



NATIONAL PETROCHEMICAL COMPANY
STANDARDS

MATERIAL STANDARD
FOR
DISTRIBUTED CONTROL SYSTEM
NPCS-MS-IN-40
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1 GENERAL

1.1 SCOPE

1.1.1 This standard outlines the technical requirements for the supply of Distributed Control System (DCS) for control end monitoring of the process units.

.1.2 In case of contradiction between this **standard** and other documents, purchaser shall be consulted after which a written settlement will be given to vendor.

.2 STANDARDS AND CODES

In general, all codes and standards of International Standards Organization "ISO", International Electrotechnical Commission "IEC" and Institute of Electrical and Electronics Engineers "IEEE" shall be applicable for the supply of the Distributed Control system "DCS" and auxiliaries.

.3 SYSTEM LAY-OUT

.3.1 The plant will be controlled and monitored by Distributed Control Systems (DCS) located in control room and auxillary room.
The control room will contain, among other facilities, CRT based operator consoles and an auxiliary room for all remaining front-end control and data acquisition equipment.

.3.2 Design of the system shall meet or exceed the requirements listed in this standard. Compliance with requirements shall be confirmed by vendor in writing and per item the deviations shall be explained.

.3.3 SYSTEM COMMUNICATION MODULES

The data communication system between the various modules shall provide full redundancy.

.3.4 DATA STORAGE MODULES

A data storage system supporting hard disc(s), floppy disc(s) and tape streamer (optional) for historical recording purposes to be provided.



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L.4 CONTROL EQUIPMENT LOCATED IN THE CONTROL BUILDING(S)

L.4.1 The operator and engineer console(s) will be located in the control room and the following control equipment will be located in the auxillary room :

- Control modules.
- Auxiliary equipment, e.g. converters, electronic switches, programmers, etc.
- Marshalling cabinets.

L.4.2 Operator and Engineer Console

L.4.2.1 Console Functions

The function of the operator and engineer console is to provide the operators and engineers with adequate means to achieve safe and efficient operation of the plant involved.
To enable this, the console shall consist of, but not limited to, the following functions :

- Alarm generation.
Process data collection and indication.
- Process control parameter manipulation.
- process control configuration
- Graphic displays.
- Report generation.
- Short-term and historical trending.

The above functions shall be organized and presented in a reliable and efficient way to the operator.

L.4.2.2 Console Build up

The console shall be a microprocessor based system consisting, as a minimum, of the following functional modules :

VDU Based Operator Interface Modules.

Functionally the operator interface is a window to the process and shall include redundancy to provide maximum availability.

The console will consist of, in total, operator VDU/Keyboard workstations and related peripherals.



1.4.3

Auxiliary Equipment

1.4.3.1

Auxiliary equipment shall consist mainly of signal conditioning modules and electronic switches. Calculation facilities, e.g. temperature and/or pressure compensation of flows, etc., shall be included in the DCS.

1.4.3.2

In many cases auxiliary equipment will be involved in control, alarm or shut-down functions. Vendor shall determine if (external) auxiliary equipment is required for its system. If so, vendor shall quote this auxiliary equipment. Therefore, module integrity/reliability and power supply redundancy shall be provided.

1.4.3.3

All auxiliary equipment will be located in the auxiliary room.

1.4.4

Modules

1.4.4.1

Controller Modules

The control and related functions shall be performed in redundant controller modules.

Shared equipment, which is common to more than **one** control loop and which is essential to the operation of those loops, shall be furnished with redundant or "back-up" systems. The redundant system shall be furnished with automatic switching and bumpless to redundant module to maintain loop integrity in the event of malfunction of the primary device.

Malfunction of the primary or redundant device or system shall be alarmed.

In addition to the loop integrity redundancy requirements, portable manual units (with quick-connect plugs) or permanently cabinet mounted maintenance panels shall be provided.

Loop integrity shall be such that failure of a single input or output point will not require manual operation of more than one final control element.

1.4.4.2

Bulk I/O Modules

Less essential process monitoring functions may be handled by nonredundant Bulk I/O modules. The reliability of these modules shall be considered for minimum availability.

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1.4.5

Marshalling Cabinets

Dedicated Marshalling cabinets will be used for all incoming and outgoing field signals. From these cabinets the signals will be distributed over the various DCS and auxiliary cabinets. In general screwed terminals instead of plug and sockets shall be used for connection of signal cables between cabinets.

The marshalling cabinets design shall be based on the following:

- Two rows of screw-type terminals; one row for field cabling and one row for auxiliary room cabling.
- Test/disconnect-type terminals at the field cabling row.
- One cable clamping bar with facilities to ground all cable armoring.
- One isolated instrument earth bar to connect all instrument field cable overall screens.
- Cable entry shall be from the open bottom of the cabinets.
- Cross-wiring conductor, size (for 110 V AC power) 2.5 mm².
- Cross-wiring conductor, size (for solenoid circuits) 1.5 mm².
- Cross-wiring conductor, size (for all other circuits) 0.75 mm².
- Cross-wiring conductor for T/C shall be suitable type extension 20 AWG.
- All cross wiring shall have crimped taper pins at both sides.
- All cross wiring shall be tagged on both sides.
- All terminals shall be tagged and trip signals shall carry a Red label.
- To support incoming and outgoing cables sufficient supporting material shall be installed.
DCS seller shall state the preferred marshalling cabinet arrangement in its proposal.



Seller shall size marshalling cabinets based upon the number of signals entering/leaving the control building.

20% spare terminals to be installed for future expansion/spread of spare terminals determined by JB schedule.

2

SYSTEM DESCRIPTION

2.1.

SYSTEM ARCHITECTURE

2.1.1

General

2.1.1.1

The DCS supplied under this standard shall be capable of performing, as a minimum, the following functions:

- a) Regulatory control functions.
- b) Display of control loop status including process input, controller set point, controller output, and controller mode.
- c) Calculation of process related variables and parameters.
- d) The capability for the operator to assume manual control of a control loop, and to change controller set points, modes and tuning constants from operator's console.
- e) Display of process variables (both analog and digital).
- f) Trend recording of process variables (records to be stored in RAM and/or rotating bulk memory, and to be available as displays on operator's CRT and output to the printer/plotter).
- g) Display and control of equipment status such as valves and pumps.
- h) Display and audible annunciation of alarms to advise the operator of abnormal or dangerous process conditions and system failures.

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- i) Accumulation of measured and calculated data to form a historical data base.
- j) Report generation by using actual and historical data.
- k) Logging of alarms and events.
- l) Color graphic displays of sections of the plant including relevant control loops and live process data.
- m) System diagnostics.

2.1.1.2

Redundancy shall be provided for all control functions, data communication, power supplies and operator interfaces.

2.1.1.3

The design shall be such that :

- a) Failure of the data communication link shall have no effect on operation of the microprocessor-based process controllers .
- b) Failure of an individual operator's CRT shall neither affect the function of another CRT in the system nor limit any of the control and monitoring functions of the system . Each CRT with its related electronics should be stand-alone.
- c) Failure of a single data storage module shall not result. in loss of recording functions or plant data.
- d) For DCS it is required that the configuration programming and data base assembly be determined by purchaser such that the configured system can be inspected at the factory before delivery.

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2.1.2 Operator Consoles

2.1.2.1 Operator Interface

The system shall provide redundant operator interface, with the use of independent electronics, CRT operator stations and interfaces.

The control room consoles shall be designed and constructed as integrated assemblies, comprising as a minimum of :

- Two operator VDU/Keyboard workstations.
- Communication panels, including, two wall mounted telephone set.
- Table top desk space.
- Disk memory.

Integration of the hard-wired annunciator with the operator console may be considered for feasibility. Stacked CRT and annunciator is not acceptable.

2.1.2.2 Operator's console shall support two printers (b/w) and a screen copy facility (in color). One printer shall be dedicated to alarm logging; the other to report logging. The functional capabilities of these devices are specified in detail in section 3.

2.1.2.3 The DCS shall support nonvolatile memory media (disk drive or equivalent) for storage of configuration data, historical data and system reloading.

2.1.2.4 Vendor shall include in his proposal, drawings which detail his proposed system.

2.1.2.5 Each operator work station shall have access to displays such as trend data, alarm summaries, control group and loop displays, overview displays and graph displays.

2.1.2.6 Process control functions from graphic displays shall be possible by means of pointer/cursor selection of the item to be controlled.

2.1.2.7 It shall be possible to reload the operating system data base quickly and simply, by loading a floppy diskette or directly from hard disk. Seller shall detail in his proposal how his system achieves this and the maximum time required.

2.1.2.8 The operator workstation shall be up-dated within a 2 second interval for all data presented.

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2.1.2.9 Process parameter modification may be either by a typed data value entry or by a camping technique. When ramping a process parameter, the up-date period shall be maximum 1/2 second.

2.1.2.10 The following features shall be provided, as a minimum, as part of seller's standard software and hardware:

- a) The highest level of the display hierarchy shall provide the operator with an overview of all systems within the plant. Multipage overviews are required.
- b) The second level of the display hierarchy is the group display which will display eight to twelve loops per page. Conventional analog type representation is preferred with bar graph type displays for measurement, set point and output values as well as indication of alarm limits and control modes. SI metric engineering units (with exceptions as per instrument schedule) shall be displayed. Other loops in the group display shall remain on the CRT screen as the individual loop is addressed.
- c) The third display level shall provide information concerning a single loop. All parameters of the loop at this level shall be displayed the same as in the group level. In addition, the controller tuning details, such as proportional band, integral time, etc., shall also be displayed.
- d) The fourth display level is the detailed alarm display. The control system shall continuously monitor all process variables for alarm conditions. Alarms shall be indicated on all levels of the display hierarchy utilizing flashing video, color differentiation or both. An alarm shall be reported to the operator in less than one second of occurrence. New alarms as well as current alarms shall be indicated to the operator at the operator console regardless of which display is currently selected. Each alarm, its acknowledgement and its return to normal condition shall be automatically logged on an alarm printer.

Note: In addition to the DCS alarm display and logging facilities, for some alarms a hard-wired annunciator system shall be provided.



- 2.1.2.11 The system shall have the facility to perform process control functions from custom graphics displays by means of pointer/cursor controlled item selection.
- 2.1.2.12 Process data point creation shall be a conversational or "fill in the blanks" technique. It shall be possible to link process data points to create advanced control schemes. All such configuration data, which is normally stored in RAM shall also be stored in nonvolatile medium, e.g. floppy disc for rapid downloading when required.
- 2.1.2.13 For each individual point, alarm limit settings shall be configurable and/or under keylock protection against unauthorized changes. Preferably, the DCS will have different alarm priority levels configurable for each point.
- 2.1.3 Process Controllers
- 2.1.3.1 Process controllers shall be located in the auxiliary room. Regulatory control shall be microprocessor based, with redundancy as defined in Clauses 2.1. and 4.3.
- 2.1.3.2 Vendor shall offer only standard, field proven equipment.
- 2.1.3.3 Process controllers shall perform data acquisition and regulatory control functions. The units shall also transmit and receive data along the data communications link to and from the operator console. They shall have the facility to allow the operator to perform manual control of the controller output from the console.
- 2.1.3.4 Process controllers shall continue to operate, if communication with the operator console is lost. Loss of communication over the data communication link shall not affect regulatory control performance.
- 2.1.3.5 Redundant process controllers (including redundant power supplies) shall be supplied, which shall be continually checked for availability, and any outage shall be alarmed. Failure of any active controller shall result in switching over to a redundant controller which shall be automatic and bumpless and shall not interrupt control capability, but shall be alarmed.
- 2.1.3.6 Process controllers shall have, as standard, all basic control and data manipulation algorithms required for regulatory control. The required algorithms shall include but not be limited to those listed in Clause 4.2.

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- 2.1.3.7 Process controller hardware shall meet all of the requirements of section 4 of this standard.
- 2.1.4 Process Interface Equipment
- 2.1.4.1 Process interface equipment shall be located in the auxiliary room.
- 2.1.4.2 All process interface equipment shall meet the requirements detailed in section 5 of this standard.
- 2.1.5 Sequence of Event Recording
- 2.1.5.1 The DCS shall be capable to print out alarms with sufficient resolution to determine the sequence in which they occurred.
The printout will be on the alarm printer.
A time tagging resolution of one second or less is preferred.
Seller shall indicate in his proposal the performance of his system, with regard to sequence of event recording.
If a satisfactory performance is not feasible with standard DCS hardware, a separate sequence of event recorder, might be considered.
- 2.1.5.2 The system shall have the facility to store and retrieve 2000 of the most recent alarms and events. Vendor shall detail the possibilities of its system.
- 2.1.6 Data Communication Link
- 2.1.6.1 A data communication link shall provide the means for operator CRT's, process controllers and other process interface equipment to exchange data and commands.
- 2.1.6.2 Redundant data communication link systems shall be supplied; each with one active and one alternate path. The alternate data communication links shall be continually checked for availability and any fault shall be alarmed. The checked for availability and any fault shall be alarmed. The system shall alarm and automatically switch to the alternate data communication link without interruption of service or loss of signals.
- 2.2 SYSTEM DESIGN CRITERIA
- 2.2.1 General
- For operational reliability and availability, the following guidelines shall be followed in design of the DCS.



- 2.2.1.1 The primary method of control shall be via microprocessor based process controllers which shall be physically located in the auxiliary room.
- 2.2.1.2 Redundancy for all control functions is required, see Clauses 2.1 and 4.3 of this standard.
- 2.2.1.3 The system shall require minimum maintenance and routine calibration, and shall have comprehensive self-checking, calibration and self-diagnostic fault detection capabilities including failure alarms. Comprehensive system status information shall be available for display on standard operator consoles. Seller shall include 10% usable (installed) spare in the process connected parts of the DCS. This spare shall be equally spread over the various plant sections.
- 2.2.1.4 In order to achieve the performance requirements specified for the system, specific allowance must be made for the environmental conditions under which the various system components will be expected to operate. Under normal conditions, there shall be a controlled environment for the system. However, in the case of malfunctioning of the environmental equipment, the system shall conform to environmental conditions of section 2.2.4 of this standard.
- 2.2.1.5 The system shall be of field proven design. System modules shall be of proven technology and shall have a history of successful operation for past four years. During at least ten years after start-up, vendor must guarantee the delivery of parts and service facilities.
- 2.2.1.6 The system shall be flexible with regard to configuration of loop connection and display formats to suit changes in operational requirements. Reconfiguration of loop control algorithms must be easily accomplished from operator's console or a dedicated engineering console. It shall be possible to link process data points to create advanced control schemes.

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Configuration shall be possible in an on-line fashion and shall not require more than one CRT workstation. It shall be possible to quickly download a previously configured control scheme to the controller over the data communication link. Configuration data storage should reside on a bulk memory device with removable media to provide downloading capabilities for several controllers. It should also be possible to up-date an individual loop configuration in the multiple loop controller, including the addition of functional elements, without disrupting the normal operation of other loops resident in that controller.

2.2.1.7

The maximum number of control loops assigned to a console consisting of two VDU operator workstations shall be about one hundred and fifty (150). In case more control loops are involved the operator console shall be extended and operator manageability shall be considered.

2.2.1.8

Each control area shall have its dedicated DCS hardware and software (consoles, controllers, process interface equipment auxiliary cabinets, etc.).

2.2.2

Spare Capacity Requirements

2.2.2.1

System hardware and software shall be modular and the system shall be designed with flexibility for future expansion. This expansion shall be achieved by straight addition, not modification of hardware and with a minimum of software and configuration changes. Vendor shall include 10% usable(installed) spare in the process connected parts of the DCS. This spare shall be equally spread over the various plant sections.

2.2.2.2

Spare capacity shall be available both in field inputs and outputs as well as functional software blocks. The DCS shall have an additional 20% prewired spare slot space.

2.2.2.3

The loading of the communication links shall not exceed 70% of total time during all loading conditions, including upsets.

2.2.2.4

The system supplied shall have a minimum installed spare capacity of 30% with regard to CPU load, memory, data communication links and disk storage.



2.2.3 Area Classification

2.2.3.1 The control room and auxiliary room where process controllers and operator interfaces are to be installed, is classified nonhazardous per IEC 79-8 (CENELEC EN 500141).

2.2.3.2 Most field mounted devices (transmitters and switches) are located in area.

2.2.3.3 Dust Contamination

Based on information from similar locations the dust in air concentration is as per information which will be specified in data sheets. The system shall be suitable for working under these conditions.

2.2.3.4 Vendor shall state the total system and individual equipment, cabinet and console heat dissipation under normal operation.

2.2.4 Environmental Conditions

2.2.4.1 The system equipment will be installed in a temperature controlled environment.

2.2.4.2 Vendor to determine the maximum temperature and humidity that the system can withstand.

2.2.4.3 The system shall withstand also the environment conditions during a normal air conditioning system failure with no degradation.

2.2.4.4 Storage Conditions

Temperature -30°C to +70°C.

2.2.5 Electrical Power Supplies

2.2.5.1 Purchaser will provide AC power, derived from an uninterruptable power supply (UPS) system. The power supply will be 110 V AC, 50 Hz nominal, single phase; solenoid valves are 24 V DC (see also Section 10).

2.2.5.2 Vendor shall provide redundant power supply systems, with memory battery back-up for 24 hr. Vendor shall clearly indicate his provisions in proposal. Low battery voltage (and if used charging system malfunction) shall be alarmed on operator's console.

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- 2.2.5.3 The failure of one such redundant system shall not interrupt system operation and shall be alarmed on operator's console.
For shared DC power supplies, current overload protection shall be by means of current limiting. Current cutoff (fold back) and "Crow bar" circuits shall not be used.
- 2.2.6 Radio-Frequency Interference (RFI)
- 2.2.6.1 Standard commercial UHF and VHF hand held personal radio equipment of 5 W nominal output power will be operated as close as 0.5 m from the equipment.
- 2.2.6.2 Vendor shall state whether his standard system design and construction incorporates the necessary features to render the installed system immune to interference from such radio operation with equipment cabinet doors open. Vendor shall state in his proposal the RFI susceptibility of all equipment supplied (both with open and closed cabinet doors) with reference to IEC 801.3, class 2 and SAMA PHC-3301, class 2.
- 2.2.7 Electromagnetic Interference
- Vendor shall clearly state minimum clearances or shielding required between data communication link cables and high voltage power cables, transformers, motors, etc.
- 2.2.8 System Availability
- 2.2.8.1 Overall system availability shall be better than 99.998%, i.e. 1 hr downtime per year).
- Availability = $NTBF / (MTBF + MTTR)$.
MTTR = 4 hr,
in which MTBF stands for meantime between failure and MTTR for meantime to repair.
- 2.2.8.2 The system shall be designed such that single component failures shall have minimum possible effect on overall system availability.
- 2.2.8.3 Vendor shall prepare and submit with his proposal, availability calculations showing the theoretical performance achievable within certain assumed constraints.



Equipment reliability figures, i.e. MTBF and MTTR, used in the calculations shall be based on field performance or other documented data. The assumed constraints are listed below :

- a) All sub-systems not furnished by vendor shall be assumed to be available 100% of the time.
- b) Failure caused by accidents, fires or other nonequipment related external conditions shall not be considered.
- c) Repairs shall be carried out efficiently by replacing faulty modules or circuit boards.
- d) All tools and test equipment, recommended by vendor, shall be available.
- e) Mobilization and travel time for maintenance personnel to get to the faulty location shall be considered as 1 hr.
- f) A process interface equipment fault resulting in the nonavailability of a single input or output point, and therefore requiring immediate maintenance actions, shall be classified as a failure of that respective point.

2.2.8.4

Availability calculations for each respective type of input and output shall be based upon reliability figures for all vendor's hardware in the loop.

2.2.8.5

Surge Protection

Conditions, initiated by surge induced on any input or power line connection that may cause malfunction or illegal operation either through the hardware or software, shall be detailed in vendor's proposal. Vendor shall also detail isolation practices, provided for his hardware.

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3 OPERATOR CONSOLES.

3.1 DESIGN AND FACILITIES

3.1.1 Color CRT's/Keyboards

color CRT's and associated keyboards shall comply with the following requirements :

- a) Displays shall feature a color monitor that provides a minimum of eight colors, including Black and White.
- b) The CRT shall provide a sufficiently sized format to enable the system pages to be displayed without loss of clarity or definition. Vendor shall clearly specify the format size proposed in text and graphic mode.
- c) The CRT shall provide facilities to present data on the screen in graphic and alphanumeric form with multicolor capabilities.
- d) Minimum CRT size shall be 19" diagonal.
- e) The CRT mirror effect shall be reduced to a minimum by using antiglare screens or antiglare coating for the CRT's.
- f) One operator keyboard unit shall be supplied for each CRT, mounted into the console work top. The operator keyboard shall be spillproof and preferably have tactile feedback keys.
- g) A key lock feature shall be provided to select the system accessibility (Operator Engineer, etc.)

3.1.2 Alarm and Report Loggers

The alarm and report logger, provided for each operator console, shall meet the following requirements :

3.1.2.1 The alarm logger shall be capable of the following functions :

- a) Logging of alarms, and alarm return to normal as these conditions occur.
- b) Logging of shut-down trip event data.

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c) Logging of such events as :

- Set-point changes.
- On/off, open/close commands.
- Mode changes of controller (manual/automatic/cascade) taken off "off/on" alarm scan.
- Other changes in DCS parameters of settings.
- System diagnostic failures and hardware malfunctions.

d) Logging of date and time of day for each printer entry.

3.1.2.2

The alarm and report logger shall meet the following general specifications :

- a) Type : Letter quality printer.
- b) Print rate : 150 characters per second minimum.
- c) Line length : 132 columns, 10 characters per inch.
- d) Paper feed : Adjustable pin feed for standard fan fold computer stationery.
- e) Character Set : Characters set compatible with CRT display format.
- f) Paper, : Standard computer paper only shall be acceptable. Loggers shall be capable of handling 15" wide paper.

3.1.2.3

Alarm and report loggers shall be equipped with paper stacker and stand (unless mounted within a console).

3.1.2.4

The reliability (MTBF) of each logger shall be better than 2500 hr.

3.1'3

Screen Copier

One screen copier shall be supplied for each operator console. The copier operation shall be initiated by the operator pressing the appropriate key in the function section of any CRT keyboard. The copier shall be capable of copying both process and graphics CRT displays in color (minimum size of printed image : 210 mm X 160 mm).