Control Wiring Ad Hoc Results

The ad hoc group met on Tuesday, with 27 persons in attendance.

We reviewed the work previously conducted by the ad hoc group with respect to control wiring.

Some minor editorial changes were suggested and implemented.

All were in agreement with moving forward.

Control Wiring Ad Hoc Results

Background:

The ad hoc group reviewed and compared the requirements from the following standards:

C37.20.1
C37.20.2
C37.20.3
C37.20.9
C37.21

With the goal of harmonizing requirements for control circuits and wiring.

Control Wiring Ad Hoc Results

The group developed harmonized text to be used in all the standards. This text is shown in the following slides.

In some cases, there are some minor additions to the harmonized text, for example:

C37.20.1 -- Special DC requirements

C37.20.9 – Special requirements for wire in gas

These minor differences are not included in this presentation. Complete versions for each standard are being provided separately to the SA committee

Control Wiring - General

7.3.1 General

All voltage circuits used for control, relaying, or metering shall be protected within the switchgear as follows:

a) All circuits supplied from external sources (ac or dc) shall have short-circuit protection. This may be provided by a single set of short-circuit protective devices within the control source incoming section.

b) All circuits supplied from internal sources (ac or dc) circuits shall have short-circuit protection within the same section as the supply source. If these circuits are supplied by a control power transformer, this protection may be in the primary circuit only.

c) Overcurrent protection of voltage circuits may be provided in addition to the required short-circuit protection.

d) Other circuits supplying loads, such as heaters, receptacles, and lights, shall have overload and short-circuit protection.

e) Overcurrent protection of current transformer secondary circuits shall not be provided.

Control Wiring – VT Fusing

7.3.2 Voltage transformer fusing

The following requirements shall be met:

a) Primary circuits of all voltage transformers shall include current-limiting fuses

b) Secondary circuits of all voltage transformers shall include fuses or their equivalent

EXCEPTION: Fuses may be omitted from secondary circuits of voltage transformers if the secondary burden includes voltage regulators, protective relays, or other devices considered sufficiently essential to the operation of the installation to make it preferable to incur the hazards associated with the possible destruction of the voltage transformer by a sustained secondary short-circuit rather than to risk interruption of the voltage supply to such devices as a result of a momentary secondary short-circuit.

Primary and secondary protective devices may be omitted from voltage-dividing devices such as capacitive and resistive voltage dividers.

Control Wiring – Secondary and Logic-Level

7.3.3 Control, secondary, and logic-level wiring

Flame-resistant, 600 V insulated stranded copper wire shall be used for internal wiring between components of switchgear assemblies and to terminals for connection to external controls, metering, or instrumentation. Wiring within components is assumed to be covered by standards applicable to those devices and is not covered by this standard. Wiring for the purpose of conveying power to external switchgear loads is not covered by this clause.

The switchgear manufacturer is responsible for the performance of the wiring system provided by the manufacturer within the switchgear. This applies to the integrity of internally generated signals in the control wiring and may require the use of special precautions such as shielded wire and segregation of certain wires.

Wiring Across a Hinge

7.1.3 Wiring across a hinge

Wiring that crosses a hinge shall be suitable for this use, as defined by the following criteria:

a) Wire shall be sized according to 7.3.3.2, and

b) Single conductors shall be stranded wire, and

c) The wire shall be sufficiently flexible to withstand repeated door movement without sustaining damage to wire strands or insulation,-and

d) The loop formed by the wiring as it crosses the hinge shall be secured to the equipment at both ends, in such a manner that negligible strain is transmitted to wire beyond the securements, the door can be opened a minimum of 90 degrees, and

e) The wiring shall not prevent the door from opening to the intended maximum ~~opening~~, with a minimum of 90 degrees, and

f) The wire loop is to be protected between the securements to provide a degree of protection against damage to the wire insulation as the door is moved, and

g) No sharp edges or objects are allowed in the path swept by the wire loop as the door is operated, and

h) If the wire is No. 14 AWG or larger, the wire shall be no less flexible than Class C or D stranding.

Wire Size

7.3.3.2 Wire size

Wire shall be suitable for the anticipated maximum steady-state load. The size chosen should also accommodate voltage drop within the switchgear, including the effect of intermittent heavy loads (shunt trip coils, inrush from relays, and the like). The following criteria shall be used as minimums:

Maximum steady-state load (A)	Minimum wire size (AWG)	
Load	Wire Size (AWG)	Wire Size (metric)
30 < Load ≤ 40	No. 8	8.37 mm2
20 < Load ≤ 30	No. 10	5.26 mm2
15 < Load ≤ 20	No. 12	3.3.1 mm2
10 < Load ≤ 15	No. 14	2.08 mm2
7 < Load ≤ 10	No. 16	1.31 mm2
Load ≤ 7	No. 18	0.824 mm2

EXCEPTION: Multiple-conductor cable (two or more insulated wires inside a common insulated jacket) used in logic-level and/or supervisory circuits may use wire sized as required by the circuit.

Wire Size - continued

Wiring for control loads over 40 A shall be applied using ampacities from the 75° C of Table 310.15(B) ((16) (formerly, table 310.16) in National Electrical Code® (NEC®) (NFPA 70).

Wiring for current transformer and shunt trip circuits shall be no less than No. 14 AWG, regardless of load.

Thermocouple wiring is specifically excluded from the above ampacity requirements. It shall meet the voltage, current, and temperature requirements of the circuit in which it is used and the location where it is installed.

When required for connection to a specific component, low-energy signaling and communication wiring is specifically excluded from the above ampacity requirements. The wire shall meet the voltage, current, and temperature requirements of the circuit in which it is used and the location where it is installed.

Wire protection and support

7.3.3.3 Wire protection and support

Bushings, grommets, or other mechanical protection shall be provided for wiring where it passes through a metal sheet, barrier, or raceway. Wiring shall be adequately supported to prevent stress from causing damage of any kind to the conductors or the insulation. Wiring for circuits operating at different voltages shall be separated unless all wiring is insulated for the highest operating voltage of all the circuits intended to be bundled or closely grouped.

Wire Type

7.1.3.1.5 Wire type

Wiring shall be rated for 600 V, 90 °C, be flame-retardant, and shall meet the requirements of NEMA WC70 / ICEA S-95-658. Preferred wire is type SIS as listed in NFPA 70 (NEC®) or an equivalent such as XHHW, RFHH-2, RFHH-3 or the like. Other wires which meet the requirements of this clause are also acceptable.

EXCEPTION: In addition, low-energy signal wiring may be used as required by the manufacturer of a specific component. This exception includes wiring such as the following:

– Resistance temperature detectors (RTDs)
– Low Energy Signal Communication Cables (e.g. RS232, RS485, Ethernet, fiber optic, and similar networking cables)
– Thermocouples
– Coaxial cables
– Ribbon cables
– Shielded twisted pair
– Unshielded twisted pair

Special consideration of such wiring should be given with respect to the criteria in 7.3.3.1.

Proposal

Use the results of the Ad Hoc group's work to generate amendments to C37.20.1, C37.20.2 and C37.21 immediately.

Where other amendments have been identified, include those in this amendment (such as the viewing windows revisions)

C37.20.3 and C37.20.9 are already open for revision, these changes were already rolled into those drafts.

Proposed text for C37.20.1

7.1.3.1 General
All voltage circuits used for control, relaying, or metering shall be protected within the switchgear as follows:
a) All circuits supplied from external sources (ac or dc) shall have short-circuit protection. This may be provided by a single set of short-circuit protective devices within the control source incoming section.
b) All circuits supplied from internal sources (ac or dc) circuits shall have short-circuit protection within the same section as the supply source. If these circuits are supplied by a control power transformer, this protection may be in the primary circuit only.
c) Overcurrent protection of voltage circuits may be provided in addition to the required short-circuit protection.
d) Other circuits supplying loads, such as heaters, receptacles, and lights, shall have overload and short-circuit protection.
e) Overcurrent protection of current transformer secondary circuits shall not be provided.
f) Overcurrent protection shall be provided in accordance with NFPA 70 (NEC), except in circuits where interruption of the circuit may create a hazard. g)
Circuits connected directly to the bus shall be grouped separately from the other components and wiring, and be kept to minimum length.
(Note for amendment - Strikethough all text in current 7.1.3.8.1 and insert "See 7.13.1.")

7.13.2 Voltage transformer fusing
The following requirements shall be met:
a) Primary circuits of all voltage transformers shall include current-limiting fuses
b) Secondary circuits of all voltage transformers shall include fuses or their equivalent
EXCEPTION: Fuses may be omitted from secondary circuits of voltage transformers if the secondary burden includes voltage regulators, protective relays, or other devices considered sufficiently essential to the operation of the installation to make it preferable to incur the hazards associated with the possible destruction of the voltage transformer by a sustained secondary short-circuit rather than to risk interruption of the voltage supply to such devices as a result of a momentary secondary short-circuit. Primary and secondary protective devices may be omitted from voltage-dividing devices such as capacitive and resistive voltage dividers.

7.13.2 Control, secondary, and logic-level wiring
Flame-resistant, 600 V insulated stranded copper wire shall be used for internal wiring between components of switchgear assemblies, and to terminals for connection to external controls, metering or instrumentation. Wiring within components is assumed to be covered by standards applicable to those devices, and is not covered by this standard. Wiring for the purpose of conveying power to external switchgear loads is not covered by this clause.
The switchgear manufacturer is responsible for the performance of the wiring system provided by the manufacturer within the switchgear. This applies to the integrity of internally generated signals in the control wiring, and may require the use of special precautions such as shielded wire, twisted-pair wire, or segregation of certain wires, such as those connected directly to the main or riser bus.

All wire used to connect instruments, meters, relays or other components directly to the main power circuit of ac or dc switchgear, shall have an insulation rating equal to or greater than the maximum voltage of the assembly and subject to dielectric tests in accordance with 6.2.3.

For LV dc switchgear, wiring used to connect instrument, meters, and relays directly on circuits up to 3200 V, and any wiring connected directly to higher voltage circuits in LV dc switchgear rated up to 3200 V, shall use wire rated for the maximum design voltage of the switchgear.

7.1.3 Wiring across a hinge

Wiring that crosses a hinge shall be suitable for this use, as defined by the following criteria:

a) Wire shall be sized according to 7.1.3.1.3, and

b) Single conductors shall be stranded wire, and

c) The wire shall be sufficiently flexible to withstand repeated door movement without sustaining damage to wire strands or insulation,-and

d) The loop formed by the wiring as it crosses the hinge shall be secured to the equipment at both ends, in such a manner that negligible strain is transmitted to wire beyond the securements, the door can be opened a minimum of 90 degrees, and

e) The wiring shall not prevent the door from opening to the intended maximum, with a minimum of 90 degrees, and

f) The wire loop is to be protected between the securements to provide a degree of protection against damage to the wire insulation as the door is moved, and

g) No sharp edges or objects are allowed in the path swept by the wire loop as the door is operated, and

h) If the wire is No. 14 AWG or larger, the wire shall be no less flexible than Class C or D stranding.

7.13.4 Wire size

Wire shall be suitable for the anticipated maximum steady-state load. The size chosen should also accommodate voltage drop within the switchgear, including the effect of intermittent heavy loads (shunt trip coils, inrush from relays, and the like). The following criteria shall be used as minimums:

Maximum steady-state load (A)	Minimum wire size (AWG)	
Load	Wire Size (AWG)	Wire Size (metric)
30 < Load ≤ 40	No. 8	8.37 mm2
20 < Load ≤ 30	No. 10	5.26 mm2
15 < Load ≤ 20	No. 12	3.3.1 mm2
10 < Load ≤ 15	No. 14	2.08 mm2
7 < Load ≤ 10	No. 16	1.31 mm2
Load ≤ 7	No. 18	0.824 mm2

EXCEPTION: Multiple-conductor cable (two or more insulated wires inside a common insulated jacket) used in logic-level and/or supervisory circuits may use wire sized as required by the circuit.

Wiring for control loads over 40 A shall be applied using ampacities from the 75 °C column of Table 310.15(B) ((16) (formerly, table 310.16) in National Electrical Code® (NEC®) (NFPA 70).

Wiring for current transformer and shunt trip circuits shall be no less than No. 14 AWG, regardless of load.

Thermocouple wiring is specifically excluded from the above ampacity requirements. It shall meet the voltage, current, and temperature requirements of the circuit in which it is used and the location where it is installed.

When required for connection to a specific component, low-energy signaling and communication wiring is specifically excluded from the above ampacity requirements. The wire shall meet the voltage, current, and temperature requirements of the circuit in which it is used and the location where it is installed.

Wire connected directly to the main power circuit of the dc traction power switchgear bus system shall be at least No. 14 AWG.

7.1.3.1.4 Wire protection and support

Bushings, grommets, or other mechanical protection shall be provided for wiring where it passes through a metal sheet, barrier, or raceway. Wiring shall be adequately supported to prevent stress from causing damage of any kind to the conductors or the insulation. Low-energy signal wiring shall be separated from wiring operating at higher voltages unless both wires are insulated for the highest voltage.

Except for wires connected directly to the main power circuit, wiring shall be adequately supported to prevent contact with the switchgear bus system.

7.1.3.1.5 Wire type

Wiring shall be rated for 600 V, 90 °C, be flame-retardant, and shall meet the requirements of NEMA WC70 / ICEA S-95-658. Preferred wire is type SIS as listed in NFPA 70 (NEC®) or an equivalent such as XHHW, RFHH-2, RFHH-3 or the like. Other wires which meet the requirements of this clause are also acceptable.

EXCEPTION: In addition, low-energy signal wiring may be used as required by the manufacturer of a specific component. This exception includes wiring such as the following:

– Resistance thermal detectors (RTDs)
– Low Energy Signal Communication Cables (e.g. RS232, RS485, Ethernet, fiberoptic, and similar networking cables)
– RS485 cables
– Thermocouples
– Coaxial cables
– Ribbon cables
– Shielded twisted pair
– Unshielded twisted pair

Special consideration of such wiring should be given with respect to the criteria in 7.3.3.1.

Wiring used for connection directly on circuits above 600 V shall be rated for the voltage involved (or higher), 90 °C, and shall be flame-retardant. In addition, wiring used for dc circuits for rated voltages of 48 Vdc or above shall not contain PVC insulation.

Proposed text for C37.20.2 and C37.20.3

7.3.1 General
All voltage circuits used for control, relaying, or metering shall be protected within the switchgear as follows:
a) All circuits supplied from external sources (ac or dc) shall have short-circuit protection. This may be provided by a single set of short-circuit protective devices within the control source incoming section.
b) All circuits supplied from internal sources (ac or dc) circuits shall have short-circuit protection within the same section as the supply source. If these circuits are supplied by a control power transformer, this protection may be in the primary circuit only.
c) Overcurrent protection of voltage circuits may be provided in addition to the required short-circuit protection.
d) Other circuits supplying loads, such as heaters, receptacles, and lights, shall have overload and short-circuit protection.
e) Overcurrent protection of current transformer secondary circuits shall not be provided.

7.3.2 Voltage transformer fusing
The following requirements shall be met:
a) Primary circuits of all voltage transformers shall include current-limiting fuses
b) Secondary circuits of all voltage transformers shall include fuses or their equivalent
EXCEPTION: Fuses may be omitted from secondary circuits of voltage transformers if the secondary burden includes voltage regulators, protective relays, or other devices considered sufficiently essential to the operation of the installation to make it preferable to incur the hazards associated with the possible destruction of the voltage transformer by a sustained secondary short-circuit rather than to risk interruption of the voltage supply to such devices as a result of a momentary secondary short-circuit. Primary and secondary protective devices may be omitted from voltage-dividing devices such as capacitive and resistive voltage dividers.

7.3.3 Control, secondary, and logic-level wiring
Flame-resistant, 600 V insulated stranded copper wire shall be used for internal wiring between components of switchgear assemblies and to terminals for connection to external controls, metering, or instrumentation. Wiring within components is assumed to be covered by standards applicable to those devices and is not covered by this standard. Wiring for the purpose of conveying power to external switchgear loads is not covered by this clause.
The switchgear manufacturer is responsible for the performance of the wiring system provided by the manufacturer within the switchgear. This applies to the integrity of internally generated signals in the control wiring and may require the use of special precautions such as shielded wire and segregation of certain wires.

7.1.3 Wiring across a hinge
Wiring that crosses a hinge shall be suitable for this use, as defined by the following criteria:
a) Wire shall be sized according to 7.3.3.2, and
b) Single conductors shall be stranded wire, and
c) The wire shall be sufficiently flexible to withstand repeated door movement without sustaining

damage to wire strands or insulation,-and
d) The loop formed by the wiring as it crosses the hinge shall be secured to the equipment at both ends, in such a manner that negligible strain is transmitted to wire beyond the securements, the door can be opened a minimum of 90 degrees, and
e) The wiring shall not prevent the door from opening to the intended maximum, with a minimum of 90 degrees, and
f) The wire loop is to be protected between the securements to provide a degree of protection against damage to the wire insulation as the door is moved, and
g) No sharp edges or objects are allowed in the path swept by the wire loop as the door is operated, and
h) If the wire is No. 14 AWG or larger, the wire shall be no less flexible than Class C or D stranding.

7.3.3.2 Wire size
Wire shall be suitable for the anticipated maximum steady-state load. The size chosen should also accommodate voltage drop within the switchgear, including the effect of intermittent heavy loads (shunt trip coils, inrush from relays, and the like). The following criteria shall be used as minimums:

Maximum steady-state load (A)	Minimum wire size (AWG)	
Load	Wire Size (AWG)	Wire Size (metric)
30 < Load ≤ 40	No. 8	8.37 mm2
20 < Load ≤ 30	No. 10	5.26 mm2
15 < Load ≤ 20	No. 12	3.3.1 mm2
10 < Load ≤ 15	No. 14	2.08 mm2
7 < Load ≤ 10	No. 16	1.31 mm2
Load ≤ 7	No. 18	0.824 mm2

EXCEPTION: Multiple-conductor cable (two or more insulated wires inside a common insulated jacket) used in logic-level and/or supervisory circuits may use wire sized as required by the circuit.

Wiring for control loads over 40 A shall be applied using ampacities from the 75 °C column of Table 310.15(B) ((16) (formerly, table 310.16) in National Electrical Code® (NEC®) (NFPA 70).
Wiring for current transformer and shunt trip circuits shall be no less than No. 14 AWG, regardless of load.

Thermocouple wiring is specifically excluded from the above ampacity requirements. It shall meet the voltage, current, and temperature requirements of the circuit in which it is used and the location where it is installed.

When required for connection to a specific component, low-energy signaling and communication wiring is specifically excluded from the above ampacity requirements. The wire shall meet the voltage, current, and temperature requirements of the circuit in which it is used and the location where it is installed.

7.3.3.3 Wire protection and support
Bushings, grommets, or other mechanical protection shall be provided for wiring where it passes through a metal sheet, barrier, or raceway. Wiring shall be adequately supported to prevent stress from

causing damage of any kind to the conductors or the insulation. Low-energy signal wiring shall be separated from wiring operating at higher voltages unless both wires are insulated for the highest voltage.

7.1.3.1.5 Wire type

Wiring shall be rated for 600 V, 90 °C, be flame-retardant, and shall meet the requirements of NEMA WC70 / ICEA S-95-658. Preferred wire is type SIS as listed in NFPA 70 (NEC®) or an equivalent such as XHHW, RFHH-2, RFHH-3 or the like. Other wires which meet the requirements of this clause are also acceptable.

EXCEPTION: In addition, low-energy signal wiring may be used as required by the manufacturer of a specific component. This exception includes wiring such as the following:

– Resistance thermal detectors (RTDs)
– Low Energy Signal Communication Cables (e.g. RS232, RS485, Ethernet, fiberoptic, and similar networking cables)
– Thermocouples
– Coaxial cables
– Ribbon cables
– Shielded twisted pair
– Unshielded twisted pair

Special consideration of such wiring should be given with respect to the criteria in 7.3.3.1.

Proposed text for C37.20.9

6.3.1 General
All voltage circuits used for controlling, relaying, or metering shall be protected within the MEGIS as follows:
a) All circuits supplied from external sources (ac or dc) shall have short-circuit protection. This may be provided by a single set of short-circuit protective devices within the control source incoming section.
b) All circuits supplied from internal sources (ac and dc) shall have short-circuit protection within the same section as the supply source. If these circuits are supplied by a control power transformer, this protection may be in the primary circuit only.
c) Overcurrent protection of voltage circuits may be provided in addition to the required short-circuit protection.
d) Other circuits supplying loads (such as heaters, receptacles, or lights) shall have overload and short-circuit protection.
e) Overcurrent protection of current transformer secondary circuits shall not be provided.

6.3.2 Voltage – Current sensing, measuring and protection`
6.3.2.1 Voltage Transformers
The following requirements shall be met:
a) Primary circuits of all voltage transformers shall include current-limiting fuses
b) Secondary circuits of all voltage transformers shall include fuses or equivalent protective devices

EXCEPTION:
Fuses may be omitted from secondary circuits of voltage transformers if the secondary burden includes voltage regulators, protective relays, or other devices considered sufficiently essential to the operation of the installation to make it preferable to incur the hazards associated with the possible destruction of the voltage transformer by a sustained secondary short-circuit rather than to risk interruption of the voltage supply to such devices as a result of a momentary secondary short-circuit.

Primary and secondary protective devices may be omitted from voltage-dividing devices such as capacitive and resistive voltage dividers.
The voltage transformers shall comply with IEEE Std C57.13

6.3.2.2 Low power voltage and current measuring devices.
Low power measuring devices shall comply with IEC 61869-6.

6.3.2.3 Non-traditional voltage sensing and measuring devices
Voltage sensing and measuring devices (also referred to as voltage dividers) that are not transformers shall comply with Annex D.

Disconnecting means are not required for devices such as capacitive and resistive dividers.
Primary and secondary protective devices may be omitted from voltage-dividing devices such as capacitive and resistive voltage dividers (non-traditional voltage sensing and measuring devices).

6.3.2.4 Current Transformers

The current transformers shall comply with IEEE Std C57.13 and 5.12 of this document.

6.3.3 Control and secondary, and logic-level wiring

When exposed to air, flame-resistant, 600 V insulated stranded copper wire shall be used for internal wiring between components of switchgear assemblies and to terminals for connection to external controls, metering, or instrumentation. Wiring within components is assumed to be covered by standards applicable to those devices and is not covered by this standard. Wiring for the purpose of conveying power to external switchgear loads is not covered by this clause.
The switchgear manufacturer is responsible for the performance of the wiring system provided by the manufacturer within the switchgear. This applies to the integrity of internally generated signals in the control wiring and may require the use of special precautions such as shielded wire and/or segregation of certain wires.

Wiring exposed to gases other than air shall have the required ampacity rating for the current, be suitable for its application and be compatible with the gas.

6.3.3.1 Wiring across a hinge
Wiring that crosses a hinge shall be suitable for this use, as defined by the following criteria:
a) Wire shall be sized according to 6.3.3.2, and
b) Each wire (conductor) shall be stranded, and
c) The wire shall be sufficiently flexible to withstand repeated door movement without sustaining damage to wire strands or insulation, and
d) The loop formed by the wiring as it crosses the hinge shall be secured to the equipment at both ends in such a manner that negligible strain is transmitted to wire beyond the securements to prevent damage to the wire insulation as the door is moved, and
e) The wire loop is to be protected between the securements to provide a degree of protection against damage to the wire insulation as the door is moved, and
f) The wiring shall not prevent the door from opening to the intended maximum opening, with a minimum of 90 degrees, and
g) No sharp edges or objects are allowed in the path swept by the wire loop as the door is operated.
h) If the wire is No. 14 AWG or larger wire, the wire shall be no less flexible than Class C or D stranding.

6.3.3.2 Wire size

Wire shall be suitable for the anticipated maximum steady-state load. The size chosen should also accommodate voltage drop within the switchgear, including the effect of intermittent heavy loads (shunt trip coils, inrush from relays, and the like). The following criteria shall be used as minimums:

Maximum steady-state load (A)	Minimum wire size (AWG)	
Load	Wire Size (AWG)	Wire Size (metric)
30 < Load ≤ 40	No. 8	8.37 mm2
20 < Load ≤ 30	No. 10	5.26 mm2
15 < Load ≤ 20	No. 12	3.3.1 mm2
10 < Load ≤ 15	No. 14	2.08 mm2
7 < Load ≤ 10	No. 16	1.31 mm2
Load ≤ 7	No. 18	0.824 mm2

EXCEPTION: Multiple-conductor cable (two or more insulated wires inside a common insulated jacket) used in logic-level and/or supervisory circuits may use wire sized as required by the circuit.

Wiring for control loads over 40 A shall be applied using ampacities from the 75 °C column of Table 310.15(B) ((16) (formerly, table 310.16) in National Electrical Code® (NEC®) (NFPA 70).

Wiring for current transformer and shunt trip circuits shall be no less than No. 14 AWG, regardless of load.

Thermocouple wiring is specifically excluded from the above ampacity requirements. It shall meet the voltage, current, and temperature requirements of the circuit in which it is used and the location where it is installed.

When required for connection to a specific component, low-energy signaling and communication wiring is specifically excluded from the above ampacity requirements. The wire shall meet the voltage, current, and temperature requirements of the circuit in which it is used and the location where it is installed.

6.3.3.3 Wire protection and support

Bushings, grommets, or other mechanical protection shall be provided for wiring where it passes through a metal sheet, barrier, or raceway. Wiring shall be adequately supported to prevent stress from causing damage of any kind to the conductors or the insulation. Low-energy signal wiring shall be separated from wiring operating at higher voltages unless both wires are insulated for the highest voltage.

6.3.3.4 Wire type

Wiring shall be rated for 600 V, 90 °C, be flame-retardant, and shall meet the requirements of NEMA WC70 / ICEA S-95-658. Preferred wire is type SIS as listed in NFPA 70 (NEC®) or an equivalent such as XHHW, RFHH-2, RFHH-3 or the like. Other wires which meet the requirements of this clause are also acceptable.

EXCEPTION: In addition, low-energy signal wiring may be used as required by the manufacturer of a specific component. This exception includes wiring such as the following:

– Resistance thermal devices (RTDs)
– Low Energy Signal Communication Cables (e.g. RS232, RS485, Ethernet, fibreoptic, and similar networking cables)
– Thermocouples
– Coaxial cables
– Ribbon cables
– Shielded twisted pair
– Unshielded twisted pair

Special consideration of such wiring should be given with respect to the criteria in 6.3.3.1.

Proposed Text for C37.21

7.1.3.1 General
All voltage circuits used for control, relaying, or metering shall be protected within the LV switchgear as follows:
a) All circuits supplied from external sources (ac or dc) shall have short-circuit protection. This may be provided by a single set of short-circuit protective devices within the control source incoming section.
b) All circuits supplied from internal sources (ac or dc) circuits shall have short-circuit protection within the same section as the supply source. If these circuits are supplied by a control power transformer, this protection may be in the primary circuit only.
c) Overcurrent protection of voltage circuits may be provided in addition to the required short-circuit protection.
d) Other circuits supplying loads, such as heaters, receptacles, and lights, shall have overload and short-circuit protection.
e) Overcurrent protection of current transformer secondary circuits shall not be provided.

7.13.2 Voltage transformer fusing
The following requirements shall be met:
a) Primary circuits of all voltage transformers shall include current-limiting fuses
b) Secondary circuits of all voltage transformers shall include fuses or their equivalent
EXCEPTION: Fuses may be omitted from secondary circuits of voltage transformers if the secondary burden includes voltage regulators, protective relays, or other devices considered sufficiently essential to the operation of the installation to make it preferable to incur the hazards associated with the possible destruction of the voltage transformer by a sustained secondary short-circuit rather than to risk interruption of the voltage supply to such devices as a result of a momentary secondary short-circuit. Primary and secondary protective devices may be omitted from voltage-dividing devices such as capacitive and resistive voltage dividers.

7.1.5.1 Control, secondary, and logic level wiring
Flame-retardant, 600 V insulated stranded copper wire shall be used for internal wiring between components of switchboard assemblies and to terminals for connection to external controls, metering, or instrumentation. Wiring within components is assumed to be covered by standards applicable to those devices and is not covered by this standard. Wiring for the purpose of conveying power to external switchgear loads is not covered by this clause.
The manufacturer is responsible for the performance of the wiring system provided by the manufacturer within the switchboard. This applies to the integrity of internally generated signals in the control wiring and may require the use of special precautions such as twisted pair, shielded wire, or segregation of certain wires.
No splices shall be allowed in the switchboard wiring.

7.15.11 Wiring across a hinge

Wiring that crosses a hinge shall be suitable for this use, as defined by the following criteria:

a) Wire shall be sized according to 7.15.12, and

b) Single conductors shall be stranded wire, and

c) The wire shall be sufficiently flexible to withstand repeated door movement without sustaining damage to wire strands or insulation,-and

d) The loop formed by the wiring as it crosses the hinge shall be secured to the equipment at both ends, in such a manner that negligible strain is transmitted to wire beyond the securements, the door can be opened a minimum of 90 degrees, and

e) The wiring shall not prevent the door from opening to the intended maximum, with a minimum of 90 degrees, and

f) The wire loop is to be protected between the securements to provide a degree of protection against damage to the wire insulation as the door is moved, and

g) No sharp edges or objects are allowed in the path swept by the wire loop as the door is operated, and

h) If the wire is No. 14 AWG or larger, the wire shall be no less flexible than Class C or D stranding.

7.15.12 Wire size

Wire shall be suitable for the anticipated maximum steady-state load. The size chosen should also accommodate voltage drop within the switchgear, including the effect of intermittent heavy loads (shunt trip coils, inrush from relays, and the like). The following criteria shall be used as minimums:

Maximum steady-state load (A)	Minimum wire size (AWG)	
Load	Wire Size (AWG)	Wire Size (metric)
30 < Load ≤ 40	No. 8	8.37 mm2
20 < Load ≤ 30	No. 10	5.26 mm2
15 < Load ≤ 20	No. 12	3.3.1 mm2
10 < Load ≤ 15	No. 14	2.08 mm2
7 < Load ≤ 10	No. 16	1.31 mm2
Load ≤ 7	No. 18	0.824 mm2

EXCEPTION: Multiple-conductor cable (two or more insulated wires inside a common insulated jacket) used in logic-level and/or supervisory circuits may use wire sized as required by the circuit.

Wiring for control loads over 40 A shall be applied using ampacities from the 75 °C column of Table 310.15(B) ((16) (formerly, table 310.16) in National Electrical Code® (NEC®) (NFPA 70).

Wiring for current transformer and shunt trip circuits shall be no less than No. 14 AWG, regardless of load.

Thermocouple wiring is specifically excluded from the above ampacity requirements. It shall meet the voltage, current, and temperature requirements of the circuit in which it is used and the location where it is installed.

When required for connection to a specific component, low-energy signaling and communication wiring is specifically excluded from the above ampacity requirements. The wire shall meet the voltage, current, and temperature requirements of the circuit in which it is used and the location where it is installed.

NOTE—Where long connections to the control source are necessary, the cable must be large enough to prevent excessive voltage drop.

7.1.5.1.3 Wire protection and support

Bushings, grommets, or other mechanical protection shall be provided for wiring where it passes through a metal sheet, barrier, or raceway. Wiring shall be adequately supported to prevent stress from causing damage of any kind to the conductors or the insulation. Low-energy signal wiring shall be separated from wiring operating at higher voltages unless both wires are insulated for the highest voltage.

7.15.14 Wire type

Wiring shall be rated for 600 V, 90 °C, be flame-retardant, and shall meet the requirements of NEMA WC70 / ICEA S-95-658. Preferred wire is type SIS as listed in NFPA 70 (NEC®) or an equivalent such as XHHW, RFHH-2, RFHH-3 or the like. Other wires which meet the requirements of this clause are also acceptable.

EXCEPTION: In addition, low-energy signal wiring may be used as required by the manufacturer of a specific component. This exception includes wiring such as the following:

– Resistance thermal detectors (RTDs)
– Low Energy Signal Communication Cables (e.g. RS232, RS485, Ethernet, fiberoptic, and similar networking cables)
– Thermocouples
– Coaxial cables
– Ribbon cables
– Shielded twisted pair
– Unshielded twisted pair

Special consideration of such wiring should be given with respect to the criteria in 7.15.11