



Merford's ERGOSEAT

Evaluation of an innovative seat design for container cranes

In STS cranes, RTGs and RMGs, work requires the operators to look downwards almost continuously. Such a viewing angle forces the neck and back in an unfavourable, flexed posture. Consequently, many crane drivers suffer from neck and back complaints. Can this problem be solved by a progressive crane seat design? This article describes this problem and discusses the potential advantages of a new seat design.

A few years ago, Merford launched the Ergoseat in combination with a "round-model cabin" called Ergocab 2000.

To find out about the advantages of the Ergoseat compared to the more traditional seats for container cranes, Merford asked TNO Work and Employment as an independent scientific institute to make an objective comparison. Below are the results from a bio-mechanical analysis and a practical study performed at Thamesport (UK).



Merford's Ergoseat

Activities, postures and problems of crane drivers

The crane driver performs several activities. The viewing demands of some of these activities more or less dictate the crane driver's working posture. A lot of time is spent looking downwards while positioning the spreader on top of the container or positioning the container. The typical crane driver's posture is quite a slumped posture. The trunk does not remain straight and does not flex forward in the hip joint as sometimes depicted by simple manikins (see figure 1-I). Instead the hip angle remains around 90° and the trunk is flexed to a C-form (see figure 1-II). The backrest can hardly be used. Because of this slumped posture the neck flexion is only moderate (20-30° from neutral). The legs are spread to be able to view downwards thereby limiting the positions where controls can be placed (see figure 2).

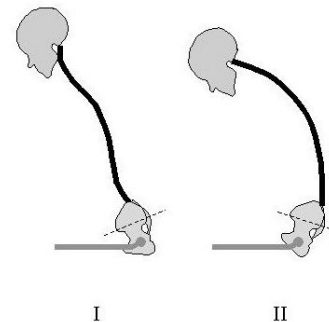


Figure 1 Typical operator posture (right)

So the crane driver's working posture involves significant back and neck flexion for prolonged periods of time. Prolonged bending of the neck and prolonged bending of the trunk are known as risk factors for the development of neck pain (Ariëns, 2001) and back pain (Hoogendoorn, 2000). In addition to the above posture problems, the shocks of the cabin are certainly an aggravating factor, therefore it is no surprise that many drivers have complaints. A study of Zondervan (1989) mentioned that 64% of the crane drivers are suffering from back complaints and 42% of them from neck complaints, while Burdorf et al. (1993) found a prevalence of back problems over the past year among crane drivers of 50%.



Figure 2 View downwards between the legs

Other complaints that are heard from crane drivers concern the climate conditions, noise and visibility.



A progressive new seat design

The question was whether a new design of the crane driver's seat combined with a well designed cabin could solve the main problems.

Merford invented a new concept aiming at reducing the loads on the back and neck muscles and at the same time improving the outside view. The operator's bent forward posture is made easier by giving a new way of support. Within this concept, the support of the upper body is provided by the installation of two armrests with integrated controls, one on each side of the driver. These armrests are fully adjustable, which means that they can be adjusted in height, in a fore-aft direction, in slope and they can pivot towards each other. Thus, the driver is able to bend over with his body while leaning on his forearms. In addition, in the new concept the seat is no longer positioned on the cab's floor, but it is suspended from the ceiling. This construction together with the armrest-mounted controls allow for more glass in the cab's floor. The main viewing window can be extended underneath the operator and extra viewing windows can be created to the left and right of the operator for viewing backwards.

Based on this conceptual idea, Merford developed the Ergoseat for container cranes. To find out whether the seat would live up to its expectations, Merford had TNO evaluate the seat on biomechanical grounds and in real life at Thamesport.

Biomechanical evaluation

The figures 3a and 3b illustrate the bio-mechanical context of the traditional working posture of a crane driver (figure 3a) and of the new posture that he can adopt in the Ergoseat (figure 3b). The figure shows that differences in neck and trunk posture between the Ergoseat and a conventional seat are only minor. The same was found at Thamesport where nine crane drivers were observed during work in both the Ergoseat and a traditional seat. In the traditional seat the low back is under significant stress since the back muscles need to generate muscle forces to counteract the forward torque of the upper body. However, in the Ergoseat, a significant part of the weight of the trunk, head, arms and hands is carried at the armrests. The mechanical loading on the low back is thereby reduced.

On the basis of the total body mass of the operators, the body segment lengths, the orientation of the body segments and the measured pressure at the armrests, TNO quantified this reduction. It appeared that the Ergoseat is capable of reducing the loading on the low back by more than 50%, compared to the traditional situation. The further forward the operator leans, the more this reduction may be.

With regard to the neck they did not find any significant difference between both types of sitting. Regarding the shoulder load, the differences between seats are not clear. In the Ergoseat with arm support, the stabilizing forces at shoulder level would be lower (e.g. Attebrant et al., 1997). However, this decrease in internal shoulder load might be counterbalanced by the muscle activity that is required at shoulder level when leaning on the armrests with 30-40 N per side as measured. Nevertheless, a clear advantage of the Ergoseat is the potential variation in shoulder load over the day: the crane operators may vary the load on their shoulders (and low back) by varying the extent to which they lean on the arm support (ranging from total support to none). In contrast, in the traditional situation the loading on shoulder and low back level while operating the crane is constant and continuous.

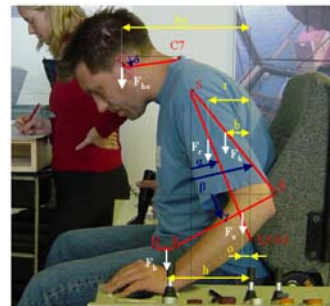


Figure 4a Traditional working posture

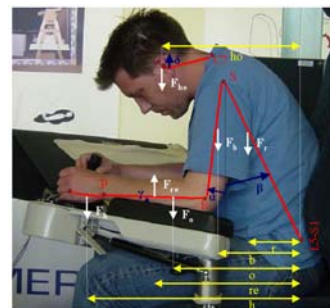


Figure 4b Working position in Ergoseat



Practical evaluation

To find out about the experiences with the Ergoseat in real life, TNO conducted a comparative study at Thamesport in the United Kingdom. Quite an ideal research situation was found, as the container terminal had six quay cranes in operation, two of which were equipped with an Ergocab 2000 (round model) and Ergoseat.

Thamesport has been working for more than two years with the Ergoseat. Operators were used to operate both type of cranes and regularly switched between cranes. Hence, TNO could make a clear comparison between work in the Ergocab and work in a traditional cab.

Concerning the general cabin aspects, the Ergocab is preferred above the traditional cab. The outside view, the climate control (in heat and in cold), the noise insulation, and the suspension are all considered to be better in the Ergocab/Ergoseat. The only aspect they find not to be improved in the Ergocab 2000 compared to the traditional cabin is the 'sense of space'. This is quite clear since the tested Ergocab is smaller than the traditional cab. As mentioned before, Merford nowadays mostly applies the Ergoseat in cabs with a more traditional appearance.

With regard to the seats, one could say that the Ergoseat is preferred above the traditional seat, mainly because of its suspension characteristics and its larger adjustability. Those who prefer the traditional seat do this mainly because the seat back can be set further back. Operators leave it in this position and stretch their back whenever they can. A feature of the Ergoseat that is widely appreciated is a wedge in the front part of the cushion and the possibility to spread the legs underneath the armrests (consoles). Not only does the seat no longer obstruct the view, leg support is also maintained while sitting with the legs spread.

When asked about preference for joystick operation, the results are not clear. Some prefer the traditional, while others prefer the new situation. This result might be explained by the fact that the Ergoseats under investigation were equipped with joysticks that were somewhat too long. The larger for-aft travel of these joysticks and the use of armrests do not go well together. In fact, to some extent the armrests may even hamper the control of the joysticks. The latter would not have been the case, had smaller grips on the joysticks been used. Originally, the Ergoseat is specifically designed for application of finger operated, smaller joysticks.

Conclusions

The Ergoseat is a good example of an attempt to improve posture, comfort and view by use of an advanced cab and seat design. The main conclusions from the evaluation are:

- the Ergoseat reduces the static loading on the low back by more than 50%;
- the Ergoseat provides the possibility for the crane operator to vary his body posture and, thereby, vary the load between the shoulders, upper back and lower back. Hence, internal structures in the back and shoulder can recover during work! Fatigue can be postponed;
- the armrests of the Ergoseat stabilise the trunk, which may further reduce the back load in case of shocks or vibrations;
- the outside view in the Ergocab is improved. Crucial in this respect is the seat's suspension from the cab ceiling and the armrest mounted controls. This eliminates any view obstructions by the seat and traditional control consoles. It also creates the possibility to improve outside view by extending the floor window pane underneath the seat and to add windows to the seat's side. Also of importance are the reduced sill dimensions of the front and side windows and the introduction of a wedge in the seat pan;
- the Ergoseat is considered comfortable and is appreciated for its features;
- it is not unlikely that the Ergoseat will improve performance. A better view, less discomfort, less physical loading and less fatigue are all factors that may well increase task efficiency. In addition, it can be assumed that the armrests will provide more stability, which is specifically needed, for high precision tasks.



- though not tested, it is very likely that the armrests in combination with the seat's ceiling mounted suspension also reduce the influence of shocks and vibrations on the stability of control because of the integral suspension of the seat and armrest mounted controls. This is different from most traditional seats in which only the seat is suspended and the controls are not;
- in an additional comparative study on the performance at a computer-simulated crane task (static arrangement) we found that an Ergoseat with smaller joystick grips scored slightly better compared to a traditional seat with larger joystick grips. These results coincide with other results from joystick research in which smaller finger controlled joysticks outperform handheld joysticks in tasks with high precision demands (Huysmans et al., 2004);
- the Ergoseat may have a positive effect on the state of health as two main risk factors are clearly reduced. First, the magnitude of the load on the low back is reduced by more than 50%. Secondly, the operators may vary between body positions, thereby breaking the monotony of the load and offering the chance on recovering to body structures.

The present study also provide some other issues that need to be stressed here.

- It has become clear that the armrests on the Ergoseat are less suitable for application of larger joystick handles.
- Within the current design of the Ergoseat, it is quite difficult to stretch the back during micro breaks in the cab.
- A traditional seat requires a larger cabin compared to the Ergoseat. This might be advantageous in that a smaller cab can be applied. However, one should be aware of a potential drawback on the operator's 'sense of space'.
- The Ergoseat with its large variety of adjustment possibilities and its smaller joysticks (this differs from what most crane drivers are used to) requires a good introduction and some time to get used to.

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More information

For more information please contact Frank Krause
T: +31 23 5549 546 E: f.krause@arbeid.tno.nl.