The Role of Alarm Management Functions in the Ergonomic Design of Control Consoles

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Introduction

The role of alarm detection and presentation and management is essential to the proper use of the video based operator consoles. Distributed Processing and Control (DPC) systems, the widespread use of Cathode Ray Tube (CRT) based Computer / Human Interfaces (CHI) as the primary means of monitoring and/or control access to both Batch and Continuous processes, has encouraged system designs which are larger and closer to one data becoming a responsibility of a fewer and fewer number of operators. Not only has the quantity of real-time facts about the process increased, but the types and formats of this raw data have all greatly expanded. Many new system designs represent a huge increase in the level of sophistication, not only in terms of raw data to be processed into the format of a data display console. The changes in the complexity of the relations that exist between various data items presented to the user. This dramatic expansion of data has increased the amount of data acquisition and alarm management functions of the operator's display console to a critical ergonomic design parameter for the safe operation of any large scale process.

Other factors which may add to the complexity of the interface between the human operator and the DPC system are a large amount of data that the operator must interpret and take appropriate action on. It is critical that data is meaningful because of the system's types of systems and presented in diverse graph styles on separate display systems.

Ideally, this information that is presented to the console should be acquired, processed for alarm status and other needs managed in a uniform manner. Alarm information must be closely integrated with the console's ability to represent that data to the operator in clear and meaningful ways that are consistent regardless of the source of the input data. The system must be in a manner that is not only reliable but also operable for the operator to make the proper operational decisions.

Historical Perspective

To understand the nature of the control room, it is helpful to understand that in the beginning, these CRT based interfaces were sold as "A means to reduce the 12 m (40 ft) of panels into a 48 cm (19 in) screen. Unfortunately, many of the early CRT-based control room designs that initial description was often inaccurate in terms of the amount of thought and design effort that was expended to present the interface requirements of the system in a user-friendly way. For man-machine interaction.

Some of the early CRT systems simply presented a continually scrolling list of the current plant data with no attempt to assist the user in interpreting the meaning of this data. These data loggers were intended to provide a display of data scanning and recording functions. The primary goal of such devices was to eliminate the need for humans to take notes as the panels and pens to physically walk around the plant and capture operating data.

Early attempts to improve this data logger included text displays which closely mimicked the existing panelboard control stations and switches. Early systems used many pages of these station and sink switches displays to duplicate the panelboard functions. Later, the concept of using a printed circuit or template of the process control displays was gained acceptance and brought the graph CRT to the forefront of the control room. The advent of powerful microprocessors and their attendant decrease in price performance, in the stand alone CRT based integrated control system console.

At the same time that graph CRT displays were being used to reduce the panelboard area of control room in terms of gages, meters and switches there was a steady increase in both the type of useful information available for operations and the methods used to transform data into useful operating information.

On line analysis, spectrographic, as well as the inferential types of instrumentation became available for use in the
ref nement of the contro l applic at on and the extens on of equ pment fe Rea time performance analy s s, process mode ng and stat stica l process and qua ty contro l (SPC/SQC) ca cu at o n s a so became pcss b e Greater understand ng of the app cat ions and the nature of the r contro l, mand ated the nsta t on of add t ona l pr mary nstrum entat ion in some cases Proper use of all of this nformat ion cou ld a ow a sk ed operator to mon tor and contro l the process to t ight er parameters and to ach eve h gher and h gher goa ls of product v ty Once ach ed, these new leve ls of product v ty became the base l e s for future expect at ions and enhancements

The Operator’s “Assistant”

At the focus of this array of data and potent a productiv ty ga in f ow n to the contro l room, the operator becomes the s ng e, most cr t ca va ar be n the safe contro l of the process v ty, ava ab ly and prof tab ly of any process contro l oper at ion. The human capacity for process ng nformat on s at best magnitudes ower then what s requ red to mon tor and corre ate th s huge data stream as it funne s into the contro l room nor th terms of the operator to be able to succeed n th s nformat ion on packed env ironment the operator s ve de iso ay conso e must be fu y integrated w th the data acquis iton and contro l system to the po nt of becom ng the operator s trusted Ass stant

An ana y s of operator funct ions for any arge contro l app cat on qu cky establ ishes that CRT based Computer Human Interface (CHI) systems must be capable of reducing the complexity of the data presented to the user. Advanced techn ques n data group ng nformat on on sorting and status or or f ng of th s data n t oms that are re evant to the current s tuat on and status of the process are requ red. The use of the ast eve opem ents n ergonom cs and human b technology to convey th s nformat on to the operator are on y part of the answer. The ab ty of the operators ass stant to re ab y mon tor those thousands of data po nts that the hum an operator does not observ ng at any g ven moment. and to br ng the re evant changes n the cond t on of the process to the operator s attent on quickly and unerr ng y s the h dden factor n the ergonom cs of console des gns

mo betat on of conso es des gns ut z ng cr ter a developed through the study of human phys ca parameters and cogn t ve percept on as a means to reduce operator stress w be n the resu tal dev ce s not perce ved and trusted by ts user to br ng re evant nformat on to ts attent on qu cky and predictab y Add t ona y h s ass stant s hould ed or prompt h m to the proper d sp ays or func ons necessary to resolve the a armed cond t on n the east traumat c manner

Architectural Considerations of Alarm Management

The arch tecture of the DPC system w to some degree determe ne the ab ty of the man mach ne nterface to prov de these Operators Ass stant funct ons Some DPC system arch tures attempt to accomp sh alarm process ng n an o d fash on centra zed a arm detect on fac ty (sometimes ntegrated with the system stor an funct ons) Th s approach can resu t n the same set of eng neer ng compr ose s that restr cted the centra ized DDC & DAS (D rect D ata Contro l & Data Acquis iton Systems ) of the 70 s and ear y 80 s Th ese restr cts ons w ch nc eded data throughput and process ng as wel as resu ted n the modern D str buted Process ng and Contro l (DPC) conceps and caused DPC systems to become the dom nant process contro l cffer ng of the later ha f of the 80 s and 90 s Many central are a arm process ng systems are n ted n the rate at wh ch they can acq u re (po nt scan) process and test the po nts n the system Somet mes on y a subset of system po nts can be a arm mon tored Some arch tures can only prov e m ted a arm types or restr ct the ab ty to pr orize or group a arms nto m ea- ng ful ca ses or cogn t ve gro ups at differ ent conso es around the system A of these restr cts ons resu re ergonom c comprom ises to the CHI of the contro l conso e

A of the des gn cr ter a wh ch led to the deve opment and dom nat on of mut process ng arch tures for D str buted Contro l Systems are aso va d for Data Acquis iton Systems and ar e mperat ve for ntegr ated DCS / DAS systems A arm test ng and detect on must be done at the d str buted process cr level n order to ach eve a useful rate of test ng (a arm detect on reso ut on ) and the qua ty (a l po nts n the system) of a arm mon tor ng required to support the operator n monitor ng the process

Alarm Detection Methods

A arm management beg ns w th a arm detect on at the owest eve poss b e n the DPC system Some of the com mon forms of alarm detect on are eve e and mut eve Leve a arm ng s mply cor rap es a mon tored va ue w th pre con gured mits and generates an a arm status when a Hgh or Low eve exceeds Mult evel s an enhanced form of eve a arm process ng that quant f es the degree of mon tored var ab e var at on on y means of ncremental va ues above the pr mar y Hgh alarm evel and be ow the primary Low a arm eve

A useful var at on of s mp e a arm eve process ng s var ab e a arm eve s n wh ch the va ue used as the pr mar y a arm eve s tse f a dynam c va ue der ved from other e ements n the system Th s techn que allows the alarm
levels for a measured variable to track the operating event feed rate or load rate of that area of the process. This is one way of preventing nuisance arm start-up or low event of operation. As in fixed multilevel alarming, var abe multilevel alarming tests for the additional levels of alarm at specified increments above and below the user-specified currently being used for var abe. High and Low arm levels Level alarm detection is one of the most widely used methods of determining a process excursions and drawing the operator focus to it.

Deviation on a arm detect on s in essence a variation on variable Level alarming. The current value of some other variable depends on the system (reading or calculated) is specified as the reference to determine this points alarm status. A percentage bandwidth above and below serves as the reference value is calculated in real time and used as the monitored variable high and low deviation alarm events. As long as the monitore variable falls within the upper deviation target, no alarm is generated. But if the deviation between these two values (monitored and reference) fails to remain within the specified percentage, a deviation alarm condition on which exceeds the specified percentage, a deviation alarm is generated.

Rate a arm s a means of having the system determine if the manner in which a variable changes is changing. The specified rate of change (engineer units / time unit) boundaries. This allows the operators assistant to monitor only the important variables. By comparing the operating levels to the established operating levels, it is then decided if the alarm is necessary or not.

Another way of preventing an arm from issuing a chatter filter function is usually defined in terms of event crossings per unit of time and can be used as the actve alarm as long as the number of alarm state crossings per unit time is exceeded. This means that the system is not desensitized to detect the level alarm condition on should one occur. But if the chatter filter does prevent false multi-state arm status changes when a contact bounces or a control loop's seek is near an arm event.

Console Alarm Grouping Methods

Once the alarm condition has been determined, the re at onsh p of th s nformat on to other plant data must be determined. Normally th s s accomplished by group all the nformat on com ng from a common area of the process together at the users CRT console. Since individual data and arm condition may be the critical responsibility of one operator (console) but only nformat on to another. The associating of any part of a data to another must also be available for different levels at one console to another that system. Th s w requires that each console be able to assign a group ng and have a totally independent means of prioritizing and responding to both individual and common data sets.

Nuisance Alarm Prevention Methods

Because operator confidence in the credibility of the alarm system is critical to the computer/human interface concept, nuisance or inappropriate alarms must be minimized. An alarm system which cries wolf very often increases the operators stress by reducing the confidence that the system is properly functioning. An arm out of occupation arm cutouts which disable the arm process when pre-configured conditions are met. The process is then tested and found true and cannot reduce the false alarms (If the pump is not running, don't alarm the low pressure in the output line).

Another way of preventing a arm from issuing a chatter filter on a variable which contains a cycle into and out of a arm condition. Th s is the basis of functions is invoked when a monitored variable is crossed into and out of designated arm event. A less sophisticated arm system can attempt to prevent these types of false alarms by increasing the deadband of alarm levels.

Note: Deadband may be defined as a value by which the monitored variable must be greater than a high arm limit or higher than a low alarm limit, before that monitored variable is recognized as having returned to the next lower alarm state or nominal (non-alarm) state.

A chatter filter function is usually defined in terms of event crossings per unit of time and can be used as the active alarm as long as the number of alarm state crossings per unit time is exceeded. This means that the system is not desensitized to detect the level alarm condition on should one occur. But if the chatter filter does prevent false multi-state arm status changes when a contact bounces or a control loop's seek is near an arm event.

Alarm Routing and Console Prompt Methods

Because these consoles group ngs and data associate on technical queues are valid for both normal nformat on "brows ng by the operator as well as alarm announcements and response prompt by the system the establishment provides a useful ergonomic means of reducing the operators time to access nformat on. These groups or areas can be related to logical functions within the process or even geographic process boundaries. As members of pre-defined groups or areas the alarm status of a number of ndvidual po nts on the group can be condensed and used to summarize the alarm status of the group as a geographic or logical entity that the group represents.
These summary points, in turn, can be used as elements of plant or facility overview or as indicators of alarm conditions in the summary area. By integrating these annunciators with display selection buttons one method of automatic routing the operator to the proper display can be achieved.

A method of operator prompting and display selection can be implemented by the use of alarm summaries with the console areas or groups. These summaries are normally presented to the user sorted into chronological order. Another option is to sort them by pre-established priority within the group. For each entry canceled in an alarm summary an indented comment can be included to prompt the operators act on in response to that specific condition. Prompting the reference to other information in the system (e.g., "Check drum level") as well as advancing and rectifying (e.g., Disengage pump actuator) is also supported in this manner. Selection of the primary graphic display offering access to the control of the alarmed control point is achieved directly from the alarm summary by cursor entry or indented button selection. These methods can be used to reduce the total number of pendant devices or processes where data spectrum trees for the console user.

An alarm condition's relevance to an indented operator (console device) can then be determined and displayed by referencing against other conditions in that operators responsibility. The assignment of priority within the groups of an indented operator's responsibility can also be accomplished (at that console) and that operator's reaction prompted by pre-configured alarm comment or helpful-y in the not so distant future an expert system response.

Summary

This paper has attempted to show that the function of the alarm detect on processing analyzing and presentation of a distributed Process & Control system data is a key parameter in the ergonomic design considerations for control consoles. The arm management function is a primary element in maximizing the Computer to Human Interface (CHI) for these systems. The concept of the integrated console arm system as trusted Operator's Assistant in the monitoring and safe profile of a process has been introduced with a group of methodologies for reducing pendant de data to manageable terms. As a result it is hoped that the role of a alarm detect is on presentation and management is essential to the proper use of the video-based operator console. Distrusted Process & Control (DPC) systems are better understood.

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