EPD®

Metropolitana di Roma Linea C

Environmental Product Declaration

Rev. 0 - Date: 04/05/2011

Approval date: 26/05/2011

Registration N. S-P-00276

UN CPC Code 495

AnsaldoBreda

A Finmeccanica Company

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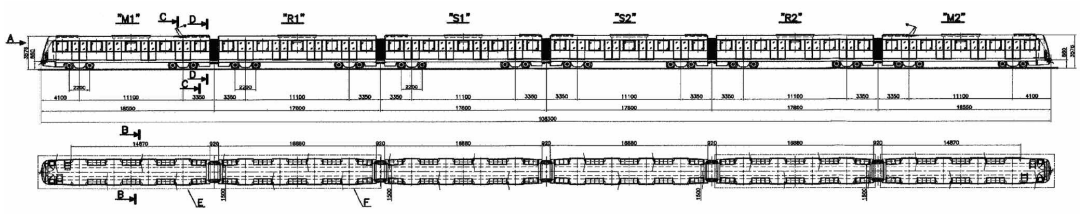
The Company

AnsaldoBreda S.p.A. is a company specialized in the production of rail vehicles and is part of Finmeccanica Group.
AnsaldoBreda S.p.A. rises from the merger of Ansaldo Trasporti and Breda Costruzioni Ferroviarie in 2001. Both previous companies already were the most important heirs of historical Italian tradition in the field of electric transport, both being set up in the second half of the nineteenth century.
Today AnsaldoBreda S.p.A. is organized in four Plants in Italy: Napoli, Pistoia, Reggio Calabria and Palermo. Furthermore, it can rely on some operating plants abroad, achieving an overall number of about 2,400 employees.
Metro Roma C is produced in Napoli, where the body components are built, and in Reggio Calabria, where the carpentry, painting and assembly operations are performed.

The Product

Metro Roma C is an urban metro designed for passengers transport. Train configuration is showed in the following figure.



Metro Roma C consists of six carbodies with five articulations. The traction is supplied by sixteen electric engines, coupled on eight of the twelve bogies; the other four trucks are only trailers.

Management system and safety train

The train, through configuration's selectors, can select 4 different modes of operation:

- AUTO: all transactions are handled automatically, and it's not required the presence of the driver. The security system is maintained by ATP
- ATO+ATP: the gait is automatic, but the door closing is made by the driver
- ATP: the gait is manual, but ATP system security is active
- ATC-bypass: the gait is manual, without the control ATP Safety

The train is equipped with a system of safety and operability of the vehicle ATC which includes:
- ATO: manages the vehicle and the management of the station stops
- ATP: ensures the operating vehicle safely
- ATS: collects diagnostic information on the vehicle and directs the activities of solution failures

Health protection

The use of materials that can cause allergic reactions is absolutely excluded in the train.

Technical information

Dimensions	
• Length	109.8 m (to coupler)
• Width	2.85 m (external)
• Height from railway plane	3.64 m
Net weight	192,886 kg
Weight with different loads	
• L1	245,311 kg - All seats filled + 3 passengers per m²
• L2	257,911 kg - All seats filled + 4 passengers per m²
• L3	283,186 kg - All seats filled + 6 passengers per m²
Maximum speed	90 Km/h
Maximum number of passengers	1,204 whereof:
• seat	194
• standing	1,010
Power supply	Electric
Line voltage range	1000÷1800 V
Available power	187 kW x 16 = 2,992 kW

L3 is the configuration used for environmental impacts assessment.
Following table shows distribution of materials which the Metro is made of.

Product group	Materials (kg) vehicle							
	Metals	Polymers no elastomers	Elastomers	Glass	Fluids	MONM	Other	Total
1 - Carbody	36,944	336	630	12	4	-	47	37,973
2 - Interior, windows and doors	21,048	786	2,308	3,542	74	2,604	2,307	32,670
3 - Bogies and running gears	81,484	28	3,371	37	124	19	242	85,304
4 - Propulsion and electric equipment	24,594	2,133	1,662	233	1,342	-	1,937	31,900
5 - Comfort systems	4,752	86	81	-	106	-	16	5,040
Total	*168,822*	*3,368*	*8,053*	*3,823*	*1,649*	*2,623*	*4,548*	*192,886*
	87.5%	*1.7%*	*4.2%*	*2.0%*	*0.9%*	*1.4%*	*2.4%*	*100.0%*

MONM = Modified Organic Natural Materials (i.e. leather. wood. cardboard. etc.)

Following table shows distribution of materials which Metro Roma C is made of, referred to the functional unit.

Product group	Materials (g) U.F.							
	Metals	Polymers no elastomers	Elastomers	Glass	Fluids	MONM	Other	Total
1 - Carbody	0.6127	0.0056	0.0105	0.0002	0.0001	-	0.0008	0.6298
2 - Interior, windows and doors	0.3491	0.0130	0.0383	0.0587	0.0012	0.0432	0.0383	0.5418
3 - Bogies and running gears	1.3514	0.0005	0.0559	0.0006	0.0021	0.0003	0.0040	1.4147
4 - Propulsion and electric equipment	0.4079	0.0354	0.0276	0.0039	0.0222	-	0.0321	0.5290
5 - Comfort systems	0.0788	0.0014	0.0013	-	0.0018	-	0.0003	0.0836
Total	*2.7998*	*0.0559*	*0.1336*	*0.0634*	*0.0273*	*0.0435*	*0.0754*	*3.1989*
	87.5%	*1.7%*	*4.2%*	*2.0%*	*0.9%*	*1.4%*	*2.4%*	*100.0%*

MONM = Modified Organic Natural Materials (i.e. leather. wood. cardboard. etc.)

Following regulated hazardous material are included inside the products that constitute the Metro:

Hazardous materials	kg	Where
Cadmium	386	Battery
Lubricants/oil/grease	168	Coupler, brakes, electric engines, HVAC
Gas refrigerants	70	HVAC
Nickel	524	Electric equipment

The Metro doesn't contain SVHC (Substances of Very High Concern) as defined by the Regulation 1907/2006/EC (REACh).

Environmental Performance Declaration

Methodology

The environmental performance of the considered product has been quantified by Life Cycle Assessment (LCA) approach in accordance with ISO 14040 and ISO 14044. Data used for the study refers to years 2009 for Napoli site plant and 2008 for Reggio Calabria. Specific and generic data fulfil General Program Instruction criteria for EPD as well as PCR for preparing EPD for rail vehicle. Contribution given by generic data is less than 1% of the total. The use phase has been modelled using simulating computation that takes into account following issues:

- Maximum speed
- Average speed (commercial)
- Average slope of the run
- Maximum acceleration on horizontal rectilinear railway step
- Jerk in traction
- Maximum deceleration on horizontal rectilinear railway step
- Deceleration normally used for station stop
- Jerk in deceleration
- Normal load
- Length of the route
- Number of station along the run and distance between one station and the next one
- Average number of runs per day and year

The model adopted is coherent with "*Specification and verification of energy consumption for railway rolling stock - Railenergy WP 2.2: Input to future UIC/UNIFE Technical Recommendation*" (EC contract N. FP6-031458).
In calculation, the mission of the Metro Roma C municipality has been used as specific route.
Following assumption has been taken:

• Route length (round trip)	49.357 km
• Life span of the Metro	30 years
• Maximum number of Metros in exercise on the route	30
• Number of passengers	1,204 (L3)
• Load factor	6.2 (L3)

- Different runs frequency for weekdays and holydays

Italian electricity energy mix for the use phase has been assumed (Boustead Model database).
Boustead Model database has been used for all processes and basic materials production with the exception of waste treatment processes and electronic parts production which Ecoinvent database has been used for.

Functional Unit

According to relating PCR, the functional unit is the transport of **1 passenger for 100 km.**

System boundaries

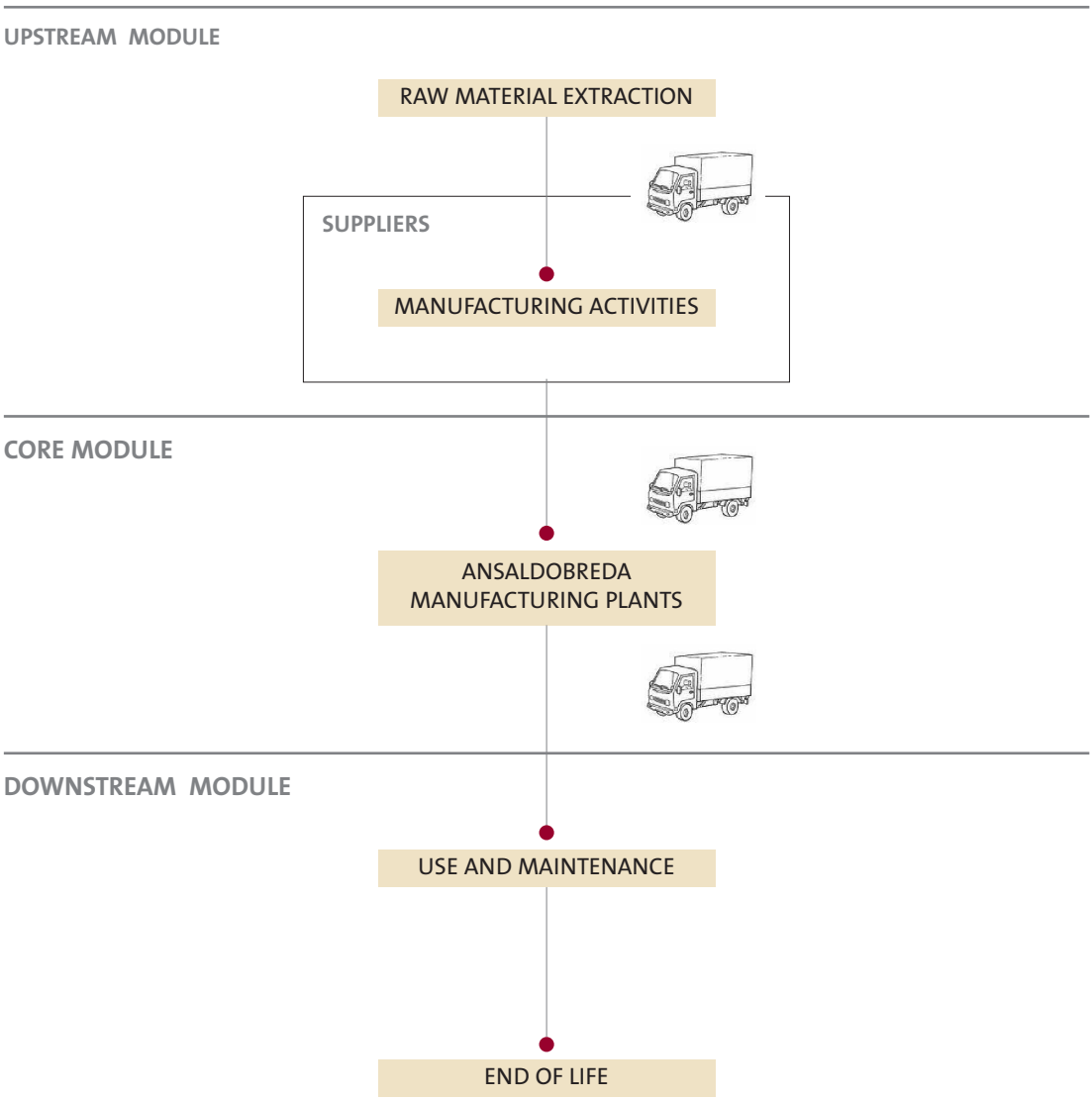


Figure 1 – System boundaries. All main module from the extraction of natural resources to the end of life are included

The considered System is split into three phases according to the following hypothesis.

Upstream Module

- Extraction and production of raw and basic materials
- Electricity, heat, steam and fuel production
- Production of auxiliary materials for rail vehicle assembly/manufacturing
- Production of maintenance materials and spare parts
- Transportation of products from supplier's manufacturing facilities to rail vehicle AnsaldoBreda plants
- Generation and treatment of waste for included upstream processes

Core Module

- Electricity, heat, steam, fuel and auxiliary material used for rail vehicle assembly/manufacturing
- Transportation of the rail vehicle to the customer (Rome) via truck
- Generation and treatment of waste for included core processes

Downstream Module

- Electricity consumption for rail vehicle operation
- Consumption of maintenance materials and spare parts
- Waste from maintenance materials and spare parts
- Direct disposal of materials
- Incineration of materials with no energy recovery

Exclusions (Cut off)

Following operations of downstream module have not been taken into account because their contribution to each impact category is less than 1% of the total environmental impact:

- Rail vehicle dismantling
- Building, maintenance, dismantling and disposal of rail vehicle disassembly and waste treatment facilities
- Transport of spare parts from supplier plants to maintenance site

Environmental Results

Resources used for Energy conversion processes

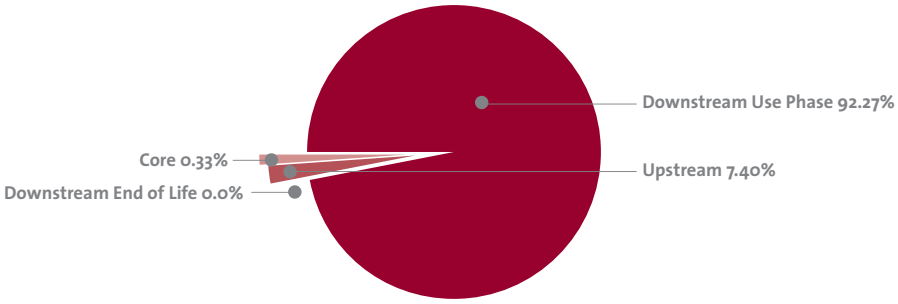
Non renewable resources data for transport of 1 passenger for 100 km	Life Cycle Modules				Total life cycle
	Upstream	Core	Downstream		
			Use phase	End of life	
(kg)					
Crude Oil	0.0030485	0.0004387	0.1245350	0.0000003	0.1280225
Natural gas	0.0025279	0.0004988	0.1058800	-	0.1089068
Coal	0.0113546	0.0001750	0.0699901	-	0.0815198
Lignite	0.0003629	-	-	-	0.0003629
Others	0.0000210	-	-	-	0.0000210
Total	*0.0173149*	*0.0011125*	*0.3004051*	*0.0000003*	*0.3188330*
(MJ)					
Crude oil	0.2726189	0.0197823	5.6046319	0.0000133	5.8970464
Natural gas	0.2610772	0.0264857	5.5755631	0.0000010	5.8631270
Coal	0.6136620	0.0050461	2.0158924	0.0000001	2.6346006
Lignite	0.0070798	-	0.0000005	0.0000001	0.0070804
Uranium	0.0607876	0.0037047	1.4965908	-	1.5610831
Others	-	0.0002062	0.0853836	-	0.0855898
Total	*1.2152256*	*0.0552250*	*14.7780623*	*0.0000144*	*16.0485272*

Renewable resources data for transport of 1 passenger for 100 km	Life Cycle Modules				Total life cycle
	Upstream	Core	Downstream		
			Use phase	End of life	
(kg)					
Natural rubber	0.0002109	-	-	-	0.0002109
Biomass (including water)	0.0000915	0.0000215	0.0088316	-	0.0089445
Other	0.0000077	-	-	-	0.0000077
Total	*0.0003101*	*0.0000215*	*0.0088316*	-	*0.0091630*
(MJ)					
Hydropower	0.1040591	0.0039330	1.6197853	0.0000002	1.7277776
Biomass	0.0008060	0.0001905	0.0783739	-	0.0793704
Wind power	0.0000732	0.0000222	0.0090542	-	0.0091495
Solar energy	0.0000006	0.0000354	0.0145946	-	0.0146305
Geothermic	0.0000003	0.0000005	0.0001722	-	0.0001729
Others	0.0031215	0.0000163	0.0005021	-	0.0036400
Total	*0.1080607*	*0.0041979*	*1.7224822*	*0.0000002*	*1.8347409*

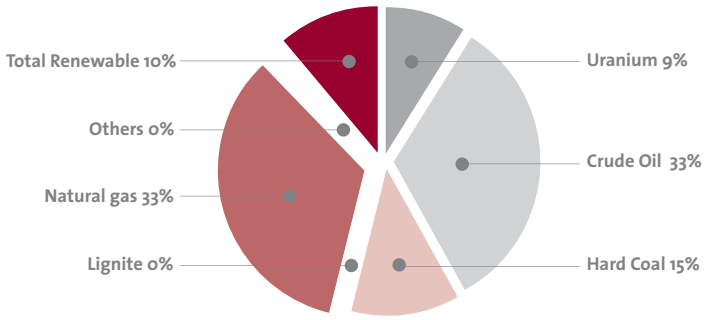
Material resources

Renewable resources data for transport of 1 passenger for 100 km	Life Cycle Modules				Total life cycle
	Upstream	Core	Downstream		
			Use phase	End of life	
(kg)					
Wood	0.0007432	0.0000017	-	-	0.0007449
Non Renewable resources					
(kg)					
Bauxite	0.0052054	-	0.0000002	-	0.0052056
Fe	0.0169884	0.0000050	0.0000470	-	0.0170405
Limestone ($CaCO_3$)	0.0053747	0.0000011	0.0000098	-	0.0053856
Sand	0.0019486	-	-	-	0.0019486
Cu	0.0027472	-	-	-	0.0027472
Others	0.0065310	0.0056018	0.0055970	-	0.0177298
Total	*0.0397293*	*0.0056128*	*0.0056540*	-	*0.0509961*

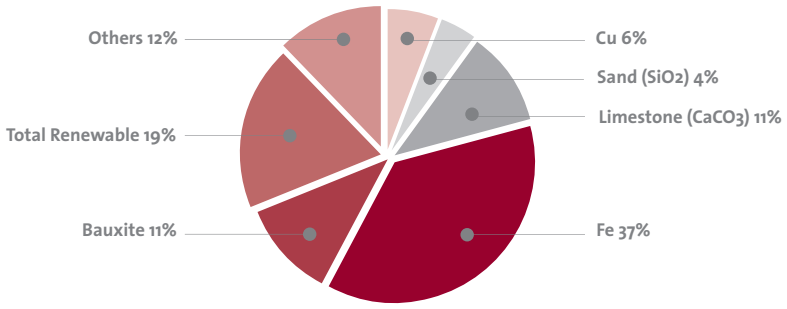
ENERGY CONSUMPTION



ENERGY RESOURCES SHARING



RAW MATERIAL SHARING



TOTAL CONSUMPTION	Life Cycle Modules				Total life cycle
	Upstream	Core	Downstream		
			Use phase	End of life	
Energy (MJ)	1.3232862	0.0594229	16.5005445	0.0000146	17.8832681
Raw materials (kg)	0.0381714	0.0000473	0.0088959	-	0.0471145

WASTES data for transport of 1 passenger for 100 km	Life Cycle Modules				Total life cycle
	Upstream	Core	Downstream		
			Use phase	End of life	
Hazardous (kg)	0.0000898	0.0000083	0.0017396	0.0000663	0.0019040
Non hazardous (kg)	0.3555656	0.0007414	0.0178013	0.0000721	0.3741804
Total (kg)	***0.3556554***	***0.0007497***	***0.0195409***	***0.0001385***	***0.3760844***

Other information data for transport of 1 passenger for 100 km	Life Cycle Modules				Total life cycle
	Upstream	Core	Downstream		
			Use phase	End of life	
Water use (l)	7.2974693	0.0324693	0.1721998	0.0000001	7.5021384
Electricity consumption manufacturing (kWh)	0.0469240	0.0035950	1.4808376	-	1.5313565
Use of recycled resources (kg)	0.0000020	-	-	-	0.0000020

Pollutant emissions expressed in terms of potential environmental impacts

ENVIRONMENTAL IMPACTS data for transport of 1 passenger for 100 km	Life Cycle Modules				Total life cycle
	Upstream	Core	Downstream		
			Use phase	End of life	
GWP (kg CO2eq)	0.0935878	0.0038366	1.0263203	0.0000357	1.1237803
ODP (kg CFC-11eq)	-	-	-	-	-
AP (kg SO2eq)	0.0010317	0.0000296	0.0102799	-	0.0113412
EP (kg PO4eq)	0.0001122	0.0000018	0.0003801	-	0.0004940
POCP (kg C2H4eq)	0.0000717	0.0000018	0.0005544	-	0.0006279

Additional Information

Metro Energy Consumption

Under the hypothesis assumed in the simulation, Metro Roma C electricity consumption is of 17.83 kWh/km. In order to evaluate environmental impact due to downstream use phase Italian electric mix has been adopted. Number of passengers used in the calculation corresponds to 1,204. The load factor is 6.2 (L3).

Noise emissions

Apart from wheels, among the main sources of noise and vibrations systems installed on board are the following: HVAC, air compression circuit, traction engine, reducer, auxiliary converter, traction converters, compressed air system, trumpets.
Following table represents active noise sources in different operating conditions of the train.

	INDOOR NOISE Operating conditions		
	Stationary conditions	V max Open field	V max Tunnel
Noise caused by interaction between wheels and bogie	OFF	ON	ON
Noise caused by interaction between wheels and rail	OFF	ON	ON
Auxiliary equipment			
HVAC	ON	ON	ON
Engine and reducer	OFF	ON	ON
Compressor	ON	ON	ON
Traction converter	OFF	ON	ON
Auxiliary converter	ON	ON	ON

The noise analysis that was conducted on the vehicle according to ISO 3095 and ISO 3381 has reported the following results:

- Indoor noise (open field) measured in the centre of the compartment:
  - In stationary conditions with all auxiliary systems on: $L_pA_{eq}T \leq 69$ dB(A)
  - Speed of 80 km/h: $L_pA_{eq}T \leq 74$ dB(A)
- Outdoor noise (open field) measured at 7.5 m from the centre of the track:
  - In stationary conditions with all auxiliary systems on: $L_pA_{eq}T \leq 70$ dB(A)
  - Speed of 80 km/h: $L_pA_{eq}T \leq 84$ dB(A)

Acceleration sound pressure level will be measured within 1 month from the commissioning.

Potential recyclability and recoverability

	Recovery		Undefined residue
Reuse (Component Parts) 0	Recycling (Materials) 449,009.61 kg	Energy recovery (Materials) 22,378.43 kg	Waste (Materials) 43,248.9 kg
Recyclability rate 87.2%			
Recoverability rate 91.6%			
Vehicle mass 192,886 kg			

	Recyclability	Recoverability
End of life	91.2%	94.7%
Maintenance	84.9%	89.7%
Total life cycle	*87.2%*	*91.6%*

Lower recyclability percentage for spare parts substitution during maintenance activity is mostly due to the fact that brake pads are assumed to be not recyclable.

Environmental Philosophy of the Company

AnsaldoBreda S.p.A has developed and certified environmental (ISO 14001) and health and safety (OHSAS 18001) management systems.

AnsaldoBreda recognises as its strategic objectives:
- customer needs fulfilment, both on the product and service point of view
- the health and safety of its employees
- the safety, reliability and quality of its products

Glossary

Acidification Potential (AP). Phenomenon by which atmospheric rainfall has a pH which is lower than average. This may cause damage in forests and cultivated fields, as well as in water ecosystems and objects in general. This phenomenon is due to the emissions of SO_2, of NO_x, and NH_3, which are included in the Acidification Potential (AP) index expressed in masses of SO_2 produced.

ATC. Automatic Train Control

ATO. Automatic Train Operation

ATP. Automatic Train Protection

ATS. Automatic Train Supervision

Eutrophication Potential (EP). Enrichment of the watercourses by the addition of nutrients. This causes imbalance in water ecosystems due to the overdevelopment encouraged by the excessive presence of nourishing substances. In particular, the Eutrophication Potential (EP) includes phosphorous and nitrogen salts and it is expressed in grams of oxygen (kg O_2).

Global Warming Potential (GWP). Phenomenon by which the infrared rays emitted by the earth's surface are absorbed by the molecules in the atmosphere as a result of solar warming and then re-emitted in the form of heat, thus giving rise to a process of global warming of the atmosphere. The indicator used for this purpose is GWP (Global Warming Potential), that includes the emissions of carbon dioxide, the main greenhouse gas, as well as other gases like methane (CH_4), nitrogen protoxide (N_2O), chlorofluorocarbons (CFC), which are expressed according to the degree of absorption of CO_2 (kg CO_2).

HVAC. Heating, Ventilating, and Air Conditioning.

MONM.Modified Organic Natural Materials.

Ozone Depletion Potential (ODP). Degradation and depletion of the ozone layer in the stratosphere, which has the property of blocking the ultraviolet components of sunlight thanks to its particularly reactive compounds, originated by chlorofluorocarbons (CFC) or by chlorofluoromethanes (CFM). The substance used as a point of reference for assessing the ODP (Ozone Depletion Potential) is trichlorofluoromethane, or CFC-11.

Photochemical Ozone Creation Potential (POCP). Production of compounds which by the action of light are capable of encouraging an oxidising reaction leading to the production of ozone in the troposphere. The indicator POCP (Photochemical Ozone Creation Potential) includes especially VOC (volatile organic compounds) and is expressed in grams of ethylene (kg C_2H_4).

SVHC. Substances of Very High Concern.

- Life cycle assessment of Metro Roma C - Final report, Altran Italia and AnsaldoBreda S.p.A., April 2011
- AA071YE Rev 01 - Piattaforma Metropolitana di Roma Linea C. Simulazione di tratta - 21/04/2010
- Product Category Rules (PCR 2009:05) for preparing an Environmental Product Declaration (EPD) for rail vehicles - UNCPC CODE: 495
- General Programme Instructions For Environmental Product Declarations, EPD, Version 1.0, 2008-02-29
- ISO 22628:2002
- EN 15380:2006
- EN 12663:2000
- Boustead Model 5.0 and Ecoinvent databases and suppliers for data used for calculation including database required by the PCR
- (1) Reference laws about hazardous substances
  - Regulation 1907/2006 "REACh" (Annex XVII)
  - Directive 94/62/EC on packaging and packaging waste and subsequent updates
  - Regulation (CE) 1005/2009 on ozone depletion substances
  - RoHS Directive 2002/95/CE
  - Regulation (CE) n. 648/2004
  - Directive 2002/72/CE
  - Directive 2001/41/CE
  - Directive 67/548/CEE

PCR review was conducted by: Sara Paulsson

Independent verification of the declaration and data, according to ISO 14025:
☐ Internal x External

Third party verifier:
RINA Services S.p.A. - Via Corsica 12, I - 16128 Genova (Italy)
Tel: +39.010.53851 - Fax: +39.010.5351000 - www.rina.org
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For further information refer to www.environdec.com

Please note that EPDs within the same product category but from different programmes may not be comparable.

AnsaldoBreda S.p.A.

Via Ciliegiole, 110b | 51100 Pistoia | Italy (IT)
Tel +39 0573 3701 | Fax + 39 0573 370616

Via Argine, 425 | 80147 Napoli | Italy (IT)
Tel. +39 081 2431111 | Fax +39 081 2432698

Reference Contact Person
Davide Bonaffini | Tel +39 0573 370773
bonaffini.davide@ansaldobreda.it

Technical consulting
ALTRAN Italia | Via Goito, 52
00185 Roma | Italy (IT)
daniele.pace@altran.it

Graphic designer
Francesca Dantini

Printed on CYCLUS OFFSET
100% recycled paper

AnsaldoBreda
A Finmeccanica Company