

# **B11.TR1–2016**

**ANSI Technical Report for Machines –**

# **Ergonomic Guidelines for Design, Installation, and Use**

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## **Foreword**

The ANSI B11 Accredited Standards Committee (ASC) for Machine Safety formed a subcommittee consisting of professionals that are involved in manufacturing, safety, design and ergonomics to revise the 1993 technical report giving guidelines for the application of ergonomic principles to machines during the design, installation and use phases. The revised guideline, approved and published in 2004, is a significant change and upgrade from the 1993 guideline. It was updated in 2016 to incorporate additional information in the segmental vibration section and include updated ISO anthropometry discussion and references. Clause 2 references have been updated and there are some additions to the general references. New Annex H provides a listing of common ergonomic assessment tools for upper limb and multiple body applications with guidance for each on physical risk factors and body regions considered and tool complexity. This Technical Report Guideline is intended to be a hands-on design reference to help reduce or eliminate work-related factors associated with musculoskeletal disorders (MSDs) and injuries associated with human error.

This guideline offers an ergonomic risk assessment flow chart and risk reduction hierarchy referencing ANSI B11.0. This guideline is not intended to provide specific decisions as to risk acceptability nor replace existing ergonomic risk assessment tools now used within existing ergonomic programs. The guideline does offer ergonomic design references for strength, forceful exertions, posture, control and display selection and design, environmental exposures such as temperature, vibration, noise and illumination. Three sample checklists are offered in Annex G to assist with prioritizing risk factors for continuous improvements during design, installation and use.

In addition, Lifting, Lowering, Pushing, Pulling and Carrying Tables are provided in Annex C. The data in these tables were developed by Liberty Mutual and have been in use since 1978 (Snook 1978; Snook and Ciriello 1991). The Liberty Mutual Tables in Annex C differ from all previously published versions of the "Snook" Tables; e.g., population percentage is provided rather than maximum acceptable weights and forces. These tables are easy to use and flexible but ergonomic training as discussed in clause 9 is recommended before utilizing them.

## **Metric units**

While the body of this Technical Report conforms to the B11 ASC Metric Policy ('soft' metric units, followed by parenthetical 'hard' english units), space precludes conformance to this policy in some portions, e.g., many of the Annex tables.

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# Ergonomic Guidelines for the Design, Installation and Use of Machines

## 1 Scope and Purpose

This document provides ergonomic design guidelines intended to improve quality, performance and safety by reducing fatigue and injury associated with manufacturing systems, including individual and integrated machines and auxiliary components. It is intended to be a resource that can be applied to:

- a) Design or major modification, installation and use of machines and their auxiliary components;
- b) Design of a manufacturing system supporting machines and auxiliary components;
- c) Improve safety, quality and productivity, and reduce errors associated with a manufacturing system.

Integrating ergonomic concepts early in the design process should maximize the impact and cost effectiveness of ergonomic interventions during the design process. The goal of this document is to provide guidance on the practical application of ergonomic principles in order to avoid work-related injuries and musculoskeletal disorders (MSDs), increase productivity, and improve product quality.

This document is directed towards technicians, engineers, designers, and safety and health practitioners who deal with general ergonomic issues related to machines. It is not intended to replace in-depth analysis by qualified and experienced ergonomists.

## 2 References

The following references were either used as a basis for developing this document, or they represent other good reference sources that may be consulted for additional information on a particular topic.

1. The Ergonomics of Workspaces and Machines: A Design Manual, Clark, T.S. and Corlett, E.N. 2<sup>nd</sup> Edition, Taylor & Francis, London, UK 1995.
2. *Kodak's Ergonomic Design for People at Work*, Somadeepti N. Chengalur, Suzanne H. Rodgers, and Thomas E. Bernard, Second Edition, John Wiley & Sons, New York, 2004.
3. *Fitting The Task To The Human: A Textbook on Occupational Ergonomics*, Kroemer, K. & Grandjean, E. 5th Edition, Taylor & Francis, London, UK 1999.
4. *Human Factors Design Handbook*, 2nd Ed. Woodson, W., Tillman, B., & Tillman, P. McGraw-Hill, New York, NY 1992.
5. *Industrial Noise Control Manual*, NIOSH Technical Report 79-117, National Institute For Occupational Safety and Health, Cincinnati, OH 1978.
6. *Hearing Conservation Manual*, 5th Edition, Council for Accreditation in Occupational Hearing Conservation, Fairfax, VA 2014.
7. *Industrial Ventilation: A Manual of Recommended Practice for Design*, 28th Edition, ACGIH, Cincinnati, OH 2013.
8. *Human Factors in Engineering and Design*, Sanders, M. & McCormick, E. 7th Ed., McGraw-Hill, New York, NY 1993.
9. *The Occupational Ergonomics Handbook, Interventions, Controls and Applications in Occupational Ergonomics*, 2<sup>nd</sup> Edited by Karwowski, W., Marras, W.S., CRC/Taylor & Francis, 2006.
10. *Handbook of Human Factors and Ergonomics*, Salvendy, G., John Wiley & Sons, New York, NY, 2006
11. *Manufacturing Engineering Handbook*; Geng, Hwaiyu. 2nd Ed., McGraw-Hill, New York, NY, 2015
12. *Human Engineering Guide To Equipment Design*, (Van Cott & Kinkade), Am. Inst. for Res., Washington, D.C., 1972.