BOMBARDIER

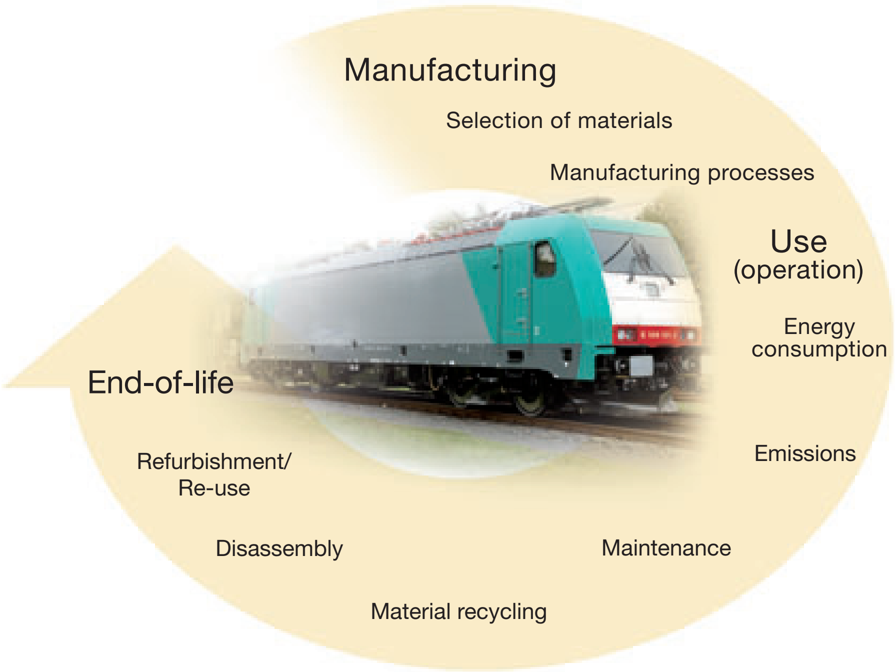
TRAXX 4 Environment
Environmental Product Declaration: TRAXX F140 MS

EMAS
VALIDATED
INFORMATION
D-139-00007
Site Kassel

In accordance with ISO 14025

Applying A Total Lifecycle View

Bombardier Transportation is committed to improving the environmental performance of its activities and products continuously, and to applying a total lifecycle view to their design.
Environmental Product Declarations are our way of providing customers, operators and other stakeholders with relevant, reliable and objective environmental information. We apply the international standard ISO 14025 for communicating environmental product information, the most advanced and demanding standard in this field. In this way, our customers are not only able to assess environmental impacts as early as in the tendering phase, but also to communicate vehicle performance to their customers, whether these are passengers or industrial companies who intend to award contracts for cargo transport.



This Environmental Product Declaration refers to the locomotive *Bombardier** *TRAXX** F140 MS, for which Bombardier Transportation is responsible for engineering, manufacturing of main components, final assembly and delivery.
The declaration was developed by the Bombardier Transportation Center of Competence for Design for Environment (CoC DfE), with support from Fivewinds Europe, in compliance with ISO 14025:2006 and validated in accordance with EMAS regulation (EC) No 761/2001. In addition, the mandatory verification of Product Category Rules (as required by ISO 14025) was performed in line with EMAS. External validation of product information by an independent verifier in our view is essential to ensuring the appropriate credibility of the information and data provided, when products with relevance for the general public are concerned.

A lifecycle inventory (LCI) has been performed that includes manufacturing, operating (including maintenance) and end-of-life treatment. Using the Class 185 data as the starting point the LCI was primarily based on a material inventory and a calculation of energy consumption. This Environmental Product Declaration provides information about the materials used in the vehicle, conclusions regarding environmental impacts of the locomotive in general and, as far as applicable, also demonstrates improvement of environmental performance.

Edmund Schlummer
President Locomotives
Bombardier Transportation

*Trademark(s) of Bombardier Inc. or its subsidiaries.

The Class 185 Forms The Basis Of The TRAXX Platform

The Class 185 locomotive is the origin and technical basis of the Bombardier *TRAXX* Locomotive platform. This platform consists of 4-axle Electric and Diesel locomotives for passenger and freight services throughout Europe. There are four types matching the needs of the various rail networks:

- *TRAXX* AC: 15 & 25 kVAC
- *TRAXX* DC: 3 kVDC
- *TRAXX* MS: 15 & 25 kVAC + 1.5 & 3 kVDC
- *TRAXX* DE: Diesel-electric

All *TRAXX* locomotives have the same design and are built using modular components and systems. The carbodies, bogies, traction motors, driver's cabs, locomotive layout and communication systems are the same for all types. A selection of drive systems is available for a maximum speed of 140, 160 and 200 km/h for freight, regional and intercity services respectively. All *TRAXX* locomotives can be equipped with country-specific devices for national or cross-border services. The *TRAXX* locomotive design complies with the requirements of interoperability within Europe. There is a large ongoing activity of homologation in many countries and for important cross-border corridors.

D	CH	F	L	A	DK	S	N	HU	..	I	NL	B	PL

Country-specific homologations

AC

MS

DC

DE

***TRAXX* Platform**
Types: AC, MS, DC & DE
Drives: 140, 160 & 200 km/h
Operations: Cross-border

140 km/h

160 km/h

200 km/h

	TRAXX AC	*TRAXX* MS	*TRAXX* DC	*TRAXX* DE
Line voltage	15 + 25 kVAC	15 + 25 kVAC+ 1.5 + 3 kVDC	3 kVDC	Diesel-electric
Mass (max.)***	82 t	85 t	81 t	80 t
Length	18,900 mm			
Width	2,977 mm			
Height	3,845 mm			4,264 mm
Wheel base	2,600 mm			
Wheel diameter	1,250 mm / 1,170 mm			
Power 15 & 25 kVAC	5,600 kW		--	2,200 kW Diesel
Power 3 kVDC	--	5,600 kW		2,200 kW Diesel
Power 1.5 kVDC	--	4,000 kW	--	2,200 kW Diesel
Tractive effort	300 kN			270 kN
Braking effort	240 kN			150 kN
Driver's cab	air-conditioning / pressure pulse protection			
Speed	140 / 160 / 200 km/h			
First delivery date	--	07/2007	03/2007	07/2007
Fuel tank capacity	--			4,000 l

*** Weight depends on country-specific equipment

The *TRAXX* platform gives the operators a choice of locomotive types for specific rail networks. The high degree of commonality between the types contributes to cost reductions and efficiency improvement at the railways with a mixed fleet of locomotives. The *TRAXX* locomotives are service-proven with high levels of reliability and availability.

Lifecycle costs have been reduced by the use of state-of-the-art technologies, e.g. IGBT* propulsion with high power efficiency, oil-free compressor and a highly integrated brake control system. The carbody complies with the latest technical specifications for interoperability (TSI**), increasing driver safety and reducing repair costs in the event of an accident. *TRAXX* locomotives are available with the highly integrated train safety systems for cross-border operation including the European Train Control System (ETCS) and a highly integrated train radio which supports country-specific radio systems as well as GSM-R.

* Insulated-Gate Bipolar Transistor
** Technical Specification for Interoperability, www.era.eu.int/public/interoperability

Manufacturing

The table below shows the majority of the materials used for the realisation of one *TRAXX* locomotive – summarised into material groups (as given in the PCR document).

The degree of inventoried materials is about 99 weight %. It is based on the detailed inventory of the locomotive Class 185.

Manufacturing materials*	Weight (kg/vehicle)*
Metals	72,312
Polymers	2,958
Renewable materials	2,755
Chemicals	606
Composites	548
Other materials	510
Unspecified	4,388
Total	**84,077**
*as of 2006	

Great care was taken during the manufacturing process of the locomotive in implementing environmentally sound materials, exceeding applicable legal obligations. However for technical reasons there is lead in the batteries and a few plates in the engine room are chromated.

Already during the design phase of the *TRAXX* locomotives our engineers focused on minimising the amount of resources used and the environmental impacts. As an example, a new design of the wall between machine room and driver's cab resulted in elimination of aluminium and glue. The major environmental impact of manufacturing processes within Bombardier Transportation originates from painting, glueing, and welding.

Continuous reduction of environmentally harmful materials

In the past few years, targets were set at all locations to reduce unfavourable environmental influence. The traction converter cooling volume could be reduced due to new IGBT technology. For *TRAXX* F140 MS, the cooling of the new IGBT converter is by means of a water/glycol mixture.

Reduction of hazardous emissions in case of fire was enabled by replacing toxic flame retardents and using modified materials. Other examples are biodegradable wheel flange lubricants and an oil-free compressor for the brake system supplied by Knorr.

By using novel painting methods (warm painting method), the total quantity of solvent used for the top coat has been reduced by 5 liters per carbody.
A reduction of paint materials containing isocyanates was possible by using an MS sealant (modified silicone) to replace polyurethane sealant. The choice of the paint system, however, ultimately depends on customer requirements with respect to fire protection, for example, or anti-graffiti properties.

Manufacturing Infrastructure

Environmental targets are established (e.g. resource consumption) and are regularly monitored in accordance with our environmental management systems (ISO 14001, EMAS II). We consider possible environmental aspects in all our activities and continue to improve and review our environmental protection programs.

The following environmental achievements are worth being mentioned:

- Reduction of energy consumption at the facilities by e.g.:
  - Building renovation with thermal insulation
  - Using welding equipment with reduced energy consumption (approx. 40 % at Wroclaw 2004–2005)
  - Continuously improving our paint shops
  - Modernising the heating and lighting systems
- Reducing water consumption by approx. 15 % annually (2004–2005)
- Using lean manufacturing principles:
  - Reducing the space used for manufacturing
  - Reducing packaging material by introducing dedicated bin management systems like reusable packaging materials
  - Reducing cycle time for carbody manufacturing and final assembly of locomotives
- Meeting the requirements of the European VOC directive in paint shops at Kassel and Wroclaw.

Environmental module "Common": Bombardier crash-optimised driver cabin in paint shop in Wroclaw.

Operational Features

The environmental impact described in this section has been evaluated and quantified on the basis of the intended use of the locomotive. The operator will have a major influence on the environmental impact of the locomotive during operation and maintainance.

Noise and vibration

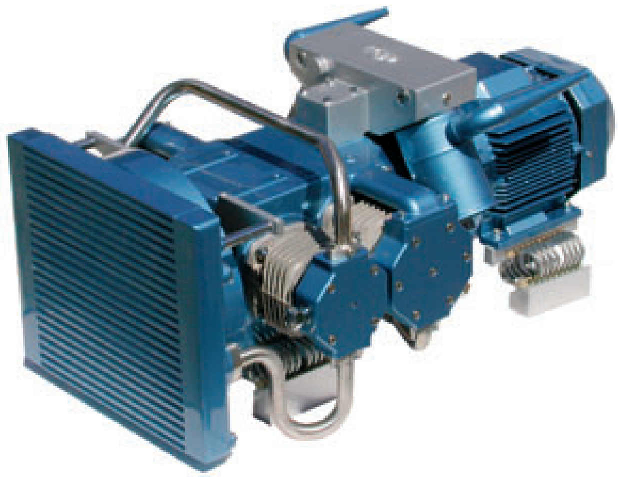
Low external noise levels of the locomotive are the result of the development of this locomotive. Different design concepts to reduce the noise were considered and assessed through noise calculations. The *TRAXX* F140 MS fulfils the new TSI “Conventional Rail” requirements.

The external pass-by noise is below 85 dB(A) at 80 km/h in a distance of 7.5 m. It was possible to reduce the inside noise in the cab down to 72 dB(A) at 140 km/h to improve the working environment for the driver.

Env. Module “Power pack”:
Converter *Bombardier** *TRAXX** TC
with electronic *Bombardier** *MITRAC** CC

Maintenance materials

The following table displays the weight of the main materials used during planned maintenance based on a 30 year lifetime. These weights are based on a mean planned kilometric performance of 150,000 km per year.



Env. module “Common”: Oil-free compressor Knorr (Env. award City of Munich, 2003)

Only those materials are included which are replaced according to our standard. The largest part is steel that is used to substitute the wheels and different bearings. Lead from the batteries is included in category “metals”. Batteries have to be recycled separately.

The category “other materials” includes the worn-out brake pads. This figure is very low, because the brake function is being fulfilled predominantly by transformation of traction energy into electrical energy (regenerative braking).

Maintanance materials	Material weight (kg/vehicle/ 30 years)*
Metals	15,361
Renewable materials	1,890
Other materials	790
Chemicals	538
Polymers	382

*as of 2006

*Trademark(s) of Bombardier Inc. or its subsidiaries.

Energy Consumption

As the *TRAXX* F140 MS is a newly developed locomotive, no measured data regarding energy consumption exist. The values reported here therefore are based on calculations for a typical track on the north-south corridor. The following basic calculation procedures were performed:

1. Calculation of the power-efficiency factor with a model of the traction chain. The traction chain includes: Main transformer, main traction converter, traction motor, gear, wheel and auxiliary consumption.

2. An efficiency diagram over speed is calculated.

3. The energy consumption is calculated using the efficiency/speed diagram and track-/train conditions of a dedicated route.

Model Journey

The calculation was made over one of the busiest north-south international European heavy goods corridor from Basel to Milano. For the energy data sheet, we selected a track characteristic that is very common in the European heavy goods traffic. Basel – Erstfeld – Basel is on the very frequently used north-south connection, however, without steep alpine tracks.

Track information a train running diagram, without any stop and normal track conditions was the base for the calculation. This defines the speed of the train and the needed power and tractive-/braking effort of the locomotive. The train configuration used is a very common train load for a single 4-axle locomotive.

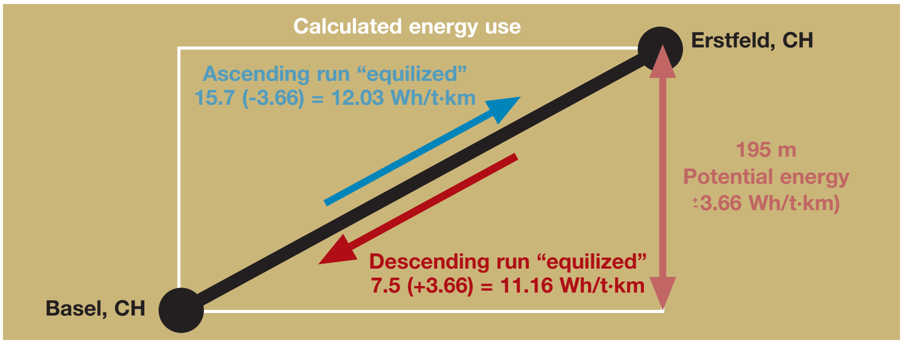
This load can be hauled over a maximal track gradient of 12 ‰. It consists of 1 *TRAXX* F140 MS Electric locomotive from Bombardier Transportation and 13 wagons for steel coils with a total train weight of 1,260 ton.

Other conditions

• Ambient temperature	15° C
• Power transmission voltage	16 kV
• Recuperation to catenary	yes
• Auxiliary power	140 kW
• Train power supply	non
• Train resistance curve	yes

Calculation results

The following table summarises the calculated energy use. The energy consumption value has resulted in the specific value Wh/t·km, which is Watt-hours (= Energy) per Tonnes (t) and Kilometer (km).



This value can be used easily to calculate the energy use for any other load and distance. The different energy consumption for the "North" and "South" direction is related to the fact, that Erstfeld is located 195 m higher above sea-level than Basel. The potential energy difference for this train journey is 3.66 Wh/t·km. This results in the corrected specific energy consumption factors.

Conclusion

The resulting average specific energy consumption factor is approx. 12 Wh/t·km under the above mentioned conditions.

It should be pointed out that this value depends very much on other factors e.g.
- driving style of locomotive driver (e.g., excessive use of pneumatic brake),
- time schedule ("time buffer" to optimize the drive style).
- signalling stops with pneumatic brake have a large influence and
- no recuperation for electrical brake energy possible into the catenary.

Those factors can easily increase the specific energy consumption factor up to 20 Wh/t·km.

End-of-life

Recycling

One of the novel features of the *TRAXX* family, its modular design, also provides environmental benefits: individual components can be easily exchanged and upgraded, which means that over their lifetime the locomotives can be extended and an upgrade of the environmental standard is simplified.

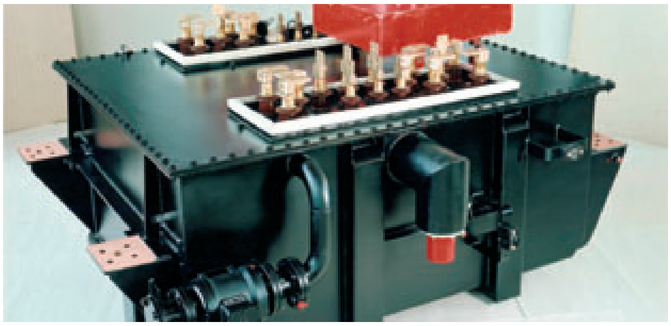
Once taken out of service, these locomotives are relatively easy to recycle since they are generally produced from materials that are well suited to recycling. Also, due to the modular design, they are easy to disassemble and segregate into the various material categories.

Recyclability rate calculation is based on the existence of recycling processes that are commercially available and technically possible today. Reuse of material and energy recovery are all included in the total recyclability.

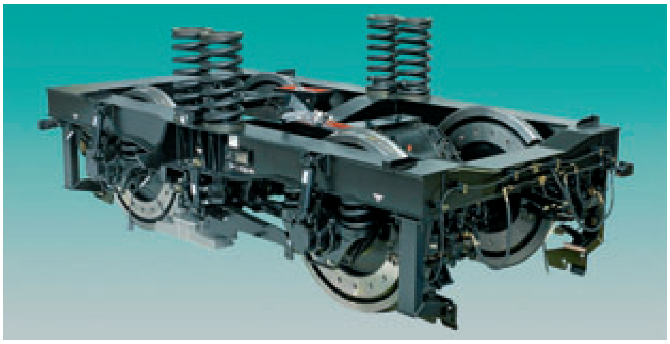
Based on the weight of the materials used in the locomotive, the total recyclability for *TRAXX* F140 MS is calculated to 93 %.

The figures given for each material group are not precise, they do however give an idea of the extent of recycling that is possible. Any losses in the recycling processes have not been included – the figures are based on the amount of scrapped material that is put into the process. The output (amount and quality) depends on the chosen recycling method and the purity of the scrapped material.

Env. module “Country”:
ETCS cubicle *Bombardier** EBI* CAB 2000 with electronic *Bombardier* MITRAC** CC



Env. module “Power pack”: Main transformer



Env. module “Bogie”: Bogie Bombardier FLEXIFLOAT with drive *Bombardier* MITRAC** DR

Material group	Weight (%)*	Recyclability (%)*
Metals	86.01	99.99
Polymers	3.52	99.45
Renewable materials	3.28	100.00
Chemicals	0.72	11.54
Composites	0.65	0.00
Other materials	0.61	0.00
Unspecified	5.22	0.00
Total locomotive	**100.00**	**92.85**

*as of 2006

*Trademark(s) of Bombardier Inc. or its subsidiaries.

Environmental Profile

Env. module "Common":
HVAC (heating, ventilation, air-conditioning)

The Environmental profile is based on a lifecycle assessment (LCA) study.
The functional unit is: transport of 1 ton of gross mass (vehicle + load) for 1 km.

The weight of the locomotive used for the calculations is: 84.7 ton.

The train load used for calculations are 1,260 ton (see calculations for the energy consumption). The intended service life of the locomotive is 30 years with an average running distance of 150,000 km per year.

Resource utilization

Material resources	Unit	Manufacturing per transport of 1 ton 1 km	Manufacturing per total lifetime	Use per transport of 1 ton 1 km	Use per total lifetime	End-of-life per transport of 1 ton 1 km	End-of-life per total lifetime	Total
Non renewable								
Steel	kg	$9.6\cdot10^{-6}$	58,059	$2.3\cdot10^{-6}$	13,676	$-11.9\cdot10^{-6}$	-71,735	0
Copper	kg	$1.3\cdot10^{-6}$	7,867	$0.002\cdot10^{-6}$	11.44	$-1.3\cdot10^{-6}$	-7,878.44	0
Aluminium	kg	$0.8\cdot10^{-6}$	5,009	$0.1\cdot10^{-6}$	515	$-0.9\cdot10^{-6}$	-5,524	0
Renewable								
Biological oil (rapeseed)	kg	$0.085\cdot10^{-6}$	515	0		$-0.085\cdot10^{-6}$	-515	0

Primary energy resources	Unit	Manufacturing per transport of 1 ton 1 km	Manufacturing per transport total load 1 km	Use per transport of 1 ton 1 km	Use per transport total load 1 km	End-of-life	Total per transport of 1 ton 1 km	Total per transport total load
Non renewable								
Nuclear	Wh	0.00409	5.50	3.82	5,131	0	3.82	5,136
Oil	Wh	0.00094	1.25	0.73	976	0	0.73	977
Coal	Wh	0.00416	5.59	3.68	4,944	0	3.68	4,949
Gas	Wh	0.00181	2.44	1.6	2,157	0	1.6	2,159
Renewable								
Hydropower	Wh	0.00228	3.06	2.02	2,711	0	2.02	2,714
Biomass	Wh	0.00020	0.27	0.18	242	0	0.18	242
Wind power	Wh	0.00050	0.068	0.04	60	0	0.04	60

Waste	Unit	Manufacturing per transport of 1 ton 1 km	Manufacturing per total lifetime	Use per transport of 1 ton 1 km	Use per total lifetime	End-of-life	Total per transport of 1 ton 1 km	Total per total lifetime
Hazardous waste	kg	$3.29\cdot10^{-8}$	119	$5.30\cdot10^{-8}$	321	0	$8.59\cdot10^{-8}$	440
Non-hazardous waste	kg	$51.2\cdot10^{-8}$	3,099	$44.3\cdot10^{-8}$	2,680	0	$95.5\cdot10^{-8}$	5,779

The **material resources** cover the most important raw materials used for manufacturing and maintenance of the locomotive.

The **energy resources** cover energy needed during manufacturing and use of the locomotive. Average European mix during the use phase is assumed.

The **waste** arises from the raw materials used for manufacturing and maintenance of the locomotive that are not recyclable.

Manufacture covers the materials and energy needed for assembly of the locomotive until delivery to the customer.

Use covers the predicted and estimated processes during the use phase.

End-of-life covers recycling, incineration and landfill. The negative values arise from recycling of metals.

Total sums up the manufacture, use and end-of-life phase.

Included in the LCA:

- Cradle to gate data of the raw materials used
- Transport of main components to final assembly
- Energy consumption during assembly and use
- Major materials used in maintenance
- Recycling of metals
- Incineration of polymers with energy recovery
- Other materials to landfill

Not included:

- Manufacturing processes at suppliers
- The raw materials waste produced in the manufacturing process
- Effects of possible accidents
- Direct emissions from operation (e.g. brake pad dust)
- Energy used in maintenance
- Energy and emissions for the end-of-life treatment

Env. module “Power pack”: Roof installation

This table shows the impact categories to which all the emissions are grouped.
Most of the emissions during manufacturing arise from extraction and purification of raw materials.

The emissions during the use phase arise mainly from the generation of electrical energy.

Impact category	Unit per transport of 1 ton 1 km	Manufacturing	Use	End-of-life	Total
Global Warming Potential (GWP)	kg CO_2 equiv.	0.000052	0.006140	-0.000028	0.006164
Ozone Depletion Potential (ODP)	kg CFC 11 equiv.	$5.63 \cdot 10^{-12}$	$1.01 \cdot 10^{-9}$	$-5.34 \cdot 10^{-13}$	$1.01 \cdot 10^{-9}$
Acidification (AP)	k mol H+ equiv.	0.000008	0.001250	-0.000003	0.001254
Eutrophication (NP)	kg O_2 equiv.	0.000001	0.000069	-0.0000001	0.000069
Photochemical Oxidant formation (POCP)	kg Ethene equiv.	$1.03 \cdot 10^{-8}$	0.000001	$-2.57 \cdot 10^{-9}$	0.000001

Environmental Management

Management systems for environment (EMS) and for health & safety have been implemented at Bombardier Transportation as part of its Integrated Business Management System (as is the case with QMS in accordance with ISO 9001:2000), in order to ensure that our operations are managed safely, ecologically, and in a sustainable manner. They enable the organisation to establish and systematically control the level of environmental impacts and to continuously improve environmental performance. The Integrated Management System at Bombardier Transportation complies with the requirements defined in the international standard ISO 14001:2004. Certification is achieved in accordance with this standard. Several sites also apply the more demanding European EMAS eco management and auditing scheme. Furthermore, our sites also hold certificates in accordance with the OHSAS 18001 standard on health & safety. External suppliers are evaluated with regard to environmental management using the standardised approach of the German industry associations ZVEI, VDA and VDMA, which forms part of our general requirements for suppliers.

Supplier	Site	Major systems/ Products	ISO 14001(1)/EMAS(2) (issue date of first first certificate, all certificates are valid at date of publication)
Bombardier Transportation Germany	Kassel	Final Assembly Testing of complete vehicle	June 1997(1)/ November 1995(2)
	Mannheim	Traction converter, auxiliary converter	July 1997(1)/ July 1996(2)
	Siegen	Bogies	November 1997(1)/ November 1997(2)
	Hennigsdorf (PPC)	Drive, cubicles	April 2000(1)/ planned for 2007(2)
Bombardier Transportation Poland	Wroclaw	Carbodies, bogie frames	July 2000(1)/ October 2006*(2)
Behr GmbH & Co.	Stuttgart	Cooling tower	December 1998(1)/ –
Knorr	Munich	Brake system	January 2004(1)/–
ABB Sécheron SA	Geneva	Transformer	May 1998(1)/–
Liebherr, Austria	Korneuburg	HVAC	December 1999(1)/–

*planned

Independent suppliers manufacture a significant portion of the components in *TRAXX* locomotives. This includes more than 20 tons of environmentally relevant electric and electronic equipment like electric motors, components for the transformer, cables and plugs, electronic parts for the power converters as well as for the driver's cab. For these reasons, it is of great importance to consider the ability of relevant suppliers to manage environmental issues. Our main suppliers contributed information on the materials used in their components to facilitate development of this product declaration. Their competent support is warmly acknowledged.

Mandatory Information In Accordance With ISO 14025 And Validation

This EPD is developed under the Bombardier EPD program "Rail vehicles". Information is available through www.transport.bombardier.com/about_us/sustainable_mobility

Environmental product declarations from different programs may not be comparable.

About Bombardier Transportation

Serving a diversified customer base around the world, Bombardier Transportation is the global leader in the rail equipment manufacturing and servicing industry. Its wide range of products includes passenger rail vehicles and total transit systems. It also manufactures locomotives, bogies, propulsion & controls and provides rail control solutions. Bombardier Transportation's revenues for the fiscal year ended January 31, 2006 amount to $ 6.7 billion US. It is a unit of Bombardier Inc., a global corporation based in Canada, world-leading manufacturer of innovative transportation solutions, from regional aircraft and business jets to rail transportation equipment. Bombardier Inc.'s revenues for the fiscal year ended January 31, 2006 totalled $ 14.7 billion US and its shares are traded on the Toronto Stock Exchange (BBD). News and information are available at www.bombardier.com

Details on the LCA and EPD approach followed are given in the document "PCR for Locomotives" available at www.transport.bombardier.com/about_us/sustainable_mobility

PCR review was conducted by

Review panel:
Dr. Eva Schmincke (chair)
Dr. Ralf Utermöhlen, AGIMUS
Dipl.-Ing. Jürgen Schmallenbach, INUTEC
and two operator's representatives

Dr. Schmincke can be contacted through Bombardier Transportation, Group HSE, hse@de.transport.bombardier.com

Independent verification of the declaration and data, in accordance with ISO 14025:2006

❑ Internal ☒ External (following EMAS requirements)

Dipl.-Ing. Jürgen Schmallenbach, EMAS verifier D-V-0036, c/o INUTEC Engineering & Management GmbH, Schillerstrasse 1/5, D-89077 Ulm

Validated information in accordance with EMAS (Regulation EC 761/2001)

This is to confirm that due to the performed verification of the data and information presented herein, the statements of this product declaration of the locomotive TRAXX F140 MS are accurate, reliable, and non deceptive. The relevant environmental issues are taken into consideration adequately. This Environmental Product Declaration provides an extension and a more detailed description of the environmental declaration of the Bombardier Kassel site with a special focus on product related information. Reported product and manufacturing data are representative of the overall environmental performance of Bombardier Transportation, Locomotives Division. Further applicable documents are the EMAS statements of the sites Mannheim, Siegen, and Wroclaw* which are also registered under EMAS.

This EPD will need revalidation at the latest 01.09.2009.

Mannheim, 01.09.2006

Dipl.-Ing. Jürgen Schmallenbach
(Environmental Verifier D-V-0036)
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* at the time of printing, the statement was only available as draft, and the site had not been registered

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