G-CYLINDER™ TRIAL SUMMARY

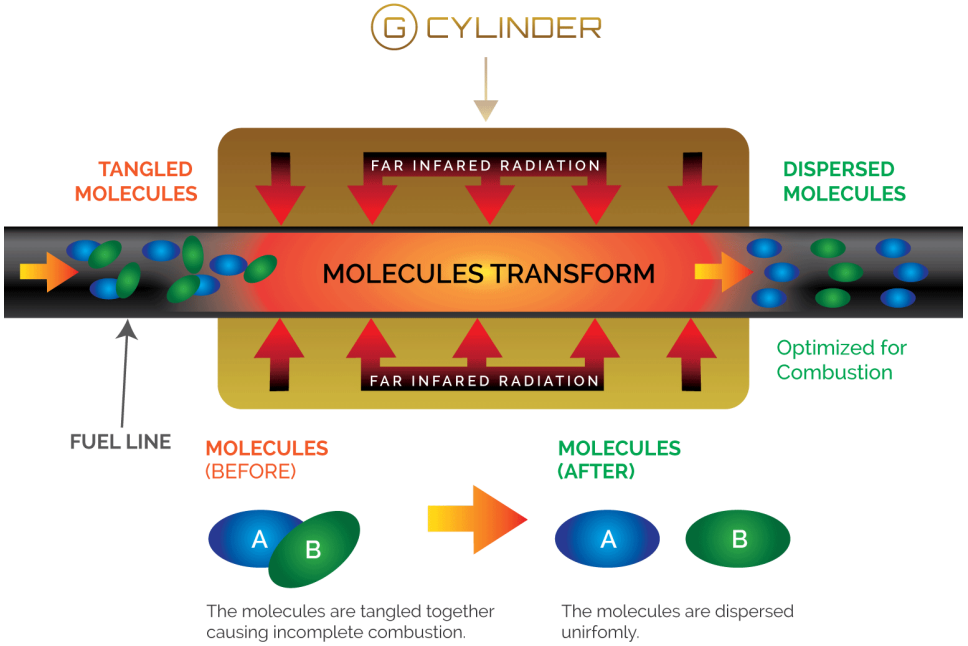
Client: Bhagwan Marine

Vessel: MV Tempest

May 17, 2019


TEMPEST
BM
BM

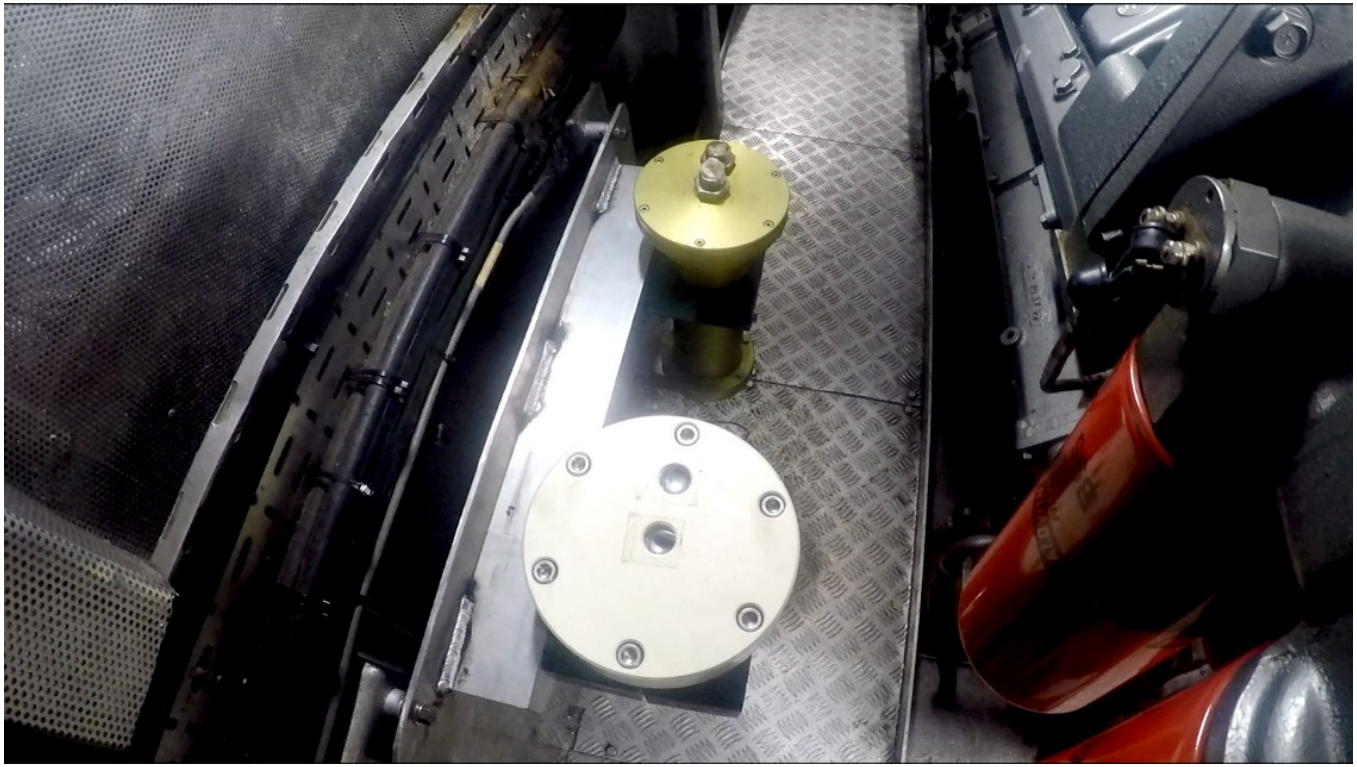
PCM Technology



G-Cylinder “Petro diesel Conditioning Marine” (PCM) units are Infrared (IR) emitting superconductor made in Japan. IR emitted from PCM has a positive effect on combustion of diesel fuel. The IR is derived from Graphene, Tourmaline and Carbon Nano Tube Compound.

http://gcylinder.com/how-it-works/

Installation



Installation of G-Cylinder PCM-1030 and PCM-930 in series on the fuel line before the both MV BM Tempest main engines.
(Units installed in series after the racor fuel filter and prior to the secondary fuel filter).

Data Collection

1. Performance data was collected from 21 trips over 5 months November 2018 to March 2019.

2. Data collection was performed by recording fuel level before and after trips, with the vessel's dipstick and sight glass. The difference in fuel level was recorded as fuel consumed for the trip. Other data recorded was; distance travelled (taken from the ships GPS data), main engine speed (RPM), average speed (knots) and other comments recorded included cargo weights, wind direction and tides.

3. At the end of each trip a liters per nautical mile (L/NM) figure was calculated by dividing the total fuel consumption figure by the distance travelled.

4. This method was the easiest way for BM to test efficacy under normal operation. A comparison of the total performance averages with historical Tempest fuel usage data would be recorded.

5. Historical tempest fuel usage data includes, data from 9 frequent trip destinations, including their lowest, average and highest recorded fuel usage in L/NM.

   (See Table: "Historical Data").

Historical Data

BM Vessel Tempest **HISTORICAL TEMPEST FUEL USAGE DATA**							
DESTINATION	**DISTANCE (NM)**	**MIN L USED**	**L/NM**	**AVERAGE L USED**	**L/NM**	**MAX L USED**	**L/NM**
REINDEER	94	2000	21.3	2898	30.83	3760	40
WS#1/2 IA#1/2	18	400	22.2	887	49.28	1500	83.33
OKHA	130	3950	30.4	4216	32.43	4600	35.38
NORTH RANKIN	150	4000	26.7	4455	29.7	4950	33
GOODWYN	160	4500	28.1	4750	29.69	5000	31.25
JULIMAR FIELD /PLUTO A	176	4377	24.9	6115	34.74	7400	42.05
STAG	74	2900	39.2	2900	39.19	2900	39.19
CAPE LAMBERT ANCHORAGES	76	3500	46.1	3500	46.05	3500	46.05
WESTERN ANCHORAGES	50	1541	30.8	1975	39.5	2500	50
			30		**36.82**		**44.47**

Testimonial.

Tempest Master, Brian Reghenzi, commented on the noticeable improvements on the trips to Reindeer platform. Where:

(i) ***"The lowest ever recorded trips to Reindeer platform were recorded"*** with the G-Cylinder devices installed, 15.64, 17.56 and 18.91 L/NM in comparison to the previous historical low at 21.3L/NM.

(ii) The comparison of historical averages of Reindeer trips (30.83 L/NM) and the performance averages of the trips to Reindeer platform with the G-Cylinder installed, demonstrates a ***27% improvement in fuel consumption.***

(See Table: "Reindeer" on next page)

Reindeer Trips

BM	**Vessel**	**Tempest**								
Performance Data Technology ON										
Date	***Time 24Hr*** **Start**	**Finish**	**GPS Data *Distance Travelled NM**	**Vessel RPM**	**Av Speed (knots)**	**Fuel Starting Level**	**Fuel Ending Level**	**Fuel Total Consumption**	**Comments: cargo weight/weather/tides**	**L/NM**
27.11.18	730		52	1650	15	7661	5979	1682	HH-WA Return. 11tonne cargo. SW25kts	32.35
30.11.18	720	1005	55	1700	17.5	5700	4660	1040	HH-Reindeer platform. 5tonne. SW20kts	18.91
30.11.18	1035	1330	55	1700	17.5	4660	3800	860	Reindeer platform - HH Nil cargo. SW20kt	15.64
05.12.18	500	815	52	1700	17.5	10250	8900	1350	Nil Cargo	25.96
05.12.18	900	1300	52	1700	17.5	8900	7800	1100	8t Cargo	21.15
19.02.19	1315	1650	50	1700	16.5	9150	8272	878	W 20kts 15.2t of cargo	17.56
03.03.19	530	1530	52	1790	18	5800	4400	1400	18.6t Cargo W 2knts	26.92
									Average L/NM with Tech ON	**22.64**
									Historical L/NM Averages with Tech OFF	**30.93**
									Difference L/NM	**8.19**
									% Savings	**27%**

"The lowest ever recorded trips to Reindeer platform were recorded" with the G-Cylinder devices installed, 15.64, 17.56 and 18.91 L/NM in comparison to the previous historical low at 21.3L/NM.

Total Performance

Of the 21 trips recorded, the total performance averages of 29.11L/NM was produced in comparison to historical average fuel use of 36.82L/M, demonstrates a

21% improvement in fuel consumption.

(See Table: "Performance Data")

BM	**Vessel**	**Tempest**								
Performance Data Technology ON										
Date	***Time 24Hr*** **Start**	**Finish**	**GPS Data** ***Distance Travelled I**	**Vessel RPM**	**Av Speed (knots)**	**Fuel Starting Level**	**Fuel Ending Level**	**Fuel Total Consumption**	**Comments: cargo weight/weather/tides Variables**	**L/NM**
19.11.18	1:50	5:00	67	1850	20.5	9600	7700	1900	Nil cargo / SW 25-30 Flooding tide	28.36
19.11.18	8:45	14:00	88	1750	16.5	7700	5709	1991	Total FO used OKHA return trip 3891L	22.63
20.11.18	7:00	1545	74	1750	19	11496	9961	1535	8Tonne cargo, SW@20-25Knots outgoing tide	20.74
27.11.18	730		52	1650	15	7661	5979	1682	HH-WA Return. 11tonne cargo. SW25kts	32.35
30.11.18	720	1005	55	1700	17.5	5700	4660	1040	HH-Reindeer platform. 5tonne. SW20kts	18.91
30.11.18	1035	1330	55	1700	17.5	4660	3800	860	Reindeer platform - HH Nil cargo. SW20kt	15.64
05.12.18	500	815	52	1700	17.5	10250	8900	1350	Nil Cargo	25.96
05.12.18	900	1300	52	1700	17.5	8900	7800	1100	8t Cargo	21.15
20.01.19	305	745	89	1800	18.5	11880	10000	1880	Nil cargo 10 kt variables	21.12
20.01.19	1150	1620	89	1800	20.4	10000	7700	2300	Nil cargo 10-15kts WNW	25.84
10.02.19	830	915	12.5	1700	18.5	6150			20t cargo. Variable 10kts	
10.02.19	1215	1330	12.5	950	10				13t Cargo. NE 15	
10.02.19	1540	1630	4	800	9				13t Cargo. NE 15	
10.02.19	1650		4	1700	19.8		4750	1400	NW 15kts	42.42
18.02.19	1030	1305	28	1700	16.6	12600	11990	610	WSW 20kts. 9.6t of cargo	21.79
18.02.19	1350	1625	29	1700	16.6	11990	11080	910	WSW 20kts. 3.8t of cargo	31.38
19.02.19	520	950	50	1700	15.7	11080	9150	1930	W 20kts 12.3t of cargo	38.60
19.02.19	1315	1650	50	1700	16.5	9150	8272	878	W 20kts 15.2t of cargo	17.56
02.03.19	600	1345	14	1700	14	6600	5800	800	12t Cargo w 5kts	57.14
03.03.19	530	1530	52	1790	18	5800	4400	1400	18.6t Cargo W 2knts	26.92
04.03.19	600	1805	77	1790	15	11900	9200	2700	21t Cargo W 1knt	35.06
05.03.19	655	1645	14.5	1650	14	9200	8400	800	28.5t Cargo W 1knt	55.17
15.03.19	245	700	77	1800	20.1	13250	11000	2250	Nil cargo / WSW 15 - 20kts	29.22
15.03.19	1430	1900	77	1800	20.7	11000	9200	1800	Nil cargo / WSW 15 - 20kts	23.38
Average L/NM with Tech ON										**29.11**
Historical L/NM Averages with Tech OFF										**36.82**
Difference L/NM										**7.71**
% Savings										**21%**

Potential Outliers

There were several “outliers” discussed with Brian Reghenzi, about fuel consumption data presented where Tempest lay on idle for most part of the day and only traveling very short distances.

These outliers contributed to abnormal L/NM figures as high as 55.17L/NM.

With these outliers removed from the performance data, the average consumption is improved again to 25.37 L/NM.

This figure in comparison to historical average data demonstrates an improvement in fuel consumption of 31%.

(See Table: Outliers Removed)

BM	**Vessel**	**Tempest**								
Performance Data Technology ON										
Date	***Time 24Hr*** **Start**	**Finish**	**GPS Data** ***Distance Travelled NM**	**Vessel RPM**	**Av Speed (knots)**	**Fuel Starting Level**	**Fuel Ending Level**	**Fuel Total Consumption**	**Comments: cargo weight/weather/tides Variables**	**L/NM**
19.11.18	1:50	5:00	67	1850	20.5	9600	7700	1900	Nil cargo / SW 25-30 Flooding tide	28.36
19.11.18	8:45	14:00	88	1750	16.5	7700	5709	1991	Total FO used OKHA return trip 3891L	22.63
20.11.18	7:00	1545	74	1750	19	11496	9961	1535	8Tonne cargo, SW@20-25Knots outgoing tide	20.74
27.11.18	730		52	1650	15	7661	5979	1682	HH-WA Return. 11tonne cargo. SW25kts	32.35
30.11.18	720	1005	55	1700	17.5	5700	4660	1040	HH-Reindeer platform. 5tonne. SW20kts	18.91
30.11.18	1035	1330	55	1700	17.5	4660	3800	860	Reindeer platform - HH Nil cargo. SW20kt	15.64
05.12.18	500	815	52	1700	17.5	10250	8900	1350	Nil Cargo	25.96
05.12.18	900	1300	52	1700	17.5	8900	7800	1100	8t Cargo	21.15
20.01.19	305	745	89	1800	18.5	11880	10000	1880	Nil cargo 10 kt variables	21.12
20.01.19	1150	1620	89	1800	20.4	10000	7700	2300	Nil cargo 10-15kts WNW	25.84
18.02.19	1030	1305	28	1700	16.6	12600	11990	610	WSW 20kts. 9.6t of cargo	21.79
18.02.19	1350	1625	29	1700	16.6	11990	11080	910	WSW 20kts. 3.8t of cargo	31.38
19.02.19	520	950	50	1700	15.7	11080	9150	1930	W 20kts 12.3t of cargo	38.60
19.02.19	1315	1650	50	1700	16.5	9150	8272	878	W 20kts 15.2t of cargo	17.56
03.03.19	530	1530	52	1790	18	5800	4400	1400	18.6t Cargo W 2knts	26.92
04.03.19	600	1805	77	1790	15	11900	9200	2700	21t Cargo W 1knt	35.06
15.03.19	245	700	77	1800	20.1	13250	11000	2250	Nil cargo / WSW 15 - 20kts	29.22
15.03.19	1430	1900	77	1800	20.7	11000	9200	1800	Nil cargo / WSW 15 - 20kts	23.38
Average L/NM with Tech ON										**25.37**
Historical L/NM Averages with Tech OFF										**36.82**
Difference L/NM										**11.45**
% Savings										**31%**

Outliers Removed

After Slip

Tempest master, Brian Reghanzi considered the performance data compared to historical data collected after an “Off Slip” service with the bottom clean and serviced propeller, would provide indication of the technology working.

The G-Cylinder performance data delivers a 15% improvement on historical off slip data.

(See Table: After Slip)

BM	**Vessel**	**Tempest**					
Historical Data Off Slip* (Technology OFF) *Historical data collected after new prop and bottom clean off the slip							
Date	***Time 24Hr*** **Start**	**Finish**	**GPS Data** **Distance Travelled NM**	**Fuel Starting Level**	**Fuel Ending Level**	**Fuel Total Consumption**	**L/NM**
11.08.17	600	1700	50	9100	7000	2100	42
23.09.17	630	1810	50	10600	8500	2100	42
24.09.17	530	1500	50	8500	6050	2450	49
25.09.17	600	1645	50	6050	3880	2170	43.4
04.10.17	400	1830	94	13600	1100	2600	27.66
05.10.17	430	1720	47	1100	8770	2230	47.45
06.10.17	600	1000	47	8770	7800	2230	47.45
09.10.17	600	1830	50	7800	6560	1240	24.8
11.10.17	500	1600	94	13600	1104	1960	20.85
12.10.17	600	1850	50	11640	9420	2220	44.4
15.10.17	400	1700	94	9420	6600	2820	30
17.10.17	630	1910	50	6600	4770	1830	36.6
19.10.17	1200	2045	50	10570	9200	1370	27.4
21.10.17	1145	1730	50	9200	7870	1330	26.6
29.10.17	400	1650	94	11250	8470	2780	29.57
01.11.17	600	1810	100	7972	4694	3278	32.78
04.11.17	400	1630	94	12694	10250	2444	26
07.11.17	400	1315	94	9820	7080	2740	29.15
09.11.17	600	1630	94	7080	4940	2140	22.77
12.11.17	630	1530	50	12440	10250	2190	43.8
15.11.17	700	1305	50	10250	9200	1050	21
16.11.17	700	1530	50	9200	7600	1600	32
28.11.17	500	1600	50	7600	5650	1950	39
30.11.17	605	1815	50	11950	9700	2250	45
10.12.17	1450	1730	50	9700	7700	2000	40
11.12.17	1450	1820	50	7700	6480	1220	24.4
15.12.17	600	1700	50	11200	9800	1400	28
20.12.17	1330	1830	50	8200	6800	1400	28
24.12.17	600	1400	50	11000	9000	2000	40
28.12.17	600	1600	50	9000	7400	1600	32
Average L/NM After Slip 11.08.17							**34.1**
Historical L/NM Averages with Tech On							**29.11**
Difference L/NM							**4.991**
% Savings							**15%**

BHAGWAN BM
marine

19/12/2018

Re: Successful trial of G-Cylinder™ PCM Technology on the Tempest a 2600hp/150 tonne utility vessel

Bhagwan Marine (BM) has successfully evaluated and proven the effectiveness of G-Cylinder™ in improving fuel efficiency on our Utility Vessel 'Tempest'. Based on initial positive results BM has given approval for further testing on 'Tempest' so that further evaluation can be done. Both companies are excited about the potential application of the technology for cost savings and prolonged engine life.

installation Specs: Twin engine: 1x PCM-1030 & 1x PCM-930 (in series) on each side. No recirculation tank or other optimizations were needed.

Signed,

Loui Kannikoski
Managing Director (Bhagwan Marine)

Bryan Reghenzani
Fleet Mechanic (Bhagwan Marine)

ABN: 81 009 154 349

Lvl 3 / 251 St Georges Tce
Perth
Western Australia 6000

T: +61 8 9424 2300
F: +61 8 9479 5202
admin@bhagwanmarine.com

bhagwanmarine.com

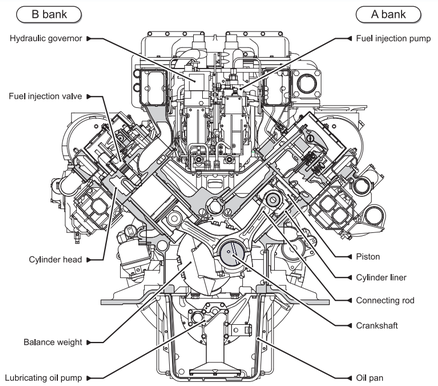
For Harmonious Living with Global Environment

Normally, when NOx emissions are reduced, the fuel consumption and smoke generation will increase, adversely affecting both the environment and management. As a solution to this, YANMAR has developed "Eco Diesel", which is designed so as to comply with marine environmental protection.
It improves the fuel consumption and smoke generation in addition to reducing NOx emissions.

EcoDiesel
Lower fuel consumption
Lower NOx emissions

Reborn V12 power you can rely on, developed from years of experience with the latest technology

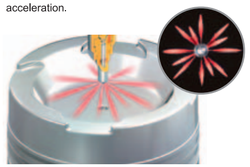
Since the 12LA and 16LA series engines were first sold in 1980's, Yanmar has supplied more than 2,000 of them around the world.
Based on this success, we have developed the new 12AY series, a reliable, high-performance V12 engine reborn as our 1,000 hp-plus high-power model. We use the same proven technology from our best-selling 6AY series, meeting IMO Tier II exhaust emission standards without electronic engine control. With its stable high torque, this engine features a prolonged lifecycle design that boasts low NOx and fuel consumption thanks to a new, efficient combustion method, improved durability, and ease of maintenance. This engine will help cut costs and reduce downtime.



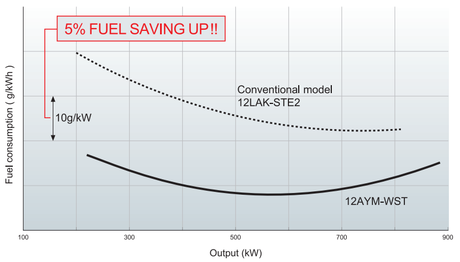
Performance

Good Fuel Economy together with Lower Emissions

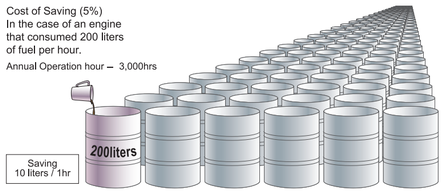
The micro-sized multiple holes in the all-new injectors produce an even finer fuel-oil mist and, combined with deep combustion chambers and new cylinder head shapes, produce even more power.
It is power delivered smoothly, due to optimum combustion conditions being maintained across a far wider operating range. And it leads directly to the bonus of lower exhaust emissions and lower fuel consumption. The boost compensator dramatically reduces black smoke under hard acceleration.



Staggered Layout Injection System



Cost of Saving (5%)
In the case of an engine that consumed 200 liters of fuel per hour.
Annual Operation hour — 3,000hrs



Annual saving=30,000 liters
200liters Drum×150

Both mono-grade and multi-grade lubrication oil can be used.

YANMAR
Solutioneering Together

MARINE DIESEL ENGINE

12AYM-WST

H-rating 1030kW [1400mhp] / H-rating 882kW [1200mhp]

Photograph may show optional equipment.

Reborn
Power and Quality

IMO TierII Compliant / Mechanical Engine Control

1200mhp
1400mhp

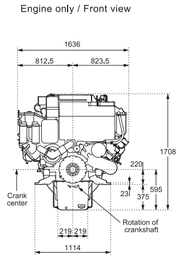
LONG STROKE

Engine Specifications

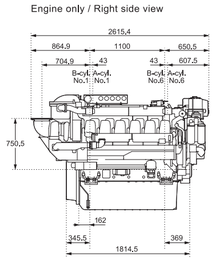
Model		12AYM-WST	
Type		V-type, vertical, water-cooled, 4-cycle diesel engine	
No. of cylinders, Bore × stroke	mm	12, 155 × 180	
Displacement	lit.	40.76	
Rated output	kW(hp)/rpm	H: 1030 (1400) / 1900 (at flywheel)	H: 882 (1200) / 1850 (at flywheel)
Emission		IMO Tier II	
Fuel consumption	gr/kW・hr	H: 211$^{+5\%}$ at rated output (without marine gear)	H: 205$^{+5\%}$ at rated output (without marine gear)
Direction of rotation		Counterclockwise, when viewed from the flywheel side (crankshaft)	
Combustion system		Direct injection	
Cooling system		Constant high temperature cooling system	
Cooling fresh water capacity	lit.	211 (jacket)	
Lubricating system		Wet sump system, forced lubrication by gear pump	
Lubricating oil capacity	lit.	Max.: 170 Min.: 110 (sump tank) (in engine piping line: 25)	
Lubricating oil grade		SAE40 or SAE15W-40	
Starting system		Electric starting motor DC24V-8.0kW×2 or air motor×2	
Flywheel housing size	inch	SAE #00, 21	
Dry weight	kg	4950 (without marine gear)	

Dimensions (Unit : mm)

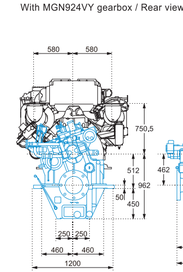
Engine only / Front view



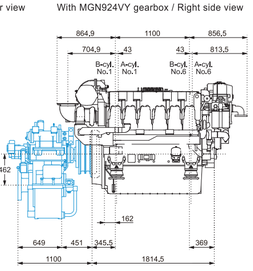
Engine only / Right side view



With MGN924VY gearbox / Rear view



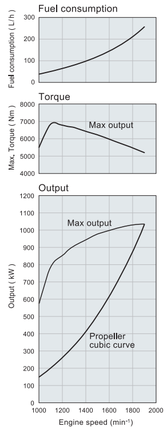
With MGN924VY gearbox / Right side view



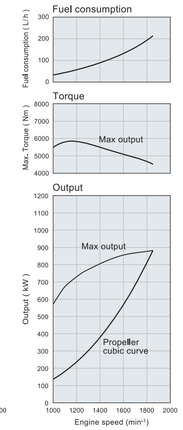
— Marine gear

Performance Curves

H rating 1030kW [1400mhp]



H rating 882kW [1200mhp]



Rating definitions : hp=0.7355kW Ratings are based on conditions of 100kPa, 30% relative humidity at 25˚C.
H=For applications where use of rated power is less than 24 hours continuous out of every 30 hours and operation is less than 4000 hours per year.
When combined with a correctly matched propeller which allows the engine rated speed to be achieved in a fully loaded vessel state, the reduced-power operation can be at or below 50 min⁻¹ of the rated speed.
Fuel rates : Specific gravity 0.835g/cc, low calorific value 42700kj/kg (10200kcal/kg), Cetane No.45.

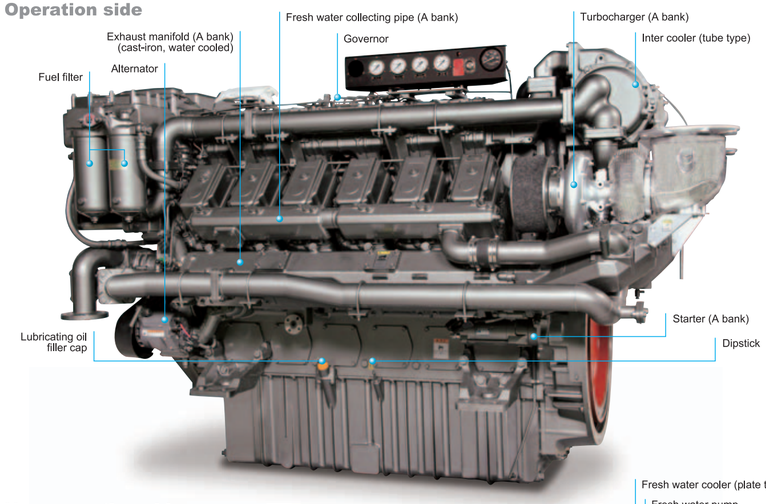
YANMAR CO., LTD.
Marine Operations Division.
5-3-1,Tsukaguchi Honmachi Amagasaki, Hyogo, Japan
Tel : +81-6-6428-3261 Fax : +81-6-6421-2202
yanmar.com

Note : All Data Subject to Change Without Notice. Please contact YANMAR or local distributor for the details of each model.

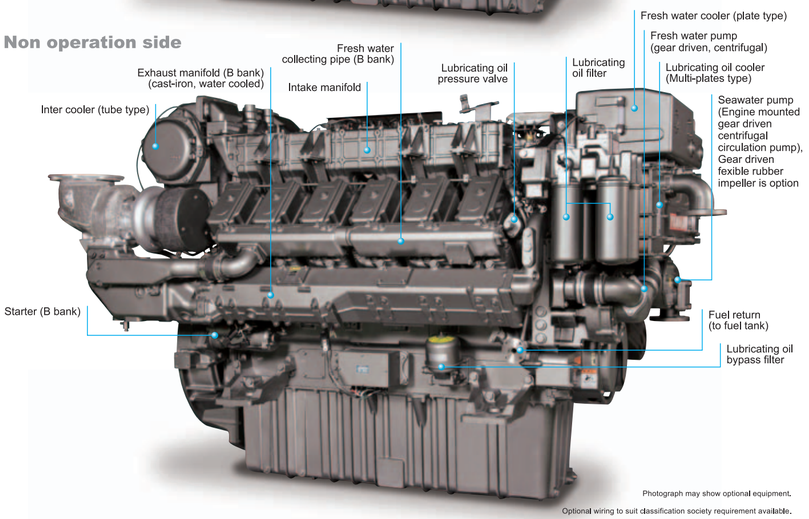
Printed in Japan 001M0-G00560 1303Ⓢ

YANMAR, Providing Quality Propulsion Engine Packages for Over 60 Years.

Operation side



Non operation side

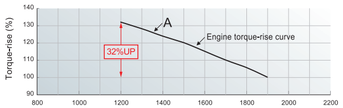


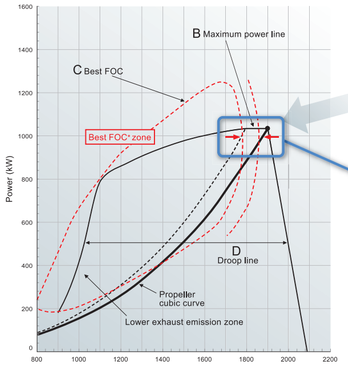
Photograph may show optional equipment.

Optional wiring to suit classification society requirement available.

High Torque

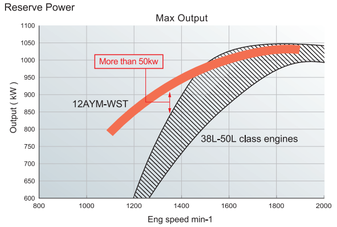
Excellent Torque-Rise Characteristics in High Speed and High Load Range Enable Stable Performance of Job Duties even at High Load





This figure indicate in case of 12AYM-WST

Reserve Power



Wider Propeller (FPP) design margin with further fuel economy (ferry boat applications, except Tug, Trawler)

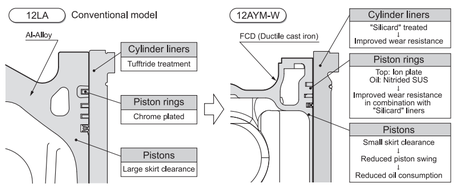
- ☑ Fuel economy less than 1850 min-1
- ☑ Best fuel economy less than 1750min-1

The Engine Performance Gives Following Advantages:

1. The engine torque-rise characteristics having much in reserve, (Line A)
   →Stable cruising with least speed reduction against sudden load changes.
2. Wide Max. Power Range, (Line B)
   →A wide range reserve power, from the passenger ship (light/medium duty) to tug boat (heavy duty), is possible.
3. Min. Fuel Consumption Range is Wide, (Line C) Best FOC* zone
   →Economical with wide min. fuel consumption range both during cruising or performing job duties. * FOC: Fuel Oil Consumption
4. Wide Medium Load Range, (Line D)
   →Produces stable engine performance even doing other job duties.

Toughness

1. Low, stable LOC (Lubricating Oil Consumption) and long overhaul interval, thanks to sillicard** (kind of artificial ceramic) treatment cylinder liner and nitrided stainless steel rings and the finely judged clearance between piston and liner. No cylinder kit replacement concept inYANMAR overhaul program.
2. Purpose built marine engine with long stroke, optimized flywheel weight, water cooled exhaust manifold and special treatment injection nozzle. A Leak-free engine.
3. Type Approved by Marine Class Societies.

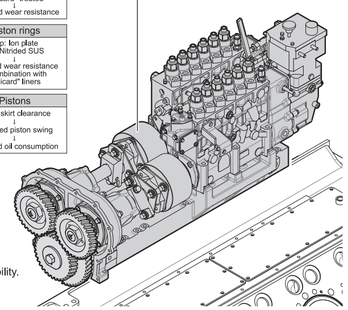


** SiliCard is a surface treatment that uses a special method to embed powdered Silicon Carbide (SiC), an artificial ceramic second only to diamond in hardness, to provide superior wear resistance and durability.

Yanmar Original Heavy Duty Fuel injection Pump (Made by Yanmar FuelInjection Pump factory, Omori Plant, Shiga Prefecture, Japan)

Uses the same fuel pump as the six-cylinder 6AY Series for improved serviceability.

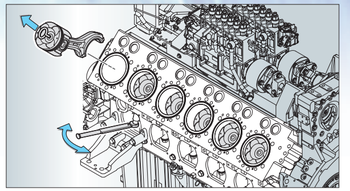
Fuel injection Pump



Lower Down Time

Easier Routine Inspection, Easier Maintenance.

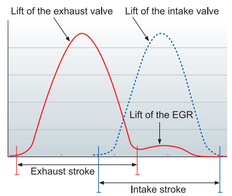
1. Large inspection windows on the side of the block allow in-site replacement of pistons.
2. Full mechanical engine management avoids the chance of delicate and expensive electronics failing in hot, marine engine room conditions.
3. 500 hours service interval.
4. Individual cylinder heads for each cylinder.



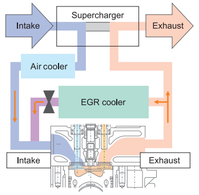
Techniques for Complying with IMO Tier II Emission Standards :

Exhaust Gas Recirculation (EGR)

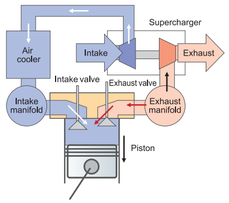
In the 12AY engine, the internal EGR system is used. This design does not require any external control devices or any significant changes to the engine structure. In external EGR, the line of the engine and supercharger must be equipped with devices such as EGR solenoid valves and coolers, and control must be performed for them. But in internal EGR, these functions can be performed by controlling the lift of the intake and exhaust valve.



External EGR system



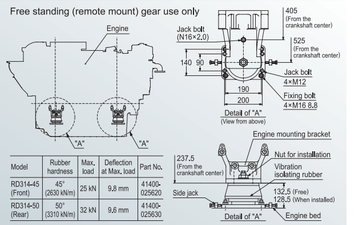
Internal EGR system (YANMAR)



Rubber mounts (option)

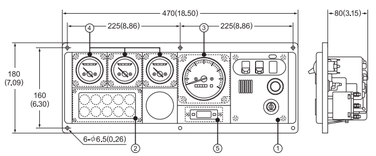
(Unit:mm)

Free standing (remote mount) gear use only



Model	Rubber hardness	Max. load	Deflection at Max. load	Part No.
RD314-45 (Front)	45°	25 kN (2630 kN/m)	9.8 mm	41400-025620
RD314-50 (Rear)	50°	32 kN (3310 kN/m)	9.6 mm	41400-025630

Detail of instrument panel D-type (Unit : mm)



① Switch unit
- Key switch
- Alarm buzzer
- Alarm buzzer stop switch
- Illumination switch
- Stop button (red button)

② Alarm lamp unit with Alarm monitor device
- Battery not charging
- C.W. high temp.
- L.O. low pressure
- Clutch oil low pressure
- L.O. filter clogged
- C.W. low level
- L.O. high temp.

③ Tachometer unit
- Tachometer with hour meter

④ Sub meter unit
- L.O. pressure meter
- C.W. temp. meter
- Boost meter (Turbo)

⑤ Clock unit
- Clock