INSTALLATION AND CONSTRUCTION STANDARD

FOR

TRANSMISSION SYSTEMS

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PAGE No.

FIGURES :

1. SCOPE

This Standard explains the general rules and basic instructions for the installation of pneumatic lines, electrical signal wires and cables. It is intended to be used in oil, gas and petrochemical industries.

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	"Installation of Refinery Instruments and Control Systems" Part I : "Process Instrumentation and Control" Sections 3, 7 and 10

ANSI/NFPA (AMERICAN NATIONAL STANDARD INSTITUTE/NATIONAL FIRE PROTECTION ASSOCIATION)

70	"National Electrical Code" (NEC), Article 500

IPS (IRANIAN PETROLEUM STANDARDS)

E-GN-100	"Units"
E-IN-190	"Engineering Standard for Transmission Systems"
M-IN-190	"Material Standard for Transmission Systems"
M-IN-100/3	"General - Field Inspection and Testing of Instruments"

3. UNITS

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

4. GENERAL

4.1 This Standard covers the requirements for signal lines for process instrumentation.

4.2 In the context of this Standard, signal lines convey:

a) Pneumatic signals from pneumatic transmitters to their receiving instruments, and from pneumatic controllers to the relevant final control element;

b) Electric signals, analogue or digital (including RTDS and e.m.f.s from thermocouples) from transmitters to their receiving instruments and from controllers, safeguarding systems etc. to solenoid valves, motor starters and other final control elements.

4.3 As detailed further in the following paragraphs, most of the signal lines may be laid together in common trenches or trunking for instrument signal lines, with a general exception for cables carrying signals which could cause interference on other signal lines.

4.4 Each plant-mounted instrument shall have individual signal lines, which shall be connected as soon as feasible to a multicore cable.

All multicore cables shall be installed in uninterrupted lengths unless the distance to be covered is more than can be reasonably supplied on one reel. Terminal boxes for connecting individual signal lines to multicore cables shall be easily accessible.

4.5 At the moment of plant commissioning, approximately 20% of the signal lines in the installed multicore cables shall still be available as spares for modifications, unless otherwise specified.

4.6 Above ground, multicore cables and most of the individual lines shall be laid on trays or in trunking.

4.7 To reduce risks of damage to the signal lines they shall be laid underground wherever possible in trenches which shall penetrate as far as possible into the processing units.

5. INSTALLATION OF TRANSMISSION AND CONTROL TUBING

a) The installation drawings will indicate the extent and arrangement of the major transmission and control tubing runs between the control panels and the field junction points.

b) Transmission and control tubing between the control panels and field junction points will generally be of the "bundled" type, run in trenches or trays (trenches are preferable).

c) Tubing in the tray shall be arranged in an orderly manner and firmly secured to the tray by means of commercially available clips or field fabricated clamps. Care shall be taken, when clamping in place, that tightening of the clamp does not result in damage to the tubing.

d) Where tubing requires bending, care shall be taken to assure that a reasonable bending radius is maintained and tubing is not flattened nor pinched.

e) Cutting of tubing shall be done with a commercial tubing cutter. Ends shall be cut 90° to the wall of the tubing and shall be reamed to the original inside diameter of the tube. All "chips" or shavings shall be removed.

f) Where bundled tubing is terminated at control panels or field junction points the bundle end shall be securely clamped to existing members such that no strain is imposed on the tubing fittings.

g) Tubing fittings for transmission and control tubing shall be as specified on the contract documents. Fitting sealing shall be made by utilizing Teflon tapes.

h) Prior to tightening the tubing collar to the fitting, care shall be taken to assure that the tubing end is square, inserted fully through the ferrule into the tube fitting and is properly aligned with the fitting. Tightening of the collar shall be done with the proper sized wrench.

i) Tubing continuations from the field junction points to the field instrument will usually be single tube type. Interconnection with bundled tubing to be through tubing bulkhead or junction box.

j) Where possible single tubes shall be grouped and run together in small carrier channels. Coiled tubing shall be fully straightened before installation.

k) Routing of single tubes or groups of single tubes shall be determined in the field. Care shall be taken in planning the installation that tubes are grouped in an orderly manner and their carrier channels are routed as directly as possible to the instruments.

l) Tubing bends shall be made with an approved tubing bender and terminations shall be made as discussed under bundled tubing installations above.

m) Carrier channels shall be rigidly mounted to permanent structural members and shall not be bracketed to equipment which may be removed for maintenance purposes.

n) Tubing shall be securely clamped to the carrier assuring that the tube is not pinched or damaged when clamped in place.

o) Where cutting of the carrier channel is required, raw edges shall be painted or coated with a material equal to the original finish.

p) The service of the tubes shall be so arranged that in the processing area the length of individual tubing is as short as possible.

q) In the trunking, when it is desired to be used instead of trays, the individual tubes shall be connected to the multicore cables by means of straight couplings. These individual tubes shall continue in the trunking as far as possible, pass through trunk wall, and reach the instrument by being clamped to the instrument air supply piping, refer Figs. 2, 3 & 4 on pages 22, 23 and 24. For this purpose the instrument air supply piping system shall be installed underneath the trunking.

r) Where tubing has to be connected to equipment without air supply (e.g. control valves not having a booster or positioner) the tubing shall be clamped around 15 mm (half-inch) dummy piping which is firmly attached to process piping, or stand pipe.

s) Pneumatic tubing shall never be clamped to process piping.

6. ELECTRIC SIGNAL WIRING AND CABLES

6.1 General

a) Extreme care is to be used in the handling of electronic instruments to assure that dirt and oils from the hands do not come in contact with the various resistors, terminals and other components.

b) Cables on reels and wire in coils shall be protected from damage by construction activities.

c) Conductors shall be carefully handled during installation to avoid damage of any kind. They shall be unreeled or uncoiled slowly in order to prevent damage to the insulation or sheath due to sudden bending. Repeated bending shall be avoided., sharp kinks shall be avoided in unreeling, uncoiling and pulling.

d) Every possible precaution shall be taken to ensure that the measurement signals are not subjected to electrical interference. (refer to Table No. 2 on page 18).

This is of special importance when digital indicators, data loggers and/or computers are applied.

e) The above point requirements are based on the use of cables with signal wires twisted in pairs or quadruples (quads) with full screening.

f) Special signal cables such as coaxial cables for pH electrodes shall be installed in accordance with the manufacturer's instructions.

g) All electric signal lines shall be installed and terminated as indicated on the drawings.

h) All external services between cables and cable glands in the plant shall be sealed with proper sealing compound.

i) At low temperature most plastics are so brittle that they may crack when bending the cable, and therefore no cables shall be installed during freezing weather.

j) Mineral insulated, copper covered, PVC sheathed wires shall be used wherever practical. Whenever MICC cables are used sufficient spare lengths of cable shall be provided at the gland termination points to allow rejoining when required.

k) All thermocouple wires in conduits and multicore cables run to control rooms shall terminate in appropriate junction boxes with leads carried in wireways to the panel.

l) Water tight junction boxes shall be used for outdoor services. Gasketed sheet metal junction boxes shall be used inside control rooms.

m) When conduits are sealed at both ends, appropriate vents shall be provided between the seals.

n) Where electrical or electronic instruments are used, these shall be of a type which can be serviced, without violating the area safety requirements of an operating unit.

The intrinsically safe instruments with integral barrier circuits shall be considered for field instruments, the housing conduit and fittings for such instruments is not required to meet the flame proof or explosion proof specifications.

o) The ends of the cable should be properly sealed before pulling-in to prevent moisture and other damaging substances from entering.

6.2 Cable Specifications

6.2.1 Armoured cable shall be specified for (refer Table No. 2 on page 18):

a) All non-intrinsically safe circuits in Division I areas.
b) Cables to be connected to flame-proof instrument housing in Division 1 or 2 areas.
c) Cables with lead-sheathing.
d) Cables above ground when liable to mechanical damage.
e) Cables buried in roads, tank farms, etc., if there is danger of mechanical damage due to excavation work.

6.2.2 Unarmoured cable shall be specified for all applications where armoured cable is not required.

6.2.3 Lead sheathing shall be specified for underground cables when considerable soil contamination by liquids aggressive to the cable insulants is anticipated.

6.2.4 All low voltage signal cables shall have tape-screening with drain wire.

6.2.5 The signal wires shall be twisted in pairs or quads. With a minimum of 20 twists per meter.

6.2.6 For cables used with resistance thermometer elements, the cable-resistance shall be compatible with instructions from the manufacturer of the resistance-elements and/or the instrument.

6.2.7 The maximum permissible current rating and allowable voltage drop shall be observed for control cables.

Note:

Cables having conductors of 0.8 mm diameter (cross section area approx. 0.5 mm^2) have a maximum current rating of 1 ampere per core. The fuse rating for these cables shall not exceed 4 amperes.

6.2.8 In an intrinsically safe circuit, the total capacitance of the cables and either:

a) The total inductance of the cables, or

b) The L/R ratio of any of the cables shall not exceed the value stated on the certificate of intrinsic safety, or in the case of no value being stated as in following para.

6.2.9 The following values are typical for 28 volt barriers, but may only be used in preliminary work, or as in foregoing para.

NEC 70 ARTICLE 500 GROUP	REPRESENTIVE GAS	Max. PERMISSIBLE CABLE CAPACITANCE MICROFARADS	Max. PERMISSIBLE CABLE INDUCTANCE MILLIHENRIES	Max. PERMISSIBLE L/R RATIO OF CABLE
D	PROPANE	5.0	3.1	1000
C	ETHYLENE	1.9	1.2	380
B	HYDROGEN	0.4	0.25	80

$$*\text{L/R ratio} = \frac{\text{Include per unit length (microhenries)}}{\text{Resistance per unit length (ohm)}}$$

6.2.10 When specifying the size of signal transmission cable the maximum loop impedance in to which the transmitter is specified to operate shall be taken in to consideration.

6.2.11 When an intrinsically safe circuit is protected by barriers the circuit connected to terminals 3 and 4 (external circuit connected to the barrier) shall be adequately insulated from earth in the danger area.

6.2.12 Cables for intrinsically safe circuits shall have a blue outer sheath exclusively.

6.3 Sharing of Multicore Cables

6.3.1 All Electric signals for measurement and control shall be grouped in 7 classes as shown in Table 1.

6.3.2 The examples given for each class are typical, but not exhaustive. For each signal in a project, the classification shall be carefully considered, based on best similarity with the examples given.

6.3.3 It is preferred to use separate multicore cable(s) for each signal class.

6.3.4 Where, however, for the smaller projects this would result in a large number of separate cables, sharing of multicore cables for different signal classes in one multicore cable (within the limitations shown in Table 1) is allowed.

6.3.5 For each combination, a further segregation is required between cables connected to equipment with a certificate of intrinsic safety and cables for equipment without this feature.

6.3.6 Intrinsically safe wiring shall be separated from non-intrinsically safe wiring by one of the following methods:

a) Use of separate conduits, cable trays, or ladders.

b) Compartmenting of cable trays of ladders by the use of an insulating or grounded metal partition.

c) Use of separate armored cables, for the non-intrinsically safe and intrinsically wiring.

6.3.7 Multicore cables containing intrinsically safe circuits shall not contain any non-intrinsically safe circuits.

6.3.8 More than one intrinsically safe circuit may be run in the same multicore cable provided that at least 0.010 in (0.25 mm) thickness insulation is used on each conductor.

TABLE 1 - SHARING OF INSTRUMENT SIGNAL CABLES

SIGNAL CLASS	SIGNALS	ALLOWABLE SHARING OF CABLES	
		LENGTH BELOW 250 m	LENGTH 250 m AND MORE
1	Analogue low level (≈mV) e.g. thermocouples, radiation pyrometers, I.B.P., F.B.P., F.P. analyzers		
2	Analogue medium level (≈1V) e.g. resistance thermometer elements, strain gages, oxygen analysers, gas chromatographs		
3	Analogue high level (≈10V,≈mA) e.g. electronic instrumentation loops		
4	Digital low level (pulse train) e.g. turbine meters, P.D. meters		
5	Digital high level (pulse train) e.g. tank-gauging systems		
6	On-Off low level (below 42 V.DC, 60 V AC) e.g. alarm-systems, interposing relays not exceeding 20 W rating		
7	On-Off high level (and digital) (above 42 V. DC, 60 V. AC, not exceeding 40 W rating) e.g. initiating circuits for process-control and emergency systems, solenoid valves, control circuitry for typewriters		

Note:

I.B.P. = Initial boiling point analyzer.
F.B.P. = Final boiling point analyzer.
F.P. = Flash point analyzer.
≈ = Denotes: in the ranges

Remarks:

1) For thermocouple signals, the signal lines shall consist of pairs of dissimilar materials, to match the e.m.f. characteristic.

Typical examples:

THERMOCOUPLE MATERIAL		SIGNAL LINE MATERIAL	
CHROMEL	- ALUMEL	COPPER	- CONSTANTAN
COPPER	- CONSTANTAN	COPPER	- CONSTANTAN
PLATINUM/RHODUIM	- PLATINUM	COPPER	- COPPER ALLOY
IRON	- CONSTANTAN	IRON	- CONSTANTAN

2) Signals with higher power levels than specified in Table 1, shall be accommodated in separate cables and laid in the trench, such as electric cables, power and illumination, and the electric power cables for instrumentation installed in the processing area.

6.4 Segregation in Trenches

6.4.1 The instrumentation cables shall be laid in "trenches for instrumentation cables: as follows:

a) where no physical separation between intrinsically safe and non-intrinsically safe cables is required, cables for signal classes 1-4 incl. shall be laid on one side of the trench, cables for signal classes 5-7 incl. on the other side, the pneumatic tubing shall be laid in between .

where the user requires physical separation between intrinsically safe and non-intrinsically safe cables, these 2 groups shall be laid on opposite sides of the trench, with the pneumatic tubing in between.

In order to reduce interference between cables for signal classes 1-4 and those for signal classes 5-7, a further separation shall be made between them e.g., by means of vertical cable tiles.

6.4.2 Cross-section drawings of trenches shall show the location and laying pattern of each group of cables.

6.5 Segregation in Trunking or Cable Trays

All electric signal cables in instrument cable trenches shall continue above ground in trunking or by use of cable trays, together with the pneumatic tubing cables.

Where the user require separation of cables for intrinsically safe circuits, separate trunking or cable trays shall be installed.

6.6 Segregation in Terminal Boxes

6.6.1 The terminal boxes may be shared for signal classes 1-4, or for signal classes 5-7.

However, cables for intrinsically safe circuits shall not share a terminal box with cables for non-intrinsically safe circuits.

6.6.2 Terminals for intrinsically safe circuits shall be segregated or separated from non-intrinsically safe terminals by one of the following methods:

a) locating intrinsically safe and non-intrinsically safe terminals in separate enclosures.
b) using an insulating or grounded metal partition between terminals.
c) separating intrinsically safe and non-intrinsically safe terminals by a minimum distance of 50 mm.

6.6.3 Terminal strips in enclosures containing different intrinsically safe circuits shall be the type with insulating or grounded metal partitions between terminals i.e. "barrier type".

6.6.4 Wiring methods shall prevent contact between circuits should a wire become disconnected from its termination. Wire-tie downs are acceptable for this purpose.

6.7 Construction of Terminal Boxes

6.7.1 For use in Division 2 areas, the terminal boxes shall be reinforced polyester with transparent from cover, if the user does not accept polyester boxes in Division 2 areas, sheet steel boxes shall be specified.

The terminals in these boxes shall be of railmounted clip-in construction, material shall be high-grade track-resistant melamine, if the user does not allow this material in Division 2 areas, terminals with glazed steatite body shall be speci-

fied. Cable glands shall suit the diameter of the cable. For armoured cables and unarmoured cables, nylon cable glands shall be specified, where these are not obtainable, brass glands shall be specified.

For armoured cables weather-proof cable glands shall be specified.

For all cable glands, a locknut inside the terminal box is required to ensure at least 5 engaged threads for mechanical strength.

6.7.2 The above construction details are also applicable to terminal boxes for:

a) intrinsically safe circuits in Div. 1 areas
b) non-intrinsically safe circuits in Div. 1 areas

Non-intrinsically safe circuits in Div. 1 areas shall be accommodated in flame-proof terminal boxes.

6.7.3 For safe areas in the plant, terminal boxes identical in construction to those described for Division 2 areas shall be specified for standardization reasons.

6.7.4 For use in control center with basements, much larger terminal-boxes may be required, they shall be designed to suit the application.

6.7.5 The number of terminals in each box shall be sufficient to terminate all signal wire (including spares) and to interconnect the cable screens.

6.7.6 For terminal boxes in the plant, adaptor plates for glands, trays or trunking shall preferably only be applied in the bottom of the terminal box. This is mandatory when sheet steel covers are applied to protect plastic terminal boxes.

6.7.7 For terminal boxes in the control center with basement, the glands shall preferably be in the bottom of the box.

6.7.8 Underground junction boxes are not permitted.

6.7.9 Terminals for intrinsically safe circuits should be enclosed by a cover suitably marked and distinctively colored (e.g. "intrinsically safe circuits" on a light blue background).

6.7.10 Plugs and sockets for intrinsically safe circuits shall be separate and non-interchangeable except when it can be established that no hazard can arise from an interchange.

6.7.11 Sufficient length of cable shall be provided for termination to be remade if necessary.

6.7.12 When ever a termination is made to a measuring element which has to be withdrawn (e.g. thermocouple) sufficient length of lead shall be allowed for the element to be withdrawn with out electrical disconnection. The minimum additional length for this purpose shall be 600 mm.

6.7.13 Cables associated only with data processing apparatus shall be brought direct to the apparatus input cabinet. Double terminal, removable link-type connectors shall be used for this duty cables concerned also with process control shall be taken first into the control room signals required by the apparatus from process instrumentation shall then be fed from the process control panel to the input cabinet.

6.7.14 Where plastic tubing is used underground and copper tubing is used above ground, a sheet steel terminal box shall be provided at the riser point to accommodate the bulkhead couplings necessary for the transition from copper tubing to plastic tubing.

Note:

Where cubicle panels are installed at grade level the underground cables shall terminate on bulkhead connectors inside the cubicle.

In cases where the distance between control room and processing area requires field-mounted blind controllers, special weather-proof cubicles shall be designed. The upper part of these cubicles shall accommodate the controllers, the lower part shall serve as a termination point for the underground cables.

6.8 Accommodation of Individual Signal Lines

6.8.1 Unarmoured signal cables e.g., to thermocouples or resistance thermometer elements shall be run in galvanized conduit (25 mm) diameter. This conduit shall be connected to the trunking by means of a smooth bore coupling, it shall be connected to the measuring element head by means of plastic covered flexible conduit. The length of flexible conduit shall be sufficient for withdrawal of the measuring element without need for disconnecting the signal cable.

6.8.2 Armoured signal cables shall be installed similar to the cables for power and lighting and have a cable loop near the instrument.

6.8.3 Electric signal cables shall be connected to field-mounted instruments such as transmitters, valve positioners, etc., by means of armoured cable and proper terminal box.

6.9 Screening of Signal Cables

6.9.1 Cable armours shall not be used for screening purposes. All cable screening shall be kept isolated from cable armouring, instrument housings, steel structures and any other electric conductors.

All screening shall be electrically continuous. When two lengths of cable are to be connected, a separate terminal shall be provided to maintain screen continuity.

All cable screening shall be earthed at one point only, usually at the receiving instrument or safety barrier strip.

The measuring elements shall be earthed only at the receiving instrument via the screen, the measuring elements shall therefore be kept free from local earth. To satisfy this requirement, thermocouples shall be specified, where necessary in metal sheathed mineral.

6.9.2 If the measuring element cannot be kept free from local earth (as may be the case with certain on-line process stream analysers) and the signal is in class 1 or 2 of Table 1, the screen shall also be earthed at the sensor side and be extended into the control room without any further connection to screens of other cables.

6.9.3 In case shunt-diode safety barriers are used, the screens shall be earthed at the safety barrier ground connection.

6.9.4 For typical example, refer Fig. 1, on page 21.

6.9.5 Grounding shall be as indicated in the following Table:

SERVICE	SPECIFIC GROUNDING REQUIREMENTS
Signal wires	Ground at the power supply end
Thermocouple extension wires: Wire-Type thermocouples	The extension wire shield is directly grounded at the receiving instrument
Sheath type thermocouples	Grounding at the measuring junction end by use of grounded hot junctions
Differential temperature thermocouple applications or systems where thermocouple wiring to be made intrinsically safe	Proposed grounding design to be reviewed with user's engineer
Electronic equipment such as data loggers, computers or multiplexers	Proposals for grounding designs, other than the above, to be approved by user's engineer

6.10 Use of Quad Cables

6.10.1 The service of the wires in a quad shall be arranged as follows:

a) For signals requiring 2 wires, the diametrically opposed wires shall be used.

The other pair of wires in the quad may be used for another signal, (within the limitations specified in Table I).

The unused wire(s) in a quad shall be connected in parallel to used wires in the same quad, using crimp-on wire pins or fork lugs, (depending on type of terminal).

b) For signals requiring 3 wires, e.g. for resistance thermometer elements in bridge-circuits, two wires diametrically opposed shall be combined for connection to the null-detector, the other two for extension of bridge-arms.

These wires shall have sufficient excess-length to allow converting a 3-wire circuit into a 4-wire circuit if so desired later.

c) For signals requiring 4 wires, e.g., for resistance thermometer elements in a constant current circuit, the current carrying wires shall occupy one pair of diametrically opposed wires, the measuring signal shall occupy the other pair.

6.11 Numbering and Identification

6.11.1 Numbering system for instrument cables and terminal boxes

a) In order to obtain uniformity in the various numbering systems of instrument cables and boxes the following system shall apply.

b) Cables for each function shall be numbered starting from 101 upwards. The cable numbers 1 to 100 shall be reserved for use by the user.

c) The cable number shall be preceded by a letter for identifying its typical function, viz.:

PN	for pneumatic tubes
T	for temperature measuring cables
E	for other electric signal cables such as: cables connecting safeguarding systems, signalling devices, measuring elements, transmitters, transducers and other electric and/or electronic instruments.

For cables containing intrinsically safe circuits, this letter shall be followed by an i, such as Ti and Ei.

d) Terminal boxes shall be designated by one of the following letters, PN, T, E, Ti or Ei in accordance with the function of the cables, and numbered from No. 11 upwards. the box numbers 1-10 shall be reserved for use by the user.

6.11.2 Identification of cables and terminal boxes

a) All cables and terminal boxes shall be marked clearly, durably and consistently in accordance with 6.11.1 and as specified below.

b) Underground cables shall be marked at approx. 5 m intervals by means of embossed strips of corrosion-resistant material (e.g. stainless steel or nylon).

c) Above-ground cables shall be marked at their termination points (outside the terminal box where applicable) with a suitable label, of engraved or embossed plastic.

d) Terminal boxes shall be marked externally with suitable nameplates of engraved plastic.

e) Terminals in the terminal boxes shall be numbered consecutively in accordance with relevant cable connection diagrams.

f) All wires shall be individually marked on each side of each terminal with plastic markers.

g) Termination points of multicore tubing shall be marked on the outside of the trunking.

h) Individual copper tubing shall be marked with instrument tag number at the point of connection to the multicore tubing.

6.12 Pulling into Conduits

a) Where instrument cables are to be pulled through conduit, the conduit shall be completely dry prior to installation and the ends shall be temporarily sealed to prevent entrance of moisture and rain during installation.

b) Conduit installations shall be planned such that rain cannot enter conduit fittings after installation is complete. All fitting covers must be securely tightened to prevent entrance of rain or moisture. Thread compound shall be used on all threads to assure tight seal.

c) Where it is necessary to use pulling compound for instrument cables the pulling compound shall be of the dry type. Wet compound shall not be used.

d) Ends of conduit shall be inspected to assure that no raw edges are present which would damage cable insulations during pulling.

e) Particular care shall be applied when pulling shielded cables to assure that pulling forces do not separate or otherwise damage the cable shield.

6.13 Installation of Insulated Wire and Cables

a) Cables shall be in continuous lengths consistent with availability from manufacturers.
b) The cable manufacturers minimum bending radius shall be observed.

6.14 Separation of Cables

a) The following precautions are necessary to minimize interference in signal cables.

Signal cables shall not be run in the same conduit or cable tray as power cables. The physical separation of signal and power cables shall be not less than shown below:

POWER CABLE	MINIMUM SPACING
Up to 125 V or 10 A	0.30 m
250 V or 50 A	0.50 m
440 V or 200 A	0.75 m
5 kV or 800 A	1.50 m

b) If it is intended to use the same cable trench for power and instrument cables, the above separation shall be obtained by positive means.

c) When a cross-over is unavoidable, the routing shall be such that signal and power cables cross at right angles to each other.

d) A minimum of 2 m of clearance shall be allowed between any noise generating equipment and a run of signal carrying cable.

6.15 Terminations

6.15.1 Exposed sheathed wiring shall be installed in a neat and workman-like manner, straight and true as far as possible. Where installed in groups, the cables shall be parallel in so far as practicable.

6.15.2 Where stranded wire is used the terminal ends shall be securely twisted to assure that no frayed ends are present to cause shorting or grounding. Terminal lugs are to be used only where indicated.

6.15.3 Where any confusion exists as to the identification of wires or terminals it is to be reported promptly to the Construction Superintendent for clarification; no assumptions are to be made.

6.15.4 The use of field terminal points other than those indicated on the instrument schematic wiring diagrams is not permitted.

6.15.5 Care shall be taken where field splices are required in hot or neutral leads that the proper hot or neutral is used. The wiring philosophy, for process reasons, may contain more than one hot and neutral leg. Use of random "hot" or neutral legs is not permitted.

6.15.6 Above ground wiring systems shall be routed, wherever possible, to provide at least 7.5 m, horizontal clearance from equipment which is designated as a source of sustained fire.

6.15.7 Above ground wiring systems routed less than 7.5 m from such equipment shall be fire proofed using a covering of 50 mm of high temperature mineral wool or calcium silicate insulation, or equivalent, and a galvanized or stainless steel jacket. Additionally, any junction boxes in such areas shall be fire proofed.

6.15.8 Where a plug and socket outlet is used as wiring connection to the instrument, the socket must be labeled with the instrument identification symbol. Plug and socket type shall be such that the plug cannot be inserted with reverse polarity.

6.15.9 To prevent entrance of water, the cable entry point into a field mounted instrument shall be from the bottom wherever practicable. Where top entry must be used, conduit shall have a seal and drain fitting within 450 mm (18 inch.) of the instrument to prevent liquid collection in the conduit from entering the instrument.

6.15.10 Thermocouple lead wire shall run from the thermocouple to the terminal points indicated on the drawings. No splicing shall be permitted.

6.15.11 Thermocouples will be permanently tagged with metal-discs, with item numbers stenciled in securely attached with noncorrosive wire.

6.15.12 Shielded wire and cable shall run directly from point to point as indicated on the drawings. No splicing shall be permitted.

6.15.13 When extension wire is run next to fired heaters or other heat radiating equipment, every effort shall be made to keep wire in areas where temperature are not excessive. If this is not practical, wire with a moisture resistant, high temperature insulation shall be used. As soon as lead wire is away from a hot area a common junction box shall be provided for splicing into lead wire with PVC insulated wire which shall be run the remaining distance to instrument.

6.15.14 Where instruments are local or mounted close by on heater panels, and lead wire has to be run in a heated area that would caused damage to PVC insulation, wire with moisture resistant, high temperature insulation shall be run continuously from the thermocouple to local instrument.

6.15.15 Where a tower has alternate temperature points and all are not used at a given time a terminal block enclosed in a weather proof fitting shall be provided so that thermocouple leads can be changed when necessary.

6.15.16 Initial installation shall include 20% spare thermocouple extension and instrument signal wires between the junction box on the control board and the principal junction boxes in the area.

6.15.17 All conductors shall be terminated in strict accordance with the manufacturers' recommended methods. Particular care and compliance with manufacturers' instructions shall be utilized in connection with terminating high voltage cables.

6.15.18 Solderless crimp type cable connectors shall be used on insulated cable sizes #10 A.W.G. (6 mm^2) and smaller.

6.15.19 Solderless crimp type spade wire connectors shall be used on low voltage signal wiring (16 A.W.G) 1.5 mm^2 and smaller.

6.15.20 Numbered or lettered wire Markers shall be installed on control and instrument leads and thermocouple cables at all terminal points. Identification shall be in accordance with applicable job drawings (see 6.11 Numbering and identification).

6.15.21 Manufacturers' instructions or recommendations for installing, splicing wire or cable, splicing materials, wiring accessories or other wiring materials shall be adhered to.

Insulating paint shall be used over the insulation of all taps, splices and terminations exposed to the weather, if applicable.

6.15.22 Cutting wire or cable to required lengths as it comes off a reel requires a location free from sharp objects. The jacket and insulation thickness on many instrument cables are much thinner than on power cables and greater protection against damage is necessary. A paved area is usually ideal but, if not available, a grassy or sandy area is adequate.

Crushed stone, muddy, and shelled areas should be avoided. Where traffic must cross wire as it is laid on the ground, temporary board ramps should be provided to keep vehicles from damaging the wire. Additionally these ramps will reduce the tripping hazard to personnel which can result in serious injury.

6.15.23 Excess length should be allowed for pulling in. Later this excess length will be discarded, but the amount must be carefully considered. A reel of wire 1,500 meters long may be used to make 15 No. ninety-meter runs. If 10-meters cutting allowances are used, and included in the 15 one hundred meters lengths which are cut, the reel will be adequate in length. If more than 10 meters are allowed, the reel will not be adequate and additional wire will have to be secured.

6.15.24 A cable end preparation should accomplish the following:

a) Terminate jackets and shield material without nicking insulation underneath.

b) If no pair jacket is used, and pairs are individually shielded, then insulating tape or sleeving should be applied to exposed shielding in order to protect against accidental grounds and hold any spiral wrapped shielding material in place without unravelling.

c) Ground drain wires should be insulated against accidental grounds.

d) Shields should be stripped back a minimum distance from the ends of the wires. A maximum of 25 mm is recommended.

e) Tagging should identify cable, pair, and service.

f) All cable ends should be protected against moisture entry prior to connecting the cable to its permanent terminations.

6.15.25 Stripping insulation from wire should be done without nicking the conductor. Such nicks result in stress concentration which can cause failure while bending the wire during installation, repair, or normal vibration. Although this is of greater importance with solid wire than with stranded wire, it is a matter of concern with stranded wire also. The simplest way of avoiding nicks is to use commercially available stripping tools of proper design.

6.15.26 Terminal screws should be torqued adequately to get good contact with the wire inserted under the screw.

6.15.27 On tubular screw terminals and wire smaller than 2 mm^2 (14 AWG), it is recommended to doubling back the wire under the screw to assure good connections.

6.15.28 Proper compression of the terminal screws is necessary to prevent products subject to corrosion from later causing poor continuity, galvanic, or rectification action.

6.15.29 Spade lugs should be used to terminate wire ends where screw terminals are used, specially for 1.5 mm^2 (16 AWG) and smaller if solid, and for all sizes of stranded wire.

6.15.30 All wires or leads terminated of a connection should have sufficient slack to reduce the effects of vibration.

6.15.31 In applications where multiple wires are routed from a common cable trunk to equally spaced terminals, the vibration bends should be uniform in length to prevent stress on any one wire.

6.15.32 Proper cable support is necessary to avoid having cable weight supported from wire terminations.

6.15.33 Support bars and tiedowns in junction boxes should be incorporated, for the weight support if applicable.

6.16 Installing Cable Trays

6.16.1 Interconnecting wiring between the panel mounted instruments and the field mounted transmitters and control valve transducers shall be installed in wiring trays.

6.16.2 Trays shall be punched bottom type with high sides.

6.16.3 Thermocouple wiring may be installed in the same trays with input or output signal wiring for electronic instruments. No other wiring may be installed in these trays.

6.16.4 Separate trays or conduit may also be used to support thermocouple wiring.

6.16.5 Cable tray and tray support materials, when assembled and mounted, shall support workmen and equipment, as required, in addition to the full cable load, without permanent deformation, and a maximum of 20 mm deflection.

6.16.6 Tray fittings, such as branches, reducers, flat elbows, tees and crosses, shall be used for changes in direction and elevation. The dimensions of tray fittings shall provide ample bending radii for the cables contained in them at all changes in tray direction.

6.16.7 Tray shall be carefully aligned and leveled plumb and true. Tray sections and fittings shall be assembled on their supports and joined together, using manufacturers' standard connector units, properly aligned, and secured.

6.16.8 Steel angles, trapeze hangers, channels, bolting and miscellaneous materials required for the support of trays from the building structure, shall be supplied and installed. Additional supports as required shall be provided for individual cables where the cables leave trays before reaching their final terminations.

6.16.9 Where it is necessary to field cut and fit galvanized tray, the sub-contractor shall remove all rough edges and burrs and touch up bare metal surfaces with primer followed by aluminum paint.

6.16.10 To repair damage to the polyvinyl chloride coating and where it is necessary to field cut and fit polyvinyl coated tray the sub-contractor shall remove all rough edges and burrs and shall apply PVC protective coating or epoxy paint in accordance with the tray manufacturers detailed procedures and recommendations.

6.16.11 Polyvinyl chloride coated trays and fittings shall be furnished with the splice plate or connection device area not coated, in order to assure metal to metal contact and assure earth continuity. The splice or connection device and adjacent uncoated area shall be restored in the same manner as described for field cut and fit procedures.

6.16.12 The polyvinyl chloride coated tray system is to be connected to the grounding system. To accomplish this, the polyvinyl chloride coating shall be removed on the side channel, a hole shall be drilled and an earthing connector attached by means of a round head machine screw, lockwasher, and nuts, the head of the machine screw being on the inside of the tray. The adjacent disturbed area shall be restored in the same manner as described for field cut and fit procedures.

6.16.13 Long runs of cable shall be fixed to suitable cable trays or otherwise supported throughout its length. The cable shall be mechanically supported up to the point of entry to the equipment in which it is being terminated, except that flexible leads may be unsupported for the last 600 mm.

6.16.14 Instrument cables shall be located at a sufficient distance from any hot surface to avoid damage.

6.16.15 In control rooms runs from the junction boxes terminating multi-core cables to individual instruments should be in non-metallic troughing with protective covers.

6.16.16 Cable trays and trunking can be made of conducting or non-conducting materials. The latter is preferred. Metal cable trays should preferably be plastics coated.

6.16.17 For more details refer to Figs. 6 & 7, on pages 26 & 27.

TABLE 2 - TYPICAL CABLE APPLICATIONS

CONSTRUCTION AREA	SINGLE CABLE	UNSCREENED	BRAIDED SCREEN OR S. WIRE ARMOUR	
	MULTICORE CABLE		OVERALL BR. SCREEN OR S. WIRE ARMOUR	INDIVIDUAL SCREENED PAIRS AND OVERALL BRAID OR SWA
Safe area		1. High level signals to indicators and recorders alarm contacts, SOVs, controller outputs to convertors & valve pos. analyser and instrument sequencing signals	2. High level signals to controllers trip systems low level signals to indicators and recorders	3. All signals to computers low level signal to controllers, converters and trip amplifiers
Div. 2 area	I.S. service Non-I.S. service	4. Not recommended Not permitted	5. All high level signals as listed and low level signals to indicators & recorders for I.S. and Non-I.S. services	6. Low level signals to controllers and trip systems
Div. 1 area	I.S. service Non-I.S. service	7. Not permitted Not permitted	8. All high level signals as listed above, for Non-I.S. services only under 1.&2.	9. All Signals as listed above for I.S. services

6.17 Wire Testing

6.17.1 For analog instruments, testing of wire is necessary after installation to verify freedom from grounds.

6.17.2 Where "meggers" are used, care should be exercised to not use a voltage in excess of the insulation's rated voltage, as some meggers have much higher test voltages, in the order of 5 kV.

6.17.3 During testing, all instruments should be disconnected to avoid damage to the instruments.

6.17.4 Wire to wire and wire to ground resistance should normally exceed 10 megohms.

6.17.5 The shield drain wire should be tested for accidental shorts or grounds and treated as just another conductor requiring high resistance to ground.

6.17.6 All instrument electrical wiring shall be checked for continuity.

6.17.7 For more details refer to IPS-M-IN-100 "General-field inspection & testing of instruments and instrument system".

7. TRENCHES, TRUNKING AND CONDUITS

7.1 Routing

The shortest possible routing shall be selected, taking into account the aspects mentioned below.

7.2 Trenches

7.2.1 The trenches shall be kept away from those for electric cables for power and illumination and wherever possible shall not run in parallel with them at a distance of less than 0.6 meter.

7.2.2 At crossing of trenches for signal cables with those for electric power cables the separation between the highest cable in the lowest trench and the lowest cable in the highest trench shall be at least 0.3 m.

7.2.3 Trenches shall be kept away from buried pipes containing hot fluids and from pipes liable to temperature rise due to steaming-out.

7.2.4 It is of paramount importance to avoid deterioration of signal lines due to ingress of solvents, acids, etc., in the trenches. Where possible the trenches shall be kept above ground-water level.

7.2.5 The signal lines shall be at such a depth that they are not damaged by traffic passing over them.

7.2.6 Where trenches are made in soft soil, signal lines shall be laid with sufficient slack (especially at riser points) to prevent stresses.

7.2.7 Signal lines shall be laid on, and be covered with, sand on top of which tiles shall be laid for mechanical protection.

7.2.8 The location of trenches shall be clearly marked and no excavation shall be allowed without permission given by instrument department.

7.3 Trunking and Conduits

7.3.1 Connections to vibrating or movable equipment shall be by means of flexible metallic conduit.

7.3.2 The trunking shall not obstruct traffic, nor interfere with accessibility or removal of process equipment (pumps, motors, heat exchanger bundles). The layout of the trunking shall be such that only the instrumentation in the immediate vicinity will be disengaged if a plant fire damages the signal lines.

7.3.3 Trunking shall be routed away from hot environments, places with potential fire risks such as hydrocarbon process pumps, burner fronts of furnaces and boilers, or where subject to mechanical abuse, spilled liquids, escaping vapors and corrosive gases.

7.3.4 In particular, trunking for electric signal lines shall be routed away from high voltage cables and overhead power lines, and switched circuits of any voltage.

7.3.5 Trunking shall be safely and easily accessible for maintenance purposes.

7.3.6 To avoid unnecessary bends, space for trunking shall be reserved in plant structure, pipe tracks, etc., in an early engineering stage.

7.3.7 Trunking shall continue after the last multicore cable has been terminated for accommodating the individual signal lines. The trunking may end only when the quantity of individual tubes is 3 (or less) or the quantity of signal lines is less than can be accommodated in a 25 mm conduit.

7.3.8 For typical layout of trunking, refer Figs. 2, 3 & 4, on pages 22, 23, and 24.

7.3.9 The conduits shall never be supported from process piping.

7.3.10 Provision shall be made for thermal expansion or movement of supports and swaying of towers in high winds.

7.3.11 All conduits shall be fastened with pipe clamps or U-bolts, and shall not be tack welded. Substantial steel hangers shall be provided for groups of conduits where it is not practicable to clamp directly into building walls or structural members.

7.3.12 Where fire damage is possible, adequate flame barriers shall be provided. For thermocouple wires and other low current signal wires, jacketing may be considered.

7.3.13 Thermocouple extension wires may be run in conduits or by means of multicore compensating cables of appropriate metal. If the wire is run in conduit, vapor proof fitting shall be used. A loop of flexible conduit shall be used, when attaching conduit to thermocouple heads.

7.3.14 The conduits shall be adequately sealed off to isolate the flexible conduit entrances and the conduit entrances to the control rooms. Seals shall also be provided where conduit enters field instruments.

7.4 Construction Details

7.4.1 Trenches

a) In paved areas between control center and processing areas, trenches may be excavated from the soil.

b) In plant floors and other areas with (reinforced) concrete surfaces, the trenches shall be fabricated to support ends of floors.

c) The depth of the trenches shall be compatible with the quantity of signal lines and required height of fill-back. Where large quantities of signal lines cross or branch-off, trench depth shall be increased locally. Trench bottoms shall have a maximum slope of 10 degrees, transition to horizontal surfaces shall have smooth curvature.

d) Width of trenches shall be dependent on quantity of cables to be accommodated, and the corners shall be compatible with bending radius of armoured cables.

e) After cables have been laid, trenches shall be filled with sand, cable covers and soil.

Trenches in plant floors, etc., shall be covered with a layer of concrete to prevent ingress of liquids into the trenches.

f) At each riser point, trenches shall be provided with a concrete adaptor for connecting the above ground trunking.

Wherever possible, these adaptors shall be an integral part of the plant floor.

Where riser points are liable to damage by traffic, they shall be protected by free-standing and sturdy mechanical structures.

7.4.2 Trunking

a) The trunking shall be firmly supported, wherever possible the supports shall be arranged in such a way that cables can be laid sideways into the trunking instead of pulling them through consecutive holes.

b) To prevent stresses on cables, they shall be suitably fixed in the trunking, especially in vertical trunking.

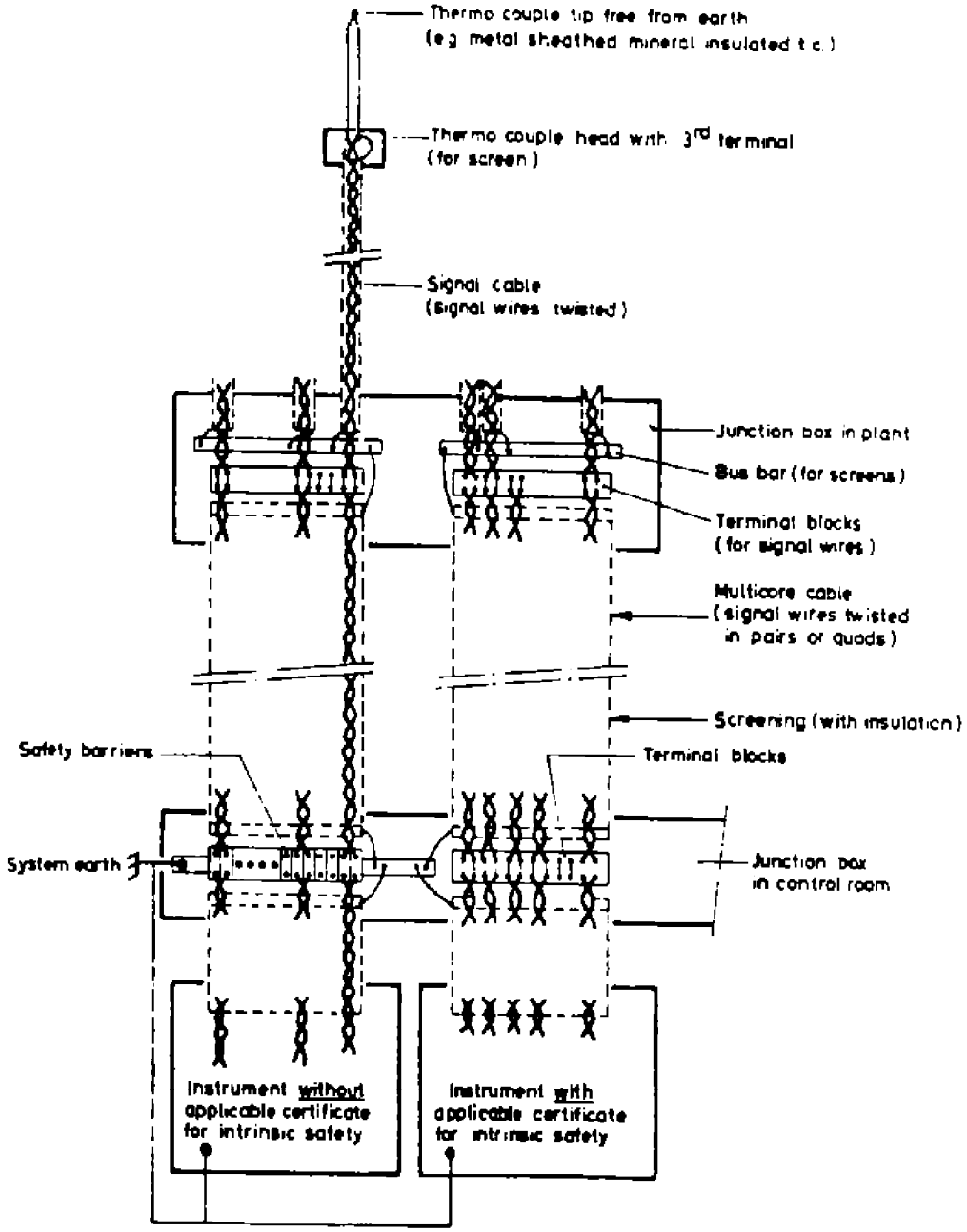
c) Based on an average cable diameter of approx. 25 mm, the following table gives the quantity of cables to be accommodated in each standard size of trunking, leaving space for individual signal lines, possible later extensions, etc.

CHANNEL WIDTH (mm) CHANNEL HEIGHT (mm)	50 100 150 200 300 50 100 100 100 100
QUANTITY OF MULTICORE CABLES	1 9 12 18 27

8. FIELD INSPECTION AND TESTS

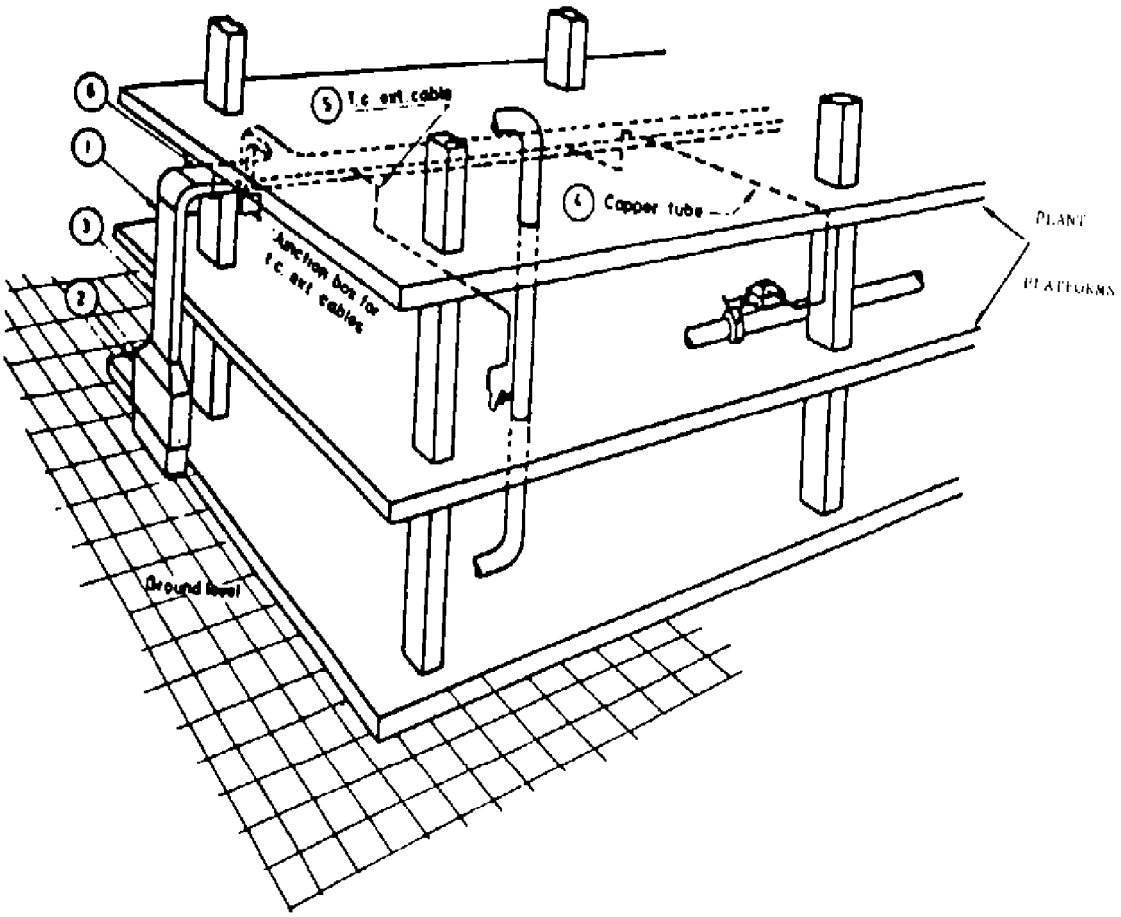
Refer to IPS-M-IN-100/3 "General-field inspection and testing of instruments and instrument systems".

FIGURES



SCREENING OF INSTRUMENT SIGNAL CABLES

Fig. 1



TYPICAL INSTALLATION OF INSTRUMENTATION CABLES IN THE PROCESSING AREA

Fig. 2

Notes:

1) Front of trunking to be kept free to facilitate laying of cables.

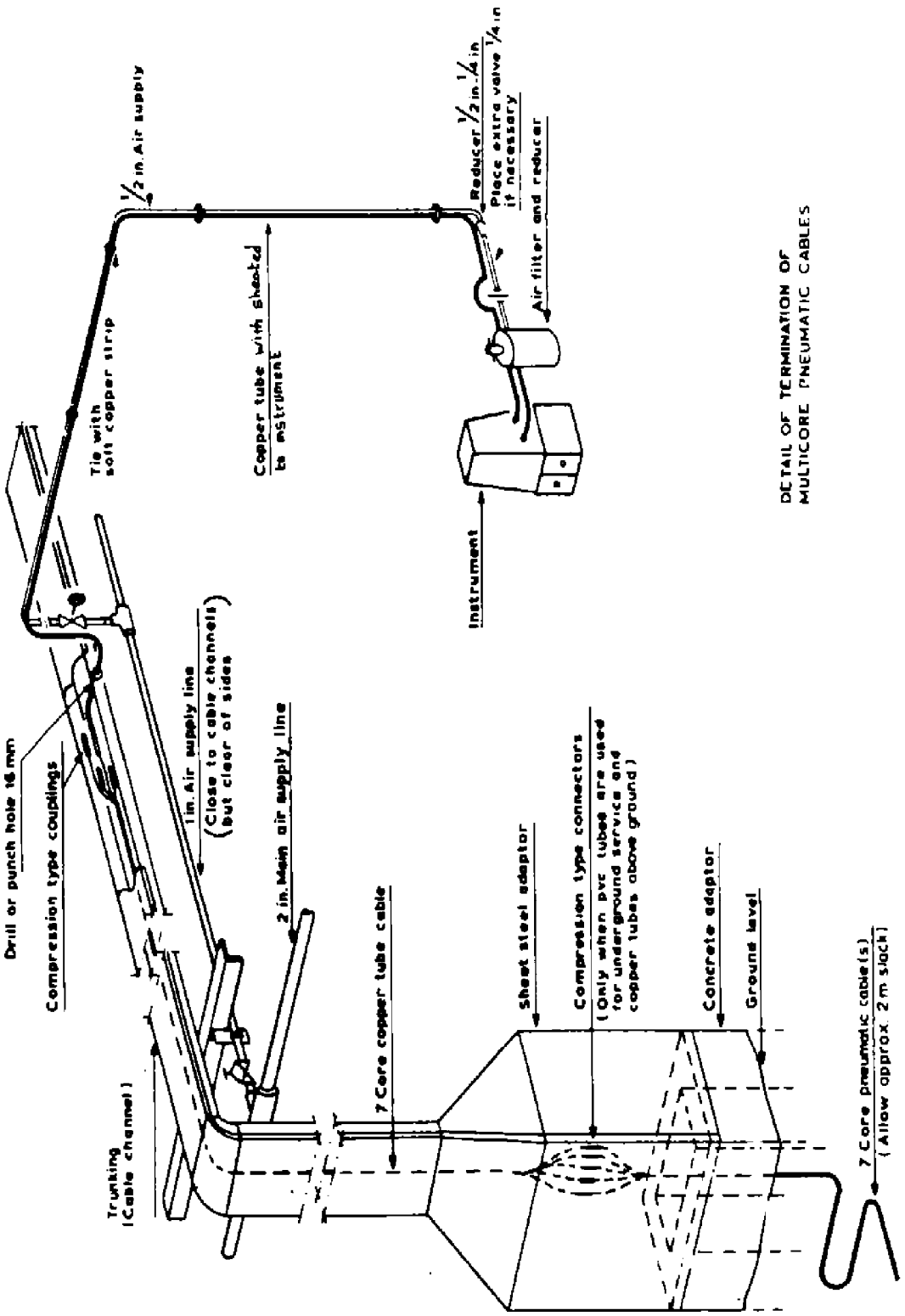
2) Multicores to penetrate as far as possible into plant before coming above ground, consistent with above ground runs being located away from potential fire hazards as much as possible.

3) Pneumatic multicores and ext. cable to be laid in same trunking as required.

4) details of pneum tubing-refer Fig. 3.

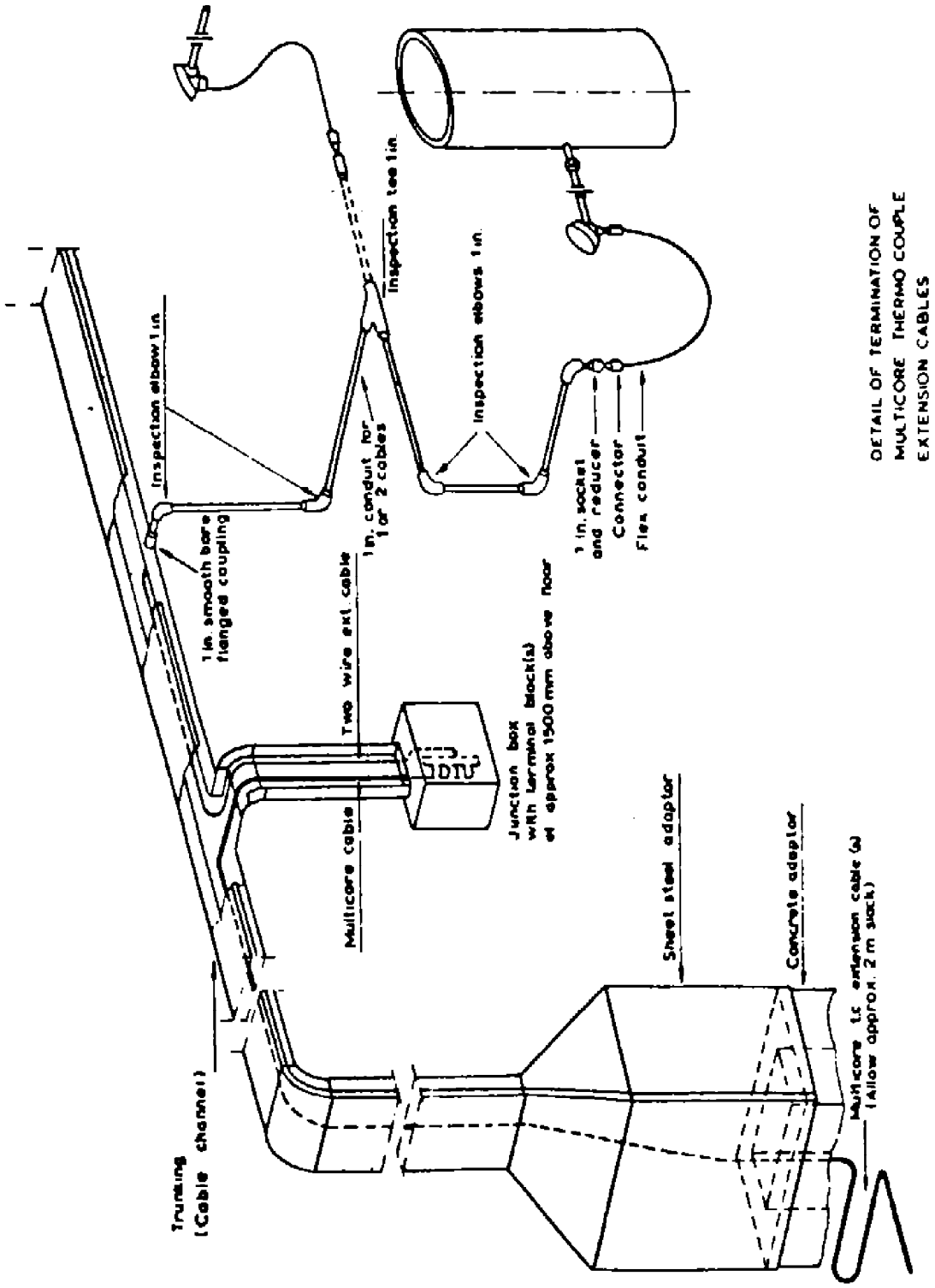
5) Details of t.c. wiring-refer Fig. 4.

6) sufficient headroom required to easily remove channel covers.



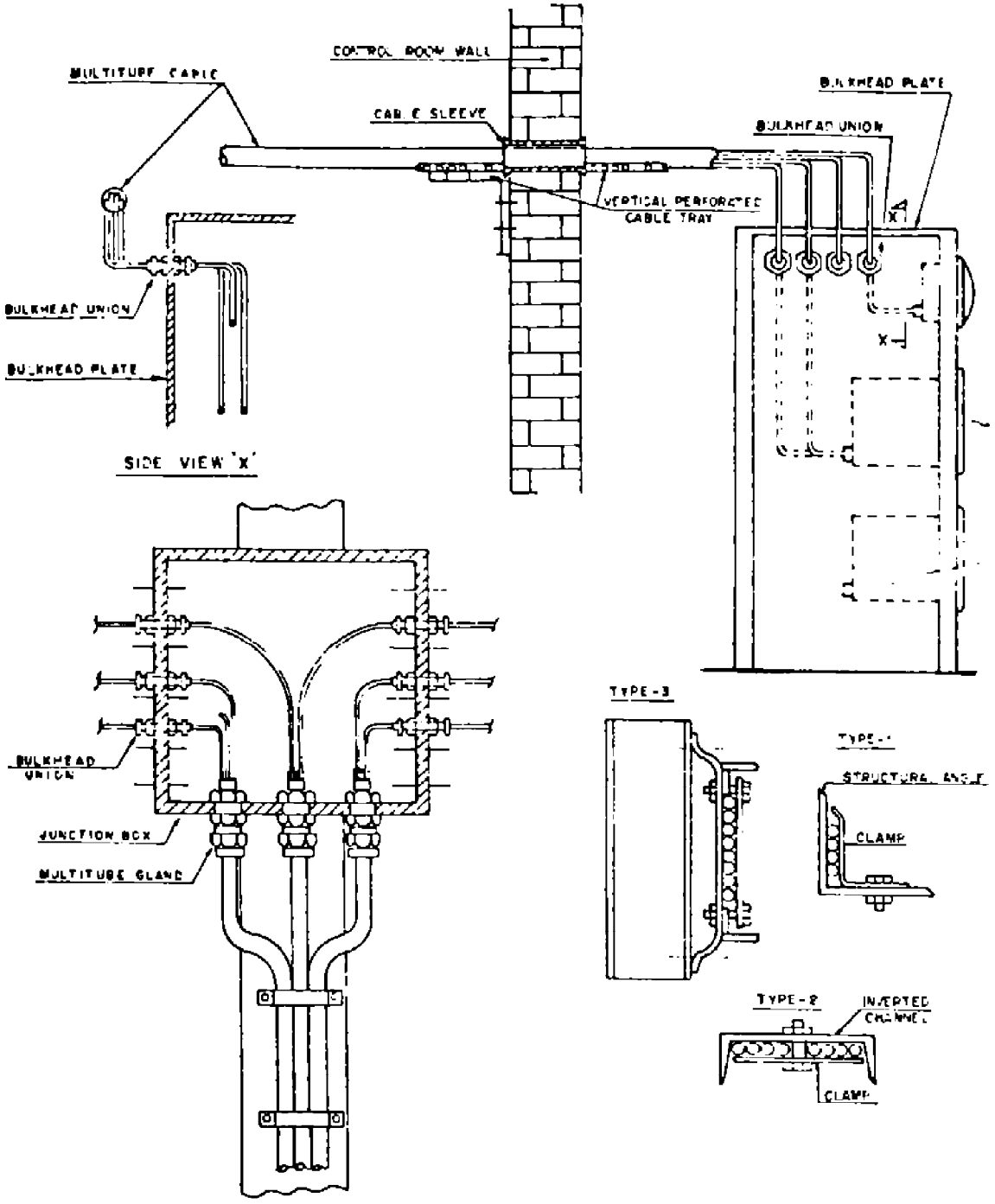
TYPICAL INSTALLATION OF INSTRUMENTATION CABLES IN THE PROCESSING AREA

Fig. 3



TYPICAL INSTALLATION OF INSTRUMENTATION CABLES IN THE PROCESSING AREA

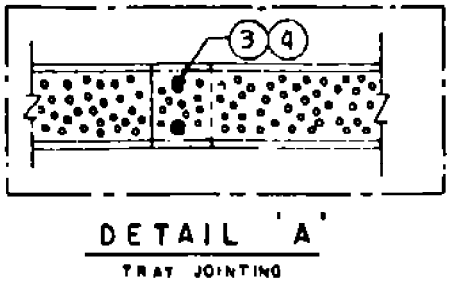
Fig. 4

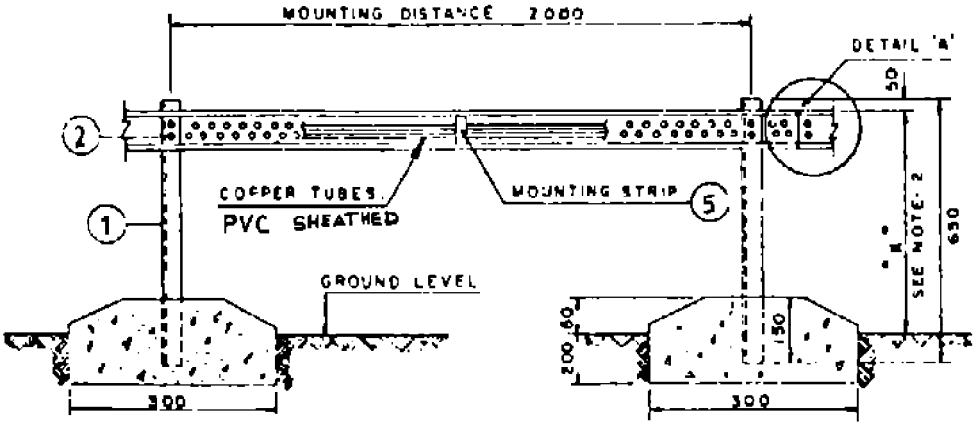


TYPICAL MULTITUBE CABLE INSTALLATION

Fig. 5

Note: Cable trays shall be installed vertically





TYPICAL INSTALLATION AND MOUNTING CABLE TRAY

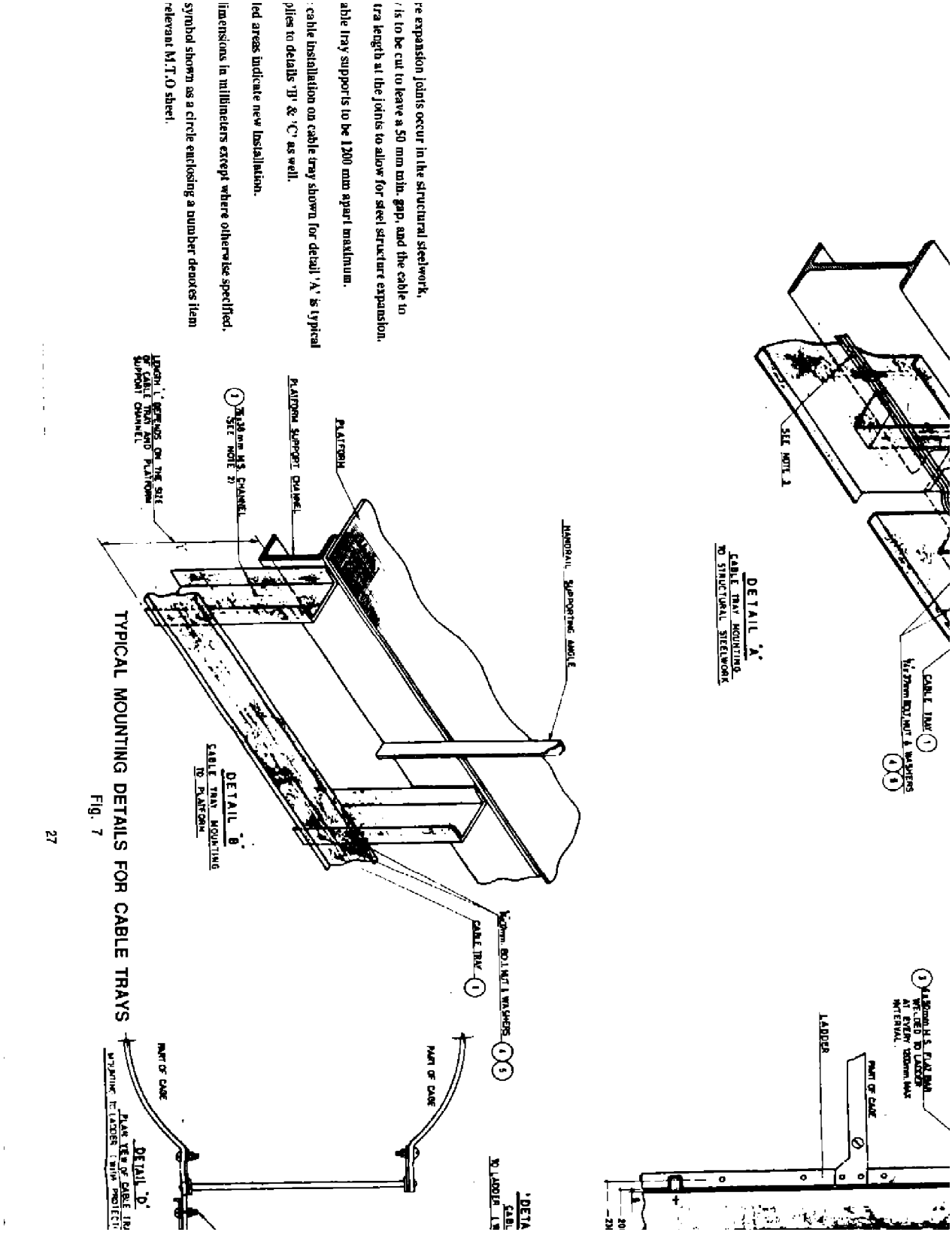
Fig. 6

ITEM	QUAN.	SIZE	DESCRIPTION	MATERIAL
1		50 × 50 × 6	Angle iron. equal	Steel
2		1/4" × 1"	Black bolt & nut	Steel
3		6 × 20	Roofing bolts & nuts	Steel galv.
4		5/16"	Washer, round, flat, black	Steel
5		3/4" × 1/8"	Mounting strip for cable tray	Galv. steel

Notes:

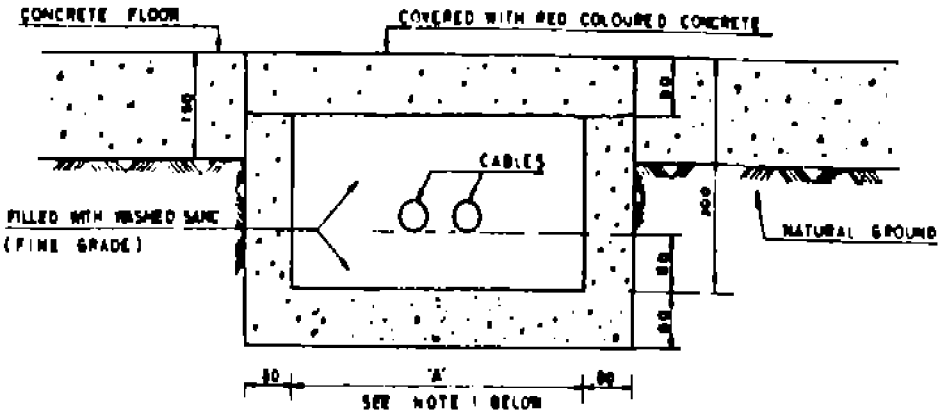
1) All dimension in millimeters unless stated otherwise.

2) Dimension "X" to be 500 mm, unless stated otherwise.



TYPICAL MOUNTING DETAILS FOR CABLE TRAYS
Fig. 7

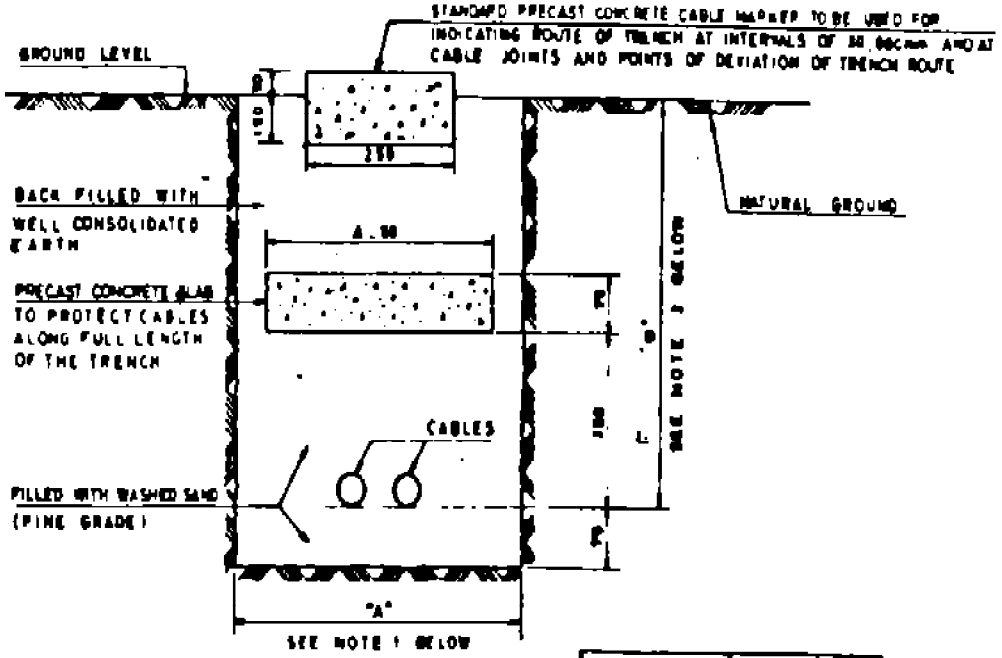
TYPICAL MOUNTING DETAILS FOR CABLE TRAYS
Fig. 7



DETAIL OF TYPICAL CABLE TRENCH
INSIDE BUILDINGS

FOR DETAILS SEE DRG Nº SA 5.6001

N.T.S.



NOTES:

1- DIMENSION 'A' TO BE 250 TO 750 mm DEPENDING ON NO OF CABLES LAID IN THE TRENCH IT RISES BY INCREMENT OF 75

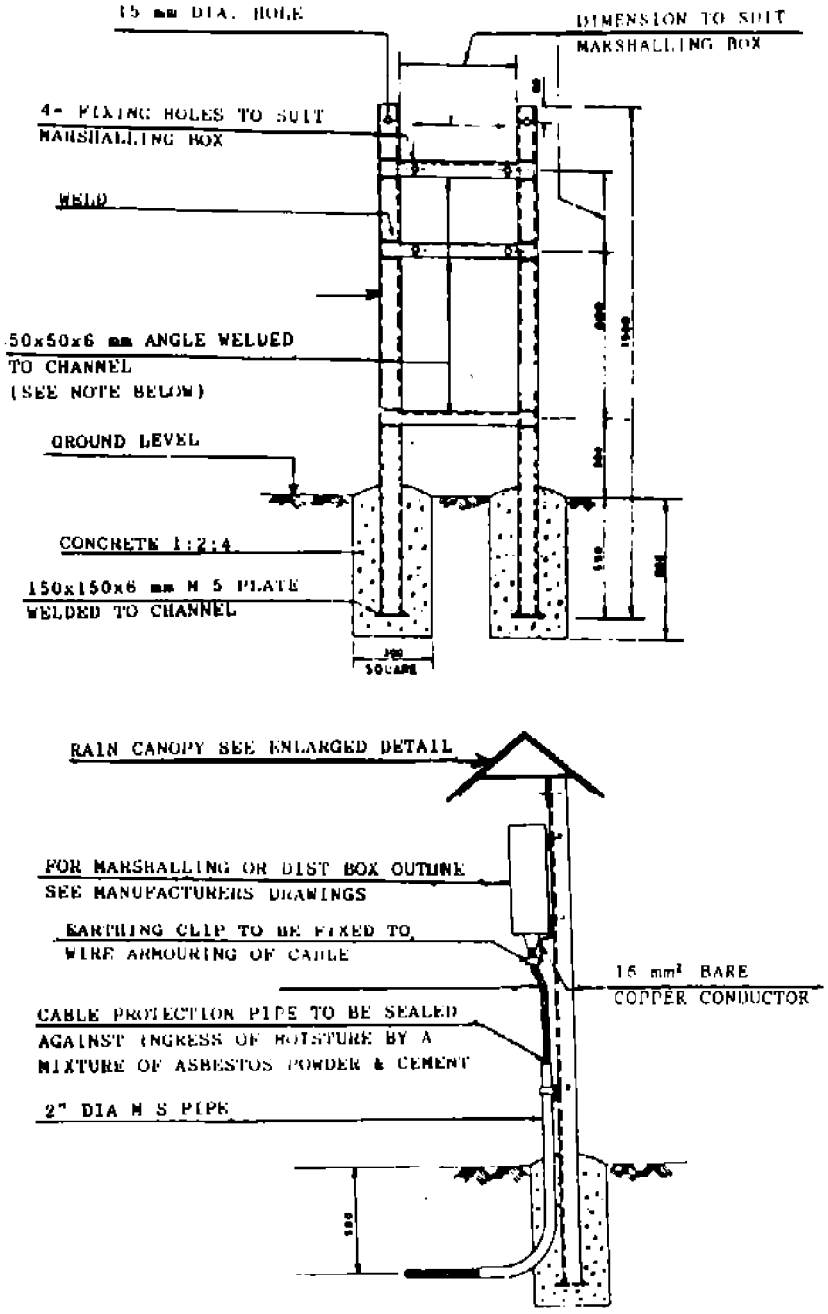
2- CONSIDERATION SHOULD BE GIVEN TO INCREASING DEPTH "B" WHERE THERE IS APPRECIABLE SPILLAGE OF DELETERIOUS PETROLEUM PRODUCTS AND / OR CHEMICALS

3. SPECIAL MARKER TO BE USED AT CABLE JOINTS TO INDICATE VOLTAGE AND LOCATION OF JOINT BOX

CABLE VOLTAGE KV	RECOMMENDED DEPTH "B"
0.24	500
0.44	700
3.3	900
11	900
33	1000

DETAIL OF TYPICAL CABLE TRENCH OUTSIDE BUILDINGS

Fig. 8

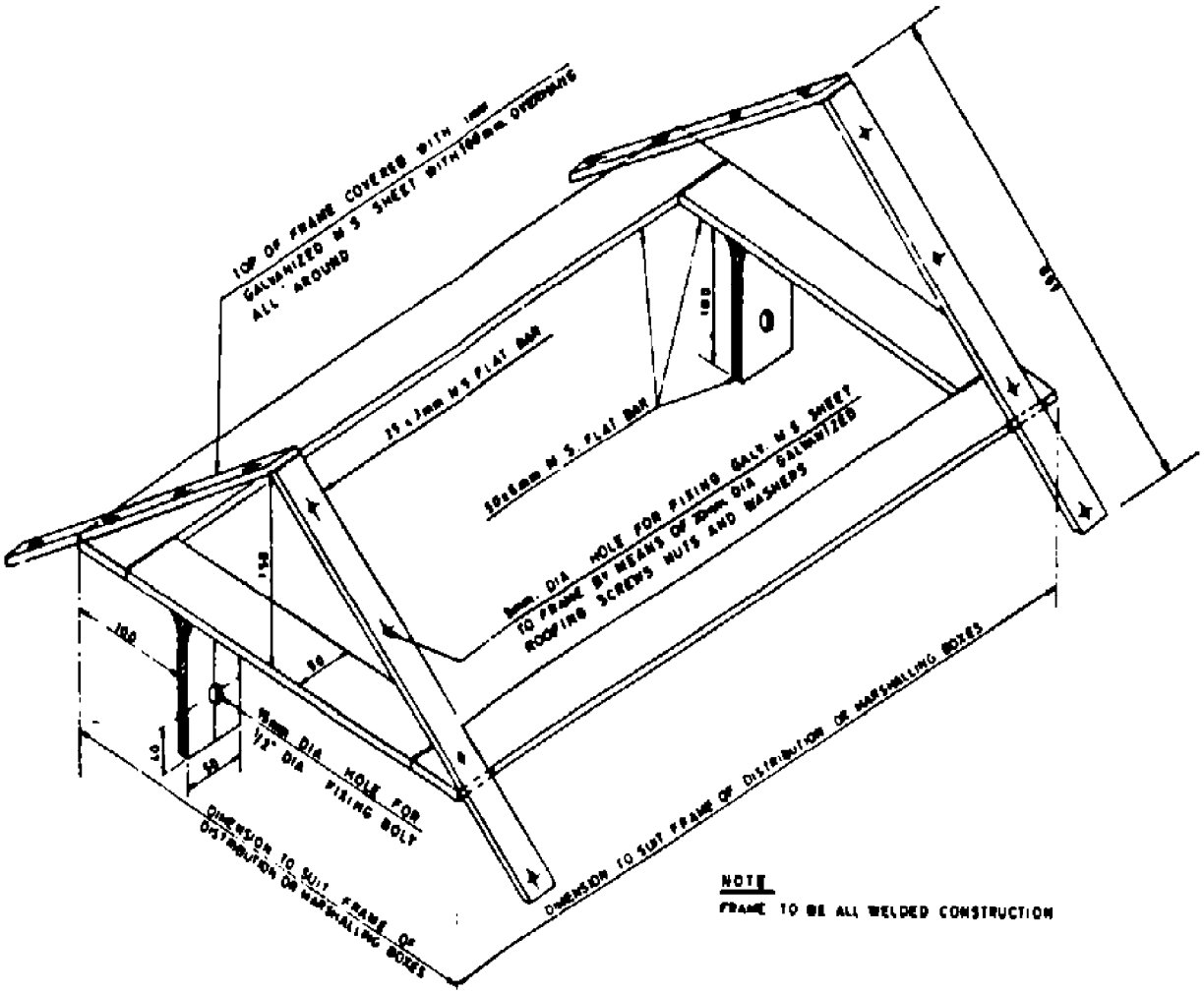


METHOD OF MOUNTING MARSHALLING & DISTRIBUTION BOXES

Fig. 9

Note:

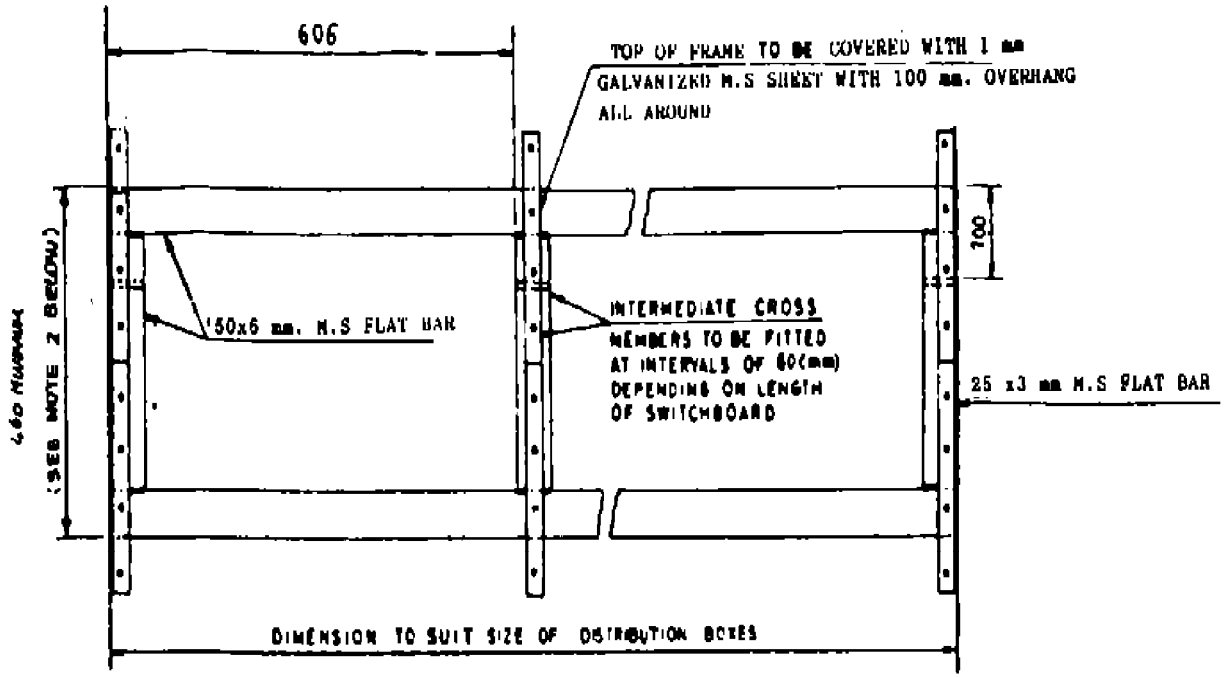
Length of angle to be increased if two marshalling boxes are installed adjacent to each other.



ISOMETRIC VIEW

DETAIL OF RAIN CANOPY FOR MARSHALLING & DISTRIBUTION BOXES

Fig. 10



PLAN VIEW

DETAIL OF RAIN CANOPY FOR NON WEATHERPROOF LARGE DISTRIBUTION BOXES

Fig. 11

Notes:

1) Rain canopy for distribution box to be constructed similar to rain canopy for marshalling box given on this drawing.

2) Width of frame to be increased if necessary depending on width of distribution box to give 150 mm overhang at front of distribution box.

3) Frame to be all welded construction.