

14.03.2007 10:25

Carriages for the Railway over the roof of the world

Press release

Railvolution 01/07

Carriages for the railway over the roof of the world

After just over four years of construction through some of the most inhospitable terrain on this planet, on 15 October 2005 the final piece of rail on the 1,142 km Golmud to Lhasa line was lowered into position on the banks of the Lhasa River. The Age of the Train in Tibet dawned on 1 July 2006, when the railway, which reaches a literally breath-taking altitude of 5,072 m at Tanggula on the Tibetan plateau, was inaugurated.

The Chairman's Dream Come True

Although the earliest projects for a railway from Beijing to Lhasa date from 1919, it was not until after China had annexed Tibet (now an autonomous region) in 1950 that Chairman Mao Tse-Tung took steps to convert these into reality. A road over the Tibetan plateau was completed four years later, but the railway ambition was dogged not only by political and economic difficulties, but also by the technological one of building a line over the permafrost that affects the northern half of the high plateau. It was only in 1999 that the Chinese Government authorised construction of the line, which was budgeted at 33 billion Yuan (3.35 billion EUR). The chosen starting point in the north was Golmud, served by an 814 km railway from Xining and Qinghai whose construction started in 1979 and which was inaugurated in May 1984. A new route through the Kunlun mountains was surveyed, final governmental approval came in February 2001 and work began on 29 June that year. The line abounds in superlatives. On account of the permafrost there are no fewer than 283 viaducts and major bridges, totalling 156 km (the longest, over the Qingshuihe River and floodplain is 11.7 km long), the 1,338 m Fenghushan tunnel is the highest in the world, at 4,905 m. Tanggula station is the highest in the world - 5,068 m. The line's highest point, at 5,072 m, sets a world record. The longest tunnel is Yangbajing, 3,345 m. 960 km of route lie above the 4,000 m contour. Measures had to be taken not only to preserve the permafrost (to prevent the track from subsiding in summer) poration, a state-owned Chinese company formed to build rolling stock and equipment for the Chinese market. Out of the 367 vehicles, 49 are de-luxe carriages which will be built by BSP and used for tourist services by RailPartners, which is a subsidiary of TZG Partners and Aman-Resorts Group, but also to reduce heat exchange between air and rock in the tunnels (to reduce the risk of ground distortion). In winter, temperatures on the Roof of the World can plummet to below -40 OC. From Golmud at an altitude of 2,829 m the line climbs steadily at 2 % to the high plateau at Budongqang, the descent to Lhasa at 3,641 m being somewhat more broken. There are 11 staffed stations, five viewpoint platforms, and 18 unstaffed halts. Maximum line speed is 120 km/h on ordinary terrain, 100 km/h over permafrost, no mean achievement considering the severe speed restrictions in place at present on some sections of the Trans-Siberian where the latter traverses permafrost zones. 550 km of the route is built on frozen ground.

Special Carriages For A Special Line

The Chinese Ministry of Railways (MoR) looked to the New World for both locomotives and rolling stock for the newline. General Electric is supplying a large batch of type 1038A Co's (Chinese Railways Class NJ2) diesel-electric Co's (up to 78 could be built), designed specially for high altitude work. Some of the construction is taking place at the Oishuyang Locomotive Factory. In 2005 an order was placed with Bombardier for 367 carriages, these vehicles to be built at the

latter company's Sifang works (BSP of Qingdao) and at the factory of China South Locomotive & Rolling Stock Co. (CSR), a State-owned concern also located in Sifang. BSP is a joint venture between Bombardier, Power Corporation of Canada and China South Locomotive and Rolling Stock Industry (Group) Corporation, a state-owned Chinese company formed to build rolling stock and equipment for the Chinese market. Out of the 367 vehicles, 49 are de-luxe carriages which will be built by BSP and used for tourist services by RailPartners, which is a subsidiary of TZG Partners and Aman-Resorts Group, and the Qing-Zang Railway Company, a Chinese Railways subsidiary. The remainder are various types for ordinary trains to and from Lhasa. Of these Bombardier Sifang Power built 173, while CSR was responsible for the remainder, these including 20 generator cars. While all the standard stock was delivered between December 2005 and May 2006, in readiness for the inauguration, the RailPartners stock will be delivered from early 2008 onwards. TZG Partners is based in Shanghai, and is involved in the real estate, leisure, retail and hotel industries. Aman-Resorts is an international hotel group, based in Singapore.

Stock For Ordinary Services

Through services to Lhasa operate from Beijing (daily), Shanghai, Guangzhou, Chongqing and Chendu (alternate days). Trains are formed of 16-car rakes seating 930 passengers: - There are four "hard class" JV-931-0010-8 carriages. These have 98 seats in 2 + 3 bay configuration, with tables. - Then comes the JV-931-0016-8 restaurant/kitchen car, with 44 seats - ten bays with 4 seats and two with two seats each. The kitchen is equipped with a microwave, three inductive ovens, a fryer, an appliance for steaming food, two fridges, two sinks, and a steriliser. The kitchen also has an exterior door, to facilitate provisioning and the off-loading of rubbish. At the restaurant end of the kitchen there is a bar counter with a refrigerated display cabinet housing alcoholic and non-alcoholic drinks. A trolley service of meals and light refreshments is also provided. - Beyond the restaurant car come the sleepers - most long distance rail journeys in China are of sufficient duration for these to be an essential feature on many trains. First are two "soft class" JV-931-0014-8 cars. These have a capacity of 32 passengers in eight four-berth compartments, each of the latter measuring 2,083 by 1,940 mm. "Soft class" passengers have the luxury of an LCD TV screen in their compartments, with four entertainment channels. Out in the corridor, seven tip-up seats are provided, mounted on the partition wall between the corridor and the compartments. At each end of the corridor there are LED information panels. On-board music broadcasts and public address announcements are made from a staff office in one of the "hard class" sleepers. Smoke and fire detection systems are installed, as is an automatic extinguishing system. - Behind these two vehicles comes one "hard class" JV-931-0012-8 sleeper with a handicapped WC and nine six-berth compartments (total capacity 54 passengers). Reflecting normal Chinese sleeper practice, the compartments do not have doors. - Then come seven standard "hard class" sleepers (JV-931-0011-8), only differing from the previous vehicle in having ten six-berth compartments (60 passengers) and WC cubicles of standard size. The compartments in all eight vehicles measure 2,054 by 1,688 mm, while in "soft class" the individual berths are 2,040 mm long and in "hard class" 1,998 mm. The "hard class" vehicles have nine tip-up seats out in the corridors. In all vehicles the space between the corridor ceiling and the roof forms luggage bins, one for each compartment, and accessed from within the latter, above the doorway. With the exception of the restaurant/kitchen car, all carriages also incorporate a compartment for train staff at one end, while at the other there are two WC cubicles, together with a separate washing area with three washbasins. One of the special features of the rolling stock is the incorporation of a compartment housing oxygen-generating equipment. This produces a flow of enriched air (40 % oxygen) via the HVAC ducts to the saloons to maintain the oxygen content of the saloons between 23 and 25 % at high altitudes. The carriages are also equipped with individual oxygen nozzles which passengers can fit into their noses while seated. The windows of the stock are also specially designed to reduce ingress of ultra-violet rays from the sun - a problem which is accentuated in thin air at high altitudes. Bringing up the rear of each train is a generator car, housing two Cummins QSK45-G6 diesel/LSA50.1 600 V DC generators. These are each rated at 800 kW at sea level, and are fed from a tank with a capacity of 6,000 kg of fuel oil.

The De-Luxe Stock

These vehicles will be used on tourist trains linking various Chinese cities with Lhasa, and are expected to enter service in 2008. Construction, by Bombardier Sifang Power, will be based on the standard carriage underframes and bodyshells, but the interior design and layout will be vastly different to that of the ordinary stock. The 49 vehicles will form three 16-car trains accommodating just 96 passengers each. Each rake will incorporate 12 sleeping cars of five-star level. Each of these vehicles will have just four en-suite compartments, the sleeping arrangements being flexible - a double bed which can be easily transformed into two singles according to booking requirements. Each compartment has a wardrobe, dressing table, minibar and electronic safe, while the bathrooms incorporate a shower, washbasin and WC. The fresh water tanks have sufficient capacity for each passenger to take up to two showers a day. The restaurant/lounge car is marshalled in the centre of the train, and can be used for both the serving of meals and for

entertainment. Also in the centre of the rake are two restaurant/ kitchen cars, these also incorporating a display cabinet for drinks, an office for the train manager, and a staff WC. The total dining capacity of all three cars is 96, sufficient for all passengers to be served at a single sitting. Bringing up the rear of the rake there is a generator car.

Carriage Design

Both standard and de-luxe versions are designed and built to the latest standards, with special consideration being given to factors influencing passenger comfort and to the exacting conditions under which the stock has to run. The carriages are designed for an operating life of 30 years. Bodysell construction is of steel, with the framework designed to withstand an end-on compressive force of 1,200 kN. Standard automatic couplings are fitted, together with buffers. The harsh climatic extremes dictate the use of highly effective thermal insulation. The type SW220K bogies, manufactured by CSR Sifang, are designed for 160 km/h running and have "H"-shaped main frames. The two longitudinal beams are united by two broad cross-beams, on which the brake units of the disc brake are mounted -two disc brakes per wheelset. The disc brakes are fitted with wheelslip/slide protection systems. The brakes are supplied by the Beijing Railway Academy of Science and Technology, and the hand brake wheel is located in an external cabinet at one end of the carriage. The primary suspension consists of a single steel helicoidal spring which works together with a hydraulic damper. The secondary suspension comprises two air pouches. ContiTech Air Spring Systems developed an air suspension system that guarantees a very smooth ride, regardless of the state of the track. The materials incorporated in the air suspension systems - steel, rubber, polyamide and bolts - all had to be tested to ensure they still performed faultlessly at temperatures below -45° C. Many materials become brittle at such low temperatures, so the components had to be chosen carefully to provide an ample safety margin. The wheelsets are guided by a system of horizontal rods. A welded traverse is used to unite the bogies with the bodysell underframe. Yaw dampers are mounted in both horizontal and vertical positions between the main frame of the bogie and the traverse. The cars are fitted with elastomer buffers designed by Kamax of Poland, and manufactured by the joint-venture company Qingdao Kamax Buffer Equipment, of Qingdao. They are designed to withstand heavy end-on impacts, and have also been tried and tested to perform well under extremely low temperatures. The sleeping cars and open saloons have entrance vestibules at both ends, the entrance doors being 930 mm wide and of the single-leaf, plug-sliding, electro-pneumatic type. Passenger-operated push-buttons are provided for selective opening. Anti-trap devices are fitted to ensure trouble-free closing. Flooring throughout the vehicles is of plywood covered by rubberised carpeting, both the plywood and the carpets being extended part-way up the inside walls to prevent the ingress of water. Fire extinguishers are housed in cabinets in each end vestibule. The inter-car gangways have automatically-opening doors. There are no folding seats either in the end vestibules or in the corridors. The WC bowls are of Chinese style in the "hard class" sleepers and open saloons, and of "Western" design in the "soft class" sleeper and in the cubicle for handicapped passengers. The WC cubicles feature anti-slip rubber floors, and wall panels are of fibre-reinforced plastics. All WCs are of vacuum retention type. The washbasin taps are activated using a push button. Interesting is, there are three washbasin side by side. A fold-down table for the changing of babies' nappies are not provided. Most of the electrical equipment is housed in boxes beneath the underframe. The air conditioning units, produced by Shanghai Faiveley, are roofmounted, one per carriage, above the staff compartment. These units draw in fresh air, which is channelled through ducts to the interior, to maintain a temperature of 26 0C in summer and 22 0C in winter. In addition to the air conditioning, each car has concealed wallmounted electric heaters at floor level. Should the air conditioning fail, two of the windows on each side have a hinged flap which can be lowered (though this of course means letting in air with a low oxygen content!). Two windows on each side are also designed for use as emergency exits. The on-board electrical systems are powered by two DC/AC invertors for the 380/220 V AC and 110 V DC circuits. The emergency lighting is sustained by a 110 V DC battery. There are smoke and fire sensors mounted throughout the vehicle. These trigger an alarm in the staff compartment should a fire break out. Text panels, video screens, public address and intercom provide a comprehensive information system for passengers. The staff compartment in the generator car also has a monitor screen which shows on-board system diagnostics.

Unique Design Challenges

While the Chinese Government has been extremely concerned about protecting the ecosystems of the Tibetan plateau during and after construction of the line, the railway has presented some unusual challenges for the carriage designer and builder, as well. These include the lack of oxygen and low barometric pressure at high altitudes, the intense ultra-violet radiation, the climate, and the ecosystems themselves - the frequent sand and snow storms together with the lightning strikes interfering with electrical and communications systems. While responding to these, the manufacturer

also had to take into account vehicle reliability and also bear in mind the need to produce the carriages within the cost framework laid down in the contract. In spite of all these constraints, the first carriage was outshopped just ten months after the contract with the Chinese Ministry for Railways had been signed.

Oxygen Supply

At an altitude of 5,000 m the oxygen content of the air is between 35 and 40 % lower than it is at sea level. This led to a host of special measures being provided for construction teams working on the Roof of the World, and also affects the well-being of train crews and passengers alike. Some press reports state that the carriages used on the line are pressurised. This is not in fact the case, although the windows, doors and gangway connections are tightly sealed (see later). Pressurising would not be very effective on a train providing a stopping service between Golmud and Lhasa, with doors being opened and closed at all the stations. Instead, each carriage features a specially developed system which enriches the interior oxygen content from 21 % to between 23 and 25 %, while reducing the amount of CO₂ by 0.5 % for the duration of the journey. Individual nostril nozzles are provided in boxes under the seats, and these can be used by passengers who suffer from altitude sickness to give themselves a dose of air with 40 % oxygen content. The air supply system is 100 % redundant, so that if any element fails, quality of operation is not affected. Each carriage has its own oxygen generation and air feed system, and these systems are interconnected along the length of the train via the main compressed air pipe. This means that should the system in one vehicle fail to provide sufficient compressed air to the oxygen generating equipment, the system at train level can compensate for this by feeding in compressed air from a different vehicle. How does the system work? Air compressed at between 8 and 10 kPa passes through the membrane of the oxygen generating machine, being transformed into separate flows of nitrogen gas and air enriched at 40 % oxygen. The nitrogen is exhausted out of the train via an outlet pipe beneath the underframe, while the oxygen-enriched air enters the main duct of the HVAC system. It is also fed into the boxes under the seats and sleeping car berths, to be ready there "on tap" as required by passengers.

Sealed Bodysells

The exterior doors, produced by Nan Jing Kang Ni, are tightly-fitting. So are the inter-car gangway connections, a Hübner product. The WC vacuum systems, produced by Ji Nan Hua Teng, are designed to prevent ingress of air. The HVAC systems maintain an interior air pressure which is about 15 Pa higher inside the train than it is outside, by means of air damper regulators on the air intakes and exhausts. Qing Dao Kelin supplied specially designed pressurecompensating windows, with highly efficient sealing. These are mounted by means of screws to the inside of the bodysell.

UV Ray Protection

Excessive exposure to ultra-violet rays can be harmful both to humans and to equipment, and on the Roof of the World the strength of such rays is calculated to be 1.6 times that at sea level. The carriage windows are of laminated design, with a layer of film which filters out 95 % of ultra-violet radiation while still offering passengers an unimpaired view of the landscape. Ultra-violet rays can also accelerate deterioration of materials and equipment. For that reason, the bodysells of the carriages are coated in special paint which offers high resistance to these and also protects against abrasion from flying sand during sandstorms. Similar coatings are applied to vulnerable pieces of exterior-mounted equipment, such as the rubber air springs on the bogies. The inter-car gangways are made of a special fabric designed to resist the effects of both ultra-violet rays and ozone.

Extreme Weather Conditions

These come in all shapes and forms - we have already mentioned sandstorms. In winter, severe frosts, icing-up and heavy snowfall are all commonplace. Thunderstorms occur on average on 82 days each year! All equipment mounted on the exterior of the carriages, and particularly beneath their underframes, is covered to prevent the ingress of sand, water and snow. Specially designed filters inside the intakes of the HVAC system ensure that the fresh air enters without the unwelcome accompaniment of sand, dust, water or snow. To protect the vehicles against lightning strikes, the radio and GPS antennae are fitted with earthing rings, while in the electrical equipment cupboards in each car there are anti-strike features which protect the main power, control, monitoring and communication systems against voltage spikes. At the ends of each car there is also an earthing system which links all the carriages at the same potential and

ensures that the bodyshells are earthed with the bogies and with the ground outside. This is achieved via a current collector mounted on the extremities of the axles, ensuring that any lightning strike on the carriages is earthed, and that all electrical equipment is protected against voltage spikes.

Operating Details

At present four passenger train pairs operate over the line each day, and some freights will also start running in the near future. The seven-platform terminus in Lhasa, architecturally reflecting the Potala Palace on the opposite bank of the river, is situated just east of a three-track depot, of sufficient length to house the three trainsets and nine locomotives that regularly spend the night at the Tibetan capital. The level of infrastructure provision here might appear lavish, but work is soon to start on a 270 km extension to Tibet's second largest city, Xigaze - the first stage in the development of a domestic Tibetan rail network. This line is scheduled for inauguration in 2009 or 2010, and may subsequently be extended into Nepal (Kathmandu). Other lines to Nathu-la on the Sikkim border, and to Dali, on the border with Assam, in India are also being talked about. By European standards, the distances covered by the trains to and from Lhasa, and the journey times, are incredible: -Train T27 is the service to and from Beijing Xi (West), departing daily at 21.30 on day one, calling at Shijiazhuang, Xi'an, Lanzhou, Xining, Golmud and Nagqu, and reaching Lhasa at 20.58 on day three - 47 h 28 for a 4,064 km run. The return working (T28) leaves Lhasa at 08.00 on day one, reaching Beijing at 08.00 on day 3. -Train T22/3 is the 18.18 service from Chengdu. It runs every other day with principal stops at Guangyuan, Baoji, Lanzhou, Xining, Golmud and Nagqu, a journey of 3,360 km realised in 48 h 50, reaching Lhasa at 18.28 on day three. The return working T24/1 sets off at 09.05, reaching Chengdu at 09.55 on day 3. On alternate days the starting point is Chongqing at 19.20, the service is designated Train T222/3 and T224/1, and the distance covered is 3,654 km. Journey time to Lhasa (18.28 on day 3) is 47 h 08; the return working departs at 09.05 and reaches Chongqing at 09.55 on day 3. -Train T164/1656 runs on alternate days from Shanghai (departing at 16.11) reaching Lhasa on day 3 at 19.50, leaving the latter city at 08.32 and arriving in Shanghai at 13.45 on day 3. -Train T264/265 is the alternate day service from Guangzhou, departing at 10.29 and reaching Lhasa at 19.50 on day 3. The return working leaves Lhasa at 08.32 and reaches Guangzhou at 19.37 on day 3. -Trains N917/K917 are "short workings", from Xining (20.07) and Lanzhou (16.45) on alternate days, and are the only trains calling at all stations between Golmud (departing at 07.22 daily) and Lhasa (arriving at 22.30). Departure from Lhasa is at 09.32 and from Golmud at 00.02 daily, Xining being reached at 12.12 and Lanzhou at 15.45 on the second day. Fares, by European standards, are not excessive. A single fare in "hard class" seated accommodation from Beijing to Lhasa (4,064 km) costs 389 Yuan (48.60 USD), in a "hard class" sleeper it rises to 813 Yuan (101.60 USD), and in "soft class" it costs 1,262 Yuan (157.75 USD). Fares for the 1,972 km run from Xining to Lhasa are 226, 523 and 810 Yuan (28.25, 65.38 and 101.25 USD) respectively. Naturally, there was a great deal of foreign interest in the new line once services started up, and with seat reservations being possible up to 10 days in advance, trains were becoming fully booked almost as soon as tickets were made available. A large number of pilgrims are using the trains to visit the spiritual home of their leader, the exiled Dalai Lama. It will soon be possible to make reservations over the internet via organisations such as ChinaHighlights.com, www.china-tripadvisor.com, and www.china-train-ticket.com. Full timetables and further detailed information can be found on www.tibettravel.info/explore-tibet/qinghai-tibet-railway.html. Excursions from Europe are offered by UK operator GW Travel. As for the RailPartners/Chinese Railways "Tangula Express", using the de-luxe stock, this will operate from Beijing to Lhasa and also to Lijiang, and should start up in 2008, but so far no precise dates, timings or fares have been announced.

Mike Bent, Petr Kadeřávek
Jaromír Perník
using Bombardier sources
Photos unless cited
and drawings:
Bombardier

www.hubner-germany.com

info@hubner-germany.com

