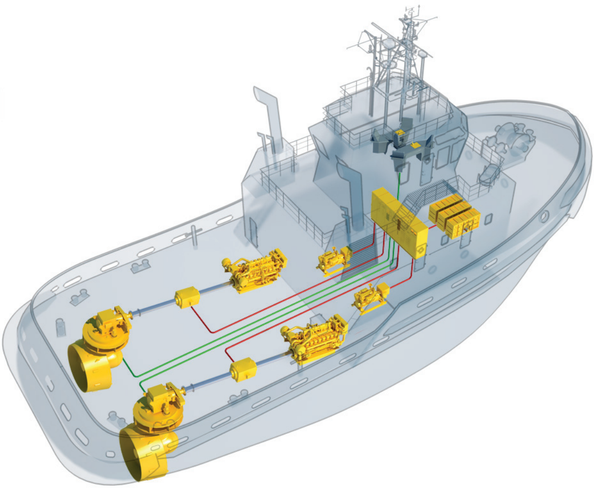
Selection Guide for Harbor and Terminal Tugboats



May 2014

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Propulsion Packages for ASD / ATD Tugs

BP *)		No. of Propulsions	Engine Type	Engine Rating	Power per Diesel Engine	Total Tug Power	Max. engine speed	Propulsion type	Prop. diameter
					[kW]	[kW]	[rpm]		[m]
30	T	2	C32	C	970	1,940	1,800	MTA 318	1.80 m
34	T	2	C32	C	1,081	2,162	2,100	MTA 318	1.80 m
40	T	2	3512	C	1,230	2,460	1,800	MTA 420	2.00 m
45	T	2	3512	C	1,500	3,000	1,600	MTA 420	2.00 m
50	T	2	3512	C	1,500	3,000	1,600	MTA 524	2.40 m
55	T	2	3512	C	1,765	3,530	1,800	MTA 524	2,40 m
60	T	2	3512	D	1,902	3,804	1,800	MTA 524	2.40 m
60	T	2	3516	B	1,920	3,840	1,600	MTA 524	2.40 m
65	T	2	3516	C	2,000	4,000	1,600	MTA 627	2.70 m
70	T	2	3516	B	2,240	4,480	1,800	MTA 627	2.70 m
80	T	2	3516	C	2,350	4,700	1,800	MTA 730	3.00 m
85	T	2	3516	D	2,525	5,050	1,800	MTA 730	3.00 m
90	T	2	C175	B	2,850	5,700	1,800	MTA 730	3.00 m
95	T	2	C175	B	2,850	5,700	1,800	MTA 832	3.20 m
100	T	2	C175	B	2,850	5,700	1,800	MTA 834	3.40 m

*) Calculated using industry standard thrust deduction in metric tons.

Propulsion Packages for Rotortugs

BP *)		No. of Propulsions	Engine Type	Engine Rating	Power per Diesel Engine	Total Tug Power	Max. engine speed	Propulsion type	Prop. diameter
					[kW]	[kW]	[rpm]		[m]
45	T	3	C32	C	970	2,910	1,800	MTA 318	1.80 m
50	T	3	C32	C	1,081	3,243	2,100	MTA 318	1.80 m
50	T	3	3512	C	1,051	3,153	1,600	MTA 318	1.80 m
60	T	3	3512	C	1,230	3,690	1,800	MTA 420	2.00 m
70	T	3	3512	C	1,500	4,500	1,600	2 x MTA 420, 1 x MTA 524	2.00 m, 2.40 m
80	T	3	3512	C	1,765	5,295	1,800	MTA 524	2.40 m
85	T	3	3516	C	1,864	5,592	1,800	MTA 524	2.40 m
100	T	3	3516	C	2,000	6,000	1,600	MTA 627	2.70 m

*) Calculated using industry standard thrust deduction in metric tons.

Hybrid Propulsion Packages for ASD / ATD Tugs (Hybrid A)

BP *)		No. of Propulsions	Engine Type	Engine Rating	Power per Diesel Engine	Power per Hybrid Motor / Generator	Total Tug Power	Max. engine speed	Propulsion type	Prop. diameter
					[kW]	[kW]	[kW]	[rpm]		[m]
50	T	2	3512	C	1,500	500	4,000	1,600	MTA 524	2.40 m
60	T	2	3516	B	1,920	500	4,840	1,600	MTA 524	2.40 m
65	T	2	3516	C	2,000	500	5,000	1,600	MTA 627	2.70 m
70	T	2	3516	B	2,240	500	5,480	1,800	MTA 627	2.70 m
80	T	2	3516	C	2,350	500	5,700	1,800	MTA 730	3.00 m
85	T	2	3516	D	2,525	500	6,050	1,800	MTA 730	3.00 m
90	T	2	C175	B	2,850	500	6,700	1,800	MTA 730	3.00 m
95	T	2	C175	B	2,850	500	6,700	1,800	MTA 832	3.20 m
100	T	2	C175	B	2,850	500	6,700	1,800	MTA 834	3.40 m

*) Calculated using industry standard thrust deduction in metric tons

Hybrid Propulsion Packages for Rotortugs (Hybrid A)

BP *)		No. of Propulsions	Engine Type	Engine Rating	Power per Diesel Engine	Power per Hybrid Motor / Generator	Total Tug Power	Max. engine speed	Propulsion type	Prop. diameter
					[kW]	[kW]	[kW]	[rpm]		[m]
80	T	3	3512	B	1,678	500	6,534	1,800	MTA 524	2.40 m
85	T	3	3516	C	1,765	500	6,795	1,800	MTA 524	2.40 m
100	T	3	3516	C	2,000	500	7,500	1,600	MTA 627	2.70 m

*) Calculated using industry standard thrust deduction in metric tons.

Hybrid A: A system where additional power does not need to be provided electrically to the shaft to achieve maximum bollard pull. The main engines remain the same size as a conventional vessel and the shaft motor generator is used only for low power maneuvering when mains are shut down or to provide electrical power for vessel services when the mains are running.

Hybrid Propulsion Packages for ASD / ATD Tugs (Hybrid B)

BP *)		No. of Propulsions	Engine Type	Engine Rating	Power per Diesel Engine	Power per Hybrid Motor / Generator	Total Tug Power	Max. engine speed	Propulsion type	Prop. diameter
					[kW]	[kW]	[kW]	[rpm]		[m]
50	T	2	C32	C	1,081	500	3,162	2,000	MTA 524	2.40 m
60	T	2	3512	B	1,425	500	3,850	1,600	MTA 524	2.40 m
65	T	2	3512	C	1,500	500	4,000	1,600	MTA 627	2.70 m
70	T	2	3512	C	1,765	500	4,530	1,800	MTA 627	2.70 m
80	T	2	3512	D	1,895	500	4,790	1,800	MTA 730	3.00 m
85	T	2	3516	C	2,000	600	5,200	1,600	MTA 730	3.00 m
90	T	2	3516	B	2,240	600	5,680	1,800	MTA 730	3.00 m
95	T	2	3516	B	2,240	600	5,680	1,800	MTA 832	3.20 m
100	T	2	3516	B	2,240	600	5,680	1,800	MTA 834	3.40 m

*) Calculated using industry standard thrust deduction in metric tons.

Hybrid Propulsion Packages for Rotortugs (Hybrid B)

BP *)		No. of Propulsions	Engine Type	Engine Rating	Power per Diesel Engine	Power per Hybrid Motor / Generator	Total Tug Power	Max. engine speed	Propulsion type	Prop. diameter
					[kW]	[kW]	[kW]	[rpm]		[m]
80	T	3	3512	C	1,051	600	4,953	1,600	MTA 524	2.40 m
85	T	3	3512	C	1,380	500	5,640	1,800	MTA 524	2.40 m
100	T	3	3512	C	1,500	500	6,000	1,600	MTA 627	2.70 m

*) Calculated using industry standard thrust deduction in metric tons.

Hybrid B: A system where additional power needs to be provided electrically to the shaft to achieve maximum bollard pull. The main engines can be smaller than in a conventional vessel because the shaft motor generator are able to provide additional power to the shaft line. The shaft motor generator are therefore used for low power maneuvering when mains are shut down, to provide electrical power for vessel services when mains are running, and to "top up" shaft power when achieving maximum bollard pull.

Fuel Consumption – High Speed Engines are the Number One Choice in the Tug and Salvage Industry

Cat high-speed engines are ideally suited for your tugboat and will provide excellent fuel economy. Since harbor and terminal tugboats spend most of their time at low load, high-speed engines consume much less fuel at lower loads than do medium-speed engines (Fig. 1).

Conversely, medium-speed engines are most efficient at high load, but the point where the fuel curves of high- vs. medium-speed engines cross is around 50-70% of full engine load (Fig. 2).

Operational Profile – Harbor & Terminal Tugboats

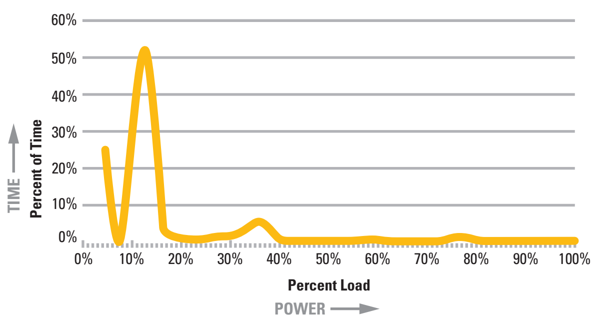

Fig. 1

Relative Fuel Consumption 65 T Harbor & Terminal Tugboat Solution

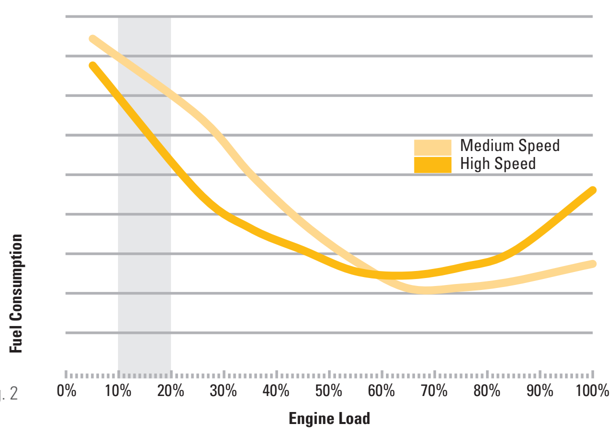

Fig. 2

Bollard Pull

Horsepower (hp) or Kilowatts (kW) alone are not sufficient to gauge a tugboat's power. Since many factors play into propulsion system effectiveness, the best measurement of tugboat power is Bollard Pull, the zero-speed pulling capability of a tug, stated in tons.
A standard indication of maximum pulling force a ship can exert on another ship or object, it allows for comparisons between vessels, particularly tugboats. Bollar Pull measures the real-world usefulness of a tugboat, such as in stranding scenarios or holding larger vessels.

There are three types of Bollard Pull:

- Sustained Bollard Pull – Mean value during a specific period of time or readings.
- Maximum Static Bollard Pull – The highest 30 seconds measured during the test and is always greated than Sustained Bollard Pull.
- Maximum Bollard Pull – The single measured value, and is substantially higher than Sustained Bollard Pull and should not be referred to only as "Bollard Pull".

Bollard Pull can be measured in three ways:

- Practical trial
- Calculation / Simulation
- Conversion of hp or kW into BP using rules of thumb

Ideally, Bollard Pull is verified when a tug is built then certified by one of the marine classification societies. This is done by tying a towing line from an on-shore bollard to a measuring instrument, then again from the measuring instrument to the tugboat.
Prior to a vessel completed, however, Caterpillar Marine can calculate the estimated Bollard Pull.

Subject to change without notice.

Leaflet No. 107 · 05.14 · e · L+S · VM3

LEDM0068-00

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