ENGINEERING AND INSTALLATION STANDARD

FOR

CONTROL CENTERS

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1. SCOPE

This Standard covers the design and engineering of control centers for process operations. The term control center, as used in this Standard defines a building which encompasses the control room with control panels and other associated control equipment, termination room, computer equipment room (if required) associated offices, utility and mechanical equipment,and any other facilities housed with in the building.

The standard covers guidelines for locating the control center in reference to the processing units controlled from it, discusses factors associated with the design and engineering of the building, primarily those factors affecting the instrumentation within the building, and presentes common practices for the construction and installation of the various types of control panels and auxiliary control equipment.

Regarding D.C.S. panels, reference to be made to IPS-E-IN-250 "D.C.S. Systems".

2. REFERENCES

Throughout this Standard the following standards and codes are referred to. The editions of these standards and codes that are in effect at the time of publication of this Standard shall, to the extent specified herein, form a part of this Standard.

The applicability of changes in standards and codes that occur after the date of this Standard shall be mutually agreed upon by the Company and the Contractor.

API (AMERICAN PETROLEUM INSTITUTE)

RP 550	"Manual on Installation of Refinery Instruments and Control Systems"
Part I	"Process Instrumentation and Control, Section 12 Control Centers"

IPS (IRANIAN PETROLEUM STANDARDS)

E-IN-180	"Electrical Power Supply and Distribution System"
E-IN-190	"Transmission Systems"
C-IN-190	"Transmission Systems"
M-IN-220	"Control Panels and System Cabinets"
E-IN-250	"Distributed Control System"
M-TP-125	"White Alkyd Paint for Top Coat"
E-SF-900	"Noise and Vibration Control"

3. UNITS

This Standard is based on International System of Units (SI), except where otherwise specified.

4. GENERAL

It is recommended practice to centralize control of process units, particularly when their operations are integrated.

Centralization of control requires a careful choice of control center location; evaluation of control center building design factors, and regulation of the building internal environment for the comfort of operating personnel and protection of the control equipment.

5. CONTROL CENTER LOCATION

In selecting a control center location, the following factors, shall be considered:

5.1 Control Center Size

a) Control center size will vary in accordance with the number of process units to be controlled from that location;

b) It also contains auxiliary equipment such as, power supplies, logic cabinets, etc.

c) Auxiliary equipments may be installed in a separate room, specially those parts of instruments (such as logic cabinets power supplies) which are not to be manipulated by the operators.

d) The future expansion, shall be taken in to consideration.

e) Since it is working quarters for operators, process engineers, and technicians, it is usually necessary to provide such facilities as offices, conference rooms, etc.

f) The installation of a computer may require a separate computer room along with offices for analysis or programmers, or both.

g) The computer shall be located so as to minimize cabling lengths between the computer room and both the terminal and control rooms.

5.2 Safety Aspects

5.2.1 Area classification

a) It would be very costly and, in many cases, very restrictive if it were necessary to install explosion proof equipment in the control center.

b) Therefore, the building shall be located in an unclassified area, where this is not possible, the building shall be pressurized to be safe internally.

c) In classifying areas, the latest edition of API RP 500A, classification of Areas for Electrical Installations in Petroleum Refineries, or any other equivalent standard shall be considered.

5.2.2 Recommended distance from process units

a) If possible, the control center shall be located far enough from the operating areas so that the vapors will be dispersed before reaching the control center.

b) The minimum distance between the control center and process units shall be 20 meters.

c) Control centers shall be located away from sources of vibration.

d) The control center shall preferably be located on high ground so that open drainage lines or hydrocarbon spills will not carry hydrocarbon vapors to the control center.

5.2.3 Protection from external explosions

Large control centers created to consolidate operations have also created a consolidation of risk.

Damage to the building containing all the control systems necessary for the operation of a complete plant or a large number of process units could result in a very costly shutdown of a tremendous amount of equipment, This situation has made it advisable to consider constructing these control centers with an appropriate degree of blast resistance.

5.3 Accessibility and Communication

a) Location of the control center near the physical center of the plant will reduce signal transmission distances and the time it takes for an operator to reach the more remote areas.

b) Location of the control center on the periphery of the plant will increase the average signal transmission distances and could curtail operator inspection of the more remote areas.

c) The use of electronic transmission systems and radio communication will circumvent these problems.

d) Peripheral location will likely prove to be less of a problem from the viewpoint of future expansion and hazard criteria.

5.4 Environmental Factors

a) The direction of the prevailing winds, and noise from the process areas, shall be considered, when locating the control center.

b) The control center shall be located up wind from cooling towers, possible sources of hydrocarbon vapors, or other hazardous and/or corrosive gases such as hydrogen sulfide or chlorine.

c) The control center shall be located in an area where the water table is below the entrance of cables in to the control center.

6. CONTROL CENTER BUILDING REQUIREMENTS

6.1 Interior Space Considerations

6.1.1 Panels

a) Panels shall be arranged to permit the operator to survey the maximum panel area.

b) It is desirable to design the control room around a control panel rather than design the control panel into a control room.

c) The control room floor plan can be determined, after determination the length of the panel, either by estimation or actual design.

6.1.2 Consoles

a) Where consoles are installed as separate components from the panels, they shall be located in front of the control panel, with a minimum aisle of 2 meters between the console and the panel.

b) If necessary, these devices can be integrated with the panel instruments into one console or panel.

6.1.3 Auxiliary equipment and utilities

Space shall be provided for auxiliary control equipment and other control center facilities, such as auxiliary equipment racks, termination cabinets, computer main frames, office space for personnel, housekeeping facilities etc.

6.2 Architectural Considerations

6.2.1 General design considerations

a) Blast-resistance design shall include consideration of foundation, exterior walls, roof, doors and hardware, above grade penetrations (not desirable), and air intakes.

b) Building codes and standards in force for the particular geographic area shall be used to cover snow loading, wind loading and seismic requirements.

6.2.2 Windows and doors

a) Because all openings in the exterior of blast-resistance type of building are considered weak points, they shall be kept to the absolute minimum.

b) Blast-resistant design usually precludes exterior windows.

6.2.3 Lighting

a) Typical in-service-lighting intensity invarious areas of the control room, shall be as follow:

AREA	IN-SERVICE INTENSITY	ELEVATION
Vertical control panels and consoles	15 meter-candles	All instrument areas
General control room area	10 meter-candles	Floor
Back of panel areas and corridors	5-10 meter-candles	Floor

b) The use of diffusers and nonreflecting glass on instrument bezels will minimize glare, unsightly appearance and physical discomfort.

c) Rear panel lighting could either be incandescent or fluorescent.

d) Usually, an emergency lighting system around the perimeter of the panel shall be connected to an emergency supply so that in the event of a power failure, orderly limited operation or shutdown action can be executed.

6.2.4 Ceiling

a) The minimum recommended floor to ceiling height shall be 3 meters in order to accommodate equipment and provide a good appearance.

b) An economic ceiling shall be a non-dusting type of acoustical tile or board with an exposed grid suspension system.

6.2.5 Floor design

a) An access or computer type floor may be sometimes used in rooms with electronic instrumentation (including DCS and computer rooms).

b) This type of floor simplifies the routing of cables between control panels and auxiliary equipment or consoles.

c) It is also easily adaptable to additions or revisions to the control room equipment.

d) A floor height of 45 cm to 55 cm from the concrete to the top of the floor is recommended.

e) An alternative design is one with a cable spreading and distribution room below the control room, used as auxiliary room, which provides a place for installation of auxiliary equipment, as well.

f) The floor shall be designed in away to hold the full weight of control panels and other control room equipments plus certain safety factor addition.

6.2.6 Painting

a) The interior and exterior painting shall follow the industrial standards in force. (Refer to IPS-M-TP-125 "White Alkyd Paint for Topcoat").

b) A smooth color gradation from the floor to ceiling and color continuity throughout the building shall be considered.

6.2.7 Cable entry

a) The initial installation shall have a generous allowance for additional future requirements.

b) Ducts, conduits cable trenches, or entry plates shall be sealed in accordance with applicable electrical codes to prevent the entrance of vapors.

6.3 Internal Environment

6.3.1 Air conditioning

a) Air conditioning equipment shall be selected and sized to maintain the conditions that are conductive to human comfort and required to protect the instrumentation located in control centers.

b) The extent of air conditioning sizing other than for human comfort shall be governed by the type of equipment housed within the control center and the ambient conditions outside the control center. Under all conditions, the temperature shall be maintained at 22°C ±2°C; the humidity shall be between 50 and 60% RH and the rate of change in temperature shall not exceed 0.25°C/ minute.

c) Consideration shall be given to potential problems caused by air conditioning failure.

d) Either local fans or redundant air conditioning systems shall be considered to prevent serious overheating of electronic equipment.

6.3.2 Air purification

In addition to providing for human comfort, air purification shall be considered to protect the instrumentation in the control center against corrosion, abrasion, extraneous electrical leakage conducting paths, and potentially hazardous fire or explosive conditions.

6.3.3 Positive air pressure system

a) When control centers are located in hazardous areas and contain general purpose electrical equipment or other potential ignition sources, they shall be designed to prevent the entry of flammable atmospheric vapors or gases in order to achieve a general purpose classification.

b) The preventation of the entry of flammable atmospheric vapors or gases shall be accomplished with a positive pressure ventilation system using a clean air source in conjunction with effective safeguards against ventilation failure.

c) The system shall be capable of maintaining a pressure of at least 5 mm W.C. in the control center with all opening closed.

d) In case of external fire or spill of hazardous material the air conditioning system shall be placed on total recirculation with no intake of air.

6.3.4 Fresh air intake

The source of air for positive air pressure systems in control centers shall be free of hazardous concentrations of flammable vapors, gases, corrosive contaminants, and any other foreign matter, by taking the inlet air from non-classified location and air filteration.

6.3.5 Noise

a) Noise within the control center, especially within the control room; shall be limited to reduce the possibility of hearing damage and physical discomfort and enable effective speech communication either direct or by telephone radio, intercom, and so forth.

b) Sound absorption materials shall be considered to reduce the noise level to a maximum of 50 decibels absolute with the room unoccupied. For more information refer to: IPS-E-SF-900 "Noise and Vibration Control".

6.4 Hazardous Vapor and Fire Detection System Requirements

a) Hazardous-vapor detection systems shall be installed in control centers which have unclassified interiors due to pressurization. These would be essentially hydrocarbon detectors but other devices such as fire or smoke and toxic material detectors may also be installed.

b) A sufficient number of portable CO_2 fire extinguishers of suitable size shall be provided in the control room as well as the auxiliary rooms.

6.5 Electrical Grounding

a) Reliable ground systems shall be provided to electrically ground panel boards, computers, temperature consoles, and related control equipment.

b) For more details refer to IPS-E-IN-190 "Transmission System Standard".

7. CONTROL PANELS

7.1 General

The purpose of any control panel is to aid the unit operating personnel in maintaining efficient and safe performance of the unit from a central location. Therefore, the instruments generally found on the control panel include remote recorders or controllers, or both, as well as those indicators which are important for the control of the unit.

7.1.1 Panel shapes

The type of panel selected is dependent on a number of factors such as space available, need for graphic displays, number of instruments per operator, and so forth. As each user has different concerns in panel design, the following typical designs are presented for consideration.

a) The most widely accepted panel is flat-faced (except for a toe recess) and extends from floor to ceiling as shown in (Fig. 1, Item A). In some cases it is preferable from an aesthetic viewpoint, or for reasons of improved air circulation to maintain a space between the top of the panel and the ceiling. Panels with slightly inclined faces (Fig. 1, Item B) are sometimes used to improve the readability of instruments, especially those at the lowest point, or to improve visibility of alarms or graphic sections at the top of the panel.

Walk-in panels (Fig. 1, Item C) can sometimes eliminate the need to provide a separate control room. They can also be completely shop-fabricated and tested to reduce installation and check-out time.

Sloping front panels (Fig. 1, Item D) offer somewhat more mounting space than upright panels but the section facing upwards is usually reserved for devices that require frequent or easy manipulation and do not have to be observed from afar.

Cabinet type panels (Fig. 1, Item E) usually contain shop-fabricated rack mounted equipment which may be located in a terminal room or behind the main control panel. They are not generally used for equipment that provides indication for the normal operation of the process.

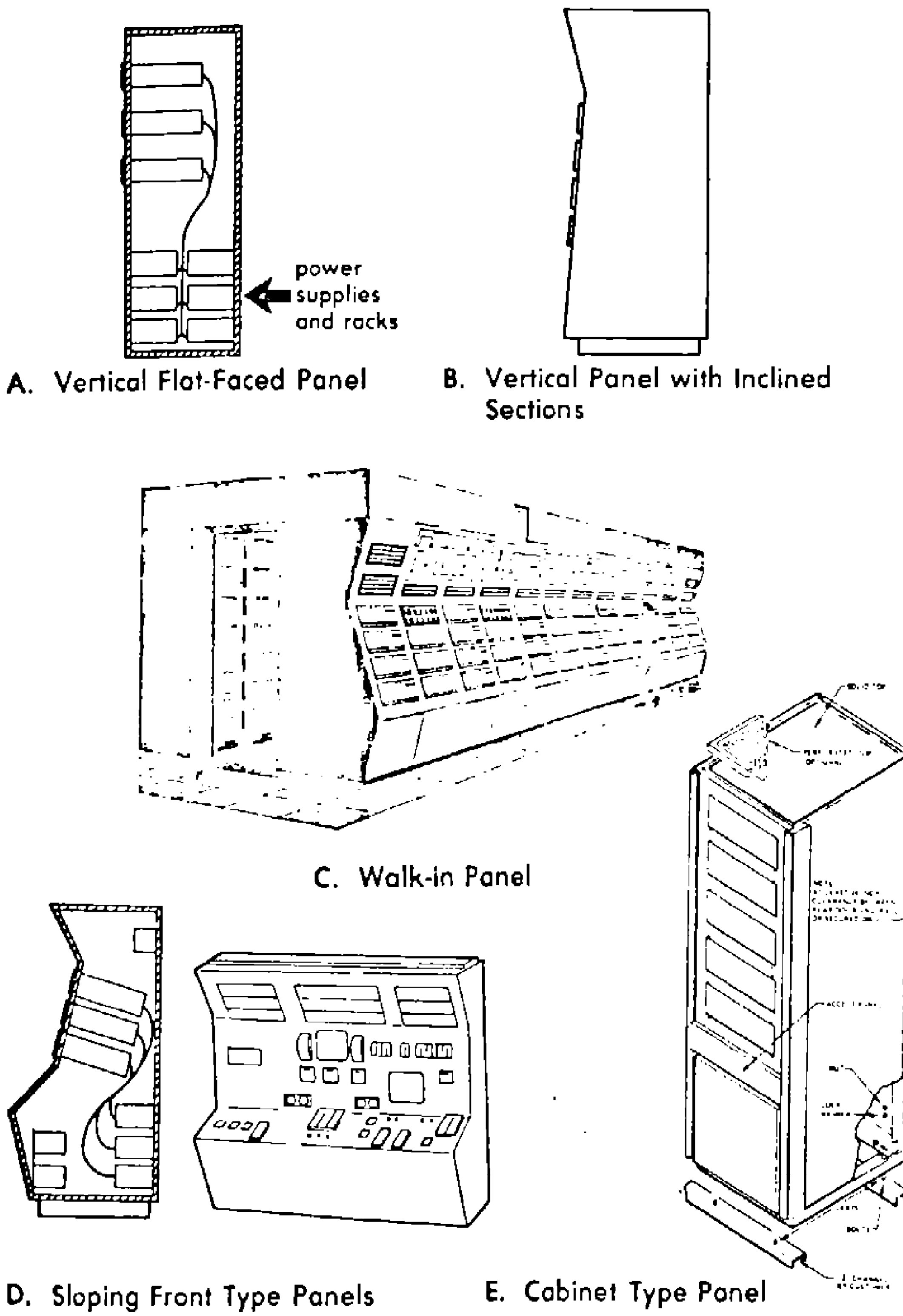
b) Consoles are free standing units with a closed top and back. Heights vary, with many being lower than eye level of a man standing. Typical consoles are shown in Fig. 2.

c) Console desks not only provide an operator display but also a writing work area. The display is usually confined to one type of process variable such as temperature indications.

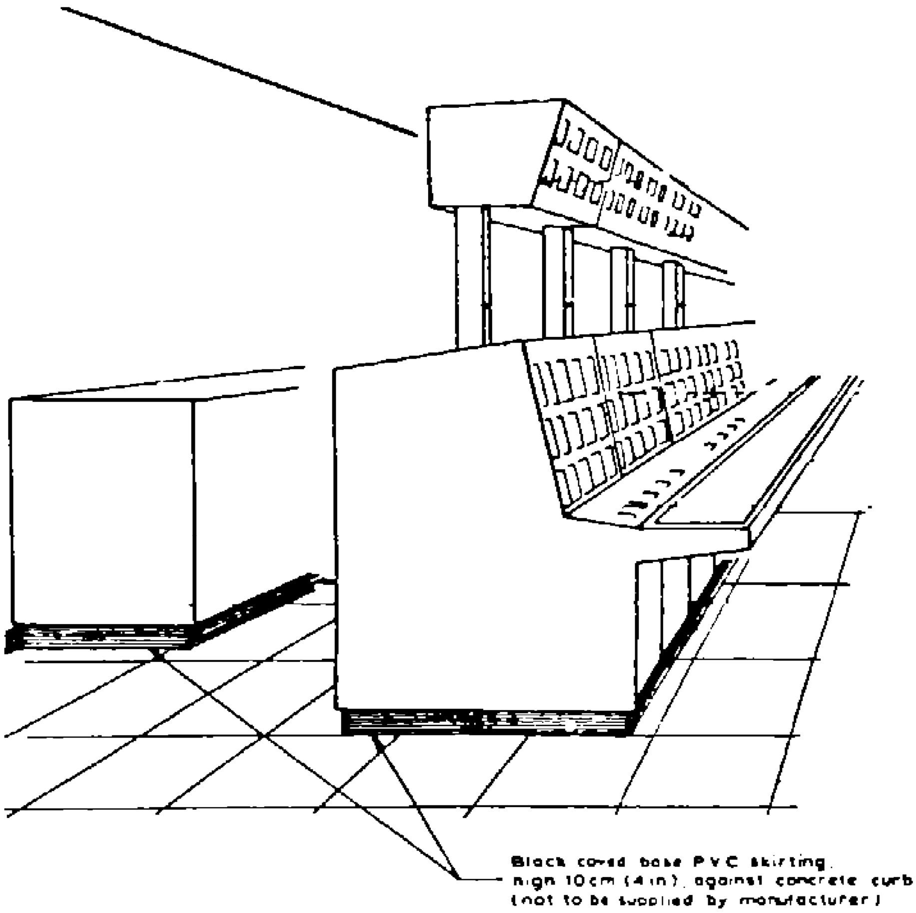
d) Bench boards are almost unique to the power industry. They are used to give operator access to large arrays of manual switches and lights with only minor instrumentation.

7.1.2 Panel clearance

a) Clearance between the back of the panel and the control room wall shall be a minimum of 1500 mm.



TYPICAL PANEL SHAPES
Fig. 1



TYPICAL CONSOLE
Fig. 2

b) When auxiliary equipment is mounted on the wall or special equipment (such as analyzer programmers or terminal racks) are located along the wall, the distance from panel to wall shall be increased to maintain a 1500 mm clearance.

7.1.3 Instrument arrangements

a) Layout

All controllers and significant recorders shall be located in the most convenient and accessible location. An attempt shall be made to have the panel layout follow the actual process flow scheme or material flow pattern as closely as possible. A system which will enable an operator to quickly identify any particular instrument is desirable and shall be considered in the panel layout. Nameplates, color codes, or symbols shall be used. Spare panel space, about 20 percent, shall be provided in the panel layout for future modification and expansion. See Fig. 3.

b) Mounting Heights

Normally, a limitation is placed on the maximum and minimum heights for mounting instruments on the panel. These heights shall be based on visibility and accessibility.

c) Density

The density of instruments varies with the type of panel, type of instruments, complexity of the process, and preference of the user. Average panel density for the various types of panels based on recording and controlling instruments per running meter is tabulated in Table 1.

TABLE 1 - PANEL INSTRUMENT DENSITY

NUMBER OF INSTRUMENTS PER LINEAR METER OF PANEL			
Type of Panel	Large-Case Instruments (larger than 144 × 144 mm	Miniature Instruments (Nominal 144 × 144 mm Larger than 72 × 144 mm)	Subminiature Instruments (72 × 144 mm and smaller)
Conventional	3-6	9-15	45-90
Graphic	—	5-7	8-12
Semigraphic	—	9-15	30-90
Console	—	9-15	30-60

7.2 Conventional Panels (Non-Process Displays)

A conventional panel is defined as a panel with subminiature, miniature, or large-case instruments, or any combination thereof, mounted in horizontal and vertical rows. Large-case instruments are usually mounted in two rows. Smaller instruments (miniature and subminiature) are usually mounted three or four rows high.

The distance between these rows of instruments depends upon the type of instrument and accessibility for maintenance and adjustment. Such items as individual alarm lights and miscellaneous indicators normally are mounted near the top of the panel. Alarm cabinets for annunciator systems sometimes are considered large case instruments and are mounted accordingly. In other arrangements they are mounted above the top row of instruments. Refer to Fig. 3 for arrangement design of the panel.

7.3 Graphic Panel (Fixed Displays)

A graphic panel include a simplified flow plan of the unit as a visual aid to the unit operators. The layout of the flow plan shall present as much information as possible but with a minimum amount of label or nameplate reading. Locally mounted indicators, recorders, and controllers generally shall be omitted from the graphic presentation.

7.3.1 Full graphic panel

A full graphic panel is defined as a panel with miniature instruments, switches, lights, and so forth mounted in a simplified flow plan of the unit depicted on the face of the panel.

Panels shall be limited to special processes where large numbers of status lights and switches in the symbols are an aid to understanding the system. Examples are blending systems, solids handling, bins and conveyor systems. End or wing panels shall be added for large-case and specialized instruments.

Because of low instrument density (high panel cost) and the difficulty of making changes, full graphic panels are seldom used now for process units.

7.3.2 Semigraphic panel

The semigraphic panel combines the compactness of a conventional panel (using miniature instruments) with the flow plan feature of the graphic panel. Such a panel has a simplified flow plan of the unit located above grouped instruments.

The flow plan may be:

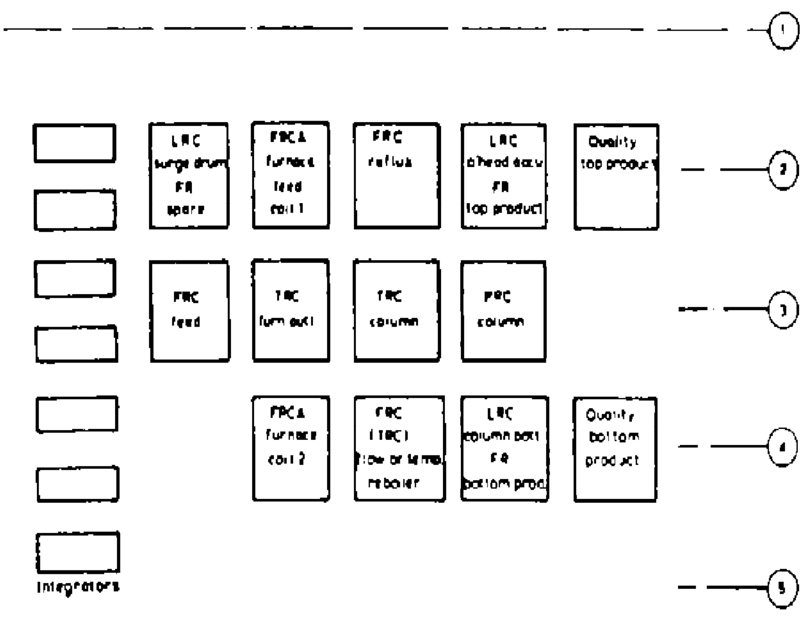
a) painted or laminated on the panel face,
b) done on a separate removable part of the panel face, or
c) done on a drawing or print mounted under glass or clear plastic.

Another type is a semigraphic flow plan drawing made on a translucent film and mounted on a light box. The various alarm or signal lights are mounted in the light box so that they can shine through the film at the appropriate location in the flow plan.

7.4 Other Information Displays

7.4.1 CRT display

When there is a computer installed in the control center, process information (such as flow diagrams, measured variables, alarms, limits, and operator instructions) may be displayed on a cathode ray tube (CRT). This type of display has the advantage that the information can be consolidated or concentrated in one location so that the operator does not have to move about.



RULES FOR INSTRUMENT PANEL LAY-OUTS
Fig. 3

Row 1 Alarm lights, round indicators etc.
Row 2 e.g. FRC feed, reflux, instrument top products. (In general the "top"-instruments.)
Row 3 Most important instruments: e.g. temperature and pressure of columns, temperature furnace outlet.
Row 4 Levels of column bottoms. Flow records of bottom products. (In general the "bottom"-instruments.)
Row 5 In general secondary or auxiliary instruments e.g. sub-panels for manual control, push-buttons etc.

Notes:

1) The lay-out of instruments of a unit on the panel be process-wise from left to right.

In case of integrated units the lay-out of the units shall follow the process-line, provided the panel lay-out is not conflicting with the physical location of the individual process units in the plot.

2) Lay-out to be such that all important control valves can be manually controlled from the panel with an indication or a record of the controlled variable.

3) Second recording pens generally to be used for records, which have an operational relation, with the main instrument (first recording pen).

4) Integrators shall be grouped together in logical sequence and unit wise so that photographs can be taken of the entire group. The group shall include a clock.

5) Sub-panels for cascade or ratio control to be mounted below the relevant instrument.

7.5 Fabrication

7.5.1 Control room panels

a) Control room panels shall be free standing in the form of a box or console, which is made of structural shapes welded together with a panel front bolted or welded to the frame. Bolting shall be used for easier replacement.

b) Bolting shall be from the rear to provide a smooth front appearance. Openings in the panel front for instrument mounting shall be cut before mounting on the panel frame. Spare cutouts with cover plates shall be provided for additional future instruments. Removable lifting lugs on the four corners of each panel section shall be provided for field handling.

c) If doors are required at the rear of the panel, they shall be louvered for ventilation. Removable doors or doors of a sliding or folding type shall be considered so that open doors will not obstruct passage behind the panel.

d) Check heat loads and provide louvered enclosures and cooling fans, if required, for all internal panel enclosures such as relay boxes. Heat producing items shall be mounted in the higher portions of the panel to allow the heat to vent out of the enclosure without coming in contact with other equipment in the panels.

e) The open ends of panels, where no adjacent panel sections are installed, can be covered with steel plate or other material. These end enclosures shall be removable for future expansion of the panel. When panel configurations contain an enclosed working area, alternate exits from the rear of the panels shall be provided.

f) Cables, conduit, pneumatic tubing, or piping entering or leaving the panel shall be provided for in the top, rear, or bottom of the panel supporting structure.

g) The overall size and weights of control panel sections shall be based on the following:

1) Dimensional and weight limits for aircraft shipment.
2) Sea shipment container sizes.
3) Enclosed van and van door sizes.
4) Dimensional requirements for export packing.
5) Control center access doors and handling facilities.

7.5.2 Field panels

Field-mounted panels shall be of steel construction although other materials may be used. They shall be designed to provide adequate instrument display and to protect instruments from the weather. They may be located in areas where atmospheric corrosion is severe. Field panels may be enclosed in the rear with walk-in access for rear-of-panel service or they may have rear access doors for service. Doors shall be gasketed and furnished with latches. Air purging may be required for environmental reasons as well as for electrical safety.

The panel shall be provided with a steel top and canopy with lighting installed beneath the extended canopy. Framework shall be made of structural shapes with lifting lugs for field handling. Provisions for instrument heat dissipation shall be made.

7.5.3 Panel front materials

a) Panel fronts shall be fabricated from steel plates.

b) The thickness of panel front shall be normally 4 mm. The rear of this front shall be reinforced with stiffeners to maintain a flat surface and prevent buckling after the instruments are installed. One sheet of steel with milled vertical edges shall be used to cover the entire front of the panel section to form butt joints with adjacent panel sections. Alternatively, plates with rolled edges may be used.

c) Steel plate for panels shall be selected for levelness and smoothness. The finished product shall have flat faces and be free from warping and distortion. All corners and folds shall present straight lines.

7.5.4 Panel framework

a) The framework shall be made of steel structural shapes. It support all equipment, piping, and wiring duct mounted on the rear of the panel. Design of framing shall not unduly restrict access for maintenance.

b) The framing shall be designed to prevent buckling or distortion of the panel during shipment, handling, and erection. Supports shall be provided to limit stress on panel-mounted instruments if they do not have shelves or mounting supports.

7.5.5 Panel base

a) Panels may be placed directly on the floor of the control center or mounted on some type of base. The base may be a 80 to 150 mm concrete curb. Another commonly used mounting base can be made by bolting or welding channels (front and rear), running the full length of the panel section, to the panel framing.

b) The front channel may be positioned to provide 50 to 80 mm deep toe clearance beneath the panel front. The channels can be fastened to the control room floor. In many cases, fastening large free standing panels to the floor is not necessary. However, bolting between sections is desirable. Although not frequently required, vibration mounts should be considered, particularly for local panels.

7.5.6 Auxiliary racks

a) Auxiliary control and measurement loop electronic and pneumatic devices (such as pressure switches, signal transducers, integrators, power supplies, and other items) shall be mounted in racks when the density of these components behind the panel would restrict service access. In some instrument control systems, racks may be used as a matter of course to house control system components. Racks shall be free standing, steel framed. Environmental conditions may require that they be enclosed and provided with doors.

b) Racks may also be used as termination points for electronic signal wiring to and from field components.

c) Wiring between the rack and panel-mounted components shall be shop installed and checked. One end of interconnecting cables can be disconnected and coiled for shipment to minimize field wiring and checking.

7.5.7 Integrated panel assemblies

The display portion of the panels and the auxiliary equipment racks may be combined into integrated panel assemblies often called walk-in panels (see Fig. 1, Item C). These shall be completely assembled, wired, piped, and checked out at the panel fabricators shop. After shipment to the job site only field wiring and tubing connections are required. These assemblies take more shop time and are much bulkier than separate pieces to transport and install in the control center; but they can save a considerable amount of field installation and check-out costs.

7.6 Painting

Color selection, finish, surface preparation, and paint specification shall be based on plant experience with paint finishes and esthetic considerations. The necessary preparations noted for the following panel parts shall be considered as required.

7.6.1 Panel front

Steel plate panel surfaces shall be cleaned, primed, and finish painted. Paints which provide a quality, corrosion-resistant surface shall be used.

Finish paint shall be semigloss or textured. Paint for panel repairs shall be provided for panel touch-up.

7.6.2 Back of panel

The backs of panels and interior surfaces of a console or cubicle normally shall be painted white to minimize light absorption. Subassembly framing or enclosures generally shall be painted before mounting within the panel structure. The back-of-panel and structural members require cleaning, a primer coat, and a finish coat.

7.6.3 Field panels

Special consideration shall be given to environmental and local conditions in the selection of finish for outdoor mounted panels. Surface painting or coatings which are resistant to local environmental corrosion are necessary.

7.7 Electrical Installation

a) Refer to IPS-C-IN-190 "Transmission System Standard" for detailed information concerning electrical installation. Electrical installation shall be in accordance with the latest edition of the National Electrical Code, and relevant IPS electrical standards. The area classification and instrument components will determine the minimum enclosure size, conduit, and sealing requirements.

b) For ease of maintenance and checking, it is desirable to terminate incoming and outgoing field leads in auxiliary racks and to mount in the racks such items as power supplies, current alarm relays, annunciator components, loop protection auxiliary devices for analyzers, and resistors for computer inputs.

c) All incoming and outgoing electrical leads shall be terminated on suitably enclosed terminal strips except for low-level signals which shall run directly to instruments. AC wiring shall terminate in cabinet separate from DC wiring. Special consideration shall be given to the requirements of intrinsically safe installations.

d) AC power wiring shall be run in separate conduit or duct from DC signal and power wiring. The conduits, trays, or ducts shall be separated as far as practical to avoid signal distortion.

7.7.1 Electrical supply

a) AC power supply to panelsin shall be 110-Volt, 50 Hz, 3-wire, grounded, gle-phase.

b) DC power supply required for loop power to electronic instruments may be furnished from externally mounted common power sources, back- of-panel mounted instrument power units, or power supplies built into the receiving instruments.

c) Refer to IPS-E-IN-180 & IPS-E-IN-190 "Power Supply and Transmission Systems Standards".

7.7.2 Wiring

a) AC Power

(AC) wiring shall be 2.5 mm² stranded with a standard color code and 600-volt insulation. The following color code shall be adhered:

AC supply hot	brown
AC supply neutral	light blue
Ground	green/yellow
Alarm system	yellow
Control and shutdown system	red

Each device requiring AC power shall be wired so that when wires are removed from any one device (1) power will not be disrupted to any other device and (2) ground will not be broken from any other device.

10 to 20 percent spare space shall be provided for power wiring.

It is recommended that a 110-Volt AC service or convenience outlet independent of instrument power supplies be provided for each panel section to allow plugging in portable tools or test instruments.

Each wire end shall be tagged for identification by means of a printed slip-on sleeve, self-stick label, or similar means.

b) DC Power and Signal

DC power wiring shall be 2.5 mm² stranded, although larger wire size will likely be required for supply (+) and return (-) buses. Current densities must be checked to determine required wire size.

DC signal wire shall be 1.5 mm² stranded.

Thermocouple extension wire shall be 1.5 mm² (multi-conductor cables shall be 0.5 mm² and color coded as per IPS Standard with wire types). (Usually, thermocouple wiring shall be run directly to the receiving instruments from the field thermocouples).

Each wire end for power, signal and thermocouple wiring shall be tagged for identification by means of a printed slip-on sleeve, self-stick label,or similar means.

c) Interwiring

Terminal strips shall be provided at all shipping section joints for interpanel section wiring. Terminals shall be on both sides of the joints with short interconnecting jumper leads provided between the terminals. Terminals shall be enclosed in boxes and wires pulled back in panel boxes for shipment.

7.7.3 Disconnect switches

Disconnect switches on the AC power supply to each temperature indicating instrument and each annunciator can be single pole for the usual one-side-grounded supply system. It is common practice to have one disconnect switch serve as many as six instruments when only chart-drive power is involved. For cabinet type annunciators with multiple-alarm units, on power disconnect switch is usually used for each cabinet. Each disconnect switch shall be clearly labeled to identify the particular instruments or alarm unit served by that switch. Each 110-Volt. AC-powered electronic instrument shall be provided with a separate power disconnect. A standard 3-pin grounding or twist-lock plug may be used instead of a switch. Power is often distributed to such plugs through a plugmold/wiremold channel.

7.7.4 Terminal blocks

a) Terminal blocks shall be provided on panels and subassemblies for power-supply wiring, alarm-system wiring, and electrical transmission lines. Normally, no terminal blocks are permitted for thermocouple extension wires, nor for some types of analyzers (pH and so forth). It is preferred that these be run directly to the receiving instrument. The terminal blocks shall be clearly identified with permanently marked terminal numbers and terminal block number.

b) 25 percent spare terminals shall be considered. Good practice indicates the use of doors on terminal strip enclosures. As a minimum, covers shall be provided for terminals.

7.7.5 Panelboard grounding

a) The panel shall be grounded through attachment to a ground bus which is attached to the panel. The principle reason for the bus is to ground the instrument circuits, but it will also ground the panel if the two are properly connected. On some installations the instrument ground system must be isolated from other system grounds. This requires the instrument ground bus to be electrically isolated from the panel, its ground, AC power supply grounds, and incoming conduit or trays.

b) Separate ground buses for AC and DC circuits offer a reasonable safeguard against feedback through the ground system from one instrument to another. Such buses shall be typically copper, 6 mm thick and 25 to 40 mm wide. Each panel section shall have its own buses, with the center of the buses connected to a ground point which is common to all panel section grounds and from which an adequately sized conductor leads to the earth ground.

c) Reference to be made to transmission systems, standard for a detailed discussion of panel grounding requirements (IPS-C-IN-190).

7.8 Piping

7.8.1 Supply header

a) Practice regarding instrument air supply to panels varies. On small panels with few instruments, it is preferable to use a separate pressure reducing filter-regulator for each instrument. The more commonly used system consists of a single air header supplied from two parallel filters and regulators, each capable of supplying 100 percent of the panel requirements. Each filter and regulator combination shall be provided with inlet and outlet block valves. The reduced air pressure header shall be 1½" in diameter, or larger as required. If pressure drop considerations require more than a 2" diameter header for extremely long panels, a duplicate dual reducing station arrangement shall be furnished at each end of the header.

b) Individual take-offs, ¼" size for each user are brazed, or if the header wall has sufficient thickness, threaded into the top of the header. Each take-off shall be valved and provided with nameplate to show service. Ten percent spare valved and plugged take-offs shall be provided for future use. Where more than one panel section is required to make-up the panel length, unions shall be provided on the header between panel sections for interconnection in the field. A valved drain connection (bottom of header) is desirable at the end of the header remote from the reducing stations. A header pressure gage is also required so the regulators can be adjusted, along with a pressure switch to alarm a low header pressure and a relief valve to protect against overpressure.

c) Consideration shall be given to prefabricated copper or aluminum sections which can be purchased in sizes from 1" to 3" with ¼-inch NPT taps and standard lengths of 1200 mm (special 2400 mm). These can be assembled with copper water-tube fittings for complete header make-up.

7.8.2 Interconnecting tubing

Interconnecting tubing on the panel can be copper, aluminum, or plastic with tubing fittings of brass, aluminum, or nylon. Copper tubing, when used, shall be ¼" OD with 1 mm wall thickness, soft annealed. Aluminum tubing shall be ¼" OD, 1 mm wall thickness, seamless annealed aluminum alloy, ASTM B 210 Gr 1060 Temper 0. The tubing shall be supported by clamping to panel structure and shall be arranged for access to instrument components. Plastic tubing should preferably be color coded. It shall be run in plastic ducts with covers.

7.8.3 Bulkhead connections

Control and transmission lines and interconnecting lines between panels and field shall be brought to bulkhead fittings.

The simplest form of bulkhead consists of a steel plate with bulkhead fittings to join the tubing from the field to the tubing from the panel instruments. In a normal prefabricated panel, the connections from or to the field instruments are the only ones required to be made during installation of the panel. Each bulkhead connection shall be clearly labeled with the designation of the particular instrument and connection it serves. A take-off connection in the piping from the bulkhead connection to the panel instruments shall b e considered for testing or for future connection to a logging system or to other instruments. 10 percent to 20 percent spare bulkhead connections shall be considered for the future addition of instruments.