



LNG Engine Power for Inland Shipping Application

7th CIMAC CASCADES 2015

中国石油集团济柴动力总厂
CNPC JICHAI POWER EQUIPMENT COMPANY
2015/10/19

CNPC JPEC



Content

- **Company introduction**
- **Gas &DF engine**
- **DF engine in inland shipping**
- **summaries**





Company Introduction



中国石油集团济柴动力总厂 CNPC JICHAI POWER EQUIPMENT COMPANY



1965 Z12V190B diesel engine was successfully developed for oil drilling industry in China.



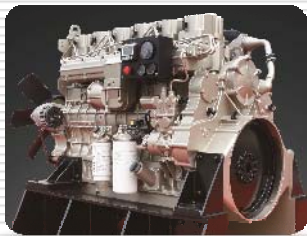
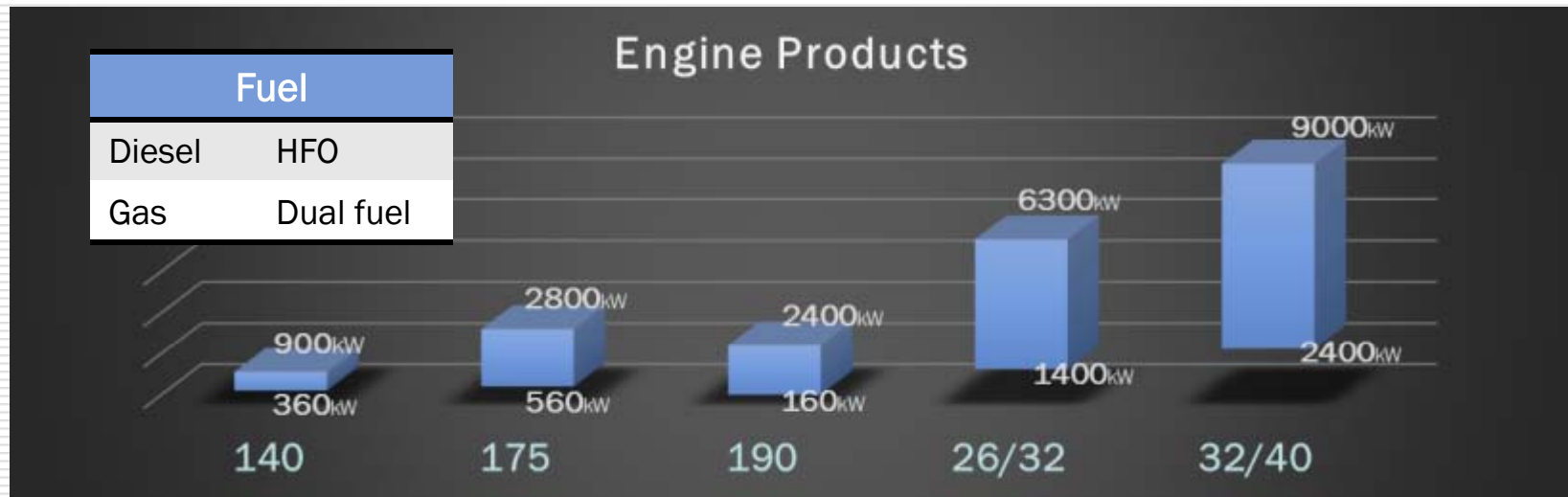
1988 The first gas engine with medium & large power in China was born in our company.



2010 The company name is changed to CNPC JiChai Power Equipment Company.



Engine products



L6 ~ V12



V8 ~ 20



L6, L8, V8, V12, V16



L6, L8, L9, V12, V16, V18



L6 ~ V18



Content

- Overview
- **Gas &DF engine**
- DF engine in inland shipping
- summaries



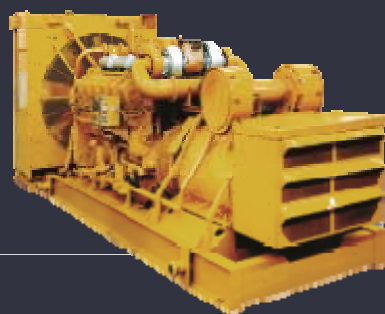


CNPC-DF Engine

- Diesel / DF model conversion with one key
- Without loss of diesel engine power
- Speed control performance is the same as Diesel engine
- flexible proportion adjustment



2000 series DF gen-set



3000 series DF gen-set



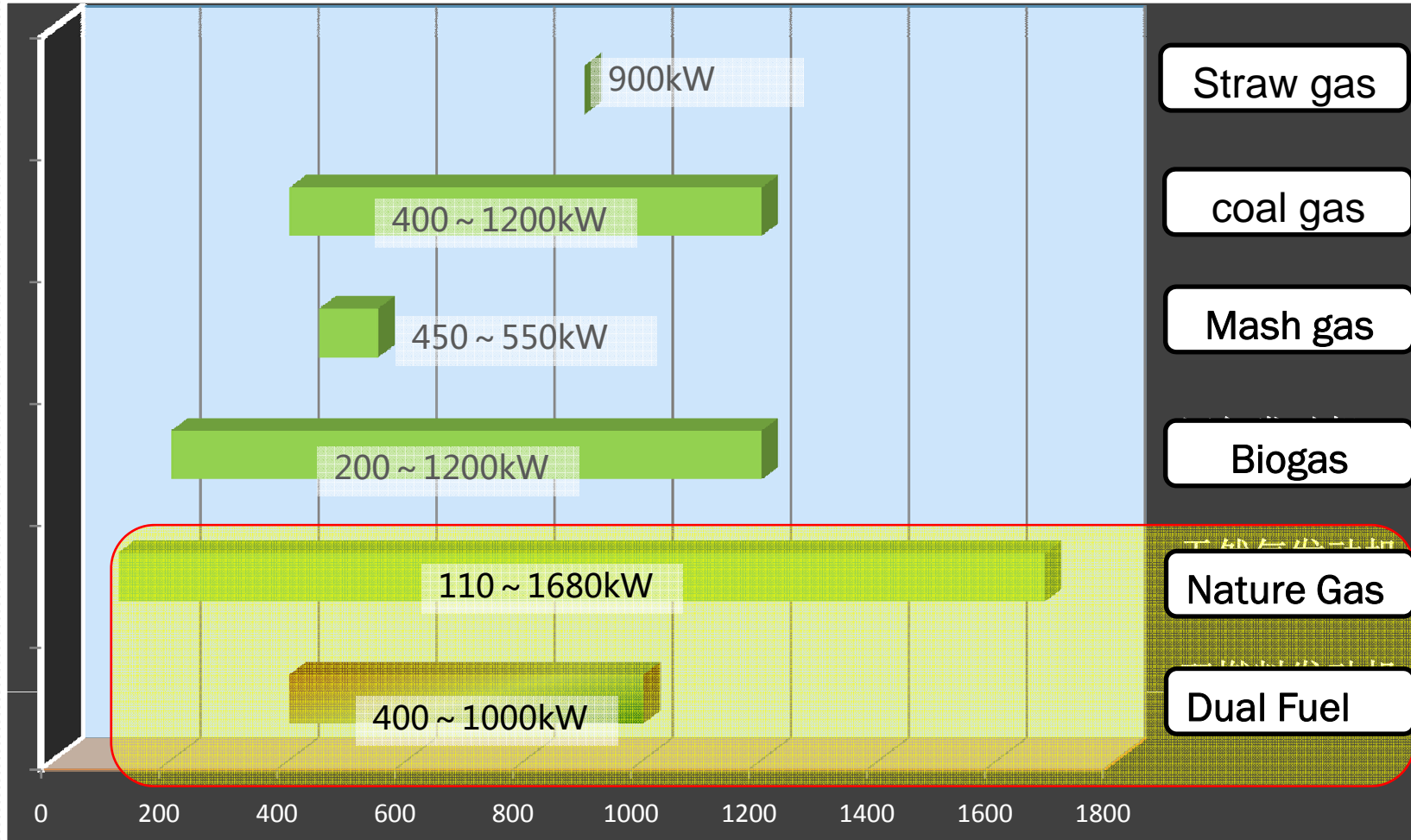
C, L4/6/8-190 DF marine engine



DF Engine in XinJiang
TUHA, 2005



CNPC-Gas Engine





Engine development

Certification doc. of DF ENGINE

排放试验报告
Emission Test Report
(C6190Z,CS-1) Engine E3 Cycle

测试机构 Test Agency	大连海事大学排放试验中心 Exhaust Gas Analysis Center of Dalian Maritime University
审核 Verifier	<i>[Signature]</i>
日期 Date	17th June 2011
制造厂 Maker	中国石油集团济柴动力总厂 CNPC JICHAI POWER EQUIPMENT COMPANY

出厂技术证明书
TECHNICAL CERTIFICATE
FOR
MODEL C6190ZLC DIESEL/GAS DUAL FUEL ENGINE
SW286LHS3-05

中华人民共和国
济柴集团柴油机有限公司
JINAN DIFUJIL ENGINE CO., LTD
PEOPLE'S REPUBLIC OF CHINA



Gas & DF engine

Gas & Dual Fuel engine inland shipping



CNPC
中国石油天然气集团公司
CHINA NATIONAL PETROLEUM CORPORATION



中国石油集团济柴动力总厂
CNPC JICHAI POWER EQUIPMENT COMPANY

昆仑能源有限公司
KUNLUN ENERGY COMPANY LIMITED
Incorporated in Bermuda with Limited Liability

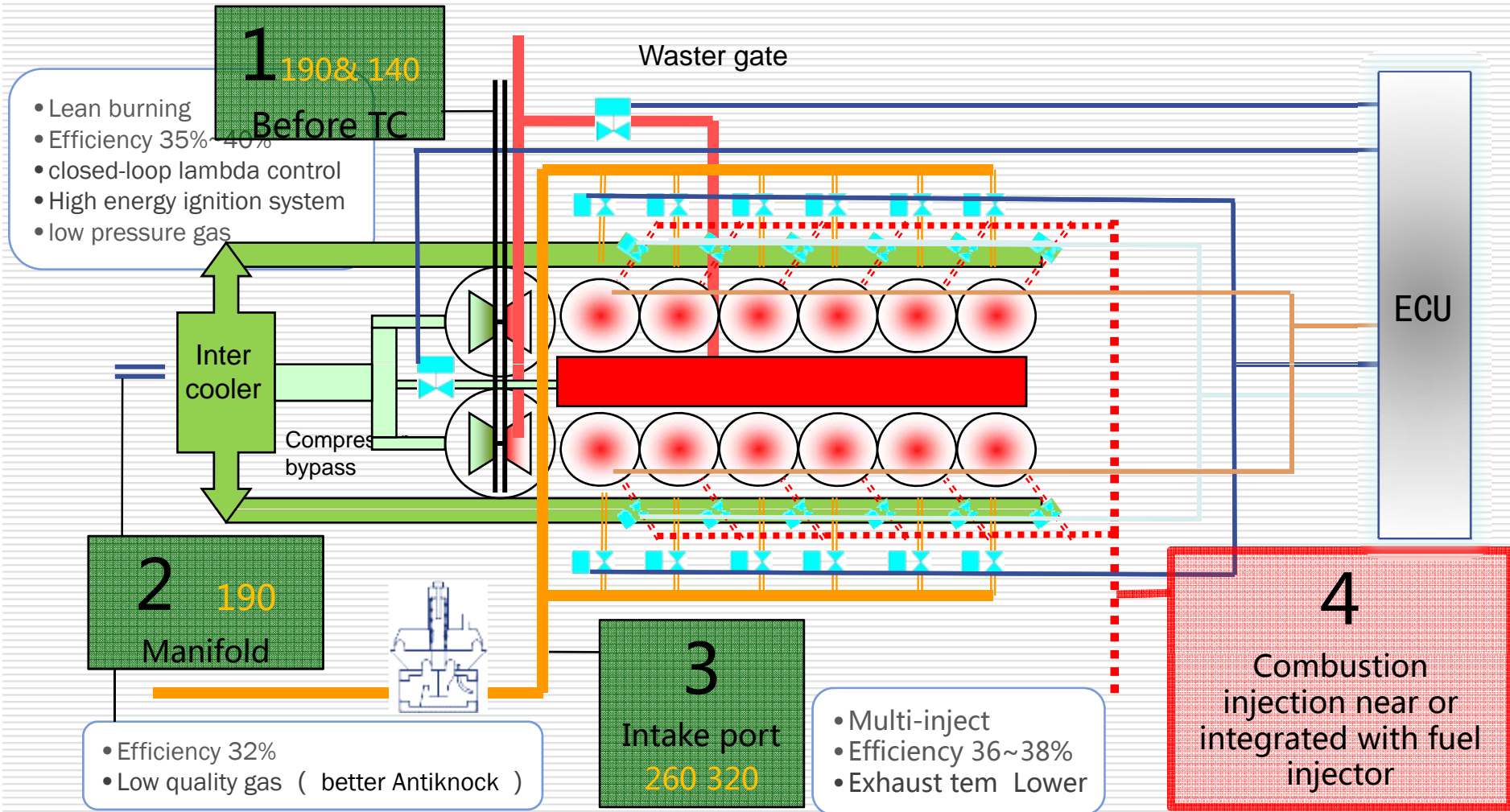
Reconstruction of old ship diesel engine to DF engine

DF engine on new ship building

Dual fuel hereinafter DF



CNPC-Gas Engine





Content

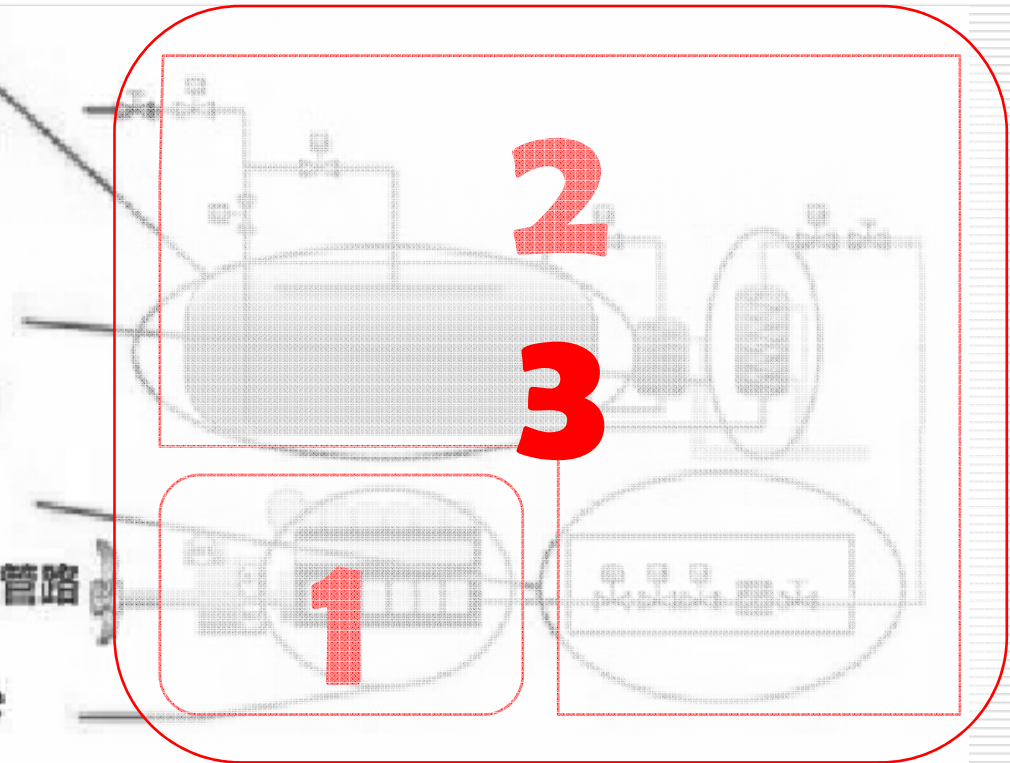
- Overview
- Gas & DF engine
- **DF engine in inland shipping**
- summaries





Engine development

- 气罐 tank
 - C型气罐，绝热形式的选择
 - 气罐支撑处的局部加强
- 热交换器 heat exchanger
 - 空温式或简单的水浴式热交换器
- 供气管路 gas supply pipe
 - 本安型机舱或增安型机舱的供气管路
- 发动机改造方案 gas engine
 - 单点喷射或多点喷射



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Wuhan Rules & Research Institute, CCS

p19



微信号: LN

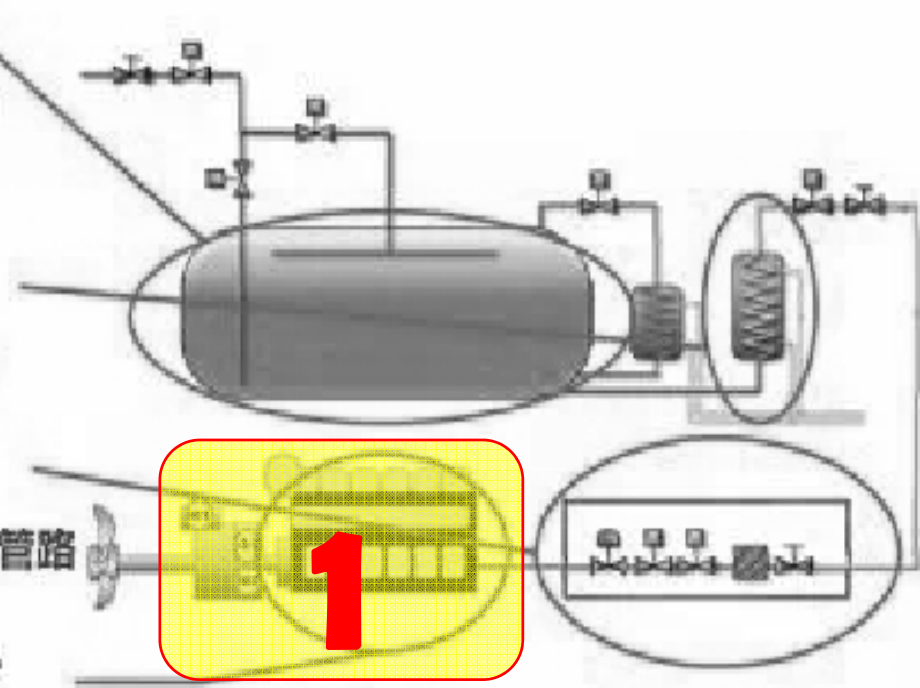
excerpt





Engine development

- 气罐 tank
 - C型气罐，绝热形式的选择
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excerpt

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Wuhan Rules & Research Institute, CCS

p18



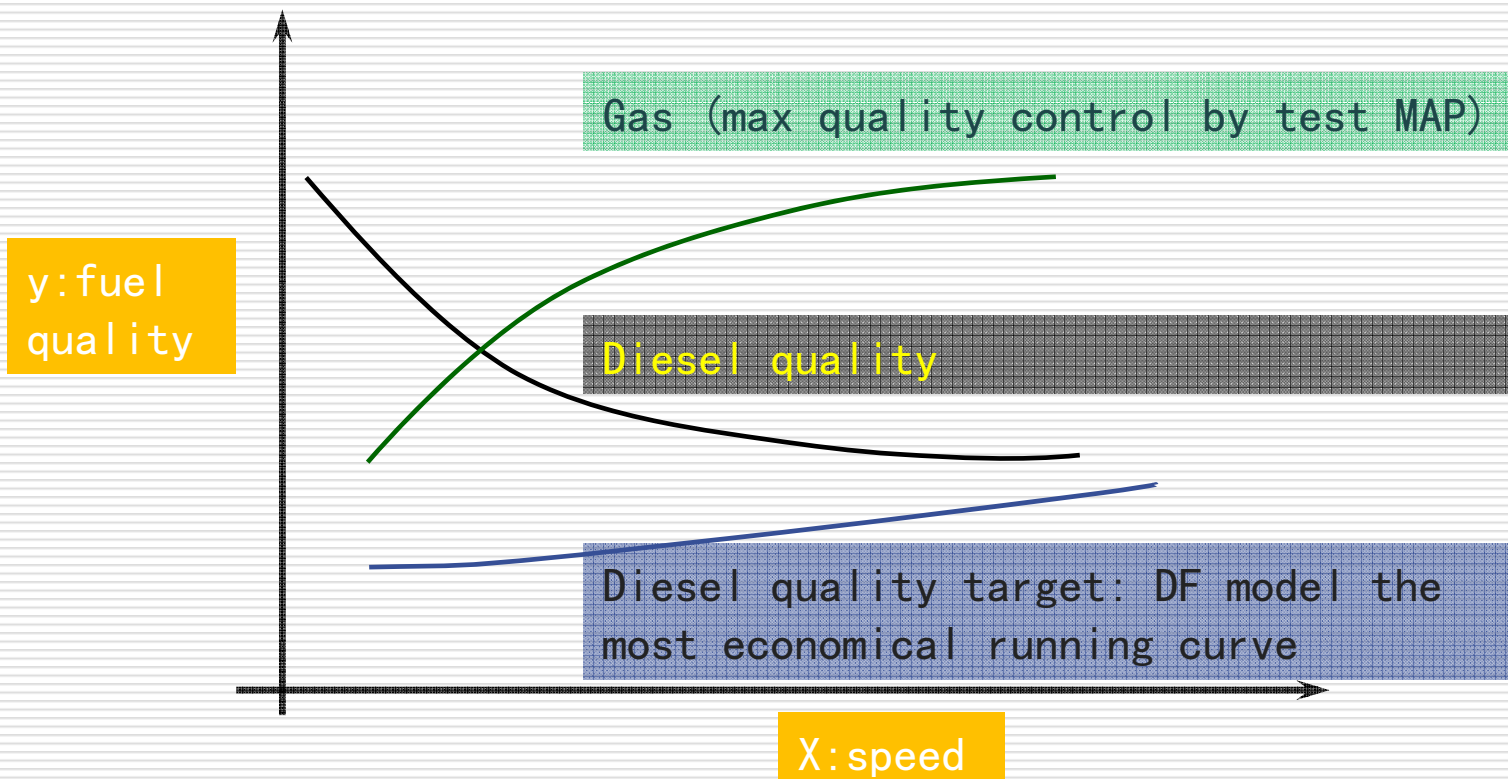
微信号: LN





Engine development

DF model running





Engine development

Engine Test

configuration

- Optimize Pump and injector small quantity properties
- SOI adjusting test
- Mixer matching test
- Nozzle comparison test
- Unit Pump comparison test
- Turbocharger matching test

Typical test reference: 《Rules for classification of sea-going steel ships 》 Part 3, chapter 9 , appendix 5 《Mass Production of Internal Combustion Engines: Type Test Conditions》

Base on diesel engine



Engine development

Fuel Pump, Injector small quantity characters

In order to control small quantity which pilot gas burning, it must strictly control unit pump injection properties,

company technical standard:

Speed: 600r/min stroke: 200; Fuel quantity: $2X0 \pm 1\text{ml}$ rack position:: L1

Speed: 600r/min stroke: 200; Fuel quantity: $1X8 \pm 1\text{ml}$ rack position:: L2

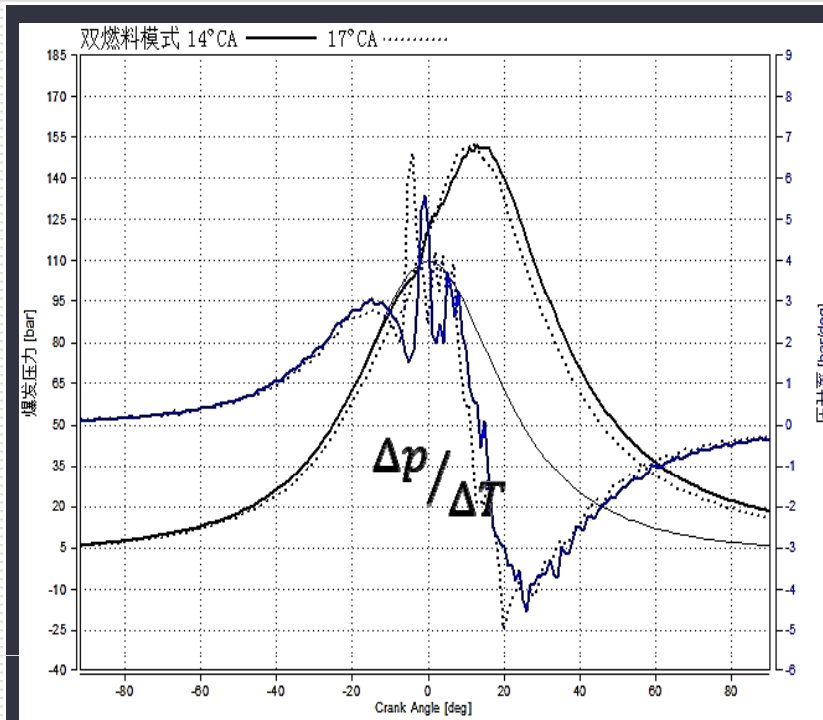
Speed: 600r/min stroke: 200; Fuel quantity: $3X \pm 1\text{ml}$ rack position:: L3

Remarks : L1、 L2、 L3 distance between pump center to rack end

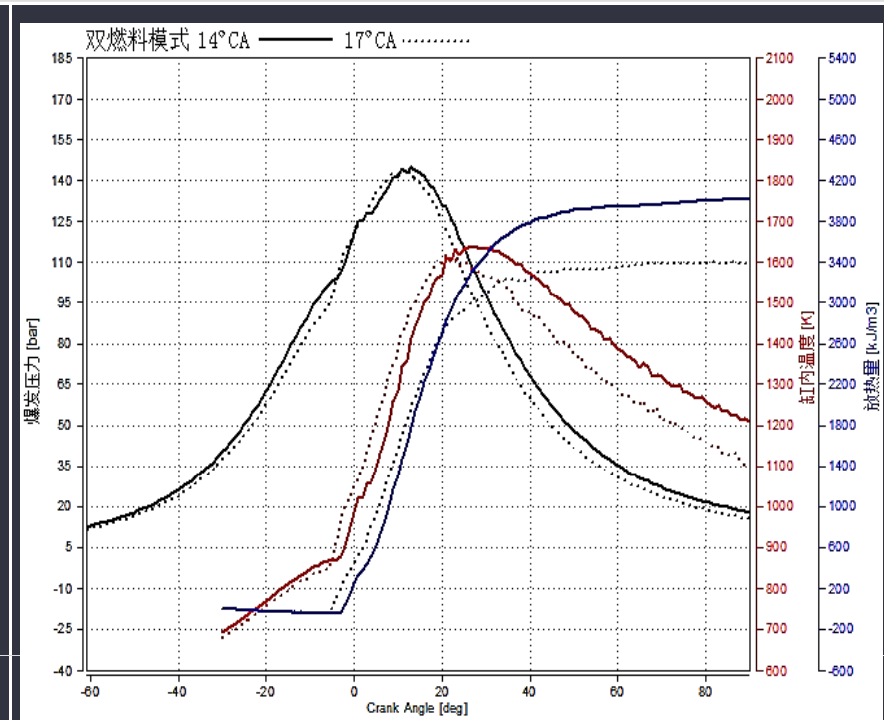


Engine development

DF model running (DIF SOI: 14 vs 17)



P- Φ diagram



Heat release & combustion tem.



Engine development

DF model running (DIF MIXER)

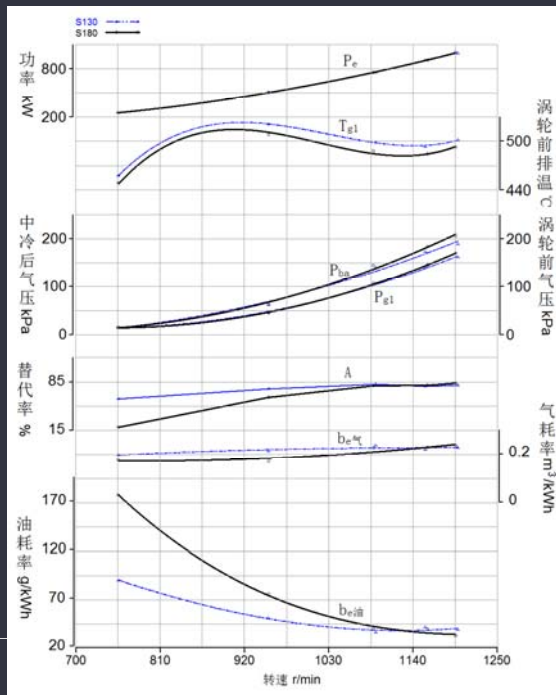


Diagram: a

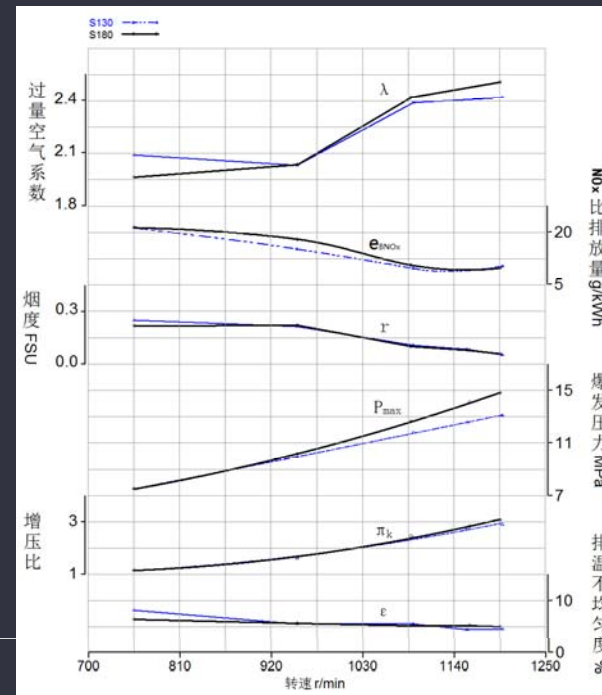


Diagram: b



Engine development

DF model running (DIF nozzle)

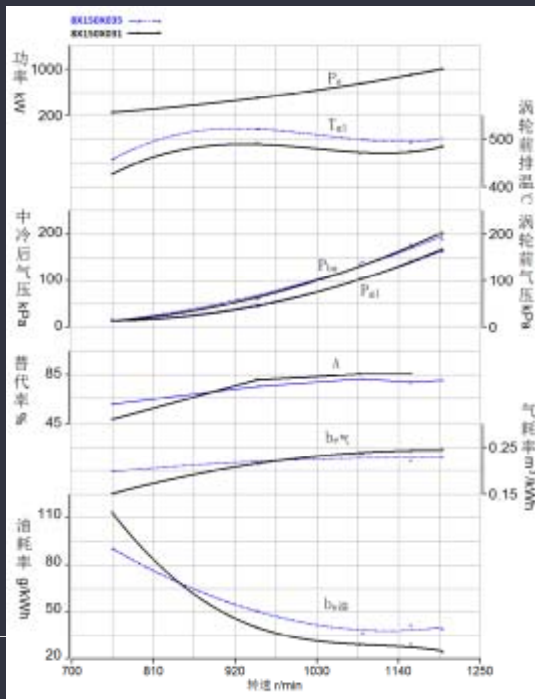


Diagram: a

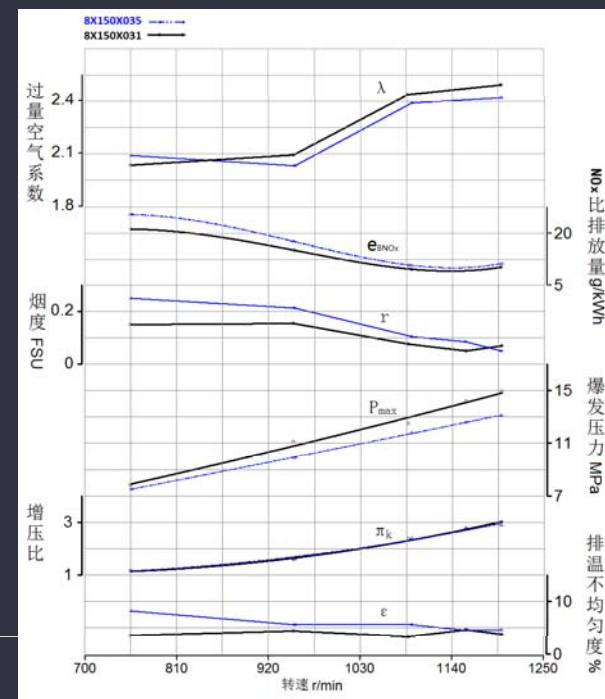


Diagram: b



Engine development

DF model running (DIF fuel pump)

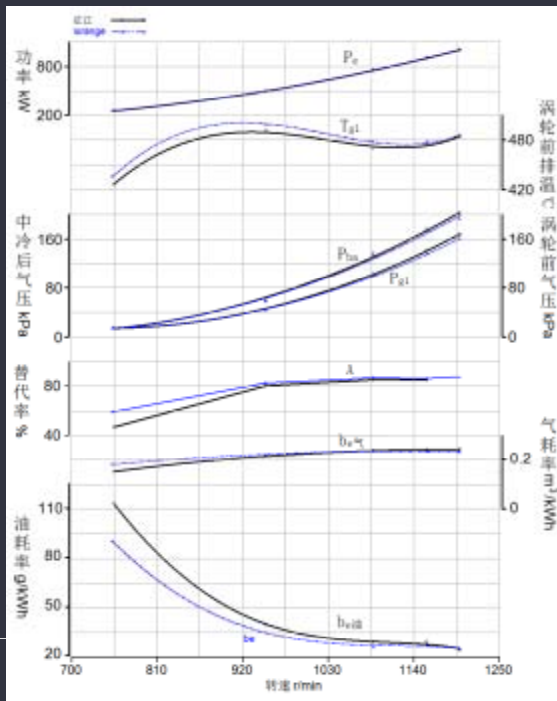


Diagram: a

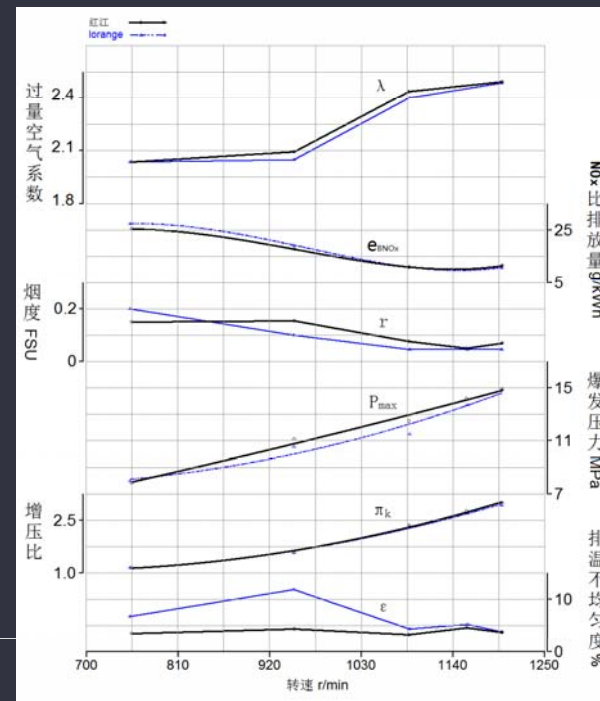


Diagram: b



Engine development

DF model running (DIF TC)

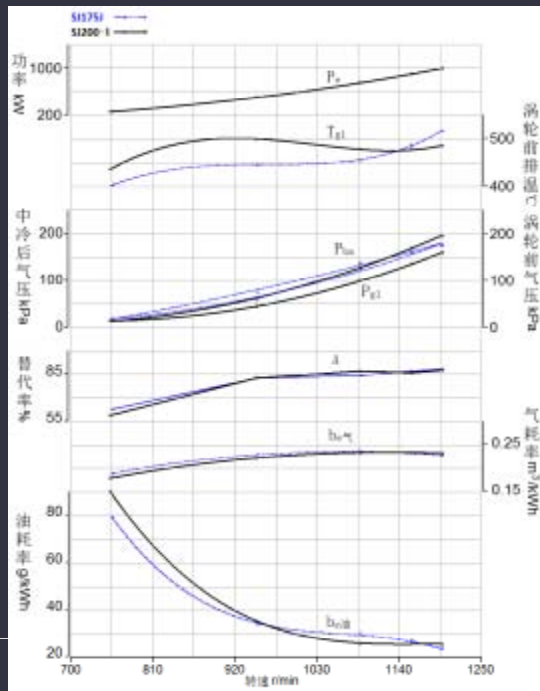


Diagram: a

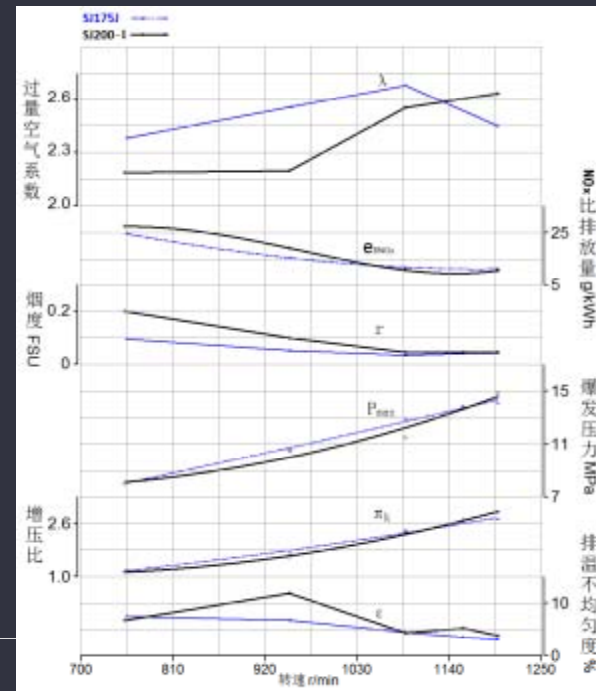


Diagram: b



Engine development

DF model running (DIF TC Compressor)

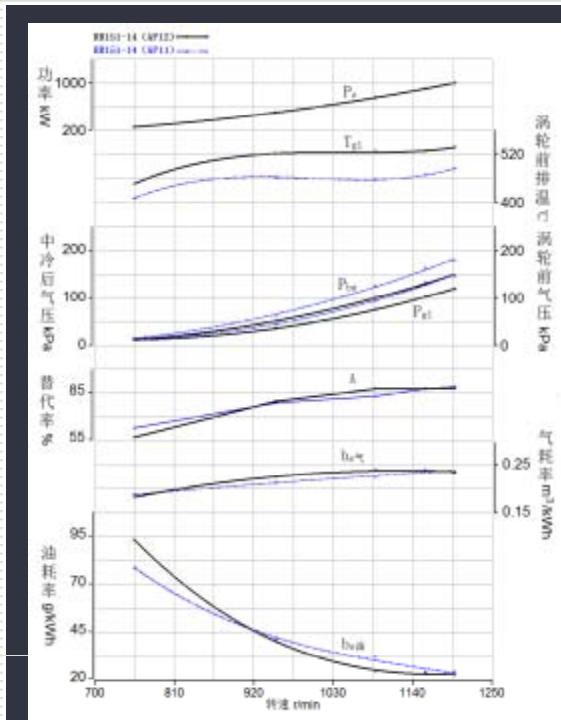


Diagram: a

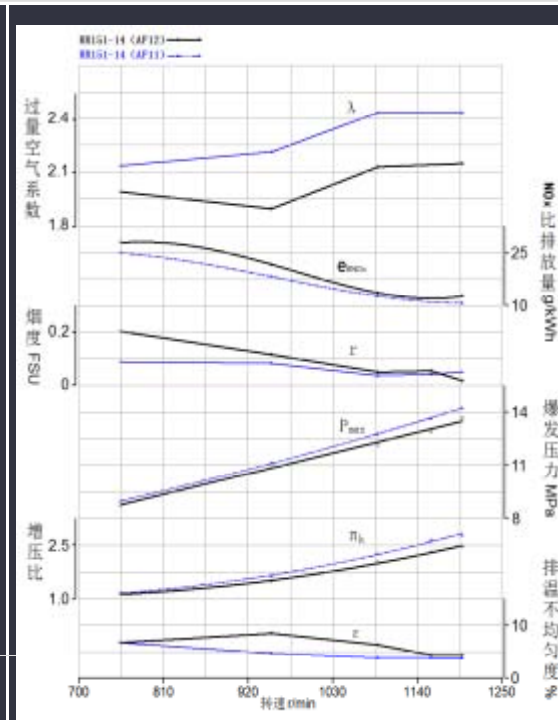
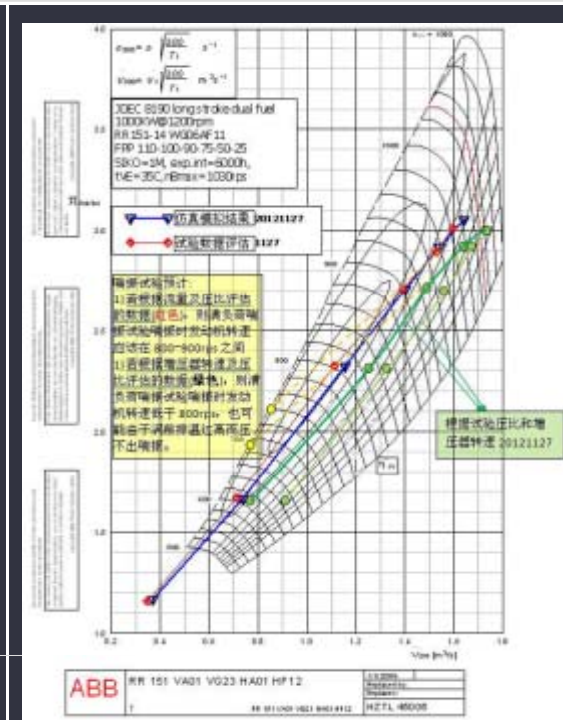


Diagram: b

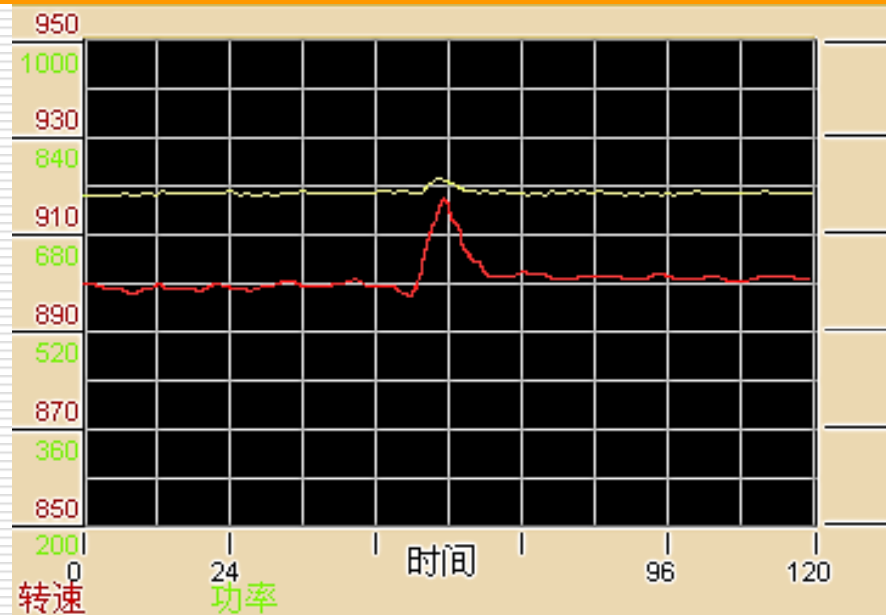


压气机特性曲线与发动机运行线对比图



Engine development

Fuel model convert test



Model	n_{\max} (r/min)	n_{\min} (r/min)	T(s)
Diesel->DF	918	900	12
DF->Diesel	900	875	11



Engine development

Cylinder work uniformity test

Exhaust tem. after cylinder (Diesel model)

Cyl.	1	2	3	4	5	6	7	8	average	deviation
T (°C)	464	465	456	432	453	457	434	462	452.7	4.6%

Exhaust tem. after cylinder (DF model)

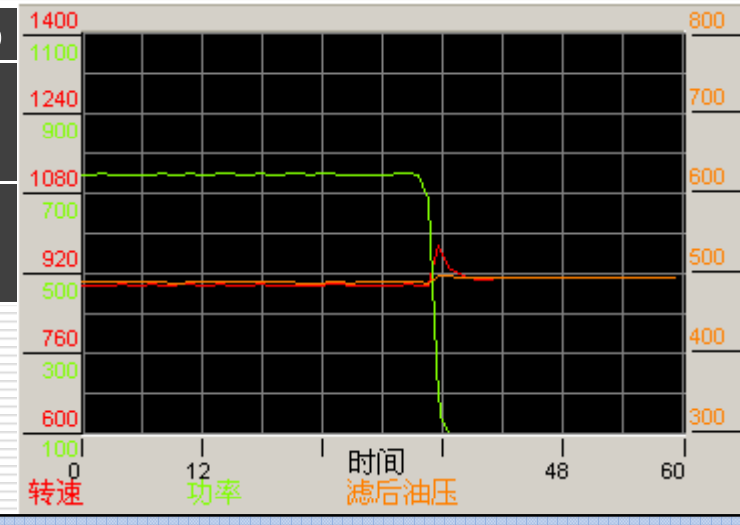
Cyl.	1	2	3	4	5	6	7	8	average	deviation
T (°C)	463	461	453	461	452	450	453	448	455.0	1.8%



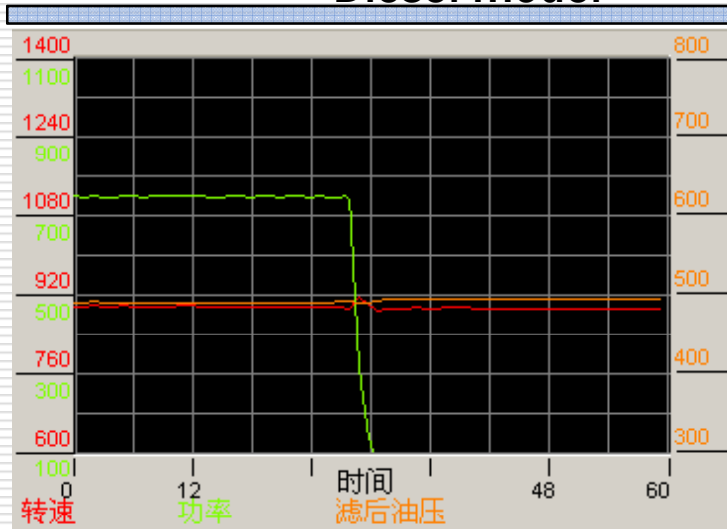
Engine development

load shutdown test

Item		n(r/min)	P _e (kW)	n _{max} (r/min)	t(s)	δ(%)
1st	before	900	749.7	961	5	6.8
	after	912	5.5			
2nd	before	900	748.9	958	4	6.4
	after	911	5.2			



Diesel model



DF model

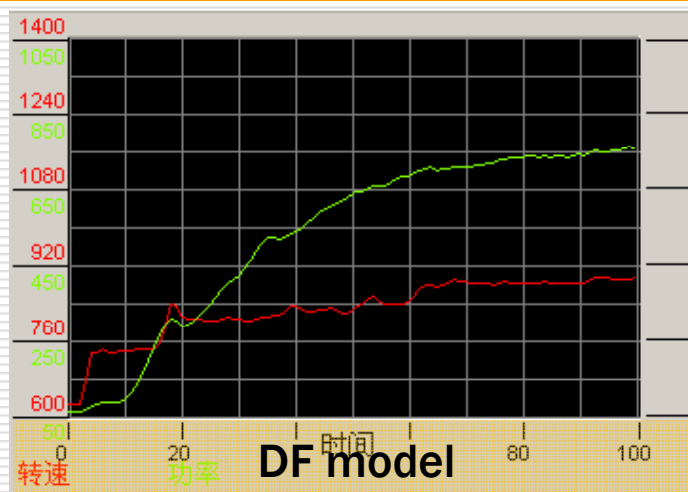
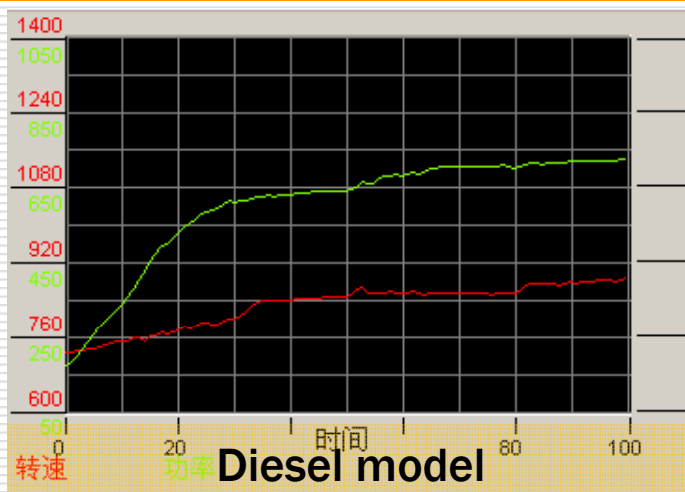
Item		n(r/min)	P _e (kW)	n _{max} (r/min)	t(s)	δ(%)
1st	before	900	750.8	920	4	2.2
	after	898	5.6			
2nd	before	900	749.2	921	3	2.3
	after	899	6.1			



Engine development

Increase speed test

540rpm/162kW→900rpm/750 kW



Speed control character

ITEM	Standard	Test data
Governor property %	Stable speed regulating rate : ≤ 8 Transient : fishing boat ≤ 15 ; other ≤ 12	0.9
speed fluctuation test	0.75%	0.36%



Engine development

Safety protection device test



Over speed

Lub. Oil pressure

Emergency shutdown

Exhaust tem.

HT water tem.

.....

audible & visual alarm

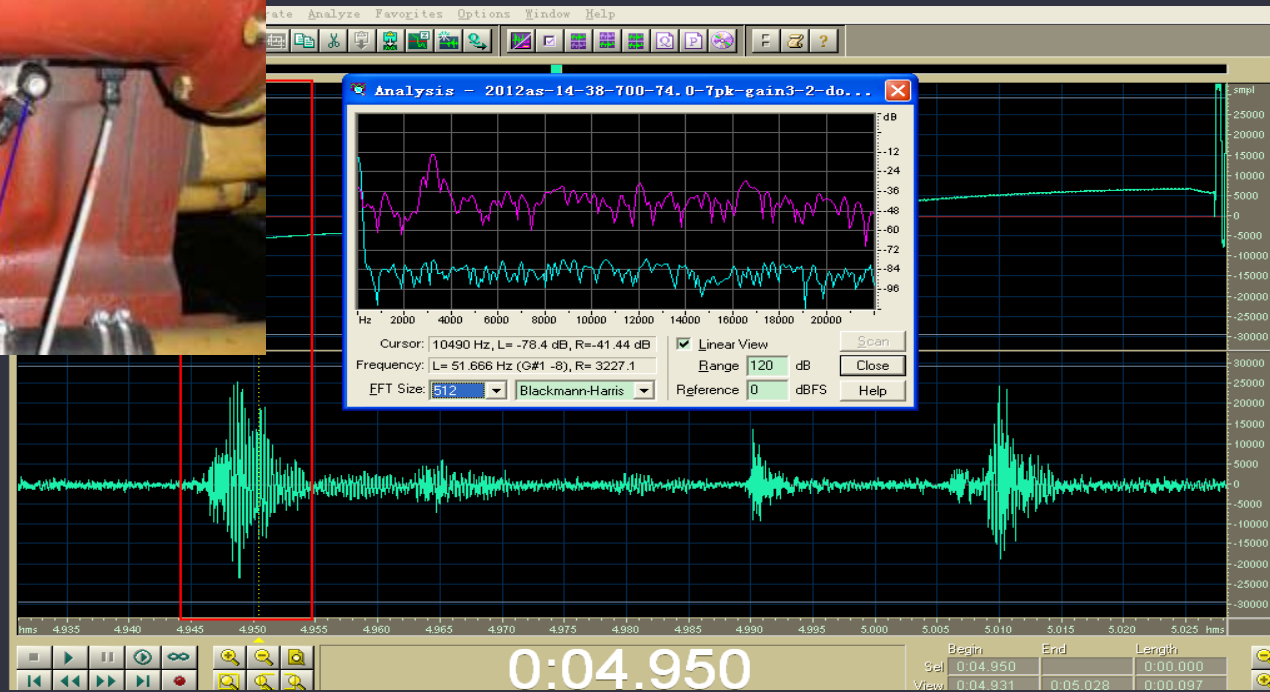


Engine development

Knocking test



< 3400Hz





Engine development

DF model running (Emission test measurement)

NOx emission

DF model

8~10% lower

Diesel mode

Authoritative organization

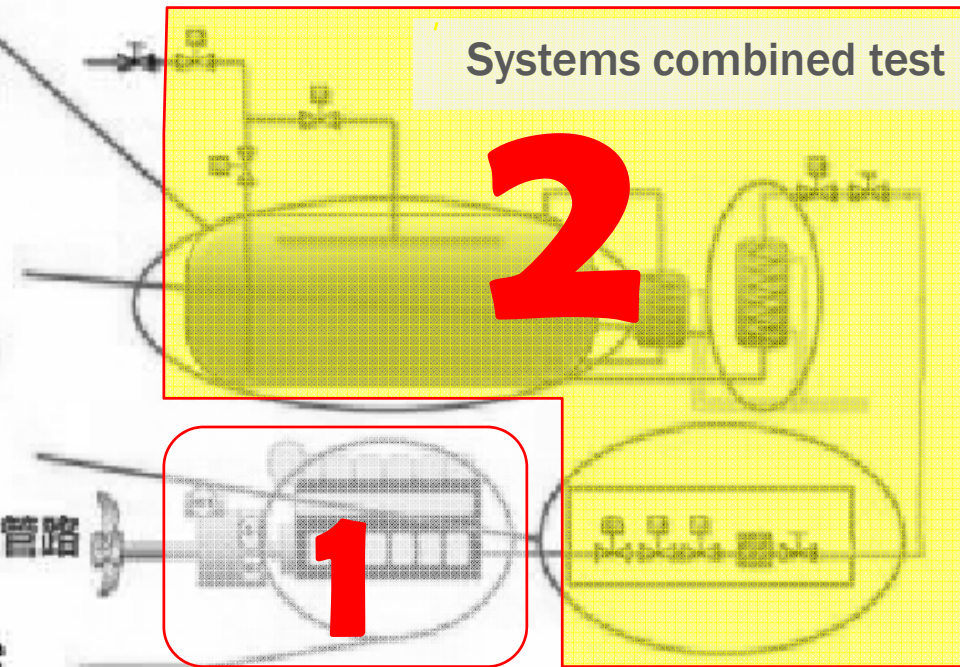
CCS+ Exhaust Gas Analysis Center
of DaLian Maritime University

1. 双燃料发动机参数							
1. Dual Fuel Engine Information							
特定试验条件							
Specified Ambient Conditions							
最大海水温度	32 °C						
Maximum seawater temperature							
最大进气温度(如适用)	50 °C						
Maximum charge air temperature, if applicable							
冷却系统规格, 中间冷却器	<input checked="" type="checkbox"/> 是 Yes <input type="checkbox"/> 否 No						
冷却系统规格, 中间冷却器	中间						
冷却系统规格, 进气阶段	Single Stage						
冷却系统规格, 进气阶段							
冷却系统规格, 冷却系统设定温度	60/85 °C						
最大进气压力	2 kPa						
Maximum inlet depression							
最大排气背压	2 kPa						
Maximum exhaust back pressure							
燃料规格	DM4/重油/天然气/LNG						
Fuel of specification							
燃料温度	20 °C						
Fuel of temperature							
排放试验结果 Emission Test Results							
运行模式	试验模式 Cycle	83	100%	75%	50%	25%	
氮氧化物	NOx	g/kWh	6.17	6.14	6.19	11.06	12.86
氮氧化物	NOx	g/kWh	7.56	5.69	7.11	10.65	15.93
注: 排放试验结果在25°C NOx 排放限值范围内, 且未超过排放限值25°C NOx 排放限值。							
试验号	DMU201111E3064						
试验日期	2015-11-01						
试验地点	中国石化集团大连石油装备有限公司 试验室 CNPC JICHAI POWER EQUIPMENT COMPANY TEST SHOP						
试验编号	ETC-0141						
监督员	CCS						
报告日期和地点	2015-12-15 大连 Dalian						
签字							



Engine development

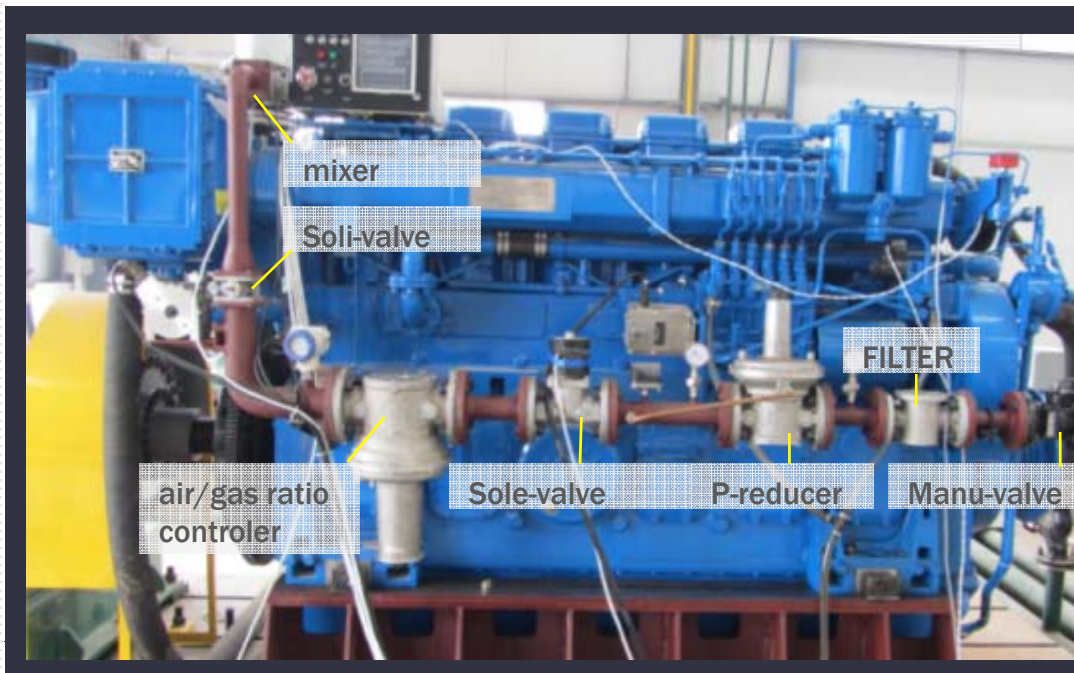
- 气罐 tank
 - C型气罐，绝热形式的选择
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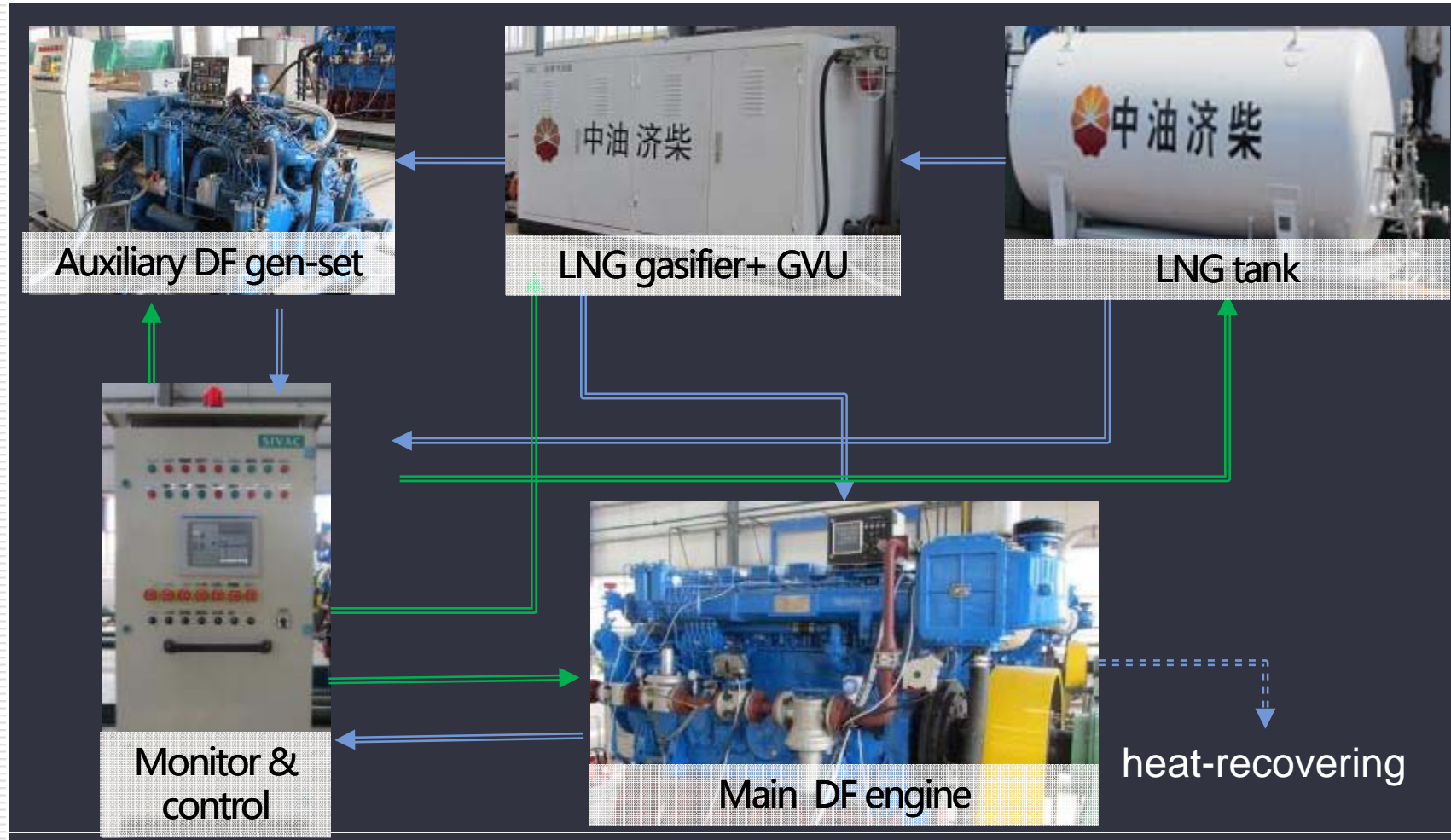
Engine development

DF Engine Test for Inland Shipping





Engine development





Engine development

LNG GVU + DF engine performance test :

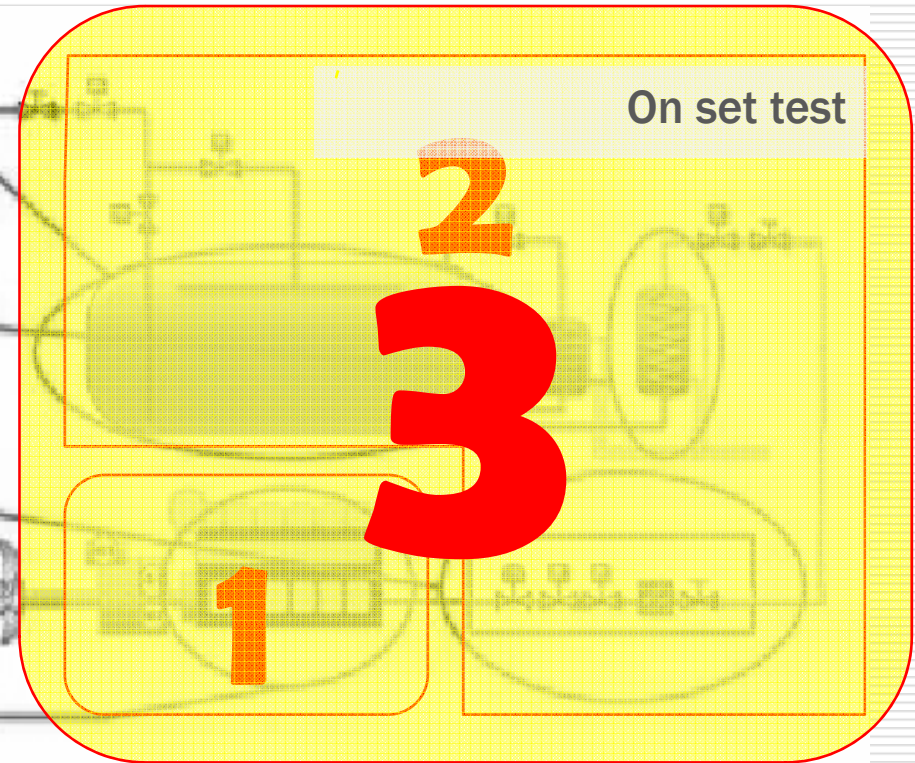
g/kwh		25%	50%	75%	90%	100%	110%
DIESEL	combined	240	220.5	210	211.2	213.8	218
	factory	277	217	219	212.6	219.1	221.6
DF	combined	115	55	45.7	60	81	106.8
	factory	131	62.8	41.9	67.9	96.5	131.1

In each operating intervals, to memorize fuel consumption in pure diesel oil and duel fuel operation, compared with FAT test results, if the two figures are all same, that illustrates the **GVU could satisfy dynamitic module utilization requirement.**



Engine development

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Engine products

DF Engine in Inland Shipping



中国石油



武汉理工大学

Wuhan University of Technology



武汉交发船舶设计有限公司

WUHAN JIAOFA SHIP DESIGN CO., LTD



中国船级社

天然气燃料动力船舶规范
Rules for Natural Gas Fuelled Ships

2013年9月1日 生效

Effective from 1st September, 2013

二〇一三年九月



APPLICATION

DF Engine in Inland Shipping

HaiChuan No. 2 & No. 3

- 3100T Dual fuel engine cargo (later to container ship)
 - DIESEL-LNG ENGINE (400kW) 1pc
 - DIESEL-LNG GEN-SET (64kW) 1pc
 - LNG GVU 1pc
 - LNG tank and gasifier (15m³+ 200m³) 1pc
 - Safety protect ,engine control cabinet 1pc

The Beijing-Hangzhou Grand Canal

SERVE IN 2013



Engine development

DF Engine in Inland Shipping

HaiChuan No. 2 & No. 3



Total length	79.62	m	ship length	76.20	m	full load Waterline length	78.66	m
Ship width	13.60	m	Ship depth maximum	13.63	m	Model depth	4.70	m
Ship height maximum	21.05	m	Water line no load	1.080	m	full load Waterline length	3.950	m
full load displacement	3586.044	t	No load displacement	745.638	t	model type	Mixed frame type, duel housing	
running zone :A class	A级		Jet leg	J2		engine material	steel type	
No of barn	2		barn cap type	---		Rib plate	10	
Referenced cargo load quantity	Operationzone		Class A			Class B		
	load cargo quantity		2773.93			2924.31		



Engine development

DF Engine in Inland Shipping

HaiChuan No. 2 & No. 3

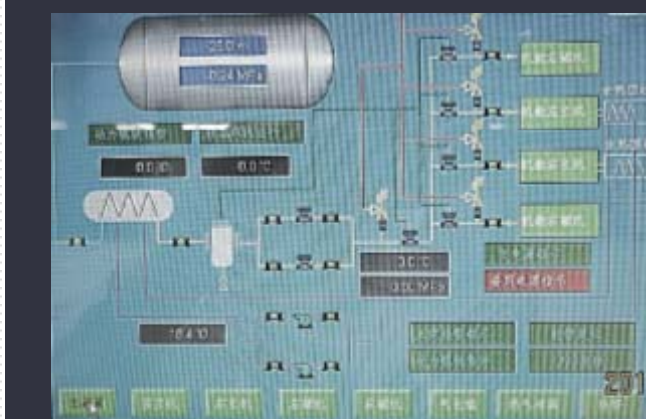




JPEC DF ENGINE ON SHIP

DF Engine in Inland Shipping

HaiChuan No. 2 & No. 3



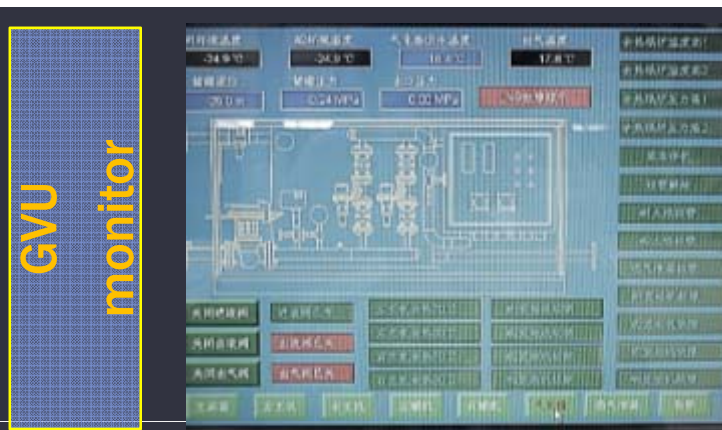
Ship power monitor



Main power monitor



Auxiliary power monitor



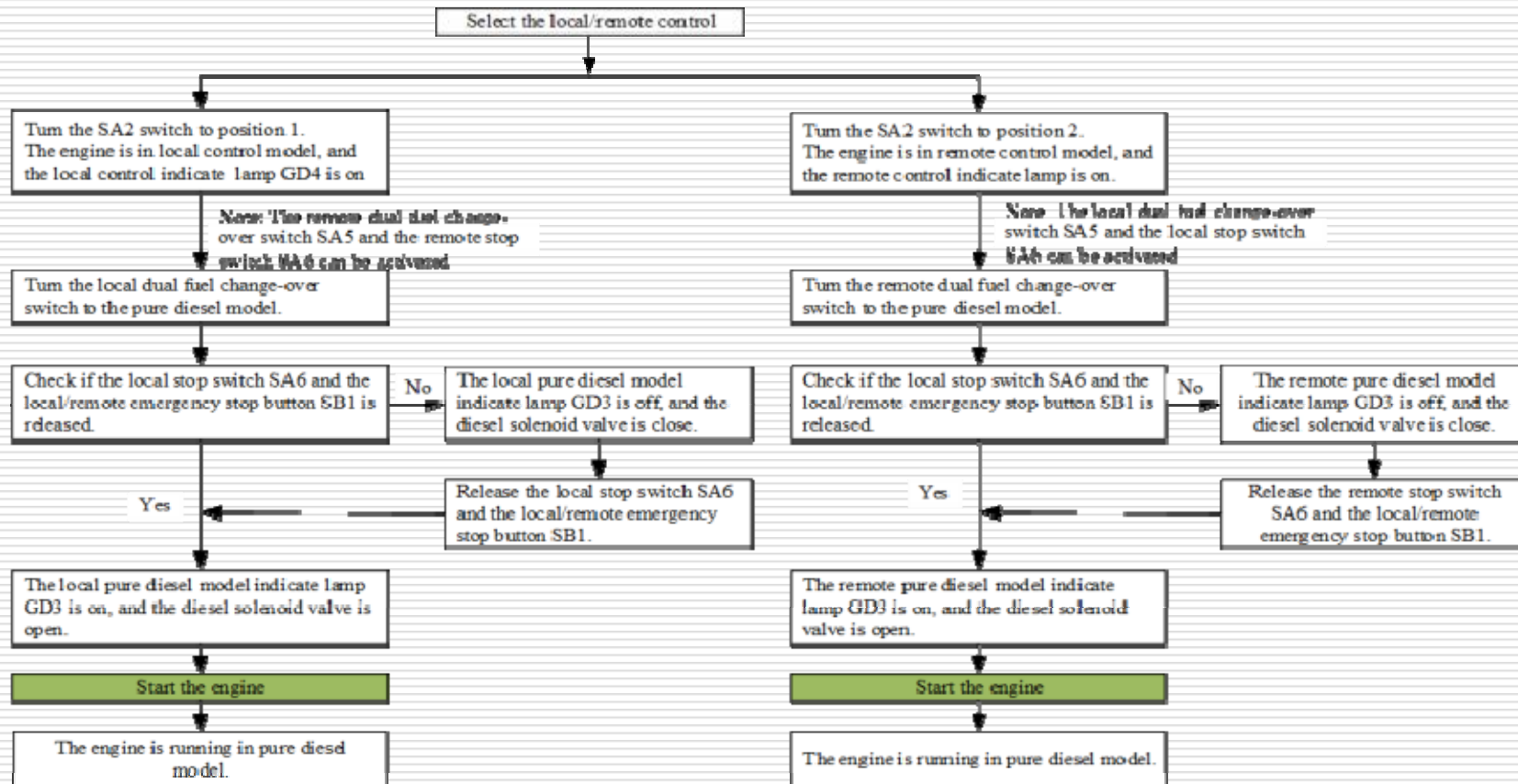
GUV monitor



Engine development

DF Engine Start

HaiChuan No.2 & No.3

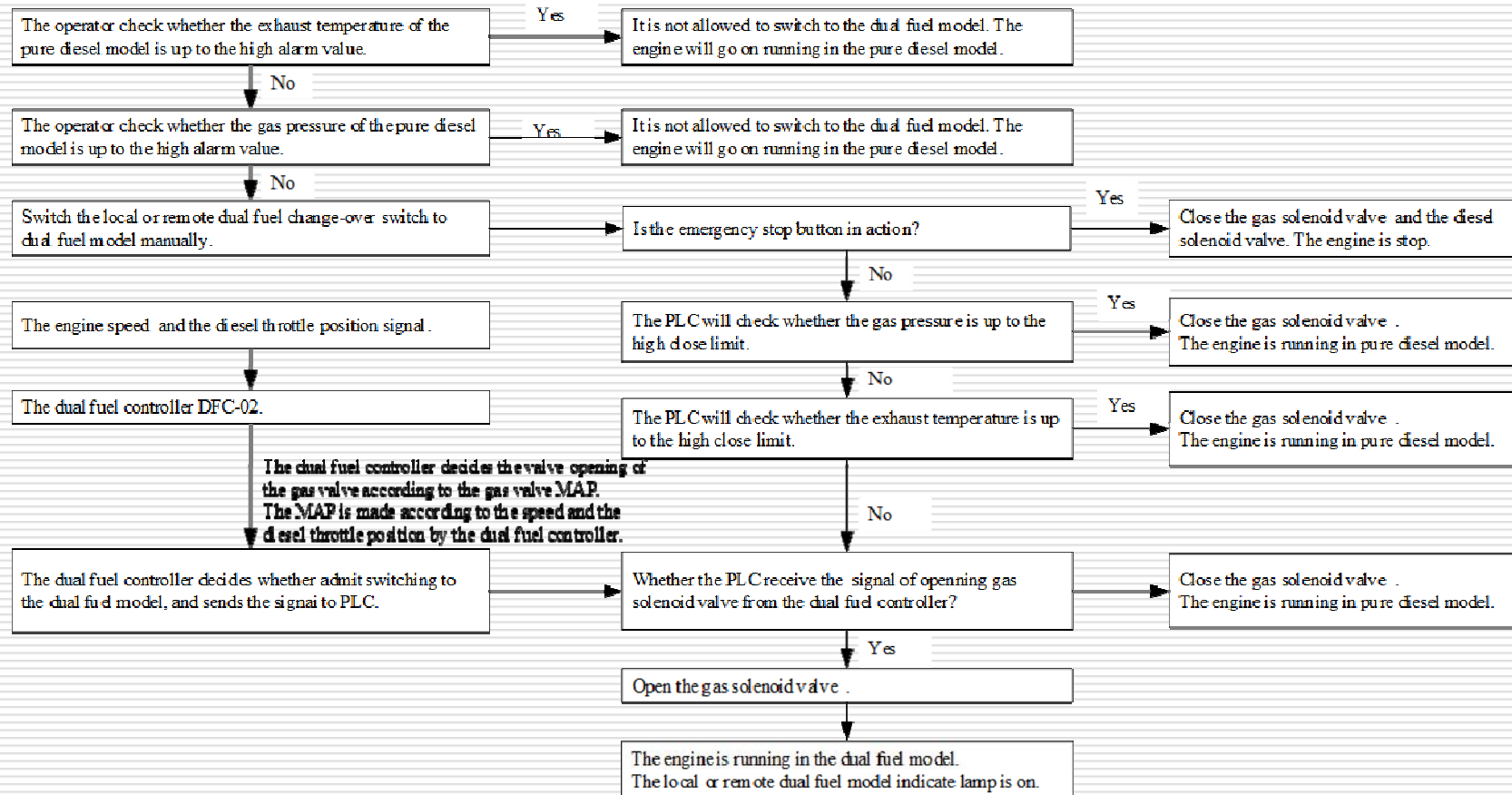




Engine development

Engine running in dual fuel model

HaiChuan No.2 & No.3

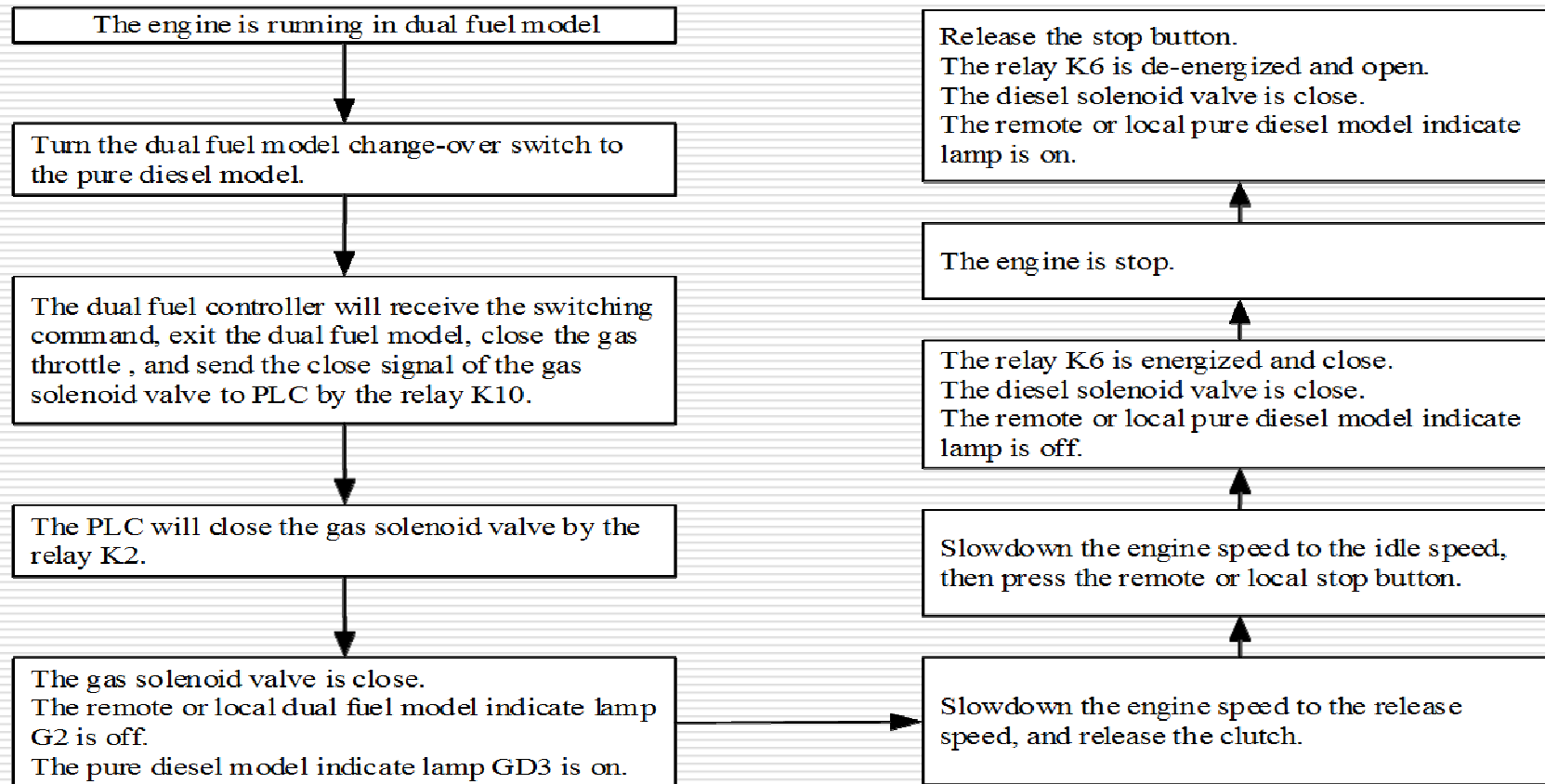




Engine development

Engine stop from DF running

HaiChuan No.2 & No.3

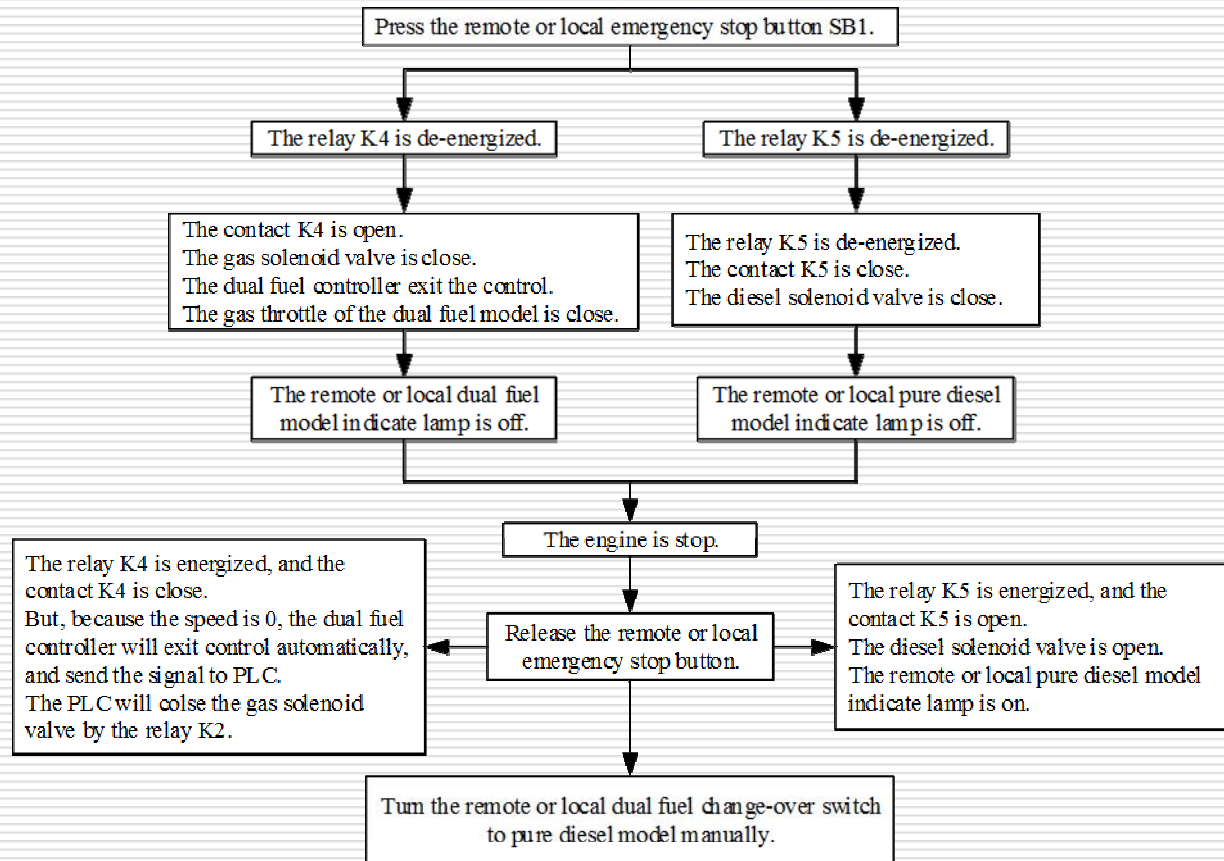




Engine development

Emergency stop from DF running

HaiChuan No.2 & No.3





JPEC DF ENGINE APPLICATION

DF Engine in Inland Shipping

HaiChuan No.2 & No.3





JPEC DF ENGINE ON SHIP

DF Engine in Inland Shipping

HUAN CHUAN 2# & 3#



WuHan HaiChuan No 2/3 DF engine cargo Aug. 2013
《Rules of Natural Gas Fuelled Ships》 effective form 1th Sep. 2013



JPEC DF ENGINE APPLICATION

DF Engine in Inland Shipping

OTHER INLAND SHIPPING





JPEC DF ENGINE APPLICATION

DF Engine in Inland Shipping

No 2 XingTong reconstruction
Danjaingkou, Hubei province

(First duel fuel engine ship build in
Beijing HangZhou Grand Canal)

Yancheng in Jiangsu
province, 5/10
finished.

(First duel fuel engine new
ship build in GuangXi)

2/9 finished
Guigang, Guangxi
province

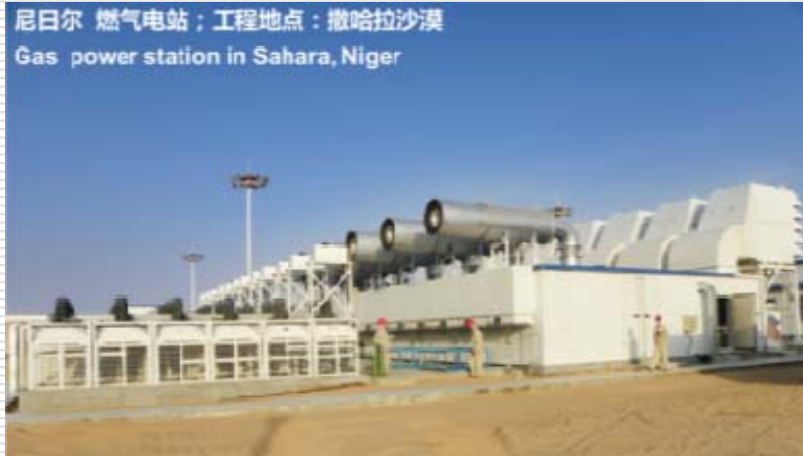
"PuHai 211" container
ship reconstruction.
finished in May,2014;

it is the first re-construction ship
according to the new regulation

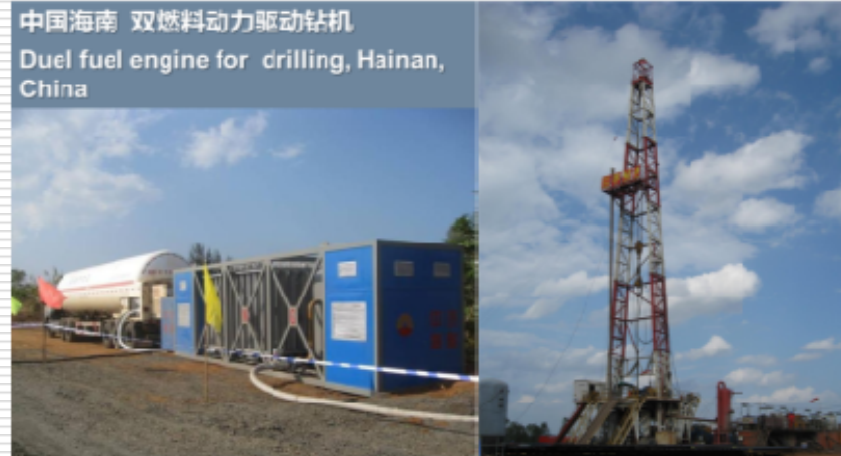


JPEC DF ENGINE APPLICATION

尼日尔 燃气电站；工程地点：撒哈拉沙漠
Gas power station in Sahara, Niger



中国海南 双燃料动力驱动钻机
Duel fuel engine for drilling, Hainan, China



中海油 采油平台 燃气发电模块
Gas Genset module for CNOOC, offshore platform



哈萨克斯坦，气驱压缩机组（集输）
Gas engine powered compressor sets, Kazakhstan





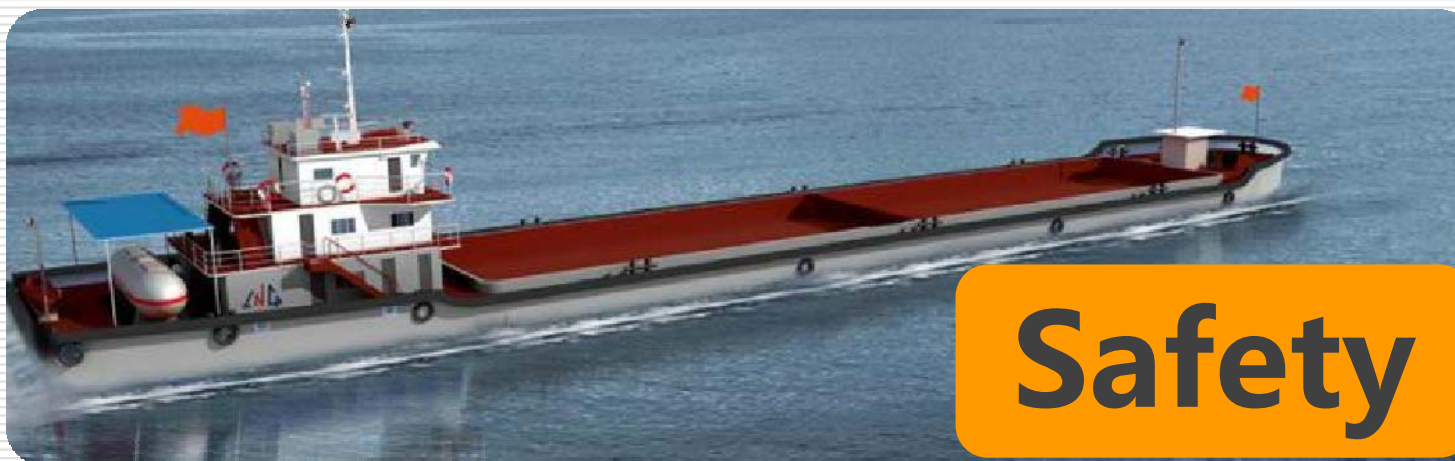
Content

- Overview
- Gas & DF engine
- DF engine in inland shipping
- **Summaries**





Summary



- Customer pay more attention on cost, many key function part's price is much higher, such as control system, gas control valve, mixer.....
- Also we realize the DF engine maintenance work is difficulty, especially injector and fuel pump's calibration



Summary

I do believe that our effort can enlarge clean energy's application furtherly, and inland river & lake will become more and more clean!



Thank you!

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