

poses since he may be representative of the average in only one or a few of his physical dimensions. To illustrate, civilian males 69 inches tall (median value) have seat lengths throughout a range of about 17 to 21 inches and back heights that vary from about $26\frac{1}{2}$ to 31 inches so that the term "average" must be specifically qualified if it is to be of use for design purposes.¹⁷

b. *The Standard Deviation.* Owing to the numerous objections to the use of only average values in equipment design, a second statistical value, the standard deviation (S.D. or σ) is presented for the data in Table 1. This measures, in the same unit as the average or mean, the extent to which the individual values are scattered within the group. Sixty-eight per cent of any normal group will fall within the range of one standard deviation above and below the mean. A range of plus and minus two standard deviations will include 95 per cent of the whole series, and three standard deviations will include well over 99 per cent. Hence an inspection of both the mean and standard deviation of a normally distributed group indicates roughly how large a percentage of this group can be accommodated by a given measurement. For example, consider the body measurement of normal sitting eye height for commercial vehicle drivers (see Table 2). This is an important dimension used to establish the minimum and maximum allowable eye levels for adequate visibility and comfort. For this group the mean is 29.6 inches with a standard deviation of 1.2 inches. Thus, one can tell immediately that 68 per cent of the group have a normal seated eye level between 28.4 and 30.8 inches; 95 per cent between 27.2 and 32.0 inches and over 99 per cent between 26.0 and 33.2 inches.

c. *The Percentile Table.* In general, however, the most effective means of presenting data useful to the design engineer is the percentile table, a statistical device that can present the numerical values for a given dimension for any selected percentage of the population. Often the data may be given at 5 per cent intervals from the 5th percentile (only 5 per cent are smaller) to the 95th percentile (only 5 per cent are larger). Table 2 and Figure 2 illustrate this technique with regard to normal sitting eye height in commercial drivers. Thus a glance at the table shows not only the average or median value for this dimension but also the range for any given percentage of the population. With the aid of percentile distribution tables for certain selected human body dimensions, a given piece of equipment can be evaluated to determine what percentage of the operator population can be adequately accommodated in those dimensions, from the points of view of safety and efficiency. Examples might be the varying dimensions of the seat; height of a bench or table; various reach distances for controls, tools, or other items; location of eye level for adequate visibility; etc.

d. *Correlations.* Correlation tables of anthropometric dimensions show how one body measurement varies in relation to another measurement. For any given

¹⁷ F. E. Randall, A. Damon, and D. I. Patt, Human body size in military aircraft and personal equipment, *AAF Tech. Rept. 6601*, Air Materiel Command, Wright Field, Dayton, Ohio, June, 1946.

TABLE 2
Normal Sitting Eye Height¹¹
(Distribution in percentiles)

Percentiles	Inches (civilian drivers)
5	27.72
10	28.11
15	28.39
20	28.58
25	28.74
30	28.98
35	29.13
40	29.29
45	29.45
50	29.61
55	29.72
60	29.88
65	30.00
70	30.16
75	30.43
80	30.55
85	30.75
90	30.98
95	31.61

Number 309
Range: 26.38-32.68
Median: 29.61

Civilian Drivers

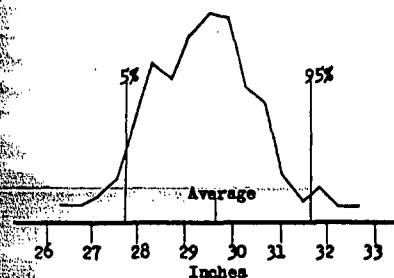


Figure 2—A graphic presentation of the data in Table 2. The eye-height-of-90-per cent of the group, 5th to 95th percentiles, varies from 27.7 to 31.6 inches, a range of about 4 inches. Assuming a single eye level for optimum visibility, 4 inches of vertical adjustability should be provided in the seat in order to accommodate this portion of the group. If only a single seat height is provided, based on the "average" eye level height, it may be 2 inches too low for the short man or 2 inches too high for the tall man. These measurements apply specifically to commercial bus and truck drivers and will probably differ for other working groups. (From McFarland, et al.¹¹)