ADVANCES IN MICROPROCESSOR CONTROLS FOR OPTIMISATION OF INDUSTRIAL PROCESSES AND THEIR APPLICATION TO SHIP MANAGEMENT

BY

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SUMMARY

With marine and offshore applications of its latest range of digital microprocessor based industrial control equipment, Australia's largest instrumentation company is poised to offer the marine market an integrated range of field proven hardware and control instrumentation, developed during the last decade, against a background of spiralling energy costs.

Of particular importance to the marine field is the adaptation of powerful industrial energy optimization software packages to provide for the first time, distributed control, with a total ship management centre.

1. OPTIMISATION OF PROCESSES

Economic pressures for maximum product at minimum cost has led to development of digital electronic instrumentation which offers enhanced opportunities for optimisation of energy costs, and which allows available human resources to be used more effectively.

This instrumentation is based on microprocessor technology and the principle of distributed control.

The purpose of this paper is to illustrate the optimisation features which one particular range of such instrumentation offers and shows how it may be put to use in the marine environment.

In the following sections, a distributed processor control system for marine application will be described. The system will be based upon the TDC 2000 (Total Distributed Control), a control system developed by the Process Control Division of Honeywell Incorporated (U.S.). The system was introduced in Shoreside Industry approximately 7 years ago and has since enjoyed widespread acceptance and success. It serves as the basis for the data acquisition and control systems now being supplied to the marine industry by Honeywell.

Distributed Control System Major Elements and Their Function

The Data Hiway

The Data Hiway is a redundant pair of coaxial cables along which bit serial, time multiplexed data flows between the system elements.

Each cable has an independent electronic interface with each Hiway device for complete redundancy. Access to the Hiway and the designation of which of the two cables is in use is controlled by the Hiway Traffic Director (HTD). This device, the hub of the data communications network, is a card file which is normally located in the central control room. It, too, is fully redundant. The HTD can support three Hiway branches, each of which may be up to 5,000 feet long.

The Operator Station

Centralised display and operator control is provided by operator stations consisting of a 19-inch colour CRT, a specially designed keyboard, and a tape cassette handler. Each operator station also contains its microprocessor, Hiway interface, and power supply. Each station may also have a printer or strip chart recorder output. For example in a recent ship automation system two operator stations with printer data Logger and an eight-channel strip chart recorder are used.

This arrangement is shown in Figure 1. Each station is completely independent and can perform all display and operator control functions by itself. Multiple units are provided not only for redundancy, but for simultaneous display of different information.

The following displays and controls are available to the operator at the operator station:

Overview Display - The display in Figure 2 is designed to present the information normally available to an operator looking across a room at a bank of conventional central control panels. It gives a simultaneous overview of up to 288 critical parameters, arranged into groups which correspond to the equipment or subsystems being monitored.

Group Display - The display in Figure 3 is designed to represent the close inspection by the operator of an individual control panel on a conventional console. Analog values are represented by bar graphs, as well as numerically, and digitals are indicated by coloured, labelled "annunciator lamps", depicted on the screen. The operator may raise or lower analog alarm limits, target values, and set points. Similarly, he may activate digital commands with keys on the keyboard which mimic the displayed push buttons.

Detailed Display - This display is designed to show, and allow modification of, the basic configuration data concerning a point. Changes affecting operation of a remote device are automatically passed to the appropriate unit by the operator station, over the Data Hiway.

Trend Display - This display shows a paragraph of historical trend information for any point selected from a controller with trend memory option.

Alarm Summary Display - Normally, one operator station is assigned by the operator as the alarm display. The alarm summary display provides a chronological list of all active alarms in the system, together with their time of occurrence. As alarms occur, a horn is sounded and the alarm message is added at the top of the list. Unacknowledged alarms are identified by flashing characters next to the message. As alarms clear, they are removed from the list. A record of all alarm occurrences with time and date is generated on the printer.

Alarm Group Display - At any time, the alarm status of all points within 1 of 36 alarm groups can be examined on any operator station. In the station doing alarm scanning, the light corresponding to the alarm group in question flashes when a new alarm is detected. After acknowledgement, this light will stay on until the alarm clears or is manually disabled.

Other Displays - The operator station provides several other important, but less often used displays, such as Data Hiway and device status, operator station assignments, etc.

Printer - An interface board in the operator station transmits information to a printer for printing alarms, logging, trending, and screen copying.

The operator station is also used to make the initial entry of the system configuration parameters. When configuration entry is complete, this information is saved on cassette tape cartridges for later system restoration. This is required because the solid-state memories used in the operator stations and the remote units will lose their content if power is interrupted.

The operator stations are ruggedised for the offshore application by adding some internal stiffeners and vibration isolators. Also, air conditioning of the central control room is recommended to control temperature and humidity. This corresponds closely to the amount of protection necessary for the centralised computer control system.

The Controller

Controllers are microprocessor-based devices capable of receiving and transmitting 4-20mA analog signals. In the example system for engine room automation, two controllers are utilised for functions such as thermostatic control valves and boiler control loops.

The following is a general description of TDC 2000 Controller.

- Inputs from process: Sixteen 4 to 20mA or 1 to 5Vdc signals.
- Outputs to valves: Eight 4 to 20mA signals
- Computational capability: Eight computational slots configurable to provide control algorithms and strategies such as:
    - One, Two or Three Mode controllers, with or without cascade or ratio.

- Computer back-up stations - computer-manual, computer-manual-automation, or supervisory set point stations.

- Auxiliary functions, such as:
  Multiplication/Division
  Square Root Extraction
  Addition/Subtraction
  Lead/Lag, Override, High or Low signal selection
  Hi/Lo Process Variable or deviation alarming

- Independently perform up to 8 loops of control.
- Configured locally or from a remote location via the communication system.
- Data entry panel is a locally mounted controller interface satisfying operational, engineering and maintenance needs. It can be either a portable plug-in device or panel-mounted.

  Provides digital display showing process variable and certain selected variables in either percent or engineering units. Dedicated pushbuttons are used to call up a particular loop for display.

  Normal operating adjustments such as mode, set point, output, ratio, and bias are made by pushbutton but are protected from unauthorised changes by a keylock.

  It also displays basic controller diagnostic codes.

Process Interface Unit

The Process Interface Unit (PIU) is a remote device for interface to the machinery for both analog and digital input/output signals. The configuration of each PIU is controlled by the selection of input/output (I/O) cards and the addition of card files. The range of signals handled includes 4 to 20mA, high and low-level analog voltage inputs, RTDs, thermocouples, pulse counters, contact closures, and TTL, 24-Vdc or 48-Vdc digital levels. Optical isolation, relay isolation, fuse protection and filtering are provided in the conditioning circuits depending on the particular type of signal. The PIU's provide the terminal strips for interconnection of wiring to the sensors and actuators.

The microprocessor in each PIU continuously scans its inputs, rescales analog inputs to engineering units, checks for alarms and stores the current and past values in memory. It executes analog or digital output commands received from the operator station. The PIU continually executes selfchecking diagnostics and sets a status word which is read and reported at the operator station. In cases of trouble, this error detection scheme can isolate the fault to an individual PIU card.

The standard PIU's are modified for marine use as follows. First they are repackaged into drip-proof enclosures. Then, additional dc power supplies are provided to isolate digital circuits and to provide redundancy.

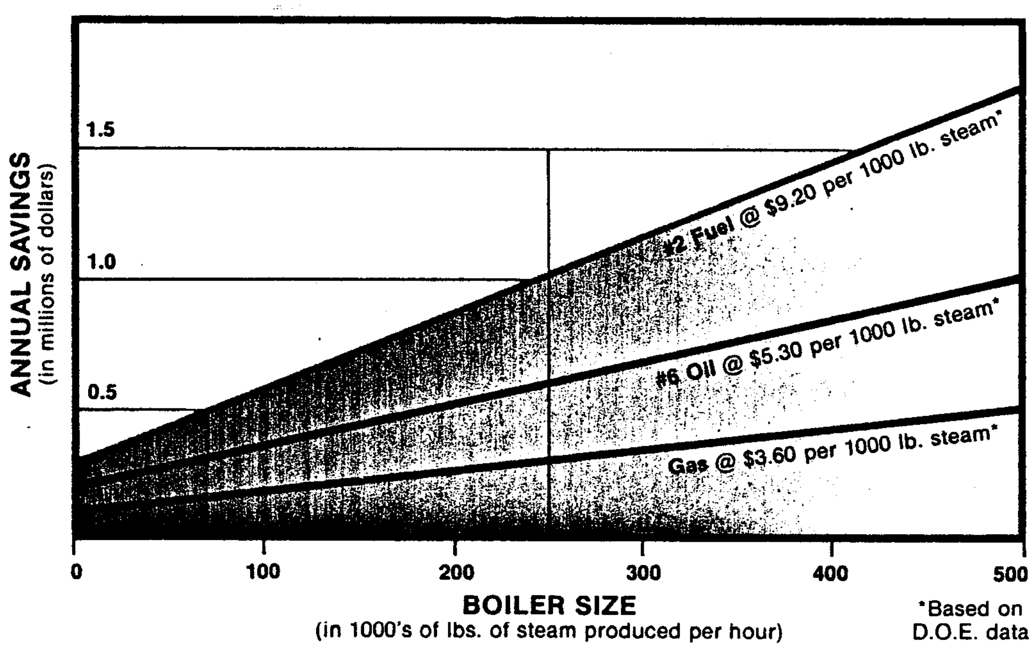
2. ENERGY CONSIDERATIONS

With fuel costs rising and EPA regulations tightening, efficiency has taken on a new meaning. Today, boiler efficiency must be measured by the boiler's ability to squeeze a maximum amount of energy out of every fuel dollar spent, while complying with increasingly restrictive emission control standards.

Many industrial process boilers today run inefficiently by any definition; they waste fuel, labour, and generating capacity. The cause of this waste lies most often in their old inadequate, unreliable control systems. These systems require frequent tuning adjustments. They do not easily accommodate varying BTU content fuels or changing steam demand conditions.

The key to consistently efficent steam generation is a reliable automated combustion control system. It must provide accurate, repeatable and responsive control, and adapt simply and economically to changing plant needs.

At current fuel prices, even a slight improvement in boiler efficiency leads to substantial savings. As the chart below demonstrates, a 5% efficiency improvement in a boiler producing 250,000 pounds of steam per hour translates into a $300,000 to $1,000,000 savings per year, depending upon fuel used.



In plants where TDC 2000 process control system have been applied to boilers, users report up to 20% improvement in boiler efficiency, with payback most often achieved in less than a year.

TDC 2000 improves operating efficiency through:

Greater Precision and Repeatability

Unlike analog devices, TDC 2000 is not subject to drift. When process performance depends on delicately balanced operating parameters, even a slight imbalance in one of these values could cause a major decrease in operating efficiency and fuel economy. A fuel-air ratio deviation of even 0.5% could cost several million BTU's/year, and cause increased gaseous and particulate emissions.

Improved Reliability

In conventional control systems, a controller malfunction goes unnoticed until the process upsets. It may even shut down the boiler. TDC 2000 with its built-in self-diagnostics, pinpoints a controller malfunction as it occurs, and identifies the nature and location of the problem. Circuit card replacement is quick and easy, and overall boiler efficiency is not affected.

Increased Adaptability

With traditional control systems, a change in operating conditions often calls for a complete overhaul. With TDC 2000, you simply re-configure system loops to implement a wide variety of control strategies. And you can expand TDC 2000 easily to accommodate additional boilers, new fuels, and new equipment.

An example of this adaptability lies with boilers operating with oxygen trim on liquid fuel combustion control systems.

As liquid fuel costs escalate, many owners are looking seriously at coal conversion. With coals need for greater excess air the ability of an oxygen trim combustion control system to cope with coal can be marginal.

With a TDC 2000 equipped boiler, changing the combustion control system from oxygen trim to opacity trim at the time of a fuel conversion to coal, may be achieved by a series of simple pushbutton keystrokes with no changes in wiring, field instrumentation or control actuators (subject, of course, to the boiler having been fully equipped with a comprehensive range of field instrumentation in the first place).

3. USE OF COMPUTERS

With the use of microprocessor based electronic control systems comes the ability for easy interface to a host computer.

This facility arises from the fact that all microprocessors operate on a digital basis, including both those in TDC 2000 components and those in computers. Thus, by designing the Basic TDC 2000 microprocessor to operate using computer compatible communication protocols, and by providing (as part of the standard range modular options), a General Purpose Computer Interface, the addition of a computer can be easily accomplished.

Particular TDC 2000 computer applications that are already at sea can be found in semi submersibles serving offshore developments. In these cases Hewlett Packard computers have been linked with the TDC 2000 system to provide optimisation control for machinery plant and services. Such systems have an enhanced ability to undertake very complex control strategies such as those needed for Automatic Station Keeping (or Dynamic Positioning) and drilling parameters as well as the ability to provide a greater range of management level historical records concerned with such aspects as vessel efficiency, reliability, and endurance.

Other applications may be found in some of the latest container vessels, where Honeywell Level Six Computers have been linked into the Data Hiway to achieve not only Main Propulsion control monitoring and alarm functions, but also monitoring and calculations associated with loading, ballasting, and temperature control of the refrigerated containers.

Another vessel type believed to be particularly suited to the application of a TDC 2000 computer system, is the LNG tanker. Such a system could contribute significant economies to any suitably equipped vessel, by allowing reliable automatic optimisation of such things as the use of boil off gas, refrigeration controls, main propulsion, ballasting, power generation, and hotel services.

4. CONCLUSION

There is little doubt that digital electronic technology and the employment of microprocessors is now well established in industry ashore.

Continued use of such equipment will inevitably lead to broader applications of this technology at sea.

The Honeywell TDC 2000 system is already well established and proven in arduous service ashore and offers outstanding ability to minimise operational costs to marine operators.

References: Offshore System Management with Digital Technology
by
G. Soghomonian
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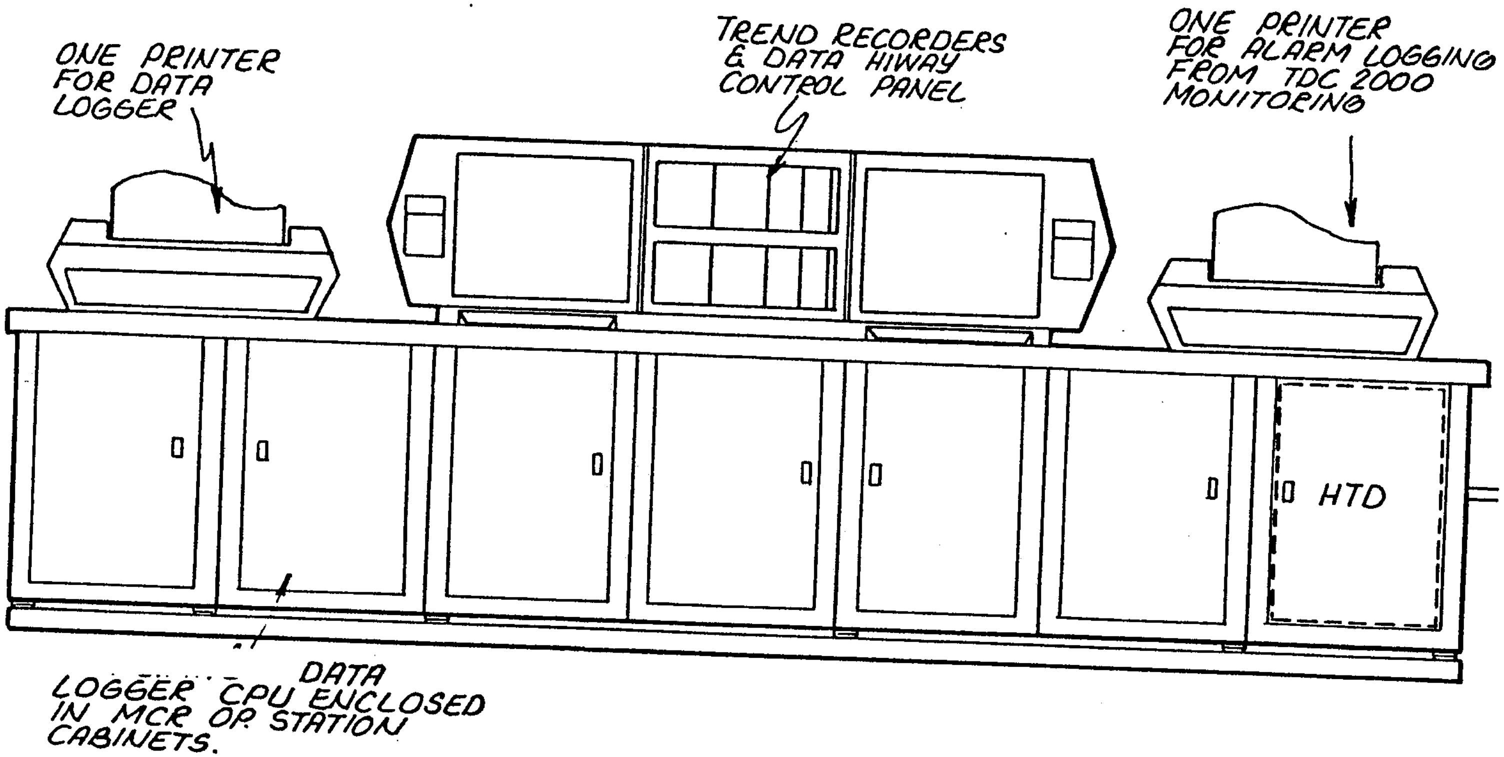


FIGURE 1 - TYPICAL OPERATING CENTRE

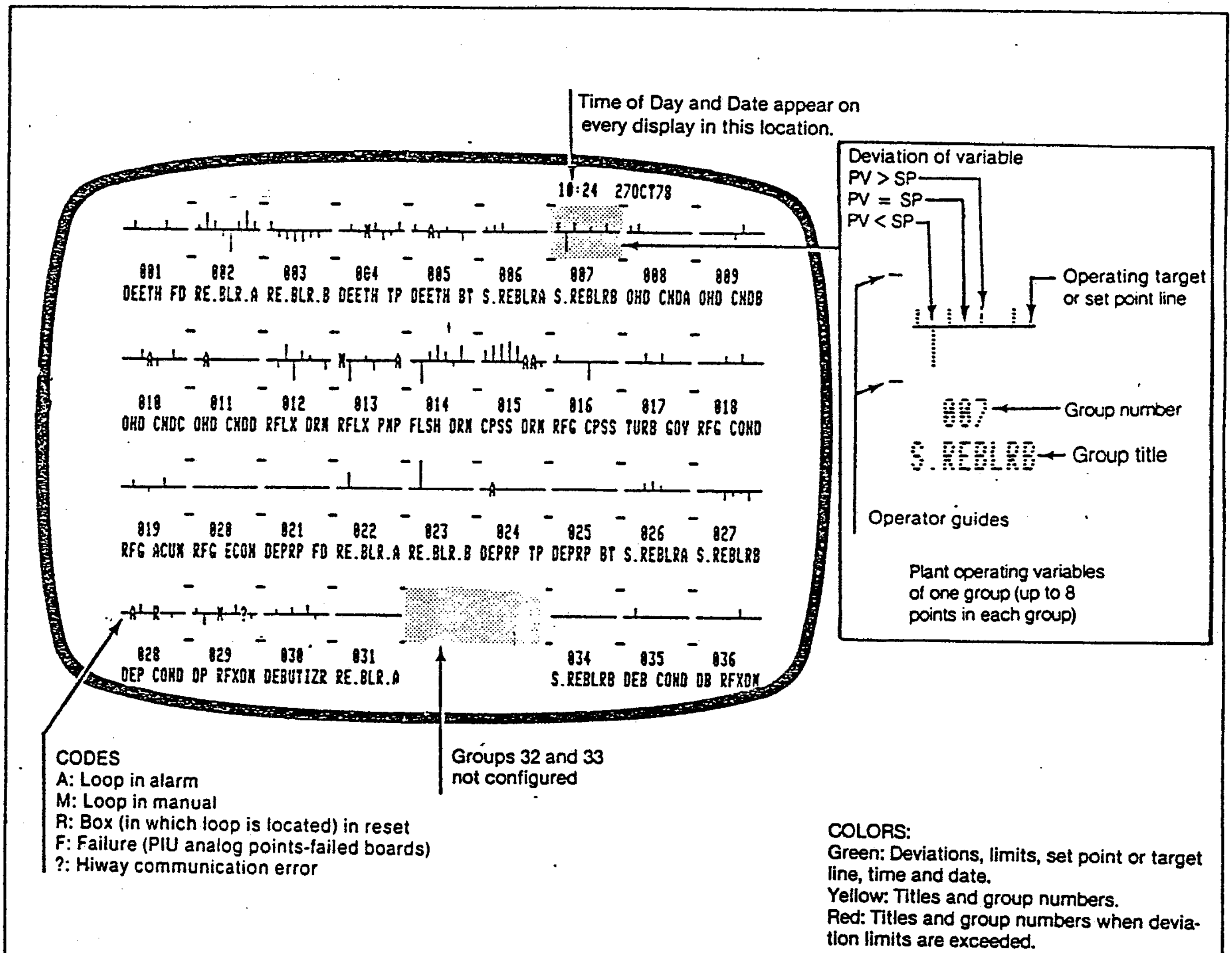
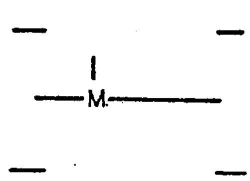


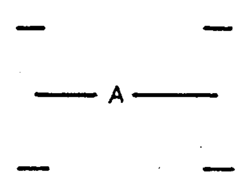
Figure 2 – Overview Display

Manual Conditions



When a tag is placed in manual, either by the Basic Operator Station, DEP, or the Analog Display; an M appears at the tag's position on the base line. Significant deviations above or below the M are also shown.

Alarm Conditions



If an alarm condition is reached, the bar graph disappears and is replaced by an "A". At all stages of deviation, the operator can see which loops are controlled properly and which are upset, and whether or not a deviation is a problem to the plant-wide process or a temporary local upset instead. NOTE: Alarm conditions for the Basic Controller Lead/Lag algorithm are not reported in the Overview, Group, or Detail Display.

Digital Points

If digital points are included in any of the 36 groups (288 points) they do not show deviation, but do show alarm conditions as configured.

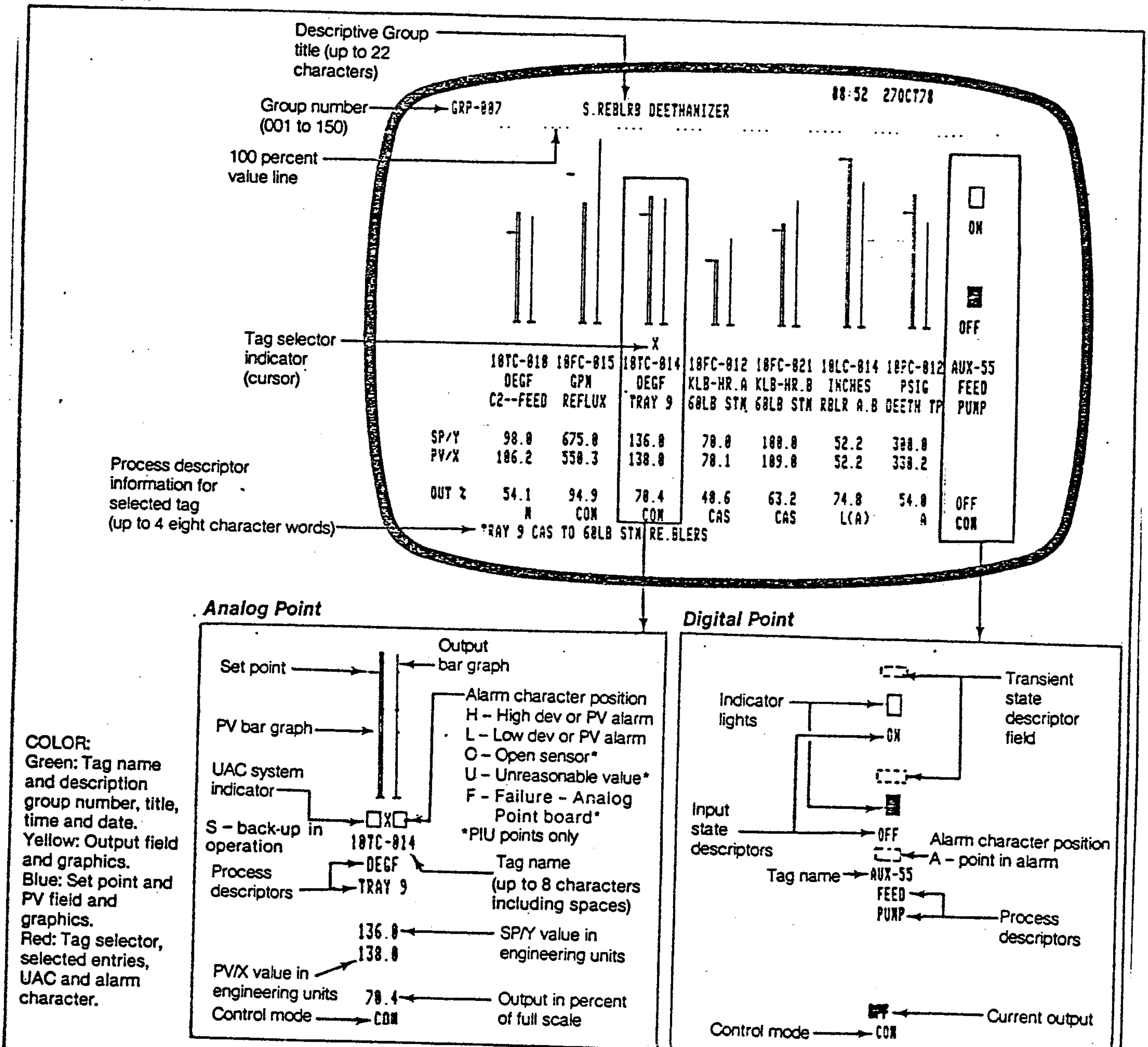


Figure 3 – Group Display