

# Next Generation Engineering Standards and Specifications

## Specification for Low Voltage Switchgear Assemblies

### Specification Number 0303

#### Document Control

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Title	<b>Next Generation Engineering Standards and Specifications</b> <b>Specification for Low Voltage Switchgear Assemblies</b>				

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## Appendix A

Low Voltage Switchgear Assemblies Data Sheet (Template)

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## 1 Introduction

This document is a component of Almarai's Next Generation Engineering Standards & Specifications Design Toolkit, which was developed to support construction activities at Almarai's existing and future sites in the Kingdom of Saudi Arabia (KSA) and the United Arab Emirates (UAE). The documents are proprietary and confidential.

This document resides on Level 2 – Specifications.

Level 2 – Specifications are documents that set out general performance requirements associated with each distinct area within a facility, and outline the minimum standard required. They should be read in conjunction with other documentation in the Next Generation Engineering Standards & Specifications Design Toolkit, particularly the relevant Level 1 Design Toolkit Document and the series of Civil, Structural, Mechanical, Electrical, Fire and Architectural specifications.

This document is for use by Almarai Project Management, and by Consultants and Contractors to Almarai when appropriate.

The User shall be responsible for compliance to all applicable Codes, the Owner's requirements including those stated above, and the requirements of Almarai's insurance carrier. If there are conflicts between the above stated requirements, the more onerous shall be used.

## 2 Acronyms & Abbreviations

The following acronyms and abbreviations apply to this Electrical Specification:

AC	-	Alternating Current
ACB	-	Air Circuit Breaker
BMS	-	Building Management System
BS	-	British Standard
CD-ROM	-	Compact Disc Read-only Optical Memory device
CE	-	European Conformity
CT	-	Current Transformer
EMC	-	Electromagnetic Compatibility
EN	-	European Standard
EU	-	European Union
FAT	-	Factory Acceptance Test
FBA	-	Factory Built Assembly
FDS	-	Functional Design Specification
IEC	-	International Electrotechnical Commission
IP	-	Ingress Protection
Isc	-	Short Circuit Current
KSA	-	Kingdom of Saudi Arabia
LED	-	Light Emitting Diode

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LSF	-	Low Smoke and Fume
LSI	-	Long Time, Short Time, and Instantaneous function
LSIG	-	Long Time, Short Time, Instantaneous, and Ground Fault
LV	-	Low Voltage
MCB	-	Miniature Circuit Breaker
MCC	-	Motor Control Centre
MCCB	-	Moulded Case Circuit Breaker
PCC	-	Process Control Centre
RMS	-	Root Mean Square
RoHS	-	Restriction of Hazardous Substances Directive
THD	-	Total Harmonic Distortion
TN-S	-	Earth Neutral Separate - Earthing System
WEEE	-	Waste Electrical and Electronic Equipment Directive

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### 3 Applicable Codes and Standards

Compliance with local and national codes and standards for the region in which the construction is to be undertaken is mandatory.

BS-EN standards shall be the governing standards for the works, except for Fire Protection, which will be based on NFPA requirements.

Only where expressly stated in the Electrical Specification shall other standards be applicable to the works.

All reference British, European and other standards, regulations and requirements of statutory bodies shall mean the latest published editions and National Annexes to those standards at the time of reading this Electrical Specification and/or contract award by relevant third party.

Where such standards, regulations and requirements are amended after contract award and affect the Contractor's responsibilities during the course of the works, immediately inform Almarai Project Management team in writing.

If unable to comply with the governing standards or regulations and proposing to substitute other standards, the Low Voltage Switchgear Vendor shall inform Almarai Project Management team with the summary of deviations from the Level 2 document.

The Low Voltage Switchgear Vendor shall guarantee that the performance of the Low Voltage Switchgear shall meet all the performance criteria and standards established by this specification and the latest edition of the following codes standards and guidance, including but not limited to the following:

- SBC 401                Saudi Building Codes Electrical
- EN 50267            Common test methods for cables under fire conditions
- EN 55011            Industrial, scientific and medical equipment - Radio-frequency disturbance characteristics - Limits and methods of measurement
- EN 55022            Information technology equipment - Radio disturbance characteristics - Limits and methods of measurement
- EN 55024            Information technology equipment - Immunity characteristics - Limits & methods of measurement
- EN 60034            Rotating electrical machines
- EN 60073            Basic and safety principles for man-machine interface, marking and identification. Coding principles for indicators and actuators
- EN 60204            Safety of Machinery – Electrical Equipment of Machines
- EN 60255            Measuring relays and protection equipment
- EN 60269            Low Voltage Fuses
- EN 60309            Plugs, socket-outlets and couplers for industrial purposes
- EN 60332            Tests on electric and optical fibre cables under fire conditions
- EN 60439            Low-voltage Switchgear and Controlgear assemblies
- EN 60754            Test on gases evolved during combustion of materials from cables
- EN 60801            Electromagnetic compatibility for industrial-process measurement and control equipment. Electrostatic discharge requirements

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- EN 60898 Electrical accessories - Circuit-breakers for overcurrent protection for household and similar installations
- EN 60947 Low-voltage Switchgear and Controlgear
- EN 61000 Electromagnetic Compatibility (EMC)
- EN 61034 Measurement of smoke density of cables burning under defined conditions
- EN 61439 Low Voltage Switchgear and Controlgear assemblies
- EN 61508 Functional safety of electrical/electronic/programmable electronic safety related systems
- EN 61511 Functional safety - Safety instrumented systems for the process industry sector
- EN 61558 Safety of power transformers, power supplies, reactors and similar products
- EN 61869 Instrument transformers. Additional requirements for capacitor voltage transformers
- EN 62061 electronic Safety of machinery - Functional safety of safety-related electrical, and programmable electronic control systems
- EN 62305 Protection against Lightning
- EN ISO 13849 Safety of machinery - Safety-related parts of control systems
- EN 60529 Degrees of protection provided by enclosures (IP Code)
- EN 60947 Low-voltage switchgear and controlgear. Ancillary equipment
- IEC TR 61641 Enclosed Low-voltage Switchgear and Controlgear assemblies – Guide for testing under conditions of arcing due to internal fault
- IEC 1000-2-5 Electromagnetic compatibility (EMC)
- IEC 60051 Direct acting indicating analogue electrical measuring instruments and their accessories
- IEC 60364 Low-voltage electrical installations
- IEC 60617 Graphical symbols for diagrams
- IEEE 1584 Guide for performing Arc Flash hazard calculations
- ISO 3864 Graphical symbols. Safety colours and safety signs
- BS 5472 Specification for low voltage switchgear and control gear for industrial Terminal marking and distinctive number
- BS 6121 Mechanical cable glands. Armour glands. Requirements and test methods
- BS 6231 Electric cables. Single core PVC insulated flexible cables of rated voltage 600/1000 V for switchgear and controlgear wiring
- BS EN 60947-4-1 Low-Voltage Switchgear and Controlgear Assemblies. Electromechanical contactors and motor starters
- BS EN 61095 Electromechanical contactors for household and similar purposes

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- EN ISO 9001      Quality management systems. Requirements

A document or statement is required from all Vendors of non-EU electrical/electronic equipment to state that it complies with relevant European WEEE and RoHS regulations and is CE certified. Any costs associated in complying with this requirement will be borne by the Contractor and Vendor.

### 3.1 EU Council Directives

- Machinery Directive 2006/42/EC and amending directive 95/16/EC
- Electromagnetic Compatibility (EMC) Directive 2014/30/EU
- Low Voltage Directive 2014/35/EU
- ATEX Directive 2014/34/EU - Equipment and protective systems intended for use in potentially explosive atmospheres
- RoHS Directive 2011/65/EU - Restriction of the use of certain hazardous substances in electrical and electronic equipment

Note: All electrical equipment and systems supplied shall conform to the appropriate EU Directives and shall carry the applicable CE Marking.

For electrical equipment and systems within the scope of supply, the Vendor's documentation shall include Declarations of Conformity for electrical equipment as required by the EU Machinery Directive, the Low Voltage Directive and the Electromagnetic Compatibility Directive.



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## 4 General Requirements

### 4.1 General

This Specification covers the minimum technical requirements for the design, manufacture, assembly, testing, delivery and performance of factory built Low Voltage Switchgear Assemblies.

This specification applies to switchgear assemblies for use on Low Voltage systems purchased directly by Almarai or provided as part of a scope of contracted works.

All deviations from the requirements of this specification shall be explicitly stated in the bid documentation. In the absence of such a statement, it shall be understood that all requirements of this specification are fulfilled without exception.

## 5 Vendors Responsibilities

- The Vendor shall be responsible for the following:
  - Equipment design and the provision of Drawings and data submittals as set out later in this specification.
  - Manufacture and fabrication.
  - Testing and Certification.
  - FAT Testing witnessed by Purchaser.
  - Shipping to site.
  - Setting in place.
  - Final assembly and site installation.
  - Pre-commissioning.
  - Commissioning.
- Exclusions:
  - Off loading
  - Civil works
- The Vendor shall be responsible for co-ordinating between themselves and all their sub-contractors for materials and services provided. The Vendor shall be responsible for the overall equipment and for compliance with the specified requirements.
- The Vendor shall be responsible for obtaining necessary approvals, authorisation and certification from third party inspection agencies. Upon receiving the approvals, all certificates shall be submitted to the Engineer prior to delivery of the equipment.
- Should a Vendor identify any discrepancy deficiency or lack of clarity in any part of this specification or attached documents, he shall notify the Engineer of his proposed alternative(s) and any impact on the price and/or schedule.
- The Vendor shall not commence any fabrication work prior to obtaining written approval of drawings and procedures from the Engineer. The Vendor is responsible for maintaining strict quality control procedures to ensure compliance with codes, specifications, drawings and instructions issued by the Engineer during the manufacture of equipment.

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7. Vendor shall carry out load flow, short circuit coordination taking into account the current limiting feature of the low voltage switchgear.
8. Vendor shall
  - Provide under voltage trip on the mains incomer board switchgear
  - Interlock sympathetic tripping of the upstream power supply on main switchgear only.

All components shall be Type 2 coordinated.

Almarai Project Management will approve drawings but this will not relieve the Vendors of their responsibility for the design and functionality of the equipment.

## 6 Project Submittals

### 6.1 With Bid

Provide the following in addition to the standard requirements with the Bid:

- Descriptive literature describing features
- Sketch with external dimensions and initial General Arrangement drawing
- Shipping weight
- Typical equipment electrical characteristics and hook up requirements

### 6.2 4 Weeks after Award

Provide the following information submitted "For Approval" within 4 weeks after award of order, or to a timeframe agreed with Almarai Project Management.

- Include front and side views of enclosures with overall dimensions shown
- Submit fully comprehensive manufacturer's technical data (including time-overcurrent coordination curves) and manuals for the proposed equipment and assemblies. Components not manufactured by Vendor, shall be noted as such
- Submit factory shop drawings prepared specifically for this unit. Use IEC standard drawing symbols
- Submit bill of materials, listing the part number and quantity of all component devices
- Submit Factory Acceptance Test protocol for review/approval
- Submit Site Acceptance Test protocol for review/approval
- Confirm shipping splits and weights with the installation contractor to ensure that the contractor has proper rigging services and access to equipment location

### 6.3 Prior to Shipment

Provide the following information submitted "For Approval" at 6 weeks prior to shipment of equipment to site.

- Final electrical and instrument wiring Diagrams and cable schedules
- Interconnecting wiring diagram with terminal numbers. Terminals for internal and external wiring shall be clearly identified
- Final Instructions for handling and installation.

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- Submit component and module wiring diagrams
- Submit Factory Acceptance Test Reports
- Submit description Functional Design Specification (FDS) of operations of all functions of the system
- Submit as-built drawings and O+M Manuals
- The format for final layout and wiring drawings is AutoCAD current version, with two CD-ROM discs provided for final record

#### 6.4 Product Data

Include project specific model numbers and equipment data sheets for all elements of the switchgear and ancillary systems, including but not limited to:

- Switchgear assemblies.
- Circuit breakers and electronic protection.
- Frame size and trip ratings.
- Time-current curves for all equipment.
- Fault current withstand ratings.
- Metering equipment.
- Surge protection devices.
- Battery back-up.
- Indicating lamps.
- Current transformers, ratio class, terminal markings and outputs.
- Total weights of switchgear configuration.
- Enclosure details and physical dimensions.
- Ventilation of panels

### 7 Services during Construction

The equipment Vendor scope of work under services during construction shall include:

- Provide a single contact point of reference to respond to site queries/requests for Information
- Undertake regular visits to site and inspections to ensure the equipment is being protected during cable connection by the Electrical Contractor
- Ensure all sub-systems are complete and ready for commissioning
- Carry out pre-commissioning checks and support first energisation
- Carry out commissioning and first energisation of equipment
- Install preliminary and final relay settings

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## 8 Performance Requirements

The switchgear Vendor shall be a company specializing in manufacturing the products specified in this Section with minimum 10 years' documented experience.

The switchgear assembly shall be capable of operating to its design limits for a minimum period of fifteen years, assuming that regular maintenance, in accordance with the system manufacturer's recommendations is carried out.

The LV Switchgear assemblies shall be designed to operate safely under the site service conditions.

The LV Switchgear assemblies shall be designed for continuous operation under the electrical service conditions.

The switchgear assemblies, circuit breakers and busbars shall be rated for the full rating shown on the single line diagrams. No de-rating or diversification shall be applied.

## 9 General Requirements

### 9.1 Enclosure and Arrangements

The LV Switchgear shall be totally enclosed, metal clad, freestanding, multi-cubicle Factory Built Assembly (FBA). The form of separation shall be Form 4b type for main boards, Form 3b for Motor Control Centres (MCCs) and Process Control Centres (PCCs), and Form 2b for sub-main boards as defined by EN 61439. A plug-in system or busbar with prongs is preferable to a basic 2b system.

The assembly shall be designed and constructed for a TN-S power system i.e. with separate neutral and protective bus bars unless otherwise specified.

The enclosure shall be of rigid and sturdy construction and shall be of sufficient mechanical strength to withstand the stress to which it may be subjected.

The switchgear finish shall be of high quality durable, impact resistant, corrosion resistant, long life paint or powder coating, standard manufacturer's finished coat over primer.

Switchgear located in wet production areas shall be IP55 rated and shall have a sloped roof to allow for easy cleaning. In dry production areas switchgear shall be IP54 rated. In non-production areas switchgear shall be IP44.

The design shall facilitate operation, inspection, cleaning, repair and maintenance and shall ensure safety under all normal operating and maintenance conditions.

Access by hinged doors to control circuitry, instruments and relays shall only be possible by the use of a lockable handle.

The LV switchgear shall have a maximum height of 2400mm.

The minimum thickness of the sheet steel of the enclosure shall be 2mm, braced where necessary to achieve a rigid construction.

Door gaskets shall be heavy gauge appropriate for each location and suitable for repeated opening.

Internal cable connections from droppers to all units such as starters, isolators, switch fuse units etc., must be kept as short as possible (200mm max.) and shall be capable of withstanding the stresses occurring in the cables during a fault.

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The electrical panels being provided greater than 30kg shall be furnished with lifting lugs or eyebolts specifically designed for ease of handling during installation.

The Vendor shall pay particular attention to providing stable panels (not top heavy). Where, due to design reasons, this cannot be wholly achieved, the Vendor shall provide markings on the panels and on the individual panel shipping sections clearly indicating the hazards involved with the handling of the panel, including section weights and any special lifting instructions. These hazards shall be highlighted in advance of shipping to the material handling personnel.

Gland plates shall be secured by bolts into tapped holes or nuts. Self-tapping screws are not permitted. The gland plates are to be connected by a flexible earth connection to the main earth bar.

Separate gland plates shall be provided above the cable chamber made of Aluminium.

Gland plates for single core cables shall be of non-ferrous material.

A cable spreader box shall be provided (if required) to the same standard as the LV board to facilitate glanding of cables.

Means of support shall be provided for cables which run the greater part of the height of the assembly (over 1 metre in length) or where the weight of the cable would impose excessive strain on the cable gland.

All access for installation, maintenance and extension shall be possible from the front.

Compartment doors shall be fully interlocked to prevent access to live equipment. Busbar side connections which remain live when the compartment door is open must be shrouded and fitted with a suitable warning label.

Other live conductors and components shall be protected from inadvertent contact by persons while that door is open. This will normally consist of a barrier which can be removed only by means of a tool. A warning label shall be provided on the barrier.

Hinged metal doors shall be provided with a flexible earth connection.

Adequate protection in the form of shrouding and/or vertical and horizontal screening between compartments and sub-compartments shall be provided to minimise the risk of accidental short circuits, and the insulation shall be capable of providing adequate and lasting protection under specified normal conditions and recognised overcurrents and overvoltages.

When the switchgear is an integral part of a unit substation or the main low voltage distribution board in an installation a fully rated neutralising link shall be located in the incoming cable compartment. Alternatively the link shall be in a separate accessible enclosure. The link shall be a solid copper bar connecting the switchboard neutral bar to the earth bar, and shall be clearly identified as to its purpose.

The neutral shall be fully insulated against contact with the true earth, other than at the earth point itself.

Items of equipment and materials that are mounted or located within the assembly shall not exceed their permitted and rated temperature rise and maximum temperature and these shall be compatible with those allowable of the FBA.

The Vendor shall state the conventional enclosed thermal current of the equipment when mounted within the enclosures provided, with the ventilation provided and at the maximum ambient temperature.

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The diversity factor to be applied for assessing the temperature rise of an assembly of motor starters shall be not less than 0.9 and for an assembly of distribution switchgear it shall be in accordance with BS EN 60439.

No other diversity factors are to be applied.

For the purpose of assessing temperature rise, vacant compartments shall be assumed to be equipped at the maximum rating appropriate within the FBA.

## 9.2 Busbars

The busbars shall be of rectangular hard drawn high conductivity copper. Each busbar and joint shall be fully insulated to restrict the initiation and propagation of arcs.

Arc propagation barriers shall be provided to prevent arcs occurring in incoming bus duct from flashing through or around the main incoming unit to the main busbar.

A three phase and neutral main horizontal busbar arrangement shall be provided, with a minimum current carrying capacity as required by the Vendor's design.

The vertical busbars(droppers) shall have a minimum current carrying capacity equal to the sum of the ampere capacities of the outgoing circuits supplied from the busbars with due consideration

given to prospective short circuit fault currents.

A main copper earth bar rated at 50% minimum of the phase bar shall be run the length of the assembly to which the cubicle structures shall be bonded and shall be sized to carry the maximum fault current.

The main earth bar shall be positioned and prepared so as to receive bonding straps from the incoming and outgoing cables. Additionally, earth studs shall be provided at each end to receive earth cables.

Busbars shall be enclosed in separate air insulated compartments.

The neutral busbar shall be equal to 100% (unless stated otherwise) of the phase busbar cross sectional area.

All busbars shall be suitably braced to withstand the short circuit fault current specified on the single line diagrams. Where no single line diagrams are issued the following table outlines the minimum various fault levels (**I<sub>sc</sub>**) applicable.

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Location on Power Train	Busbar or Breaker rating	Isc Applicable
Main substation level fed from transformer (3.5MVA Transformer, 7% impedance)	2500A to 5000A busbars or incomers	75kA RMS for 1 second
Main Distribution Board (3.5MVA Transformer, 7% impedance)	1250A to 2500A busbars or incomers	75kA RMS for 1 second
Sub-Main Distribution Boards	250A to 1600A busbars or incomers	50kA RMS for 1 second
Panel boards or Control Panels	250A incomer with MCB outgoing	35kA RMS for 1 second

All busbars shall be copper and joints shall overlap completely. Busbar joints shall be made with high tensile steel bolts with a protective finish such as zinc chromate for corrosion resistance. All busbar joints shall be torqued in accordance with the system manufacturer's instructions, and marked accordingly.

Busbars shall be effectively separated from other compartments within the Assembly in such a way as to comply with the requirement of the forms of construction. Busbars shall be separated from all outgoing terminals.

Systems at different voltages shall be completely segregated from each other.

The busbars shall be identified at 1000mm intervals with coloured PVC tape. Colours shall be as per local code requirements for each phase and neutral.

A ventilation Fan shall be provided if the temperature of the Bus Bar is expected to rise beyond 80°C.

### 9.3 Earthing

A copper main earth bar of suitable cross section shall run the whole length of the main switchboard and shall be drilled with 10mm holes for earth cable connections at each end.

Each section or compartment of the main assembly shall be provided with an effective earth connection to the earth bar by earth conductors of adequate cross section. Earth conductors (minimum 2.5mm<sup>2</sup> cross section of area) flexible multi-strand shall be provided for the effective earthing of any hinged door to the main structure of the Assembly.

Joints in the main earth bar shall be tinned and bolted with galvanised or cadmiumised bolts, nuts and non-loosening washers.

Particular attention shall be given to the effective earthing of withdrawable items when in the test position and also door mounted equipment. Reliance shall not be placed on hinges for earthing.

The earthing contacts of withdrawable items shall make before the main electrical contacts and break after the main electrical contacts.



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Where a neutral earthing arrangement for an incoming transformer circuit is required, the neutral shall be fully insulated against contact with the true earth, other than at the earth point itself.

The neutral earthing arrangement shall be achieved via an accessible removable link. The link shall be clearly identified as to its purpose.

All metallic non-current parts shall be effectively bonded together and connected to the high conductivity copper main earth bar which shall be electrically continuous over the entire length of the switchgear.

The earth bars shall be identified at 1000mm intervals by green/yellow tape.

#### 9.4 Internal Wiring

All wiring shall be carried out in LSF insulated multistrand copper cable, rated at 600/1000V and with a minimum cross-section of 1.5mm<sup>2</sup>.

The bunching of cables into large looms shall be avoided and no loom of control cables shall exceed 15 conductors.

Wiring shall not be installed in busbar compartments.

The phase sequence of the supply shall be L1, L2, L3 as per local colour code designation. All power conductors and connections shall be arranged to follow this sequence, reading from left to right or top to bottom, when observed from the front of the Assembly. Earth conductors shall be coloured green and yellow.

All cables and cable looms must be retained by cable ties or strapping designed to prevent damage to the cable insulation and to provide adequate support to the cables and cable looms. Cableways shall be adequately sized to allow the installation of 20% more cables at a future date.

Where equipment is located on any hinged or sliding panel section or door, it shall be wired in a LSF insulated flexible cable holder suitably supported and protected against undue strain and chaffing. The hinged or sliding panel section or door shall be provided with a flexible earth connection.

All power and control cabling shall be permanently identified by means of numbered and/or lettered ferrules at all terminations. The cable references shall be shown on the schematic wiring diagrams for the starter circuits.

All current transformer secondary connections shall be suitably identified to avoid inadvertent open circuiting.

Where assemblies are split for transportation purposes, terminals shall be provided in each section for interconnection of wiring. Such terminals shall be clearly labelled and positioned for easy access during both installation and routine maintenance, and their position shall be shown on the Layout or General Arrangement drawings.

Cables of different voltages shall be suitably separated on different terminal blocks with adequate protection against accidental contact during termination of external control wires etc. The terminal blocks shall be clearly identified with their respective voltages.



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Where ratings of less than 100A are specified for functional units, connection between busbars, all sub-circuit wiring and apparatus terminals shall be made in LSF insulated copper tails suitably rated and braced to withstand thermal effects under normal conditions and mechanical stresses in faulty conditions. The current rating of the interconnecting tails shall be equal to or less than the current rating of the upstream protection device.

Wiring between terminals shall be continuous. Joints are not permitted. All wiring shall be carried out in such a way so as to avoid damage from all causes such as over-tensioning, abrasion from sharp edges, insulation failure due to heat sources etc. Crimped terminals shall be used where possible. A maximum of two wires per terminal is permitted.

Power terminal shall be rated for 35mm<sup>2</sup> (maximum) only. Cable size above 35mm<sup>2</sup> shall be connected to the bus bar extension from the MCCB.

Proprietary type cross-connecting links shall be used where conductors are to be "commoned" together.

The terminal blocks shall be located to afford easy access for termination, testing, shipping and maintenance, and shall incorporate 10% spare capacity. Single deck terminals shall be used for both power and control wiring.

Terminations shall be arranged in functional groups, each group being clearly labelled.

Any terminals which are accessible and which of necessity are required to remain energised shall be screened-off or shrouded to prevent danger. WARNING LABELS shall be fitted. In particular, terminals which may carry signals of voltages from sources outside the assembly shall be shrouded and labelled.

Crimped pin connectors shall be used for all control wiring and sub-circuit wiring on each sub-distribution centre.

## 10 Components

### 10.1 General

The ratings specified are those required when the Low Voltage Switchgear Assembly is installed and working in the specified location, without the use of cooling fans and are continuous ratings. The conditional rating of all devices and equipment shall correspond to the specified rating of the main circuits.

Switching devices or fuses shall not be arranged in parallel to provide the ratings specified.

The neutral conductor and terminals in each outgoing circuit shall have a current carrying capacity equal to the phase conductors.

Motor isolators shall have a Utilisation Category AC-23 and a sufficient mechanical and electrical endurance to EN 61439-2.

Where a disconnecter or fuse-disconnector is required and does not form part of a motor starter, it shall have a Utilisation Category AC-22 and a sufficient mechanical and electrical endurance to EN 61439-2.

All door mounted isolators shall be padlockable in the "OFF" position only.

Contactors shall have a Utilisation Category AC-3.

Contactors shall have sufficient auxiliary contacts for the functions required by the specified control circuit. In addition, provision for at least 1 each future Normally Open (N/O) and Normally Closed (N/C) contact shall be possible.

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Each motor starter shall have a thermal overload relay or microprocessor based thermal model type electronic overload release which shall be ambient temperature compensated (designated by the associated motor full load current) and shall be phase failure sensitive. The time-current characteristics of overload relays shall be provided on request.

Current transformers shall comply with EN 61869.

Current transformers shall be such that the relays will operate correctly when set at any point within their ranges.

Current transformers secondary wiring shall be earthed on one side through a removable link. Where current transformers are connected in star, the star point shall be earthed through a removable link.

Shorting links shall be provided for each current transformer.

## 10.2 Air Circuit Breakers

Circuit breakers shall be of the non-fused, air break, trip-free type and rated for continuous duty.

They shall have a short circuit performance category P-1 or P-2 and shall be suitable for uninterrupted duty.

Motor wound spring operating mechanisms shall be automatically recharged following the closing operation.

All circuit breakers shall have a manual mechanical trip facility.

ACBs shall be fitted with electronic release trips to include LSIG functionality.

Facilities shall be provided for electrically testing the circuit closing and tripping mechanism when the circuit breaker is in the isolated, and withdrawn test positions.

The closing and tripping supplies shall be protected by fuses or miniature circuit breakers. All protection devices shall form a co-ordinated system of protection.

Each ACB shall have lockable isolation facilities.

The circuit breakers shall have a trip indication flag to indicate the cause of the trip, which shall be retained following the trip.

At the main substation level, the breakers including the bus coupler shall be draw-out. All feeder outgoing breakers will be fixed type.

The main substation LV panel incomer ACB breaker shall be 3 pole and the bus coupler shall be 4 pole.

## 10.3 Moulded Case Circuit Breakers

Preference shall be given to the use of MCCBs. Use of ACBs should be warranted by short circuit current limit/cascading. All MCCBs must be provided with overcurrent, short circuit and earth fault features. Moulded case circuit breakers (MCCBs) shall be of the non-fused, air break, trip-free type.

MCCBs shall have thermo-magnetic trip releases or electronic trip releases with LSI or LSIG functionality depending on the system requirements.

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MCCBs shall have a short circuit performance category P-1 or P-2 and shall be suitable for continuous duty.

Documentation shall be furnished to verify that the circuit breakers have been type tested to demonstrate effective through-fault co-ordination with contactor/overload combinations and other downstream devices.

Where moulded case circuit breakers are used for feeder circuit protection their rating and characteristics shall be chosen in such a way as to ensure proper discrimination with other upstream and downstream protection devices within the assembly, and with protection devices external to the assembly.

Thermal overload devices which are an integral part of the moulded case circuit breaker that are used for motor overload protection shall have a performance characteristic in accordance with BS EN 60947-4-1.

The Vendor shall advise the maximum number of direct driven circuit breaker auxiliary contacts available.

The Vendor shall co-ordinate the complete electrical distribution network to ensure proper discrimination.

Each moulded case circuit breaker shall have lockable isolation facilities.

The circuit breakers shall have a trip indication flag to indicate the cause of the trip, which shall be retained following the trip.

**Note:** Particular care shall be exercised in the selection of thermal overload protection devices for ATEX rated motors.

#### 10.4 Circuit Breaker Interlocks

All withdrawable circuit breakers shall be provided with a complete set of interlocks to ensure the safety of the operators and to prevent incorrect operation.

Interlocks shall be mechanical in nature and shall be preventative rather than corrective in operation.

Circuit breaker interlocks shall be provided to prevent as a minimum:

- The circuit breaker being withdrawn from, or being inserted into, the isolating contacts when the circuit breaker is closed
- The moving portion being moved or replaced, unless the circuit breaker is open and isolated
- The circuit breaker being closed in the service position, without first closing the auxiliary circuits between the fixed and moving portions
- The circuit breaker door (where fitted), being opened unless the circuit breaker is open

#### 10.5 Current Transformers

Current transformers (CTs) shall be of the bar primary type, or wound primary type, depending on application.

The CTs shall be installed either in air-insulated chambers in the case of circuit breakers or within the motor starter, and in all cases shall be located on the "CIRCUIT" side of the switching device.

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The CTs shall be capable of withstanding, without damage, the peak making, breaking and short time currents. The saturation factor for current transformers shall be such that the instruments are not endangered at maximum fault current.

CTs for protection purposes shall have accuracy class designation 5P20. Instrument CTs shall have accuracy class 1 designation or better and the instrument security factor shall be compatible with the instruments selected but shall not exceed  $F_s = 5$ .

Current transformers positioned on the "CIRCUIT" side of fuses, shall be short-time rated for the maximum prospective short circuit let-through value of the fault current when the largest fuse is fitted.

The secondary windings of each set of CTs shall be earthed at one point only and the earth connection made through an accessible removable link.

Magnetising curves shall be available for all CTs for review, quoting the resistance at 75°C, knee point voltage  $V_k$  and the magnetising current at  $V_k$ , as minimum requirement.

The CT requirements per circuit shall be determined by the Vendor and shall include function, ratio, class etc. The metering instrument range shall match with the CT ratio for proper display.

The Vendor shall ensure that the current transformers are such that the relays will operate correctly when set at any point within their range.

## 10.6 Protective Relaying

With the exception of motor thermal overload relays, all protective relays which do not form an integral part of a circuit breaker assembly shall be of the flush mounted withdrawable type.

Protective relay requirements, including contact requirements, flag indications, etc., shall be as required by the design.

It shall not be possible to operate any relay by hand, without opening the relay case; external reset facilities shall be provided.

Each protective relay shall enable testing and calibration using an external power source, without the need to disconnect the permanent wiring or to remove the relay.

Current operated relays shall be provided with CT "short circuiting" facilities.

Several protective elements may be incorporated into a single relay case, but separate indication of each function must be provided.

Relays shall maintain their accuracy over the full range of supply voltage variations.

All relays shall be rated for continuous normal operation.

If the protection relay is self-powered, the microprocessor relays shall be provided with an auxiliary power supply unit to prevent nuisance tripping under low load conditions.

## 10.7 Metering, Instruments and Interface to BMS

Incomers on the switchboard shall be equipped with high accuracy power quality meters.

The power quality meters shall provide the following features:

Power quality analysis;

- Waveform capture
- Disturbance direction detection

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- Compliance monitoring
- Dip and swell, transient
- Harmonic distortion
- Programmability (logic and math functions)
- Setpoint learning
- Voltage sag and swell detection
- Up to 63<sup>rd</sup> harmonic

Type of measurement

- Apparent power total
- Apparent power per phase
- Active total power
- Reactive power total
- Reactive power per phase
- Voltage
- Current
- Frequency
- Power factor total
- Power factor per phase

Outgoing circuit cubicles to be equipped with Multi-function meters arranged in a daisy chain connection.

Multi-function meter shall have the following as a minimum displayed via keypad push buttons

- Phase to Neutral Voltage and Phase to Phase Voltages
- Current per phase and kVA Load per phase
- Neutral current and THD %
- Total kW's/kVA/kVAr
- Power Factor

Switchgear Protection Relays and Multi-function metering to be equipped with data communications for integration with the BMS network via an Ethernet connection.

Parameters such as breaker status signals, voltage, frequency, kVA, alarms etc., shall be available for inclusion in a BMS graphic for load logging and analysis purposes via the Ethernet connection.

Voltage present indication shall be simple LED type as specified below and arranged to show that phase voltages are present at the load terminals of the main isolator.

All Metering Instruments shall be provided with Open Protocol/TCIP for higher level interface.

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## 10.8 Control, Signalling Units and Push Buttons

Signalling units shall be domed glass.

Signalling units shall be of the LED type and shall be individually fused.

"Start" push buttons shall be of the shrouded or recessed type to prevent accidental starts and be coloured green.

"Stop" push buttons shall be of the raised head or mushroom head type and be colour red.

All other push buttons shall be of the shrouded type.

A lamp test circuit shall be provided with connections to all signal units for checking LED failure.

## 10.9 Control Transformers

Where indicated or where more than five electro-magnetic coils are incorporated in one assembly, control transformers shall be provided.

Control transformers shall be 220 volt primary, 110 volt secondary isolating type with earthed screen between windings. One side of the secondary winding shall be solidly connected to earth.

Transformers shall be continuously rated for full load conditions and shall have a voltage regulation of no more than 3%.

The primary power supply shall be protected by a double pole MCB. The unearthed side of the secondary winding shall be protected by means of a single pole MCB having thermal overload and instantaneous electro-magnetic tripping characteristics suitably rated to afford close excess current protection of the unit.

Control transformers shall be rated to serve equipment provided within the enclosure together with the associated external loads, e.g. solenoid valves. 25% spare capacity shall be provided in all cases.

## 10.10 Spare and Spare Space

"Spare" means cubicles or ways which are supplied, connected and fully fitted out ready for the connection of outgoing cabling.

"Spare Space" means cubicles or ways which are supplied structurally complete and fitted with doors but without devices, components or terminals. Shutdowns should not be required to fit functional units and ancillary equipment after the switchgear has been commissioned and put into service.

An additional 20% space capacity shall be included in all assemblies.

Additional 10% spare ways shall be fully fitted out complete with functional units and all equipment necessary to bring the spare way into service.

Cable sizes for spare ways shall be equal to the largest size cable indicated for functional units of the same rating in the assembly or the next largest size cable to that cable size required to carry the fully current of the functional unit concerned, whichever is larger.

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## 11 Cables and Terminations

Particular attention shall be given to the problems/difficulties associated with the termination of large cross sectional area cables.

Suitable terminals for all main and auxiliary cables shall be provided from circuit breakers and switch fuses. These terminals shall be of adequate size to take the cables as per the cable schedules.

Gland plates for single core cables shall be of non-ferrous material.

Separate undrilled gland plates shall be provided for circuit breakers auxiliary cables.

## 12 Labels

Main labels on equipment shall contain the following information.

- Manufacturers name or identifiable mark
- Country of origin
- Type, designation number or code
- Rated voltage and frequency
- Rated current of each circuit if applicable
- Symmetrical short-circuit current kA (RMS)
- Year of manufacture

All items of low voltage equipment shall be fitted with warning labels showing a black 'lightning' symbol inside a black triangle against a yellow background.

Each item of equipment will be fitted with labels to provide information describing its function and point of isolation.

### 12.1 Racks and Equipment Panels

Electrical equipment, Switchboards, Motor Control Centres, equipment panels and Control Panels shall be marked with laminated engraved white-black-white Traffolyte 100mm high labels to show main tag name of the equipment (with 50mm high letters) secured by non-corrosive self-tapping screws.

### 12.2 Enclosures

Control panels, isolators, panelboards, transformers shall be marked with laminated engraved white-black-white Traffolyte 50mm high labels to supply information of the equipment (with 20mm high letters) secured by non-corrosive self-tapping screws.

### 12.3 Motor Starters

Individual motor starters shall be marked with laminated engraved white-black-white 25mm high labels to supply information of the equipment (with 10mm high letters) secured by non-corrosive self-tapping screws.



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#### 12.4 Internal Wiring

All internal wiring shall be individually numbered, using computer printed sleeves, at each termination point. Designations shall be identified with those used on the Vendor's schematics.

#### 12.5 Arc Flash Label

In addition to the normal labels for IEC switchgear outlined above the switchboard shall be supplied with Arc flash warning labels to provide the following information:

- Arc Flash Density cal/m<sup>2</sup>
- Arc Flash Boundary
- Limited Approach Boundary
- Restricted Approach Boundary
- Prohibited Approach Boundary

These items of information must be calculated by the equipment Vendor using the short circuit current levels given in the Data Sheet or on the drawings issued with this specification.

### 13 Anti-Condensation Heaters

Suitably rated anti-condensation heaters shall be provided where required.

Bus wiring shall be provided as necessary on each section of the assembly for anti-condensation heaters.

An ON/OFF switch with "heater supply on" lamp shall be provided to isolate the bus wired supply to all heaters.

The supply voltage shall be 220V ac.

### 14 Inspection and Testing

Before inspection by Almarai Project Management team the Vendor shall confirm satisfactory completion of all routine tests and when the equipment will be ready for formal Factory Acceptance Testing (FAT) witnessed by Almarai Project Management team.

The following FAT tests shall be carried out on the completed assembly by the Vendor and witnessed by Almarai Project Management or/and their representative:

- Physical checks on equipment cubicles including wiring checks
- Demonstration of proper mechanical and electrical operation of all functional parts including auxiliaries, meters, indicators and relays, etc.
- Primary current injection tests of circuit breaker protection relays, and CTs at a minimum of 10% randomly selected on the day of FAT by Almarai Project Management or/and their representative
- High voltage withstand and insulation resistance measurement
- A full electrical function check

The Vendor shall provide a complete set of test certificates for each switchgear assembly.



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Almarai Project Management or their representative shall have the right to request any additional tests that are deemed necessary to prove that the assembly conforms to the specification.

Sample test certificates of switchgear assemblies, withdrawable modules, etc. shall be included with the Vendor's quotation. Test certificates shall include a specific section for protection of relays. Ticks are not acceptable as a result of a test - a value or comment shall always be inserted.

Test certificates shall make reference to the switchgear assembly drawings and control wiring diagrams (drawing. no., revision no., date).

Following successful testing the Engineer will approve shipment of the Switchgear to site.

Should any test fail it shall be rectified at the Vendors cost and retested. Additional witness testing may be required by Almarai Project Management team prior to release for shipment to site.

## 15 Erection, Commissioning and Field Quality Control

Following release for shipment the Switchgear shall be dispatched to site with suitable bracing and supports to prevent accidental damage or exposure to the elements.

While in transit the insurance of the Switchgear shall be covered by the Vendor.

Upon arrival on site the Switchgear will be off-loaded and put in *place by the Switchgear Vendor*.

The Vendor shall provide all necessary trade certified labour for the final assembly/re-assembly, testing and commissioning of the Switchgear at the job site, including the temporary provision of all necessary test equipment.

All erection and testing work is to be supervised by the Vendors Project Manager on site.

Following assembly of the switchgear on site, all of the above inspections and routine tests shall be repeated, in accordance with IEC Rules/EN Standards. High voltage D.C. tests of the appropriate voltage levels may be performed instead of power frequency tests with agreement from Almarai Project Management.

Following Installation and commissioning the Vendor shall provide all as built drawings and Operation and Maintenance (O+M) manuals as required by Almarai Project Management.

During the commissioning and power-up of the equipment the Vendor shall provide the following services:

- Carry out post install physical checks for damage during cable connection.
- Open all compartments and confirm they are free from debris/spoil.
- Carry out pre-energisation checks including testing inter-tripping with upstream and downstream substations. Test all switchgear for proper operation in all modes. Test all alarms, indicating lamps, circuit breaker control switches and manual parallel controls. Insert protection device settings as per the coordination study.
- Confirm equipment ready to receive voltage. Remove and replace any malfunctioning units with new units, and retest

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- e) Protective Relay Settings: Verify settings given in the coordination study are appropriate for final system configuration and parameters. Where discrepancies are found, recommend final relay settings for approval before making final adjustments. All relay settings to be inputted by the Vendor and recorded.
- f) Support power-on and resolve any technical issues arising.

## 16 Special Tools

The Vendor shall supply a complete set of special tools, templates, operating handles and any devices necessary for the erection, operation, testing and maintenance of the switchgear/MCC.

A handling truck/lifting arrangement shall be provided to facilitate maintenance of any withdrawable items exceeding 40kg.

The tools and equipment shall be housed in a separate lockable box.

Duplicate keys shall be provided for all lockable devices, together with a separate lockable key box for mounting locally.

## 17 Documentation

The following documentation is required to be provided by the Vendor and issued for approval. This data will subsequently form part of the O+M manuals.

- General arrangement drawings shall be provided showing locations and termination/glanding arrangements (including terminal sizes) of all incoming cables. The information submitted by the Vendor shall contain all information necessary to complete the design of connections to the plant power and instrumentation systems including cable and terminal numbers.
- Circuit and wiring diagrams shall be provided in sufficient detail to show individual circuit elements such as relays, instruments, etc. Devices such as rectifiers, power supplies, etc. may be shown as blocks.
- Test records for the switchgear.
- Where applicable, the Vendor shall supply calibration certificates for instruments as part of O+M package.

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Appendix A

Low Voltage Switchgear Assemblies Data Sheet (Template)

Almarai Quality Assurance Forms/Attachments							
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Title	Next Generation Engineering Standards and Specifications			Effective Date		Status	Initiate
<b>Data Sheet for Low Voltage Switchgear (Template)</b>				<b>Equipment Tag:</b>			
<b>Supplier:</b>				<b>Manufacturer's Name:</b>			
	<b>ITEM</b>			<b>SPECIFIC DETAILS</b>		<b>NOTES</b>	
	<b>ELECTRICAL SERVICE CONDITIONS</b>			Note 1			
1	OPERATIONA VOLTAGE,			Note 1			
2	INSULATION VOLTAGE			Note 1			
3	OPERATIONAL FREQUENCY, Hz, ( +1% -1% )			Note 1			
4	3 PHASE, 4 WIRE SYSTEM			Note 1			
5	SYSTEM EARTHING ( E.G. TN - S )			Note 1			
6	CURRENT CARRYING CAPACITY - MAIN BUSBARS ( A )			Note 1			
7	3 PHASE SYMMETRCAL SHORT - CIRCUIT CURRENT Ip Ka ( 100 kA )			Note 1			
8	SHORT CIRCUIT CURRENT WITHSTAND TIME ( SECONDS )			Note 1			
9	CONTROL VOLTAGE			Note 1			
10	NEUTRALISING LINK REQUIRED(YES/NO)			Note 1			
				Note 1			
11	MAIN BUSBAR INSULATED			Note 1			
12	NEUTRAL BUSBAR RATING			Note 1			
13	MISCELLANEOUS			Note 1			
14	POWER FACTOR CORRECTION CT'S (YES/NO)			Note 1			
15	CENTRAL LAMP TEST (YES/NO)			Note 1			
16	ANTI - CONDENSATION HEATERS			Note 1			
	<b>ENVIRONMENTAL CONDITIONS</b>						
17	AMBIENT TEMPERATURE ( °C )						
	°C MINIMUM			Note 1			
	°C MAXIMUM			Note 1			
	°C AVERAGE OVER 24 HRS.			Note 1			
18	RELATIVE HUMIDITY	MAMIMUM % @ 30 °C		Note 1			
19	RELATIVE HUMIDITY	MINIMUM % @ 30 °C		Note 1			
20	ALTITUDE			Note 1			
21	LOCATION	INDOOR / OUTDOOR		Note 1			
22	EXPLOSIVE HAZARDS CLASS			Note 1			
	<b>ENCLOSURE/ACCESS</b>						
23	DISTRIBUTION BOARD ASSEMBLY TYPE CLASS			Note 1			
24	COLOUR ( STANDARD VENDOR )			Note 1			
25	INGRESS PROTECTION			Note 1			
26	SWITCHGEAR ASSEMBLY TYPE ( FIXED / WITHDRAWABLE )			Note 1			
27	NUMBER OF SECTIONS			Note 1			
28	DIMENSIONS ( WIDTH ) ( mm )			Note 1			
29	DIMENSIONS ( LENGTH ) ( mm )			Note 1			
30	DIMENSIONS ( HEIGHT ) ( mm )			Note 1			
31	WEIGHT OF HEAVIEST SECTION			Note 1			
32	ANTI - CONDENSATION HEATERS (YES/NO)			Note 1			
33	INCOMING CABLE ENTRY ( TOP / BOTTOM )			Note 1			
34	OUTGOING CABLE ENTRY ( TOP / BOTTOM )			Note 1			
35	PLINTH REQUIRED (YES/NO)			Note 1			
36	ACCESS ( E.G. FRONT ONLY )			Note 1			
37	MAX HEIGHT			Note 1			
38	SWITCHROOM DOOR DIMENSIONS			Note 1			
39	<b>COLOUR CODING</b>						

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Forms/Attachments							
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<b>Data Sheet for Low Voltage Switchgear (Template)</b>				<b>Equipment Tag:</b>			
<b>Supplier:</b>				<b>Manufacturer's Name:</b>			
<b>40</b>	<b>BUSBAR / POWER CABLING</b>						
<b>41</b>	L1			Note 1			
<b>42</b>	L2			Note 1			
<b>43</b>	L3			Note 1			
<b>44</b>	N			Note 1			
<b>45</b>	PE			Note 1			
<b>46</b>	<b>CONTROL WIRING</b>						
<b>47</b>	230V AC LIVE			Note 1			
<b>48</b>	230V AC NEUTRAL			Note 1			
<b>49</b>	VOLT FREE			Note 1			
<b>50</b>	INTERNAL INTERLOCK			Note 1			
<b>51</b>	24V DC ( + OR - )			Note 1			
<b>52</b>	PUSH BUTTONS			Note 1			
<b>53</b>	EMERGENCY STOP ( RED )			Note 1			
<b>54</b>	THERMISTOR RESET (YES/NO)			Note 1			
<b>55</b>	HAND - OFF - AUTO (YES/NO)			Note 1			
<b>56</b>	INDICATOR LAMPS			Note 1			
<b>57</b>	RUN ( GREEN )			Note 1			
<b>58</b>	TRIP ( YELLOW )			Note 1			
<b>59</b>	STOP ( RED )			Note 1			
<b>60</b>	CONTROL WIRING ( PVC / LSF )			Note 1			
<b>61</b>	INSTUMENTS AT MAIN INCOMER			Note 1			
<b>62</b>	AMMETER (YES/NO)			Note 1			
<b>63</b>	VOLTMETER (YES/NO)			Note 1			
<b>64</b>	MULTIMETER (YES/NO)			Note 1			
<b>65</b>	ON SITE COMMISSIONING BY SUPPLIER (YES/NO)			Note 1			

Note 1. Template to be updated by Almarai prior to releasing to Vendor



<b>Almarai Quality Assurance</b>					
Applied at	CAPITAL PROJECTS DIVISION	EtQ Ref#		Revision	
		Doc Ref#	0303	Effective Date	
Title	Next Generation Engineering Standards and Specifications Specification for Low Voltage Switchgear Assemblies				

Document Revision History

Revision	Date	Reason for Change

Phase Tracking History

Assigned to	Phase	Submitted Date	Due Date	Completed Date