# IEC 60960 Revision: Human Factors Issues in SPDS Design in Nuclear Power Plant


2024-03-26

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# Revision Process

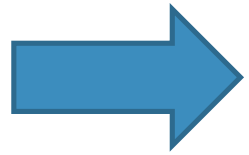
# 01 Revision Process

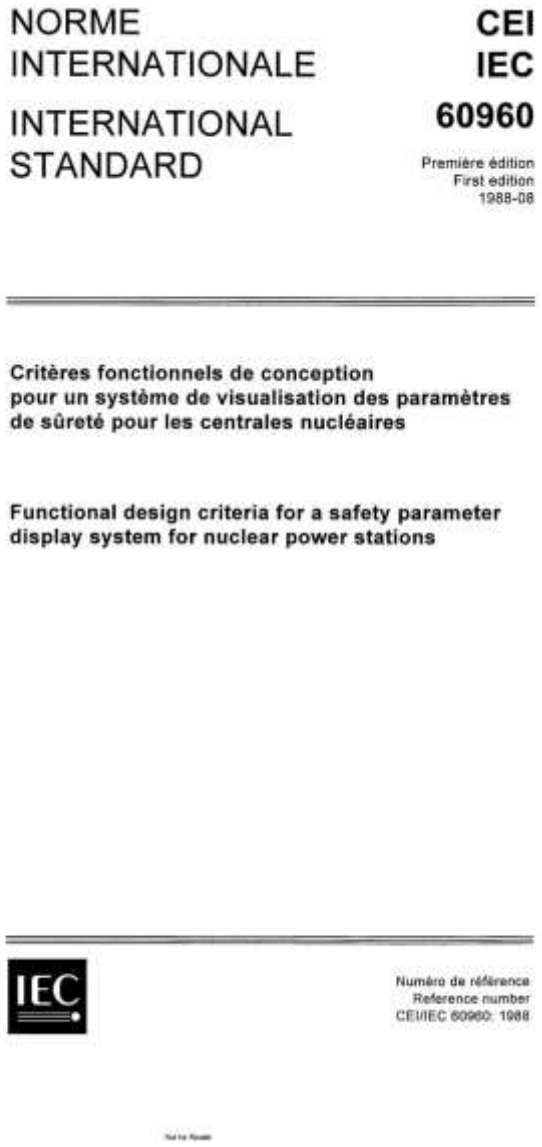


- **Oringin of IEC 60960-1988**

SPDS aims to make up for the deficiencies in displaying the safety status of nuclear power plants in HMI, drawing from the lessons of accidents related to the human-machine interface(HMI) and human factors engineering(HFE) in control rooms(CR) and emergency response facility(ERF) from the accidents in Three Mile Island.

**IEC 60960-1988: *Functional Design Criteria for a safety parameter display system for nuclear power stations*** was published to standardize the design of SPDS, in order to achieve functional performance goals as much as possible under the technical conditions at that time.





NORME INTERNATIONALE
INTERNATIONAL STANDARD

CEI
IEC
60960

Première édition
First edition
1988-08

Critères fonctionnels de conception pour un système de visualisation des paramètres de sûreté pour les centrales nucléaires

Functional design criteria for a safety parameter display system for nuclear power stations

IEC

Numéro de référence
Reference number
CEI/IEC 60960: 1988

# 01 Revision Process



## ● The Position of IEC 60960 in IEC/SC45A/WGA8

SC45A： Instrumentation, control and electrical systems of nuclear facilities

└ WGA8：Control rooms, Human-machine interfaces and Human factor Engineering

IEC 60960 is a human machine interfaces design related standard in the architecture

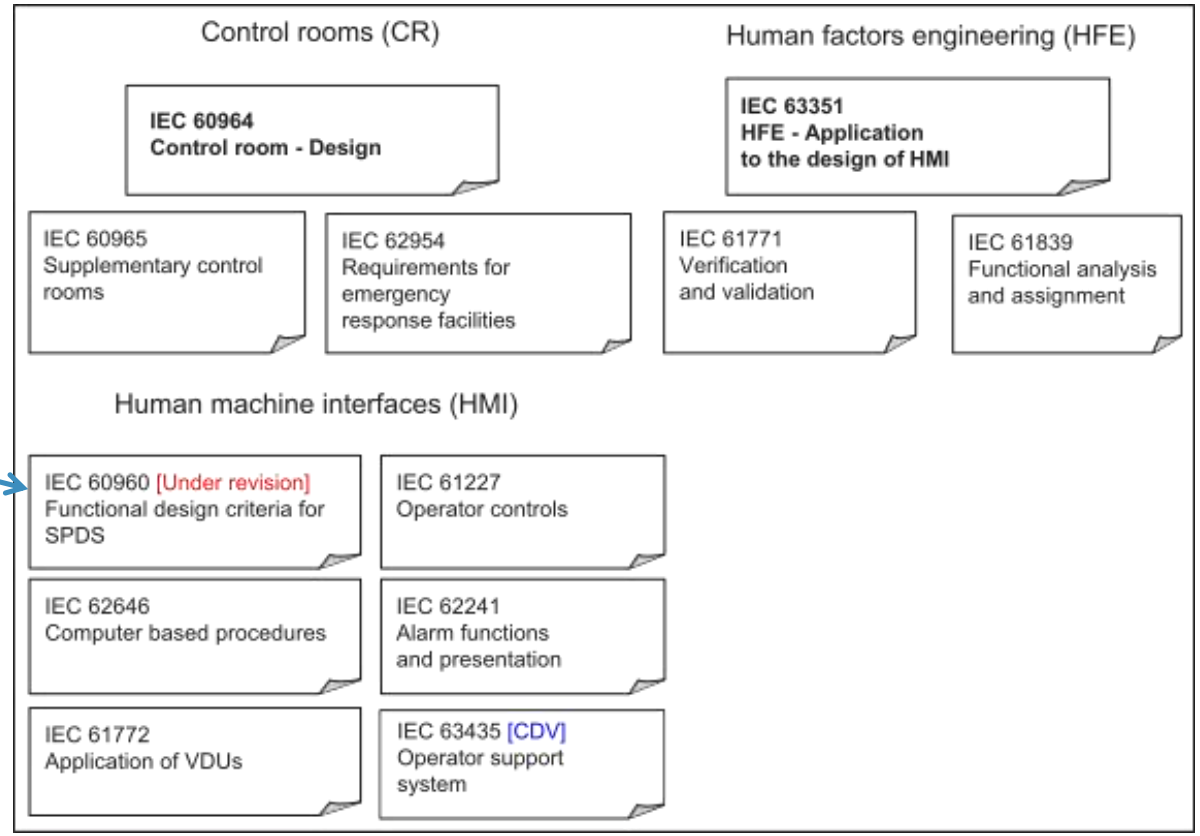



Figure from IEC/SC45A/WGA8

# 01 Revision Process



中国核动力研究设计院 Nuclear Power Institute Of China

深圳大学 SHENZHEN UNIVERSITY

- Our team is composed of members from the Nuclear Power Institute of China (NPIC) and Shenzhen University.

**2023-02-28**

Presented our revision intention for the first time at SC45A/WGA8 meeting.

**2023-10-18**

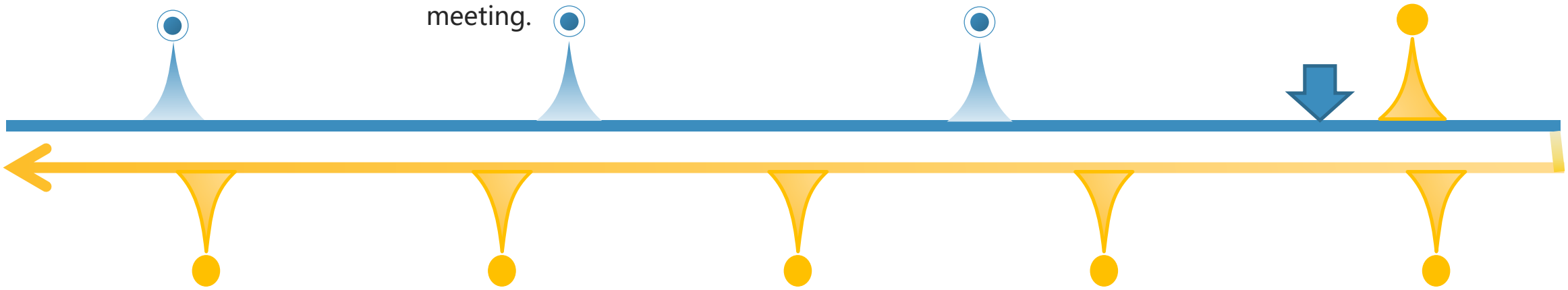
Presented and submited our Proposal of Revision at SC45A/WGA8 annual meeting.

**2023-12-26**

Submited the Working Draft Ver. 1.0. and gathering comments from WGA8 members.

**2024-03-27**

WGA8 Intermediate meeting for IEC 60960 Revision.



Standard publication.

**2026-10**

Plan to enter FDIS stage .

**2026-02**

Plan to enter CDV stage.

**2025-06**

Plan to enter CD stage.

**2024-10**

IEC/SC45A Secretariat will publish the Review Report (RR).

**2024-06**

# 02 Revision Orientations

# 02 Revision Orientations



## Scope of IEC 60960-1988

IEC 60960-1988 considers the **functional design criteria** for a Safety Parameter Display System (SPDS)

### Component

- Instruments
- Displays
- Hardware
- Computer software

### Form

- Standalone system, or
- Integrated into the control information system

### Function

- Provide information in a **concise** manner to aid reactor personnel, particularly under **abnormal conditions**.
- Display parameters associated with critical safety functions of **light water reactors** by computer-based systems:
  - Reactivity control
  - Reactor coolant system integrity
  - Reactor core cooling
  - Heat removal from the primary system
  - Radioactivity control
  - Containment integrity

### Scope

IEC 60960-1988 provides functional design criteria only and is only applicable to plant control rooms that are **not designed in accordance with the IEC control room design standard**.[1]

[1] IEC control room design standard series were not completed when IEC 60960-1988 released. It made up for the design absence in the built and under construction control room.

# 02 Revision Orientations



## ● Overview of Functional Design Criteria in IEC 60960-1988

### Provided Information :

- Necessary under normal transient and accident condition(pre- and post-)
- Concise and minimum set of plant parameters

### Form

- Standalone system, or
- Integrated into the control information system

### Location

- Applicable in CR and ERF (no reduction in SPDS performance)

### Display

- Two display: primary for presenting states with critical safety functions and alerting opeartors while significant change ; second for auxiliary information.
- Minimum operation action to change displays.
- Capable to continuous display and presenting magnitude and trends of parameters.

### Data Validation

- Identify unvalidated and relevant information
- Train operators to resovle unsuccessful data validation.

### Interfaces

- Electrical isolation and physical seperation with safety system.

### Training and procedures

- Operator shall handle the transient and accident conditions both with and without SPDS available.

### • Availability

- Above cold shutdown status: unavailabillity goal maximum 0.01

- Cold shutdown and refulling mode:
- unavailabillity goal 0.2

# 02 Revision Orientations



## Revise Motivations

- Continuous improvement of the control rooms and HFE design system for nuclear power plant by IEC ;
- Different types of reactors (HWRs, HTGCRs) implemented SPDS ;
- The application of digital technology (digital display, digital data transmission, computer performace improvement) in SPDS;
- The application of intelligent technologies.

**The development over these years (1980s~recent years)**

**Our revise motivations**

- However, IEC 60960 is still in the 1st. Edition in 1988.
- IEC 60960-1988 needs to be revised.

# 01 Revision Orientations



## Revision Orientations

### To update the normative references

- Queto latest related standards of IAEA/IEC.

### To adapt to the format template of the IEC standard

- Accordance with requirements in ISO/IEC Directives, Part 2.

### To adapt to different types of reactors

- Mention 3 fundamental safety functions which are applicable to different reactor types. Specific parameters need to be analyzed and carried out based on actual engineering conditions.
- List examples for types of reactors such as HWRs and HTGCRs, in informative Annexes.

# 02 Revision Orientations



## Revision Orientations

### To incorporate the requirements for digital technology applications

- Add new requirements for digital display.
- Add recommendations for applying digital data channel/network.
- Add HMI/V&V/Availability requirements for integration with plant computer system.

### To Implement the design principles of HFE

- Be compatible with the requirements in HFE and control room design standard systems.
- Add requirements for SPDS used by different users, such as personnel in CR, ERF and sometimes Nuclear safety Authority.

### To consider the introduction of intelligent technology

- Consider the interfaces between functions via advanced technologies with SPDS , to better aid the detection and diagnosis.

# 03 Revision Contents

# 03 Revision Contents



- **Revision Contents**

CONTENTS



*Add clause "Introduction"*

*Add clause 2 "Normativereferences" /Clause 3 " Terms and definitions" / "Abbreviations"*

*Add Appendix B/C respectively for lists of critical safety function meassurements for a HWR and HTGCR.*

# 03 Revision Contents



## Foreword/ Introduction

Descriptions：

- Make adaptive modifications according to the latest IEC file format.

## 1 Scope

Descriptions：

- Expand the applicable scope of the reactor types.
- Expand the standard application range to “control rooms of nuclear power plants designed according to IEC control room design standards.”
- Add the background of SPDS development.
- Add the relationships with other standards.

## 2 Normative references

Descriptions：

- Change IEC 639 to IEC 60709.
- Added some referenced standards, such as IEC 60964-2018, IEC 63351-20xx, etc.

## 3 Terms and definitions

Descriptions:

- Add terms and definitions according to the specific revision content, such as control room staff, nuclear safety engineers, emergency response staff, operating procedures, etc.

## 4 Abbreviations

Descriptions:

- Add relevant abbreviations according to the specific revision content, such as Safety parameter display system (SPDS), human factors engineering (HFE), human-machine interfaces (HMI), etc.

# Revision Contents



## 5 General performance requirements

Descriptions:

- Add suggestion: "SPDS can be fully integrated with the computer and control system of the nuclear power plant."
- Supplement: SPDS can provide display content and operational requirements for severe accidents.
- Add suggestion: "The supplementary control room can have SPDS functionality."
- Add the application content of the HFE design guidelines, making it clear that: Carry out SPDS design according to the HFE framework of IEC 63351 and control room design framework of IEC60964.
- According to the current functional safety objective decomposition carried out by IAEA and engineering design, SPDS design should meet the safety parameter display requirements needed for functional safety objectives.

## 6 Functional design criteria

Descriptions：

- Add methods of selecting safety parameters that cover the safety functions of different reactor types.
- Provide examples of safety functions for other reactor types, in addition to light water reactors,
- Supplement: The HMI of SPDS should consider the requirements for diverse digital displays.
- Supplement: Provide suggestions for secondary data processing and intelligent functions in SPDS.
- Supplement: The VDUs of SPDS should meet the application requirements referenced in IEC61772.
- Supplement: SPDS design should follow the principles of HFE design, including general HFE principles, function requirements analysis and allocation, and V&V. Specifically, function analysis and allocation should be carried out according to IEC61839, and V&V should be conducted according to IEC61771.

## 7 Functional testing

Descriptions：

- Supplement the requirements that the functional tests of the SPDS in a digital nuclear power station can be integrated into the V&V of the integrated control room.
- Supplement the relevant requirements in the software V&V of SPDS.
- Supplement the requirements for V&V of HFE in SPDS.

# Revision Contents



## 8 Location

Descriptions:

Supplement the statements that the SPDS in a digital nuclear power plant can share equipment with computerized workstations, such as operator stations in control areas like the main control room and supplementary control room.

## 9 Staffing

Descriptions:

Supplement the users of SPDS, such as nuclear safety engineers, emergency response personnel, safety regulatory personnel, etc.

## 10 Design criteria for the instrumentation system input to the SPDS

Descriptions:

- Add the requirements of IEC 63147.
- Update the reference from IEC 639 to IEC 60709.

## 11 Training and procedures

Descriptions:

Supplement the requirement that SPDS design should consider the integration with the operating procedures.

## 12 Availability

Descriptions：

Supplement the statement that "For nuclear power plants where SPDS is integrated with a computer and control system, the availability requirements of SPDS can refer to the availability requirements of the plant computer information and control system."

## Annex A (May add annex)

Descriptions:

- Appendix A: Supplement parameters for severe accidents, such as in-core temperature, pressure vessel water level, etc.
- Consider adding the lists of critical safety function measurements for other reactor types, such as heavy water reactors, etc.

# 04

# Discussion on HFE and HMI Issues in Design

# Discussion on HFE and HMI Issues in SPDS Design



## Discussion 1: the development trend SPDS form

Examples of data acquisition and distribution systems are shown in Figures 2 and 3 of this document. The configuration in Figure 3 is the anticipated data acquisition system that will be implemented. If the conditions of Section 2.8 are met, the configuration shown in Figure 2 could be acceptable. (subclause 7.2 in NUREG-0696)

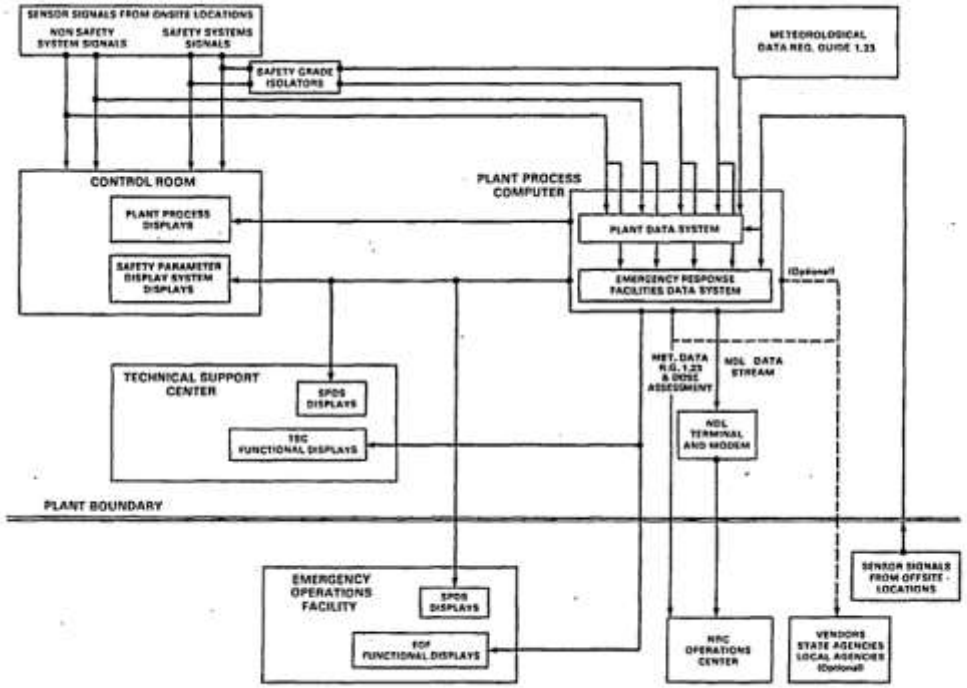



Figure 2. Example of a Functional Block Diagram of Data Flow Using Plant Process Computer.

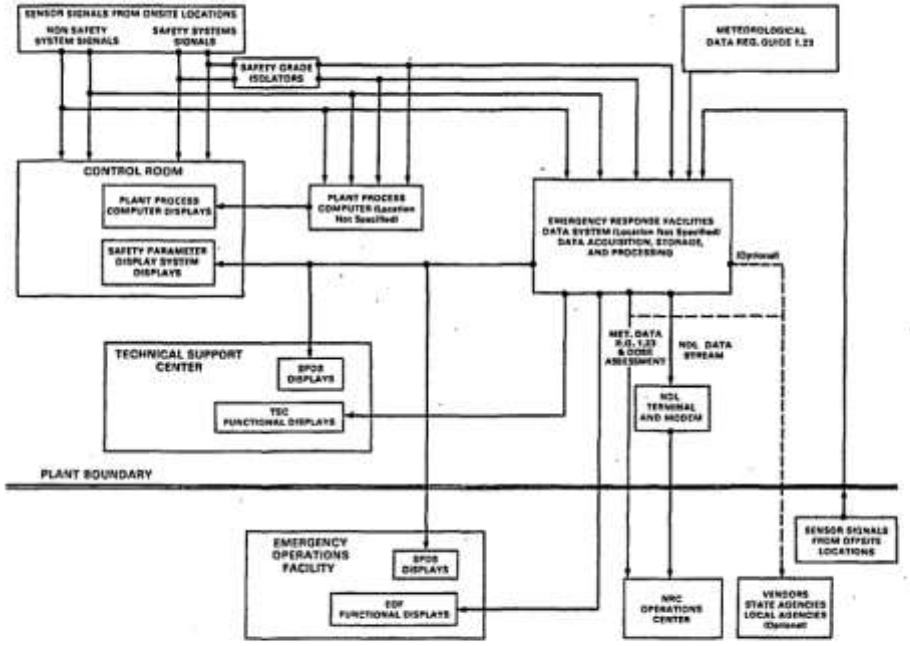



Figure 3. Example of Functional Block Diagram Flow Without Using Plant Process Computer.

# Discussion on HFE and HMI Issues in SPDS Design



**Discussion 2: The methods of combining SPDS with Symptom-based emergency operating procedures like SEOP.**

**Discussion 3: Is it necessary to require SPDS to provide the function of overall safety status in severe accidents, as there are safety level devices such as PAMS that display serious accident status at present ?**

# Discussion on HFE Issues in Control Room Design



**Discussion 4: Experiment methods of personnel performance monitoring in one of the HFE factors in NPPs. Where are the sources of Experiment data, what are the evaluation methods, and how to analyze the results ?**

**Discussion 4: Application of methods in HFE other than FA&A and TA in NPPs and other energy facilities. For example, Focus analysis method, etc.**

# Thanks You!

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Nuclear Power Institute Of China

2024-03-27