

Alarm Sounds

This document describes how engineered sounds for control system alarms improve Operator responsiveness.



Alarm Sounds for Multi-Console Control Rooms™ communicate more information, take advantage of human strengths, and are well received by operators.



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Table of Contents

Introduction..... 3

Alarm Sounds Included with the System 3

Alarm Sounds for Multi-Console Control Rooms™ 4

Can Human-Centered Alarm Sounds Make a Difference? 5

Operator Usability Findings..... 5

Custom Alarm Sound Solutions..... 6

Introduction

Experts agree that human centered design of the process control room substantially contributes to greater Operator situational awareness, efficiency and effectiveness. This whitepaper addresses one aspect of the control room environment, alarm sounds. Selection of alarm sounds should not be a casual matter. Poorly conceived alarm sounds can contribute to Operator stress and confusion. Smart sound selection is especially important in multi-console control room environments.

By special licensing arrangement with Human Centered Solutions, LLP (HCS – at www.applyHCS.com), the DeltaV Process Control System features **HCS Alarm Sounds for Multi-Console Control Rooms™**, which have the power to communicate more information, take advantage of human strengths, and have a proven record for Operator acceptance.

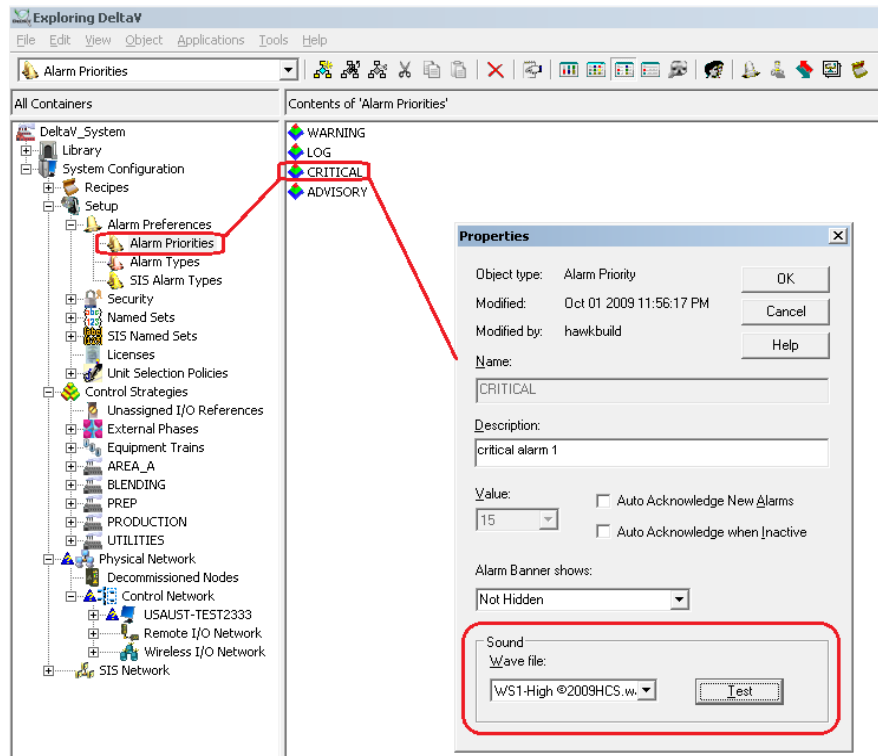
Alarm Sounds Included with the System

The DeltaV system comes supplied with six copyrighted WAV files (©2009HCS in the file name), licensed for use by the system owner subject to the end-user System Software License Agreement. These six WAV files comprise two sets of alarm sounds, one each for two distinct operator console positions, where each set has three files that correspond to three levels of alarm priority.

High, medium and low priority alarm sounds are provided with the system for two console operator positions. Console1 high, medium and low HCS WAV files are the default selections for critical, warning and advisory priority alarm sounds on a first console. All workstations within this first console would use this same set (e.g., Console1 high, medium, and low HCS WAV files).

For a second console in the same control room, selecting Console 2 high, medium and low HCS WAV files results in easily distinguishable alarm sounds between the two consoles. Operators for either console will easily recognize which console and alarm priority is indicated.

For DeltaV systems previous to v11, original sound selections are retained during system migration, requiring re-selection to enable HCS alarm sounds.



Alarm Sound selection by alarm priority.

Alarm Sounds for Multi-Console Control Rooms™

Specifically designed to account for human factors principles related to human audition and hearing, HCS Alarm Sounds for Multi-Console Control Rooms™ simultaneously differentiate between console locations as well as alarm priority.

HCS Alarm Sounds for Multi-Console Control Rooms™ features:

- Unique three-tone combinations make up the various sets of alarm sounds to differentiate between consoles
- Consistent, unique tone speeds for each alarm priority level, across all console-specific alarm sounds, to differentiate alarm priorities within a set of alarm sounds
- A fundamental frequency for each alarm tone is chosen from humans' most sensitive hearing region
- Each alarm tone is comprised of multiple harmonic frequencies, to address both potential masking from environmental noise as well as potential hearing deficiencies in the operator workforce
- Specified onset and offset envelopes are used to eliminate abruptness and the associated 'startle effect'

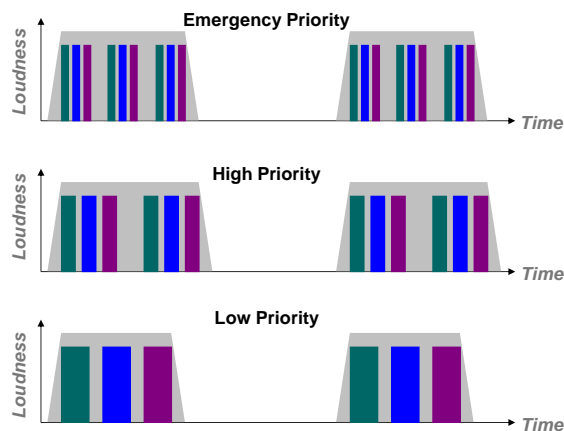
HCS partners have been key contributors in research studies conducted within the ASM® Consortium to understand challenges associated with current industry practices and to develop new concepts to improve operators' ability to prevent and respond to abnormal situations. In addition, HCS' recent work with process industry clients has advanced the state of the art in operator interface design techniques, including the design of audible alarm annunciation. These innovations are embodied in the HCS Alarm Sounds for Multi-Console Control Rooms™.

Can Human-Centered Alarm Sounds Make a Difference?

Anecdotally, we all know that sound (and music) strongly influence our emotions, stress, and so on. Most people can more calmly watch a suspense thriller or horror movie with the sound completely muted. The sound score contributes significantly to the anxiousness and stress that we experience. Sound can also strongly influence our mental workload and ability to concentrate. Most of us have experienced this phenomenon while driving in traffic. In light traffic, we can maintain a conversation with the passenger(s) while listening to the radio. However, as traffic gets heavier and heavier, demanding more attention and mental resources to continue driving safely, the driver will typically turn down or turn off the radio. If traffic continues getting worse, the driver typically disengages from the conversation. Finally, the physical generation of the sound can create sharp, abrupt sounds that startle individuals and make them 'jump'.

In the early 1980s, the UK's Civil Aviation Authority (CAA) developed a protocol for designing auditory alarms for the avionic systems that were being added to cockpits. Roy Patterson's idea at the CAA was to design alarm sounds that indicated the alarm's urgency while simultaneously indicating which system generated the alarm without creating 'startle' reactions or interfering with pilots' ability to communicate and think. HCS has adapted Patterson's protocol to create Alarm Sounds for Multi-Console Control Rooms™.

The following figure shows a conceptual drawing of how these alarm sounds have been designed. For a single console operator position, each color can be thought of as a unique sounding note or tone. Each console has a unique tonal pattern. That pattern is the same for that console for all three alarm priority levels. However, this 'melody' is repeated slowly once for low-priority alarms, repeated twice slightly faster for high-priority alarms, and repeated three times at an even faster rate for emergency-priority alarms.



Conceptual Drawing of the HCS Alarm Sounds for Multi-Console Control Rooms™

Professional operators played a vital role in the development of the Alarm Sounds for Multi-Console Control Rooms™. HCS worked with console operators to determine the most appropriate note and pause lengths to create the 'melodies' for the low-, high-, and emergency-priorities. In addition, HCS drew upon musical composition theory to combine the individual notes into melodies that are pleasing to the ear and do not create additional stress themselves.

Operator Usability Findings

HCS has evaluated the usability and usefulness of the HCS Alarm Sounds for Multi-Console Control Rooms™ across four shifts of four console positions in the same control room after those consoles had been using the new alarm sounds for a range of approximately three weeks to three months. The table below summarizes the operators' feedback ratings. Overall, the ratings by indicated positive acceptability on most dimensions for all consoles. All consoles had a positive, overall acceptability rating and most operators provided very positive comments about the alarm sounds.

Performance Impact Characteristics	Acceptability Rating (+3 to -3)
Recognize my sound from others	0
Distinguish alarm priority level	+1.8
Interference with communications	+2.1
Difficulty hearing my alarm sound	+2.5
Annoyance of my alarm sound	+1.9
Distraction from other consoles	+1.1
Contribution to my workload	+2.4
Overall Rating	+1.8

Operator Acceptability Ratings

Operators reported some inability to discriminate between consoles, but this mostly occurred when they were at team table in center of room, far removed from their consoles, or when similar console alarm sounds were coming from across the room. HCS re-assigned alarm sounds to maximize disparity of patterns between consoles and operator reported improved discrimination.

A lesson from this evaluation is that audible annunciation is not a reliable method of informing operators of alarms when the operators are not at their consoles. This is true for several reasons, such as having to have the alarm sound volume turned up so loud that it is a distraction or annoyance to neighboring operators who are at their own consoles or creating confusion for operators both away from their consoles and at their consoles as to where the sound is coming from. Human factors research shows that people perceive louder sounds as being closer than quieter sounds, so a louder alarm from someone's console may lead another operator to mistake it for their own alarm if it is louder than their own alarms. Likely a better approach for off-console alarm annunciation would be a 'light tower' on each console or pager for each console, either of which would be used when the operator is away from their console.

Another finding from this operator evaluation was the impact of alarm sound volume control. Operators at this site had the ability to adjust the sound volume on the console workstations. In some cases, a given operator position had turned the sound volume down considerably, almost to the point of being inaudible. These operators would likely have difficulty hearing their alarms over those of the two adjacent consoles. There is a 'standard' design recommendation to have audible signals 15 dB louder than the ambient background noise level. However, this can create several challenges, depending on the ambient background noise level. Sites should take measurements at each console and set the volume for their alarms at approximately 10 dB above the local ambient noise. This level should typically be sufficient to hear alarms at a given console as long as the operator is in or near that console work area, without being so loud as to interfere with radio or face-to-face communications.

Custom Alarm Sound Solutions

Have more than two consoles or three alarm priorities? Additional WAV files for more consoles or for additional alarm priority level indications may be obtained from HCS.

Have an existing control room with acoustic challenges? HCS can work collaboratively with clients to customize and assign Alarm Sounds for Multi-Console Control Rooms™ wav files to each console position, based on console layout within their control rooms, to maximize the differentiation between alarms from each console.

Designing a new control room? HCS offers workplace design services, to help structure the work environment to maintain an alert 24-7 operations staff, optimize work flow, minimize unnecessary business disruptions, and enhance collaboration between operations and other disciplines.

Evaluating overall operations staffing, console re-assignment or consolidation, or which console to assign a new unit? HCS offers operations staffing and console complexity analysis services to help sites benchmark job complexity for both console and field operating positions to determine how to best balance workload or address workload driven by job complexity. For console complexity analysis, HCS has a database of more than 300 consoles positions in hydrocarbon industry against which to benchmark the console operator job complexity for a new site.

Contact your local Emerson sales office or business partner, or Human Centered Solutions for more information.

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