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Human Machine Interfaces for Process Automation Systems

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Preface

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Introduction

Purpose

The purpose of this standard is to address the philosophy, design, implementation, operation, and maintenance of Human Machine Interfaces (HMIs) for process automation systems, including multiple work processes throughout the HMI lifecycle. It is also intended to help users to understand the basic concepts as a way to better and more readily accept the style of HMI that the standard is recommending.

The standard defines the terminology and models to develop an HMI and the work processes recommended to effectively maintain the HMI throughout the lifecycle. Use of this standard should:

a) provide guidance to design, build, operate and maintain HMIs to achieve a safer, more effective, and more efficient process control system under all operating conditions.

b) improve the user's abilities to detect, diagnose, and properly respond to abnormal situations.

The HMI is the collection of hardware and software used to monitor and interact with the control system and ultimately with the process.

The target audiences are end users, designers, developers, and implementers of HMI systems.

Organization

This standard is organized into nine clauses. The first three clauses are introductory in nature. Clause 4 presents the lifecycle model for the HMI. Clauses 5 through 9 provide additional details to support the lifecycle. The main body of the standard (Clauses 4-9) presents mandatory requirements and non-mandatory recommendations as noted. If a clause contains mandatory requirements, it is noted at the beginning of the clause.

1 Scope

1.1 General applicability

This standard addresses Human Machine Interfaces for equipment and automated processes. If the standard, recommended practices and methodology are followed, the result should enable the users to be more effective yielding improved safety, quality, productivity and reliability.

The recommendations in this document are applicable to any process using an HMI to interface to a control system, including but not limited to continuous, batch, and discrete processes. There may be differences in implementation to meet the specific needs based on process type.

1.2 Exclusions

1.2.1 Change management

Some requirements and recommendations to be included in a change management procedure are included in this document. However, a specific change management procedure has not been included in this document.

1.2.2 Jurisdictions

In jurisdictions where the governing authorities (e.g., national, federal, state, province, county, city) have established process safety design, process safety management, or other requirements; those requirements take precedence over any requirements defined in this document.

1.2.3 Purchase specification

This document is not intended to be used as a Human Machine Interface system selection or procurement specification, although at the discretion of the person specifying or requiring it, suppliers could be requested to provide an HMI system including the features mentioned herein. This document does not eliminate the need for sound engineering judgment. No particular platform or technology is mandated nor implied.

1.3 Intended audience

This document's target audiences are end users, designers, developers, and implementers of HMI systems. However, the designs developed by using this standard should include the inputs and needs of all the intended users. These users are the personnel in contact with the HMI systems, such as those from the process, operations, engineering, maintenance, risk assessment (including safety), and quality control user groups.

2 Normative references

2.1 References

The following referenced documents should be considered for the application of this document. For dated references, only the edition cited applies. For references without a date, the latest edition of the referenced document applies.

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

ANSI/ISA-5.06.01-2007, *Functional Requirements Documentation for Control Software Applications*

ANSI/ISA-18.2-2009, *Management of Alarm Systems for the Process Industries*

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

ANSI/ISA-95.00.01-2010 (IEC 62264-1 Mod) - *Enterprise-Control System Integration – Part 1: Models and Terminology*

ANSI/ISA-100.11a-2011, *Wireless systems for industrial automation: Process control and related applications*

ANSI/ISA-62381-2011 (IEC-62381 Modified), *Automation Systems in the Process Industry – Factory Acceptance Test (FAT), Site Acceptance Test (SAT), and Site Integration Test (SIT)*

ANSI/ISA-62443-1-1 (99.01.01)-2007, *Security for industrial automation and control systems Part 1: Terminology, concepts, and models*

ANSI/ISA-62443-2-1 (99.02.01)-2009, *Security for industrial automation and control systems: Establishing an industrial automation and control systems security program*

ANSI/ISA-62443-3-3 (99.03.03)-2013, *Security for industrial automation and control systems Part 3-3: System security requirements and security levels*

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

ISO 11064-4:2004, *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*

3 Definition of terms and acronyms

Defined terms are used in this standard. Synonymous terms, which are not used in this standard, are listed in parentheses.

3.1 Definitions

For the purposes of this document, the following definitions apply.

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 response. [ANSI/ISA-18.2-2009]

3.1.2 Alert

An audible and/or visible means of indicating to the operator an equipment or process condition that requires awareness, that is indicated separately from alarm indications, and which does not meet the criteria for an alarm. [ANSI/ISA-18.2-2009]

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 coding

The use of auditory signals to convey information to operators.

3.1.5 Auditory signal

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

3.1.6 Call up time

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

3.1.7 Chromatic distortion

Color fringing or smearing caused by unequal focusing of different colors.

3.1.8 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.

3.1.9 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). See Figure 1.

3.1.10 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.

3.1.11 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-18.2-2009]

3.1.12 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 standard, the term controller is used as defined in Clause 3.1.12.

3.1.13 Dashboard

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

3.1.14 Display (Graphic, window)

A visual representation of the process and related information used by the operator for monitoring and control. See Figure 1.

3.1.15 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.

3.1.16 Drill-down

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

3.1.17 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.

3.1.18 Graphic element

A component part of a graphic symbol, such as a line or circle. See Figure 1.

3.1.19 Graphic symbol

A visual representation of a process component, instrument, or condition in a display composed of a combination of simple graphic elements. See Figure 1.

3.1.20 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.

3.1.21 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.

3.1.22 Keyboard

An input device that allows the user to type characters, values or commands to affect the control system. See Figure 1.

3.1.23 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. See Figure 1.

3.1.24 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.

3.1.25 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.

3.1.26 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 standard, the term controller is used as defined in Clause 3.1.12.

3.1.27 Platform

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

3.1.28 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). See Figure 1.

3.1.29 Popup (Popup display, overlay)

A display that appears (pops up) in the foreground of the screen, possibly obscuring part or all of other displays. See Figure 1.

3.1.30 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).

3.1.31 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).

3.1.32 Salience

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

3.1.33 Screen

The part of the monitor that shows an image. See Figure 1.

NOTE See Resolution, Clause 3.1.30, for more information.

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

3.1.34 Script

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

3.1.35 Scripting

A feature provided by some HMI platforms to allow execution of scripts.

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). See Figure 1.

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).

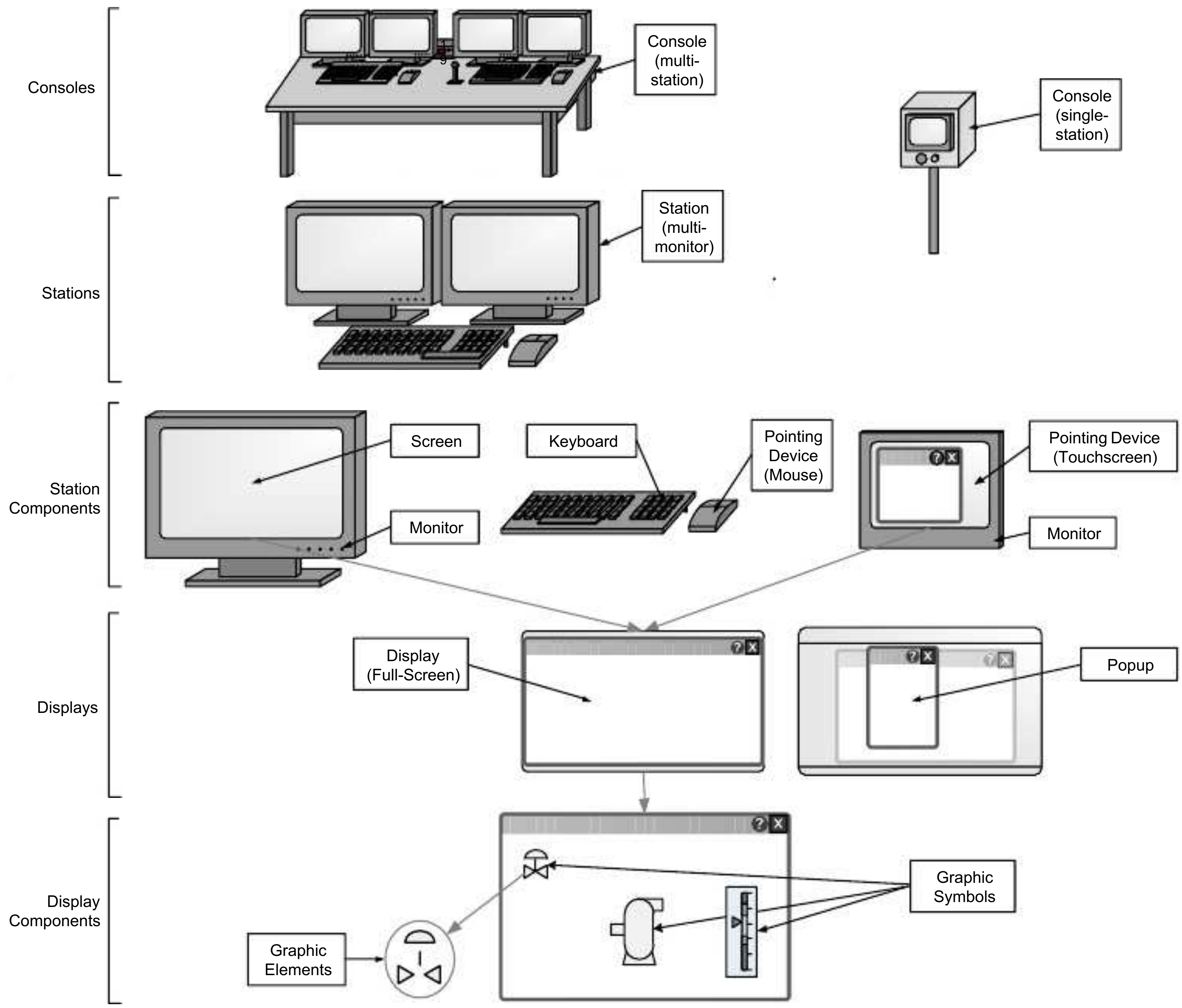


Figure 1 – Selected HMI terms and their interrelationships

NOTE Figure 1 is intended to illustrate selected, defined terms (in boxed text) and their interrelationships only and is not intended as a suggested design. Stations can be fixed or portable with related wired or wireless network connections.

3.2 Acronyms

3.2.1 ANSI: American National Standards Institute

3.2.2 CCTV: Closed Circuit Television

3.2.3 DCS: Distributed Control System

3.2.4 FAT: Factory Acceptance Test

3.2.5 HFE: Human Factors Engineering

3.2.6 HFES: Human Factors and Ergonomics Society

3.2.7 HMI: Human Machine Interface

3.2.8 I/O: Input / Output

3.2.9 MOC: Management of Change

3.2.10 P&ID: Piping and Instrumentation Diagram

3.2.11 PFD: Process Flow Diagram

3.2.12 PLC: Programmable Logic Controller

3.2.13 RTU: Remote Terminal Unit

3.2.14 SAT: Site Acceptance Test

3.2.15 SIT: Site Integration Test

3.2.16 SCADA: Supervisory Control and Data Acquisition

4 HMI System Management

NOTE THIS CLAUSE CONTAINS MANDATORY REQUIREMENTS.

4.1 Introduction

The HMI shall be developed and managed through a lifecycle model; for example, see Figure 2.

System standards shall be created and used to establish the foundation for the HMI lifecycle. The System standards, as shown in Figure 2 include: the HMI philosophy, the HMI style guide and the HMI toolkits. These items should be maintained over the life of a facility. Once created, they are not commonly recreated or significantly modified unless the overall philosophy has changed. Occasionally, project requirements will dictate creation of new standards or drive significant change to the existing system standards.

The HMI main lifecycle stages are design and review, implement and operate. Two entry points are shown Figure 2.The first entry point is at System Standards for a new system or major changes to an existing system which may include migration from a legacy HMI platform. The second entry point is at design for either new display design(s) or display changes.

Two continuous improvement steps are shown in the lifecycle. The first shows a cycle between design and system standards. This recognizes that improvements can be made continuously in HMI design that are reflected back to the system standards. The second continuous improvement process is between operate and design, recognizing improvements to the specific system in operation. Ideas for improvement can occur at any point in the lifecycle, but the major connections are shown where the actual changes occur.

Continuous work processes of Management of Change (MOC), audit and validation are also shown across the entire lifecycle.

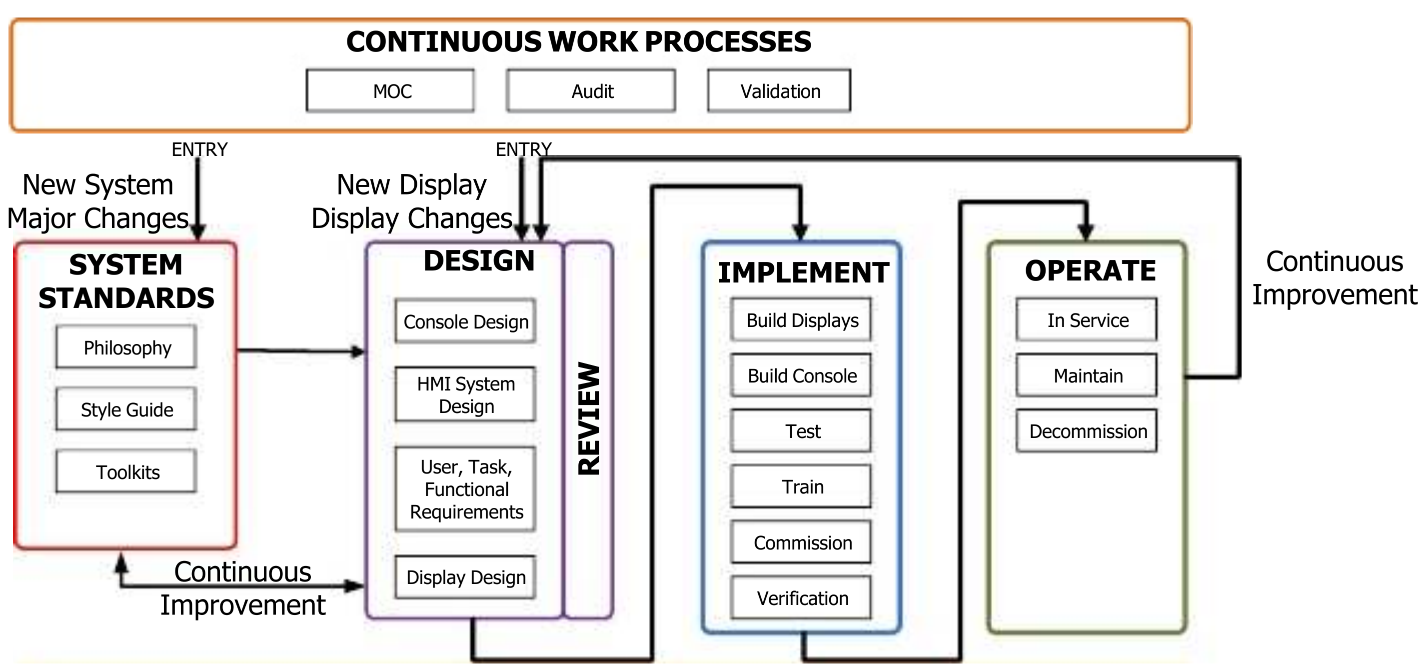


Figure 2 – HMI lifecycle

Each stage of the HMI lifecycle is discussed in detail below. Tables 1-5 below provide some details around the activities integral to all stages of the lifecycle. The tables include the major objectives, inputs and outputs for each stage of the lifecycle.

4.1.1 User types

Throughout this document, the term "user" refers to the various individuals who will use the HMI. The concept of primary and secondary users should be defined, see Clause 3.1.26.

In many cases, there may be different types of users based on their different job functions. Therefore, the unique requirements for each type of user should be identified and understood in the design and lifecycle of the HMI. Each user, or type of user, may have different privileges and levels of access to various displays, diagnostic capabilities, and other functions via the HMI, based on their individual roles. The types of users and their requirements should be included in the design process and be documented in the HMI philosophy. Roles and responsibilities can vary from industry to industry and from facility to facility, examples of types of users are:

a) Operations-users who monitor and perform control and operation of the plant or facility (this may include both operators in the main control room as well as the extended operations team which may include remote users and users of portable interface devices);
b) Maintenance-users who perform troubleshooting and/or maintenance of the process, instrumentation and final control elements and rotating equipment;
c) Engineering-users who perform modifications, additions or deletions to the HMI or control system;
d) Administrators-users who perform updates to the control system itself, or assign security to other users;
e) Management-users who monitor the operation of the plant or facility;
f) Analysts-users who monitor the system to improve plant performance;
g) Others-users who use or interact with system for other purposes, for example, quality management personnel.

4.2 System standards

The system standards stage of the lifecycle includes development of: the HMI philosophy, HMI style guide and HMI toolkits.

See Table 1 for details on objectives, inputs and outputs for the system standards stage of the example lifecycle.

Table 1 – System standards stage activities

Stage	Clause	Activity	Objectives	Inputs	Outputs
HMI System Standards Stage	4.2.1	HMI philosophy development	Provide guiding principles and conceptual foundation for HMI design. This includes details on how the HMI is designed and used.	User experience, conceptual user, task, and functional requirements, best practices, standards, guidelines and Human Factors Engineering considerations, work processes, HMI security model.	HMI philosophy (independent of platform)
	4.2.2	HMI style guide development	Apply the guiding principles and concepts of the HMI philosophy to provide implementation examples and guidance. (This does not include all technical details, though the design needs to be feasible in all target platforms or include preferred work around methods).	HMI philosophy, platform experience and expertise (to confirm feasibility; develop early proof of concept designs).	HMI style guide
	4.2.3	HMI toolkit development	Generate all graphical symbols and other supporting elements as required to implement the HMI style guide.	HMI style guide, platform experience and expertise, conceptual user, task, functional requirements.	HMI toolkit(s) (platform-specific).

4.2.1 HMI philosophy

The HMI philosophy is a strategic document addressing the guiding principles that govern the design structure of the HMI. Guiding principles may include, but are not limited to:

a) alignment with human factors (see Clause 5),

b) user, task and functional requirements for all modes of operation that require HMI support,

c) design standards and guidelines,

d) work practices for the development and management of the HMI, including the conceptual design of the console, number of screens, number of keyboards/pointing devices, etc.,

e) HMI security model.

The HMI philosophy should provide a foundation of concepts such that new developers and users can grasp the underlying principles and technical rationales, allowing an effective HMI to be created and maintained.

The HMI philosophy should not provide the platform specific implementation details. Those details are covered in the HMI style guide and HMI toolkit. The HMI philosophy and HMI style guide can be combined into a single design document, though the HMI philosophy is less likely to need periodic updates in support of technological changes. In facilities with varied platforms, it can be effective to decouple the documentation maintenance of the HMI philosophy document from the platform specific issues captured in the HMI style guide.

General guidelines for the HMI security model, with respect to how user groups will interact with the system and each groups required functionality and permissions, need to be developed. This high level description will then be used to ensure the HMI style guide and ultimate toolkit are developed that will support the intended security model for the system. Security can also include how changes to the system are logged, who can change the system, and how change is controlled at an HMI systems level.

4.2.2 HMI style guide

The HMI style guide is a document that contains facility, and/or company specific standards and guidelines for the design and implementation of a configurable HMI. An HMI style guide should include general design principles for the displays and associated applications as well as specific implementation standards. The HMI style guide should reinforce the guiding principles from the HMI philosophy, including human factors, design standards, and user, task and functional requirements. The work practices recommended to manage the HMI outlined in the HMI philosophy may be further defined. Guidance on display types and their preferred use should also be included (see Clause 6). In order to ensure an effective HMI, implementation guidance should include some expectations of HMI performance (see Clause 8).

The HMI style guide uses the guiding principles and concepts of the HMI philosophy to establish implementation examples and guidance. As an example, for major dynamic graphic objects, the HMI style guide should contain a description of the object's behavior, presentation (size, color, etc.) and illustrations of possible states. The HMI style guide is not meant to hold all of the platform specific technical documentation of the HMI design. The HMI style guide should be created with proof of concepts prototyping for all intended platforms in order to ensure feasibility.

The HMI style guide should provide the rules for designing and building displays.

4.2.2.1.1 Use of scripting or embedded logic

One area of common concern is the use of scripting or embedded logic in individual displays. For some HMI platforms it is possible to embed logic or data manipulation in the configurable portion of the display to handle a variety of tasks. Sound design principles should be used for scripting; including handling of all expected communication delays and failure modes.

The use of display specific scripting should be discussed and the acceptable level and type of custom scripting should be specified in the HMI style guide. Distributed display based scripting can be difficult to manage and should only be used where the capabilities support the maintenance requirements.

It is important to note that many computers used for HMI applications do not have the level of reliability that exists within controllers. Scripting to perform logic for the purposes of control and/or automated procedure implementation should be implemented in the control system component (HMI or control system) and in methods that meet availability requirements and are supported by the maintenance work processes.

4.2.2.1.2 Use of color

It is common and effective practice to use color as one method to differentiate objects and their various states in displays. Color should not be used as the only method of differentiation. Color should be used to direct attention and add meaning to the display. The HMI philosophy and/or HMI style guide should specify the appropriate use of color. See Clause 5 for additional discussion of this topic.

4.2.3 HMI Toolkit

The HMI toolkit is a collection of design elements for use within the HMI platform. Toolkit elements are designed to meet the style guide requirements. Toolkits can be supplied with the HMI, by the control system vendor, other third parties, or may be custom developed for the platform, or any combination of these.

The HMI toolkit can be managed as a single library or split into separate toolkits that are managed independently. A main toolkit would include display templates, pop-ups and faceplates, and static and dynamic graphic symbols. Separate toolkits may be maintained for different platforms or special application support. All toolkits are designed in support of the concepts in the HMI philosophy and the HMI style guide(s). Each design element is created to support specific classes of user, task or functional requirements. As requirements and technologies change, toolkits are updated to meet requirements and improve HMI performance.

Changes to the HMI toolkit shall be accomplished under a management of change process. The HMI toolkit should be documented, either within the HMI platform or in separate documents. The scope of change control may include different releases of the operating system and the platform software. In complex cases, revision controls with history may be an effective means to manage the HMI toolkit.

4.3 The design process

The design process stage includes the following four steps:

a) console design,

b) HMI system design,

c) user, task and functional analysis,

d) display design.

Appropriate HMI design documentation should be maintained over the lifecycle of the system (from entry through decommission). See Table 2 for the objectives, inputs and outputs of the design stage of the example lifecycle.

Table 2 – Design stage activities

Stage	Clause	Activity	Objectives	Inputs	Outputs
Design Stage	4.3.1	Console design	To provide hardware and software design for the console. This includes furniture and supporting systems.	User, task, functional requirements. vendor specifications, Human Factors Engineering design standards (see Clause 5).	Console design documents.
	4.3.2	HMI system design	Identify design basis for the HMI system.	User, task, functional requirements. control system design standards, network design standards, preliminary network design, security model.	HMI system design documents.
	4.3.3	User, task and functional requirements	Identify primary and secondary requirements supported in the HMI.	HMI philosophy, HMI style guide, preliminary console design, prior user, task and functional requirements documents.	User, task and functional requirements document(s).
	4.3.4	Display design	Identifies conceptual design for displays and the navigation hierarchy. (This may include some prototype displays on complex applications or processes).	HMI philosophy, HMI style guide, user, task, functional requirements document(s), user input during review(s).	Display design document(s).

4.3.1 Console design

The console design sets the operator's micro-environment and includes the console furniture, local environmental considerations (lighting, temperature, sound, etc.) and related console equipment (telephones, shutdown buttons, annunciator panels, radio, intercoms, etc.). This also includes support for the operator's physical workspace, which may be located in a control room office type environment or on the plant floor. Depending on the location and functional requirements, this workspace may include business computing equipment and/or other dedicated special use equipment. Use of multiple screen sizes may require special consideration in physical arrangements and to the toolkit design.

If no experience with similar processes is available, an operator workload analysis may be useful to determine the number of operators required. With an understanding of the number of operators and their scope of control, a preliminary display hierarchy should be established as a means to determine the size and number of monitors required in the console design. The number and size of monitors impacts the physical design of the console hardware and furniture. The number of monitors also has an impact on software design decisions, including the size of the different screen components, types of displays (overviews, operating and detail displays), interaction methods and general navigation design.

Due consideration of requirements during abnormal operating modes should be given when evaluating the monitor and console design. Where multiple consoles are present in a single control room, an operator adjacency study should be performed in order to determine the optimal console placement. See Clause 5, Human factors engineering and ergonomics for further details.

It is important to understand that some industries have additional requirements that impact the design of the console, depending on the type of industry and/or the regulatory requirements. Care should be taken to integrate this equipment with the operator station hardware in a manner that supports expected operator tasks and accounts for human factors and ergonomic design standards. See HFES100 and ISO 11064 for further details on console and control room design.

Consideration should also be given to the location of the computing hardware, the impact on ambient noise and heat levels, and accessibility for maintenance. The computers related to workstations can be remotely located, allowing for noise and heat load elimination at the operator work location. This remote location can make computer maintenance and support easier.

4.3.2 HMI system design

The foundation of the HMI system design includes the selection of the control platform and related operating system and choosing HMI toolkits to be used in the system.

Concepts of network design, user roles and security, and other third party interfaces should be considered. It is important to note that these decisions impact the design and functionality of the HMI.

4.3.3 User, task, and functional requirements

The user, task, and functional requirements activity will document the requirements of the HMI, including its intended functions and users (both primary and secondary). Primary users are those directly responsible for the operation of the equipment controlled from the HMI. Secondary users are those supporting the operations activities whether maintenance, engineering, or management.

Once the basic user roles and requirements are defined, the actual tasks to be performed by the users are captured, reviewed and potentially optimized. Considerations include:

a) normal and abnormal operating conditions,

b) need for specific user help supporting information (either online or offline),
c) requirements related to user roles and account privileges,
d) terminology in use by the user and the user model of the facility and /or process,
e) functional HMI support needs

It is important to note that satisfying the secondary users' requirements should not impede meeting the primary users' requirements. In cases where the needs are too diverse to be effective in a single display or set of displays, separate displays to support secondary users' needs should be generated.

The HMI requirements may also be defined as part of the control system or control application functional requirements process.

This documentation is an input to the design stage. See ANSI/ISA-5.06.01-2007 for further detail on functional requirements.

Different techniques are available to determine task requirements:

a) Hierarchical task analysis is perhaps the most thorough and routinely used technique in which a comprehensive list of the tasks that make up a job or function are clustered / grouped around commonalities and then organized within each group to show the hierarchical relationships for learning and decision making.
b) Timeline analysis is another useful technique in which the tasks are broken down into events and shown on a chart over the time horizon.
c) Link analysis demonstrates the frequency of linkage between tasks. It is useful for streamlining tasks and can also be used to identify how often a user has to navigate from one display to another.
d) Other more advanced techniques such as abstraction hierarchical analysis, cognitive work analysis and ecological analysis exist but may require Human Factors Engineering (HFE) expertise to complete.

In cases where complex custom applications are needed to support user needs, application specification functional requirements should be developed to support the application design.

4.3.4 Display design

Once the requirements are defined, a conceptual design of the HMI should be developed with input from the primary and secondary users. This verifies that the requirements were adequately captured before detailed design is started. It is relatively common to perform a first "layout" review where the basic content is shown, followed by a final review with all information and interaction between devices completed.

For more complex systems, an effective HMI may require refining the user specification documents in an iterative process, ensuring that the final HMI effectively supports the requirements. The review cycle is shown as a parallel process to the design to emphasize the ongoing nature of this part of the HMI lifecycle.

For highly regulated industries, specific validation testing may be required for this stage of the lifecycle. Validation is achieved and maintained through the adoption of continuous lifecycle activities. This verification step is shown as a continuous work process in the lifecycle, since it impacts various stages of the lifecycle (e.g., design, implement, operate) and may include specific procedures and reports and related documentation.

4.4 The implementation stage of the HMI lifecycle

During the implementation stage of the HMI lifecycle, the HMI is built in the target platform software and hardware using the outputs from the previous stages (system standards and design). The specific processes include:

a) build displays,

b) build console(s),

c) test,

d) train,

e) commission,

f) verify.

See Table 3 for details on objectives, inputs and outputs for the implement stage of the example lifecycle.

Table 3 – Implement stage activities

Stage	Clause	Activity	Objectives	Inputs	Outputs
Implement Stage	4.4.1	Build displays	Complete construction of displays and supporting items. (User review occurs in the design stage, which include prototypes).	Display design documents.	Displays, training Materials.
	4.4.2	Build console	Complete construction of console hardware and software. Test viewing angles, screen elevations, keyboard and input device placement and location of other elements.	Console design documents.	Console

Stage	Clause	Activity	Objectives	Inputs	Outputs
Implementation Stage	4.4.3	Test	Integrated test of HMI and console.	User, task, functional requirements documents, usability and performance criteria. Console and displays.	HMI ready to commission, testing documents.
	4.4.4	Train	Train users.	HMI philosophy, HMI style guide, Display design documents. Console and displays. User manuals and online help (as required) Training materials.	Updated training materials, training records, trained users.
	4.4.5	Commission	Final testing of HMI in production environment.	Console, displays, user manuals and online help (as required).	HMI ready to verify (as required), commissioning documents, approval/ acceptance.
	4.4.6	Verification	Verify HMI ready to operate.	Verification plan, commissioning documents.	Verification documents, HMI ready to operate, approval/ acceptance.

NOTE Highly regulated industries may require verification. This step may not be present or extensive in all HMI lifecycles.

4.4.1 Build displays

In the build displays activity, displays are created from HMI toolkit graphic objects and elements. Any custom configuration or scripting is also completed. If practical, the displays can be built and tested by the developer in a development system. Implementation can also be done directly on the live control system, with the proper engineering controls.

4.4.2 Build console(s)

For new systems, the console may need to be built prior to final display testing and training. The console build includes installation and configuration of the operating system and control system software. It may also include a testing system using the final display hardware and related furniture. For existing systems, building and testing displays may require changes to the console software, which essentially requires changes to the existing system in order to start testing and/or commissioning activities.

4.4.3 Test

Test is the integrated system testing against requirements both for usability and general performance.

Initial functional testing is also commonly done in a development or offline environment prior to or concurrent with integration with the live system. Actual integrated system testing may be required prior to commissioning based on the level of customization and the relative acceptance level of the HMI toolkit graphics objects. See ANSI/ISA-62381 for guidance and requirements for acceptance testing.

Issues discovered in development and in testing will likely minimize the cost and effort in commissioning. A verification test and documentation plan may be required for this stage of the lifecycle in some industries. This verification will be part of an overall validation plan. Testing may be part of an audit event. Management of Change, validation and audit are shown as continuous work processes.

If operator training simulators are available, these can be useful for testing with operators performing relevant tasks with the system they will be operating, confirming requirements are met in a real life setting. If available, simulated upsets and other abnormal conditions can test the effectiveness of the HMI under different modes of operation.

Documentation requirements should be generated specific to the test verification, validation plan reporting, and commissioning of the HMI. Certain highly regulated industries may have specific requirements for these documents. Topics typically addressed in this type of documentation include:

a) test plans,
b) test methodology,
c) validation plan requirements, specific to this verification step,
d) deficiency tracking system,
e) human factors engineering criteria,
f) change management.

4.4.4 Train

Operator training and related documentation of the training requirements are defined and accomplished in this stage of the lifecycle.

Depending on the complexity of the HMI application and the current knowledge of the operator, this may be accomplished through on-the-job training, or as part of a more formal training process. Training may be conducted in a classroom, on an electronic self-paced system, on a training simulator, on a development system or on the live system.

Training may also be required for other members of the operating team, including maintenance and engineering.

In many cases, the HMI is built from HMI toolkit items without need for further customization. If a display uses only HMI toolkit items, it may be acceptable to provide detailed training on the HMI toolkit and limited training on the individual displays.

See Clause 9 for additional information regarding HMI training.

4.4.5 Commission

Commissioning is final testing with process data connections, and field verification and documentation (as required) to confirm all requirements have been satisfied. For some highly regulated industries, a specific validation plan is required, which may include requirements related to, testing. Verification approvals and a documentation plan may be required for this stage of the lifecycle activity. A commissioning plan should be established.

Any planned user manuals and online help systems should be in place for use in the commission activity.

4.4.6 Verify

More highly regulated industries may require specific verification plans with related documentation and approvals before proceeding to the operate stage. Verification establishes confirmation through objective evidence that requirements of the HMI have been fulfilled. Validation is the continuous work process that ensures that verification testing is appropriately implemented. Validation plans may specify specific lifecycle stages where verification is required. Verification checks prior to the final check between commission and operate are documented in the validation plan.

4.5 The operate stage of the HMI lifecycle

Once the HMI has been commissioned and verified, it moves into the operate stage of the HMI lifecycle. The specific activities include:

a) in service,

b) maintenance,

c) decommission.

See Table 4 for details on objectives, inputs and outputs for the operate stage of the example lifecycle.

Table 4 – Operate stage activities

Stage	Clause	Activity	Objectives	Inputs	Outputs
Operate Stage	4.5.1	In service	HMI in service.	Commissioning/Verification approval, user manuals and online help.	HMI in service.
	4.5.2	Maintain	Ensure HMI is valid and reflects current process conditions. Ensure backups exist for recovery	Approved Management of Change requests to fix errors or to add enhancements or updates to reflect changes in the process. Backups.	Management of Change logs, updated HMI, user manuals, training materials and online help.
	4.5.3	Decommission	HMI removed from service (end of life).	Management of Change change requests.	HMI (or part of HMI) removed from use, archived for approved records period.

4.5.1 In service

Upon completion of commissioning (and verification, if required), the HMI is considered to be in service. Changes to the HMI shall be handled in a Management of Change process (as shown in continuous work processes in Figure 2).

4.5.2 Maintain

Maintain refers to the lifecycle stage activity where changes are made to the HMI. This includes: operating system, security or platform software modifications, corrections to existing errors, modifications to reflect changes in the process itself, or to support new functionality. This is part of the continuous improvement cycle shown in Figure 2.

Once the system is in the operate stage of the lifecycle, backups should be performed at a regularly scheduled interval. Backups should include all necessary control system files to minimize recovery time and effort in the event of a loss, not just display related files that are required to restore the HMI. This may include such items as:

a) embedded programs,

b) control system configuration,

c) any other control system code that is required for the HMI application to be functional.

Technical documentation with instructions on how to restore the system using these backups should exist. The restoration process should be tested to ensure successful recovery.

4.5.3 Decommission

Decommissioning is the activity that removes all or parts of the HMI from service. A process should be established that includes updates to any related documentation and may require testing and training, particularly if other parts of the HMI remain in service.

4.6 Continuous work processes

Continuous work processes are shown across the entire lifecycle to highlight the continuous nature of these activities. The specific activities include:

a) Management of Change (MOC),

b) audit,

c) validation.

See Table 5 for details on objectives, inputs and outputs for the continuous work stage of the example lifecycle.

Table 5 – Continuous work processes stage activities

Stage	Clause	Activity	Objectives	Inputs	Outputs
Continuous Work Processes Activities	4.6.1	Management of Change (MOC)	Manage change, ensure consideration of all known impacts	Changes in process or user, task and functional requirements	Change completed following the approved work practices
	4.6.2	Audit	Verify that the HMI is being managed under the approved work practices	HMI philosophy, HMI style guide, related documents	Audit records, change requests to correct any deviations, updates (as needed) to HMI philosophy, HMI style guide, HMI toolkits and related documents
	4.6.3	Validation	Verify HMI meets user, task and functional requirements	Validation plan	Validation system, validation records

NOTE Highly regulated industries may require validation. This step may not be present or extensive in all HMI lifecycles.

4.6.1 Management of Change (MOC)

Once the HMI is in service, changes to the HMI shall be handled with a Management of Change (MOC) process which includes definition of the portions of the HMI to be covered. This process should include enforcement of and adherence to the system standards (HMI philosophy, HMI style guide, and HMI toolkit components).

Revision control of the HMI toolkit with a focus on maintaining the system standards will help to maintain the established standards.

In some industries, it may be appropriate to use a document control mechanism for the custom displays as may be done for other configurable aspects of the control system.

4.6.2 Audit

Audit is the work process that ensures the HMI is being managed in accordance with the lifecycle and the system standards (HMI philosophy, HMI style guide and HMI toolkit). Periodic audits should be completed to verify compliance. In more highly regulated industries, documented audits may be required with specific time frequency.

4.6.3 Validation

In some industries and for some processes an audit may be a requirement. More highly regulated industries may require specific validation plans across the lifecycle of the HMI.

5 Human factors engineering and ergonomics

NOTE: THIS CLAUSE CONTAINS MANDATORY REQUIREMENTS.

5.1 General principles of HMI design

The purpose of this clause is to provide a coherent set of principles, allowing the HMI designer to understand the underlying foundation of key design decisions.

The proper application of Human Factors Engineering (HFE) principles related to HMI users' cognitive and sensory capabilities and limitations supports an effective HMI design. The HMI design shall support the users' primary tasks of process monitoring and control. The HMI design should minimize the impact of secondary tasks (e.g., display navigation within the HMI) that may distract the HMI user from performing their primary tasks.

The following general principles shall be considered during the HMI design:

a) The HMI is an effective tool for the safe and efficient control of the process.
b) The HMI assists in the early detection, diagnosis, and proper response to abnormal situations.
c) The HMI is structured to aid operators to prioritize response to major or multiple simultaneous system upsets.
d) Failure of a display or items on the display are immediately apparent to the operator.

5.1.1 Consistency of design

The HMI should have a consistent "look and feel" with consistent design concepts for information display and user interaction. The HMI philosophy and HMI style guide should set key expectations for "look and feel".

5.1.2 Design lifecycle involvement

HFE should be included throughout the HMI design stages, both for the HMI and for the related physical console. The HMI designer's understanding of the design basis is augmented by incorporation of HFE concepts into the HMI design documentation (e.g., HMI philosophy; user, task and functional requirements; HMI style guide; and the HMI toolkit) (see Clause 4 for design lifecycle details).

5.1.3 General HFE concepts

The HMI should be based on task requirements and operator needs. Since there are different users of the HMI, each of their needs should be considered in the design; however it is important that the needs of the primary users (plant operators) take precedence over those of all other users.

Examples of general HFE concepts include:

a) The way the HMI functions should be intuitive to the user.
b) The HMI should be designed to support tasks related to all commonly expected modes of operation, including abnormal conditions (e.g., the handling of alarms).
c) The HMI should provide information or controls appropriate to the task.

d) The information should be presented in forms or formats that are appropriate to the user's goals (e.g., if the operator takes a field reading in metres, centimetres, feet, or inches and sixteenths, then the HMI should display the information in that format, rather than in percent or range).

e) Supporting information should be readily available to the user (e.g., procedures used to start up a piece of equipment or batch process, alarm response procedures, or HMI user manuals, etc.).

f) The terminology used in the HMI displays should be consistent with user's common descriptions.

5.1.4 Situation awareness

Situation awareness means:

a) being aware of what is happening in the process,

b) understanding the process state now,

c) understanding the likely process state in the future.

The HMI should support the awareness and understanding of the system and process status. When the process is functioning as expected, the display should exhibit minimal sensory stimuli. As the process deviates from expectations, the HMI should provide visual and/or audible signals with appropriate salience for the situation.

Inadequate situation awareness has been identified as one of the primary factors in accidents attributed to human error. Fixation on parts of information to the exclusion of others can limit situation awareness. Having an operator focus on one problem, to the exclusion of other potentially more important information (often lost in the volume of data presented), results in reduced situation awareness.

5.2 User sensory limits

The HMI design should incorporate ergonomics principles that are based on the user's sensory limits (e.g., visual, auditory) and an understanding of the expected user functional requirements.

It is important to consider thresholds and upper limits of the user's sensory systems while also considering common sensory system deficiencies (e.g., color blindness, hearing loss, vision impairment).

5.2.1 Visual considerations

The HMI design should take into account the visual limitations of the user population for the environments in which the process related tasks are to be performed.

5.2.1.1 Ambient lighting and screen luminance

The HMI design should be based on the expected work environments. When deploying an HMI that will be viewed under multiple lighting situations, the system and displays should be designed at acceptable performance levels for all expected conditions. The HMI screen luminance should be appropriate given the ambient environment. Prevent eyestrain by avoiding the use of excessive contrast.

5.2.1.2 Color

Color perception deficiencies (for example, color-blindness or age-related deficiencies) and visual presentation of color combinations should be considered during design. Common types of color blindness include red-green, green-yellow, and white-cyan. Appropriate differential contrast and brightness should be utilized. The chosen colors should be distinguishable from each other by the user population, generally involving usability testing. As a general rule, color should be used for emphasizing key information such as alarms and abnormal conditions.

Contrast and brightness may be utilized within the context of the operating environment to accommodate color-blindness. Consideration should be given to age-related vision deficiencies, if applicable in the user environment. Age-related deficiencies include:

a) difficulties with focus on near field information,
b) decrease in the ability to refocus quickly between near and far objects,
c) chromatic distortions related to lens discoloration that tends to dull blues and purples to gray.

The placement and adjustability of monitors should consider the use of various corrective lenses (e.g., bifocals, trifocals, and progressive lenses).

In accordance with the facility's alarm philosophy and ANSI/ISA-18.2-2009, colors used for alarm presentation should be reserved and not used for any other purpose in order to strengthen their cognitive meaning and speed of operator response to alarms. Color should not be relied on as the sole indicator of an important condition. Color coding should be redundant to other means of presenting the information including, but not limited to, shape, text, brightness, size and texture. The selection of colors used on a display should reflect the importance of the information being presented. The most noticeable colors of a display should be used for the information that is most important. Important information should be more perceptually salient than less important information.

Further color coding can be used for emphasis and clarity. Color gradients should not be used for static or non-dynamic elements on the display, but may be used to highlight a dynamic element.

Color should be used conservatively and consistently to denote information throughout the HMI. Color and/or flashing of symbols (see Clause 5.2.1.5) should direct the operator's attention to newly developing critical situations.

5.2.1.3 Background-foreground interactions

The following items relate to background-foreground interactions:

a) The background should be an unsaturated or neutral color (e.g., light gray) in order to limit chromatic distortions and ensure the salience of the information displayed. For example, in most applications, the use of background colors that may cause excessive contrast (e.g., black) should be avoided.
b) Foreground and background color combinations should provide sufficient contrast.
c) The background color should be selected to provide acceptable and sufficient contrast in expected ambient lighting conditions.

It is helpful to test a colored image by rendering it into grayscale to ensure all element combinations have sufficient contrast to be detectable by a user with color deficiency.

5.2.1.4 Density of displayed information

The information density of a display should be based on the function or purpose of the display, tempered by human perception limits. Display pertinent information that can be quickly interpreted by the operator while avoiding unnecessary information. Display elements should be placed consistently and aligned spatially to avoid clutter. If initial user requirements specifications result in excessive information on a single display, it may be necessary to redesign. Redesign options include:

a) consolidating data into information of a lesser overall screen density,
b) using the most effective display style for more effective operator interpretation,

c) providing some information on demand only,
d) splitting the display into multiple displays.

Information presented to the user should be based on the function and task analysis results.

5.2.1.5 Visual dynamics

Because of limits to perception and cognition, only a limited number of colors can be used effectively on displays. As a result, visual dynamic coding techniques such as motion, blinking, flashing, and conditional visibility can be used to draw the operator's attention to specific information.

Motion uses changes in position, rotation, or size of graphic elements or graphic symbols to simulate movement.

Blinking alternately renders a graphic element visible and not visible. An example of a typical blinking element is a text insertion cursor.

Flashing is the repeated alternation of color(s) or intensity of a graphic element (such as swapping foreground and background colors) which never renders the element invisible.

Excessive or persistent motion, blinking or flashing can be distracting. The following design concepts should be employed to manage animation:

a) Blinking should be reserved for items which are intended to appear and disappear, such as symbols or borders for unacknowledged alarm identification.
b) Text and numbers themselves should not move or blink, because the changing position or angle, or the alternating appearance and disappearance of the text or numbers, make reading them difficult.
c) No part of the display should blink or flash unless an action is required by the operator. The use of visual dynamics should be reserved for highlighting abnormal situations, or situations requiring operator attention (e.g., an alarm indication).
d) A means of stopping the blinking or flashing should be made available to the operator.

5.2.2 Auditory considerations

The HMI design should take into account the ambient conditions as well as the auditory limitations of the user population. Auditory warnings should provide redundant information in conjunction with visual warnings.

5.2.2.1 Auditory coding

Auditory signals should be provided to alert the user to situations that require attention, such as a new alarm, an incorrect input action, or a failure of the HMI to process an input from the user. Auditory signals should provide localization cues that direct users to where attention is required.

Auditory signals should be designed so they do not startle listeners, add significantly to overall noise levels, or prevent communication among users. The intensity, duration, and source location of the signal should be compatible with the acoustical environment in the signal area.

The meaning of each auditory signal should be clear and unambiguous.

Auditory warning signals should be audible in the normal operating position on the console. In control rooms with multiple consoles the auditory signal should not be so loud as to be a distraction to operators at other unrelated consoles. A method should be provided to silence an audible indication once it has been acknowledged by the operator.

If the operator is not required to stay in immediate proximity to the HMI, alternate/auditory methods should be used that will reach all expected work areas.

5.2.2.2 General limitations

The overall design of the control room should be factored into the selection of the sound devices and the specific sounds used in design. In consolidated control rooms with multiple operator areas, care should be taken to achieve clear sound separation of alarms in each area.

Support should be provided for operators with partial hearing impairment. The use of adjustable speakers and/or earpieces should be considered to allow control of the sound in response to higher than expected levels of ambient noise. Auditory signal intensities should not exceed levels specified by hearing conservation policy or regulatory body. If there are audible signals that should not be muted, appropriate control mechanisms should be employed.

In areas with high ambient noise issues, noise control devices (sound absorption) can be employed.

5.2.2.3 Audible alarm priority indication

ANSI/ISA-18.2-2009 states that when the alarm philosophy provides a set of alarm priorities used in the HMI to assist the operator in selecting the sequence of alarm response actions then an audible and visual indication should be used. A unique combination of visual indications, audible indications or both should be used to distinguish the alarm priority. In environments where an audible indication is not used as a priority indication, a visual priority indication should be used.

5.3 User cognitive limits

The cognitive processes that transform, reduce, store, recover and use sensory input are important to human performance. A user’s performance and the underlying cognitive processes are affected by the workload level, situation awareness, and task complexity, each of which can be optimized by the design of the HMI.

Grouping data in a consistent manner will result in the group of data being processed cognitively as a single object, speeding operator response. Placing data on top of owning objects can also speed processing with a mental grouping. Information that cannot be connected to the display elements directly can also be processed more efficiently when grouped into simple boxes. Operators quickly understand that boxes are for certain types of information that they can selectively process.

6 Display Styles and Overall HMI Structure

NOTE: THIS CLAUSE DOES NOT CONTAIN MANDATORY REQUIREMENTS.

6.1 Introduction

Display styles refer to how the information on a display or part of a display is presented. Displays are the main building blocks that create the overall HMI structure.

Selection of a display style should be based on the functional requirements of the display as determined in the HMI design process. The most effective presentation method will also likely be influenced by the expected variation in the process data.

Selection may also be affected by technological and/or physical limitations of the HMI. For example the following considerations may impact the choice of display style:

a) user interaction with the display, such as the use of touch screens,

b) position of the display,

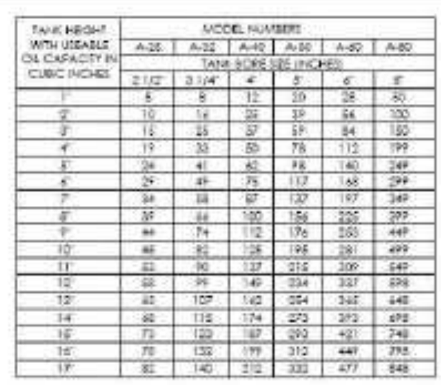
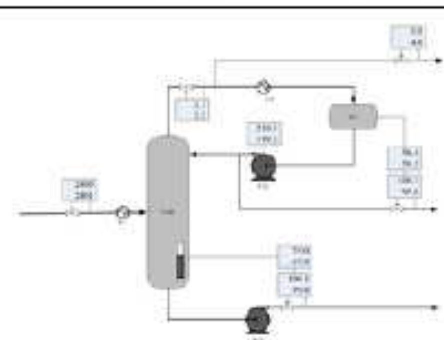
c) physical size of the screen,

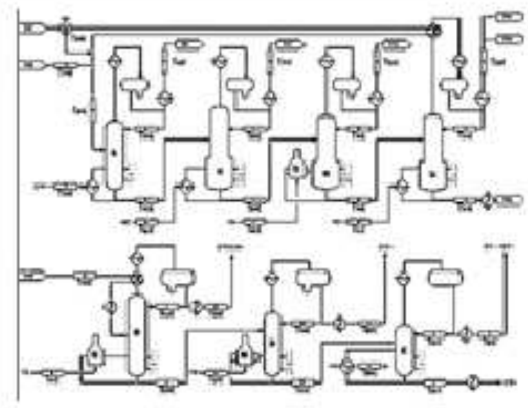
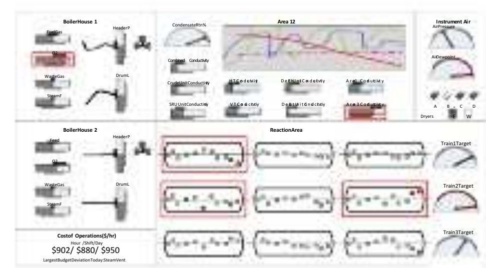
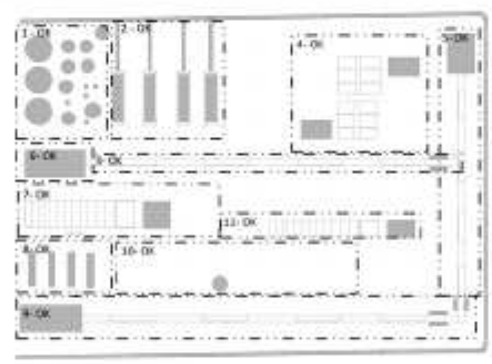
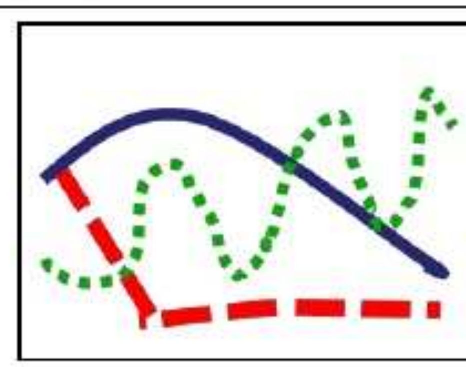
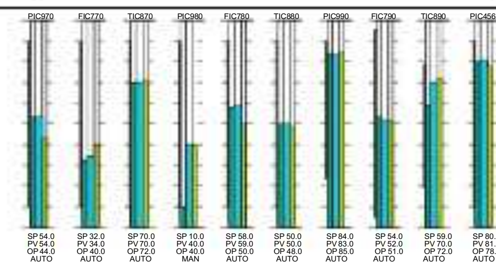
d) quantity of information that can be handled by the user.

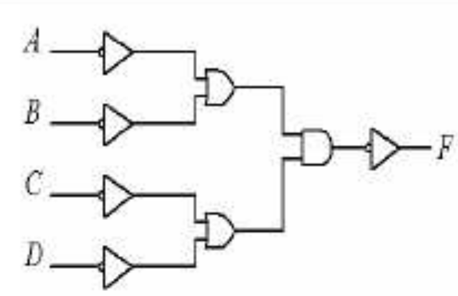
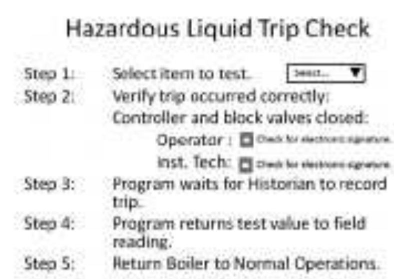
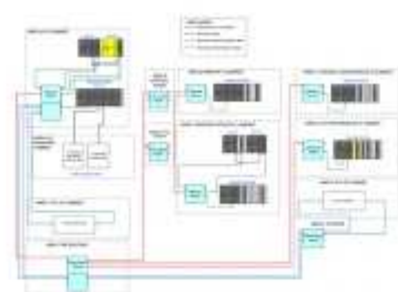
6.2 Display styles

Table 6 provides a list of the most commonly used display styles, examples of their usage, and conceptual samples.

Table 6 – Display styles

Type	Description	Examples	Sample
List	Rows or lists of data, Text and numeric data may be intermingled with process equipment symbols	Tank strapping tables, safe operating limit tables, equipment lists	
Process	Graphic representation of process equipment, piping and instrumentation	PFD or P&ID style layouts	

Type	Description	Examples	Sample
Schematic overview	Informational overview of an operator's span of control. The types of controls and indicators needed will depend on the functional requirements.	Process area, utilities or transport overviews	
Functional overview (Dashboard)	Representation of functional relationship of data	Data types as required (e.g., key performance indicators)	
Topology (location)	Representation of logical layout of a system	System network Electrical system one-line Fire detection status display	
Graph	Chart based representation of real time or historical data	Real time or historical trends Statistical quality control or statistical process control charts	
Group	Task based collection of point display faceplates	Multi-unit boiler control valves Distillation column flow control valves	

Type	Description	Examples	Sample
Logic monitor	Display representing logical relationships between system functions	Boolean / Logic diagrams, function block diagrams, ladder logic diagrams, sequence diagrams	
Procedural	Display of procedural control logic	Sequential function chart diagrams	
Video	Displays of live or recorded video	Process video monitoring Security CCTV	
Health/Diagnostic	Display of status of certain infrastructure components of the HMI and control system.	Network health display	
Alarm list	Display a list of status information	Alarm summary display Shelved alarm list Out of service alarm list Message list Lightbox	

6.3 Display hierarchy

A display hierarchy is recommended to provide the operator with a structured view of their entire scope of responsibility while providing the ability to drill down to greater levels of detail and control functionality. Information content will convey increasing levels of detail and focus. A maximum of four levels is recommended, with level 1 having the broadest scope and level 4 having the most focused scope. Although hierarchical in nature, display levels are not necessarily aligned with a navigation hierarchy which may have fewer or more levels. Each level is described in the following sub-clauses.

6.3.1 Level 1 displays

Level 1 displays are used to provide an overview or summary of the key parameters, alarms, calculated process conditions and disturbance propagation paths of an operator's entire span of control on one display, as shown in Figure 3. On larger systems, the level 1 display could span multiple screens provided they are all visible at the same time. Such displays have the broadest scope and lowest level of process or system detail. Level 1 displays can be used as a collaborative tool to enable the sharing of key information between operators and secondary control room users.

The following considerations should be made for level 1 displays:

a) separate overview displays should be considered for all operating modes, for example start-up and shutdown. Additional displays for this purpose should ensure that all information available on the normal overview remains visible and consistently positioned,

b) displaying all top priority alarms indicating acknowledged status, located to convey functional relationship (i.e., adjacent to associated equipment or device),

c) containing actual values, abnormal status, and severity of deviation for key process parameters or calculated process conditions that depict the health of high-level process areas (e.g., furnace, reactor or distillation column). If possible, it is also recommended to provide access to deviation values, direction of change indications and/or trends,

d) containing additional information on related plant facilities, such as utilities, downstream and upstream areas,

e) displaying embedded trends on important parameters,

f) orienting the operator to the existence, severity, location and direction of change of abnormal process conditions,

g) displays generally not used for performing control functions (e.g., controller setpoint changes).

Figure 3 shows an example of a level 1 display.

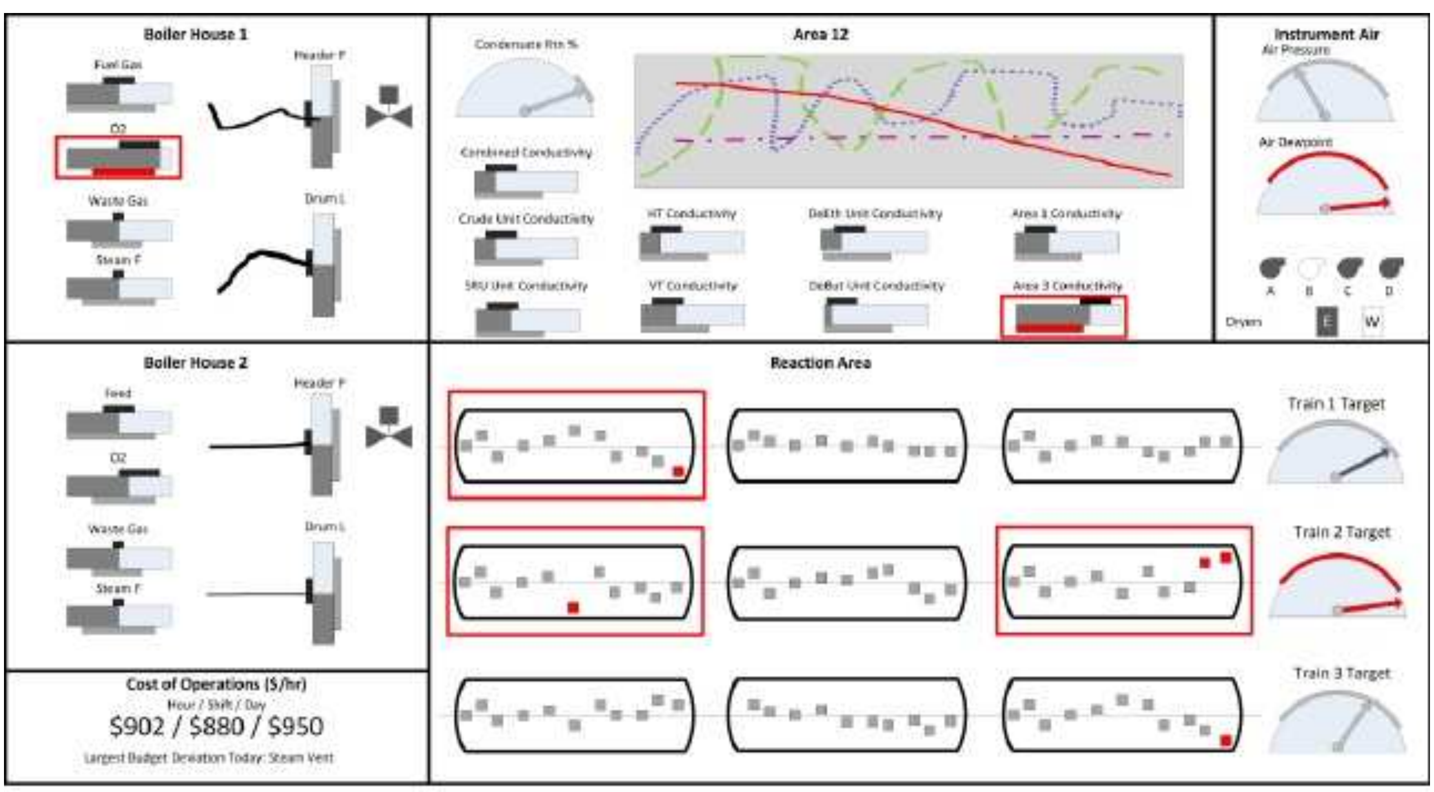


Figure 3 - Sample level 1 display

6.3.2 Level 2 displays

Level 2 displays are best described as high level process displays. They typically contain more detail than the level 1 displays. Level 2 displays should be the operator's primary operating display during normal operations for routine changes and monitoring. Level 2 displays can include process unit overviews or primary displays for every major system (e.g., the process unit controlled by the assigned operator). These are often referred to as system and subsystem overviews. Figure 4 shows an example of a level 2 display. Level 2 displays provide easy navigation to greater detail provided on the level 3 and 4 displays. Whereas level 1 displays provide a continuous overview of an operator's span of control, level 2 displays should be task based to allow the operator to perform tasks using a limited number of displays and minimal navigation.

The following considerations should be made for level 2 displays:

a) process unit overviews, primary displays for every major system, for example the process unit controlled by the assigned operator. These are often referred to as system and subsystem overviews,

b) displaying all top and middle priority alarms for the specific system or subsystem,

c) providing clear navigation cues for non-displayed low priority alarms,

d) providing enough information and controllers within the main control interface to control the system under most conditions,

e) containing the primary controllers for the specific process area,

f) displaying task-specific information for start-up and/or shutdown.

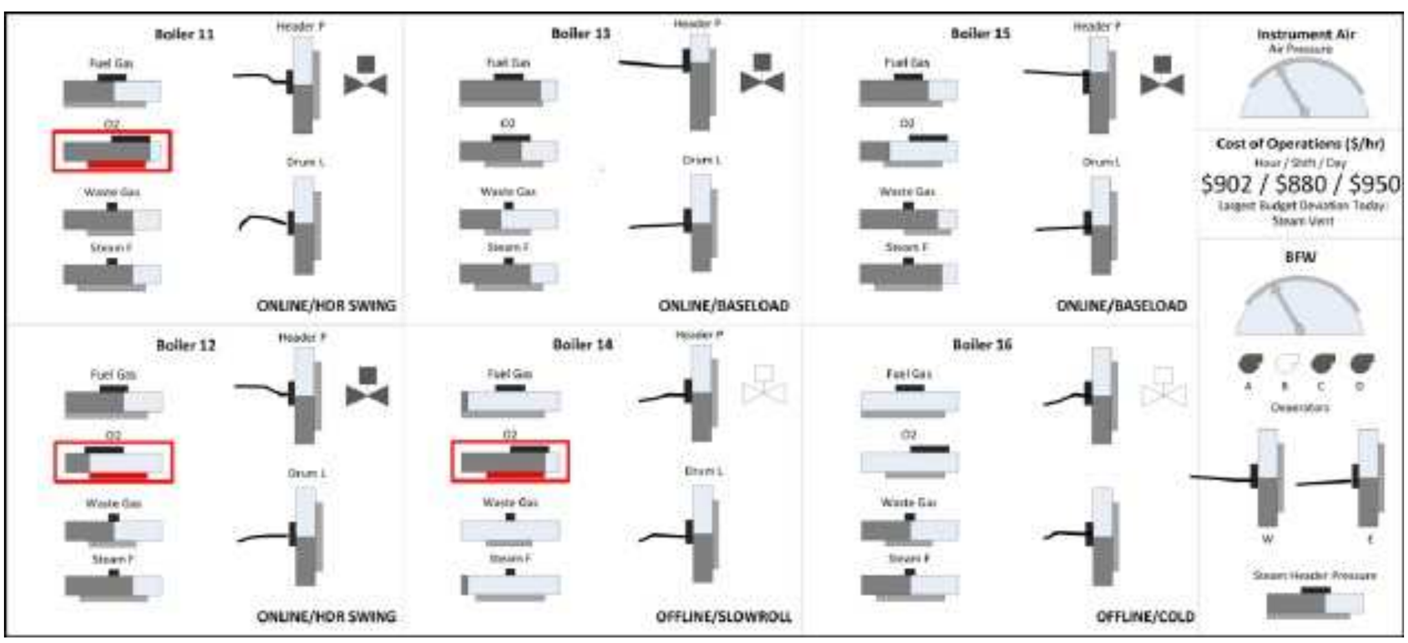


Figure 4 - Sample level 2 display

6.3.3 Level 3 Displays

Level 3 displays are best described as system or subsystem detail displays. They typically contain more detail than the associated level 2 displays. Level 3 displays should be the displays the operator uses to perform non-routine operations such as lineup changes, equipment switching, or complex routine tasks. Level 3 displays should provide sufficient information to facilitate process diagnostics and should be task based to allow the operator to perform tasks using a limited number of displays and minimal navigation.

The following considerations should be made for level 3 displays:

a) containing the control loops and indicators for process equipment,

b) displaying alarms of all priorities,

c) displaying the status of various interlocks for the depicted equipment.

Depending on the specific process, plant, display designs, and overall display hierarchy, this level 3 information may be combined in a level 2, or level 4 presentation.

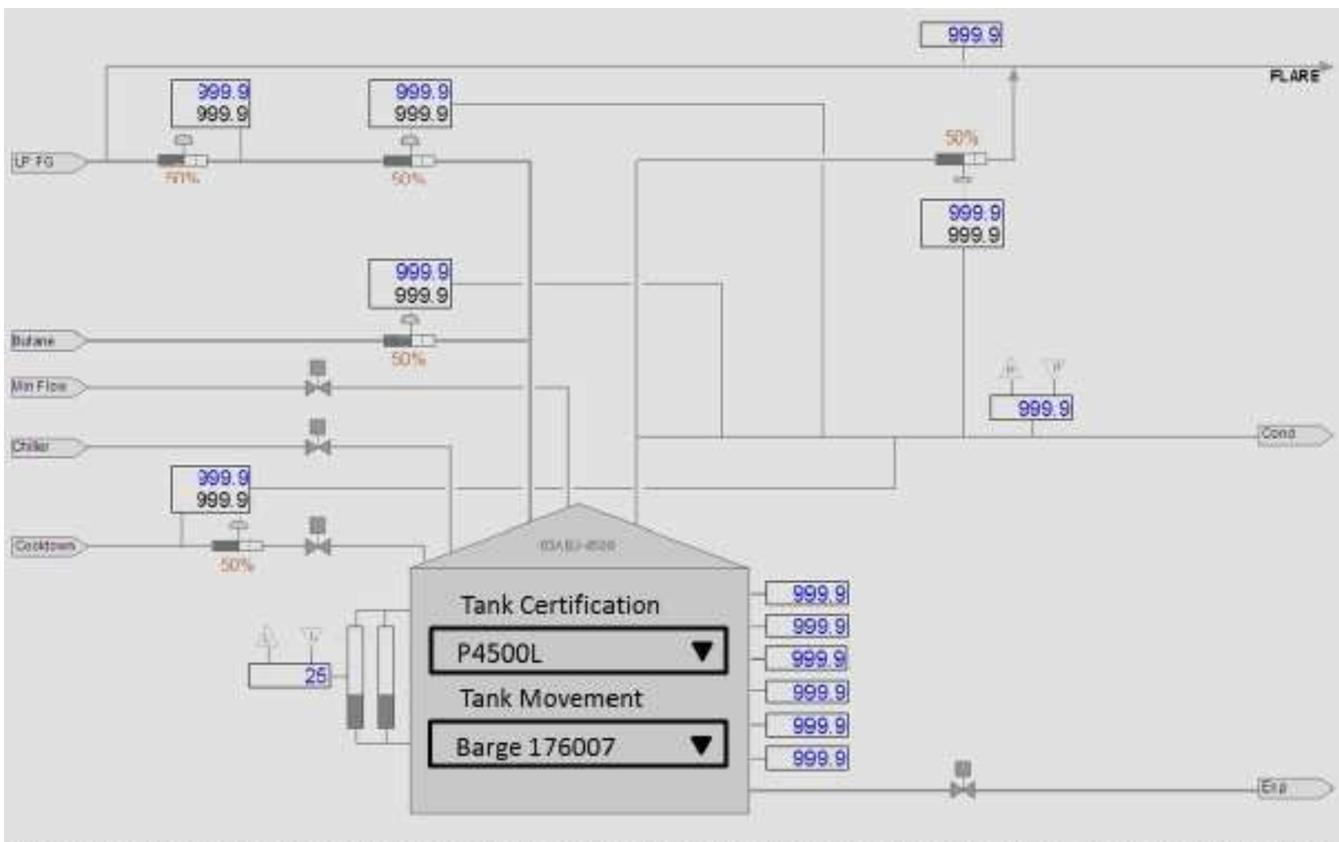


Figure 5 - Sample level 3 display

6.3.4 Level 4 Displays

Level 4 displays are best described as diagnostic displays. All system information should be available on displays at this level. Level 4 displays are not intended to be used for process or system control, however, the functionality to perform control may exist in these displays such as point details. Level 4 displays may not require a full-screen display allowing system information to be displayed in faceplates or a popup, due to the brevity or intermittence of use.

Level 4 displays are characterized as:

a) providing operating procedures for individual pieces of equipment,

b) providing help information for equipment control and diagnostics,

c) containing detailed safety shut downs,

d) containing interlock and permissive information.

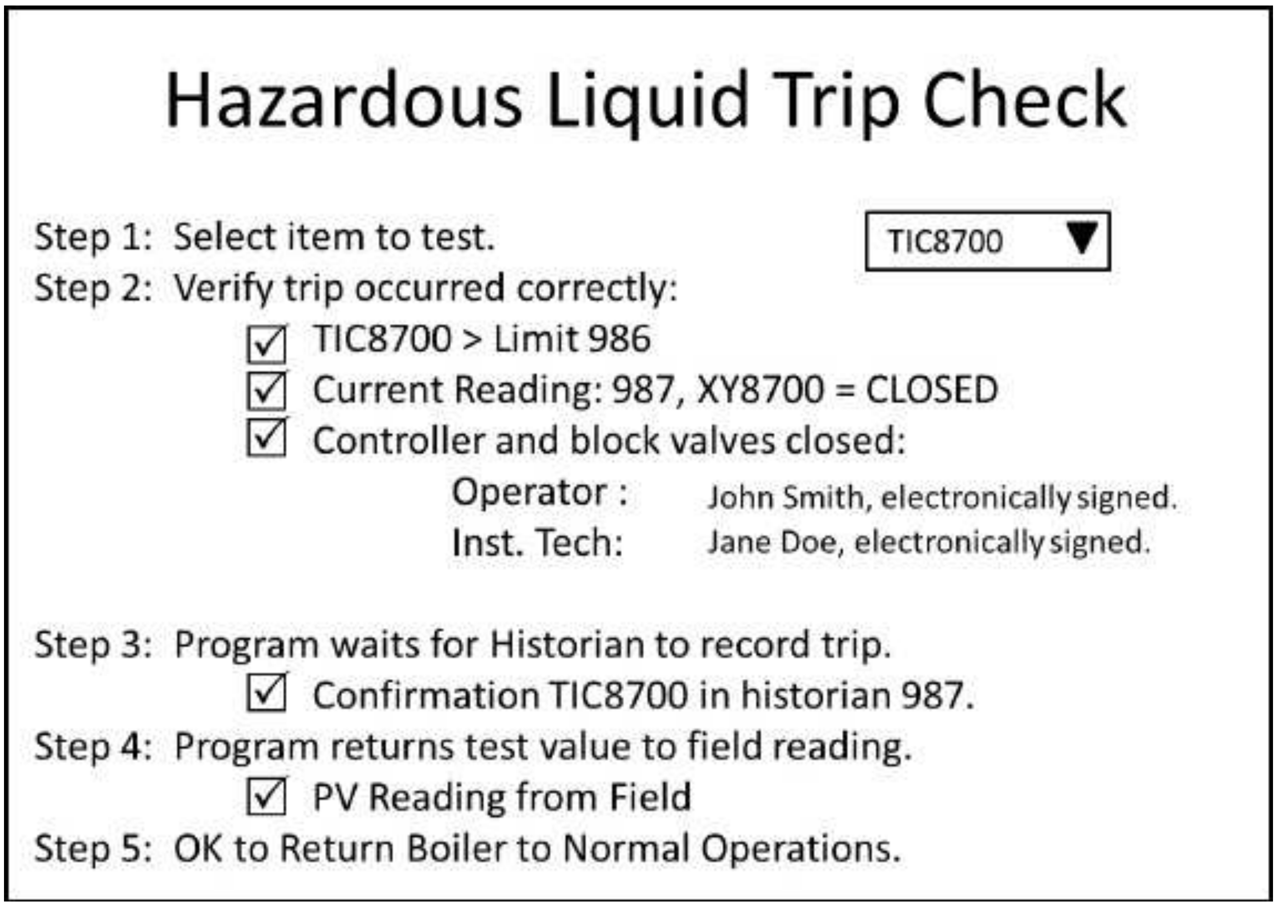


Figure 6 - Sample level 4 display

7 User interaction

NOTE: THIS CLAUSE DOES NOT CONTAIN MANDATORY REQUIREMENTS.

7.1 Introduction

This clause focuses on software methods and hardware devices enabling users to interact with the HMI.

7.2 Software methods for user interaction

In many HMI platforms, sophisticated user interaction is supported. High level requirements for user interaction may be defined in the HMI philosophy (see Clause 4.2.1) and/or in the HMI style guide (see Clause 4.2.2.). This may be supplemented with application specific user documentation.

User interaction methods include: Data entry, Navigation, Error avoidance, Off-system messaging and User access security.

Key design principles to consider include:

a) consistency in execution across all modes of interaction,

b) timely feedback for data entry and control actions,

c) streamlined user interaction (minimized number of selections or amount of typing),

d) use of appropriate salience for error messages,

e) limited use of complex conditional methods.

7.2.1 Data entry methods

7.2.1.1 Introduction

Consistent presentation of data entry should be employed. Common conventions include:

a) inset entry fields,

b) clear indication of current selection,

c) grayed items that are not available for entry,

d) “hand” cursor to reflect selectable item.

If a specific input method is required, the operator should be given visual format clues. If the entry has the wrong format, it should be rejected and the operator alerted to the error visually and/or audibly. In cases where error avoidance techniques are employed to enforce limits on data entry, methods should be used to clarify the reason for rejection.

User interaction should be designed in a consistent manner in order to speed operator response. Additionally, common operator interaction needs should be contained on the display or in a popup or faceplate-style display that only changes a portion of the screen. The operator should only be required to change screens or navigate deeper into the HMI structure for non-routine or less important interactions.

7.2.1.2 Number presentation and entry

The font selected should be discernible from the normal operator position (see also ISO11064 for guidance). If the numeric range is excessive, scientific notation can be used to display large or small values. Leading zeros on whole numbers should be suppressed, but should be displayed for numbers between -1 and 1.

The engineering units should be available for operator reference (e.g., on the faceplate, available as a show/hide feature, in a tooltip, or shown directly on the screen).

Presentation should generally follow the appropriate decimal format resolution required by users to perform their tasks. The resolution should be supported by the underlying accuracy of the process measurement. Conventions should not require that displays present more (or fewer) significant digits than required.

Table 7 – Example numeric decimal formatting

Engineering range	Decimal formatting
100 - 9999.9	XXXX
10 - 99.99	XX.X
1 - 9.999	X.XX
0 - 0.9999	X.XXX

Negative numbers should be represented in a manner consistent with the user population, generally in parentheses or with a “-” preceding the number.

Numbers with decimal formatting should be justified consistent with the user population in which the HMI display is being used.

If automatic rescaling of the decimal format is used, care should be taken to suppress rapid changes in decimal formatting to avoid repetitive shifting of the decimal point.

Numbers should be updated with new data at an appropriate frequency to meet user needs (see Clause 8.3.2).

Numbers should be presented in directly usable form. The operator should not have to compute a change in units. For example, if entering a tank level in meters or centimeters, the HMI should directly support that data entry. Additionally, any instruments that require transformation should be processed for the operator, an example being a wind direction that is measured in degrees being converted into presentation as a compass direction.

Where appropriate, numbers should be referenced to normal and other operating ranges. The reference to normal and critical can be accomplished in a variety of manners, including the use of an abnormal color or reference curves and lines. Critical values can be referenced in a similar manner, with clear indication of impending or actual critical range violations.

7.2.1.3 Text presentation and entry

Text should be justified with the normal reading direction for the user population.

Mixed or title case lettering has been shown to be easier to read than uppercase and should be generally used. If a paragraph is required, the text width should be wide enough for rapid scanning. Care should be taken when using capitalization for emphasis, since capitalized text is harder to scan. Single words and short phrases can be capitalized, but entire paragraphs or pages should generally not be capitalized.

Abbreviations and acronyms should be avoided unless they are part of the normal operator language. Do not abbreviate unless this results in a significant space improvement and will still be understood by the operator and other users.

Underlining for emphasis should not be used. It is recommended that underlined text be reserved for hyperlinks. If all underlined text is a hyperlink, it is not necessary to employ a separate color coding for hyperlinks.

Since capitalization and underlining are often restricted, the most common methods for text emphasis are size, placement and text effects (bold or italic). Color can also be used as an aspect of emphasis, if appropriate.

Display of text should be oriented horizontally unless unavoidable or for clarity. The font selected should be discernible from the normal operator position and should have clear character definition (the most common issues are related to the presentation of 1, I and L).

When operator feedback is requested and longer text segments are displayed, affirmative statements rather than negative statements should be used. Active voice should be employed. Instructions that are to be executed in order should be presented in order. Hyphenation should be avoided.

If the text to be entered can be selected from a list of options, these options should be made available to support ease of use and consistency of recorded data.

7.2.1.4 Command entry

Command entry should employ the following design concepts:

a) All inputs to, and effects of, a given command should be visible to the user where possible.
b) Commands that result in direct action to the process should require multiple input actions from the operator and not be possible from a single inadvertent input action.
c) If the command entry requires multiple selections by the operator, these selections should be followed by a confirmation of the entire list of actions before the command is executed (e.g., selecting a new recipe and confirming additive sources and product destinations).
d) If selection lists of options are long, groupings should be constructed to allow for easier navigation, scanning and identification of desired selection.
e) Command dialogs should be designed to support the expected work process of the user.
f) Users should have a method for canceling a command change during the change process or have a means for recovering quickly to prior configuration or both.
g) Feedback should be provided for all entries that are outside of an expected range. If an input is critical, acceptable limits on entry should be enforced.

7.2.1.5 Buttons

Button design should employ the following design concepts:

a) Button label text should be clear to the users and be clearly associated with the button, either on or near the button.
b) If the label text is dynamic with the process conditions, the label should depict the button action using a simple verb or active voice (e.g., stop pump).
c) Buttons should be sized large enough to allow users to select them rapidly and accurately with the pointing device in use.

d) Buttons that interact directly with the process should be visually distinct from buttons that provide navigation linkages or launch applications.

e) If appropriate to the task, any buttons that are currently unavailable (due to the state of the process or the access level of the user logged on to the console) should remain visible. However, any buttons that are unavailable should indicate their temporary unavailability with consistent visual coding. If multiple buttons are used and the interaction requires a certain sequence, the buttons should be made available only when appropriate or feedback support and incorrect order rejection should be employed.

f) Feedback confirmation should be provided for button execution.

g) Button color conventions and animation should be defined within human factors constraints (see Clause 5.2.1.2).

7.2.1.6 Faceplates and other popups

Faceplates and other popups should employ the following design concepts:

a) A timeout period should be configured (after which the popup would close without any user interaction). The operator should have control of when special use popups are closed, including the ability to override any configured timeout period.

b) Popups should be designed so as not to cover or obscure important parts of the HMI display. If they are not designed to ensure that the display is not covered, the operator should be able to be move the popup.

c) If multiple popups are used, care should be taken to ensure the operator is aware of the faceplate that has focus and connection to keyboard entry.

d) All presentation and interaction methods should be consistent with the rest of the HMI.

7.2.2 Navigation methods

7.2.2.1 General

An effective and intuitive navigation scheme can directly impact the speed and accuracy of operator intervention. The key design basics for navigation are performance, consistency and intuitiveness. Depending on user requirements, multiple navigation methods should be provided for robustness and to facilitate quick and consistent access to displays.

The navigation methods include graphic symbols on displays, as well as keyboard buttons, menu entries, toolbar buttons, folder trees, tabs, and right-click context shortcut menus. Automated navigation techniques like yoking can also be used to make multiple changes to the HMI based on operator selection of objects or on new display callup. Yoking can include other displays, faceplates, trends, and related detailed displays.

A network display navigation drawing may be appropriate to document the path between various displays. The navigation drawing should show the main drill down paths as well as other lateral paths that are expected to be commonly used. Example network drawings are shown in Figures 7 and 8.

There are two examples, one for a simple batch application, and one for a complex plant-wide application.

For the batch application in Figure 7, there are two lines of aspirin production shown. If staffed with one operator per line, then the general monitoring may occur at the overview level, the work flow across the line would be monitored with the second level of main operating displays that show navigation from left to right.

More detailed troubleshooting would be done using the detailed displays shown linked underneath each of the main operating displays. However if common feedstocks and utilities were used, it may be important for line to line comparisons to be monitored from one train to another for specific areas of both trains.

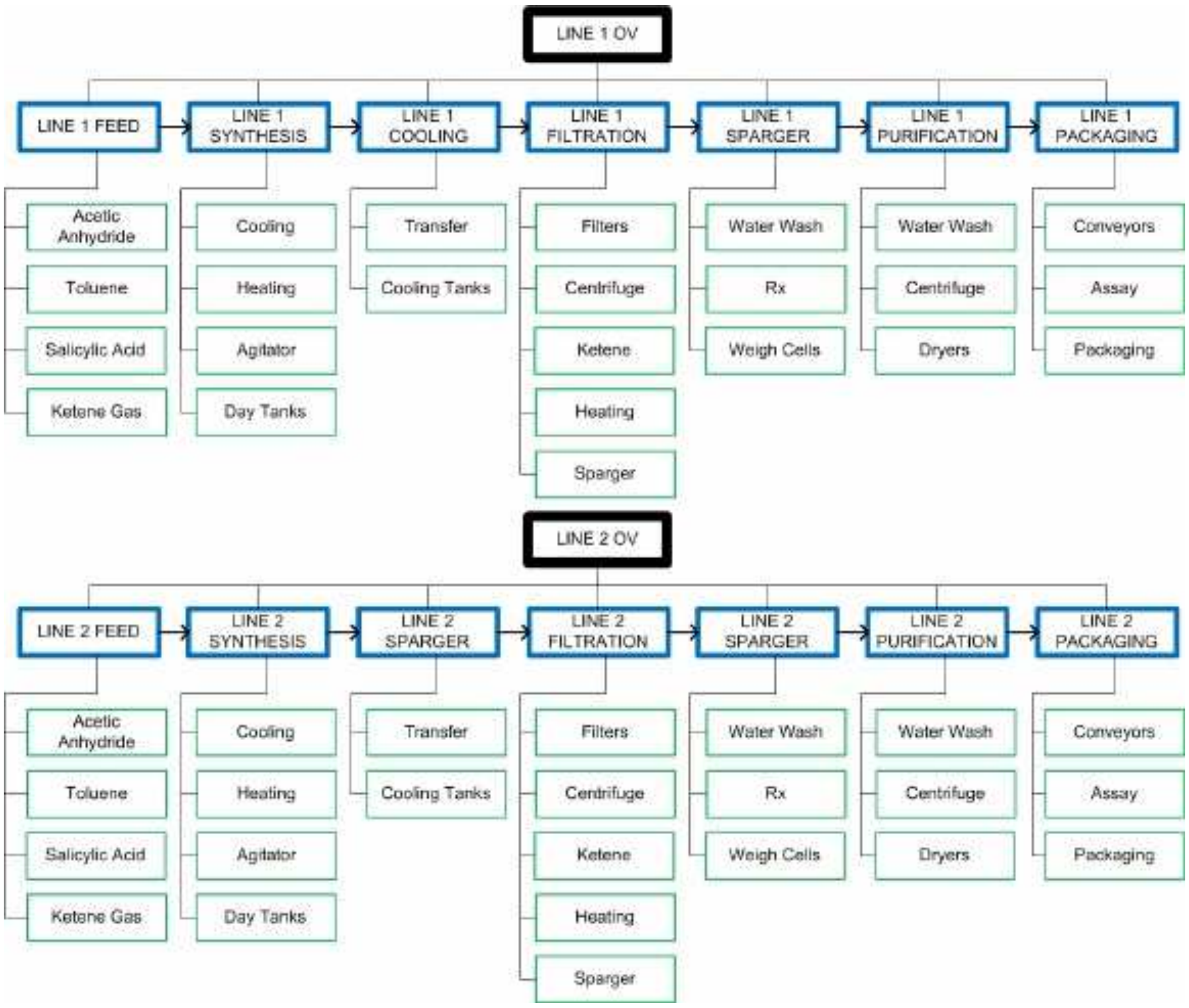


Figure 7 – Batch application navigation normal operations example

NOTE Secondary navigation methods for unit operations in each line may be required for troubleshooting. These are generally not shown explicitly in the drawing as the number of lines can be too complex. This may be referred to as up-down column navigation and side-to-side row navigation.

For larger facilities with continuous integrated operations, the navigation hierarchy drawing is necessarily larger. An example is shown in Figure 8. In this example, the line connections between the top level overview, second level process display and lower level detailed displays are omitted and inferred by position. In this example, navigation includes up-down column navigation and side-to-side row navigation.

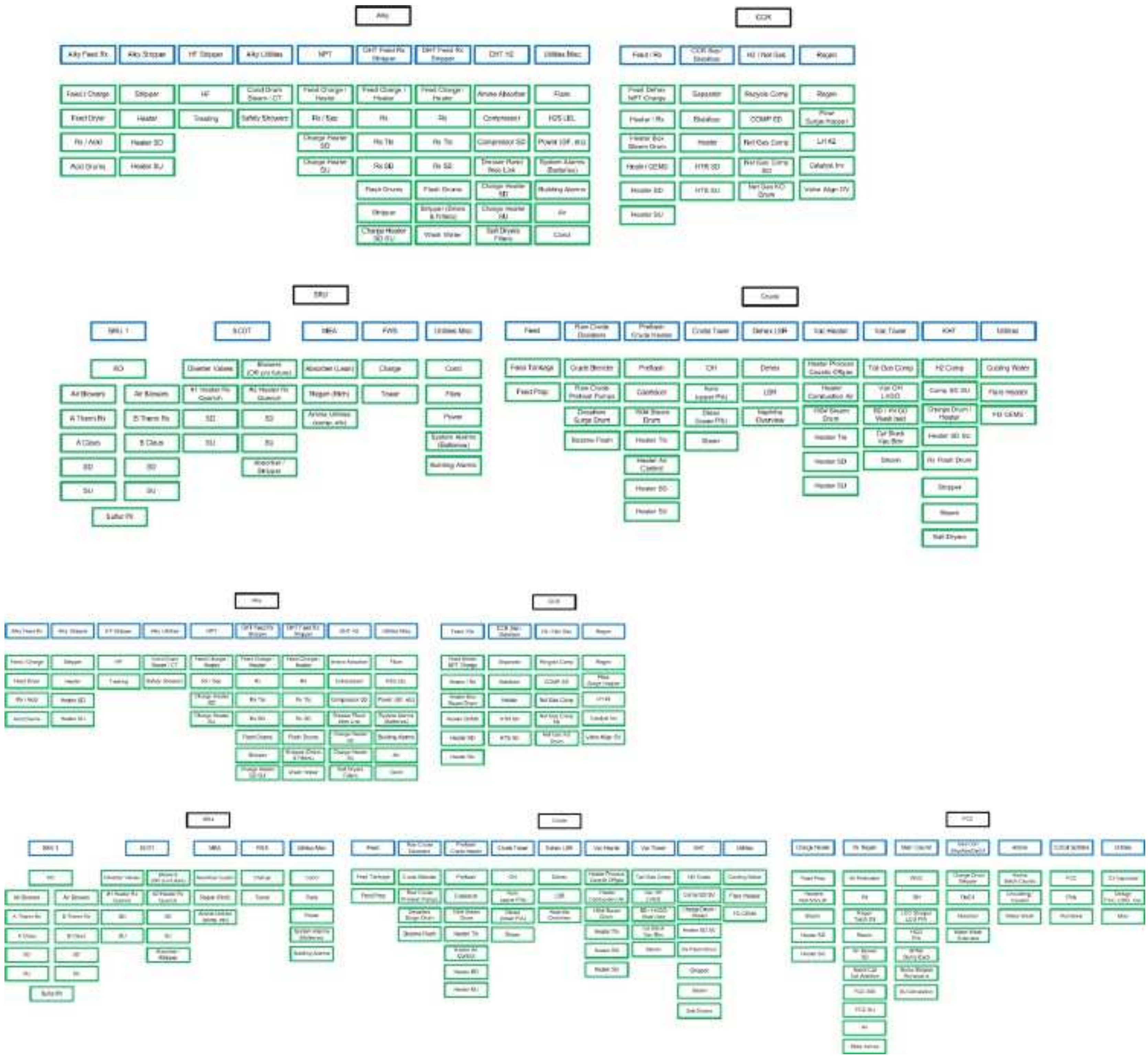


Figure 8 – Plant-wide navigation example

7.2.2.2 Navigation design types

There is no single navigation design that is appropriate to all processes. The navigation design should be tailored to meet the HMI functional requirements.

Common types of navigation designs include:

a) Hierarchical – This is the most commonly used design, where information is organized based on the physical organization of the process. It uses an inverted tree structure in which the lower branches provide increasingly specific information related to the upper branches and backbone. Hierarchical structure may be described in terms of depth (number of levels in the hierarchy) and breadth (number of options per node). When the hierarchical structure of navigation is used, it is not uncommon to have display types defined for displays in each level of the hierarchy (see Clause 6.3). The batch control (ANSI/ISA-88) and enterprise control standards (ANSI/ISA-95) provide an explanation of a hierarchical view of the equipment in any particular plant whether batch, discrete or continuous. This high level understanding of plant and process hierarchy can be used to define the displays and the navigation path between displays,

b) Relational – Relational display designs have multiple links between nodes, which are based on a variety of relationships. If the likely navigation path varies with the type of upset, a formalized relation structure may be the most effective design. This can be an effective method in a distributed utility system, where the desired navigation may be to all producers, all consumers, a specific producer/consumer or to system shedding controls. Additionally, in a utility system, a wide number of different systems may be managed simultaneously, but lack the level of instrumentation to support a 3 to 4 level drill-down structure. This design commonly includes side to side navigation links,

c) Sequential – A sequential display design organizes display pages in a series. This can be effective in batch environments where the process flows sequentially through a logical structure, but that structure changes from batch to batch based on specific products being manufactured.

7.2.2.3 Navigation design concepts

The following guiding principles for navigation should be considered:

a) Display access should be designed to minimize the operator keystroke-equivalent actions. See Table 8.

b) It should not be necessary for an operator to type in the display name or point identification, though support for that interaction should be provided.

c) Display symbols that are navigation targets should have consistent and distinct visual coding.

d) Display symbols that are selectable should have consistent and distinct visual coding.

e) Displays should be implemented in a standardized content structure that supports progressive exposure of detailed information. The content structure should be related to a logic grouping that is intuitive to the operator and supports functional relationships.

f) The HMI should support work flow for normal and abnormal conditions.

g) Where useful and appropriate, advanced HMI techniques can be employed to automatically show relevant information.

Table 8 – Example access and navigation performance

Metric	Display type	Maximum access times
Access to alarm displays	Alarm summary	1 sec
	Alarm lists such as suppressed alarms	5 secs
Navigation (Note 1)	Critical displays	1-2 clicks
	Non-critical displays	3 clicks
	Alarm summary	1 click
	System diagnostics	1-2 clicks
System state changes (Note 2)	Switching operators	5 secs
	Language change	5 secs

NOTE
1 Click could be any user interaction such as a mouse click, button selection, soft key selection, etc.
2 Not all systems are able to switch between languages at run-time.

7.2.2.4 Navigation methods

Navigation methods to consider include:

a) embedded hyperlinks,
b) display symbols with hyperlinks,
c) menus (pull-down or flat),
d) trees,
e) tabs,
f) toolbars/ribbons,
g) dashboards/task panels,
h) buttons on the displays,
i) custom keyboard buttons (function and other custom buttons),
j) context menus (e.g., mouse button right-clicks for a drop-down menu),
k) show/hide mechanisms for detailed information,
l) links to directories of files,
m) display transfer buttons,
n) voice commands,
o) yoking.

7.2.3 Error avoidance methods

Consideration should be given to error avoidance techniques and confirmation steps for important items. The items should be limited to avoid diluting the importance of the method.

The error avoidance methods should not excessively hamper the operator's ability to make changes rapidly. It may be useful to reject entries outside of an approved range or allow the change, but capture the reason for entries outside of an expected range.

The HMI philosophy and/or HMI style guide should clearly indicate the error avoidance methods employed. If error avoidance methods are used, the user interaction should be intuitive.

Confirmation steps can be in the form of signatures (either through password or biometrics), dialog boxes, confirmable messages, selection of options or direct text entry. In support of verification, the HMI may provide the ability to capture operator comments, to be annotated in the process records.

7.2.4 Off-system messaging

Off-system messaging methods are used to help the operating team manage the process. This is used in support of control rooms that are not continuously manned or to send notification of significant events to personnel outside of the direct control room staff.

Access to operating screens from outside of the production control room can be very effective and is common in some industries. Additional user and network security may be required in remote locations or in use of systems from remote locations.

Messaging systems should be designed for adequate robustness to support the functional requirements. At a minimum, the systems should be automatically monitored for availability. In more critical systems, a backup system should be in place to provide the required functionality in the event of an outage.

Off-system messaging methods include, but are not limited to:

a) auto-dialer voice messages,
b) remote alarms,
c) pagers,
d) digital message pagers,
e) text messages,
f) emails.

For off-system messaging related to the alarm system, see also ANSI/ISA-18.2.

7.2.5 User access security

The HMI system may have some level of HMI application specific security.

This scope does not include the overall user account management, which is covered by ANSI/ISA-62443.

HMI specific considerations include:

a) temporary log over (ability to increase user rights without logging off completely) for specific tasks,
b) concept of multiple roles and privileges within an application (role-based restriction),
c) information access restriction based on the user's scope of authority,
d) location-based content restriction,
e) use of electronic signatures,
f) authentication notes (requirement of a user to add a reason for a control action),
g) use of biometrics.

7.3 Hardware interfaces

Selected HMI display and input devices should support the functional needs of the users and the level of robustness required in the intended environment. It is not uncommon to use multiple types of input devices for different operating environments within the same facility (e.g., control room, field mounted station, mobile devices, etc.).

7.3.1 HMI devices

HMI monitor equipment can vary from hand-held devices to indoor and outdoor monitors of varying sizes to larger post or wall-mounted monitors.

Device selection should include consideration of ergonomic factors, including viewing angles and resolution for color perception and readability, physical reach for input devices, and related environmental factors including lighting and sound (including speaker selection and placement).

When a fixed workstation is desired, some consideration of sitting and standing options should be made. With portable devices, the battery life and ruggedness are likely to be key considerations. Wireless devices have special security and reliability considerations that are outside the scope of this standard (see ANSI/ISA-100).

7.3.2 Size considerations

The size of the HMI device should take into consideration the amount of data displayed, the methods of data entry, and the physical location on the console, including portable devices. Significant differences in aspect ratio of the monitor hardware may require special toolkit support to ensure usability on all hardware. The aspect ratio of an image describes the relationship between its width and its height. It is commonly expressed as two numbers separated by a colon, as in 16:9. A common misconception is that x and y represent actual width and height. Actually, they represent the relation between width and height. As an example, 8:5, 16:10 and 1.6:1 are the same aspect ratio.

Devices larger than a typical desktop monitor are perhaps best suited for use in the display of overview information, including topological, architectural, process flow diagrams with efficiencies and other key performance metrics. Larger screens are generally viewed from a distance, which may require unique graphics objects designed for legibility.

Very small devices may limit interaction methods using touch screens with potentially less selection resolution than desktop devices, such as a trackball or mouse. It is also important to consider the design implications of the use of multiple monitors on a single workstation, as well as widescreen (16:9) versus (4:3) aspect ratio and overall screen resolution.

7.3.3 User input devices

Interaction devices have similar breadth of design issues related to the resolution and speed with which they are operated. These interaction devices include, but are not limited to:

a) keyboards,

b) pointing devices (mouse, trackball, etc.),

c) custom keyboards or keypads,

d) touch screens,

e) video wall controls,

f) handwriting input devices,

g) voice input,

h) bar-code scanners,

i) RFID readers(radio-frequency identification),

j) cameras,

k) pushbuttons/toggle switches,

l) others (biometric readers for security, etc.).

8 Performance

NOTE: THIS CLAUSE DOES NOT CONTAIN MANDATORY REQUIREMENTS.

8.1 Introduction

This clause focuses on performance factors. These performance factors can be viewed in two categories:

a) HMI duty factors – these factors are related to display response, including such metrics as call up times, display refresh times, and key clicks (reference Clause 7.2.2),

b) performance shaping factors – these factors are related to how fast an operator is able to detect, diagnose and take action.

The effectiveness of an HMI application depends on the manner in which the displays are structured. The overall performance of the operation 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.

Interfaces are designed to provide repeatable behaviors and predictable response times. Fast call up of process and historical information is required to minimize any delays in providing the operator with information that may be needed to address an abnormal operating condition. In most cases, a display should be presented and completely populated with live data within 3-5 seconds.

In some cases, displays may require longer call up times (e.g., large trend sets, remote access). In these cases strategies such as showing the graphic and then updating the graphic with information as it arrives will allow the user to begin processing data earlier.

8.2 HMI categories

This clause includes categories which are used to partition the target systems. The response times are for the system or the machines being controlled by the system, not the humans in the loop.

8.2.1 High speed machine control

The HMI is typically closely coupled to a machine where fast response is required. Examples include high speed packaging and robot or machine tool.

8.2.2 Process systems

A process system includes a system with numerous instruments and controlled equipment.

Small systems typically include a group of interconnected equipment in a manufacturing environment. A system of this size is controlled or could be controlled by a single PLC, a small Distributed Control System (DCS), or a Programmable Automation Controller (PAC). Examples include filling and packaging with a number of machines, a boiler in a building, or a small water treatment plant.

Larger systems may be spread out over a large area requiring considerable travel time if personnel are required to go between the HMI and the field equipment on foot. Examples include a chemical plant, oil refinery, or large wastewater treatment plant.

8.2.3 SCADA

A SCADA system is a system that supervises and links several smaller systems. Examples include mill control, plant control, and systems that oversee distributed systems such as those used for pipelines and city water treatment and distribution. High level displays may be used to manage movements across sites. For many of these cases the high level displays present transports and ANSI/ISA-95 inventory locations, storage zones and storage units as well as high level representations of each site. More detailed data from individual sites may be accessible via drill-downs from the multi-site displays.

8.2.4 Geographically widespread RTU systems

An RTU system is a specialized type of SCADA I/O-based system which is spread out over great distance. The difference between a SCADA system and an RTU-based system is that RTUs may be scanned in terms of minutes. The network technology used in these cases is often over radio, public networks or satellite. Examples include electric utility transmission line substations, petroleum pipeline valves, monitoring and pumping stations; and sewage lift stations distributed throughout a city. In some cases these systems may be used to poll data from multiple sites.

8.3 HMI duty factors

This clause summarizes performance values that should be met by the control system and HMI together. Measures such as display call up time are important, particularly during startup, shutdown, or upset situation scenarios when the operators are navigating through many displays in rapid succession. As a general rule, display refresh times need to be in the 2-3 second range on faceplates and 5 second range for most parameters on regular process displays. Values for these measures should be determined by the user requirements but may be limited by system capabilities. The measures are described in the following sections.

8.3.1 Call up time

Call up time is the time from when a display change is requested until when all display elements have been refreshed. Displays used for operational purposes should display quickly when invoked. Displays such as trend and history displays may be slower. There are many factors influencing how fast a display is initially rendered and values updated. In some cases, to improve display call up times, displays will be cached; in other cases displays will be both cached and values pre-loaded. For improved call up times static elements can be grouped and embedded as a single object. Overview display and alarm summary display are often continuously displayed on dedicated monitors in multi-monitor HMI systems. In these cases the display call up time is not applicable.

8.3.2 Display refresh rate

After displays have initially been called up, they continue to be updated. The rate that they are updated is referred to as display refresh rate. Displays should be capable of updating quickly enough to depict values relative to the speed at which the process is capable of changing. The display refresh rate should be appropriate to the dynamics of the system and no slower than about 50% of the fastest expected response time. This setting allows sustained oscillations in the control loop to be detectable by the operator during process transitions. Display refresh rates of 1-5 seconds are normally seen as acceptable. Sub-second refresh rates are unlikely to help the operator and can result in the display of distracting, jittery numbers.

Display refresh rate is impacted by both the HMI category and display type.

8.3.3 Write time

This is the time from when an operator initiates a change to the time the controller receives the value.

8.3.4 Write refresh time

Write refresh time is the time from when an operator initiates the action from the HMI (e.g., pushing a button, selecting an item from a drop down list) to the time the feedback is displayed on the HMI indicating the action started and completed. Write refresh time is often not detectable and the value shown is the value entered by the operator. The actual value accepted by the control system will come back in the next refresh cycle. Data entry and error avoidance are described in Clause 7.2.1 and Clause 7.2.3.

9 Training

NOTE: THIS CLAUSE CONTAINS MANDATORY REQUIREMENTS.

9.1 User training

Multiple aspects of an HMI may require training to enable effective use. These include the logistical aspects of how to interact with the HMI objects in general and the specific objects related to a given functional task.

With the introduction of a new system or a new operator, for example, the users should be trained on the basic operation of the platform application. This would cover items such as:

a) interpreting graphic symbols,

b) manipulating display elements (i.e., opening / closing valves or changing setpoints),

c) identifying and interacting with alarms, process events, and sequencing,

d) navigating around the displays.

While the HMI philosophy, the HMI style guide, the HMI toolkit and the system design documentation would cover at least part of this information, these documents may not be sufficient for user training. Therefore, requirements for the development of any additional specific HMI user training materials need to be identified.

HMI training shall be incorporated into the existing training process of the end user organization and will also follow relevant management of change requirements. This could include verification and documentation of user training.

Highly regulated industries may have a periodic refresher training requirement as well. Following is a list of typical topics covered in the training process for use of an HMI. The same topics may be listed for different users and should be presented at a degree of detail appropriate for each level of responsibility.

9.1.1 Operations

Operations training should include the use of the HMI to accomplish required operational tasks, these may include:

a) interaction with the control system under all modes of operation,

b) use of the alarm system,

c) recognition of abnormal control conditions such as forced values,

d) responding to process or control upsets,

e) understanding the display navigation design,

f) retrieval of historical data,

g) adjusting setpoints,

h) adjusting parameters such as modes and outputs,

i) starting up a batch or initiating a pre-programmed sequence,

j) starting up or shutting down a complex continuous process,

k) recognition of special equipment or device operating conditions such as maintenance modes,

l) familiarity with HMI philosophy.

The use of simulators with an HMI identical to the actual plant HMI is an acceptable and effective method of training for operations personnel.

9.1.2 Maintenance

Training for plant/site maintenance staff responsible for the process equipment as well as the HMI and control system should include:

a) use of HMI to accomplish required maintenance tasks,

b) vendor documentation for HMI hardware components,

c) vendor documentation for HMI configuration tools,

d) familiarity with operations functionality,

e) familiarity with HMI, control system, and process diagnostic tools,

f) Management of Change process covering the HMI,

g) familiarity with the HMI philosophy.

9.1.3 Engineering and administrators

Training for engineering and administrators responsible for the implementation of and modifications to the HMI should include:

a) use of HMI and HMI platform tools to accomplish engineering tasks,

b) vendor documentation for HMI hardware components,

c) vendor documentation for HMI configuration tools,

d) familiarity with operations functionality,

e) familiarity with diagnostic tools,

f) system backup and recovery procedures,

g) HMI security and how HMI user accounts and user privileges are to be used,

h) Management of Change process covering the HMI,

i) familiarity with the HMI philosophy, style guide and toolkits,

j) any necessary periodic revisions or updates to operating systems, security tools, etc.

9.1.4 Management

Management training should include the use of the HMI to accomplish required management tasks. These tasks typically include access to high level production and plant operating information, which may or may not be available outside of the HMI environment. If the HMI is needed to access this information, training of these individuals is warranted.