TECHNICAL SPECIFICATION

LOW-VOLTAGE SWITCHGEAR AND CONTROLGEAR ASSEMBLIES (AMENDMENTS/SUPPLEMENTS TO IEC 439-1)

DEP 33.67.01.31-Gen.

January 1998

DESIGN AND ENGINEERING PRACTICE

PREFACE

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The Hague, The Netherlands,

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The objective is to set the recommended standard for good design and engineering practice applied by Group companies operating an oil refinery, gas handling installation, chemical plant, oil and gas production facility, or any other such facility, and thereby to achieve maximum technical and economic benefit from standardization.

The information set forth in these publications is provided to users for their consideration and decision to implement. This is of particular importance where DEPs may not cover every requirement or diversity of condition at each locality. The system of DEPs is expected to be sufficiently flexible to allow individual operating companies to adapt the information set forth in DEPs to their own environment and requirements.

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APPENDICES

PART 1 INTRODUCTION

1.1 SCOPE

This DEP specifies requirements and gives recommendations for low voltage switchgear and controlgear assemblies.

This DEP is a revision of the DEP of the same number dated December 1994. Other than editorial changes, the main purpose for this revision was to include Appendix 1 to cover Integrated Motor Control Systems (IMCS).

Part 2 of this DEP amends and supplements IEC 439-1 (1992), referring to the same clause numbers. The additional requirements specified in this DEP are required in order to:

a. Make selections from the options given in the IEC 439-1,
b. Specify additional and more stringent requirements, as necessary, to operate and maintain the gear in continuously operating plants,
c. Specify supplementary provisions required to make the gear suitable for operation in the overall process control design.

Integrated Motor Control Systems (IMCS) when specified shall comply with Appendix 1.

The requirements specified apply to type-tested assemblies (TTA). For assemblies used as sub-distribution systems, with incoming feeders protected by short-circuit current limiting devices of a nominal current of maximum 355 A, less rigorous requirements can be accepted. This is indicated in ***bold italic text*** under the specific headings, and makes a reference to this section for the above definition.

1.2 DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS

Unless otherwise authorised by SIOP, the distribution of this DEP is confined to companies forming part of the Royal Dutch/Shell Group or managed by a Group company, and to Contractors and Manufacturers/Suppliers nominated by them (i.e. the distribution code is "F", as described in DEP 00.00.05.05-Gen.).

This DEP is intended for use in oil refineries, gas plants, chemical plants, exploration and production facilities and supply/marketing installations.

If national and/or local regulations exist in which some of the requirements may be more stringent than in this DEP the Contractor shall determine by careful scrutiny which of the requirements are the more stringent and which combination of requirements will be acceptable as regards safety, environmental, economic and legal aspects. In all cases the Contractor shall inform the Principal of any deviation from the requirements of this DEP which is considered to be necessary in order to comply with national and/or local regulations. The Principal may then negotiate with the Authorities concerned with the object of obtaining agreement to follow this DEP as closely as possible.

1.3 DEFINITIONS

1.3.1 General definitions

The **Contractor** is the party which carries out all or part of the design, engineering, procurement, construction, commissioning or management of a project or operation of a facility. The Principal may undertake all or part of the duties of the Contractor.

The **Manufacturer/Supplier** is the party which manufactures or supplies equipment and services to perform the duties specified by the Contractor.

The **Principal** is the party which initiates the project and ultimately pays for its design and construction. The Principal will generally specify the technical requirements. The Principal may also include an agent or consultant authorised to act for, and on behalf of, the Principal.

The word **shall** indicates a requirement.

The word **should** indicates a recommendation.

1.3.2 Specific definitions

Integrated Motor Control System (IMCS)	A system comprising control modules, central unit(s), a serial bus connecting the control modules to the central unit and a serial communication facility enabling connection of the central unit to a distributed control system (DCS).
Panel	A constructional unit of a (multi-) cubicle type assembly between two successive vertical delineations.
Requisition	is one of the following: DEP 33.67.01.93-Gen. (requisition for LV switchboard). DEP 33.67.01.94-Gen. (requisition for lighting distribution board). NOTE: DEP 33.67.01.80-Gen. (schedule for LV switchboard) is normally attached to the requisition.
Restarting relay (RR)	A relay which initiates the reclosure of a motor circuit under predetermined conditions, after a voltage depression or interruption.
Section	A constructional unit consisting of a number of panels connected to a continuous busbar system.
Sectionalizing unit	A mechanical switching device to connect the busbar of two sections.
Time delayed restarting relay (TMR)	A time delayed relay which initiates a delayed re-closure of a motor circuit controlled by the process control system, under predetermined conditions, after a voltage depression or interruption.

1.4 CROSS-REFERENCES

Where cross-references to other parts of this DEP are made, the referenced section number is shown in brackets. Other documents referenced by this DEP are listed in (Part 3).

PART 2 AMENDMENTS/SUPPLEMENTS TO IEC 439-1

In this part, sections of IEC 439-1 are amended or supplemented, or new sections are added. Sections of IEC 439-1 that are not mentioned shall remain applicable as written.

3. CLASSIFICATION OF ASSEMBLIES

Add to this section:

Although this standard is mainly concerned with fully withdrawable gear of the (multi-) cubicle type assemblies for indoor installation, it shall also apply to fixed and semi-withdrawable cubicle type assemblies, multi-box type assemblies and assemblies located outdoors.

4. ELECTRICAL CHARACTERISTICS OF ASSEMBLIES

4.1 RATED VOLTAGES

Add to this section:

The assembly shall be suitable to form part of a system with coordinated insulation values in accordance with IEC 664-1, overvoltage category IV, and shall be type tested accordingly.

4.2 RATED CURRENT

Add to this section:

Unless otherwise specified in the requisition, the assembly shall be arranged for a TN-S power system, i.e. with separate neutral and protective busbars throughout the system.

The main busbars shall be rated for the nominal current over the entire length of the assembly and shall not be rated lower than the incoming and sectionalizer units.

4.7 RATED DIVERSITY FACTOR

Add to this section:

For temperature rise tests or temperature rise calculations, a diversity factor of 1.0 shall be applied for each switchboard panel containing only one functional unit. If a panel contains two or more functional units, the rated diversity factor applied shall be not less than 0.9 when considering the circuit loads as known at the time of final inspection at the Manufacturer's works. Spare circuits and skeleton compartments shall be considered as being loaded to 90% of their rated current.

This supplement does not apply to assemblies used as sub-distribution systems as defined in (Part 1; 1.1), to which the original clause of IEC 439-1 shall apply.

5. INFORMATION TO BE GIVEN REGARDING THE ASSEMBLY

5.1 NAMEPLATES

Add to this section:

Nameplates including circuit labels, instruction and warning plates and caution notes shall be made of durable, corrosion resistant material.

Add new section:

5.1.1 General equipment nameplate

The following information shall be given on the general equipment nameplate, which shall be mounted on the front of the assembly, e.g. on the sectionaliser or incoming feeder:

a. Manufacturer's name or trade mark,
b. Type designation,
c. Purchase order number,
d. Year of manufacture,
e. Rated voltage,
f. Rated frequency,
g. Rated current of busbar system,
h. Rated voltage of auxiliary circuits (if applicable),
i. Rated peak and short time withstand current and withstand time,
j. Degree of protection.

The above information together with the other information of IEC 439-1 clause 5.1 shall be given in the relevant documents of the Manufacturer.

Add new section:

5.1.2 Circuit labels

Each circuit of the assembly shall be provided with the following circuit identification labels:

a. Circuit identification tag number in accordance with standard drawing S 67.021. The circuit labels shall be installed on the front of the fixed and the removable part of a withdrawable or removable unit and repeated at the main and auxiliary cable terminations which are not clearly identifiable from the physical layout, e.g. cable compartments at the rear or bottom of the assembly.
b. Identification number of connected equipment or circuit destination as per the Schedule for LV switchboard.

Add new section:

5.1.3 Synoptic diagram

Assemblies shall be provided with a durable one-line synoptic diagram, indicating the busbar circuit and the specific function of the different compartments.

Synoptic diagrams are not required when the busbar system and the branch circuits can be viewed via transparent covers.

Add new section:

5.1.4 Instruction plates

When the operating sequence or procedure of certain equipment items in the assembly is not evident, e.g. mechanical interlocking features, instruction plates shall be provided fixed near the point of operation. The instruction shall be given as far as possible in a pictorial manner.

Add new section:

5.1.5 Warning plates, caution notices

In locations where dangerous situations may inadvertently be created, warning plate(s) or caution notice(s) shall be installed, identifying the danger point(s). This may be either in a compartment or on the outside of an assembly.

5.3 INSTRUCTIONS FOR INSTALLATION, OPERATION AND MAINTENANCE

Add to this section:

The Manufacturer shall supply at least the following drawings/documents in the quantities and at the times stated in form DEP 40.10.01.93-Gen, attached to the requisition:

a. Final single-line diagram *,
b. Schematic diagrams of all different types of circuits,
c. Documentation as specified in Appendix 1 (in case of IMCS only),
d. Final assembly arrangement drawing showing main circuits, main dimensions, panel layout, floor plan and shipping sections *,
e. Minimum clearances around the assemblies for ventilation and safety during operation and maintenance *,
f. Total mass of the assembly and of the individual shipping sections *,
g. Transport, installation, commissioning, operation and maintenance instructions, limited and specific to the assembly and its components,
h. List of recommended spare parts (see DEP 70.10.90.11-Gen.),
i. List of applicable type test certificates,
j. Test report of the final routine testing.

NOTE*: Items marked * may be combined, provided all information indicated above is included.

All documents shall show the relevant order number, item and Manufacturer's references, and shall be distributed as specified in the purchasing documents.

Assemblies supplied in transport units shall have these units clearly marked to facilitate assembly at site.

Erection instructions and any special tools required for erection and maintenance shall form an integral part of the order and shall be packed with the equipment.

The language used shall be as specified in the requisition.

6. SERVICE CONDITIONS

6.1 NORMAL SERVICE CONDITIONS

Add to this section:

The actual service conditions shall be specified in the requisition if they are more onerous than those stated in IEC 439-1.

6.1.2.3 Pollution degree

Add to this section:

Unless otherwise specified in the requisition, the assembly and the components installed therein shall be suitable for use in a pollution degree 3 environment. However, the air will be laden with dust, salt and/or sulphur as encountered in the petrochemical industries or in oil/gas fields.

6.2 SPECIAL SERVICE CONDITIONS

Add to this section:

Any special service condition that the switchgear may be required to withstand in its operational location shall be specified on the requisition.

Unless otherwise specified, the switchboard shall be suitable for installation in a non-hazardous area as defined in IEC 79-10.

6.3 CONDITIONS DURING TRANSPORT, STORAGE AND ERECTION

Add to this section:

The requisition shall specify any special conditions that may arise, e.g. shock and vibration and/or extreme temperatures.

7. DESIGN AND CONSTRUCTION

7.1 MECHANICAL DESIGN

7.1.1 General

Add to this section:

The assemblies shall be designed for continuous operation at full load for at least 40,000 hours without maintenance which would require the main busbars and the distribution busbars (dropper system) to be de-energized.

All structural work shall be adequately protected against corrosion. Frame and partitions may be of galvanised steel without a further paint coating. Those parts/covers requiring painting shall be properly pre-treated before the final coat(s) of oil resistant finishing paint is (are) applied. Manufacturer's standard colour is acceptable. If a Manufacturer does not have a standard colour, light grey is preferred for the external surface.

Assemblies shall comprise one or more sections of busbars to which incoming and outgoing units are connected. Busbar sections shall be linked through sectionalizer units.

In addition to the outgoing units specified in the requisition, spare skeleton compartments shall be included in each switchboard. The number of skeleton compartments shall be 10% of each size of outgoing units of which at least three units are installed. They shall be allocated to the switchboard sections in accordance with the actual load distribution. The skeleton compartments shall be so equipped that completion can take place safely without the need to de-energize the switchboard or any other panel.

7.1.3 Terminals for external conductors

Add to this section:

Terminals shall be suitable for copper conductors.

For main outgoing power circuit cabling, terminals allowing the conductors to be connected without the use of cable lugs of any type are strongly preferred.

In view of the substantial cable derating that is normally applied, adequate terminals and cable termination space shall be provided for the main cabling.

For busbar wiring and outgoing control circuits, individual terminals shall be provided for each external conductor. These terminals shall be of the non-loosening wedge type or cage type construction, obviating the use of cable lugs. They shall be constructed in such a way that direct contact between screw, bolt or nut and conductor is avoided.

NOTE: For the termination of internal control wiring, push-on connections with insulation support of the compression type may be used.

Terminals for the interconnection of the IMCS shall be in accordance with Appendix 1.

Terminals shall be identified in accordance with the related wiring diagram. The layout shall be consistent and logical. Unless otherwise specified, terminal arrangements for the control of motors shall be in accordance with drawing S 67.004.

As a standard, assemblies shall have facilities for the entry of cables from below. Cable entries, support facilities for cable clamping, and earthing facilities shall be provided suitable for the type, size and number of cables as specified.

Cable glands or metal gland plates should only be included if specified in the requisition.

Gland plates and glands for single core cables shall be of non-magnetic material. In the case of single core cables with armour and/or lead sheathing, the requirement for special glands which allow for insulation between armour/lead sheath and the gland plate shall be specified in the requisition.

7.2 ENCLOSURE AND DEGREE OF PROTECTION

Add to this section:

Switchgear assemblies shall be completely enclosed, self-supporting and suitable for floor or wall mounting, in multi-cubicle or multi-box type structures. The floor shall not be considered as being part of the enclosure.

Cover bolts or nuts shall be retained in place when undone (captive bolts and nuts).

Any insulation material used shall have flame retardant properties. The degree of protection as per IEC 529 for any assembly shall be:

- For indoor use (in enclosed buildings) IP 41
- For outdoor use (protected by e.g. rain canopy) IP 55

NOTE: Outdoor switchgear shall always be provided with a rain/sun canopy to make access possible under adverse weather conditions

The requirement for anti-condensation heating shall be specified in the requisition. If anti-condensation heating is required inside the assembly, it shall be supplied from a separate source connected between system phase and neutral. The heating system of each section shall be separately protected and switched for isolation purposes by means of a miniature circuit breaker in combination with an earth leakage protecting device of 30 mA sensitivity. When the heating system is live, this shall be indicated by means of a prominently situated red light. The heating system shall be designed in such a way that the heat is adequately distributed over all functional units.

7.3 TEMPERATURE RISE

Add to this section:

The temperature rise limits as given in Table 3 shall not be exceeded when the assembly is fully loaded in accordance with the diversity factors as given in clause 4.7 of this specification.

7.4 PROTECTION AGAINST ELECTRIC SHOCK

Add to this section:

All switchgear components requiring maintenance shall be easily accessible. All components in wall or back-to-back mounted switchgear shall be accessible from the front only.

Exposed parts within the assemblies which have to be accessible during normal operation, maintenance or equipping of spare compartments, shall either not be live in the opened position or shall be protected to a degree of protection of at least IP 20.

NOTE: It must be realized that the terminals of the incoming and sectionalizer switching devices can be live when the device is in the off position. Consequently these terminals shall always be protected to a degree of at least IP 20.

HBC fuses and associated fuse carriers shall only be accessible when they are fully isolated or when they offer a degree of protection to live parts of at least IP 20 when the fuses are inserted, withdrawn or during withdrawal.

Terminals of equipment installed on a compartment door and which can be live when the door is opened, shall be shrouded to a degree of protection of at least IP 20.

Compartment doors or covers shall be interlocked to prevent opening when the isolating switch is in the 'ON' position. The isolating device shall only be operable when the door is closed and when the withdrawable unit is in the inserted position.

The above paragraphs do not apply to assemblies used as sub-distribution systems as defined in (Part 1; 1.1) provided that all live parts inside the compartment have a degree of protection of at least IP 20.

When a withdrawable unit has been removed from the assembly, the live parts inside the fixed compartment shall be protected against touch, with a degree of protection of at least IP 20. Where shutters are fitted to comply with above requirement, they shall be mechanically operated by the movement of the withdrawable unit and not be dependent on gravity. Each set of shutters shall be capable of being individually operated and padlockable in the closed position. Shutters shall be marked as follows:

'BUSBAR' on shutters covering busbars,
'INCOMING SUPPLY' on shutters covering incoming feeder cables,
'CIRCUIT' on shutters covering outgoing feeder cables.

If a test position is provided (partly withdrawn unit), the degree of protection shall be at least IP 20.

Interlock systems shall be of a mechanical lever type and shall not rely on the operation of springs or gravity.

All practicable measures shall be taken to prevent danger to personnel working on a disconnected functional unit with adjacent units still in operation. Parts likely to be removed for maintenance shall have retainable fastening means.

7.5 SHORT-CIRCUIT PROTECTION AND SHORT-CIRCUIT WITHSTAND STRENGTH

7.5.1 General

Add to this section:

In the event of an internal fault in a functional unit, the damage shall be confined to that unit, so that the busbar system and all other functional units remain fit for further service. Likewise, an internal fault in a dropper system shall be confined to the associated panel, so that the busbar system and the other panels of the assembly remain fit for further service.

Assemblies shall comply with IEC 1641 with regard to internal arc testing.

Type test reports should be made available in the quotation stage.

The above paragraphs do not apply to assemblies used as sub-distribution systems as defined in (Part 1; 1.1), to which the original clause of IEC 749-1 shall apply.

The prospective short-circuit current shall be stated in the requisition and shall be based on parallel operations of all supplies which can be paralleled during normal operations and temporary operations during change-over periods; it will also include the contribution that can be expected from the connected load.

NOTE: For sub-distribution assemblies the prospective short-circuit current will be limited by the supply fuse rating.

7.5.3 Relationship between peak and r.m.s. values of short circuit current

Add to this section:

The values of the factor ‘n’, giving the relation between peak and r.m.s. value of the short circuit current, shall be as stated in table 5. An upward adjustment may be required if a power factor rating lower than standard is expected. If applicable, this shall be stated in the requisition.

7.5.4 Co-ordination of short-circuit protective devices

Add to this section:

In motor starter units, the co-ordination between starter and protective device shall comply with type “2” as specified in IEC 947-4-1. This generally implies that a starter is sufficiently protected by the short-circuit protection so that no damage will occur to the starter in case of a through-going fault current.

Type test reports shall be made available on request.

7.5.5 Circuits within an assembly

Add to this section:

The busbar system which under the terms of this specification includes all live conducting parts from the incoming terminals of the assembly up to the circuit protection inside the single outgoing functional units shall be considered as being a ‘fault free zone’. The arrangements shall be such that a fault in this zone shall be virtually impossible under all conditions.

The short circuit protection device inside each outgoing functional unit shall be connected directly to the busbars.

This supplement does not apply to assemblies used as sub-distribution systems as defined in (Part 1; 1.1), to which the original clause of IEC 749-1 shall apply.

7.6 SWITCHING DEVICES AND COMPONENTS INSTALLED IN ASSEMBLIES

7.6.1 Selection of switching devices and components

Add to this section:

All components shall be standardized as far as practical

The connections of the auxiliary circuits of withdrawable units shall be of the plug-and-socket type, automatically operated by the unit.

Circuits, components, wiring and terminal arrangements shall be installed in accordance with the relevant standard drawings of group S 67.

Add new section:

7.6.1.1 Busbar system

The phase, neutral and earth busbars shall be of hard or medium hard drawn, high conductivity copper.

The phase and neutral busbars should be located in the top compartments of the switchboard. Rear mounted busbars can be quoted as an alternative provided:

a) it is clearly stated in the quotation;

b) access is provided to the busbar joints via a firmly secured window that is at least IP 41 and has captive bolts/nuts.

The busbar system shall be accessible for construction and maintenance duties. In case of a busbar short circuit, it shall be possible to clean or to replace the busbars and the support system.

The neutral bar shall be insulated from earth and shall be extended to all compartments reached by the phase busbars. In three phase switchboards carrying a balanced load under normal conditions, the neutral busbar shall have a cross section of at least 50% of that of the phase busbars with a minimum of 16 mm^2. For busbar systems with a cross section below 16 mm^2 the neutral conductor shall have the same cross section as the phase conductors.

The earth bar shall be located in the top or bottom compartments and in all cable riser compartments of the switchboards and shall be easily accessible. Sufficient connection points with adequate terminating facilities shall be provided for terminating the cable earth leads.

In the busbar compartment the phase busbars shall be fully insulated. The insulation shall be type tested for withstanding at least an AC test voltage of 2 kV for a period of 60 seconds applied between the bar and an aluminium foil wrapped closely around the insulation over a length of at least one metre.

The distribution busbars (droppers) shall have full segregation by insulated material. The insulation of the busbar joints and branching points shall be of equal quality to that of the main bars and shall be removable and easily replaceable for inspection.

The comparative tracking index (CTI as per IEC 112) of the insulating material used for the supports and insulation of the busbar and dropper systems shall be at least 300. The CTI for the insulation materials used for the components protected by the short-circuit protective devices in the outgoing functional units shall be at least 175.

The neutral busbar may be uninsulated in the busbar compartment but shall be insulated in all other compartments with the same insulation level as the phase conductors.

This supplement does not apply to assemblies used as sub-distribution systems as defined in (Part 1; 1.1).

Add new section:

7.6.1.2 Incoming and sectionalizing units

Incoming and sectionalizing units shall be mounted in separate compartments and shall be provided with independent manually operated air break switches. When circuit breakers are specified they shall be mounted in separate panels. The utilization category for the manually operated switches as per IEC 947-3 shall be at least AC 22 for switching devices up to and including 630 A and may be AC 21 for devices with higher current ratings. The utilization category for circuit breakers as per IEC 947-2 shall be category A, unless otherwise specified.

Switching devices shall switch all phases or poles (i.e. 4-pole type for 3 phase + neutral systems). For balanced systems, the neutral pole current rating shall be not less than as specified for the neutral busbars (7.6.1.1).

The switching devices shall have padlock facilities in the 'OFF' position. Key interlock systems between incoming and sectionalizer units shall only be provided when specified.

Each incoming unit shall be provided with one voltmeter, connected to the busbar side between L1 and L3 phase, and one ammeter in the L2 phase. The meters shall be suitably scaled in actual values for the rated voltage and current.

The metering supply to volt and watt-hour meters etc. shall be protected with HBC-type fuses of the fully insulated pattern fixed directly to the busbar system. A second set of fuses or miniature circuit breakers, discriminated with the HBC-type fuses, shall be mounted local to the instrument(s).

The set of HBC-type fuses is not required for assemblies used as sub-distribution systems as defined in (Part 1; 1.1).

Add new section:

7.6.1.3 Switches (mechanical)

Switches shall be of the independent manual operating, air-break type with quick snap action make and break features.

They shall comply with and be type tested to IEC 947-3. They shall have a utilization category AC 22 when switching mixed resistive and inductive loads, and AC 23 when switching motor loads or other highly inductive loads.

Switches shall be easily accessible and operable from the front of the switchboard without opening a cover.

In sub-distribution systems as defined in (Part 1; 1.1), switches up to 25 A for isolation purposes may be of the dependent manual operating type and installed inside the assembly.

Switching devices shall be of the 4-pole type for 3 phase + neutral systems and 2-pole for single phase circuits.

The neutral pole of a switching device in balanced 3 phase + neutral systems shall have a current rating equal to that of the other poles up to and including 63 A and, if above 63 A, not less than 50% of that of the other poles with a minimum of 63 A.

Switches shall have a rated (conditional) short-circuit making capacity in conformity with the prospective short-circuit currents, as specified for the busbar system.

NOTES:
1. The term 'conditional' is specified in IEC 947-1 (clause 4.3.6.4) and covers the current limiting action of fuses or other protective devices.

2. Incoming and busbar section switches of multi-section boards may have a short circuit rating based on the actual distribution of the short circuit current. (e.g. 50% of the maximum short circuit current flows through each incomer in case of a coupled two-section board).

All switches used for isolating a circuit shall be padlockable in the 'OFF' position.

Add new section:

7.6.1.4 Circuit breakers

Circuit breakers in outgoing circuits shall only be used if specified in the requisition or with

the approval of the Principal. They shall comply with the requirements as specified for switches as far as operating accessibility, padlocking and phase and neutral switching are concerned.

Circuit breakers shall comply with and be type tested to IEC 947-2 and shall have utilisation category A, except for circuit breakers feeding sub-distribution switchboards which shall have utilisation category B. Circuit breakers shall have a rated short-circuit making and breaking capacity in conformity with the prospective short-circuit current as specified in the requisition.

Circuit breakers in a change-over supply duty should be withdrawable but shall at least have isolating facilities for maintenance and testing purposes.

Add new section:

7.6.1.5 Fuses

High breaking capacity (HBC) type general purpose fuse links, utilisation category gG in accordance with IEC 269-1 shall be used. The breaking capacity shall be equal to the short circuit rating of the busbar system with a minimum of 80 kA. The requisition shall indicate what type of fuse system in accordance with IEC 269-2-1 shall be installed, i.e.

- fuse-links with blade contacts ('DIN' fuses)
- fuse-links for bolted connections ('BS' fuses)

Metal removal tags of 'DIN' fuses shall be potential free.

'DIN' fuses of the D-type shall only be applied up to maximum 63 A and shall be backed up by short-circuit current limiting devices of maximum 355 A rating to reduce the short-circuit level.

Add new section:

7.6.1.6 Motor starters and contactors

As a standard, contactors shall be of the holding coil type with an operating voltage derived from phase and neutral. If a latched contactor is required for a special purpose, this shall be indicated in the requisition.

With reference to IEC 947-4-1, motor starters and contactors shall conform to the requirements of both uninterrupted duty and intermittent duty class 12 (12 operating cycles per hour), at rated operational current. They shall have a mechanical durability level of one million no-load operating cycles.

The utilization category AC-3 (starting of squirrel-cage motors, switching off motors during running) shall be applied. For motors in inching or reversing rotating service, utilization category AC-4 shall be used. The Schedule for LV switchboards attached to the requisition shall indicate to which motors this is applicable.

For special loads such as transformers, capacitors, lighting, etc. a suitable current rating and utilization category shall be selected by the Manufacturer.

On-off position indication of contactors shall be provided on the front of the compartment by clear red light for 'ON' and clear green light for 'OFF'. The indication lights shall be of the long life, low power consumption type, e.g. multisegment LED or neon. Local contactor closing facilities shall not be provided on the assembly for motor starter units. In addition to the required number of auxiliary contacts needed for the control and indication circuits, each contactor and motor starter shall be provided with at least one make and one break contact element, double gap, potential free, and wired up to the auxiliary terminal block of the compartment.

Reference is made to drawing S 67.004.

Add new section:

7.6.1.7 Motor overload protection relays

Overload protection relays shall be installed in all phases and shall include protection against single phasing (at least 10% faster) and shall be at least of trip class 20 in

accordance with IEC 947-4-1. The relays shall be of the temperature compensated type and shall be equipped with manually reset facilities on the front of the compartment (resettable without opening the assembly). An inadvertent reset action shall not trip a circuit.

If bimetallic thermal relays are used, direct heating elements shall be provided up to a nominal current of 40 A. For nominal currents above 100 A, standard nominal 5 A or 1 A relays shall be used in combination with linear current transformers. Between nominal currents of 40 A and 100 A either direct heating elements or 5 A or 1A elements connected via current transformers may be used.

For motors with running up times in excess of 5 seconds, saturable current transformers in combination with a standard nominal 5 A or 1 A relay shall be provided. Alternatively electronic protection relays with suitable protection curve shall be supplied.

For motors with operating conditions beyond those covered by overload relays, special protection systems may be considered, e.g. installation of thermistor temperature sensors in the motor windings with their relays installed in the switchgear compartment. Agreement shall be reached with the Principal in the quotation stage.

Overload relays protecting electric motors of the Ex'e' type installed in Zone 1 areas shall have a current/time characteristic below the maximum locked rotor time (t_E) as indicated on the Schedule for LV switchboards attached to the requisition and shall be certified by an approved testing authority such as BASEEFA or PTB.

Add new section:

7.6.1.8 Motor earth fault protection

Motors of 30 kW and above shall be fitted with core balance type earth fault protection relays. Relays shall be manually resettable after opening of the compartment cover. The sensitivity of the relays shall not exceed 3% of the rated nominal motor current or 6 A, whichever is the greater. The relays shall be equipped with a clear trip indication on the relay.

Add new section:

7.6.1.9 Motor restarting facilities

If specified in the requisition, each motor control compartment shall be equipped and wired with a U-type relay base of the 'Sprecher und Schuh' type, for future insertion of a restart relay.

Restart relays shall be included only for those motors as indicated on the schedule attached to the requisition. Reference is made to drawing S 67.004.

Add new section:

7.6.1.10 Current transformers

Current transformers shall be in accordance with IEC 185.

Current transformers for measuring purposes shall be of accuracy class 3 (accuracy class 1 for measuring supplies from or to third parties) with an instrument security factor such that the instruments are not endangered at maximum fault current. The secondary current rating shall be 5 A or 1 A for ammeters and watt-hour meters mounted on the switchboard and 1 A for remote ammeters, either directly or via intermediate current transformers.

Preferred primary ratings of instrument current transformers for remote ammeters are:

10 A	50 A	150 A	400 A
20 A	75 A	200 A	500 A
30 A	100 A	300 A	

Protective current transformers shall be of accuracy class 5P except in cases where class 10P is specified as adequate by the relay Manufacturer. The short-circuit rating shall be at least 1 second if applied for short-circuit protection. The wiring of the secondary circuits shall have a cross section of at least 2.5 mm^2.

NOTE: CTs for motor overload relays shall be as specified by the relay Manufacturer (7.6.1.7).

Secondary circuits of all current transformers shall be earthed.

Add new section:

7.6.1.11 Voltage transformers

If voltage transformers are required, they shall be in accordance with IEC 186 and shall be of class 3 (class 1 for measuring supplies from or to third parties).

The secondary voltage of metering transformers shall be 110 V.

Secondary circuits of voltage transformers shall be earthed.

Add new section:

7.6.1.12 Measuring instruments

All instruments shall be of the flush mounting type and shall have an enclosure with a degree of protection of at least IP 52 for indoor and IP 55 for outdoor applications.

All meters should be of the square pattern type, and mounted at a suitable height for easy reading from the front. Scales shall be graduated in actual values.

Meters shall be installed in the associated functional units. Recording instruments, if required, may be mounted in any other accessible location or common panel provided that the equipment is properly labelled.

Ammeters and voltmeters shall be accuracy class 1.5. Watt-hour meters and maximum demand meters shall be accuracy class 2.5 (accuracy class 1 for measuring supplies from or to third parties). See IEC 51 and IEC 521.

Ammeters for motor duty (if required) shall have a compressed overload scale and shall be suitable to withstand the motor starting currents.

Watt-hour and maximum demand meters shall have 5 A elements and cyclometric type registers. All watt-hour integrating meters shall be fitted with a pulse transmitter for input to a remote supervisory system or a metering summation scheme.

The number of elements shall be suitable for the system to be measured. Watt-hour meters in motor circuits, if specified, may be of the single element, balanced load type.

Outgoing feeders to sub-switchboards with current ratings in excess of 300 A shall be provided with an ammeter.

Motor starter units with a motor feeder cable of 4 mm^2 cross section or larger (usually for 4 kW and above) shall be equipped with a current transformer for a remote ammeter. Motors connected with a feeder cable of 2.5 mm^2 will use a direct reading remote ammeter.

A 4-20 mA output transducer complying with IEC 688 shall be provided for each analogue signal to a remote supervisory system (e.g. DCS). Detailed requirements shall be specified in the requisition.

Add new section:

7.6.1.13 Integrated motor control

If specified in the requisition, an Integrated Motor Control System (IMCS) in accordance with Appendix 1 shall be included in the switchboard. The details and the extent of the IMCS shall be agreed with the Principal in the quotation stage.

7.6.2.1 Accessibility

Add to this section:

A free space of at least 0.2 m shall be available between the lowest cable termination, switch, push button, indication light or measuring apparatus of a floor mounted assembly and the floor.

The maximum height of the above-mentioned components shall not be more than 2 m

above floor level.

7.6.2.5 Cooling

Add to this section:

For switchgear and control assemblies only natural cooling shall be applied.

7.6.4 Removable parts and withdrawable parts

Add to this section:

Withdrawable units which are mechanically identical but electrically have a different function shall be non-interchangeable, e.g. it shall not be possible to install a motor starter unit into a space for a plain feeder unit of the same size.

7.7 INTERNAL SEPARATION OF ASSEMBLIES

Add to this section:

Partitions or barriers shall be provided in the assemblies to obtain Form 4 or 3B separation of compartments. Form 3B is only acceptable if all terminals have a degree of protection of at least IP 30.

The partition shall comply with following degree of protection:

Location	Minimum degree of protection
between horizontal busbar compartments and any other compartment	IP 4X
between incoming and sectionalizer units	IP 4X
between main busbar systems of two separate sections	IP 4X
between compartment of each functional unit towards other compartments	IP 4X

NOTE: IP 30 is acceptable for vertical partitions of functional unit compartments, provided that a straight wire of 1 mm diameter and a free length of 100 mm, when passed through any IP 30 aperture, cannot come into contact with a live part.

In multi-box type assemblies used in sub-distribution service as defined in (Part 1; 1.1), the busbars, incoming feeder and sectionalizer units shall be installed in separate boxes.

Partitions between the busbar compartments and functional units shall have a degree of protection of at least IP 20.

Outgoing circuits up to and including 25 A may be housed in combined boxes provided the live parts inside the boxes have a degree of protection of at least IP 20.

The terminals for outgoing cabling shall be clearly indentified and termination of the individual circuits must be possible without removing the IP 20 protection. Outgoing cabling shall not pass internally through other functional units. If necessary, pre-wired terminal boxes shall be provided with a degree of protection inside the box of at least IP 20. Cubicle type assemblies used in sub-distribution service as defined in (Part 1; 1.1) do not require separation of functional units by barriers or partitions provided the live parts inside the cubicle have a degree of protection of at least IP 20.

Operational activities such as switching, replacing fuses, resetting relays, and termination of outgoing cabling shall be possible without removing the IP 20 protection.

8. TEST SPECIFICATIONS

8.2 TYPE TESTS

Add to this section:

Type tests shall be carried out in accordance with IEC 439-1 provided that additional requirements specified (e.g. busbar insulation, diversity factor, etc.) are taken into consideration.

Certificates shall be available at the quotation stage. Certificates issued by independent testing laboratories are strongly preferred.

Components installed within the assembly shall be type tested in accordance with the applicable IEC publications (e.g. IEC 947). Certificates, obtained from the Manufacturers of the components, shall be made available at the request of the Principal.

8.3 ROUTINE TESTS

Add to this section:

Before dispatch the Manufacturer shall carry out the routine tests in accordance with IEC 439-1 on the total assembly, or parts thereof if delivered separately, and the results shall be recorded in a test report.

If specified in the requisition, the Principal shall witness the final routine testing, for which the Principal shall be given at least ten working days' notice.

Inspection and tests shall be carried out on the complete assembled switchgear. Transportable units can be wired together instead of completing busbar joints.

The following checks and tests shall at least be carried out:

Switchgear shall be visually inspected for technical execution and conformity with the latest issue of the approved drawings and with the order. Spot checks shall be made to verify:

- degree of protection of the enclosure;
- degree of protection within the compartments;
- effectiveness and reliability of safety shutters, partitions and shrouds;
- effectiveness and reliability of operating mechanisms, locks and interlock systems;
- insulation of the busbar system;
- creepage distances and clearances;
- proper mounting of components;
- internal wiring and cabling system;
- correct wiring of main and auxiliary circuits;
- suitability of clamping, earthing and terminating arrangements;
- correct labelling of functional units;
- completeness of the data on the nameplate;
- availability of the earthing system throughout the switchgear;
- interchangeability of electrically identical components;
- non-interchangeability of mechanically identical but electrically different withdrawable units (7.6.4).

An insulation resistance test shall be performed between each phase and neutral against earth, with the remaining phases and neutral connected to earth. The insulation resistance tests shall be carried out with all manually operated and latched type switching devices in the closed position and all main fuses installed. The insulation resistance measured shall be at least 5MΩ. The voltage applied shall be at least 1.1 times Un DC.

A dielectric test shall be carried out in accordance IEC 439-1, but for 1 minute. The test voltage shall be as follows:

	Minimum test voltage
For main circuits	2500 V (a.c.)
For control and auxiliary circuits	2xUn+1000 V (a.c.), with a minimum of 1500 V

The mechanical and electrical operation of a number of functional units, including their control and protective devices, shall be tested on a random basis. Unless otherwise specified in the requisition, these tests shall be done on 10% of the number of similar functional units with a minimum of two units.

The IMCS shall be fully tested in accordance with Appendix 1.

PART 3 REFERENCES

In this DEP, reference is made to the following publications:

NOTE: Unless specifically designated by date, the latest edition of each publication shall be used, together with any amendments/supplements/revisions thereto.

SHELL STANDARDS

Index to DEP publications and standard specifications	DEP 00.00.05.05-Gen.
Standard Forms binder	DEP 00.00.10.05-Gen.
Requisitioning binder	DEP 30.10.01.10-Gen.
* Standard Form: “Schedule for LV switchboard”	DEP 33.67.01.80-Gen.

NOTE: Standard Forms can be found in the Standard Forms binder (DEP 00.00.10.05-Gen.)

** Requisition for LV switchboard	DEP 33.67.01.93-Gen.
** Requisition for lighting distribution board	DEP 33.67.01.94-Gen.
** Requisition for engineering documents	DEP 40.10.01.93-Gen.

NOTE: Requisition sheets can be found in the Requisitioning binder (DEP 30.10.01.10-Gen.)

Spare parts	DEP 70.10.90.11-Gen.

STANDARD DRAWINGS

Schematic diagrams of control circuits for LV motors	S 67.004
LV switchboard panel identification	S 67.021

INTERNATIONAL STANDARDS

Direct acting indicating analogue electrical-measuring instruments and their accessories	IEC 51
Electrical apparatus for explosive gas atmospheres	IEC 79
Method for determining the comparative and the proof-tracking indices of solid insulating material under moist conditions	IEC 112
Current transformers	IEC 185
Voltage transformers	IEC 186
Low voltage fuses	IEC 269
Low-voltage switchgear and controlgear assemblies, part 1: Type-tested and partially type-tested assemblies	IEC 439-1 (1992)
Class 0.5, 1 and 2 alternating-current watt-hour meters	IEC 521
Degrees of protection provided by enclosures (IP code)	IEC 529
Insulation co-ordination for equipment within low-voltage systems	IEC 664
Electrical measuring transducers for converting a.c. electrical quantities to analogue or digital signals	IEC 688
Low-voltage switchgear and controlgear	IEC 947

Electromagnetic compatibility (EMC)	IEC 1000
Guide for testing under conditions of arcing due to internal fault	IEC 1641

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Copies can also be obtained from national standards organizations.

APPENDIX 1 INTEGRATED MOTOR CONTROL SYSTEM (IMCS)

A1.1 INTRODUCTION

This Appendix specifies the technical requirements for a microprocessor based Integrated Motor Control System (IMCS) to be incorporated into an LV Switchboard to control, protect and monitor both motors and feeders.

A simplified block diagram of the IMCS is given in Figure A1.1.

A1.2 DEFINITIONS AND NOMENCLATURE

A1.2.1 TERMINOLOGY

The following terms and interpretations shall apply for the purpose of this specification:

- **Motor Control Unit - MCU**

Motor Control Unit is a microprocessor based device with integrated control, monitoring and protection functions and communication facility serving a single motor starter.

- **Feeder Control Unit - FCU**

Feeder Control Unit is a microprocessor based device with integrated control, monitoring and protection functions and communication facility serving a single contactor, circuit breaker or fused feeder.

- **Central Control Unit - CCU**

A Central Control Unit is a microprocessor based interface device used to monitor and control a number of MCUs and FCUs via a serial bus and enabling communication with a higher level of control.

- **Integrated Motor Control System - IMCS**

A system comprising MCUs FCUs, CCUs, a serial bus connecting the MCUs and FCUs to the Central Control Unit and a serial communication facility enabling connection of Central Control Unit to a Distributed Control System (DCS) and/or a Supervisory Control and Data Acquisition System (SCADA).

A1.2.2 ABBREVIATIONS

CCR	- Central Control Room
CCU	- Central Control Unit
DCS	- Distributed Control System - providing regulatory control of the plant.
EMC	- Electromagnetic Compatibility
EWS	- Engineering Work Station
FAR	- Field Auxiliary Room
FCU	- Feeder Control Unit - Outgoing feeder
HHT	- Hand Held Terminal
IMCS	- Integrated Motor Control System (Motor Management System)
IPS	- Instrument Protective Systems
IRB	- Interposing Relay Board/Panel
LAN	- Local Area Network
MCU	- Motor Control Unit
PC	- IBM compatible Personal Computer
RCU	- Remote Control Unit
SCADA	- Supervisory Control and Data Acquisition System
SS	- Safety Switch
Switchboard	- Motor Control Centre/LV Switchboard

A1.3 GENERAL

A1.3.1 SCOPE OF SUPPLY

The scope of supply of a IMCS shall include all design activities, supply of materials including spare parts where specified, factory acceptance tests and provision of documentation and instructions as stated in this specification.

The scope of supply also includes start-up assistance and if specified, site installation. The Manufacturer shall indicate in his tender his capabilities for carrying out site installation work and training of operational and maintenance staff.

If specified in the requisition the Manufacturer shall also supply a simulation unit to be used as a training tool complete with all the required software, converters and cabling to enable maintenance and operation staff to become fully conversant with the routine operation and maintenance of the MCU, FCU and CCU. This unit may be used in collaboration with the DCS Manufacturer for communication field testing.

A1.3.2 RESPONSIBILITY

The Purchase Order for the IMCS shall e placed with the Switchboard Manufacturer. Both IMCS and Switchboard Manufacturers shall be approved by the Principal.

The Swithchboard Manufacturer shall be responsible for the performance of the IMCS as described in this specification and shall liaise with the DCS Manufacturer for procedures, execution of interface and testing.

The IMCS Manufacturer shall be responsible for obtaining certified field test reports for the communication with the connected DCS and/or SCADA, as nominated by the Principal, using the actual CCU configuration to be supplied.

A1.3.3 INFORMATION TO BE SUBMITTED WITH THE TENDER

The Manufacturer shall submit a technical specification of the IMCS which shall include a description of the design, operation, construction, performance and maintenance aspects of the equipment.

The Manufacturer shall verify in the tender that the equipment fully complies with this specification and the applicable international and national standards and directives. Where applicable the Manufacturer shall supply type test certificates to verify such compliance. Any deviations from this specification shall be highlighted and the technical consequences shall be noted.

The Manufacturer shall state in the tender the country of origin of the main components of the system. For maintenance and trouble shooting at site, the Manufacturer shall indicate the nearest service organisation recommended for the location where the equipment will be installed.

A1.4 BASIC REQUIREMENTS

A1.4.1 SET-UP

The IMCS shall be a microprocessor based intelligent motor/feeder protection, control and monitoring system comprising:

- MCU and FCU to be mounted in, or adjacent to the Switchboard starter/feeder compartment providing measurement, control and protection functions.
- Per Substation a CCU arrangement shall be provided linking the MCUs and FCUs, in that substation.
- The CCU shall be able to be connected to at least one EWS.
- The CCU arrangement shall provide separate serial connections to the plant DCS and SCADA systems via a serial link.

- Current transformers for protection, voltage transformers and if required transducers to be used for measurement and control.

A1.4.2 DUAL REDUNDANT CONFIGURATION

Where 100% system availability of the IMCS is required a dual redundant CCU and a dual redundant serial link configuration shall be provided. This shall be indicated in the switchgear requisition. If a dual redundant CCU arrangement is required it shall be a Master - Slave, hot standby system, such that in the event of a failure of one unit, the second shall take over control in a bumpless fashion and shall also provide both a local and remote alarm to indicate the failed unit. The system shall be designed such that any failure in any part of the system shall not result in loss of availability of the system.

A1.4.3 FUTURE DEVELOPMENT

Any new generation of this equipment including software developed subsequent to delivery shall be compatible with the design of the original equipment, and it shall be relatively easy to extend, modify or adapt the original equipment or software to incorporate such new developments. The Manufacturer shall clarify in his tender the method by which this aspect can be demonstrated.

Notwithstanding the above, the Manufacturer shall guarantee that the spare parts and software support for the original equipment will remain available for the duration of the expected lifetime of the system with a minimum of 10 years.

A1.4.4 CE MARKING

All IMCS systems for installation in countries which are part of the European Union (EU) Trading Area shall be supplied with the required CE certificate and markings in accordance with local legislation. In addition the entire installation shall conform fully with all the applicable EU Directives. For other areas CE certification shall also be provided, if specified by the Principal, together with any local regulations, if applicable.

A1.5 DESIGN, CONSTRUCTION & TECHNICAL REQUIREMENTS

A1.5.1 GENERAL

A1.5.1.1 The IMCS shall be capable of withstanding and maintaining operation during and after the supply voltage and frequency deviations specified in Section 4.3.2 of DEP 33.64.10.10-Gen.

A1.5.1.2 Each motor circuit and outgoing feeder shall be controlled by the MCU or FCU which serves to perform it's functions of measurement, control and protection and constitutes a complete and self sufficient protection system with a non-volatile memory of all specific pre-programmed parameters. The use of battery back up is not permitted. The units shall be automatically able to maintain operation capability after a voltage interruption.

A1.5.1.3 The EWS shall be able to set the parameters and to monitor the operating status of any connected drive or feeder.

Access to change the operating parameters shall be restricted by means of a password or key.

A1.5.1.4 In the event of a failure of the protection and control functions of an individual MCU/FCU, the associated circuit shall be field configurable to either automatically trip or to maintain the current operation. In the event of a communication failure of any individual MCU/FCU or any failure of the CCU the associated circuit(s) shall be field configurable to either trip or maintain the current operation. Any such failure of either the communication or the MCU/FCU shall generate an alarm in the CCU for onward transmission to the DCS.

A1.5.1.5 In conjunction with the Principal the required default configuration to be adopted for all MCU/FCUs shall be determined.

A1.5.1.6 In the event of a failure of an individual MCU/FCU module it shall be possible to replace any failed module and readily download or program the specific drive/feeder parameters to the replacement module via the EWS or HHT without specialised software knowledge. The specific drive/feeder parameters shall be stored in the memory of the EWS.

A1.5.1.7 The control set-up of the MCU shall allow for possible additional hardwired control of the motor.

A1.5.1.8 The MCU and FCU modules shall be adequately protected against external short circuits or earth faults on the connected control cables and shall maintain full operation after clearance of any such fault.

A1.5.2 PROTECTION AND MEASUREMENT

A1.5.2.1 The MCU shall constitute of a complete control and self-sufficient protection system. Each motor starter unit, whether of the direct-on-line or reduced voltage type or dual speed type etc., shall be equipped with a microprocessor based motor protection, monitoring and contactor control device. The device shall provide as a minimum the following:

- Motor overload protection, setting, status, pre-alarm and time to trip, including certified thermal curves for EEx e motors, according to IEC 79 part 7 Increased Safety ‘e’. The unit shall model the hot and cold motor thermal capacity utilising fixed or adjustable thermal time constants (see also clause 7.6.1.7).
- Load unbalance, setting and status, including pre-alarm.
- Earth fault protection, setting and status (see also clause 7.6.1.8).
- Thermal status of the motor, including restart inhibit time.
- Motor current.
- Stalling protection setting and status.
- Run up time.
- Automatic re-start setting on loss of voltage, as per (A1.5.4).
- Motor operating time (operating hours).
- Number of contactor operations.
- Local Stop on each MCU.
- Manual reset of all alarms and trips (except locked rotor and earth fault which are to be reset via a password or a key).
- A minimum of one configurable input for external trips.

As an option the following functionality may be provided if required:

- Monitoring of consumed active power and the power factor.
- Thermistor or Pt100 element for over-temperature protection including pre-alarm.
- Under-load protection, setting and status, including pre-alarm.
- Under-voltage trip for latched contactors, setting and status per unit or from a central unit.

A1.5.2.2 The FCU shall be capable of monitoring the typical power feeder parameters listed below as a minimum:

- Feeder current.
- Switching device status.
  As an option the following functionality may be provided:
- Consumed active power.
- Power factor.
- Overcurrent protection (adjustable for grading purposes).
- Earth fault protection including possibility to delay the earth fault trip time for co-ordination purposes, if the unit is electrically controlled.
- Reset of earth fault via a password or a key.

A1.5.2.3 Trending and recording facilities shall be made available at the CCU suitable for monitoring and recording by the EWS and the connected SCADA on an as-required basis. A facility for generating print-outs of events and trend logs from the EWS/SCADA by connecting a standard printer shall be incorporated.

It shall be possible to configure all measurable variables such as current, power etc. for trend recording and to define the recording trigger event such as a motor start.

A1.5.2.4 MCU modules may provide either a 4-20 mA or 0-20 mA output for connection to the RCU ammeter as an alternative to a dedicated 1A secondary current transformer.

A1.5.2.5 All protection and control devices shall incorporate self supervision and checking routines with a watchdog function to indicate system errors and or failures directly to the CCU.

A1.5.2.6 Programming of the protection and operational parameters shall be carried out in a user friendly manner by the EWS or via a local keypad.

Once protection and operating parameters are loaded into the system, they shall be stored in non-volatile memory so that all information is retained during power failures. The need to reload parameters from the EWS or HHT following any power failure is not acceptable.

A1.5.2.7 Monitoring of the operating status of all connected drives and or feeders, including a log of alarms, shall be available via the connected SCADA.

A1.5.3 MOTOR CONTROL

Every drive shall be controlled as detailed below :

A1.5.3.1 Local, adjacent to the motor

Local control shall be from a position close to the motor. This is done via at least one RCU and/or SS allowing the motors to be started and stopped manually. The RCU is a three position switch with "Off-O-On" positions and a spring return to the "O" allowing remote automatic control by the DCS.

For contactor controlled motor starters the "Off" position of the RCU/SS can be padlocked and should be regarded as a safety switch. In this position the RCU/SS shall be hardwired switched into the motor starter contactor circuit. Furthermore an additional contact of the RCU/SS shall be used to short circuit the contactor coil when the RCU is in the "Off" position.

All RCU/SS stop commands shall in all cases overrule the IMCS and MCU. The RCU/SS shall at all times be able to stop the drive even with the MCU defective.

All control schemes shall be in line with the existing standard RCU/SS arrangement as shown on Standard Drawing S67.004.

A1.5.3.2 Remote, from a DCS/IPS system

Remote control shall be possible from the 'process' DCS or IPS system. This type of control, if required for plant operation, shall be applied in addition to the manual control described above. Automatic process control shall consist of the following :

- "On" and "Off" controls.
- IPS control signals which shall be hardwired into the motor starter circuit.
- DCS control signals which may be hardwired into the motor starter circuit or preferably serially connected into the IMCS, as determined by the Principal.
  No “On” command may be given by the MCU, HHT or EWS during normal plant operating conditions.

A1.5.4 AUTOMATIC RESTART OF MOTORS

An automatic restart facility shall be provided to restart the motor after voltage dips of up to 4 s duration. This facility should be incorporated in all MCUs, and shall be fully configurable per drive.

The automatic restart facility shall be initiated under the following conditions :

- Voltage dip detection level at 65% of Un.
- Voltage restoration detection level at 90% of Un.
- Immediate restart after voltage dips $\leq$ 0.2 s
- Delayed restart after voltage dips of > 0.2 s with an adjustable maximum of 60 s in steps of 5 s after which the unit shall be not restarted without an external start command.
- If a second voltage dip, with a duration less than 0.2 s, occurs within 1 s after the first voltage dip, a delayed restart command shall be given
- The undervoltage memory time buffer shall be at least 4.5 s.

The minimum detection time for a voltage dip shall be less than the drop time of the contactor (considered to be 10 ms) therefore ensuring that the MCU will detect a voltage dip even after a transient interruption has occurred.

A1.5.5 OPERATION, MONITORING AND EVALUATION

The IMCS shall also be capable of displaying the following either directly from MCU/FCU or at the CCU.

- Alarm outputs including watchdog alarms.
- Pre-trip conditions.
- Stop control of motors.
- Motor/Feeder status - Available/Running/Tripped etc.
- Trip LED Indication plus type of trip.
- Running/Stop LED indication.
- Maintenance time interval data.

A1.5.6 COMMUNICATIONS

A1.5.6.1 Each MCU and FCU shall have a serial connection for communication with the CCU. This connection shall be of the “daisy chain” type thus ensuring that even if the communication link is broken at a single point, all devices are still accessible from the CCU. The CCU shall be able to communicate with all the MCUs and FCUs in the Switchboard(s) within a single substation.

Each MCU and FCU shall be selectable from the EWS and/or HHT via unique equipment tag number as defined by the Principal. Selection by module address only is not acceptable.

A1.5.6.2 The IMCS shall communicate with the DCS via either a single or dual redundant serial link, as determined by the Principal, according to the IMCS availability and process control requirements. This communication should interface directly to the DCS control network. If a communication interface module is not available for the selected DCS Manufacturer, the communication to DCS shall be via a serial link in the Modbus RTU format (DCS master, IMCS slave). A TCP/IP connection may be used if approved by the Principal.

A1.5.6.3 In case of loss of communication with the DCS or SCADA system, the IMCS shall continue to operate undisturbed unless configured otherwise.

A1.5.6.4 All selected data shall be available in the CCU and selected data as defined by the Principal shall be accessible from the DCS or SCADA system.

A1.5.6.5 The serial data link from the Substation CCU to both the DCS and/or SCADA systems shall be either a single or a fully redundant link by either a twisted pair copper cable or preferably, a fibre optic cable.

The Manufacturer shall provide certified field test reports verifying the successful communication of the CCU with the selected DCS and/or SCADA system. The Manufacturer shall ensure that the IMCS can communicate effectively with the selected higher level system and shall supply the required converters and software. The Manufacturer and the nominated DCS/SCADA Manufacturer shall provide a field simulation demonstration of the communication link between the two systems using all the required converters and software.

A1.5.7 RESPONSE TIME

A1.5.7.1 The set up of the IMCS shall be such that stop commands from the DCS system shall always have priority over data collection and other DCS commands.

A1.5.7.2 The SCADA system is primarily a data collection and monitoring system. The preferred method of data collection is for the CCU data to be loaded into a table which is then refreshed at regular intervals and the SCADA system only accesses data on request.

A1.5.7.3 The Manufacturer of the IMCS shall specify the response and scan times of the system for control and monitoring. The maximum response time for priority control/data signals shall not be greater than 0.6 s with the maximum number of MCU/FCU modules connected to the CCU.

A1.5.8 CURRENT TRANSFORMERS

A1.5.8.1 The current transformers shall ensure galvanic separation between the measuring circuit and the power circuit. The number and accuracy of current transformers shall be such that phase unbalances can be detected.

A1.5.8.2 The earth fault protection current transformer of the motor circuits shall be of the core balance type with the accuracy to maintain the sensitivity specified in Part 2, Section 7.6.1.8 of this DEP.

A1.5.8.3 The current transformers shall be designed to cover the accuracy and current ranges of the drives and feeders as specified and the type of protection such as overcurrent, earth fault, etc. The required accuracy for all measurements is plus/minus 5 %.

A1.5.9 CONTROL SUPPLY

A1.5.9.1 Manufacturer shall advise the maximum power supply requirements required for the complete IMCS.

A1.5.9.2 The Manufacturer shall provide any necessary converters, etc. required for the control, monitoring, indication etc. of the IMCS.

A1.5.9.3 Preferably the power supply for the CCU shall not be taken directly from the Switchboard main busbars.

A1.5.9.4 The power supply to the individual MCU and FCU modules shall be derived from the starter/feeder which is being protected. The use of a central power supply is not preferred.

A1.5.9.5 Where a centralised DC power supply is required a DC/DC converter shall be included in the CCU power supply unit to avoid the CCU earthing an external DC power source such as the substation trip/close DC supply.

A1.5.10 THE MOUNTING OF MCU AND FCU MODULES

A1.5.10.1 All MCU and FCU modules shall be suitable for mounting in the Switchboard starter compartments or in a compartment adjacent to the starter/feeder. If the unit is mounted within the starter unit, the electronics shall be rated accordingly. If for cooling purposes the unit is mounted in the cable compartment the integrity of the separation shall not be

undermined by any ventilation requirements.

A1.5.10.2 The interface between the installed starter/switching unit and the communication bus within the Switchboard shall be an integral part of the starter/feeder. The unit shall remain withdrawable. The connection to the communication bus and interface unit shall be a single connection using self centring plugs and sockets.

A1.5.11 TEST FACILITIES

Facilities shall be provided to allow functional testing of the MCU and FCU modules, without having to run the motor.

This facility may be provided by a test setting on the switchgear or by means of a stand alone test rig to simulate all possible control functions, including the automatic restart function.

A1.5.12 ENGINEERING ACCESS

A1.5.12.1 The IMCS software shall allow access for engineering purposes to any MCU or FCU, on or off line. Facilities shall be provided to change setpoints, prepare or examine a motor trend analysis, etc. Access to vital motor settings and the CCU configuration shall be governed by a password.

A1.5.12.2 Three levels of access shall be available on the EWS and/or HHT :

Level 1 : View Only

The maintenance engineer or operator shall only be able to view the set parameters and actual data but is not permitted to change any settings or reset any lock out trips.

Level 2 : Settings and Reset

The maintenance engineer shall be able to reset all trips and reconfigure the MCU and FCU drive and protection parameters.

Level 3 : CCU Configuration

It shall be possible to reconfigure the CCU to accommodate additions and modifications to the system and configure the CCU/DCS/SCADA communication parameters.

A1.5.13 RELIABILITY

A1.5.13.1 The hardware of the IMCS shall be suitable for the temperatures that will occur in the Switchboard. This should be achieved by derating all electronic components and suitable burn-in of the PCBs of all the units to prevent failures.

A1.5.13.2 Failure rate including all component failures shall be less than 0.50% over the lifetime of the units. The MTBF (Mean Time Between Failures) of the MCU/FCU and CCU modules shall not be less than 150,000 hrs.

A1.5.13.3 The design of the IMCS shall be such that the Mean Time To Repair (MTTR) shall be minimised. This means that suitable plug-in assemblies are preferred conventionally wired modules. The Manufacturer shall also provide estimated MTTR figures for all components with the tender.

A1.5.14 SOFTWARE

The software package(s) required to operate the IMCS and for the communication with the CCU shall be part of the scope of supply of the LV switchgear Manufacturer. The

Manufacturer shall provide a demonstration version if available, of the software for training purposes.

All software shall be user friendly and menu-driven, and all configurations of the communication to the DCS/SCADA and the loading and modification of drive/feeder setpoints shall be designed for use by engineer/technicians without specialised software knowledge.

A1.5.15 SPARE PARTS

The Manufacturer shall include sufficient spare parts to fully cover the on site commissioning activities. In addition the Manufacturer may be requested in the requisition to provide a detailed quotation for spares covering 2 years of operation. The Manufacturer shall provide full spare part capability and support, including software for at least 10 years after installation.

A1.6 PERFORMANCE REQUIREMENTS

A1.6.1 ELECTRICAL IMMUNITY

The IMCS shall be immune to voltage and frequency fluctuations within the limits given in (A1.5.1.1).

The IMCS shall be able to generally withstand the impact of the electrical tests imposed upon the Switchboard as defined in IEC 439 and IEC 947, without any damage to or malfunction of the IMCS.

Loss of control power supply shall not result in the loss of the application software, data or the dynamic data relevant to the operation of protection systems, e.g. available thermal capacity of motors (up to 60 seconds) and operation of the automatic motor restart. On restoration of the power supply the system should be able to automatically resume normal operation. Battery back-up of individual MCU and FCU modules is not acceptable.

A1.6.2 DISTURBANCE IMMUNITY

The entire IMCS shall be suitably screened to optimise electromagnetic compatibility (EMC).

Any electromagnetic disturbance generated by the IMCS and individual components shall not exceed a level which would affect the correct operation of both radio and telecommunications equipment. In addition the IMCS shall have an adequate level of intrinsic immunity to external electromagnetic disturbance to enable it to operate as intended.

The complete IMCS shall be type tested in accordance with IEC 1000 part 4, level 3 - typical industrial environments, as detailed below :

IEC 1000- 4-2 - Electrostatic Discharge - level 3 - 8 kV air discharge
IEC 1000- 4-3 - Radiated Electromagnetic Field (RFI) - level 3 - 10 V/m
IEC 1000- 4-4 - Electrical Fast Transient - level 3 - 4 kV common mode
IEC 1000- 4-5 - Surge - 2 kV line -earth and 1 kV line-line

The Manufacturer shall provide type test certificates from a recognised testing authority to verify that the complete IMCS is effectively screened against EMC in line with the applicable IEC standards.

A1.6.3 COMMUNICATION INTEGRITY

The communication interface bus between the CCU and the MCU/FCU Modules shall be tolerant to the electromagnetic disturbances referenced in (6.2) and shall be fully protected against any short circuit or similar faults without loss of communication.

Reliability of the communication bus shall be monitored in terms of overruns, quality (i.e. framing, parity and checksum errors) and response time-outs.

Failure of communication bus shall generate an alarm to the CCR via the CCU but the current state of devices shall be maintained unless configured otherwise.

A1.7 CONSTRUCTIONAL REQUIREMENTS

A1.7.1 UNIT ENCLOSURE

The individual MCU and FCU module enclosures shall provide a degree of protection of not less than IP 41 in accordance with IEC 529.

The CCU enclosure, if mounted separately, shall have a degree of protection not less than IP 41. The floor shall not be considered as forming part of the enclosure.

A 19" rack type draw out or a plug in type unit is preferred.

A1.8 INSPECTION AND TESTS

A1.8.1 GENERAL

Prior to dispatch, the IMCS Manufacturer shall verify by tests that the operation of the equipment complies with the requirements specified in the requisition, and shall submit to the Principal a report incorporating the results of all tests performed.

If specified on the requisition, a representative of the Principal shall witness the functional factory acceptance tests (A1.8.3 & A1.8.4) and shall carry out an inspection of the assembled equipment and related documents to verify compliance with the requirements of the purchase order.

A1.8.2 QUALITY CONTROL

The IMCS Manufacturer shall make available for review by the Principal a quality control program, based on ISO 9001, regarding inspection and testing of the components and total IMCS. This program shall include 24 hour heat-soak and burn in of all components.

A1.8.3 TESTING THE COMMUNICATION OF THE IMCS AND THE DCS

The Manufacturer of the IMCS shall allow a full functional communication test with the DCS.

The test is to check the complete communication between the DCS and the IMCS. All functions of the IMCS shall be tested and verified.

A1.8.4 TESTING OF THE IMCS IN THE LV SWITCHGEAR.

The MCU and FCU modules shall be individually functionally tested. Additionally the operation of the CCU and the communication between the CCU and all MCU and FCU shall be verified by witnessed testing.

The IMCS test in the LV switchgear works shall include, but not be limited to the following:

- Primary injection test:
  The complete system operation shall be verified by injecting current through the phase and earth fault current transformers.
- Dielectric strength test:
  A complete Switchboard check shall be carried out, with IMCS installed but disconnected, to verify the dielectric strength i.e. flash testing. This shall be carried out by the Manufacturer as part of the standard in-house testing, prior to final witnessed inspection.
- Phase current functions
- Overload condition
- Earth fault current functions
- Input functions

- Thermistor/Pt 100 input tests where applicable
- Power fail test including restart functionality
- External hardwired commands

A1.8.5 TYPE TESTS

The Manufacturer shall submit to the Principal, for review and approval, the type test results of the electrical, disturbance and environmental immunity test requirements as per (A1.6).

A1.9 DOCUMENTS

The Manufacturer shall provide, preferably on a CD ROM, in accordance with the purchase order requirements, technical manual(s) and drawings which shall include, but not be limited to the following documents:

- General arrangement drawing showing MCU/FCU dimensions, HHT dimensions, CCU dimensions mounting details of the units, connections etc.
- Typical wiring diagram of fixed type starters/feeders, withdrawable type starter/feeder and the core balance wiring (earth fault protection).
- Cabling showing power input, output, terminals of MCU/FCU, HHT, EWS interface connections.
- Setpoint setting tables for all MCUs and FCUs as set in the factory, as hardcopy and on computer (floppy) disk.
- Configuration software on computer (floppy) disk for CCU and MCU/FCU.
- Wiring diagrams showing all interconnecting wiring between MCUs , FCUs and the CCU.
- Wiring diagrams showing all external cable connections and terminal assignments.
- Programming (logic) diagrams.
- Recommended spare parts lists
- Test reports
- Certificate of conformity for communication with DCS/SCADA systems.
- Operating manuals incorporating installation, commissioning, operating and maintenance instructions, and fault finding procedures.

FIGURE A1.1 Simplified block diagram of a Motor Control System