



System 800xA Operator Effectiveness

# Extended Operator Workplace EOW-x Comparison with sight-angle standards and related issues of operator ergonomics

# Advanced visual ergonomics help operators meet modern process control challenges



Fig 1. A traditionally-planned central control room with two-tier monitor stacking and larger screens mounted on a distant wall or stand. Arrangements like this put a strain on operators and may compromise their ability to work effectively.

Process operators rely almost exclusively on computer monitors and large display screens for the information they need to run plants safely and efficiently. Monitor position is known to have a profound influence on the way they interact with control room workstations and detailed guidelines have been produced to optimize the HMI interface and reduce operator stress. EN 894 standard, for example, recommends sight-lines and gaze-angles that improve the ergonomics and efficiency of operators interacting with computer screens.

Unlike most traditionally-planned control room solutions, System 800xA EOW-x workstation not only complies with EN 894, it surpasses its requirements for sight-angle criteria. By offering flexible solutions that let individuals optimize both sight-lines and gaze-angles, EOW-x maximizes process visibility and clarity. This lowers operator stress levels, allows them to focus on the task in hand, and improves collaborative decision-making.

## Traditional control room designs may compromise operator efficiency

Many process control rooms and adjacent areas are still built and planned with a very low level of system integration that often requires the individual operator to monitor and track multiple monitors displaying information from different systems. To save space and minimize operator movement, it is quite common to stack the operator's personal monitoring screens on top of each other, usually in two tiers. Larger wall-mounted overview display screens are also common. This type of arrangement, such as that shown in Figure 1, fails to take account of modern research into human factors. From an ergonomic point of view, this is far from ideal; the operators' ability to run plant processes safely and efficiently may be compromised.

Furthermore, the increasing complexity of control systems plus the introduction of more and more advanced third-party systems puts more strain on system users (see the statement by visual ergonomic specialists Ankrum Associates).

### Ergonomics of monitor placement

“The position of the monitors has a profound influence on the ergonomics and comfort of the operator’s interaction with the workstations. Many guidelines have recommended placing the top of the monitors nearest to the operators at or slightly below sight level. The reasons for these recommendations include minimizing the postural load on the muscles of the neck and preventing the user from tilting the head too far back or forward.

The location of visual targets limits the possible postures, which will force the operator to twist his or her neck towards the visual object in order to achieve visual comfort. Generally head movement occurs when the eye excursions are greater than 8 to 10 degrees, which will lead to better visual comfort at the expense of postural discomfort. This is however manageable for the operators within a certain limit as he or she can turn their bodies as a whole to compensate.

A bigger problem occurs with regard to the vertical position of the visual objects. The preferences for the vertical position of visual objects among operators and office workers interacting with computer screens are normally slightly or significantly lower compared to the horizontal sight line (eye-ear line). The scientific reason for downward sight angles is connected to the capabilities of the visual system. The eyes are simply better at focusing as gaze angles tilt downward, which in turn reduces stress on the eye muscles and improves the ability to accommodate. This in turn leads to fewer reports of headaches, eye strain and fatigue”. (See References.)

### Modern HMI solutions with attention to human factors

Modern HMI layouts and better ergonomics can reduce this operator burden, primarily by positioning both monitors and large screens to ensure that they are used in the most optimized way. Figure 2 shows a well-planned control room with optimally positioned monitors and overview screens. In creating such an environment, the gaze angles and sight lines of the operators are key factors in optimizing their interaction with the screens.



Fig 2. An ergonomically-planned control room with optimally positioned consoles and screens helps operators monitor processes and detect events.

# Recommended gaze angles and sight lines for operators

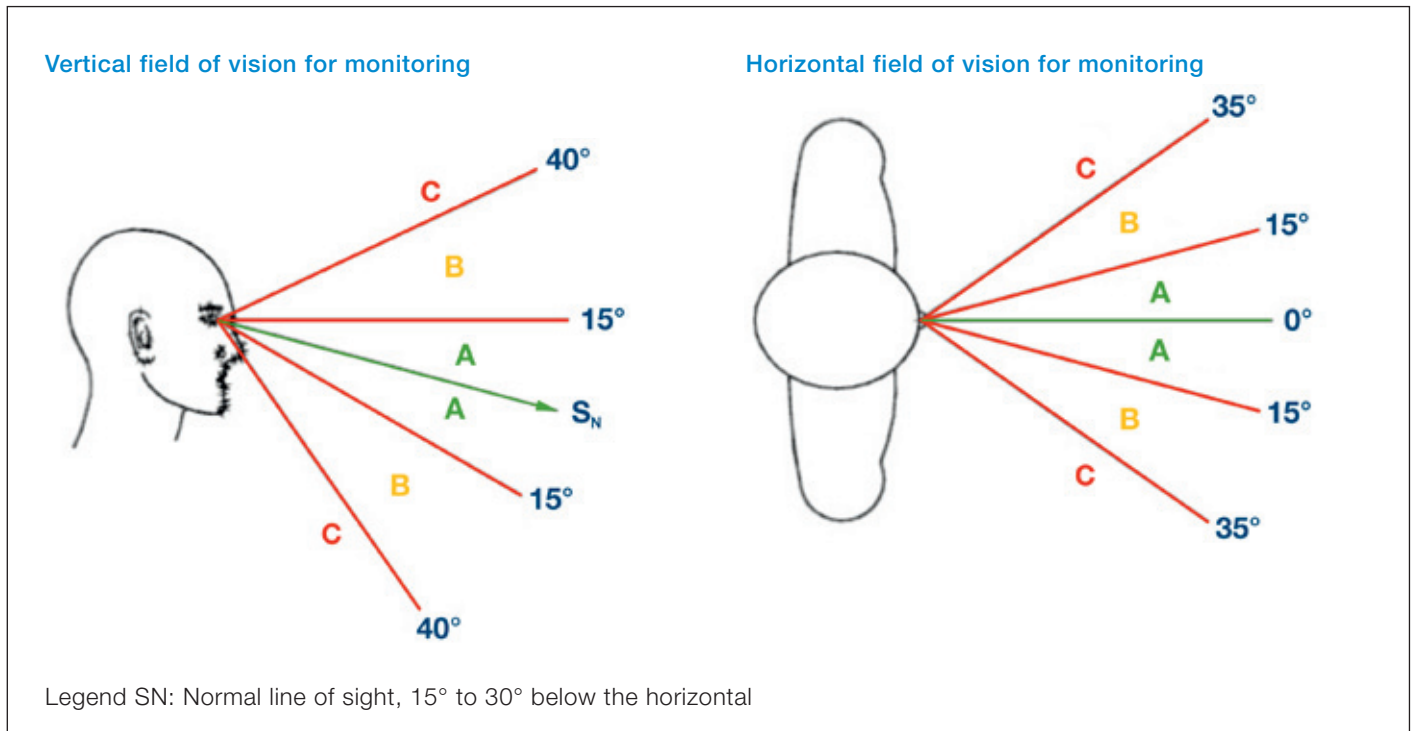


Fig 3 A. Vertical and horizontal fields of vision for monitoring showing what is recommended, acceptable or not suitable according to the EN 894 industrial standard.

When designing operator HMIs and positioning their sources of information such as monitors, two different types of visual task must be distinguished – monitoring tasks and detection tasks. Monitoring is where the operator actively seeks information (e.g. navigates through the HMI to find trend data). Detection is where the operator has to be alerted by the system (e.g. an alarm). In both cases (but in slightly different ways), operator gaze angles and lines of sight will play important roles.

Detailed recommendations on gaze angles and sight lines for operators interacting with computer screens are outlined in the EN 894 standard. This standard identifies three zones of decreasing performance efficiency for visual detection and monitoring tasks: recommended, acceptable and not suitable.

The center-lines of the zones lie in the median plane and correspond with the line of sight (see Figure. 3 A monitoring tasks and B detection tasks). For monitoring, displays should preferably be positioned around a line of sight that is at an angle slightly below the horizontal. This is more comfortable for the operators (EN 894-2, 4.4.1). For detection, the line of sight depends on the main centre of attention.

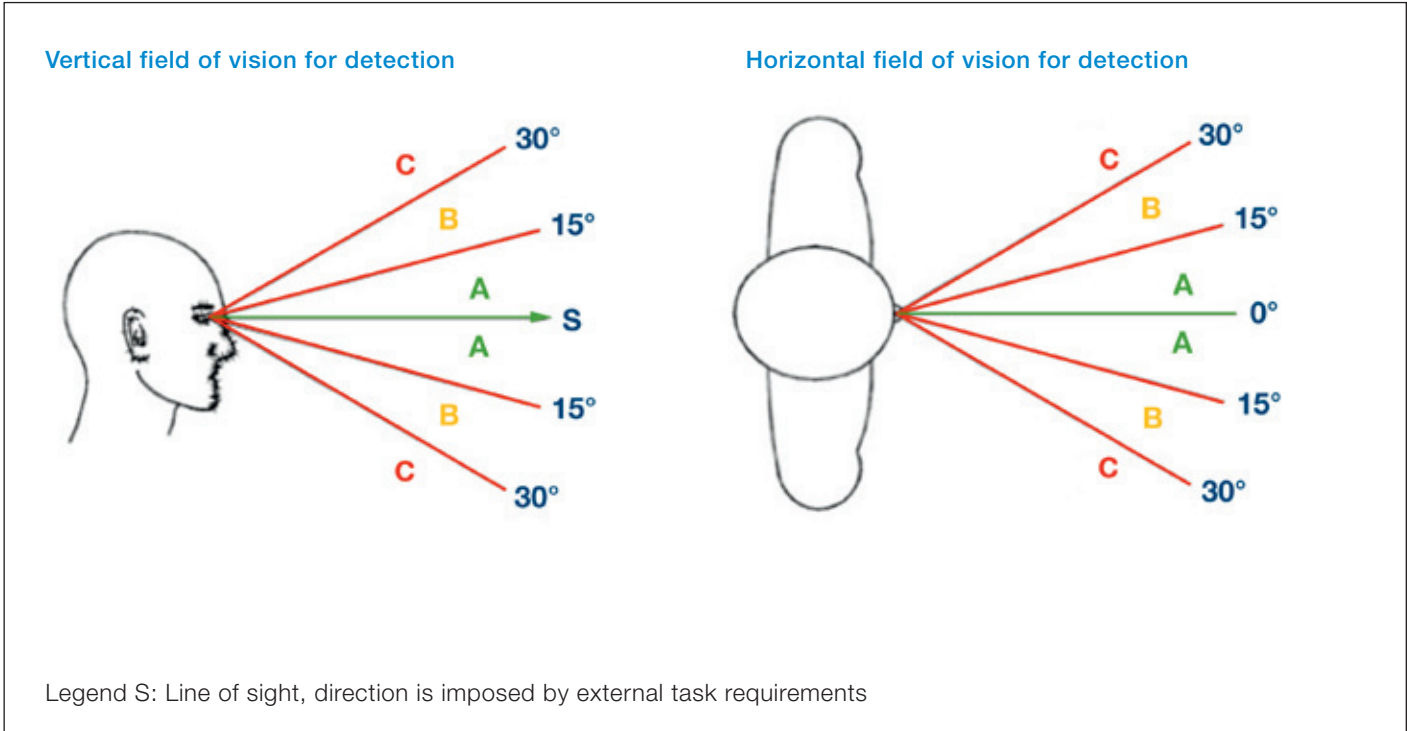


Fig 3 B. Vertical and horizontal fields of vision for detecting showing what is recommended, acceptable or not suitable according to the EN 894 industrial standard.

Level of suitability	Significance
A: Recommended	This zone shall be used wherever possible
B: Acceptable	This zone may be used if the recommended zone cannot be used
C: Not suitable	This zone should not be chosen

According to EN 894, visual displays should not be placed outside the recommended and acceptable zones unless appropriate supporting aids are provided. The not suitable zone should only be used for displays that are not critical for safe operation.

These line-of-sight recommendations for operators interacting with computer screens reflect one aspect of the attention given to human factors in the design of the EOW-x. General information is provided below. Further details of EOW-x's compliance with sight-angle criteria are given later.

In addition, the operator's line of sight shall be uninterrupted for all ergonomically acceptable working positions, and for all anthropometric (measurements related to an individual's body) characteristics of the user population. The preferable population used is from the 5th percentile of women (height equals 1.56 m) to the 95th percentile of men (height equals 1.90 m).



# Operator ergonomics and performance

**System 800xA Extended Operator Workplace (EOW-x) is a flexible operator workstation equipped with a combination of small and large high-resolution LCD screens, PA speakers, a directed sound speaker system, high-frequency lighting (+100Hz) and a multi-client keyboard.**

The flexible monitor and display arrangements can be very easily adjusted to fit different process situations. Figure 4 shows one arrangement. Adapting workstations to fit new process requirements is impossible with fixed-type control room solutions.

## **New roles for process operators**

Today, process control operators often have to switch between radically different roles. In normal situations they function as a 'pilot', in critical situations as a 'fire-fighter', after certain events as an 'analyst', and in some circumstances as a 'researcher'.

- Pilot – handles routine process control
- Fire-fighter – takes charge of extreme, high-stress situations, e.g. critical alarms
- Analyst – performs complex and time-consuming tasks with clearly-defined goals
- Researcher – driven by the need to explore, learn and discover new insights

This changing role is driven by business needs to maximize the return on plant investment, as well as by other economic factors. It is generally unavoidable in most modern enterprises. What's more, operator time constraints and stress levels vary greatly, e.g. between the researcher and fire-fighter functions. Their focus and interests will be narrower when dealing with a problem, at the same time as the stress will reduce their mental capabilities.

Regardless of which function he/she is currently engaged in, EOW-x and its built-in functions has been ergonomically developed to give the operator superior visibility and support.



Fig 4. EOW-x3, a workstation based on six operator monitors and a large overview display (built up of three screens). Multiple motorized solutions, personal lighting and directional sound systems allow operators to adapt their personal workplace to suit their individual needs.



Fig 5. In this EOW-x3, the motorized desk has been raised so that operators can stand while working. Varying working position in this way relieves physical stress and helps operators stay alert.

### Maximum visibility, clarity and collaboration

Maintaining maximum visibility and clarity lowers stress levels and allows the operator to focus on the task in hand.

During critical conditions, EOW-x further assists the operator by switching to a layout that allows colleagues to interact and help. For example, key process data and alarm conditions can be shown on the large overview display, easily viewable by a group of people.

This collaboration, aided by dynamic interactive HMIs, promotes quick and reliable decision-making.

### Able to deal with more information

EOW-x also helps operators deal with the larger volume of information that is increasingly associated with their broader role in plant operations. This information frequently comes via third-party systems such as CCTV, PAGA, Maintenance Management Systems, as well as integrated Process and Power Automation and Asset/Alarm Management.

The ability to integrate these systems with System 800xA and thus making the information available directly in the 800xA EOW-x operator environment, combined with the interactive large display and a control room environment optimized for human factors, once again help operators work efficiently and make more informed decisions.

### Highly flexible and motorized solutions

The highly flexible and motorized EOW-x solution makes it possible to adjust screen height and position to suit an individual user's needs, including how these needs may change according to plant status and events. For example, as angles and heights can easily be changed (see Figure 5), the level of muscular stress experienced by the EOW-x operators is less than that of any other system design currently available. This has been rigorously tested and verified in R&D facilities.



Motorized height adjustment reduces muscular stress and can play a key role when control room colleagues need to gather together and collaborate.

#### Flexible working positions and sight-angle criteria

Figure 6 illustrates how the motorized nature of the EOW-x console permits great flexibility in positioning the screens to fulfill sight-angle recommendations, even for operators with different individual body measurements. For example, the distance between the operator's eyes and the monitor screens can be incrementally adjusted 150 mm in depth and angled from +5° to -45°. Adjusting screen position and distance in this manner will significantly reduce the amount of stress experienced by the eyes as well as various viewing muscles used when monitoring HMI systems.

All movements are also motorized. By utilizing EOW-x's 'intelligent ergonomics' the workstation can, in fact, be configured so slowly as to be imperceptible to the system user.

EOW-x consoles also have motorized height adjustment. This again helps reduce muscular stress, but it will also prove valuable when unexpected plant conditions occur, e.g. an alarm that requires immediate attention and action. When such events occur, operators are generally out of their seats and control room managers often gather round the console screens to see what is happening and to offer advice.

By extending the console to the standing position, EOW-x gives all involved detailed process data as well as a clear overview without having to huddle over poorly-positioned screens. This leads to greater collaboration plus faster and more efficient problem-solving. Note that the EOW-x can also be programmed to automatically move the monitors to pre-set positions should certain alarm conditions arise.



### A detailed look at sight angle criteria

As noted earlier, the EN 894 standard recommends gaze angles and sight lines for operators who interact with computer screens.

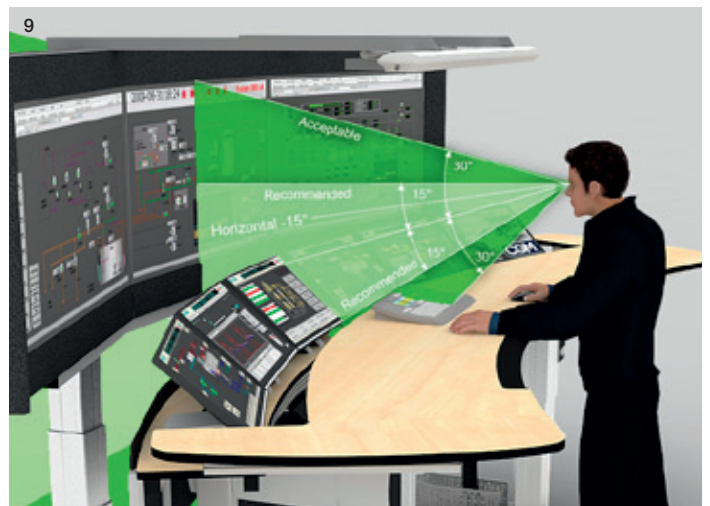
The design of the EOW-x takes into account the ergonomic criteria of EN 894 as well as other important standards such as NUREG 0700 and NORSOC S-002. The whole design ethos has been to ensure system operators are 'ergonomically managed' in the most effective way irrespective of whether they are standing or seated and regardless of what task they are currently engaged in.

Figure 7-9 shows how the EOW-x viewing concept meets EN 894 requirements for the vertical field of vision.

Solutions consisting of the standard common General Practice 'two-tier monitor stacking' operator workstation in combination with fixed screens are shown in Figure 1-4 on the following page.

Each illustration shows recommended sight angles according to the EN 894 standard. The eye position of each operator is placed at heights corresponding to a selection of operators equivalent to the 5th percentile women (156 cm) and 95th percentile men (190 cm) in sitting and standing positions. Comparing these to the EOW-x single-tier monitor concept shown in Figure 7-9 shows that the EOW-x solution is far less demanding on the neck muscles.

Fig 6. Adjusting EOW-x screen position and distance reduces stress on the eyes as well as viewing muscles. | Fig 7. Vertical field of vision for monitoring (sitting position). | Fig 8. Vertical field of vision for detection (sitting position). | Fig 9. Vertical field of vision for detection (standing position). The light green areas show the recommended field of vision, the dark green the acceptable field. EOW-x fully complies with the EN 894 standard.



# EOW-x workstation versus traditional General Practice guidelines

Fig 10. Site angles Female 5% Sitting

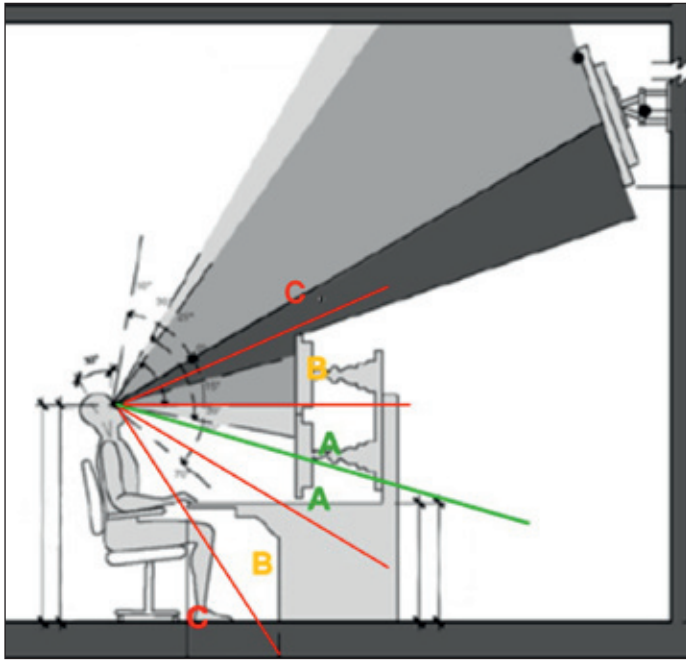
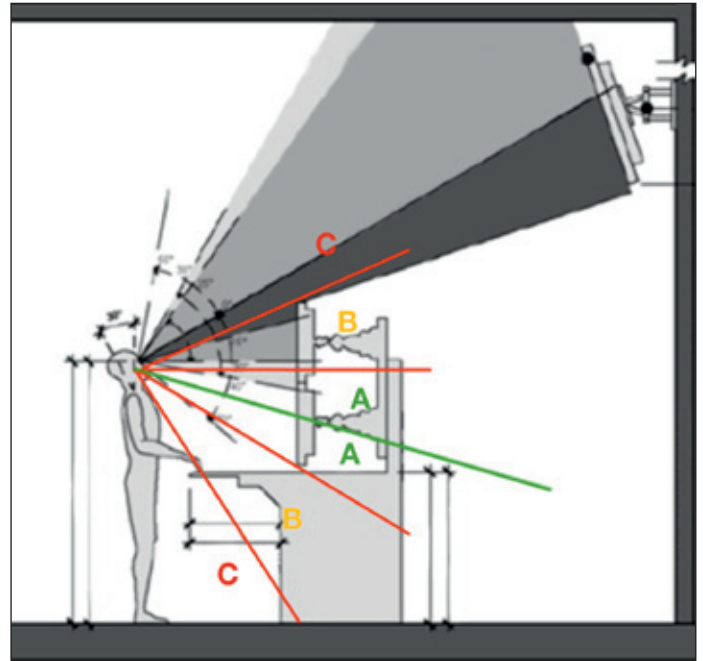


Fig 11. Site angles Female 5% Standing



Recommended sight angles according to EN 894. 10) Monitoring tasks, 5th percentile women, sitting. 11) Monitoring tasks, 5th percentile women, standing.

Figure 14 complements the illustrations shown in Figure 10-13. It emphasizes the importance of securing good seated and standing positions for operators challenged with the different roles they face in modern 24/7 environments.

Figure 14 shows head and neck movement in the vertical plane. Acceptable head movement is between the 30° angles. This guide is often used to determine acceptable height and location to support the effective functioning of the operator. Having the neck in the rear positions is to be avoided as much as possible.

Not following this recommended positioning (and with older designs this is impossible to avoid) will have an adverse affect on the long-term suitability of the system. Any stress reduction techniques employed to improve operator well-being will not achieve their desired effect.

Figure 15 is a sectional analysis illustrating mounting heights of the operator overview screens in relation to the two-tier monitor row. The seated operator is female but the typical leaning back head movement occurs for all operators faced with this arrangement of consoles and screens.

Operators do not have acceptable visibility if they have to raise their vertical line of sight from 0° to -30° to view the information on the large overview screen. This non-ergonomic position lies within the 'not suitable' zone as specified by EN 984 and should be avoided. Since the recommendations of this standard are based on extensive research aimed at creating a healthy working environment with regard to sight angles, this is a serious threat to the well-being of the operators.

The EOW-x concept avoids this drawback. It not only takes into account the EN 984 standard and complies with its findings, it surpasses the requirements outlined for sight-angle criteria.

In the modern control room environments of today and tomorrow, where operators are challenged by an ever-increasing number of tasks, industry-leading EOW-x solutions promote an efficient stress-free collaborative working environment.

Fig 12. Site angles Male 97,5% Sitting

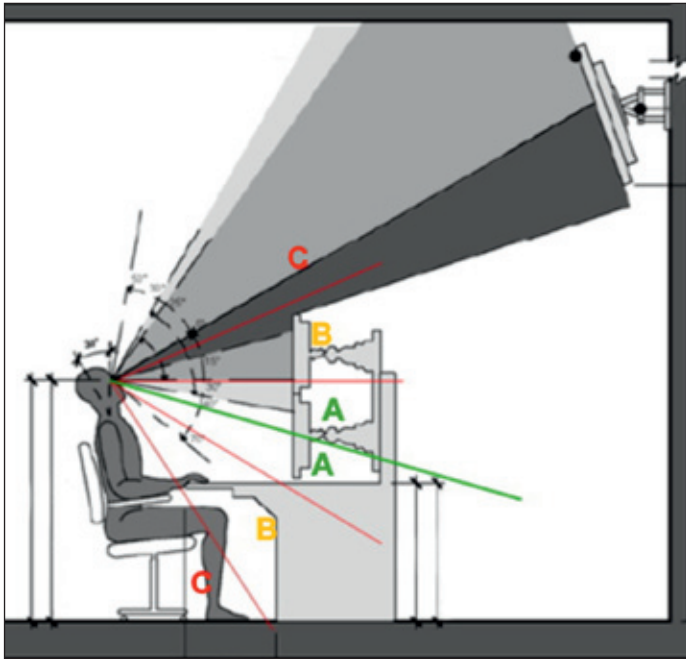
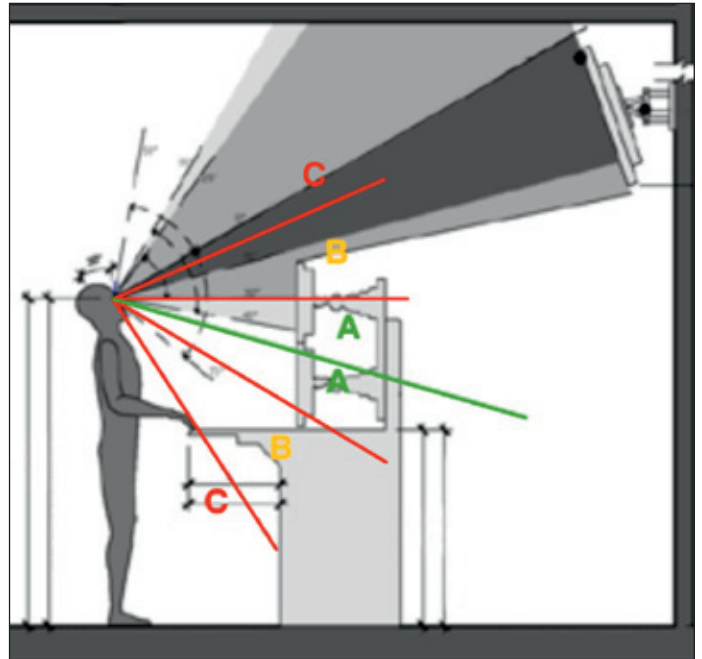


Fig 13. Site angles Male 97,5% Standing



Recommended sight angles according to EN 894. 12) Monitoring tasks, 95th percentile men, sitting. 13) Monitoring tasks, 95th percentile men, standing.

Fig 14.

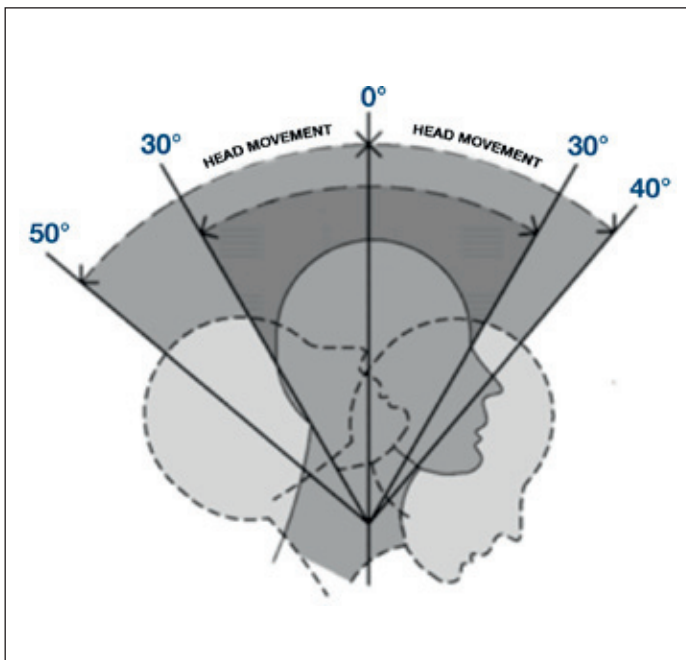
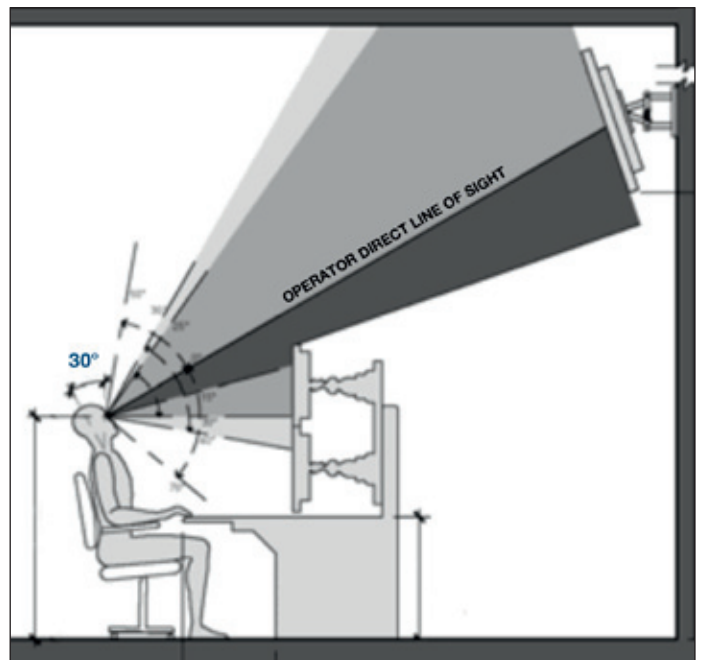


Fig 15.



Lines of sight in the vertical plane. 14) Acceptable head and neck movement is between the 30° angles. 15) Vertical lines of sight for overview screens in relation to the two-tier monitor row. This leaning back head movement contradicts recommendations of the EN 984 standard and should be avoided.

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