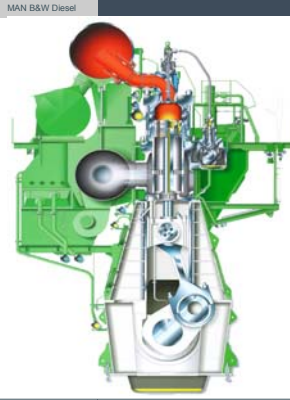




# MAN B&W Diesel



## General Descriptions of MC - Engines by Preben Noeies

## The Founding of the Company



In 1843 Hans Heinrich Baumgarten establishes a mechanical workshop in Copenhagen



In 1846 a partnership is established with Carl Christian Burmeister and they establish a company named "Baumgarten & Burmeister"

The activities include a mechanical workshop and a foundry

In 1854 a shipyard is established

In 1861 Hans Heinrich Baumgarten retires from the company



William Wain joins the company in 1865, and the name of the company is changed to Burmeister & Wain (B&W)

## History



C. C. Burmeister



W. Wain

## The First B&W Diesel Engine

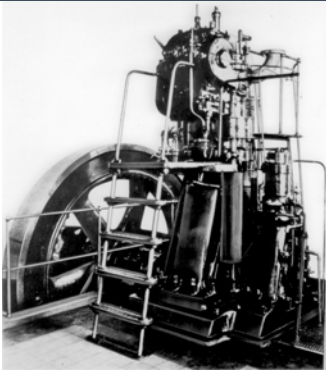


The first B&W four-stroke diesel engine was delivered in 1904

Engine No. 1

Type: 140

Customer: N. Larsen, Carriage Manufacturer, Frederiksberg, Denmark



## The First Diesel Engine for Ocean-going Ship Propulsion

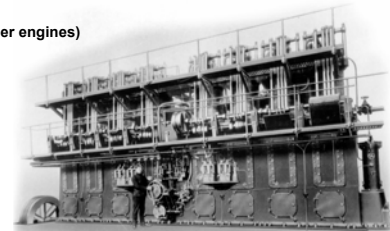


M/S Selandia, delivered to the Danish East Asiatic Company in 1912, is the world's first ocean-going diesel motor ship.

Type: DM 8150-X (2 x 8 cylinder engines)

Power: 2,500 IHP total

Ship's speed: 11 knots

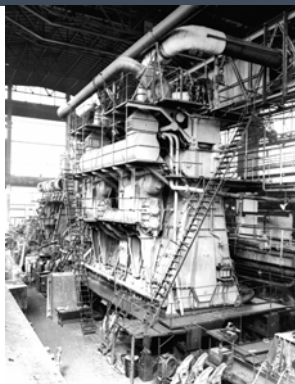


# The World's First Turbocharged Two-stroke Diesel Engine



M/S Dorthe Mærsk, delivered to the Danish company A. P. Møller by Odense Steel Shipyard in 1952, is the first ship to be powered by a turbocharged two-stroke diesel engine

Engine type: 674VTBF-160  
Power: 7,500 BHP @ 115 r/min



# Engine Development 1952 - 1980



- 1952:** The world's first turbocharged two-stroke engine  
Type: 674VTBF-160 – Power: 7,500 BHP  
(Introduced on M/S Dorthe Mærsk)
- 1967:** Introduction of the K-EF range of engines, as well as the large K98FF type (3,800 BHP/cyl. @ 103 RPM)
- 1973:** Delivery of the first K-GF engine
- 1976:** The first to introduce modern long stroke diesel engines  
Type: L-GF, with a stroke-bore ratio of 2.5:1
- 1978:** The first with constant pressure turbo charging of modern uniflow scavenged diesel engines
- 1979:** The first to test a rotating air-spring on exhaust valves in service
- 1980:** The first to introduce layout flexibility, as well as a specific fuel oil consumption below 140 g/BHP – Type: L-GFCA

# The History of MAN B&W Diesel



# Diesel Chronicle



**1843**  
H.H. Baumgarten establishes his company

**1898**  
Burmeister & Wain signs license agreement with Rudolf Diesel

**1912**  
M/V Selandia is launched

**1933** The first to introduce uniflow on a two-stroke engine

**1952** The first to introduce turbocharging on two-stroke slow speed diesel engines

**1978** The first with constant pressure turbocharging of modern uniflow engines

**1981** The first to demonstrate engine efficiency of more than 50% corresponding to specific fuel oil consumption figures below 125 g/BH-PH

**1994** The first to introduce an engine with power above 90,000 bhp

**1998** The first to introduce a new generation of compact engines

**1998** The first to introduce the Environmentally Friendly prop. system

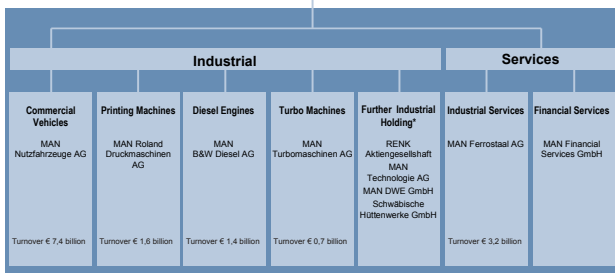
**2000** The first to put an electronically controlled engine into service

...and still leading the world in diesel economy

# The MAN Group - 2005



**MAN**  
61,259 employees  
Turnover € 14,9 billion  
PBT € 453 million



# Locations of MAN B&W Diesel



**Great Britain**  
Paxman  
Ruston  
653 employees  
Four-stroke engines

- Marine propulsion
- Military marine
- Power generation
- Rail traction

**France**  
Pielstick  
723 employees  
Four-stroke engines

- Marine propulsion
- Military marine
- Power generation
- Rail traction
- Service
- Licensor

**Denmark**  
MAN B&W Diesel A/S  
2.349 employees  
Two-stroke engines

- Research and development
- Marine propulsion
- Power generation
- Service
- Spare parts
- Licensor

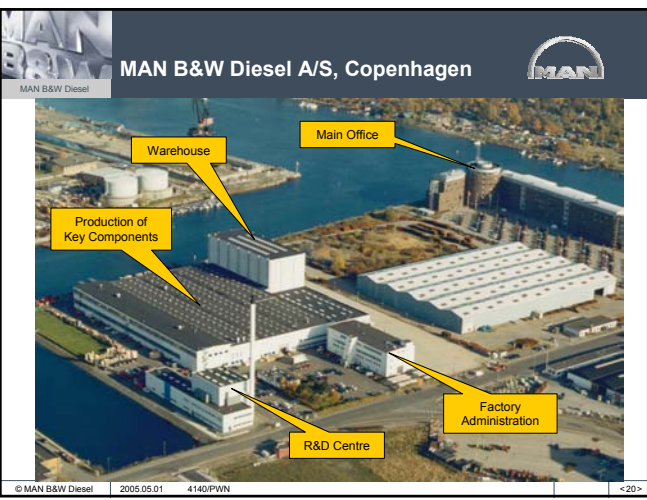
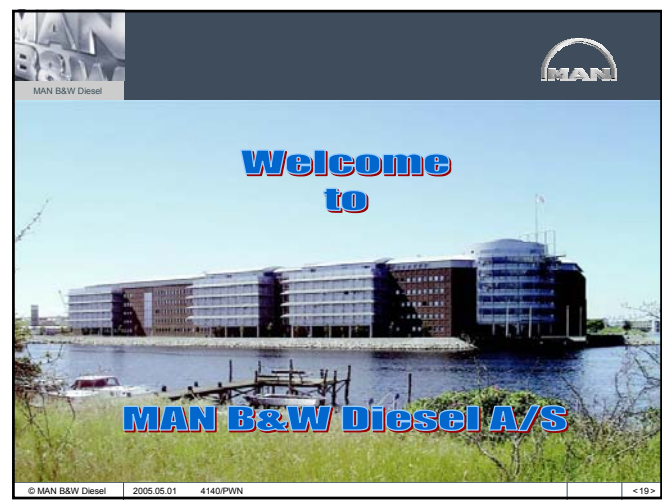
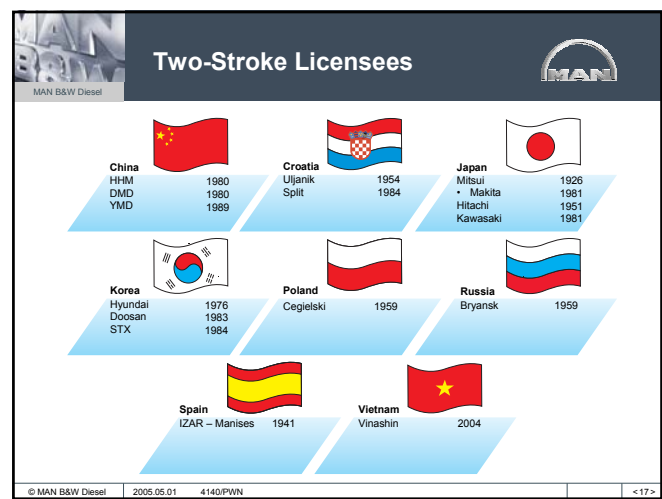
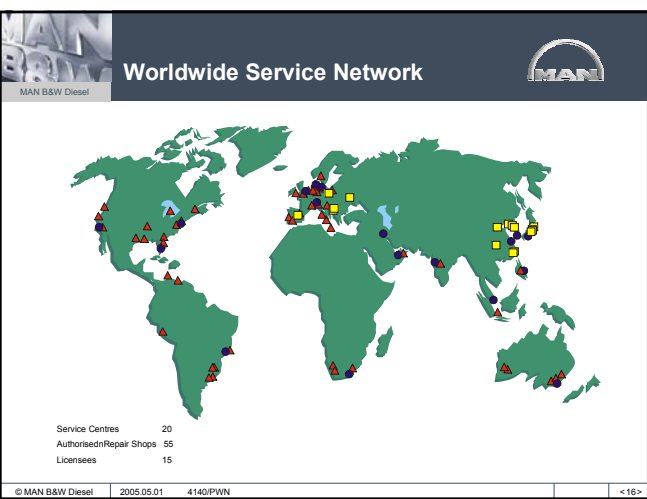
**Four-stroke engines**

- Complete propulsion package
- GenSets
- Power generation
- Licensor

**Germany**  
MAN B&W Diesel AG  
2.719 employees  
Four-stroke engines

- Research & development
- Marine propulsion
- Power generation
- Service
- Licensor

As at 31 March 2005  
**Total 6.474**





MAN B&W Diesel **MAN B&W Diesel A/S, Research Centre**

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MAN B&W Diesel **Research engine 4T50ME-X**

Engine type	4T50MX
Initial engine output	10,200 BHP
Engine speed	123 r/min
Cylinder diameter	500 mm
Piston stroke	2200 mm
Stroke to bore ratio	4.4 : 1
Firing pressure	180 bar
Mean effective pressure	
Mean piston speed	9 m/s

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MAN B&W Diesel **MAN B&W Diesel A/S, Frederikshavn**

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MAN B&W Diesel **MAN B&W Diesel A/S, Høleby**

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MAN B&W Diesel **MAN**

**12K98MC**      **12K98ME-C**

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MAN B&W Diesel **MAN**

6 L R O P C A

- A = uprated version
- C = constant pressure turbocharging
- F = direct coupled marine propulsion
- L = geared marine engine
- P = turbo-prop engine
- R = stationary
- O = stage of development: E, F, G
- 60 = cylinder bore in cm
- L = long stroke
- R = short stroke
- 6 = number of cylinders

6 S 60 MC - C

- C = compact engine
- S = stationary engine
- 6 = economy version
- 6 = container (not used any more)
- T = tanker (not used any more)
- M = engine programme
- C = camshaft controlled
- E = electronic controlled (Intelligent Engine)
- 60 = cylinder bore in cm
- stroke/bore ratio = S = super-long stroke
- L = long stroke
- K = short stroke
- 6 = number of cylinders

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# 12K98MC



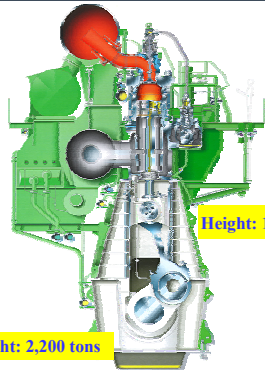
MAN B&W Diesel

**Bore:** 0.98 meter  
**Stroke:** 2.66 meter  
**Speed:** 94 rpm  
**Output:** 93,360 Bhp  
 68,640 kW  
**Piston speed:** 8.3 m/sec

**Consumption per day:**

**Fuel oil** 303 tons  
**Sulphur (3.5%)** 10 tons  
**Cyl. lube oil** 2.0 tons  
**Air** 15,000 tons

**Weight: 2,200 tons**



**Height: 15 m.**

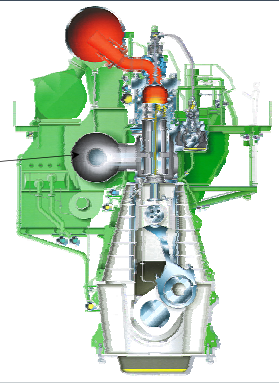
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<31>

# 12K98MC



MAN B&W Diesel



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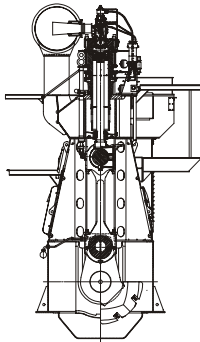
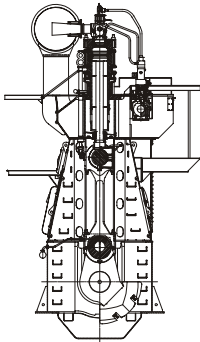
## Electronic Controlled Engine



MAN B&W Diesel

**Conventional engine**

**With electronic control**



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## Reference List for ME Engines



MAN B&W Diesel

Engine type	Engines ordered	Owner	Yard/no	Engine builder	Ship name
6L60MC/ME	1	Odffjell	Flore 137	Hitachi	Bow Cecil
7S50ME-C	1	Odffjell	Flore 144	MAN B&W	Bow Firda
6S70ME-C	1	Teekay		HSD	Nordic Brasilia
6S70ME-C	1	Teekay		HSD	Nordic Rio
6S70ME-C	1	Viken		HSD	Erviken
6S70ME-C	2	Samsung		HSD	
12K98ME	5	Hapag-Lloyd		HHI-EMD	Colombo Express
6S90ME-C	2	Kristen Nav.		HHI-EMD	
12K98ME-C	5	NVA		HSD	Savannah Express
7S50ME-C	1	Japanese		MES	Million Trader 3
7S60ME-C	5	Sovcomflot/Primorsk		HHI-EMD	SCF Aidan/SCF Byrranga
7S60ME-C	3	K-Line		Nacks	Kawasaki
6S50ME-C	1	Nissho		Hitachi	High Power
6S50ME-C	2	Andromeda		HHI-EMD	Emerald Star
6S50ME-C	2	D'Amico		STX	High Valor - High Courage
6S60ME-C	2	D'Amico		STX	
6L42MC/ME	1	Korea University		STX	
6S70ME-C	6	Unicom/Exxon		Hyundai	HHI-EMD
12K98ME-C	4	OOCL		Samsung	HSD
6S60ME-C	6	TK-Skaugen-Berg.		Tsuneshi	MES
8K98ME	4	Pajans		Hyundai	HHI-EMD
10K98ME-C	6	CSAV/Döhle		Hyundai	HHI-EMD
7S70ME-C	1	Fednav		Maizuru	Hitachi
7S70ME-C	4	Unicom		Daewoo	HSD

As per 04 May 2005

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## Reference List for ME Engines



MAN B&W Diesel

Engine type	Engines ordered	Owner	Yard/no	Engine builder	Ship name
6S60ME-C	4	A.P. Møller	Daewoo	HSD	
12K98ME	4	K-Line	IHI	MES+Kawasaki	
12K98ME	4	K-Line	IHI	Kawasaki	
6S60ME-C	2	A.P. Møller	Hyundai	HHI-EMD	
8S60ME-C	6	MPC	Zhejiang	Hudong	
7S65ME-C	5	Dynacom	Universal	Hitachi	
7K80ME-C	4	CP Offen	Mipo	HHI-EMD	
7S60ME-C	1	Teekay	Daewoo	HSD	
6K80ME-C	6	Döhle	Yangzijiang	Hudong	
6L70ME-C	6	Döhle	Sietas	MDE	
6S70ME-C	8	Pronav	Daewoo	HSD	
7K80ME-C	2	Döhle	Szczecin	HCP	
6S70ME-C	2	OSG	Samsung	HSD	
6S70ME-C	2	OSG	Hyundai	HHI-EMD	
6S60ME-C	4	Targel Marine		STX	
6S50ME-C	1	Nissho	Naikai	Hitachi	
7S60ME-C	2	Stena	Hyundai	HHI-EMD	
6S60ME-C	2	A.P. Møller	Samho	HHI-EMD	
7L70ME-C	10	A.P. Møller		HSD	
7S60ME-C	1	Lundquist		HSD	
<b>Total</b>	<b>143</b>				

As per 04 May 2005

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## Development of the ME-engine



MAN B&W Diesel

- 1991** Start of Intelligent Engine Project
- 1993** 4T50MX equipped with Electronic Engine Control equipment
- 1997** 4T50MX with 2nd generation control equipment
- 1997/98** Design - Production - Installation of mechanical/hydraulic components for service test on M/T "Bow Cecil"
- 1997/98** Design and implementation of governor functionality, and service test onboard "Shanghai Express"
- 1998/2000** Design - Production - Test - Installation of Engine Control System on M/T "Bow Cecil"
- 2000** Start of service test on M/T "Bow Cecil"
- 2003** First production engine



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# Hydraulic Cylinder Unit

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ME systems connected for service test

Fuel Booster pump

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# Engine Room at Bow Cecil

MAN B&W Diesel

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# Engine Room at Bow Cecil

MAN B&W Diesel

Inspection onboard Bow Cecil after 4137 running hours as ME engine

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# The ME Engine Type

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Hydraulic Power Supply (HPS)

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# MC versus ME Engine

MAN B&W Diesel

plus the ME Engine Control System

MC Engine

ME Engine

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# HPS Hydraulic Power Supply

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Before engine start, the hydraulic oil pressure used in the mechanical/hydraulic system for controlling the actuators is generated by electrical driven start-up pumps. After start, the engine driven pumps will take over the supply.

Start-up pumps

Self cleaning filter 10µ

Accumulators

Safety and accumulators block

Start-up pumps

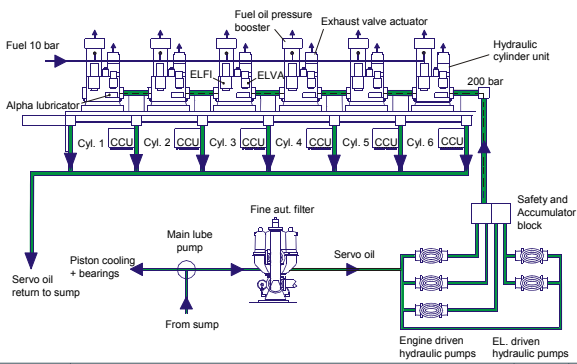
Engine driven axial piston pumps

Redundancy filter 25µ

The hydraulic power supply uses the engine system oil

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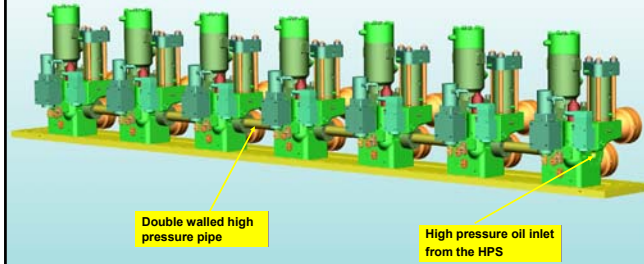
## The ME Engine Hydraulic Oil Loop



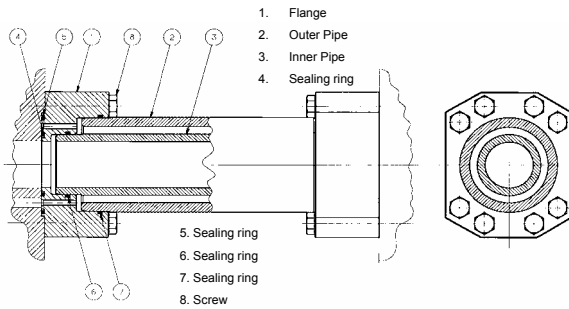
## Hydraulic Cylinder Units (HCU)



HCUs mounted on common base plate



## ME-C Engines Double Wall Pipe



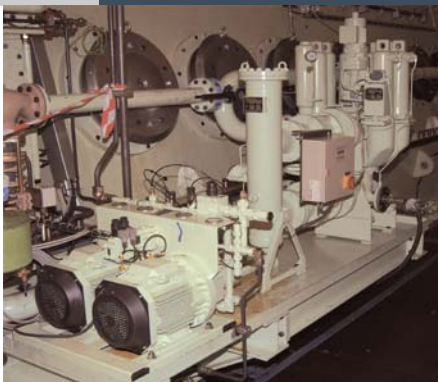
## The ME Engine Hydraulic Power Supply (HPS)



### Main components:

- Self-cleaning filter with 10-micron filter mesh
- Redundancy filter with 25-micron filter mesh
- Start up pumps:
  - High pressure pumps with supply pressure of 175 bar
  - Low pressure pumps for filling the exhaust valve push rod with supply pressure of 4 bar
- Engine driven axial piston pumps supplying high pressure oil to the Hydraulic Cylinder Unit with oil pressure up to 250 bar

## Start Up Pumps and Filters



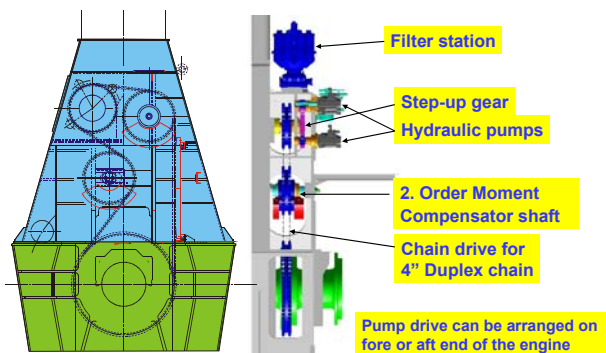
Start-up pumps and filter unit are placed aft, on the lower gallery on the exhaust side

Self cleaning filter

Redundancy filter

Start-up pumps

## ME – Engine, Pump Drive and Moment Compensator

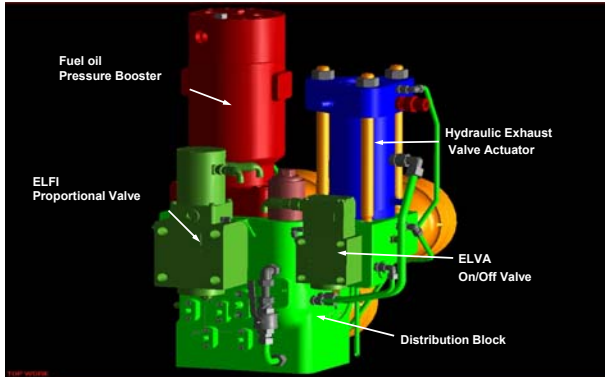




## Hydraulic Cylinder Unit



MAN B&W Diesel

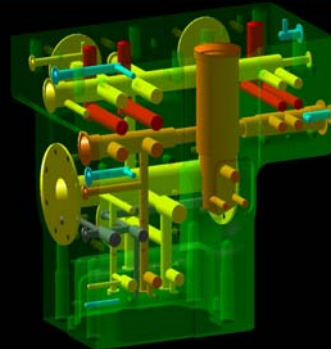


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## Oil Channel in the Distributor Block



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The oil channels connect the NC-valve, the Fuel Oil Pressure Booster, the Exhaust Valve Actuator and the Accumulator

No risk of oil leakage as pipe connection is avoided

Manually operated valve for isolation of oil to the actuators in case of need for overhauling – running engine

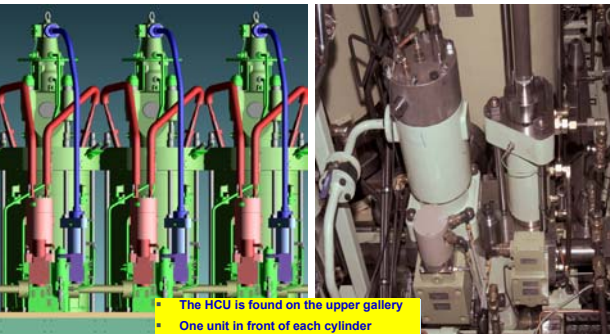
X-ray picture of the Distributor Block

© MAN B&W Diesel 2005.05.01 4140/PWN <53>

## Hydraulic Cylinder Unit (HCU)



MAN B&W Diesel



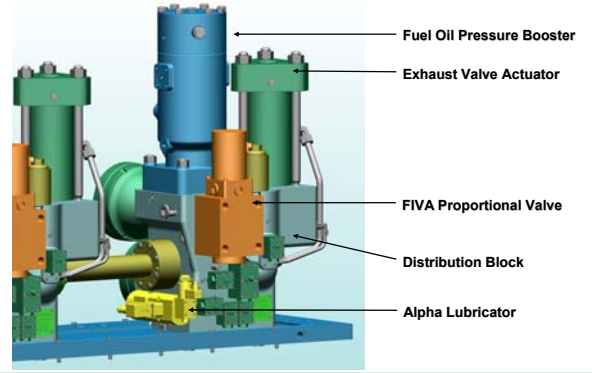
The HCU is found on the upper gallery  
One unit in front of each cylinder

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## Hydraulic Cylinder Unit (HCU)



MAN B&W Diesel

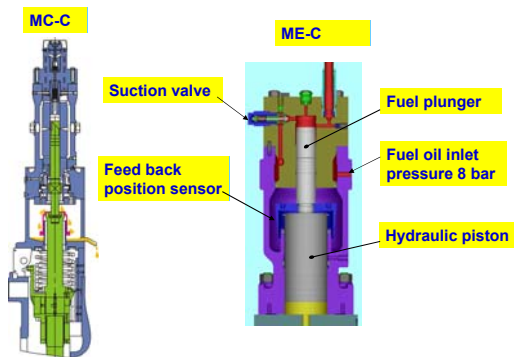


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## ME Fuel Oil Pressure Booster



MAN B&W Diesel

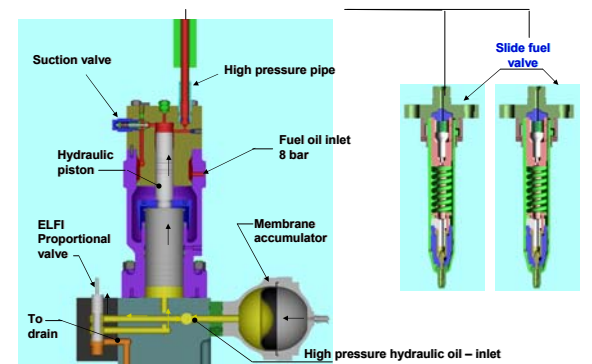


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## ME Fuel Injection System



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**M E Exhaust Valve System**

Hydraulic push rod

Exhaust valve Actuator

ELVA on-off valve

To drain

Membrane accumulator

Exhaust valve

High pressure hydraulic oil - Inlet

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**ME Exhaust Valve**

Self-adjusting damper piston

Hydraulic nut/measuring cone

Contact less sensor with integrated electronics

Inlet lube oil

Outlet lube oil

Damper

Air inlet

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**The ME Engine Exhaust Valve Timing**

mm

Dg. C. A.

- Early closing
- Late closing
- Early opening
- Late opening
- Reference

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**ME Tacho System**

- 2 redundant set of sensors
- Each set measure engine speed and crankshaft position for synchronisation of the control events
- Each set consist of four sensors. Two quadrature sensors measure on a trigger ring with 360 tooth and two marker sensors measures on one

Trigger segment with a sine-curved tooth-profile The total trigger ring is build by 8 equal segments

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**Angle Encoder**

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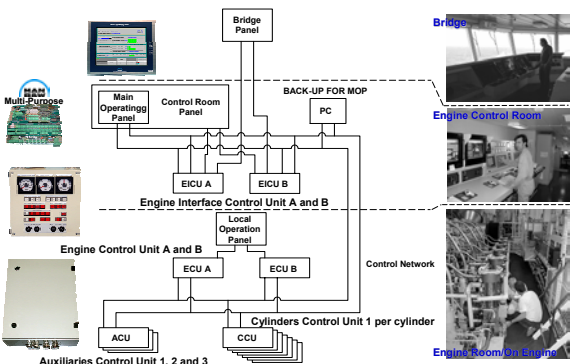
**Angle Encoder – 12K98ME**

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# ME Engine Control System



MAN B&W Diesel



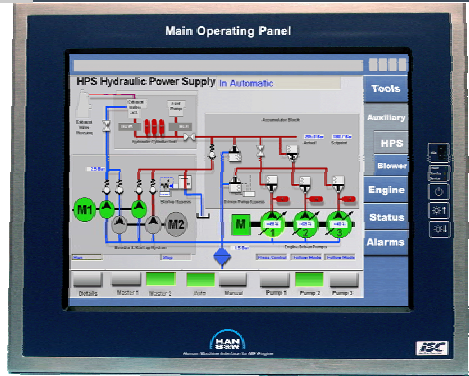
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# Main Operating Panel (MOP)



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# Engine Control System MPC



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# Local Operating Panel (LOP)



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Local Instrument Panel

Local Operation Panel

The Local Operation Panel is located on the middle gallery on the manoeuvring side of the engine --

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# ME SIMULATOR at MAN B&W in Copenhagen



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**6S35MC and 10K98MC-C on Testbed**

MAN B&W Diesel

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**The Licensees' Reported Order Book**

Status: 2005-05-25

30 GW

25

20

15

10

5

0

1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004

■ South Korea ■ Japan ■ China ■ Europe

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**12K98MC-C on Test bed**

MAN B&W Diesel

As at January 2000

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**12K90MC on Test bed**  
**Output 74,640 BHP at 94 r/min**

MAN B&W Diesel

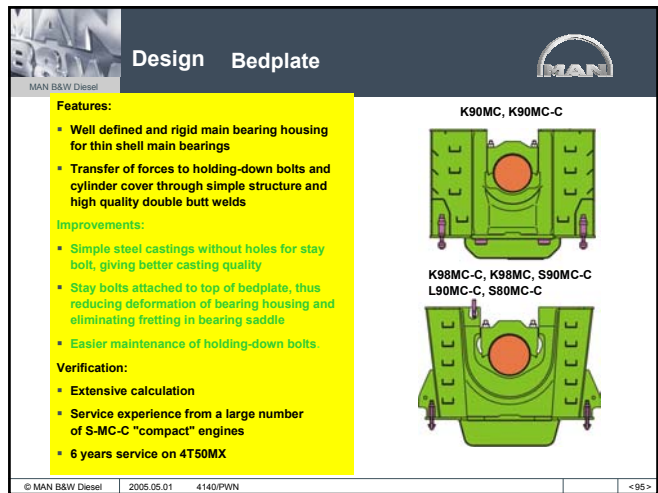
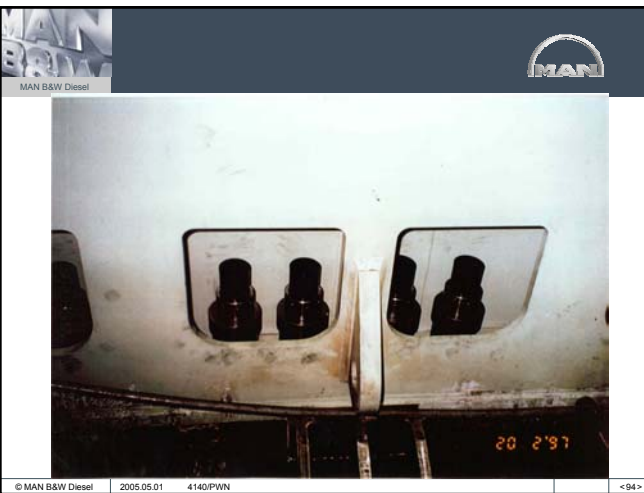
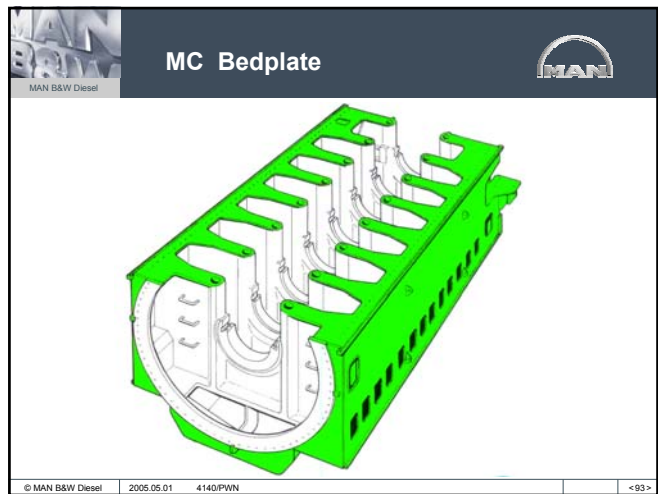
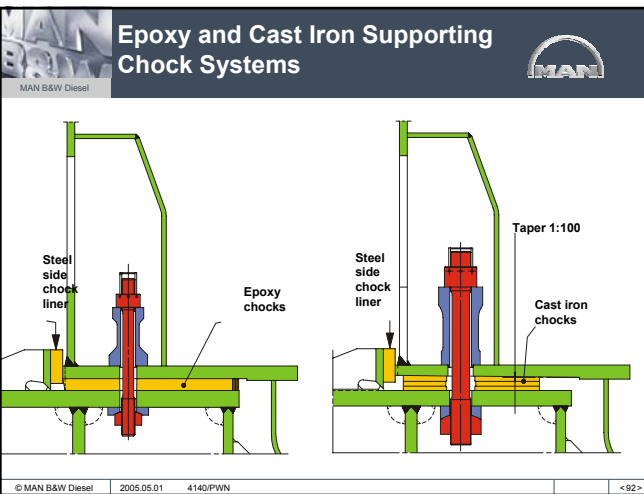
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MAN B&W Diesel

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MAN B&W Diesel

© MAN B&W Diesel 2005.05.01 4140/PWN <89>



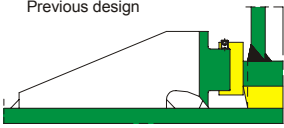
# Installation Aspects



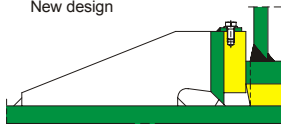
MAN B&W Diesel

## Side chocks, modified design

Previous design



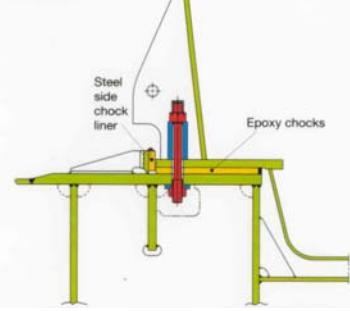
New design



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<98>

## Epoxy supporting chock system, latest engine types



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<97>



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<98>



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L60MC-C Bedplate

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<99>



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<100>

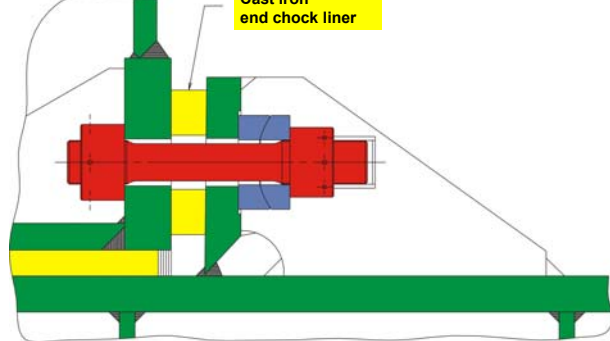
# Installation Aspects



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End chocks

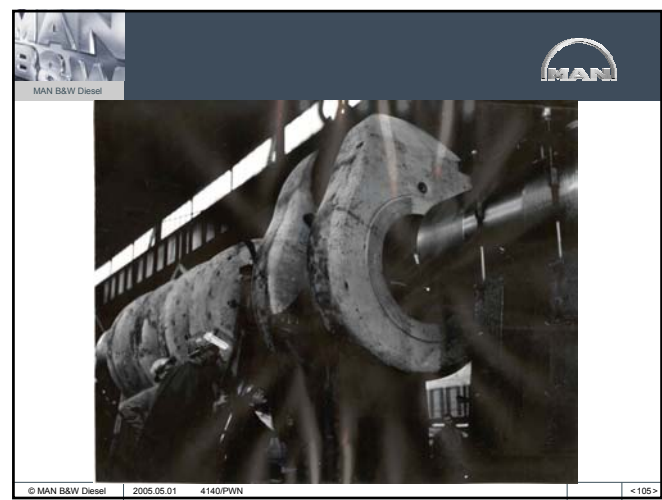
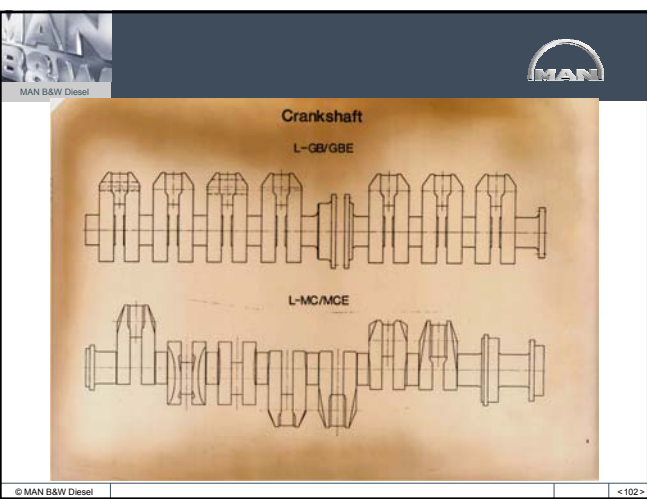
Cast iron end chock liner

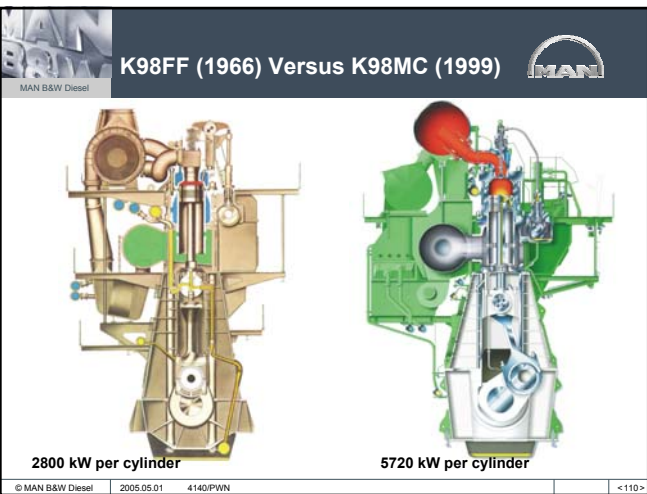
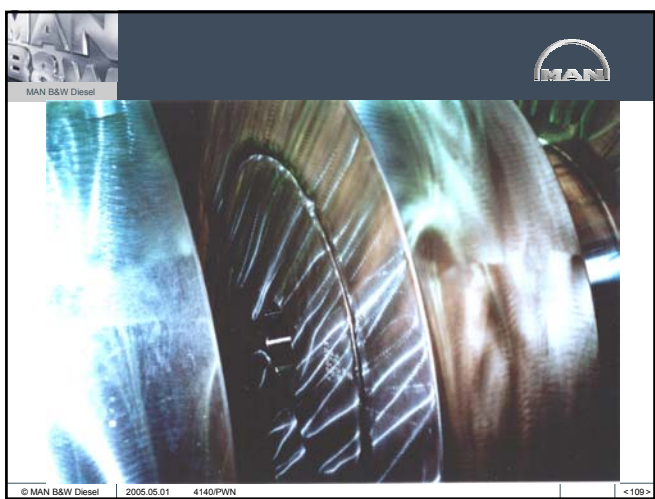


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<101>







Crankshaft

		12K98MC-C	12K108MC
Total	tons	412	542
Fore	tons	216	255
Aft	tons	196	287
Total length	mm	25,195	27,615

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**S80MC Main bearing**

Main bearing/crankshaft

White metal - 2.5 mm

Bedplate/bearing cap

Top clearance min. 0.75 max. 0.55

Side clearance min. 0.15 max. 0.25

Shims for adjustment of top clearance

**K90MC-C Main bearing**

Thin shell bearing white metal - 1.5 mm

Top clearance 0.25-0.85

Side clearance 0.56-0.52

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**Main bearings**

**A: Thick shell design**  
Original design for the MC engines (S50-80MC, L50-70MC, K90MC)

Gradual increase of main bearing damage.

**B: Thin shell design**  
Introduced on the small bore MC, later on the MC-Compact and K98MC/MC-C, S80/90MC-C, L90MC-C, K80/90MC-C, L80MC engines

Good experience  
Reliable design

SL98-355/SBJ July 1998

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**Traditional Excitation Technique**  
Axial vibration

Radial force

Equivalent forces

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**Axial Vibration Damper: Physical Model**

Oil inlet

c Damper restrictions

Front end of crankshaft

k

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**Axial vibration damper of S-MC-C**

Oil damper shims

Damper piston

Damper casing

Lub. oil

- 60% thicker damper piston
- 18% larger diameter of damper piston
- Easy adjustment by damper shims

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### The Axial Vibration Monitoring System (AVM-system)

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### Earthing Device

#### Spark erosion in main bearings

Bronze: Propeller = +

Potential difference  $< 50 \text{ mV}$

Main bearing

Current Earthing device

Steel: Hull = +  
Intermediate shaft  
Propeller shaft

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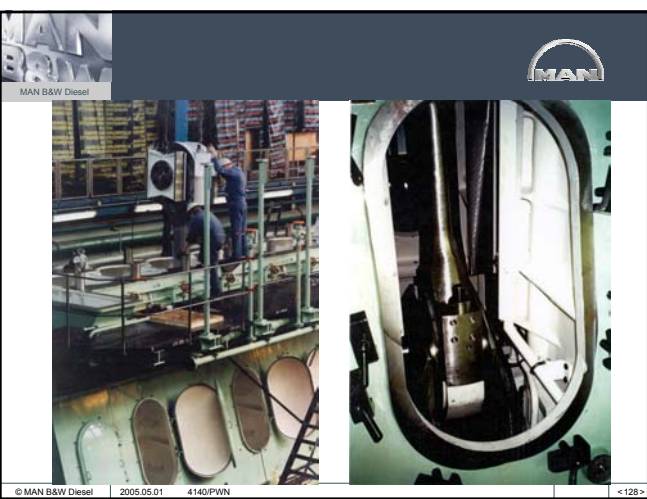
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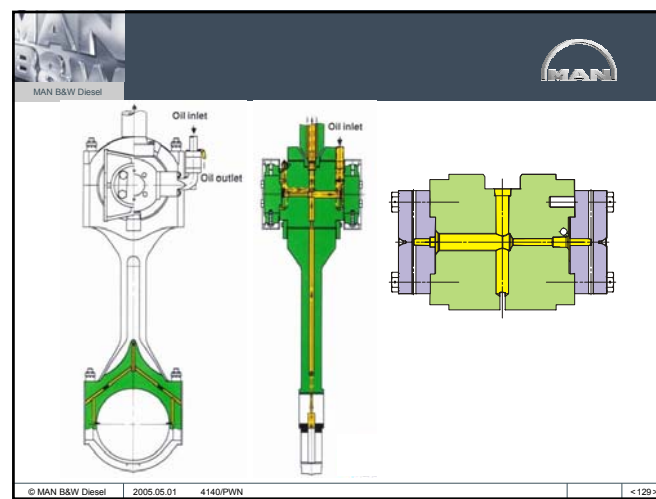
MAN

L50MC/C A-Frame Mounted on Bedplate.

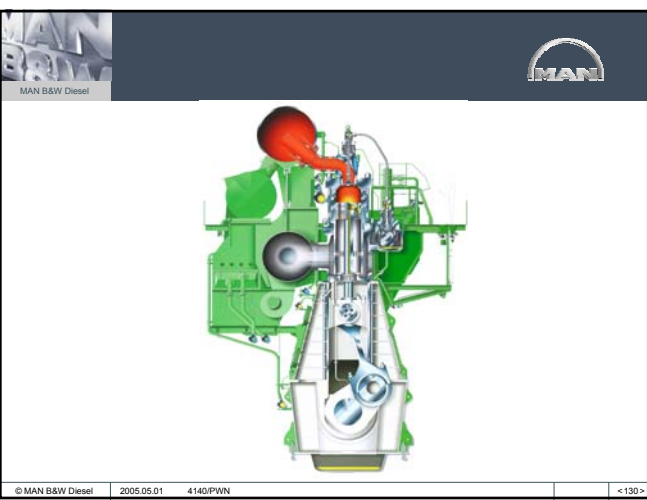
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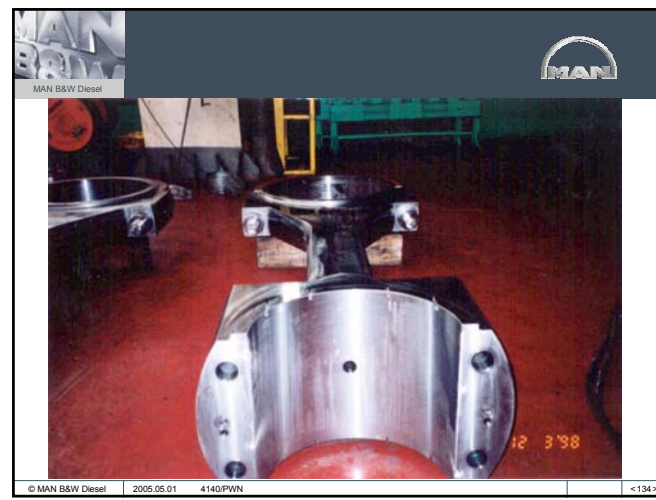
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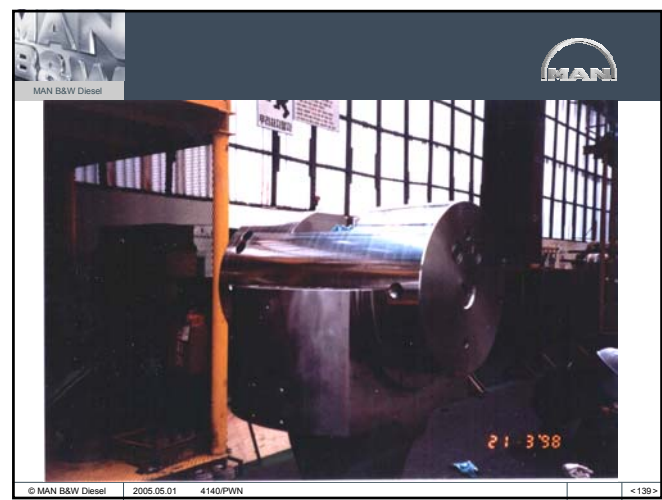
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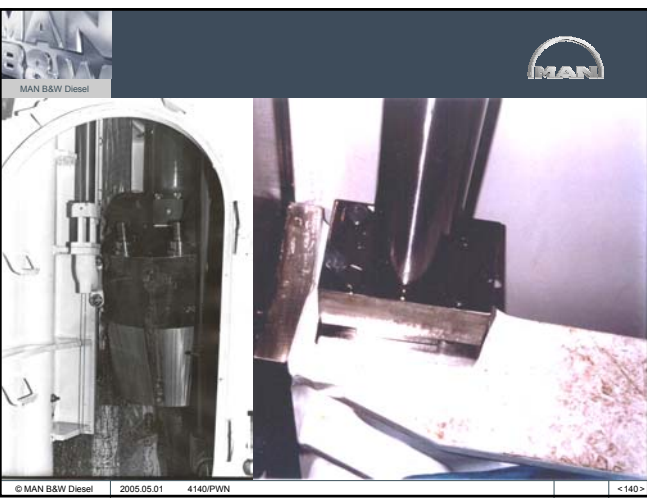
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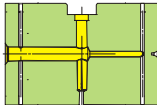
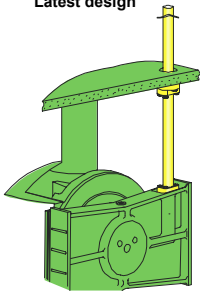
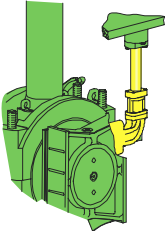


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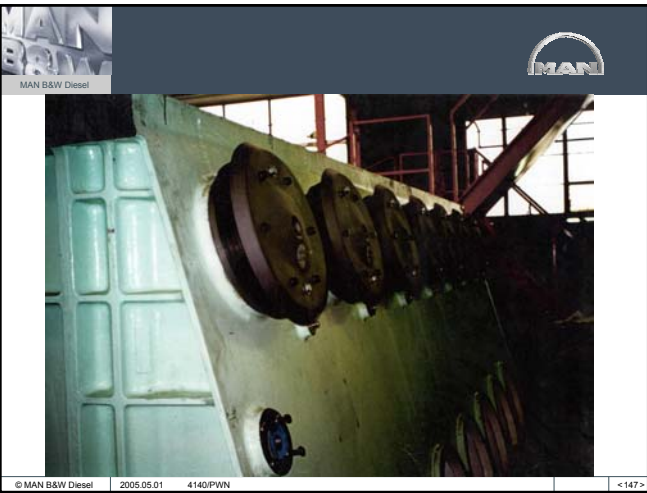
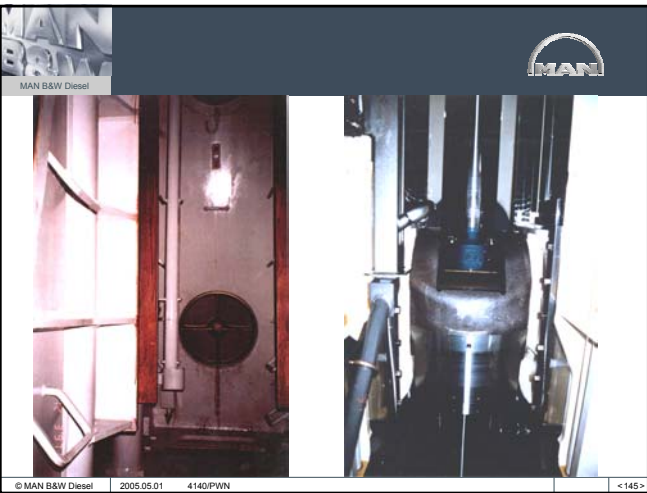
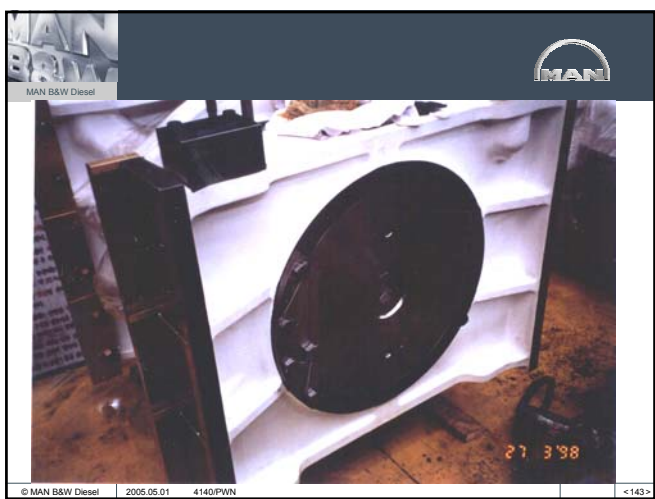
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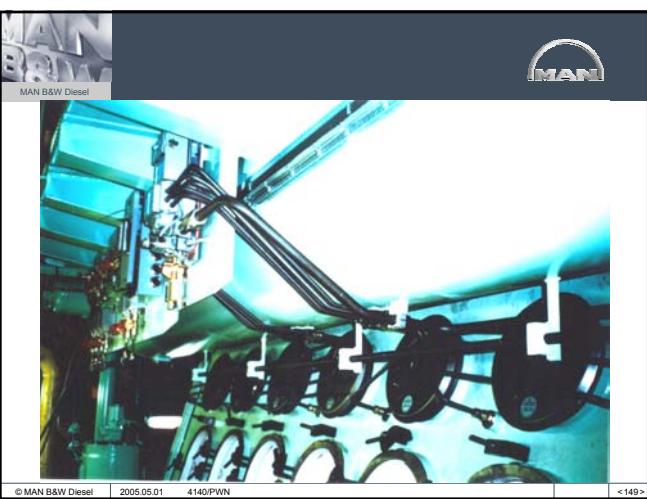
### Design Features

Crosshead	Latest design	Traditional design
		
<ul style="list-style-type: none"> <li>• Telescopic pipe mounted in wide guide shoes</li> <li>• No need to dismantle the telescopic pipe at overhaul of piston</li> </ul>		

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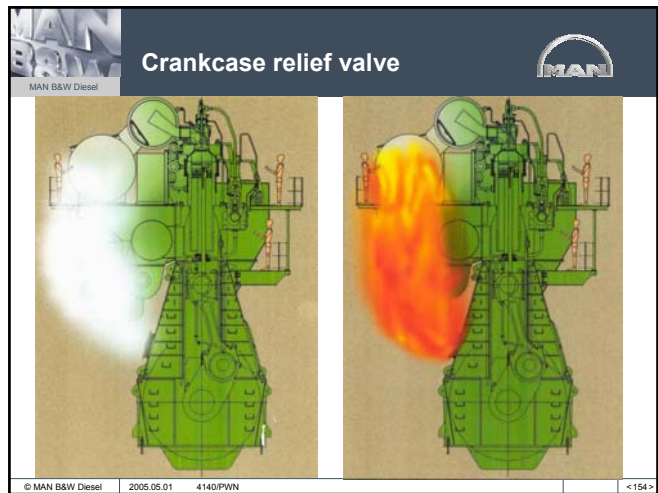
### Crankcase relief valve

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**Test equipment for Relief Valves**

**ONLY**  
 Hoerbiger type EVN  
 and  
 Mt Halla type HCSG-N  
 Approved by MAN B&W

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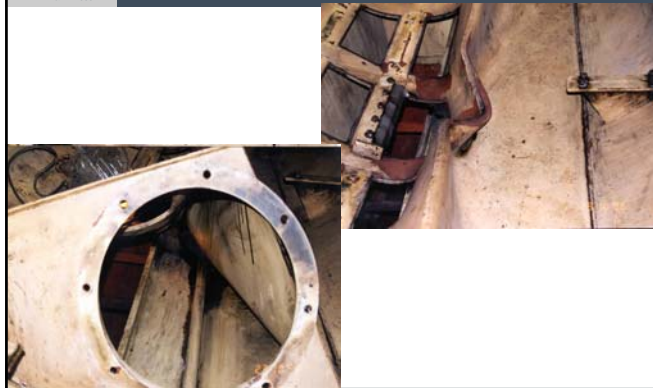
## Cases of explosions where the cause is known

Year	Cause of Explosion	Cause of Failure
1995	Bearing in PTO gearbox	
1996	Inlet pipe for piston cooling oil falling off	Incorrect tightening
1997	Incorrect spring mounted in piston rod stuffing box	Unauthorised spare part
1997	Piston rod interference with cylinder frame	
1999	Weight on chain tightener falling off	Incorrect tightening
1999	Fire outside the engine	
2000	Main bearing	
2000	Camshaft bearing	
2000	Incorrect shaft in camshaft drive	Unauthorised spare part
2001	Crankcase failure	
2001	Piston crown failure	
2001	Main bearing	
2001	Crankpin bearing	
2002	Inlet pipe for piston cooling oil falling off	Incorrect tightening

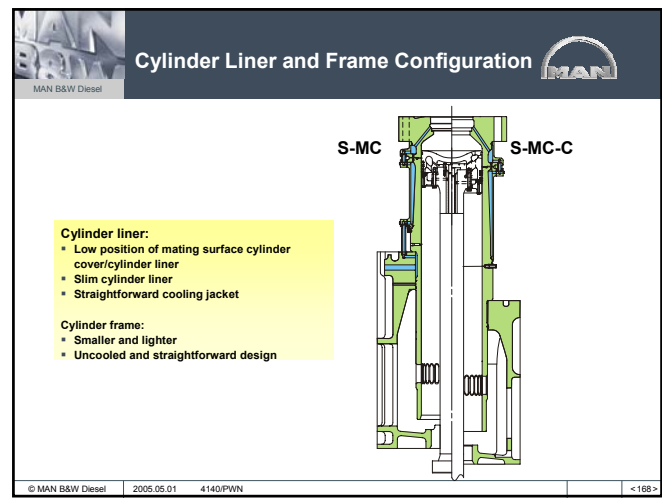
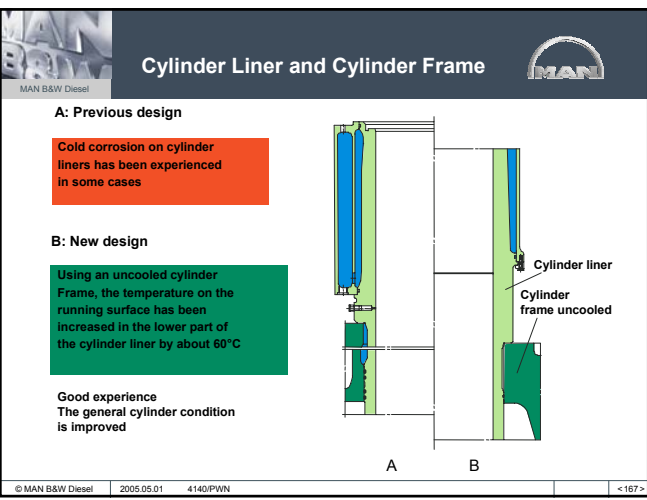
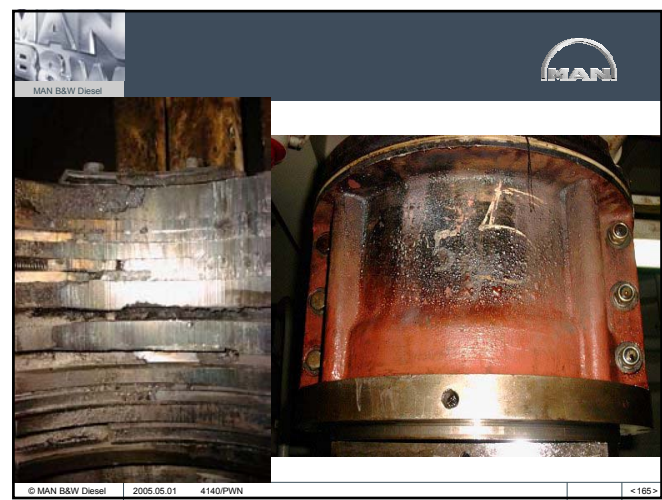
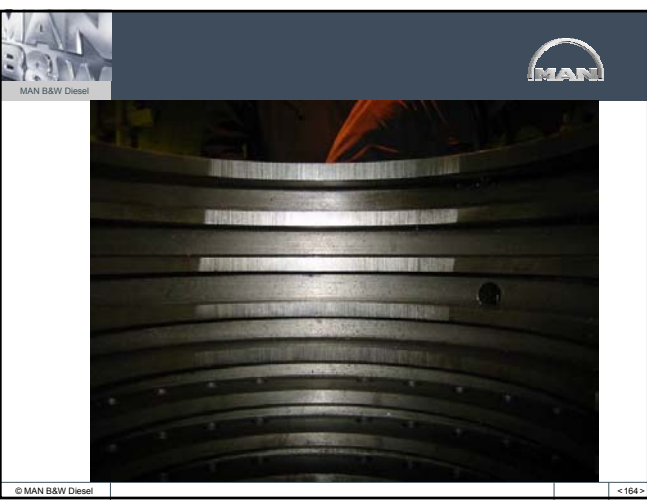
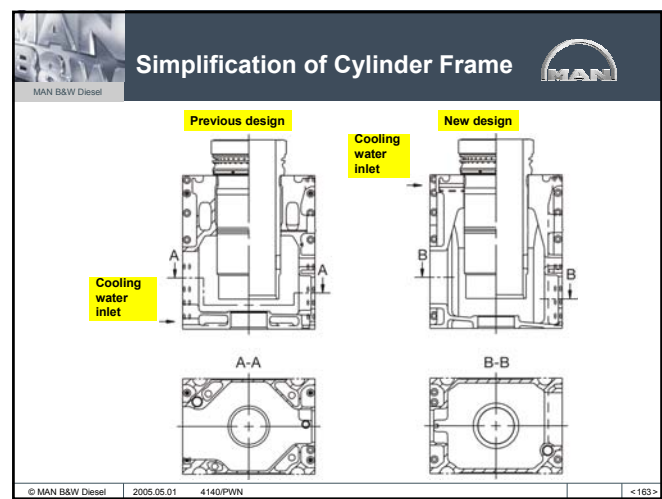
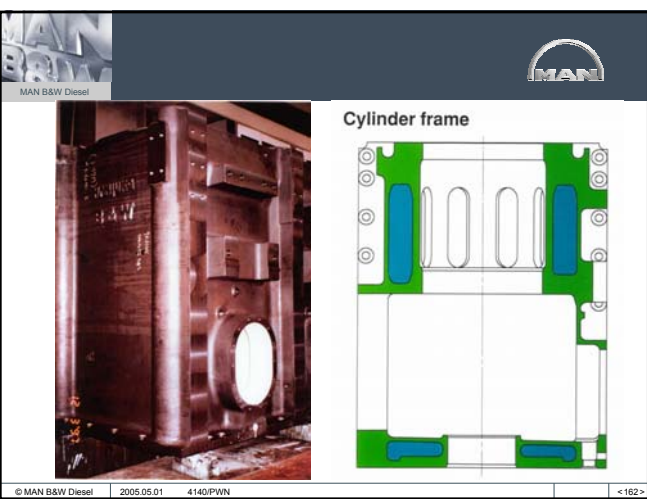


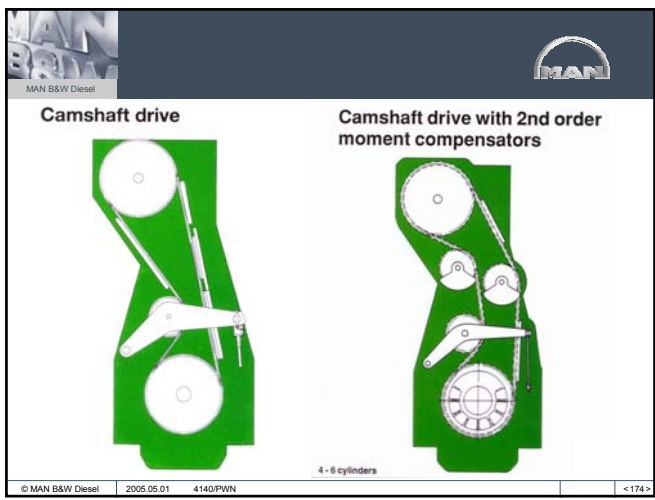
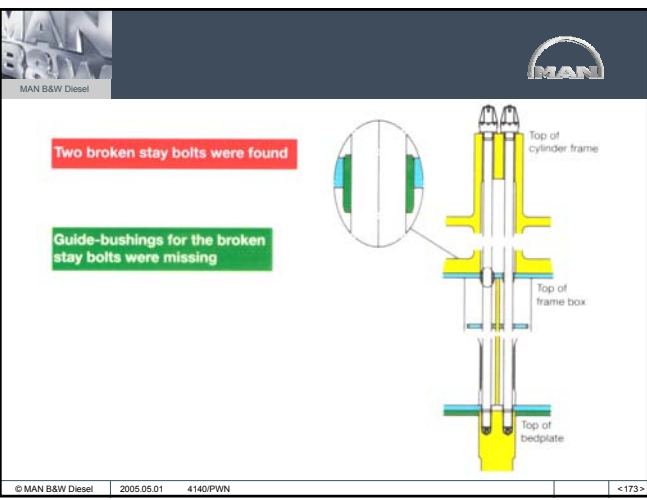
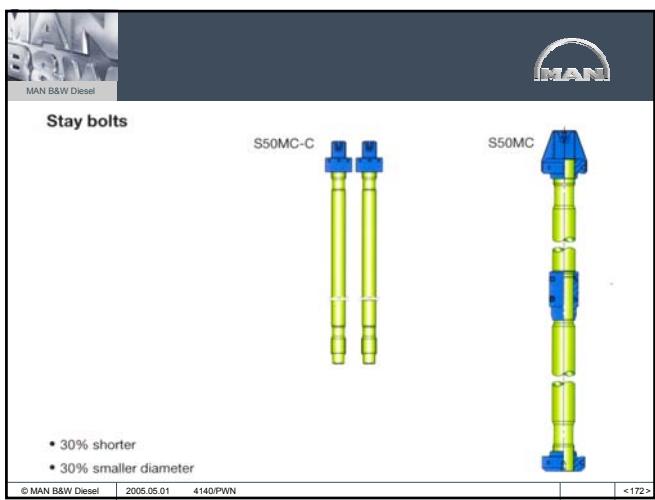
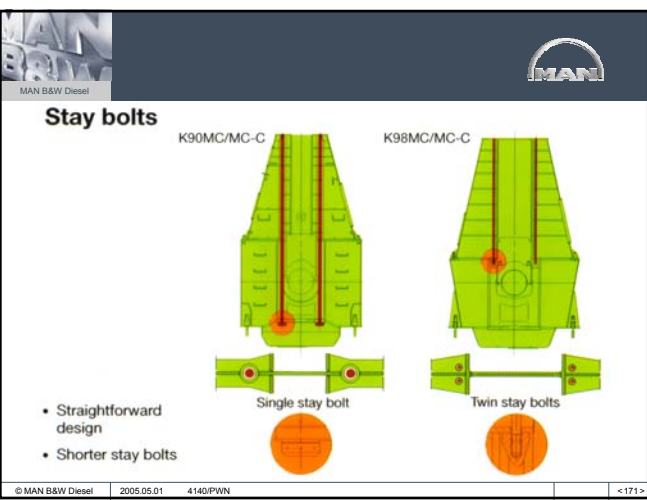
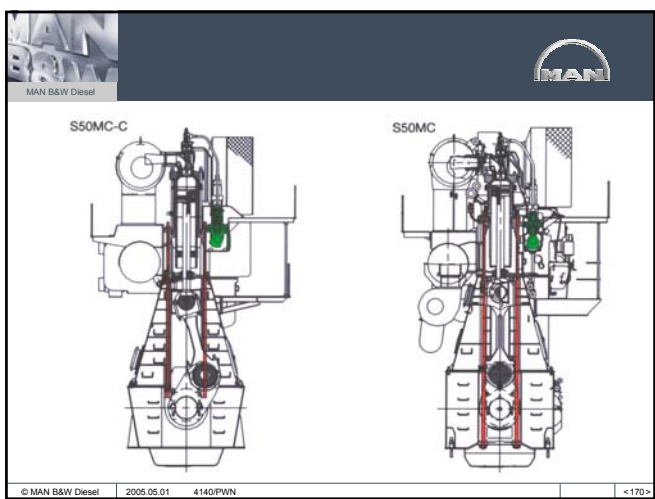
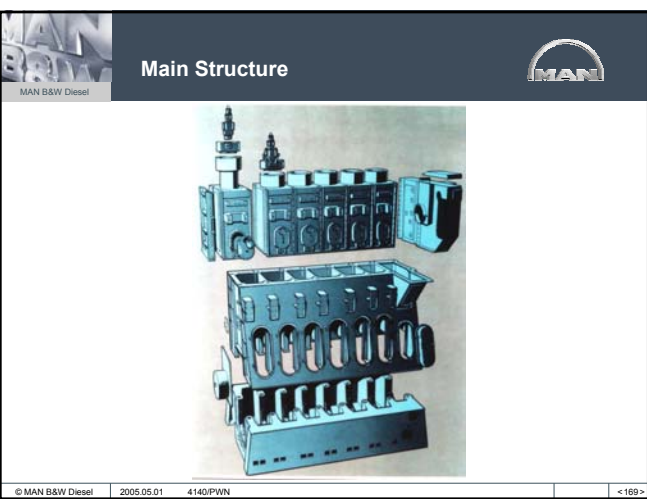
## Crankcase Explosion

Crankcase doors after a crankcase explosion









**Vibration Aspects**

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**General terms**  
Internal forces

Piston

Crosshead

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**2nd order moment compensators**  
"Fore"

4-6 cylinders

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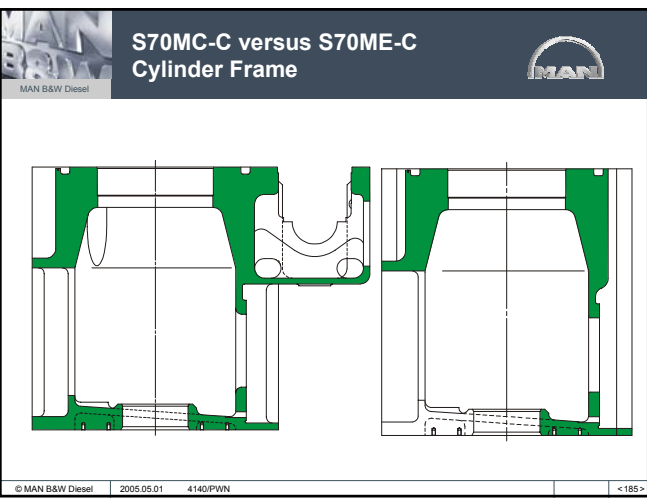
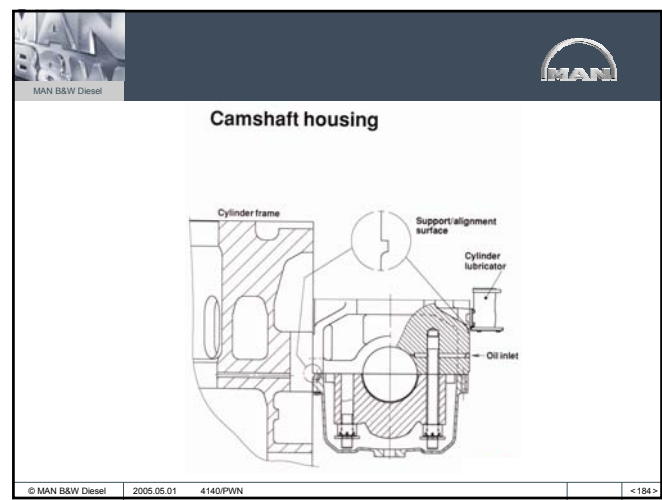
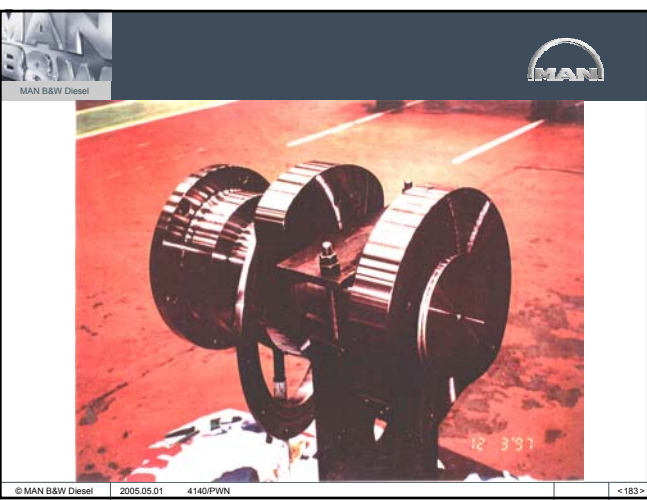
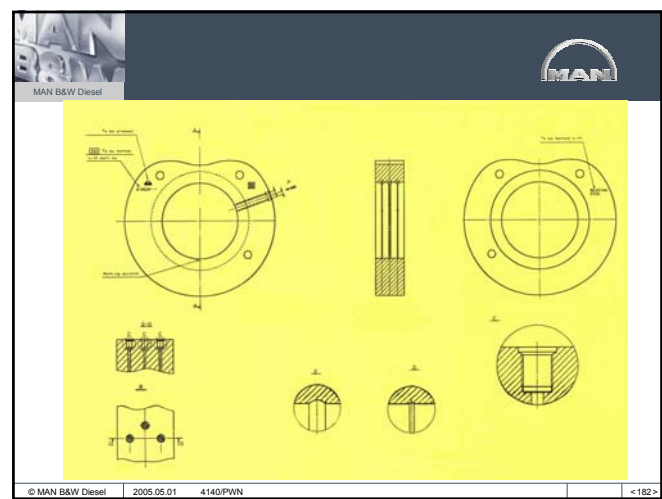
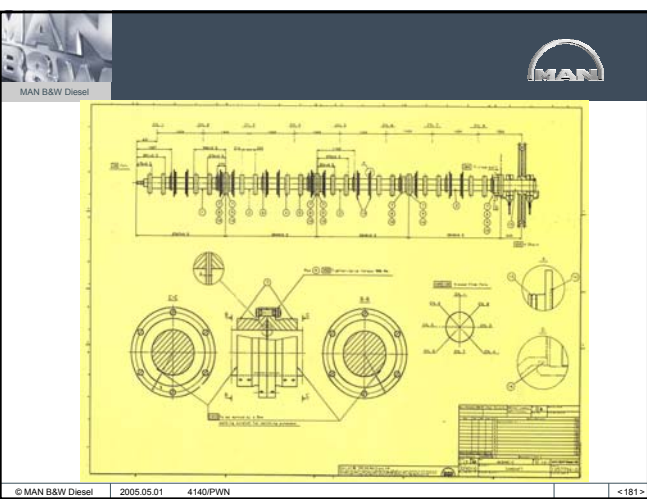
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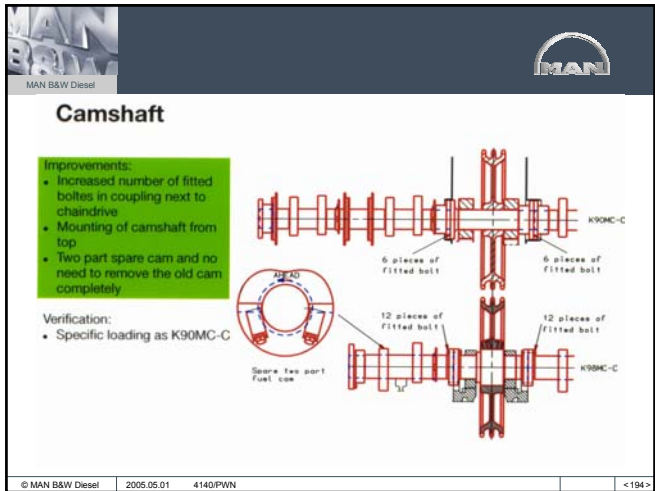
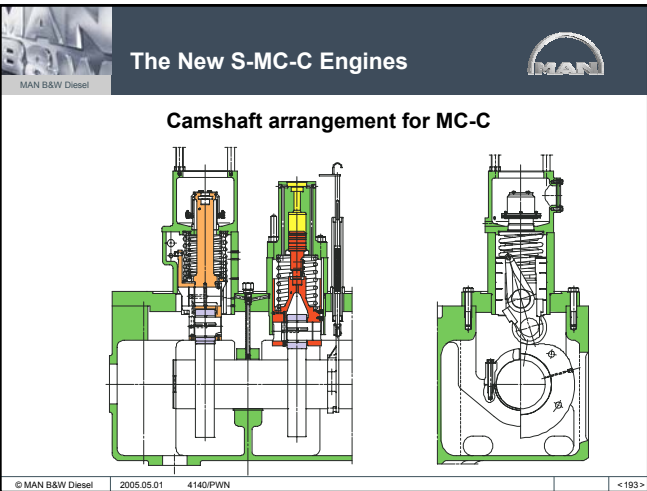
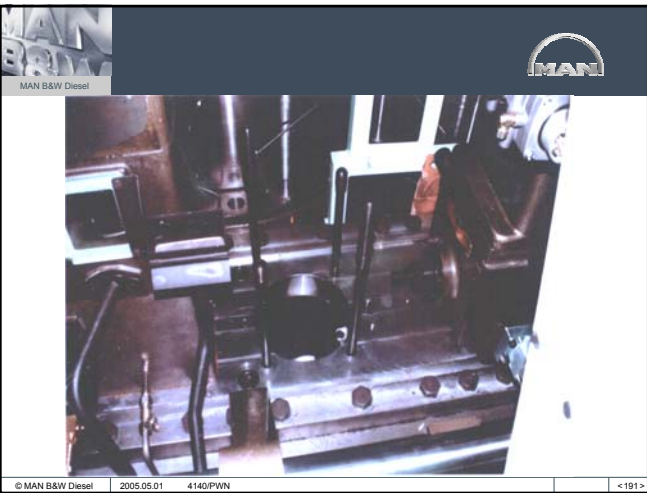
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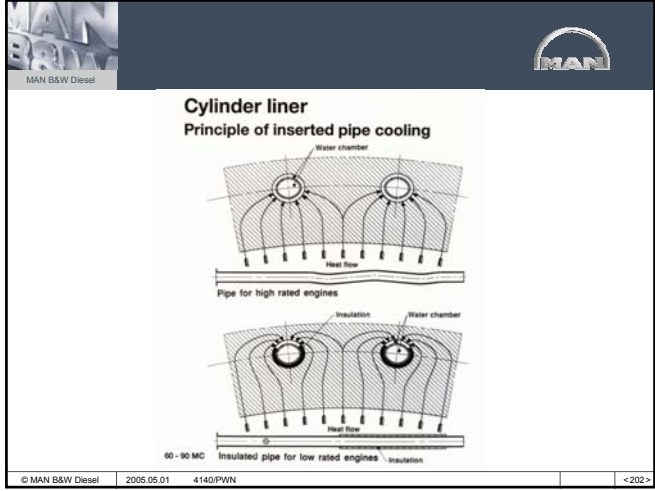
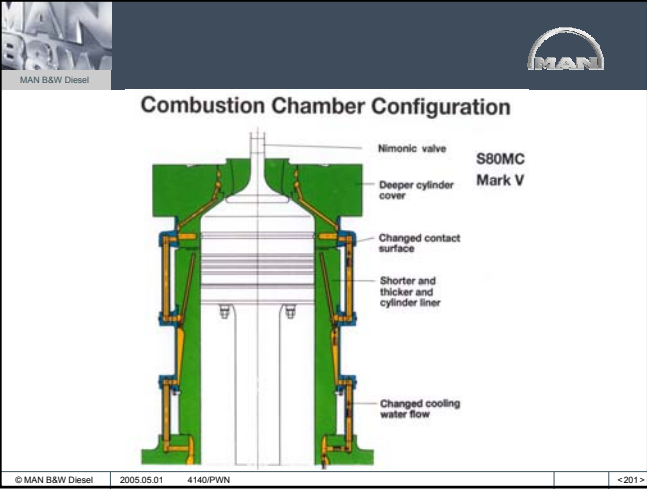
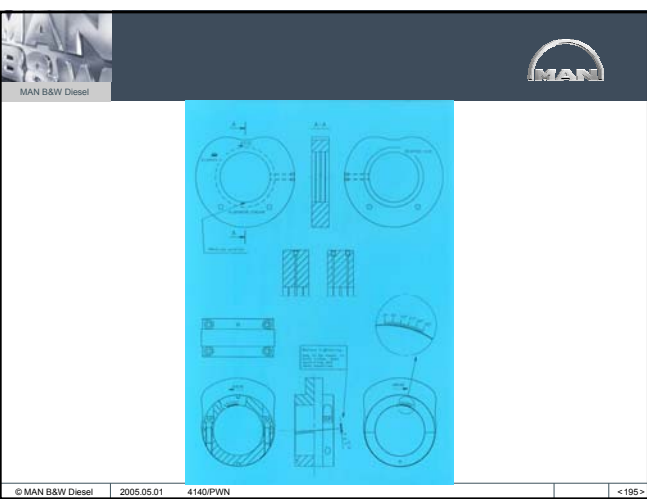
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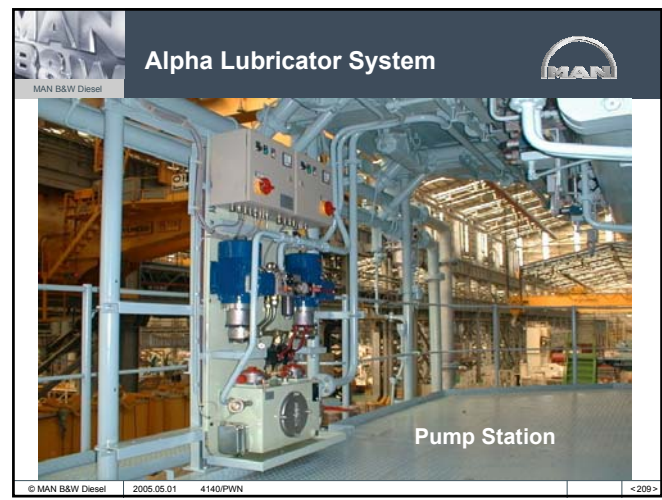
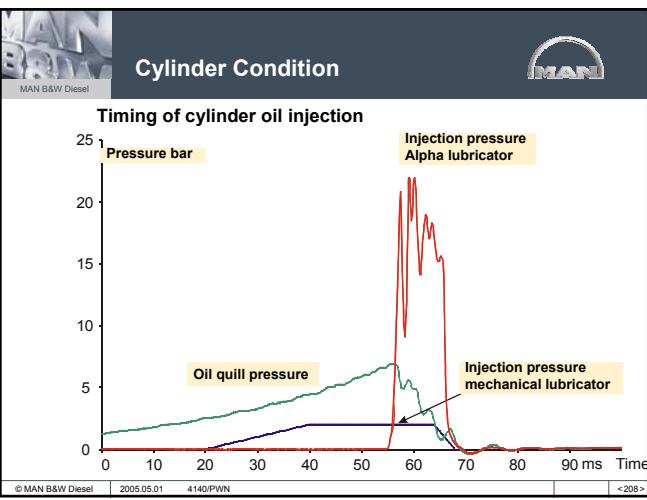
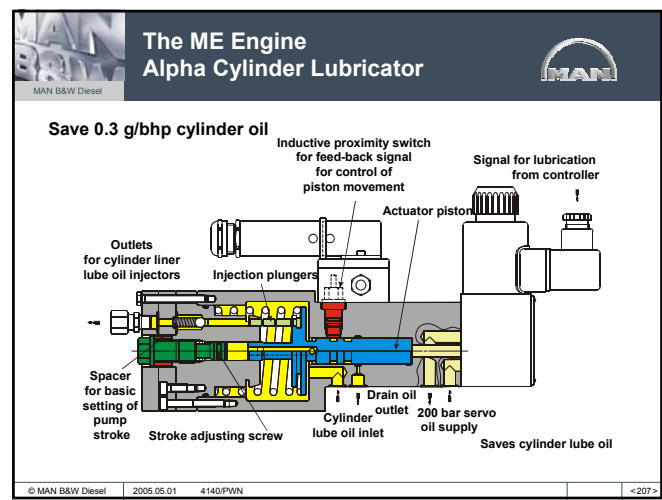
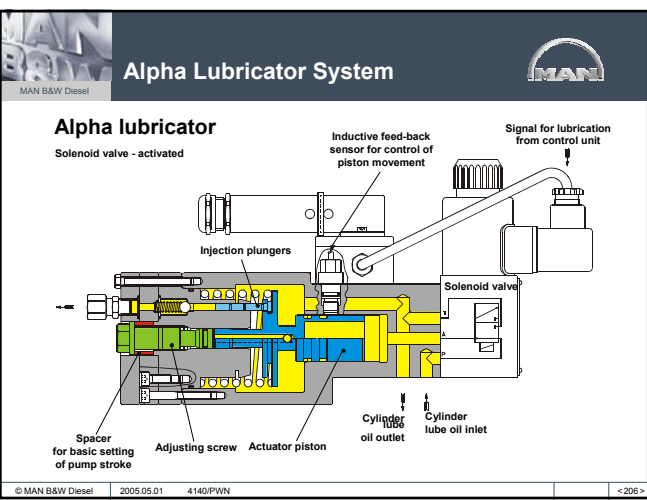












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**Piston rod and stuffing box**

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**Cylinder Condition**  
Piston skirt with copper belt

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**Piston assembly**

Inconel 625 layer for TCS and all K-type MC plants

30% higher piston rings

Relief groove

Hardened

Surface of O-ring groove etc. N7 (smooth)

New standard on 98-60 MC  
Piston skirt with lead bronze bands

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**Combustion Chamber Design**  
S-MC-C and S50MC

**S-MC-C**      **S-MC**

- Piston with high top land  
Cylindrical top land
- Piston ring further away from combustion space
- Lower mating surface between cylinder cover and cylinder liner
- First piston ring special patented CPR ring
- PC ring
- Bronze band

Top land

Mating surface

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**K90MC-C Design**

**Combustion chamber**

**Previous**      **New**

**Features:**

- High top land
- Oros shape of piston top
- CPR top piston ring
- Alu-coat piston rings
- Bore cooled, forged piston of heat resistant steel
- Piston cleaning ring

**Improvements:**

- Approx. 100 °C lower temperature on top compared with former type piston
- Elimination of inconel coating on piston top
- Increased chrome layer thickness in bottom of ring grooves
- Anti erosion bushing in oil outlet in piston rod foot

**Verification:**

- Extensive calculations
- Comprehensive tests on K90MC and K90MC-C
- Service test on K90MC

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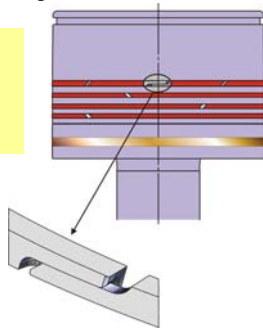


## Combustion chamber engines – Piston rings

- High 1<sup>st</sup> piston ring to accommodate CPR design
- Optimal pressure drop over the upper piston ring reduces the heat load on the second piston ring significantly
- All piston rings Alu-coat

Good performance of the piston ring pack means high reliability of the combustion chamber components and the cylinder condition

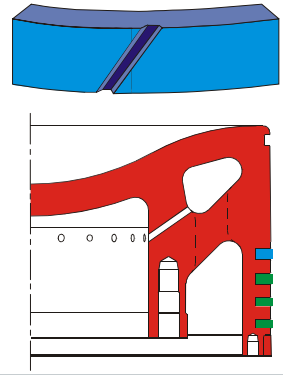
### Controlled Pressure Relief (CPR) gaps



## Genuine spare parts

### Piston ring with controlled pressure relief (CPR piston ring)

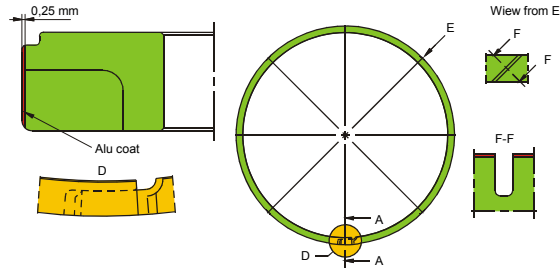
- Reduced differential pressure on piston ring No. 2
- Reduced temperature on piston ring No. 2



## Piston Ring CPR Alu Coat



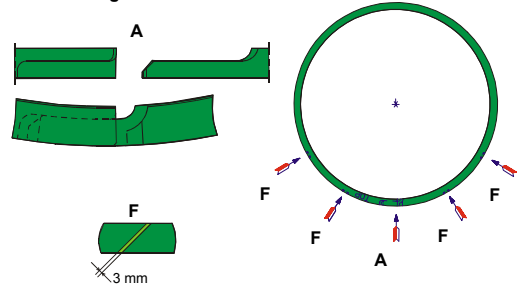
### Pressure relieved



## Cylinder Condition



### Controlled pressure relief piston ring (CPR) 90 and 98 bore engines



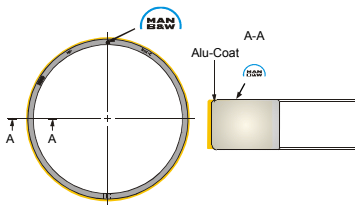
## Alu-Coated Piston Ring



### Genuine spare parts

Developed at our Research Centre

- Reduced running-in time by more than 50%
- Thus saving cylinder oil
- Thickness: about 0.3 mm

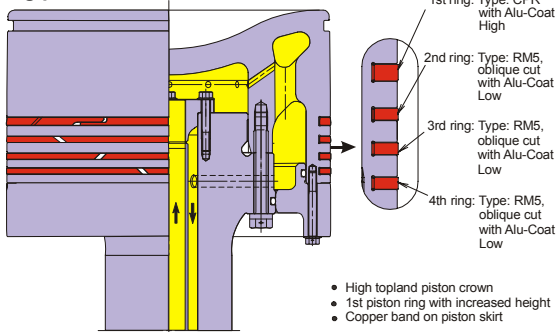




# Alu-coated Piston Ring



## Ring pack

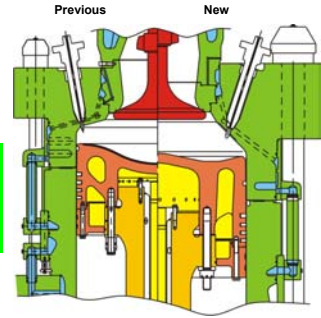


# K90MC-C Design



## Combustion chamber

- Features:
- High topland
  - Oros shape of piston top
  - CPR top piston ring
  - Alu-coat piston rings
  - Bore cooled, forged piston of heat resistant steel
  - Piston cleaning ring
- Improvements:
- Approx. 100 °C lower temperature on top compared with former type piston
  - Elimination of Inconel coating on piston top
  - Increased chrome layer thickness in bottom of ring grooves
  - Anti erosion bushing in oil outlet in piston rod foot
- Verification:
- Extensive calculations
  - Comprehensive tests on K90MC and K90MC-C
  - Service test on K90MC



# Production



## Piston and piston rings

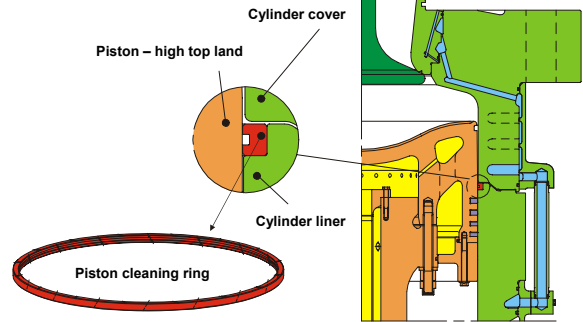
- Oros Piston
- ALU Coated Piston Rings



# Combustion Chamber Layout



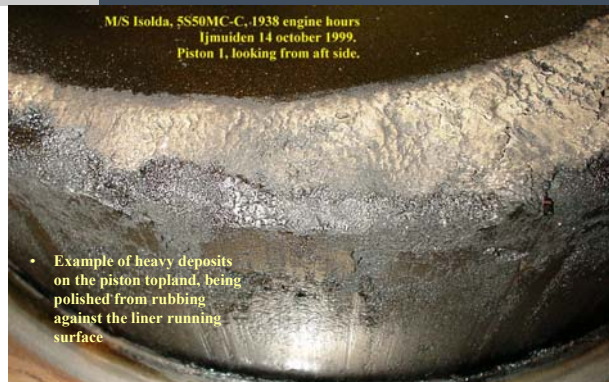
## Piston – high top land



## “Bore polish” from topland deposits.



M/S Isolda, 5550MC-C, 1938 engine hours  
 Ijmuiden 14 october 1999.  
 Piston 1, looking from aft side.



## “Bore polish” from topland deposits.



M/S Isolda, 5550MC-C, 1938 engine hours  
 Ijmuiden 14 october 1999.  
 Cyl 1, for side.

Example of, polished liner surface, from heavy deposits on the piston topland, rubbing against the liner surface.



**Piston Rod and Stuffing Box for S-MC-C**

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- Hardened piston rod
- Higher scraper ring tension
- Reduced piston rod drain oil amount

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**Piston rod and stuffing box**

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**Stuffing box**

- Scraper ring  
Material: Tin bronze
- Sealing ring  
Material: Tin bronze
- Sealing ring  
Material: Tin bronze
- Seperate drain
- Scraper ring
- Drain to crankcase
- Back up spring
- Base ring
- Cast iron lamel

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**Design Piston Rod Stuffing Box**

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**Original standard**

- Scraper ring
- Sealing ring
- Sealing ring
- Stuffing box drain
- Scraper ring
- Lamella
- Return oil to crankcase
- Back up spring
- Relief groove
- Base ring

**New standard**

- Sealing ring
- Stuffing box drain
- Scraper ring
- Relief groove

SL Modification of stuffing box SL 02-408

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## ME Starting Air System

### MC-C design

Starting air distributor

Starting valves

### ME-C design

Blow-off

Pilot air inlet

NC-valves

Connection for ECS

Starting valves

The NC valve is mounted on the main starting pipe behind the cylinder cover

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## Manoeuvring System

### Starting valve

Ensure clearance

Before modification

After modification

Too soft material

Deformation of housing

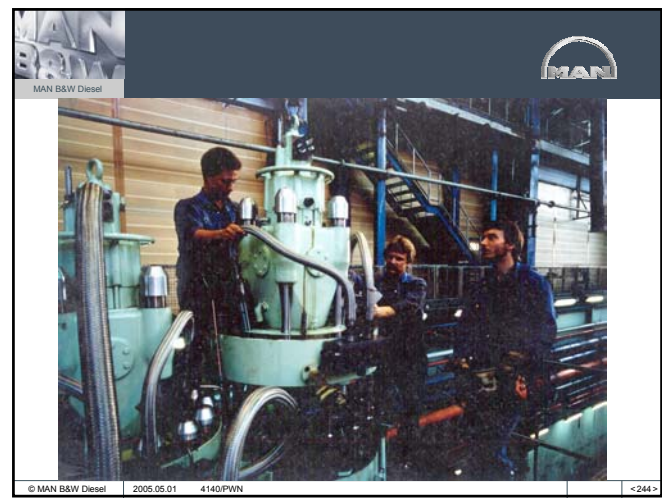
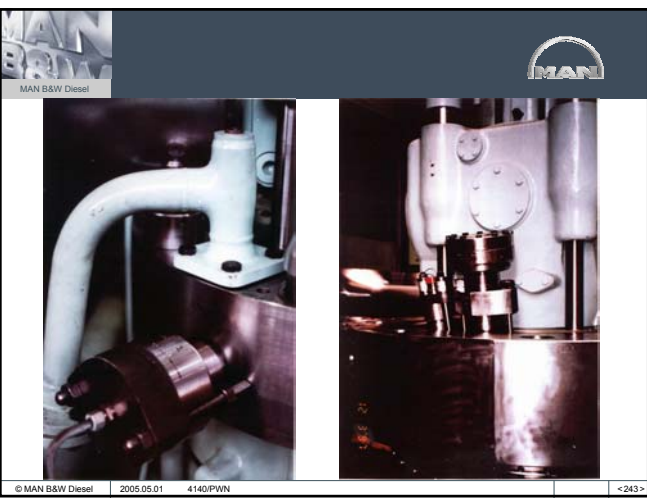
Sticking/Clearance

Pilot air

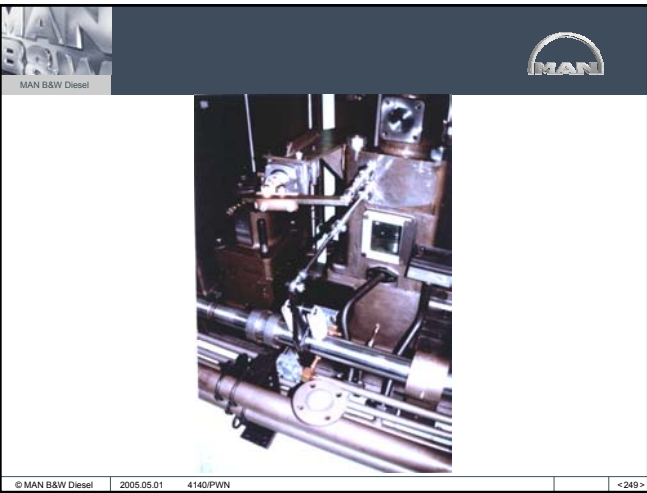
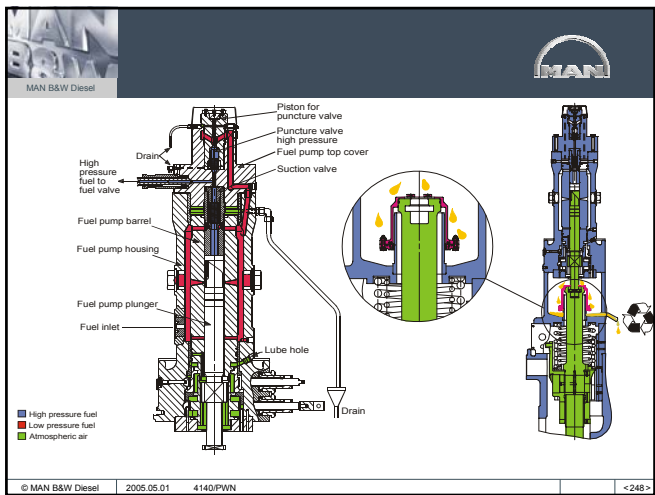
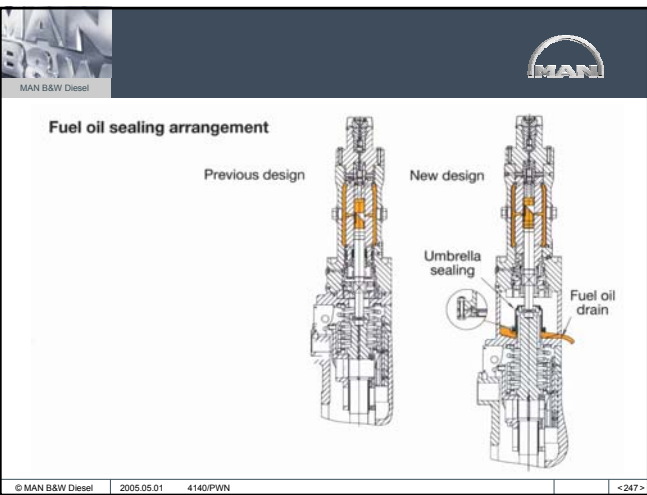
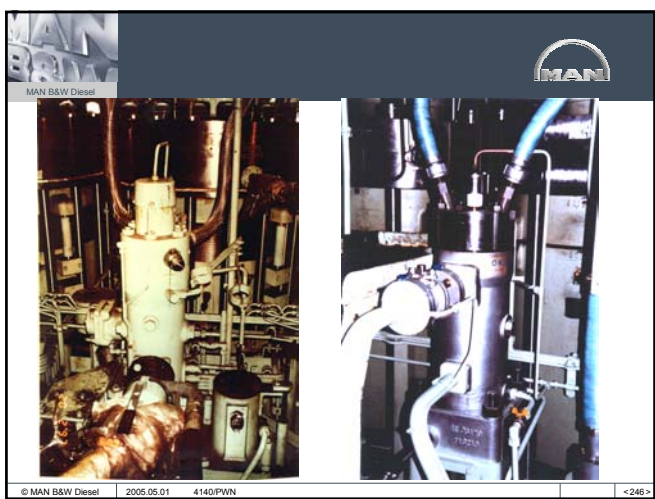
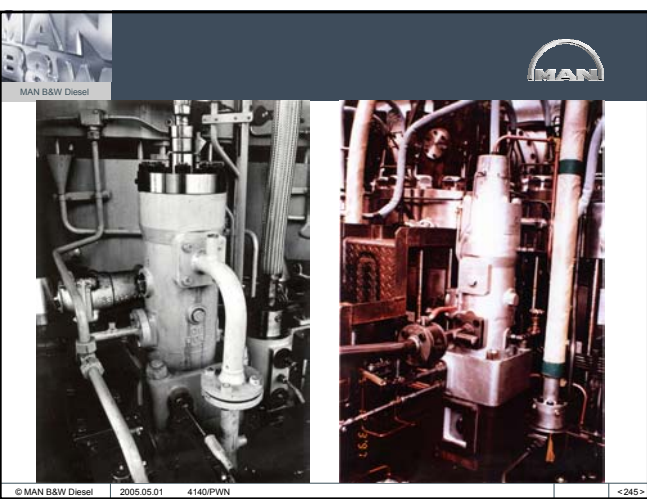
Starting air

Ensure clearance

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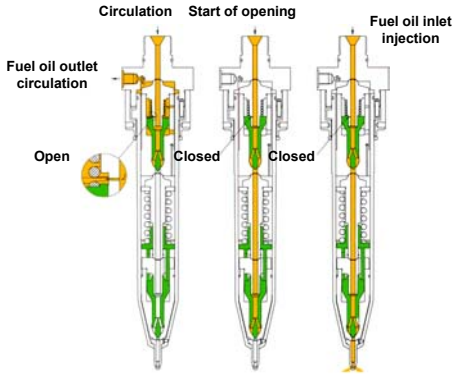




# Fuel Valve



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# Performance



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## Fuel Valves



Conventional fuel valve  
Sac volume 1690 mm<sup>3</sup>



Mini-sac valve  
Sac volume 520 mm<sup>3</sup>



Slide-type fuel valve  
Sac volume 0 mm<sup>3</sup>

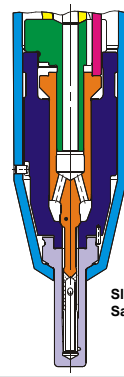
# Slide-type Fuel Valve



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Conventional fuel valve  
Sac volume 1690 mm<sup>3</sup>



Slide-type fuel valve  
Sac volume 0 mm<sup>3</sup>

Now used as standard

Possibility for retrofit

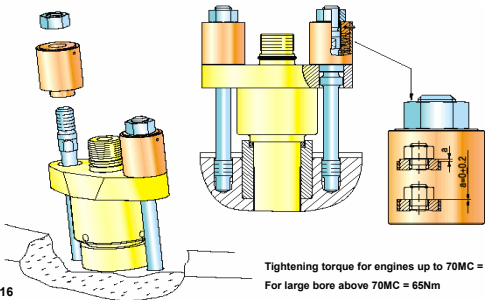


# Fuel Valve, Spring Housing



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## Malfunction due to incorrect tightening

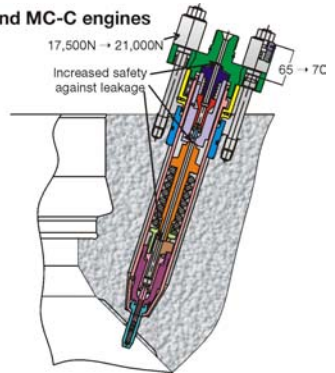


Tightening torque for engines up to 70MC = 60Nm  
For large bore above 70MC = 65Nm

## 80, 90 and 98 bore MC and MC-C engines



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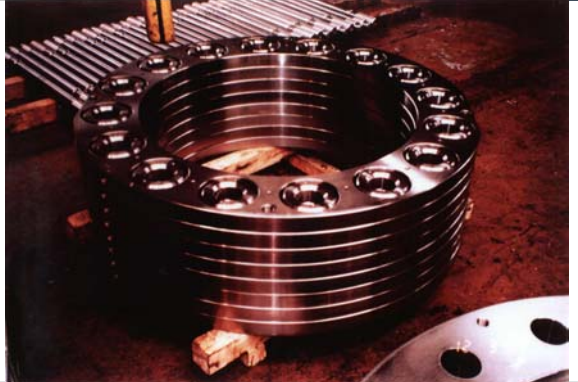
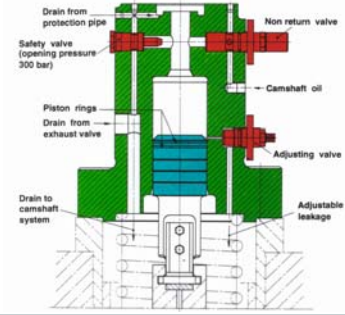
17,500N → 21,000N  
Increased safety against leakage  
65 → 7C

### Damaged Piston Crown

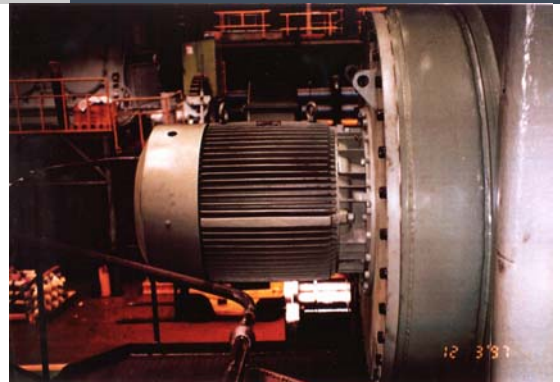
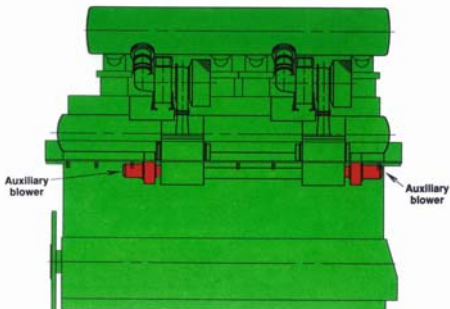
Reason: Fuel valves in bad condition



### Exhaust Valve Actuator



### Auxiliary Blower Arrangement K90MC-C





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## Auxiliary Blowers

8K90MC

Auxiliary blower

8K90MC-C

Auxiliary blower

Auxiliary blower

Auxiliary blower

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NA-Turbocharger

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## "Finish with Engine"

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# Auxiliary Systems

