Prism Power Group

Switchgear • Critical Systems • Intelligent Solutions • Maintenance Services

The UK leads Europe in high-power LV Switchboard Design

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Prism Power Limited delivers high integrity Critical Power Solutions.

This document is one in a series of white papers prepared by Prism Power. If you would like further information, please contact Prism Power on +44 (0)1923 296 700 or visit www.prismpower.co.uk

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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 colocation 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.

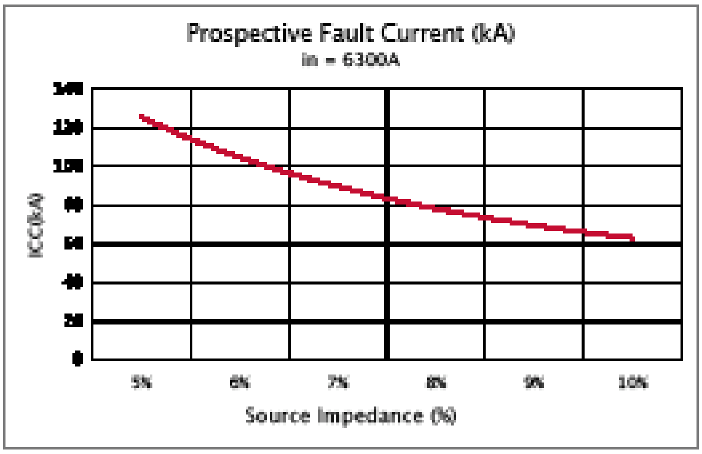
These size facilities therefore create the demand for switchboards and power distribution capable of safely handling 6300A with ultimate reliability. This particularly includes operating at 100% load with safe operating temperatures and capable of handling high-energy short-circuit faults in such a manner 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.



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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 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-CW004A-C101) 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?

DDespite 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 45° angling of the bars to form a natural chimney effect, which draws the cooling air in without fan assistance.

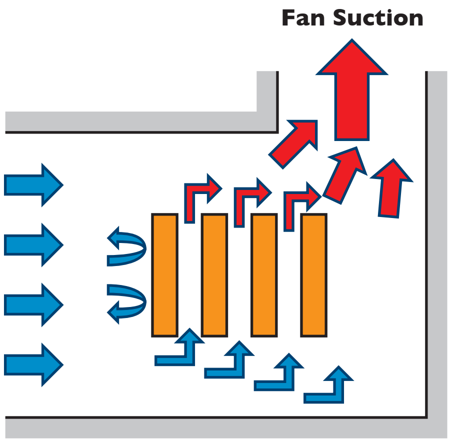

Figure 2: Rear busbar is hottest

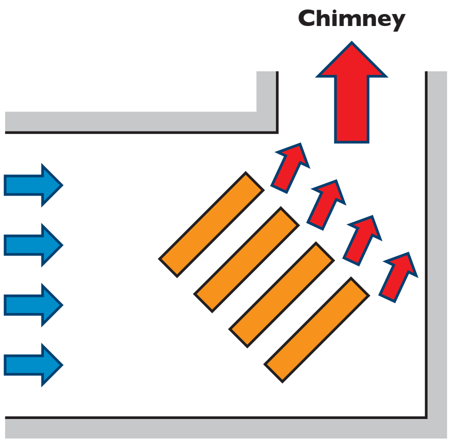

Figure 3: Natural Convection

Conclusion

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.

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

H. Glabsch .... **ASTA Observer H. Glabsch**

C. Kinch-Evans .... **DIRECTOR**

16th August 2007 .... **Date**

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