

TECHNICAL REPORT

ISA-TR101.02-2019

HMI Usability and Performance

Approved 24 June 2019

ISA-TR101.02-2019, HMI Usability and Performance

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Preface

This preface, as well as all footnotes and annexes, is included for information purposes only and is not part of ISA-TR101.02-2019.

This technical report has been prepared as part of the service of ISA, the International Society of Automation, toward a goal of helping in the understanding and use of the ANSI/ISA-101.01-2015 standard as applied for usability and performance. To be of real value, this document should not be static but should be subject to periodic review. Toward this end, the Society welcomes all comments and criticisms and asks that they be addressed to the Secretary, Standards and Practices Board; ISA, 67 T.W. Alexander Drive; P.O. Box 12277; Research Triangle Park, NC 27099; United States of America; Telephone +1-919-549-8411; Fax +1-919-549-8288; E-mail: standards@isa.org.

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Foreword

The ISA101 standards development committee was established by ISA's Standards & Practices to create standards and technical reports for computer-based human-machine interfaces (HMI) for the process industries. In 2015, the committee's first standard was approved by the American National Standards Institute and published as ANSI/ISA-101.01-2015, *Human Machine Interfaces for Process Automation Systems*. Starting in late 2015, the ISA101 committee established working groups to produce technical reports to augment the standard with additional rationale, usage guidelines, and examples in different areas of human-machine Interfaces. Four technical reports are being created by these working groups:

- WG1 – HMI Philosophy, Style Guide & Design Guide
- WG2 – HMI Usability and Performance
- WG3 – HMI for Mobile Platforms
- WG4 – HMI for On-Machine Applications

Each technical report is intended to be a stand-alone document. To minimize repetition, the technical reports have cross references.

This technical report (TR), ISA-TR101.02-2019, is designed to provide guidance, rationale, and examples for those with a need for understanding and application of ISA-101 for usability and performance.

ISA-TR101.02 is organized into two parts. The first four clauses are introductory in nature. The main body (Clauses 5-7) present information and examples on how sections of the HMI lifecycle activities described in the ISA-101 standard apply to the usability and performance of the HMI. To facilitate use of this TR as an extension of the standard, Clauses 5-7 refer to the same lifecycle activities in both the standard and this TR.

Readers should be aware that following the recommended guidance in this TR will not necessarily ensure that HMI problems will be avoided. It will, however, help to identify and address HMI specification, design, implementation, and management opportunities important to the usability and performance of the HMI. It may also help minimize performance or usability issues that could complicate and frustrate an operator's awareness, understanding, and response to abnormal situations.

The guidance as presented in this document is general in nature and should be applied to each system as appropriate by those knowledgeable in the given manufacturing processes and control systems. Selection of activities and practices for a given system is the responsibility of the users and/or support staff of the system.

It is intended that TR will be updated over time, as experience is gained. As such, while the general format of this guidance is expected to remain relatively stable, the specifics of its application and specific solutions are expected to evolve. ISA welcomes and encourages readers to send suggestions and input to improve the content of this document to standards@isa.org.

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1 Scope

1.1 General applicability

This ISA technical report (TR) addresses the specification, design, implementation details, and management (recommended practices) of an HMI (Human-Machine Interface) focused on usability and performance. It explains how the ANSI/ISA-101.01-2015 standard (called hereafter ISA-101) applies to determining the best solution in order to achieve the process goals using examples that have been shown to be effective.

The ISA-101 standard covers the HMI lifecycle, including all general concepts until its decommissioning, applying a practical and management approach.

The purpose of having an automated process is to enhance process operations based on safety, performance, process improvements, availability, repeatability, and other relevant factors. HMIs are the main interface for users to interact with the process itself and they have the opportunity to facilitate operation or confuse users. This TR was written to provide guidance for the use of the ISA-101 standard as it applies to usability and performance, with due consideration to other guidance documents that have been developed throughout industry. Refer to clause 2 for references to these documents.

HMI enhancements for improved usability and performance are often associated with additional specifications, custom design, implementation, and management considerations, in addition to vendor-provided functionality and features. This technical report is intended to include examples of these considerations within the HMI lifecycle, including the continuous work processes of audit, validation, and management of change (MOC).

2 References

The following is a list of normative and informative documents referred to within this technical report. Users should identify the normative references applicable to their project.

2.1 Normative references

ANSI/ISA-101.01-2015, *Human Machine Interfaces for Process Automation Systems*

ANSI/ISA-18.2-2016, *Management of Alarm Systems for the Process Industries*

ANSI/ISA-88.00.01-2010, *Batch Control Part 1: Models and Terminology*

ANSI/ISA-62443 and IEC 62443, *Security for Industrial Automation and Control Systems*

ANSI/HFES 100-2007, *Human Factors Engineering of Computer Workstations*

ANSI/HFES 200-2008, *Human Factors Engineering of Software User Interfaces*

ISO 11064-1:2000, *Ergonomic design of control centres -- Part 1: Principles for the design of control centres*

ISO 11064-2:2000, *Ergonomic design of control centres -- Part 2: Principles for the arrangement of control suites*

ISO 11064-3:1999, *Ergonomic design of control centres -- Part 3: Control room layout*

ISO 11064-4:2013, *Ergonomic design of control centres -- Part 4: Layout and dimensions of workstations*

ISO 11064-5:2008, *Ergonomic design of control centres -- Part 5: Displays and controls*

ISO 11064-6:2005, *Ergonomic design of control centres -- Part 6: Environmental requirements for control rooms*

ISO 11064-7:2006, *Ergonomic design of control centres -- Part 7: Principles for the evaluation of control centres*

2.2 Informative references

1. Bullemer, P. T., Reising, and D. V. *Effective Console Operator HMI Design: Second Edition - Revised* (ASM Consortium Guidelines). Published by CreateSpace Independent (2015).
2. Engineering Equipment Materials Users' Association. *Alarm Systems – A Guide to Design, Management and Procurement*. EEMUA Publication No. 191 (London: EEMUA, 2013).
3. Engineering Equipment Materials Users' Association. *Alarm Systems – Process Plant Control Desks Utilizing Human-Computer Interfaces*. EEMUA Publication No. 201 (London: EEMUA, 2010).
4. Endsley, M. R. *Designing for Situation Awareness: An Approach to User-Centered Design*, 2nd Edition. CRC Press (2016).
5. Hollifield, B., Oliver, D., Nimmo, I., and Habibi, E. *The High Performance HMI Handbook*. Houston, PAS (2008).
6. Hollifield, B., and Perez, H. *High Performance HMI Case Studies, Recommendations, and Standards*, Part 2 of 2, White Paper. Houston, PAS.com (2015).
7. Ware, C. *Information Visualization: Perception for Design*. Elsevier (2012).
8. GAMP (Good Automation Manufacturing Practices). *Guide for Validation of Automated Systems in Pharmaceutical Manufacture*. ISPE (International Society for Pharmaceutical Engineering) (January 2008).
9. Few, Stephen. *Information Dashboard Design: Displaying Data for At-a-Glance Monitoring*, 2nd Edition. Analytics Press (2013).
10. ISA-TR18.2.1-2018, *Alarm Philosophy*
11. National Eye Institute. https://nei.nih.gov/health/color_blindness/facts_about. (Last accessed October 16, 2018).

12. Liptak, Bela G. (Editor). *Instrument Engineers' Handbook, Vol. 2: Process Control and Optimization*, 4th Edition, Section 4.11. CRC Press (2006).
13. Pikaar, R.N. HMI conventions for process control graphics. *Work*. 2012, 41, 2845-2852. IOS Press
14. Pikaar, R., de Groot, N., Mulder, E. and Remijn, B. 2016. Human Factors in Control Room Design and Effective Operator Participation. *SPE Intelligent Energy International Conference and Exhibition*. September 2016. Society of Petroleum Engineers.
15. Fitzpatrick, B. A. Section 4.11, DCS: Management of abnormal conditions. In B. Liptak (Ed.), *Instrument Engineers' Handbook, Vol. 2: Process Control and Optimization*, 4th Edition. CRC Press (2006). 706-718.

3 Definition of terms and acronyms

3.1 Definitions

Unless noted, the following definitions used in this technical report are defined in ISA-101 Clause 3 and repeated here.

3.1.1

alarm

an audible and/or visible means of indicating to the operator an equipment malfunction, process deviation, or abnormal condition requiring a timely response [ANSI/ISA-18.2-2016]

3.1.2

alert

an audible and/or visible means of indicating to the operator an equipment or process condition that requires awareness and which does not meet the criteria for an alarm [ANSI/ISA-18.2-2016]

3.1.3

aspect ratio

the ratio between the total horizontal and total vertical pixels on a screen (e.g., 4:3 or 16:9)

NOTE Displays designed for one aspect ratio screen (e.g., 4:3) may appear distorted when shown on a screen with a different aspect ratio (e.g., 16:9).

3.1.4

auditory signal

a particular, unique, recognizable sound used to convey a particular, unique meaning

3.1.5

call up time

the lapsed time for all display elements to be refreshed after a display change has been requested

3.1.6

commissioning

procedures prior, or related, to handing over a system for placing into service. These procedures often include acceptance testing (FAT, SAT and SIT); handing over of drawings and documentation; delivering instructions for operation, maintenance, and repair; and providing training to personnel.

3.1.7**console**

the hardware, software, and furniture or enclosure at which users monitor and/or control the process, which may include multiple stations, communication devices, and other devices (e.g., cameras, barcode devices, pushbutton stations)

3.1.8**control room**

a room with at least one HMI console from which a process is monitored and/or controlled and possibly containing other control system equipment and/or other facilities for operators

3.1.9**control system**

a system that responds to input signals from the equipment under control and/or from an operator and generates output signals that cause the equipment under control to operate in the desired manner [ANSI/ISA-18.2-2016]

3.1.10**controller**

the hardware which executes functions for monitoring and control of one or more process variables

NOTE In some industries, the primary user of the HMI is called the controller. Within this technical report, the term controller is used as defined in ANSI/ISA-101.01-2015 Clause 3.1.12.

3.1.11**dashboard**

a graphical summary showing various pieces of important information typically used to give an overview of a process or part of a process

3.1.12**display (graphic, window)**

a visual representation of the process and related information used by the operator for monitoring and control

3.1.13**display style (display format, graphic layout)**

a description of the generic layout of a display and its presentation of information, not referring to any particular content

3.1.14**drill-down**

a method of navigation in which successive displays show increasing detail for smaller subsets of the system scope

3.1.15**faceplate**

a display, part of a display, or popup used for monitoring and/or direct operation of a single control loop, device, sequence, or other entity

3.1.16**graphic element**

a component part of a graphic symbol, such as a line or circle

3.1.17

graphic symbol

a visual representation of a process component, instrument, or condition in a display composed of a combination of simple graphic elements

3.1.18

human factors engineering (HFE, ergonomics)

a scientific discipline concerned with the understanding of interactions between human and other elements of a system that applies theory, principles, data, and methods to design in order to optimize human well-being and overall system performance

3.1.19

human machine interface (HMI, HMI system)

the collection of hardware and software used by the operator and other users to monitor and interact with the control system and with the process via the control system

3.1.20

keyboard

an input device that allows the user to type characters, values or commands to affect the control system

3.1.21

margin

the space between an object and surrounding objects on a display or between an object and the edge of the display

3.1.22

monitor (video display unit, VDU, computer screen, LCD display) - noun

an electronic device for the display of visual information in the form of text and/or graphics

3.1.23

monitor - verb

to maintain awareness of the state of a process, by observing variables or the change of variables against limits or other variables, to keep track of operations and enable timely and appropriate response to abnormal conditions

3.1.24

navigation

a function which supports users in locating desired information in an HMI-based information system, and also in guiding the selection of displays, or the act of selecting a display

3.1.25

operator

the primary user of the HMI, the person who monitors and makes changes to the process

NOTE In some industries, the primary user of the HMI is called the controller. Within this technical report, the term controller is used as defined in ANSI/ISA-101.01-2015 Clause 3.1.12.

3.1.26

padding

the space between the border of a display object and the image or text inside the display object border

3.1.27**performance factors**

expectations, agreed beforehand, that help define desired work-related behavior, skills, and performance

3.1.28**platform**

a particular family of HMI products capable of using a common toolkit

3.1.29**pointing device**

an input device which translates physical movements to movements of a pointer, cursor or other indicator across the screen (e.g., a mouse, trackball, or touchscreen)

3.1.30**popup (popup display, overlay)**

a display that appears (pops up) in the foreground of the screen, possibly obscuring part or all of other displays

3.1.31**resolution (screen resolution)**

the size and pixel density of the screen, usually specified by the number of vertical and horizontal pixels (e.g., 1024 horizontal x 768 vertical) and the diagonal dimension. The resolution determines the fineness of detail that can be distinguished in an image on a screen. Alternately, this fineness of detail can be specified in pixels per linear dimension (e.g., 96 DPI – dots per inch).

3.1.32**remote terminal unit (RTU)**

one or more monitoring and/or control devices at a location geographically separate from, but communicating with the control center (e.g., in a Supervisory Control and Data Acquisition (SCADA) system)

3.1.33**salience**

distinctiveness, prominence, obviousness, or conspicuousness of a graphic symbol or other part of a display, for the purpose of quickly drawing operator attention

3.1.34**screen**

the part of the monitor that shows an image

NOTE 1 See Resolution, Clause 3.1.31, for more information.

NOTE 2 Some computer operating systems support a software “screen” (desktop) spanning multiple monitors, but for the purposes of this technical report, a screen is the part of a single monitor on which displays are shown.

3.1.35**script**

a code module which performs tasks executed on the HMI platform and usually invoked by some operator action or other control system event

3.1.36

situation awareness

the relationship between the operator's perception of the plant's condition and its actual condition at any given time

3.1.37

station (workstation)

the primary user interface which includes one or more monitors and supporting software, user input devices (e.g., keyboard, pointing device), and output devices (e.g., speaker, printer)

3.1.38

supervisory control and data acquisition (SCADA)

a system for monitoring and control of processes which are geographically widespread. This includes all equipment and functions for acquiring, processing, transmitting, and displaying the necessary process information.

3.1.39

tag (point)

the unique identifier assigned to a process measurement, state, calculation, device, or other entity within the HMI or controller

3.1.40

task analysis

a method of extracting a user's requirements based on a review of tasks performed by the user

3.1.41

toolkit

a collection of custom or pre-defined HMI configuration items that reduce time and effort to produce a control system

3.1.42

trending

a feature for displaying real-time and/or historical data in various chart formats, usually with respect to time

3.1.43

usability

the extent to which a system can be used by specified users to achieve specified goals with effectiveness, efficiency, and satisfaction in a specified context of use

3.1.44

validation (qualification)

process of demonstrating by examination, testing, or other objective evidence that the HMI, as installed, meets applicable requirements and specifications

NOTE Requirements and specifications include HMI philosophy, HMI style guide, and user, task and functional requirements.

3.1.45

verification

process of demonstrating by examination, review, testing or other objective evidence that the outputs of an HMI lifecycle activity meet the objective and requirements defined for the activity

3.1.46**yoking (spawning, linked navigation)**

a method by which specific combinations of related displays and display contents are called up via a single navigation action (commonly used with multiple monitors)

3.2 Acronyms

Acronyms used in this technical report are defined in ISA-101 Clause 3 and repeated here. Additional acronyms used but not previously defined are found below as well.

ANSI: American National Standards Institute

BPCS: Basic Process Control System

CCTV: Closed Circuit Television

DCS: Distributed Control System

FAT: Factory Acceptance Test

HFE: Human Factors Engineering

HFES: Human Factors and Ergonomics Society

HMI: Human Machine Interface

I/O: Input / Output

KPI: Key Performance Indicator

MOC: Management of Change

P&ID: Piping and Instrumentation Diagram

PFD: Process Flow Diagram

PLC: Programmable Logic Controller

RTU: Remote Terminal Unit

SAT: Site Acceptance Test

SIT: Site Integration Test

4 HMI usability and performance**4.1 The HMI lifecycle**

Figure 1 shows a diagram of the scope of the HMI lifecycle, reproduced from the ISA-101 standard. HMI enhancements to improve usability and performance affect the system standards,

design, implement, and operate stages of the lifecycle. The HMI lifecycle is referenced throughout this technical report.

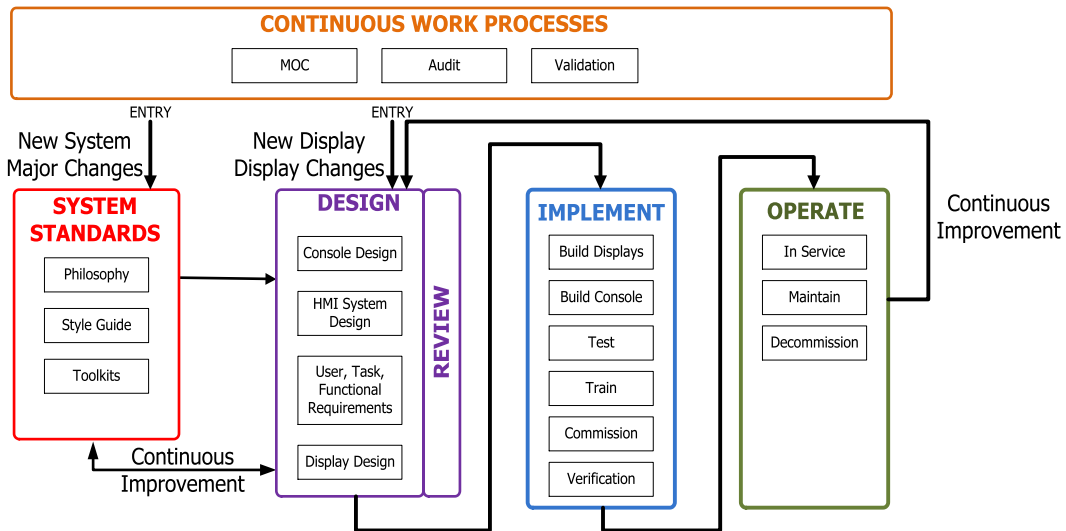


Figure 1- HMI Lifecycle

4.2 Introduction to usability and performance

ISA-101 includes content on HMI usability and performance. This technical report expands upon that content as it relates to the HMI lifecycle.

This technical report investigates the effect of human factors on HMI usability and performance and may aid in determining usability criteria.

The effectiveness of an HMI application depends on the manner in which the displays are designed for both content and navigation. This technical report defines HMI effectiveness in terms of usability and performance and provides example criteria and methodology for evaluating HMI effectiveness.

4.3 HMI effectiveness

4.3.1 Usability

Usability is dependent on the quality of the design specifications, the adherence of the specifications to ISA-101, and the degree to which the final design meets these specifications.

This technical report provides example criteria for assessment of project specifications and the engineered HMI solution to assess the HMI usability. Example criteria are also provided for evaluation of an operator's ability to perform his or her intended tasks on the HMI and to assess HMI performance. These criteria may be used to benchmark an existing HMI before an upgrade as well as to benchmark a new HMI. These criteria may also be used to monitor usability and performance throughout the HMI lifecycle.

HMI usability is related to how well the HMI achieves design conformance with the requirements contained in the specification documents such as the HMI philosophy, HMI style guide, any user HMI design standard, and user HMI toolkit.

4.3.2 Performance

Performance is how well the HMI responds, and how well the change management and continuous improvement processes work. The HMI system should be designed to allow the operator to use the system in the best way possible.

Performance can be assessed by how well the HMI achieves the tasks it was designed to execute. The HMI can be evaluated in two main categories:

- a) HMI duty factors – which are related to display response, including such metrics as call up times, display refresh times, and key clicks;
- b) Performance-shaping factors – which are related to how fast an operator is able to detect, diagnose, and take appropriate action.

The overall performance of the process is affected by the operator's span of responsibility, the complexity of the process, the presence of advanced control applications, the alarm management system, and other factors.

Performance factors include the operator's ability to recognize abnormal process conditions and take the proper corrective action. Performance-shaping factors impact how well an operator identifies when corrective action is needed and how often they are taking the right corrective action.

All of these factors impact the operator's ability to identify and respond to abnormal situations.

4.4 User roles

4.4.1 General

The primary focus of this technical report is on the process operator responsible for monitoring and interacting with the process. Other roles/responsibilities may be mentioned in examples throughout the text. These other roles should be revealed by a task analysis of all possible HMI users.

Having adequate numbers of or dedicated consoles for engineers and maintenance can improve the usability of the HMI to the operator. This means the operator does not have to compete with maintenance or engineers for resources or access. Competing for resources does not make the HMI less effective. Instead, it makes the HMI less available. Having dedicated HMI for the other users may improve the design of the HMI and make it more effective for operators.

The ISA-101 standard describes "user types," and user type is related to the user role.

4.4.2 Operations, maintenance, and training

The operator's use of a dedicated, unshared console may be beneficial to avoid workflow interruption. Occasional or limited use of part of the console for engineering or maintenance purposes may be acceptable in some cases. If such use is frequent, a separate console for engineering and/or maintenance use is recommended.

In situations where a console is not continuously staffed, it is important the console is always available to the operator and some method of notifying the operator for alarms is implemented.

When the HMI is in operation or maintenance stages, a key consideration is handling of changes to the HMI and the related training requirements.

Usability should also address training needs. Dedicated consoles for training may be desirable so that operators can review and familiarize themselves with HMI changes prior to their deployment. This method may also improve the ability to sign off on MOC requests before the production system is updated. Training should not impede the usability of the on-line HMI system. While sometimes expensive, having dedicated console(s) for training is one solution.

4.4.3 Example testing of HMI modifications

Consider a case in which several existing displays are to be modified to incorporate additional functionality, for example, the addition of embedded trending and alarm information retrieval elements. Under a management of change plan, the older versions of displays should be archived prior to being modified. Modifications to the HMI should be tested by the operators prior to the replacement of the original display versions, using one of the following recommended methods.

Method 1: Newly created/modified displays available only on the engineering console.

Operators are directed to familiarize themselves with the modified displays on the engineering console. After familiarization and any corrections made based on feedback, the modified displays replace the versions on the operator's console.

Method 2: Newly created/modified and renamed version of displays available only on the operator's console.

Limit access to these by requiring that they be called up via direct name entry rather than incorporation into the HMI navigation, or make them selectable in a secured access "TEST" section of the HMI navigation. Direct the operators to use these graphics for testing and familiarization. When completed, delete the original displays and rename the modified ones to those original names, thus ensuring their proper access in the existing HMI navigation and links to other displays.

Method 3: Prior to deployment, newly created/modified displays available only on a training or development system.

In some cases, testing, familiarization, and operator training is carried out on a system completely separate and isolated from the actual process to avoid any chance of the testing affecting the process. For thorough testing, simulation of the process is possible.

For some HMI systems, the final replacement of the original displays with modified ones may also require a reboot or reload of the individual stations making up the console or a client restart.

5 Usability

5.1 General

Usability is impacted by the HMI lifecycle stages of system standards, design, implement, and operate. The HMI lifecycle components are shown in Figure 1.

The usability of the HMI should be based on the foundation of the recommended system standards. The recommended HMI philosophy, HMI style guide, and HMI toolkit should all be created with the goal of optimizing the HMI usability.

The usability of the HMI should be formatted during the design stage. This is done by capturing suitable console design; HMI system design; display design; and user, task, and functional requirements.

The usability of the HMI during the implement stage should be solidified. This is achieved during display building, console building, operator training, commissioning, and verifying.

The usability of the HMI during the operate stage may be impacted by the placing in service. It may be more likely the usability of the HMI could be impacted during maintaining under MOC.

Stages of the HMI lifecycle are covered in this section as follows:

- a) Clause 5.2 covers the system standards stage;
- b) Clauses 5.3 to 5.8 cover the HMI design stage;
- c) Clauses 5.9 and 5.10 cover the implement stage;
- d) Clauses 5.11 and 5.12 cover the operate stage; and
- e) Clause 5.13 covers continuous work processes stage.

5.2 System standards stage

The system standards stage of the HMI lifecycle includes the HMI philosophy. HMI usability is enhanced when the system is designed to the relevant user specification documents, such as the HMI philosophy, the HMI style guide, and the HMI toolkit.

5.3 Console design

5.3.1 Overview of console design

Console design is essential for HMI usability. A recommended user console layout or user criteria for console layout should be documented in the HMI philosophy.

Many factors need to be considered such as:

- a) work practices;
- b) control room layout;
- c) monitor layout;
- d) human factors and ergonomic considerations;
- e) workplace environmental conditions; and
- f) communications equipment.

Locations of other equipment should be considered so the operator can see all screens and simultaneously use the communications equipment.

Console design recommendations can be found in the ISO 11064-4 and/or HFES 100 standard and are not included here.

5.3.2 Control room layout

Human factors issues associated with the control room layout should be considered. ISO 11064 identifies that user participation is key to the success of a control room layout design. Including a human factors study, to solicit user input and identify common human factors issues associated with the control room layout, may be desirable. The preferred user control room layout or control