

Electrical Requirement of Package Equipment

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1. GENERAL

1.1 Scope

This specification defines the minimum requirements for the electrical equipment and materials furnished and electrical installation as part of the packaged equipment.

1.2 Units

Unless otherwise specified, international SI units shall be used for all drawings and documents to be submitted by the manufacturer.

1.3 Manufacture's drawing and documents

Drawing and documents shall be submitted according to the list of Vendor data requirement and schedule. Purchaser's approval for such drawings and documents shall not relieve manufacturer of his responsibility to meet all requirement of the purchase order.

1.4 General requirements

All necessary electrical apparatus and materials shall be furnished to provide a complete, safe, and operable unit to the extent required by the equipment specification and data sheets. The electrical equipment and materials furnished shall be suitable for operation in the environmental conditions specified in Paragraph 3.5.

Reliability of all electrical equipment to perform continuously in the service conditions specified is essential. Equipment typical of that being supplied shall have been in operational use elsewhere for the term which is stipulated in the contract. Prototype or unproven equipment not having a well-established record shall not be employed. Reference record shall be provided.

2. CODES AND STANDARDS

The electrical equipment, materials, and their installation shall conform to the applicable provisions in the latest edition of the following codes and standards:

1) API (American Petroleum Institute)

API RP 500 (2012) : Recommended Practice for Classification of Locations for Electrical Installations at Petroleum Facilities Classified as Class 1, Division 1 and Division 2

API RP 505 (2018): Recommended Practice for Classification of Locations for Electrical Installations at Petroleum Facilities Classified as Class 1, Zone 0, Zone 1 and Zone 2

API RP 540 (1999): Electrical Installations In Petroleum Processing Plants

2) IEEE (Institute of Electrical and Electronics Engineers)

IEEE C37.20.1 (2015): IEEE Standard for Metal-Enclosed Low-Voltage (1000V ac and below, 3200V dc and below) Power Circuit Breaker Switchgear

IEEE 519 (2014): IEEE Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems

3) KS (Korean Industrial Standard)

KS C IEC 61439-1 (2019): Low-voltage switchgear and controlgear assemblies - Part1 : General rules

KS C IEC 60364-5-52 (2012): Electrical installations of buildings - Part 5-52 : Selection and erection of electrical equipment - Wiring systems

4) KGS (Korea Gas Safety) Code

KGS GC102 (2018): Design, Selection and Installation Code for Explosion-proof Electrical Equipment

5) IEC (International Electrotechnical Commission)

IEC 60529 (2013): Degrees of protection provided by enclosures (IP Code)

IEC 60079-0 (2017): Electrical apparatus for explosive gas atmospheres - Part 0: General requirements

IEC 60079-1 (2014): Electrical apparatus for explosive gas atmospheres – Part 1: Equipment protection by Flameproof enclosures “d”

IEC 60079-2 (2014): Electrical apparatus for explosive gas atmospheres – Part 2: Equipment protection by pressurized enclosure “p”

IEC 60079-7 (2017): Electrical apparatus for explosive gas atmospheres – Part 7 : Increased safety “e”

IEC 60079-10-1 (2020): Electrical apparatus for explosive gas atmospheres – Part 10-1: Classification of areas – Explosive gas atmospheres

IEC 60079-11 (2011): Electrical apparatus for explosive gas atmospheres – Part 11: Equipment protection by intrinsic safety “i”

IEC 60079-14 (2013): Electrical apparatus for explosive gas atmospheres – Part 14: Electrical installations design, selection and erection

IEC 60079-15 (2017): Electrical apparatus for explosive gas atmospheres – Part 15: Type of protection “n”

6) NEC (National Electrical Code)

NFPA 70 (2020)

7) NEMA (National Electrical Manufacturers Association)

NEMA MG-1 (2016) Motors and generators

8) LOCAL Code and Regulations (KEC and KOSHA Code)

For electrical equipments and instruments such as motor, control panel, etc., to be installed in hazardous area, certification for hazardous application which is issued by Korea Occupational Safety & Health Agency (KOSHA) for Korean Government’s approval shall be submitted to purchaser.

In cases where no relevant code or standard exists for a particular item, the Manufacturer shall identify these items, and shall provide sufficient data regarding the proposed design to enable the Purchaser to evaluate the general standard to which the plant shall be designed, constructed, tested and guaranteed.

3. GENERAL CONDITIONS OF USE

3.1 Supply Conditions

3.1.1 The following electrical power supplies shall be made available for use:

- 1) For normal power supplies **(HOLD)**
 - 6.6kV, 3Ph 3wire, 60 Hz : Low resistance grounded
 - 440V, 3Ph 3wire, 60 Hz : High resistance grounded
 - 380-220V, 3Ph 4wire, 60 Hz : Solidly grounded
- 2) For UPS power supplies
 - 380/220V, 3Ph 4 wire, 60Hz

UPS power is only available to packages requiring uninterrupted power to safely monitor and shutdown systems on loss of normal power. It is not available for general use.

- 3) For DC control voltage
 - DC 110V

3.1.2 The system/equipment shall be fed from the following system voltages

- 1) Motors
 - Motors above 149.2kW (200HP) : 6.6kV, 3ph 3w, 60Hz
 - Motors up to 149.2kW (200HP) : 440V, 3ph 3w, 60Hz
- 2) Lighting, receptable, electric heat tracing : 380/220V, 3ph 4w, 60Hz
- 3) Space heater : 220V, 1ph 2w, 60Hz

The primary power of above power supply will be supplied by the Purchaser. If The redundant power supply unit and voltage other than those mentioned above is required, the equipment Vendor shall furnish, install, and wire as part of the package the necessary transformation equipment. The Supplier shall state in the proposal the power consumption required for the operation of the package system. All equipment shall be fully rated for the operating conditions.

3.2 Service conditions

The area of installation is made corrosive by traces of chemicals normally present in the plant site, and other environmental conditions at the plant site such as high winds and snow storms. Service conditions shall take into account climatic conditions, unless otherwise specified.

3.3 Installation conditions

In all cases, electrical equipment shall be suitable for service at the location where it is installed. All electrical equipment, materials and installation for use in hazardous (classified) locations must comply with the standards and regulation.

3.4 Area classification

The area classification will be stated in the basic equipment specification. If the area classification is not given, the equipment Vendor shall contact the Purchaser to establish the designated classification before starting the design, manufacture, and installation of the electrical equipment and materials.

4. EQUIPMENT AND DESIGN

4.1 Motor

4.1.1 Motors shall be of the type and construction described in the motor specifications and data sheets.

4.1.2 Vendor shall provide detail electrical power consumption list including motor and heater data sheets.

4.1.3 All motors shall be furnished by the packaged equipment vendor. When motors are supplied with skid mounted and located at inconvenient place for direct wiring by Purchaser, junction box(es) with interconnection by means of conduit to the motor shall be provided by the Vendor. The junction boxes shall be provided with "NPT" thread type conduit entrance. Ground terminals shall be provided on the skid where required. The further requirements for junction box are described in section 4.5.

4.1.4 Motor controls, generally, will be supplied by the Purchaser in the motor control centers. The equipment Vendor shall state the characteristics of the starting equipment required. If, in special cases, the equipment Vendor normally provides motor starters, they shall be approved combination magnetic starter with molded case circuit breaker of appropriate rating and housed in suitable enclosure for the service condition.

4.1.5 VVFs are required for soft-start and speed control applications and shall be used in conjunction with motors. The VVFs shall have the capability to deliver sequential starting and loading duties without restriction. The VVFs shall be rated to continuously supply 100% of the motor full load current and capable of delivering nominal power constantly. To avoid disturbances, all the VVFs have to supply minimum amount of harmonics and meet the IEEE Std. 519.

4.1.6 The VVVF shall be installed in the Vendor's panel. Principal specifications are below.

- Output frequency accuracy $\pm 0.5\%$ for maximum output

- Acceleration time to be suitable for each load
- The starting current and time of motor connected with VVVF shall be optimized to suitable for the process condition and the power system by Vendor.
- Installation space shall be designed to minimize.

4.1.7 VVVF shall communicate with the Vendor's control system as follows. (minimum)

Signal	Interface Condition
Start/Stop	Dry Contact (24Vdc)
Emergency Stop	Dry Contact (24Vdc)
Speed reference signal	4-20mA = 0-100% Speed
Operating ready signal	Dry Contact (24Vdc)
Running signal	Dry Contact (24Vdc)
Fault signal	Dry Contact (24Vdc)
Motor Speed	4-20mA=0-125% speed

4.2 A package unit and control panel

When a package unit contains a number of motors and other electrical devices to be controlled as a unit, a control panel shall be furnished by the equipment Vendor. This control panel shall contain all the necessary pushbuttons, selector switches, indicators, relays, timers, control transformers, contactors, etc., required for control and operation of the unit. The requirements of the above mentioned control components are described in section 4.10.

- 1) All electrical devices within the control cabinet shall be pre-wired by the Vendor. Terminals blocks shall be provided within the cabinet for wiring to any externally located devices. Spare terminal block capacity of 20% shall be provided.
- 2) The control cabinet shall be mounted on the packaged unit skid, and the Vendor shall install all wiring between the cabinet and skid mounted devices. The electric control cabinet shall be separated from instrument control cabinet.
- 3) If, for some reason, the control cabinet cannot be physically mounted on the packaged unit skid, the Vendor shall wire all skid mounted devices to a skid terminal box.
- 4) The scope of wiring shall be defined on the configuration block diagram to be submitted at the stage of Quotation. This configuration block diagram shall show all the electrical equipment and devices.
- 5) Control panels shall be provided with a minimum of 20 percent spare space for future additions to the associated control systems. This space shall be allocated for each of the control logic, and power distribution sections of the panel and cabinet.
- 6) Cable entrance to control panels/cabinets shall be designed to be possible from bottom.

4.3 Enclosure

- 4.3.1 Enclosure shall be suitable for the site conditions and area classification stated in the equipment specification and data sheets. Control panel and wiring system must be compatible with the Purchaser's design.
- 4.3.2 The material of control panels/cabinets for indoor use shall be rolled steel for general structure SS400 and stainless steel SUS304 for outdoor use. The thickness of enclosures of control panels/cabinets shall be at least 2.3mm, but the thickness of front faces where control switches or meters are installed shall be at least 3.2mm. All bolts, screws, washers etc. shall be stainless steel.
- 4.3.3 Adequate ventilation shall be provided depends on the operation and installation conditions in case of the high heat generation and ambient temperatures in order to remain within the specified limit.
- 4.3.4 Protection degree of electrical equipment enclosure
The enclosure located in non-hazardous indoor area shall be IP42(Minimum), outdoor area shall be IP55(Minimum). Where outdoor equipment is subject to routine deluge testing or other powerful water jets, it shall have minimum degree of protection equal to IP55 as defined in IEC 60529. Electrical equipment and materials located in hazardous area shall be in accordance with area classification by IEC 60079.
Where higher degrees of protection are required as part of the certification requirements for explosion protected apparatus, these higher values shall be used.
- 4.3.5 All enclosures specified for outdoor installation shall be designed to shed rainwater and prevent the accumulation of standing water on any part of the enclosure. All joints and seals shall be designed to totally prevent ingress of water. Luminaires, marshalling boxes, junction boxes, remote control units and socket outlets installed in outdoor locations shall be of a standard pattern to avoid a multiplicity of different types, and shall be certified for use in the highest classification of hazardous area in which they are installed.

4.4 UPS

UPS system supplies 380/220V power to essential instrumentation circuits, all Local Control Panel operation circuit, lighting circuit in the switchboard, safety lighting etc.

4.5 Junction Boxes

- 4.5.1 All outgoing electrical connections from the package shall be grouped and wired to junction boxes located in an accessible position, with adequate space for routing and connection of outgoing cables, allowing for Manufacturer's minimum bending radii.
- 4.5.2 On-skid junction boxes shall be provided by the Supplier. Separate junction boxes shall be provided for low-voltage control, indication circuits and power circuits.

- 4.5.3 Explosion proof junction box shall be selected according to the group of hazardous areas..
- 4.5.4 The material of enclosures of junction boxes shall be stainless steel and the thickness shall be at least 1.5mm.
- 4.5.5 Junction boxes provided for the Purchaser connections shall be positioned or bottom cable entry unless otherwise specified.
- 4.5.6 The size of cable for entry hole will be provided later according to the cable size calculation.

4.6 Lighting

- 4.6.1 Interior lighting shall be provided where feasible and for condition whereby on site localized lighting is required due to packaged equipment obstruction (e.g. shed, container, cabinet).
- 4.6.2 Each control panel shall be equipped internal LED or Fluorescent lamp controlled by the door switches.
- 4.6.3 The voltage for lighting is applied as single-phase 220V unless otherwise specified.
- 4.6.4 Explosion-proof luminaires shall be selected according to the group of hazardous areas.
- 4.6.5 The Manufacturer shall provide package equipment lighting system and shall submit a lighting scheme for approval

4.7 Hazardous Area Classification

Selection of electrical equipment and materials shall be in accordance with recommendations and standards, API RP 505 and IEC 60079 (Electrical apparatus for explosive gas atmospheres). Classifications of hazardous areas for selection of electrical equipment shall be in accordance with IEC 60079. Suitably certified equipment shall be used in the designated hazardous areas.

4.8 Earthing

Main mesh grounding grid will be provided with the grounding resistance below 1Ω. Earthing within the package shall be the Manufacturer's responsibility and shall be connected to the main mesh grounding grid. To ensure the requirements for earthing, each packaged unit shall be provided with two M10(SUS316)-earth bolts, nuts, washers and lugs easily accessible and at diagonally opposite ends of the skid. The position of all earthing connections shall be visible and easily accessible. Earthing points shall be protected against corrosion and designed to ensure that effective electrical and mechanical connections can be made. The earthing symbol or legend shall identify this device. The Supplier's certified drawings shall show the location and type of grounding provisions for each frame size for Purchasor's approval.

4.9 Nameplate

Externally visible, permanent nameplates shall be provided for each control panel (part of packaged system) to identify each instrument, switch, meter, relay, control switch, indicating light, circuit breaker, etc. Equipment and terminal blocks within the control panel shall be suitably identified as well. Nameplates shall be Stainless Steel with clearly engraved text and numbering characters. Nameplates shall be attached with stainless steel drive screws. Adhesives are not permitted.

4.10 Control components

Motor starters, contactors, relays, push buttons, selector switches, indicators and contacts to be furnished are subject to approval to ensure uniformity of materials and devices for the project.

4.10.1 Motor starters including overload, relay contactors and control transformer

- 1) Minimum size of starter shall be NEMA 1 with 3 overload relays. Overload protection shall consist of electronic devices, three thermal overload relays with open-phase protection device and ambient temperature compensator. Overload relay operation mode shall be manual reset only and external reset button shall be provided to enable overload relay to be RESET from control panel, without opening the cover.
- 2) For each motor starter, control transformer shall be furnished with secondary fuse in ungrounded circuit to protect the control transformer
- 3) Magnetic contactors supplied by the Supplier to control non-motor loads such as heaters shall not include overload elements.
- 4) Magnetic contactors for those loads critical to plant operation shall be the mechanically held type, if required.

4.10.2 Relays

- 1) On front of control panels and cabinets, protection relays and instruments shall be installed. The protective relays shall be semi-flush mounting or draw-out type with test devices. The type and details shall be subjected to the approval of Purchaser.
- 2) Relays having electronic device shall be connected by plug-in. The relays shall have fixing tools for keeping the state at service position.
- 3) Relays shall be enclosed by dust proof cases. Metal bases and frames of all relays except that insulated for special purpose shall be grounded. Essential relays for protection shall be installed on front of panel and other relays shall be installed on the rear of panels for easily inspection and wiring.
- 4) Contacts of relays shall have sufficient capacity for “making” at the maximum current that can occur in control circuit. Also the contacts shall have sufficient capacity for “breaking” without auxiliary devices. Contacts shall be made of proper material for

repeated operation without damage of contact side. The relays shall not be influenced by mechanical shock, vibration or external magnetic field.

- 5) The relays shall have an operation indicator.
- 6) The relays shall be installed against influx of dust into the relay mechanism when the case open. The time delay adjustment shall not be used dashpot type when relays are required time delay operation.

4.10.3 Push buttons and Selector Switches

Push buttons and selector switches shall be the heavy duty, oil-tight, water-tight type.

Detail type of push buttons, selector switches and emergency stop pushbutton shall refer to Specification for Instrumentation for Package Items

4.10.4 Indicating Lights

Indicating lamp shall be LED (Light Emission Diode) type including resistance to meet KS C 2606 requirements. Lamps and lens shall be replaceable from the front of the panel. The colors of indicating lights are as follows :

- 1) Red : Equipment or process operating, flowing or in an increasing conditions, breaker closed.
- 2) Green : Equipment or process not operating, not flowing or in a decreasing conditions, breaker open.
- 3) Yellow : Overload, automatic trip.
- 4) White : Ready or automatic standby.

Blue indicating lights shall be avoided because of the low level of brightness obtained with this color. Lights that indicate equipment status such as motor operated valves, or isolation gates shall show both red and green lights when in intermediate positions.

4.10.5 Contacts for use in control and instrument transmitters located outdoors shall be hermetically sealed where available to provide maximum protection against dust and corrosion.

4.10.6 Control panel mounted ammeters and voltmeters shall be provided, where it is necessary to monitor amperes, volt, kilowatts and kilowatts hours on the metering as a minimum.

4.11 Testing

The unit shall be completely factory wired and tested.

4.12 Operation requirement

4.12.1 Electrical devices shall be selected on the basis that a voltage dip down to 90 percent of the system voltage of several seconds duration does not cause the equipment to shutdown.

4.12.2 Motor shall be capable to accelerate to nominal speed at 80 percent of rated voltage at the motor terminals.

4.13 General requirement of protection

Suitable circuit protection shall be supplied for controls so that any one electrical fault does not affect more than one unit or system. The protection can be accomplished by either circuit breaker or fuse, except that fuses shall be allowed only 110V, single-phase circuits.

4.14 Control circuits and transformer

Control circuits shall be DC 110V for SWGRs and AC 220V, 60Hz for MCC (Motor control center). Manufacturer shall supply, mount, and wire the necessary control devices and transformers. The secondary of each control transformer shall be fused on one side and solidly grounded on the other side.

4.15 Control and alarm circuits

Control and alarm circuits shall be designed to fail safe. That is, open-circuiting of one wire, short-circuiting of one wire or failure of a component shall not cause machinery to start up. Failures shall trip an overload element, or render equipment inoperative, or for critical service sound an alarm

4.16 DC control

If DC control power is required, solid state conversion units of the silicon type are preferred.

4.17 Instrument Control Panel

4.17.1 Refer to the appropriate instrument control panel specification.

4.17.2 The Control Panel shall be mounted on the packaged unit skid, and the Vendor shall install all wiring between the cabinet and skid mounted devices

4.17.3 If, for some reason, the Control Panel cannot be physically mounted on the packaged unit skid, the Vendor shall wire all skid mounted devices to a skid terminal box.

4.17.4 The scope of wiring shall be defined on the configuration block diagram to be submitted at the stage of Quotation.

This configuration block diagram shall show all the E&I equipment and devices.

4.18 Space heaters

4.18.1 Outside-mounted control panels shall be provided with thermostatically controlled anticondensation heaters. Thermostat control of the space heater shall turn the heater on/off

depending on the internal temperature of panels. Heaters and thermostats must be installed for easy removal and replacement.

4.18.2 Space heaters shall be wired for 220V, 1Ph operation.

4.19 Other heaters

4.19.1 Other heaters shall be wired as follows:

- 1) Up to 3kW, 220 volts, 1Ph
- 2) Above 3.1kW, 440 volts, 3Ph 3w

4.20 Painting

According to manufacturer's standard procedures, surface of control panels and cabinets shall be cleaned and performed uniformly anticorrosive final painting. Interior and exterior finish color of control panels and cabinets shall be Munsell No.N7.5

5. WIRING SYSTEM

5.1 Wire and Cable

The Vendor shall install all wiring between devices supplied by vendor and terminal boxes for Purchaser's cable connections. All cabinet, panel, or control device wiring for connection to external circuits shall be wired, to terminal blocks or connectors. The purchaser will provide only the wiring between the packaged unit and devices which are located remote from the skid.

5.1.1 When equipment must be furnished or shipped in different sections (or skids), the Vendor shall provide a terminal box on each section of the packaged system.

5.1.2 All wiring shall be protected from sharp edges and corners. Enough terminals should be provided to accommodate all field device wiring plus 20 percent spare terminal points. Adequate wireways shall be provided for the external cabling to the terminal blocks.

5.1.3 In hazardous area, the connection between wires and equipment shall be made in the explosion-proof housing. In order to protect the equipment, sealing devices (sealing fitting or packing type cable gland) shall be installed. The distance from the nearest surface of the sealing device to the housing shall be less than 50mm.

5.1.4 The Purchaser will install any wiring required between the different section terminal boxes and devices terminal boxes which are remote from the packaged system. Then Vendor shall clearly label all terminal blocks, terminals and wires.

5.1.5 Wiring systems are classified into three major groups as follows:

- 1) Medium voltage (6600 V)
- 2) Low voltage (600 V and below)
- 3) Instrumentation (low level)

Care shall be taken not to induce voltages in low-level signal wiring and electronic instruments. Segregation of low-level signals, AC power, and alarm wiring shall be maintained.

5.1.6 Medium voltage cable (6600V)

Conductors for 6.6kV circuits shall be stranded copper, single conductor, 6.6kV 90°C with extruded conductor shield, cross linked polyethylene insulation, tape or extruded insulation shield, 5 mils overlapped copper tape shield, and polyvinyl-chloride jacket. Cable terminations shall be the outer shrink tube with tinned copper UL 2-hole lugs for MV applications. Minimum cross section shall be 95sq.mm.

- MV cable : 6/10kV F(or TFR)-CV cable

5.1.7 Low voltage power and control cable (600 V and below)

Conductors for circuits below 600 volts shall be stranded copper. Minimum wire size shall be 4 sq.mm, except that 2.5 sq.mm can be used for control wiring. Type of the LV and control cable shall be following :

- 1) LV cable : 0.6/1kV F(or TFR)-CV cable

- 2) Control cable : 0.6/1kV F(or TFR)-CVV, F(or TFR)-CVVS, F(or TFR)-CVVSB
- 3)

5.1.8 Wire size shall not be less than the following:

- 1) Power circuit 125% of equipment rated current
- 2) CT and PT circuit min. 4 sq.mm
- 3) Control circuit min. 2.5 sq.mm
- 4) Instrument circuit min. 1.5sq.mm
- 5) Other low energy circuit By Vendor's standard

5.1.9 Wires to anti-condensation heaters shall be of heat resistant type.

5.1.10 Cable color

Cable color shall be in accordance with the table below. For multi core control cable, KEC standard shall be applied.

Cable		Color
Sheath	Medium Voltage Power	Black
	Low Voltage Power	Black
	Control	Black
	Signal	Black
	Communication	Black
	Grounding	Green/yellow striped
Power Cable Core (3Ph)	L1	Brown
	L2	Black
	L3	Gray
	Neutral	Blue
	PE	Green/Yellow striped
Power Cable Core (1Ph)	L1	Brown
	Neutral	Blue

5.1.11 Earthing Cables

Earthing cables shall have a stranded, annealed copper conductor and minimum cross section shall be 4sq.mm.

- Earthing cable : B.C wire, F-GV, 450/750V HFIX cable

5.1.12 Cable Trays

All cabling shall be carefully supported, routed and fixed into place to avoid cable sag, stress on cable terminations and mechanical damage. Covers manufactured from Stainless Steel (STS 304) shall be provided for top layer of the cable tray exposed to sun or flare radiation. The cables shall be brought to motors and other devices using a conduit or a branch of cable tray for mechanical protection. The cable tray shall be Hot Dip Galvanized steel. The size of cable tray shall comply with the following:

- 1) For power cable : total cross-sectional areas shall not be more than 20% of the sectional area of the cable tray.
- 2) For control cable : total cross-sectional areas shall not be more than 40% of the sectional area of the cable tray.

5.1.13 Conduits

The size of the conduit is designed and reflected in consideration of the margin value to prevent reconstruction after installation of the conduit. The conduit shall be Hot Dip Galvanized steel. Total cross-sectional area including the insulated material of the electric cable shall not be more than 48% of the sectional area of the conduit. In case of installation of different thicknesses of the wires in the same conduit, it shall be not more than 32%.

5.2 Instrument cable

5.2.1 Instrument cable may be shielded single pair or triad, twisted with 600/1000 volts, PVC- insulated copper wire or multiple shielded pairs or triads cable with overall shield, 600/1000 volts, PVC- insulated copper wire.

5.2.2 Thermocouple extension wire material shall be the same as the thermocouple material.

MATERIAL	ISA Symbol
Copper - Constantan	Tx
Iron - Constantan	Jx
Chromel - Alumel	Kx

5.2.3 Single pair thermocouple extension wire shall be solid, twisted pair, size 1.5 sq.mm. Minimum insulation shall be 105°C PVC for the inner conductors and 80°C PVC for the overall jacket. A shield of aluminum mylar tape with copper drain wire shall be provided for each single pair.

5.2.4 Multipair thermocouple extension cable may be used when eight or more pairs of thermocouple extension wire are required.

5.2.5 Multipair thermocouple extension cable shall contain not less than eight pairs or more than 24 pairs.

5.2.6 Multipair thermocouple extension cable shall be solid, 1.5 sq.mm. Insulation shall be a minimum of 105°C PVC for the inner conductors and 80°C PVC for the overall jacket. An overall aluminum mylar tape shield and copper drain wire shall be provided.

5.2.7 A minimum of 15 percent of the total number of pairs shall be provided as spares.

5.3 Wiring Method

5.3.1 All electrical equipment, enclosures, wiring and installation methods shall conform to the latest edition of the standards and regulations mentioned in this document, and State and other local codes and regulations having jurisdiction at the job site.

5.3.2 Wiring method shall be made in accordance with NEMA standard, Class II.

5.3.3 Wiring type shall be used type B for power and type C for control system.

5.3.4 All wiring shall be carried in rigid galvanized steel conduit, except that a short section (not to exceed 1500mm.) of flexible liquid-tight conduit or explosion proof flexible coupling may be used for flexibility and vibration. Minimum conduit size shall be 22mm except that the conduit connecting a single electrical instrument or device to a major conduit run or to a junction box may be 16mm.

5.3.5 For external wiring to the terminal blocks, suitable conduit shall be provided. The size and type of the conduit shall be selected in accordance with KS standard based on operation and installation conditions.

5.3.6 Wiring shall have a minimum bending radius suitable for wire used (sharp-bends shall not be used), and be free of abrasions and tool marks. Wiring shall be supported to prevent sagging and breakage caused by vibration

5.3.7 The minimum wire size of single wires pulled in a conduit shall be 1.5 sq.mm.

5.3.8 Wiring shall be routed to minimize accidental mechanical abuse and possible damage from fire or overheating.

5.3.9 Terminations on stranded wire shall be made by using solderless flanged spade lugs.

5.3.10 Each wire shall be tagged at both ends by means of heat-shrink type marker. Wire tag shall be in accordance with approved wiring diagram.

5.3.11 Wiring of different voltage levels shall be placed in separate conduit. The following shall be grouped in its own conduit to its own junction box.

- 1) Thermocouples
- 2) Analog signals (4-20 mA DC)
- 3) Contact closures for alarms which use DC voltage and DC voltage signals for relays and solenoids
- 4) 220V AC signals and 220V AC power

5.3.12 Wiring shall run from terminal to terminal with no splices or twist-on wire connectors.

5.3.13 Terminations of thermocouple extension wire shall be directly to the instrument terminals or to junction box terminals. Terminal connections shall be made directly to the terminals without the

use of lugs or other connections. The shield of a single pair thermocouple extension wire shall be grounded at the thermocouple head only, except where individual thermocouple wiring is collected at a local field junction box. The shields for the individual pairs shall be connected to the overall shield for the multiple cable and grounded at the local junction box.

5.4 Marking and Labeling

5.4.1 The numbering procedure shall refer to Owner's Spec.

5.4.2 All interconnecting wiring internal cabinets and between cabinets shall be the responsibility of the Vendor. Permanent markings shall identify each terminal(at device and terminal block) in accordance with the wiring and schematic diagrams. Each conductor shall be similarly identified at each terminating point using PVC lables with transparent tube cover to prevent the number from being erased. It shall be a sleeve type smear-proof, non-conductive wire marker. Marking should be able to withstand the same environment as the cable insulation. All interconnecting wiring shall be labeled on the way can easily readable.

The color of mark bank shall be following :

Phase	L1	L2	L3	N	DC(P)	DC(N)
Color	Brown	Black	Gray	Blue	Red	Black

5.5 Grounding System

5.5.1 Grounding loop connections inside skid and vendor's equipment shall be furnished by vendor considering following sub-articles. Purchaser shall connect between main ground loop and vendor's grounding bosses.

5.5.2 Grounding and bonding shall be applied to all non-current carrying metallic parts of major electrical equipment to include switchgear, starters, control panels, transformer tanks, motors, generators etc.

5.5.3 The grounding and bonding shall be designed to protect person and equipment against earth fault currents, lightning and static discharge.

5.5.4 The panel main earth conductor shall be hard-drawn high-conductivity copper bar (min. 25mm x 6mm), sized to carry a current equivalent to the fault current and time detailed in data sheet.

5.5.5 The main earth bar shall run the full length of the assembly. For direct connection to the station earth grid, earthing bolts, nuts and spring washers shall be provided suitable for stranded copper cable sized 95sq.mm at both ends of the main earth bar.

5.5.6 Bonding connections for earthing doors shall be so arranged to preclude damage during door opening and closing.

5.5.7 Lightning protection for tall steel structures such as towers, etc. shall be provided by connecting the structure to a lightning protection grounding system. Air termination shall be provided at the

top of masonry stacks and other tall masonry or concrete structures, and shall be connected to the lightning protection grounding system by means of GV 95sq.mm attached to the outside of the structure. The lightning protection system shall be installed in accordance with NFPA or equivalent

6. OTHER EQUIPMENT MANUFACTURER

All purchased equipment and devices such as relays, timers, instruments, motors, etc., shall be identified by manufacturer's name, model number, and complete electrical rating in the instructions and parts lists.

7. DOCUMENTATION

The following documents and drawings, as a minimum shall be submitted.

- 1) Equipment outlines and arrangement drawings.
- 2) Elementary or schematic diagrams.
- 3) Connection wiring diagrams.
- 4) Control panel (All drawings).
- 5) Bill of material - Parts list.
- 6) Installation operating instructions.
- 7) Necessary conduit and/or entry arrangement and sizes.

8. TESTING

Each unit of Electrical Equipment shall undergo the following tests and checks by Vendor. Test shall comply with the requirements of all relevant standards listed in this document.

- 1) Except for low energy and electronic circuits, wiring at all voltage levels shall be checked for insulation resistance.
- 2) All circuits shall be checked for continuity.
- 3) A functional test shall be performed, in addition to the continuity check, before shipping. A functional test consists of simulating the Purchaser's devices with breadboard switches, relays, lights, or resistors and of exercising each circuit.
- 4) A functional test on site shall be implemented by Vendor after equipment installation and Vendor shall submit the inspection and Test Procedure (ITP) prior to testing.