ERGONOMIC DATA FOR CONSOLE DESIGN

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INTRODUCTION

Console workplaces are suitable for many types of military and industrial jobs that involve monitoring a number of displays, making decisions based on information conveyed by the displays, and operating controls to carry out the decisions. Typical applications include air defense, air traffic control, nuclear power plant operations, industrial process control, and plant security.

The console designer is responsible for the basic configuration of the workplace and the placement of displays and controls. Visual displays must be located where they can be easily seen and interpreted, and controls should be placed where they can be easily reached. Hence, the anthropometric characteristics of the operators and their perceptual-motor capabilities and limitations must be known. Other factors that must be considered in order to maintain operator alertness and to minimize fatigue over long periods of time include operator comfort and safety (including body posture), mental workload, and task complexity.

A considerable amount of ergonomic data has been obtained to assist designers of console workplaces. This paper reviews those data concerning functional arm reach for horizontal and vertical work surfaces, three-dimensional reach envelopes, work surface height, primary and secondary visual work zones, reaction time as a function of control type and location, console configuration, and console dimensions. When properly applied, this information will enable designers to design consoles that ensure a high level of operator performance and system reliability.
The data reviewed in this paper and recommendations for console design were obtained primarily from technical publications originating in the United States and Canada. For a discussion of console design from a European perspective, see H. Rühmann's paper "Basic Data for the Design of Consoles".

FUNCTIONAL ANTHROPOMETRY

One of the prime requirements for the layout of any console is that all controls be located where they can be easily reached and manipulated. To achieve this, it is necessary to know just how far various percentages of the operator population can reach to perform anticipated tasks. Static anthropometric measurements (e.g., Webb Associates, 1978, Vol. II) have historically been less than satisfactory for predicting dynamic reaching capabilities. Functional anthropometric measurements, such as the ones described below, have been more successful.

Work Area for a Horizontal Surface

Most consoles have an extended shelf or other horizontal surface which may be used as a writing surface or for supporting books, telephones or other small items. Sometimes controls and operating diagrams are also placed on this surface.

Barnes (1949) has described the normal working area for a horizontal plane as the area that can be conveniently reached without extending the upper arm. The outer boundary for the right hand, according to Barnes, is a semicircle determined by sweeping the right hand and forearm across the work surface while the upper arm remains at the side of the body in a natural position. The boundary for the left hand is also a semicircle and is similarly determined. The normal work area was defined as the area enclosed by the two semicircular arcs. For males, the radius of each arc is 15 1/2 inches (39 cm). Barnes also described the maximum working area for a horizontal surface as the area that can be reached by extending the arm from the shoulder.

In later editions of his book, Barnes (e.g., 1958) cited a study by Farley (1955) which provides additional information concerning the dimensions of the normal and maximum work area and includes data for females as well as males. The radii of the arcs for females and males for the normal work area are 14 inches (36 cm) and 15 1/2 inches (39 cm), respectively. For the maximum work area, the radii are 23 1/2 inches (60 cm) for females and 26 1/2 inches (67 cm) for males. The work areas proposed by Farley, although similar in shape to those proposed by Barnes, are significantly smaller. Barnes assumed that the elbows rest near the front edge of the work surface, while Farley assumes a horizontal distance