Rail

SOLUTION GUIDE

Edition 1/19, valid from 10/2019

A Rolls-Royce solution

CONTENTS

PIONEERING THE POWER THAT MATTERS

Rolls-Royce provides world-class power solutions and complete life-cycle support under our product and solution brand MTU. Through digitalization and electrification, we strive to develop drive and power generation solutions that are even cleaner and smarter and thus provide answers to the challenges posed by the rapidly growing societal demands for energy and mobility. We deliver and service comprehensive, powerful and reliable systems, based on both gas and diesel engines, as well as electrified hybrid systems. These clean and technologically-advanced solutions serve our customers in the marine and infrastructure sectors worldwide.

A solution provider

MTU systems power the largest yachts, the strongest tugboats and the biggest land vehicles and provide energy for the world's most important mission-critical applications. Through advanced solutions such as microgrids, we integrate renewable energies and manage the power needs of our customers.

Our customized service offerings help you maximize uptime and performance and are supported by our digital solutions, which enable remote monitoring, predictive maintenance and a range of other benefits that keep your systems running at their best.

For over 110 years, we have provided innovative power solutions for our customers – meeting even the most demanding drive requirements. Our products and services span a wide range of applications and power needs, with both standard and customized options.

An expert in technology

As part of Rolls-Royce, we have long been known for cutting-edge innovation and technological leadership in product development. That same spirit of innovation inspires our sustainability efforts. Our focus is on developing and implementing system solutions that both maximize efficiency and reduce emissions -- which in turn work to reduce our impact on the environment.

A passionate and reliable partner

We at Rolls-Royce spend every day working together with our customers, to deliver engines, systems and complete life-cycle solutions that best fit your needs. We understand that each application is different and has its own specific demands. Our engineers embrace the challenge of finding the perfect solution for your unique power requirements. Every step of the way – from project planning, through design, delivery and commissioning; to the lifetime care of your equipment – we are dedicated to helping you get the most from your MTU investment.

1

2

3

1 ISO 9001

2 ISO 14001

3 UIC

GENERAL SPECIFICATIONS

Four-stroke diesel engine for traction

- Direct injection
- Liquid-cooled
- V or In-line configuration
- Suitable for mechanical, hydrodynamic, hydrostatic and electric power transmission

Power Definition

All power ratings are service standard power in accordance with UIC specifications.

Ambient air pressure:	1000 mbar
Height above sea level:	100 m
Intake air temperature:	25 °C
Charge-air coolant temp.:	45 °C

Fuel consumption in accordance with DIN/ISO 3046

Exhaust emission standards

EU = EU Nonroad Directive 97/68 EC (as amended by 2010/26/EC)
EPA = US Regulation 40 CFR 9,85
UIC = International Railway Association

Please note, specifications are subject to change without further notice. All dimensions are approximate, more detailed information is included within installation drawings.

For further information on our rail products please contact your distributor or visit: www.mtu-solutions.com

EXPLANATION OF THE ENGINE DESIGNATION

Series 1800, 1600, 2000, 4000 – Example

16 V 4000 R 4 3 L

- Additional engine features
- Design index
- Application/power segment
- Application: R = Rail
- Series
- Cylinder configuration: V = V-engine, H = Horizontal In-line engine
- No. of cylinders

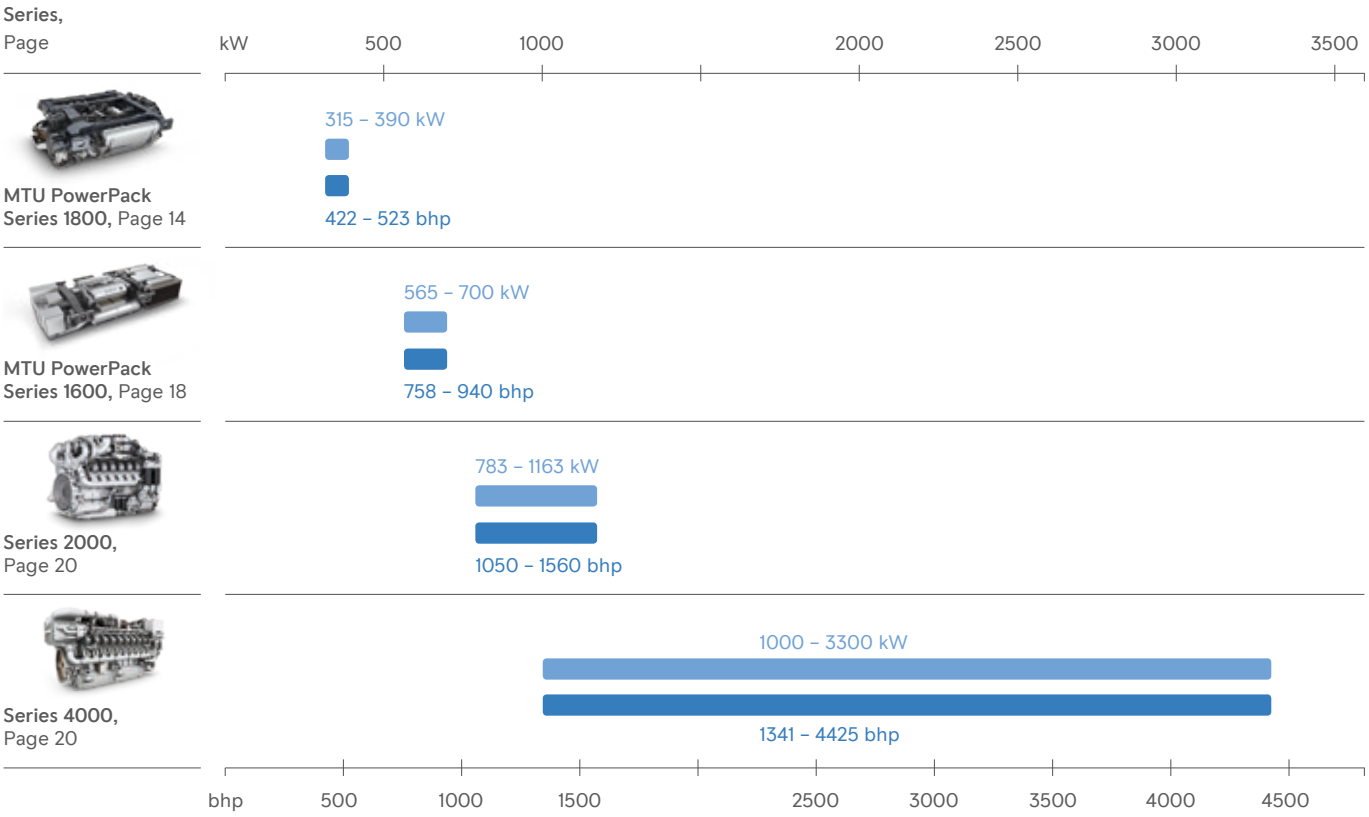
Additional engine features	
Power uprated	L
Speed/power reduced	R
MTU PowerPack	P

PowerPacks and Engines

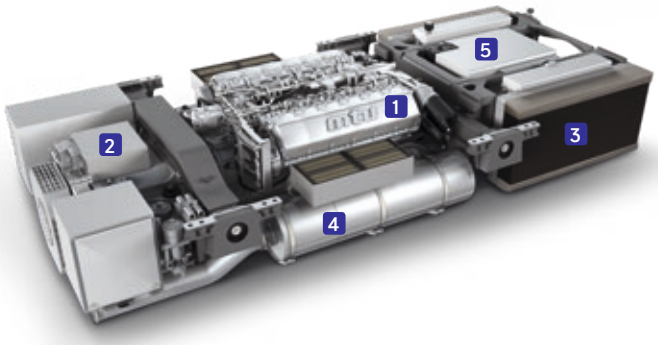
ALL ENGINES AT A GLANCE.

Railcars	315 kW - 700 kW	Page
MTU PowerPacks for railcars - underfloor/roof installation		10 - 19

Push-pull trains/locomotives	783 kW - 3300 kW	Page
Engines for push-pull trains and locomotives		20 - 31



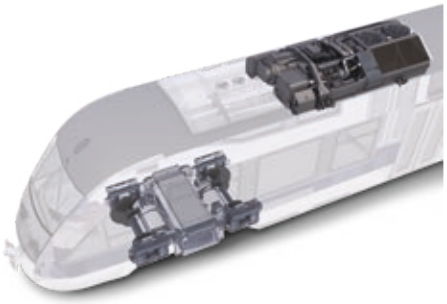
POWERPACKS FOR RAILCARS



MTU PowerPack –
the highly compact, highly integrated solution.
Representation of a diesel-electric MTU PowerPack 12V 1600 with SCR technology (EU Stage IIIB). We have developed a series of individualized solutions involving a range of different frames and will use our extensive experience to find the appropriate solution to suit the requirements of any specific vehicle.

Standard scope of supply		
1 Engine	6H 1800	
	12V 1600	
2 Power transmission		
Transmission	ZF 6 AP 2000R	Voith T211
	ZF 6 AP 2500R	Voith T212
Traction alternator	Permanent magnet synchronous generator	
	External excited synchronous generator	
	Asynchronous generator	
3 Cooling system	Underfloor or roof installation	
	Hydraulic or electrical fan drive	
4 Exhaust system	EU Stage IIIA compl. – exhaust silencer	
	EU Stage IIIB – SCR exhaust aftertreatment system	

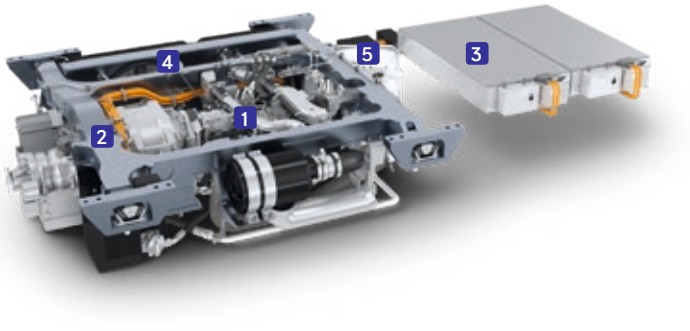
Additional scope of supply		
5 On-board power generation	28V/DC	3P~AC 50 Hz
	110V/DC	3P~AC 60 Hz
Air compressor		
Air conditioning comp.		
Preheating		
CaPos smart edition		
SafeMon		
Autom. oil replenishment		



Roof mounting

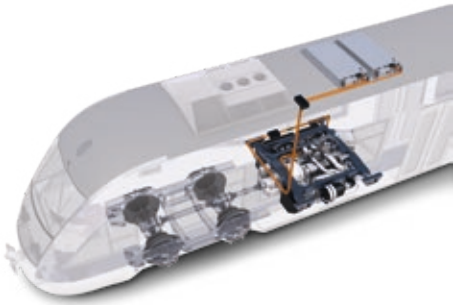
Underfloor mounting

HYBRID POWERPACKS FOR RAILCARS

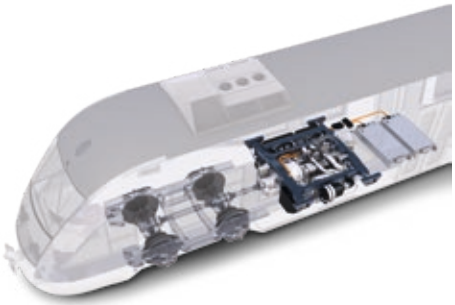


Hybrid PowerPack –
the next generation of railcar drive systems.
Representation of a Hybrid PowerPack 6H 1800 with two MTU EnergyPacks and SCR technology (EU Stage IIIB). A proven hybrid drive system, ready for commercial operation: our modular platform offers customizable drive solutions that can be combined to ensure maximum efficiency, flexibility and sustainability.

Standard scope of supply	
1 Engine	6H 1800
	12V 1600
2 Power transmission	
Traction alternator	Diesel mechanical (ZF 6 AP 2500R and MTU electrical drive 200 (200 kWmech.))
	Diesel electrical (370 kVA electrical drive)
3 Battery system	
MTU EnergyPack	
15M1P	30.6 kWh
15M2P	61.2 kWh
15M3P	91.8 kWh
15M4P	122.4 kWh
4 Cooling system	EU Stage IIIA compl. – exhaust silencer
	EU Stage IIIB – SCR exhaust aftertreatment system
5 Exhaust system	EU Stage IIIA compl. – exhaust silencer
	EU Stage IIIB – SCR exhaust aftertreatment system



Roof mounting of MTU EnergyPacks



Underfloor mounting of MTU EnergyPacks

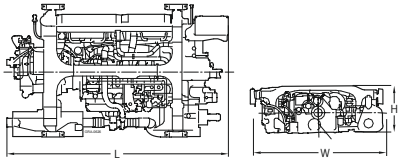
PowerPacks for railcars

UNDERFLOOR AND ROOF INSTALLATION

© Federico Santagati

– For underfloor installation
– Horizontally mounted inline engines

315 KW – 390 KW (422 BHP - 523 BHP)



Dimensions: PowerPacks with standard equipment

PowerPack model		6H 1800 R81P	6H 1800 R82P	6H 1800 R83P	6H 1800 R82P
Rated power	kW (bhp)	315 (422)	335 (449)	360 (483)	390 (523)
Speed	rpm	1800	1800	1800	1800
Exhaust emissions		EU Stage IIIA compl./EPA Tier3 compl.	EU Stage IIIA compl./EPA Tier3 compl.	EU Stage IIIA compl./EPA Tier3 compl.	EU Stage IIIA compl./EPA Tier3 compl.
Fuel consumption at rated power	g/kWh	214	212	212	216
	l/h (gal/h)	81.2 (21.5)	85.6 (22.6)	92.0 (24.3)	101.5 (26.8)
at best point	g/kWh	198	198	198	198
Drive systems [1]		DM/DH/DE	DM/DH/DE	DM/DH/DE	DM/DH/DE
PowerPack – dimensions & masses					
Length (L) [2]	mm (in)	2600 - 4000 (102.4 - 157.5)	2600 - 4000 (102.4 - 157.5)	2600 - 4000 (102.4 - 157.5)	2600 - 4000 (102.4 - 157.5)
Width (W) [2]	mm (in)	2100 - 2800 (82.7 - 110.2)	2100 - 2800 (82.7 - 110.2)	2100 - 2800 (82.7 - 110.2)	2100 - 2800 (82.7 - 110.2)
Height (H) [2]	mm (in)	770 - 850 (30.3 - 33.5)	770 - 850 (30.3 - 33.5)	770 - 850 (30.3 - 33.5)	770 - 850 (30.3 - 33.5)
Mass, dry [2]	kg (lbs)	2900 - 4000 (6393 - 8819)	2900 - 4000 (6393 - 8819)	2900 - 4000 (6393 - 8819)	2900 - 4000 (6393 - 8819)
Mass, wet [2]	kg (lbs)	3050 - 4200 (6724 - 9259)	3050 - 4200 (6724 - 9259)	3050 - 4200 (6724 - 9259)	3050 - 4200 (6724 - 9259)
Engine main data					
No. of cylinders/arrangement		6/inline	6/inline	6/inline	6/inline
Bore/Stroke	mm (in)	128/166 (5.0/6.5)	128/166 (5.0/6.5)	128/166 (5.0/6.5)	128/166 (5.0/6.5)
Displacement/cyl.	l (cu in)	2.14 (130)	2.14 (130)	2.14 (130)	2.14 (130)
Displacement, total	l (cu in)	12.8 (782)	12.8 (782)	12.8 (782)	12.8 (782)

1) Drive systems: DM = diesel mechanical; DH = diesel hydraulic; DE = diesel electrical

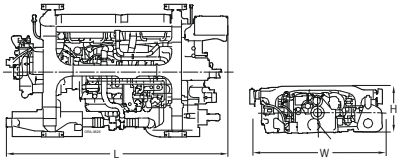
2) Depending on scope of supply
Further variations on demand

PowerPacks for railcars

UNDERFLOOR AND ROOF INSTALLATION

– For underfloor installation
– Horizontally mounted inline engines

315 KW – 390 KW (422 BHP - 523 BHP)



Dimensions: PowerPacks with standard equipment

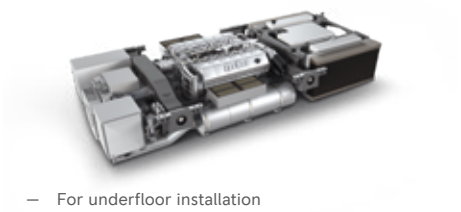
PowerPack model		6H 1800 R75P	6H 1800 R75LP	6H 1800 R85P	6H 1800 R85LP
Rated power	kW (bhp)	315 (422)	335 (449)	360 (483)	390 (523)
Speed	rpm	1800	1800	1800	1800
Exhaust emissions		EU Stage IIIB	EU Stage IIIB	EU Stage IIIB	EU Stage IIIB
Fuel consumption at rated power	g/kWh	198	199	201	207
	l/h (gal/h)	75.1 (19.9)	80.3 (21.2)	87.2 (23.0)	97.3 (25.7)
at best point	g/kWh	184	183	183	183
Drive systems [1]		DM/DH/DE/ Hybrid	DM/DH/DE/ Hybrid	DM/DH/DE/ Hybrid	DM/DH/DE/ Hybrid
PowerPack – dimensions & masses					
Length (L) [2]	mm (in)	2600 - 4000 (102.4 - 157.5)	2600 - 4000 (102.4 - 157.5)	2600 - 4000 (102.4 - 157.5)	2600 - 4000 (102.4 - 157.5)
Width (W) [2]	mm (in)	2100 - 2800 (82.7 - 110.2)	2100 - 2800 (82.7 - 110.2)	2100 - 2800 (82.7 - 110.2)	2100 - 2800 (82.7 - 110.2)
Height (H) [2]	mm (in)	770 - 850 (30.3 - 33.5)	770 - 850 (30.3 - 33.5)	770 - 850 (30.3 - 33.5)	770 - 850 (30.3 - 33.5)
Mass, dry [2]	kg (lbs)	2900 - 4000 (6393 - 8819)	2900 - 4000 (6393 - 8819)	2900 - 4000 (6393 - 8819)	2900 - 4000 (6393 - 8819)
Mass, wet [2]	kg (lbs)	3050 - 4200 (6724 - 9259)	3050 - 4200 (6724 - 9259)	3050 - 4200 (6724 - 9259)	3050 - 4200 (6724 - 9259)
Engine main data					
No. of cylinders/arrangement		6/inline	6/inline	6/inline	6/inline
Bore/Stroke	mm (in)	128/166 (5.0/6.5)	128/166 (5.0/6.5)	128/166 (5.0/6.5)	128/166 (5.0/6.5)
Displacement/cyl.	l (cu in)	2.14 (130)	2.14 (130)	2.14 (130)	2.14 (130)
Displacement, total	l (cu in)	12.8 (782)	12.8 (782)	12.8 (782)	12.8 (782)

1) Drive systems: DM = diesel mechanical; DH = diesel hydraulic; DE = diesel electrical

2) Depending on scope of supply
Further variations on demand

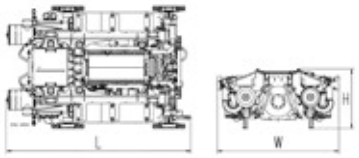
PowerPacks for railcars

UNDERFLOOR INSTALLATION



— For underfloor installation

565 KW – 700 KW (758 BHP - 939 BHP)



Dimensions: PowerPacks with standard equipment

PowerPack model		12V 1600 R70P	12V 1600 R70LP	12V 1600 R80P	12V 1600 R80LP
Rated power	kW (bhp)	565 (758)	625 (838)	660 (885)	700 (939)
Speed	rpm	2100	2100	1900	1900
Exhaust emissions		EU Stage IIIB	EU Stage IIIB	EU Stage IIIB	EU Stage IIIB
Fuel consumption at rated power	g/kWh	207	207	200	200
	l/h (gal/h)	140.9 (37.2)	155.9 (41.2)	159.0 (42.0)	168.7 (44.6)
at best point	g/kWh	190	190	191	191
Drive systems [1]		DM/DH/DE/ Hybrid	DM/DH/DE/ Hybrid	DE/ Hybrid	DE/ Hybrid
PowerPack – dimensions & masses					
Length (L) [2]	mm (in)	3900 - 5000 (153.5 - 196.9)	3900 - 5000 (153.5 - 196.9)	3900 - 5000 (153.5 - 196.9)	3900 - 5000 (153.5 - 196.9)
Width (W) [2]	mm (in)	2100 - 2800 (82.7 - 110.2)	2100 - 2800 (82.7 - 110.2)	2100 - 2800 (82.7 - 110.2)	2100 - 2800 (82.7 - 110.2)
Height (H) [2]	mm (in)	850 - 950 (31.5 - 37.4)	850 - 950 (31.5 - 37.4)	850 - 950 (31.5 - 37.4)	850 - 950 (31.5 - 37.4)
Mass, dry [2]	kg (lbs)	4500 - 6500 (9921 - 14330)	4500 - 6500 (9921 - 14330)	4500 - 6500 (9921 - 14330)	4500 - 6500 (9921 - 14330)
Mass, wet [2]	kg (lbs)	4700 - 6750 (10362 - 14881)	4700 - 6750 (10362 - 14881)	4700 - 6750 (10362 - 14881)	4700 - 6750 (10362 - 14881)
Engine main data No. of cylinders/arrangement		12	12	12	12
Bore/Stroke	mm (in)	122/150 (4.8/5.9)	122/150 (4.8/5.9)	122/150 (4.8/5.9)	122/150 (4.8/5.9)
Displacement/cyl.	l (cu in)	1.75 (107)	1.75 (107)	1.75 (107)	1.75 (107)
Displacement, total	l (cu in)	21.0 (1284)	21.0 (1284)	21.0 (1284)	21.0 (1284)

1) Drive systems: DM = diesel mechanical; DH = diesel hydraulic; DE = diesel electrical

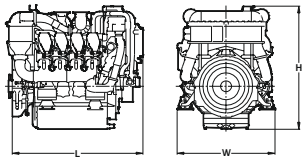
2) Depending on scope of supply
Further variations on demand

Engines

FOR PUSH-PULL TRAINS AND LOCOMOTIVES

— For new locomotives or repowering
— Economical space requirements

783 KW – 1200 KW (1050 BHP - 1609 BHP)



Dimensions: Engines with standard equipment

Engine model		12V 2000 C66R[2]	8V 4000 R43	16V 2000 S96[2]	8V 4000 R43L
Rated power	kW (bhp)	783 (1050)	1000 (1341)	1163 (1560)	1200 (1609)
Speed	rpm	1800	1800	2100	1800
Exhaust emissions		Emission optimized w/o certificate	EU Stage IIIA compliant[1]/ UIC IIIA	Emission optimized w/o certificate	EU Stage IIIA compliant[1]/ UIC IIIA
Fuel consumption at rated power	g/kWh	200	206	209	206
	l/h (gal/h)	–	248.2 (65.6)	–	297.8 (78.7)
at best point	g/kWh	198	194	195	194
Engines – dimensions & masses					
Length (L)	mm (in)	2030 (80)	2000 (78.7)	2370 (94)	2000 (78.7)
Width (W)	mm (in)	1280 (50)	1565 (61.6)	1280 (50)	1565 (61.6)
Height (H)	mm (in)	1460 (57)	1860 (73.2)	1480 (58)	1860 (73.2)
Mass, dry	kg (lbs)	2950 (6500)	5270 (11618)	3350 (7385)	5270 (11618)
Mass, wet	kg (lbs)	3135 (6910)	5610 (12368)	3600 (3935)	5610 (12368)
Engine main data No. of cylinders		12	8	16	8
Bore/Stroke	mm (in)	135/165 (5.3/6.2)	170/210 (6.7/8.3)	135/165 (5.3/6.2)	170/210 (6.7/8.3)
Displacement/cyl.	l (cu in)	2.23 (136)	4.77 (291)	2.23 (136)	4.77 (291)
Displacement, total	l (cu in)	26.8 (1633)	38.1 (2327)	35.7 (2177)	38.1 (2327)

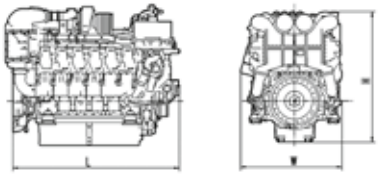
1) EU IIIA type approved, EU IIIA certificate available
2) For rail specific usage please contact your local partner.

Engines

FOR PUSH-PULL TRAINS AND LOCOMOTIVES

- Well differentiated choice of engines spanning wide range of power outputs
- High power-to-weight ratios for lightweight trains

1500 KW – 1800 KW (2012 BHP - 2414 BHP)



Dimensions: Engines with standard equipment

Engine model		12V 4000 R43	12V 4000 R43L
Rated power	kW (bhp)	1500 (2012)	1800 (2414)
Speed	rpm	1800	1800
Exhaust emissions		EU Stage IIIA compliant [1]/ UIC IIIA	EU Stage IIIA compliant [1]/ UIC IIIA
Fuel consumption at rated power	g/kWh	205	210
	l/h (gal/h)	370.5 (97.9)	455.4 (120.3)
at best point	g/kWh	192	190
Engines – dimensions & masses			
Length (L)	mm (in)	2386 (93.9)	2386 (93.9)
Width (W)	mm (in)	1562 (61.5)	1562 (61.5)
Height (H)	mm (in)	2015 (79.3)	2015 (79.3)
Mass, dry	kg (lbs)	6613 (14579)	6613 (14579)
Mass, wet	kg (lbs)	7080 (15609)	7080 (15609)
Engine main data No. of cylinders		12	12
Bore/Stroke	mm (in)	170/210 (6.7/8.3)	170/210 (6.7/8.3)
Displacement/cyl.	l (cu in)	4.77 (291)	4.77 (291)
Displacement, total	l (cu in)	57.2 (3491)	57.2 (3491)

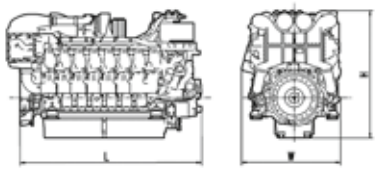
1) EU IIIA type approved, EU IIIA certificate available

Engines

FOR PUSH-PULL TRAINS AND LOCOMOTIVES

- Well differentiated choice of engines spanning wide range of power outputs
- High power-to-weight ratios for lightweight trains
- Meeting emissions regulations EU Stage IIIB

1500 KW – 1800 KW (2012 BHP - 2414 BHP)



Dimensions: Engines with standard equipment

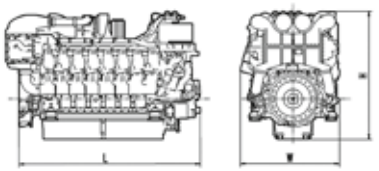
Engine model		12V 4000 R64	12V 4000 R84	12V 4000 R54
Rated power	kW (bhp)	1500 (2012)	1800 (2414)	1800 (2414)
Speed	rpm	1800	1800	1800
Exhaust emissions		EU Stage IIIB	EU Stage IIIB	EPA Tier 3
Fuel consumption at rated power	g/kWh	203	202	199
	l/h (gal/h)	366.9 (96.9)	438.1 (115.7)	431.6 (114.0)
at best point	g/kWh	193	193	195
Engines – dimensions & masses				
Length (L)	mm (in)	2670 (105.1)	2670 (105.1)	2670 (105.1)
Width (W)	mm (in)	1696 (66.8)	1696 (66.8)	1696 (66.8)
Height (H)	mm (in)	2001 (78.8)	2001 (78.8)	2001 (78.8)
Mass, dry	kg (lbs)	7700 (16976)	7700 (16976)	7700 (16976)
Mass, wet	kg (lbs)	8200 (18078)	8200 (18078)	8200 (18078)
Engine main data No. of cylinders		12	12	12
Bore/Stroke	mm (in)	170/210 (6.7/8.3)	170/210 (6.7/8.3)	170/210 (6.7/8.3)
Displacement/cyl.	l (cu in)	4.77 (291)	4.77 (291)	4.77 (291)
Displacement, total	l (cu in)	57.2 (3491)	57.2 (3491)	57.2 (3491)

Engines

FOR PUSH-PULL TRAINS AND LOCOMOTIVES

- Cutting-edge technology with built-in potential
- Uniquely low emissions and consumption
- Market leader in its class for European diesel locomotives

2000 KW – 2400 KW (2682 BHP - 3218 BHP)



Dimensions: Engines with standard equipment

Engine model		16V 4000 R43R	16V 4000 R43	16V 4000 R43L
Rated power	kW (bhp)	2000 (2682)	2200 (2950)	2400 (3218)
Speed	rpm	1800	1800	1800
Exhaust emissions		EU Stage IIIA compliant [1]/ UIC IIIA	EU Stage IIIA compliant [1]/ UIC IIIA	EU Stage IIIA compliant [1]/ UIC IIIA
Fuel consumption at rated power	g/kWh	207	206	205
	l/h (gal/h)	498.8 (131.8)	546.0 (144.3)	592.8 (156.6)
at best point	g/kWh	196	196	196
Engines – dimensions & masses				
Length (L)	mm (in)	2865 (112.8)	2865 (112.8)	2865 (112.8)
Width (W)	mm (in)	1562 (61.5)	1562 (61.5)	1562 (61.5)
Height (H)	mm (in)	2015 (79.3)	2015 (79.3)	2015 (79.3)
Mass, dry	kg (lbs)	7930 (17483)	7930 (17483)	7930 (17483)
Mass, wet	kg (lbs)	8510 (18761)	8510 (18761)	8510 (18761)
Engine main data No. of cylinders		16	16	16
Bore/Stroke	mm (in)	170/210 (6.7/8.3)	170/210 (6.7/8.3)	170/210 (6.7/8.3)
Displacement/cyl.	l (cu in)	4.77 (291)	4.77 (291)	4.77 (291)
Displacement, total	l (cu in)	76.3 (4654)	76.3 (4654)	76.3 (4654)

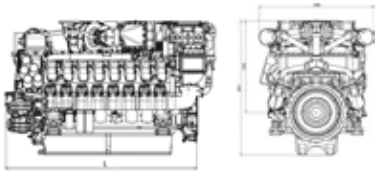
1) EU IIIA type approved, EU IIIA certificate available

Engines

FOR PUSH-PULL TRAINS AND LOCOMOTIVES

- Cutting-edge technology with built-in potential
- Uniquely low emissions and low consumption
- Meeting emissions regulations EU Stage IIIB

2000 KW – 2400 KW (2682 BHP - 3218 BHP)



Dimensions: Engines with standard equipment

Engine model		16V 4000 R64	16V 4000 R74	16V 4000 R84	16V 4000 R54
Rated power	kW (bhp)	2000 (2682)	2200 (2950)	2400 (3218)	2400 (3218)
Speed	rpm	1800	1800	1800	1800
Exhaust emissions		EU Stage IIIB	EU Stage IIIB	EU Stage IIIB	EPA Tier 3
Fuel consumption at rated power	g/kWh	201	202	199	199
	l/h (gal/h)	484.3 (128.0)	535.4 (141.5)	575.4 (152.0)	575.4 (152.0)
at best point	g/kWh	190	190	190	195
Engines – dimensions & masses					
Length (L)	mm (in)	3140 (123.6)	3140 (123.6)	3140 (123.6)	3140 (123.6)
Width (W)	mm (in)	1696 (66.8)	1696 (66.8)	1696 (66.8)	1696 (66.8)
Height (H)	mm (in)	2001 (78.8)	2001 (78.8)	2001 (78.8)	2001 (78.8)
Mass, dry	kg (lbs)	9050 (19952)	9050 (19952)	9050 (19952)	9050 (19952)
Mass, wet	kg (lbs)	9670 (21319)	9670 (21319)	9670 (21319)	9670 (21319)
Engine main data No. of cylinders		16	16	16	16
Bore/Stroke	mm (in)	170/210 (6.7/8.3)	170/210 (6.7/8.3)	170/210 (6.7/8.3)	170/210 (6.7/8.3)
Displacement/cyl.	l (cu in)	4.77 (291)	4.77 (291)	4.77 (291)	4.77 (291)
Displacement, total	l (cu in)	76.3 (4654)	76.3 (4654)	76.3 (4654)	76.3 (4654)

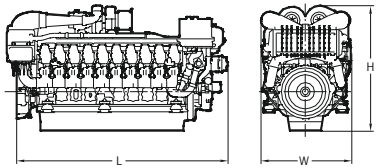
1) EU IIIA type approved, EU IIIA certificate available

Engines

FOR PUSH-PULL TRAINS AND LOCOMOTIVES

– Outstanding power density. Unbeaten power-to-weight ratio
– Up to 3,300 kW for 4-axle locomotives and 6-axle locomotives

2700 KW – 3300 KW (3621 BHP - 4425 BHP)



Dimensions: Engines with standard equipment

Engine model		20V 4000 R43	20V 4000 R63R	20V 4000 R43L	20V 4000 R63	20V 4000 R63L
Rated power	kW (bhp)	2700 (3621)	2700 (3621)	3000 (4023)	3000 (4023)	3300 (4425)
Speed	rpm	1800	1800	1800	1800	1800
Exhaust emissions		EU Stage IIIA compliant [1]/ UIC IIIA	EU Stage IIIA compliant/ UIC IIIA	EU Stage IIIA compliant [1]/ UIC IIIA	EU Stage IIIA compliant/ UIC IIIA	EU Stage IIIA compliant/ UIC IIIA
Fuel consumption at rated power	g/kWh	208	204	210	206	206
	l/h (gal/h)	676.6 (178.8)	663.6 (175.3)	759.0 (200.5)	744.6 (196.7)	819.0 (216.4)
at best point	g/kWh	194	194	194	197	195
Engines – dimensions & masses						
Length (L)	mm (in)	3335 (131.3)	3592 (141.4)	3335 (131.3)	3592 (141.4)	3592 (141.4)
Width (W)	mm (in)	1562 (61.5)	1570 (61.8)	1562 (61.5)	1570 (61.8)	1570 (61.8)
Height (H)	mm (in)	2015 (79.3)	2015 (79.3)	2015 (79.3)	2015 (79.3)	2015 (79.3)
Mass, dry	kg (lbs)	9860 (21738)	10400 (22928)	9860 (21738)	10400 (22928)	10400 (22928)
Mass, wet	kg (lbs)	10520 (23193)	11070 (24405)	10520 (23193)	11070 (24405)	11070 (24405)
Engine main data No. of cylinders		20	20	20	20	20
Bore/Stroke	mm (in)	170/210 (6.7/8.3)	170/210 (6.7/8.3)	170/210 (6.7/8.3)	170/210 (6.7/8.3)	170/210 (6.7/8.3)
Displacement/cyl.	l (cu in)	4.77 (291)	4.77 (291)	4.77 (291)	4.77 (291)	4.77 (291)
Displacement, total	l (cu in)	95.3 (5818)	95.3 (5818)	95.3 (5818)	95.3 (5818)	95.3 (5818)

1) EU IIIA type approved, EU IIIA certificate available

References

DIESEL ENGINES AND POWERPACKS IN RAILCARS/PUSH-PULL TRAINS AND LOCOMOTIVES

High-Speed-Trains and Locomotives

Deutsche Bahn
V290
1 x 1000 kW

CNR
Dalian DL class
1 x 2700 kW

Siemens ER 20D
„EURORUNNER“
1 x 2000 kW

CZ
Loco 2M62
2 x 2200 kW

Siemens/Alstom
BB 475000
1 x 2000 kW

Railcars

Alstom
Lint 54 PowerPack
1-4 x 390 kW
(depending on class)

PESA
Link PowerPack
2 x 390 kW

Hitachi
IEP PowerPack
1-5 x 700 KW
(depending on class)

Bombardier
Turbo Star PowerPack
2 x 390 kW

Rotem
Class 22000 PowerPack
3 x 360 kW

References

DIESEL ENGINES AND POWERPACKS FOR SPECIAL-PURPOSE RAIL VEHICLES

- Individual traction system solutions
- Flexibility in design and installation
- Emissions optimized engines for tunnel operations with particle filter/exhaust catalyst

Remote-controlled shunter

Rotary Snow-Plow

Fire fighting and rescue train

Auxiliary locomotive for tunnel operations

Grinding train

Railroad inspection vehicle

Track layer

Rail crane

Further appplications with MTU system solutions are e.g.:
- Locomotives for underground railways
- Mountain railways

Overhead line inspection railcar

Repowering

WITH DIESEL ENGINES

For economical reasons, many railway companies and locomotive operators have decided to repower older locomotives and rail cars which are in good general condition with modern diesel engines. Due to their high technical standards, MTU engines fulfill all technical criteria for repowering projects:

- Economical alternative to new procurement
- Reduced investment costs
- Increased availability equal to that of a new vehicle
- Individual solutions to suit existing system interfaces

We are your competent partner for a successful repowering project and offer everything you require:

- Active support provided by a professional engineering service during all phases of a repowering project
- Design and realisation of the traction plant
- Engines adaptable to existing parameters
- Reliable and sturdy engines with low fuel and lube oil consumption rates
- Long maintenance intervals and low life-cycle costs
- Compact dimensions for easy installation in existing engine rooms
- Low installation and maintenance effort
- The accessories incorporate clearly defined interfaces and are mounted to the engine in such a manner as to be easily accessible for maintenance operations
- Excellent power-to-weight ratios permit installation of higher power ratings without exceeding permissible axle loads
- Qualified support by our Product Support organisation
- Meet all applicable exhaust gas and noise emissions limit values

Automation and peripheral systems

ALL PRODUCTS AND BENEFITS AT A GLANCE

Automation system	PowerControl	Safemon (Saftey Monitor)	Powerline	CaPoS (Capacitor Power System)	CaPoS smart edition
					
Scope of supply	– PowerPack Automation	– SIL (Safety Integrity Level) certified monitoring unit – Safety- and approval-related documentation	– ADEC Governor – PAU Engine (Power Automation Unit) – POM (Power Output Module)	– Ultracap – DC/DC voltage transformer – Connection cable	– Ultracap
Advantages at a glance	– Automation for complete system – Powerful and scalable – For new rolling stock and repowering projects – An intelligent system for the entire PowerPack line-up	– Monitors safety-relevant functions and ensures safe operation – Documentation simplifies the approval process –	– Special rail automation system – Central interface for complete system – For new-production and repowering projects – Certified for rail applications	– Electrical system voltage 16V DC – 154V DC – CAN interface – Maintenance-free	– Integral charger – Stand alone component – Enclosure rating IP66 – Maintenance-free
MTU PowerPacks for Railcars Series 1800 	■	■			■
Series 1600 	■	■			■
Engines for Railcar Trainsets, Push-Pull Trains and Locomotives Series 4000 			■	■	■ only available for 8V 4000 engines
Page	40	44	46	52	54

PowerControl Automation

LIKE A DIGITAL NERVOUS SYSTEM THAT DOESN'T MISS A THING.

Visionary, and packed full of benefits: The MTU PowerControl Automation system is our innovative high-end technology for rolling stock, i.e. railcars. MTU PowerControl Automation optimizes the control, regulation and monitoring of the entire drive system. The modular system ensures that the drive system can be adapted to the complex operating conditions that occur in railway applications.

PowerControl Automation enables:

- Simple integration with new or – in the case of conversions – existing vehicle control systems
- Flexible adjustment capability to suit the vehicle, its components and project-specific requirements
- Automatic power adjustment or, if required, engine shutdown by the integrated safety system as well as all other required monitoring and safety functions
- The built-in automatic power management system ensures that maximum available drive power is always to hand
- Maximum uptime in the tough operating conditions that confront rail operators, including extremes of heat, cold, airborne dust and water spray

The new PowerPack generation therefore offers you:

- High power efficiency
- Minimum fuel consumption
- Minimum exhaust emissions that are significantly below statutory requirements (e.g. valid EU Stage IIIA and EU Stage IIIB)
- Flexible, standardized interface solutions

An optimum environment for diagnosis and maintenance:

- Provision of operating and diagnostic data for maximum drive system uptime
- Unlocking the full potential of MTU systems using our digital solutions MTU Go! Act and MTU Go! Manage, for example via
  - proactive failure prevention
  - fast service support through efficient communication tools
  - intelligent troubleshooting
  - optimized maintenance planning

MTU PowerControl Automation

LIKE A DIGITAL NERVOUS SYSTEM THAT DOESN'T MISS A THING.

PowerControl Automation in the PowerPack

PowerPack system components

Gearbox control system

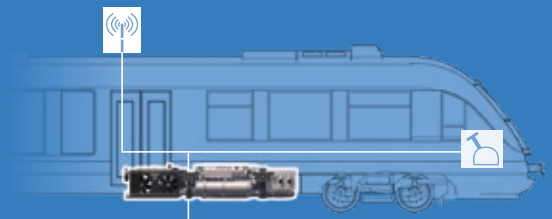
Axle reversing transmission control

Engine sensors and control elements

ADEC governor [1]

PowerControl Automation across the entire vehicle group

Connectivity for digital solutions (Go! Act, Go! Manage)



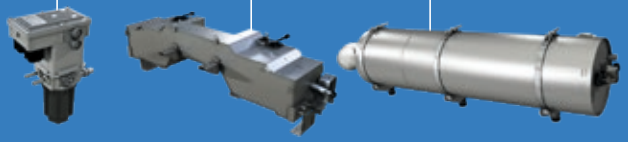
Train control and management system

PowerControl Automation

Exhaust Gas Aftertreatment

Engine management system with integrated SCR system
– typical configuration –

SCR interface module



Urea dosing unit; Heating valve and urea nozzle

Urea tank [2/3]

SCR muffler with catalyst [2]

System highlights and benefits:

- Complete system supplied from one single source
- Modular design
- Optimized diagnostic function
- Intelligent CAN bus technology
- Fast project implementation
- Easy integration

1) Engine mounted
2) PowerPack mounted
3) Vehicle mounted

Automation

SAFEMON FOR POWERPACKS: THE INTEGRATED SAFETY CENTER

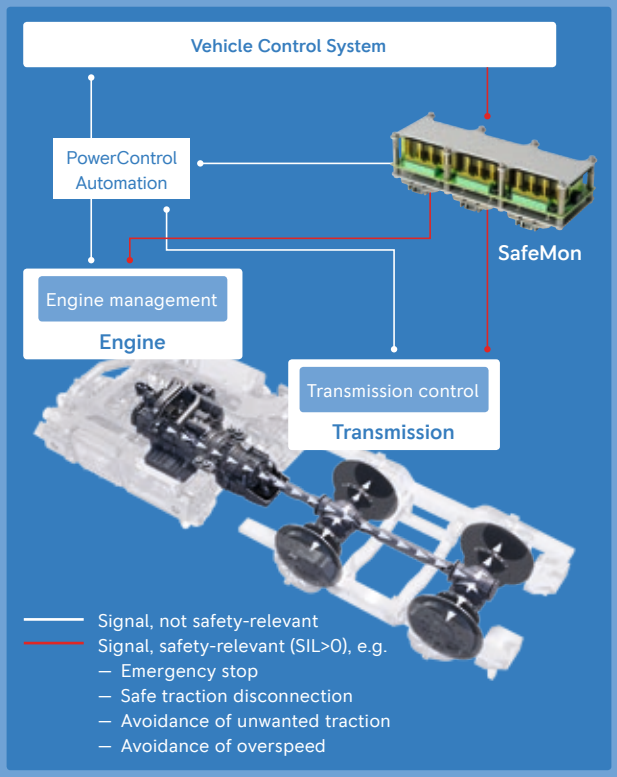
For vehicle manufacturers and railway operators, the safety of their passengers has top priority. With the SafeMon (Safety Monitor) we help you to reduce operational risks – and to achieve the set safety objectives even faster and easier.

SafeMon consists of a certified monitoring unit for safety-relevant functions as well as the associated safety- and approval-related documentation. The functions that control these signals fulfill the level of safety specified by the operator, rated according to Safety Integrity Level (SIL). This specifies, that in the event of faulty or defective components, safety-relevant procedures, such as braking, coupling or uncoupling, are guaranteed just as before. As a result, consequential damage due to unwanted traction or overspeed is prevented.

We develop safety technology in-house - which therefore is perfectly oriented to the MTU PowerPack. SafeMon is integrated directly in the power system via a simple hardware interface, existing vehicles can also be readily upgraded. Manufacturers of rail vehicles receive a complete package that has already been subjected to all hazard- and risk assessments and certified for the safety level that they require; we prepare the corresponding documentation. The separate safety certificate can be included directly in the report for the independent assessment body. This considerably simplifies the approval process for the complete vehicle.

With SafeMon you are safely en route at all times:

- Complete safety concept for the entire power train
- Control of all safety functions according to the required safety level – completely documented and already examined by external bodies
- Complete power system from a single source, certified according to the European Standard for Proof of Safety (EN 50129)
- We supply the associated documentation and thereby simplify the approval process



Implemented safety functions

SIL 1	SIL 2	SIL 3
– Avoidance of unwanted traction – Protection against overspeeds	– Safe shutdown of the PowerPack, if required (Emergency Stop) – Safe uncoupling	– Safe disconnection of the propulsion power (traction)

Optional: Monitoring pressure and temperature for other safety functions

The Safety Integrity Levels have been determined in accordance with the CSM Regulation (Common Safety Methods) and confirmed by independent experts.

Automation

POWERLINE FOR SERIES 4000

powerline – our automation system for train drive units – represents a step into a whole new future of technology for rail vehicles. Even with only the basic components ADEC, POM and PAU, the powerline automation system makes the integration of the engine into the locomotive a simple process. POM, like ADEC, is an electronic module mounted permanently to the engine. Control, regulation and monitoring are all part of the package that we deliver. With the help of optimized interface technology, the engine is quick and easy to install.

ADEC engine control systems

The engine control system ADEC (Advanced Diesel Engine Control) for Series 4000 R03/R04 is a system that has been developed and produced by us specifically for use with the very latest high-performance diesel engine technology – designed not only for full control of the Common Rail technology in the Series 4000, but above all for the management of frequent extreme loads and sudden load changes, which can be overcome effortlessly and smoothly using this system.

The most important features at a glance:

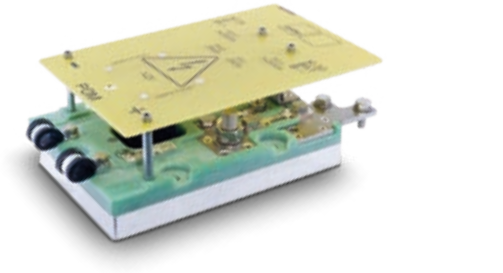
- Component mounted on and wired into the engine
- Integrated control and monitoring system
- Fuel-optimized output regulation
- Integrated safety and self-test system
- Data bus interface

POM (Power Output Module) for Series 4000 R03/R04

Module with actuating function for the starter motor and alternator, with the following features:

- Component mounted on the engine
- Starter relay and other conventional power routing not required
- Optimization of start-up process; starter motor monitoring with engaging function
- Alternator function monitoring
- Line break and short circuit monitoring
- Battery voltage monitoring with start-up intervention plus status indication and error report function
- ADEC and POM linked via CAN data bus
- Fully automated start-up control with ADEC

ADEC - Engine Management



POM - Interface Module

Automation

POWERLINE FOR SERIES 4000

powerline for new locomotives or repowering with Series 4000

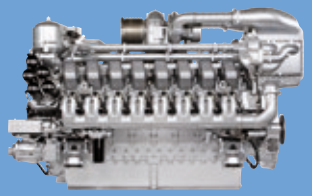
PAU Engine (Power Automation Unit)
Module for the monitoring, control and system integration of peripheral engine components, with the following features:

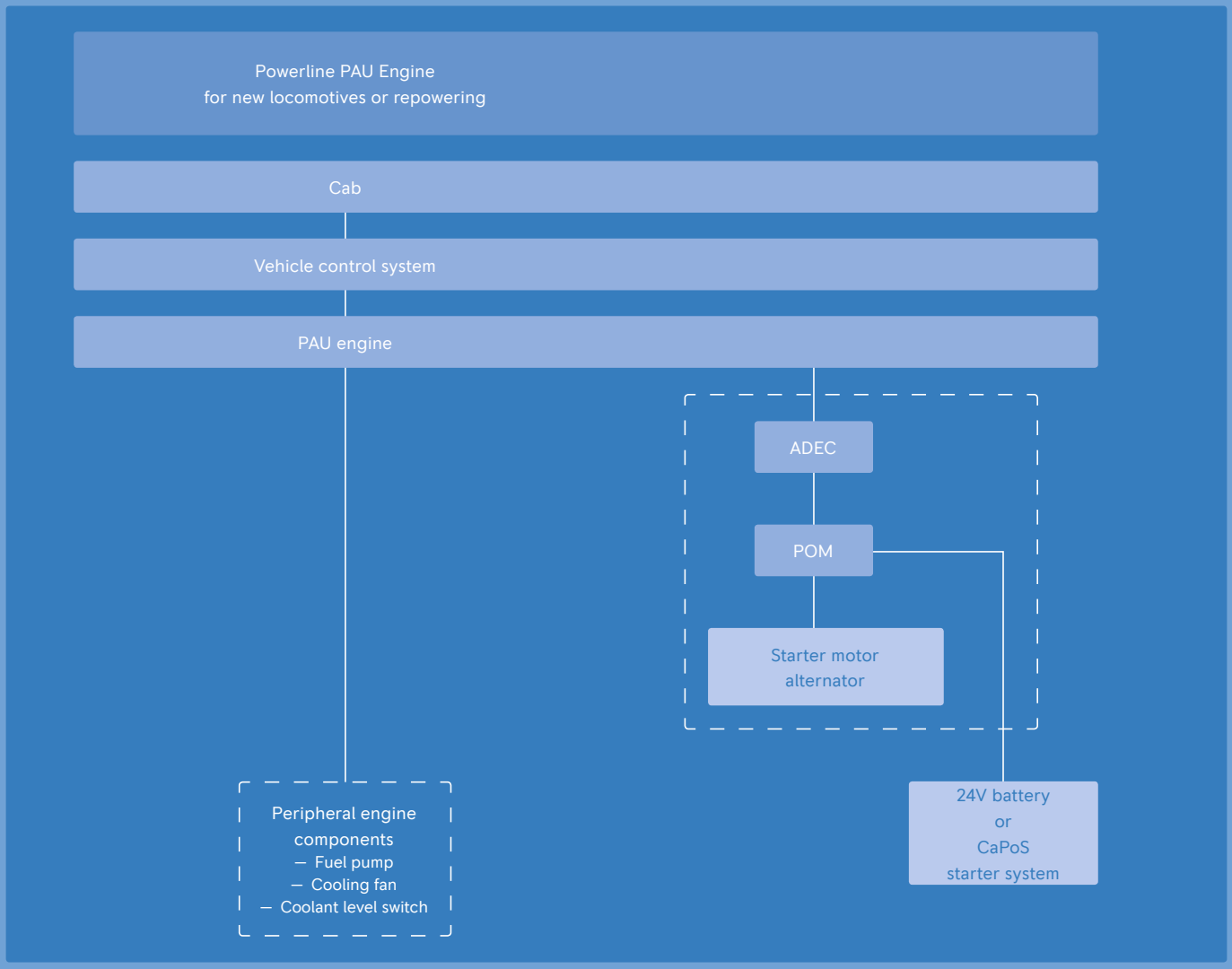
- Stand-alone component with (redundant) CAN-open interface to vehicle control system
- Transfer of all engine-related operational data including diagnostics to the vehicle control system
- Additional monitoring and control of peripheral engine systems
  - Coolant level monitoring
  - Fuel pump actuation
  - Air filter monitoring
  - Integrated safety functions
  - Data output for fuel consumption indicator
  - Ethernet diagnosis interface (e.g. service laptop)
  - Fault ring buffer
  - Cooling fan regulation
  - Preheating control

PAU - Engine

POWERLINE FOR SERIES 4000 R03/R04

ADEC = Advanced Diesel Engine Control
PAU = Power Automation Unit
POM = Power Output Module





Automation

CAPOS – CAPACITOR POWER SYSTEM FOR SERIES 4000

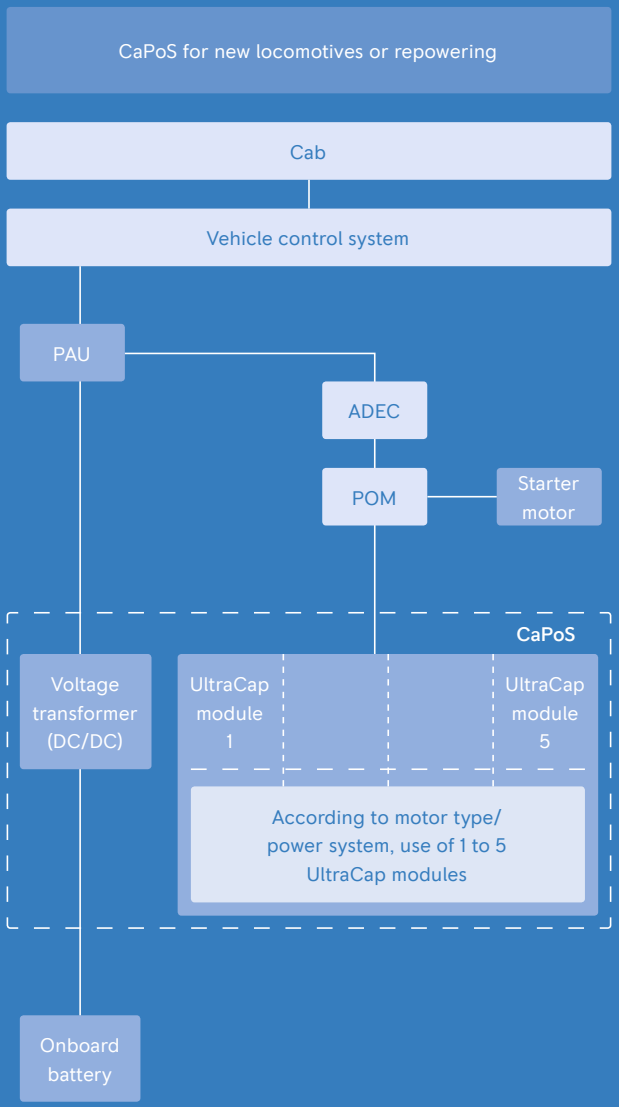
Innovation right from the start.
CaPoS is an innovative UltraCap voltage supply system which obviates the need for conventional starter batteries in railroad applications.

CaPoS uses capacitor technology to optimize startup behavior. The number of UltraCap modules used is dependent on the motor type/power system and its breakaway torque. CaPoS may be used autonomously or in conjunction with the powerline automation system.

The most important features at a glance:
- Autonomous and modular construction
- Maintenance-free system
- Significant reductions in weight and volume compared with conventional starter batteries
- Optimized cold-starting properties
- Low life-cycle-costs
- No voltage dip in the onboard network during the start procedure
- Onboard voltage of 16V – 154V possible
- Wired-up complete system
- CAN interface with powerline

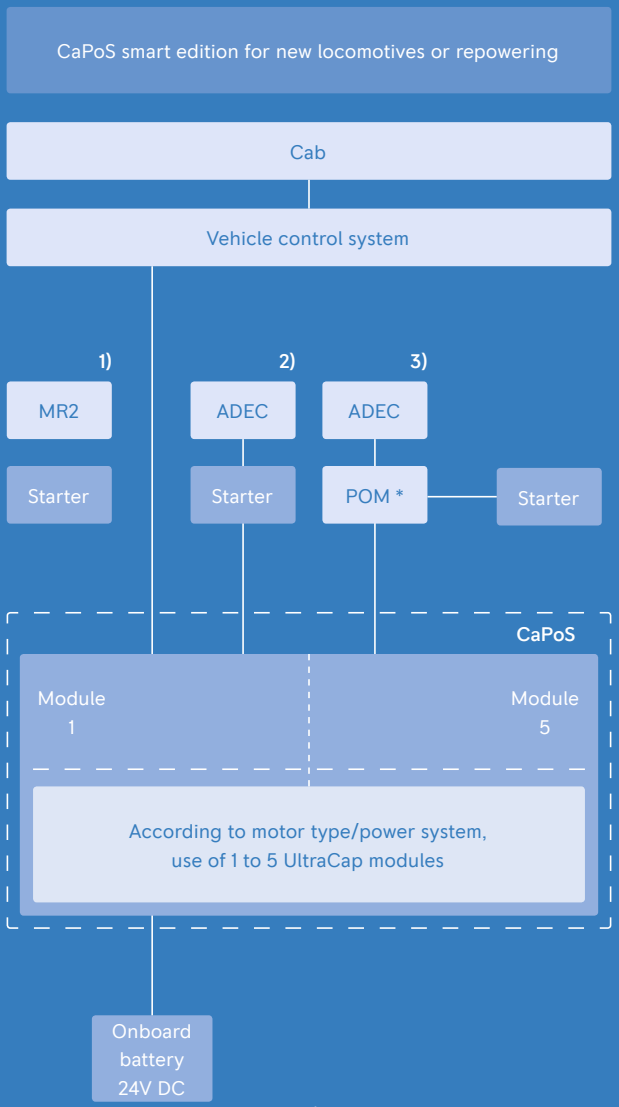
CaPoS with powerline - Sample for the 12V 4000

CAPOS WITH POWERLINE



for Series 4000 R03/R04

CAPOS SMART EDITION



1) for Series 1800
2) for Series 8V 4000
3) for Series 1600, Series 8V 4000
* Optional for Series 1600

Automation

CAPOS SMART EDITION – CAPACITOR POWER SYSTEM FOR SERIES 1600, 1800 AND 4000

Reliable power right from the start.
CaPoS smart edition was especially developed for heavy and duty applications and provides the high energy required by the 24V DC starters during the starting sequence.

CaPoS smart edition uses capacitor technology to optimize start-up behavior. The number of modules used is dependent on the motor type/power system and its breakaway torque.

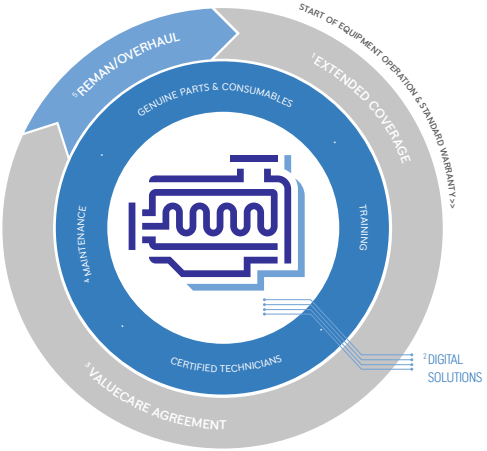
The most important features at a glance:
- Autonomous and modular construction
- Maintenance-free system
- Significant reductions in weight and volume compared with conventional starter batteries
- Optimized cold-starting capabilities
- Low life-cycle-costs
- No voltage dip in the onboard network during the start procedure
- Onboard voltage of 24V DC
- Integrated self-monitoring system with interface to vehicle control system
- Integrated DC-/DC converter for automatical recharging
- IP66 protection

CaPoS smart edition – Sample for the 12V 1600

Complete lifecycle solutions.

ENSURE A LONG, RELIABLE LIFE.

As your equipment ages, its needs—and yours—change. Our full portfolio of service solutions wrap around your investment, providing 360 degrees of customized support, for optimal value at every stage of life.



1 Avoid the unexpected with added protection beyond the standard warranty.
2 Make better decisions faster with data-enhanced tools.
3 Maximize availability and optimize lifecycle costs with a ValueCare Agreement.
4 Improve system performance and extend equipment life with on-demand support.
5 Keep a good thing going with factory reman/rebuild solutions.

Complete lifecycle solutions.

RELY ON OUR EXPERTISE.

To give your equipment a long and productive life, choose a partner you can trust. Only factory-certified technicians know how to get the job done right using proven service methods, factory-specified maintenance schedules and genuine OEM parts.

From preventive maintenance to complete overhaul, we are your true lifecycle partner. Whatever level of support you need, our global network of factory-trained professionals knows all about your equipment and is ready to help you maximize performance and minimize lifecycle costs.

Never compromise
MTU engines and systems are built to last with legendary high standards. When it's time for service, don't settle for anything less. Protect the life of your equipment with professional certified service technicians and genuine OEM parts and consumables—the only options that live up to our standards for craftsmanship, quality and performance. To get the most from your equipment, there are no shortcuts. For maximum reliability, performance and uptime, choose a name you can trust.

If you need us a little:
On-Demand Support—including professional inspections and preventive maintenance recommendations from us—we help you to identify and address problems early, save on repairs or unexpected downtime, and optimize your equipment's performance and longevity. Inspections include visual assessment, test run and leak check, on-site oil and coolant analysis, diagnostic evaluation and reporting.

If you need us a lot:
ValueCare Agreements make it easy to keep your business running smoothly and reduce total cost of ownership by maximizing uptime, optimizing lifecycle costs and helping you avoid equipment-related business disruptions through preventive maintenance.

ValueCare Agreements

FOCUS ON YOUR OPERATIONS. LEAVE THE REST TO US.

Service solutions designed around your priorities
ValueCare Agreements make it easy to optimize lifecycle costs, maximize uptime and devote more time and resources to your core business, with tailored solutions to move your business forward.

Gold

Maximize operational uptime

- Operational uptime commitment to meet or exceed your availability targets
- Regular supervision by local service partner (e.g. monitoring of parts stock,
- 24/7 emergency assistance with on-site support
- Monthly reports, including availability and average repair times
- Asset health monitoring
- Annual performance meetings and trend analysis with us to address technical updates, engine fleet data, operational optimization and more

Gold also includes all benefits of Silver & Bronze levels

Silver

Eliminate unexpected maintenance costs

- Proactive maintenance planning, troubleshooting and remote engine health monitoring
- Fixed pricing per operating hour for maintenance and repairs
- Key corrective maintenance components always in-stock at our main warehouses
- 24/7 standby service with remote technical support
- Quarterly reports, including reliability analysis (mean time between failure)

Silver also includes all benefits of Bronze level

Bronze

Ensure parts availability and price stability

- Digital connectivity (Go! Connect) and platform access (Go! Manage)
- Automated delivery of parts (preventive) at a predefined rate based on operating hours
- Preventive maintenance labor options to fit your business needs
- Dedicated support for technical issues
- Quarterly reporting of completed and upcoming maintenance and costs
- Annual on-site engine health check by our technician

ValueCare Agreements help you:

- Increase operational uptime
- Guarantee parts availability and service quality
- Predict equipment-related costs
- Optimize maintenance planning
- Connect to us, 24/7

Digital Solutions

THE FUTURE IS DIGITAL.

Fueled by your system's data—and supplemented with our exclusive expertise, smart analytics and extensive database—digital solutions magnify the power of your investment.

From proactive failure prevention and intelligent troubleshooting to instant failure support and smart maintenance planning, digital solutions unlock the full potential of your MTU system.

Go! Act

Service in your pocket
Designed to support on-site operators, Go! Act:
- Receives push notification of failure codes from connected assets
- Provides crew members with vital information about failure codes
- Supports event reporting with convenient photo capture functionality
- Enables direct communication with fleet managers or our Customer Assistance Center

Go! Manage

Monitor your fleet
Built for fleet managers, Go! Manage:
- Provides a live overview of fleet, asset and engine conditions
- Displays active and closed alarms
- Enables interaction and communication with on-site staff via Go! Act
- Shows maintenance schedule, with completed tasks clearly marked
- Supports remote troubleshooting via multigraph

Remanufactured Products

EXCHANGE AND SAVE.

Factory remanufactured products deliver the same high standards of performance, service life and quality as new products, along with identical warranty coverage—at a fraction of the cost. And with design and model-related updates, they also feature similar technological advancements. Developed by R&D engineers, the remanufacturing process saves you time and money, while benefiting the environment through the reuse of materials. To help you work efficiently, a wide range of remanufactured parts, engines and systems are available worldwide.

Reduce lifecycle costs.
As you evaluate your long-term power needs, you must consider a variety of factors. Factory remanufactured products are a smart solution, helping you reduce the total lifecycle cost of your equipment.

Save time.
Factory remanufactured products put your equipment back to work faster than an overhaul, which reduces downtime, service time and indirect costs such as storage.

Maintain standards.
All products are remanufactured to our strict standards by our certified technicians at our regional reman centers. Only we can remanufacture our parts, engines or systems to original factory specifications.

Protect the environment.
Since remanufacturing is an efficient use of resources and energy, factory remanufactured products benefit the environment as well.

Service Network

LOCAL SUPPORT. WORLDWIDE.

The most important part of your power system isn't a part at all—it's your local service team. With more than 1,200 service locations worldwide—backed by regional Parts Logistics Centers in Europe, Asia and America—you can count on responsive support by expert technicians, wherever work takes you. To find your local service partner, visit **www.mtu-solutions.com.**

Always on call, 24/7
Whether it's connecting you with a local service partner or assigning an urgent problem to a dedicated team of our experts, we're ready to assist you—wherever you are, whatever you need.

Europe, Middle East, Africa +49 7541 90-77777
Asia/Pacific +65 6860 9669
North and Latin America +1 248 560 8888
info@ps.rolls-royce.com

Series and emissions qualification

ENGINES OVERVIEW

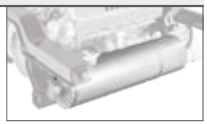
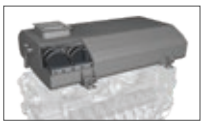
Model	UIC IIIA	EU Stage IIIA compliant	EU Stage IIIB certified	US EPA Tier3	Fuel cons. opt. w/o certificate
MTU PowerPacks for Railcars Series 1800 		■	■	■	
Series 1600 			■		
MTU Engines for Push-Pull Trains and Locomotives Series 2000 					■
MTU Engines for Railcar Trainsets, Push-Pull Trains and Locomotives Series 4000					
8V/12V/16V/20V 4000 R43[1]	■	■			
20V 4000 R63	■	■			
12V/16V 4000 R54				■	
12V/16V 4000 R64/74/84 			■		

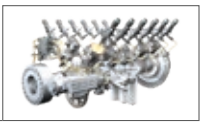
1) EU IIIA type approved, EU IIIA certificate available

Key technologies for the reduction of emission and consumption

ENGINE TECHNOLOGY

Engine model	Exhaust Gas Aftertreatment			Internal Emission Technology		
	SCR	DPF	DOC	EGR	2st Turbocharging	Advanced CR
Railcars Series 1800 	■					
Series 1600 	■					■
Locomotives Series 2000 				■	■	■
Series 4000 		■	■	■	■	■

Exhaust Gas Aftertreatment	
Selective Catalytic Reduction (SCR)	
Diesel Particulate Filter (DPF)	
Diesel Oxidation Catalyst (DOC)	

Internal Emission Technology	
Exhaust Gas Recirculation (EGR)	
Two-Stage Turbocharging	
Advanced Common Rail Fuel Injection	

EXHAUST EMISSIONS

Many countries have implemented environmental legislation to protect people from consequences of polluted air. For this reason an increasing number of countries regulate emissions from specific mobile and stationary sources.

Emission standards may apply internationally, nationally and/or for specific areas. The enforcement of an emission legislation may depend for example on the area where the equipment is used and the way it is operated. The emission legislations may be categorized by power range and/or cylinder capacity.

Emission legislations generally require a certificate which states compliance. Stationary applications may require on-site approvals (on-site emission test) depending on the particular emission legislation.

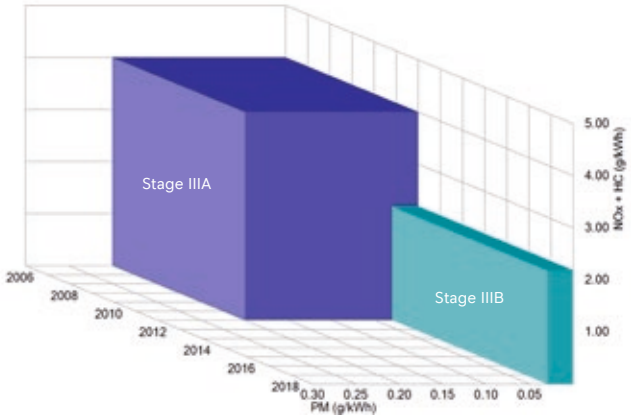
Please find as follows examples of emission standards which apply to the rail industry. For details please consult the applicable legislation and/or permitting authority.

- European emission legislation differentiates between locomotive and railcar applications.
- US emission legislation differentiates between line-haul and switch-haul locomotive applications.
- US rail emission legislation is specific for ratings 750 kW and above. For ratings below 750 kW nonroad mobile machinery legislation applies.
- UIC (International railway association) emission standards may be applied when national legislations is not available.

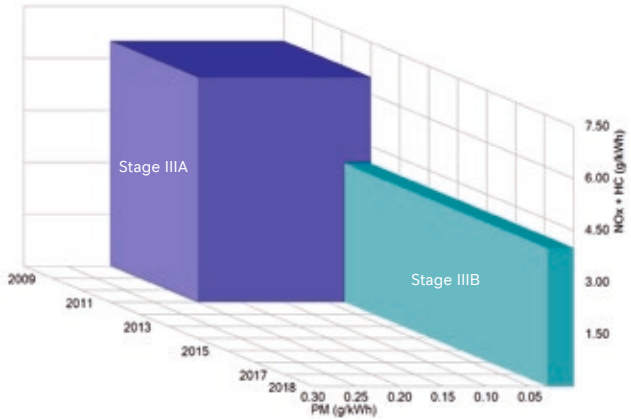
Please note

That the engines and systems (only) comply with country or region specific emission requirements and have appropriate emission certification(s) which are explicitly stated in respective technical specifications. Any export/import/operation of the engine in countries or regions with different applicable emission law requirements is at the customers responsibility.

Samples for emission stages in rail industry::
EU Railcar
EU Rail Railcar > 130 kW

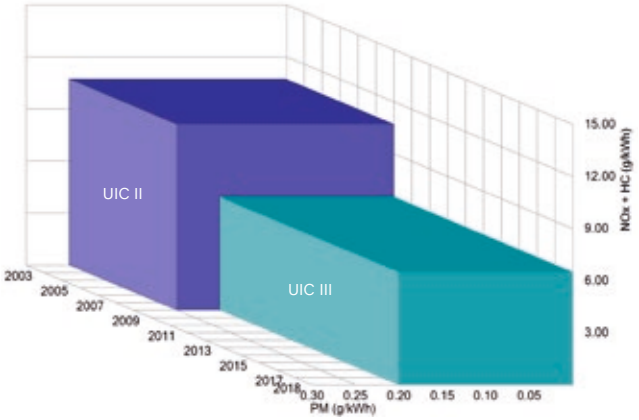


EU Locomotive
EU Rail Locomotives > 560 kW



UIC Locomotive

UIC Rail > 560 kW/ > 1,000 rpm



Examples for emission level description:

- certified - e.g. EU Nonroad St IIIB (97/68/EC)
- compliant with CoC - e.g. EU Nonroad St IIIA Comp (97/68/EC)
- compliant without CoC - e.g. EU Nonroad St IIIA Comp

NOTES

NOTES

Further special solution guides

- Marine
- PowerGen
- C&I, Agricultural, Mining
- Oil & Gas Industry

CONVERSION TABLE

1 kW	= 1.360 PS	g	= 9.80665 m/s²
1 kW	= 1.341 bhp	Л	= 3.14159
1 bhp	= 1.014 PS	e	= 2.71828
1 oz	= 28.35 g	e	= 2.71828
1 lb	= 453.59 g	1 lb	= 16 oz
1 short ton	= 907.18 kg	1 short ton	= 2000 lbs
1 lb/bhp	= 447.3 g/PSh	1 ft lb	= 1.356 Nm
1 lb/bhp	= 608.3 g/kWh	1 ft/min	= 0.00508 m/s
1 gal/bhp (US)	= 4264 g/kWh	pDiesel	= 0.83 kg/l
1 kWh	= 860 kcal	1 lb/sqin	= 0.069 bar (1 psi)
1 cal	= 4.187 J	1 mm Hg	= 1.333 mbar (133.3 Pa)
1 BTU	= 1.055 kJ	1 mm H_2O	= 0.0981 mbar (9.81 Pa)
1 inch	= 2.540 cm	T (K)	= t (°C) + 273.15
1 sq. inch	= 6.542 cm²	t (°C)	= 5/9 x (t (°F) -32)
1 cu. inch	= 16.387 cm³	t (°C)	= 5/4 x t (°R)
1 foot	= 3.048 dm	1 foot	= 12 inches
1 sq. foot	= 9.290 dm²	1 yard	= 3 feet
1 mile	= 1.609 km	1 mile	= 5280 feet
1 naut. mile	= 1.853 km	1 naut. mile	= 6080 feet
1 UK Gallon	= 4.546 l	1 US Barrel	= 0.159 m³
1 US Gallon	= 3.785 l		= 42 US Gallons
Energy:	1 J = 1 Ws = 1 VAs = 1 Nm		
Power:	1 W = 1 VA = 1 Nm/s		
Force:	1 N = 1 kgm/s²		
Pressure:	1 Pa = 1 N/m² (1 bar = 10^5 Pa)		
MEP (bar)	$= \frac{P_{cyl}(kW) \times 1200}{n(1/min) \times V_{cyl}(l)}$		
Torque (Nm	$= \frac{P_{ges}(kW) \times 30000}{n(1/min) \times \pi}$		

Subject to change. | 16120356 | Edition 01/19 | ESM 2019-10 | Printed in Germany on chlorine-free bleached paper.

Rolls-Royce Group
www.mtu-solutions.com