CRANE OPERATOR HEALTH & SAFETY

PORT EQUIPMENT MANUFACTURERS ASSOCIATION (PEMA)

The rise of containerization has brought new challenges for ports and terminals concerned about the health of their operators. Despite increasing focus on crane cabin and workstation design, ergonomic issues such as awkward posture, and environmental factors including heating, ventilation, noise, and vibration, continue to impact crane operators' wellbeing. Beyond its personal cost, poor employee health also has detrimental effects on 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 workstations. This paper provides baseline specifications for workstations 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 that they should also be included as standard features in suppliers' initial quotations.

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, and improve the reputation of the container terminal industry and equipment manufacturers in general.

BACKGROUND

For many years, crane cab and workstation 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% of the crane operators it surveyed suffered back complaints; and 42% neck complaints. Burdorf et al., (1993), found that 50% of crane drivers were prone to back problems.

In 2001, Ariens concluded that there is 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% of crane drivers surveyed suffered neck complaints, and between 67 and 86% 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%), lower back (88%), mid-back (50%), and shoulders (50%). 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.

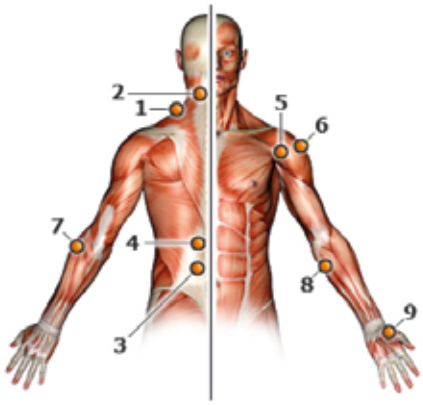
More recent research, based on European Standards EN 1005-3/4/5 and focused on biomechanical analysis by the EPM Research unit – Ergonomics of the body posture and movement and the Biomedical Technology Department of the University of Milan (2007-2008), in collaboration with PEMA member Brieda Cabins,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

These tests showed that 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. It 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 ISO recommendations.

Design also has an overall impact on safety, as it can improve poor visibility typically associated with crane cabins, mitigate 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 operators caused by poor crane cabin design, the detrimental effect of employees' poor health on relationships between operators and port management should also be considered.



1) UPPER TRAPEZIUS
2) CERVICAL SPINAL ERECTORS
3) LOW LUMBAR SPINAL ERECTORS
4) HIGH LUMBAR SPINAL ERECTOR
5) FRONT DELTOID
6) MIDDLE DELTOID
7) FINGERS EXTENSORS
8) FINGERS FLEXORS
9) THUMB ADDUCTOR

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 – STS and RTG cranes – drivers are required to look downwards almost continuously. 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, drivers' legs often obscure their vision. Looking around while driving, and looking sideways under beams while searching for trucks causes awkward posturing. Sideways movement, in combination with RTG tyres, creates a swinging motion in the cab 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 issues where thinner, removable glass was used to assist cleaning, the latter being protected inside and out by metal safety grills which reduce visibility.

The need for shock and vibration absorbers on cabins and control stations has emerged in part due to reports that increased speeds of modern cranes have resulted in greater vibration levels. ISO 2631-1 Mechanical Vibration and Shock should be considered a benchmark in this area when drawing up crane cab specifications. Comfort is one element here, but there is also the issue of effective control of items such as touchscreens. Similarly, correctly positioned handholds are necessary to help drivers climb in and out of crane cabs and move 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 adjustable in all directions including tilt, with forearm rests to reduce pressure on the lumbar region.

Seats and control stations also need

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 50m³/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.
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.
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.

to support the body through periods of biomechanical stress, 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 for ease of use and to prevent drivers not using seat belts they consider unnecessarily restrictive.

The positioning of displays and lighting inside 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 in side panels where operators risk missing important system information. Touchscreens 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 glass floors to keep them free from moisture. Furthermore, cabins must be positively pressurised with clean air to keep out pollutants.

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.

This article summarizes the main findings of a revision paper, prepared by Siro Brieda of Brieda Cabins, with input from Daan Potters from BTG Special Products BV on behalf of the Safety & Environment Committee of the Port Equipment Manufacturers Association (PEMA).

ENQUIRIES

Web: www.pema.org/publications