MARINE DIESEL SPECIALISTS, INC
SURVEY REPORT

March 9, 2026

Arrow USA Yacht Management
1700 Las Olas Blvd. Suite 104
Ft. Lauderdale, FL 33301

M/Y "CUPCAKE" 2001 40 M (132') WESTSHIP TRIDECK
MAIN ENGINES
MTU 12V 396 TE94 – 2285 HP (1680 KW) at 2000 RPM
Port Engine Number: 558 3368 **Gearbox: ZF BW 465** S/N: 5970 1663 Hours: 6,130
Stbd. Engine Number: 558 3369 **Gearbox: ZF BW 465** S/N: 5970 1664 Hours: 6,129

DESCRIPTION

The MTU 12V396 TE94 is a four-stroke diesel engine with a 90-degree V, enclosed liquid cooling, twin sequential turbochargers, freshwater charge-air cooler, direct injection, wet type cylinder liners, piston cooling and electronic governor control. The cylinder block is cast iron, and the engine is equipped with individual cylinder heads consisting of two intake and two exhaust valves per cylinder. The cylinder bore diameter is 165 mm and the stroke is 185 mm with a displacement of 3.96 liters per cylinder. The engine is equipped with sequential turbochargers located at the end of the exhaust manifolds boosting into a charge-air cooler. The charge-air cooler serves to cool the intake air, making it denser and in conjunction with the exhaust gas driven turbochargers, allowing more fuel to be burned efficiently increasing engine horsepower. The engine is equipped with triple wall, liquid cooled exhaust manifolds and turbo exhaust covers. The engines are resiliently mounted. The engine monitoring systems are standard MTU electronic monitoring and alarm system with standard LOP control panels in the engine room with monitoring and alarms in the bridge. The throttle and clutch controls are electronic. Turbocharger switching is both electronically and pneumatically controlled.

MAIN ENGINE PERFORMANCE

The engines were slowly brought up to 1400 RPM in order to allow temperatures and pressures to stabilize. All temperature and pressure readings were within normal parameters for this engine application at 1400 RPM. The engines were then brought up to 1600 RPM, then 1800 RPM. All temperature and pressure readings were within normal parameters for this engine application. The engines were then brought up to maximum RPM of 2099 on Port and 2053 on STBD. Periodic full load operation is necessary in order to test cooling system efficiency as well as general engine performance characteristics since potential problems may not always be detected while operating at lower engine speeds. The port engine had a high exhaust gas temp alarm ETC B Bank E214/0 at wide open throttle.

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The engine application group for this yacht is IDS which is applicable to fast passenger vessels, ferries, hydrofoils, catamarans, and Surface Effect Ships (SES).

COOLING SYSTEM

The engine cooling water temperatures were within normal parameters during sea trial. Cooling system components such as sea strainers, water pumps and the heat exchanger require periodic inspection and maintenance. This engine model is equipped with a titanium plate type heat exchanger located at the front of the engine. The heat exchanger plates should be removed and cleaned periodically and new inhibitor added to the cooling system every two years.

EXHAUST SYSTEM

The exhaust system is connected to the exhaust outlet of the turbocharger housing through a flexible compensator which is blanketed with soft fiberglass insulating material and connects to the ships exhaust system and muffler. The exhaust is injected with seawater at the spray ring and is then diverted through the hull bottom in the engine room. Both port and starboard exhaust systems incorporate a bypass that exits the hull sides at the waterline. This is designed to reduce back pressure at slower speeds. The exhaust risers are supported by exhaust brackets attached to the overhead in the engine room. The overall condition of the exhaust system appears to be satisfactory, however, due to age the exhaust risers should be disassembled and tested.

GAUGES

The engine room is equipped with the MTU LOP panel with gauge and start / stop capabilities. The bridge is also equipped with MTU full monitoring system including gauges and MTU complete alarm system. All LOP's and alarms were functional during sea trials.

FUEL SYSTEM

Fuel is routed from the main tanks through a centrifuge and then to the day tank. The primary fuel filters consist of dual Separ model 2000/40 and they were inspected and appear to be in good condition. Separ WIF sensors are installed. Engine mounted filters are normal MTU type double canister with internal cartridge filter. The fuel system appears to be in good condition at this time. However, due to the Separs having metal bowls we could not visually inspect the fuel.

STARTER / ALTERNATOR

The engines are equipped with the standard MTU supplied Bosch 24-volt starters and alternators. Both port and starboard starters are functioning properly at this time. The alternators charging voltage was 26.7-27 volts.

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OIL SAMPLES

Oil samples were drawn from the main engines, marine gears and the generators. The samples indicate severe levels of iron and abnormal levels of sodium in the port generator. The starboard main engine has severe levels of aluminum and abnormal levels of chromium. All other equipment is within normal wear limits. Recommend changing oil and resampling after 10 hours of operation. Sample results are attached.

COMBUSTION AIR SUPPLY

Combustion air is supplied to the engines through MTU supplied nylon mesh type air filters that are connected to the air inlet of the turbocharger via hose. They are manufactured by MANN Co. This application utilizes engine room air supply. The filter elements are slightly dirty at this time. They can be removed and ultrasonically cleaned.

COUPLING

The coupling is manufactured by Geislinger, and it is a spring loaded oil bathed type coupling. The coupling appears to be functioning in that there were no obvious problems, however, the coupling was not disassembled and inspected due to time constraints and major disassembly required for this procedure.

CHARGE AIR COOLER

The charge air coolers were visually inspected and appear to be in serviceable condition at this time. The charge air pressures and temperatures were within manufacturer's specifications. There were leaks noted at this time.

MOUNTS

The engines are resiliently mounted with front mounts located at the front of the engine and rear mounts connected to the transmissions. The mounts appear to be in fair condition and there was no excessive movement noted while maneuvering or while on the sea trial. The mounts have surface rust and should be cleaned and painted as needed.

TURBOCHARGERS

The turbochargers were inspected for excessive axial and radial play in the turbine shaft, and they were all found to be normal and in good condition. There was no excessive carbon build up noted on the compressor wheels. Both port and starboard flap actuators are functioning properly at this time. There was no air leaks noted. Turbocharger speeds were where they should be according to the manufacturer specifications.

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CONTROLS

The vessel is equipped with controls provided by Mathers Corp. The controls feature single levers for port and starboard. The controls also feature push button control for taking command, troll and synchronization. All functions and controls are working properly at this time except for starboard engine troll function. There are four control stations aboard the vessel, a main helm station along with port and starboard wing stations and a fly bridge station. The emergency control station is located in the engine room at the LOP's. All associated controls are functioning properly at this time. Starboard engine troll function is not working.

ELECTRONICS

Both port and starboard engines were supplied with the standard MTU-ECS-UNI electronic control units (ECM). These units measure parameters and control the electronic governor on the engines. The engines are equipped with MTU monitoring systems. All of the associated engine electronics are functioning properly at this time.

PREHEATERS

Both port and starboard engines are equipped with coolant preheat assemblies provided by MTU. They are manufactured by Kim Hotstart Corp. model CSX30602-000. They are designed to prevent cold start up along with prolonging engine life. The preheat assemblies are 240-volt AC. The port preheater is functioning properly at this time however the starboard preheater turns on but does not heat up.

MARINE GEARS – Zahnradfabrik Friedrichshafen (ZF) BW 465

The marine gears are manufactured in Germany with a gear reduction ratio of 2.529/1. They utilize a light alloy cast housing and are hydraulically operated. The internal parts consist of an input shaft, output shaft, reversing shaft, related gearing and a forward and reverse clutch pack. The gearbox is a reduction and a reversing unit with replaceable clutch packs. The selector valve serves to direct oil flow to the clutch packs thereby providing forward, neutral or reverse depending upon direction of oil flow. The marine gears were visually inspected, and they appear to be in good condition at this time. There was no slipping noted with temperatures and shifting normal. The marine gear is supplied with an oil cooler, which requires periodic inspection and maintenance. The marine gears are flanged onto the engines set up in a conventional configuration. Port gear has an oil leak and starboard gear oil pressure alarm was present.

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DISCREPANCIES MAIN ENGINES

PORT

1. Charge air cooler seeping oil out of end plate gasket.
2. Random rocker box and valve cover o-rings seeping oil.
3. Random Exhaust manifold to head sealant is seeping.
4. Rust and corrosion on random surfaces. Clean and paint as needed.
5. Oil leak noted on back of gear by the PTO hydraulic pump. Clean and observe to determine location.
6. Oil prelube pumps did not work.
7. Alternator drive is seeping oil.
8. Gearbox high pressure oil lines need replacement.
9. Crankcase breather pipe is seeping oil from fitting on B bank by air inlet on turbo.
10. Risers should be tested due to age.
11. High exhaust temp alarm ETC B Bank E214/0 was noted during sea trial at wide open throttle.
12. Oil leak at oil filters.
13. Oil leak on gear box banjo fitting above gear oil cooler.
14. Oil pump out hose is deteriorating.

STARBOARD

1. High gear oil pressure alarm was noted during sea trial.
2. Charge air cooler seeping oil out of end plate gasket.
3. Random Exhaust manifold to head sealant is seeping.
4. Random rocker box and valve cover o-rings seeping oil.
5. Troll valve does not work.
6. Rust and corrosion on random surfaces. Clean and paint as needed.
7. Oil prelube pumps did not work.
8. Emergency bilge pump is seeping oil from the seal.
9. B bank oil leak noted near flywheel housing and block. Clean and observe.
10. Alternator drive is seeping oil.
11. Gearbox high pressure oil lines need replacement.
12. LOP engine room panel backlight not working.
13. Risers should be tested due to age.
14. It was noted that at 1450 RPM the port engine was constantly emitting a brown, black smoke overboard out the exhaust.
15. Coolant block heater inoperable.
16. Oil leak at oil filters.
17. Oil pump out hose is deteriorating.
18. Oil leak noted on back of gear by the PTO hydraulic pump.
19. Severe levels of aluminum and abnormal levels of chromium in oil sample.

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GENERATORS: (2) NORTHERN LIGHTS 80 KW

PORT	**STARBOARD**
Model: 6068TE001	**Model:** 6068TE001
Serial #: TO6068T50001	**Serial #:** TO6068T58002
Hours: 31,791	**Hours:** 31,552
Coolant temp: 182 F	**Coolant temp:** xxx F
Oil press: 50 PSI	**Oil press:** xxx PSI
KW: 80	**KW:** 80
KVA: 80	**KVA:** 80
Frequency: 60 htz.	**Frequency:** 60 htz.
RPM: 1800	**RPM:** 1800
Batt. V: 24	**Batt. V:** 24
Voltage: 120/240	**Voltage:** 120/240
Amp: 277	**Amp:** 277

The port generator performed well and carried the vessels electronic load. There was no excessive smoke noted during operation. **We could not test the starboard generator due to a no start issue.** The generators feature dual Separ primary fuel filter assembles. Model SWK2000/5 U. There was no water or algae present at this time.

Port and Starboard Generator Discrepancies

1. Port and stbd sea water pumps have some rust / corrosion around water seal but not leaking at this time.
2. Starboard oil leak at front of pan. Clean and observe.
3. Starboard coolant recovery bottle was empty.
4. Starboard oil leak at oil pan pump out fittings.
5. Port and stbd hour meter on run panel is not secure or accurate.
6. Port volt gauge on run panel is broken inside.
7. Starboard oil pressure gauge on run panel inoperable.
8. Port oil PSI and coolant temp gauges are inoperable on the TecPower electrical panel.
9. Could not test Starboard generator do to a no start issue.
10. Port and stbd hour meters are incorrect, not really sure of generator hours.
11. Severe levels of iron and abnormal levels of sodium in stbd generator oil sample.

GENERAL COMMENTS

The main engines and marine gears, along with generators, were found to be in serviceable condition at this time. An external visual inspection was performed with the outward appearance of the main engines and marine gears is satisfactory. The engines need servicing to remedy the discrepancies noted above. We could not test the starboard generator due to a no start issue.

NOTE:

The comments as stated in this report are based on engine inspections that were performed to the best of our ability and with as much attention to detail as possible. The results are believed to be an accurate evaluation as to the general condition of the engines at this time.

However, Marine Diesel Specialists, Inc. offers no warranty either express or implied on the engines of **M/Y "CUPCAKE"**. Survey results are intended to represent the physical condition of the vessel only on the day of the survey, based on the facts presented and discovered, in the opinion of the surveyor. This report will not specify or imply any type of warranty of the vessel or the vessel's machinery.

This report is issued subject to the condition that it is understood and agreed that neither this office, nor any surveyor or employee thereof is under any circumstances whatsoever to be held responsible in any way for any error in judgment, default or negligence, nor for any inaccuracy, omission, misrepresentation or misstatement in this report, and that the use of this report shall be construed to be an acceptance of the foregoing conditions. This report is issued without prejudice to the rights of whom it may concern.

Thank you for the opportunity to be of service and if you have any questions, please call.

Sincerely,

Peter Angel
President

Marine Diesel Specialists

Sea Trial Data Port

BOAT NAME: **CUPCAKE**
GEARBOX TYPE: **ZF**
NAME: **ERIC**
ENGINE TYPE: **MTU 12V396 TE94**
GEARBOXNR: **59701663**
DATE: **03/09/2026**
ENGINE NR: **558 3368**
LOAD CONDITION: **40%**
WEATHER: **P/C**
OPERATING HOURS: **6,130**
LOCATION: **Sea Haven Marina**
SEAS: **2-4**

Engine Speed	RPM	1000	1400	1600	1800	2000
Eng. Speed Actual	RPM	1015	1440	1614	1814	2099
ACTUAL DBR	MM	9.19	12.89	14.14	15.41	16.71
Fuel Rack	MM	6.19	8.03	9.35	12.26	16.67
Outside Air	Deg C°	29.2	29.2	29.3	29.2	29.3
Air Before Turbo	Deg C°	35	36	37	38	40
Charge Air Temp	Deg C°	64.5	62.6	61.8	59.1	60.8
S.W. Aft. Pump	Deg C°	27.8	27.8	27.8	28	28
F.W. Temp	Deg C°	72.6	74.3	75.3	76.9	81.1
Exhaust Temp A	Deg C°	351	464	507	675	694
Exhaust Temp B	Deg C°	363	475	521	708	726
Engine Oil Pressure	BAR	4.71	5.22	5.23	5.27	5.27
Charge Air Press	BAR	0	0.8	1.25	1.20	1.70
Exhaust Turbo Speed A1	KRPM	18.3	38.5	46.5	42.8	55.1
Exhaust Turbo Speed B1	KRPM	0.0	0.0	0.0	51.6	66.6
Gear Lube Oil Temp	Deg C°	43	45.6	47.9	51.2	56.3
Gear Lube Oil Press	BAR	18.1	17.8	18.1	18.1	18.8

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Sea Trial Data Starboard

BOAT NAME: **CUPCAKE**
GEARBOX TYPE: **ZF**
NAME: **ERIC**
ENGINE TYPE: **MTU 12V396 TE94**
GEARBOXNR: **59701664**
DATE: **03/09/2026**
ENGINE NR: **558 3369**
LOAD CONDITION: **40%**
WEATHER: **P/C**
OPERATING HOURS: **6,129**
LOCATION: **Sea Haven Marina**
SEAS: **2-4**

Engine Speed	RPM	1000	1400	1600	1800	2000
Eng. Speed Actual	RPM	1016	1437	1625	1828	2053
ACTUAL DBR	MM	8.90	12.83	14.11	15.43	16.68
Fuel Rack	MM	5.64	7.95	9.54	11.96	16.75
Outside Air	Deg C°	29.2	29.2	29.3	29.2	29.3
Air Before Turbo	Deg C°	35	36	37	38	40
Charge Air Temp	Deg C°	64.0	61.4	62.8	59.3	61.8
S.W. Aft. Pump	Deg C°	27.8	27.8	27.8	28	28
F.W. Temp	Deg C°	72.2	74.7	77.1	77.9	82.1
Exhaust Temp A	Deg C°	364	471	518	656	697
Exhaust Temp B	Deg C°	366	474	530	686	729
Engine Oil Pressure	BAR	4.81	5.28	5.29	5.34	5.36
Charge Air Press	BAR	0	0.8	1.30	1.20	1.80
Exhaust Turbo Speed A1	KRPM	18.2	38.8	47.4	42.9	53.6
Exhaust Turbo Speed B1	KRPM	0.0	0.0	0.0	54.2	64.5
Gear Lube Oil Temp	Deg C°	47.8	49.2	51.2	54.9	56.7
Gear Lube Oil Press	BAR	18.3	18.5	18.6	18.7	18.8

MARINE DIESEL SPECIALIST **Phone:** **Email:** **Fax:** ___-___-____	**Machine ID:** CUPCAKE **Machine Year :** NA **Component Description:**	**Component ID:** T06068T50001 **Component Make:** NORTHERN LIGHTS **Component Model:** 6068TE001 **Component Year:** NA **Component Type :** DIESEL ENGINE **Component Location:** PORT GENERATOR **Sump Capacity:** 16 Litres	M✓C **MOTORCHECK LAB** **2000 N FLORIDA MANGO RD 104** **WEST PALM BEACH FL 33409** **561-684-7799**

Sample ID	Date Taken	Hours on Component	Hours on Oil	Oil Weight	Oil Brand	Oil Type	Oil Changed	Date Analyzed	User Sample ID
31074	3/11/2026	44050	25	15W40	UNKNOWN	UNKNOWN	No	3/11/2026	
Comments	PHYSICAL DATA SUGGESTS THAT OIL IS EITHER NEW OR LIGHTLY USED. CYLINDER, CRANK OR CAM SHAFT WEAR INDICATED. SODIUM LEVEL HIGHER THAN TYPICAL, CHECK FOR SOURCE OF COOLANT AND/OR SALT WATER LEAK. ADVISE USE OF ADDITIONAL DIAGNOSTIC TOOLS TO DETERMINE COURSE OF CORRECTIVE ACTION.								

	Wear Metals(ppm)							*Contaminant Metals (ppm)*			*Multi-Source Metals (ppm)*					*Additives (ppm)*				
Sample ID	Iron	Chromium	Aluminum	Copper	Lead	Tin	Vanadium	Silicon	Sodium	Potassium	Titanium	Molybdenum	Nickel	Manganese	Boron	Magnesium	Calcium	Barium	Phosphorus	Zinc
31074	182	4	16	<2	<2	<2	X	7	69	<2	X	11	X	X	X	X	X	X	X	X

	Contaminants				*Physical Properties*								
Sample ID	Fuel	Soot	Water	Glycol	Nitration	TBN	Oxidation	V40C	V100C	VIndex	V40C Limit	V100C Limit	Visc Mode
31074	-	<0.1	<0.1	-	3.8	7.4	<2.0	109	14.4	135	92 - 124	12.5 - 16.3	C

ABNORMAL | SEVERE | D = DETECTED | - = NOT DETECTED | X = NOT TESTED / NOT APPLICABLE | NA = NOT AVAILABLE | C = CALCULATED | M = MEASURED

MARINE DIESEL SPECIALIST **Phone:** **Email:** **Fax:** ___-___-____	**Machine ID:** CUPCAKE **Machine Year :** NA **Component Description:**	**Component ID:** T06068T58002 **Component Make:** NORTHERN LIGHTS **Component Model:** 6068TE001 **Component Year:** NA **Component Type :** DIESEL ENGINE **Component Location:** STARBOARD GENERATOR **Sump Capacity:** 16 Litres	M✓C **MOTORCHECK LAB** **2000 N FLORIDA MANGO RD 104** **WEST PALM BEACH FL 33409** **561-684-7799**

Sample ID	Date Taken	Hours on Component	Hours on Oil	Oil Weight	Oil Brand	Oil Type	Oil Changed	Date Analyzed	User Sample ID
31075	3/11/2026	38950	25	15W40	UNKNOWN	UNKNOWN	No	3/11/2026	
Comments	PHYSICAL DATA SUGGESTS THAT OIL IS EITHER NEW OR LIGHTLY USED. ALL ENGINE WEAR RATES NORMAL. SAMPLE APPEARS FREE OF EXTERNAL CONTAMINATION. ANALYSIS INDICATES PROPER PERFORMANCE OF THE LUBRICANT AND UNIT.								

	Wear Metals(ppm)							*Contaminant Metals (ppm)*			*Multi-Source Metals (ppm)*					*Additives (ppm)*				
Sample ID	Iron	Chromium	Aluminum	Copper	Lead	Tin	Vanadium	Silicon	Sodium	Potassium	Titanium	Molybdenum	Nickel	Manganese	Boron	Magnesium	Calcium	Barium	Phosphorus	Zinc
31075	6	6	13	<2	7	<2	X	8	<2	<2	X	13	X	X	X	X	X	X	X	X

	Contaminants				*Physical Properties*								
Sample ID	Fuel	Soot	Water	Glycol	Nitration	TBN	Oxidation	V40C	V100C	VIndex	V40C Limit	V100C Limit	Visc Mode
31075	-	<0.1	<0.1	-	3.8	7.4	<2.0	109	14.4	135	92 - 124	12.5 - 16.3	C

ABNORMAL | SEVERE | D = DETECTED | - = NOT DETECTED | X = NOT TESTED / NOT APPLICABLE | NA = NOT AVAILABLE | C = CALCULATED | M = MEASURED

MARINE DIESEL SPECIALIST **Phone:** **Email:** **Fax:** ___-___-____	**Machine ID:** CUPCAKE **Machine Year :** NA **Component Description:**	**Component ID:** 5583368 **Component Make:** MTU **Component Model:** 12V396 TE94 **Component Year:** NA **Component Type :** DIESEL ENGINE **Component Location:** PORT MAIN **Sump Capacity:** 180 Litres	M✓C **MOTORCHECK LAB** **2000 N FLORIDA MANGO RD 104** **WEST PALM BEACH FL 33409** **561-684-7799**

Sample ID	Date Taken	Hours on Component	Hours on Oil	Oil Weight	Oil Brand	Oil Type	Oil Changed	Date Analyzed	User Sample ID
31076	3/11/2026	6130	20	15W40	UNKNOWN	UNKNOWN	No	3/11/2026	
Comments	PHYSICAL DATA SUGGESTS THAT OIL IS EITHER NEW OR LIGHTLY USED. ALL ENGINE WEAR RATES NORMAL. LOW TIME ON OIL LIMITS ACCURACY OF TEST DATA; HOWEVER, SAMPLE APPEARS FREE OF EXTERNAL CONTAMINATION. ANALYSIS INDICATES PROPER PERFORMANCE OF THE LUBRICANT AND UNIT.								

	Wear Metals(ppm)							*Contaminant Metals (ppm)*			*Multi-Source Metals (ppm)*					*Additives (ppm)*				
Sample ID	Iron	Chromium	Aluminum	Copper	Lead	Tin	Vanadium	Silicon	Sodium	Potassium	Titanium	Molybdenum	Nickel	Manganese	Boron	Magnesium	Calcium	Barium	Phosphorus	Zinc
31076	3	<2	<2	<2	<2	<2	X	9	<2	<2	X	12	X	X	X	X	X	X	X	X

	Contaminants				*Physical Properties*								
Sample ID	Fuel	Soot	Water	Glycol	Nitration	TBN	Oxidation	V40C	V100C	VIndex	V40C Limit	V100C Limit	Visc Mode
31076	-	<0.1	<0.1	-	3.8	7.4	<2.0	109	14.4	135	92 - 124	12.5 - 16.3	C

ABNORMAL | SEVERE | D = DETECTED | - = NOT DETECTED | X = NOT TESTED / NOT APPLICABLE | NA = NOT AVAILABLE | C = CALCULATED | M = MEASURED

MARINE DIESEL SPECIALIST **Phone:** **Email:** **Fax:** ___-___-____	**Machine ID:** CUPCAKE **Machine Year :** NA **Component Description:**	**Component ID:** 5583369 **Component Make:** MTU **Component Model:** 12V396 TE94 **Component Year:** NA **Component Type :** DIESEL ENGINE **Component Location:** STARBOARD MAIN **Sump Capacity:** 180 Litres	M✓C **MOTORCHECK LAB** **2000 N FLORIDA MANGO RD 104** **WEST PALM BEACH FL 33409** **561-684-7799**

Sample ID	Date Taken	Hours on Component	Hours on Oil	Oil Weight	Oil Brand	Oil Type	Oil Changed	Date Analyzed	User Sample ID
31077	3/11/2026	6129	20	15W40	UNKNOWN	UNKNOWN	No	3/11/2026	
Comments	PHYSICAL DATA SUGGESTS THAT OIL IS EITHER NEW OR LIGHTLY USED. LOW TIME ON OIL LIMITS ACCURACY OF TEST DATA; HOWEVER, PISTON WEAR INDICATED. POSSIBLE RING PROBLEM DEVELOPING. SAMPLE APPEARS FREE OF EXTERNAL CONTAMINATION. ADVISE USE OF ADDITIONAL DIAGNOSTIC TOOLS TO DETERMINE COURSE OF CORRECTIVE ACTION.								

	Wear Metals(ppm)							*Contaminant Metals (ppm)*			*Multi-Source Metals (ppm)*					*Additives (ppm)*				
Sample ID	Iron	Chromium	Aluminum	Copper	Lead	Tin	Vanadium	Silicon	Sodium	Potassium	Titanium	Molybdenum	Nickel	Manganese	Boron	Magnesium	Calcium	Barium	Phosphorus	Zinc
31077	<2	39	52	4	8	<2	X	4	<2	<2	X	31	X	X	X	X	X	X	X	X

	Contaminants				*Physical Properties*								
Sample ID	Fuel	Soot	Water	Glycol	Nitration	TBN	Oxidation	V40C	V100C	VIndex	V40C Limit	V100C Limit	Visc Mode
31077	-	<0.1	<0.1	-	3.8	7.4	<2.0	109	14.4	135	92 - 124	12.5 - 16.3	C

ABNORMAL | SEVERE | D = DETECTED | - = NOT DETECTED | X = NOT TESTED / NOT APPLICABLE | NA = NOT AVAILABLE | C = CALCULATED | M = MEASURED

MARINE DIESEL SPECIALIST **Phone:** **Email:** **Fax:** ___-___-____	**Machine ID:** CUPCAKE **Machine Year :** NA **Component Description:**	**Component ID:** 59701663 **Component Make:** ZF **Component Model:** BW465 **Component Year:** NA **Component Type :** GEARBOX **Component Location:** PORT **Sump Capacity:** 60 Litres	M✓C **MOTORCHECK LAB** **2000 N FLORIDA MANGO RD 104** **WEST PALM BEACH FL 33409** **561-684-7799**

Sample ID	Date Taken	Hours on Component	Hours on Oil	Oil Weight	Oil Brand	Oil Type	Oil Changed	Date Analyzed	User Sample ID
31078	3/11/2026	6130	20	SAE 40	UNKNOWN	UNKNOWN	No	3/11/2026	
Comments	GEAR UNIT WEAR RATES NORMAL. SAMPLE APPEARS FREE OF EXTERNAL CONTAMINATION. ANALYSIS INDICATES PROPER PERFORMANCE OF THE LUBRICANT AND UNIT.								

	Wear Metals(ppm)							*Contaminant Metals (ppm)*			*Multi-Source Metals (ppm)*					*Additives (ppm)*				
Sample ID	Iron	Chromium	Aluminum	Copper	Lead	Tin	Vanadium	Silicon	Sodium	Potassium	Titanium	Molybdenum	Nickel	Manganese	Boron	Magnesium	Calcium	Barium	Phosphorus	Zinc
31078	<2	<2	<2	<2	10	5	X	6	<2	<2	X	11	X	X	X	X	X	X	X	X

	Contaminants				*Physical Properties*								
Sample ID	Fuel	Soot	Water	Glycol	Nitration	TBN	Oxidation	V40C	V100C	VIndex	V40C Limit	V100C Limit	Visc Mode
31078	X	X	<0.1	X	X	X	<2.0	157	14.4	88	133 - 181	12.5 - 16.3	C

ABNORMAL | SEVERE | D = DETECTED | - = NOT DETECTED | X = NOT TESTED / NOT APPLICABLE | NA = NOT AVAILABLE | C = CALCULATED | M = MEASURED

MARINE DIESEL SPECIALIST **Phone:** **Email:** **Fax:** ___-___-____	**Machine ID:** CUPCAKE **Machine Year :** NA **Component Description:**	**Component ID:** 59701664 **Component Make:** ZF **Component Model:** BW465 **Component Year:** NA **Component Type :** GEARBOX **Component Location:** STARBOARD **Sump Capacity:** 60 Litres	M✓C **MOTORCHECK LAB** **2000 N FLORIDA MANGO RD 104** **WEST PALM BEACH FL 33409** **561-684-7799**

Sample ID	Date Taken	Hours on Component	Hours on Oil	Oil Weight	Oil Brand	Oil Type	Oil Changed	Date Analyzed	User Sample ID
31079	3/11/2026	6129	20	SAE 40	UNKNOWN	UNKNOWN	No	3/11/2026	
Comments	GEAR UNIT WEAR RATES NORMAL. SAMPLE APPEARS FREE OF EXTERNAL CONTAMINATION. ANALYSIS INDICATES PROPER PERFORMANCE OF THE LUBRICANT AND UNIT.								

	Wear Metals(ppm)							*Contaminant Metals (ppm)*			*Multi-Source Metals (ppm)*					*Additives (ppm)*				
Sample ID	Iron	Chromium	Aluminum	Copper	Lead	Tin	Vanadium	Silicon	Sodium	Potassium	Titanium	Molybdenum	Nickel	Manganese	Boron	Magnesium	Calcium	Barium	Phosphorus	Zinc
31079	<2	<2	<2	<2	15	<2	X	4	<2	<2	X	<2	X	X	X	X	X	X	X	X

	Contaminants				*Physical Properties*								
Sample ID	Fuel	Soot	Water	Glycol	Nitration	TBN	Oxidation	V40C	V100C	VIndex	V40C Limit	V100C Limit	Visc Mode
31079	X	X	<0.1	X	X	X	<2.0	157	14.4	88	133 - 181	12.5 - 16.3	C

ABNORMAL | SEVERE | D = DETECTED | - = NOT DETECTED | X = NOT TESTED / NOT APPLICABLE | NA = NOT AVAILABLE | C = CALCULATED | M = MEASURED

M✓C™ *UNDERSTANDING YOUR REPORT*

	ENGINES	TRANSMISSIONS
ALUMINUM:	PISTONS, BEARINGS, HOUSINGS, THRUST WASHERS, BUSHINGS	TORQUE CONVERTER, THE CASE, THRUST WASHERS, HOUSINGS, GEAR AND VANE PUMPS
CHROMIUM:	COMPRESSION RINGS, LOW FRICTION BEARINGS, LINERS, CHROMATE COOLING SYSTEM	BALL AND ROLLER BEARINGS, ALLOY OF STEEL PARTS
COPPER:	BEARINGS, BUSHINGS, THRUST WASHERS, OIL COOLER, CLUTCHES, AND AN OIL ADDITIVE IN SOME GASOLINE ENGINE OILS.	CLUTCH PLATES, BRONZE BUSHINGS, OIL COOLER OXIDES, BRASS FITTINGS
IRON:	CRANKSHAFT, CYLINDERS, PISTONS, LINERS, BEARINGS, VALVE TRAIN	GEARS, BEARINGS, SHAFTS, SOME CASES, CLUTCH PLATES
LEAD:	BEARINGS, CONTAMINATION FROM LEADED GASOLINE	GEARS
TIN:	PISTON SKIRTS, BEARINGS, AND BUSHINGS.	SOME BEARING CAGES
SILICON:	AIRBORN DIRT, SEAL MATERIAL, GASKETS, USED IN SOME OIL ADDITIVES, SPRAY LUBRICANTS, WHEN FOUND WITH POTASSIUM INDICATES GLYCOL ISSUE	AIRBORN DIRT, SEALERS, GASKETS, USED IN SOME OIL ADDITIVES, SPRAY LUBRICANTS, WHEN FOUND WITH POTASSIUM INDICATES GLYCOL ISSUE, SAND-CASTED PARTS
POTASSIUM:	INDICATION OF GLYCOL OR SALTWATER INTRUSION, ADDITIVE IN SOME OILS	INDICATION OF GLYCOL OR SALTWATER INTRUSION, ADDITIVE IN SOME OILS
SODIUM:	FOUND IN SOME OIL ADDITIVES, GLYCOL, ENVIRONMENTAL COMTAMINANT OR SALT WATER	FOUND IN SOME OIL ADDITIVES, GLYCOL, ENVIRONMENTAL COMTAMINANT OR SALT WATER
WATER:	MEASURED IN % VOLUME, CAN BE INDICATION OF CONDENSATION, COOLING SYSTEM LEAK, OR OUTSIDE CONTAMINATION	
GLYCOL:	MEASURED IN % VOLUME, IN THE FORMULATION OF MOST COMMERCIAL COOLANTS	
OXIDATION:	THIS IS THE RESULTS OF OXYGEN IN THE AIR REACTING WITH THE OIL AT ELEVATED TEMPERATURES. THIS IS A NORMAL PROCESS AS THE OIL AGES. IF AN ENGINE IS OPERATED CONTINUOUSLY AT A HIGH TEMPERATURE FOR EXTENDED PERIODS, OR IF DRAIN INTERVAL IS OVER EXTENDED, OIL CHANGE IS RECOMMENDED.	
NITRATION:	FORMED DURING COMBUSTION PROCESS, LEADS TO ACCELERATED OIL DETERIORATION.	
SOOT:	NORMAL COMBUSTION BY PRODUCT OF DIESEL FUEL AND APPEARS AS CONTAMINANT IN THE OIL CAUSING AN INCREASE IN VISCOSITY. INDICATE AN INPROPER AIR/FUEL RATIO, DEFECTIVE AIR INTAKE, FAULTY INJECTORS, OR BLOW-BY	
VISCOSITY:	CALCULATED MEASUREMENT OF THE OIL'S ABILITY TO FLOW AND LUBRICATE, INDICATES IF OIL IS TOO THICK OR THIN	
TBN:	MEASUREMENT OF OIL'S ALKALINE BASE RESERVE, ADDITIVE IN OIL CAPABLE OF NEUTRALIZING ACIDIC CONTAMINANTS, WHEN TBN IS BELOW 3, IT IS AN INDICATION THE OIL IS NO LONGER SERVICEABLE	
FUEL DILUTION:	MEASURED IN % VOLUME, CAN INDICATE FAULTY COMBUSTION, RICH AIR/FUEL MIXTURE WHEN PRESENT BETWEEN 2%-5%. INJECTOR PROPBLEM OR INTERNAL FUEL LINE LEAK IS TYPICALLY INDICATED WHEN FUEL IS DETECTED AT HIGH LEVELS	

ACCURACY OF RECOMMENDATIONS IS DEPENDENT ON THE REPRESENTATIVE OIL SAMPLES AND COMPLETELY CORRECT DATA ON BOTH UNIT AND OIL. THIS ANALYSIS IS INTENDED AS AN AID IN PREDICTING MECHANICAL WEAR. NO GUARANTEE, EXPRESS OR IMPLIED, IS MADE AGAINST FAILURE OF THIS COMPONENT, MOTOR CHECK(OIL LAB LLC.) LIABILITY IN ANY CASE IS LIMITED TO THE COST OF THE REPORTED ANALYSIS.

MTU_Value*Service*
Technical Documentation

Diesel Engine
V 396 TE94
Application Group 1DS

Maintenance Schedule
M050705/03E

applicable for ...

12V396TE94
16V396TE94
8V396TE94

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Subject to alterations and amendments.

1 Preface

MTU maintenance concept

The maintenance system for MTU products is based on a preventive maintenance concept. Preventive maintenance facilitates advance planning and ensures a high level of equipment availability.

The maintenance schedule is based on the load profile / load factor specified below. The time intervals at which the maintenance work is to be carried out and the relevant checks and tasks involved are average values based on operational experience and are therefore to be regarded as guidelines only. Special operating conditions and technical requirements may require additional maintenance work and/or modification of the maintenance intervals. In order to be authorized to carry out the individual maintenance jobs, maintenance personnel must have achieved a level of training and qualification appropriate to the complexity of the task in hand. The various Qualification Levels QL1 to QL4 reflect the levels of training offered in MTU courses and the contents of the tool kits required:

QL1: Operational monitoring and maintenance which can be carried out during a break in operation without disassembling the engine.
QL2: Component exchange (corrective only).
QL3: Maintenance work which requires partial disassembly of the engine.
QL4: Maintenance work which requires complete disassembly of the engine.

The maintenance schedule matrix normally finishes with extended component maintenance. Following this, maintenance work is to be continued at the intervals indicated.

The numbers stated in the list of jobs provide a reference to the scope of parts required.

Notes on maintenance

Specifications for fluids and lubricants, guideline values for their maintenance and change intervals and lists of recommended fluids and lubricants are contained in the MTU Fluids and Lubricants Specifications A001061 and in the fluids and lubricants specifications produced by the component manufacturers. They are therefore not included in the maintenance schedule (exception: deviations from the Fluids and Lubricants Specifications). All fluids and lubricants used must meet MTU specifications and be approved by the relevant component manufacturer.

Amongst other items, the operator/customer must carry out the following additional maintenance work:

- Protect components made of rubber or synthetic material from oil. Never treat them with organic detergents. Wipe with a dry cloth only.
- Fuel prefilter:
  The maintenance interval depends on how dirty the fuel is. The paper inserts in fuel prefilters must be changed every two years at the latest (Task 9998).
- Battery:
  Battery maintenance depends on the level of use and the ambient conditions. The battery manufacturer's instructions must be obeyed.

The relevant manufacturer's instructions apply with respect to the maintenance of any components which do not appear in this maintenance schedule.

This Maintenance Schedule may include components which are not installed on your engine; these may be disregarded.

Out-of-service periods

If the engine is to remain out of service for more than 1 month, carry out engine preservation procedures in accordance with the Fluids and Lubricants Specifications, MTU Publication No. A001061.

Application Group

1DS	Continuous operation, variable, low load

Load profile

Load factor	100%	70%	<10%
Corresponding operating time	10%	70%	20%

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2 Maintenance schedule matrix

0-5.250 Operating hours

Item	Limit	Operating hours [h]																					
		Daily	250	500	750	1.000	1.250	1.500	1.750	2.000	2.250	2.500	2.750	3.000	3.250	3.500	3.750	4.000	4.250	4.500	4.750	5.000	5.250
Engine operation	-	X																					
Engine oil filter	2 a																						
Emergency air shut-off flaps	1 a		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Engine oil edge-type filter	1 a		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Centrifugal oil filter	1 a		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Valve gear	18 a			X		X		X		X		X		X		X		X		X		X	
Air filters	1 a			X		X		X		X		X		X		X		X		X		X	
Lubrication points	1 a			X		X		X		X		X		X		X		X		X		X	
Fuel filter	2 a			X		X		X		X		X		X		X		X		X		X	
Starter	18 a							X						X						X			
Fuel injectors	18 a							X						X						X			
Battery charging generator	18 a							X						X						X			
Engine coolant circuit	18 a							X						X						X			
Combustion chambers	18 a							X						X						X			
Engine mounts	2 a							X						X						X			
Air filters	3 a							X						X						X			
Turbochargers	18 a													X									
Turbocharger control system	18 a													X									
Component maintenance	18 a													X									
Battery charging generator	18 a													X									
Cylinder heads	18 a													X									
Turbocharger control system	18 a																						
Extended component maintenance	18 a																						

w = weeks
m = months
a = years

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5.500-6.000 Operating hours

Item	Limit	Operating hours [h]																						
		5.500	5.750	6.000																				
Engine operation	-																							
Engine oil filter	2 a																							
Emergency air shut-off flaps	1 a	X	X	X																				
Engine oil edge-type filter	1 a	X	X	X																				
Centrifugal oil filter	1 a	X	X	X																				
Valve gear	18 a	X		X																				
Air filters	1 a	X		X																				
Lubrication points	1 a	X		X																				
Fuel filter	2 a	X		X																				
Starter	18 a			X																				
Fuel injectors	18 a			X																				
Battery charging generator	18 a			X																				
Engine coolant circuit	18 a			X																				
Combustion chambers	18 a			X																				
Engine mounts	2 a			X																				
Air filters	3 a			X																				
Turbochargers	18 a			X																				
Turbocharger control system	18 a			X																				
Component maintenance	18 a			X																				
Battery charging generator	18 a			X																				
Cylinder heads	18 a			X																				
Turbocharger control system	18 a			X																				
Extended component maintenance	18 a			X																				

w = weeks
m = months
a = years

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3 Maintenance tasks

Qual-ifica-tion level	Inter-val [h]	Limit	Item	Maintenance tasks	Task
QL1	Daily	-	Engine operation	Check engine oil level .	W0500
				Carry out visual inspection of engine for general condition and leaks .	W0501
				Inspect intercooler drain system (if fitted) .	W0502
				Inspect service indicator of air filter .	W0503
				Check relief bores of coolant pump(s) .	W0505
				Check for abnormal running noises, exhaust gas color and vibration .	W0506
				Drain off water and contamination from fuel prefilter (if fitted) .	W0507
				Check service indicator of fuel prefilter (if fitted) .	W0508
QL1	-	2 a	Engine oil filter	Drain off oil sludge and test for metallic residues. Fit new filter inserts when the oil is changed or at the latest when the time limit has been reached.	W1096
QL1	250	1 a	Emergency air shut-off flaps	Check operation of emergency air shut-off flaps (electrical) .	W1024
QL1	250	1 a	Engine oil edge-type filter	Actuate ratchet lever several times.	W1080
QL1	250	1 a	Centrifugal oil filter	Check thickness of oil residue layer. Clean. Fit new sleeve (if fitted) .	W1009
QL1	500	18 a	Valve gear	Check valve clearance .	W1002
QL1	500	1 a	Air filters	Clean air filter(s) .	W1173
QL1	500	1 a	Lubrication points	Apply lubricant at lubrication points.	W1053
QL1	500	2 a	Fuel filter	Fit new fuel filter or new fuel filter insert .	W1001
QL1	1500	18 a	Starter	Starter: Inspect carbon brushes.	W1061
QL1	1500	18 a	Fuel injectors	Remove fuel injectors, inspect them and fit new sealing rings.	W1060
QL1	1500	18 a	Battery charging generator	Battery-charging generator: Inspect carbon brushes and coupling .	W1174
QL1	1500	18 a	Engine coolant circuit	Clean strainers in coolant return line .	W1189
QL1	1500	18 a	Combustion chambers	Inspect cylinder chambers using endoscope .	W1011
QL1	1500	2 a	Engine mounts	Check buffer clearance of resilient mounts Check proper seating of securing screws .	W1026
QL1	1500	3 a	Air filters	Fit new air filters .	W1005
QL3	3000	18 a	Turbochargers	Overhaul turbochargers (MTU-ZR-turbocharger).	W1038
QL3	3000	18 a	Turbocharger control system	Overhaul exhaust flaps, air flaps, actuating cylinders and solenoids.	W1131
QL3	3000	18 a	Component maintenance	Before starting maintenance work, drain the coolant and flush the cooling systems .	W2000
				Clean air ducting .	W2002
				Clean intercooler and inspect for leakage .	W2003
				Inspect centrifugal oil filter for wear (if fitted) .	W2009
				Clean engine coolant cooler and, if possible, inspect it for leaks .	W2017
				Check engine alignment .	W2036
				Starting air distributor: Inspect components. Check settings. Adjust if necessary .	W2041
				Overhaul engine coolant pump .	W2110

w = weeks
m = months
a = years

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Qual-ifica-tion level	Inter-val [h]	Limit	Item	Maintenance tasks	Task
				Overhaul raw-water pump .	W2111
				Overhaul bilge pump (if fitted) .	W2112
				Exhaust line: Clean housing and hot components and check for cracks .	W2113
				Fuel injection pumps: Check basic setting of injection timing .	W2105
				Fit new seals/sealing materials for all disassembled components .	W2062
QL3	3000	18 a	Battery charging generator	Overhaul battery-charging generator.	W1043
QL3	3000	18 a	Cylinder heads	Overhaul cylinder heads. Visually inspect piston crowns and wear pattern on cylinder liner running surfaces .	W1063
QL4	6000	18 a	Turbocharger control system	Overhaul exhaust flaps, air flaps, actuating cylinders and solenoids.	W1131
QL4	6000	18 a	Extended component maintenance	Completely disassemble the engine.Inspect engine components as per assembly instructions and repair or fit new components as required .	W3000
				Replace all elastomeric parts and seals with new ones .	W3001
				Fit new conrod bearings .	W3003
				Fit new crankshaft bearings .	W3004
				Fit new oil separator for crankcase breather system .	W3009
				Fit new fuel delivery pump .	W3010
				Fit new exhaust flap bearings .	W3013
				Remove pistons. Inspect skirts and crowns. Fit new piston rings .	W3015
				Inspect gear train for cracks. Inspect bearings .	W3017
				Fit new camshaft bearings and camshaft thrust bearings .	W3018
				Remove and inspect vibration damper. Repair if necessary .	W3019
				Re-hone cylinder liners or fit new ones if necessary .	W3061
				Overhaul fuel injection pump.	W3071

w = weeks
m = months
a = years

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