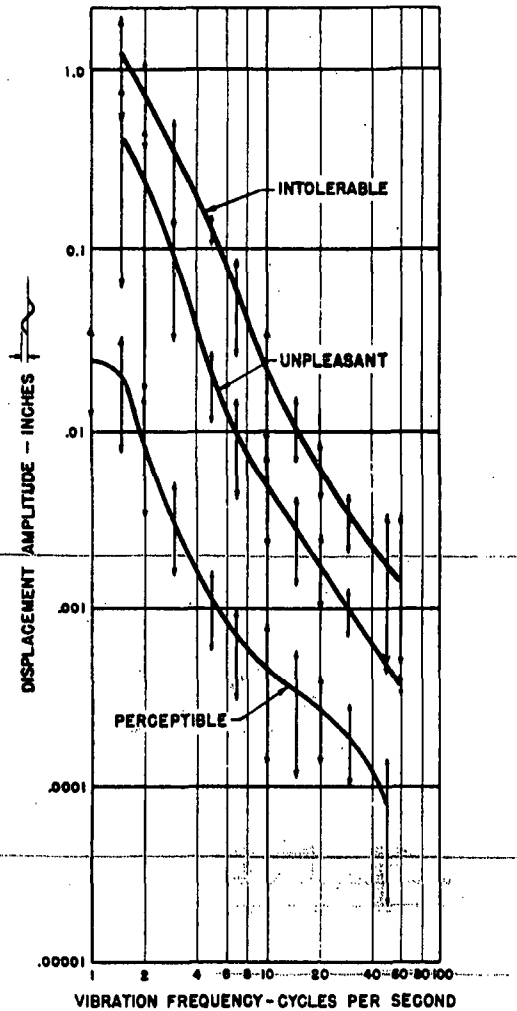

Figure 13. Subjective responses to vibratory motion. The chart is based on the averaged values of various investigators and is valid for exposures up to a few minutes. The vertical arrows represent one standard deviation above and below the means. (From Goldman.[100])

amplitude must be to maintain a given level of comfort, and vice versa. By referring to Figure 13 limits may be determined for any given amplitude or frequency.[100] Ideally, of course, both should be reduced as much as possible.

V. Summary and Conclusions

The objective of this chapter is to indicate methods of controlling the human factors involved in industrial accidents through the application of human engineering principles to problems of equipment design. It is emphasized that closer collaboration should be developed and maintained between the medical and biological scientist and the design and safety engineer. The latter can assist those concerned with human variables by defining the practical problems that exist in industry, while the former can furnish data in regard to human capabilities and limitations. The areas relating to human factors that have been found to have implications for industrial safety are outlined. Emphasis is placed on the fact that safety will be improved if mechanical design is more intimately related to the anatomical, physiological, and psychological characteristics of the operators of machines. This implies that machines and working areas be designed from the man outward, with the instruments and controls considered as extensions of his nervous system and body appendages. On the engineering side, an advance analysis of all possible faults in the equipment and working areas is necessary, for if defects are present, it is only a matter of time until some operator fails and has an accident. These operational analyses may be made with the aid of such techniques as interviews and questionnaires, time and motion studies, and the study of errors and near accidents.

After the biologist has become familiar with the specific industrial problems and working situations he can furnish the anthropometric data necessary to insure minimum clearances, adequate accessibility to controls and materials, and proper seat design. Anthropometric data and methods of application are presented, which should assist in this regard.

Consideration is next given to the design of displays and controls. Displays impart to the various sense organs information regarding the functioning of the machine or the equipment. Factors affecting visibility are discussed in relation to size of critical detail, contrast, illumination, time of exposure, and color. Experimental findings are reported in regard to optimum shape, size, and design of dials and indicators. Many of these findings are applicable to the design of gauges, graphic recording apparatus, and so forth, and various other industrial mechanical devices that are frequently misread or misinterpreted. The use of auditory, tactual, and kinesthetic displays that impart information to the workers is also discussed.

[100] D. E. Goldman, A Review of subjective responses to vibratory motion of the human body in the frequency range 1 to 70 cycles per second, *Project NM-004-001, Report 1,* National Naval Medical Research Institute, March, 1948. See also *Ride and Vibration Data,* Special Publications Dept. (SP-6) Soc. Automotive Engrs., New York, 1950.