

UX Design Considerations for CCE Monitoring Devices

New Horizons | September 2024

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Term	Definition
Appliance	Vaccine refrigerator or freezer
CCE	Cold-chain equipment (i.e., a fridge)
EMS	Equipment Monitoring System: The general term used to describe the associated components, sensors, devices, appliances, and data systems that enable cold chain equipment monitoring. In 2022, the WHO PQS group (see “PQS”, below), published the EMS standards, which define requirements for next-generation CCE monitoring systems.
EMD	Equipment Monitoring Device: The component of a EMS that provides a user interface and, optionally, data transmission.
HCW	Healthcare Worker
WHO PQS	WHO Performance, Quality, and Safety: The WHO division and associated processes that prequalifies products and devices to assure suitability for use in immunization programs.
Technician	A biomedical technician, responsible for preventative and corrective maintenance on CCE.

What is this?

This document is a collection of UX Design Guidance for digital displays in CCE monitoring equipment. It is an attempt to capture best-practices for designing clear and intuitive displays for cold chain equipment.

It reflects the collective and subjective perspective of New Horizons, based on years of experience using and developing cold chain equipment.

About New Horizons

New Horizons is a nonprofit engineering organization dedicated to addressing technical challenges in global health. Our mission is chartered and supported by a single philanthropic donor, whose support enables us to pursue ambitious projects to improve health outcomes worldwide.

Relation to the WHO PQS EMS standard

This is not associated with WHO PQS and it is not part of the EMS standards. Following the publication of the EMS standards, New Horizons recognized that many suppliers would be developing new CCE monitoring equipment. Our intention for this document was to articulate and refine our design thinking in this domain. We are releasing it publicly in the hopes that other teams may find it useful for their own efforts and, ideally, provide valuable feedback to improve the perspectives.

Emphasis on stationary CCE

The guidance in this document is focused on stationary cold chain equipment. Transportable CCE has special considerations that will likely benefit from somewhat different approaches. Designers should evaluate this guidance accordingly.

Almost 20 years ago, during a lunch with vaccine industry suppliers, Mr. Umit Kartoglu of WHO PQS detailed the problems of temperature monitoring in vaccine refrigerators and described the features of a hypothetical device that could address those problems.

That same year in December, Andrea Berlinger visited Mr. Kartoglu at WHO and presented him with a prototype Fridge-tag, the first data logger designed specifically for monitoring vaccine refrigerators. That device made it possible to actually see the historical performance of vaccine refrigerators. In the following months, the Fridge-tag became the first-of-its-kind device in the 30-day temperature recorder (30DTR) category. This was a pivotal moment in vaccine safety and the Fridge-tag remains an essential tool in immunization programs around the world.

Subsequent innovations, such as Remote Temperature Monitoring Devices (RTMDs) and the Equipment Monitoring Systems (EMS) specification, have expanded on Mr. Kartoglu's original vision, enhancing the ability to monitor fridge performance and safeguard vaccines.

Given this document's emphasis on making CCE performance *visible*, we want to recognize Mr. Kartoglu as the inspiration and catalyst for modern cold-chain equipment monitoring solutions. We also extend a special thanks to Berlinger for their foundational efforts to develop Fridge-tag.

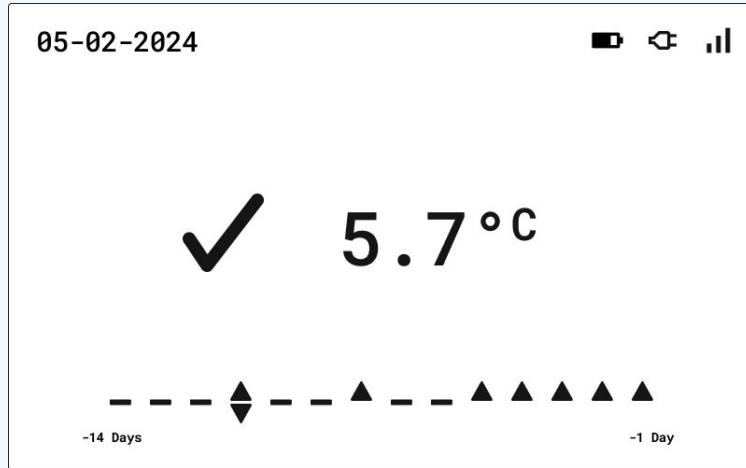
Caveat

This document is not intended to be prescriptive or inflexible.

The contents are a point-in-time snapshot of New Horizons' perspectives on design patterns. We readily acknowledge that there are different and reasonable ways to design CCE displays, other than the ones described here. **You are encouraged to use this document as a resource to inform your own implementations.**

Home Screen

The image shows a minimalist home screen design. The background is a light blue color. A diagonal line runs from the bottom left corner towards the top right, creating a triangular section in the bottom right corner that is a darker shade of blue. The text "Home Screen" is positioned in the upper left area of the light blue section.



The home screen is the **default interface view**. Its primary purpose is to indicate whether the refrigerator is effectively protecting the stored vaccines, especially for healthcare facility staff who use the system daily.

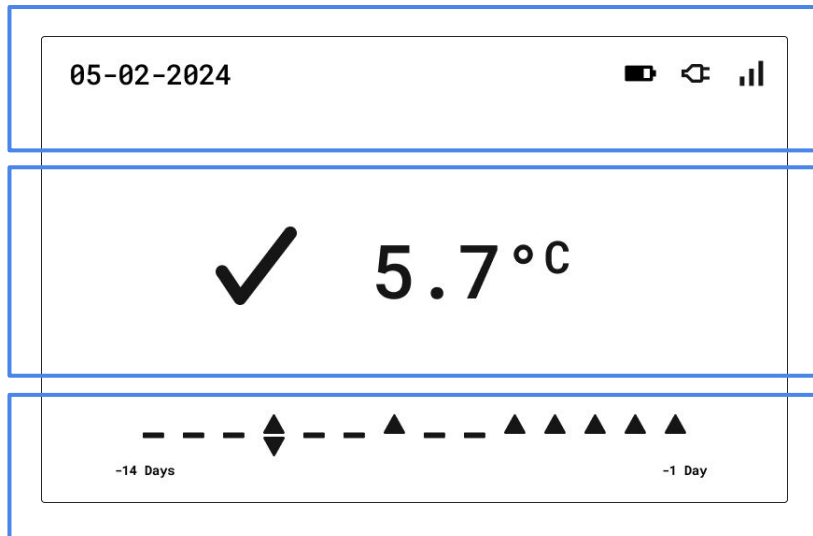
Effective home screen designs **prioritize the display of the most essential information**, especially:

- Current temperature of the vaccine compartment
- Alarm status (✓/X)
- Active alarm list
- Alarm history
- System error indicator

Information that is needed less frequently or by more technical users can be made accessible through menus or secondary displays, ensuring the primary display is not overburdened.

Content Layout

CONSIDERATION



Screen designs should clearly emphasize the most important elements for the user. A common and effective layout uses three content areas to organize information:

1. **Header:** system toolbar
2. **Main Body:** vaccine chamber temperature
3. **Footer:** multi-day alarm history

This layout centers and enlarges the most essential information (i.e., vaccine chamber temperature and alarm status), enabling facility users to quickly identify this critical information.



Header variation:

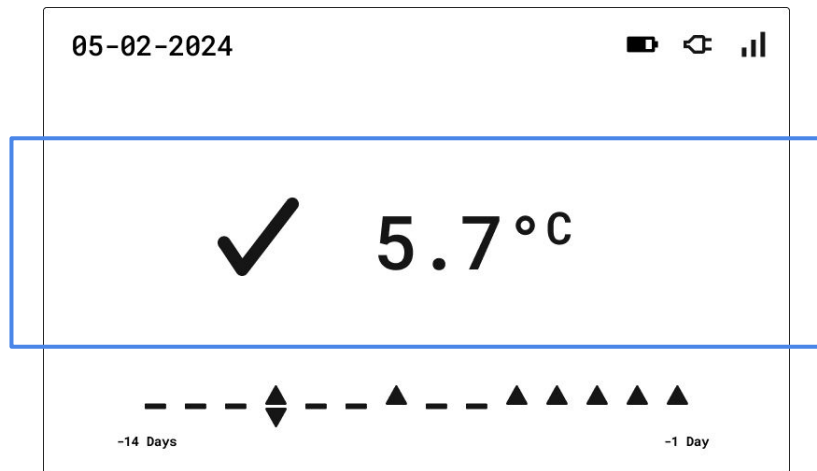


The header adopts the design pattern from mobile phones to **display secondary status indicators** that are commonly understood and space-efficient. This includes:

- Page Context (indicated here by today's date)
- Power / Battery status
- Connectivity status (cellular, Wi-Fi)

Although this information is of secondary importance, it may be reasonable to display the header on each screen, similar to how mobile and desktop operating systems behave.

Note that different monitoring systems might require the display of various data points (e.g., Wi-Fi connectivity status; combined power/battery indicators; relative time indicators, etc.).



Main Body variation:



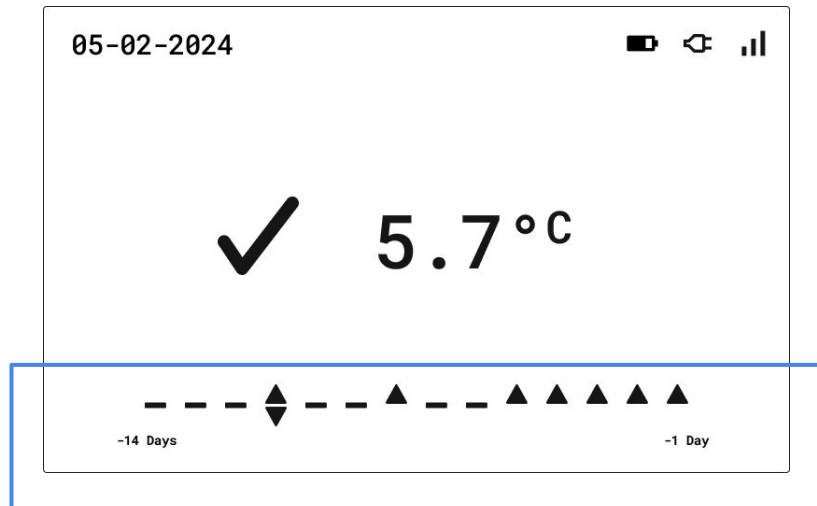
The main body of the home screen should **prominently display the most critical information**:

- Vaccine chamber temperature
- Visual indicator of alarm status (✓/X)
- Active alarms
- System Errors (not shown here)

The vaccine chamber temperature is the most critical data on the display. Facility staff refer to this metric multiple times each day.

The ✓ / X symbols are common in CCE monitoring systems and provide a visual indication of whether the system is adequately protecting vaccines.

Information about active alarms and system errors should be displayed when such conditions are present. See the *Alarms* section for a more detailed discussion of these indicators.



Footer variation:

Alarm count (30d): HEAT 9 FREEZE 0

The footer can be used to provide **insights into historical temperature alarms**.

The graphical format shown here is a multi-day summary of previous temperature alarms, popularized by common 30DTR devices. It enables a user to quickly assess whether alarms were triggered *in recent days*. Other design strategies might also achieve this objective, but this format is both **space-efficient** and **broadly understood** in the immunization ecosystem.

If adopting this format, using additional annotations can ensure that users accurately interpret the chronological orientation of the chart (e.g., whether recent data is on the left or the right). Such annotations can be incorporated in the display (i.e., digitally) or placed adjacent to it (e.g., on the face of the device).

The importance of Performance History

CONSIDERATION



Home Screens should communicate the alarm history of the appliance.

Before 30DTRs were introduced, simple thermometers were the the main tool for monitoring fridge performance. However, thermometers only display the current temperature and provide no insight into the fridge's historical performance.

The ability to track and communicate historical fridge performance was a groundbreaking improvement. These capabilities put current fridge performance into a larger context, which is critical for both CCE users and technicians.

Character Size and Accessibility

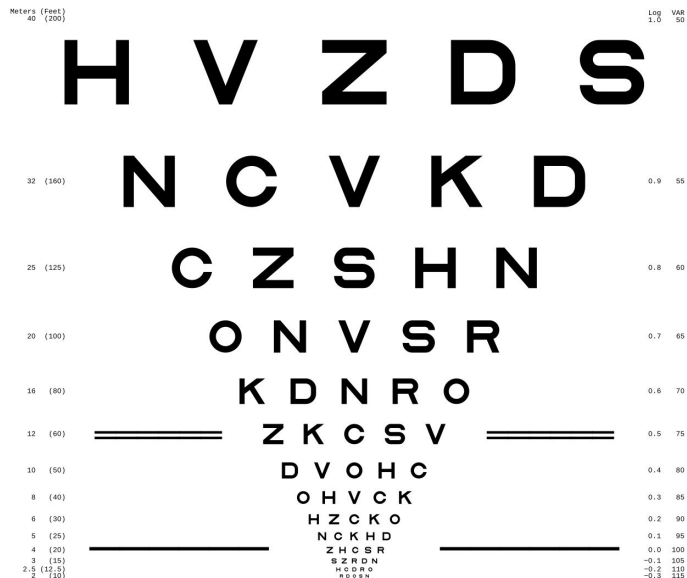
CONSIDERATION

According to the WHO, at least 1 billion people worldwide have preventable or unaddressed vision impairment¹, so it is essential for screen designs to consider and accommodate users with uncorrected vision impairments.

The Americans with Disabilities Act (ADA)³ accessibility standards for digital displays (e.g., ATMs, payment terminals)² recommends the following practices:

- Use sans serif fonts.
- Make characters at least 4.8 mm high.
- Ensure high contrast between text and background.

These recommendations enhance readability and accessibility for all users.



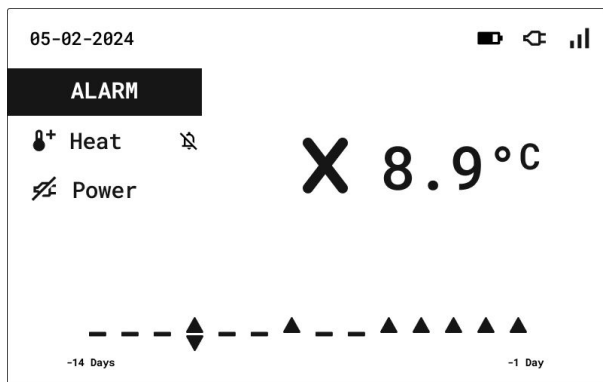
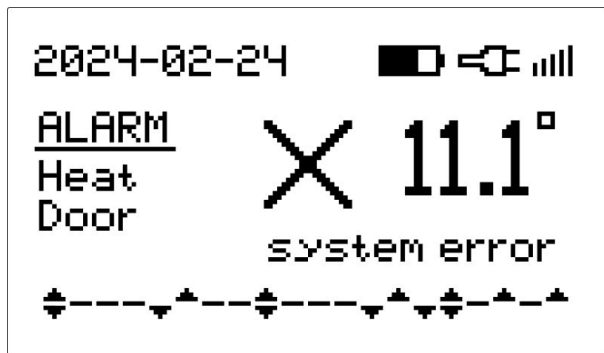
¹ <https://www.who.int/publications/i/item/9789241516570>

² https://www.access-board.gov/ada/#ada-707_7_2

³ Most international accessibility standards require that text size should be scalable by the user. The ADA also provides recommendations for non-scaled displays, which makes it noteworthy in this context.

Interface Resolution and Capability

CONSIDERATION



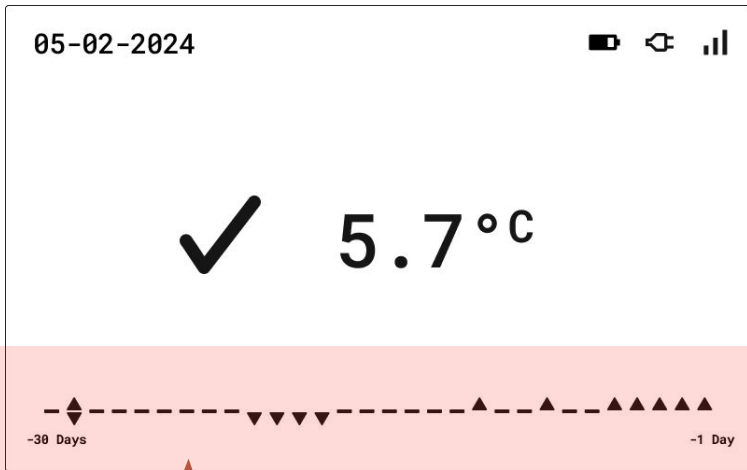
Different systems will have different display resolutions. The example at upper left show Home Screen representations based on a monochromatic 128x64 LCD display¹, which are small and low-cost. **As display resolution decreases, it may be necessary to eliminate some information from the screen** in pursuit of simplicity and clarity. Higher resolution displays (example at lower right) provide more options for system designers.

In all cases, designers should **prioritize inclusion of vaccine chamber temperature, alarm status (✓ / X), and historical performance information on the Home Screen**, as these are the most critical elements.

¹ The low-resolution example is shown larger than the actual scale of a physical 128x64 module. Further refinement would likely be required to achieve accessibility and legibility goals.

of Days Displayed

CAUTION



⚠ Displaying more days might reduce legibility

Preserve legibility by
displaying fewer days

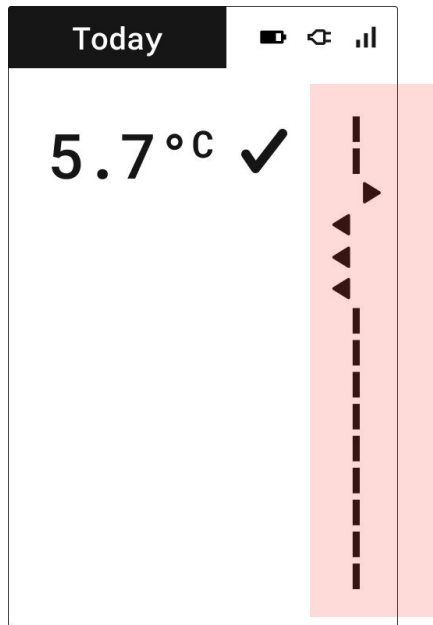


Some common monitoring devices display 30 days of historical alarm data, but **it is crucial not to sacrifice legibility for quantity**. To preserve legibility, it may be necessary to change the format for displaying historical data or to decrease the number of days displayed. This historical information provides critical context, so you should strive to display the full 30 days of context.

Be aware that displaying *at least* 30 days of alarm history is a requirement in the WHO PQS EMS specifications. Therefore, systems must include a method to achieve this, even if the home screen displays fewer than 30 days.

Orientation of Historic Data

CAUTION



Risk: vertical representations of chronological data may be misunderstood

Instead, use a horizontal display



When presenting historic alarm data in a visualization, **avoid using a vertical layout**. Using a horizontal layout is a strong convention in visualization of time-oriented data¹, which provides an intuitive indication of past and future directions.

¹ See, for example, Aigner, Wolfgang & Miksch, Silvia & Schumann, H. & Tominski, Christian. (2023). Visualization of Time-Oriented Data. 10.1007/978-1-4471-7527-8.

Text-only Display Approaches

CAUTION

System	GOOD
Current Temp	5.7 °C
Alarms	No
Date	05/04/2024
Power	Connected
Cellular	Strong



**Risk: this may be hard to scan
and understand at-a-glance**

Avoid text-only screens for the home screen, to ensure key information is presented clearly to daily users.

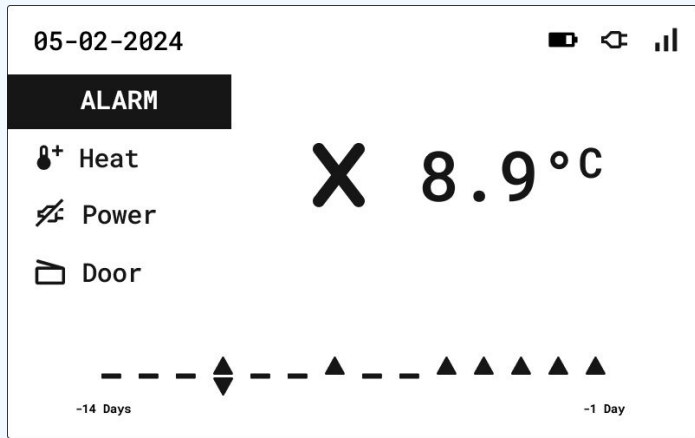
Where text-only screens are unavoidable (especially, screens for more technical users), establish a clear visual hierarchy so users can quickly focus on critical information. This screen at left presents similar data as shown on previous pages, but the uniform size of text and lack of grouping is an obstacle to understanding.

Use varying sizes, icons, and graphics to highlight key data points, emphasize important information, and reduce cognitive load on users.

Consider that text-only screens may create a larger burden when translating to other languages. Iconography is inherently multi-language, which can be an advantage to comprehension.

Alarms

A decorative graphic element consisting of a solid blue shape that starts from the bottom left corner and extends diagonally upwards towards the right, filling the bottom half of the slide.



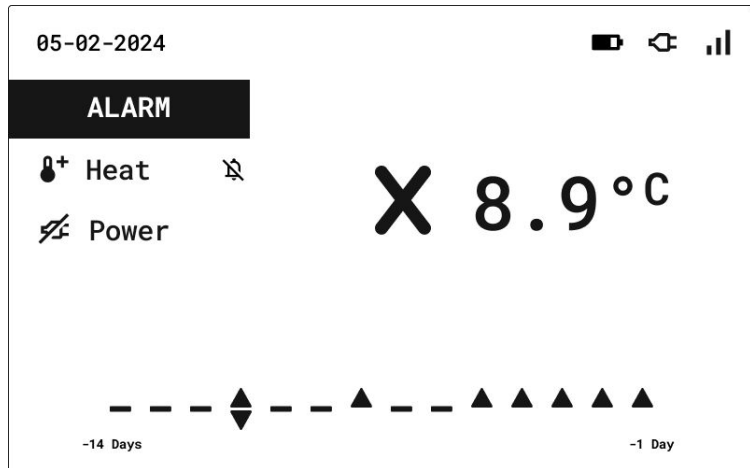
Alarms play a vital role in ensuring the safety and efficacy of vaccine storage systems. Effective alarm systems must provide clear, immediate, and easily understandable signals to prompt swift action.

During active alarms, the home screen should clearly identify active alarm(s). Avoid using a symbol alone to indicate an alarm. Combining a symbol with an explicit alarm label can improve understanding across different languages and literacy levels.

In systems that implement an alarm status indicator, the indicator should be changed to reflect unhealthy status (e.g., from ✓ to X). To increase the visual prominence of alarms, **consider adding a blinking LED (shown as ) to indicate a general alarm status.**

Acknowledging an Alarm

CONSIDERATION



Alarms should have audible and visual indicators and allow for acknowledgement by users.

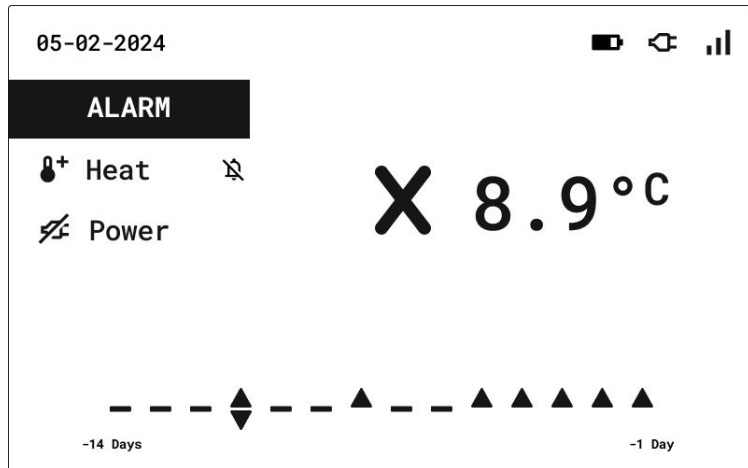
The process to acknowledge an alarm on the monitoring device should be clear and obvious, even to first-time, non-technical users. **After acknowledgment, the system should visually indicate this status next to the alarm** (shown here as  although other approaches are reasonable).

Keep in mind that a system might have more than one active alarm. Visual indicators should help users distinguish between acknowledged and unacknowledged alarms.

If using LEDs to signal the presence of alarms, consider blinking () and non-blinking () states to communicate acknowledgement (or lack thereof).

Acknowledging an Alarm (cont.)

CONSIDERATION



[alarm silencing button]

There is a variety of words that are used in relation to alarm acknowledgment, which may result in confusion:

- Acknowledging [an alarm]
- Silencing
- Muting
- Disabling

We recommend the following interpretation:

- **Silencing** and **muting** are equivalent terms.
- **Silencing** an alarm also **acknowledges** it.
- **Disabling** an alarm is a distinct concept that prevents new alarms from being raised.

Implementing a dedicated button to silence (and thus acknowledge) active alarms is an intuitive approach, though other methods are possible. Once an alarm is silenced, it should remain silent and not re-announce itself on regular intervals.

ALARM



Heat



Freeze



Power



Door

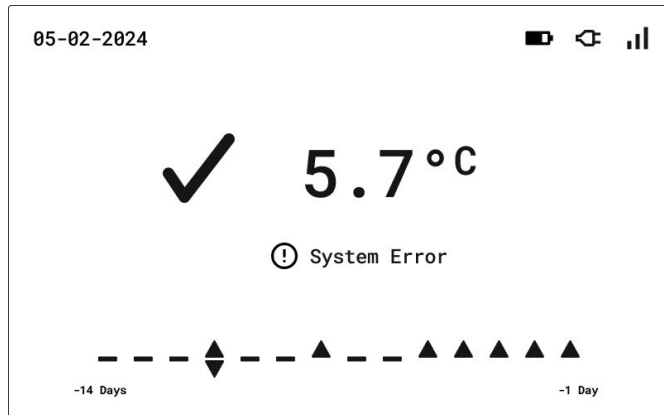
Use plain language when identifying active alarms to ensure even first-time users can understand them.

The WHO PQS EMS specification provides standard names for alarms¹, such as **Heat**, **Freeze**, **Door**, **Power**, and **Disconnect**, written as full words.

¹ PQS Performance Specification: Data Standards for Cold Chain Equipment Monitoring, E006/DS01: section 4.2

System Errors

CONSIDERATION



Variation:



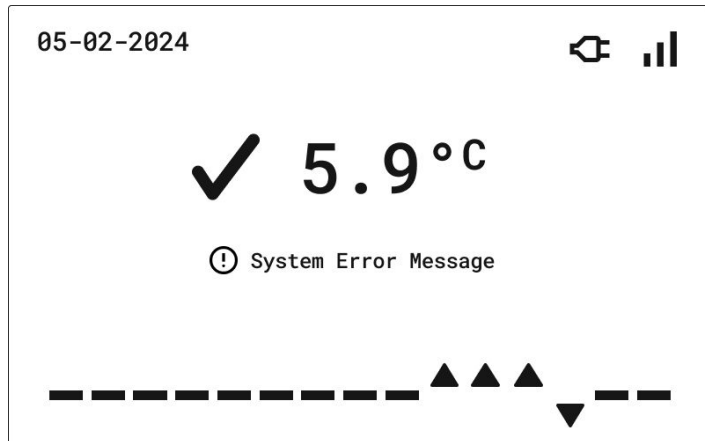
System errors cover a wide variety of supplier-defined issues, which may (or may not) impact the ability of the CCE to safely store vaccines. As shown here, the **system error indicator is smaller and visually separated from the alarm indicators**. This approach distinguishes and de-emphasizes System Errors in relation to WHO-defined Alarms.

It is good practice to **display a generic "System Error" message** on the home screen, with detailed information accessible on other screens. This approach uses minimal space and avoids technical jargon on the home screen. In cases where a system error is concurrent with an alarm, the alarm(s) and system error should both be displayed, as shown at bottom.

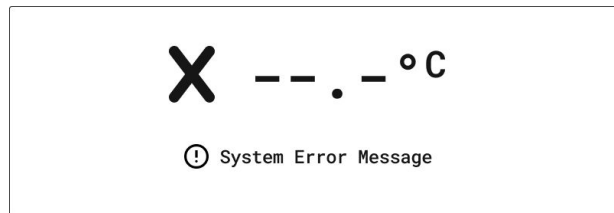
Given that healthcare workers are the primary users of the home screen, consider displaying a "System Error" message only in cases where the HCW should take action or request assistance.

✓ X System functionality

CONSIDERATION



Variation:



Among existing CCE monitoring devices, the function of **the alarm status indicator (✓ /X) varies by implementation and is prone to misinterpretation**. In some devices, it only indicates the presence of active alarms, while in others, it also indicates the presence of historical alarms.

To avoid confusion, consider using the ✓ /X symbols to indicate whether the CCE is currently capable of protecting vaccines.

Implications

1. The ✓ / X indicator should respond to presence (or absence) of active alarms, as shown previously.
2. The indicator should also respond to *System Errors* that result in indeterminate measurements of vaccine chamber temperature (if detectable), as shown in bottom left.

✓ X System functionality (cont.)

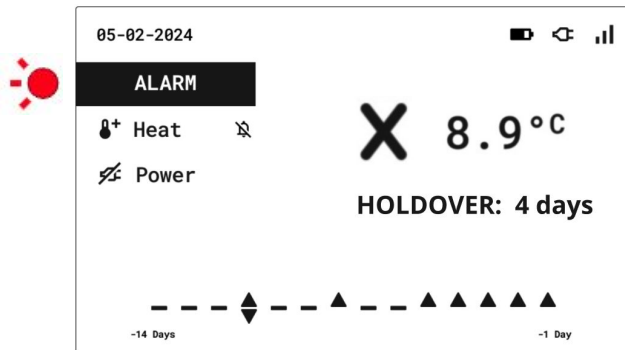
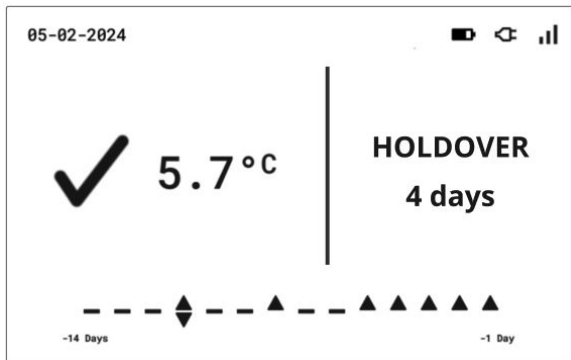
CONSIDERATION

Active alarms?	System Errors?	Indeterminate chamber temp?	Alarm status indicator
NO	NO	NO	✓
YES	NO	NO	X
YES	YES	NO	X
NO	YES	NO	✓
NO	YES	YES	X
NO	NO	YES	This state should not be possible

This table provides additional detail to the previous slide, illustrating how **Alarms**, **System Errors**, and **confidence in vaccine chamber temperature measurement** can influence the value of the alarm status indicator (✓ /X).

Holdover

CONSIDERATION



Holdover is an estimate of how long a fridge can maintain suitable vaccine temperatures without power, expressed in days, based on thermal characteristics and operational variables, such as compressor and door activity.

If a device calculates holdover, it should be displayed clearly and prominently on the Home Screen.

Users will rely on this estimate to make operational decisions, such as running a generator or moving vaccines to a contingency facility.

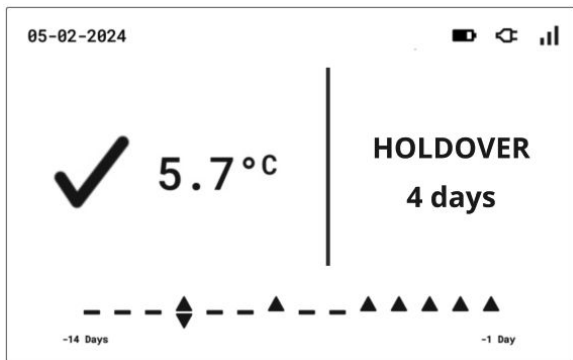
Holdover (cont.)

CONSIDERATION

Holdover time should be **expressed in units that reflect the inherent imprecision** of the estimate and should **err on the caution**.

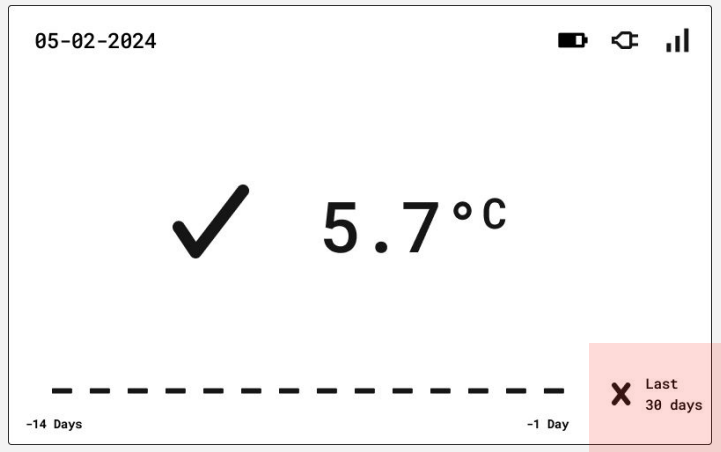
For devices with long holdover periods, it may be reasonable to represent holdover as whole units of days. For instance, if the fridge computes fractional holdover days (e.g. 2.65 days), rounding down to the nearest whole number would prevent *overestimation* of holdover and reduce risk to vaccines.

For devices with shorter holdover periods or higher confidence in the holdover estimate, it may be reasonable to represent holdover with finer resolution (e.g., 2.5 days). Regardless of the approach, the metric should be expressed in terms that can be understood by non-technical users.



Unacknowledged historical alarms

CAUTION



The meaning of historical alarm indicators is not clear and obvious, which can lead to user confusion.

Local CCE monitoring devices **should not enable acknowledgement of historical alarms**. Neither should they display the acknowledgement status of historical alarms.

Managing the acknowledgement status of the *active alarms* is sufficiently complex without adding functions to manage (i.e., acknowledge) historical alarms. Implementing such functions is likely to produce UX designs that are confusing to users, without providing sufficient value for the day-to-day operation of the healthcare facility.

Holdover Time

CAUTION

05-02-2024

75%



Percentage in an ambiguous measure of time

05-02-2024

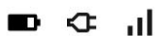
Holdover: LOW



"LOW" is also an ambiguous measure

05-02-2024

4D



Icon & days indicator is confusing

05-02-2024



4 Days



Icon meaning not clear

Exercise caution when using iconography to represent the Holdover metric. Using the word "Holdover" as an explicit label provides a clearer representation of this concept.

Holdover is not yet widely understood by all users in the immunization ecosystem, although it is conceptually similar to a battery (albeit a *thermal* battery). If designing iconography for Holdover, be aware that users might confuse these symbols with standard symbols representing electrical batteries.

Various suboptimal designs for Holdover are shown.

Using LED Indicators

CAUTION

-  DOOR
-  POWER
-  COMPRESSOR
-  ALARM
-  OKAY



Risk: Many LED Indicators and unclear color indicators that become conflicting & confusing

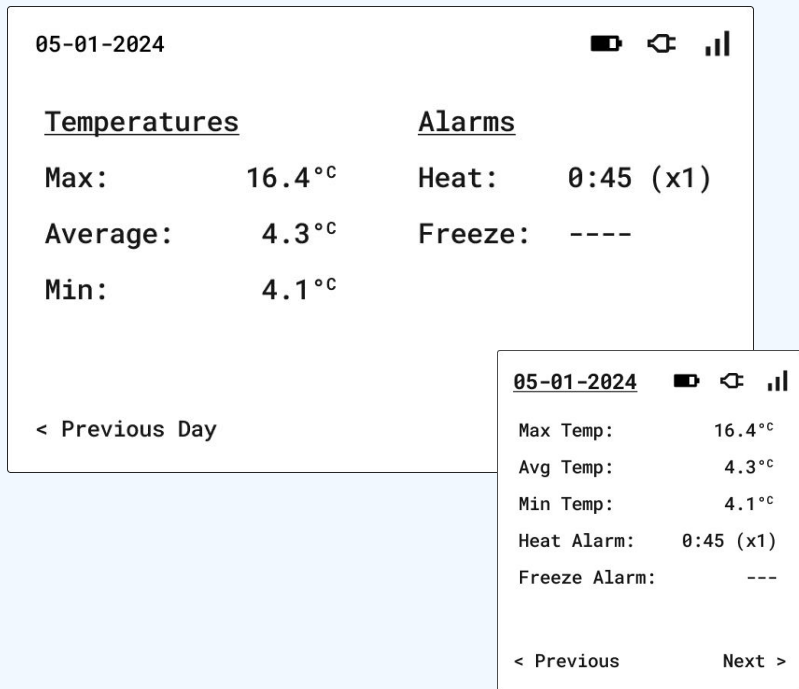
LED indicators can be helpful to signal the existence of a problem that requires attention. **Lighted indicators are especially effective at conveying binary states** represented as a simple on/off states.

Avoid using multi-colored LEDs to prevent confusion and ensure clarity. Multi-colored LEDs can be difficult to interpret quickly and may not be easy to interpret for users with color vision deficiencies. Instead, use single-color LEDs for clear, unambiguous signaling.

As mentioned in the **Alarm** section, consider using a single LED to reflect a general alarm condition, prompting the user to investigate further.

Historic Data





Historic Data screens display a day-by-day view of recorded appliance data, summarizing daily temperature and alarm metrics. The data shown on these screens is defined by the WHO PQS/E006/EM01 specification.

The displays on the left represent simple, intuitive layouts with clearly labeled data. For landscape-mode displays, the data can be organized in two categories: **Temperatures** and **Alarms**. For small screen layouts or vertical orientations, the data labels may need to be adjusted for additional clarity.

Relative Time Systems

CONSIDERATION

05-01-2024



Yesterday



1 Day Ago



-1 Day



Systems may vary in their connectivity and ability to track absolute time. When displaying Historic Data, some systems will need to use relative-time indicators instead of absolute time.

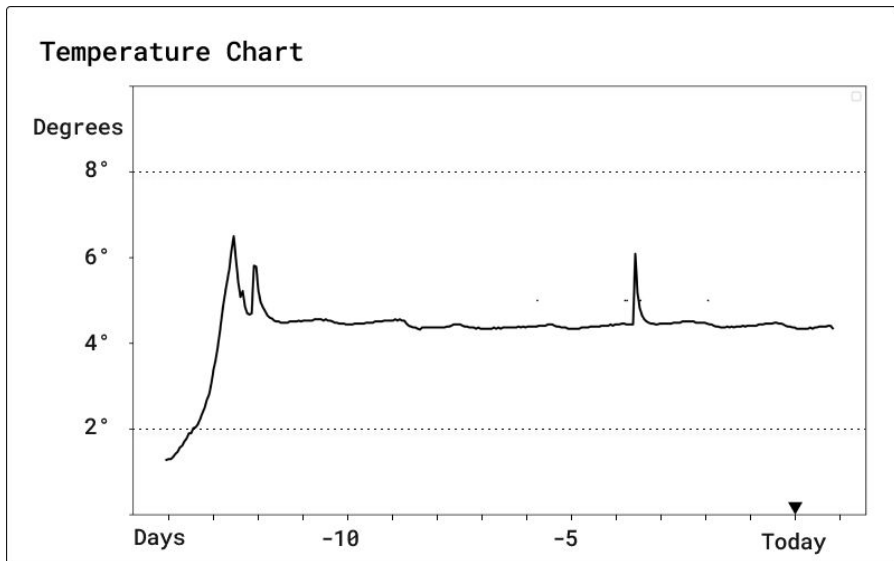
Common relative time indicators include:

- Yesterday
- 1 day ago
- -1 day

Unlike “Yesterday,” the last two options (“**1 day ago**” and “**-1 day**”) can be uniformly applied across various time intervals, improving clarity and, potentially, simplifying language translation. Collect direct user feedback to determine which approach is most effective for your users.

Charting Historic Data

CONSIDERATION



Historical temperature charts can be helpful in quickly understanding trends and diagnosing anomalies and some manufacturers may choose to include this functionality.

Charts, if any, should be kept very simple, starting with a straightforward line-plot of vaccine chamber temperature with clearly labeled axes, as shown here. It may also be helpful to **indicate periods when the door is open or power is unavailable**, provided the information can be communicated clearly to users.

Historic Data

CAUTION

HISTORY

<u>05-01-2024</u>	<u>05-02-2024</u>	<u>05-03-2024</u>
Max Temp: 9.4°C	Max Temp: 16.4°C	Max Temp: 13.2°C
Avg Temp: 4.3°C	Avg Temp: 7.3°C	Avg Temp: 5.7°C
Min Temp: 4.1°C	Min Temp: 4.1°C	Min Temp: 4.1°C
<u>Alarms</u>	<u>Alarms</u>	<u>Alarms</u>
Heat: ---	Heat: 20:45	Heat: 00:45
Freeze: ---	Freeze: ---	Freeze: ---

< Previous 3 Days

When displaying Historic Data, **avoid presenting a large number of data points on one screen**. Each additional piece of information competes for attention, potentially overwhelming the user.

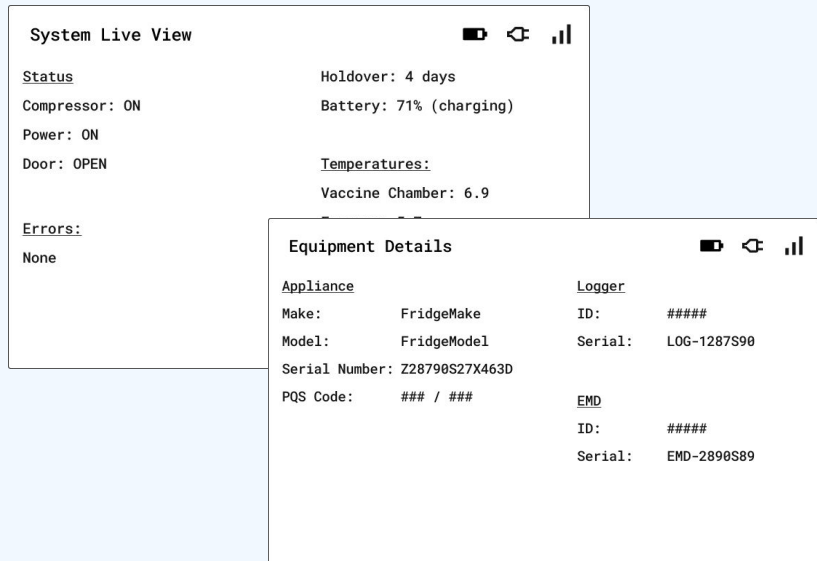
Even with a good visual hierarchy, an overabundance of data on a single screen can lead to confusion or mistakes by end users. Prioritize clarity and simplicity to ensure the information is easily understood and actionable.



Risk: the total volume of information on this screen might be confusing

System Details & Technical Views

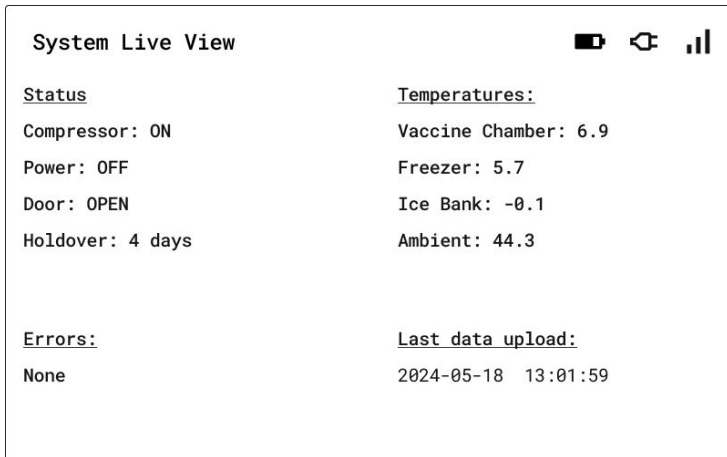




The System Details section includes screens that present more detailed information about the system.

Primarily used by technicians, these interfaces may need to convey a large volume of data. By utilizing visual hierarchy and grouping related content, these pages remain easy to read and navigate.

Additionally, they provide error codes and more comprehensive error messages to help diagnose problems.



When performing routine maintenance or troubleshooting specific issues, it can be valuable for technicians to **monitor the current status and measurements of many sensors and system components at the same time**. Think of this as a “Live View” of the system for technical users.

In the absence of such a view, technicians would need to switch between multiple screens to understand system operation. This is inefficient and places an unnecessary burden on the technician’s memory.

Consider displaying the following data in a live view:

- Temperatures
- Door position
- Power attributes (distinct for AC and SDD CCE)
- Compressor (or cooling) status¹
- Holdover remaining
- Data connectivity status
- System Errors and details

Equipment Details

CONSIDERATION

Equipment Details

Appliance		EMD	
Make:	FridgeMake	ID:	#####
Model:	FridgeModel	Serial:	EMD-2890S89
Serial Number:	Z28790S27X463D	Software:	1.2.11
PQS Code:	### / ###		

The Equipment Details view aggregates metadata about the CCE appliance and the integrated monitoring equipment, ideally in a single screen. This view will contain numerous data points, so it should be **designed for easy scanning and quick retrieval of information**. This can be achieved by grouping related content and establishing a clear visual hierarchy.

The layout shown here groups data into three categories: the CCE Appliance, the Logger, and the EMD. For small displays or systems that need to present more extensive information, consider using sub-navigation, pagination, or scrolling to maintain intuitive content groupings.

It is crucial to carefully select and use words in digital displays.

CCE monitoring interfaces will use a combination of words, numbers, and symbols. Although numbers are largely universal, symbols and words can be misinterpreted, especially in settings where users' primary languages are frequently different from the interface language.

Some recommendations are provided at right.

Avoid Truncation

- Avoid truncating content if possible. If unavoidable, truncate the least distinguishing characters (e.g., the left side of a serial number or right side of a manufacturer's name).

Readable Typography:

- Use easy-to-read typography that avoids character ambiguity.¹ Avoid using all-caps text, as it can be hard to read and distinguish when scanning content. See also the **Character Size and Accessibility** slide, earlier in this document.

Anticipate Translation:

- Use clear, simple language that can be easily translated into other languages. Avoid idiomatic expressions and cultural references that may not translate well. If possible, translate words and phrases early in the product life cycle to inform design decisions and collect feedback from native speaking users before finalizing screen language.

¹ WebAIM: Typefaces and Fonts <<https://webaim.org/techniques/fonts/>>

Avoid technical jargon

CAUTION

Equipment Details



AID:	289028S	EMDID:	#####
AMOD:	FridgeModel	EMDSRL:	EMD-2890S89
APQS:	E003/##	RTCW:	P1247SJL82L
ASER:	###-####	LUUID:	1238390217
AMFR:	BQS2890S0	SUUID:	1238901287
LMFR:	NAME	LMACADR:	EC: 3C: 18: 8F: 09: 6C
RELT:	P14DSJ89SL08	SMACSDR:	EC: 3C: 18: 8F: 2B: 73
LSRL:	LOG-1287S90		



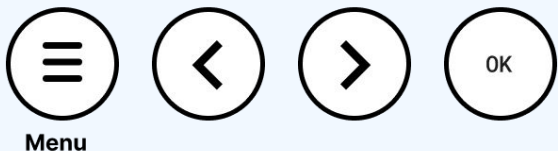
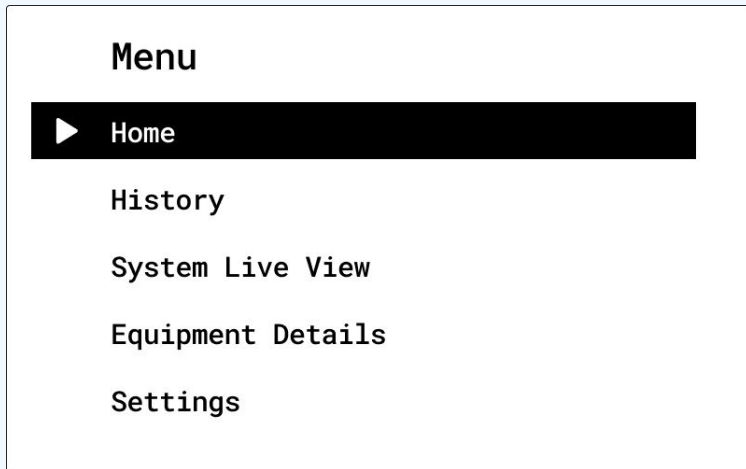
Risk: use of abbreviations like these is likely to be unclear to most users

Avoid using technical jargon, custom system codes, and abbreviations, unless they are widely understood by non-technical users. For example, *Temp*, *Min*, and *Max* are common abbreviations for Temperature, Minimum and Maximum in many languages and should be understood by many users. The more universal an abbreviation, the more suitable it is for use on a CCE display.

In contrast, the names of data fields from the EMS Data Standard (as shown at left) are not broadly understood, *even by technical users*.

Navigation & Buttons

A decorative graphic element consisting of a solid blue shape that starts from the bottom left corner and extends diagonally upwards towards the right, filling the bottom half of the slide.



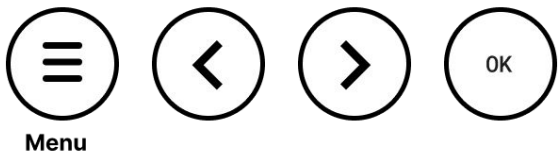
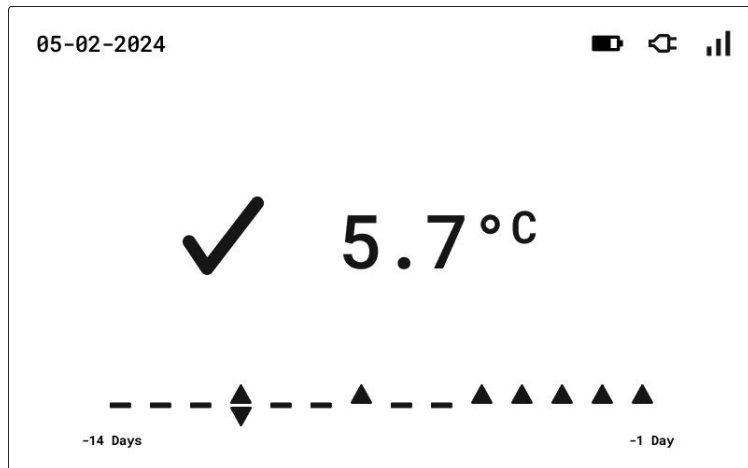
Effective navigation ensures that users can easily access the information and functionalities they need, enhancing both usability and efficiency. This section explores various strategies for organizing and presenting navigation elements.

Cold chain displays will benefit from a relatively flat hierarchy of screens (i.e., not deeply nested), while still grouping related functionalities. Different navigation paradigms will be discussed later. Regardless of the paradigm employed, **screens and navigation should be ordered by frequency of use by the primary users.** Apart from the Home Screen, the most frequently accessed screens are likely Historic Data screens (e.g., alarms and temperatures).

Screens tailored to technicians, such as technical detail or settings screens, are used less frequently and can be placed near the bottom of a menu or accessed via secondary controls.

Minimum Button Configuration

CONSIDERATION



In systems with physical buttons, **prioritize user experience and accessibility of essential functions** when deciding the count and purpose of the buttons.

For most cold chain displays, **four buttons may be optimal**:

- One button to open the menu or switch views
- Two directional buttons (**Left/Right** or **Up/Down**)
- One selection button (represented here by **OK**)

Using three buttons is possible, but it likely eliminates bidirectional navigation due to dropping one of the directional buttons. Bidirectional navigation is efficient for browsing historic data, especially when flipping back and forth to compare adjacent days. In systems with only one directional button, these efficiencies are likely to be lost, which could discourage users from reviewing data.

Menu Based Navigation

CONSIDERATION

Menu

▶ Home

History

System Live View

Equipment Details

Settings

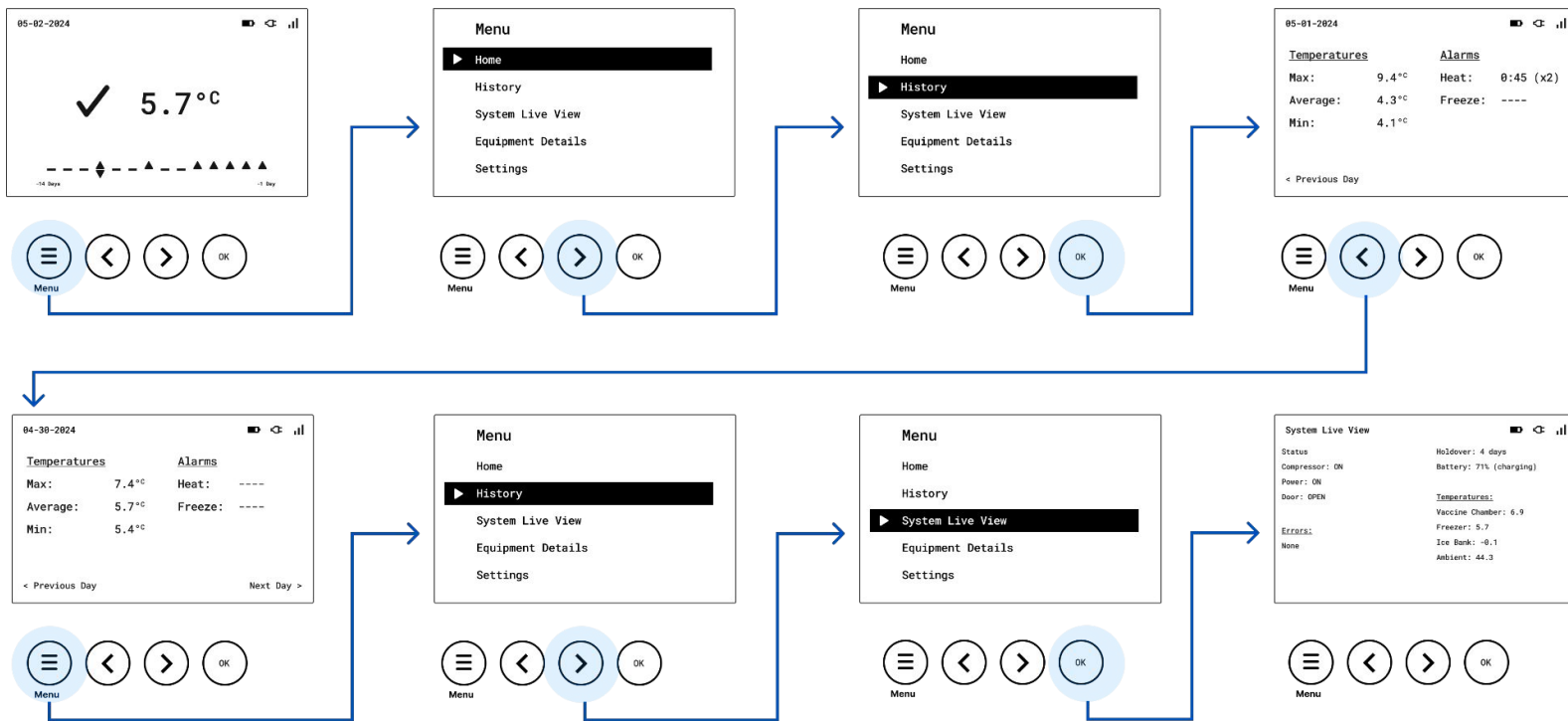
A menu-based navigation system presents a list of logical sections, allowing the user to select the desired page. This approach **reinforces the naming structure and relationships between pages** of the system. While it enables **direct selection** of the desired page, it may require additional clicks on the interface, especially with physical buttons.

When opening a menu, consider highlighting the current page to enable the user to navigate from that point, rather than defaulting to the top element in the menu.

An example of a menu-based UX is shown on the next page.

Menu User Flow

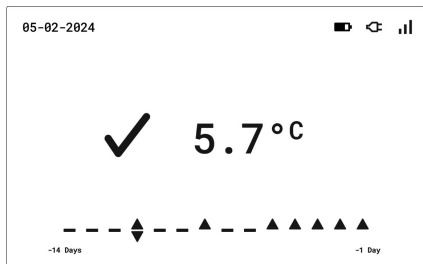
CONSIDERATION



In this flow, the Left/Right directional buttons sometimes operate as Up/Down buttons (i.e., when browsing the menu) and sometimes as a Left/Right buttons (e.g., when paging in the History section). This compromise minimizes the number of buttons while remaining intuitive.

View Switcher Navigation

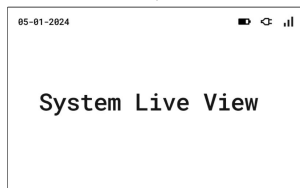
CONSIDERATION



Switch
Views



Switch
Views



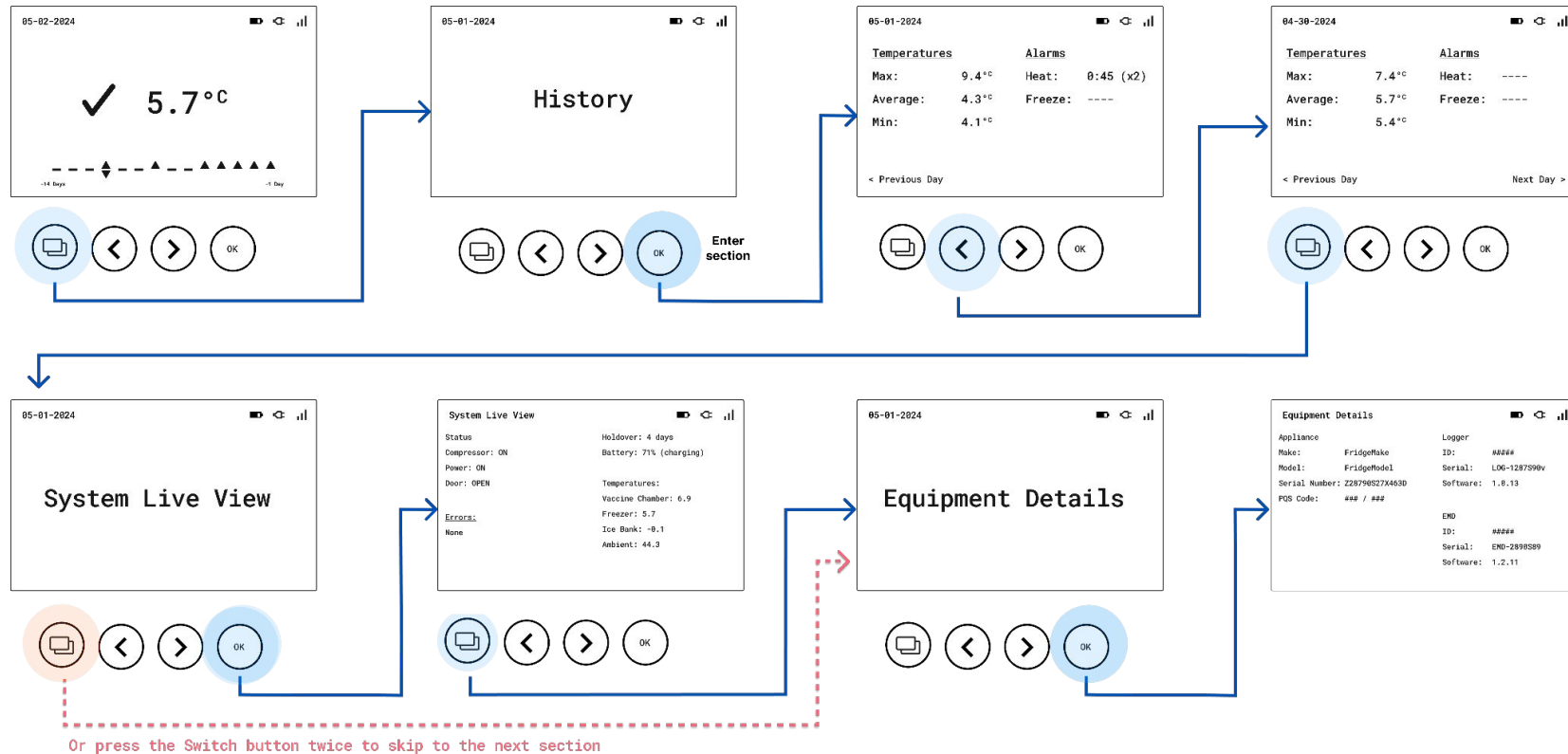
A view-switcher navigation replaces the *Menu* and *OK* buttons from a Menu-based navigation structure with a single button to change between sections. This paradigm can be simple to use and **effective when there are only a few top-level sections**, each containing a single page or a flat hierarchy of pages. Within a section, directional navigation buttons (up/down or left/right) can be used to scroll through the available pages.

However, view-switcher navigation becomes **unintuitive for systems with nested hierarchies** of information and is **inefficient for systems with a large number of top-level sections**. For first-time or infrequent users, the lack of an explicit menu makes it unclear what options are available within the system. Users must press the button repeatedly to explore the different views and discover the available functionalities. Additionally, non-technical users would be forced to scroll through technician-specific sections with the view-switcher approach.

An example of a view-switcher UX is shown on the next page.

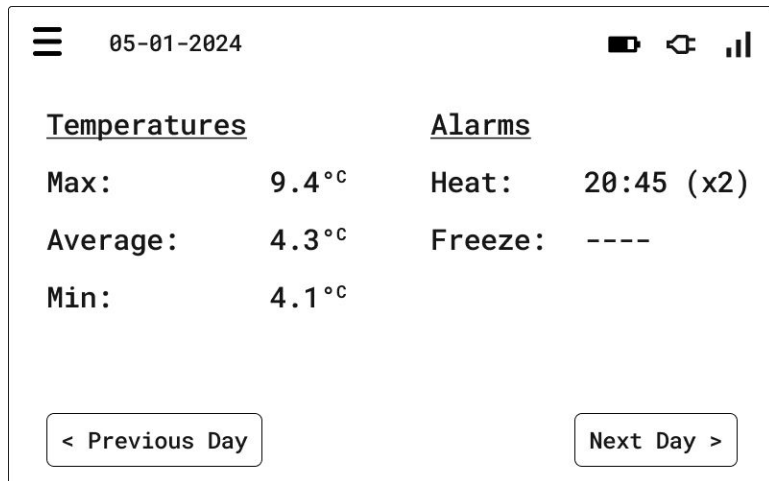
View Switcher User Flow

CONSIDERATION



Physical vs Touchscreen buttons

CONSIDERATION



This section has explored designs that primarily reflect systems with physical buttons. **Similar concepts can be achieved with touchscreen displays.** When implementing touchscreen navigation, **ensure the buttons are large enough to be pressed with precision.**¹

Touchscreen navigation is particularly interesting because software-defined buttons can be tailored to the specific context of individual pages and can be changed via software updates. This flexibility allows for dynamic and adaptable interfaces.

WCAG defines minimum tap target size for mobile devices to be 44x44 CSS pixels (roughly 0.45 inches). *Target Size Minimum*, W3.org.
<<https://www.w3.org/WAI/WCAG22/Understanding/target-size-minimum>>

Importance of Feedback

CAUTION



Examples of good digital button feedback states

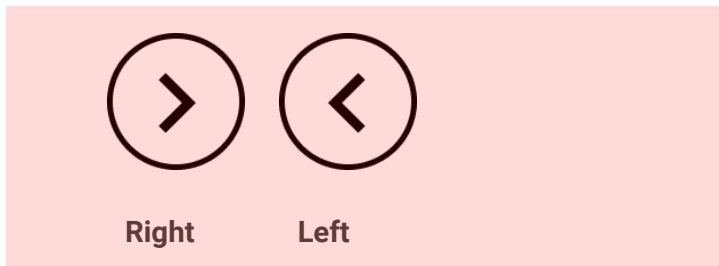
Button feedback is crucial for indicating button functionality and efficacy to users. It signals that their action was successful and that the system has received their input. When implementing non-mechanical buttons (e.g., touchscreen or capacitive touch), **ensure the button provides feedback** to indicate it has been pressed. This can be achieved through visual or haptic feedback. Most **mechanical buttons naturally provide physical feedback** during operation.

When pressing a button, the definitive feedback is a change in the interface. If there is no button feedback and a delay in the interface change, users may not realize their action has succeeded. This can lead to frustration, confusion, and repeated button-presses (with indeterminate results).

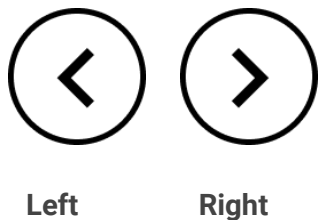
Source: Google Material Design UI Kit 2 - Buttons - <<https://m2.material.io/components/buttons>>

Match Buttons to Real World Conventions

CAUTION



 **Risk: this relative placement is confusing**



Instead, use relative placement that corresponds to the button's action

Buttons should correspond directly to the actions they represent. For directional arrows, their **orientation and relative placement should correspond to the resulting direction of the action** within the system. For example, the left-arrow button should be positioned to the left of the right-arrow button.

This arrangement intuitively matches the directions they represent, enhancing user experience by reinforcing the relationship between directional inputs and their corresponding actions.

When using physical buttons, ensure **each button has a single, easily understood purpose** in all contexts.

Avoid reusing the same button for multiple functions, as this can lead to unexpected or inaccessible actions. For example, it would be confusing if a button performs one action (e.g., returning to the menu) when pressed once and a different action (e.g., selecting or entering) when pressed for three seconds.

As a general rule, if users need to read a manual to understand how to use a button, the button is likely too complicated.¹

The only **exception to this principle is when functionality should be intentionally difficult to access** to prevent accidental usage.

For instance, a hard reset button may be physically hidden, require a tool to operate, or necessitate a specific combination of button presses. These interactions are appropriate to prevent accidental activation by everyday users.

Appendix



Additional concepts requiring exploration

The following topics are not currently covered in this document, but would be valuable additions:

- UX related to *acknowledging* an alarm. The document currently discusses how the system could indicate that an alarm is acknowledged, but it does not describe UX to perform the acknowledgement.
- UX related to *disabling* alarms, including disabling from remote monitoring platform. Interesting questions include:
 - How do local users disable alarms?
 - How does the system indicate that alarming is disabled?
 - Does the local system need to indicate whether alarms have been remotely disabled?
- UX related to *charts and graphs* for temperature and other performance data.

Common Words

The following is a list of words that might commonly appear on CCE monitoring devices. This list is not intended to be comprehensive and most real-world systems could probably be implemented using on a subset of these words, especially considering that some words overlap meanings (e.g., “CURRENT”, “NOW”, and “TODAY”). It’s also worth noting that some words might be used together to express additional context (e.g., “SYSTEM ERROR”).

Words associate with measurements (esp., temperature)

AVERAGE (AVG)
COLD
FREEZE
HEAT
HOT
MAXIMUM (MAX)
MINIMUM (MIN)
TEMPERATURE (TEMP)
HOLDOVER

Words for the system, its components, or its identity

APPLIANCE
BATTERY
COMPRESSOR
DOOR
FIRMWARE
FREEZER
IDENTIFIER | ID
MAKE
MODEL
[PQS] CODE
[PQS] CATEGORY
SERIAL [NUMBER]
SOFTWARE
SYSTEM
TYPE
[VACCINE] CHAMBER

Words about System Status

ALARM
CONNECTED
COOLING
ERROR
POWER
OFF
OKAY
ON
STATE | STATUS

Words related to time

CURRENT
DAY
HISTORY
LIVE
NOW
TIME
TODAY
YESTERDAY

Heuristics

We have used these heuristics internally to evaluate the success of an interface design. These are derived from [Jakob Nielsen's 10 general principles for interaction design](#) and the EMS standards recommendations for human factors.

1. **Keep it Simple** - Interfaces should not contain information that is irrelevant or rarely needed. Every extra unit of information in an interface competes with the relevant units of information. Information should be presented in such a way that's not overwhelming to users who have limited experience with technology.
2. **Visibility of System Status** - users should always be informed about what is going on through appropriate feedback. The system should clearly communicate to users the system's state. Essential performance and safety information should be displayed prominently to users.
3. **Help users Recognize and Diagnose errors** - Error messages should be expressed in plain language. Error messaging should be specific and precisely indicate the problem.
4. **Match between system and real world** - The design should speak the users' language rather than internal jargon. Follow real-world conventions, making information appear in natural and logical order and controls that match real-world outcomes.
5. **Clear and Obvious Affordances** - Ensure that users can understand meaning without having to reference a guideline or instruction manual. Information required to use the interface (e.g. menu items or button consequences) should be visible or easily retrievable when needed. Basic capabilities of the system should be easily discoverable by users and not require extensive training or reading of manuals.
6. **Information should be easily accessible** - displays should allow users to access required information in as a few clicks or interactions as possible. Minimize the user's mental load by making related information displayed in one place. The user should not have to remember information from one part of the interface to another.

Visual Hierarchy Basics

Size

Larger items take visual prominence over smaller items. We automatically assign relative importance to larger items and often our eye will be drawn to these first. The size of text can convey its role and purpose in relation to other texts on the screen. In this document, you can observe a difference in both size and weight of text between the name of a section and the body content within it. The fact that the word “Visual Hierarchy Basics” is both bold and larger than the text below tells you that it’s a label or a title for the content that comes beneath.

Position

Where an element is placed in relationship to all the other elements on an interface can imply a sequential reading order (for western displays this is left to right and top to bottom) or imply relationships. When elements are grouped together on a screen it implies that they are related to one another. Conversely, items that are related to one another but placed in different locations can be difficult to understand their relationship.

Typography

In choosing typography there are many different approaches. For interface displays we recommend a typeface that provides sufficient disambiguation between letters (so for instance one can read the difference in a lowercase “l” and a 1). Additionally, ensure sufficient contrast between type and background colors. [WCAG](#) recommends at minimum a 4.5:1 ratio for text to background contrast.

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Visual Hierarchy Basics

Color

There are extensive nuances to how we understand and perceive color: things like red = bad or stop and green = good or go may be based on our prior experiences with traffic signals or warning signs. This use of color can convey additional information or emphasize a concept that is being presented (such as danger ahead!). But color can have different meanings across cultures and geographies: for instance in China red is a symbol of luck and prosperity. So any use of color should be sensitive to the cultural context it might be placed into.

Because not all eyes can perceive color in the same capacity, when using color in displays it is important to never convey information only through color. It should be used only as an additional indicator so that if it is not visually perceived, the user still can understand the display.

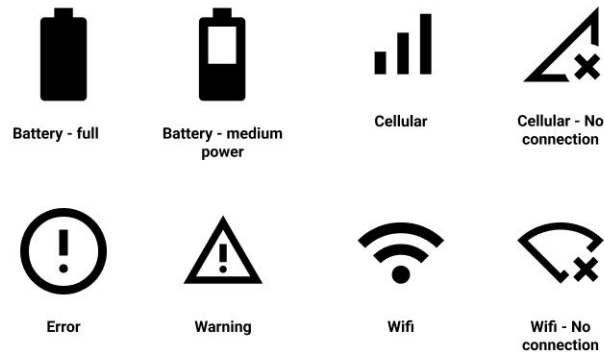
Even in black and white displays, we still perceive value differences that can create emphasis and draw attention to elements that need to stand out. Contrast between elements and their relative darkness or lightness draws our eyes to areas with the most contrast. For instance, on a primarily light display an area of darkness will draw our eye right to it.

Iconography

The use of icons or symbols to convey meaning can be especially helpful for creating designs that are universal (regardless of language). The visual representation of an icon is most effective when it is as simple as possible - especially when displaying on small screens. Detailed drawings or complicated illustrations are not conveyed at a glance and may increase confusion if a user cannot understand what the image represents.

Despite the prevalent use of icons and symbols in technology and interface design, there are very few truly universally understood icons. When using an icon, if possible, include a text label as well to increase clarity and comprehension.

What follows is a selected group of recommended iconography options. These are drawn from the open source [Google Material Design Icon](#) reference.



Alarms

