

be obtained with the aid of the metrical and statistical techniques of anthropometry, a branch of physical anthropology dealing with the measurement of man.

It is suggested that the engineer consult with the anthropologist during the initial design stages rather than at a later period when modifications may be costly. Although handbooks of biological data are of value as general reference and orientation material for the industrial specialist, the technical background and experience of the anthropologist are desirable for the most efficient gathering, interpretation, and application of the data.

When the design engineer works in collaboration with the anthropologist he should be sure that the anthropologist (1) is adequately instructed as to the role of the man in the specific industrial operation; (2) knows the composition of the group of future operators in terms of age, sex, and any requirements used in personnel selection; (3) is aware of the body position(s) for operation of the equipment; and (4) is present to interpret and assist in the application of his data when the plans are being drawn.²

In some cases it may not be feasible or possible to design new machines "from the man out"; instead, the anthropologist may be forced to evaluate existing models. On such occasions the suggested procedure is as follows: he should, first, describe his population; second, ascertain the proportion of that population accommodated and the quality of that accommodation, with respect to comfort, efficiency, health, and safety; and, third, if not all operators are accommodated, establish size limits for selection and training. It seems obvious that a man should not be given intensive instruction only to find that he cannot fit the machine for which he has been trained; but such instances have occurred. In such a case the anthropologist must, fourth, then ascertain the nature and cause of any difficulties encountered and attempt to remedy them. His chief interest will inevitably be in specific installations within the working area, since these are usually responsible for many operational difficulties. After these first four steps have been taken, the experience gained in such evaluations should be used to set up criteria for new designs.¹¹

A. THE APPLICATION OF ANTHROPOMETRIC DATA

1. Traditional Anthropometric Measurements

Anthropometric measurements were originally devised to facilitate the study of evolution and race and hence some of the available data are of little use to the design engineer. In general, however, many of the traditional anthropometric dimensions are of some utility in problems of space design. For the most part they consist of body lengths, breadths, depths, and circumferences as illustrated

¹¹ R. A. McFarland, A. Damon, H. W. Stoudt, A. L. Moseley, J. W. Dunlap, and W. A. Hall, *Human Body Size and Capabilities in the Design and Operation of Vehicular Equipment*. Harvard School of Public Health, Boston, 1953.

in Figure 1. These static dimensions, as they may be called, are useful in determining clearances and allowances in the working area. Examples would be the minimum width of a chair as based on seat breadth, or minimum head clearance as based on sitting height or stature. In some cases new static measurements must be devised to fit special situations that arise only in space-design problems, such as the distance from the floor to the under side of thigh (popliteal height), when seated, in order to assure a comfortable seat height. For uniformity and accuracy all anthropometric measurements should be taken either by anthropologists or by those adequately trained in the techniques of anthropometry. Past experience has shown that human body dimensions taken during the course of routine military physical examinations, for example, can rarely be accepted at face value.

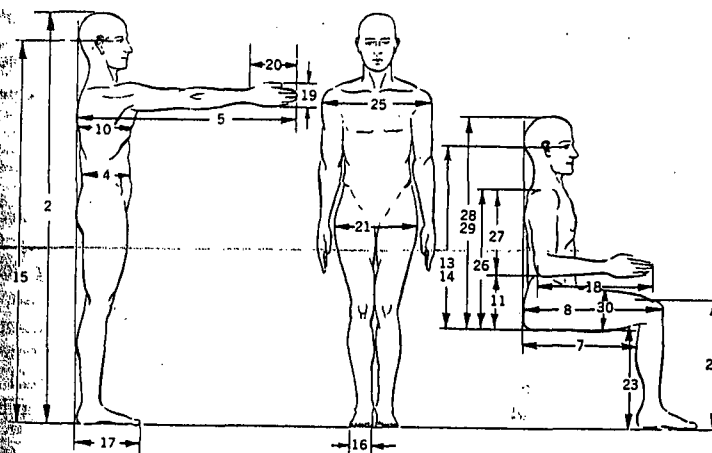


Figure 1. Body measurements applicable to various kinds of equipment design. The individual dimensions may be identified by number. See Table 1 for the means and standard deviations of these measurements for selected groups. (After Randall *et al.*)

It should be remembered that many industrial occupational groups are highly selected, differing from other groups and from the general public as well. Therefore the population that will use a given machine should be measured directly, if possible, or at least indirectly. This is good practice, especially where limitations of weight and space have been imposed upon the designer. An example of using noncomparable groups would be the application of measurements taken on men only when designing equipment to be used by a mixed population. Other difficulties will arise when an equipment dimension satisfactory for one condition conflicts with the requirements for a different condition. For example, Hooton studied a series of 3,867 people, using approximately equal numbers of both sexes,