

FEWA-PL-SS-E-0064 REV.0

**TECHNICAL SPECIFICATION
SMALL WIRING, TERMINATIONS, JUNCTION
BOXES AND TERMINAL BOXES**

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1. GENERAL

All wiring shall have insulation incapable of supporting combustion.

The size of wiring cores shall be selected with due regard to thermal requirements, voltage drop and mechanical strength. Particular attention is to be paid to fatigue failure of cores due to flexing or vibration including damage at terminations, which require disconnection for test purposes. Cores shall be multi-stranded and terminated with a crimped termination.

The minimum size of wiring other than for light current (telephone type) apparatus shall be 1.5 mm² copper, except for current transformer secondaries, which shall be not less than 2.5 mm². The wires shall have voltage grade of 0.6/1 kV as per IEC.

Small wiring shall be black or other approved uniform colour unless otherwise specified or extensions are involved, to existing plant which has already coloured wiring in which case, the existing wire colouring scheme shall be retained as far as existing switchboards are concerned. If coloured wiring is specified for new switchboards then colours shall comply with the following code:

<u>Circuit particulars.</u>	<u>Colour of wires.</u>
First, second and third phase connections Respectively when directly connected to the Primary circuit or connected to the Secondary circuits of Current and voltage transformer	<u>Red, Yellow and Blue respectively</u>
Connections to the earth.	<u>Green / Yellow</u>
A.C. neutral connections earthed or unearthed either directly Connected to the primary circuit or connected to the Secondary circuit of Current or voltage transformer, a.c connections- Other than those above and connections in the A.C./D.C. circuits.	<u>Black</u>
Connections in D.C. circuits	<u>Grey</u>

When approved uniform colour, there should be additional ferrules matching with the phases (Red, Blue, Yellow, black) for C.T and V.T terminals for clear identification of phases. Any other method by the manufacturer for identification of phases can be adopted subject to approval by FEWA.

All wiring shall be neatly run and securely fixed in cleats, bunched in neat forms or run in approved wiring troughs or non-corrodible tubes. The numbers of wires in any one bunch trough or tube shall not exceed 20 and number in trough shall not exceed the number and size for which it is designed. The practice of doubling back wires on themselves to absorb slack is not acceptable.

Bunch trough or tube shall not exceed 20 and the number in a trough shall not exceed the number and size for which it is designed. The practice of doubling back wires on themselves to absorb slack is not acceptable.

Cleats shall be of moulded or metal-reinforced insulating material and shall be of the limited compression type. Insulated strapping shall be used for bunched wires. Wiring troughs shall be of insulating material.

Wiring passing out of cubicles and wiring between compartments of metal-clad switchgear shall be run in robust ducting, corrosion resistant flexible tubes or conduit. Wiring shall be protected from sharp edges. Indoor conduit shall be either aluminium, steel or plastic.

All wiring accessories of plastic materials, such as cleats, troughs, conduits and strapping shall be non-ignitable or resistant to flame propagation.

Wherever practicable, wiring shall be accommodated on the sides of the cubicles and the wires for each circuit shall be separately grouped. Back of panel wiring shall be so arranged that access to the connecting stems of relays and other apparatus and to contacts of control and other switches is not impeded. Where provision is made for addition of equipment not required initially, means shall be adopted for supporting and terminating wiring during the interim period.

All wiring shall be taken to terminal boards and wires shall not be jointed or teed between terminal points.

Stranded conductors shall be terminated with a crimped termination.

Identification ferrules shall be fitted to internal wiring and to all multicore cable tails. Ferrules shall be of white insulating material with glossy finish to minimise adhesion of dirt. They shall not be affected by damp or oil and shall be clearly and permanently marked in black.

The ferrules shall be of sleeve type so fitted that they cannot slip along the cable or be removed from the cable without re-terminating.

All wires forming part of a tripping circuit shall be suffixed with an additional red ferrule marked "Trip" or "T".

Each wire shall have a letter to denote its function followed by a number to identify the individual wire. A wire shall bear the same identification mark at both ends. Every branch of any particular connection shall bear the same identification mark.

Spare cores in multicore cables shall be ferruled U1, U2, etc., upwards at both ends of each cable and connected to individual spare terminals. The spare cores shall be so arranged that they can be readily identified on site with the cable containing them. This shall be achieved by suitable grouping, and unless the location of each group is clear from the diagram, the groups shall be labelled.

Alternatively, the core identification shall be preceded by the cable reference.

Identification ferrules shall be in accordance with the following system. The same ferrules shall not be used on wires in different circuits on the same panels.

2. STANDARD IDENTIFICATION FOR SMALL WIRING FOR SWITCHGEAR AND ASSOCIATED RELAY AND CONTROL PANELS AND KIOSKS, ETC.

2.1. General

Each wire shall have a letter to denote its function, e.g. control of circuit breaker, current transformer for primary protection, voltage for instruments, metering and protection. The function letter shall be followed by a number identifying the individual wire. Every branch of any connection shall bear the same identification mark. Where it is necessary to identify branches, which are common (e.g. current transformer leads), different identification marks for the branches may be employed only if they are common through links, or are connected to separate terminals which are then common by removable connections. Suffix letters shall be used as indicated in Clause 2.4 of this Section.

Identification shall read from the terminals outwards on all wires.

Double ferrules shall be provided on each wire or core where a change of number cannot be avoided. The change of numbering shall be shown on the appropriate diagrams of the equipment.

Bus- wires shall be fully insulated, and shall be run separately along the top or bottom of the cubicle. Fuse and link shall be provided to enable all circuits in a cubicle, except the lighting and heating circuit, to be isolated from the bus-wires.

Wherever practicable all circuits in which the voltage exceeds 125 volts shall be kept physically separated from the remaining wiring, the working voltage of each circuit shall be marked on the associated terminal boards. Except for the lighting and heating circuit the working pressure of A.C. circuits brought into relay or control cubicles shall not exceed 125 volts. Lighting and heating circuit in excess of 125 volts shall be fully shrouded throughout.

The D.C. trip and associated wiring to main protective gear, and that for back-up protection shall be segregated each from the other. Each such group shall be fed through separate fuses direct from the main supply fuses or the bus- wires. There shall not be more than one set supplies to the apparatus comprising each group. The A.C. voltage supplies shall also be kept segregated in each group cables between equipment shall be similarly segregated in each group. Cable between equipment shall be similarly segregated.

Terminal boards shall have separate terminals for incoming and outgoing wires and shall be of the Klippon type (or equivalent). Not more than two wires shall be connected to any one terminal. Insulating barriers shall be provided between adjacent pairs of terminals. The height of the barriers and the spacing of the terminals shall be such as to give adequate protection while allowing easy access to terminals.

Terminal boards for CT connections shall have shorting, testing and disconnecting facilities which will allow tests to be conducted with the circuit on load and which may be operate without disturbing the connecting wiring.

All terminals on door that are exposed when door is open shall be shrouded with securely fixed but recovers of transparent insulating material.

Terminations shall be grouped according to function and labels shall be provided to show the group function.

Covers of insulating transparent material shall be provided on terminal board on which connections for circuits with a voltage greater than 125 volts are terminated and DANGER, notice shall be fixed.

Rows of terminal boards shall be spaced not less than 100 mm apart. They shall be mounted vertically at the sides of the cubicles and set obliquely toward the rear doors to give easy access to terminations and enable ferrule numbers to be read without difficulty.

The bottom of terminal boards shall be spaced at least 200mm above the cable crutch of incoming multi-core cables.

The use of terminal board as junction points for wires, which are not required in the associated cubicle, shall be avoided.

Sufficient terminations shall be provided in each cubicle to terminate all Multi core cable cores including spares at least 10% of each type.

Screw type terminals shall utilize a pressure plate arrangement; single point screw terminations will not be accepted. The size of screws for screw clamps is not restricted provided that the screws are captive; otherwise they shall comply with the requirements for and stud terminals.

2.2. Function Letters

Where part of a circuit is common to more than one function, the first in alphabetical order of the appropriate function letters in the table shall be used for the common part. Where the circuits split at a separable contact (e.g. fuse, link, switch or relay contact) the function letter shall change if necessary from the splitting point onwards.

Circuits having functions not included in the function letter table shall not have letters. For example, circuits of devices which provide a continuous indication, such as remote winding temperature indicators or resistance thermometers, shall not have a letter unless the circuit of the particular indication already has a function letter. Where, however, an indication or alarm is initiated by the opening or closing of an auxiliary contact letters 'L' or 'X' should be used as appropriate.

Where relays are employed, the coil and the contact circuits do not necessarily bear the same function letter; this should be determined by the function of the individual circuit, e.g. the coil circuit of a series flag relay may be 'K' but the contact circuits may bear letters such as 'X', 'L' or 'N' as appropriate.

The following rules shall apply to current and voltage transformer function letters:

Current Transformers for Protection

Letter 'C' shall be used for all types of over current protection (whether used as primary or back-up protection), standby earth fault, generator negative phase sequence, transformer winding temperature protection, and instruments fed from separate current transformers. Where duplicate primary protection is applied.

Letter 'A' shall be used for both, the second line being distinguished by adding 300 to the number.

Interposing and Auxiliary Transformers

The function letters shall follow through any interposing and auxiliary current and voltage transformers, including such transformers when used for light current circuits, provided that these are not used as isolating transformers to couple circuits, which have differing functions.

Where an a.c. supply, reflecting the primary quantities and derived from a current or voltage transformer, is rectified for the operation of instruments or relays, the d.c. circuit shall carry the same function letter as the a.c. circuit.

Current Transformer Connections for Line Drop Compensation or compounding

Letter 'D' shall be used for these circuits, including the current side of the isolating transformer. The connections to the voltage circuit from this transformer shall have letter 'F'.
Voltage Transformer Connections for Automatic Voltage Control

Letter 'F' shall be used for these circuits.

Light Current Equipment

Light current equipment may require schemes differing from the above for complete identification. In such cases, where connections from such equipment are associated with power equipment wired in accordance with this Specification, the identification of such connections shall include the appropriate function letter (J, W, X or Y) to distinguish them. The letter 'W' is generally used for the light current side of interposing relays for control purposes.

2.3. Identification Numbers

The wire number may consist of one or more digits as required. For functions A-G, H, J and M, the numbers shall be as given in the column under "Wire Numbers" Clause 2.5 below. D.C. supplies from a positive source shall bear odd numbers and d.c. supplies from a negative source shall bear even numbers. Where coils or resistors are connected in series the change from odd to even shall be made at the coil or resistor lead nearest to the negative supply.

2.4. Suffix Letters

Where similarly numbered leads from separate primary equipments are taken to a common panel (e.g. bus zone protection, summation metering, banked transformers, etc.) suffixes A, B and C, etc. should be used to distinguish them. Where similarly numbered leads from different parts of a unit of primary equipment are taken to a common panel (e.g. generator and unit transformers, HV and LV sides of a transformer, etc.) the leads of the subsidiary or lower voltage equipment shall be distinguished by adding 500 to the wire numbers. When more than two sets of leads require to be distinguished specific wire numbering schemes appropriate to the case shall be issued by means of a standard diagram showing the scheme to be adopted. The method of distinguishing between sets of leads shall be shown on the individual schematic (circuit) and wiring diagram.

The distinguishing suffixes or numbers apply only in the common panel and at each end of the interconnecting cores.

2.5. Table of Wire Identification

<u>Function Letters</u>	<u>Wire Numbers</u>
A - Current transformers for primary protection excluding over current	} 10-29 Red Phase 30-49 Yellow Phase 50-69 Blue Phase 70-89 Neutral
B - Current transformers for busbar protection	
C - Current transformers for over current protection (including combined earth fault protection) and instruments residual circuits & neutral current transformers	
D - Current transformers for metering voltage control Earth wires directly connected to the earth bar.	
E - Reference voltage for instruments, metering and Test windings, protection normally inoperative.	91-99
F - Reference voltage for voltage control	
G - Reference voltage for synchronising	
H - A.C. and A.C./D.C. supplies Switchgear and generators	1-69
J - D.C. supplies Transformers	70-99
K - Closing and tripping control circuits	
L - Alarms and indications initiated by auxiliary switches and relay contacts, excluding those number from remote selective control and for General Indication 1 upwards equipment	
M - Auxiliary and control motor devices, e.g. governor Switchgear	1-19
motor, rheostat motor, generator AVR	20-69
Generators	
control, spring charging motors, transformer cooler	70-99
Transformers control, motors for isolator operation	
N - Tap change control, including AVC, tap position and progress indications	
O - An indication that the ferruling is not in accordance with the general scheme and that if it is not altered double ferruling will be required for co-ordination with the remaining equipment in the station	
P - D.C. tripping circuits used solely for busbar protection	

- R - Interlock circuits not covered above
- S - D.C. instruments and relays, exciter and field circuits for Any generators number from 1 upwards
- T - Pilot conductors (including directly associated connections) between panels, independent of the distance between them, for pilot wire protection, for intertripping or for both
- U - Spare cores and connections to spare contacts
- V - Automatic switching circuits not integral with circuit breaker control schemes
- W - Light current control connections
- X - Alarms and indications to and from General Indication and remote selective control equipment
- Y - Telephones

If for functions A-G, H, J and M more numbers are required, multiples of hundreds shall be used (e.g. 10-29 may be extended to 110-29, 210-229, etc).

Note:

'Local' control shall refer to control at the switchboard or item of plant, 'Remote' control at the control panel at the Substation and 'supervisory' control at a point away for the Substation.

At those points of interconnection between wiring carried out by separate manufacturers, double ferrules shall be provided on each wire or core where a change of number cannot be avoided. The change of numbering shall be shown on the appropriate diagrams of the equipment.

Wiring diagrams for control and relay panels shall be drawn as if viewed from the back and it shall be clearly stated on each diagram. They shall show the terminal boards as arranged in service.

Bus-wires shall be fully insulated, and shall be run separately along the top or bottom of the cubicle. Fuses and links shall be provided to enable all circuits in a cubicle, except the lighting and heating circuit, to be isolated from the bus-wires.

Wherever practicable all circuits in which the voltage exceeds 125 volts shall be kept physically separated from the remaining wiring. The working voltage of each circuit shall be marked on the associated terminal boards. Except for the lighting and heating circuit the working pressure of a.c. circuits brought into relay or control cubicles shall not exceed 125 volts. Lighting and heating circuits in excess of 125 volts shall be fully shrouded throughout. The d.c. trip and associated wiring to Main 1 protective gear, that associated with Main 2 protective gear and that for back-up protection shall be segregated each from the other. Each such group shall be fed through separate fuses direct from the main supply fuses or the bus-wires. There shall not be more than one set of supplies to the apparatus comprising each group. The a.c. voltage supplies shall also be kept segregated in each group cables

between equipment shall be similarly segregated in each group. Cables between equipment shall be similarly segregated.

3. EXTERNAL WIRING

Any wiring liable to come in contact with oil shall have suitable oil-resisting insulation. The bared ends of stranded conductors shall be sweated together to prevent creepage of oil along the wire.

There shall be no possibility of oil entering connection boxes for cables or wiring.

Where the use of conduits is agreed the runs shall be laid with suitable falls and the lowest parts of the run shall be external to the kiosks or boxes. All conduit runs shall be adequately drained and ventilated. Conduits shall not be run at or below ground level.

The external cabling on transformers and between transformers and marshalling kiosks shall have with a minimum cross-section of 2.5 mm^2 . The wiring shall enter the bottom compartment of the kiosk through the gland plate in such a manner that the rear is kept clear for access.

4. TERMINAL BOARDS

Terminal boards shall have separate terminals for incoming and outgoing wires and shall be of the Klippon type (or equivalent). Not more than two wires shall be connected to any one terminal. Insulating barriers shall be provided between adjacent pairs of terminals. The height of the barriers and the spacing of the terminals shall be such as to give adequate protection while allowing easy access to terminals.

Terminal boards for CT connections shall have shorting, testing and disconnecting facilities which will allow tests to be conducted with the circuit on load and which may be operated without disturbing the connected wiring.

VT terminals shall have isolation and injection test facility. No shorting provision shall be provided for VT terminals. CT and VT terminals shall be two different types meeting the above requirements.

Terminal boards for SCADA connections shall have an isolating link to allow disconnection of SCADA inputs from the SCADA equipment without disturbing the wiring.

All connections shall be made to the front of the terminal boards. Current shall not be carried through the boards by the studs, except in the case of oil-tight terminations, e.g. for oil-immersed current transformers. No live metal shall be exposed at the back of the terminal boards.

Terminations shall be grouped according to function and labels shall be provided to show the group function.

Covers of insulating transparent material shall be provided on terminal boards on which connections for circuits with a voltage greater than 125 volts are terminated.

Rows of terminal boards shall be spaced not less than 100 mm apart. They shall be mounted vertically at the sides of the cubicle and set obliquely towards the rear doors to give easy access to terminations and to enable ferrule numbers to be read without difficulty.

The bottom of terminal boards shall be spaced at least 200 mm above the cable crutch of incoming multicore cables.

The use of terminal boards as junction points for wires, which are not required in the associated cubicle shall be avoided.

Sufficient terminals shall be provided in each cubicle or box to terminate all multicore cable cores including spares.

Screw type terminals shall utilise a pressure plate arrangement, single point screw terminations will not be accepted. The size of screws for screw clamps is not restricted provided that the screws are captive, otherwise they shall comply with the requirements for bolt and stud terminals.

Terminal boards for each application shall have Sl. No. starting from 1,2,3 etc. in sequence.

5. TERMINALS ON DOORS

All terminals on doors, which are exposed when the door is open shall be shrouded with securely fixed but removable covers of transparent insulating material.

6. JUNCTION BOXES & TERMINAL BOXES

6.1. General

All junction boxes, terminal boxes and marshalling kiosks shall be constructed of steel or where approved for external use or difficult environment areas, fibreglass. Each unit shall be provided with an earth stud.

All main equipment shall be arranged so that it is accessible from the front of the box or kiosk.

6.2. Outdoor Boxes And Kiosks

Outdoor boxes and kiosks shall have domed or sloping roofs and shall be of weatherproof and vermin-proof construction, with adequate ventilation and draining facilities. They shall be so designed that condensation does not affect the insulation of the apparatus, the terminal boards or the cables. Where necessary heaters shall be provided. Where these exceed 40 watts, they shall be controlled by means of a watertight switch mounted on the outside of the box or kiosk.

Any divisions between compartments inside the boxes or kiosks shall be perforated to assist the natural air circulation.

6.3. Access Facilities

Access shall be provided at both the front and back of kiosks and junction boxes, except for small terminal boxes of the type normally employed for wall mounting.

Doors and access covers shall be easily opened and shall not be secured by nuts and bolts. Doors and covers under 14 kg weight may be of the slide-on pattern, above this weight they shall be hinged.

Kiosk doors shall be fastened with integral handles. Nuts, bolts, or carriage keys shall not be used. Provision shall be made for padlocking each door.

Hinged doors on outdoor boxes and kiosks shall be provided with stays to retain the doors in the open position.

6.4. Low Voltage Connections

If voltages in excess of 125 V are present in box or kiosk, they shall be adequately screened or insulated and an appropriate "DANGER" notice shall be fixed on the outside and inside of the box or kiosk. Voltages in excess of 600 V shall not be taken through junction boxes.

6.5. Cable Termination

All cables shall enter boxes and kiosks at the base.

Conduits shall not be run at or below ground level, but shall wherever practicable enter boxes or kiosks near the base.

Plates for supporting cable glands shall be at least 450 mm above ground level. Cable glands and conduits shall project at least 20 mm above the gland plate to prevent any moisture on the plate draining into cable crutches or conduits. Means shall be provided to drain water off the surface of the gland plate. The back, sides and front of the box or kiosk shall project at least 50 mm below the gland plate to prevent moisture draining on to the plate and cable glands.

Where armoured cables are employed the armouring shall, unless otherwise approved, be earthed inside the cable glands.

6.6. Labels

Labels shall be provided inside each junction box or kiosk to describe the functions of the various items of equipment. Where the kiosk is divided into compartments each door shall have an external label to identify the compartment.