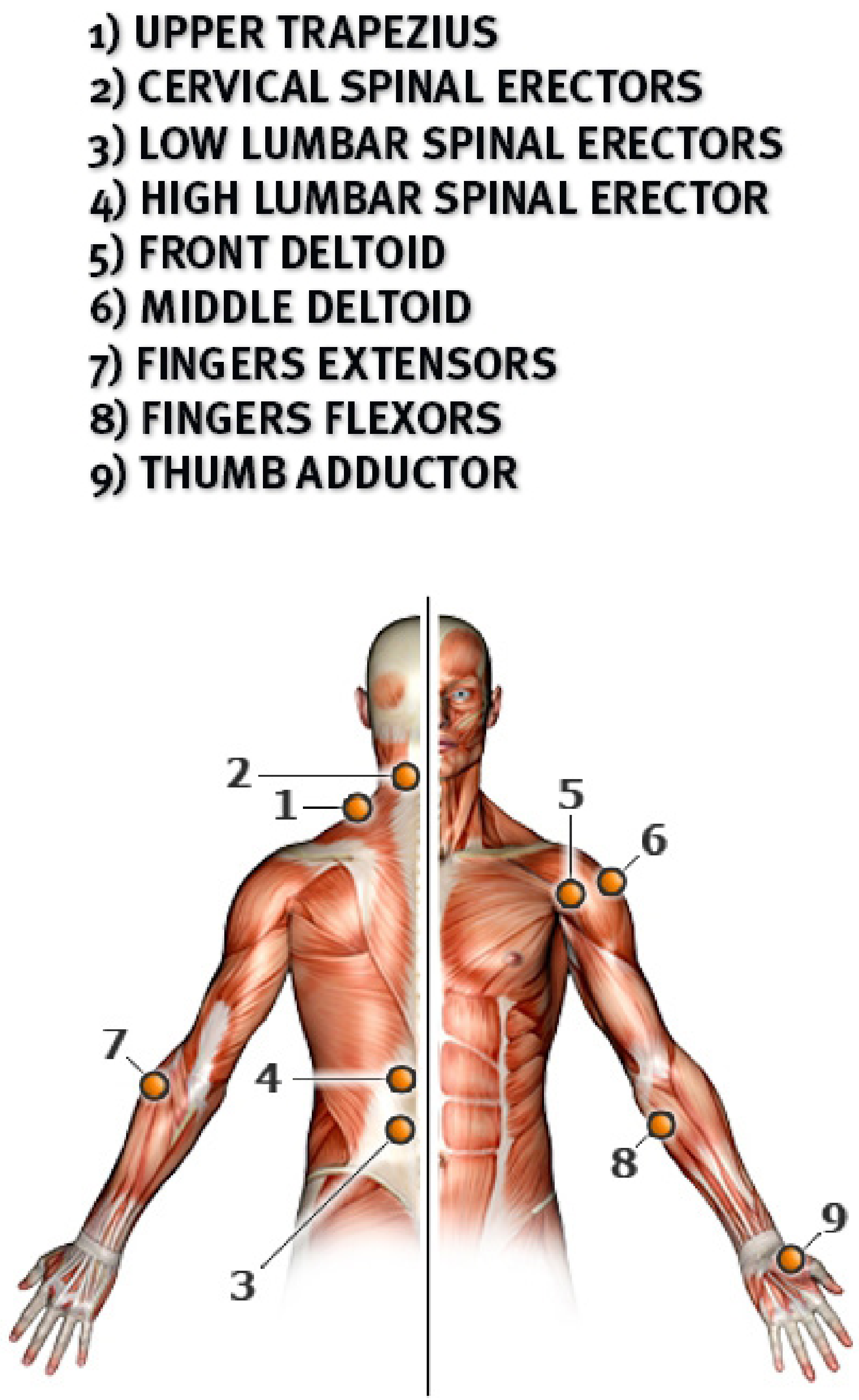


Fig. 3 Biomechanical Analysis based on Body-Electromyograph

3 | KEY CONSIDERATIONS

Several issues need to be considered when drawing up specifications for crane cabins and control stations. A more exhaustive list of possible specifications is included in this paper, (see below); such stipulations do, however, fall into several broad categories.

In container cranes – Ship-to-Shore (STS) and Rubber Tyred Gantry (RTG) cranes – drivers are required to look downwards almost continuously. In addition, each type of container crane has its own specific characteristics.

STS crane cabins significantly accelerate and decelerate when moving backwards and forwards. Passing the boom junctions creates low frequency shocks. Due to the heights and speeds typical of container cranes, drivers need to be constantly highly focused. Drivers' downwards viewing angle is relatively limited due to crane height.

RTG drivers have a different field of vision. Because the spreader is relatively close to the cabin, the viewing angle is wider. As a result, driver' legs often obscure their vision. Looking around while driving the machine, and looking sideways under beams while searching for trucks causes awkward posturing. Sideways movement, in combination with RTG rubber tyres, creates a swinging motion in the cab and the driver when starting and stopping.

There are also structural points to consider such as 40mm safety laminate fixed floor glass. The development of glass of this thickness resolves some of the issues where thinner, removable glass was used to assist cleaning, the latter being protected inside and out by metal safety grills which lead to poor visibility.

The need for shock and vibration absorbers on cabins and their control stations has emerged due in part to reports from operators that the increased speeds of modern cranes have resulted in greater vibration levels inside cabs. ISO 2631-1 Mechanical Vibration and Shock, which provides guidance on human exposure to whole body vibration, should be considered a benchmark in this area when drawing up specifications for crane cabs. Comfort is one element here, but there is also the issue of effective control of items such as touch screens. Similarly, correctly positioned handholds are necessary to help drivers climb in and out of crane cabs, as well as moving around inside the cabin.

Anecdotal evidence from drivers, and detailed research by the EPM Research unit – Ergonomics of the body posture and movement and the Biomedical Technology Department of the University of Milan (2007-2008), shows that seats and control stations need to be fully adjustable in all directions including tilt, with forearm rests to reduce pressure on the lumbar region.

Fig. 4 Example of Control Cabin Station

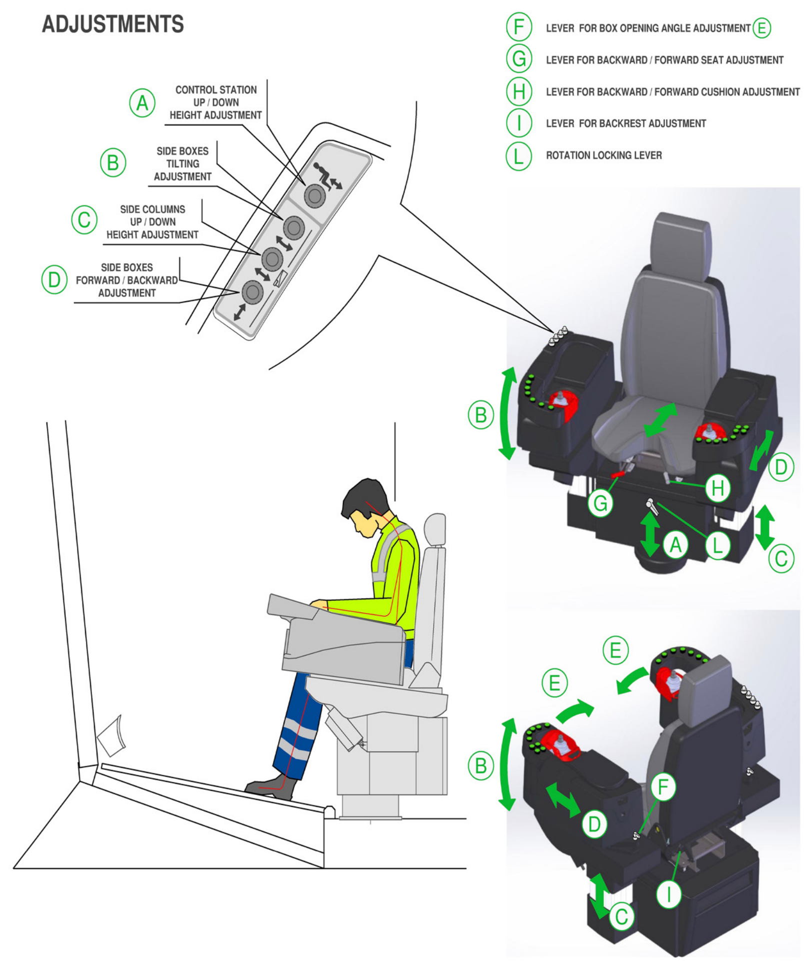
Seats and control stations also need to support the body through periods of biomechanical stress caused, for example, by trolley acceleration and deceleration, while hand supports allow for precise control during joystick operations.

Related to this is the need for good quality, self-retracting safety belts – cabins are prone to sudden jolts and stops that can, in some cases, unseat operators. However, freedom of movement needs to be maintained both for ease of use and to prevent drivers simply abandoning seat belts that are felt to be unnecessarily restrictive.

The positioning of displays and lighting inside crane cabins is critical to effective crane operation. Experience and evidence from other industries where crane use is prevalent, shows that monitors need to be between 45° and 50° from the driver's eye level to avoid strain. Further, key system indicators, including fault and overload lights, should be within drivers' forward and downward field of vision, rather than set into side panels where operators risk failing to be alerted to important system information. Touch screens and other control tools also need to be adjustable.

Other important issues that need to be considered in crane cab design include adequate air conditioning and heating, with sufficient warmth being directed across the glass floor to keep this free from moisture. Furthermore, crane cabins must be positively pressurised with clean air to keep out pollutants.

Fig. 5 Adjustments of ergonomical dynamic operator control station



4 | INDUSTRY RECOMMENDATIONS

The following is not intended to be a comprehensive source of cabin and control station safety items. Rather, it aims to provide terminals, operators and suppliers a solid minimum baseline of safety features that are practical and effective.

Based on experience, records and insurance claims analysis, the table includes systems, structures, features, equipment and technology that have been shown to reduce injury or damage that are currently not standard.

Table 1: Recommended list of cabin and driver control station minimum standard safety features

ITEM	RISK	SAFETY FEATURE	FUNCTIONAL REQUIREMENT
1	High frequency vibrations on cabin and crane driver and possible disturbing noise due to vibration.	ANTI-VIBRATION SYSTEM	Cabins should be fitted with 3D high frequency anti-vibration dampers and brackets to improve safety, control, and maintenance access. Anti-vibration mounts should be calculated according to weight, point of gravity of the cabin and platforms, and acceleration/deceleration of the trolley.
2	Maintenance and access to crane cabins.	MAINTENANCE PLATFORM AND PLATFORMS FITTED TO CABINS	Cranes should be fitted with a back platform for safe general maintenance of the cabin. Cabins should be fitted with lightweight platforms for maintenance, safe access, and the ability to rescue injured personnel.
3	High temperatures and condensation inside the cabin.		Cabins should be equipped with a split air conditioning unit to decrease noise levels inside cabins, improve comfort, maintain an inside temperature of 21°C and take fresh air supply of 50m^3/h into account. Noise levels should not exceed 68 dB(A). The capacity of the air conditioning unit should be calculated on environmental temperatures, insulation of the cabin and internal heat sources. Condensation water to be drained to the outside of the cabin to prevent sight obstruction due to condensation on windows.
4	Airflow from air conditioner apparatus.	AIR CONDITIONING APPARATUS	Main airflow not directed onto the crane driver. Direction of secondary airflow to be adjustable to improve driver comfort.
5	Low temperatures inside the cabin.	HEATED AIR FLOW ON THE MAIN FLOOR GLASS	Cabins must be equipped with heating units installed in the floor bottom, complete with thermostat with the main airflow on the main floor glass. Direction of secondary airflow to be adjustable to improve the comfort perception of the driver. Airflow strength should be appropriate to local ambient conditions; 21°C is frequently cited as a desired cabin temperature. The capacity of the heating unit should be calculated according to local ambient temperatures and insulation of the cabin. Maximum noise levels should not exceed 68 dB(A).
6	Harmful emissions and pollutants.	POSITIVE PRESSURE AND AIR FILTRATION UNIT	Cabins should be fitted with a proven, positive pressurized air filtration system, with high efficiency particulate and gas absorbers or similar to protect drivers from harmful emissions from ships or other pollutants.

ITEM	RISK	SAFETY FEATURE	FUNCTIONAL REQUIREMENT
7	Structural strength of glass floors.	LAMINATED, CERTIFIED FLOOR GLASS	Floor glass should be fixed, walk-on safety laminated glass, at least 40mm thick, with sliding and lockable footrest grids for optimal visibility of the working area below.Floor windows should resist a concentrated load of 2,500N/ft2, and a divided load of 1,500N/10ft2 simultaneously.
8	Fall risk to drivers during operating phases due to cranes stopping suddenly.	FOUR-POINT SAFETY BELTS	It is advisable to have safety belts for the shoulder and waist, so the driver is held safely during operations, and blocked in the event of the trolley suddenly stopping.
9	Bending and tilting of drivers.	SAFETY BELTS	Safety belts for the shoulder and waist with type-approved roller to allow the free movement of the driver.
10	Failure to monitor and control visual indicators.	FRONTAL POSITIONING OF VISUAL INDICATORS	It is advisable to install all mission-critical indicators in the lower front frame of the horizontal position, in boxes of suitable size, to avoid obstructing visibility, thereby giving drivers all necessary information, (spreader lights, container weight, container height, hoist/trim position, twist lock locked/unlocked, crane faults, windspeed, sudden high winds, overload, anti-collision alarms etc.). These are located in the driver's main working direction, which is the look through the front and floor glass. This enables the safe control of loading/unloading operations.
11	Failure to monitor and control visual indicators.	ANGULAR POSITIONING OF VISUAL INDICATORS	Display screens should be positioned between 45° and 50° to drivers' eye level while seated, ensuring the safe control of information necessary during operations.
12	Difficulties related to the use and accessibility of auxiliary devices.	LATERAL POSITIONING OF AUXILIARY DEVICES	Auxiliary control panels and radio/transmitters should be designed according to cabin vibration; and should be placed on the right- or left-hand wall and should be within easy reach of the driver by hand when seated at the control station with a maximum rotation of the head of 90°. Main (turn on/off) switches and microphones should be positioned to allow drivers to maintain sight on driving the crane while using communication equipment.
13	Failure to use touch devices, noise and vibration.	INTERNAL NOISE DAMPERS, ISULATION AND ABSORPTION MEASURES	No equipment installed in cabins should produce noise due to vibration of the cabin. Cabin structure and windows should be isolated to avoid unwanted noise entering the cabin. Cabins should be provided with sufficient sound absorbent material to reduce reverberation.
14	Lumbar spine, neck flexion and general driver overload.		It is advisable to lean the forearms while using joysticks to minimise lumbar overload. Leaning forward responsibly makes it possible to reduce neck flexion when looking downwards.

ITEM	RISK	SAFETY FEATURE	FUNCTIONAL REQUIREMENT
15	Acceleration and inertial forces on drivers.	ERGONOMIC SUPPORT OF THE BODY AND LIMBS	Control station design should take into account biomechanical stress due to trolley acceleration and deceleration.
16	Incorrect control of joysticks during acceleration/ deceleration.	ERGONOMIC JOYSTICK SUPPORT	The hands have to be based on an ergonomic support during the activation of the joystick to have a better control of the movements
17	Incorrect control of joysticks during acceleration/ deceleration.	ERGONOMIC PLACEMENT OF CONTROL BUTTONS/ SELECTORS	Positioning of push buttons/selectors on control stations should reflect ergonomic principles during use, and frequency of use.
18	Transferral of crane vibration to driver.	ANTI-VIBRATIONAL DAMPERS	Control stations should be sufficiently robust to minimise movement of fittings. Shock absorbing devices to mitigate lower frequency shocks in the seat and control boxes are recommended. Such devices should not be installed in the seat, because they tend to wear excessively. Shock absorbers should be installed in the column of the control station's support. This ensures driver movement and joystick boxes are united/compact.
19	Control workstation conflicts with anthropometric data.	ADJUSTABLE CONTROL BOXES	Control boxes should be provided with all necessary adjustments: -height in relation to seat cushion -forwards/backwards related to seat cushion -tilting For a correct definition of optimal posture, see EN241 standards - 11226 - 1005-11064 Control boxes must not prevent drivers from spreading their legs for better visibility downwards.
20	Control workstation conflicts with anthropometric data.	ADJUSTABLE CONTROL WORKSTATION	Control stations should be adjustable to correctly adapt to different drivers' heights, (P5 female to P95 male worldwide according to Dined). This includes height related to foot grills, length of the seat cushion, height of the lumbar support and the forward - backward adjustment to bring the eyes in the required position for optimal visibility for crane operation.

APPLICABLE STANDARDS – Please note that behind PEMA statements there are international standards that impact equipment safety, and these must be reviewed, and their implications incorporated.

Applicable international, national or local regulatory standards should be respected in all cases.

1.APPENDIX 1:

P Wicks, Ergonomic Analysis of Human Factors Affecting Optimum Performance of Mobile (Tower) Crane Drivers, University of Surry, 1975

Brieda Cabins, Ergonomic Solutions in designing workstation for operators of harbour cranes, 2007

ABOUT THE AUTHORS & PEMA

ABOUT THE AUTHORS

This paper has been prepared by Siro Brieda of Brieda Cabins, with input from Daan Potters from BTG Special Products BV.

ABOUT PEMA

Founded in late 2004, the mission of PEMA is to provide a forum and public voice for the global port equipment and technology sectors, reflecting their critical role in enabling safe, secure, sustainable and productive ports, and thereby supporting world maritime trade.

Chief among the aims of the Association is to provide a forum for the exchange of views on trends in the design, manufacture and operation of port equipment and technology worldwide.

PEMA also aims to promote and support the global role of the equipment and technology industries, by raising awareness with the media, customers and other stakeholders; forging relations with other port industry associations and bodies; and contributing to best practice initiatives.

MEMBERSHIP OF PEMA

PEMA membership is open to:

- Manufacturers/suppliers of port equipment
- Manufacturers/suppliers of port equipment components
- Suppliers of technology that interfaces with or controls the operation of port equipment
- Consultants in port and equipment design, specification and operations

Please visit www.pema.org for more information or email the PEMA Secretariat at info@pema.org

PEMA CONSTITUTION & OFFICES

PEMA was constituted by agreement dated 9 December 2004 as a non profit making international association (association internationale sans but lucratif /internationale vereniging zonder winstoogmerk).

PEMA is governed by the Belgian Law of 27 June 1921 on "associations without a profit motive, international associations without a profit motive and institutions of public utility" (Articles 46 to 57).

Company Number/ Numéro d'entreprise/ Ondernemingsnummer 0873.895.962 RPM (Bruxelles)

PEMA – Port Equipment Manufacturers Association

Registered Office: p/a Glaverbel Building, Chaussée de la Hulpe 166 Terhulpsesteenweg, B-1170 Brussels, Belgium

President Office: Via S. Balestra 27, CH-6900 Lugano, Switzerland

Finance & Secretariat Office: 15-17 St Cross St, London, EC1N 8UW, United Kingdom

Secretariat Contact Details:
Tel: +44 2034 093 100 | +44 (0)7766 228958
Email: info@pema.org

PEMA – Port Equipment Manufacturers Association

Registered Office: p/a Glaverbel Building, Chaussée de la Hulpe 166 Terhulpsesteenweg, B-1170 Brussels, Belgium

President Office: Via S. Balestra 27, CH-6900 Lugano, Switzerland

Finance & Secretariat Office: 15-17 St. Cross St, London, EC1N 8UW, United Kingdom

Secretariat Contact Details:
Tel: +44 2034 093 100 | +44 (0)7766 228958
Email: info@pema.org

PEMA
PORT EQUIPMENT MANUFACTURERS ASSOCIATION