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Long Distance Cable Temperature Monitoring System for the Olympic City 2008 Beijing

1. The Project

With more than a hundred high voltage orders received in China up to now, Brugg Cables is a reliable supplier for customized cable system solutions. This was the main reason for the Capital's utility *Beijing Electric Power Corporation* to select Brugg Cables in 2005 as supplier for its 220 kV Lianhuachi Project. The realized connection is part of an overall undergrounding project related to the construction works for the Olympic Games in 2008. It consists of a 7 km long 1000 sqmm conductor cable circuit leading through an existing underground cable tunnel (Fig. 1). Commissioning was in June 2006.
Besides the delivery and installation of XLPE power cables and accessories, Brugg Cables equipped the circuit with a long distance Distributed Temperature Monitoring System (DTS). This installation is the first power cable application of the newly developed 10 km range OFDR (Optical Frequency Domain Reflectometry) based system supplied by LIOS Technology, the global leader in the development and supply of state of the art frequency domain based Raman DTS Systems.

Fig. 1: Power cables with attached fibre-optic sensor cables (yellow)

2. The Temperature Monitoring System

DTS units from LIOS have been successfully proven in critical applications like fire detection in road and rail tunnels and special hazard buildings, power cable and transmission line monitoring, in oil & gas exploration for permanent downhole monitoring and for industrial induction furnace surveillance. These systems have been equipped in worldwide projects with more than 1000 permanent installations since 1997.

New Extended Range DTS

LIOS Technology chose this cable project in Beijing to introduce its next generation temperature sensing instrument OTS100P (Fig. 2) to the electrical power industry. This new product series delivers increased performance at an extended measurement range of up to 10 km at a single end multimode fibre offering up to 8 fibre optic channels.

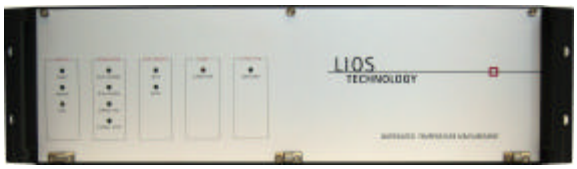

Fig. 2: DTS System OTS100P

Hotspot Sensitive Along The Entire Sensor Length

The applied OFDR principle ensures a temperature survey even over long distances at an attractive spatial resolution, which meets the requirements of the electrical asset operators.
The OFDR technology provides an almost invariant spatial resolution along the entire sensor length, which ensures to detect and accurately quantify hotspots (e.g. at cable joints, cable crossings or wall transitions) at early stages, even at most remote distances of currently up to 10 km. This is different from other measurement principles, e.g. laser pulse principle, which are sensitive to dispersion effects and therefore affected by a broadened spatial resolution at longer measurement distances. In other words: The hot spot sensitivity of pulse type measurements degrade with a function of distance.

System Configuration, DTS Settings

The 220 kV power cable installation at Lianhuachi is characterized by the following system parameters:

Circuit length	7 km
Number of joints	11 per phase
Measurement points	6.144
Spatial resolution	1,5 m
Temperature resolution	1 Kelvin
Measurement cycle	3 min

In addition to the internal DTS hardware calibration and the temperature calibration, both generally carried out at the manufacturer's premises, the adaptation to the fibre optic setup on site is generally required for DTS Systems. This adaptation, also called field calibration, targets the influences of reflections at connectors or at the fibre end as well as losses at splices. A simple online calibration of the fibre optic evaluation unit in the frequency domain is a unique and exclusive feature of OFDR Raman technology. This calibration algorithm can also be performed for a field calibration as it is easy to apply. There it determines the optical disturbances along the fibre and provides an automatic correction to eliminate any fibre influences in the temperature measurement.

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De-Facto Standard For DTS Visualization

The OTS100P evaluation unit is mounted in a 19" cabinet in the substation building. A communication link to the local rack mounted PC as well as to the overall dispatch centre of *Beijing Electric Power Corporation* is ensured by the embedded Ethernet TCP/IP server. In addition, basic temperature alarms for individual zones are reported by switch contacts.

The visualization software CHARON_02 from LIOS Technology provides a database built storage of all measurement and configuration data based on the single-line diagram and other constructional features like wall transitions.

In this case each phase is separated into 12 zones, one for the feeder section and 11 for each cable section between two joints. With CHARON_02, for each phase temperature profiles along the cable route and temperature drifts at critical points can be processed and displayed efficiently (Fig. 3).

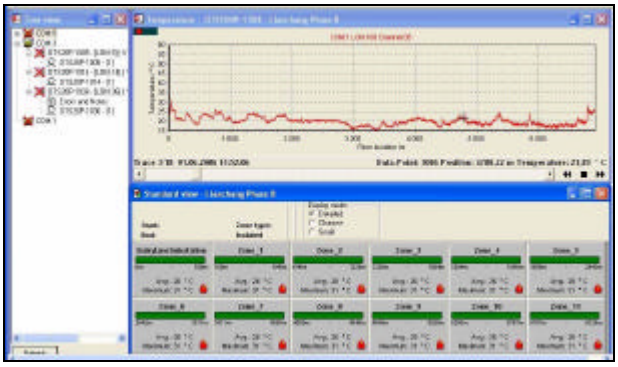

Fig. 3: CHARON_02 screenshot showing temperature profile of one cable phase and its assigned zone display

A schematic view (Fig. 4) showing the cable routing with temperature maximum, average and status indications per zone are at the operator's disposal at real time.

Fig. 4: CHARON_02 Enhanced View screenshot of the cable route

3. Analysis Of Temperature Survey

The screenshot of the temperature survey before initial operation (Fig. 5) reveals already the complexity of the cable route. The average temperature of the tunnel is about 20°C. Lowest temperatures of about 16°C are seen in the area of a railway crossing at an increased laying depth. Several peaks are caused by cable crossings of high and medium voltage cables (mark ❸). The two peaks at the beginning and at the end (marks ❶ and ❹) result from higher temperatures of the fibre optic feeder cables installed in cable ducts till the wall transition (mark ❷). Especially the temperature peak at mark ❹ close to the edge of this installation at 7 km distance is precisely covered, as the spatial resolution setting applies for the entire sensor range. This is a unique feature of the OFDR measurement principle.

The installed DTS system enables the operator to monitor continuously the cable conductor's maximum operating temperature of 90°C in a narrow surrounding with a large amount of other cables and cable crossings. It supports the real time management of possible hotspots along the cable route even under overload conditions and thereby helps to avoid early breakdowns.

Characteristic temperature readings at the base profile, measured at the un-powered circuit	
❶	Sensor cable outside the substation in cable feeder duct
❷	Temperature drop at wall transition of entry into the tunnel
❸	Temperature hotspots at cable crossings in the tunnel
❹	Cable duct at entry to substation

Successful Turnkey Solution

The displayed results show that the chosen features and settings of the DTS System at Lianhuachi are perfectly suited for permanent temperature monitoring of power cables.

This project was the premiere of a successful cooperation between Brugg Cables and LIOS Technology. Both partners are currently developing further projects for power cable monitoring even with integrated dynamic rating systems (RTTR).

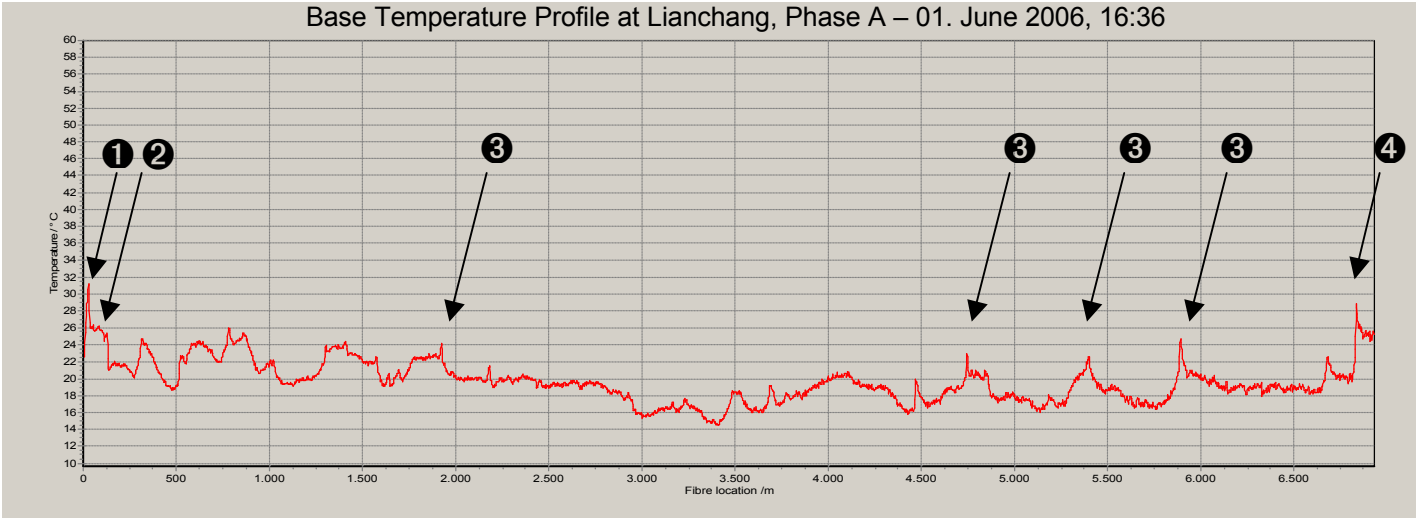

Fig. 5: Base temperature profile at Lianchang Phase A, 7 km length (01.06.2006) – measured by LIOS OTS100P (8 channels)