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Dragon Batch Locomotives
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Newag's Dragon Locomotives Powered By ABB

Combining their international experience with know-how gained during fifty years of modernisation and repair works of the rolling stock as well as with their own market research, designers from Newag Gliwice have created the first modern Polish-built electric locomotive for hauling heavy freight trains adapted to the needs of the Polish market.



On 29 January 2014 both Dragon variants met at Newag Gliwice works, positioned outside the testing hall. On the left is E6ACT-005, the first for LOTOS Kolej, and on the right E6ACT-002, destined for STK of Wrocław. At that time, LOTOS Kolej's E6ACT-006 and 007 locomotives were in the final assembly stages.

Photo: Maciej Duczyński, Newag Gliwice

The design phase on Dragon project started in 2006 with the goal to build a powerful, safe, attractively priced, economical, well equipped locomotive, using state-of-the-art technologies. Its **prototype**, E6ACT-001, was presented on the TRAKO fair in 2009 and started homologation tests in March 2010. Then the prototype made its wider international debut at InnoTrans 2010.

The single voltage Dragon is the first vehicle of a Newag Gliwice six-axle locomotive platform. Its main advantage is a high tractive force of 375 kN which in connection with the locomotive weight of 118 t and individual drive of each axle allows to haul trains weighing up to 5,000 t. The 3 kV DC power supply, maximum axle load below 20 t and high durability makes the Dragon perfectly adapted to difficult opera-

tional conditions and low permitted axle load. During the design process, focus was set on safety and driver's high comfort, providing ergonomically designed **cab** and control panel, the safety cage and anti-climbing structure protecting the driver in case of collision, the air conditioning unit and CCTV.

The Dragons are powered by asynchronous traction motors, fed by IGBT based traction inverters. The locomotive

has a modular construction allowing, through a mere adaptation of the existing platform, to offer solutions customised to the specific needs of operators - such as multiple voltage locomotives (3 kV DC/25 kV AC/15 kV AC), or electric locomotives equipped with an additional diesel engine.

Dragon is equipped with micro-processor control systems that allows to adapt the operating mode to the



E6ACT-001, the Dragon prototype, at Żmigród test circuit on 7 April 2010. This locomotive is now owned by STK, Wrocław.

changing conditions, and on-board diagnostics system with full visual information and data registration module that facilitate finding the location or prediction of possible failures. Newag Gliwice high production standards, confirmed by such certificates as IRIS and PN-EN ISO 9001: 2009, guarantee the highest quality of the locomotives.

After more than a year of intensive commercial operation of the E6ACT-001 locomotive with STK freight trains, all the return of experience has been taken into account before launching the **batch** production. So far two contracts were signed for the delivery of eight locomotives for the Polish freight operators STK (E6ACT-002 to 004) and LOTOS Kolej (E6ACT-005 to 009).

In particular, the serial locomotive has been seriously improved by including a **traction** system newly developed by ABB to fulfil very high client expectations. ABB traction equipment is known for their high reliability and easy maintenance. The converters are built on a modular platform design with standardised, easy to handle Power Electronic Building Blocks.

Another important improvement brought on the serial Dragons is the driver's cab modernisation. All the drivers who have driven both the prototype and the batch locomotives agree, that the latter are much more ergonomic and better insulated, and the air conditioning is more efficient. In addition, the standardisation level has been

greatly increased by adapting the same driver desks as those already used and tested on Griffin, the Newag Gliwice's first four-axle locomotive. This resulted into very simple and similar control of both types, bringing advantages for future operators using simultaneously these six- and four-axle locomotives.

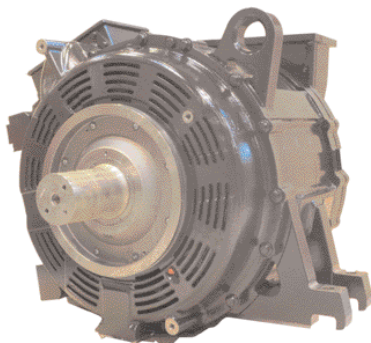
Traction System

The ABB traction system for Dragon includes the following main subsystems (see diagram on the opposite page right below): the line filter cubicle, the BORDLINE® CC1500 DC traction converters, the auxiliary filter cubicle and the traction motors.

The two traction converters are directly fed from the 3 kV catenary via autonomous DC-line filters in the line filter cubicle. Each traction motor is supplied by its individual motor inverter. The single-axle drive ensures highest adhesion performance and a beneficial system redundancy. In addition, each traction converter includes an auxiliary converter and a battery charger for a redundant on-board supply system.

Main Subsuppliers Of E6ACT Locomotives:

- pantographs - Stemmann-Technik,
- line filter cubicle, traction converters, auxiliary converters, battery chargers, auxiliary filter cubicle and traction motors - ABB,
- braking system - Knorr Bremse,
- braking resistor - Microelettrica Scientifica (Knorr Bremse Group),
- TCMS - Inteco,
- gearboxes - ZF,
- cooling towers - Voith Turbo,
- traction motor blowers - Comet (Knorr Bremse Group),
- HVAC - OE Industry,
- train radio - Radionika,
- event recorder - Hasler.



A type AMXL450 ABB traction motor.



Photo: Newag

A design comparison of the driver's consoles on prototype (above) and batch Dragon locomotive, E6ACT-002 (below).



Photo: Newag

Principal Technical Data Of Batch Dragons

Track Gauge	1,435 mm
Loading Gauge	UIC 505-1
Axle Arrangement	Co'Co'
Operating Voltage	3 kV DC
Maximum Speed	120 km/h
Continuous Rating Output	5,000 kW (at wheel rim)
Starting Tractive Force	374 kN
Max. Train Weight (at 6 ‰ gradient)	5,000 t
Electrodynamic Brake Output	
- During Recuperation	5,000 kW
- During Braking Into Resistors (max. loading)	2,400 kW
Maximum EDB Force	150 kN
Length Over Buffers	20,330 mm
Wheel Diameters (new/worn)	1,250/1,170 mm
Minimum Curve Radius	120 m
Weight	118 ±2 t
Brake Systems	pneumatical, electrodynamic
Parking Brake	spring parking brake at each axle
Traction Converter	IGBT, BORDLINE® CC1500 DC
Traction Motors	Asynchronous
Auxiliary Voltages	3 x 400 V AC 50 Hz and 230 V AC 50 Hz 110 V DC
Train Supply	3,000 V DC
Work shop power supply	3 x 400 V AC 50 Hz
ATP systems	SHP, CA (vigilance unit), RS (radio stop system)



Power Electronic Building Block (PEBB).

Filter Packages For Line Input And Auxiliaries

The line filter cubicle includes redundant air-core DC-line chokes. The chokes are environmentally friendly forced air cooled. For a safe and efficient cooling the temperatures of each choke are monitored and the air ventilation is adjusted depending on the load.

The air-cooled auxiliary filter cubicle includes a LC sine filter and a three-phase transformer to feed the on-board loads at 3 x 400 V AC and 1 x 230 V AC. A change-over switch is included to select one of the redundant auxiliary outputs of the traction converters. For user-friendly maintenance, the components of both filter cubicles are easy accessible directly from the machine room aisle of the locomotive.

BORDLINE® CC1500 DC Traction Converter

The BORDLINE® CC1500 DC is a very compact and highly integrated IGBT traction converter. The rugged IP54 converter housing contains on the right side the Power Electronic Building Blocks (PEBB) and the DC-link capacitors. The environmentally friendly water cooled PEBBs are configured as motor converter (3x), braking chopper, auxiliary converter and as a battery charger module. The lightweight PEBBs are optimised for service aspects: easy to handle and to exchange.

The motor converters, braking chopper and the auxiliary converter are based on two-level technology with standard 6.5 kV IGBT modules. The battery charger is realised with low voltage IGBTs. The converter control and power supply units are placed on a swing frame in front of the PEBBs providing excellent access to all key components.



BORDLINE® CC1500 DC traction converter with closed control swing frame (right side).

The AC800 PEC **control** platform is probably the most powerful modular controller on the market also used in ABB wind converters, high power industrial drives and many other applications. This unit covers all control and protection functions, sensor inputs, diagnostics, and provides a simple interface to the vehicle control. In cooperation with the train control management system, standard ABB software modules control for example the slip-slide functionality, pantograph bounce or enhanced electrical braking mode of the locomotive.

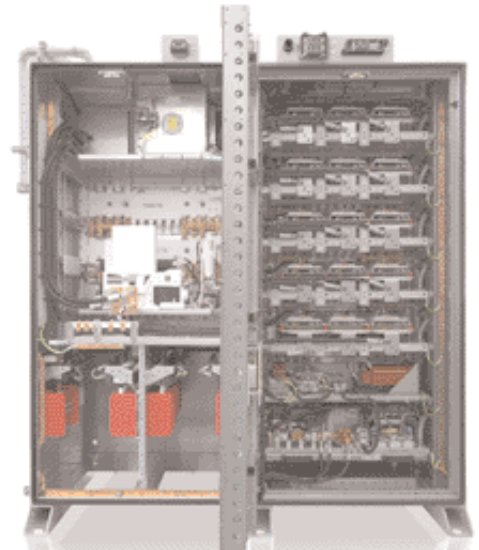
For **diagnostics**, an Ethernet interface is available. In-depth data can be obtained using BORDLINE® - View, a diagnostic tool including an advanced self-diagnosis function, which gives advice and instruction for smooth service and repair. It runs on standard PCs.

On the left side of the traction converter the internal fan/heat exchanger unit, the pre-charge module, current transducers and the power terminals are located.

The BORDLINE® traction converters for Dragons are produced at ABB Poland in Łódź. Furthermore ABB provides local service and a logistic concept for spare parts, close and dedicated to customer's needs.

Traction Motors

The Class E6CAT locomotives are fitted with ABB's AMXL450 traction



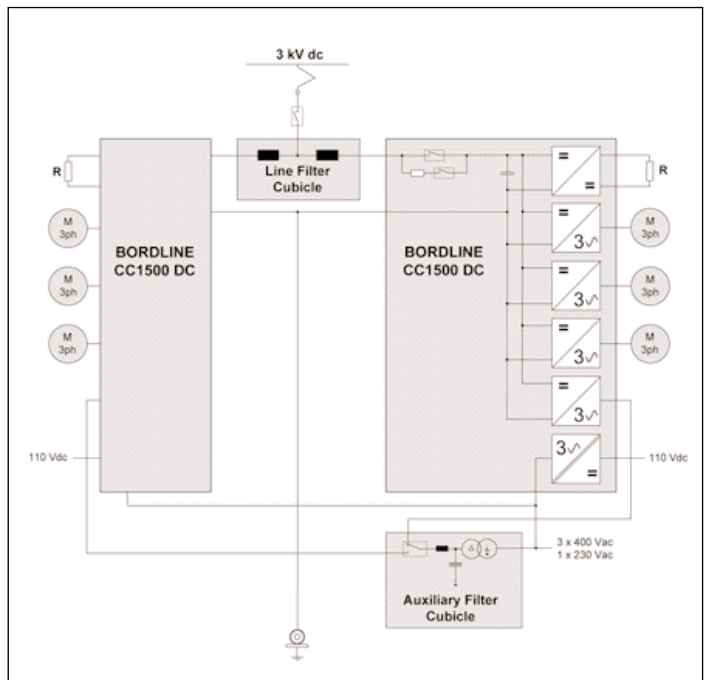
BORDLINE® CC1500 DC traction converter with open control swing frame. On the left side are power terminals, input switches, etc. On the right side the PEBBs.



Auxiliary filter cubicle.



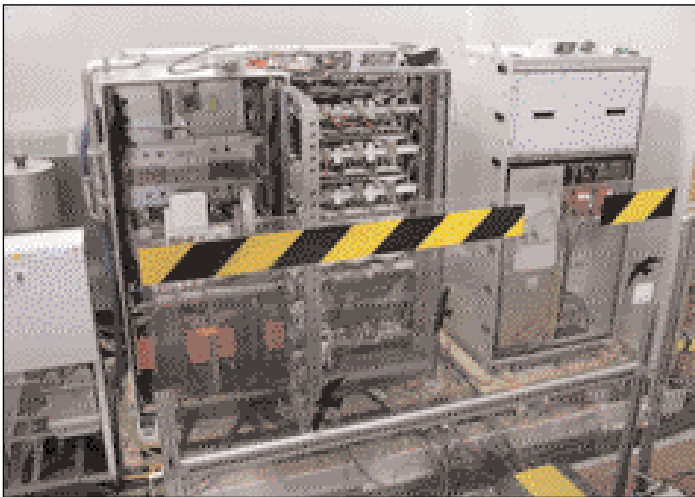
Line filter cubicle.



A diagram of the traction system, which was designed in very close cooperation between ABB Switzerland and Newag Gliwice designers.

Main Data Of BORDLINE® CC1500 DC Traction Converter

Input	3 kV DC
Traction Output	3 x 833 kW (at the wheel)
Braking Chopper	1,200 kW
Auxiliary Output	175 kVA
Battery Charger	15 kW/110 V DC
Vehicle Control Interface	CanOpen
Dimensions (l x w x h)	1,800 x 875 x 2,030 mm
Cooling	Water/Glycol
Protection Type	IP54
Weight	1,380 kg



Combined test of a traction converter and an auxiliary filter cubicle.

motors. They are axle hung three-phase asynchronous motors with a Class 200 vacuum pressure insulation. The motor with its grease lubricated bearings designed for robustness and reliability is highly integrated into the vehicle structure, and it includes sensors for temperature and speed measurements.

Commissioning And Homologation

Before commissioning, ABB's traction system underwent comprehensive verification and validation tests. The protection functions, normal operation but also special operating conditions such as line voltage variations (over-voltage, under-voltage), operating through neutral sections, pantograph bounce and weak line supply (rotating converters) have been verified on the real time simulator. This is a „Hard Ware in the Loop Simulation“ with original converter control HW and SW.

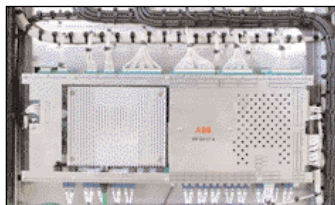
Besides type **tests** of all components, ABB also performed a combined test on traction converter, traction motor and auxiliary filter cubicle in order to optimise the system already before commissioning on the locomotive. Both, the real time simulator tests and the combined test have reduced significantly the time and effort for commissioning and homologation.

The static commissioning was performed at Newag in Gliwice. After tests on Żmigród test circuit performed by Instytut Kolejnictwa (a Polish Notified Body) in last quarter of 2013 all changes has been approved by Notified Body, and serial Dragon received type license. All the results were positive, not a single test needed to be repeated.

Additionally the Dragon passed an intensive test program with loads of up to 3,905 t on gradients up to 10.7 ‰ and the first batch locomotive, E6ACT-002, was finally handed over to STK Wrocław in December 2013.

Market Outlook And Further Dragon Versions

There is a big interest for Dragons on the market of freight operators. From one side, operators need a heavy duty locomotive to allow them to haul as



AC 800PEC control.

many full-loaded wagons, as possible. On the other side, on a big part of the railway network, the maximal permitted axle load is quite low (e. g. up to 20 t per axle), especially in coal mine areas. In such a situation, a six-axle locomotive is an ideal solution to haul heavy trains, of up to 5,000 t.

As an answer to various customer requests, Newag Gliwice has started the design of following Dragon **variants**:

- a single voltage 25 kV AC version,
- a multi voltage AC/DC version,
- a dual power version with additional 350 kW diesel engine,
- a heavy version with 450 kN starting tractive effort.

This makes Dragon platform even more attractive for potential customers. Together with Griffin platform this gives the possibilities to fulfill all customer needs in terms of locomotives.

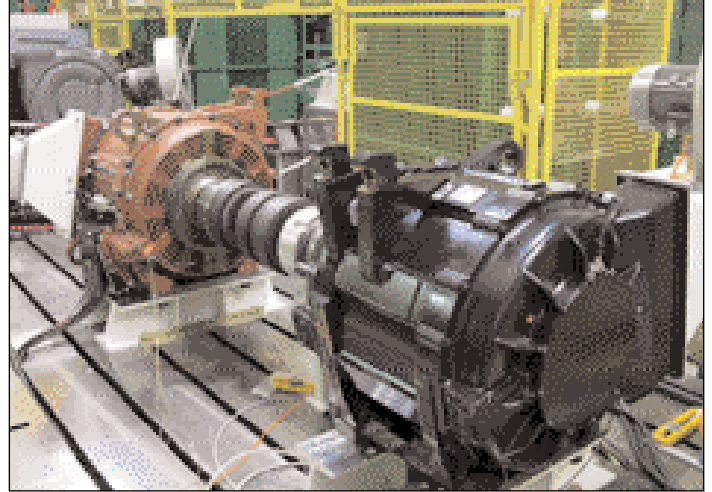
Majid Belkhayat,
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ABB Switzerland Ltd.

Photos and diagrams,
unless cited, by ABB

Photo on the right:
The flagships of Newag Gliwice:
Griffin and Dragon. This photo
was taken at Gliwice works on
29 January 2014.

Photo: Maciej Duczyński,
Newag Gliwice



Traction motor with load machine on the test bench at ABB.



ABB's Real Time Simulator at ABB Switzerland in Turgi.



BORDLINE® CC1500 DC converters production at ABB Poland in Łódź.

