In for the long haul

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Customized service for turbochargers on diesel locomotive engines
Historically, diesel locomotives have always provided a focal point for BBC/ABB turbocharger development and applications. In fact, it was in the 1930s that a diesel locomotive and a BBC turbocharger were paired for the first time. In the intervening years ABB has continued to supply turbochargers to the railway market, starting with the VTR series, then the VTC, and now, in keeping with this proud tradition, our tailor-made locomotive turbocharging product, the TPR.

As of today more than 2,000 TPR turbochargers are in long-haul service in the main rail markets, for example in India and China, while Russia has meanwhile also seen the first TPR application on a traction engine. For shunting applications and where smaller power outputs are required, our TPS and A100 turbochargers are also being successfully introduced to this market.

This special edition of charge! looks at the broad range of conditions in which railway markets operate and the demands – highest performance combined with reliability and flexibility – made on all the locomotive equipment. The articles provide an insight into ABB’s state of the art turbocharging technology and how its advantages are being turned into solid benefits for the railway operators. We will visit the four big markets in which diesel locomotives are being built today, and discover the similarities as well as the differences which characterize them. And you can read why, based on their individual experience, rail operators place their trust in the unique technology and dependable long-term behavior offered by ABB turbocharging products and solutions.
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China: Diesel locomotive technology enters a new age

New locomotives for China have to meet high standards in fuel economy, emissions control and power rating.

Text Jason-Rui Liu, Photography DLOCO, QSY, Michael Reinhard

China’s railways entered a new phase of development in 2004 with the adoption of the country’s Mid-to-Long-Term Railway Development Plan, revised in 2008 and updated in 2011 in accordance with China’s 12th Five Year Plan. The intention is for China to increase the total railway network from 91,000 km in 2010 to 120,000 km by 2020. With the implementation of this plan, China continues with its railway fixed asset investment, which sees an estimated average of CNY 600 billion (USD 97 billion*) being invested annually during the 12th Five Year Plan (2011 – 2015).

Development plans for the diesel traction include some new line construction in the west of China, while at the same time some of the existing diesel lines in the country’s eastern regions are being electrified. In total, it is expected that diesel locomotives will operate on around 48,000 km of track up until 2020.

According to the Chinese Railway Corporation (CRC) there are approximately 10,000 diesel locomotives in operation in China, of which about one third are more than 25 years old. Normally, the lifetime of a diesel locomotive is around 25 years, so if CRC wants to keep the number of diesel locomotives at about 9,000 units in the future it will need more than 300 new units per year to replace the old ones, not to forget the 5,000 or so shunting locomotives in industrial operation and running on branch lines.

As the market has developed, CRC has set up new requirements that must be met by all new locomotives that are built. For example, emissions must comply with EPA Tier II limits and fuel consumption must be equal to or lower than that of the latest locomotives built.

* Exchange rate as of August 14, 2014.

Railways in China

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A new high point for long-term cooperation: two new locomotive types are to be equipped with TPR56 turbochargers.

As a market and technology leader, ABB Turbocharging has a long history of cooperation with Chinese diesel locomotive manufacturers. It was around 30 years ago that ABB delivered the first turbocharger for a Chinese railway application; in recent decades, ABB VTC series turbochargers have been widely applied on Chinese designed and built diesel locomotives.

ABB turbochargers have helped China’s locomotives to reduce fuel consumption and increase power density, as well as ensure high efficiency and high reliability. The ABB VTC254 turbocharger has been the standard turbocharging solution for Chinese DF series locomotives for thirty years. More than 3,000 VTC254 units are still running in the field.

Recently, ABB Turbocharging received orders to equip some 100 units of the newly developed HXN3B locomotive as well as for a large batch of first deliveries for HXN5B locomotives, both of which are powered by 4,400 hp diesel engines.

Prior to the orders being placed, the turbocharger series had to pass strict tests and prove the benefits claimed for it, not only on the test engine but also in locomotive field trials for more than one year. The TPR 56-F, as ABB’s tailor-made fixed geometry traction turbocharger, has meanwhile been certified on the HXN3B diesel locomotive, and the TPR 56-FV, featuring Variable Turbine Geometry (VTG) technology, on the HXN5B shunting locomotive, each with two units. Both
The new developed 4,400 hp HXN series diesel locomotives, equipped with ABB turbochargers of type TPR 56, meet perfectly the demands of the market by combining all the development trends: excellent performance, good economic efficiency, environmental friendliness, high applicability, easy maintainability and high reliability.

Within the frame of the new HXN standards, China’s locomotive makers are also developing a smaller locomotive with 3,300 hp that will be equipped with a TPR 61 turbocharger, aimed at smaller shunting locomotives and some branch line units.

In the future, there will be three diesel locomotive platforms:
- 6,000 hp HXN series locomotives with imported technology; here, however, market demand seems to be covered by existing units.
- 4,400 hp HXN series locomotives, just launched on the market and expected to be the main diesel locomotive type in the future.
- 3,300 hp HXN series locomotives, designed to complement the 4,400 hp platform and foreseen for operation on secondary lines.

Chinese locomotive manufacturers in several ongoing development projects involving ABB’s newest turbocharging solutions and products, such as high-pressure single stage turbocharging and Power2®, the company’s two-stage turbocharging technology.

Last but not least, ABB Turbocharging further provides full customer support to China’s railways with a package upgrade solution for the existing diesel locomotive fleet. This helps locomotive operators to reduce their running and maintenance costs, to extend turbocharger service intervals and improve reliability.

On its way of continuous improvement towards new diesel engine technology standards Chinese Railways shall fully rely on ABB’s support in conceptual and practical turbocharging solutions.
Zhong Huaiqing sees turbochargers with Variable Turbine Geometry (VTG) reducing fuel consumption for the HXN5B locomotive by 5%.

China’s railways on track for high performance turbocharging

Zhong Huaiqing explains the key role of turbochargers in the complex engine working conditions in China.

Interview Jason-Rui Liu, Photography QSY

Zhong Huaiqing, how do you see the engine market for locomotives developing in the near future?

In my view, market demand for diesel locomotives in the future will continue to be stable. There are medium- and long-term development plans in the domestic railway market to upgrade, step by step, a population of around 9,000 locomotives by replacing them with new ones which are, more economical, more reliable and more environmentally friendly. With the large scale electrification of China’s main railway artery, we will also see greater demand for medium power locomotives for passenger and freight transportation on secondary lines. In addition, the gradual implementation of the national western region’s development strategy will create some demand for high altitude locomotives.

It is also likely that as the railway transportation system develops, demand for shunting locomotives in the different networks and regions will grow considerably. It is expected that in the next five to ten years more than 1,000 shunting loco-
The interviewee

Zhong Huaiqing is Director of the Technical Design Department at CSR Qishuyan Locomotive Co., Ltd. (CSR QSY), an ABB Turbocharging customer. He has over twenty years of experience in diesel engine and locomotive R&D, in which field he currently also teaches. Zhong Huaiqing has received from the Ministry of Railways and Jiangsu Province an Outstanding Contribution Award for his promotion of scientific and technological advancement.

Motives will be needed for China Railway Corporation (CRC). Moreover, we can expect to see an additional annual demand of 100 shunting locomotives from industrial and local railways as well as for upgrades of their existing fleet of more than 5,000 locomotives.

Where do you see turbocharging playing a part in locomotive engine development, and what do you think are the benefits of turbochargers with VTG?

Turbochargers play a key role in diesel locomotives by increasing the engine’s power and reducing its emissions. An important additional benefit is that ABB is applying its VTG technology to the new turbocharger types.

VTG has major advantages for the newly developed HXN5B locomotives in terms of the operating costs and emissions reduction, and it also optimizes the part-load and high altitude performance. With the help of VTG, fuel consumption for the HXN5B can be reduced by 5% compared with other locomotives.

What is it, in your opinion, that the leading turbocharger manufacturers should focus on in order to meet the future needs of Chinese engine manufacturers, and CSR QSY Plant in particular?

With regard to the HXN5B locomotives, CSR QSY will develop, as we mentioned before, series products like AC transmission passenger train locomotives that will travel at 160 km/h, AC transmission passenger and freight train locomotives traveling at 120 km/h, AC transmission highland diesel locomotives and DMUs (diesel multiple units).

In your opinion, what role will CSR QSY Plant play in China’s railway development?

In the future, locomotive development work will focus mainly on energy conservation and environmental protection, cost-saving and reliability, and the AC drive and product platform.

The long-term development plan of QSY is to focus on energy saving and environmentally friendly locomotives. Growing global environmental awareness has resulted in stricter emissions regulations in the developed countries of Europe and America, while the larger developing countries are also moving positively to put related environment protection rules in place. This puts the onus on us, as diesel locomotive engine builders, to develop more environmentally friendly and energy saving engines with low emissions and low fuel consumption.

Viewing this from the end users’ perspective, priority should be given to new locomotives that ensure high reliability and high economic efficiency.
A shared commitment to excellence

Two-stage turbocharging promises to become the key technology in engine development.

Interview Jason-Rui Liu, Photography DLOCO

An Jun, in which direction do you see China’s locomotive engine market moving in the coming years?

Over the next few years development trends for diesel-electric locomotives at home and abroad will, in my opinion, remain stable and reflect, especially, the increased demand for high-power engines with low fuel consumption and low emissions. The development of diesel-electric locomotives for China’s railways will focus primarily on the issues of AC transmission, economy and emissions.

What role do you see CNR (Dalian) Diesel Engine Co., Ltd. playing in this overall picture?

Our company is committed to maintaining its leading position in the Chinese locomotive engine market and is investing a great deal of effort in the development of new medium- and high-speed, high-power engines. We see this effort as our mission. These engines will provide the power and performance that is so much in demand by the locomotive market, both at home and abroad.

What part can turbocharging play, especially two-stage turbocharging, in this development?

Well, turbocharging is, of course, a core technology in engine development, and the key to improving economy and reducing emissions. With two-stage turbocharging you can achieve high compression ratios, enabling strong Miller cycles to be used for lower engine emissions. This improves operational economy and the high altitude adaptability of the engine.

What do you think should be the main focus of the leading turbocharger manufacturers in order to meet the needs of China’s engine builders in the future, and especially of CNR (Dalian) Diesel Engine Plant?

Our company, like other Chinese engine builders, knows that ABB provides the full range of products and services that end users expect, and we have total trust in ABB’s commitment to continue to offer and improve them. It is this commitment to excellence that makes us confident that ABB will go on being a dependable partner.

The interviewee

An Jun is Vice President at CNR (Dalian) Diesel Engine Co., Ltd., an ABB Turbocharging TPR customer. He has been working at DLOCO for 27 years, mainly in engine research and development. An Jun is CNR’s chief expert in the field of diesel engines. In 2012 he was granted the Outstanding Contribution Award by China’s Society for Internal Combustion Engines.
Currently, locomotive production in Russia stands at 600 units per year. This number is firmly set to go up. The Russian Federation is making a great effort to renew the locomotive fleet and its national rail network.

Text Oleg Zaichikov, Photography Corbis, OJSC RZD, JSC Kolomna Plant
Russia's railway is characterized by one of the largest traction stock fleets in the world (with more than 20,000 locomotives), but also by the high level of its depreciation and an acute need for the stock's modernization and renewal. This makes the market the largest and most attractive in the world, and it has drawn noticeable interest from engineering companies in the USA, Europe and China with a view to related imports and the creation of joint ventures. Billions of US dollars are to be invested in the Commonwealth of Independent States (CIS) countries, with their 1,520 mm broad gauge railway lines, for infrastructure development, replacement of existing rolling stock and the introduction of high-speed traffic.

The Russian Federation is the world's largest country and there are very significant distances both between population centers and between suppliers of raw materials and their intermediate or end customers. Not surprisingly, the railway system is therefore the country's key mode of transportation, with an operational length of over 85,000 kilometers at the end of 2013 according to Russian Railways (RZD).

Rail plays an integral part in freight transportation in Russia, accounting for approximately 43% of the country's overall freight turnover in 2013 (data from the Federal State Statistics Service, Rosstat). The high share of rail in the Russian freight transportation market is driven by the country's geography, the economic importance of commodity production and heavy industry in Russia as well as by the limitations of other transportation networks.

Russian Railways is implementing a massive spending program aimed at modernizing and expanding the national network to meet future traffic needs.
In the years 2018–2020 locomotive procurement should increase to an average of 900 units per year.

allowing the purchase of 453 locomotives, less than 60% of the demand for fleet renewal has been met.

As has already been mentioned, the national railway company RZD operates a fleet of 20,000 locomotives (50% diesel, 50% electric). 70% of the installed base of both diesel and electric units have reached the end of their operating life. The average age of the locomotives is just over 27 years, and RZD has set itself the target of reducing it to about 20 years by 2030. Locomotive production volumes are increasing on a year to year basis, and 600 units were produced last year; however, this is not enough for a full fledged renewal of the locomotive fleet. The government is encouraging private equity to further invest in new rolling stock development and production facilities for rail equipment.

In 2011–2012 the shortage of locomotives in Russia was seen to be one of the key reasons for the rail network’s operational figures worsening, the slowing of freight delivery and the decreasing reliability of rail transport. Despite the fact that in 2011 RZD implemented a record breaking investment program, allowing the purchase of 453 locomotives, less than 60% of the demand for fleet renewal has been met.

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Constructing and upgrading lines

RZD is implementing a massive spending program aimed at modernizing and expanding the national network to meet future traffic needs. Approved by the government in 2008 and covering the period up to 2030, the “Strategy for Developing Rail Transport in the Russian Federation” foresees investments in infrastructure and rolling stock that could reach RUR 13.8 trillion (USD 385 billion*).

Under the program up to 20,700 route km of new lines are to be constructed at a cost of RUR 4.2 trillion (USD 117 billion*); 1,500 km are for high-speed passenger services. A further RUR 3.2 trillion (USD 89 billion*) will be spent on upgrading existing lines, including upgrading passenger routes for higher speeds. To meet freight traffic forecasts,

priority is being given to developing fast transit corridors between Asia and Europe and to building new lines to move Russia’s abundant natural resources.

Already under way is the wholesale modernization of RZD’s locomotive and rolling stock fleet, with investments of more than RUR 3.1 trillion (USD 87 billion*) expected by 2030. Many projects in this field are the result of strategic partnerships between leading foreign companies and their Russian counterparts, boosting business opportunities for international companies keen to serve the country’s rail market.

RZD plans in the long term to increase the purchase of new locomotives by 22% by redirecting some of the investment from rail track electrification and construction. Overall capital expenditure will, however, increase due to rising costs for upgrading and renovating the rolling stock fleet. It is expected that in the years 2014–2020 RZD will purchase 6,158 new locomotives, 22% more than originally planned. The total cost of acquisition is estimated at 743 billion rubles (USD 21 billion*).

In the next three years RZD plans to purchase about 700 to 770 locomotives per year. This means almost full production capability for the domestic related industry. In the years 2018–2020 procurement should increase to an average of 900 units per year.

* Exchange rate as of August 14, 2014.

Railways in Russia

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Oleg Zaichikov graduated as a propulsion engineer at the Naval Academy in St. Petersburg in 1989 and worked as chief engineer in a diesel submarine for several years. He joined ABB Turbocharging in Russia in 2005 as its New Business sales manager. He gained an MBA in 2010. Today he is ABB Turbocharging LBU Manager in Russia.
ABB Turbocharging and Russian diesel engine OEMs are actively working on a number of new engine platforms which will soon be phased in as traction powerpacks.

Capitalizing on several years of close cooperation with local OEMs, ABB Turbocharging now has turbochargers starting commercial operation on shunting locomotives in Russia. The locomotive types foreseen are the TEM14 and TEM18W manufactured by OJSC Sinara Transport Machines and Transmashholding. These two large railway engineering and machine-building holdings include engine OEMs in their portfolios: Sinara works closely with Ural Diesel Motor Works (UDMW), and Transmashholding with JSC Kolomna Plant and Penzadieselmash.

The medium-speed 12 cylinder engine D500 designed by JSC Kolomna Plant is currently undergoing extensive testing with ABB TPR axial turbochargers and there are further plans to install turbochargers with ABB Turbocharging’s Variable Turbine Geometry (VTG) technology on it as well as to extend the platform with 16 and 20 cylinder versions for power generation. This high-power package aims at long-haul applications, whereas medium powers are required for shunting. The D200 engine from Penzadieselmash equipped with ABB A130 or A135 radial turbochargers will cover that power range.

ABB Turbocharging’s single-stage turbocharging system featuring VTG as well as its two-stage concept are currently being adapted to Russian engine platforms. These solutions meet both present day and future requirements in terms of performance, reliability, flexibility and maintenance – parameters on which Russian OEMs and railway operators place special importance as they strive to meet the country’s transportation needs and at the same time comply with stricter emissions standards.
Meeting the Russian railway challenge

Valery Ryzhov sets out the challenges facing the turbocharging system on diesel locomotive engines.

Interview Oleg Zaichikov, Photography JSC Kolomna Plant

Valery Ryzhov, do you see any major changes in the locomotive engine market in the near future?

According to the forecasts of the International Council on Combustion Engines, CIMAC, diesel engines will remain in demand in the locomotive industry, in shipbuilding and on small power plants for a long time on account of the many advantages they offer.

What part do you see JSC Kolomna Plant playing in the future development of Russia’s railways?

It is clear that locomotive and diesel engine development is an important issue for countries which have extensive railway systems with diesel traction carrying large amounts of freight, like the USA, Russia, China and Canada, especially when climate and geographical features make special demands on this mode of transport. As a leader in Russia in the research, development and manufacture of diesel locomotive engines, JSC Kolomna Plant is a key player in this area and we hope that we will retain our position at the forefront of Russian railway development.

What role can turbocharging play in the ongoing development of the locomotive engine?

Increased competition, new customer demands and international standards require engine builders to continually improve their products. The main aim is an improved “workflow” for the diesel engine, and here a vital role is played by the formation of the mixture. The two main ingredients of this mixture are, of course, the fuel supply and air supply, and the turbocharger plays a very important, even the primary role in this.

What should be the focus of the leading turbocharger manufacturers if they are to meet the future demands of Russian engine manufacturers?

It is obvious that flexible control of the fuel injection parameters and air supply is necessary to achieve the promising values being predicted, and which ultimately will lead to the creation of an adaptive engine. Ideally, the turbocharging system should provide the optimal air-fuel ratio in the cylinder for every working mode. This can be achieved, for example, through use of electrical rotor assistance and variable turbine and compressor geometry, with the simultaneous expansion of its working area and increased efficiency for the compressor and turbine stages. I think these very complex challenges should be thoroughly investigated.

The interviewee

Valery Ryzhov graduated from Moscow State Engineering University, Kolomna Branch in 1974 and specialized in Internal Combustion Engines. In 1984 he received his doctor’s degree in technical sciences. Since 1974 he has worked as a senior engineer at the laboratory of automation systems and power engines. For more than 14 years he headed the department of fuel control equipment at JSC Kolomna Plant, becoming Chief Designer there in 2001.
India: Reliability in focus

India: 115,000 km of track over a route of 65,000 km.
Increased passenger numbers and freight transport demands for higher locomotive power; separated freight corridors and passenger high-speed lines. Reliability is imperative for train operation in India.

Text Ashish Khanna, Photography Lalam Mandavkar, DMW, ABB Turbocharging in India, Michael Reinhard
Indian Railways (IR) is an Indian state-owned enterprise, operated by the Government of India through the Ministry of Railways. It operates one of the world’s largest railway networks comprising 115,000 km (71,000 mi) of track over a route of 65,000 km (40,000 mi) and 7,500 stations, according to IR. As of January 2014, it carried over 30 million people daily, roughly half of whom were suburban passengers, adding up to an annual total of over 10 billion passengers. In the 2012–2013 financial year IR had revenues of some INR 1,120 billion (USD 18 billion *), roughly three quarters of it from freight and one quarter from passenger tickets.

* Exchange rate as of August 14, 2014.

Indian Railways runs about 10,000 trains daily. Its rolling stock comprises some 240,000 freight wagons, 60,000 passenger coaches and more than 9,500 locomotives.
ABB Turbocharging in India started with its fuel efficient offerings way back in 1994.

Key topics for further development

IR operates with its nodal agency, the Ministry of Railways, which issues policy frameworks and work guidelines, and controls its production units, e.g. the Diesel Locomotive Works (DLW), Varanasi and Diesel Loco Modernization Works (DMW), Patiala, for diesel locomotives. The Research Development Standardization Organization (RDSO) and Ministry of Railways cooperate in ensuring that all new and upgraded noble parts of the locomotives undergo stringent reliability and durability tests before being approved for serial production at the respective IR production units. IR is one of the very few locomotive manufacturers globally that also exports locomotives to price sensitive countries, mainly in Africa and Southern Asia.

In order to ensure it can fulfill the mission of national transport in India in the long term, IR is focusing on further development in the following areas:

- Reliability of train operations; this is one of the most important tasks and is given great attention. Basically, it involves minimizing unplanned downtime of trains and locomotives as well as professional maintenance and overhauling of rolling stock.

- Increased capacity of the rail network; this is a natural requirement for an economy which is growing steadily. Speed may be the key for passenger transport, and extended haulage for freight transportation. These in turn call for higher locomotive power and longer trains, but also for separated freight corridors and new passenger high-speed lines.

- Fuel economy; one challenge IR is facing is the increasing cost of fuel, which has resulted in diesel locomotives posting the highest running expenses, namely up to USD 2.5 billion per annum.

- Emissions; diesel locomotive emissions are a key topic in the global rail industry and IR is actively working on new technologies to reduce them.

- Exports; the export of diesel locomotives has long been an extended business arm of IR and it is intended to intensify this business over the next decade on account of the improved economies in African and South Asian countries.

Railways in India

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Ashish Khanna became LBU Manager of ABB Turbocharging in India September 1, 2014. He holds an electrical engineering degree from the Indian Institute of Technology, Roorkee, and an MBA with specialization in marketing. He started his career in 1994 as a management trainee at ABB India. Since 1995 Ashish Khanna has worked in various capacities at ABB Turbocharging in India; as end user sales manager, Service Station manager for Delhi, and area manager, following which he was responsible for OEM Sales and headed up the Delhi Turbocharging Service Station.
ABB Turbocharging in the Indian railway market

2,700 ABB turbochargers are reliably powering more than half of all diesel locomotives operating in India. Indian Railways (IR) is now gearing up for the next technology step, with strong support provided by ABB Turbocharging.

ABB Turbocharging in India has been associated with IR for more than 25 years, building a turbocharging relationship which has graduated from ABB being a supplier to its current status of business partner. Through its “In The Country and For The Country” approach, ABB Turbocharging has not only ensured that operations and service are close by but also fulfills the request for local production in India, with five Service Stations strategically located near the respective zonal railways and diesel sheds and with the manufacturing unit located at Vadodara, Gujarat. ABB Turbocharging in India is capable of meeting the current and future demands of IR with a strong foothold of more than 2,700 turbochargers on a fleet of approximately 5,200 diesel locomotives. ABB Turbocharging’s present scope of delivery includes the supply of new turbochargers, remanufacturing of damaged turbochargers, overhauling of turbochargers after a scheduled Time Between Overhaul (TBO) as well as the supply of spares for VTC 304, VTC 214 and VTR 250 turbochargers, technical support and training.

ABB Turbocharging in India started with its fuel efficient offering way back in 1994 when IR decided to adopt new technologies under a policy framework that opened the door to new vendors. An immediate solution was found: VTC 304 turbochargers, which helped IR achieve a 5% improvement in fuel consumption compared with the traditional ALCO 720 turbochargers.

In a next step aimed at enhancing the power output with the existing ALCO engine block, IR looked into the suitability of various new technologies, including high horsepower motors, alternators, a modified engine block, and microprocessor controlled traction controls. This also included a new opportunity in 2002 for ABB Turbocharging in India to

A new WDM3D locomotive with TPR61 turbocharger rolls out of the DMW production facility in Patiala.
A robust, reliable platform

The 2,000th TPR 61-A10 turbocharger rolled out of ABB India’s facilities at Vadodara in May 2014. The TPR 61-A10 is based on the TPR concept, designed to provide a robust, reliable platform for locomotive diesel engines rated up to 3,100/3,300/3,600 hp per turbocharger. The TPR 61 combines highest performance and reliability with fuel economy and environmental compatibility.

Diesel Locomotive Works (DLW) at Varanasi and Diesel Loco Modernization Works (DLMW) at Patiala have been the primary customers for the TPR 61.
USA: Diesel or natural gas?

Dual-fuel diesel/natural gas traction engines are being widely tested, Positive Train Control (PTC) is in the midst of implementation, and introduction of the USA’s Environmental Protection Agency’s (EPA) Tier IV emissions legislation is right around the corner. An update.

In the USA, railroads are divided into smaller regional railroads and the larger, Class I railroads (railroads with at least USD 430 million in operating revenue). Of the 574 US owned railroads, only seven Class Is exist.

The two largest railroads in Canada – Canadian National and Canadian Pacific – and in Mexico – Ferrocarril Mexicano and Kansas City Southern de México – are also considered Class Is, even though they are based outside of the US. The seven US Class Is operate 25,000 locomotives and 261,000 km (162,000 mi) of track, transporting 2.75 trillion ton kms for a mere 2.46 cents per ton km (revenue). These are long-haul, heavy freight trains. In 2012 the average US Class I train weighed 3,458 tons and traveled 1,566 km (at an approximate speed of 35 km/h), yet the heaviest trains can be over 15,000 tons and more than 4 km long. The entirety of the North American network (USA, Canada, and Mexico) nearly doubles the km of road operations and increases the number of locomotives in service to 31,800. (Association of American Railroads statistics 2013.07.09).

There are three major topics that will influence the locomotive industry.

Topic 1: The fuel question. The two largest locomotive manufacturers in the United States: GE Transportation (GE-T) and Electro-Motive Diesel, Inc. (EMD) have both released dual-fuel diesel/natural gas powered locomotives for testing with four Class I railroads: BNSF, CN, CSX, and UP. With LNG (liquefied natural gas) tenders, the locomotives could travel from Chicago to Los Angeles (over 3,000 km) without refueling. These engines have the potential to significantly reduce operating costs since LNG is selling for approximately 20% per kilojoule compared to diesel fuel.

According to an independent engineering consultancy, the UK version of the Powerhaul family provides an 18% fuel saving measured against Class 66 UK locomotives in use today.
Topic 2: Positive Train Control (PTC) is an advanced technology designed to automatically stop or slow a train to prevent train to train collisions, derailments caused by excessive speed, or movement of trains onto sections of track under repair. The US Rail Safety Improvement act of 2008 requires Class I railroads to install PTC on tracks that carry passengers by the end of 2015. So far, the Class I railroads have spent approximately USD 4 billion (of the estimated 8 billion required) to start equipping 100,000 km of track and 20,000 locomotives with these controls.

Topic 3: At the same time, EPA Tier IV will be required for all locomotives manufactured after January 1, 2015. This new emissions standard requires a fourfold reduction in NOx for line haul locomotives, as the following table shows:

<table>
<thead>
<tr>
<th>Engine category</th>
<th>Year</th>
<th>PM*</th>
<th>NOx*</th>
<th>HC*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tier 3 line haul</td>
<td>2012</td>
<td>0.10</td>
<td>5.50</td>
<td>0.30</td>
</tr>
<tr>
<td>Tier 3 switch haul</td>
<td>2011</td>
<td>0.10</td>
<td>5.00</td>
<td>0.60</td>
</tr>
<tr>
<td>Tier 4 line haul</td>
<td>2015</td>
<td>0.03</td>
<td>1.30</td>
<td>0.14</td>
</tr>
<tr>
<td>Tier 4 switch haul</td>
<td>2015</td>
<td>0.03</td>
<td>1.30</td>
<td>0.14</td>
</tr>
</tbody>
</table>

*(g/hp)*

Source: EPA

Both GE-T and EMD have spent millions to develop and redevelop engines to meet these standards without the use of selective catalytic reduction (SCR) and urea to minimize the impact to rail infrastructure. However, engine manufacturer Cummins Inc. has taken the opportunity to introduce a new engine with the use of SCR technology, touting the simpler design, and won a major contract with Siemens for passenger locomotives.

These three major legislative and operational challenges will change the face of the US rail market as locomotives become safer, cleaner and more cost efficient to run.

Class breaking fuel economy

In 2007 UK rail freight company Freightliner Group Ltd. ordered from GE-T a modern powerful, freight locomotive for the UK market. The GE-T Powerhaul was delivered in November 2009. This 129 ton 2,750 kW locomotive, equipped with ABB Turbocharging’s A135 turbochargers, proceeded to set class breaking fuel economy standards.

It was confirmed: In an independent study, engineering consultancy Ricardo UK tested GE-T’s Powerhaul and found that it provided an 18% fuel saving measured against existing Class 66 UK locomotives which are commonly used in the UK today. According to GE-T the UK version of the Powerhaul family generates 13% more horsepower, 32% more starting tractive effort, and 61% more continuous tractive effort than the EMD class 66 fleets.

After watching the Powerhaul’s years of reliable service in Freightliner’s fleet, European rail infrastructure service company Colas Rail has signed up for delivery of ten units. As reported in media like the Railway Gazette, Stephen Haynes, Managing Director of Colas Rail Services, stated that Colas would benefit from “a significant increase in tractive effort”, enabling it to haul heavier trains up steep gradients, which would allow “to serve an expanding portfolio of customers and contracts, delivering the highest levels of service”.

Today, you can find the A100 turbochargers successfully operating on locomotives in the UK, Turkey, Korea and Australia.
ABB Turbocharging in the US railway market

The A135 turbocharger is one of the youngest members of the ABB Turbocharging railway portfolio. It is responsible for boosting USA manufacturer GE-T’s Powerhaul locomotive, which is now operating on three continents.

The A135 radial type turbocharger from ABB – capable of providing boost pressures in excess of 5 bar – has been integral in providing the Powerhaul’s engine with the response and boost pressure necessary to meet the needs of customers around the world. The turbocharger’s life is a hard one. Tunnel operation, for example, can push turbocharger air intake temperatures to above 45 °C and turbine inlet temperatures up to about 700 °C, yet the turbocharger has to run flawlessly for two decades.

In order to ensure that the A135 survives such service, the turbocharger mounting was designed and evaluated under extreme mechanical loads to manage hard coupling shock loads. Compressor wheel cooling was implemented in order to provide reliable service through the most rigorous duty life in heavy haul and switching applications. Today, you can find A100 turbochargers successfully operating on locomotives in the UK, Turkey, Korea and Australia, bringing state of the art turbocharging to locomotives everywhere.

South Korean national operator KORAIL has taken delivery of the locally manufactured Powerhaul after the usual testing phase. In Australia, manufacturing partner UGL Ltd. is also beginning local testing.

The next decade will show which fuel(s) will move the American trains and what technologies will need to be developed to cope with market demand and legislation. ABB Turbocharging is ready to assist any engine solution with its latest turbocharging technology.
Pierre Jacoby, you’ve just returned from China. What was the purpose of your visit?

ABB Turbocharging is qualifying a new turbocharger platform for commercial operation. It is specified on new generations of diesel-electric locomotives from both CNR (Dalian) Diesel Engine Co., Ltd. and CSR Qishuyan Locomotive Co., Ltd. It was an opportunity to review the situation.

Is everything going according to plan?

Yes, we are about to get the product qualified, which is a fine achievement knowing that the Chinese authorities have strict regulations for the safe operation of locomotive engines. Our next step will be to focus on producing the volumes requested; to ramp up production of a newly developed product within a short time is quite a challenge.

Which types of turbocharger are we talking about?

Our TPR 56 turbochargers have been specified on two applications, one with our Variable Turbine Geometry (VTG) option. But more generally I refer to the TPR platform, ABB’s tailor-made product for rail traction applications.

Locomotive engines are subject to constant variations, such as load modulation, but even more specifically ambient conditions.
Interview

Pierre Jacoby, General Manager of the New Business department.
TPR is the backbone of our concept for single-stage turbocharging on heavy-duty rail traction applications, with VTG as a premium option to further enhance engine performance.

What are the features of the TPR platform? Any special options?

The TPR platform offers high performance based on a reliable design with great flexibility. High performance means that all technical characteristics are at a high level: a robust, rigid design with compact dimensions ideal for locomotives, complemented by high pressure ratios, high efficiencies and long operating life. Its reliable design has been proven by the field experience we have gained in India over the last twelve years, with a population in commercial operation that today totals more than 2,000 units. The flexibility aspect is enhanced by the unique Variable Turbine Geometry feature, or VTG for short. It allows precise control of boost pressure to improve the diesel combustion process. This is its first use in China on heavy-duty diesel-electric locomotives.

As you say, VTG is new to China. But ABB Turbocharging has been present for decades in China.

Indeed. We launched our VTC series for rail applications around thirty years ago and it has proven to be a rock solid turbocharging system in the field. Today, there are thousands of them running in China and India, where we have also set up a suitable service structure. So much for history – the VTC series has reached its design limits. In the meantime we have constantly pushed ahead with developments to meet contemporary market needs. This has materialized in a radial turbocharger series for smaller, lower power engines and an axial model for engines of typically more than 4,000 horsepower – V-engines with a twin turbocharger arrangement. And, of course, VTG, a development path we are pursing vigorously.
Were there special requirements in China?

There are special demands on turbocharging systems for rail applications as a whole and they are well illustrated by the requirements in China. Locomotive engines are subject to constant variations, such as load modulation, but even more specifically ambient conditions. The range of variations comes from the obvious fact that locomotives travel around, so they are much more prone to changes in ambient air pressure and temperature than, say, marine or stationary engines. And in China, these can be extreme.

As with all our customers, the railways’ investments have to be worthwhile.

How extreme?

Our turbochargers have to ensure engines can operate at full power in temperatures as high as 50 °C in summer and as low as –50 °C in winter. And this can be combined with altitude variations from sea level up to 2,500 m with engines at full power, or even 5,000 m high with the engine de-rated. These are no easy tasks, and then there are tunnels with their high temperatures and limited air supply as well as new, stricter emissions regulations. But whatever the circumstances, TPR is the backbone of our concept for single-stage turbocharging on heavy-duty rail traction applications, with VTG as a premium option to further enhance engine performance – as it leads to a saving of up to 2% on fuel costs in a typical heavy haul commercial rail application.

You have given a technical overview of the offerings in rail traction. What are the economic needs that ABB Turbocharging has to address?

As with all our customers, the railways’ investments have to be worthwhile. Economic viability is a central aspect of our offering. Quite rightly, locomotive operators want good, reliable products at competitive prices that raise their productivity. Railway companies are focusing more and more on the Total Cost of Ownership (TCO) as their yardstick. This translates into challenges for both, locomotive OEMs and, in turn, ABB Turbocharging. For the turbocharger, it comes down to the right balance between performance, reliability and flexibility – the major features of the TPR platform we discussed already – but also the proximity of a capable service network.

TPR turbocharger: Benefits at a glance

- High performance, high reliability product, tailored to heavy-duty rail traction applications.
- Unique VTG feature that provides improved engine response and a fuel saving of up to 2%.
- Versatile turbocharging for fuel flexibility (diesel to gas and vice-versa).
- Proven turbocharger platform to cover both current and future market demands
- Modular design to facilitate ABB Turbocharging’s Unit Exchange maintenance concept.
How does economic viability translate for turbochargers in the field?

In measures to reduce costs. We improved the ease-of-service of our turbochargers but also significantly reduced the scope of maintenance work that needs to be carried out. Their Time Between Overhaul (TBO), that used to be between two and three years is now four to six years, depending on the operating profile of the turbocharger. These are major benefits for operators who can then achieve a better TCO. Another common practice is extending the service life of a fleet of, say, 12 to 15 year old locomotives by refurbishing them to the latest performance standards.

You just mentioned refurbishment – to keep the existing fleets fit?

Exactly, “fit” is actually quite well suited here. Refurbishment provides the possibility of introducing more advanced, cost saving technology into an existing fleet, aiming once more at optimizing TCO. It can involve the use of gas instead of diesel fuel, reducing emissions by changing components or simply the request for improved reliability. Upgrades might also be motivated both by emission regulations and the fact that rail is in competition with other modes of transport, while its equipment has a longer effective lifetime. It needs to take measures to stay attractive.

How does ABB Turbocharging go about covering service and maintenance needs in such large countries as Russia, China and India?

A characteristic of railways is that trains usually operate locally – it is essentially a local business when compared to the marine markets in which ABB Turbocharging is also present. With railways we typically have a large population of similar turbochargers in a relatively limited region and have adapted our service concept to that aspect. For example, our Unit Exchange concept is highly appropriate to this situation. Exchanging a turbocharger rather than servicing it on the engine guarantees minimal disruption to operating schedules. We can then work on the turbochargers at our Service Stations, even in large countries like Russia. After all, ABB Turbocharging is known for its worldwide customer proximity.

What is the potential of two-stage turbocharging in rail traction applications?

Stricter emissions regulations, whether EPA, EURO or GOST, and demands for higher power density and broader locomotive operating profiles imply higher turbocharger pressure ratios. They also result in more complex charging systems, especially when Exhaust Gas Recirculation (EGR) is the chosen emissions reduction solution. When pressure ratios are needed beyond the scope of our single-stage turbochargers we have a full range of two-stage solutions at our disposal. Indeed, we are currently working on two-stage turbocharging solutions for new engine platforms for railway applications. First tests are scheduled over the next few months before the start of a full qualification program. So, in short, ABB Turbocharging has been present in rail for some decades now, is very active and busy preparing products for the next decade. We are definitely committed to it.

Pierre Jacoby

Pierre Jacoby has an M.Sc. in mechanical engineering from the von Karman Institute for Fluid Dynamics in Brussels, Belgium, and an MBA from the University of Chicago. Starting his career in 1994 at ABB Poland in steam turbine testing, he moved in 1995 to gas turbine development at ABB Kraftwerke AG in Mannheim, Germany. In 1996, he relocated to Baden, Switzerland, and worked in turbocharger application engineering. As head of application engineering in China from 2005 to 2010 he was responsible for all domestic four-stroke engine projects. Since 2010 he has been General Manager of the New Business department leading the rail projects worldwide.
Best practice – timely maintenance and its value in the long run

Locomotives, their engines and especially their turbochargers, have to cope with heavy loads on a day to day basis. ABB Turbocharging provides customized service worldwide in recognition of the fact that a correctly working turbocharger is vital in an efficient and well run railway.

Text Christof Schneider, Photography ABB Turbocharging in India, Michael Reinhard
Railways comprise complex mechanical and electrical systems, with hundreds of thousands of moving parts. For a railway service to be reliable, the equipment must be kept in good working order. Regular maintenance is essential to achieving this. If equipment is allowed to deteriorate due to a lack of maintenance the operational viability of a railway will suffer accordingly. Maintenance does of course come at a certain cost, but the early replacement of failing equipment will be more costly if necessary maintenance is neglected. And the neglect of timely maintenance has another downside: deteriorating equipment is less energy efficient, so energy costs are higher.

A railway’s rolling stock is very maintenance intensive, and will suffer quickly if regular maintenance is neglected. Rail delays, often causing reduced timetables on lines with heavy traffic, are an extremely unwelcome consequence of a stalled train, both for passengers and the rail operator.

If the dependability of the rolling stock is key for successful railway operations, the reliability of the turbochargers on the prime mover of a diesel locomotive clearly plays a key role in ensuring it. If the turbochargers on a modern diesel engine fail, the engine will stall and the train will come to a standstill on the track. Turbochargers fitted on today’s engines are subjected to very heavy loads and regular service, carried out by properly qualified personnel, is required to maintain their reliability and efficiency. And there is a knock on effect: high efficiency has the additional benefit that operators keep their fuel bills to a minimum.

Unit Exchange involves the removal of the entire turbocharger from the engine after a specified time and its replacement with a new or overhauled unit.
A service concept that meets requirements

ABB Turbocharging has devised a service concept that has Unit Exchange at its center. This involves the removal of the entire turbocharger from the engine after a specified time and its replacement with a new or overhauled unit.

Working together with the locomotive and engine manufacturers, ABB Turbocharging strives to customize and streamline the service schedule in a way that best suits the needs of the engine as well as the railway operators. The specified duty cycle of the locomotives is therefore always taken into account. Data loggers are also fitted on newly introduced locomotives or in new target markets with a different deployment or operation profile to determine or confirm the correct duty cycle for the turbocharger, following up with the optimum maintenance intervals.

ABB Turbocharging offers overhaul schedules which are proven in the field and specifically geared to the needs of locomotive operators. These schedules maximize the lifetime of the turbochargers under the operating conditions specific to railroad duty.

The overhaul process includes disassembling, cleaning and a strictly defined assessment of the parts. Depending on the condition, the parts are reconditioned or exchanged with new ones. Bearings and rotating parts are replaced, based on predefined exchange intervals, or sooner if the condition requires it. Complete turbocharger units are reassembled with new consumables.

Exchanged turbocharger units come with the functionality, performance and warranty of new units, ensuring renewed engine power, fuel economy, low emissions and reliable operation until the next service interval is due.

Reconditioning of individual components, including entire Variable Turbine Geometry (VTG) modules, is performed in dedicated facilities within the global service network, using state of the art equipment and processes. The reconditioned parts or VTG modules are available as exchange parts, all with the well-known ABB availability.

For larger railway fleets (upwards of about 100 turbocharger units) ABB Turbocharging can offer Unit Exchange programs with a fixed price per unit. Unit Exchange programs can greatly improve the availability of the locomotives by enabling railway depots to simply exchange the complete units in their facilities in a small time frame and let the experts from ABB Turbocharging do the overhaul or repair job in the company’s dedicated workshops. Classic on-call and on-site services are offered as well.

ABB Turbocharging is committed to offering comprehensive service and optimally supporting operators in order to ensure continuous railway operation, thereby avoiding unplanned downtime.

ABB Turbocharging offers overhaul schedules which are proven in the field and specifically geared to the needs of locomotive operators.

Christof Schneider has a mechanical and process engineer’s degree from HTWG Konstanz, Germany. He started at ABB Turbo Systems Ltd in Baden, Switzerland, in 1996 as a test engineer, was claims manager Technical Service for seven years, then head of Technical Service at ABB Turbocharging in Shanghai, China. Since 2010 Christof Schneider is Regional Manager End User Sales and Rail Service Manager in Baden.
VTG turbocharging – a valuable concept for traction applications

Why the TPR turbocharger series and Variable Turbine Geometry (VTG) perfectly meet the demands for railway engines.

Text Robert Dötl, Photography Michael Reinhard

Greater demands are being placed today on railway engine applications. The impact of rising fuel prices underscores the need for more efficient solutions at the same time that railway operators are having to comply with stricter emissions legislation that is coming into force. While the focus is on these two challenging aspects, existing and upcoming engine power-packs still need to be able to meet the known requirements of traction applications: high reliability, long durability and operation over an extremely wide range of ambient and load conditions.

Today, ABB Turbocharging offers a dedicated railway turbocharger platform, the TPR series, with proven operational reliability based on more than 2,000 units delivered for commercial operation. The series is structured around two frame sizes, TPR56 and TPR61, with typical traction engines equipped with two units of the TPR56 or 61 for power-pack ratings of typically 4,500 or 6,000 hp, respectively.
Moreover, the increasing requirements of engine builders have been addressed by the introduction of new features, namely:

– Enhanced compressor stage capabilities
– Variable Turbine Geometry (VTG) module

**TPR compressor stage capabilities**

Increasingly, traction engine builders are having to address the issues of improved power density and emissions compliance in their development programs. One element that can play its part in achieving this is high-pressure turbocharging, as provided by ABB’s F compressor technology.

Fig. 1 depicts the capability of the F-stage as compared with previous compressor technologies. The result is a substantial increase in the effective pressure ratio that can be reached in traction applications, namely up to 4.7:1 (F-3x stages). In a next step, the limit will be extended even further to 5.8:1 by introducing the latest single stage compressor technology, resulting in TPR-F6x versions and featuring compressor cooling as standard.

**TPR VTG module for the turbine stage**

Generally speaking, the VTG turbocharging system decouples the delivered boost pressure from the engine load, allowing tighter control of the boost pressure. As a result, the air excess to the engine can be modulated as a factor of the load points, ambient conditions or other operating parameters.

This flexibility is obtained by mounting each nozzle vane on a rotating axis that allows a synchronized rotation of all vanes – a slot ring facilitates vane pitch control and therefore also the turbine stage flow area – see fig. 2. The turbine’s effective area can be changed by 50% – from a closed VTG position, defined by the mechanical integrity, to an open VTG position that could still be used on an engine from the turbocharging point of view.

Full interchangeability between a fixed and VTG turbocharger with regard to the connecting flange dimensions is ensured. This is a critical aspect for upgrading an existing fleet from fixed to VTG geometry. The module is mounted between the gas inlet and gas outlet casing. A worn out module is easily replaced by a new or remanufactured one, with limited downtime. This suits the Unit Exchange maintenance model popular today in the rail business particularly well.

Besides the VTG module described above, ABB Turbocharging has also developed a control system that permits operation of VTG turbocharging modules on two turbochargers in parallel – the typical configuration for V-engines – and which prevents the boost pressure as well as turbocharger speed exceeding preset values. The scope of supply therefore consists of turbochargers with speed sensors, VTG, control unit and boost pressure sensors.

![Fig. 1: TPR compressor pressure ratios vs. volume flow.](image1)

![Fig. 2: Cross section of the Variable Turbine Geometry (VTG) module.](image2)
VTG turbocharging potential

VTG suits the specifics of traction load profiles particularly well since it acts uniformly over the power range that locomotives mainly operate in and its flexibility delivers key benefits from idling to full load.

As part of the evaluation of the VTG turbocharging system a “back to back” measurement was performed on a long-haul traction engine (4,500 hp at 1,000 rpm) operating along a typical locomotive operation line. “Back to back” in this case means that only the turbocharging system was modified from fixed geometry to VTG. The VTG position was kept closed as long as the boost pressure did not exceed a preset level. As a result, the boost pressures and, subsequently, the efficiencies, increased significantly in part-load duty. And at the maximum engine peak firing pressure, the VTG position is adjusted so that the design limit of the engine is not exceeded and the turbocharger speed is kept below a pre-set value. Four critical parameters (see fig. 3) depict the benefits well, namely:

- Substantially lower fuel consumption
- Tight control of boost pressure
- Turbine inlet temperature reduction
- Limitation of engine peak firing pressure

**Fig. 3: TPR56 fixed geometry vs. Variable Turbine Geometry – engine test results.**

The substantial benefit of VTG is primarily recorded in an engine power range over which long-haul locomotives operate most of the time.

**VTG turbocharging: Benefits at a glance**

- Fuel consumption reduced by 2%
- Lower engine thermal load; increases engine reliability/durability
- Extends locomotive operation field and flexibility
- Smooths out ambient temperature and altitude effects on engine operating conditions
- Increases locomotive load pick-up capability
- Less smoke
Moreover, it is worthwhile pointing out that the substantial benefit is primarily recorded in an engine power range over which long-haul locomotives operate most of the time. A detailed investigation over a typical long-haul load profile and operating ambient conditions indicates that a fuel saving of about 2% is achieved in commercial operation by just upgrading from a fixed geometry to a VTG turbocharger.

Behavior during changing ambient conditions was the other aspect evaluated. In traction applications the suction temperature can fluctuate over a wide range, typically varying by more than 80°C. Similarly, the altitude also changes; on some railway lines it can vary by more than 2,500 m. The VTG turbocharging system features a control concept that smooths out these effects.

In load transient operation, powerpacks equipped with the VTG turbocharging system have the advantage that they will operate with higher boost pressures and subsequently higher air excess over a low-to-mid load range (see fig. 4). This translates into faster acceleration and reduced smoke emissions.

Full interchangeability between a fixed and VTG turbocharger with regard to the connecting flange dimensions is ensured.

Further optimization potential
A combination of the latest single-stage compressor technology with VTG would allow for further optimization in terms of even stronger Miller timings. For a given engine design, the peak firing pressure is basically fixed and will be normally reached at the nominal rating load point by trading off three main parameters:

– Boost pressure
– Injection timing and engine combustion parameters
– Cylinder geometrical compression ratio

Assuming a given mechanical limit for the engine, investigations show that the previously mentioned fuel saving of 2% could reach 4 to 5% when the full engine optimization potential is realized, while all the other above-mentioned advantages remain unchanged.

Conclusion
The turbocharging module plays a major role in every engine optimization, mainly on account of its effective thermodynamics potential at the nominal engine rating point and, of equal importance, its capability to perform over the low-to-mid load range along the specific engine operating line. In respect of the latter, the VTG turbocharging system provides some new possibilities, leading to an even earlier intake valve closure, shorter scavenging period and higher cylinder geometrical compression ratio than a fixed geometry turbocharging module would allow.

The harsh environments and highly varying conditions in which traction engines run call for extraordinary flexibility. ABB’s answer is available in the form of a very flexible system, combining turbocharging technologies that enable these engines to meet their requirements in full.

Information for this article has been taken from CIMAC Paper No. 116, Shanghai 2013.
His devotion was total. John Montagu, Fourth Earl of Sandwich (1718 – 1792) was passionate about playing cards. As well as being Britain’s Postmaster General and First Lord of the Admiralty at various times, the aristocrat would spend days and nights at the card table. So much so that he had no time for proper meals.

A new form of eating was required. Something practical, so that he could keep one hand free and not get grease stains on the card table. His club’s head cook found a solution: he served His Grace two diagonally halved slices of white bread with a piece of meat between them. The original sandwich was born. It was taken up enthusiastically by his fellow players. They ordered “the same as Sandwich” – and so the snack got its name.

Due to the lack of contemporary sources, there is some doubt about whether this story is true. What is certain is that the handy sandwich has remained in fashion until this day as one of the most popular forms of eating when traveling.

An Orient Express exhibition in Paris this year elevated the traveler’s sandwich to its rightful place. The French gastronomic journalist Evelyne Ramelet spoke of the origins of the sandwich’s success: “Previously, eating in station buffets was expensive and often rather risky. The meal had to be paid for in advance, but was often brought too late for the passenger to get his connecting train. Very
tight connections forced passengers to cater for themselves. And in the early days, even short distances meant long journeys, so taking a picnic along became more or less obligatory.”

Today, traveling by rail is better organized and the trains are fast and reliable. But the sandwich has survived as a practical snack on the move. As with John Montagu, one hand is free to read a newspaper, or play cards, and your clothes stay clean – as long as you choose a sandwich without too much mayonnaise.

Here is Evelyne Ramelet’s recipe for a tasty, spicy traveler’s sandwich, “a refresher for your journey” that is quick and easy to prepare in the rush to iron your clothes and pack.

Sandwich
“Fraîcheur de voyage”

for four people

Ingredients
2 tender chicken breasts
½ cucumber, thinly sliced
4 tbs. soft cheese (e.g., St Môret or Philadelphia)
10 leaves mint, finely chopped
A few lettuce leaves washed and dried
8 slices wholemeal bread
Salt, pepper, ground hot paprika or d’Espelette pimentos, or ground chili, or a pinch or two of ground Cayenne pepper.

Preparation
1. Heat a little oil in a frying pan and fry the chicken breasts until the meat is completely white.
2. Slice the chicken breasts into fine strips.
3. Mix the cheese with the chopped mint and the spices.
4. Spread the cheese mix onto half the bread slices.
5. Then place the chicken slices and the lettuce leaves on the cheese.
6. Complete the sandwich with the remaining bread slices.

Recipe provided by Evelyne Ramelet.
Assuring the availability of your application is a critical part of securing your business. The right service reduces downtimes and increases your application’s performance and lifetime. You also save costs by preventing repeat maintenance and redundant spare part purchases. Getting your service plan from ABB Turbocharging guarantees dependable delivery of results and lower total cost of ownership of your turbocharger. We are dedicated to providing our customers a comprehensive turbocharging service offering 24/7, 365 days a year across the globe. Get the right service.

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