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RECOMMENDED WIRING PROCEDURES FOR INDUSTRIAL INSTRUMENTATION AND CONTROL SYSTEMS

Although industrial instrumentation and control systems vary greatly in function and application, they are generally comprised of components that fall into three major categories; *input devices*, signal conditioning or *processing devices*, and *output devices*. The electrical power and control signals characteristics associated with devices from each or these categories may be a combination of AC or DC, High or Low Frequency, Analog or Digital, High or Low Impedance, and Resistive or Reactive in nature.

Interconnection of devices in an instrumentation/control system is most economically accomplished by placing electrical circuits in close proximity to each other wherever possible. This approach is generally possible when the characteristics of the individual electrical circuits are similar, however when the signals differ in nature it is most likely that signal integrity will be adversely affected. This relationship of electrical circuits is known as Electromagnetic Compatibility (EMC).

In order to properly install field wiring to interconnect instrumentation and control system devices, it is essential that all electrical circuits routed in close proximity to each other be Electromagnetically Compatible. This is the basis of the wiring recommendations that are provided in this technical bulletin, close adherence to these guidelines is further recommended to avoid Ground Loop Current and Noise Susceptibility problems.

1. System Separation

Wiring for different electrical signal sources should not share the same cables, terminal/pull boxes, or conduit. The following signal groups should be separated from each other:

i. AC Mains supply circuits.
ii. Low voltage DC control signals and digital data busses for multiplexers, Programmable Controllers, computers, etc.
iii. Low impedance instrumentation and control signals (mA current loops).
iv. High impedance instrumentation and control signals (mV signals).

2. Power and Signal Spacing

To provide accurate measurement and control, instrument signal cable and conduit must be spaced away from power cable and conduit.

2.1 For cable and conduit intersections at approximately 90 degrees where power is above 125V or Type 2 wiring is used, 1/4 spacing may be used.

2.2 Spacing between the different kinds of instrument systems is not critical except that 120V alarm, solenoid, and other similar inductive load circuits should be treated as power circuits.

2.3 When cable trays are used, cables for the different kinds of instrument systems should be physically grouped according to type in order to minimize interference between systems.

2.4 Wiring systems should normally be arranged in order of noise source and sensitivity. For example, the alarm and solenoid cables should be the instrument system nearest to any power wiring, and the thermocouple cables (high impedance signals) should be located farthest from the power and the alarm cables.

2.5 Digital communication cables should be totally enclosed in conduit that is run separate from all power cables with a minimum clearance in accordance with the equipment manufacturers specifications. Where digital data communication cables run in a tray; a minimum clearance of 2 feet (.62m) is sufficient.

3. Grounding

All electronic instruments shall be properly grounded to meet CSA / NEC requirements and reduce the effect of electrical noise. Two types of ground systems are required for electronic instruments.

i. Plant Safety Ground (per CSA C22.1 / NEC Article 250).
ii. Signal Ground

Although the two systems may share the same physical ground in some cases, it is essential that all the requirements for each system be satisfied.

3.1 A safety ground must be provided for each instrument panel, console, rack, terminal box, etc., containing electrical circuits. Every instrument using a supply voltage in excess of 50 volts must have a case ground. A ground wire for each instrument case to the ground bus should be provided if continuity between case and ground is not assured by solid connection through raceway or framing when power is applied. A solid connection is one secured with bolt and nut or lock-nut in the case of conduit or EMT. For example: an instrument or portion thereof using slides, rollers, etc., for removal while still connected with cable or umbilical cord, should have a separate case grounding lead in the cable or cord. Weight or friction alone is not considered sufficient to secure a solid connection. All safety grounding must be in accordance with the Canadian Electrical Code, Part I, CSA C22.1 (latest edition) / NEC Article 250.

3.2 For electronic equipment, a signal ground system separate from the plant safety ground system must be provided. This ground shall not be connected to any power transformers, UPS equipment distribution panels, motors, lights, radio communications equipment, etc. Care must be exercised to assure that no connections are permitted between the signal ground system and the plant safety ground system. This signal ground system must be isolated from the plant ground system or as required by control system manufacturer. Conduit or raceway must not be connected to any instrument equipment in a way that will tie the signal and plant ground systems together.

3.3 The signal ground should be connected directly to the ground rod(s) located at the control system installation site. An insulated ground conductor should be connected to a signal common ground bus bar. The signal ground bus should be located as centrally as possible to the control system and arranged to provide the minimum length of ground conductors between the rod system and bus bar.

3.4 A separate #2 AWG (typ) ground wire should be connected to Signal Common ground bus for each equipment ground function. Ground wires should be adequately sized such that the resistance between the Signal Common ground bus and the equipment ground point does not exceed 0.022 Ohms (ie.#6AWG x 50Ft = 0.020 Ohms). Some examples of such functions requiring separate ground wires to the bus bar are:

i. Control panel, console, rack, etc.
ii. Computer terminal
iii. Multiplexer
iv. Strain gauge monitoring system

3.5 Use shielded and twisted pair wiring on control signal wiring. One end of the shield (and drain wire) should be connected to the equipment ground bus. The continuity of each shield must be maintained from end to end of the signal circuit. The shields for separate signal circuits must not be connected together at any point except where there is a common designated equipment ground point.

3.6 Shields for low level signal wiring should normally be grounded at the receiver end. At the sensor, the shield should be taped back to ensure that it is insulted from other signal shields or conductive surfaces. Do not ground the shield at the sensor end. The multipair cable overall shield should be grounded at the equipment ground closest to the Signal Common ground bus.

3.7 For DC milliamp signals where the receivers normally use grounded input circuits, individual pair shields and cable overall shields should be grounded at the receiver end only.

3.8 Where computers, Programmable Controllers, or embedded micro-controllers are used, it is necessary to run the equipment ground as directly as possible to the Signal Common ground; it must not daisy chain past other devices, or pass through power ducts.

4. Transient Suppressors / Filters

4.1 Place a suitably sized Surge Suppressor / Snubber across all inductive loads (ie relays, contactors, solenoids, etc.) that are on the same AC power or physically located near the controller. R/C networks (*Quenchacs*) rated for 600VDC / 250VAC with 0.1 microfarad capacitors and 100 Ohm, ½ Watt resistors are generally recommended for 120/240VAC control circuits.

4.2 Alternately, metal oxide resistors (MOV's) should be applied to suppress energy surges that are produced by inductive loads. Note that MOV's have a finite life and may need to be replaced periodically depending on the energy levels that they must dissipate.

To reduce EMI generated by interconnection wiring, Surge Suppressors should always be located as close as possible to the inductive loads that they are 'snubbing'.

4.3 If any control device malfunctions due to electrical noise on the AC power line or control signal interconnections, and it is not possible to suppress the noise source, filter the noise through the use of an AC line filter located as close to the source as possible and enclosed in an adequately grounded, shielded enclosure.

CAUTION

Operating instrumentation and control devices in electrically noisy environments can cause unpredictable, potentially dangerous control responses and may damage control equipment. Always install equipment in accordance with the manufacturer's specifications. It is recommended that the equipment manufacturer or their representative be contacted for guidance in addressing noise related issues.

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