



IEEE Guide for Human Factors Applications of Computerized Operating Procedure Systems (COPS) at Nuclear Power Generating Stations and Other Nuclear Facilities

IEEE Power and Energy Society

Developed by the
Nuclear Power Engineering Committee

IEEE Std 1786™-2022
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STANDARDS

IEEE Guide for Human Factors Applications of Computerized Operating Procedure Systems (COPS) at Nuclear Power Generating Stations and Other Nuclear Facilities

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**Nuclear Power Engineering Committee
of the
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Approved 8 February 2022

IEEE SA Standards Board

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Abstract: The application of computerized operating procedure systems (COPS), their design (i.e., form and function), and use is presented in this guide.

Keywords: computerized procedures, human factors, IEEE 1786™, nuclear facilities

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Introduction

This introduction is not part of IEEE Std 1786-2022, IEEE Guide for Human Factors Applications of Computerized Operating Procedure Systems (COPS) at Nuclear Power Generating Stations and Other Nuclear Facilities.

IEEE Subcommittee 5 on Human Factors, Control Facilities, and Human Reliability (SC5), a unit of the IEEE Nuclear Power Engineering Committee (NPEC), has developed and maintained human factors engineering standards for nuclear facilities since the early 1980s. The SC5 has structured its standards in a hierarchical fashion. The top-level SC5 guidance document is IEEE Std 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.⁶ IEEE Std 1023 promotes the systematic integration of human performance considerations in the life cycle of commercial nuclear power plants and other nuclear facilities. IEEE Std 1023 is supported by additional standards written to address specific technical needs. IEEE Std 1786-2011 is an additional standard that provides guidance for the application of computerized operating procedure systems (COPS) in nuclear facilities.

The SC5 began considering the need for guidance on computerized procedures in the early 1990s. Since that time, advancing technology and experience demonstrated the viability of such systems, enabling the initial publication of this standard in 2011 with the consensus of industry, vendor, and regulatory participants.

Computerized operating procedure systems are systems used to present plant operating procedures via electronic visual display rather than hard copy (i.e., print) media. Using computers to present nuclear plant operating procedures has been explored at least since the early 1980s, with several commercial power plant applications implemented by the late 1990s. With the further implementation of highly computerized control rooms, the use of COPS will be increasingly widespread.

It is generally accepted that computers are well-suited to such tasks as monitoring, display, and logical evaluation of real-time data. These capabilities can address many of the routine problems that invite human error in the use of conventional, hard-copy operating procedures. At the same time, concerns remain about the impact of computers on the role and performance of human operators, and about the allocation of decision-making authority to computers. This document takes a conservative approach to these issues, such that the following principles are implicit throughout:

- Procedures are written directions for human operators, developed according to established procedure development guidance.
- When procedures are implemented by COPS, the role of COPS is to facilitate the human operator's elective use of those procedures.
- The established operator roles, directions given by a procedure (i.e., their structure, technical content, and so forth), criteria by which procedure content is judged acceptable, and the responsibility of the operator to best implement those directions, should not vary with the procedure media.

The recommendations for COPS can thus be guided, to some extent, by analogy to the organization and use of conventional hard-copy procedures. For example, operators should be able to report their locations in a procedure network at any time, as well as their reasons for being in that location. Capabilities that are not transparent to the operator, such as nondeterministic branching, dynamic structuring of procedure contents, or complex machine reasoning, are thus not recommended for COPS applications.

These guidelines should be implemented within the framework of a formal human factors program, including task analysis of the procedures to be computerized. Consideration of the user's needs and preferences will help ensure that COPS can be employed confidently and effectively.

⁶Information on references can be found in [Clause 2](#).

The guide consists of the primary guidance in [Clause 1](#) through [Clause 5](#), along with three annexes. [Annex B](#) and [Annex C](#) provide additional information (e.g., tutorials) for guide steps in [Clause 4](#) and [Clause 5](#).

The working group deemed certain topics to be outside the scope of this guide, on the basis that no unique considerations were identified for COPS and that general guidance was better provided elsewhere. These topics include the conduct of plant operations, control room communications, cybersecurity, display and control design, general human factors engineering, operator training, procedure development, system testing, and software development.

This 2022 revision updates the normative references in [Clause 2](#) and the bibliographic references in [Annex A](#) to provide more current lists. However, there have been no substantive changes to the normative text of this standard.

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1. Overview

1.1 Scope

This document provides guidance for the application of computerized operating procedure systems (COPS). This guidance concerns the design (i.e., form and function) and use of COPS. In general, this guide does not provide guidance for the technical content of the operating procedures being presented except as needed to address unique aspects of procedure implementation on COPS. Software tools that can be described as computerized procedures but reside outside the control room (such as might be used for maintenance or testing) are also beyond the scope of this document.

1.2 Purpose

The project is intended to provide application guidance, based on current industry experience, for the design and use of computerized operating procedure systems (COPS) at nuclear power generating stations and other nuclear facilities. This guide will identify acceptable practices and important considerations for applying COPS to facility operations. This guide is intended to support developers, users, and reviewers of COPS.

1.3 Word usage

The word *shall* indicates mandatory requirements strictly to be followed in order to conform to the standard and from which no deviation is permitted (*shall equals is required to*).^{7, 8}

The word *should* indicates that among several possibilities one is recommended as particularly suitable, without mentioning or excluding others; or that a certain course of action is preferred but not necessarily required (*should equals is recommended that*).

The word *may* is used to indicate a course of action permissible within the limits of the standard (*may equals is permitted to*).

The word *can* is used for statements of possibility and capability, whether material, physical, or causal (*can equals is able to*).

2. Normative references

The following referenced documents are indispensable for the application of this document (i.e., they must be understood and used, so each referenced document is cited in text and its relationship to this document is explained). For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments or corrigenda) applies.

IEEE Std 7-4.3.2TM, IEEE Standard Criteria for Programmable Digital Devices ~~Computers~~ in Safety Systems of Nuclear Power Generating Stations. 9,10 ~~1,2~~

⁷The use of the word *must* is deprecated and cannot be used when stating mandatory requirements, *must* is used only to describe unavoidable situations.

⁸The use of *will* is deprecated and cannot be used when stating mandatory requirements, *will* is only used in statements of fact.

⁹ ~~2~~ IEEE publications are available from the Institute of Electrical and Electronics Engineers, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331 ~~08854-4141~~, USA (<https://standards.ieee.org/> ~~http://standards.ieee.org/~~).

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

IEEE Std 1012™, IEEE Standard for Software Verification and Validation.

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

3. Definitions, acronyms, and abbreviations

3.1 Definitions

For the purposes of this document ~~guide~~, the following terms and definitions apply. The *IEEE Standards Dictionary: ~~Glossary of Terms & Definitions~~*³ Online should be consulted ~~referenced~~ for terms not defined in this clause.¹¹

active step: In the context of a computerized operating procedure system, a procedure step is active (i.e., has “active” status) while the step is selected on the system for evaluation and possible execution.

computerized operating procedure systems (COPS): Computer applications that present operating procedures to operators using an electronic visual display.

embedded soft control: The capability of a computer application (e.g., COPS) to issue, upon user demand, individual or sequential control commands for plant equipment.

fully determined: A statement (e.g., a procedure step) is fully determined if it is logically complete, such that it gives a deterministic result when evaluated for any given set of inputs.

¹¹ ³ ~~The IEEE Standards Dictionary: ~~Glossary of Terms and Definitions~~~~ Online is available at: <http://dictionary.ieee.org>.
~~<http://shop.ieee.org>. An IEEE Account is required for access to the dictionary, and one can be created at no charge on the dictionary sign-in page.~~

procedure-based automation: The evaluation and execution of a predefined sequence of procedure steps by COPS.

soft control: An element of a computer-generated visual display that is operationally equivalent to a physical device (e.g., a pushbutton, selector switch, potentiometer, component controller, and so forth) that is used to operate plant equipment upon user demand.

3.2 Acronyms and abbreviations

AOP abnormal operating procedure

ARP alarm response procedure

COPS computerized operating procedure systems

EOP emergency operating procedure

HFE human factors engineering

NOP normal operating procedure

4. Conceptual framework

4.1 General

The contents of this clause define the framework for the detailed design guidance that is presented in Clause 5. Additional information is contained in Annex B.

4.2 Human factors engineering principles for COPS

Human factors engineering (HFE) principles should be systematically considered throughout design and development process of COPS, including but not limited to the following:

- a) Prospective COPS users should be iteratively involved in the design process ~~so to ensure~~ that their needs are adequately addressed.

- b) Human operators are responsible for the proper application of operating procedures. Thus, COPS should be designed and implemented such that human operators remain in command of the processes being operated.
- c) The organization and structure of procedures on COPS should be compatible with the organization and structure of currently used paper-based procedures.
- d) COPS with sufficient capability may evaluate the logical conditions of one or more procedure steps, if the results in each case are fully determined by the step logic and the available process data. Steps with elements not fully determined ~~will~~ require a decision to be made by the operator. COPS should not make such decisions.
- e) Results produced by COPS evaluation should be the same as those expected from operator evaluations of the same steps.
- f) Loss of COPS should not affect the operator's ability to safely operate the plant.

4.3 Types of COPS

For the purposes of this guide, three types of COPS are identified, based on successive levels of functional capability. The capability of each type is assumed to include the capabilities of simpler types. Thus, a Type 2 system should address both Type 1 and Type 2 guidance, and a Type 3 system should address the guidance for Type 1, Type 2, and Type 3 systems (see Table 1).

4.3.1 Type 1 systems

Type 1 systems represent procedure text documents for operational use on a computer-generated visual display.

4.3.2 Type 2 systems

Type 2 systems use dynamic process data for embedded display, to evaluate conditions or procedure logic, or to monitor plant conditions during procedure-defined intervals of applicability. Type 2 COPS cannot issue control commands, but they may provide access to soft control capabilities that exist outside of the COPS.