SPECIFICATIONS
FOR
MAIN DIESEL GENERATOR ENGINE

1800 kW ACG x 720 min-1 4 sets/ship

JIANGNAN SHIPYARD(GROUP) CO., LTD.

5,100 TEU CONTAINER VESSEL

DAIHATSU DIESEL MFG.CO.,LTD.
TECHNICAL DEPARTMENT
JAPAN

HULL NO.	H2431/2/3	DRAWN BY	N.Hatano
ENG. MODEL	6DK-28	CHECKED BY	T. Tsuchi
LIST NO.	AQA10003700D		
DATE	JAN.17,2007	APPROVED BY	
REVISION	B:2007/02/08 H.K C:P.7 2007/11/27 N.H D:P.8,9 2008/01/09 N.H		

1. GENERAL

1.1 Rules and Regulations

The diesel generator engine will be complied with the requirements of the following rules and regulations of the latest issue.

1) Classification ..... GL, AUT
2)Compliance for Engine Air Pollution Prevention with Marpol, AnnexⅥ,Regulation 13
Statement of Compliance issued by GL should be submitted (SOC).
3) Japanese industrial standard ..... JIS
4) Miscellaneous
The other not specifically mentioned in this specifications will be manufactured on the basis of manufacturer's quality control standard.
5) Flag ..... Liberia or Marshall Islands

1.2 Conditions

Machinery	ambient temp. +5 to 45℃ cooling sea water temp. 32℃ relative humidity 60 % barometric press. 1000 hPa{750 mmHg}
General power source	AC 440 V 60 Hz 3-phase
Control power source	AC 220 V 60 Hz 1-phase and DC 24 V
Starting air source	2.94 MPa
Control air source	0.6 - 0.9 MPa
Heating steam source	0.7 MPa saturated, working

1.3 Installations

Diesel engine will be directly coupled to the generator as maker's standard and placed together on the common bed.
Diesel generator set should be resiliently mounted onto the hull structure as maker's standard.

1.4 Pipe connection flanges

Pipe connection flanges which are connected to the shipyard's piping will be provided in accordance with JIS.
JIS counter-flanges will be supplied by Daihatsu.

1.5 Name and caution plates

The plates will be written in English.
The caution plate will be written in English.
Unit is the SI system.

1.6 Painting

Generator engine and accessories.....	Munsell 7.5BG7/2
Electric control panel.....	Munsell 7.5BG7/2
Exhaust manifold cover	Aluminum heat resisting paint

1.7 Plans

Approval plan.....	11 copies and 1pc CD
Working plan.....	9 copies and 1pc CD
Final plan	8 copies for first vessel, 6 copies for other vessel, including instruction manuals and test report for each ship, 1 pc CDROM for Shipyard 1Original/3 copies of certificate for each ship

1.8 Fuel oil

Heavy Fuel Oil (hereinafter referred to as HFO) .....ISO 8217 F-RMK700
of viscosity up to 600 mm^2/s(cSt) at 50℃
Marine Diesel Oil (hereinafter referred to as MDO)...ISO 8217 DMB

1.9 Notes for Fuel oil pre-treatment

1) Upon deep deliberation with separator maker, the best centrifugal separation system should be applied. Especially density max.1010 kg/cm3 at 15℃ of fuel oil.
2) Recommended fuel properties before engine
Aluminum content :<10 mg/kg
Water content :<0.2 % by volume
Sodium content :<50 mg/kg

1.10 Fuel oil when engine starting and stopping

at initial start-up (cold condition)..... MDO
at normal operation ..... HFO

Note: In case that the engine is started on HFO, the standby engine needs to be pre-heated up with the circulating jacket water of 70℃.

1.11 Notices for operation

The engine, together with proper external system arrangements, can be operated on the above-mentioned fuel, still:

- fuel oil viscosity at the inlet port of engine should be kept to 14±1.5mm^2/s(cSt) in case of using HFO and min.2.5mm^2/s(cSt) in case of using MDO.

(Recommendation)
- In case of CCAI (Calculated of Carbon and Aromatics Index) ≦850 (ISO 8217 F-RMH700) continuous low load ≧20% (360kW Gen. output)

- In case of CCAI (Calculated of Carbon and Aromatics Index) >850 (ISO 8217 F-RMK700) continuous low load ≧35% (630kW Gen. output)

- no load operation on HFO before stopping is proper to as short as possible, less than 5 min.

1.12 Recommended lubricating oil

System oil .....API service grade CD SAE40 TBN40
Governor oil .....same as system oil SAE40

1.13 Fluid holdings in engine

Lubricating oil .... LO cooler 53 lit. + LO tank 2000 lit. = initial filling quantity about 2000 lit.
(engine in running condition 63 lit.)
Governor oil..... 1.3 lit.
HT-FW ..... engine 210 lit.
LT-FW..... air cooler 35 lit. + LO cooler 95 lit.

2. PRINCIPAL PARTICULARS

2.1 Type of Engine ..... vertical in-line 4-stroke single-acting non-reversible direct injection trunk piston type with exhaust turbocharger and air cooler

2.2 Type of Generator ..... synchronous self-exciting brushless self-ventilated drip-proof outside metal type self-lubricating one(1) sleeve bearing. Made in Japan supplied by Daihatsu

2.3 Direction of rotation ..... clockwise as viewed from generator end

2.4 Control ..... manual start/stop :remote and engine-side
automatic start :managed by MSB
automatic stop :caused by engine emergency shutdown
synchronization :manual/auto on MSB and engine-side

2.5 Engine starting method ..... compressed air start

2.6 Engine cooling system ..... central cooling with 36℃ LT-FW

2.7 Location of Turbocharger ..... opposite side to generator

2.8 Camshaft ..... built-up type

2.9 Diesel generator data

Engine model	6DK-28
Quantity of cylinders	6
Cylinder bore x Piston stroke	280 mm x 390 mm
Engine rated output	1900 kW {2584 PS}
Engine speed	720 min^{-1}
Mean effective pressure	2.20 MPa
Mean piston speed	9.36 m/s
Maximum pressure	≦17.0 MPa
Overload capacity	110% for an hour every 12 hours
Lube oil consumption	0.8g/Kwh (estimate at full load)
Fuel oil consumption *1)	194 g/kWh +5%

Generator capacity	2250 kVA
Generator rated output	1800 kW
Power factor	0.8 lagging
No. of poles	10
Voltage Phase Frequency	AC 450 V 3-phase 60 Hz

Quantity of DG set	Four(4) sets/ship

*1)Fuel oil consumption is based on the engine output (kW) at crankshaft-end using fuel lower calorie of 42700kJ/kg, under 100% generator load, on condition that the engine drives each one (1) of LO pump and HT-FW pump.

3. SPEED GOVERNING SYSTEM

3.1 Engine fitting (each 1 set/engine)

Governor	mechanical-hydraulic type BOSCH made model RHD10-MC
Governor motor	permanent magnetic field type DC motor speed changing time: 8 – 10 s/Hz
Governor speed control unit	potentiometer and rectifier input from MSB: AC220V 60Hz 1-phase output to governor motor: DC24V

3.2 Separate accessory (installed on hull part by shipyard): NONE

3.3 Reference data for External system

Sudden load steps	0→40→80→100%: 3 steps
Sudden off-load step	100→0%
Speed variations	within 10% momentary and within 5% permanently
Speed stabilized time	within 5 seconds

When a four-stroke diesel engine with high supercharge is used as the prime mover for driving generator, application of electrical load in more than 2 load steps can be permitted in its governing characteristics by classification society. In this case, it is considered in the designing stage that where the electric station being automatically switched on after blackout and to the sequence in which it is connected, the load value is not to exceed the value of specified in 1st load step.
This also applies analogously for generators to be operated in parallel and where the power has to be transferred from one generator to another in event of any one generator has to be switched off.

4. CHARGE AIR / EXHAUST SYSTEM

4.1 Engine fitting (each 1 set/engine)

Exhaust turbo-charger	MHI made model MET26SR with cleaning device of compressor and turbine side
Air cooler	tube with fin type fresh water cooled

4.2 Separate accessory (installed on hull part by shipyard)

Exhaust expansion joint	for exhaust gas turbocharger outlet stainless steel bellows with both end flanges size 400A x 500A (1 pc./engine)

4.3 Reference data for External system

Fresh air outlet from ventilator	to be located near the turbocharger air inlet
Required combustion air	12900 m^3 at 25℃ per one(1) engine
Charge air temp. before cylinders	operation 45 - 55℃
Exhaust gas volume	12400 m^3 normal/h per one(1) engine
Exhaust gas temp. at T/C outlet	approx.380℃
Permissible exhaust gas back press.	max.300 mmAq
Silencer	500A x 500A (1 pc/engine)

5. FUEL OIL SYSTEM

5.1 Engine fitting (each 1 set/engine)

Fuel oil final filter	notch wire duplex type with manual blow off device 200 mesh	
Press. relief valve	at oil return pipe end	Δp=0.1 - 0.2MPa
Pressure damper	on oil inlet and outlet pipe	

5.2 Separate accessories (installed on hull part by shipyard):

HFO regulating valve	set 0.7MPa (1 set/ship)
MDO regulating valve	set 0.4MPa (1 set/ship)

5.3 Reference data for External system

HFO pre-treatment with centrifugal separators	Aluminum content: < 10 mg/kg Water content: < 0.2 % by volume Sodium content: < 50 mg/kg	
MDO feed pump	≧1.28 m^3/h per one(1) engine discharge: 0.7 MPa	
HFO pre-boost (supply) pump	≧0.51 m^3/h per one(1) engine discharge: 0.5 MPa suction: static	
HFO booster (circulation) pump	≧1.41 m^3/h per one(1) engine discharge: 1.0 MPa suction: 0.4 MPa	
HFO pre-boost press.	nominal	0.4 MPa
HFO press. before engine	nominal	0.7 MPa
HFO press. before fuel inj. pump	operation	0.5 - 0.6 MPa
	low alarm	0.35 MPa
HFO press. after engine	nominal	0.4 MPa
MDO press. before feed pump	nominal	static
MDO press. after pump relief valve	nominal	static
MDO press. after engine	nominal	0.4 MPa
Fuel viscosity before fuel inj. pump	operation	14±1.5 mm^2/s(cSt)(in case of using HFO)
	operation	min.2.5 mm^2/s(cSt)(in case of using MDO)
Pump suction strainer	absolute	60 - 100 mesh (0.22 – 0.14 mm)
Automatic backwash filter	nominal	10 micron (absolute 25 micron)
Bypass strainer	absolute	350 mesh (absolute 40 micron)
Engine built-on filter	absolute	200 mesh (absolute 75 micron)

6. NOZZLE COOLING SYSTEM

HT-FW branching system

7. COMPRESSED AIR SYSTEM

7.1 Engine fitting (each 1 set/engine)

Starting air operation valve	for manual start at engine-side
Main starting air valve	starting air control to engine
Starting air rotary valve	for the pilot air distribution to starting valve

7.2 Separate accessories (installed on hull part by shipyard): NONE

7.3 Reference data for External system

Starting air source	nominal	2.94 MPa
	operation	1.5 – 2.94 MPa
	low alarm	1.5 MPa
Starting air consumption	0.7 m^3 normal/one(1) time	
Auxiliary air reservoir capacity	recommend	200 lit. per one(1) ship
Control air pressure	operation	0.6 - 0.9 MPa
Control air consumption	negligible small	

8. LUBRICATING SYSTEM

8.1 Engine fitting (each 1 set/engine)

L.O. suction strainer	punching board type of 3 mm holes built in L.O. tank
L.O. pump	engine driven gear type 41 m^3/h x 0.65 Mpa
L.O. cooler	multi-tubular type fresh water cooled
L.O. thermostat valve	wax type with hand operating bypass device
L.O. relief valve	bearing line setting pressure 0.40 - 0.55 Mpa
L.O. auto filter	Absolute 30 micron with slugde collector Boll & Kirich made
L.O. final filter	notch wire duplex type with manual blow off device 200mesh
L.O. tank	incorporated in common bed capacity 2000 lit. with overflow port
Turbocharger L.O. filter	notch wire duplex type with manual blow off device 280 mesh
L.O. bypass filter	self-rotating glacier type FM200 x 2
L.O. priming pump	motor driven gear rotary type pump 5.0m^3/h × 0.4MPa motor 2.2kW AC 440V 60Hz 3-phase TEFC(IP44) class B insulation

8.2 Separate accessories (installed on hull part by shipyard): NONE

8.3 Reference data for External system

Bearing L.O. pressure	operation	0.40 - 0.55 MPa
	low alarm	0.30 MPa
	safety stop	0.25 MPa
L.O. temperature of engine inlet	operation	40 - 60℃
L.O. centrifugal separator flow for continuous purification	min. flow (lit./h) = total L.O. q'ty (lit.) x 5 times / 23.5 hours	

9. COOLING WATER SYSTEM

9.1 Engine fitting (each 1 set/engine)

HT-FW pump	engine driven centrifugal type 50 m^3/h × 25 m TH
Engine pre-heating piping at engine inlet	screw-down non-return valve for external heating system for HFO starting engine
HT-FW temp. control valve	70℃ engine inlet.
LT-FW auto shut valve	hydraulic type

9.2 Separate accessories (installed on hull part by shipyard)

Jacket F.W. preheating unit	1 unit/ship(1 unit for 3 engines) (IP44) necessary heater capacity:20kW/engine electric heater(abt.60kW), FW flow 10m3/h AC440V, 60Hz, 1phase

C

9.3 Reference data for External system

FW expansion tank height	tank bottom higher 3 – 10 m than crankshaft center	
FW expansion tank net capacity	min. 320 lit. per one(1) engine	
LT-FW required flow	80 m^3/h per one(1) engine	
LT-FW pressure	operation	max. 0.25 MPa
Engine coolers flow resistance	approx. 10 mAq	
LT-FW temp. of engine inlet	control	36℃

HT-FW pressure of cyl. inlet	operation	0.25 - 0.35 MPa
	low alarm	0.15 MPa
HT-FW flow resistance	approx. 4 mAq	
HT-FW temp. of engine inlet	control	70℃
HT-FW temp. of engine outlet	high alarm	85℃
	safety stop	90℃

10. SAFETY DEVICE

10.1 Engine fitting (each 1 set/engine)

Cylinder safety valve ..... equipped on each cylinder head with Max. pressure gauge connection
Crankcase relief valve ..... equipped properly on the side-cover
Rupture disc and non-return valve ..... toward back fire in starting air system

11. SUNDRY

11.1 Engine fitting (each 1 set/engine)

Step ..... on FO injection pump side with ladder
Flywheel turning device ..... reduction gear type with electric motor
Motor:0.4kW AC440V 60Hz 3-phase
Flywheel guard ..... steel plate fabrication
Exhaust manifold cover ..... steel plate fabrication with inside lagging
Common bed ..... welded steel plate fabrication
Jack bolts ..... screwed into the common bed
Rubber vibration isolator ..... for resilient mounting

11.2 Separate accessories (installed on hull part by shipyard)

Flexible tube ..... each size
Turning device starter panel ..... wall hanging type with wired switch box
Power source:AC440V 60Hz 3-phase
(1panel/engine)

12. ENGINE GAUGE BOARD

Engine fitting consists of following indicators

Engine tachometer ..... direct measuring mechanical type
Pressure gauge ..... direct measuring bourdon tube glycerin-filled type
each one(1) of; Charge air
Fuel oil
Starting air
LO
T/C LO
HT-FW
LT-FW

13. LOCAL THERMOMETER

Engine fitting of direct measuring liquid filled glass stem type

Charge air	intake manifold
Exhaust gas	each cylinder outlet
	Turbo-charger inlet
	turbo-charger outlet
Fuel oil	engine inlet
Lube oil	engine inlet
	L.O. cooler inlet & outlet
HT-FW	engine inlet
	engine common outlet
Nozzle CFW	engine outlet

D

Cooler CFW..... air cooler inlet
LO cooler inlet & outlet D

14. CONTROL SYSTE (Satisfied GL)

14.1 Engine fitting (each 1 set/engine)

Remote start magnetic valve.....DC24V 15W
Fuel shutdown device.....DC24V 15W
for fuel control in process of starting
Remote stop magnetic valve.....DC24V 15W
for the fuel shutdown device of control and safety system
FO injection pump fuel-cut magnetic valve DC24V 15W
for cylinder fuel cut device of safety system
Handle switch .....for remote start stand-by
Turning safety switch.....for remote start stand-by
Speed switch .....mechanical type
signal output for Low-speed and Over-speed

LO press. switch(automatic stop).....0.20MPa
Over-speed switch(automatic stop).....112 – 115% by Speed switch
Cylinder CFW temp. switch(automatic stop) ....90℃
FO filter differ. press. switch(H. alarm) .....△0.10MPa D
LO auto filter differ. press. switch(H. alarm) ... △0.08MPa D
LO final filter differ. press. switch(H. alarm) ... △0.10MPa D
FO inj. pipe leakage level switch(H. alarm).....high level alarm in the leakage box
LO sump tank level switch(L. alarm) .....too low
LO T/C press. switch(L. alarm) 0.06MPa
Control air press. switch(L. alarm) -.....0.6MPa

14.2 Separate accessories (installed on hull part by shipyard)

Engine local control panel .....on-deck mounted/wall supported type (IP44)
power source:
AC220V 1-phase 60Hz and DC24V for Engine control circuit
AC440V 3-phase 60Hz for LO priming pump start circuit
2 sets/ship (1 panel/2 engines)
this panel is to be installed near engine.

15. MONITORING SYSTEM (Satisfied GL)

15.1 Engine fitting

15.1.1 Pressure transmitter DC 24V output 4 - 20mA in proportion to the scale range

measuring point	scale range	Normal operation	alarm setting	q'ty/eng
LO engine inlet	0 – 1.0 MPa	0.40 – 0.55 MPa	0.25 MPa low	1
High temp.FW engine inlet	0 – 0.6 MPa	0.25 – 0.35 MPa	0.15 MPa low	1
FO engine inlet	0 - 1.0 MPa	0.50 – 0.60 MPa	0.35 MPa low	1
SA engine inlet	0 – 4.0 MPa	1.5 – 2.94 MPa	1.5 MPa low	1

15.1.2 Thermo-resistance bulb Pt100 R100/R0=1.3850

measuring point	scale range	Normal operation	alarm setting	q'ty/eng
LO engine inlet	max. 200℃	40 – 60℃	65℃ high	1
Cylinder CW engine outlet	max. 200℃	70 – 80℃	85℃ high	1
Exh. gas T/C inlet	max. 700℃	<580℃	580℃ high	1

15.3 Separate accessories (installed on hull part by shipyard): NONE

16. SPARE PARTS & TOOLS

Spare parts tools will be supplied in accordance with Daihatsu standard practice which is satisfied the requirements of classification society. Detail will be described in "SPAREPARTS LIST" and "TOOLS LIST" for approval plan.

17. SHOP TRIAL

The shop trial should be performed in accordance with requirements of classification society. The diesel generator engine should be run to couple up a generator unless particular reasons, and to use Marine Diesel Oil for fuel. The load facility is of water resistance.
Details will be described in "SHOP TRIAL PROCEDURE".

17.1 Test & inspection items

17.1.01 Measurement of Crank deflection
Crank deflection should be measured in cold condition before running.

17.1.02 Starting test
The number of starting times and the minimum starting air pressure will be recorded by using of an accessory air reservoir or shop's one, testing from cold condition.

17.1.03 Load test
Under each load rate described afterward, engine data such as fuel consumption, pressure, temperature should be measured and recorded.

17.1.04 Measurement of Bearing temperature
After running, Main bearing and Crankpin bearing should be taken temperature.

17.1.05 Working test for protecting device
In case that the remote control panel is in our supply scope, its working should also be demonstrated.

17.1.06 Generating characteristic test
Voltage and frequency should be measured and recorded when generator output (kW) is changed in order of 100%, 75%, 50%, 25%, 50%, 75%, 100%, 110% and 100%.

17.1.07 Governor test
Momentary and permanent speed variations and the speed recovery time to steady speed should be confirmed to be controlled within requirements of classification and recorded, when full load is suddenly taken off or, when load is suddenly applied with loading steps approved by classification society. Speed variations are measured by the frequency meter.

17.1.08 Parallel running test
After setting the load (kW) of each generator to 75%, each generator output (kW) will be measured and recorded when total combined load is changed in order of 75%, 100%, 80%, 60%, 40%, 20%, 40%, 60%, 80%, 100% and 75%.
Load sharing is to be such that the load on any generator does not normally differ from its proportionate share of the total load by more than 15% of the rated output (kW) of the largest machine or 25% of the rated output (kW) of the individual machine, whichever is less.

17.1.09 Manual voltage change test
Using the voltage control rheostat which is supplied by generator maker, the range of voltage control will be recorded.

17.1.10 Frequency change with governor motor
Frequency change speed will be confirmed to be 8 – 12 s/Hz and recorded.

17.1.11 Overhaul inspection

One(1) cylinder per one ship will be overhauled.

17.1.12 Remote starting test

In case that the remote control panel is in our supply scope, remote starting should be demonstrated.

17.1.11 Measurement of torsional vibration

The previous measured data of the same diesel generator installation will be submitted. If it were not for such data, torsional vibration should be measured only on one (1) engine of the first ship.

17.2 Witness saving

If customer accept it, the manufacturer will not request the customer's witness to shop trial. In that case, the manufacturer should take the responsibility of doing the shop trial, and the presentation of trial record is a matter of course.

17.3 Attendant schedule

X: attend

Test & Inspection items		Customer witness	Manufacturer
1) Measure of Crank deflection			X
2) Starting test			X
3) Generator load (kW) test including fuel consumption measurement at each load	25% x 30 min.		X
	50% x 30 min.		X
	75% x 30 min.		X
	100% x 60 min.	X	X
	110% x 45 min.		X
4) Measure of Bearing temperature			X
5) Working test of Protect device	Emergency trip	X	X
	pre-alarm		X
6) Generator characteristic test			X
7) Governor test			X
8) Parallel running test			X
9) Manual voltage change test			X
10) Frequency change test with governor motor			X
11) Overhaul inspection		X	X
12) Remote starting test with remote control panel			X
13) Measure of Torsional vibration			X
All of above data should be submitted to customer.			