The UK leads Europe in high-power LV Switchboard Design

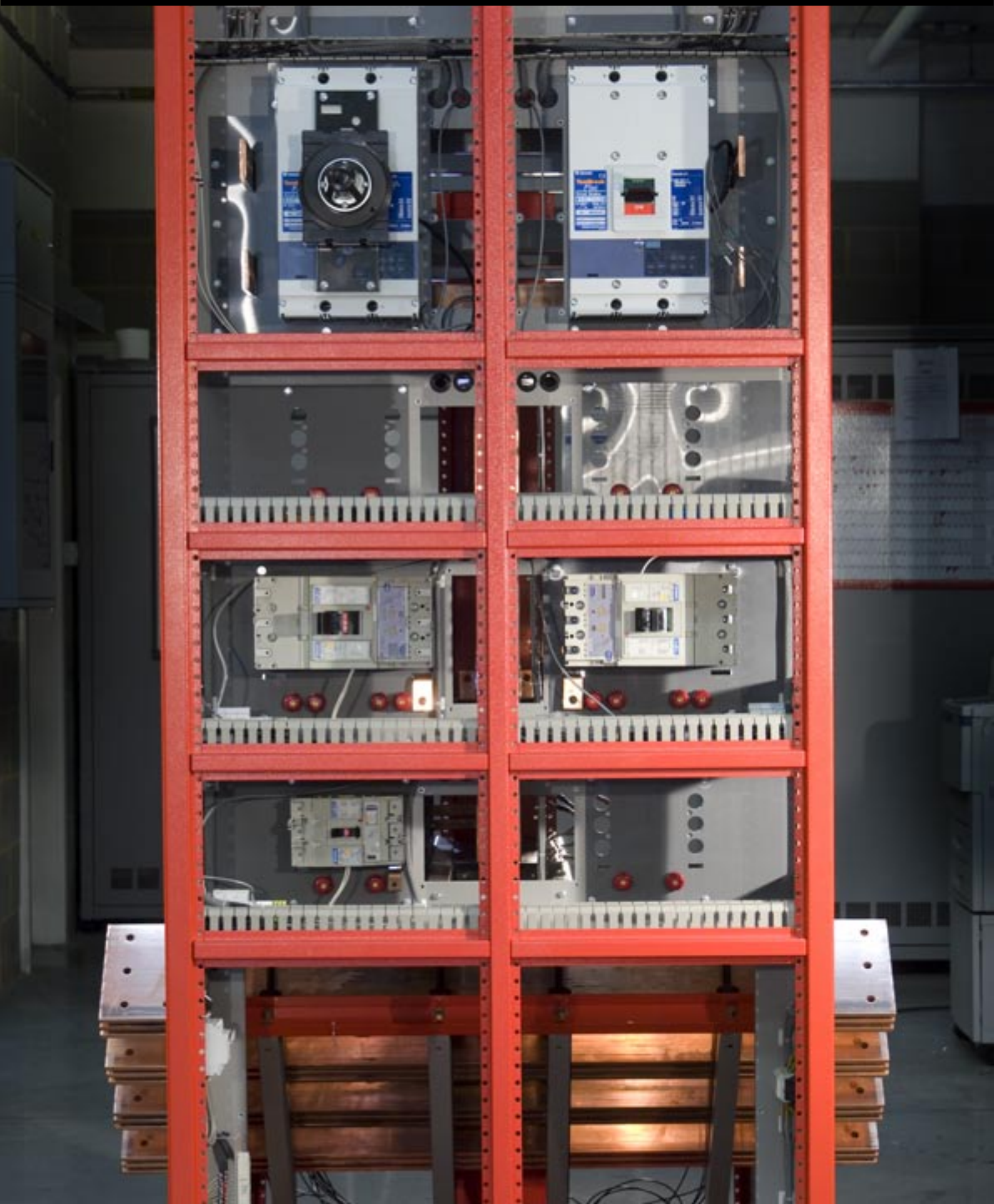
prism power

6300A 100kA LV Naturally Ventillated Switchboard





The UK leads Europe in high-power LV Switchboard Design



6300A 100kA LV Naturally Ventillated Switchboard Design

Background

Whilst most informed opinion in the UK would hold the view that indigenous heavy industry was a thing of the past – dominated as it was by the UK's emporium of world-beating coal, steel and shipbuilding industries – for low-voltage power distribution switchgear the UK has the demand for the highest possible ratings and, remarkably, leads the world in the provision of a technical solution.

That most modern of industries, Information Technology, has spawned ever-larger data processing and storage facilities - commonly referred to as 'data-centres'. The owners and operators can come from a wide range of business segments - from ultra-secure government facilities through banking & finance to collocation and internet mega-centres. These facilities are, amongst other things, where the internet 'lives' and their growth (in computing capacity and power demand) has tended to follow Moore's Law; a doubling every 18 months.

Due to the heavy concentration of Finance related business operations the UK has become the largest market in Europe for such facilities and those facilities are among the highest powered in world – with many designed to draw the same power from the National Grid as a large town of 40,000 consumes, upwards of 30MVA.

Resultant Technological Demand

The critical load demands power at 230V-1ph and that in turn is derived from 400V-3ph uninterruptible power supply systems and emergency generators. At this 400V level power circuit breakers and switches are available in ratings up to 6300A, equating to just over 4.3MVA/3.5MW, and this therefore limits the size of each 'power-cell' within a facility. For example a nominal 30MVA facility would be built up from, say, 8x4MVA or 15x2MVA sections.

These size facilities therefore create the demand for switchboards and power distribution capable of safely handling 6300A with ultimate reliability. This particularly includes operating at 100% load with safe operating temperatures and capable of handling high-energy short-circuit faults in such a manner as does not endanger human life.

Short-Circuit Capacity

Immediately upon applying 6300A switchgear into a power system the electrical designer is faced with the decision of which short-circuit rating the switchgear is to be rated to withstand.

Although the final current to be withstood depends upon the distribution distance it is easy to see from ***Figure 1*** that it is nearly always going to be higher than the UK's traditional 50kA rating and often higher than the next rating higher, 80kA.

A typical 4MVA (5775A) distribution transformer can have an impedance (sub-transient or forward transfer, reactance) as low as 5% with 95kA - so it is easy to foresee that switchboards have to be rated at 100kA, the highest rating anticipated in the BSEN standards.

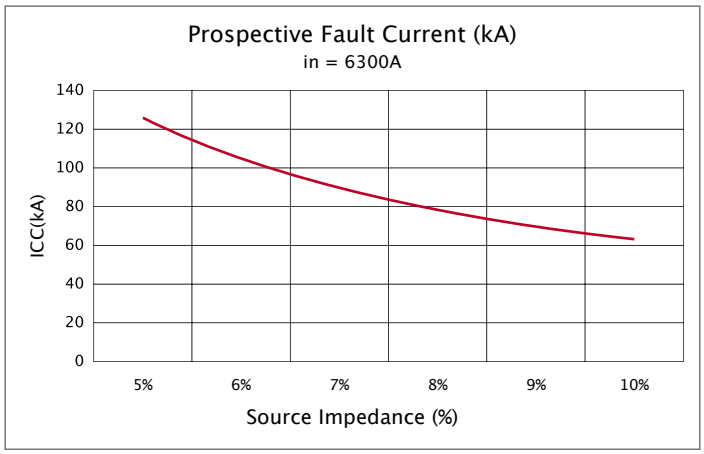


Figure 1

However, it is not just the transformer rating that can dictate the short-circuit capacity since standby generator systems are applied to provide a redundant prime power source to the grid and these generators are often installed in N+1 redundant topology. Take, as an example, a (not uncommon) N+1 system comprising 3x2200kVA sets fitted with 10% sub-transient reactance alternators. The prospective short-circuit current with all three sets running at the generator paralleling switchboard is 95kA.

When the design of a new switchboard line for the latest critical power systems of 6300A rating was considered by Prism engineers it was clear that 100kA was the only sensible rating to be catered for. In addition it was decided to design the new switchboard with Form of Construction 4 Type 7 to achieve the greatest segregation and cable connection safety possible. Form 4 construction is favoured by many UK end-users and consultants although not widely used on mainland Europe where lower standards of segregation and safety (or more stringently restricted personnel access) appears to be acceptable. The critical feature of Form 4.7 construction is the creation within the switchboard of individual chimneys for each switch to allow the ionised gases and particulates emitted upon a fault to exhaust without spreading to all the other components.

The testing and certification of the short-circuit capacity requires a heavy investment in time and money. Indeed there are, no longer, any UK testing facilities that can generate the required 100kA for 1 second applied across the phases from the Main Incomer ACB through the busbar system to the outgoing MCCB and 60kA for 1 second phase-to-phase. After the test the switchboard has to remain functional. The testing of the new Prism Power switchboard has been carried out at the IPH facility in Berlin and in the Schneider Electric facility in Grenoble. The applied 100kA tests the busbar & mountings, ACB/MCCB switches and cabinet structural integrity to the absolute limit of their withstand design. The successful outcome was full certification - included at the end of this paper.

Heat & Forced-Ventilation Fans

As electrical energy flows through the switchboard heat is generated by resistive and inductive losses of all the connected elements. A typical traditional switchboard could have 30 fans fitted to remove that heat. So, from the earliest design specification, the Prism engineers set about to minimise these losses to the point where the forced ventilation fans would no longer be required.

The avoidance of electric fans has several valuable benefits for the user:

- Lower component count leading to higher reliability
- No need for redundant fans (running at low efficiency)
- No need for air-flow switches with associated alarm circuits
- Reduced capacity for switchgear plant-room cooling
- No routine fan inspection maintenance
- No 4-yearly fan replacement cycle (sealed bearing 35,000h service-life)
- Saving 50,000kWh per year per typical switchboard (£6,000/year at £0.12/kWh)

The overall result of the avoidance of forced ventilation fans is lower CapEx, lower OpEx, higher reliability, higher availability and a low-energy 'green' solution.

During the design and testing phase the Prism engineers identified all of the sources of heat generation within the switchboard and took key design decisions to mitigate these. In particular they identified the generation of heat by inductive heating where the busbars came close to (or penetrated) any ferrous steel materials. Apart from generating heat these induced eddy-currents produced noise with a high sound pressure level at 50Hz.

In the solution that was finally certified the heat reduction actions included the following main actions:

- The use of high-quality copper busbar with 99.9% purity (BSEN13601-CW004AC101) with full traceability back to the UK rolling mill
- Wherever applicable use stainless-steel bolts

• Rather than the usual cold-rolled Zintec steel sheet use Grade 304 stainless steel or aluminium anywhere within a radius of 0.5m of the busbar system

Acceptable Heat Rise without Forced Ventilation?

Despite the use of high-purity copper the main heat generated within the switchboard still emanates from the busbar and, to assist in meeting the temperature rise test requirements, the busbar temperature has to be limited unless undue heating of the connected switches occurs. It is for this reason that forced ventilation is applied to traditional switchboards.

Figure 2 shows the traditional busbar topology and highlights the problem of the shielding that the inner bars suffer from. Each bar further from the cooling inlet runs hotter than its prior neighbour. To solve this problem the Prism design engineers came up with a naturally cooled solution (and subsequently patented the design) that reduced the busbar running temperature by a full 10oK and enabled the switchboard to be certified to ASTA & KEMA for full-load temperature test compliance to BSEN 60439.

Figure 3 shows the innovative 45o angling of the bars to form a natural chimney effect, which draws the cooling air in without fan assistance.

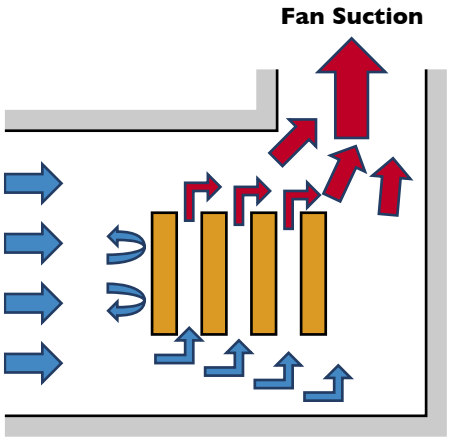


Figure 2: Rear busbar is hottest

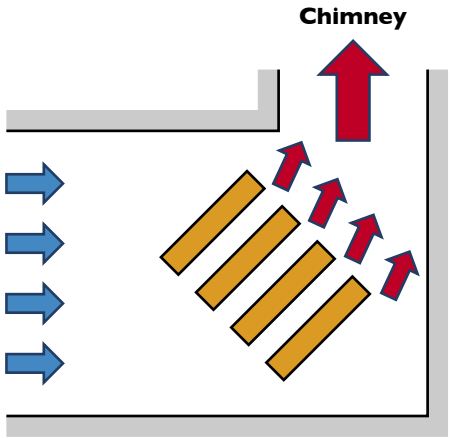


Figure 3: Natural Convection

Prism Power's 6300A 100kA Switchboard

After undertaking extensive research and investing heavily into developing a uniquely engineered and innovative power solution Prism Power designed, constructed, and independently and exhaustively tested (ASTA) the design for the totally self-ventilated 6300A 100kA Switchboard system, receiving independent certification and patented design.

A typical 6300A switchboard could be in the region of 10/20M in length. To accommodate the cooling required to this switchboard there would be a requirement of around 20/30 fans. Generally these fans could be increased to maybe 40/50 fans in the case of the need for redundancy, which would normally be the case in high availability situations e.g. critical infrastructures. Therefore to supply one switchboard there would be a requirement of between 20-50 fans. Each fan would need to be monitored and a maintenance regime would need to be put in place. Along with this the fans would need to be replaced at least 5 times in the life cycle of the switchboard.

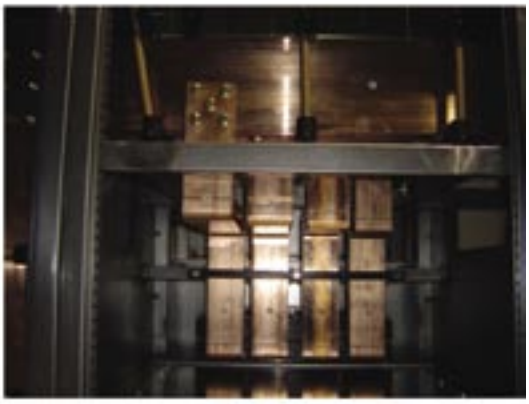
Design & Testing

Because this has never been achieved before there were no records of test where we could consider assigning a rating. Prism Power therefore had to start from scratch with a blank canvas. Our engineers formulated the idea that if they rotated the main busbars then it should allow free air to pass through the busbars effectively creating a cooling tunnel. Our designers then produced various drawings and ideas for the overall design and eventually came up with a best solution to take to test.

Testing facilities for this product are non-existent in the UK, so we sought out an independent test facility in Berlin. A series of tests were carried out which included a temperature rise test, which came out within the BSEN tolerances. This is a huge technological advance in the switchgear manufacturing industry. This now allows 6300A switchgear systems to be built and installed with great efficiency and environmental savings.

The patented design is now considered to be a modern novelty when people are looking to overseas engineers to introduce new technologies.

Prism Power's 6300A 100kA Test Panel



6300A 100kA Switchboard : Independent Testing Video Stills

Temperature Rise Test and Smoke Test : 1 to 6


1


2

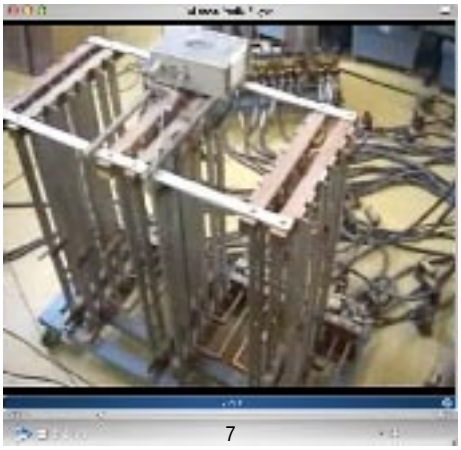

3


4


5


6

1cw 100kA 6000A through AH-60C
Calibration Shots: 8 to 9 :



7

8

Inspection of Supports: 10 to 12 :

9

10

11

12

1st Test: 12 to17 :

13


14


15

16

AR332H Load side support measured at 280mm (11") :

17


18

AR332H Load side support measured at 230mm (9") :

19

Icc 100kA through AR332H :

20

Icc 100kA through XH630PJ :

21

Compartment door opened during test :

2nd Test Icc 100kA through XH630PJ 22 to 26 :

22

23

24

Inspection from the front :

Inspection from the rear :

Breaker removed from compartment : 27 to 28 :

AH60C Phase and Neutral 1cw 60kA 1sec : 29 to 30:

Inspection of supports : 31 to 33 :


31


32

Inspection of AR332H Contacts : 34 to 36 :


33


34


35


36

ASTA

CERTIFICATE OF SELECTED TYPE TESTS

Laboratory Ref. No: 2781.0606.7.102 **Certificate No.** 16683

APPARATUS: 415 V / 690 V / 8 kV (U_e / U_i / U_{imp}), 50 Hz low-voltage switchgear assembly incorporating a three-phase with neutral and protective main busbar system and 6 outgoing circuits

DESIGNATION: Bus coupler section

MANUFACTURER: Prism Power Limited
Watford Business Park
Watford, Herts WD18 8RH
UNITED KINGDOM

TESTED BY: Institut „Prüffeld für elektrische Hochleistungstechnik" GmbH
Landsberger Allee 378 A
12681 Berlin, GERMANY

DATE(S) OF TESTS: 7 May to 11 June 2007

The apparatus, constructed in accordance with the description, drawings and photographs incorporated in this certificate has been subjected to the series of proving tests in accordance with:

IEC 60439-1: 2004-04, Sub-clauses 8.2.1, 8.2.2, 8.2.3.2.3 a), b) & d), 8.2.4.2 and 8.2.5

The results are shown in the record of Proving Tests and the oscillograms attached hereto. The values obtained and the general performance are considered to comply with the above Standard(s) and to justify the ratings assigned by the manufacturer as stated below.

For ratings assigned by the manufacturer and proved by test see Page 1.

The record of Proving Tests applies only to the apparatus tested. The responsibility for conformity of any apparatus having the same designations with that tested rests with the Manufacturer.

This Certificate comprises 62 pages, 7 diagrams, 14 oscillograms, 24 photographs, 9 drawing and no other sheets.

UKAS PRODUCT CERTIFICATION 010

ASTA Observer
H. Glabsch

DIRECTOR

16th August 2007 Date

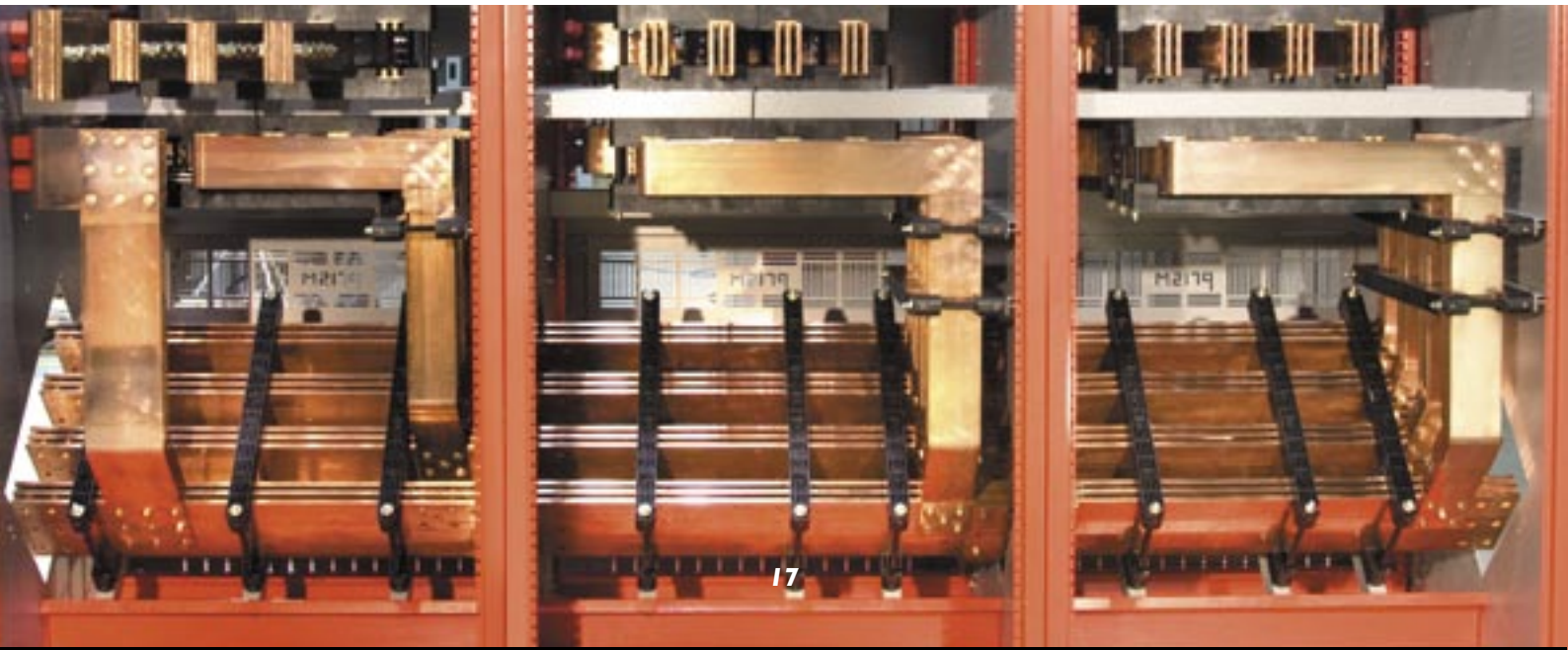
ASTA Independent 100kA Test Certificate

Conclusion

With years of successful experience behind our key personnel and using the latest design technology and equipment, Prism Power has demonstrated commitment to advancing the capabilities of power technology. The new 6300A-100kA switchboard line from Prism is the first in the world to achieve full ASTA & KEMA Certification without the use of forced ventilation fans.

The reliability and safety benefits derived from the Form of Construction type 4.7 coupled with the low-energy naturally-ventilated design and the extensive cost savings and reliability enhancement associated with having no forced ventilation fans produces an exceptional switchgear product that is totally fit-for-purpose in the most critical of applications.

Designed and manufactured in the UK by Prism Power specifically for the largest data-centre market in Europe.



The UK leads Europe in high-power LV Switchboard Design

Prism Power Ltd

Caxton Court
Caxton Way
Watford Business Park
Watford
Hertfordshire
WD18 8RH

t: +44 (0) 1923 296 700
f: +44 (0) 1923 296 707

e: sales@prismpower.co.uk