Science and Technology Facilities Council

# SPECIFICATION FOR THE SUPPLY AND BUILD OF CONTROL PANELS FOR THE DUNE PROJECT WINDING MACHINES

**Abstract**

The Deep Underground Neutrino Experiment (DUNE Project) is an international collaboration focussed on Neutrino science and Proton decay studies. The experiment consists of a Neutrino Source based at Fermi National Accelerator Laboratory in Batavia, Illinois; and two Neutrino detectors, one near field (local to the source), and one far field detector based at Sanford Deep Underground Research Facility in Lead, South Dakota. The Neutrino's travel 1300km through the earth, from the source to the far field detector located 1.5KM below ground level, in a converted mine shaft.

Anode Plane Assemblies (APA) are the building blocks to construct the large far field detector. An APA is a 6M x 2.3M rectangular frame which is wound with a fine Copper beryllium wire mesh and will be used to capture activity caused by passing Neutrino's. Electronics on the frame convert this activity into an electrical signal for measurement and analysis by Physicists.

Further information can be found at: https://www.dunescience.org/

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Daresbury Laboratory Electrical Engineering Group

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## Table of Contents

# 1. Introduction

The requirement is for the vendor to build 6 electrical control panels which will operate 6 winding machines used to produce wound APA frames for the DUNE project. 4 of the control panels produced will control winders based at Daresbury Laboratory (DL), whilst the remaining 2 control panels will be shipped to the US to run 2 winders installed at the Physical Sciences Laboratory (PSL) in Madison, Wisconsin, US. The winders will produce several hundred APA frames over the coming years.

The design of an APA winding machine, including control panel, was adopted from PSL in 2016 and a running winder was built at DL and has since produced 3 APA frames which have been successfully tested at a cryogenics lab at CERN – The European Organisation for Nuclear Research. STFC have taken the lead role in making improvements to the control system which has resulted in a larger control panel with enhanced user safety in mind. UK Research and Innovation (UKRI) – Science and Technology Facilities Council (STFC) would typically build control panels in-house, however project timescales and the effect of Covid-19 on the operability of the organisation has meant build by an external supplier is the best course of action to maintain project continuity.

# 2. Scope

This specification is intended as a guide for best practice to be used when electrical designs do not stipulate certain methods or parts specified by the engineer. Any areas of concern must be raised with the STFC engineer in the first instance.

## 2.1 Supply

The build of 6 electrical control panels 1800mm(H) x 800mm(W) x 400mm(D) of steel construction according to electrical designs (Dwg. 290/76021).

The panels will contain the following parts with detailed information contained within the Bill of Materials as detailed in AW5.2 Pricing Schedule.

- Allen Bradly Programmable Logic Controller (PLC),
- Kinetix 5700 Servo motor system (3 axis – X/Y/Z)
- Stratix Network Switch
- Low voltage power supplies (3 x 24VDC / 1 x 48VDC)
- Electrocraft DC Servo Amplifier
- Cognex CIO Micro unit
- AC power distribution via MCB’s
- DC power distribution via fuses
- General terminal block arrangements

The vendor will be responsible for purchase of all materials to build the 6 panels.

The Bill of Materials as detailed in AW5.2 Pricing Schedule lists equipment part numbers with classification as required or preferred.

The vendor must have an account with Routeco.Ltd to purchase the equipment for which they are the sole UK distributers.

## 2.2 Schedule

The vendor is requested to provide a project plan/ schedule outlining the timescales for procurement, build, testing/commissioning and shipping, clearly stating the estimated date of delivery to Daresbury Laboratory.

The panels are to be delivered to STFC Daresbury Laboratory within 5 working days from a successful Factory Acceptance Test (FAT).

The vendor is to provide bi-weekly update reports via e-mail. This may only be short notification that all is well and on schedule.

## 2.3 Payment

Milestone 1 (60%). On confirmation of the purchase of equipment by the supplier, of which UKRI STFC would own following payment. The supplier would also have to prove that they have purchased the equipment and must be marked as property of UKRI STFC and photographed as evidence. Payment will not be made until UKRI STFC have reassurance of existence ownership.

Milestone 2 (30%). On completion of Factory Acceptance Test (FAT) to UKRI STFC specification and approval at supplier site.

Milestone 3 (10%). On completion of Site Acceptance Test (SAT) at UKRI STFC Daresbury Laboratory to specification and approval.

## 2.4 FAT

The Factory Acceptance Test will be undertaken at the vendor's premises to confirm satisfactory build has been completed to the supplied specification and drawings. The FAT will consist of the following.

- Confirmation of panel build and quality inspection
- A copy of wire checked drawings signed by vendor representative
- Return information regarding modifications, changes or omissions from the intended design
- A list of spare equipment not used during the build
- An inspection checklist completed by an STFC representative to confirm that the expected equipment is present within each panel
- Photographic evidence to submit to UKRI – STFC for staged payment release

## 2.5 SAT

The Site Acceptance Test will be conducted within the DUNE building at Daresbury Laboratory and consist of the following:

- A visual Inspection upon arrival to check for damage which may have occurred during transit to DL.
- Connection of Alternating Current (AC) mains to each control panel for power up of all internal equipment.
- Uploading software to the Programmable Logic Controller (PLC) and checking functionality of Input / Output (IO) modules and communications with Servo Drive System.
- A functionality checklist completed by an STFC representative to confirm that the equipment is operating as expected.
- Photographic evidence to submit to UKRI – STFC for final staged payment.

## 2.6 Warranty

The standard manufacturer's warranty is accepted for all equipment. Though it is expected the vendor will deal with replacement of faulty equipment, under warranty, as the original purchaser.

3 Years warranty is expected of any of the work unrelated to 3rd party equipment.

Any defects reported to the vendor must be rectified as soon as possible.

## 2.7 Quality Assurance

The Supplier should maintain and apply a quality assurance program compliant with ISO-9001 or equivalent for the design, manufacture and testing of all components.

## 2.8 Delivery

The vendor will inform STFC of date of delivery, stating the size and type of delivery vehicle and whether help is required for unloading with use of a stacker truck or other lifting equipment.

Delivery to the following address is included in the quote:

STFC Daresbury Laboratory
Sci-Tech Daresbury
Daresbury

Warrington
Cheshire
WA4 4AD
United Kingdom

## 3. Definitions

| | | |
|---|---|---|
| AC | - | Alternating Current |
| BD | - | Block Diagram |
| BS | - | British Standards |
| BZP | - | Bright Zinc Plated |
| CE | - | Conformité Européene |
| DC | - | Direct Current |
| DL | - | Daresbury Laboratory |
| EEG | - | Electrical Engineering Group |
| ELV | - | Extra-Low Voltage |
| EMC | - | Electromagnetic Compatibility |
| EU | - | European Union |
| FAT | - | Factory Acceptance Test |
| GA | - | General Arrangement |
| IEC | - | International Electrotechnical Commission |
| I/O | - | Input/Output |
| ISO | - | International Organisation for Standardisation |
| KA | - | Kiloampere |
| LED | - | Light Emitting Diode |
| MCB | - | Miniature Circuit Breaker |
| N | - | Neutral |
| PLC | - | Programmable Logic Controller |
| PD | - | Power Distribution |
| PSU | - | Power Supply Unit |
| RCD | - | Residual Current Device |
| PDU | - | Power Distribution Unit |
| RCBO | - | Residual current Circuit Breaker with Overcurrent protection |
| SAT | - | Site Acceptance Test |
| SS | - | Stainless Steel |
| STFC | - | Science and Technology Facilities Council |
| TB | - | Terminal Block |
| UKRI | - | UK Research and Innovation |
| WD | - | Wiring Diagram |

Any statements within this document which include the modal verb “**shall**” are a mandatory requirement and must be followed.

Any statements within this document which include the modal verb “**should**” are recommended and can be replaced by an alternative preferred by the engineer/designer/technician provided there is valid justification for the deviation.

The “engineer” is the STFC design authority and person responsible for the overall delivery of the control panels.

## 4. General Requirements

The complete installation including all materials shall comply with all relevant British and European Standards to the latest edition.

The whole of the works shall be carried out in accordance with the latest edition of BS 7671 + amendments, the Supply Authority Regulations and the Electricity at Work Act 1989.

It is the responsibility of the supplier to ensure that competent, qualified and knowledgeable staff are used to construct and commission the electrical control panels to achieve the quality and reliability required.

## 5. Standards

The design, construction and installation of the panels shall comply with the latest edition European and British Standards. Wiring shall be carried out in accordance with BS 7671, which has been harmonised with international standard IEC60364.

This document should be used in conjunction with the standard for Safety of Machinery-Electrical Equipment of machines BSEN60204-1: to the latest amendment.

Equipment not manufactured in the EU shall be of a standard that ensures its compliance with all appropriate British and European Standards.

Other applicable regulations and standards are as follows.

- Low voltage directive 2006/95/EC.
- IEC/EN/60439-1 Low voltage switchgear and control gear assemblies.
- EMC Directive 2004/108/EC.
- IEC/EN 61000-6-1:2007 Electromagnetic compatibility (EMC) - Part 6-1: Generic standards Immunity for residential, commercial and light-industrial environments.
- ISO 9001

## 6. Design

A complete set of electrical drawings will be supplied for the vendor to follow.

This will typically consist of:

- Block Diagrams (BD) to show start and end point of connections and relationship of equipment.
- General Arrangement (GA) showing front and side elevations of panel externals. Positions of pilot devices, operator interface and switching accessories will be dimensioned with additional drilling and punching detail.
- Wiring Detail (WD) showing all terminations of wiring and external cabling within the panel.

Supporting documentation such as manuals/data sheets/installation instructions used during design can be supplied in electronic or paper copy.

Upon completion of build and during testing/commissioning, any modifications or anomalies must be marked up in the drawings and returned to the EEG Design Office for revision. The engineer shall receive a written list of omissions or changes to the intended design before the Factory Acceptance Test is attended.

Electrical Designs are completed using AutoCAD design package saved in 2010 format.

Electrical drawings will be supplied in A3 landscape format using monochrome print, unless larger print is requested. Electronic copies can be provided in PDF format.

# 7. Construction

The construction of the rack is to be according to electrical designs supplied by STFC. Where the design does not specify a particular piece of equipment, or a method of construction requires clarity, then the STFC engineer shall be consulted in the first instance.

The following subsections contain information which can be used as a guide for STFC best practice. It states preferred equipment and the preferred means of installation and wiring. A supplier may use an alternative and suitable method after written agreement with the STFC Engineer.

## 7.1 Control Panel Enclosure

The enclosure shall be of sheet steel construction and should be protected to at least IP54 unless otherwise stated.

The panel shall have a removable galvanized backplate and removable side panels with rubber gaskets.

The panel will be fitted with a 100mm plinth to allow possible future cable entry at ground level.

## 7.2 Panel isolator

Control panels shall be fitted with a 3P + N main isolator, 3 pole for a single phase supply or 4 pole for a 3 phase and neutral supply. This shall be a switch disconnector of the rotary type with a red handle which can be padlocked in the off position.

The isolator should be panel mount interlocking isolator which prevents opening of the door(s) whilst in the “on” position, forcing the operator to isolate the supply to release the door. If this is too restrictive then a defeatable isolator or bulkhead mount isolator may be installed as long as equipment in the panel is IP2X and voltages of live equipment clearly labelled.

The incoming terminals of the isolator shall be shrouded and labelled with “Danger Live Terminals” to warn staff that although the panel may be isolated, the incoming cable may still be live. If not supplied then a custom Perspex cover shall be fitted.

## 7.3 Spare Capacity

All Control Panels, Junction Boxes, trunking systems and other equipment cabinets shall be manufactured and installed with spare capacity for future expansion. As a rule of thumb, the control cabinet shall have 25% availability for further equipment.

## 7.4 Dimensions

The Panel must be 1800(H) x 800(W) x 400(D) and of steel construction.

## 7.5 Colour

A panel of mild steel construction is acceptable in a cream or grey colour. It is acknowledged that RAL7035 is a colour widely used by enclosure manufacturers.

Where paint has been damaged from cutting or drilling and general impact damage, best effort should be made to repair the damage with touch up paint to conceal and protect from rust.

## 7.6 Locking

Electrical panels must require the use of a tool or key for opening to prevent unintended access by non-electrical staff. The keys supplied with the panels must be with provided with the panels upon delivery.

## 7.7 Plinths and castors

A 100mm steel plinth is required. The plinth must be bonded to the main panel as per requirements stated in this specification.

## 7.8 Lighting

Panels shall be fitted with LED strip lights to sufficiently illuminate all equipment installed inspection and repair.

It is preferable that lighting is powered via door switches so that they automatically turn on as the enclosure door is opened, though local or built in manual switching is acceptable.

Lighting circuits can be wired from the incoming terminations of an isolator, so that any work on internal equipment can be done dead without the need for a separate source of lighting. Where this is done, the wiring to the light should be wired in orange flex to represent a permanent live as detailed in IEC60204.

### 7.9 Ventilation

Sealed enclosures such as wall mounted control panels may require ventilation. In this case the fans should force air inwards to pressurise the panel. Fans are to be mounted in the lower section of the side panels and ventilation grills to be mounted in the top section of side panels on the opposite side of the panel. This method prevents stagnant air building up and causing heat spots within the panel. Both inlet fans and outlet grills shall be fitted with dust filters appropriate to the environment.

Fans are typically 120mm diameter.

Fans should preferably be controlled by a Rittal SK3114.200 Digital Thermostat or alternative unit which provides visual temperature readout. If used, the relay contacts of a SK3114.200 should be configured to energise the fan and provide an alarm status. Unless otherwise specified the controller should be set up with the following parameters.

| | |
|---|---|
| Fan Relay K1 | 30ºC |
| NC Alarm Relay K2 | 35 ºC |
| Hysteresis (K1 & K2) | 3ºC |

### 7.10 Screws

Screws for panel mounting equipment should be bright zinc plated (BZP) or stainless steel (SS) metric thread machine screws, preferably dome head or button head or similar. Screws shall be fitted with a toothed, shake-proof washer and/or a spring washer where a nut is used for side panel/front panel mounting. This is particularly important where equipment is to be shipped a reasonable distance by road or freight where standard screws may work loose with vibration.

M6 roofing nut and bolt are **not** to be used in panel construction unless agreed with the STFC engineer.

### 7.11 Nuts & washers

Nuts and washers for fixing of equipment shall be metric thread (BZP) unless otherwise specified as stainless steel/copper. Shake-proof washers should be used to in combination with plain/spring washers where possible, particularly in equipment which is to be transported off site.

### 7.12 Trunking

Cable trunking within panels should be plastic narrow, open slot trunking.

All containment shall be installed neatly, unobtrusively and not obstruct air flow for cooling of power supplies and other equipment requiring ventilation.

Containment shall only be installed in horizontal or vertical runs.

All containment systems shall comply with the latest applicable British/European Standard and shall be installed in strict accordance with manufacturer's instructions.

The containment system selected shall be the same type and grade throughout the entire delivery/project where possible.

Separate containment, or proprietary dividers shall be installed to segregate the different categories of installation where possible.

### 7.13 DIN Rail

Din rail to be used in the panel can depend upon the mounting type of equipment to be installed. However, the most predominantly used and preferred type for panel mounted equipment and terminals is Slotted TS35.

Din rail should be cut to fill the total available area so as to allow for future addition of terminals and equipment eq. A horizontal length of DIN rail installed between two vertical runs of trunking at either side of the panel should make contact with the trunking at each end.

Care should be taken to cut the din rail with a clean 90° cut and de-burred with a de-burring tool or a fine grade file. Do not round the corners with a file as terminals and end stops do not fit correctly if the din rail is populated to the very ends.

Din rail should be mounted to panels with 5mm crosshead screws fitted with shake-proof washers. Fixings should be at each end of the Din rail with fixings between at regular intervals no greater than 200mm**.**

### 7.14 Equipment Mounting

Drilling and tapping of backpanels is the preferred method for mounting of DIN rail and equipment, however other methods may be accepted due to excess weight, fixing hole sizes or other limitations. Deviations should be discussed with the STFC engineer.

Components in panels shall be mounted with adequate clearance as specified by the manufacturer's datasheet to allow for sufficient access, ventilation and cooling.

All drilling and cutting within the panel should be carried out before mounting of equipment to avoid swarf falling into equipment through ventilation holes. If this is not possible then equipment should be covered with a barrier to prevent this occurring.

### 7.15 Wiring

Wires within the panel are to be predominantly tri rated 0.5mm unless otherwise stated by electrical drawings.

Wires should be given suitable length to allow future repositioning of the wire to other local terminations.

### 7.16 Identification of conductors

Unless otherwise stated in the drawings, wires are to be identified to the colour coding of BS EN 60204-1:

| | |
|---|---|
| **AC Power Circuits** | Black (Neutral light Blue) |
| **AC circuits (110 VAC)** | Black |
| **DC Power Circuits** | Black |
| **AC control circuits** | Red |
| **DC control circuits (PELV/SE:V)** | Dark Blue |
| **I.S Control Circuits** | Blue |
| **Supply from external source** | Orange |
| **Earthing and bonding** | Green and Yellow |

*Table 1. EN60204 cable colours*

Multicore cable colours should be in accordance with DIN47100, shown in Table 2, unless otherwise specified by the engineer.

| Number | Colour | Short form | Number | Colour | Short form |
|---|---|---|---|---|---|
| 1 | white | WH | 31 | green-blue | GNBU |
| 2 | brown | BN | 32 | yellow-blue | YEBU |
| 3 | green | GN | 33 | green-red | GNRD |
| 4 | yellow | YE | 34 | yellow-red | YERD |
| 5 | grey | GY | 35 | green-black | GNBK |
| 6 | pink | PK | 36 | yellow-black | YEBK |
| 7 | blue | BU | 37 | grey-blue | GYBU |
| 8 | red | RD | 38 | pink-blue | PKBU |
| 9 | black | BK | 39 | grey-red | GYRD |
| 10 | violet | VT | 40 | pink-red | PKRD |
| 11 | grey-pink | GYPK | 41 | grey-black | GYBK |
| 12 | red-blue | RDBU | 42 | pink-black | PKBK |
| 13 | white-green | WHGN | 43 | blue-black | BUBK |
| 14 | brown-green | BNGN | 44 | red-black | RDBK |
| 15 | white-yellow | WHYE | 45 | white-brown-black | WHBNBK |
| 16 | yellow-brown | YEBN | 46 | yellow-green-black | YEGNBK |
| 17 | white-grey | WHGY | 47 | grey-pink-black | GYPKBK |
| 18 | grey-brown | GYBN | 48 | red-blue-black | RDBUBK |
| 19 | white-pink | WHPK | 49 | white-green-black | WHGNBK |
| 20 | pink-brown | PKBN | 50 | brown-green-black | BNGNBK |
| 21 | white-blue | WHBU | 51 | white-yellow-black | WHYEBK |
| 22 | brown-blue | BNBU | 52 | yellow-brown-black | YEBNBK |
| 23 | white-red | WHRD | 53 | white-grey-black | WHGYBK |
| 24 | brown-red | BNRD | 54 | grey-brown-black | GYBNBK |
| 25 | white-black | WHBK | 55 | white-pink-black | WHPKBK |
| 26 | brown-black | BNBK | 56 | pink-brown-black | PKBNBK |
| 27 | grey-green | GYGN | 57 | white-blue-black | WHBUBK |
| 28 | yellow-grey | YEGY | 58 | brown-blue-black | BNBUBK |
| 29 | pink-green | PKGN | 59 | white-red-black | WHRDBK |
| 30 | yellow-pink | YEPK | 60 | brown-red-black | WHRDBK |

*Table 2. DIN47100 standard cable colours*

### 7.17 Installation

Cables and wires should be installed directly from source to load or between devices without intermediate connections where possible. Junction boxes with screw or spring terminals should be of high quality and labelled to identify circuit type and operating voltage.

Cables for Field Wiring should preferably be terminated on the Terminal Blocks (TB's) in core order, as shown in Table 3.

Termination of stranded cables up to 6mm should be done with use of a cable stripping tool and bare copper ends crimped with bootlace ferrules according the French colour code. 8mm crimps are suitable for din rail terminals, a minimum of 12mm crimps are required for Miniature Circuit Breaker (MCB) connections or when double crimps are used.

| Colour | Wire CSA |
|---|---|
| Violet | 0.25mm |
| White | 0.5mm |
| Blue | 0.75mm |
| Red | 1.0mm |
| Black | 1.5mm |
| Grey | 2.5mm |
| Orange | 4.0mm |
| Green | 6.0mm |
| Brown | 10.0mm |
| Ivory | 16.0mm |
| Black | 25.0mm |
| Red | 35.0mm |

*Table 3. Bootlace Ferrule French Colour Code*

Cables connected into terminals should be crimped with a correct sized bootlace ferrule and remain securely fixed when pulled with reasonable force.

Two wires connected into the same terminal should be connected within a correctly sized double bootlace crimp.

Unused cores within a cable should preferably be terminated into spare terminals, if space constraints prevent this then they should be tied back along the outer sheath of the cable with heatshrink tube. Do not cut away spare cores out of the cable.

Screened control cables must have the braid tied to ground potential at one end of the cable. This is preferably via an Electromagnetic Compatibility (EMC) cable clamp on entry to the panel. A secondary method to achieve this is to solder a green and yellow cable with an equivalent cross-sectional area to that of the conductors to the braid and tie this to ground.

Where applicable all exposed earth wires must be sleeved in green and yellow.

Cables connected to studs via a ring crimp should be fitted with a lug sized appropriately for the cable; the nuts on the stud should be suitably tightened to prevent any movement of the lug.

Any equipment or junction boxes with terminating voltages above live working voltages (50Vac and 120Vdc) should be labelled with an electrical warning notice stating their operating voltage.

All signal cables should have the shield grounded at one end of the cable, which should be identified on the drawings.

Cables should be rated appropriately for their application and be installed as stated on the electrical drawings.

Mechanical and EMC protection should be appropriate for the type of application, considering operating voltage level, cable routes and environmental conditions.

Cables should be identified at both ends with the same unique identifier, this will be identified and verified with the drawings.

Cables should be clipped to tray and supported appropriately throughout the length of the route.

All external signal cables should have their screens bonded to the panel main earth immediately after entering the enclosure.

Wires within trunking should not be cable tied together preventing tracing of cables throughout the panel.

### 7.18 AC Distribution

Exposed conductive parts, operated above live working voltages (50Vac and 120Vdc) shall be protected to a minimum of IP2X – International Protection Marking, IEC standard 60529.

### 7.19 Protective Devices

The preferred range of MCB's to be used are Schneider Acti 9.

MCB's shall be manufactured to IEC 60898-1. All final circuit protective devices (MCB / RCBO) shall be fault rated to a minimum of 10kA.

MCB's are rated correctly for their application and installed as per drawings. Taking note of the trip curve identifier Type A-D/1-4. MCB's shall only be installed into distribution boards for which they are intended.

Residual Current Devices (RCD's) or Residual Current Circuit Breaker with Overcurrent Protection (RCBO's) should have the correct earth fault current rating, appropriate for their application

Where RCBO type devices are used for final distribution they shall be of the 'passive' type. (I.e. they do not trip with a loss of power, unless otherwise specified by the engineer.

Switch Disconnectors and MCB's shall be lockable in the open/off position

Fuses should be installed into fused terminals and rated accordingly to application. Fused terminals shall be orientated so that when the fuse lever is withdrawn it swings down away from the body and the connections, avoiding accidental reconnection.

### 7.20 Terminals

Terminals within control panels should be of the spring return type unless otherwise specified. Spring return terminals have a greater mean time to failure, do not work loose under varying environmental conditions and also provide faster termination for installation and commissioning.

Neutral terminals should be coloured blue.

Earth terminals shall be green and yellow in colour with an integral connection to the din rail upon which it is mounted.

Terminals shall be numbered from 1 onwards.

Terminal Blocks shall be numbered TB# (e.g. TB1, TB2, TB3 etc.) unless otherwise stated by the engineer.

Fused terminals for 24VDC should provide a feedthrough connection for the 0VDC line.

### 7.21 Links

Common links between terminals should, where possible, be done with linking bars supplied by the manufacturer of the same range of terminals/MCBs.

Wire links shall pass back into the trunking between terminal connections. These cables must be labelled even if they are a series common connection of 24VDc or 0VDC. In this instance the cable identifier collar can be fitted around both terminals connected into a double bootlace crimp.

Links installed for testing or commissioning purposes shall be wired in a colour and size not used elsewhere in the panel. The STFC preferred option is Pink. The links shall not be placed in the panel trunking with standard links. Optional flag labels can be placed on the linking wire with information such as Date, Name & Reference Number.

### 7.22 Equipment Identification

Terminal blocks should be clearly labelled with each terminal identified with a sequential number as shown on the electrical drawings. Numbers should, if possible, be in the horizontal orientation regardless of terminal orientation.

Panel mounted equipment shall be labelled on the equipment and adjacent to the equipment on the back panel. This is to identify the equipment name in the event the item has been replaced and not re-labelled. The STFC preferred method is to use a label carrier rail above the equipment/TB containing equipment identification labels fixed with a transparent cover.

Fuses should be labelled as F# were # is the fuse number, no other assignment to be used other than numbers.

Power Supplies are to be identified as PSU# (e.g. PSU1, PSU2, PSU3 etc.)

### 7.23 Cable and wire Identification

Cable and wire labels shall be fitted at both ends of the cable/wire run.

Identifiers should be black lettering on a white background.

Slide on cable numbers to the RKM code (IEC 60062) may be used on site when making modifications.

Outgoing wires labelled as the fuse number F#+, F#-0V.

Wires between power supplies and fused terminals shall be PSU#+ and PSU#-. Where # indicates the power supply number.

Digital I/O

PLC module number / input assignment as per plc module e.g. PLC10 module, will be 10.xx were xx denotes manufacturers hardware terminal detail as per module type

Analogue I/O

PLC module number / input assignment as above but identify channel input for (+ or -) e.g. 10.xx+ or 10.xx-, this allow the + cable to be moved between current and voltage terminals of the I/O module without remarking the cable. (4-20mA or 0-10V input change).

| Module Type | Format | Example | Label |
|---|---|---|---|
| DIGITAL I/O | PLC Module.I/O assignment | Module 10<br>Input/ Output 0 | 10.00 |
| ANALOGUE I/O | PLC Module.I/O assignment | Module 11<br>Input/ Output 3 | 11.03+<br>11.03- |

*Table 4. Summary of PLC connection labels*

Cable identifiers shall read in the same direction when entering and leaving a piece of equipment or terminal, shown in fig 1. It is preferable for the text direction to read in the direction of current which normally means from left to right and top to bottom in electrical drawings.

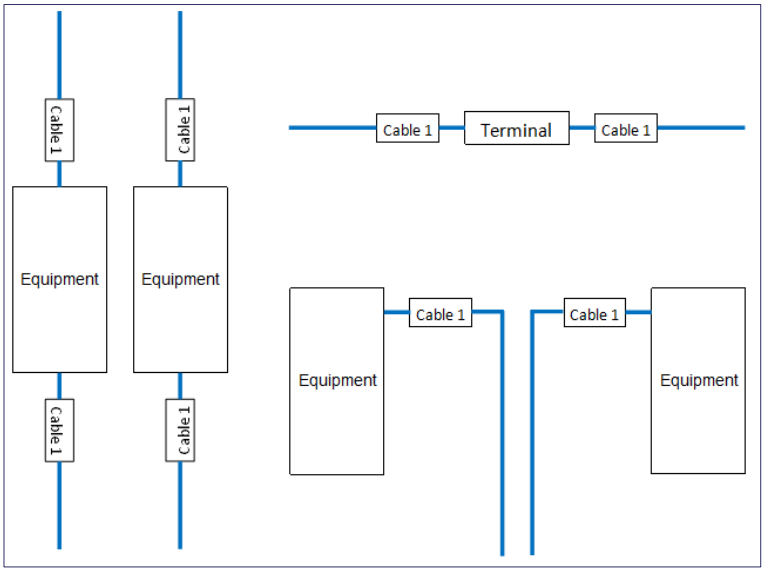


*Fig 1. Cable identification text direction*

## 7.24 Earthing

All metallic parts of the control panel shall be electrically bonded in order to maintain the integrity of the protective earth system.

All exposed metallic parts of the panel shall be bonded with green and yellow 2.5mm² cable, including removable sections such as doors, side panels, roof panel and fan assembly. An earth stud is usually provided and identified with a label, if this is not apparent then a stud must be fitted to connect all parts of the panel earth.

For panels containing equipment which use high frequency switching such as inverters and power supplies it may be necessary to use copper braid rather than standard cable. This will be specified by the design engineer.

Any earth tails should be of suitable length to allow opening of doors.

Earth wires shall not be coiled up

## 7.25 EMC

Shielded cables entering/exiting the panel must be grounded to general earth. The recommended technique is to use EMC clamp cable supports which mount to TS35 Din rail or proprietary rail at the nearest point to cable entry.

Motor cable shields are grounded at the nearest point to the drive system, the means to clamp the shield is usually integrated into the drive for pre-terminated proprietary cables. If this is not present then advice should be sought from the STFC engineer.

## 7.26 Operator Interface

All LV indicators on control panels should be LED type with a test facility built in for equipment that has an alarm LED and no external monitoring,

Colour coding should be in accordance with BS EN 60204-1 Table 2.

*Pushbuttons*

| | |
|---|---|
| Start Button | Green |
| Stop Button (emergency) | Red |
| Stop Button (Functional) | Black |
| Reset | Blue |
| Mains on | White |
| Warning | Yellow |

*Table 5. Recommended pushbutton colours*

*Indicators*

| Colour | Meaning | Explanation |
|---|---|---|
| Red | Emergency | Hazardous Condition |
| Yellow | Abnormal | Impending critical condition |
| Blue | Mandatory | Requires operator action |
| Green | Normal | Normal condition |
| White | Neutral | Monitoring |

*Table 6. Recommended indicator colours*

Column type beacons will typically be of three stack construction, including green at the base, yellow in the centre and red at the top for increased visibility of a warning state. Functionality should indicate the machine status as follows unless otherwise specified:

| | |
|---|---|
| Red Constant | Machine running |
| Red Flashing | Machine waiting to start |
| Amber | Fault |
| Green | Machine in safe condition / stopped |

*Table 7. Column stack indicator status*

Other lighting stack arrangements, including sounders, are acceptable if defined by the designer and/or engineer

## 7.27 AC/DC Power supplies

Controls voltage within control panels should be 24VDC unless otherwise specified. This is usually achieved with a 230VAC to 24VDC converter.

PULS or Omron power supplies are the preferred manufacturers of LV power supplies for control racks but other supplies meeting the same standards from approved suppliers are acceptable.

Dual power supplies may be connected via a redundancy module to maintain continuity of power in the event of failure of 1 power supply.

Consideration should be given to a Power Supply Unit (PSU) capable of indicating the current being drawn. A secondary option is to install fused terminals with an integral LED to indicate is voltage present on the control circuit.

### 7.28 Communications

Ethernet connections should be correctly terminated as straight connection or crossover when pre-made patch leads are not used.

Terminations of Ethernet into an RJ45 connector can be to standard T568A or T568B. The standard preferred by Daresbury Network support is T568B.

| Pin | T568A | T568B |
|---|---|---|
| 1 | White/Green | White/Orange |
| 2 | Green | Orange |
| 3 | White/Orange | White/Green |
| 4 | Blue | Blue |
| 5 | White/Blue | White/Blue |
| 6 | Orange | Green |
| 7 | White/Brown | White/Brown |
| 8 | Brown | Brown |

*Table 8. T568A/B Standard Ethernet Connections*

### 7.29 Emergency Stop Buttons

Panels are to be fitted with machine stops and/or emergency stops. As per IEC60204 any emergency stop shall be a red push button whereas a machine stop shall be black.

Emergency stops should preferably have 2 normally closed switches so that a dual channel safety relay can be connected. The dual channel arrangement provides cross checking for short circuit between the channels and provides a greater level of safety.

Emergency stops shall have a yellow surround stating it is an Emergency stop, with further information on what is actually stopped if there are limitations. E.g. the emergency stop isolates the output of inverter drives but the input stage is still active and electrically live.

## 8. Commissioning

### 8.1 Declaration of conformity and CE Marking

Declaration of conformity (CE marking) certificate shall be provided to the Engineer if this can be produced.

All equipment installed within the panels shall be CE marked unless the engineer in charge of work gives permission to deviate from this standard.

### 8.2 Inspection & Wire Checking

Upon completion of the panel build, the supplier shall fill in their own checklist sheet or complete set of marked off wiring drawings, in a neat and legible manner, to provide evidence that the panels meet the requirements within this specification and are built according to supplied electrical drawings. These documents shall be produced upon panel completion for the STFC engineer to add to the technical file.

The panels should be cleared of any debris caused during manufacture such as swarf, cut cables, and cable ties.

Doors should be inspected for alignment without any binding and locking mechanisms operate effectively.

Keys should be available for lockable doors.

If available, lifting points should be fitted to the top of the panels, capable of supporting the basic panel, plus contents.

Equipment, DIN rail and trunking are checked to be securely fixed and mounted level and plum.

Equipment and wiring will be clearly labelled as per the requirement in this specification and the electrical drawings.

### 8.3 AC Distribution testing

Testing of the AC distribution within the panels will be carried out by a competent person qualified to Inspect, Test and Certify and been approved. The competent person will be qualified with C&G 2391 or C&G 2394 and C&G 2395.

Electrical testing shall consist of the following:

1. Inspection
   Record the general installation details such as the type of supply used for the test at the suppliers premises. Document the cable sizes, types and means of circuit protection. All circuits should be clearly identified within the AC distribution board.
2. Polarity
   Check polarity of connections to equipment and panel services.
3. Continuity
   Measuring the R1+R2 values of circuit conductors
4. Insulation resistance testing up to 500V.
   Testing the insulation of conductors for breakdown between phases and phase to earth.
5. Earth leakage testing
   Measuring the tripping times for earth leakage devices.
6. Earth fault loop impedance and short circuit capacity tests
   These are completed to ensure protective devices act within the specified maximum permitted disconnection time and that fault current is not above the maximum level the protective device can handle.

Note: Steps 1-4 are to be completed by the supplier after the panel build but before the FAT. Steps 5 and 6 are to be completed when the panels are connected to the AC supply in their final position at DL by STFC technical staff.

### 8.4 Communications

Ethernet cables should be tested with an electronic tester in addition to verifying the cable terminations into RJ45 connectors.

### 8.5 Control panel services

Check that the panel internal services operate correctly, such as lighting and sockets.

Verify the panel cooling and ventilation has been correctly specified to keep the panel from overheating when all equipment is running at normal operating levels.

Check pilot devices and functionality of operator buttons, control keys.

### 8.6 Functionality

All auxiliary equipment within the panels should be powered and checked, including auxiliary power supplies, network switches and PLCs.

Power supplies for control circuits should be measured and adjusted if required to the desired voltage.

### 8.7 Power Loss Conditions

Before handover it shall be verified that the control system and equipment returns to a safe state upon return of power to the panel and associated equipment.

Electrical supplies to equipment powering motors or other moving parts shall be fitted with no volt release coils to prevent the unintended start upon return of power.

## 9. Spares

Where equipment and components purchased for the builds are supplied in quantities greater than is required, the remaining equipment will be delivered with the panels for use as spares in future panel maintenance.