ERGONOMIC DESIGN CRITERIA

E-911 DISPATCH CONSOLES

E-911 Dispatch communication centers present unique challenges to designers of specialized dispatch furniture. Multiple large monitors (up to 6 or more) and multiple keyboards, mouse(s), touch screen monitors and other specialized equipment requires a special focused approach to create the least stressful, most comfortable and most productive Dispatch Communications Center environment.

Ergonomic workstation design can be tailored to an individual of nearly any size, but any design for multiple users whose specific physical needs are unknown or may change along with personnel changes is typically pointed toward accommodating the 5th percentile seated female user to the 95th percentile standing male. ***Ergonomic performance benchmarks should follow this accepted practice.***

The Human Factors and Ergonomics Society is an organization whose members are comprised of working human factors engineering professionals in academia and industry. HFES published the original American National Standard for Human Factors Engineering of Visual Display Terminal Workstations (ANSI/HFS 100-1988) which was accepted by the American National Standards Institute (ANSI) on February 4, 1988.

On March 31, 2002, HFES published the first revision to the original standard – BSR/HFES 100 – which addresses changes in technology as well as standing working postures. For the last 5 years BSR/HFES 100 has been available for trial use and evaluation by various stakeholders in industry, government and product design. A canvass committee reviewed input from all sources and voted on acceptance of the final guidelines document. The document was then submitted to the American National Standards Institute (ANSI) for process approval. ANSI approval was obtained on November 14, 2007. The new National Human Factors Engineering of Computer Workstations: ANSI/HFES100 – 2007 represents the most comprehensive and up to date ergonomics guideline in the world.

Xybix considers it prudent to base our product design criteria as well as recommendations to our clients on the Human Factors and Ergonomics Society guidelines. *HFES represents the highest level of expertise, the lowest potential for conflicts of interest and is the most current ergonomic standard in the world at this point in time.*

The use of the HFES guidelines as a benchmark to determine and compare the relative ergonomic performance level of various vendors of Dispatch Console Furniture is the **SAFEST AND BEST** way to be certain that your agency is getting its money's worth. Compliance with ANSI/HFES 100 – 2007 guidelines provides assurance that you are getting a product which puts your valuable staff in the least physically stressful work environment possible.

Vendor claims that ANSI/HFES guidelines are only for office application are patently false. ANSI/HFES guidelines address the relationship between the human being and the computer equipment regardless of whether it is located in an office, a factory or an E-911 Dispatch center.

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HFES is the ***only*** Standards Developing Organization (SDO) recognized by the American National Standards Institute (ANSI) in the field of human factors engineering and ergonomics. Adherence to ANSI/HFES guidelines means maximum credibility in a court of law should any workers compensation or employment issues ever reach that level. Any attempt to personally judge the ergonomic merits or reliance on vendor claims alone has significant unnecessary risk attached.

The following recommendations for human factors engineering of E-911 Dispatch Console Furniture workstations are based on the ANSI/HFES 100 – 2007 Human Factors Engineering of Computer Workstations guidelines. Section and page numbers are referenced where appropriate.

Input Device - Keyboard / Mouse

Support Surface

1. **Input Device support surface –** The input surface (keyboard/mouse, etc.) is the primary interface with the console user. It should be strong and rigid and provide adequate room for input devices and note taking. Principal requirements for superior ergonomic performance follow:
    a. Primary horizontal work zone – The primary work zone is illustrated below and is defined as: "***It is the shape swept out on the work surface by rotating the forearm horizontally at elbow height.*** Arm motions within this area reduce the physiological cost of movement and improve movement speed and accuracy. (Konz & Johnson, 2000)"[1]

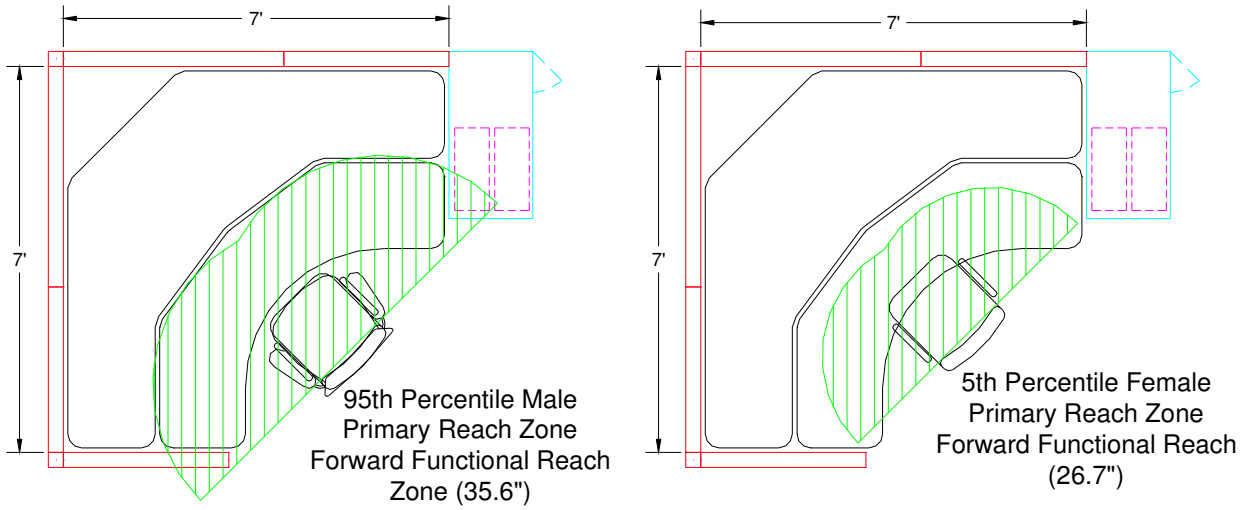

Figure 1 - Primary Reach Zones

[1] ANSI/HFES 100 – 2007 *Human Factors Engineering of Computer Workstations©2007 HFES p.17*

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Input Surface Shape

b. Work surface shape – Work surface shape has significant ergonomic implications in multiple monitor situations experienced in E-911 Dispatch centers. The drawings below illustrate the advantages of “cockpit” shapes over straight work surfaces.

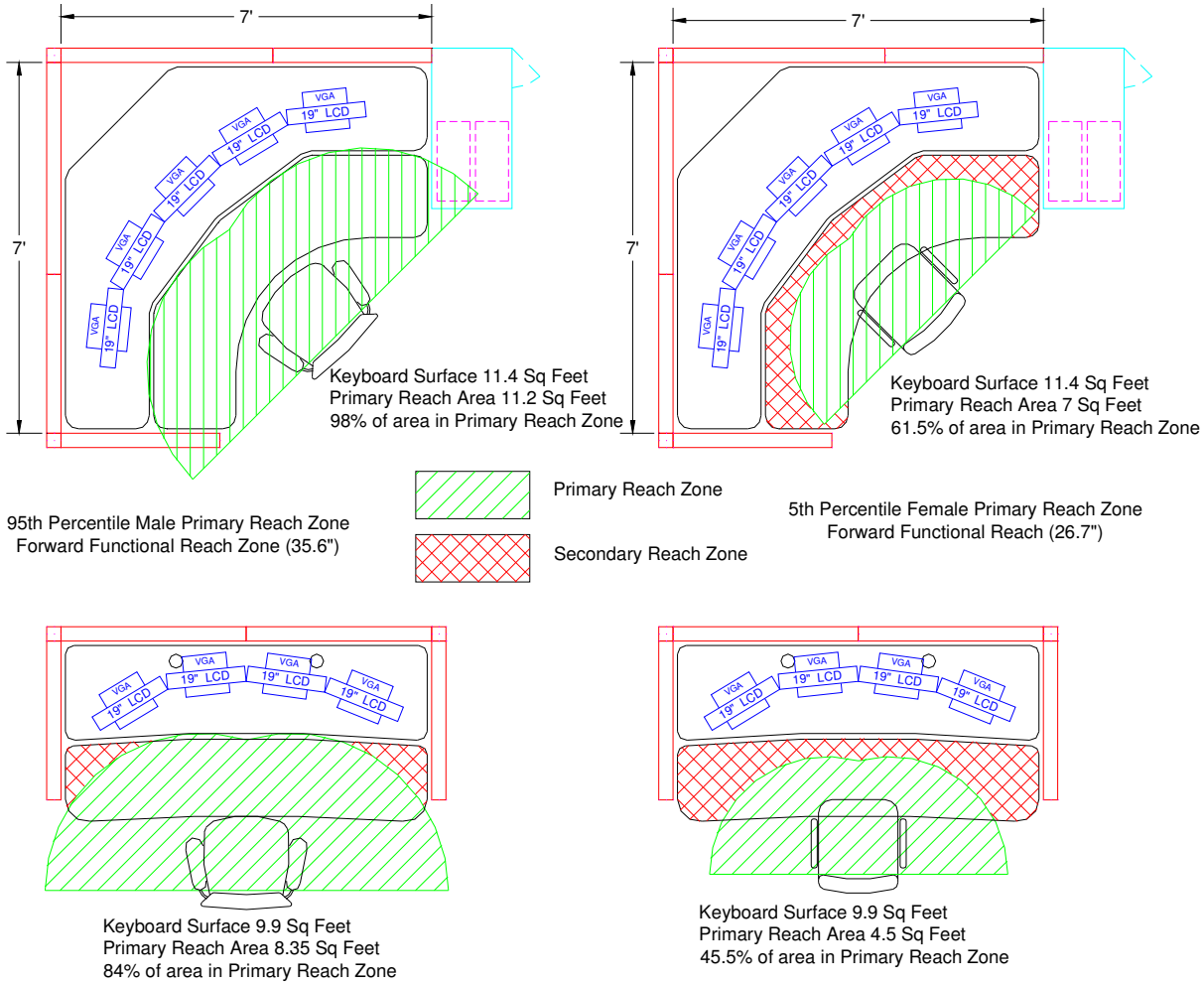

Figure 2 - Corner vs. Straight Primary Reach Zone Comparison

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Primary Input Surface Tilt

c. **Tilt or no tilt?** – While ANSI/HFES 100 – 2007 does provide specifications for support surfaces which have a "tilt" capability, the tilt function ***does not work*** with "cockpit" shaped work surfaces due to the axis of rotation being forward of the centerline of the surface. Tilt will only work with straight work surfaces. Tilt represents an unnecessary complication if height adjustment alone can provide the desired ***neutral wrist alignment***.

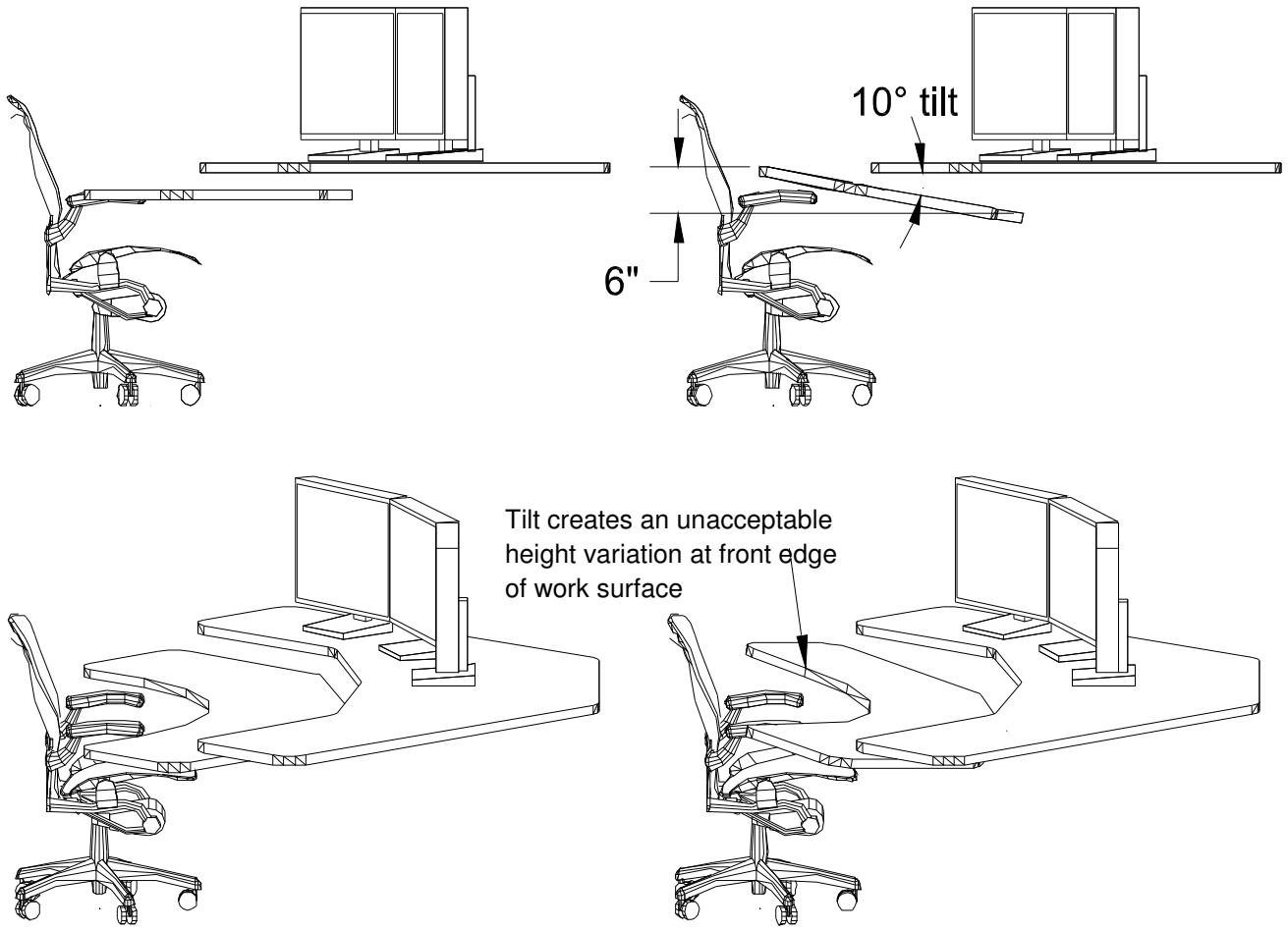

Figure 3 - Keyboard Tilt with cockpit shape work surfaces creates an uneven front edge and can compromise the required knee space envelope

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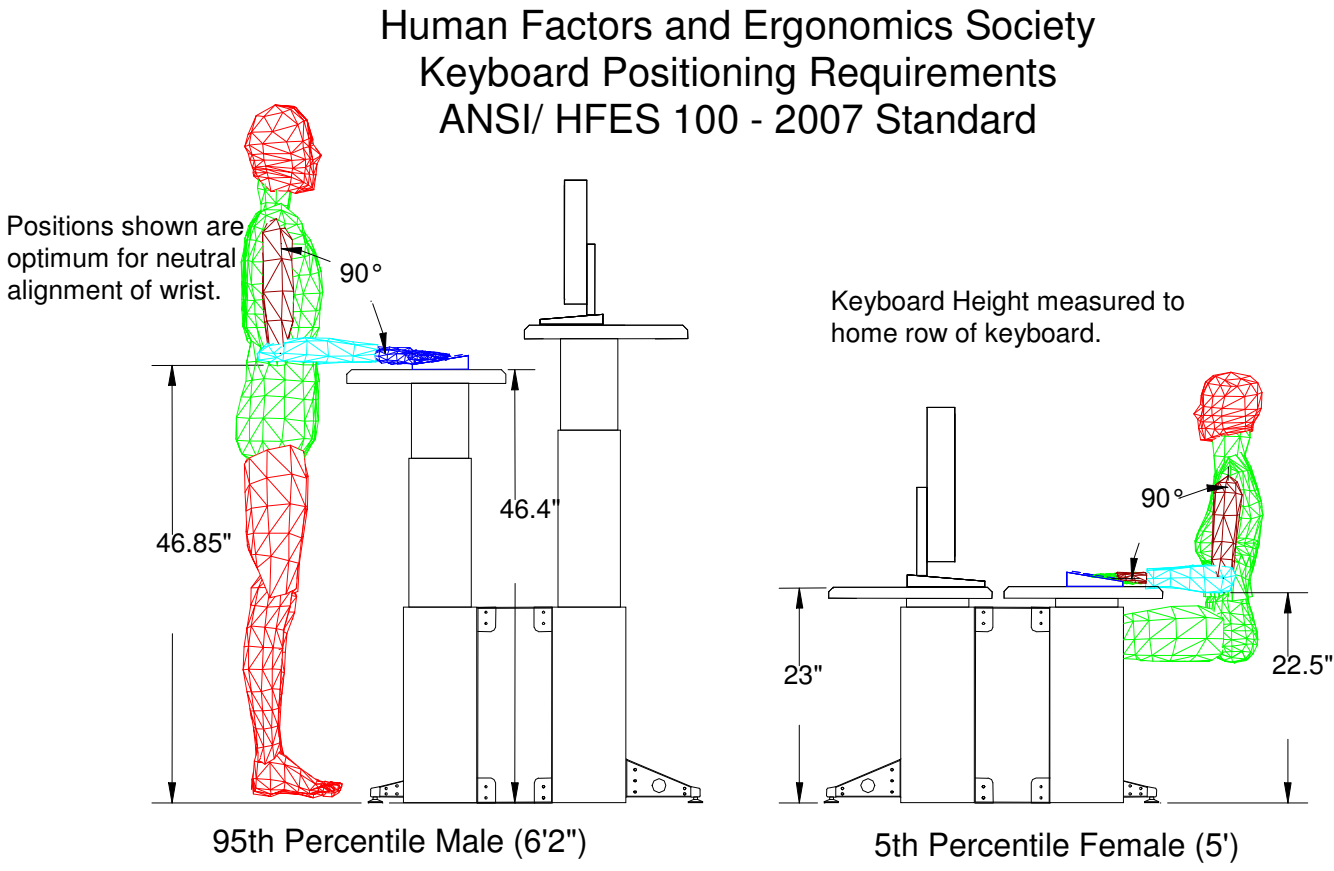
Input Surface Adjustment Range

d. **Adjustment Range** – The input surface adjustment range relates directly to ***elbow height*** of the 5th percentile seated female to the 95th standing male user. Specifications follow: "If height adjustable only, the input device support surface designed for *both sitting and standing* work postures **shall**
   i. **•Adjust in height between 56 cm and 118 cm (22 – 46.4")**
   ii. **•Comply with the clearance requirements specified in Section 8.3.2.1 when used in the seated position."**[2]



[2] ANSI/HFES 100 -2007 Human Factors Engineering of Computer Workstations©2007 HFES Section 8.3.2.4.3 p. 80

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2. **Monitor Support Surface –** The monitor support surface must not only adjust to position the user for proper view angles and correct focal lengths, it must also be designed to accommodate a range of monitor sizes and monitor mounting techniques while doing so. Most E-911 Dispatch communication centers use monitor sizes which range between 17" to 21" as the largest practical size. Proper design criteria would, therefore dictate that planning for a "worst case scenario" is prudent. XYBIX designs monitor surface adjustment ranges to meet ergonomic requirements for the use of a 21" monitor at the 5th percentile seated female posture and a 17" monitor at the 95th percentile standing male. This extends the adjustment range requirement somewhat, but guarantees that users can still adjust for proper position if monitor sizes change in the future.

   a. Adjustment Range – The adjustment range of the monitor surface is that which is necessary to accomplish the required -15° to -20° view angles below horizontal eye level to the center of the screen for the 5th percentile seated female (21" monitor) to the 95th percentile standing male (17" monitor) user.

      Note: This is particularly important in an E-911 Dispatch environment as the great majority of users are female (greater percentage of small users) - and many are of an age where the downward view angles are necessary to accommodate those who wear bi-focal or tri-focal corrective lenses.

      Compliance - Each vendor should submit a drawing which details monitor surface adjustment height, mounting details which show how high above the surface the monitors are mounted, and the size of the monitor being used. Generally, the combination of these elements should not place the top of the screen above the 5th percentile seated female user's horizontal eye height.

   b. View Angle - "The vertical height of a VDT screen represents a compromise between minimizing visual discomfort and musculoskeletal discomfort of the neck and shoulders. In general lowering a screen or increasing the viewing distance will reduce visual discomfort. However, lowering the screen increases the loading on neck and shoulder muscles. Display screen height above eye level has also been associated with musculoskeletal discomfort".[3] Specifications follow:
      i. "The entire visual area of visual display terminal workstations **should**
         1. Be located between 0° and 60° below eye height when users assume the upright sitting, declined sitting or standing reference posture.
      ii. The center of the visual display screen **should**
         1. Be located 15° to 20° below horizontal eye level
      iii. During work periods display screens **should not**

[3] ANSI/HFES 100 - 2007Human Factors Engineering of Computer Workstations©2007 HFES p. 18

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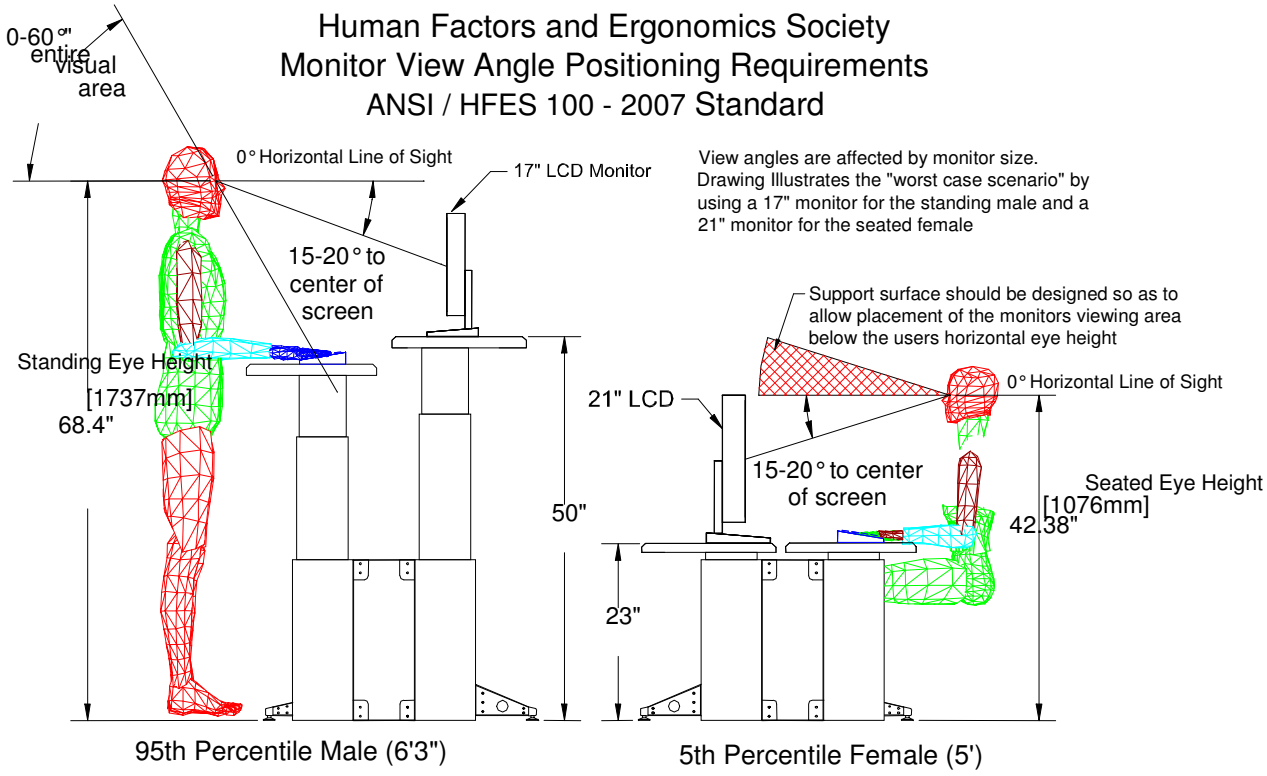
1. Be located more than 35° off axis (i.e. from the user's predominant line of sight) while the user is gazing straight ahead."[4]



Angles and heights based on ANSI/HFES 100 - 2007
Human Factors Engineering of Computer Workstations

[4] ANSI/HFES 100 -2007 Human Factors Engineering of Computer Workstations©2007 HFES p.18

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c. Focal Length - "Optimal viewing of a visual display is influenced by numerous factors in the workstation, such as the physical image quality of a monitor (resolution, addressability, pixel shape, sub pixel arrangement, luminance and color contrast, viewable screen size), the screen information layout and font characteristics (typeface, font size), the user's posture (angular alignment to the screen), visual capabilities (optometric corrections), and the ambient light conditions (screen illumination, glare, reflections). ***Display-support surfaces that allow adjustment of the alignment between the user and the viewable screen area during a work session are essential to achieving optimal viewing conditions.***[5] The elements relevant to Dispatch Furniture are the ability to adjust the distance and the alignment between the operator and the monitor screen.

   i. "Monitor Support surface – "The visual display support surface **shall**
      1. Allow users to adjust the line-of-sight (viewing) distance between their eye point and the front (first) surface of the viewable display area
      2. Allow users to adjust the tilt and rotation angle between their eye point and the front (first) surface of the viewable display area.

   ii. Monitor support surface – The visual display support surface **should**
      1. Allow users with normal visual capabilities to adjust the line of sight (viewing) distance between their eyes and the front (first) surface of the viewable display area within the range of 50 to 100 cm. (19.6-39.4")"[6]
      2. Maximum practical viewing distances are suggested to be: "Horizontal eye level to screen center angles of -15° to -20° at distances of 75 to 83 cm (29½" – 32½") appear to be a reasonable compromise"[7] (Sommerich, et al., 2001)

[5] ANSI/HFES 100 - 2007Human Factors Engineering of Computer Workstations©2007 HFES p. 18
[6] ANSI/HFES 100 – 2007 Human Factors Engineering of Computer Workstations©2007 HFES p. 17
[7] ANSI/HFES 100 – 2007 Human Factors Engineering of Computer Workstations©2007 HFES p. 19

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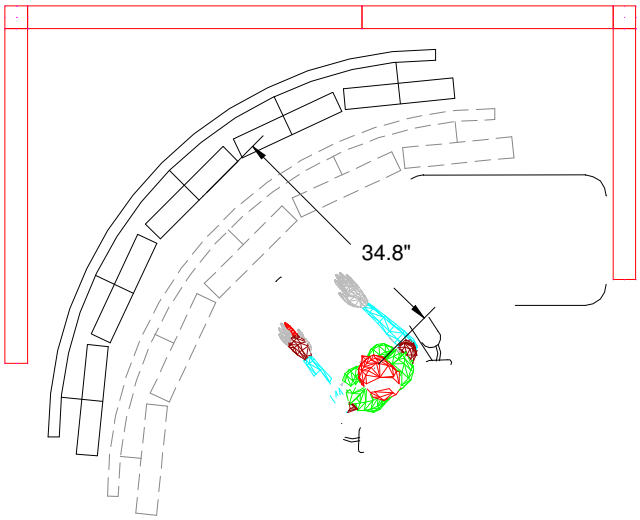
Monitor Focal Length Requirements
ANSI/HFES 100-2007



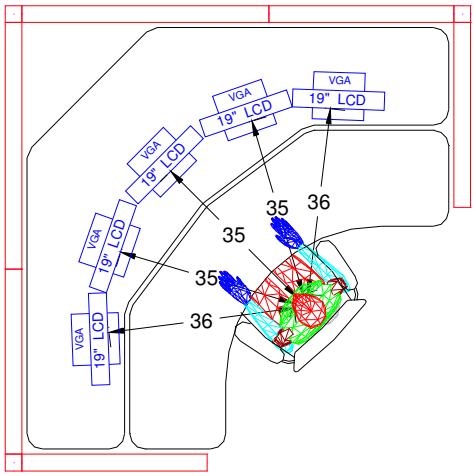
Minimum viewing distance 50cm (20")
Maximum viewing distance 83cm (32.7")

Visual Display Support Surface **Shall**

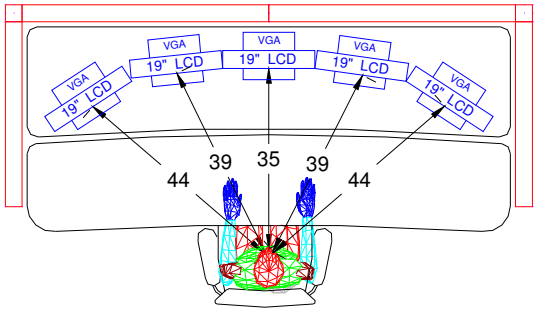
- Allow users to adjust the line-of-sight and viewing distance between their eye point and the front "first" surface of the viewable display area.
- Allow users to adjust the tilt and rotation angle between their eye point and the front "first" surface of the viewable display area.

d. Work surface shape – Work surface shape has significant ergonomic implications in multiple monitor situations experienced in E-911 Dispatch centers. Design criteria include the following:

i. Optimum monitor placement would locate monitors as close as possible to the same distance from the users' eyes in order to minimize the need for the eyes to re-focus when looking from screen to screen.
ii. The monitor screen should be as close to perpendicular to the users line of sight as possible



Cockpit workstation shape allows for consistent focal lengths. Eye strain is minimized. Monitor face is perpendicular to operator.



Rectilinear workstation shape creates inconsistent focal lengths. Eye strain occurs from re-focusing across monitors. Monitor face is not perpendicular to operator.

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Operator Clearances

e. **Operator Clearances** – "Operator clearance spaces under all working surfaces (i.e., primary work surface, display support surface, input device support surface) **shall** accommodate at least two of the three seated reference working postures, of which one must be the upright seated posture by using Method 1 or Method 2 as described below"[8] As Method 1 refers to seated postures only, Method 2 is appropriate for determining clearances of sit-to-stand workstations. Because Method 2 describes the largest operator clearance space, any operator clearance space that meets the specifications of Method 2 will automatically meet the operator clearance space specifications for upright seated and reclined seated postures.
Care must be taken to include any brackets or input platform support mechanisms which exist in the knee space of the user. The use of clearance boxes as defined in Section 8.4.1 Supplier Conformance[9] is recommended

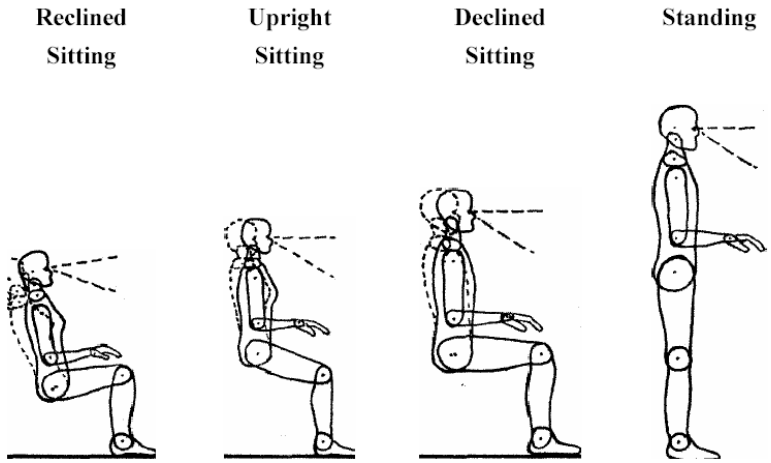

Figure 4 - Reference Postures

Reclined Sitting. In the reclined sitting posture, the user's torso and neck recline between 105° and 120° to the horizontal.

Upright Sitting. In the upright sitting posture, the user's torso and neck are approximately vertical and in line (between 90° and 105° to the horizontal), the thighs are approximately horizontal, and the lower legs are vertical.

Declined Sitting. In the declined sitting posture, the user's thighs are inclined below the horizontal, the torso is vertical or slightly reclined behind the vertical, and the angle between the the thighs and the torso is greater than 90°.

Standing. In the standing posture, the user's legs, torso, neck and head are approximately in line and vertical.[10]

[8] ANSI/HFES 100 - 2007 Human Factors Engineering of Computer Workstations©2007 HFES Section 8.3.2.1 p. 75
[9] ANSI/HFES 100 - 2007 Human Factors Engineering of Computer Workstations©2007 HFES Section 8.4.1 p. 84

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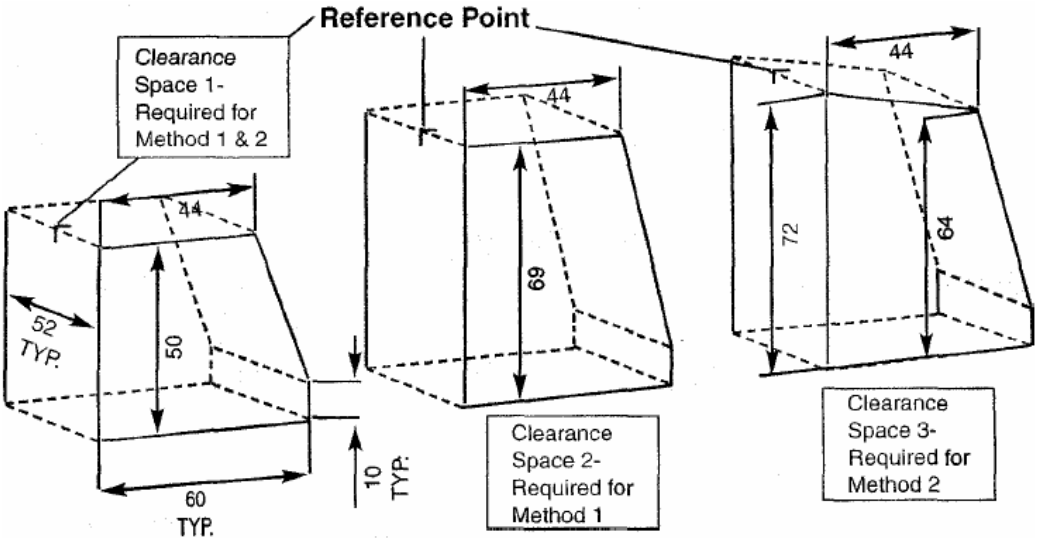
OPERATOR CLEARANCES



Supplier Conformance[11]

In order to evaluate the conformance of a surface to the required clearance for Method 2:

1. Place the furniture on a flat surface.
2. Determine the intended computer display and keyboard location(s).
3. Adjust the top of the input device surface to 56 cm.
4. Place the small seated operator clearance box (Clearance Space 1 box) under the surface, lining up the centerline of the box under the forward edge and center point of the surface.
5. Check for interference.
6. Determine intended computer display and keyboard location(s).
7. Adjust the top of the input device surface to 78 cm.
8. Place the Clearance Space 3 box under the surface, lining up the centerline of the box under the forward edge and center point of the surface
9. Check for interference.

[10] ANSI/HFES 100 - 2007 Human Factors Engineering of Computer Workstations©2007 HFES Section 8.4.1 p. 73

[11] ANSI/HFES 100 – 2007 Human Factors Engineering of Computer Workstations© 2007 HFES p. 84 - 85

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Supplier Conformance

Supplier Conformance – The intent of this section is to provide the user with a checklist and the tools necessary to determine the extent of compliance to the ANSI/HFES 100 - 2007 Human Factors Engineering of Computer Workstations standard that products of various manufacturers display and to provide a benchmark which can be used for an objective comparison.

1. Attached and identified as Appendix "D" is a matrix which identifies ANSI/HFES 100 – 2007 guidelines and allows the user to fill in the performance of various vendors for an objective comparison:

Summary: Good design allows people to work at their best with the least risk of injury.

Input (Keyboard) Surface design goals:

1. Strong and Rigid
2. Shape should optimize work surface space in users primary reach zones
    a. Corner or cockpit shapes are more effective than straight
3. Tilt can only be used on straight surfaces and is only required if adjustment ranges cannot be attained.
4. Required Adjustment Range – 22"-46.5"

Monitor Surface design goals:

1. Required Adjustment Range – as needed to achieve view angle guidelines
2. View angle to center of screen should be 15-20° below horizontal eye level
3. NO part of monitor screen should be above user's horizontal eye level
4. Focal Length from eyes to monitor should be easily adjustable from 20" to 32.5"
5. Work surface shape should allow monitors to have equal focal lengths
6. Work surface shape should allow monitors to be oriented perpendicularly to operators line of sight

Operator Clearance

1. Knee space under workstation should be free from obstructions
2. Clearance must include at least two of the seated postures including the upright seated posture.

The most expensive component of any communication center is the staff. Good design that follows national standards will improve performance, minimize injuries and reduce turnover. Best Practices demands that proper ergonomics be applied to all aspects of workstation design.

While sound ergonomic design is arguably the most important aspect of dispatch center furniture. There are many other factors to be considered including:

- Cable management
- Equipment Storage
- Finish Options
- Service and Installation

Xybix is an industry leader in all aspects of dispatch furniture. We look forward to working with you to make your project a success.

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Appendix D
Human Factors Engineering of Computer Workstations
ANSI/HFES 100 - 2007
Supplier Conformance Matrix

Ergonomic Performance Criteria	ANSI/HFES 100 - 2007	Xybix	Vendor B	Vendor C	Vendor D
Input Surface Adjustment Range	22" low 46.5" hi	23" low 50" hi			
Monitor Surface Adjustment Range in combination with monitor size and monitor mounting height – surface must be able to adjust so that the top of the viewing area of the screen is no higher than the 5th percentile seated female horizontal eye level (41.5") and that the specified view angles for the 95th percentile standing male user are achieved	-15° to -20° downward view angle from horizontal eye level to center of screen for 5th % seated female user to the 95th % standing male user	Drawing submitted detailing compliance including monitor height, mounting height and surface adjustment range			
Input Surface height required **for 5th percentile seated female user**	22"	23"			
Input Surface Height required for **95th percentile standing male user**	46.4"	50"			
Monitor (21") Surface Height required for 15° - 20° downward view angle to center of screen **5th percentile seated female user**	23"	23"			

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Ergonomic Performance Criteria	ANSI/HFES 100 - 2007	Xybix	Vendor B	Vendor C	Vendor D
Monitor (17") Surface Height required for 15° - 20° downward view angle to center of screen **95th percentile standing male user**	50"	50"			
Focal length (viewing distance) adjustability range	20" – 33"	20" – 33"			
Operator Clearance Method 2[12] **Clearance Space 3**	NO Interference	NO Interference			

[12]ANSI/HFES 100 – 2007 Human Factors Engineering of Computer Workstations © 2007 HFES p. 76

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