

IEEE Std 1023™-2004
(Revision of
IEEE Std 1023-1988)

IEEE Standards

1023™

IEEE Recommended Practice for the Application of Human Factors Engineering to Systems, Equipment, and Facilities of Nuclear Power Generating Stations and Other Nuclear Facilities

IEEE Power Engineering Society

Sponsored by the
Nuclear Power Engineering Committee



3 Park Avenue, New York, NY 10016-5997, USA

8 June 2005

Print: SH95309

PDF: S95309



Documents

Document Sharing Hub

Authorized licensed use limited to: Tsinghua University. Downloaded on March 05, 2026 at 05:19:25 UTC from IEEE Xplore. Restrictions apply.

Recognized as an
American National Standard (ANSI)

IEEE Std 1023™-2004(R2010)
(Revision of
IEEE Std 1023-1988)

IEEE Recommended Practice for the Application of Human Factors Engineering to Systems, Equipment, and Facilities of Nuclear Power Generating Stations and Other Nuclear Facilities

Sponsor

Nuclear Power Engineering Committee
of the
IEEE Power Engineering Society

Reaffirmed 28 June 2011
Approved 24 March 2005

American National Standard Institute

Reaffirmed 8 December 2010
Approved 8 December 2004

IEEE-SA Standards Board

Abstract: This document provides recommended practices for applying human factors engineering (HFE) to systems and equipment that have significant human interfaces in nuclear power generating stations and other nuclear facilities.

Keywords: control room design, ergonomics, human engineering, human error, human factors, nuclear power, nuclear facilities, task analysis, validation, verification

The Institute of Electrical and Electronics Engineers, Inc.
3 Park Avenue, New York, NY 10016-5997, USA

Copyright © 2005 by the IEEE.
All rights reserved. Published 8 June 2005. Printed in the United States of America.

IEEE is a registered trademark in the U.S. Patent & Trademark Office, owned by the Institute of Electrical and Electronics Engineers, Incorporated.

Print: ISBN 0-7381-4643-9 SH95309
PDF: ISBN 0-7381-4644-7 SS95309

No part of this publication may be reproduced in any form, in an electronic retrieval system or otherwise, without the prior written permission of the publisher.

IEEE Standards documents are developed within the IEEE Societies and the Standards Coordinating Committees of the IEEE Standards Association (IEEE-SA) Standards Board. The IEEE develops its standards through a consensus development process, approved by the American National Standards Institute, which brings together volunteers representing varied viewpoints and interests to achieve the final product. Volunteers are not necessarily members of the Institute and serve without compensation. While the IEEE administers the process and establishes rules to promote fairness in the consensus development process, the IEEE does not independently evaluate, test, or verify the accuracy of any of the information or the soundness of any judgments contained in its standards.

Use of an IEEE Standard is wholly voluntary. The IEEE disclaims liability for any personal injury, property or other damage, of any nature whatsoever, whether special, indirect, consequential, or compensatory, directly or indirectly resulting from the publication, use of, or reliance upon this, or any other IEEE Standard document.

The IEEE does not warrant or represent the accuracy or content of the material contained herein, and expressly disclaims any express or implied warranty, including any implied warranty of merchantability or fitness for a specific purpose, or that the use of the material contained herein is free from patent infringement. IEEE Standards documents are supplied “**AS IS.**”

The existence of an IEEE Standard does not imply that there are no other ways to produce, test, measure, purchase, market, or provide other goods and services related to the scope of the IEEE Standard. Furthermore, the viewpoint expressed at the time a standard is approved and issued is subject to change brought about through developments in the state of the art and comments received from users of the standard. Every IEEE Standard is subjected to review at least every five years for revision or reaffirmation, or every ten years for stabilization. When a document is more than five years old and has not been reaffirmed, or more than ten years old and has not been stabilized, it is reasonable to conclude that its contents, although still of some value, do not wholly reflect the present state of the art. Users are cautioned to check to determine that they have the latest edition of any IEEE Standard.

In publishing and making this document available, the IEEE is not suggesting or rendering professional or other services for, or on behalf of, any person or entity. Nor is the IEEE undertaking to perform any duty owed by any other person or entity to another. Any person utilizing this, and any other IEEE Standards document, should rely upon his or her independent judgment in the exercise of reasonable care in any given circumstances or, as appropriate, seek the advice of a competent professional in determining the appropriateness of a given IEEE standard.

Interpretations: Occasionally questions may arise regarding the meaning of portions of standards as they relate to specific applications. When the need for interpretations is brought to the attention of IEEE, the Institute will initiate action to prepare appropriate responses. Since IEEE Standards represent a consensus of concerned interests, it is important to ensure that any interpretation has also received the concurrence of a balance of interests. For this reason, IEEE and the members of its societies and Standards Coordinating Committees are not able to provide an instant response to interpretation requests except in those cases where the matter has previously received formal consideration. A statement, written or oral, that is not processed in accordance with the IEEE-SA Standards Board Operations Manual shall not be considered the official position of IEEE or any of its committees and shall not be considered to be, nor be relied upon as, a formal interpretation of the IEEE. At lectures, symposia, seminars, or educational courses, an individual presenting information on IEEE standards shall make it clear that his or her views should be considered the personal views of that individual rather than the formal position, explanation, or interpretation of the IEEE.

Comments for revision of IEEE Standards are welcome from any interested party, regardless of membership affiliation with IEEE. Suggestions for changes in documents should be in the form of a proposed change of text, together with appropriate supporting comments. Recommendations to change the status of a stabilized standard should include a rationale as to why a revision or withdrawal is required. Comments and recommendations on standards, and requests for interpretations should be addressed to:

Secretary, IEEE-SA Standards Board
445 Hoes Lane
Piscataway, NJ 08854-4141
USA

Authorization to photocopy portions of any individual standard for internal or personal use is granted by The Institute of Electrical and Electronics Engineers, Inc., provided that the appropriate fee is paid to Copyright Clearance Center. To arrange for payment of licensing fee, please contact Copyright Clearance Center, Customer Service, 222 Rosewood Drive, Danvers, MA 01923 USA; +1 978 750 8400. Permission to photocopy portions of any individual standard for educational classroom use can also be obtained through the Copyright Clearance Center.

Introduction

This introduction is not part of IEEE Std 1023-2004, IEEE Recommended Practice for the Application of Human Factors Engineering to Systems, Equipment, and Facilities of Nuclear Power Generating Stations and Other Nuclear Facilities.

The need for the application of human factors engineering (HFE) in the life cycle activities of nuclear power generating stations and other nuclear facilities has been demonstrated by plant operating histories and regulatory and industry reviews. Prior to the incident at Three Mile Island-Unit 2 (TMI-2) in 1979, little guidance for the application of HFE in nuclear facilities existed. Evaluation of the TMI-2 incident revealed that better application of HFE in nuclear power plant design could contribute to reducing human errors, mitigating events, and preventing accidents. Based on this potential for improved nuclear safety, the Nuclear Regulatory Commission instituted guidance for the incorporation of HFE principles in the design of nuclear power plants. Department of Energy laboratories and industry groups such as the Electric Power Research Institute and the Institute of Nuclear Power Operations have also provided research, studies, and methodologies to support the application of HFE to further the safe operation of nuclear facilities.

This Recommended Practice, IEEE 1023-2004, is provided to promote the systematic application of HFE in nuclear facility programs. It is intended to serve as the top-level program document under which additional standards are written or referenced to address specific technical needs. As the top-level document, it is beyond the scope of this Recommended Practice to offer the detailed guidance that is needed to support the various activities that may be implemented by such programs. However, since TMI 2, detailed guidance on many relevant topics has been provided by numerous sources. Such guidance may be accessed, for example, through the Bibliography given in Annex A.

This revision takes a more flexible approach than did its predecessor. A more flexible approach was deemed necessary to accommodate the Recommended Practice's expanded scope, which now 1) includes nuclear facilities besides power plants, and 2) addresses the entire facility life cycle (formerly just the design process). Flexibility was also warranted to balance the increased rigor of a Recommended Practice over a Guide, and to resolve the diversity of views existing on the Subcommittee.

In the revision process, efforts were made to add practical substance, to be compatible with other industry standards, and to consider current industry trends. A particular concern was to prepare for the increasing role of risk-informed and risk-based assessment in nuclear facility licensing and operation. The key notion of "significant human interface", retained from the original guide, was thus refined to incorporate and relate the concepts of acceptable performance, human error, and facility risk.

IEEE Std 1023 was initially published in 1988 as an IEEE Guide. The current revision was begun under Working Group 7.1 of Subcommittee 7, Human Factors and Control Facilities, and was completed under Working Group 5.1, Human Factors Applications and Methods, of Subcommittee 5 (SC-5) Human Factors, Control Facilities, and Reliability, of the Nuclear Power Engineering Committee of the IEEE.

Notice to users

Patents

Attention is called to the possibility that implementation of this standard may require use of subject matter covered by patent rights. By publication of this standard, no position is taken with respect to the existence or validity of any patent rights in connection therewith. The IEEE shall not be responsible for identifying patents or patent applications for which a license may be required by to implement an IEEE standard or for conducting inquiries into the legal validity or scope of those patents that are brought to its attention.

Errata

Errata, if any, for this and all other standards can be accessed at the following URL: <http://standards.ieee.org/reading/ieee/updates/errata/index.html>. Users are encouraged to check this URL for errata periodically.

Interpretations

Current interpretations can be accessed at the following URL: <http://standards.ieee.org/reading/ieee/interp/index.html>.

Participants

At the time this revision was completed the Human Factors Applications and Methods Working Group 5.1 had the following membership:

Hamilton C. Fish, *Administrative Chair*
Stephen Fleger, *Alternate Chair*
Robert B. Fuld, *Standard Champion*

William Banks
Valerie Barnes
Michael Boggi
James Bongarra
Ronald Bradford
Bruce Breslau
Ray Christensen
Andrew Dykes

Daryl Harmon
James Herrin
Jay Persensky
Sam Huertz
William Klein
Doug Lenker
Scott Malcolm
William Mangiante

John O'Hara
Julie Reed
Robert Sheranko
Robert Starkey
Eugene Trager
T. J. Voss
Robert Waters
James Zgliczski

The following members of the individual balloting committee voted on this standard. Balloters may have voted for approval, disapproval, or abstention.

Satish Aggarwal
Stan J. Arnot
Farouk Baxter
James Bongarra
Wesley Bowers
Daniel Brosnan
Robert Carruth
John Carter
Garry Chapman
Amir El-Sheikh
Hamilton Fish
Stephen Fleger
Ronald Fluegge
Jay Forster

Robert Fuld
Britton Grim
Randall Groves
Ajit Gwal
William Hadovski
Daryl Harmon
Wolfgang B. Haverkamp
David Horvath
Peter Hung
Paul Johnson
Gerald Lantz
John MacDonald
Faramarz Maghsoodlou
John Merando

Gary Michel
Brian Newell
Roger Parker
Julius Persensky
James Ruggieri
William Schwartz
Barry Skoras
Neil Smith
Richard Starck
James Stoner
John Taylor
James Thomas
T. J. Voss
Li Zhang

When the IEEE-SA Standards Board approved this standard on 8 December 2004, it had the following membership:

Don Wright, *Chair*
Steve M. Mills, *Vice Chair*
Judith Gorman, *Secretary*

Chuck Adams
H. Stephen Berger
Mark D. Bowman
Joseph A. Bruder
Bob Davis
Roberto de Marca Boisson
Julian Forster*
Arnold M. Greenspan

Mark S. Halpin
Raymond Hapeman
Richard J. Holleman
Richard H. Hulett
Lowell G. Johnson
Joseph L. Koepfinger*
Hermann Koch
Thomas J. McGean
Daleep C. Mohla

Paul Nikolich
T. W. Olsen
Ronald C. Petersen
Gary S. Robinson
Frank Stone
Malcolm V. Thaden
Doug Topping
Joe D. Watson

*Member Emeritus

Also included are the following nonvoting IEEE-SA Standards Board liaisons:

Satish K. Aggarwal, *NRC Representative*
Richard DeBlasio, *DOE Representative*
Alan Cookson, *NIST Representative*

Don Messina
IEEE Standards Project Editor

CONTENTS

1. Overview	1
1.1 Scope	1
1.2 Purpose	1
2. Normative references.....	1
3. Definitions	2
4. Systematic application of human factors engineering	3
5. Basic considerations of human factors engineering.....	3
5.1 Task considerations	4
5.2 Environmental considerations	6
5.3 Equipment considerations.....	7
5.4 Personnel considerations	8
5.5 Organization and support considerations.....	9
6. Implementation of human factors engineering activities.....	11
6.1 Engineering process model.....	11
6.2 Planning.....	12
6.3 Analysis	13
6.4 Specification	14
6.5 Testing and evaluation.....	16
6.6 Operations and maintenance.....	17
Annex A (informative) Bibliography	19
Annex B (informative) Sample implementations of HFE activities per the Star Model	21
Annex C (informative) Screening checklist	25
C.1 Task requirements	25
C.2 Control board, panel or rack modification	25
C.3 Component replacements	26
Annex D (informative) Design review checklist	28

IEEE Recommended Practice for the Application of Human Factors Engineering to Systems, Equipment, and Facilities of Nuclear Power Generating Stations and Other Nuclear Facilities

1. Overview

1.1 Scope

This document provides recommended practices for applying human factors engineering (HFE) to systems and equipment that have significant human interfaces in nuclear power generating stations and other nuclear facilities.

1.2 Purpose

This document provides recommended practices to engineering personnel for development of integrated programs for applying human factors engineering to the design, operation, and maintenance of nuclear power generating stations and other nuclear facilities.

2. Normative references

The following referenced documents are indispensable for the application of this document. For references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments or corrigenda) applies.

ANSI/ANS 3.1, Selection, Qualification, and Training of Personnel for Nuclear Power Plants.¹

ANSI/ANS 3.2, Administrative Controls and Quality Assurance for the Operational Phase of Nuclear Power Plants.

¹ ANSI publications are available from the Sales Department, American National Standards Institute, 25 West 43rd Street, 4th Floor, New York, NY 10036, USA (<http://www.ansi.org/>).

ANSI/ANS 3.5, Nuclear Power Plant Simulators for Use in Operator Training.

ANSI/ANS 58.8, Time Response Design Criteria for Safety-Related Operator Actions.

IEEE Std 497TM, Standard Criteria for Accident Monitoring Instrumentation for Nuclear Power Generating Stations.^{2,3}

IEEE Std 603TM, IEEE Standard Criteria for Safety Systems for Nuclear Power Generating Stations.

IEEE Std 845TM, IEEE Guide for the Evaluation of Human-System Performance in Nuclear Power Generating Stations.

IEEE Std 1082TM, IEEE Guide for Incorporating Human Action Reliability Analysis for Nuclear Power Generating Stations.

IEEE Std 1220TM, IEEE Standard for Application & Management of the Systems Engineering Process.

IEEE Std 1289TM, IEEE Guide for the Application of Human Factors Engineering in the Design of Computer-based Monitoring and Control Displays for Nuclear Power Generating Stations.

IEEE P1586TM (D1.0), IEEE Draft Recommended Practice for Human Interactions with Operating Experience Programs for Nuclear Facilities.⁴

3. Definitions

For the purposes of this recommended practice, the following terms and definitions apply. *The Authoritative Dictionary of IEEE Standards Terms, Seventh Edition*, should be referenced for terms not defined in this clause.

3.1 displays: Devices that convey information for perception by users, including but not limited to digital and analog instruments, computer screen pages, annunciator tiles, audible alarms, status lights, mimics, overviews, and indicating features of control devices.

3.2 human factors engineering (HFE): An interdisciplinary science and technology concerned with the process of designing for human use.

3.3 human error: Failure of human task performance to meet specified criteria of accuracy, completeness, correctness, appropriateness, or timeliness.

3.4 life cycle activities: The activities performed in order to plan, design, test, operate, maintain, and decommission any given facility.

3.5 significant human interface: A point of interaction between users and equipment, facilities, software, or documentation, where the resulting human performance is necessary for acceptable system performance, and the probability of human error contributes significantly to facility risk.

² IEEE publications are available from the Institute of Electrical and Electronics Engineers, Inc., 445 Hoes Lane, Piscataway, NJ 08854, USA (<http://standards.ieee.org/>).

³ IEEE standards or products referred to in this clause are trademarks of the Institute of Electrical and Electronics Engineer, Inc.

⁴ Numbers preceded by P are IEEE authorized standards projects that were not approved by the IEEE-SA Standards Board at the time this publication went to press. For information about obtaining drafts, contact the IEEE.

3.6 task: An orderly set of human actions or work behaviors that are performed to achieve a specific result.

3.7 usability: For a given human interface, the quality that acceptable human performance on necessary tasks can be readily achieved and sustained.

3.8 users: All members of the facility's technical staff, including but not limited to licensed operators, who perform testing, operations, maintenance, or decommissioning tasks on systems or equipment.

4. Systematic application of human factors engineering

Human factors engineering (HFE) should be planned as an integral part of life cycle activities. HFE should be implemented as an explicit part of coordinated planning (6.2), along with the other disciplines and processes that are required by any given activity. Planning for HFE activities should consider:

- a) Past experience and current practices, to identify relevant HFE concerns
- b) Applicability of available HFE studies, reports, guidelines, and methods
- c) Coordination of disciplines/groups/organizations to determine and perform HFE activities
- d) Development of plans and tools needed to perform HFE activities
- e) Trade-offs among HFE considerations and other life cycle activities

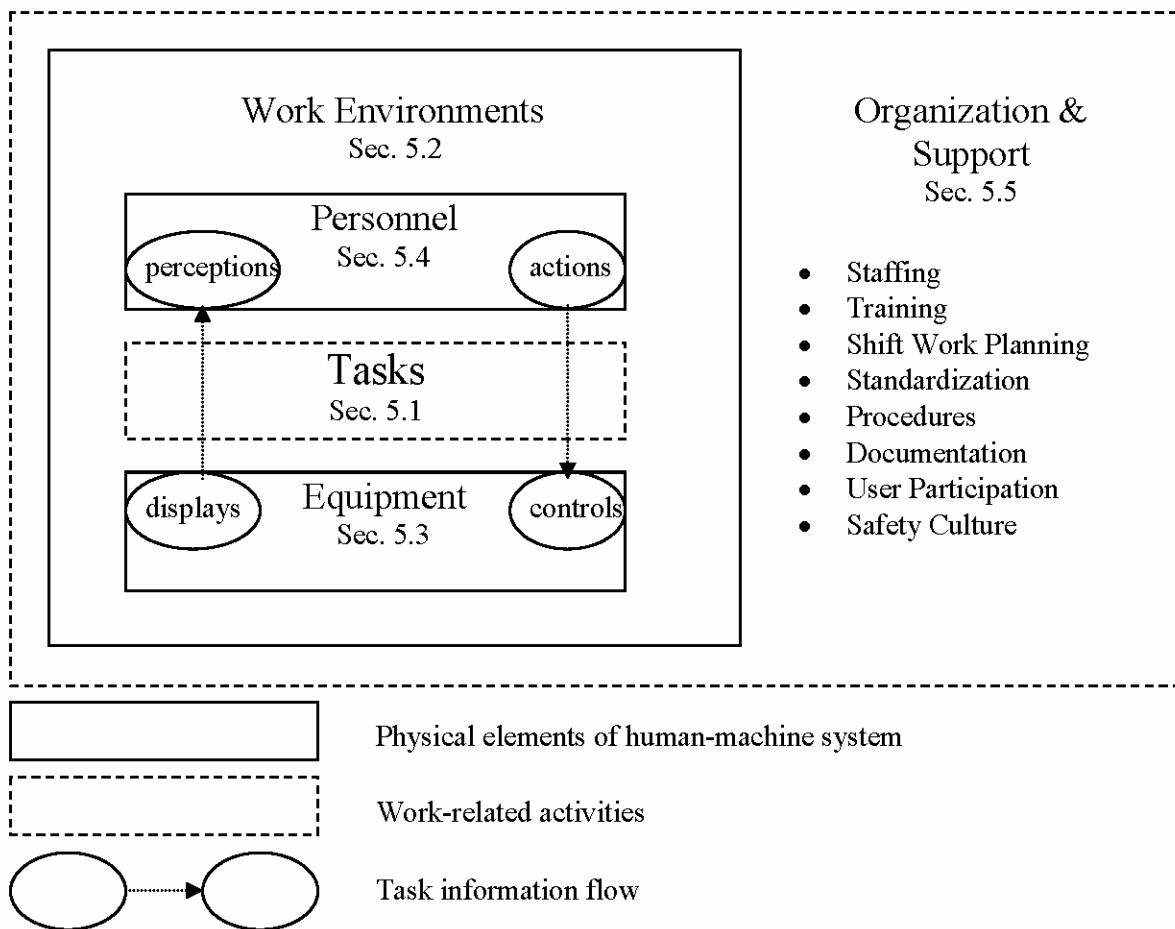
HFE should be an ongoing consideration in the evaluation or modification of existing designs, or in the development of new designs. Since the application of HFE affects interrelated life cycle activities, HFE should be considered as early as possible. Follow-up reviews should also be planned, to determine the effectiveness of HFE implementations.

5. Basic considerations of human factors engineering

Human factors engineering activities should address the following basic considerations of significant human interfaces throughout the project life cycle:

- a) Tasks
- b) Work environments
- c) Equipment
- d) Personnel
- e) Organization and support

These interrelated considerations are portrayed in Figure 1, and are addressed individually in 5.1 through 5.5.

**Figure 1— Basic considerations of HFE**

5.1 Task considerations

To ensure reliable human performance, the following considerations of tasks, task performance, and task support should be addressed in life cycle activities. Also see 6.3.3, Task Analysis.

5.1.1 Role of the user

The role of the user in a system consists of the human activities and responsibilities performed to achieve safe and effective system operation. This may be established by regulations or standards, by physical, environmental, or temporal constraints, or by the precedent of similar designs proven by operating experience. The user's role and the function of the associated equipment/process (6.3.2) should be complementary, so that the combined system is safe and effective. In terms of human performance, a user's role is acceptable if the required tasks can be achieved readily within normal human capabilities and limitations.