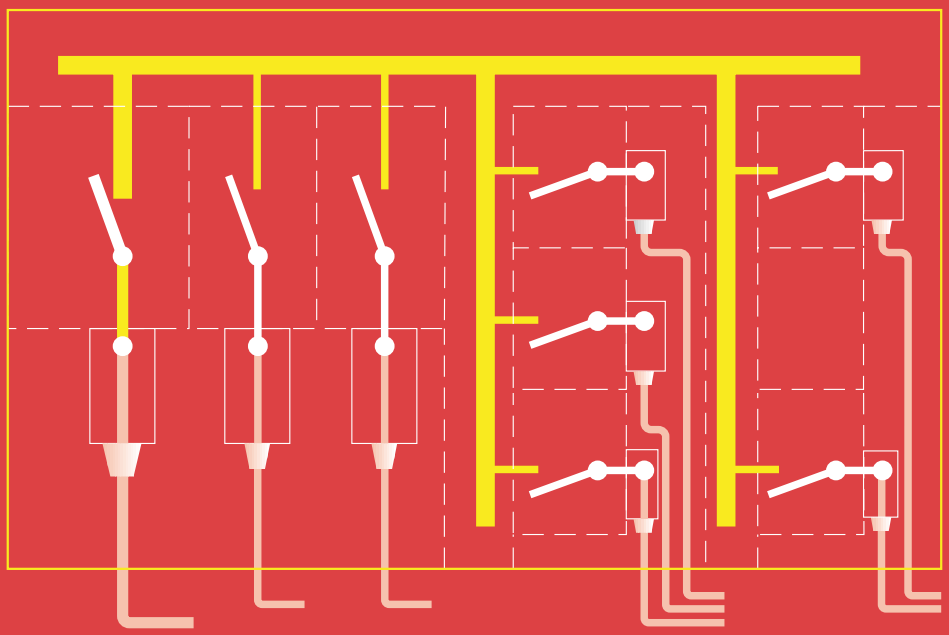
GUIDE TO FORMS OF SEPARATION



Low Voltage Switchgear and Controlgear Assemblies:

BS EN 60439-1: 1994 (IEC 439-1)

Including Amendment No1: 1995

The Electrical Installation Equipment Manufacturers' Association

INTRODUCTION TO EIEMA

EIEMA the Electrical Installation Equipment Manufacturers' Association, is an autonomous, incorporated Association of British manufacturers of electrical installation equipment. The Association's roots date back to 1915 as a product section of BEAMA - The Federation of British Electrotechnical and Allied Manufacturers' Association.

EIEMA's Low Voltage Distribution Switchboard Technical Committee consists of major UK manufacturing companies operating under the guidance and authority of the EIEMA Industrial Products Group supported by specialist central services for guidance on European Single Market, Quality Assurance, Legal and Health & Safety matters.

EIEMA members actively participate in the work of numerous International, European and National standards committees. This provides the background and support to ensure safety and performance for the design, development and manufacture of its members' products. The result is quality equipment of the highest standard throughout each group of the Association.

Membership of EIEMA Low Voltage Distribution Switchboard Technical Committee is conditional upon compliance with, or a commitment to, achieving the stringent standards of quality to BS EN ISO 9001:1994.

Other publications available from EIEMA:

Product and Members Guide
Guide to Switch & Fusegear Devices
Guide to Circuit Breaker Standards
Guide to Residual Current Devices
Guide to the IP codes for enclosures
Guide to Fuse Link Applications
Guide to LV Busbar Trunking Systems
Guide to Type Tested Assemblies and Partially Type Tested Assemblies

Acknowledgements

EIEMA would like to thank IEC and BSI for reference to their standards.
Health and Safety Executive (HSE) for their assistance with Section 10.

This publication is available at £10 plus postage and packing

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PREFACE

In May 1992 the first EIEMA Guide to the Forms of Separation to BS 5486 Part 1:1990 was published. That guide was accepted by Specifiers and Industry alike and used almost universally as an industry standard, providing a more clear understanding of the constructional requirements for the various means of meeting internal separation for Low Voltage Switchboard Assemblies.

In 1994, the Standard was amended and re-numbered to align with the European Norm EN 60439-1. Also at this time an initiative by EIEMA members contributed to the expansion of the various forms which subsequently led to the publication of a National Annex to the Standard, (see amendment 1: March 1995).

This fourth edition of the EIEMA guide reflects these changes and therefore remains essential reading for both Specifiers and Users. It is intended as an explanatory document to be used in conjunction with the Standard. Study of this guide will enable Specifiers and Users to match their specific requirements to the even wider range of options available from member companies of the EIEMA Low Voltage Switchboard Technical Committee. *(See inside back cover)*

The Standard specifically states that the Forms of Separation shall be the subject of agreement between Manufacturer and User. EIEMA believes this guide to be an appropriate basis for such an agreement and it will assist in identifying the most suitable solution for each application. Other forms of construction, however, are not precluded by the Standard.

1 INTRODUCTION

BS EN 60439 Part 1, describes a system for classifying the various forms of separation to be provided principally for:

- protection against contact with live parts belonging to the adjacent functional units.
- limitation of the probability of initiating arc faults.
- protection against the passage of solid foreign bodies from one unit of an Assembly to an adjacent unit.

Even though the Standard has now been revised with a UK National Annex to provide a wider scope of forms, it still does not give detailed advice on how to achieve these aims.

Manufacturers of switchboard assemblies employ many variations of design to meet this protection and any other additional market requirements.

The means utilised to achieve these conditions may be partitions or barriers of metallic or non-metallic material. The partitions or barriers may provide individual separate compartments or alternatively, barriered sub-sections.

Greater clarification has been included within this guide by providing some basic definitions of the terms used and explaining some of the various methods employed by manufacturers to meet the required degree of separation.

In general, the cost of an Assembly increases with enhanced levels of separation, but choosing the most expensive arrangement will not necessarily lead to the most appropriate solution.

2 USEFUL DEFINITIONS

The Standard includes definitions relating to Assemblies. Those particularly relevant to the separation of Assemblies include the following. The same clause numbering has been used to aid cross reference to the Standard.

2.1.1 Assembly: ***"A combination of one or more low-voltage switching devices together with associated control, measuring, signalling, protective, regulating equipment, etc., completely assembled under the responsibility of the manufacturer with all the internal electrical and mechanical interconnections and structural parts."*** This includes floor standing or wall mounting distribution switchboards, panelboards, and motor control centres using electromechanical and/or electronic components. It does however specifically exclude individual devices and self-contained components which control a single circuit i.e., wall mounted starters and fuse switches.

2.1.5 Functional Unit: ***"A part of an assembly comprising all the electrical and mechanical elements that contribute to the fulfilment of the same function."*** Essentially this is all parts necessary to form a complete incoming or outgoing circuit. It includes all the main current carrying equipment, including cable terminals, and control devices within the assembly, that are necessary to form the complete circuit. It excludes the connections from the unit to the busbars (busbar connections) and any insulation or shrouding with which they may be provided with. (Generally such connections have a short-circuit rating to match the rated current and short-circuit characteristics of the functional unit and historically were referred to as 'fault free zones').

2.2.1 Section: ***"A constructional unit of an assembly between two successive vertical delineations".*** Usually considered to be a single full height column containing one or more functional units. Generally several columns are required to complete an Assembly.

2.2.2 Sub-Section: ***"A constructional unit of an assembly between two successive horizontal delineations within a section".*** Abstract in nature. The area or space within a column identified and bounded by two adjacent and horizontal constructional members e.g., cross members or shelves.

2.2.3 Compartment: ***"A section or sub-section enclosed except for openings necessary for interconnection, control or ventilation."*** An enclosed area or space within an Assembly. Also includes a product complete with its own integral housing (MCB, MCCB, Moulded Switch, ACB) if protection to IP2X is assured. See also 2.4.5.

2.4.5 Enclosure: ***"A part providing protection of equipment against certain external influences and in any direction, protection against direct contact to a degree of protection of at least IP2X".***

2.4.10 Partition: ***"A part of the enclosure of a compartment separating it from other compartments".*** A component used to form the top, bottom, sides, front or back of a compartment or enclosure and which can be manufactured from metal or an appropriate plastic material.

2.4.11 Barrier: ***"A part providing protection against direct contact from any usual direction of access (minimum IP2X) and against arcs from switching devices and the like, if any".*** Prevents finger contact with live parts and/or protects operators from emissions from switching devices. It can take the form of insulating material in direct contact with the live part, e.g., heat shrink sleeving on a busbar. Alternatively it can take the form of rigid insulation or an earthed metal screen appropriately positioned relative to the live part(s).

3 FUNDAMENTALS OF SEPARATION

In accordance with the Standard, separation of the various elements of an Assembly: busbars, functional units, terminals, can be claimed providing one or more of the following criteria are met:

1. ***"Protection against contact with live parts belonging to adjacent functional units. The degree of protection shall be at least IP2X or IPXXB"***

As a minimum, finger contact with live parts in adjacent functional units is prevented. With Assemblies supplied by EIEMA Member Companies this is extended to include protection against finger contact between: functional units, adjacent busbars and busbar connections, and terminals as required for the particular form of separation being considered.

The requirement is proven with the standard test finger.

2. ***"Limitation of the probability of initiating arcing faults"***

Note: A second amendment to IEC 439-1 is presently being considered. This effectively removes this requirement from the Standard, since no common repeatable method of testing could be arrived at internationally.

EIEMA Members meet this non specific and probabilistic requirement by; good design practices and ensuring, usually by type test, the operation of switching and short circuit protective devices does not adversely affect adjacent functional units or busbars.

3. ***"Protection against the passage of solid foreign bodies from one unit of an Assembly to an adjacent unit. The degree of protection shall be at least IP2X"***

The minimum requirement is proven by the standard test finger not being able to touch live parts in adjacent units and a 12mm ball not being able to pass between units.

In practice a higher degree of protection may be required for horizontal partitions to prevent small objects from falling between compartments and should be identified in the contract specification.

These three fundamental criteria are interrelated. EIEMA Member Companies will therefore ensure all three are fully met in respect of the particular form of separation offered.

4 ACHIEVING SEPARATION

The fundamental requirements in the Standard are performance criteria and not constructional details on how separation should be achieved. There is a requirement that Assemblies are divided by means of partitions or barriers (metallic or non-metallic) into separate compartments or barriered sub-sections, but *not* for example:

- each functional unit to be in its own compartment;
- partitions and barriers to be manufactured from earthed metal, etc.

Separation can be achieved in several ways. Depending on a particular application and the requirements for maintenance, this may include:

a) PVC sleeving, wrapping or plastic coating of conductors.

b) Insulated terminal shields or PVC 'boots'.

c) Rigid insulated barriers or partitions.

d) Compartments formed from earthed metal.

e) A device's integral housing.

Where a Specifier or User has a particular preference, this should be clearly stated at the enquiry stage.

5 SELECTING A FORM OF SEPARATION

In general, the price of an Assembly will increase with increased levels of separation and / or types of construction. Choosing the arrangement with the most internal barriers will not always lead to the most appropriate solution.

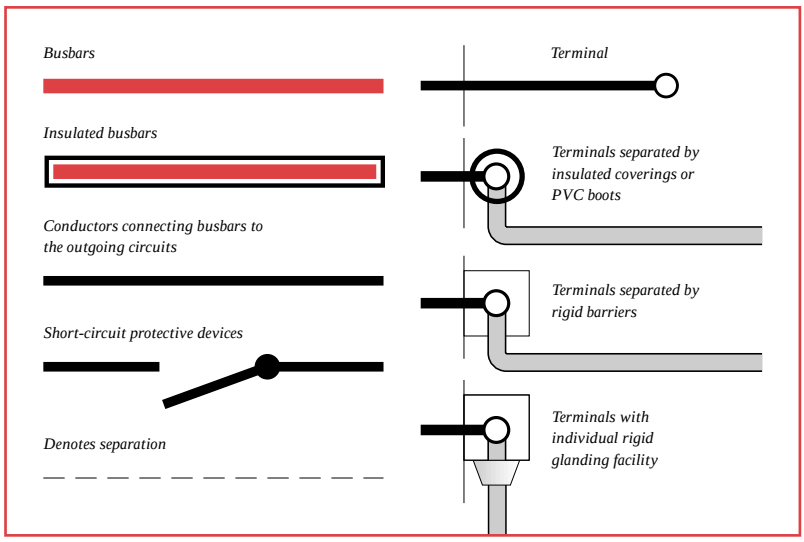
Where specific requirements are not stated or identified, the manufacturer is likely to assume the most cost effective solution will satisfy the customer's needs and offer it accordingly.

To select the most suitable arrangement for each application, EIEMA members recommend the following points are considered:

- Site and position of the Switchboard.
- Maintenance requirements of the switchgear.
- Skill level of personnel having access to the Assembly
- Probability of requiring access to the terminals of a particular circuit with those adjacent live and still in service.
- Difficulty and / or inconvenience in isolating the complete Assembly.
- Price and benefits of the different forms.

Further guidance on selection is provided in the form of a decision tree, see Section 12 page 18.

Key throughout



On the following pages the various forms of separation are drawn schematically. The forms shown in brackets ()are those included in a proposed 2nd amendment to IEC 439-1, presently still under consideration. e.g Form 4 type 3 (Form 4a Type 3).

6 FORM 1 REQUIREMENTS

Form 1 covers overall Assemblies which are enclosed so as to provide protection against contact with any internal live parts or components, but where no internal separation is provided for functional units or terminations.

For Form 1;

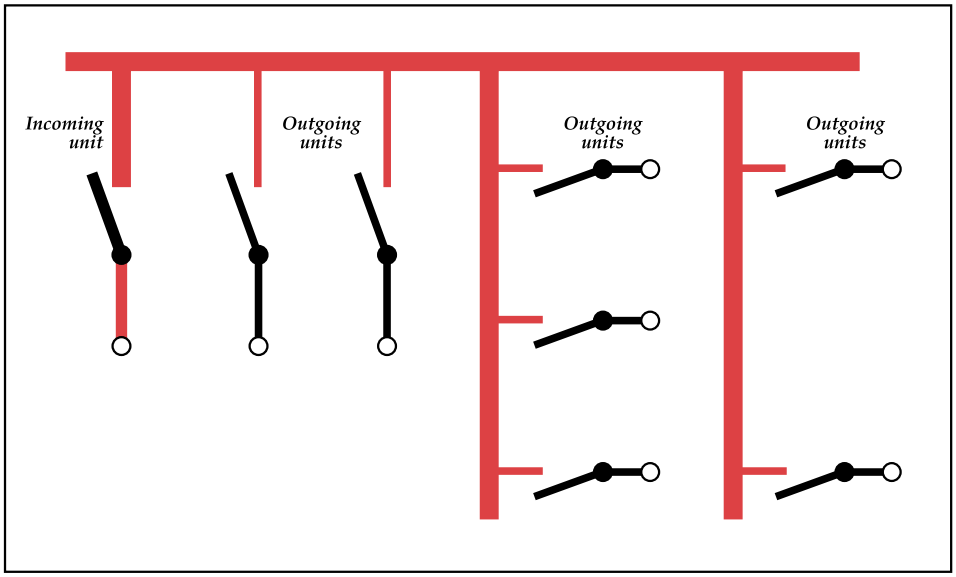
i Busbars ***are not*** separated from the functional units,

ii Functional units ***are not*** separated from other functional units.

iii Functional units ***are not*** separated from any incoming or outgoing termination.

iv Busbars ***are not*** separated from any incoming or outgoing terminations.

FORM 1



7 FORM 2 REQUIREMENTS

Form 2 defines overall Assemblies which are enclosed to provide protection against contact with any internal live parts or components, and where there is internal separation of the busbars from functional units.

The following general conditions apply;

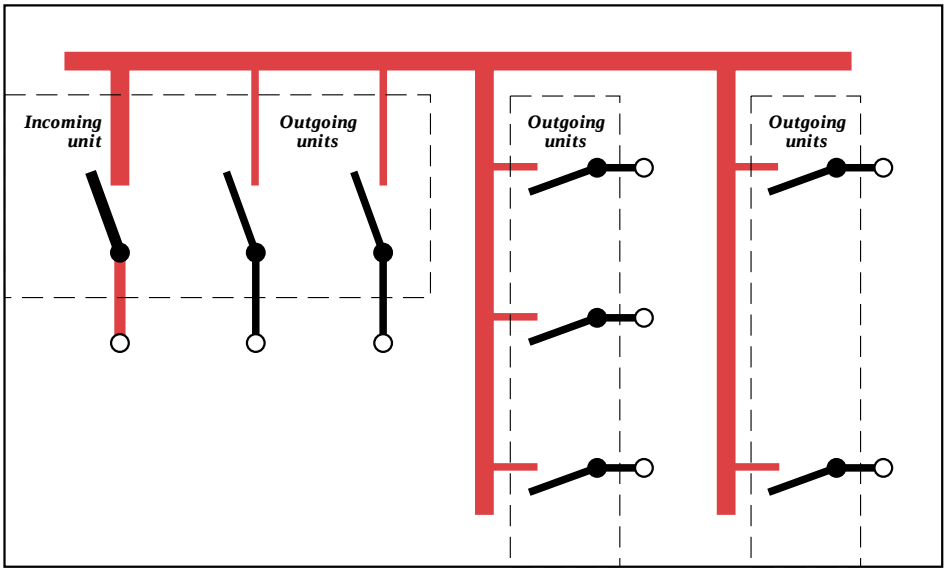
i Busbars ***are*** separated from functional units

ii Functional units ***are not*** separated from other functional units.

Compliance with the requirements of Form 2 may be offered by EIEMA manufacturers by any of the three methods. Specifiers and Users should clearly state their preference.

FORM 2 (Form 2a)

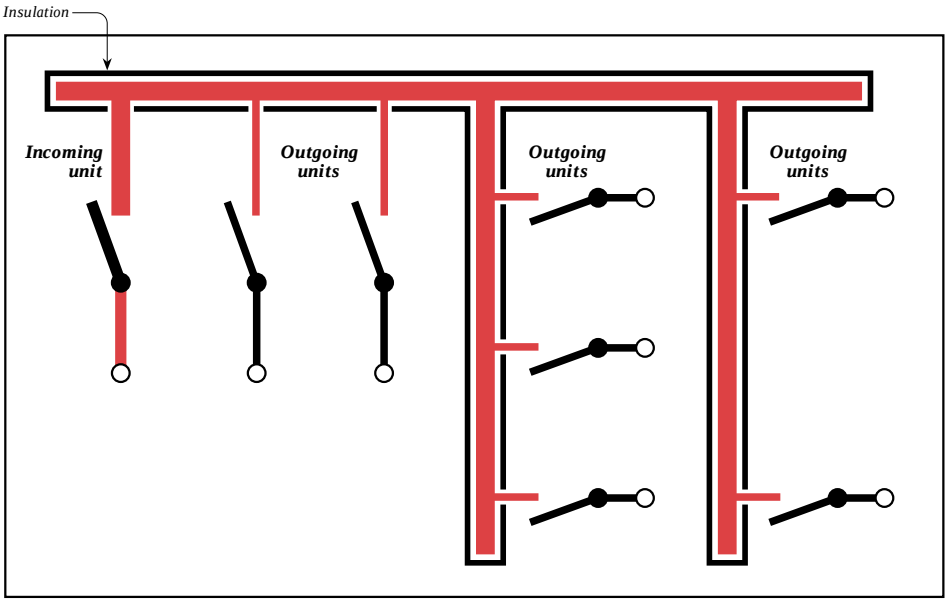
Basic form as above. However, with this method terminals ***are not*** separated from the busbars, or each other. The actual means of separation is not defined in the Standard.



FORM 2 Type 1 (Form 2b Type 1)

Main criteria as FORM 2. Busbar separation is achieved by insulated coverings, e.g. PVC sleeving, wrapping or coating.

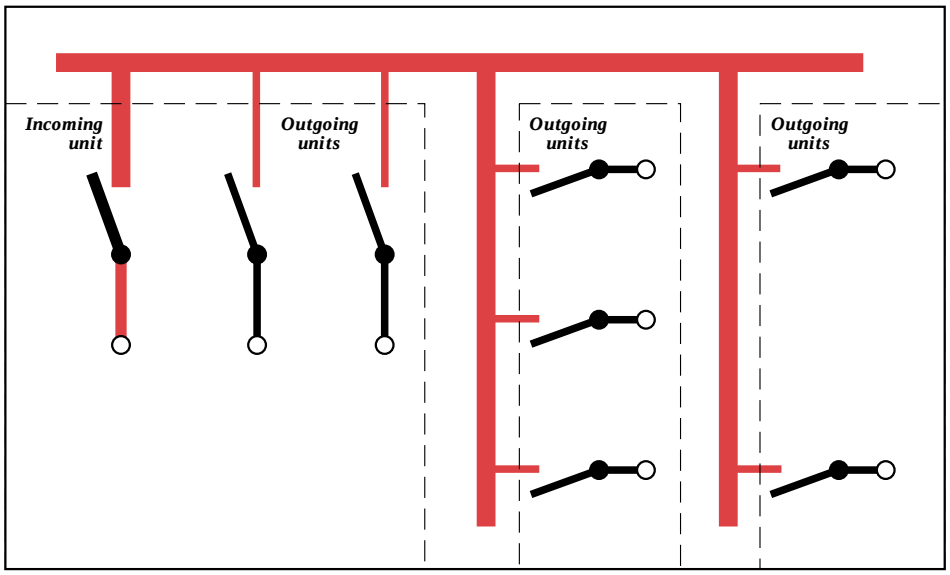
Terminals ***are*** therefore separated from the busbars, but ***not*** from functional units or each other.



FORM 2 Type 2 (Form 2b Type 2)

Main criteria as FORM 2. Busbar separation is achieved by metallic or non-metallic rigid barriers or partitions.

Terminals *are* therefore separated from the busbars, but *not* from functional units or each other.



8 FORM 3 REQUIREMENTS

Form 3 defines overall Assemblies which are enclosed to provide protection against contact with internal live parts and components, and in which there is internal separation of the busbars from functional units and separation of all functional units from each other.

The following general conditions apply;

i Busbars ***are*** separated from functional units.

ii Functional units ***are*** separated from each other.

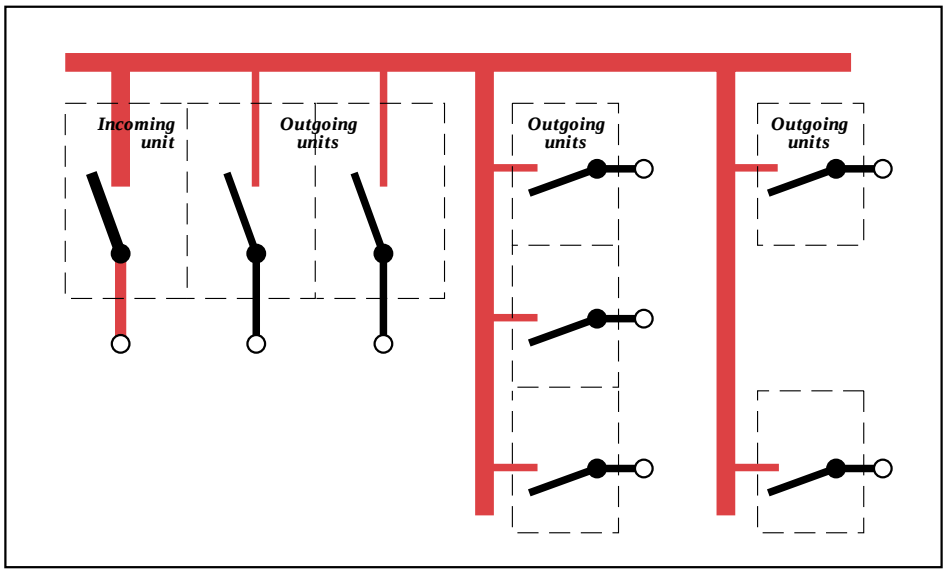
iii Functional units ***are*** separated from incoming and outgoing terminals.

iv Incoming and outgoing terminals ***are not*** separated from each other.

Compliance with the requirements of Form 3, may be offered by EIEMA manufacturers by any of the three methods. Specifiers and Users should clearly state their preference.

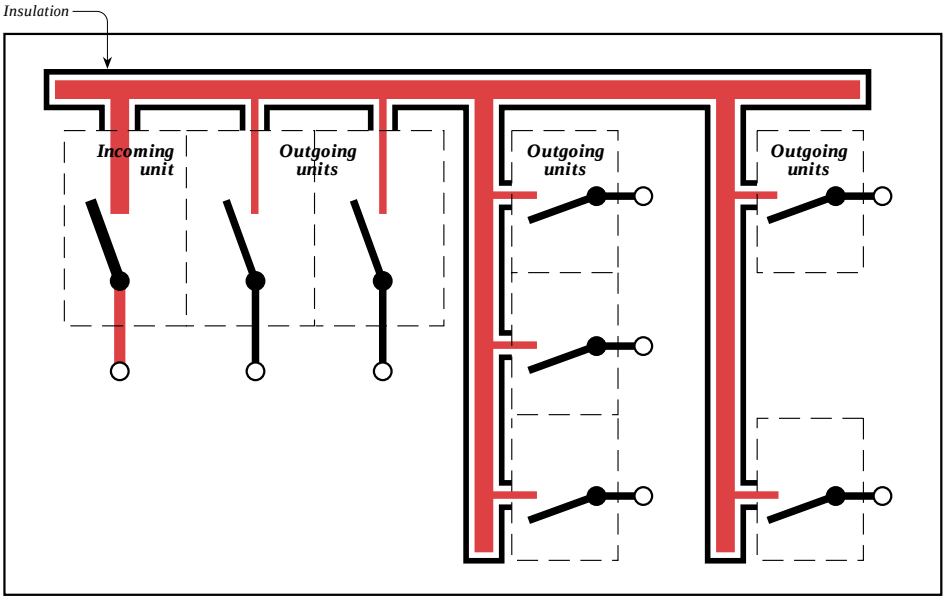
FORM 3a

Basic form as above. Terminals ***are not*** separated from the busbars or each other. The actual means of separation is not defined in the Standard.



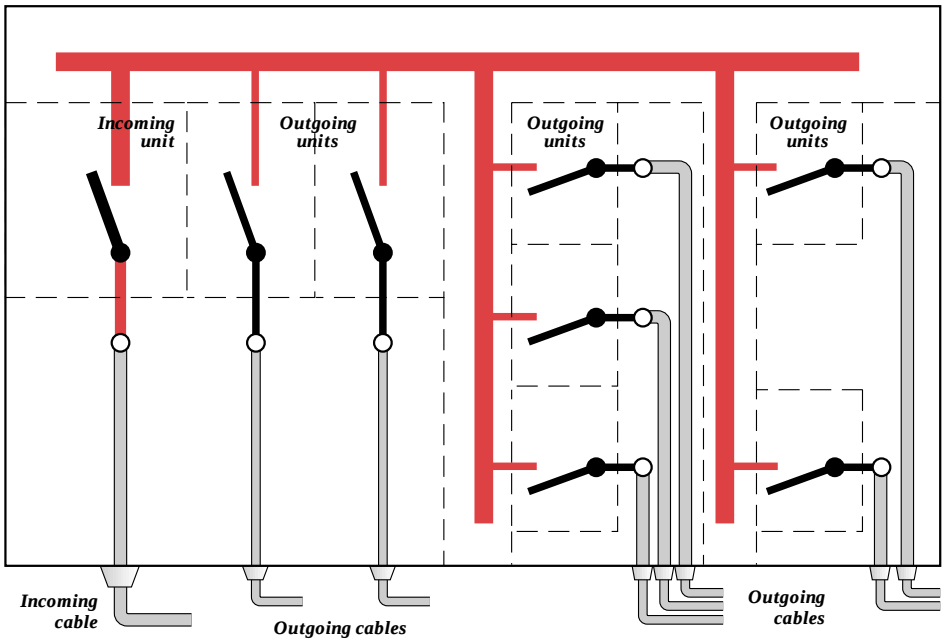
FORM 3b Type 1

As basic Form 3. Busbar separation is achieved by insulated coverings, e.g. PVC sleeving, wrapping or coating. Terminals ***are*** therefore separated from the busbars, but ***not*** from each other.



FORM 3b Type 2

As basic Form 3. Busbar separation is achieved by metallic or non-metallic rigid barriers or partitions. Terminals ***are*** therefore separated from the busbars, but ***not*** from each other.



9 FORM 4 REQUIREMENTS

Form 4 covers overall Assemblies which are so enclosed as to provide protection against contact with internal live parts and components, and in which there is internal separation of the busbar system from functional units, and separation of all functional units from each other. Incoming and outgoing terminals are also required to be separated from the busbars and from each other.

The following general conditions apply;

i Busbars ***are*** separated from functional units.

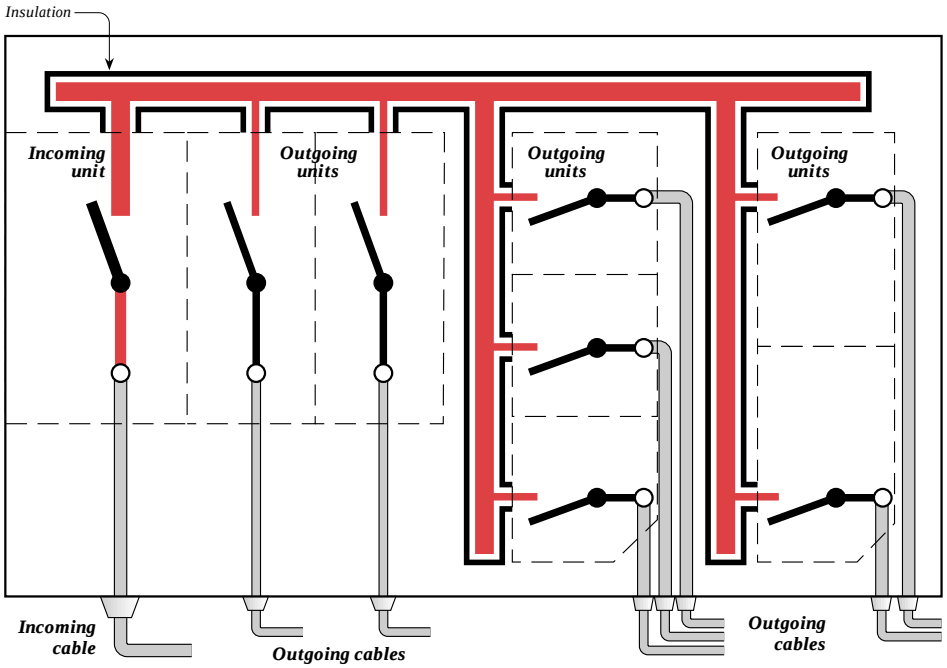
ii Functional units ***are*** separated from each other.

iii Terminations to functional units ***are*** separated from each other.

Compliance with any of the requirements of Form 4 may be offered by EIEMA manufacturers by any of the following seven methods. Specifiers and Users should clearly indicate their preference.

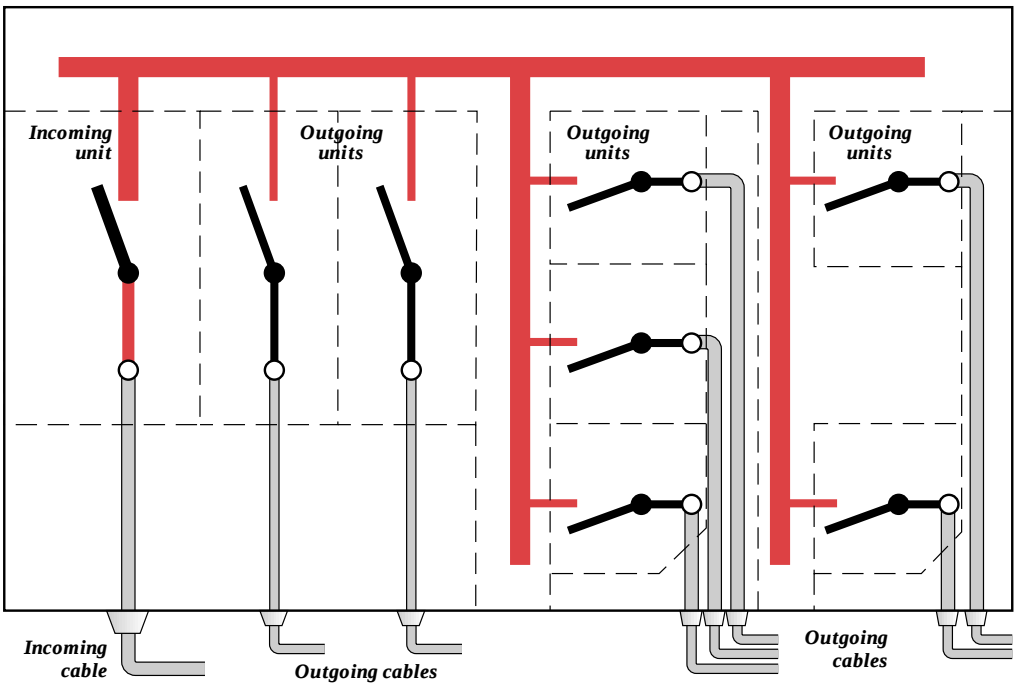
FORM 4 Type 1 (Form 4a Type 1)

As basic Form 4. Busbar separation is achieved by insulated coverings, e.g. PVC sleeving, wrapping or coating. Cables are terminated within the same compartment as the associated functional unit. Cables may be glanded elsewhere, e.g. in a common cabling chamber.



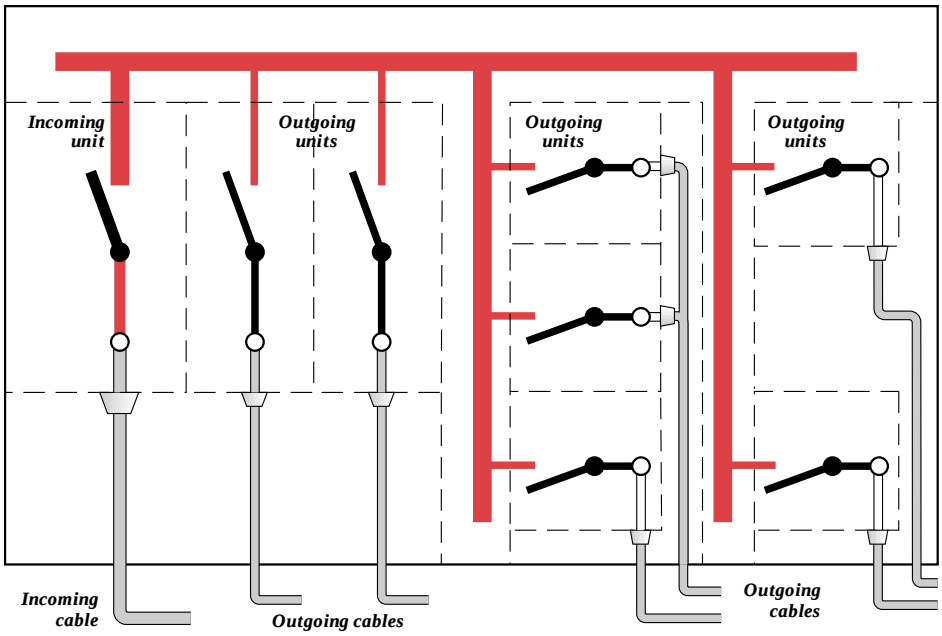
FORM 4 Type 2 (Form 4a Type 2)

As basic Form 4. Busbar separation is achieved by metallic or non-metallic rigid barriers or partitions. Cables are terminated within the same compartment as the functional unit. Cables may be glanded elsewhere, e.g. in a common cabling chamber.



FORM 4 Type 3 (Form 4a Type 3)

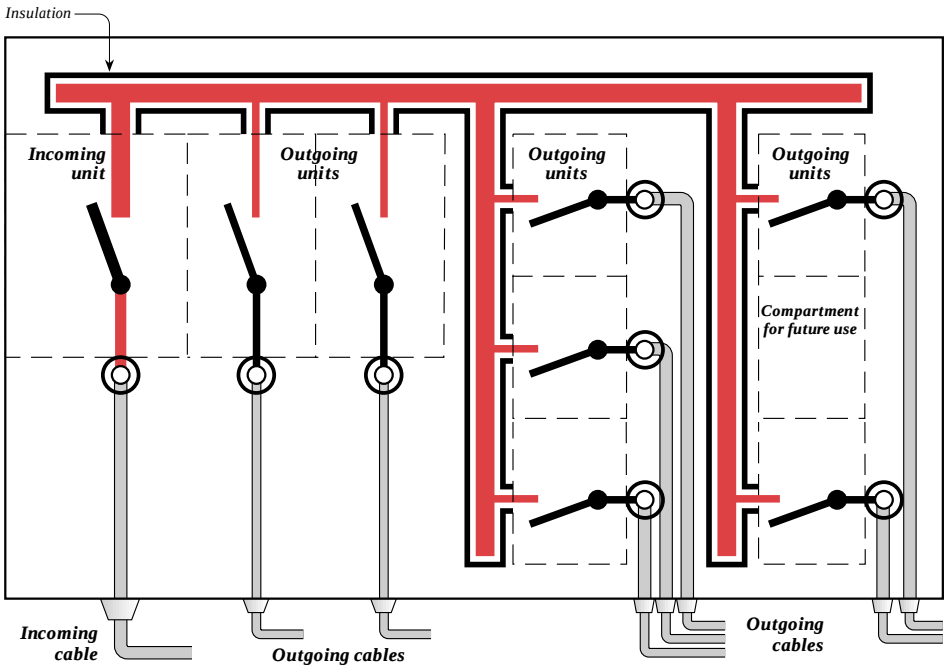
As basic Form 4. Busbar separation is achieved by metallic or non-metallic rigid barriers or partitions. Cables are terminated within the same compartment as the functional unit. The termination for each functional unit has its own integral glanding facility.



FORM 4 Type 4 (Form 4b Type 4)

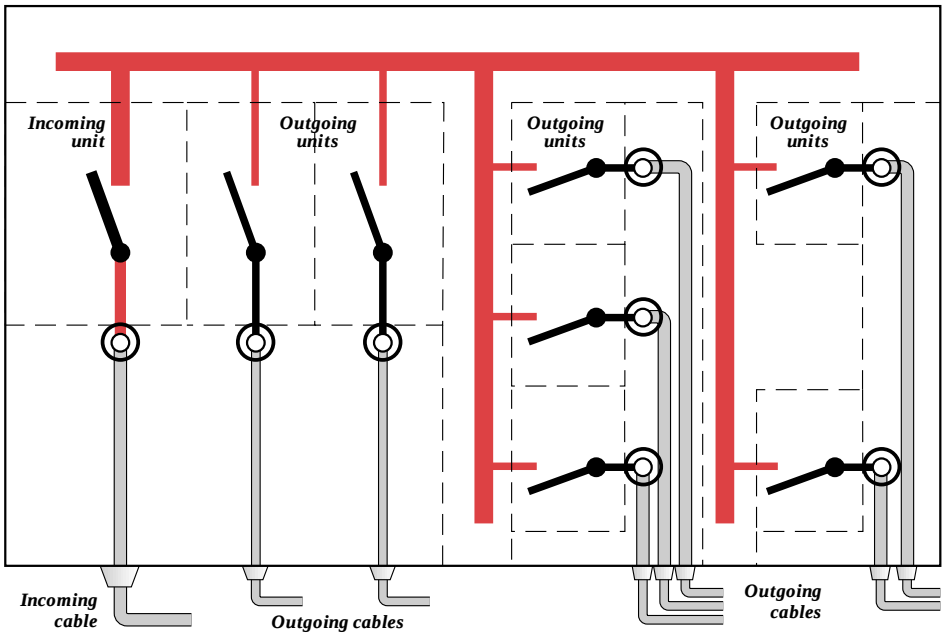
As basic Form 4. Busbar separation is achieved by insulated coverings, e.g. PVC sleeving, wrapping or coating. Terminals are external to the functional unit and separated by insulated coverings, e.g. PVC boots. Cables may be glanded elsewhere, e.g. in a common cabling chamber.

Note: Where connections between the cable terminals and the functional unit pass through the same general compartment as the busbars, busbar separation may be achieved by insulated covering of these connections only.



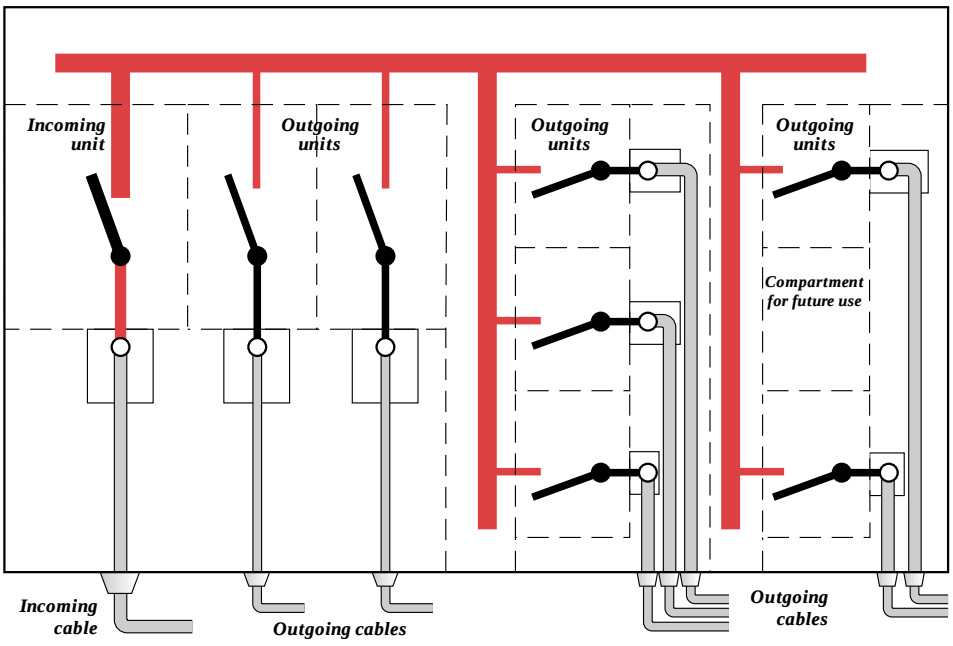
FORM 4 Type 5 (Form 4b Type 5)

As basic Form 4. Busbar separation is achieved by metallic or non-metallic rigid barriers or partitions. Terminals are external to the functional unit compartment and separated by insulated coverings, e.g. PVC boots. Cables may be glanded elsewhere, e.g. in a common cabling chamber.



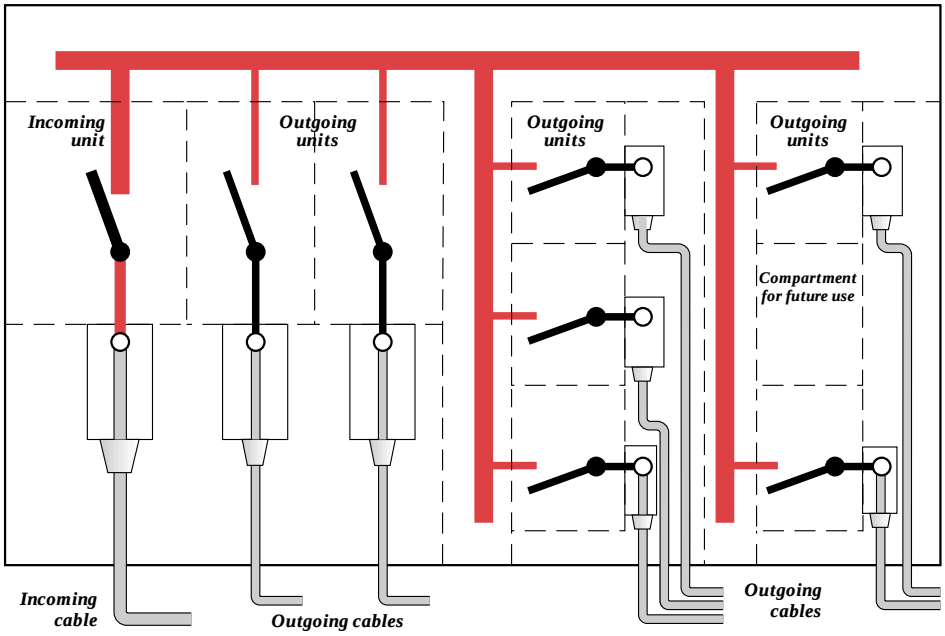
FORM 4 Type 6 (Form 4b Type 6)

As main criteria for Form 4. ***All*** separation is achieved by metallic or non-metallic rigid barriers or partitions. Terminals are external to the functional unit compartment and enclosed in their own compartment by means of rigid barriers or partitions. Cables may be glanded elsewhere, e.g. in a common cabling chamber.



FORM 4 Type 7 (Form 4b Type 7)

As main criteria for Form 4. ***All*** separation requirements are achieved by metallic or non-metallic rigid barriers or partitions. Terminals are external to the functional unit compartment and enclosed in their own compartment by means of rigid barriers or partitions complete with integral glanding facility.



10 SAFE WORKING WITH ADJACENT EQUIPMENT ENERGISED

Working safely in part of an Assembly with adjacent sections live is a sensitive issue but cannot be ignored when considering forms of separation.

First and foremost within the UK, the requirements of The Electricity At Work Regulations 1989, ***must*** be complied with. Regulation 14 is particularly pertinent and requires that:

"No person shall be engaged in any work activity on or so near any live conductor (other than one suitably covered with insulating material so as to prevent danger) that danger may arise unless:

a) it is unreasonable in all the circumstances for it to be dead; and

b) it is reasonable in all the circumstances for him to be at work on or near it while it is live; and

c) suitable precautions (including where necessary the provision of suitable protective equipment) are taken to prevent injury."

Regulation 4(4) in particular also applies to the provision and use of protective equipment.

Effectively this means that where live working is being contemplated a risk assessment and judgement must be made for every situation by the ***Duty Holder****. This must take account of all relevant factors some of which include:

- the effectiveness of isolating the Assembly,
- the task to be performed,
- the skill level of the personnel carrying out the work,
- the level of separation within the Assembly,
- the suitability of the separating barriers within the Assembly for the task being considered,
- the effectiveness of using temporary protective measures,
- use of correct tools, instruments and other work equipment,
- use of warning signs, etc.

Switchboard manufacturers therefore cannot give all embracing assurances for safe working, according to the form of separation with parts of the Assembly energised. Specifying a particular form of separation will not guarantee this for any given Form number. It can only be provided on a case by case basis depending on the work to be done. This is fully recognised in the Standard and requires a separate agreement between Manufacturer and User, as detailed in clause 7.4 and Annex E.

Note: For further reference see HSE publication Electricity at Work - Safe working practices HS(G)85.

**** Duty Holder***
The term used within the Electricity At Work Regulations 1989 to refer to the person appointed to be responsible for the electrical equipment, systems and conductors and any work or activities being carried out on or near the electrical equipment. The Duty Holder must be competent and may be the employer, an employee, or a self-employed person.

11 ACCESS FOR CABLING

Generally for front access Assemblies cable compartments are provided alongside the associated functional units. For rear access Assemblies cabling facilities are provided at the rear of the Assembly where working space is required..

In both cases, operation and access to the functional units are normally from the front.

If the Assembly is to be installed against a wall, the Assembly must be designed to ensure that all necessary access can be gained from the front.

If the Assembly is to be installed in a position where there is adequate working space all round, then cabling access may be from either front or rear. Where the Specifier or User has a preference this should be clearly stated in the enquiry.

Generally, for the same number of functional units, front access Assemblies are much longer than the rear access alternative. Conversely where cabling compartments are required at the rear, this necessitates a deeper design of Assembly.

The size of cabling compartments and the general arrangement can be influenced by the number and size of circuit cables and also the direction in which the cables need to approach the Assembly, (e.g. from overhead or via a trench).

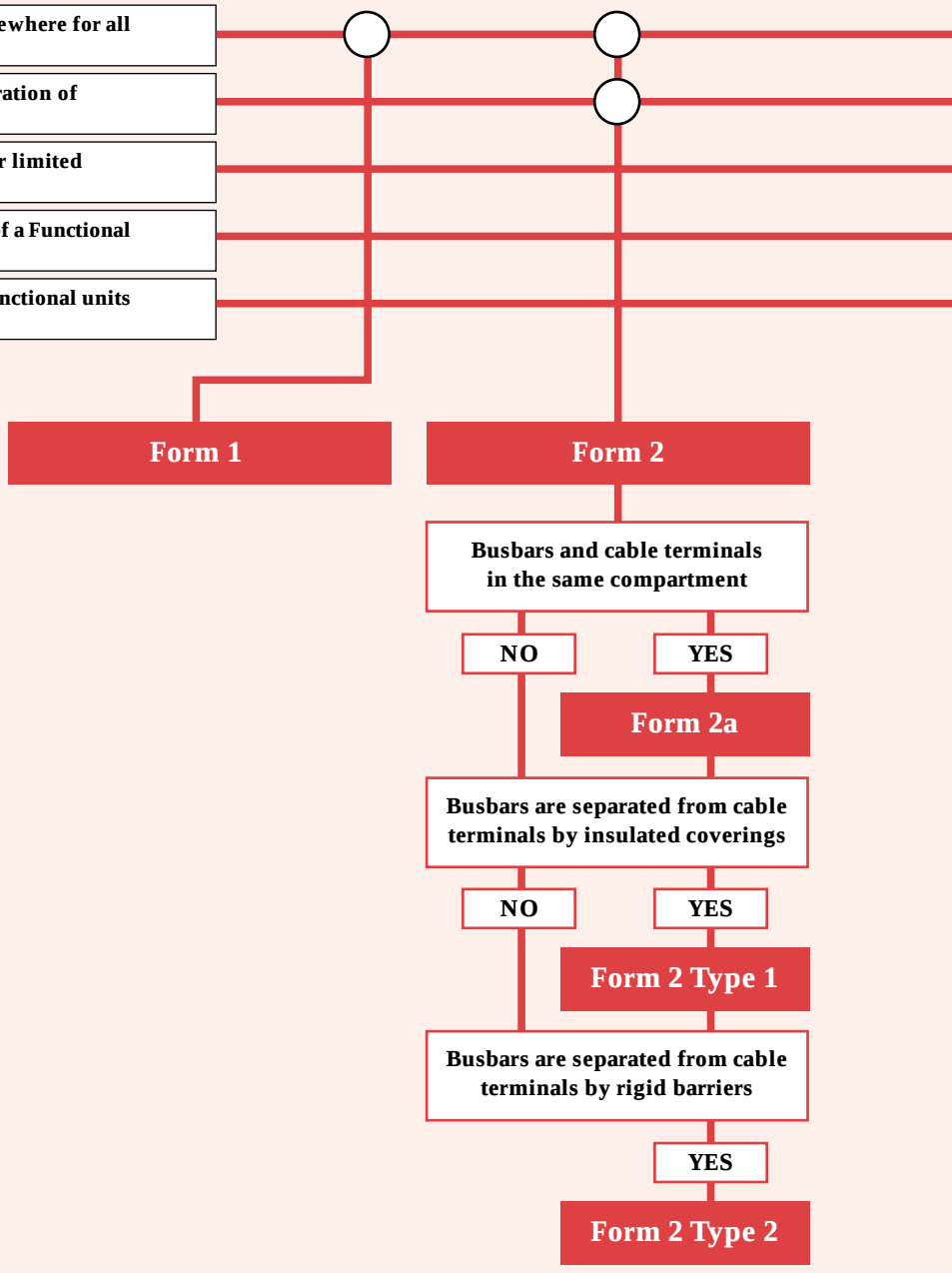
Fundamental requirements

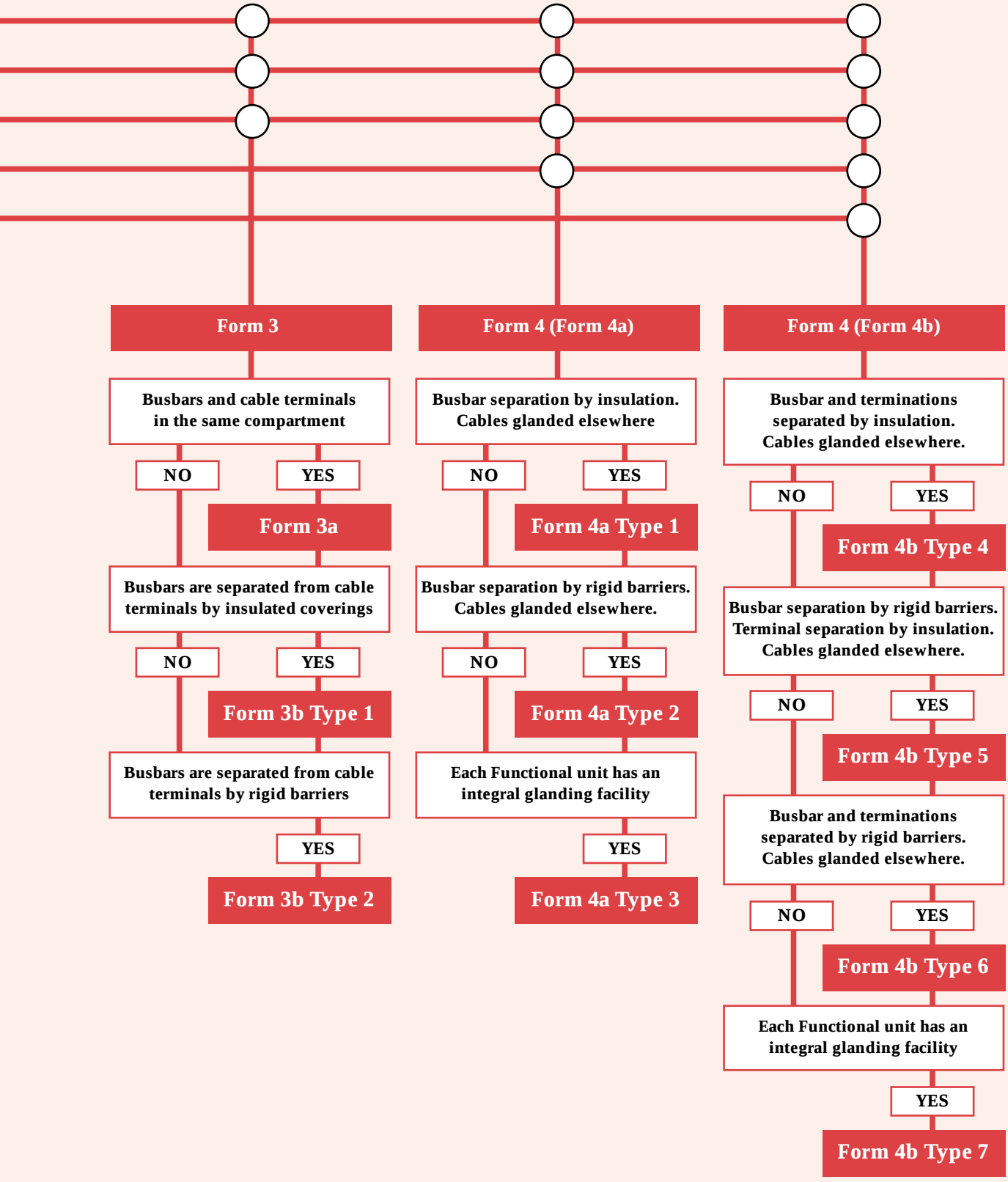
- The Assembly can be totally isolated elsewhere for all activities involving access of any kind
- Additional integrity is required by separation of Functional units from the Busbars
- Access is required to Functional units for limited maintenance with adjacent circuits live
- Access is required to the cable terminals of a Functional unit with adjacent Functional units live
- A clear boundary is required between Functional units and Cabling Contractor

12 DECISION TREE

The most appropriate solution for each requirement should be established considering all aspects of the particular application as indicated earlier.

This ‘decision tree’ is intended to assist in a logical approach to identifying the preferred Form of separation for the assembly being considered.




Form 3
Busbars and cable terminals in the same compartment
NO
YES
Form 3a
Busbars are separated from cable terminals by insulated coverings
NO
YES
Form 3b Type 1
Busbars are separated from cable terminals by rigid barriers
YES
Form 3b Type 2
Form 4 (Form 4a)
Busbar separation by insulation. Cables glanded elsewhere
NO
YES
Form 4a Type 1
Busbar separation by rigid barriers. Cables glanded elsewhere.
NO
YES
Form 4a Type 2
Each Functional unit has an integral glanding facility
YES
Form 4a Type 3
Form 4 (Form 4b)
Busbar and terminations separated by insulation. Cables glanded elsewhere.
NO
YES
Form 4b Type 4
Busbar separation by rigid barriers. Terminal separation by insulation. Cables glanded elsewhere.
NO
YES
Form 4b Type 5
Busbar and terminations separated by rigid barriers. Cables glanded elsewhere.
NO
YES
Form 4b Type 6
Each Functional unit has an integral glanding facility
YES
Form 4b Type 7

13 TYPICAL QUOTATION QUESTIONS

Full name & address

Name of Contact

Phone no:

Fax no:

Your ref:

Project title & location:

Dates: Quote by: Delivery by:

CPA ☐ Fixed price until: _____ ☐

Supply details: V. Ph. Hz

Internal separation:

(BS EN 60439-1 + Amendment 1)

FORM **1** ☐ **2** ☐ **3** ☐ **4** ☐

Indicate type required: ☐ ☐ ☐

Prospective fault current: (Ip) *(1)* _____ kA

Busbar/Panel Fault level: _____ kA _____ Secs

or limiting Device *(specify)*: _____

Neutral Busbar: Half ☐ Full ☐

Type of incoming device

Isolator ☐ Upstream device _____

Fuseswitch ☐

MCCB ☐

ACB ☐

Outgoing Circuit Protective Device

Fuseswitch ☐

MCCB ☐

ACB ☐

External Finish:

Manufacturers Standard Colour: ☐

Special (BS Colour Ref): _____ ☐

Fuses Fitted: Yes ☐ No ☐

Spare fuses (indicate quantity): _____ %

Earthing: Full length Earth Bar: ☐

Earth bar extended adjacent to gland points ☐

Other (specify): _____

Supply Authority Requirements

C/T Links: Yes ☐ No ☐

Location to incomer: Before ☐ After ☐

Meter Space:

Yes ☐ No ☐ N/A ☐

_____ h. _____ w. _____ d.

Type of access: Rear ☐ Front ☐

Manufacturers Standard Height ☐

min height _____ mm max height _____ mm

Degree of protection (BS EN 60529):

IP2X ☐ IP3X ☐ IP4X ☐ Other (specify): IP _____

Space Access Restrictions

If yes, give details: Yes ☐ No ☐

General:

Specification attached Yes ☐ No ☐

Drawing(s) attached Yes ☐ No ☐

Please attach all relevant information including a schematic

Physical layout: *(2), 3*

Incoming cables Btm ☐ Top ☐

Incoming position LHS ☐ RHS ☐

Trench / Duct available Yes ☐ No ☐

Outgoing cables Btm ☐ Top ☐

Additional requirements: *(3)*

e.g: Metering, Functional or System Interlocking, Control or protective relays etc.

Notes: 1/ Important especially where breakers are specified 2/ Please state all cable sizes and directions where known 3/ If insufficient space give details on a separate sheet.

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GUIDE TO FORMS OF SEPARATION

An EIEMA Publication
Issue No4 - June 2001

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