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TECHNICAL JOB SPECIFICATION

660/1

REVISION 0

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HIGH PRESSURE (HP) TRANSMISSION SYSTEMS

INSTRUMENT WIRING AND CABLES

QUALITY ASSURANCE PAGE

CHANGES LOG

REVISIONS LOG

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1.0 SCOPE

This specification covers cables, wiring requirements and design considerations that are unique to instrumentation systems such as electronic instruments, computers, thermocouples, and all intrinsically safe systems. All general wiring requirements not covered by this standard shall be as set forth in **Job Specification 700/5** and in **Job Specification 732/1.**

2.0 GENERAL

Instrument cables are defined as those cables carrying digital or analog signals and power supply cables with voltage level less than 200V.

Instrumentation wiring shall be designed to provide:

- Safety to personnel.
- Reliability.
- Reduced effect of electrical interference.

3.0 WIRE AND CABLE SELECTION

3.1 GENERAL

For wire and cable types and specifications, see **Table 2.**

All wire pairs shall be twisted, with maximum lay of the twist 50 mm for 0.5 mm^2, 70 mm for 1.5 mm^2 and 80 mm for 2.5 mm^2 conductors.

The minimum conductor size shall be 1.5 mm^2 for single and double pair cables and 0.5 mm^2 for multipair cables, or as recommended by the equipment manufacturer.

Multipair cables shall be standardized to 6, 12, 24 pairs, to the maximum extent possible.

All cables (single and double pair, multipair) shall be flame retardant according to **ELOT EN 60332-1.**

3.2 THERMOCOUPLE EXTENSION WIRE - HIGH AMBIENT TEMPERATURE 93 °C TO 200 °C

Individual conductors shall be 0.5 mm^2 solid alloy wire for multipair cable, 1.5 mm^2 solid alloy wire for single pair cable. Extension wire shall be insulated with extruded 205 °C Teflon and a Teflon jacket overall. This wire shall run from the thermocouple heads to a terminal box at a location where the temperature will not exceed 93 °C. General service thermocouple wire shall be run from the terminal box to the control room.

The individual conductors shall be twisted together, the lay of the twist to be no greater than 50 mm.

If general service calls for shielding, shielded wire shall be used.

3.3 COLOR CODING

The color coding for instrument cables shall be as per **Table 1.**

TABLE 1 INSTRUMENT CABLES COLOR CODE

SIGNAL VOLTAGE LEVEL/ TYPE	+ or LIVE	- or NEUTRAL	JACKET	GROUND
INTRINSICALLY SAFE CIRCUITS EXCEPT THERMOCOUPLES	BRIGHT BLUE	LIGHT BLUE OR WHITE WITH BLUE STRIPE	BRIGHT BLUE	
ALL AC DC > 48 Volts	BLACK	WHITE	BLACK	
DC Less or equal to 48 Volts	RED	WHITE	GRAY	
GROUND WIRE				Green with yellow stripe
THERMOCOUPLES	As per **ELOT EN 60584-1, -2 and -3**			
THERMO RESISTANCE	RED	WHITE	GRAY	COMPENSATION WIRE COLOR : BLACK

3.4 CABLE TYPE AND SPECIFICATION

3.4.1 The cable selections in the following table apply for ambient temperature below 93°C.

3.4.2 The capital letters in **Table 2,** on the next page, represent statements from the list that follows. For instance, the recommendations for the first category of wiring are contained in statements B, F, G, I, M and N.

TABLE 2

RECOMMENDED CABLE TYPES

SERVICE	ABOVE GROUND [Note (a)] CABLE TRAY		UNDERGROUND		
			CONDUIT		DIRECT BURIAL
	SINGLE/ DOUBLE PAIR	MULTIPAIR	SINGLE/ DOUBLE PAIR	MULTIPAIR	MULTIPAIR
- Analog Signals - On off "low-level" signals [Note (d)] - Intrinsically safe power supplies	B, F, G, I, M, N	A, B, C, H, M, O	F, G, I, M, N	A, C, H, M, O	A, B, C H, M, O
Thermocouples Extension Wire [Note (b)]	B, F, G, K, M, N	A, B, C, L, M, 0	F, G, K, M, N	A, C, L, M, 0	A, B, C, L, M, O
- On-off "high level" signals (AC, DC) [Note d)] - Power Supplies [Note (e)]	B, F, J	A, B, J	F, J	A, J	A, B, J
Digital Signals, Data Transmission (i.e. Mag Meters, P.D. Meters, Multiplex). All signal types for Computer [Note (c)]	B, F, G, M, N, 1	A, B, D, H, M, N	F, G, I, M, N	A, D, H, M, N	A, B, D H, M, N

NOTES :

(a) Cables for inside control room installation shall be similar to the cables specified for ABOVE GROUND INSTALLATION, but without armoring.

(b) See Section 3.2 for high ambient temperature extension wire.

(c) Computer manufacturer may require less protection.

(d) High level signals: DC > 48 Volts and all AC. Low level signals: DC less or equal to 48 Volts.

(e) ELECTRICAL SPECIFICATIONS should be used for cables with cross section greater than 2.5 mm^2.

LETTER DEFINITIONS (TABLE 2)

A. Multipair cables. Recommended pairing and jacket insulation shall be as follows:

No. OF PAIRS	2-8	10-24
Thickness of 80 °C Min.PVC Jacket	1.20 mm	1.50 mm

B. Cable shall be provided with overall armour of galvanized steel wires of the following recommended diameters:

No. OF PAIRS	1	6	12,24
ARMOR WIRE DIA	0.9 mm	1.25 mm	1.60 mm

C. The multipair cable shall have an overall shield; no shielding of pairs is required.

D. Each pair of the multipair cable shall be individually shielded. Each shielded assembly shall be protected and insulated.

E. The multipair cable shall have an overall shield with individual shielding of pairs. Each shielded assembly shall be protected and insulated.

F. Single and double pairs. Jacket insulation: min. thickness 1.20 mm, 80 °C minimum PVC.

G. The single and double pair cables shall be shielded.

H. 0,5 mm^2, 7 strand copper, 250 to 300 V conductor insulation of 0.50 mm min. thickness high density polyethylene or PVC, 90 °C minimum.

I. 1.5 mm^2, 7 strand copper; otherwise, same as H.

J. Same as H., except 0.5 mm^2 to 2.5 mm^2 conductor size shall be selected as appropriate.

K. 1.5 mm^2, solid alloy wire, matched and calibrated to **ELOT EN 60584-1, -2 and -3** insulated with min 1.20 mm thick of 105 °C PVC.

L. 0.5 mm^2 solid alloy wire, matched and calibrated to **ELOT EN 60584-1, -2 and -3** insulated with min 0.50 mm thick of 105 °C PVC.

M. Shield shall consist of a laminated tape of aluminium bonded to polyester, helically applied with 25% minimum overlap. Aluminium shall be in continuous contact with a 0.5 mm^2 tinned, stranded copper drain wire (solid copper drain wire for thermocouple extension wire). The shield shall be electrically insulated both inside and outside.

N. Shield thickness: 0.009 mm aluminium on 0.013 mm polyester tape.

O. Shield thickness: 0.024 to 0.05 mm aluminium on polyester tape.

P. Cable shield thickness same as O. Pair shield thickness same as N.

4.0 GROUNDING PRACTICES FOR EQUIPMENT AND CIRCUITS

4.1 GENERAL

Instrument circuits shall be grounded to reduce the effect of electrical interference upon the signal being transmitted.

Instrument Manufacturer's recommendation shall be carefully followed when locating this ground.

In general, the following rules shall apply:

(a) The circuit of a DC loop shall be grounded at only one point.

(b) Normally, the ground shall be located on the negative side of the DC loop power supply.

(c) The AC power supply shall be grounded.

(d) In loops involving a computer, the actual physical location of the ground shall be as recommended by the multiplexer supplier.

(e) When the connecting wiring for an instrument is of the shielded type, the shield shall be grounded at the control house end.

(f) Computer systems shall normally have separate grounding connections to the main ground bus for the equipment circuit, and shield grounding. For the main ground bus installation, see **Job Specification 700/5** and in **Job Specification 732/1.**

4.2 GROUNDING OF CABLE SHIELDS

All shields of shielded pairs, with the exception of thermocouples, shall be grounded at one end only, the termination point of the shield grounding to be in the control room.

Shielding shall be continuous from the signal source to the receiver.

Continuity of the shield shall be maintained throughout the cable run and isolated from ground at instruments, junction boxes, etc. This shall also apply to multipair cable with overall shielding.

Where shielded thermocouple wire is used, the shield shall be grounded near the point of the circuit ground. For grounded junction thermocouples, this means at the thermocouple head. For ungrounded junction thermocouples, this means at the control room.

Cables of thermocouple pairs having an overall shield shall have the overall shield grounded at the panel board for grounded and ungrounded junction thermocouples.

4.3 THERMOCOUPLE CIRCUIT GROUNDING

The selection of grounded junction or ungrounded junction thermocouples is usually determined by the requirements of the device to which the thermocouple is connected i.e., grounded junction thermocouples cannot be used with transmitters, mV alarms, or recorders that do not have isolated inputs.

Where ungrounded thermocouples are used, circuits shall be grounded at the receiving instrument.

5.0 ROUTING OF INSTRUMENT SIGNAL WIRING

Signal wiring shall be adequately separated from power wiring and electrical equipment to minimize noise. The following are minimum required separation distances between the signal wiring and the power conductors for parallel runs. Crossovers shall be made at right angles.

POWER WIRING CAPACITY	MINIMUM SEPARATION	
	SIGNAL WIRING OR THERMOCOUPLE WIRING IN RIGID STEEL CONDUIT	THERMOCOUPLE WIRING STEEL TRAY
125V 10A	300 mm	600 mm
250 V 50 A	450 mm	750 mm
440 V 220 A	600 mm	900 mm
5000 V 800 A	1200 mm	1500 mm

Multi-conductor cables shall contain only one type of circuit (e.g. analog signals, "on-off low level signals, "on-off" high level signals etc). An exception is that on-off "low-level" signals may be run in the same mutliconductor cable as analog signals with the Owner's Engineer approval.

Intrinsically safe wiring shall be separated from all other control, signal, and/or power wiring, as set forth in **Section 7.0.**

Where a strong magnetic field is known to exist, signal wiring shall be routed with respect to this field in such a way as to minimize interference (parallel to the magnetic flux lines).

Signal wiring shall not normally be routed through areas where ambient temperatures exceed 80 °C.

Wiring from a field junction box to individual field instruments shall consist of twisted pairs shielded and armoured, supported by cable tray.

No joints or splices shall be permitted in signal conductors except at terminal junctions in junction boxes.

Normally, single pair cable shall be installed above ground and run in cable trays. Single pair cables may be installed underground (direct barried) when field junction boxes are not foreseen, which is subject to Owner's Engineer approval. Multiconductor cables may be installed underground or aboveground as required.

When cables installed underground (direct barried) the underground route shall be identified with concrete markers at every point where the routing changes direction and at intervals not greater than 15m. Concrete markers shall be identified by metallic plates fixed by fully grouted screws/pins to the top of the concrete markers. A typical cable markers installation is provided on **Attachment A.**

Whenever feasible, transmission lines for electronic instruments and transducers shall be grouped together and run in multiconductor cable.

Transmission lines for thermocouples shall be handled in a similar manner (cabled separate from above).

Initially, at least 10% of the conductors shall be allowed as spares in each multiconductor cable.

The multiconductor cable leaving the ground, up to the junction box, shall be protected against mechanical damage.

Multiconductor cables running close to high fire risk equipment (e.g. hot pumps, heaters, etc.) shall be fireproofed or constructed from fire resistant materials according to **IEC 60331-11, IEC 60331-23.**

6.0 INSTRUMENT WIRING

6.1 GENERAL

For intrinsically safe wiring, unfused paralleling of transmitters on one DC power supply shall be avoided; a separate pair of wires shall be used. This is also advisable for non-intrinsically safe wiring.

Controllers, recorders, indicators, computer inputs, alarm relays, etc. shall operate on the voltage signal measured across vendor specified calibrated resistors. Resistors shall remain in the loop when any of these devices are disconnected for servicing. Milliammeters in a loop shall have a shunt.

Manufacturer's recommendation shall be followed when wiring special equipment such as turbine meters, magnetic flow transmitters, analyzers, etc.

Each pair of wires shall be adequately identified at any junction where other wires are present. All terminals shall be clearly identified. Terminals on the back of the main control panel shall be labeled with identification containing the instrument loop number.

6.2 WIRING OF CONTROLS

The instrument manufacturer's published limits on the resistive load which can be put on each signal generator shall not be exceeded. Allowance shall be made for low power supply voltage level.

Voltage signal receivers shall have an input impedance of more than 1000 times the impedance in the rest of the circuit. This includes the wiring and the output impedance of the signal source.

Control wiring terminal box connections shall be with a continuous drain wire for connecting all drains for pairs in cases where shielding is used.

6.3 WIRING OF CONTROLS AND COMPUTERS

In transmission circuits containing control and computer signals, the wiring practices shall be governed by the needs of the computer, as long as these practices do not conflict with intrinsic safety requirements.

The interface between computer and controls using a milliampere signal is a vendor specified precision resistor. The location of this resistor shall be the grounded side of the transmission loop or as recommended by the equipment manufacturer.

No loads other than computer loads shall be connected to the secondary of the computer isolation transformer.

All connections from the computer to the process controller shall be through circuits so designed that an open or short circuit on any computer input will minimize upset of the conventional control loop.

6.4 WIRING OF THERMOCOUPLES

The impedance of receiving instruments shall be at least 1000 times the sum of the impedance of the sensor and the connecting wire.

A thermocouple may be wired to two receiving instruments in parallel, such as a signal multiplexer and a temperature alarm, if both devices have an input impedance of one Mega Ohm or greater.

Grounding of thermocouples shall be as specified in **Section 4.3.**

Thermocouple terminal box connections shall be with tubular screw-type terminals and connections to make drain wire continuous from thermocouple to instrument, with isolation from ground in the terminal box.

7.0 WIRING OF INTRINSICALLY SAFE EQUIPMENT

Intrinsically safe equipment shall not be connected with systems:

a. Operating at different voltage levels.

b. Having different signal ground reference points.

c. Approved for different hazardous location groups, unless approved electronic safety barrier devices are used.

Intrinsically safe equipment of different manufacturers shall not be mixed without investigating the compatibility of certification.

The installation of safety electronic barriers shall comply with the following:

a. Segregation of intrinsically safe leads and terminals.

b. Protection of the barrier from dust, moisture, and exposure to an ambient temperature exceeding 48 °C and severe vibrations. Exposure to direct sunlight or sources of radiant heat shall be prevented.

c. Proper mounting and grounding of the barrier.

d. Cable shielding, when used, shall not bridge over the barrier.

To ensure an intrinsically safe system when using barriers:

a. There shall be no intrusion of outside power sources exceeding the barrier rating on the non- hazardous location side of the barrier.

b. There shall be no intrusion of outside power sources, including other intrinsically safe circuits, on the hazardous location side of the barrier.

c. There shall be no energy storage system (capacitive or inductive), in excess of the maximum permitted by the barrier design, on the hazardous location side of the barrier.

Generally, the safety barrier resistance represents a high percentage of the load capability of a transmitter or a controller. Therefore, a check shall be made to ensure that the resistance required for cabling plus other series connected devices, does not exceed the maximum load impedance of the instrument.

7.1 GENERAL

Since wiring rules for non-hazardous locations are less stringent than for hazardous locations, the likelihood for intrusion of unsafe energy into intrinsically safe circuits is greater in non-hazardous locations than in hazardous locations.

External to panels, the intrinsically safe wiring shall be separated from non-intrinsically safe wiring in enclosures, raceways, or cable trays, which are identified as containing intrinsically safe wiring. A portion of an enclosure, raceway, or cable tray compartment separated by an adequate insulating or grounded metal partition may be considered as a separate enclosure, raceway, or cable tray.

7.2 HAZARDOUS LOCATION WIRING OF INTRINSICALLY SAFE CIRCUITS

Precautions shall be taken to ensure against intrusion of unsafe energy from other circuits.

All intrinsically safe wiring shall be kept separate from non-intrinsically safe wiring.

The intrinsically safe wiring may be installed using any wiring method suitable for ordinary locations as though the hazardous location were not present.

In enclosures containing different intrinsically safe circuits, terminal strips shall be the type with physical partitions between terminals, i.e., "barrier type". Terminals for different intrinsically safe systems shall be separated by insulating or ground metal partitions.

All wiring at terminal strips shall be arranged so that it is unlikely for any conductor, upon coming loose from its termination, to contact a terminal of another circuit.

8.0 FIELD JUNCTION BOXES

8.1 ENCLOSURE

- Electrical protection according to : Area Classification.
- Degree of protection IP 55 minimum.
- Marking according to **: ELOT EN 60079-1.**
- Threads according to **: ELOT EN 10226** or **ISO 7-1**
- Terminal blocks: 2.5 mm^2, antiloosening type.
- Valve drain on bottom side.
- Ground terminals fitted internal and external.

8.2 SERVICE CONDITIONS

Service conditions are as stipulated in the project specific **BEDD Sheets.**

8.3 MATERIALS AND FINISHING

- Body and cover : Copper free aluminium or cast iron.
- Finishing : Corrosion resistant.
- Internal painting : Antifungous and anticondensation type (epoxy).
- External painting : Epoxy type, color to be light blue for intrinsically safe applications and grey for other applications.

8.4 APPLIED STANDARDS AND TEST CERTIFICATES

- **EU DIRECTIVE 94/9/EC ATEX**
- **ELOT EN 60079-0, 60079-1, 60079-7, 60079-11**

8.5 GENERAL NOTES

Manufacture/Vendor shall communicate any difference with the above specifications.

9.0 FIELD JUNCTION BOXES

Material Threads : - Stainless Steel or Nickel Plated Brass
ELOT EN 10226 or **ISO 7-1**

Degree of Protection : - Electrical Protection according to the Area Classification Study

Legislaltion/Standards : - **EU DIRECTIVE 94/9/EC ATEX**
- **ELOT EN 60079-0, 60079-1, 60079-7, 60079-11**

Service Conditions : See **BEDD Sheets.**

Notes: Cable glands to be of the double blocking type to provide:
a) Sealing of the outer sheath of the cable.
b) Sealing of the inner cable sheath.
c) Anchoring of the armour protection of the cable.
d) Earthing of the armour protection.
e) Explosion protection for Ex-d cable gland.

10.0 LABELING

A permanent label shall be attached to each end of single pair or multi pair cables. Intermediate labeling at internals not greater than 20 m and wherever there is a bend/T junction in cables trays is also required. (A typical example is given on **Attachment B).**

All conductors of both single pair - multi pair cables shall be labeled on each end. Conductors terminated as spare shall be labeled. All terminals and terminals strips shall be marked.

Junction boxes shall have a permanent label attached to the front of the box using at least four metal screws.

Labels identification shall be as per specified identification system.

11.0 CABLE TRAYS

Type : Prefabricated cable tray, complete with cover, prefabricated horizontal/vertical elbows, tees, reducing, bolts, nuts and all other accessories.

Material : Perforated steel-sheet, hop dip galvanized after fabrication.

Service Conditions : See **BEDD Sheets.**

Applied Standard : **ELOT EN** Standards and **IEC** recommendations

Dimension : Width (mm) 100, 200, 400, 600

Bar length : STD manufacturer
Side height min. 50 mm
Steel thickness min. 1.5 mm

Notes:

(1) Cable tray shall withstand the average load of a 50 kg per meter cable, for a tray width of 600 mm, plus the weight of one man required during cable laying.

(2) The cable tray shall be laid on suitable parallel support beams with cross members (perpendicular to the beams) in 1.2 meters max. distances (subject to supervisor's approval).

12.0 COMPLIANCE WITH EU DIRECTIVES

Instrumentation that complies with the "New Approach" directives shall be provided with:

a) A physical CE marking and other information, as required by the relevant directives.

b) A declaration of conformity, which lists all the directives with which the product complies.

c) Any other information specified by the directive, e.g. user instructions.

13.0 ATTACHED DOCUMENTS

1. **Attachment A**
   [Instrument Installation Details - Electrical / Cable Marker - Underground Cable Runs]

2. **Attachment B**
   [Instrument Installation Details - Electrical / Cable Tagging]

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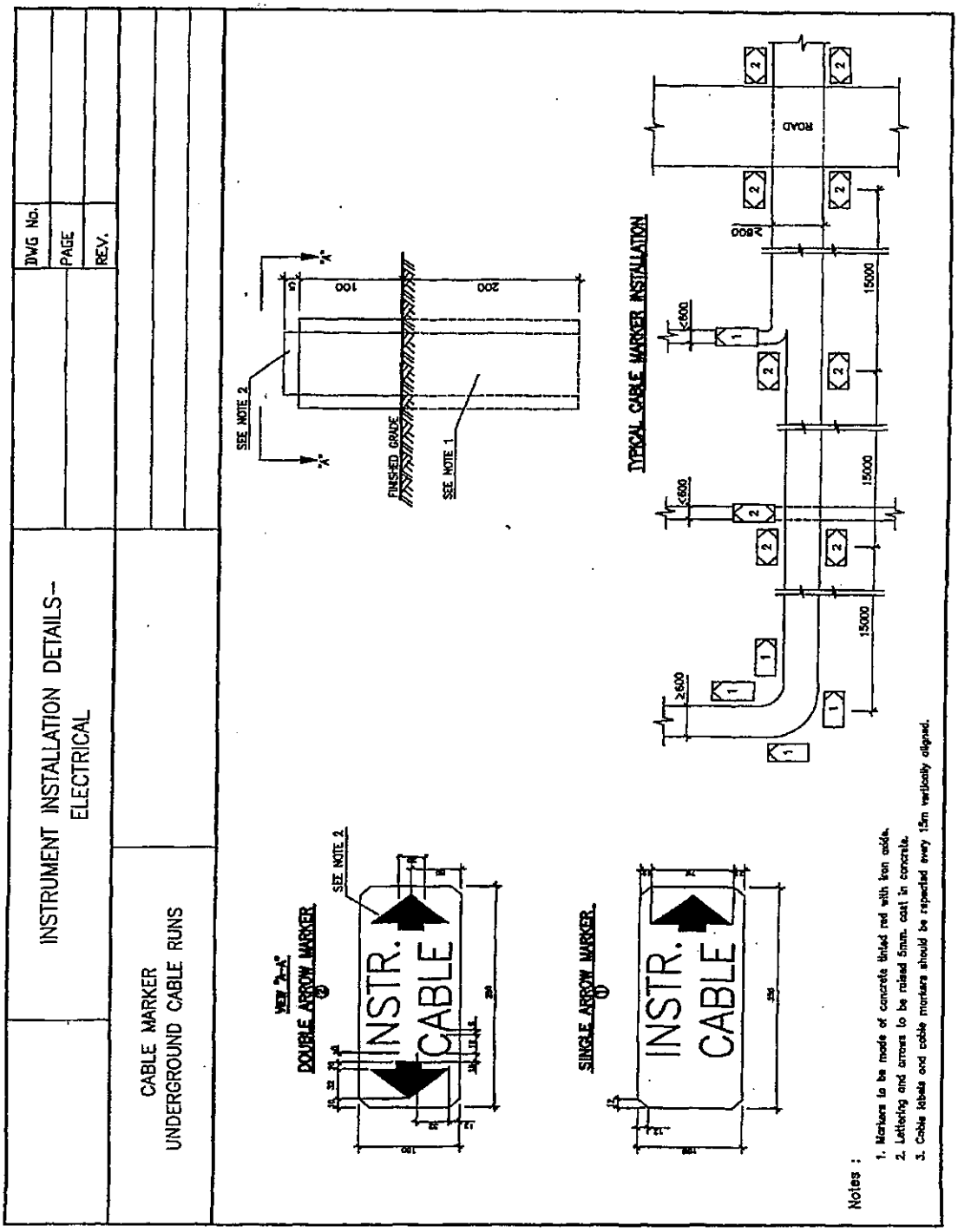
Attachment A



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Attachment B