

this would not be feasible unless there were no disadvantages entailed in sliding the buttocks forward in the seat. It should be noted that Garner,^{27,28} in two studies of industrial seating, believes that a depth of 11 inches will be ample.

Seat height. The height of the seat above the floor is most important to the comfort and efficiency of the worker. This is particularly true with excessive heights, which will cause pressures of a more or less injurious nature on the muscles and nerves of the under part of the thigh. Consequently, the seat should be sufficiently low to insure that the thighs can be kept free or almost free of the seat. This does not mean that a person may not find it comfortable to rest his thighs on the seat at times, but in general this is not a suitable position for extended periods. The pertinent body measurement in this case is taken from the floor to the tendons of the thigh in back of the knee (popliteal area) when the subject is in the sitting position.²⁹ In the general population, this body dimension (including shoe thickness) measures 16.9 inches for the 5th percentile or shortest group (men 17.6, women 16.7).¹² It is obvious that the maximum seat height should not exceed these figures; 1 inch less would be more satisfactory. If the legs must be extended forward for the operation of foot pedals, lower leg height is reduced, and it may be necessary to reduce further the height of the seat. Under most circumstances, provisions for the vertical adjustment of industrial seats will be both desirable and feasible. For many groups a 6-inch adjustability will be adequate, but since the requirements might vary considerably depending both on the body size range of the working population and on the type of work and movements required, it would be best to determine this range experimentally for individual situations.

Shape of seat. The shaped saddle-type seat with an elevation between the thighs generally has been found unsatisfactory since it requires the buttocks to be correctly fitted to the corresponding concavities of the seat. In theory, this would result in pressure being evenly distributed over the buttocks, a disadvantageous feature since both anatomical and physiological considerations make it desirable that the ischial tuberosities (the parts of the hip bones in contact with the seat) bear the larger part of the body weight. Edwards and Duntley have shown that the blood supply to the skin over the tuberosities is peculiarly adapted to weight-bearing.³⁰ The curvature of the tuberosities and their surface irregularity make it difficult to obtain definite measurements although, in general, they are slightly over 1 inch in breadth and about 1½ to 2 inches in length. Although the distance between the tuberosities is approximately 4¾ inches in men and 5 inches in women, there is enough variation in the size and shape of the buttocks so that a given shaped seat would be uncomfortable for a large percentage of any population. A generally flat surface would be superior. Since the tuberosities are so small, there is little use in having a very soft and resilient seat, for a large amount of

²⁷ B. Akerblom, *Standing and Sitting Posture*. A. B. Nordiska Bokhandeln, Stockholm, 1948.

²⁸ A. E. Edwards and S. Q. Duntley, The pigments and color of living human skin, *Am. J. Anat.*, 65, 1-34 (July, 1939).

the weight would be transferred to tissues that are not adapted for bearing it. The seat consistency, therefore, is one that gives only slightly under pressure.²⁹

Back rest. Two types of back rest may be used in industrial seating. One type consists of a large flat or curved surface that can support the entire area of the back. The back rest found in motor vehicles would be one such example. Provided only that they be about 18 to 20 inches high and about 20 inches wide, back rests of this type will be able to accommodate almost everyone in regard to the pertinent body dimensions.¹⁸

The second, and probably more common, variety consists only of a support for the lumbar region of the back, the area subject to the greatest strain. The swivel or stenographer's chair offers an example of this type of backrest. In such chairs it is desirable to leave a space below the lumbar support so that the buttocks can be shifted to the rear of the seat, thus giving a slight arch to the small of the back. Increasing or decreasing the arch in this manner creates further opportunities for the change of position important in maintaining comfort and in retarding the onset of fatigue.

The pertinent body dimensions in the construction of chairs with a lumbar support is the vertical distance from the seat to the top of the sacrum, at the position of the first lumbar vertebra. Fortunately, individual variation in this body dimension is slight, and the position of the lower edge of the lumbar support will be adequate if it is located no more than 7 to 7½ inches above the level of the seat.³¹ It should not be so high as to come into contact with the shoulder blades. In addition, the back rest should be curved to correspond as accurately as possible to the natural curvature of the lumbar region in the horizontal plane. On one male population, this curvature was found to approximate the arc of a circle of 7½ inch radius.³² If the back support is vertically adjustable, adequate provision can be made for virtually the entire population.

Slopes of seat and back rest. While the slopes of the seat and back rest are not primarily related to anthropometric measurements, brief mention of them should be made in any discussion of seat design. If the back rest is vertical it may give support to the small of the back, but it will be unable to support directly any of the weight of the body. When this is desirable, it is necessary to slope the back rest to the rear. More weight is carried by the back rest as its slope increases. In this way the supporting organs and muscles of the body will be relieved of part of their burden. Although the degree of inclination, if any, must vary with personal preference and job requirements, a slope in the vicinity of 15° from the horizontal is often found satisfactory. Under such conditions, if the seat is horizontal, pressure on the back rest will give rise to an opposing force that tends to push the buttocks forward on the seat. For this reason, the seat must

³¹ B. Akerblom, "Chairs and Sitting," in W. F. Floyd and A. T. Welford, eds., *Human Factors in Equipment Design*. H. K. Lewis, London, 1954, Ch. 5.

³² G. M. Weddell and H. D. Darcus, Some anatomical problems in naval warfare, *Brit. J. Ind. Med.*, 4, 77-83 (April, 1947).