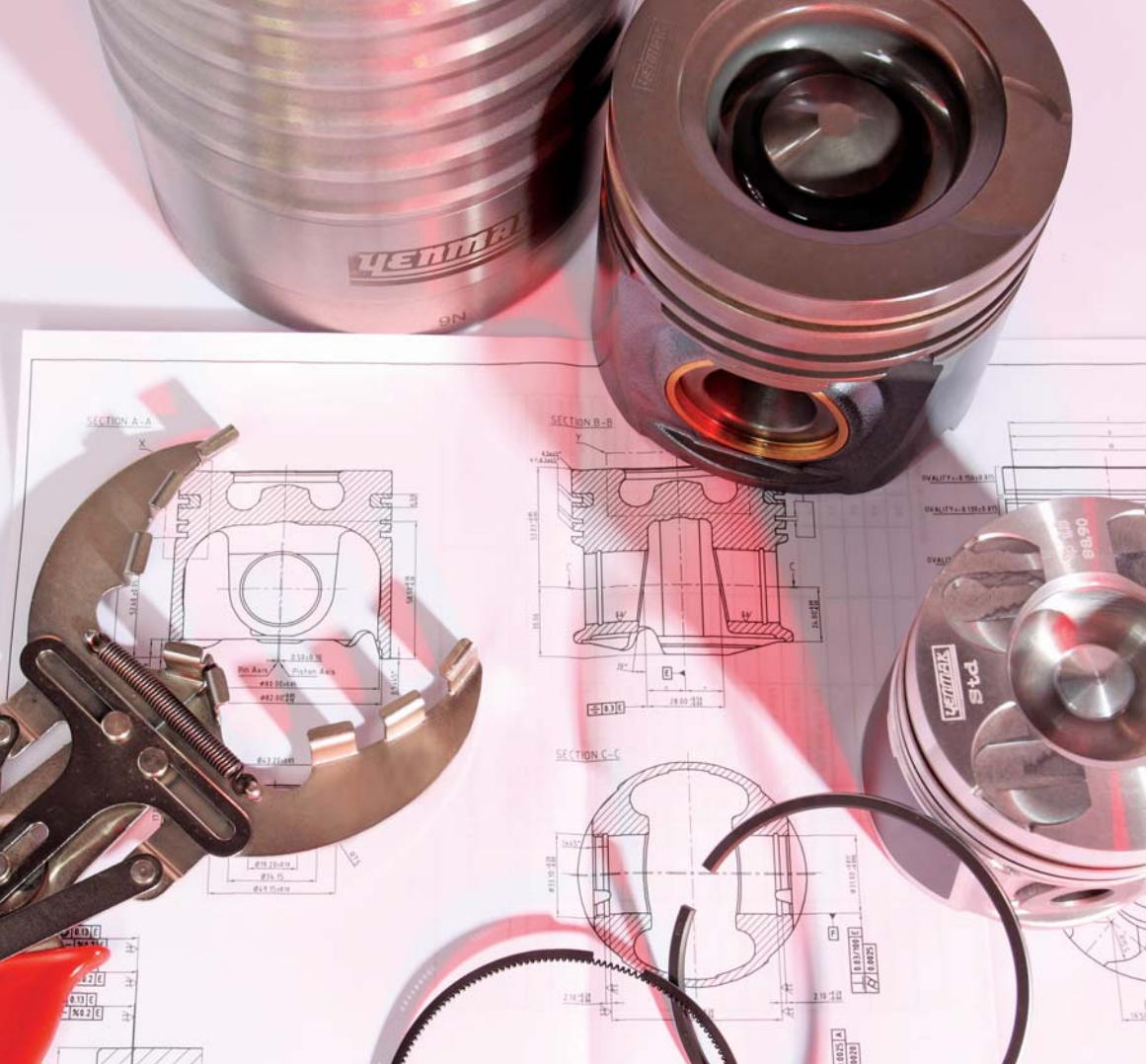


УЕНМАК

Liner | Piston | Ring | Engine Bearing

Service Manual



SERVICE MANUAL

All given information in YENMAK service manual is prepared by taking advantage of piston, ring, and liner (engine) failures related to the evaluation of the problems result of carefully researched experience by after sale service and engineering department team. Described engine failures created by as a result of experience gained at the end of the actualized engine failures.

Based on the changing and developing engine technologies different engine failures occur. Yenmak is not responsible for any material and spiritual damages, after the changing engine technology, Yenmak service failure causes and recommendations mentioned in the manual with the fact that disagreement.

Engine renewals must be performed by expert auto mechanics, service authorities and engine technicians. Engine technicians and service representatives should followed the changing engine technology and obtain the necessary information's. Yenmak service manual may contain errors may not be completed instructions or may differ from the actual information's. The accuracy, currency or adequacy of the warranty or legal responsibility is assumes by Yenmak Inc. in Yenmak service manual provided information.

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YENMAK carries out manufacture and sales of engine liners, pistons, pins, rings, engine bearings, valves and seals for all kinds of vehicles. The products of YENMAK hold ISO 9001 and ISO / TS 16949 quality management certificates.

YENMAK has been carrying out its annual manufacture of 1.5 million pieces of engine liners and 1 million pieces of pistons and pins in Turkey since 1966, utilizing advanced technology, high-quality controlling devices and the consciousness of respect to environment.

YENMAK exports 80% of its manufacture to 55 countries and these countries of export mainly consist of the EU Member States, U.S.A., Middle East, Far East, Africa Countries and Russia.

Manufacturing Facilities

HEADQUARTERS & LOGISTICS



PISTON & PISTON PIN MANUFACTURING FACILITY



CYLINDER LINER MANUFACTURING FACILITY



Quality Management Certificates



PISTON FACTORY ISO 9001 QUALITY MANAGEMENT CERTIFICATE

SERTİFİKA



DIN EN ISO 9001 : 2008'e göre yönetim sistemi

TÜV NORD CERT prosedürleri uygulanmıştır. İşbu sertifika ile



Yenmak Piston Segman San. ve Tic. A.Ş.
2. Org. San. Bölğ., Kırım Cad., Sarıççek Sok., No 12, Selçuklu,
TR-42050 Konya,
Türkiye

İsmeren Kuruluşun, belirlenen standartta göre, eşya/diğer parçaları alanında bir yönetim sistemi uygulanmış olduğuna belgelenmektedir. Geçerlilik alanı:

İçten yanmalı motorlar için piston ve piston pimi tasarımı, geliştirilmesi ve üretimi

Sertifika Tesit No: 44 100 113520

2014-08-18 tarihine kadar geçerlidir

TÜV NORD CERT GmbH -
Sertifika İşleri Merkezi

İstanbul, 2011-08-19

İşbu sertifikasyon TÜV NORD CERT'in teknik ve belgelendirme prosedürlerine göre gerçekleştirilmiştir ve düzenli aralıklarla yapılan gözlemler tabiiatindedir.

TÜV NORD CERT GmbH Langemarkstrasse 20 45141 Essen www.tuv-nord-cert.com



--3727

CERTIFICATE



Management system as per
DIN EN ISO 9001 : 2008

In accordance with TÜV NORD CERT procedures, it is hereby certified that



Yenmak Piston Segman San. ve Tic. A.Ş.
2. Org. San. Bölğ., Kırım Cad., Sarıççek Sok., No 12, Selçuklu,
TR-42050 Konya,
Turkey

applies a management system in line with the above standard for the following scope

Design, development and production of pistons and piston pins for internal combustion engines

Certificate Registration No: 44 100 113520

Valid until 2014-08-18

TÜV NORD CERT GmbH -
Sertifika İşleri Merkezi

İstanbul, 2011-08-19

This certification was conducted in accordance with the TÜV NORD CERT auditing and certification procedures and is subject to regular surveillance audits.

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CYLINDER LINER FACTORY ISO 9001 QUALITY MANAGEMENT CERTIFICATE

SERTİFİKA



DIN EN ISO 9001 : 2008'e göre yönetim sistemi

TÜV NORD CERT prosedürleri uygulanmıştır. İşbu sertifika ile



Yenmak Motor Gömlek San. ve Tic. A.Ş.
1. Org. San. Bölğ., Atabey Sok., No 6, Selçuklu,
TR-42000 Konya,
Türkiye

İsmeren Kuruluşun, belirlenen standartta göre, eşya/diğer parçaları alanında bir yönetim sistemi uygulanmış olduğuna belgelenmektedir. Geçerlilik alanı:

Her türlü silindir gömleği tasarımı, üretimi, satışı ile pistonlar için ring taşıyıcılarının üretimi ve satışı

Sertifika Tesit No: 44 100 073715

2013-12-01 tarihine kadar geçerlidir

Teknik Raporu No: TR 190

İlk sertifikasyon: 1998

TÜV NORD CERT GmbH -
Sertifika İşleri Merkezi

İstanbul, 2010-12-02

İşbu sertifikasyon TÜV NORD CERT'in teknik ve belgelendirme prosedürlerine göre gerçekleştirilmiştir ve düzenli aralıklarla yapılan gözlemler tabiiatindedir.

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--3727

CERTIFICATE



Management system as per
DIN EN ISO 9001 : 2008

In accordance with TÜV NORD CERT procedures, it is hereby certified that



Yenmak Motor Gömlek San. ve Tic. A.Ş.
1. Org. San. Bölğ., Atabey Sok., No 6, Selçuklu,
TR-42000 Konya,
Turkey

applies a management system in line with the above standard for the following scope

Design, production and sale of various types of cylinder liners; production and sale of ring carriers for pistons

Certificate Registration No: 44 100 073715

Valid until 2013-12-01

Audit Report No: TR 190

Initial certification: 1998

TÜV NORD CERT GmbH -
Sertifika İşleri Merkezi

İstanbul, 2010-12-02

This certification was conducted in accordance with the TÜV NORD CERT auditing and certification procedures and is subject to regular surveillance audits.

TÜV NORD CERT GmbH Langemarkstrasse 20 45141 Essen www.tuv-nord-cert.com



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SERTİFİKA



ISO/TS 16949:2009'a göre

(3. Baskı, 2009-06-15)

Yönetim Sistemi

Belirtilen standarda uygunluk kanıtlanmış ve TÜV NORD CERT prosedürlerine göre, aşağıda yer alan kuruluş için belgelenmektedir.

Yenmak Piston Segman San. ve Tic. A.Ş.
2. Org. San. Bölğ., Kırım Cad., Sarıçiçek Sok., No 12, Selçuklu
42050 Konya
Türkiye

Destek fonksiyonları Ek'te belirtilmiştir.

Kapsam

İçten yanmalı motorlar için piston ve piston pimi üretimi

Ürün tasarımı sorumluluğu hariç (Madde 7.3'e göre)

IATF Tescil No 0127313
Sertifika Tescil No 44 111 111647

2011-09-26 tarihinden
2014-09-25 tarihine kadar geçerlidir

kgas
TÜV NORD CERT GmbH -
Sertifikasyon Merkezi

Essen, 2011-09-26

İşbu sertifikasyon TÜV NORD CERT'in tetkik ve belgelendirme prosedürlerine göre gerçekleştirilmiştir ve düzenli aralıklarla yapılan gözetim tetkiklerine tabidir.

TÜV NORD CERT GmbH

Langemarckstrasse 20

45141 Essen

www.tuev-nord-cert.com

Sayfa 1/2



02-IAO-QMC-01021

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CERTIFICATE **TÜV NORD**

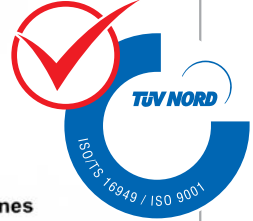
Management system as per
ISO/TS 16949:2009
(3rd edition, 2009-06-15)

Evidence of conformity with the above standard has been furnished and is certified
in accordance with TÜV NORD CERT procedures for

Yenmak Piston Segman San. ve Tic. A.Ş.
2. Org. San. Bölğ., Kırım Cad., Sarıçiçek Sok., No 12, Selçuklu
42050 Konya
Turkey

with the functions according to appendix

Scope



Production of pistons and piston pins for internal combustion engines

without product design responsibility (according to section 7.3)

IATF Registration No. 0127313
Certificate Registration No. 44 111 111647

Valid from 2011-09-26
Valid until 2014-09-25

KGaas
Certification body
at TÜV NORD CERT GmbH

Essen, 2011-09-26

This certification was conducted in accordance with the TÜV NORD CERT auditing and certification procedures and is
subject to regular surveillance audits.

TÜV NORD CERT GmbH

Langemarckstrasse 20

45141 Essen

www.tuev-nord-cert.com

Page 1/2



02-IAO-QMC-01021

Packaging

Details about packaging are given below:

Be the first to reach the product thanks to our special seals.

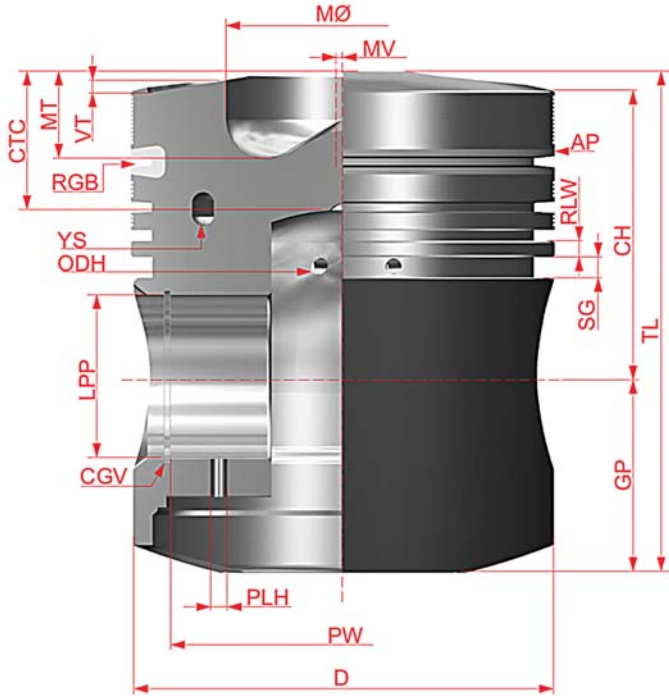


Box label placed on the boxes and used for identifying the products inside.



3D safety holograms integrated on the boxes to ensure product safety.





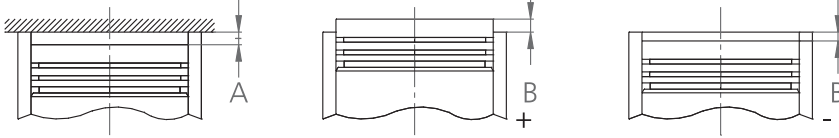
- D = Dimension (Cylinder dimension)
- CH = Compression Height + Excess - Combustion chamber depth
- TL = Total length
- GP = Skirt length
- MØ = Combustion chamber diameter
- MT = Combustion chamber depth
- CTC = Piston crown wall thickness
- RLW = Piston ring land height
- LPP = Pin bore diameter
- MV = Combustion chamber axial run-out
- RGB = Piston ring groove outside diameter
- CGV = Pin hole circlip groove
- PW = Pin length
- YS = Oil cooling gallery
- ODH = Oil return holes
- PLH = Pin lubricating holes
- VT = Valve depth
- SG = Piston ring groove width
- AP = Piston ring carrier (Alfin)

Technical Descriptions

Piston Distance Measurements

A - Measurement up to cylinder head

B - Measurement from block surface up to piston crown

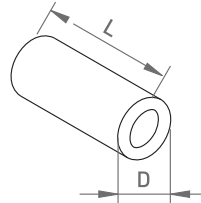


Piston Pin Measurements

L = Pin length (mm)

D = Pin outer diameter (mm)

PDB = Piston pin bore with bushing

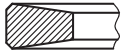


Piston Ring Types

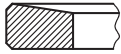
Compression Rings



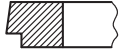
D = Rectangular ring



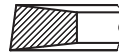
T = Keystone ring



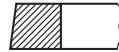
TT = Half keystone ring



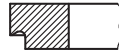
TN = Taper faced napler ring



TK = Taper faced keystone ring

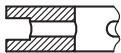


K = Taper faced ring



N = Naiper ring

Oil Rings



SC = Slotted oil control ring



DC = Bevelled edge oil control ring



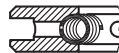
DB = Double bevelled oil control ring



ES = Slotted oil control ring with expanderspring



SY = Coil spring loaded slotted oil control ring



DY = Coil spring loaded bevelled edge oil control ring



PS = Coil spring loaded double bevelled oil control ring



VF = Multi-piece steel-rail oil control



UB = U-Flex ring (multi-piece)

Piston Ring Inner Edge Types



IF = Inner Edge Chamfer (Top Surface)



IFU = Inner Edge Chamfer (Bottom Surface)

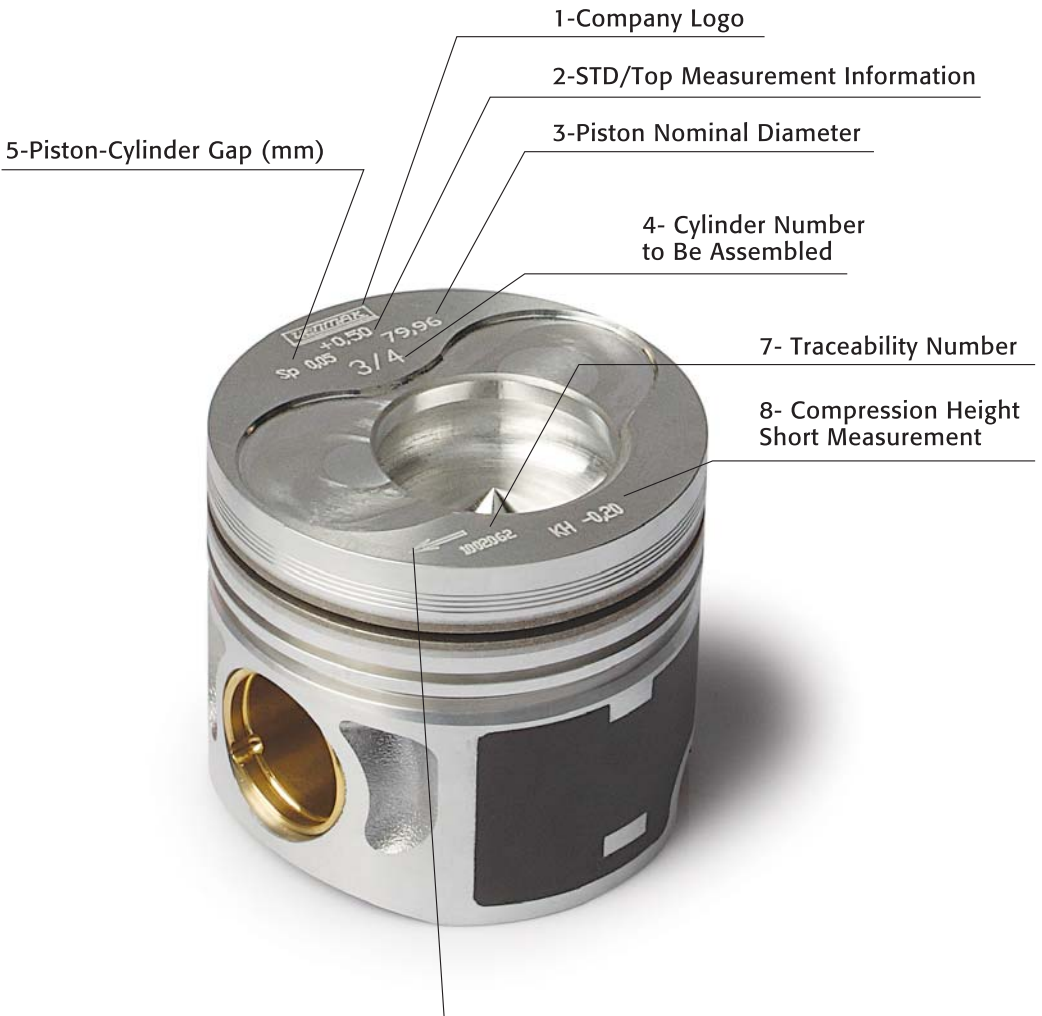


IW = Inner Edge Step (Top Surface)



IWU = Inner Edge Step (Bottom Surface)

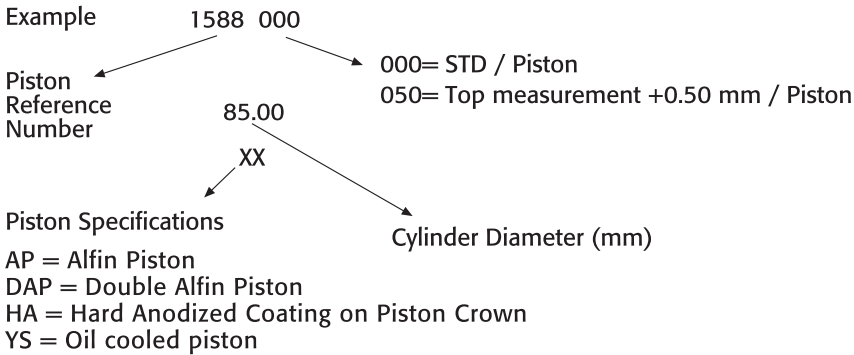
Markings on Piston Crown



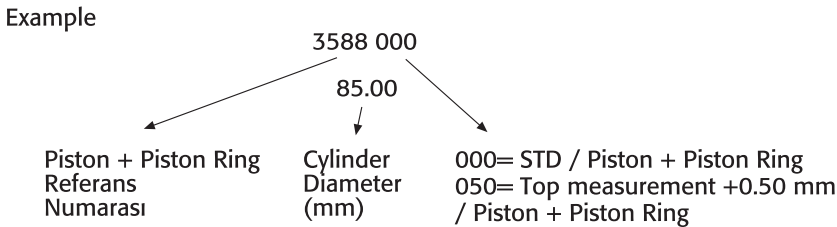
6- Piston Assembly Direction. Pin bore axial run-out might have markings indicating directions such as "front" "Abluft". The symbol "Volant" ensures accurate assembly of the piston to the engine.

Reference Number Descriptions

Piston Reference Number



Piston + Piston Ring Reference Number



Standard Liner Reference Descriptions

Standard Liner Reference Number, Example: 5840 000

Different Liner Reference Number, Example: 5840 050

The three numbers at the end of the liner reference number indicate the different outer diameter measurement of the liner or the difference in millimeters of the invoice length measurement in some wet liners of M.A.N. and Daimler Mercedes- Benz.

Liner Type Codes

FF = Wet and dry type liners with all the measurements completed

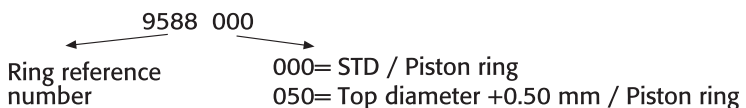
SF = Dry liners with inner measurements proportional, other measurements completed

Kit, Set Reference Descriptions

4-digits reference number used is the KIT numbers containing Liner, Piston, Piston Rings and Pin. Example; 7629

The codes K and S indicate that the products might be KIT or SET. If it is K, it means it is in a box in completely assembled form; if it is S, piston, piston rings and pin are in the same box, liner is in a separate box or in non-assembled form side by side.

Ring Reference Number



Cylinder Liner Assembly Instructions

Cylinder Liner Assembly Instructions

GENERAL

CLEANING

- You should work very carefully while removing the old liners in order not to cause any damage.
- You should clean lime, mud and other dirt away from the contacting surfaces of the cylinder in the engine block.
- You should prefer wire brush instead of scraper or chisel, which might cause scratches during cleaning.

TOLERANCE:

- All the operations must remain within the tolerance limits.
- Operations out of the tolerance may result in problems during the engine's operation.

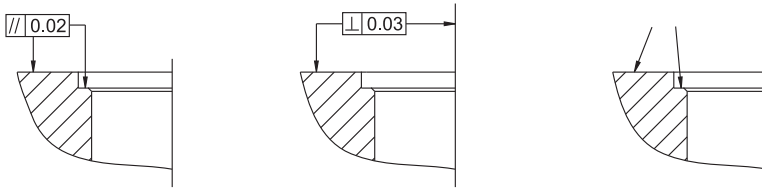
TORQUE:

- Torque wrenches must be calibrated.
- Torque wrenches must be reset at the end of each working day.

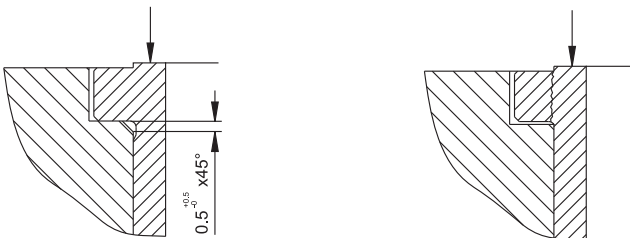
- 1) Cylinder head torque values,
- 2) Main bearing torque values,
- 3) Connecting rod torque values,
- 4) Crank counterweight torque values,
- 5) Flywheel torque values must be at the values recommended by the manufacturing company of the engine.

WET CYLINDER LINERS

- The surface, where the bottom surface of the liner flange contacts the block, and the block surface should be parallel. (Tolerance Max 20 μm)
- It should be checked whether the cylinder's axis is perpendicular to the seal surface of the cylinder block. (Tolerance Max 30 μm)
- Another important consideration is that the seat of the cylinder should not be damaged by crushing.



- In order to prevent the radius at the bottom surface of the liner flange from contacting the corner on the flange seat of the cylinder, there should be a chamfering of 0,5-1,0 mm. 45° at the point where it passes through the cylinder's diameter.
- In order to avoid the risk of breaking, the sealing force and the counterforce should be vertically opposite to each other.



Cylinder Liner Assembly Instructions

WET CYLINDER LINERS

IMPORTANT CONSIDERATIONS DURING ASSEMBLY

- It should be checked whether the block-contact diameters of the liner are within the tolerance according to the engine block diameters.
- Appropriateness of -O-rings and shims, if any, should be checked. O-rings to be used during assembly must be resistant to blistering, wearing, oil and heat. Otherwise, it might lead to water in crankcase, seizure of liner and corruption of dimensions.
- Bore diameter of the seals and outer diameter of the liner should be equal.
- In order to ensure a complete sealing in the combustion chamber, metal frame seals should be used.
- Bottom surface of the cylinder liner flange must be adjusted to the surface of the engine block.
- After the liners are fully placed, the block should be compressed by filling with water and sealing status must be checked.

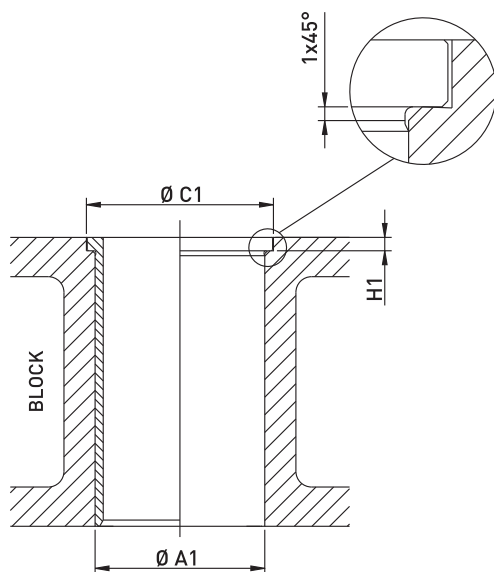
DRY CYLINDER LINERS

BLOCK CONTROL

If the block diameters (A) of the cylinders in the engine block are large or in oval or conic form bigger than 0.025 mm, these cylinders should again be processed in an upper stage or be subject to honing.

TOLERANCE TABLE FOR CYLINDER BLOCK BORES (mm)

	Block Bore Diameters (mm)
	50-180
$\varnothing A1$	± 0.01
H1	+0 -0.15
$\varnothing C1$	+0.25 +0.10



Cylinder Liner Assembly Instructions

DRY CLINDER LINERS

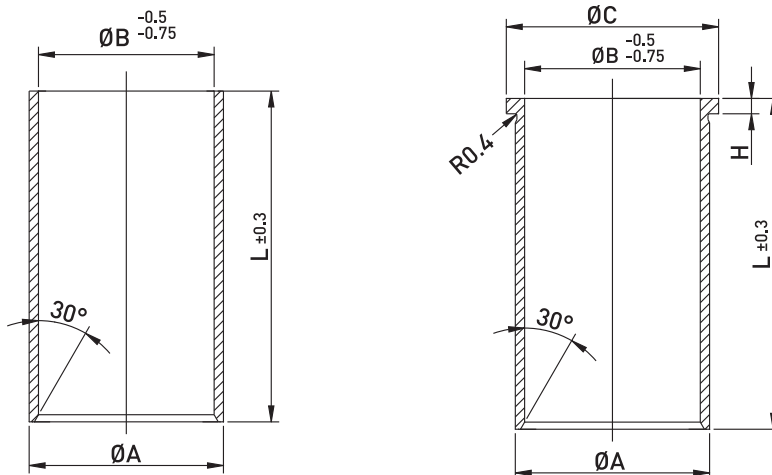
CYLINDER LINER CONTROL

Before the liners are pressed into the cylinder, their appropriateness with the nominal measurements indicated for the outer diameter (A) of the liner must be checked as stated in the table below. A force of 3,000 kg is adequate for pressing.

TOLERANCE TABLE FOR DRY CYLINDER LINERS

	Liner Outer Diameter Groups (mm)		
	50-80	80-120	120-180
$\varnothing A$	+0.070 +0.045	+0.04 +0.06	+0.05 +0.07
H1	+0.20 -0	+0.20 -0	+0.20 -0
$\varnothing C$	-0.06 -0.10	-0.07 -0.12	-0.08 -0.15

In these product assemblies, the engine block should be kept free for minimum 12 hours and the operation should be commenced after the material stress is eliminated.



Cylinder Liner Assembly Instructions



HONING

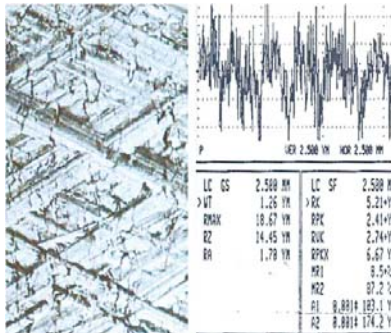
FIRST ROUGH HONING

80-120 sand honing stone is used.

While choosing the honing stone;

- 1) Cutting capability should be considered,
- 2) Honing marks should not be too deep.

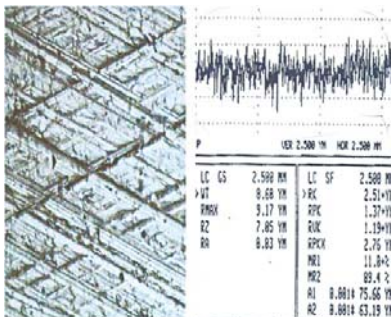
Otherwise, deep marks remaining from rough honing may not be eliminated during finish honing.



LAST (FINISH) HONING

180-220 sand honing stone is used.

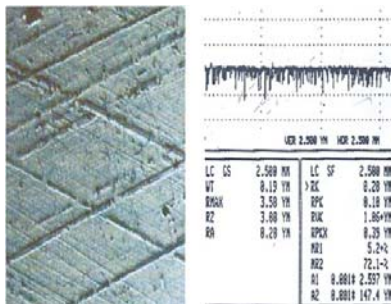
This operation is the one where oiling channels on the friction surface of ring-liner are opened.



PLATO HONING

400 to 600 sand honing stone is used.

Plato honing is the operation of simulating the engine's run-in period. That is, the elimination of liner roughness profiles performed by the ring is performed in advance on the honing counter.



Cylinder Liner Assembly Instructions

VALUES REQUIRED TO BE OBTAINED AFTER HONING

1-Honing Angle

The angle between the honing pattern lines should be 45 to 60 degrees.

2-Surface roughness

2.1 - In Diesel Vehicles

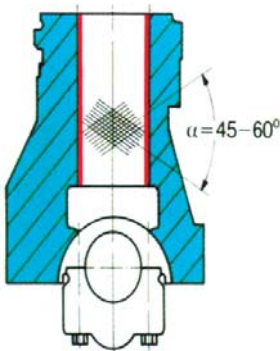
Rz 4.0 - 8.0 μm

Ra 0.4 - 0.8 μm

2.2 - In Gasoline Vehicles

Rz 3.0 - 6.0 μm

Ra 0.4 - 0.8 μm



OTHER IMPORTANT CONSIDERATIONS IN HONING OPERATION:

“Honing Oil” must be used as the cutting fluid on the honing counter.

There must be a filtration system on the honing counter in order to separate metal particles of μm size from the honing oil.

Because if the cut metal and spilling sand particles are not taken away from the cutting area;

- 1) Homogeneity in surface roughness of the liner is lost, that is an inappropriate surface is obtained.
- 2) Furthermore, cutting capability of the honing stone is lost.

Piston& Piston Ring Assembly Instructions

Piston & Piston Ring Assembly Instructions

Firstly, you should check the cleanness of the piston. Moreover, you should make sure that there is no dirt remaining in the piston ring grooves.

Secondly, the space between the ring and the piston ring groove should be checked via a feeler.

If the space between the new and parallel-surface piston ring and the piston ring groove is 0,12 mm or more, the pistons must have been damaged and need to be replaced.

If the space is between 0,05 - 0,10 mm, the piston might be used again.

If the space is = 0,11-0,12 mm, you should be careful.

If the space is $> 0,12$ mm, the ring should be replaced.



Control of Wearing in the Cylinder Liner;

If the wearing has reached 0,10 mm in gasoline engines and 0,15 mm in diesel engines, the cylinder liner should be replaced.

General Piston Ring Assembly Instructions

When a new piston ring shall be assembled to the piston, it is recommended to replace the piston rings as a complete set.

In order to ensure a proper operation, the piston rings should be assembled to the piston ring grooves in sequence starting from the bottom oil scraper ring. The piston rings should not be bent to right or left towards axial direction. The piston rings should pass over the piston without being expanded via piston ring pliers more than necessary. If they are expanded too much, the piston rings would either break or be subject to permanent deformation. The piston rings that have been subject to deformation cannot fulfill their function properly.

The piston rings, which have the markings **YEN or TOP** on one side, should be assembled to their housing in a manner that these sides face the combustion chamber. **The piston rings, which do not have any marking on them, can be assembled in any direction.**



For assembly of coil spring oil ring, you should first assembly the coil spring to the piston ring groove and connect the ends of the springs. After that, you should open the cast iron piston ring and place onto the spring inside the groove. While doing this, you should make sure that the connection point of the spring ends is placed right opposite of the piston ring outlet, that is the back part of the ring.

Piston ring coating and surface films

Cr = Chrome Coating

Mo = Molybdenum Coating

P = Phosphate Coating

Fe = Ferroxide Coating

Cu = Copper Coating

N = Nitrite Coating

Sn = Tin Coating

Piston & Piston Ring Assembly Instructions

1- There should be rhombic honing lines on the inner surface of the cylinder, where the piston shall be assembled. If a piston ready for assembly is used and/or if it is assembled to a worn cylinder, the inner surface of the cylinder should be checked for appropriateness of the honing lines. If the honing lines on the inner surface of the cylinder are partially or completely lost and a bright surface has come into existence, the inner surface of the cylinder should be subject to honing in a manner to have those honing lines again.



2- All the pistons are manufactured carefully in order to create a proper piston-ring operation gap when they are assembled inside a cylinder of proper dimensions. Inner diameters of the cylinders should be checked in order to find out their appropriateness with the dimensions indicated on the box labels and to determine whether they require reprocessing or not. When inner diameters of worn cylinders should be entered in the top measurement, it is recommended to use the tolerance 0,000-0,020 mm for the top measurement nominal diameter.



3-The piston pin should be removed from the pistons ready for assembly with appropriate methods in order not to cause damage in the piston and the pin. The piston pins have been assembled in a manner to ensure dimensional appropriateness with the respective pistons, they should not be replaced randomly.



4-You should use an appropriate ring compressor or conic assembly sleeve in order not to cause damage in the piston rings and piston while assembling the rings to the piston.

After tightening the piston rings properly, you should abstain from assembling the piston into the cylinder by using excessive force or by hitting on it and you should assemble it carefully with your hands.

Piston & Piston Ring Assembly Instructions



5- After the piston rings are assembled to the piston, you should make sure that they move freely in the piston ring grooves.

For 3-ring pistons, the piston ring gaps should be in a manner to create 120° with each other.

For 4-ring pistons, the piston ring gaps should be in a manner to create 90° with each other.

6- Prior to assembly of the piston to the cylinder, the piston should be carefully cleaned and especially the pin bore of the piston should be cleaned and lubricated. Prior to assembly, inner parts of the cylinder should be properly lubricated in order not to cause damage in piston and cylinder till lubricating occurs in the initial operation.

7- If there is a marking on the top of the piston indicating the direction of assembly, this marking should be taken into consideration during the assembly to ensure a proper assembly.

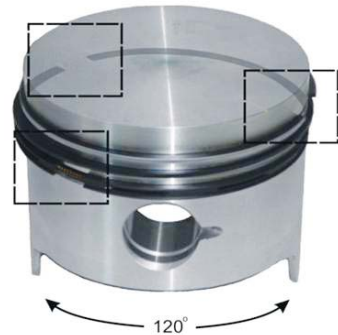
8- You should be very careful in order not to cause damage in the piston, the piston pin and the piston ring.

9- The pistons are manufactured as appropriate for other parts to be used together with them in accordance with the generally accepted norms. Therefore, you should not make any operation on them.

10- Pins and snap rings should not be used again, you should always use new pins and snap rings.

11- Control of linearity of the connecting rod to be used in the assembly is important to avoid very serious problems to occur. Linearity of the connecting rod should be checked again with appropriate devices prior to the assembly.

NOTE: You should comply with these assembly instructions. The manufacturer cannot be held responsible for problems to arise from assemblies not complying with these instructions.



Failure

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Piston & Piston Ring Failures

1.1. Seizure of Pistons in the Engine



1.1.1 Seizure on the Piston Skirt Description of the Failure

As the image of the pistons removed from the engine is seen in Figure 1, there are marks of seizure with specific intervals only at the skirt area.

Such failures usually occur in a short time following the engine overhauling operation.



Figure 1

Causes of the Failure

There are two causes for the piston to fail in a manner similar to the image in figure 1. These are;

1-Seizure due to lack of space resulting from excessive heating

The space between the Piston and the Liner is reduced due to a failure and problem in the cooling system of the engine. Since the aluminum piston expands 2 times more than the iron cast, seizure failure shall occur in excessive forces and heats.

Factors causing failure in the cooling system are;

- a-The water pump is faulty.
- b-The belt is broken off or the belt is loose.
- c-The thermostat is faulty,
- ç-The coolant water level is very low.
- d-The air discharge is faulty.
- e-The air in the engine coolant water is not taken adequately.

2-Seizure due to lack of space resulting from Manufacture and Assembly defect

The amount of space between the piston and the liner is reduced as the inner diameter of the cylinder is not processed properly.

3- Faulty engine overhauling operation

The engine cover is assembled defectively. The bolts of the engine cover are tightened more than the torque values recommended by the engine's manufacturer and the shape of the engine block is changed. In such failures, seizure occurs in the piston in the first housing of the engine.

1.1. Seizure of Pistons in the Engine

Recommendations

1-Measurement of the piston and the cylinder should be checked for accuracy. The piston diameter and piston space measurements and cylinder diameter measurements stated on the piston crown should be adjusted.

2- Checks with regard to the cooling system should be performed.

- Thermostat

- Coolant water level

- Circulation pump

- Fan belt should be checked. (Worn, defective belt should be replaced.) Tension of the fan belt should be in a manner to stretch for 1-1,5 cm. If it is more loose, the engine overheats.

- Air discharge must be performed and the air discharge system should be checked.

- Radiator cap and radiator cores should be checked.

3- You should take the air in the coolant water inside the cooling system.

4- Bolt torque values of the engine's top cover should be adjusted with the torque wrench at the values described by the engine's manufacturer.

1.1. Seizure of Pistons in the Engine



1.1.2 Seizure next to the Piston Pin Bores (45° Seizure Marks)

Description of the Failure

- In such a failure, as seen in Figure 1, the pistons are subject to seizure at 45° of the piston in areas closer to the piston pin bore at the piston skirt.
- There is usually no mark of seizure on contact surfaces of the piston skirt, marks of normal operation are seen on these surfaces.
- The piston pin is not free, it is compressed in the removed connecting rods.
- Marks of seizure can be seen when the piston pin bores are examined.



Figure 1

Causes of the Failure

- As the piston pin and the oil film around it is deteriorated and torn, these areas get overheated, unlubricated, dry operation occurs and causes marks of seizure. The causes of unlubricated operation at these areas and heating as a result of tear oil film are;
- 1 - Connecting rod is assembled defectively in pistons with shrink-fit connecting rods. After the shrink-fit connecting rod is assembled, moving the connecting rod before it is cooled down causes initial seizure and marks of seizure in the pin bore, expansion of unlubricated operation in this area and more important engine failures .
 - 2 - If the piston pin bores and the piston are not lubricated adequately during the engine overhauling operation, marks of seizure due to unlubricated dry operation occur during the initial operation fo the vehicle and the marks of seizure in this area proceed and result in engine failure.

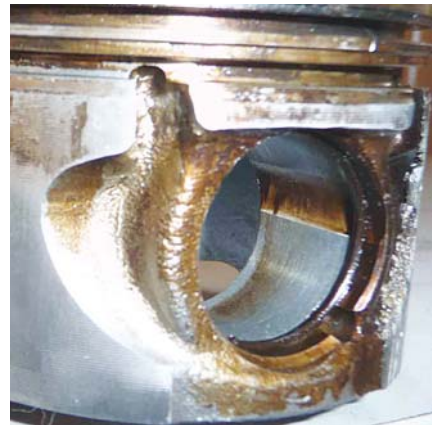


Figure 2

1.1. Seizure of Pistons in the Engine

3 - Lubrication of the pistons and the cylinder inside the engine is performed by the oil splashed as a result of the connecting rods hitting the oil inside the engine's crankcase. Operating the engine at idle for a long time to heat it up causes decrease in the engine lubrication and dry operation of the piston in the pin bore, accordingly seizure failures inside and around the pin bore.

Defective Lubrication

Normal Lubrication

4 - A sudden loading on a recently-started engine, applying too much force right after starting causes expansion of the piston upon faster heating than the engine liner and as a result, seizure failure around the piston pin bore.

Recommendations

1 - During restoration of the engines, where the connecting rod is assembled as shrink-fit, after the piston and the piston pin are assembled to the heated connecting rod, the connecting rod should not be moved. After the piston, the piston pin and the connecting rod have cooled down, they should be lubricated and it should be checked whether the piston pin moves freely in the piston pin bores.

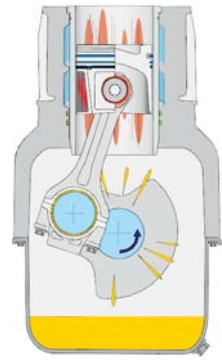
2 - Oil should be pressurized into the engine and oil should reach every area where oil circulates. The engine's oil pressure should be measured.

3 - The engine should not be operated at idle for a long time. No excessive force should be applied right after the engine start.

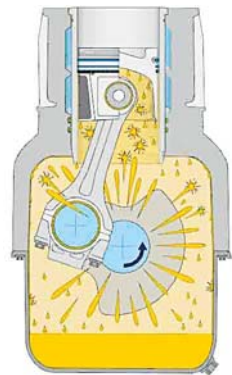
4 - The engine brake should not be used too often.

5 - After the engine overhauling operation, instead of idle operation, the vehicle should be driven at medium speed without many stop-and-goes in the traffic.

6- Oil pump should be checked. Faulty oil pump should be replaced.



Improper lubrication



Normal lubrication

1.1. Seizure of Pistons in the Engine



1.1.3 Piston Skirt Seizure on Only One Side

Description of the Failure

- Whereas there are marks of seizure on one side of the piston contact surfaces, there are marks of normal operation on the counter pressure direction. (Figure 1)
- There is no mark of seizure in piston ring areas. Marks of operation at the piston crown are normal.
- There are marks of burnt on the piston rings, although they are not evident.



Surface 1 Surface 2
Piston skirt seizure on only one side

Image 1

Causes of the Failure

The oil film on one side of the piston is lost and seizure occurs. This seizure especially occurs on the pressure dimension of the piston first. The reason is that the force applied on the pressure direction is higher than the counter pressure direction. The causes of corruption in the oil film on the pressure direction of the piston and unlubricated dry operation are as follows;

- 1 - Leakage of coolant water in the cooling system of the engine and emergence of air bubbles or inadequate level of coolant water circulation inside the engine block due to lime, dirt etc. causes local increase in heat, elimination of oil film, unlubricated dry operation and accordingly, seizure.
- 2 - Low oil level inside the engine and a short-term blockage in the bore of the oil-cooling spray, faulty assembly or failure of it results in engine failure.
- 3 - Faulty assembly of the shroud ensuring direction of the air onto the engine in air-cooled engines causes increase in engine heat and overheating of the engine.
- 4 - The oil used in the engine is not of a nature and quality to bear the engine loads. Dilution of the engine oil causes elimination of the oil film on the engine parts. Unlubricated dry operation occurs between the piston and the cylinder surfaces and piston seizure failure occurs.

1.1. Seizure of Pistons in the Engine

Recommendations

- 1 - During the engine overhauling operation, the cooling system should be checked, the cooling channels of the block should be cleaned and the parts to cause leakage of the coolant water should be replaced.
- 2 - Oils recommended by the engine's manufacturer should be used inside the engine.
- 3 - It should be checked whether the oil bores in the connecting rod should be open and operating.
- 4 - The oil level inside the engine should continuously be checked and oil should be added whenever required.
- 5 - The oil pressure should be checked. The causes of low oil pressure are worn oil pump, high amount of dirt inside the oil filter, faulty high pressure valve and corrupted viscosity of the oil. These parts should be checked and replaced.
- 6 - Engine oil should be replaced without any delay in accordance with the oil replacement intervals.
- 7 - Fuel and ignition system should be checked for fuel spillage, which might cause dilution in the engine oil.

1.1. Seizure of Pistons in the Engine



1.1.4 Seizure on the Piston Top Ring Groove Land

Description of the Failure

- The marks of wearing and seizure on the piston are mainly on the top of the piston top ring and at the piston rings lands. It is observed in failures, where the marks of seizure at the piston skirt have proceeded, the marks of seizure at the skirt are usually small. (Figure 1)

- There is too much soot accumulation on the piston head. (Figure 2)



Figure 1

Causes of the Failure

There is a problem in the injection fuel spray. The fuel is not sprayed from the injection nozzle equally into the fuel combustion chamber. Therefore, the fuel reduces the oil film on the cylinder surface. Unlubricated dry operation occurs at the piston crown upon reduction of the oil film. Overheating and unlubricated dry operation at the piston top ring land causes seizures at this area. Causes of this failure are;



Figure 2

- 1- Leaking injection nozzle;
- 2- Stuck nozzle needle due to damaged or worn injection nozzle;
- 3 - Faulty injection time;
- 4- Faulty injection system
- 5- Utilization of poor quality fuel. (Fuel with inappropriate sulfur value and mixture of faulty additives with the fuel causes failure in injection nozzles and ignition system.)

Recommendations

- 1 - The injection nozzles should be checked during the engine overhauling operation. The injection nozzles should be kept under 20 bars of pressure for 10 to 15 seconds with a clean cloth on them. At the end of this period, the cloth surface should be slightly wet.
- 2 - The injection nozzles, which are determined to be damaged, should be replaced.
- 3 - The injection bolts should be tightened to the torque value recommended by the engine's manufacturer.
- 4 - The injection and the ignition systems should be checked.
- 5 - It should be checked whether the injection timing is correct or not.

1.1. Seizure of Pistons in the Engine

1.1.5 Seizure at the Lower End of the Piston Skirt

Description of the Failure

- There are marks of seizure in a particular area at the bottom of the piston skirt. (Figure 1)
- The marks of seizure are in matt form.

Causes of the Failure

These marks that occur at the piston skirt occur due to lack of space in this area. The causes of this lack of space are as follows;

- Width of O-ring seals in the channel housing is wrong. The channel is not cleaned well.
- Piston ring grooves in wet liners are not cleaned.
- Assembly is made without lubricating during assembly of O-Ring seals.
- Cylinder head bolts are screwed to an inaccurate torque value.
- Cylinder measurement is processed inaccurately at the cylinder end and the diameter is reduced.

Recommendations

- 1 - You should be careful about choosing the O-Ring and use an O-Ring of correct thickness.
- 2 - You should apply some grease onto the O-Ring seals during assembly and avoid torsion and distortion.
- 3 - In order to avoid lack of space, you should first assemble the wet cylinder liners without seal. In this way, any lack of space can be determined in advance. After that, the cylinder liner can be assembled completely with the seals.
- 4 -After the honing, you should measure the cylinder bores at several levels and directions.



Figure 1

1.1. Seizure of Pistons in the Engine



1.1. Seizure of Pistons in the Engine

1.1.6 Asymmetrical Wear Pattern on the Piston Skirt

Description of the Failure

- There are marks of asymmetrical operation at the contact surface of the piston skirt. (Figure 1)
- There are accumulations of soot on the piston crown and in the piston ring grooves.

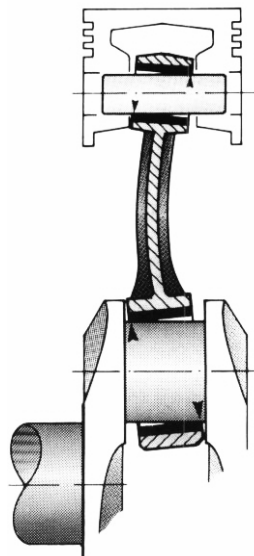
Causes of the Failure

The cause of the failure is that the piston is in inclined position inside the cylinder. Whereas one side of the piston operates facing the liner, the other side operates without facing it. The pressure, which occurs as a result of ignition, leaks from the area, which does not contact the cylinder surface, towards the crankcase. The piston rings cannot hold this pressure as the pistons are inclined, and they cause pumping of oil into the combustion chamber. The causes of the pistons operating in inclined position inside the cylinder are;

- The piston rod is bended or buckled.
- Bushing groove of the piston rod is turned on an inclined axis.
- Inaccurate assembly order and inaccurate tightening values are applied.
- Space of the rod groove in the piston rod is more than necessary.
- There is dirt on the air-cooled cylinder base. Therefore, the cylinder is inclined on the engine block. Therefore, the pistons operate in inclined position inside the cylinder.



Figure 1



1.1. Seizure of Pistons in the Engine

Recommendations

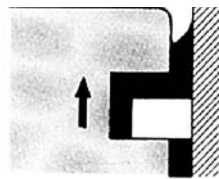
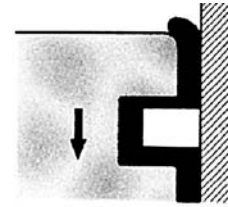
- 1 - The crankshaft and the connecting rod should be machined coaxially during overhauling of the engine and the assembly should be made coaxially.
- 2 -Cylinder head studs should be tightened at the value and in the sequence recommended by the manufacturer.
- 3 -Rod bearing spaces should be checked. Bearings with inaccurate space measurements should not be used.
- 4 -A special importance should be placed on cleaning during assembly of the engine and the seal remainders should be carefully cleaned.
- 5 -Inclination of the connecting rod should be checked during engine overhauling and the inclined connecting rod should be replaced with a new one.

1.2. Excessive Oil Consumption in the Engine

General Information about Oil Consumption

In internal combustion engines, the oil put into the oil sump is transferred by a pump to the crankcase and piston conrod bearings, camshaft and system, turbo bushing bearings and compressor, if any. After the engine oil fulfills its function in the areas where it is pumped to, it returns to the engine crankcase. The amount of oil burnt in the combustion chamber of the engine varies depending on the engine power and engine temperature. Oil consumption in an engine operating under normal conditions is minimum 0.2 and maximum 1.5 gram/kilowatt hours. There are several causes of excessive oil consumption.

Defective fuel burning, defective fuel mixture, corrosive dirt in the engine, failures in the cooling system, corruption in lubricating in the engine, utilization of inappropriate oil in the engine are the main causes to increase oil consumption. These failures result in wearing and failures of piston, piston ring and liner.



Piston ring pumping effect

Causes of Excessive Oil Consumption

- There are bearing clearances in the turbo-charging system. Oil is transferred from the turbo-charging system to the combustion chamber.
- Oil recycling pipe in the turbo-charge is blocked or melted due to high temperature. Oil goes to inlet manifold and exhaust and increases oil consumption.
- Due to a worn injection pump, oil goes into the combustion chamber together with the fuel. If the injection pump is lubricated by the lubrication system, the worn pump may increase the oil consumption.
- Dirt and dust going inside the engine through the air inlet filter of the engine increase the wearing on surfaces of the piston ring and the liner. Oil consumption increases due to corrosive impact of excessive soot and dirt.
- If oil replacement is not performed on time, it causes blockage and explosion of the oil filter. Unfiltered engine oil gets into the lubrication system.

1.2. Excessive Oil Consumption in the Engine

Causes of Excessive Oil Consumption

- Inclinations and distortions occurring in the connecting rods cause the pistons and the rings to operate in inclined position and as a result, oil to get into the combustion chamber.
- The piston rings are assembled inaccurately to the piston ring grooves. If oil scraping is not adequate, oil gets into the combustion chamber.
- Studs are assembled inaccurately. Oil leakages occur.
- The blow caused by worn piston ring, piston ring grooves and liners increases the pressure in the engine's crankcase and results in oil leakages.
- Due to high oil level or poor quality oil, the lubricating oil goes into the inlet manifold through the crankcase ventilation and from there, into the combustion chamber.
- Fuel spillage causes piston ring and liner surfaces to wear away and as a result, the oil to get into the engine's combustion chamber.
- The oil quality is poor and the oil viscosity is not at the values specified by the engine's manufacturer. It increases wearing and oil consumption.
- Poor quality honing on the liner surface reduces the oil retaining capability and amount of the surfaces. Piston, piston ring and liner surfaces wear away faster. And oil consumption increases due to the high pressure occurring in the crankcase due to worn parts and leakage of the fuel into the combustion chamber.
- There are spaces in the engine valve keepers and their guides as a result of wearing. Oil gets into the combustion chamber from these areas and the oil consumption increases.
- Utilization of inappropriate valve seal and inaccurate assembly of the seal to the valve guide can increase the oil consumption.
- The cylinder head is assembled inaccurately.
- The oil pump should be checked. Low oil pressure causes piston, piston ring and cylinder surfaces to wear away and the oil consumption to increase.

1.2. Excessive Oil Consumption in the Engine



Recommendations

- The engine parts should be cleaned carefully during the engine overhauling operation.
- During the engine overhauling operation, all the engine parts, where the oil circulates, should be cleaned. There are corrosive dirt in the oil that remains inside the engine. The oil inside the engine should be completely discharged. Otherwise, when the oil starts to circulate inside the engine, all these corrosive dirt can reach the engine's crankcase. It may cause the engine parts to wear away and the oil consumption to increase.

- An oil at the quality specified by the engine's manufacturer should be used.

In accordance with the communiqué published by EPDK, fuels containing 7000 ppm sulfur shall be taken out of the market as of 1 July 2008 and diesel fuel at the TSE EN590 standard, which contains max. 50 ppm sulfur, shall be offered instead.

Up to the present, 10W/30 engine oil (WSS-M2C921-A), which was resistant to low fuel quality, had been used in diesel engines. After the year 2008, due to the standard imposed with regard to the fuel quality, utilization of 5W/30 oil shall provide the following benefits;

- a- Inner resistances of the engine shall be reduced. Accordingly;
- b- The abrasive (corrosive) effect on the moving engine parts shall be reduced.
- c- Fuel economy shall be ensured. (2%-3%)
- d- Cold operation performance shall be improved.
- e- Lifecycle of accumulator/starter motor/flywheel ring gear shall be extended.
- Turbo-charge bearings shall be lubricated better and the lifecycle of turbo-charge shall be extended.
- Assembly of the pistons and the piston rings should be made in accordance with the instructions of the manufacturer.
- After the engine overhauling operation, the first oil replacement should be performed as early as possible.
- A detailed examination should be made with regard to the excessive oil consumption in the engine and the actual source of the problem should be determined.
- It should be considered that the pistons and the piston rings cannot fulfill their functions due to the failures causing the pistons and the piston rings to wear away.
- While performing the engine's oil replacement, "Engine lubrication system cleaning equipment" should be used. Thanks to these cleaning equipment,
- The lubrication system shall be cleaned better (even after the oil replacement, approximately 500 cc dirty oil remains inside the engine)
- Recurring repairs due to turbo-charger problems shall be avoided to a great extent.
- Possible engine failures shall be avoided.

1.3. Piston Ring Failures in the Engine

(Breaking of the Piston Ring, Wearing of the Piston Ring, The Piston Ring Land Fracture etc.)

1.3.1 The Piston Ring Land Fracture

Description of the Failure

It can clearly be observed that the piston ring lands between the first and the second compression rings and the second and the third compression rings in the piston are broken. (Figure 1)

This fracture starts from the top inner edge of the land and advances towards inside of the piston material. While advancing towards the bottom edge of the broken piston ring land, it changes its direction towards outside and goes out right through the bottom edge of the bottom of the piston ring land. Bottom part of the broken piston ring lands is longer than the top part.



Figure 1

Causes of the Failure

There are 2 causes of the piston ring land to break. These are;

1- Fracture Due to Knocking Combustion

Knocking combustion occurs due to self-combustion of the fuel inside the combustion chamber. Due to this faulty combustion, the pressure inside the engine exceeds the normal values and excessive loads are applied onto the piston.

The causes of knocking combustion in gasoline engines are;

- The ignition stroke is faulty.
- Air and fuel mixture is of very poor quality.
- A fuel with low octane number is used.
- Air inlet temperature is very high.
- Engine compression ratio is adjusted inaccurately, the compression ratio is high.

The causes of knocking combustion in diesel engines are,

- The compression ratio in the engine is very low. Defective head nose and seal is used.
- The injection nozzles are defective and cause leakage.

1.3. Piston Ring Failures in the Engine



Causes of the Failure

- The fuel pumped by the injection nozzle into the combustion chamber is too much. (It would especially affect the occurrence of the failure in winter.)
- A piston with defective combustion chamber volume is used.
- The knocking sensor is defective or faulty.

2- Hydraulic Lockout

As a result of entrance of fluid into the engine's combustion chamber, uncompressed fluid causes overload on the piston, the piston pin and the connecting rod. These overloads cause bends, fractures and ruptures in the engine parts, which might result in huge damages. The causes of hydraulic lockout in the engine are;

- Entrance of water into the fuel combustion chamber (Suction of the water by inlet manifold while passing over the water accumulation and entrance of the water into the combustion chamber).
- Entrance of water into the engine's combustion chamber due to melting and burning as a result of excessive temperature in the cylinder head gaskets
- Fuel dripping from the injection nozzle of the engine accumulates inside the combustion chamber and when the vehicle is started, the failure occurs.

Recommendations

- A fuel with the octane number specified by the engine's manufacturer should be used.
- The injection system and the ratio of air and fuel mixture should be adjusted properly.
- The spark plugs recommended by the engine's manufacturer should be used.
- The piston head nose should be adjusted properly during restoration. Low compression pressure may cause a problem.
- Loading pressure should be adjusted properly in turbo vehicles.
- Fuel dripping from the injection nozzle of the engine accumulates inside the combustion chamber and when the vehicle is started, the failure occurs. The injection nozzles should be checked and faulty or defective injection nozzles should be replaced.
- Accurate, defect-free gaskets should be used during the engine overhauling operation. Defective, faulty gaskets should be replaced and should not be used.
- Necessary checks should be performed during the engine overhauling operation.
- While the vehicle passes over a water accumulation at high speed, it is possible that the inlet system sucks the water and transfers it into the combustion chamber. Therefore, the driver should reduce his/her speed while passing over water accumulations.
- During the engine overhauling operation, you should be careful while assembling the piston and the piston rings into the cylinder and prevent the piston ring grooves from getting damaged.

1.3. Piston Ring Failures in the Engine

1.3.2 Overwear on Piston Ring Groove Surfaces and Piston Ring Surfaces

(Wearing on Surfaces Due to Dust and Dirt)

Description of the Failure

When images of damage of the piston rings are examined, it is observed that there is a matte gloss (Figure 1, Figure 2) on the surfaces of the rings.

It is observed that a big portion of the top ring coating is lost due to wearing (Figure 3).

Furthermore, in the close image of the compressor ring, breakages and damages (Figure 4) of the ring corners are observed.

A matte wearing is observed that contact point of the piston skirt with the liner surface. Moreover, piston ring channels wear away and the channel width expands.



Figure 1



Figure 2

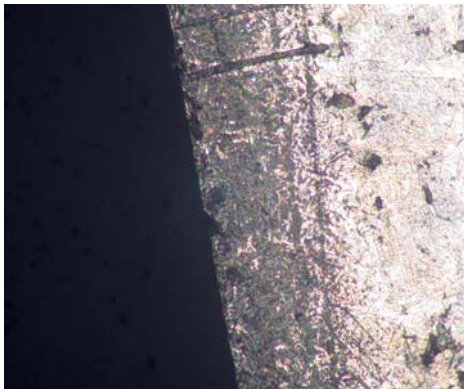


Figure 4

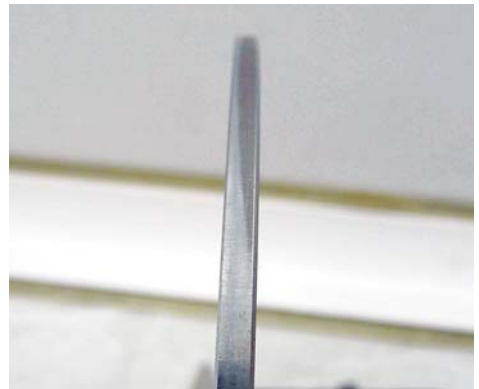


Figure 3

1.3. Piston Ring Failures in the Engine



Causes of the Failure

This is a failure caused by dust and dirt inside the engine and the remainders inside the engine after the engine overhauling operation.

If there is wearing in only one housing inside the engine and if the 1st ring wears away clearly more than the 3rd ring, this means the abrasive particles have got into the combustion chamber, where the failure occurs. It is understood that the failure arises from the dirt that is not cleaned before the assembly.

If there is damage in more than one housing and if the 1st ring wears away clearly more than the 3rd ring, this means the abrasive particles have got into the combustion chamber via the inlet system. The failure occurs due to faulty or defective air filter that cannot fulfill its function properly.

If the 3rd ring wears away clearly more than the 1st ring in all the housings of the engine, this is caused by dirty engine oil. Dust, dirt and particles inside the engine oil are smeared on all the contact surfaces together with the engine oil and cause abrasive effect.

The piston ring and the liner surfaces wear away due to the vibration caused by knocking of the valves to the piston crown and knocking operation of the engine.

Recommendations

- The air filter should be checked and replaced.
- You should pay attention to cleaning during the engine overhauling operation. The engine crankcase and the inlet system should be cleaned.

In order to clean the engine lubrication system during replacement of the engine oil, the Engine Lubrication System Cleaning Equipment should be used. When this equipment is used prior to the oil replacement during periodical maintenance:

- 1- The engine lubrication system shall be cleaned better (even after the oil replacement, approximately 500 cc dirty oil remains inside the engine).
 - 2- Recurring repairs due to turbo-charger problems shall be avoided to a great extent.
 - 3- Possible engine failures shall be avoided.
- You should not be late for the engine oil replacement after the engine overhauling operation. Oil replacement should be performed prior to its scheduled date.

1.3. Piston Ring Failures in the Engine

1.3.3 Piston Ring Fracture Failure

Description of the Failure

There is melting at the piston top ring area.

(Figure 1) . The material in this area melts and flows over.

There are marks of pieces on the piston crown, as seen in Figure 2, and these are the marks of the broken ring. The pieces of the broken ring stick into and remain in the piston crown material.

Causes of the Failure

The failure occurs due to one of the piston rings breaking inside the engine. The causes of broken piston rings are;

1 - Knocking Combustion

The piston rings that cannot bear the excessive compression pressure caused by knocking operation of the engine are broken.

2 - Defective Piston and Piston Ring Assembly

The equipment used during assembly of the rings is not tightened properly and the piston ring is damaged while pushing the piston ring into the cylinder.

3 - Excessive Radial Wearing

Abrasive parts and dirt getting into the engine cause the piston ring groove and the piston ring to wear away. Due to the excessive space between the piston ring groove and the piston ring, the piston ring is broken under overload. The oil consumption inside the engine increases before the failure occurs.

Recommendations

- The air filter should be checked and replaced.
- Piston ring compressor must be used during the engine overhauling operation.
- If the space between the piston ring and the piston groove during overhauling exceeds 0.10 mm in gasoline vehicles and 0.12 mm in diesel vehicles, the pistons must be replaced.



Figure 1



Figure 2

1.4. Fuel and Ignition System Failures in the Engine



1.4.1 Melting on the Piston Ring Lands and the Piston Crown for Gasoline Engines

Description of the Failure

Melting and pitting is observed at the piston crown. (Figure 1)

The piston crown is melted and pitted to the inner core of the piston. (Figure 1)

The piston crown melts towards the pin bore. (Figure 2)

Causes of the Failure

In gasoline engines, hot points and surfaces occur due to advanced ignition, which is caused by any source of ignition before the spark plug and which results in a huge loss of efficiency. The causes of this are;

- The spark plug causes the carbon fuel accumulating on the piston crown and the engine cylinder head to burn itself.
- The cause is the inaccurate air and fuel mixture in carburetor engines.
- Due to inaccurate adjustment of the engine valves, some valves remain hot due to hot gases they continuously leak. And these hot valves cause advanced ignition of the air and fuel mixture inside the engine.
- Utilization of a fuel with an octane number different than the required one causes the failure.



Figure 1



Figure 2

1.4. Fuel and Ignition System Failures in the Engine

Causes of the Failure

- Entrance of the lubricating oil into the combustion chamber due to worn rings and valve guides causes the failure.
- Presence of diesel fuel in the petrol used for the vehicle causes the failure.
- Excessive heat inside the engine, in general, causes the failure. The cooling system and the ignition system causing the engine to operate at high temperatures can cause the failure.
- Low temperature of the spark plug causes ignition inside the engine out of the ignition timing for the engine.



Image of failure spark plug

Recommendations

- The injection system, the carburetor and the ignition should be adjusted properly.
- A fuel with the octane number specified by the engine's manufacturer should be chosen.
- Piston ring compressor must be used during the engine overhauling operation.
- The spark plugs recommended by the engine's manufacturer should be used.
- Defective valves should be replaced. Especially the exhaust valves should be checked.
- The cooling system and the ignition system should be checked.

1.4. Fuel and Ignition System Failures in the Engine

1.4.2 Melting on the Piston Ring Lands and the Piston Crown for Diesel Engines

Description of the Failure

The piston material melts from the piston crown. Aluminum surfaces, except for the piston top ring material, melt and flow over.

Melted piston material progresses towards the pin bore area and melts the areas out of the piston top ring. There is no mark of wearing and seizure at the piston skirt. (Figure 1 , Figure 2)

Causes of the Failure

In direct-injection diesel engines, if the injection nozzle does not spray the fuel properly, unburned fuel remains inside the combustion chamber after the combustion time. Burning of the unburned fuel inside the combustion chamber continues during the exhaust time. The piston crown gets softer due to continuous burning and melts. The causes of this are;

- The injection nozzle needle is stuck in the groove.
- The injection nozzle needle does not cut off the fuel completely and continues to drip it.
- The injection adjustment is faulty or defective.
- The valve adjustments are defective and the valves cause leakage.
- The injection nozzle needle is blocked due to excessive carbon. It should be checked.



Figure 1



Figure 2

1.4. Fuel and Ignition System Failures in the Engine

Recommendations

- Faulty and defective injection nozzles should be replaced. (Stuck nozzle needle, leaking/dripping nozzle needle, blocked nozzle needle due to soot/carbon, injection nozzle with weak pressure etc.)
- The injection nozzle adjustment should be performed accurately in accordance with the values specified by the manufacturer. The injection pressure and the spraying pattern should be checked.
- An injection nozzle appropriate for the combustion chamber of the piston should be chosen.
- The valve adjustments should be performed in accordance with the values recommended by the manufacturer. The valves should be checked for proper operation. Defective and faulty valves should be replaced.
- Nozzle jets should be checked and adjusted properly in the engines, which have oil cooling nozzle jet.
- In engines, engine cylinder heads of which are grinded during the engine overhauling operation, the piston head nose should be at the values specified by the manufacturer in the catalogues.
- Fuels recommended by the engine's manufacturer should be used inside the engine. Rural diesel fuel should not be used.
- If bio-fuels are used, the oil replacement intervals should be kept very short.

NOTE:

In order to check the injection nozzle for dripping, you should clean the needle with a piece of cloth. You should apply a pressure less than 20 bars onto the injection nozzle. No dripping or wetting should occur in the needle within 10 seconds.

1.5.1 Piston and Piston Pin Fracturing and Piston Disintegration (Hydraulic Lockout)

Description of the Failure

In such failures, many parts inside the engine are subject to a huge damage;

The piston is disintegrated or the skirt is broken. (Figure 2)

The connecting rod is distorted and its structure is corrupted. (Figure 1)

There is excessive force and breaking in the piston ring grooves. (Figure 4)

In some cases, the piston pin is broken. (Figure 3)



Figure 1



Figure 2

Causes of the Failure

Volume of the fluid and the fuel entering the combustion chamber cannot be reduced and compressed. Therefore, huge loads are applied onto the engine parts. These excessive forces result in breaking, disintegration, distortion and cracking in the engine parts.

Too much fluid may enter the combustion chamber due to the causes below:

- Water enters the combustion chamber through the inlet system (while passing over accumulated water).
- The cooling water leaking from the gaskets, which burn and melt due to excessive temperature, enters the combustion chamber.
- A defective gasket is chosen and the gaskets are not assembled properly to the engine cylinder head during the assembly.
- Too much fuel enters the combustion chamber due to the faulty injection nozzle.

1.5. Piston and Piston Pin Fracturing, Cracking in the Engine



Figure 3

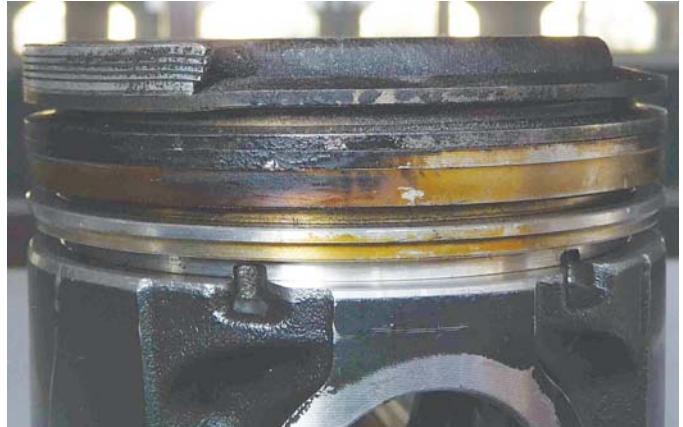


Figure 4

Recommendations

- Fuel dripping from the injection nozzle of the engine accumulates inside the combustion chamber and when the vehicle is started, the failure occurs. The injection nozzles should be checked and the defective injection nozzles should be replaced.
- Accurate, defect-free gaskets should be used during the engine overhauling operation. Defective, faulty gaskets should be replaced and should not be used.
- Necessary checks should be performed during the engine overhauling operation.
- While the vehicle passes over a water accumulation at high speed, it is possible that the inlet system sucks the water and transfers it into the combustion chamber. Therefore, the driver should reduce his/her speed while passing over water accumulations.

1.5.2 Piston Valve Knocking and Cylinder Head Impacting

Description of the Failure

There are marks of valve impacting at the piston crown. (Figure 1)

There are marks of impacting to the engine top cover and cracking towards the pin bore at the piston crown. (Figure 2)

Causes of the Failure

- Inaccurate valve timing adjustment may cause skips in the timing chain or corruption in the timing belt and as a result, the valve knocking occurs.
- The valve springs cannot take the valve back on time due to excessively high speed and accordingly, the piston crashes into a valve or valves.
- Due to the space occurring as a result of the excessively worn piston rod bearings, the valves knock the piston crown.
- After the engine cover honing operation, if the valves do not fit the groove and if there is a protrusion, the valve knocking failure occurs.
- The valve is disconnected.



Figure 1



Figure 2

1.5. Piston and Piston Pin Fracturing, Cracking in the Engine

Recommendations

- Timing should be adjusted properly during the engine overhauling operation.
- The piston head nose should be checked and adjusted at the values specified by the engine's manufacturer in the catalogues and the service manual.
- Gaskets at accurate thickness should be used.
- Piston rod bearings should be checked and bearings with faulty spaces should not be used.
- Should be carefulness during trunnion of crank case rod grinding operation for avoid eccentric grinding because this will cause a failure in the engine.
- The valves should fit the valve groove properly. Defective valves should not be assembled.
- In order to avoid wearing of valve keepers, valve guides, valve pushrods and valve rocker shaft, oil replacements should be made on time without any delay.
- After the engine is reassembled, the engine should be cycled for once and it should be checked whether the pistons knock the engine top cover or not.
- After the engine is started, if sounds of knocking or excessive noise are heard from the engine, it should immediately be stopped and checked. Otherwise, failures to cause huge damages may occur.

1.5.3 Cracking in the Piston Crown

Description of the Failure

The piston is broken towards the pin bores.

(Figure 1)

There are cracks in the piston combustion chamber.

Causes of the Failure

Microcracks occur on the piston due to the tension as a result of high temperature and sudden cooling. These cracks progress in time and break the piston. The causes of cracking and breaking at the piston crown are;

- The engine brake of the vehicle is faulty or inaccurate engine brake adjustment causes the failure.
- The vehicle is driven at high speeds with low rpm downhill. When the vehicle goes downhill, it should not be declutched. It should not be driven at high speeds.
- Inaccurate injection nozzle adjustment causes the failure.
- Correct piston appropriate for the engine specifications is not used. Utilization of a normal piston, instead of a piston with reinforced piston crown, utilization of a normal piston, instead of a piston with oil cooling gallery or utilization of pistons with different combustion chamber volumes (utilization of Euro-series engines instead of each other) may cause the failure. Machining on the piston crown can also cause the problem (Shortened stroke and length)

Recommendations

- The injection nozzle and the fuel pump should be adjusted at the values specified by the manufacturer.
- The engine brake should not be used frequently on the vehicle.
- Correct pistons should be used for the engine.
- Modifications about compression and ignition systems of the vehicle should be performed by experts.



Figure 1

1.6 Piston Pin Seizure and Pin Boss Area Failures in the Engine

1.6.1 Seizure in the Pin Bore

Description of the Failure

In the image of damages in the pistons, there are marks of wearing only in the piston pin bores. The piston surfaces are quite clean and proper. In such failures, since the failure occurs in a short time after overhauling of the engine, the piston surfaces are clean and free from the marks of wearing. (Figure 1)

Causes of the Failure

The failure occurs in a short time after the engine overhauling operation due to lack of lubrication space inside the pin bore and due to assembly fault. Therefore, there is no mark of wearing or damage on the piston surfaces that have been operating for a short time.

The causes of this failure are;

- The piston pin bore and the piston pin surfaces are not lubricated during the engine overhauling operation.
- In the engines, where the piston pin is tight in the connecting rod, assembly of the piston pin to the connecting rod is performed by heating the connecting rod. During this heating process, the temperature of the piston pin assembled into the connecting rod shall increase together with the temperature of the connecting rod. Upon expansion of the heating piston pin, the space between the piston pin bore and the piston pin shall be eliminated. The piston pin shall adhere to the piston pin bore surfaces. If the connecting rod is moved before waiting for the parts to cool down, there shall be scratches and abrasions on the piston pin bore surfaces. These abrasions shall progress with the initial operation of the engine and there shall be seizure in the pin bore. Therefore, the space between the piston pin and the piston pin bore should be checked after the parts cool down.

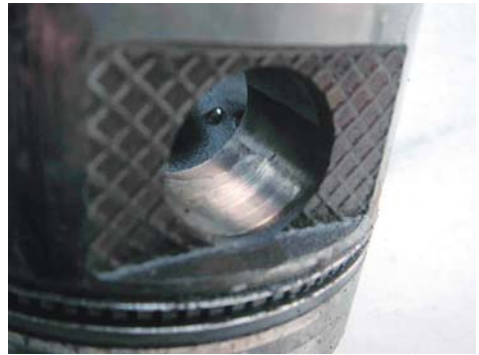
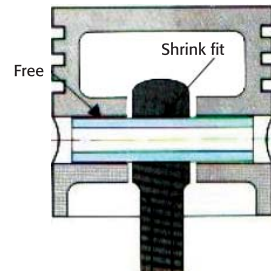


Figure 1

The piston pin in the connecting rod bearing to shrink fit and the piston pin in the pin hole to free



1.6 Piston Pin Seizure and Pin Boss Area Failures in the Engine



- As a result of fuel spillage, the oil film gets thin and seizure occurs in the pin bores.
- The connecting rod bushing is processed in a very small space measurement. Therefore, the piston pin is shrink-fit in the connecting rod.
- Oil feed is avoided due to bearings placed inaccurately (main bearing/connecting rod bearing/connecting rod bushing).

Recommendations

- Importance should be placed on the rod bushing space measurement during the engine overhauling operation.
- It should be lubricated prior to assembly of the piston pin.
- Assembly direction of the journal bearings should be correct. (oil bore, oil channels).
- The oil recommended by the engine's manufacturer should be used.
- You should be careful during assembly of the shrink-fit pistons to the connecting rod.

1.6 Piston Pin Seizure and Pin Boss Area Failures in the Engine

1.6.2 Melting next to the Piston Pin Bores (Broken Piston Pin Circlip and Dislocation)

Description of the Failure

The image of the damage caused by the failure is usually observed as melting around the piston pin circlip grooves. The image of the damage varies depending on whether the failure is a new one or the vehicle is driven for a long time with this failure.

The melting reaches up to the ring area in advanced failures. The melted piston material progresses towards the piston crown. The piston ring lands are also subject to the failure. (Figure 1)

Causes of the Failure

- The connecting rod is distorted and the circlip is dislocated due to the overloads in the engine.
- The circlip is dislocated due to the vibration that occurs at excessively high speeds.

The circlip is assembled in the inaccurate direction.

- The circlips are assembled inaccurately.

Recommendations

- New circlips should be used after the engine overhauling operation.
- While the circlip is being assembled, the direction of the circlip gap should face towards the piston crown or the bottom skirt.
- The grooves of the connecting rod should be checked for being parallel.
- The connecting rod should be checked for distortion.
- If the pin is long, no force should be applied to assemble the circlip, the pin should be replaced.



Figure 1

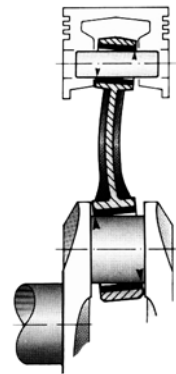


Figure 2

Cylinder Liner Failures

2.1. Longitudinal Cracking

Description of the Failure

These are the cracks, which can visually be observed on inner or outer surfaces of the cylinder liner or which go (vertically) through the length of the liner in capillary scale. (Figures 1-2)

Causes of the Failure

Longitudinal cracks usually occur due to impact during dispatch or on-site (falling, hitting etc.).

It occurs due to dirt on the surfaces where the engine block and the cylinder liner contact each other.

Hydraulic lockout occurs.

Contact surfaces of the flange of the cylinder liner and the flange housing of the engine block are not prepared as recommended.

Recommendations

Such longitudinal cracks may be visually observed, but they can also be so small that they cannot be observed. Therefore;

The outer surface of the cylinder liner and the surfaces of the engine block where the liner contacts should be cleaned as recommended and no dirt should remain there.

You should be careful while carrying the cylinder liners manually.

Heavy materials should not be stacked onto the cylinder liners.

In case of any fall or hit, the cylinder liner should be checked visually and with measurement tools.

WARNING! These small cracks may result in a total failure during operation of the engine.



Figure 1

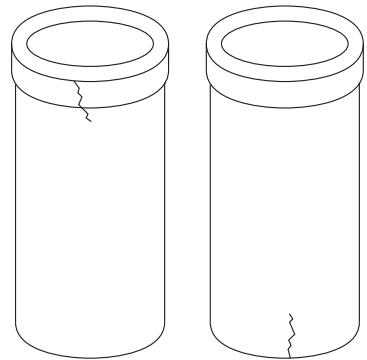


Figure 2

Description of the Failure

The flange of the cylinder liner is snapped off at the bottom with an angle from bottom to top as seen in Figure 1.

Causes of the Failure

One of the most important considerations during assembly of the cylinder block and the cylinder liner is that the seats and the contact surfaces of the flange should be parallel. If the surfaces are not prepared within the given tolerances, the flange is snapped off.

If there is dirt between the surfaces where the cylinder block and the cylinder liner flange contact each other, force is applied onto the flange upon tightening the cylinder head bolts after assembly of the liner.

If the cylinder head gaskets recommended by the engine's manufacturer are not used and the sequences and torque values of the cylinder head gaskets are not followed, the cylinder liner flange is snapped off.

If the height between the surface where the gasket contacts and the cylinder liner flange in the engine block is not appropriate, vibration occurs in the liner with the piston movement due to this gap. The liner flange is snapped off due to the impact of the force caused by the vibration.



Figure 1

2.2. Flange Snap-off

Recommendations

While performing the assembly, the outer surfaces of the cylinder liner and the surfaces where the liner contacts in the engine block should be cleaned as recommended.

You should make sure no dirt-burr remains there.

If the flange seating surfaces are inaccurate, the given measurements should be taken into consideration during correction and there should be a chamfer of 0.5 to 1 mm width under 45° angle at the corners. (Figure 3)

The importance consideration in assembly of the cylinder liner to the cylinder block is that the contact surfaces of the housing and the flange should be parallel to each other.

Since it is not possible to observe the changes in the liner housing visually, necessary tools should be used to carefully check the parallelism.(Figure 2)

Recommended gaskets should be used.

The tightening sequence and the torque values should be taken into consideration.

In order to avoid the oscillation movement of the cylinder liner inside the housing;

1. During rectification of the engine, while processing the cylinder block, adequate number of steel shims should be placed under the cylinder liner flange.
2. Or liners with flanges longer than standard values should be assembled.
3. The height difference between the block and the top point of the flange should be checked after the liner assembly.

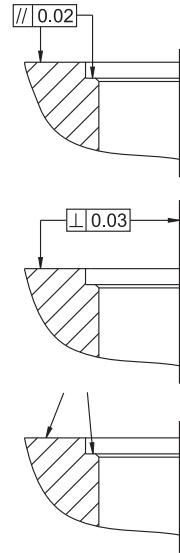


Figure 2

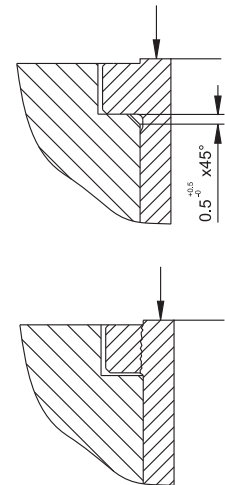


Figure 3

2.3.Cavitation and Pitting on the Cylinder Liners

Description of the Failure

In wet-type cylinder liners, holes and pittings occur in the areas where the liner contact with water, as seen in the figure. (Figure 1)

If the cylinder liner does not properly fit the cylinder block or if it is loose for the cylinder piston dimensions, the explosion at the ignition causes vibrations in the cylinder liner. These vibrations affect the flow of the coolant fluid. In this way, the cooling film on the outer surface of the liner is eliminated at certain areas. Steam bubbles occur on the surfaces, where the cooling film is eliminated, due to low pressure and high temperature. The steam bubbles start to hit the surface, where the film is not present in the liner. Due to the force applied by these bubbles, pieces snap off from the surface, holes and even pittings occur.



Figure 1

Causes of the Failure

It occurs when used pistons are used again. Used piston is not appropriate for new cylinder liner, it is worn away and a space remains between the cylinder liner and the piston.

Anti-corrosion materials added into the coolant fluid are not adequate.

Fluids containing inappropriate coolant fluids (acid water, lime water, sea water or fluids containing hazardous materials) are used.

Since the thermostat is faulty, the engine cannot reach the required operating temperature and the cylinder and the piston cannot reach the required temperatures. Therefore, the required expansion cannot be achieved and a space occurs between the piston and the cylinder liner. This space causes steam bubbles and pittings.

In order to keep the pressure of the cooling system at the required level in the engine block, pressurized radiator caps are used. If the recommended radiator cap is not used, water leaks outside the system and as there is no adequate pressure, the boiling point of the water is reduced. The coolant fluid boils and steam bubbles occur due to the temperature of the cylinders.

2.3.Cavitation and Pitting on the Cylinder Liners

Recommendations

During the engine overhauling operation, the cylinder liner, the piston and the piston rings should be used as a kit and they should be replaced within the same operation. Used products should not be assembled to the engine again.

Protective materials and anti-freeze should be added into the coolant fluid at the recommended level. Protective materials should be added continuously with small amounts as the vehicle is in use. Furthermore, the protective materials should be replaced in every two years.

Inappropriate coolant fluids (acid water, lime water, sea water or fluids containing hazardous materials) should not be used.

The radiator caps recommended by the engine's manufacturer should be used and inappropriate caps should not be assembled to the radiator upon third parties' recommendations.



2.4. Wearing on Piston Rings Contact Surfaces at Cylinder Liners

Description of the Failure

A mirror-like glaze and wearing occurs on the inner surface of the cylinder liner (Figure 1). Longitudinal polishing occurs at the areas where the piston rings operate. In this way, the sealing feature of the piston rings is eliminated and it cannot fulfill its function of sealing against oil and burnt gases. The oil consumption increases in the engine.



Figure 1

Causes of the Failure

The cylinder cap bolts are not tightened with the required torque and sequence.

Flatness of the surfaces of the engine block and the cylinder cap contacting the bolt is corrupted.

Inaccurate cylinder head bolt is used.

The cylinder head bolts are corrupted and the bolts are lost.

The contacting surfaces of the engine block and the cylinder liner or the flange measurements of the cylinder liner are corrupted.

There is dirt between the surfaces of the wet-type liners contacting the coolant fluid and the engine block.

Tightness is important for dry-type cylinder liners. The cylinder liner is either too tight or too loose on the cylinder block.

Dry-type cylinder liners are assembled to the housings in the block with press or slip-fit. As space remains between the slip-fit cylinder liners and the block surface, its shape is changed and it is subject to deformation.

If the engine block is not processed as recommended, it adopts the shape of the cylinder liner block with small wall thickness. This shape deformation attributes to the piston and the piston rings and the inner surface of the cylinder liner is worn away and polishing occurs.

Recommendations

You should make sure that the cylinder head gaskets are not corrupted and the bolts are proper. Moreover, the assembly should be performed in accordance with the torque values and the tightening sequence recommended by the engine's manufacturer.

Recommended cylinder head gaskets should be used.

Flatness of the surfaces, where the cylinder head gaskets contact in the engine block, should be checked and fixed if faulty.

Cleaning and flatness of the engine block should be checked. Since dry-type thin walled cylinder liners shall adopt the shape of the cylinder, any dirt or inaccurate measurement shall attribute to the cylinder liner.

If new cylinder liners shall be assembled to the engine block, these liners should be assembled to the adjoining cylinder liner housings in doubles and turning or honing should be made in this way.

2.5. Brightly Polished Areas in the Upper Part of the Cylinder Liners

Description of the Failure

Polishing occurs in the area that remains above the piston top ring land (Figure 1). Honing lines are completely lost in the section with a mirror-like appearance. Excessive oil consumption occurs in the engine. There is no sign of wearing or seizure in the pistons.

Causes of the Failure

Poor quality and inappropriate engine oil is used.

Burnt oil and remainders accumulate and form a layer above the piston top ring land. Friction of this layer to the cylinder liner surface causes the surface to wear away.

The form of the piston skirt contacting and seating on the cylinder liner surface is changed.

Cylinder measurements are corrupted.

Inlet valves are worn away or faulty.

Since the crankcase ventilation system cannot fulfill its function, too much engine oil enters the combustion chamber.

Recommendations

The oil recommended by the engine's manufacturer should be used.

The cylinder liners should be subject to honing as recommended.

The cylinder surface quality and the piston rings should be checked.

The inlet valves should be checked. They should be replaced if worn away or faulty.

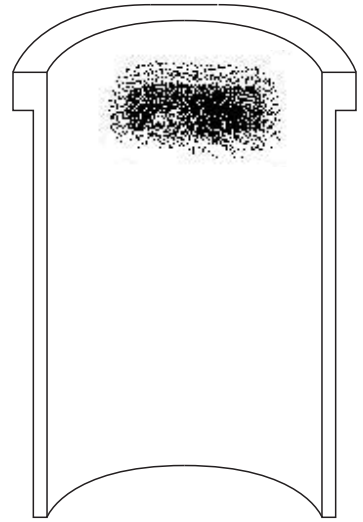


Figure 1

2.6. Crack Formation in the Cylinder Liners due to Hydraulic Lockout

Description of the Failure

Inner surface of the cylinder liner is cracked or broken at the top (Figure 1). Broken pieces cause damage in the piston. Piston seizure and marks of deformation occur. These marks of deformation can be observed throughout the piston.

Causes of the Failure

Water or fuel is pumped into the cylinder while the engine does not operate.

The vehicle passes over water and water enters the engine through the inlet system. The liquid inside the cylinder causes explosion during operation of the engine and pieces are broken off from the cylinder liner due to the pressure.

The cylinder head gasket may be faulty. The coolant fluid leaking through the gasket gets into the cylinder.

The injection nozzle needle of the system injecting fuel into the cylinder is faulty and fuel is accumulated inside the cylinder while the engine does not operate.

Recommendations

The vehicle should not pass over waters, which are high enough to let the water enter the engine.

The cylinder head gasket should be checked.

The engine's fuel injection system should be checked and faulty injection nozzles should be replaced.

The engine of the vehicle should be overhauled.

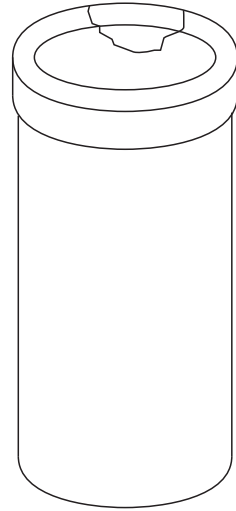


Figure 1







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