Technical Information

logstrup

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TECHNICAL INFORMATION

Contents

DESCRIPTION		PAGE / SIDE
1.	**Introduction**	4.0
2.	**Technical Specification & Standards**	
2.1.	Technical specification	5.0
2.2.	Paint specification	6.0
3.	**Enclosures**	
3.1.	Framework Open type	7.0
3.2.	Framework Cabinet type	8.0
3.3.	Base elements	9.0
3.4.	Cladding	9.0
3.5.	Internal mechanical components	10.0
3.6.	Internal form of separation	11.0
3.7.	Degrees of protection	13.0
4.	**Electrical Switchgear and Controlgear Assemblies**	
4.1.	Rating tables	14.0
4.2.	Busbar system	15.0
4.2.1	Busbar configuration	15.0
4.2.2	Contact resistance	16.0
4.2.3	Condition of contact surfaces	16.0
4.2.4	Effect of the pressure on contact resistance	16.0
4.3.	Thermal conditions	17.0
4.3.1	General requirements for electrical switchgear and controlgear assemblies	17.0
4.3.2	Temperature rise limits	17.0
4.3.3	Busbar temperature	17.0
4.3.4	Busbar temperature inside an enclosure	18.0
4.4.	Short-circuits	19.0
4.4.1	Short circuits	19.0
4.4.2	Dynamic stress	19.0
4.4.3	Thermal stress	19.0
4.5.	Introduction to type tested and partially type tested assemblies	20.0
4.5.1	The need to conform to standards	20.0
4.5.2	Type tested assembly (TTA) IEC 60439-1-1999-09	21.0
4.5.3	Partially type tested low voltage switchgear and controlgear assembly (PTTA) IEC 60439-1-1999-09 clause 2.1.1.2	21.0
4.5.4	List of verifications and tests to be performed on TTA and PTTA	22.0
4.6.	Arcs in low voltage switchgear and controlgear assemblies	24.0
4.6.1	Introduction	24.0
4.6.2	Arc tests	25.0
4.6.3	The Logstrup solution	25.0
4.6.4	Arc power	26.0
4.6.5	Rise of pressure	26.0
4.7.	Description of the types of electrical connections of functional units according to IEC 60439-1-1999-09	27.0
4.8.	Fixed type switchgear and controlgear assemblies	27.0
4.9.	Removable and Withdrawable type switchgear and controlgear assemblies	27.0
4.9.1	Removable type switchgear and controlgear assemblies	27.0
4.9.2	Withdrawable type switchgear and controlgear assemblies	27.0

DESCRIPTION **PAGE / SIDE**

5. Test & Inspection

5.1 Visual Control 28.0
5.2 Mechanical Control 28.0
5.3 Electrical Control 29.0

6. Lifting

6.1 Lifting 30.0

7. Transportation and Storage

7.1 Transportation and Storage 31.0

8. Installation

8.1 Installation 32.0

INTRODUCTION

A/S LOGSTRUP-STEEL is a Danish Company founded in 1958 by Mr. Jørgen Løgstrup.

The company is situated in Kvistgård 50 km north of Copenhagen, where the production of the Løgstrup Modular Panel System takes place.

A/S LØGSTRUP-STEEL have subsidiaries in Sweden, United Kingdom, Ireland and Germany. Furthermore LØGSTRUP is supplying Panel Builders in The Scandinavian Countries, in Europe, North America, Middle East, Far East, Australia and New Zealand.

The LØGSTRUP Panel System is a modular system delivered in Kit Form, enabling the Panel Builders to build any configuration of Main & Sub Distribution Boards and Motor Control Centres & Control Panels in Fixed and/or Withdrawable design. It is also possible to build Panels with internal form of separations according to IEC 439 Form 1-4.

The System is based on a 190 mm module (in all axes). This makes an unbeatable flexibility allowing almost any configuration and size to be designed. As we say " only your own imagination sets the limit for the use of the System ".

The System has been designed to meet the following requirements:

- High flexibility
- Easy to assemble
- Easy to maintain
- Easy to extend
- Competitive prices
- Cad design & Calculation System
- Free-standing or wall mounted design
- Meeting all International Standards
- High operation reliability
- High degree of personal safety

The LØGSTRUP System is produced according to a very strict quality control system (ISO 9001) and is being continually developed.

The following chapters contain more specific technical information on the System.

2.1 TECHNICAL SPECIFICATION

Standards	IEC 60439-1-1999-09	
	DIN EN 60439 Teil 1 (VDE 0660 Teil 500) 2000	
	BS EN 60439-1-1999-08	
	CSA - C22.2 No 31 & 14	
	DIN 43671/12.75	
	Pehla Richtlinie 4 1984	
	IEC 529	
	Ship Classification Societies	
Tests	IPH (Berlin, Germany)	
	ASTA (Rugby, England)	
	KEMA (Arnhem, Holland)	
	CSA (Rexdale, Canada)	(approval)
	Underwriters Laboratory (Melville, USA)	(approval)
	DEMKO (Denmark)	
	Elektronikcentralen (Denmark)	
	Germanisher Lloyd	(approval)
	Lloyd's Register of Shipping	(approval)
	Det Norske Veritas	(approval)
	The Russian Maritime Register of Shipping	(approval)
	Bureau Veritas	(approval)
Electrical Characteristics	Rated voltage (U_e)	690 V. AC
	Rated insulation voltage (U_i)	1000 V
	Dielectric test voltage	3 kV
	Rated impulse withstand voltage (U_{imp})	12 kV
	Rated frequency	40-60 Hz
	Rated current (I_n)	250A - 8500A
	Rated short-time withstand current (I_{cw})	Up to 130 kA 1 sec.
	Rated peak withstand current (I_{pk})	Up to 300 kA
Mechanical Characteristics	Degree of protection, IEC 529	Up to IP 54
	Corners	Aluminium alloy
	Framework steel (Aluzinc or painted)	2.0 mm
	Base frame steel (Painted)	2.5mm Dogal 350 YP
	Doors & plates steel (Painted)	1.5 or 2.0 mm
	Mounting plates steel (Aluzinc)	1.5 mm
	Internal partitions steel (Aluzinc)	1.0 mm
	Internal separation	Form 1 - 4
	Stainless steel	ANSI 304 160/80

2.2 PAINT SPECIFICATION

Paint	Polyester powder paint
Coating thickness	60-80 µ
Gloss	77°
Colour (frames & cladding)	RAL 7032 *
Colour (base frame)	RAL 9005 *

*(other colours on request)

PAINT PROCEDURE

All parts are transported on overhead conveyer through the following phases at a conveyer speed of 3-4 m/minute.

Phase 1 Degreasing and iron phosphating at a temperature of 30° C

Phase 2 Degreasing and finishing iron phosphating at a temperature of 40° C

Phase 3 Shower with fresh tap water

Phase 4 Shower with demineralised water

Phase 5 Air drying with high pressure air blower

Phase 6 Heat drying in oven at a temperature of 120° C

Phase 7 Automatic electrostatic powder painting for standard colours or larger batches of special colours. Manual electrostatic powder painting for smaller batches of special colours

Phase 8 Curing in oven for 10-12 minutes at a temperature of 170-200° C

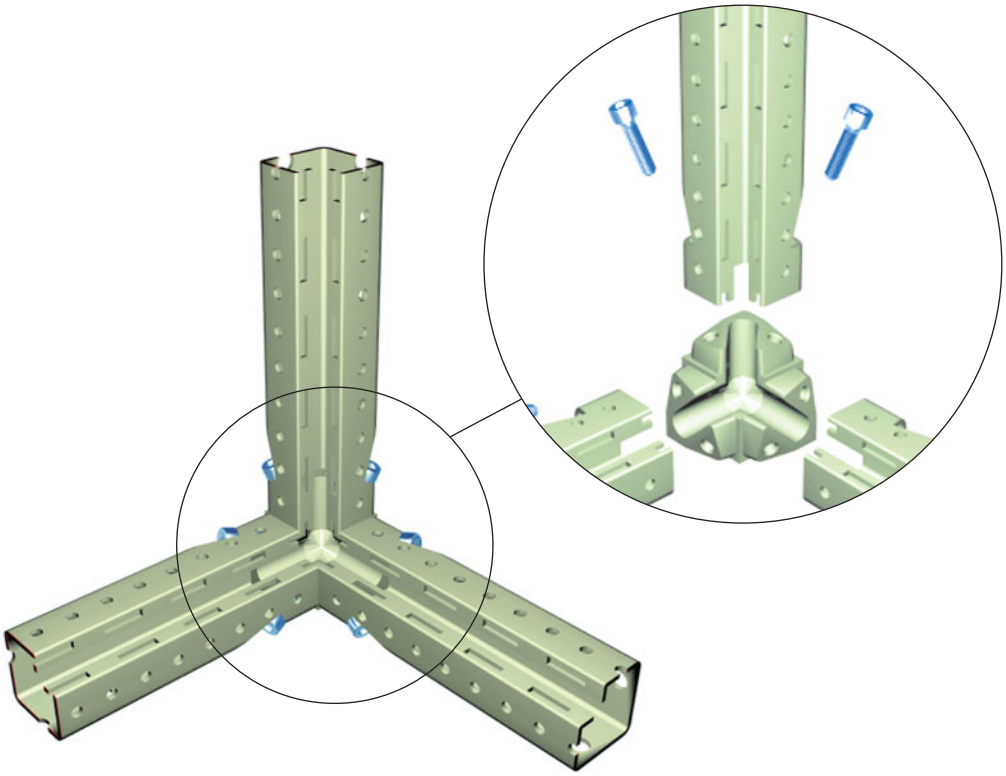
Phase 9 Quality control of random samples as follows.:

- Visual inspection against a master sample using 3 different shades of light.
- Grid cut in order to test that the enamel adhesion exceeds GT 1 acc. to DIN 53 151
- Control of coating thickness
- Control of gloss

3.1 FRAME WORK OPEN TYPE

The enclosure part of The LØGSTRUP MODULAR SYSTEM is a self-supporting sheet steel profile, consisting of framebars type AKA and crossbars type AMA made from 2mm hotgalvanised rolled steel or Aluzinc (mild steel coated with Aluminium and Zinc).
The hotgalvanised parts are coated with powder paint and the aluzinc parts are supplied unpainted.

The 2 mm enclosure profiles coupled with the unique corner jointing system provides a very strong and reliable structure far superior to other modular systems. It is possible to build panels with very heavy equipment and heavy duty busbar systems.



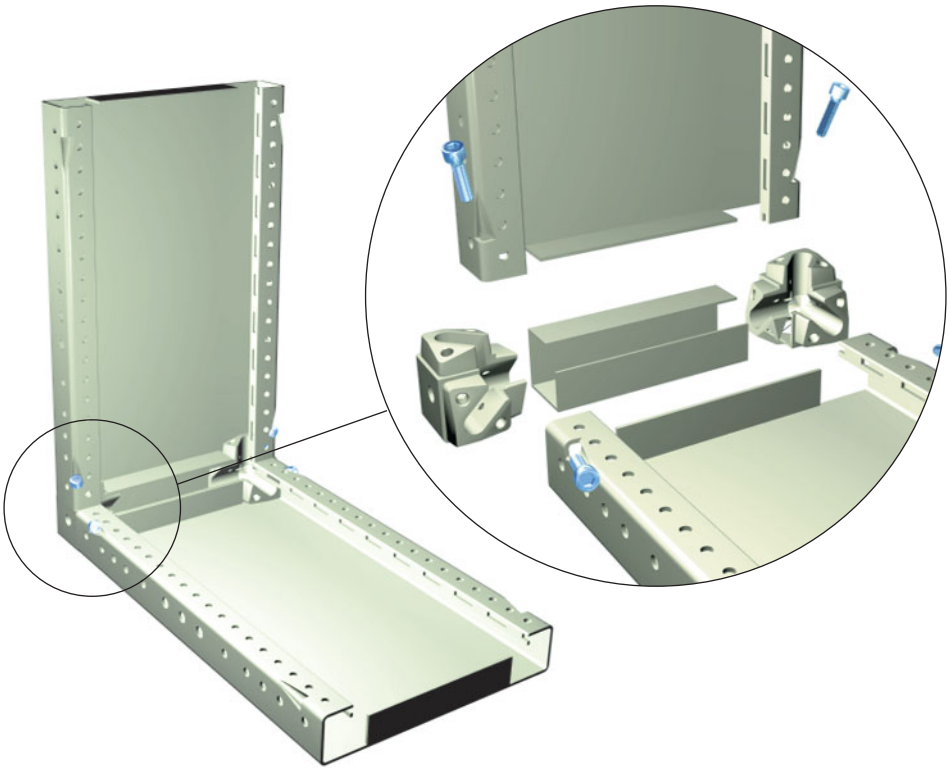
The enclosures parts are equipped with tapped holes and slots making it possible to divide the panel into sections for incoming and outgoing feeders. They are used to fix the internal parts and busbar systems.

The framebars and crossbars are supplied in sizes from 1 to 12 modules
(1 module=190 mm).

The largest single structure has a length of 2340 mm including sidepanels, a height of 2405 mm including base and top panel and a depth of 1010 mm including front and back doors / panels. For longer panels another section of same height and depth is joined by means of section couplings or by bolting the sections together.

3.2 FRAMEWORK CABINET TYPE

The Cabinet type enclosure parts are a combination of the AKA framebars and a sidepanel. It is made from hotgalvanised steel of 1.5 mm thickness for the painted as well as for the unpainted design.



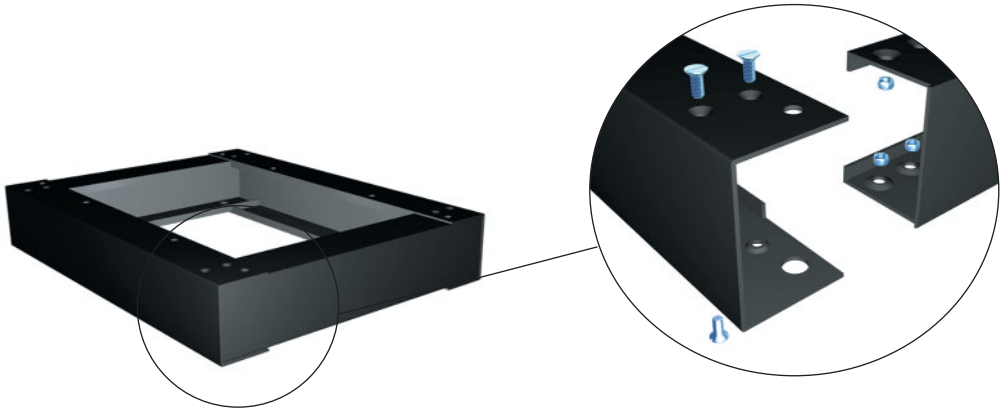
It is equipped with holes and slots like the open type system and can be used with the standard LØGSTRUP parts used in the open type framework.

The Cabinet panels are supplied in sizes from 1 to 12 modules in length and from 1 to 3 modules in depth.

The Cabinet system is mainly meant for smaller panels due to its limitation in strength and sizes.

3.3 BASE ELEMENTS

The base is made from 2.5 mm hot galvanised sheet steel type Dogal 350 YPB-Z 100 MA. It is assembled from 2 length rails and 2 depth rails and it forms a rigid base for heavy panels. All base frames are powder painted Ral 9035 as standard.



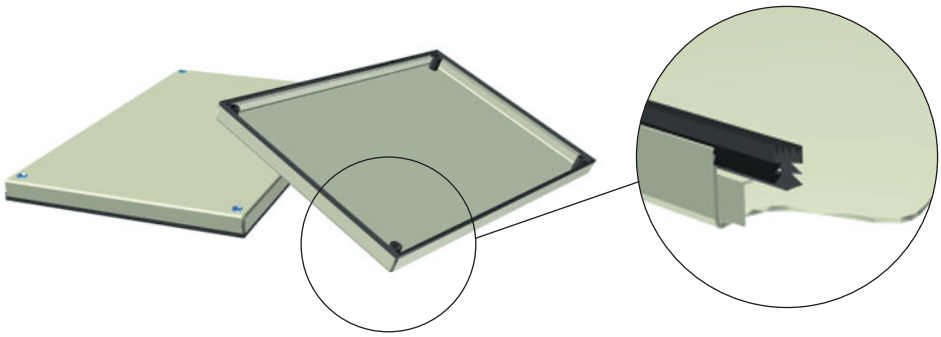
The base elements are supplied in modular lengths from 1- 12 modules, and the largest single base has a length of 2280 mm and a depth of 1010 mm.
Deeper depth rails can be supplied upon request.

3.4 CLADDING

Doors are made from 1.5 or 2 mm sheet steel coated with 60-80 µ Polyester powder paint. They are supplied in modular sizes from 1 module wide and 2 modules high, to 5 modules wide and 10 modules high as standard. Special sizes can be delivered upon request.

The doors can be hinged right or left hand side and can be hinged in the top or in the bottom.

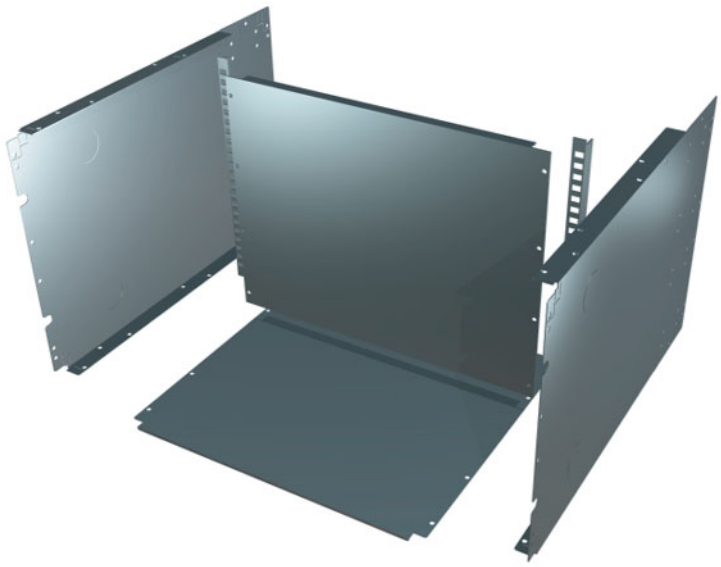
Panels are made from 1.5 mm or 2 mm sheet steel coated with 60-80 µ Polyester powder paint, and they are supplied in modular sizes from 1 module wide and 1 module high, to 5 module wide and 10 modules high as standard. Special sizes can be delivered upon request.



Common for both doors and panels is that they are always equipped with a neoprene rubber sealing gasket, which secures a degree of protection up to IP 54.
This of course only if the panel is built according to Løgstrup guidelines.

3.5 INTERNAL MECHANICAL COMPONENTS

The internal components consist of side plates, various cover plates, partition plates, cover plates for busbar systems, dividing plates, different types of mounting plates and the fixed and moving parts used for the withdrawable type panels.



All components are as standard made from Aluzinc with a thickness of between 1-2 mm depending on their application.

The internal components enable the panel builder to divide the panel into units for incoming/outgoing functional units, busbar compartments and cable compartments, thus making it possible to build panels with internal form of separation acc. to IEC 439 Form 1-4.

3.6 INTERNAL FORM OF SEPARATION

IEC 60439-1: 1999, Annex D, gives the following guidelines for the different separation types.

One or more of the following conditions can be obtained by dividing ASSEMBLIES by means of partitions or barriers (metallic or non-metallic) into separate compartments or enclosed protected spaces:

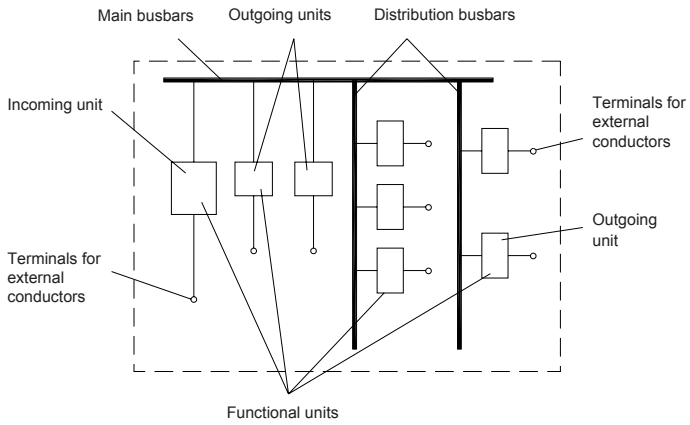
- protection against contact with hazardous parts belonging to the adjacent functional units. The degree of protection shall be at least IPXXB
- Protection against the passage of solid foreign bodies from one unit of an ASSEMBLY to an adjacent unit. The degree of protection shall be at least IP2X.

Unless otherwise stated by the manufacturer, both conditions shall apply.

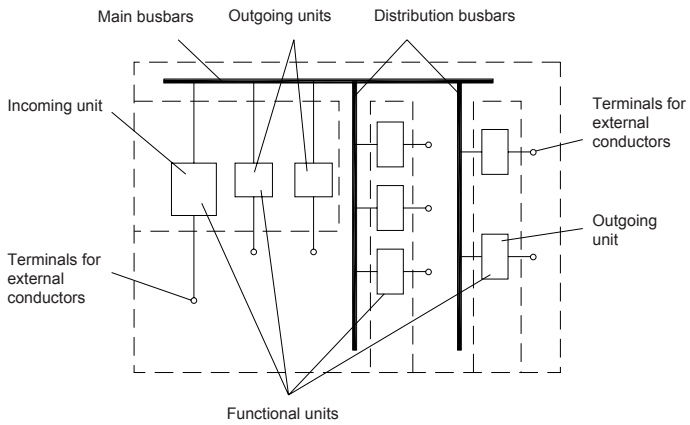
NOTE:
The degree of protection IP2X covers the degree of protection IPXXB

The following are typical forms of separation by partitions:

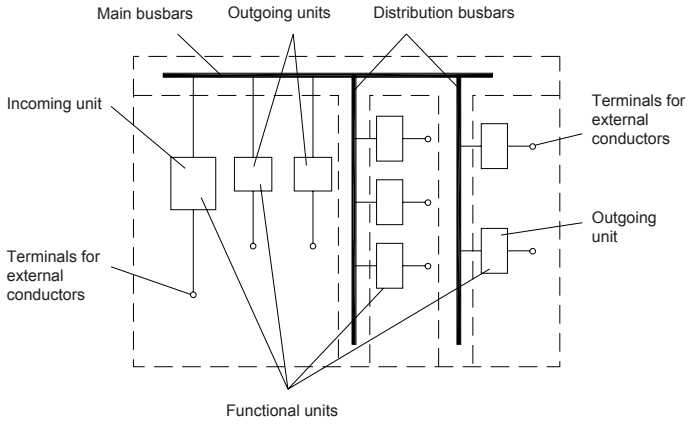
FORM 1 No separation



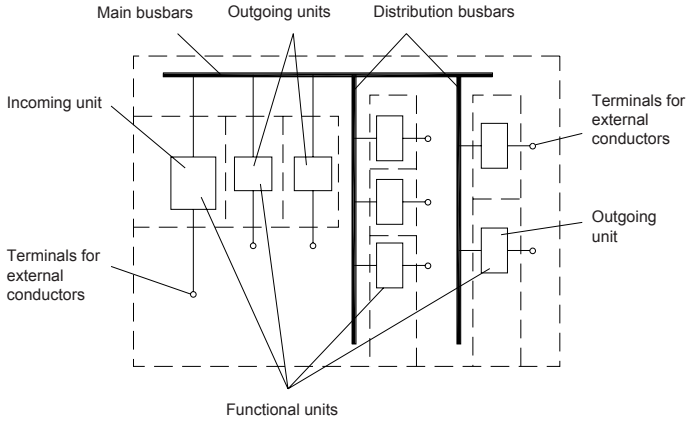
FORM 2A Separation of busbars from the functional units. The terminals for external conductors do not need to be separated from the busbars.



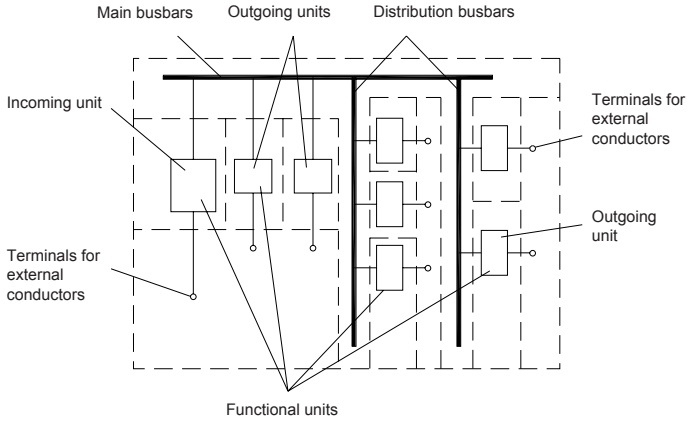
FORM 2B Separation of busbars from the functional units. The terminals for external conductors are separated from the busbars.



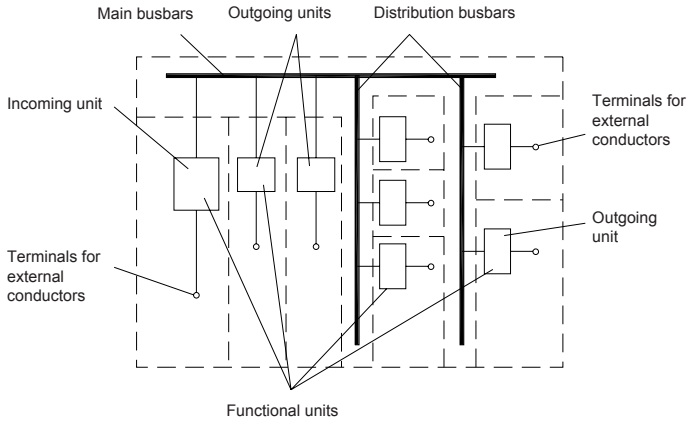
FORM 3A Separation of busbars from the functional units and separation of all functional units from one another. Separation of the terminals for external conductors from the units, but not from each other. The terminals for external conductors do not need to be separated from the busbars.



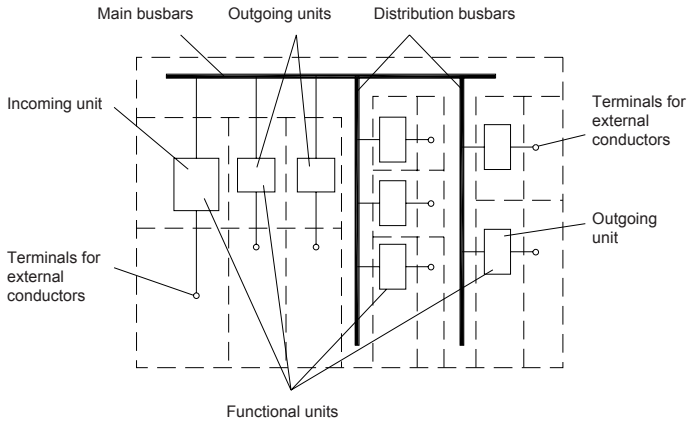
FORM 3B Separation of busbars from the functional units and separation of all functional units from one another. Separation of the terminals for external conductors from the units, but not from each other.The terminals for external conductors are separated from the busbars.



FORM 4A Separation of busbars from the functional units and separation of all functional units from one another, including the terminals for external conductors which are an integral part of the functional unit. Terminals for external conductors are in the same compartment as the associated functional unit.



FORM 4B Separation of busbars from the functional units and separation of all functional units from one another, including the terminals for external conductors which are an integral part of the functional unit. Terminals for external conductors are not in the same compartment as the associated functional unit, but in individual, separate, enclosed protected spaces or compartments



The form of separation and higher degrees of protection shall be subject to an agreement between the manufacturer and the user.

The UK National annex to BS EN 60439-1:1999

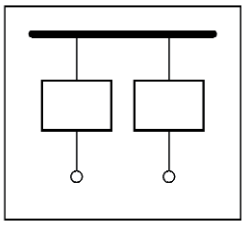
The Internal separation of assemblies by barriers or partitions is specified in 7.7, and is subject to agreement between the manufacturer and the user.

Table NA 1 gives additional information regarding different types of construction, based on typical practice in the United Kingdom. Other types of construction are not precluded, and it is not essential to adopt any of the listed types in order to comply with the requirements of this British Standard. However, in order to achieve agreement between manufacturers and users, it is recommended to adopt any of the listed types of construction.

Table NA.1 Forms of separation

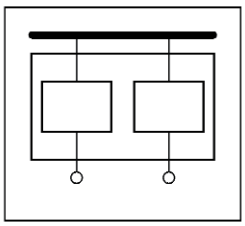
Main criteria	Sub-criteria	Form	Type of construction
No separation		Form 1	
Separation of busbars from the functional units.	Terminals for external conductors not separated from busbars.	Form 2a	
	Terminals for external conductors separated from busbars.	Form 2b	Type 1 Busbar separation is achieved by insulated covering, e.g. sleeving, wrapping or coatings.
			Type 2 Busbar separation is by metallic or non-metallic rigid barriers or partitions.
Separation of busbars from the functional units and separation of all functional units from one another. Separation of the terminals for external conductors from the functional units, but not from each other.	Terminals for external conductors not separated from busbars	Form 3a	
	Terminals for external conductors separated from busbars	Form 3b	Type 1 Busbar separation is achieved by insulated coverings, e.g. sleeving, wrapping or coatings.
			Type 2 Busbar separation is by metallic or non-metallic rigid barriers or partitions.
Separation of busbars from the functional units and separation of all functional units from one another, including the terminals for external conductors which are an integral part of the functional unit.	Terminals for external conductors in same compartment as associated functional unit.	Form 4a	Type 1 Busbar separation is achieved by insulated coverings, e.g. sleeving, wrapping or coatings. Cables may be glanded elsewhere.
			Type 2 Busbar separation is by metallic or non-metallic rigid barriers or partitions. Cables may be glanded elsewhere.
			Type 3 Busbar separation is by metallic or non-metallic rigid barriers or partitions. The termination for each functional unit has its own integral glanding facility.
	Terminals for external conductors not in the same compartment as the associated functional unit, but in individual, separate, enclosed protected spaces or compartments	Form 4b	Type 4 Busbar separation is achieved by insulated coverings, e.g. sleeving, wrapping or coatings. Cables may be glanded elsewhere.
			Type 5 Busbar separation is by metallic or non-metallic rigid barriers or partitions. Terminals may be separated by insulated coverings and glanded in common cabling chamber(s).
			Type 6 All separation requirements are by metallic or non-metallic rigid barriers or partitions.Cables are glanded in common cabling chamber(s).
			Type 7 All separation requirements are by metallic or non-metallic rigid barriers or partitions. The termination for each functional unit has its own integral glanding facility.

Form 1



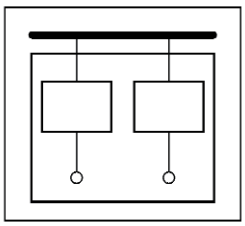
No internal separation

Form 2a



Separation of busbars from the functional units.
Terminals NOT separated from busbars.

Form 2b
Types
1 & 2

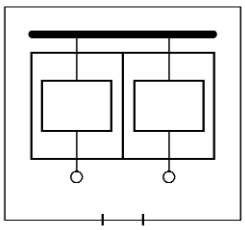


Separation of busbars from the functional units.
Terminals separated from busbars.

Type 1: Busbar separation by insulated coverings e.g sleeving, wrapping or coatings.

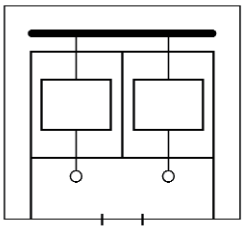
Type 2: Busbar separations by metallic or non metallic rigid barriers or partitions.

Form 3a



Separation of busbars from the functional units.
Separation of functional units from one another.
Separation of terminals from functional units but not from each other.
Terminals NOT separated from busbars

Form 3b
Types
1 & 2

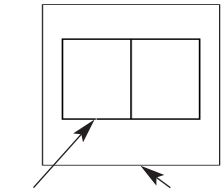


Separation of busbars from the functional units.
Separation of functional units from one another.
Separation of terminals from functional units but not from each other.
Terminals separated from busbars.

Type 1: Busbar separation by insulated coverings e.g sleeving, wrapping or coatings.

Type 2: Busbar separations by metallic or non metallic rigid barriers or partitions.

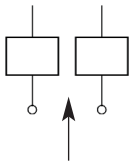
Symbol keys



Internal separation

Enclosure

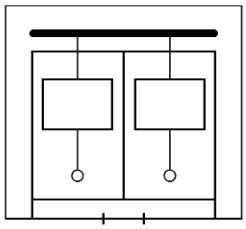
Busbar



Functional units including terminals for external conductors

cable glands

Form 4a
Types
1 & 2

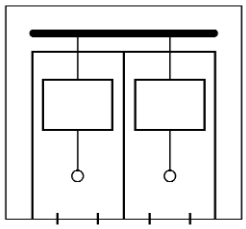


Separation of busbars from the functional units.
Separation of functional units from one another.
Separation of terminals of functional units
Terminals in same compartment as functional unit.

Type 1: Busbar separation by insulated coverings e.g sleeving, wrapping or coatings. Cables glanded elsewhere.

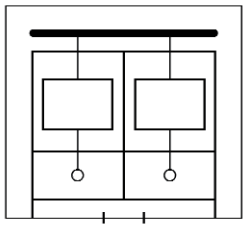
Type 2: Busbar separations by metallic or non metallic rigid barriers or partitions. Cables glanded elsewhere.

Form 4a
Type 3



Type 3: All separation by metallic or non metallic rigid barriers or partitions. The terminals for each functional unit have their own integral glanding facility.

Form 4b
Types
4,5 & 6



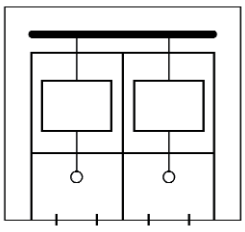
Separation of busbars from the functional units.
Separation of functional units from one another.
Separation of terminals of functional units
Terminals NOT in same compartment as functional unit.

Type 4: Busbar separation by insulated coverings e.g sleeving, wrapping or coatings. Cables glanded elsewhere.

Type 5: Busbar separations by metallic or non metallic rigid barriers or partitions.Terminals separated by insulated coverings. Cables glanded in common cabling chamber.

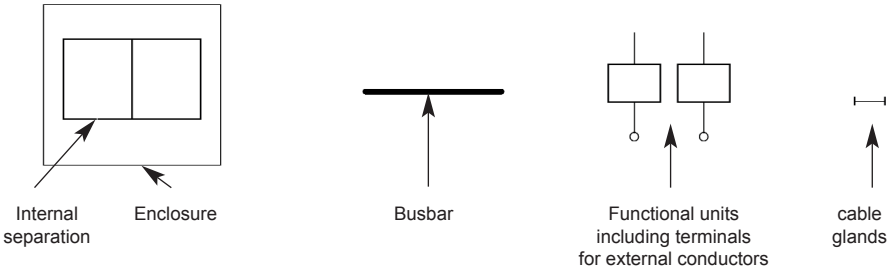
Type 6: All separation by metallic or non metallic rigid barriers or partitions. Cables glanded in common cabling chamber.

Form 4b
Type 7



Type 7: All separation by metallic or non metallic rigid barriers or partitions. The terminals for each functional unit have their own integral glanding facility.

Symbol keys



3.7 DEGREES OF PROTECTION

The LØGSTRUP system has been tested according to the guidelines as described in IEC 60529 and passed the test conditions for the IP 54 protection as laid down in Sub-clause 7.5 (first characteristic numeral) and Sub-clause 8.4 (second characteristic numeral).

The following extract from the Standard gives an idea, but for more detailed information, please see this.

DEGREE OF PROTECTION

First characteristic numeral	*Short description*	*Second characteristic numeral*	*Short description*
0	Non-protected	0	Non-protected
1	Protected against solid objects greater than 50 mm	1	Protected against dripping water
2	Protected against solid objects greater than 12 mm	2	Protected against dripping water when tilted up to 15°
3	Protected against solid objects greater than 2.5 mm	3	Protected against spraying water
4	Protected against solid objects greater than 1 mm	4	Protected against splashing water
5	Dust-protected	5	Protected against water jets
6	Dust-tight	6	Protected against heavy sea

4.1 RATING TABLES

The LØGSTRUP modular busbar system is rated as listed in the Rating Table on this page.

The rating is based on the DIN Standard 43671 and the conditions as described in the Rating Table.

RATING TABLE FOR COPPER BUSBARS ACCORDING TO DIN 43671
(Cu. quality: F 25 HH acc. to DIN 1787, and Edge radius 0.4mm acc. to DIN 1759/1761).

Rating at 40°C ambient temperature (average temperature over 24 hours : 35°C) and maximum busbar temperature 120°C.
The ratings are tested values and the tests are performed in a Form 4 type panel with a degree of protection IP 4X.

Ratings [A]	Cross section [mm]	Area [mm^2]	Rated short-time withstand current [I_{cw}]	Rated peak withstand current [I_{pk}]	Distance between supports	Configuration
250	2x6x6	72	12.5/1 sec	25	380mm	Single Support
400	2x6x12	144	20/1 sec	40	380mm	Single Support
630	2x12x12	288	50/1 sec	110	380mm	Single Support
800	2x12x18	432	50/1 sec	110	380mm	Single Support
1000	2x12x24	576	50/1 sec	110	380mm	Single Support
1250	2x12x30	720	50/1 sec	110	380mm	Single Support
1600	2x12x42	1008	50/1 sec 65/1 sec	110 143	380mm **380mm**	Single Support **Single support +BSR Insert type 11015/16**
2000	2x12x66	1584	50/1 sec 100/1 sec	110 220	380mm **380mm**	Single Support **Double Support**
2500	2x12x90	2160	100/1 sec	220	**380mm**	**Double Support**
3000	2x12x114	2736	100/1 sec	220	**380mm**	**Double Support**
3800	2x12x150	3600	65/3 sec 100/1 sec	143 220	**380mm** **380mm**	**Double Support** **Double Support**
4500	2x12x90x2	4320	100/1 sec 116/0.5 sec	220 275	**380mm** **380mm**	**Double Support** **Double Support**
6300	2x12x114x2	5472	65/3 sec 100/1 sec 107/0.5 sec	143 220 275	**380mm** **380mm** **380mm**	**Double Support** **Double Support** **Double Support**
8500	2x12x114x3	8208	130/1 sec	300	**380mm**	**Double Support**

4.2 BUSBAR SYSTEM

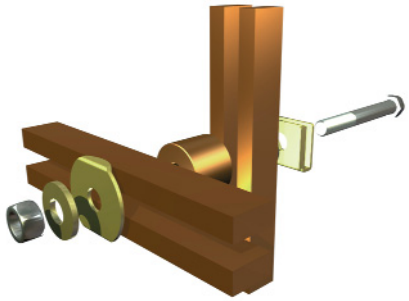
4.2.1 BUSBAR CONFIGURATION

The busbar system is the heart of any Low Voltage Panel, and it provides the electrical connections between the incoming Air Circuit Breaker and the outgoing units. It is thus essential that the busbar system is a reliable tested system meeting the requirements of temperature rise, short circuit and other conditions as described in the International Standards.

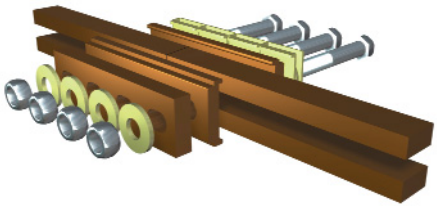
The Løgstrup Busbar System consists of modular components, which allows unlimited variations and ratings. Three, four and five wire systems can be designed with ease, and ratings up to 8500A are standard.

The Busbar System is based on a two bar per phase system, both horizontal and vertical, eliminating time consuming drilling and bending of copper bars. The Busbar joints are by means of bolts and nuts of 8.8 quality in connection with special spring washers type DIN 6796. All bolts are tightened with a torque as described in section 4 page 43 in The Løgstrup Product Catalogue.

The connections between the horizontal and vertical bars are made by a special busbar connector system and it secures a good and stable connection.
The spacer BXC 11649, has been tested to 2000A



When joining two panel sections special fishplate connections are used. They are easy to mount and secure a good and reliable connection.
The fishplate connections range from 800A up to 3000A
(see product catalogue section 4, page 18.0)



The busbar holder components are manufactured from a high grade polymer which provides a high insulation for the copper bar, good mechanical and thermal strength to meet the stress during a short circuit and ability to withstand variations in temperature during service conditions.

The system has been tested by IPH, ASTA and KEMA laboratories, and has passed type tests according to IEC 60439-1, DIN EN 60439-1 (VDE 0600 Teil 500), and BS EN 60439-1.

4.2.2 CONTACT RESISTANCE

The contact interface between two faces of a busbar joint consists of a large number of separate point contacts, the area of which increases as more contact pressure is applied and the peaks are crushed.
There are two main factors which therefore affect the actual interface resistance of the contact surfaces.

1. The condition of the surfaces.
2. The total applied pressure.

4.2.3 CONDITION OF CONTACT SURFACES

The condition of the contact surface of a joint has an important bearing on its efficiency. The surface of the copper should be flat and clean but needs not to be polished. Machining is not usually required. Perfectly flat joint faces are not necessary since very good results can be obtained merely by ensuring that the joint is tight and clean. This is particularly true where extruded copper is used.
Copper like all other common metals, readily develops a very thin surface oxide film even at ordinary temperatures and when exposed to air. Therefore it is important to clean the surface to ensure that the oxide layer is thin enough to be broken as the contact surface peaks deform when the contact pressure is applied. Tinning of the contact surfaces is normally unnecessary, although advantages can be gained in certain circumstances.
If the joint faces are very rough tinning may result in some improvement in efficiency.

4.2.4 EFFECT OF THE PRESSURE ON CONTACT RESISTANCE

It has been proved that contact pressure resistance is dependent more on the total applied pressure than on the area of contact. If the total applied pressure remains constant and the contact area is varied, as is the case of a switch blade moving between spring loaded contacts, the total contact resistance is practically constant.

The greater the applied pressure the lower will be the joint resistance and therefore for high efficiency joints high pressure is usually necessary. This has the advantage that the high pressure helps to prevent deterioration of the joint.

Joint resistance falls rapidly with increasing pressure, but above a pressure of 15 N/mm2 there is little further improvement. Certain precautions must be observed to ensure that the contact pressure is not unduly high, since it is important that the proof stress of the conductor material or its bolts and clamps is not exceeded.
As a bar heats up under load the contact pressure in a joint with steel bolts tends to increase because of the difference in expansion coefficients between copper and steel. It is therefore essential that the initial contact pressure is kept to such a level so that it is not excessive when at operating temperature. If the elastic limit of the bar is exceeded the joint will have a reduced contact pressure when it returns to its cold state due to the joint material having deformed or stretched.

To avoid this A/S Løgstrup-Steel prescribes the use of disc spring washers, (according to DIN Standard 6796), whose spring rating is chosen to maintain a substantial contact pressure under cold and hot working conditions.
The torque settings recommended by A/S Løgstrup-Steel (see Main Catalogue Section 4 page 43), are applicable to high-tensile steel bolts and nuts with unlubricated threads for normal surface finish. In the case of stainless steel bolts, these torque settings may be used, but the threads must be lubricated prior to use.

4.3 THERMAL CONDITIONS

4.3.1 GENERAL REQUIREMENTS FOR ELECTRICAL SWITCHGEAR AND CONTROLGEAR ASSEMBLIES

Electrical switchgear and controlgear assemblies should be designed to meet the electrical, mechanical and thermal conditions that they can be exposed to during normal operating conditions.

4.3.2 TEMPERATURE RISE LIMITS

According to IEC 60439-1 table 2 and hereof related norms as BS EN 60439-1 and DIN EN 60439-1 (DIN VDE 0660 Teil 500), the following temperature limits are laid down.

Ambient temperature:	24 hour average max. 35°C. Shortly 40°C.
Busbars, conductors:	Limited by mechanical strength, permissible effect on equipment and insulation material in contact with the conductor, etc.
Built-in components:	In accordance with relevant requirements for the component, if any.
Terminals for external insulated conductors:	70°K
Manual operating means:	
- of metal:	15°K
-of insulating material:	25°K
Accessible external enclosures and covers:	
-metal surfaces:	30°K
-insulating surfaces:	40°K

4.3.3 BUSBAR TEMPERATURE

The maximum busbar temperature is determined from the thermal properties of the busbar and insulating material, the capability of the busbar joints preventing cold yield and regard to the thermal stress of the busbars on the components in the panel. According to DIN 43671 section 3.2.2 and IEC draft 17 D (Germany) 37. January 1985
"Current carrying capacities of copper busbars", the upper limit temperature can be appointed at 120°C, provided that the busbar connections are carried out with bevel washers and tightened with the correct torque.

4.3.4 BUSBAR TEMPERATURE INSIDE AN ENCLOSURE

The DIN Standard 43671 takes its point of reference in an open type panel, with an ambient temperature of 35°C and a max. busbar temperature of 65°C, when calculating the busbar rating. These limits however are not obtainable inside an enclosed unventilated panel. This is why the LOGSTRUP Busbar System has been designed based on the above standard, but with the conditions inside the panel taken into consideration.

Two temperature limits have been determined :

T1 = ambient temperature measured 1 m in front of the panel and 1 m above the floor (40°C).

T4 = maximum busbar temperature (120°C).

Accordingly there will be a temperature difference of T4-T1 = 120-40 = 80 ° K consisting of two temperature rises t2 and t3.

t2 = the temperature rise of the air surrounding the busbars.

t3 = the temperature difference between the busbar temperature and the air surrounding the busbars.

This gives the following relation : $T1 + t2 + t3 = T4 = 120°C$

The temperature rise of air inside the panel is not only a result of the power loss from the busbars, but also from the other components in the enclosure. It will require a calculation of t2 if the panel is to be dimensioned in the optimum way.

The temperature limits may appear comparatively high, however it must be considered that it is theoretical values at worst, which normally only occur for a short time in standard panels. If it is a question of continuously loaded busbars it is advisable to reduce the temperatures, not because of the busbars but with a view to the built-in components, wires and cables.

4.4 SHORT-CIRCUITS

4.4.1 SHORT CIRCUITS

During a short-circuit in a panel, the busbar system and components are sometimes exposed to very heavy stresses, both thermal as well as dynamic.

This means that the panel builder has to make sure that the panel can withstand the heaviest short-circuit obtainable in the installation and also that the incoming Air Circuit Breaker used in the panel is able to clear the fault.

The short-circuit withstand strength therefore should be verified either by test (TTA), or by extrapolation from similar type tested arrangements. (PTTA)

4.4.2 DYNAMIC STRESS

The Løgstrup Busbar System consists of two parallel busbars per phase. In a short-circuit the busbars are stressed by two forces.

The parallel busbars in one phase will be attracted to one another during the short-circuit, because the current flow is in the same direction at any time. The forces between the phases will try to repel the busbars because of the opposite direction of the current flow, both resulting in damages to busbar supports and busbars.
At the same time the alternating current will tend to make the busbars vibrate, with the possibility of resonance.

Therefore the busbars, the supports and the distance between the supports must be designed and dimensioned to withstand these dynamic forces.

The dynamic withstand capacity is characterised as the Rated Peak Withstand Current Ipk, and it is the peak current which the circuit can withstand satisfactorily under the test conditions, as specified in IEC 60439-1-1999-09 clause 8.2.3.

4.4.3 THERMAL STRESS

The ability of the busbar system to withstand the thermal stress during a short-circuit, consists of three major factors. One is the thermal strength of the busbar supports and the insulating material in contact with the busbars. Another is that the busbar should be able to withstand the temperature rise, without exceeding an end temperature of 200°C (at a temperature of 220°C the busbar will start turning blue) and finally the duration of the short-circuit has a big influence.

The temperature in a busbar system will during a short-circuit rise far beyond the the normal operation temperature. This is why it is essential that the material used for the insulating parts in contact with the busbars is able to withstand the temperature without being damaged or deformed.

The thermal withstand strength is characterised as the Rated Short-Time Withstand Current Icw, and it is the short-time current the circuit can carry without damage under test conditions as specified in IEC 60439-1 clause 8.2.3.

Unless otherwise stated by the manufacturer, the time is 1 second.

4.5 INTRODUCTION TO TYPE-TESTED AND PARTIALLY TYPE-TESTED ASSEMBLIES.

IEC 60439-1-1999-09, DIN EN 60439-1 (DIN VDE 0660 Teil 500) and BS EN 60439-1 is Part 1 of the 439-series of standards and is the main part covering the general requirements for type-tested and partially type-tested assemblies. Parts 2, 3, and 4 of the standards deal with the particular requirements for certain specialised forms of assemblies (see below).

Low-voltage switchgear and controlgear assemblies

-439-1: Specification for type-tested and partially type-tested assemblies.
-439-2: Particular requirements for busbar trunking systems.
-349-3: Particular requirements for assemblies intended to to be installed where unskilled persons have access to their use.
-439-4: Particular requirements for assemblies for construction sites.

4.5.1 THE NEED TO CONFORM TO STANDARDS.

Low-voltage switchgear and controlgear come under the EU Low Voltage Directive, and since January 1st 1997, all new assemblies intended for use within the EU member states must be CE - marked to indicate that they conform with the essential safety requirements of this Directive.

The Directive requires electrical equipment to be safe and constructed in accordance with the principles generally accepted within the member states of the EU as constituting good engineering practice in relation to safety matters. It requires that the electrical equipment (assembly), together with its components, is made in a way to ensure that it can be safely and properly assembled and connected. It also requires that measures are taken to ensure that protection is assured against various hazards which might arise from the electrical equipment or by external influences on it.

Some of the hazards listed by the Directive include:

- Direct and indirect contact with live parts
- Dangerous temperatures, arcs or radiation
- Overloading
- Insulation failures
- Mechanical failures
- Expected environmental conditions
- Non-electrical dangers caused by the assembly

There is, of course, the proviso that an assembly is used in an application for which it was made, and that it is properly installed.

4.5.2 TYPE-TESTED ASSEMBLY (TTA) IEC 60439-1-1999-09 CLAUSE 2.1.1.1

A low-voltage switchgear and controlgear assembly conforming to an established type or system without deviations likely to significantly influence the performance, from the typical assembly verified to be in accordance with this standard.

Notes:

For various reasons, for example transport or production, certain steps of assembly may take place outside the factory of the manufacturer of the TTA. Such an assembly is considered as a TTA provided the assembly is performed in accordance with the manufacturers instructions in such a manner that compliance of the established type or system with this standard is assured, including submission to applicable routine test.

4.5.3 PARTIALLY TYPE-TESTED LOW-VOLTAGE SWITCHGEAR AND CONTROLGEAR ASSEMBLY (PTTA) IEC 60439-1-1999-09 CLAUSE 2.1.1.2

A low-voltage switchgear or controlgear assembly, containing both type-tested and non-type-tested arrangements provided that the latter are derived (e.g. by calculation) from type tested arrangements which have complied with the relevant tests.
(see table section 4.5.4)

4.5.4 LIST OF VERIFICATIONS AND TESTS TO BE PERFORMED ON TTA AND PTTA.

No.	Characteristics to be checked	Subclauses 439-1	TTA	PTTA
1.	Temperature rise limits	8.2.1	Verification of temperature rise by test (type test)	Verification of temperature rise by test or extrapolation from type tested assemblies
2.	Dielectric properties	8.2.2	Verification of dielectric properties by test (type test)	Verification of the dielectric properties by test according to 8.2.2 or 8.3.2 or verification of insulation resistance. According to 8.3.4 (see nos.9)
3.	Short circuit withstand strength	8.2.3	Verification of short circuit withstand strength by test (type test)	Verification of the short circuit withstand strength by test or by extrapolation from similar type tested arrangements
4.	Effectiveness of protective circuit	8.2.4	Verification of the effective connection between exposed conductive parts of the assembly and the protective circuit by inspection or resistance measurement (type test)	Verification of the effective connection between the exposed conductive parts of the assembly and the protective circuit by inspection or by resistance measurement
	Effective connection between exposed parts and the protective circuit	8.2.4.1		
	Short withstand strength of the protective circuit	8.2.4.2	Verification of the shortcircuit withstand strength of the protective circuit by test (type test)	Verification of the short circuit withstand strength of the protective circuit by test or appropriate design and arrangement of the protective conductor
5.	Clearances and creepage distances	8.2.5	Verification of clearances and creepage distances (type test)	Verification clearances and creepage distances
6.	Mechanical operation	8.2.6	Verification of mechanical operation (type test)	Verification of mechanical operation

4.5.4 LIST OF VERIFICATIONS AND TESTS TO BE PERFORMED ON TTA AND PTTA.

No.	Characteristics to be checked	Subclauses 439-1	TTA	PTTA
7.	Degree of protection	8.2.7	Verification of the degree of protection (type test)	Verification of the degree of protection
8.	Wiring, electrical operation	8.3.1	Inspection of the assembly including inspection of wiring and, if necessary, electrical operation test (routine test)	Inspection of the assembly including wiring and, if necessary electrical operation test
9.	Insulation	8.3.2	Dielectric test (routine test)	Dielectric test or verification of insulation resistance according to 8.3.4
10.	Protective measures	8.3.3	Checking of protective measures and of the electrical continuity of the protective circuits (routine test)	Checking of protective measures
11.	Insulation resistance	8.3.4		Verification of insulation resistance unless test according to 8.2.2 or 8.3.2 has been made

4.6 ARCS IN LOW VOLTAGE SWITCHGEAR AND CONTROLGEAR ASSEMBLIES

4.6.1 INTRODUCTION

Arcing faults are the most frequent short-circuit faults in low voltage panels and can cause serious personal injury, extensive material damage and loss of profit.

It is therefore very reasonable when demands are made on the ability of the panel to resist these arcs, but the problem arises when the demands are to be defined and complied with.

One can speak of 3 types of arcs in panels :

1: Primary arcs on unprotected busbars or on the primary side of the short circuit protection of the panel.
2: Primary arcs on busbars protected by short-circuit protection.
3: Secondary arcs in outgoing functional units after the short circuit protection of the unit.

Type 1 arcs will most certainly cause heavy material damages and there is a risk that the enclosure might explode, and persons close to the panel may be severely burnt and hit by flying objects. The duration of the arc is dependent on the high voltage protection and could be between 0.15 - 0.5 sec.

Type 2 arcs will typically last for 50 ms provided that the panel is protected by an Air Circuit Breaker without time lag. This will reduce the damages, but as the rise of pressure takes place within the first few milliseconds, it is still a very serious situation.

Type 3 arcs are the most frequent ones and the release of energy is quite reduced depending of course on the protective equipment. However the problem is that a "peaceful" secondary arc often "jumps" and re-ignites on the line side of the protection device, resulting in a primary arc type 1 or 2.

4.6.2 ARC TESTS

When A/S Løgstrup-Steel started with arc testing back in 1985, there was no valid IEC Standard, why we, as many other manufacturers, used the requirements as described in THE PEHLA RICHTLINIE 4, for high voltage systems.

Today, however there is an IEC Standard 1641, which describes the test and this is equal to The Pehla Richlinie 4.

PEHLA divides the panels in 2 categories depending on the erection site.

Category A - Only accessible for authorised personal.
Category B - Accessible for unauthorised persons.

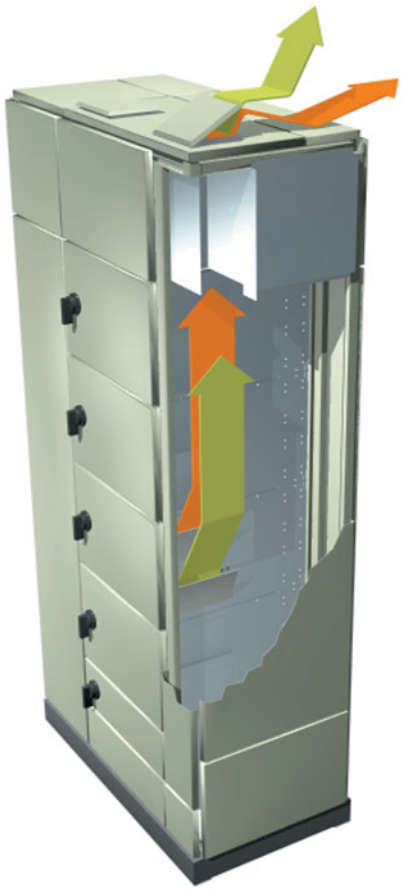
The tests for both categories requires that light cotton fabric in frames of 15 x 15cm, are placed in front of the panel. For Category A at a distance of 30 cm, for Category B 10 cm. These fabric indicators must not catch fire or be damaged during the test. If this happens the test has failed.

4.6.3 THE LØGSTRUP SOLUTION

To try to contain the huge rises in pressure and temperature is almost impossible. It will lead to the weakest part being blown off with fatal consequences as a result. A lot can be done in order to reduce the arcing time and thereby the arc power, but as the pressure builds up within milliseconds, it is important to design the panel to allow the pressure and gases to escape without harming people, and preferably also to avoid serious damages to the panel.

The LØGSTRUP System offers a possibility to provide independent explosion/ventilation ducts accessible from each functional unit, allowing the pressure and gases to escape out through the top of the panel.
This is a much safer solution than allowing the pressure and gases to escape through the door or through the cable compartment.

The solution has been successfully tested at KEMA in Holland.



4.6.4 ARC POWER

Pa	=	n x Ia xUa (mW)
n	=	numbers of arcs
Ia	=	arc current (kA)
Ua	=	arc voltage (kV)

Ia can be calculated as 80-85% of the rated short circuit withstand at 0.4 kV
Ua can be calculated as 40 + (10 x the length of the arc in cm)

Example 1.1
Arc between L1, L2 and L3 (2 arcs) in a 3 x 380 V L.V. panel direct on the main busbar

Length of the arc	=	2 x 3.6 cm
Short circuit level	=	30 kA
Ia (85% of 30 kA)	=	25.5 kA
Ua = 40 + (10 x 2 x 3.6)	=	0.112 kV
Pa = 2 x 25.5 x 0.112	**=**	**5.712 mW**

4.6.5 RISE OF PRESSURE

$$Pr = k \times \frac{Pa \times t}{v} \text{ (Atm)}$$

k	=	fixed figure 1.8 - 2
Pa	=	arc power
t	=	arc time (sec)
v	=	volume in m^3

Example 2.1
Arc in a Logstrup panel size 5.10-630 without compartments

v	=	1.14 m^3
t	=	0.1 sec
Pr	**=**	**$1.8 \times \frac{5.712 \times 0.1}{1.14}$ = + 0.9 atm.**

Example 2.2

t	=	0.3 sec
Pr	**=**	**$1.8 \times \frac{5.712 \times 0.3}{1.14}$ = + 2.705 atm.**

4.5.5 RELIEF FLAPS

f	=	k1 x Pa (m^2)
f	=	area of relief flaps
k1	=	fixed figure = 0.0125 based upon that a rise of pressure of + 0.5 atm is allowed inside the panel. This is considered as normal both for high, medium and low voltage panels.

Example
Pressure relief flap in a Logstrup panel 5.10-630 without compartments and based on the conditions as described in example 1.1

f = 0.0125 x 5.712 = 0.071 m^2

4.7 DESCRIPTION OF THE TYPES OF ELECTRICAL CONNECTIONS OF FUNCTIONAL UNITS - ACCORDING TO IEC 60439-1-1999-09

The types of electrical connections of functional units within ASSEMBLIES or parts of ASSEMBLIES can be denoted by a three letter code.

- Thee first letter denotes the type of electrical connection of the main incoming circuit:
- The second letter denotes the type of electrical connection of the main outgoing circuit:
- The third letter denotes the type of connection of the auxiliary circuits.

The following letters shall be used:

- F for fixed connections
- D for disconnectable connections
- W for withdrawable connections

4.8 FIXED TYPE SWITCHGEAR AND CONTROLGEAR ASSEMBLIES

A fixed type panel is characterised as a panel mounted with components assembled and wired on mounting plates, and connected to the main-circuit by cable or copper connections. The panels can be designed with internal form of separation, Form 1-4 acc. to IEC 60439-1.

In the case of fixed parts, the connections of main-circuits can only be established or broken when the panel is dead. In general, removal and installation of fixed parts requires the use of a tool.
The connection or disconnection of a fixed part normally requires the disconnection of the complete panel or part of it.
In order to prevent unauthorised operation, the switching device may be provided with means to secure it in one or more of its positions.

Note If under certain conditions working on a live panel is allowed, the relevant safety precautions must be respected.

4.9 REMOVABLE & WITHDRAWABLE TYPE SWITCHGEAR AND CONTROLGEAR ASSEMBLIES

4.9.1 REMOVABLE TYPE SWITCHGEAR AND CONTROLGEAR ASSEMBLIES

A removable type panel is characterised as a panel where a part may be removed entirely from the panel and replaced even though the circuit to which it is connected may be live. The removable parts shall be so designed that their electrical equipment can be safely disconnected from or connected to the main-circuit whilst this circuit is live. Minimum clearances and creepage distances as described in IEC 60439-1 clause 7.1.2.1. shall be complied with.
Removable parts shall have a connected position and a removed position.

4.9.2 WITHDRAWABLE TYPE SWITCHGEAR AND CONTROLGEAR ASSEMBLIES

A withdrawable type panel is characterised as a panel where the removable parts can be moved to a position where an isolating distance is established, whilst remaining mechanically attached to the panel. The isolation distance shall comply with IEC 60439-1 clause 7.1.2.2. The withdrawable parts shall be so designed that their electrical equipment can be safely disconnected or connected to the main-circuit whilst this circuit is live.

Note The insulation distance may relate either to the main-circuits or to the main-circuits and the auxiliary circuits.

Withdrawable parts shall have a connected position, a test position (or a test situation) and a disconnected position. They shall be distinctly located in these positions. These positions shall be clearly discernible.

NB. For both types of panels it may require the use of proper tools to connect and disconnect, and it may be necessary to ensure that these operations are not performed under load.

5. TEST & INSPECTION

5.1. VISUAL CONTROL

1. Check that the front view of the panel is in accordance with the front drawing, and that the surface is undamaged.
2. Check that all components mounted in doors or panels are correctly fitted.
3. Check that instruments have right scales, according to specification.
4. Check that markings of components are in accordance with the drawings.
5. Check that wiring is acceptable.
6. Check that the panel has been cleaned.
7. Check that doors and panels are aligned.
8. Check that labelling is in accordance with the specification.
9. Check that parts for the mechanical and electrical assembly of the transport sections are delivered with the panel.
10. Check the degree of protection is in accordance with the specification.
11. Check that the panel number is in accordance with the drawing and that it is fitted on the front, according to the regulations.

5.2. MECHANICAL CONTROL

1. Check that all mechanical operated components work properly.
2. Check interlock systems.
3. Check door functions.
4. Check that all clearance distances between phases and between phase/earth are correct.
5. Check that all creepage distances between phases and between phase/earth are correct.
6. Check that all bolt and screw connections are tightened with the specified torque.
7. Check connections from busbars to components.
8. Check that flexible wiring to components in doors are correctly fitted in protection spiral.
9. Check for loose connections.
10. Check that the arching chutes on Air Circuit Breakers are correctly fitted and undamaged.
11. Check that withdrawable units are moving untroubled, and that position locks and interlock systems are working correctly.
12. Check earth connection to all doors with electrical components.
13. Check that unintended contact with live parts is impossible during normal operation conditions.
14. Check that Internal Form of Separation is in accordance with the specification.
15. Check that degree of protection is in accordance with the specification.

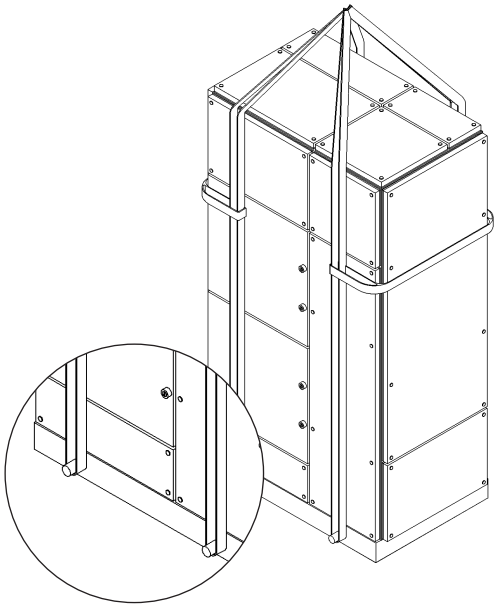
5.3 ELECTRICAL CONTROL

1. Check that the panel complies with the specified standards. (IEC, BS, DIN EN)
2. Check that the panel complies with the local requirements from Public Utility Boards.
3. Check the function of timers, relays, starters, air circuit breakers, contactors, earth fault relays and other electrical units.
4. Check current transformer circuits.
5. Check all settings on short circuit protection relays, overload relays, reverse power relays and other electrical protection devices.
6. Check that all control circuits are functioning in accordance with wiring diagrams or key diagrams.
7. Check that ratings on components, fuses, relays etc. are in accordance with specifications and drawings.
8. Check that dimensions of wires are correct, and make sure that demands for extra insulation is fulfiled.
9. Check selector switches in all positions.

High voltage test to be performed between phases, between phase/earth and phase/neutral. (Do not forget to switch off all electronic and control circuits and to open all outgoing units.) The duration of the test shall be 1 minute and with a voltage of 3 kV.
(Check that the testing apparatus is properly calibrated).

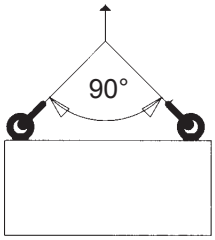
6.1 LIFTING

Logstrup type panels are to be lifted in vertical position, and preferably by using the lifting holes in the base element. The instruction shown below must be followed. Transport sections of 12 modules are recommended as maximum length .
Calculation program for the lifting capacity of round pipes can be supplied upon request.

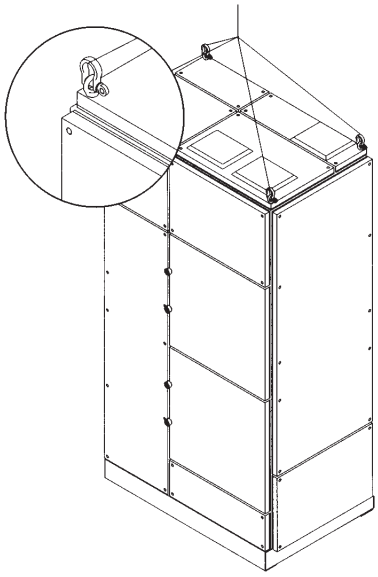


Panels of a total weight up to 200kg may be lifted by means of eye-bolts screwed into the AKA corners. The instruction shown below must be followed.

LIFTING EQUIPMENT
4 lifting eyes, 4 Shackles and 4 bolts are fitted through the top panel into the corners type AHC. The load must be lifted with the cables at an angle of 45° to the top of the panel.
MAXIMUM LOAD 200KG (4 LIFTING EYES)



Maximum Load 200kg for 4 lifting Eyes



7.1 TRANSPORTATION AND STORAGE

Transport sections should not be longer than 12 modules, but very often smaller sections are recommended depending on the access condition on site.

The panels should always be standing upright during transport.

Logstrup panels are designed for indoor use, and must therefore be protected against weather conditions during transport and temporary storage.

For longer transportations Logstrup panels should be transported in seaworthy wooden boxes supported on all sides by means of blocks of polystyrene. The panel should be wrapped in plastic foil and moisture absorbing bags with silicagel should be placed inside the panel in order to avoid condensation.

Transport boxes should have beams in the bottom, for lifting by forklifts.

The transport boxes must be handled carefully and not overturned. If top heavy the box should be labelled " TOP HEAVY EQUIPMENT ".

Upon arrival the transport boxes and the contents should be inspected for damages, and in case of damages the insurance company must be notified immediately.

Please note that the insurance must be covered by the buyer, unless otherwise agreed.

8.1 INSTALLATION

Before the panel is installed the site should be in such a condition that moisture, dust and dirt is minimised.

The floor must be properly aligned, before the panel is installed.

Eventually transport sections must be properly aligned and assembled by means of the section couplings, or by bolting the frames together.

Busbar sections must be connected by fishplates. Remember to use torque wrenches on bolted connections. The torque is stated in the product catalogue (Section 4 page 43).

Internal must be connected (multiplug terminals).

The panel must be fastened to the floor / wall.

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