R E P O R T   R E S U M E S

ED 021 091 VT 005 674

AUTOMOTIVE DIESEL MAINTENANCE 1. UNIT XX, CUMMINS DIESEL ENGINE, MAINTENANCE SUMMARY.

HUMAN ENGINEERING INSTITUTE, CLEVELAND, OHIO

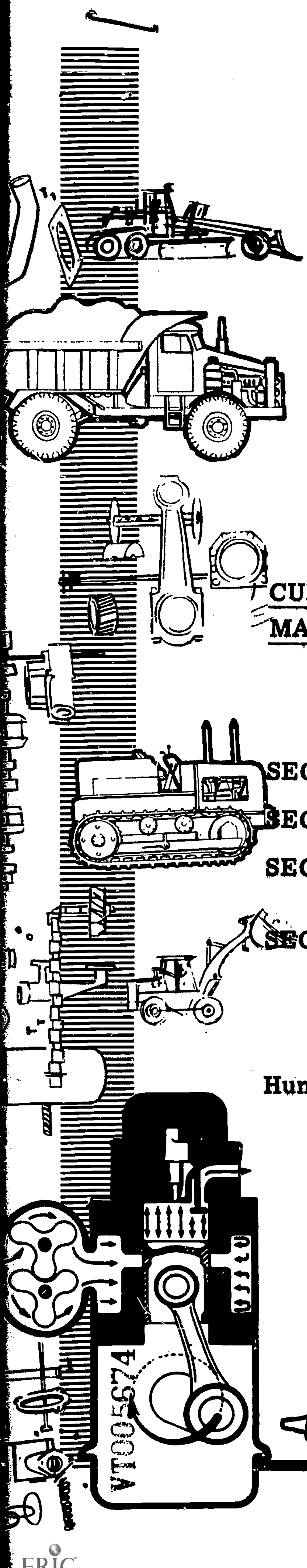
REPORT NUMBER AM-1-20 PUB DATE 21 JUL 66

MINNESOTA STATE DEPT. OF EDUCATION, ST. PAUL

EDRS PRICE MF-$0.25 HC-$1.44 34P.

DESCRIPTORS- *STUDY GUIDES, *TEACHING GUIDES, *TRADE AND INDUSTRIAL EDUCATION, *AUTO MECHANICS (OCCUPATION), *DIESEL ENGINES, ADULT VOCATIONAL EDUCATION, TRANSPARENCIES, PROGRAMED MATERIALS, INDIVIDUAL INSTRUCTION, INSTRUCTIONAL FILMS, PROGRAMED INSTRUCTION, MOTOR VEHICLES, EQUIPMENT MAINTENANCE,

THIS MODULE OF A 30-MODULE COURSE IS DESIGNED TO PROVIDE A SUMMARY OF THE REASONS AND PROCEDURES FOR DIESEL ENGINE MAINTENANCE. TOPICS ARE WHAT ENGINE BREAK-IN MEANS, ENGINE BREAK-IN, TORQUING BEARINGS (TEMPLATE METHOD), AND THE NEED FOR MAINTENANCE. THE MODULE CONSISTS OF A SELF-INSTRUCTIONAL BRANCH PROGRAMED TRAINING FILM "CUMMINS DIESEL ENGINE MAINTENANCE SUMMARY" AND OTHER MATERIALS. SEE VT 005 655 FOR FURTHER INFORMATION. MODULES IN THIS SERIES ARE AVAILABLE AS VT 005 655 - VT 005 684. MODULES FOR "AUTOMOTIVE DIESEL MAINTENANCE 2" ARE AVAILABLE AS VT 005 685 - VT 005 709. THE 2-YEAR PROGRAM OUTLINE FOR "AUTOMOTIVE DIESEL MAINTENANCE 1 AND 2" IS AVAILABLE AS VT 006 006. THE TEXT MATERIAL, TRANSPARENCIES, PROGRAMED TRAINING FILM, AND THE ELECTRONIC TUTOR MAY BE RENTED (FOR $1.75 PER WEEK) OR PURCHASED FROM THE HUMAN ENGINEERING INSTITUTE, HEADQUARTERS AND DEVELOPMENT CENTER, 2341 CARNEGIE AVENUE, CLEVELAND, OHIO 44115. (HC)



STUDY AND READING MATERIALS

AUTOMOTIVE DIESEL 1 MAINTENANCE

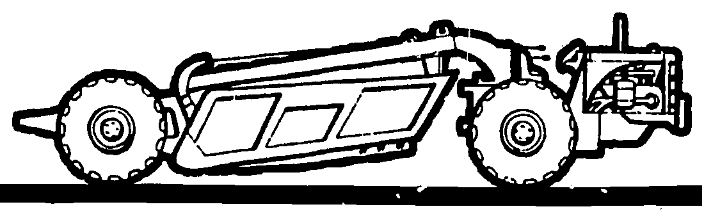
CUMMINS DIESEL ENGINE MAINTENANCE SUMMARY

UNIT XX

TABLE OF CONTENTS

AM 1-20
7/21/66

Human Engineering Institute - Minn. State Dept. of Ed. Vocational Education



HUMAN ENGINEERING INSTITUTE

SECTION A -- WHAT ENGINE BREAK-IN MEANS

Piston rings have several important functions which must be performed under extremely varying conditions of heat and pressure:

1. Provide a flexible seal between the moving piston and the stationary cylinder.
2. Conduct heat from the piston to the cooled and lubricated cylinder.
3. Guide the piston in its reciprocating motion in the cylinder.
4. Control or "meter" the lubricating film on the cylinder wall by spreading the oil over the wall, then removing the excess.
5. Provide self cleaning action to prevent accumulation of combustion products on the rings and grooves.

These functions must be carried out continuously under the following range of conditions in a four stroke cycle engine:

1. The INTAKE stroke. Naturally aspirated engines have a vacuum in the cylinder, while supercharged engines have a few pounds of pressure. Since intake air is near atmospheric temperature, some cooling of surfaces takes place. Oil tends to flow upward toward the vacuum.
2. The COMPRESSION stroke, Pressure range thru this stroke is from vacuum to low pressure, increasing to high pressure, and temperature ranges from a few degrees above outside air temperature to firing temperature of 1000 F or more. As pressure increases oil is blown downward, though the rings spread it over the wall on this up-stroke.
3. The POWER stroke. Pressure continues to rise to peak firing pressure, then falls gradually until the exhaust

valves open. Temperature is more than 1000 F as fuel is burned, and remains high as long as the cylinder is closed. Oil is burned and blown downward. Surface temperatures are high.

4. The EXHAUST stroke. Pressure falls to nominal value as the exhaust valve opens, and is only slightly above atmospheric during the stroke. Combustion gas and surface temperatures remain high. Very little oil is left on the walls or around the rings.

During each complete cycle, the gas temperature varies more than 1000 F, pressure varies more than 1000 psi, and sliding speed varies more than 1000 feet per minute.

In a typical engine, this complete range of pressures, temperatures and forces occurs sixteen times every second, at 2100 rpm. Under these conditions, it is easy to understand that every phase of design, manufacture, assembly, run-in, maintenance, and service repairs which deal with pistons, rings and cylinders is of first importance and deserves maximum consideration. A piston ring in a six inch stroke engine will "slide" nearly 70,000 miles in 3,000 hours or 100,000 vehicle miles.

Each piston ring has its own function in relation to its position on the piston.

The TOP ring must seal against the highest pressure, in the highest temperature zone, with the least lubrication. It must do these things with high efficiency, and at the same time withstand abrasion from airborne dirt and combustion products. Top rings generally are of different material than other rings, and the faces generally are chrome plated.

Top rings usually are lapped for accuracy, to enable them to withstand the severe conditions. The hard chrome plating resists abrasion, and lapping in a special lapping cylinder enables the ring to seal early in the break-in.

INTERMEDIATE rings are designed to distribute and control oil as well as to seal against pressure. They generally are designed to twist slightly under heat and pressure, so that the lower edge of the face bears more firmly against the cylinder wall than the top face does. This action enables the ring to spread oil on the up-stroke and the lower edge acts to scrape oil off the wall on the down stroke. The face of these rings usually is given a grooved finish, sometimes called a "threaded" finish, to facilitate break-in.

The OIL ring is an oil metering device to spread oil on the upstroke and scrape it on the down stroke, thus regulating the amount of oil on the cylinder wall.

The oil ring always is made with narrow bearing lands and openings between them, and the piston groove has oil drain holes in the bottom of the groove to permit oil scraped from the walls to return to the crankcase.

All rings are subjected to carbons and gums formed in combustion. While the general form of a piston ring groove is square, cleaning is provided for by making both rings and grooves tapered slightly, so that the small radial movements of the ring as it is carried over the slightly varying cylinder bore diameter causes ring side clearance to change a very small amount. This change in clearance displaces particles of dirt so that they can be carried away in the oil.

It is impossible to manufacture these parts uniformly enough to perform all of these functions perfectly when new. Some stock must be left on the surfaces to permit mating adjustment by wear in the first few hours of operation. This adjustment period is called "break-in" or "wear-in." Because proper seal efficiency is not reached until the break-in is completed, a new or rebuilt engine has more blow-by and is more easily damaged by excessive loading than a broken-in engine.

The wear stock referred to must have the proper form, to make possible a reducing wear rate as break-in progresses. Most cylinders are honed to

20-30 RMS finish. RMS is a convenient abbreviation for Root Mean Square, a mathematical term indicating the average irregularity in millionths of an inch (.000001).

The contact area of the piston rings and cylinder walls are confined to sharp peaks that are referred to as break-in surfaces. During the first short period of operation, pressure per unit of area is very high, giving a high rate of wear, and generating high local heat from the friction. Since the majority of the contact pressure is created by combustion gas pressure behind the ring, which is fairly proportional to the horsepower load, it is necessary to start the green engine out with a light load, increasing it as the wear-in progresses and friction is lowered.

After a few hours of operation, the sharp peaks are worn away, leaving flat-topped ridges with open valleys between. This is the ideal break-in condition. Unit of area loading has fallen to a small value because of the increase in contact area. This combination will run the longest service period with good oil economy and a low failure rate.

It is necessary to retain the basic honed pattern in the valleys to form an oil-wet surface. The rings scrape the oil off, and the heat and combustion blast burns away the surface oil. Oil retained in the valleys is partially protected, and on the next up-stroke some oil is brought up to renew the lubrication film on the wall. If the wall was smooth and solid, it would quickly run dry and score.

The conditions described refer to basic compression rings. Chrome plated top rings do not present a patterned face to the cylinder wall, since they are lapped to a fine matte finish (a dull finish). These rings are close to a perfect fit, and only a polishing action is required for break-in.

When new chromed rings are installed in used cylinders, the cylinder surface must be properly prepared by honing, and any out-of-round must be kept to within .0015 inch in the ring travel area.

New rings in used liners are not recommended by some engine manufacturers; unless honing is done with extreme accuracy the results are more expensive and time consuming than if both rings and liners were replaced.

Various types of spring type ring expanders sometimes are used behind the oil rings. While the compression rings are held against the walls by gas pressure, the oil ring must be held in sealing position by its tension, plus that of any expander used. At the same time, it must be quite capable of following a tapered, worn cylinder without failing to control oil. The narrow bearing face aids in sealing by concentrating the ring tension on a narrow wall area. Oil rings are sometimes chrome plated to improve the service life in high-output engines operating in dusty atmospheres.

As we have said earlier, only one surface or the other can be chrome plated. If both the ring surfaces and the liner were chrome plated there could never be a seal established sufficient to perform the functions outlined above. Some engine manufacturers chrome plate the liners, but in most instances this has proven expensive in replacement costs. Most diesel engines today use chrome plated ring surfaces.

REPAIR CONSIDERATIONS -- When an engine is disassembled for excessive oil consumption, we need to find the reason, so that a recurrence may be avoided.

Scores, scuffing and other damage will, of course, cause oil consumption and must be fully investigated. The less obvious conditions are often lumped under the common term "glazed." While any worn but undamaged cylinder wall presents a smooth, shiny appearance, only two conditions deserve to be called glazed, meaning glass-like.

> The closed wall -- Hot combustion gases have softened the hone patten, and the metal has smeared and obliterated the pattern. This condition may be found in the form of irregularly shaped spots which are so hard that a hone will not cut them. Such a surface will allow high blow-by, and lead to an eventual seizure or score. Heavy loading very early in the break-in can cause this condition.

The filled wall -- The valleys of the hone pattern are filled with carbon from burned oil, residue from incomplete fuel combustion, gum and varnish from unsuitable fuel and oil, coolant or anti-freeze residues from internal leaks, or any combination of these. Cold operation, or more likely, extensive idling is usually involved.

This type of wall is very hard to seal, since the character of the surface changes constantly as deposits are burned away and more added. Oil does not penetrate this surface well, and high friction may occur under load from lack of lubrication.

NOTE: When installing new rings it is important to stagger the ring gaps 180° from each other. This practice makes it difficult for blow-by to travel past the piston.

SECTION B -- ENGINE BREAK-IN

A great deal has been written on the subject of engine "break-in." Most engine manufacturers have presented in detail their recommendations for operating an engine to obtain good operating clearances, and piston ring and cylinder finishes. The purpose of this information is to present the reasons why and how to make the proper cylinder surface repair and operate the engine correctly after assembly. The recommendations presented are to enable you to obtain the correct amount of operational wear during the break-in period, to establish proper finishes and clearances.

Oil consumption in miles per quart is a universally used criterion for determining when an engine is broken-in (on off-highway equipment and marine applications quarts per engine hours are the criterion). The condition of the cylinder and piston ring surfaces is the primary factor in oil consumption, even though oil may be lost or consumed in many other ways. By "condition" we refer to the finish and the contour of the mating surfaces, after repair operations and during the engine operation period.

BREAK-IN -- Conditions in the first hour of operation of new parts will determine their performance of useful life. Since oil supply to the rings and cylinders is dependent on oil sprayed from the rod and main bearings, and from piston pin leakage, engine speeds must be kept high enough to provide an adequate supply. Some load is required to assist ring pressure so that the surfaces wear into adjustment. However, the load must be held below the point where blow-by burns off the oil film and permits surface damage. Normal engine temperature must be maintained, to permit good oil flow both to and around the sealing surfaces. The wear rate of these surfaces during a cold start is up to 100 times as great as after the engine is warmed up to normal operating temperature.

Normally a new or rebuilt engine is run in on a Dynamometer. For instance, GM engines are treated as follows:

Idle to check leaks
1/4 hr at 1/4 load
1/2 hr at 1/2 load
1/2 hr at 3/4 load
1 hr at full load

SUMMARY OF BREAK-IN PRINCIPLES -- We have tried to cover the basic principles of engine break-in in sufficient detail to stimulate thoughtful analysis of individual cases. There is no magic formula, since wide variation occurs in engine operation. The following general principles should be taken as a starting point:

1. If a repair for oil consumption must be made, analyze the engine condition carefully so that the true cause may be corrected. It does little good to replace the rings if worn valve guides are at fault. If it is determined that true wear has occurred in the engine (not broken lines etc.) and the oil consumption has risen to one gallon per hour (maximum), the engine should be overhauled.

2. In making such a repair, inspect carefully to avoid the re-use of unserviceable parts. Pay particular attention to piston ring groove wear, cylinder liner maximum wear and distortion, rod alignment, and any condition which may impose strains on the parts beyond their limits. No rings will seal a distorted cylinder liner.
3. Assemble the engine properly, using correct torque values and be careful to prevent dirt being left in the engine. Clean all re-honed cylinders carefully and completely.
4. Start the engine out clean, using clean and properly selected fuels, lubricants, coolants and filters.
5. Break in all engines with a minimum of no-load idling and a gradually increasing load for the first few hours of operation. New or rebuilt engines should be run-in on a dynamometer from two to four hours depending on size (HP).
6. Avoid allowing a new or rebuilt engine to operate over-fueled or overloaded.
7. Make an effort to instruct the operator properly, in a way to gain his cooperation.

SECTION C -- TORQUING BEARINGS (TEMPLATE METHOD)

After upper and lower main bearing shells have been properly installed, install main bearing caps with numbers, corresponding to number stamped on upper main bearing (engine block), toward camshaft side of engine. Main bearing caps are not interchangeable. Lubricate main bearing cap screw threads with lubricating oil and install lockplates. Start each capscrew; tighten alternately and slowly, to set caps into position.

CAUTION: Driving main bearing caps into position can jar lower bearing half out of position.

Tighten main bearing capscrews by template method. NOTE: below are specifications for one particular engine; for others, check the maintenance manual.

a. Tighten main bearing capscrews to 150 foot-pounds.

b. Tighten main bearing capscrews to 300-310 foot-pounds to "set" shells, caps and lockplates.

c. Loosen completely.

d. Retighten to 140 foot-pounds.

e. Scribe capscrew heads with sharp pencil to coincide with permanent mark on cap or scribe each cap in line with one hex corner of each main bearing capscrew.

f. Advance 30° (half-hex) from snug position; See Figure 1. This will align scribed marks (on next corner) with mark on main bearing cap or lockplate. Tighten each capscrew a little at a time and as evenly as possible until reaching operating tension.

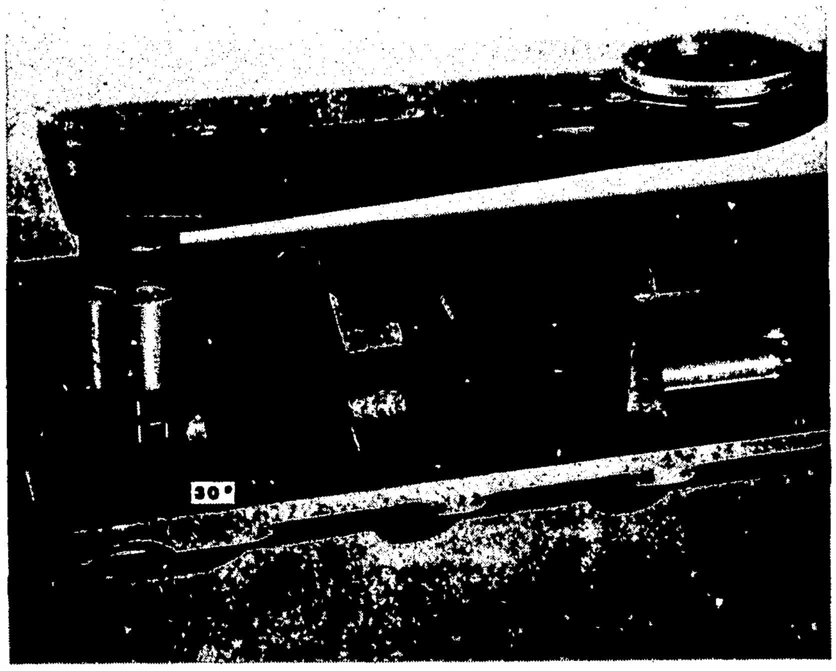


Fig. 1 Advancing capscrew 30°

SECTION D -- NEED FOR MAINTENANCE

If you watched a hundred new Cummins Diesels being built, you would expect each of them to have the same life expectancy. Further, this opinion would be confirmed after watching the engines come to life on the dynamometers and produce uniform horsepower. If the same person could see the same hundred engines a year later he would have to revise his opinion about uniform life expectancy. Two of the engines may have died an accidental death; a dozen of them may have been rebuilt, and the condition of the others would range from very good to very poor.

What makes uniform engines develop individual ailments? Why do some wear out after only a few hundred hours operation while others last ten or twenty times as long, even those working just as hard and in the same type of equipment? How can an owner make sure his engine won't be one of the short lived ones?

Engine owners and manufacturers' research departments have worked together and have found positive ways of extending life. All their recommendations can be reduced to ten maintenance steps which will result in:

Increased equipment availability
Decreased operation expense
Improved working conditions

These ten steps apply to any model or series of Cummins Diesel engines, as they do to other engines.

1. **KEEP DIRT OUT OF THE ENGINE** -- Dirt is the cause of most of the wear in an engine. Much of it is composed of gritty particles ranging in size from less than one ten-thousandth of an inch diameter to grains of coarse sand. The particles are hard enough to penetrate and toughest oil film and to wear away metal.

Valve stems, guides, faces, seats, cylinder and piston walls and piston rings suffer most from dirty intake air. These parts wear hundreds of times faster with dirty intake air than with air filtered by a good cleaner. A worn-out engine is one which has only an ounce or so worn away from the critical bearing or sealing surfaces. Replacement of these worn parts and the time loss may cost hundreds of dollars -- dollars which would have been saved by keeping out the dirt.

2. MAINTAIN A LUBRICATING FILM ON ALL BEARING SURFACES -- Lubricating oil performs four functions in an engine:

Reduces friction (heat and wear) by providing a film between the bearing surfaces.

Scavenges by picking up carbon and other small particles, carrying them to the oil filter, where they are taken out of circulation.

Cools pistons, liners and bearings.

Completes the seal of rings to pistons and cylinder walls.

There are two broad classes of lubrication failures. One group includes those caused by running an engine without oil, resulting in seizures of pistons or bearings within minutes. Many other failures are due to poor or marginal lubrication, low oil pressure, dilution, partially clogged oil passages, or improper clearance.

Downtime and overhaul expense for one engine failure may cost as much as 1,000 oil changes.

3. REGULATE THE ENGINE'S FUEL -- Fuel must be delivered to the combustion chamber at the right time, and in condition to burn readily and completely.

Fuel injection must be complete and must occur at precisely the right degree of crankshaft rotation (time).

Metered fuel charges must be uniform for all cylinders and injected as a fine spray to mix with the air and burn. The penalties for violations of these requirements are the same as for using poor grade fuel.

Fuel must be the type that will burn readily and completely within the engine. Hard starting, decreased horsepower, smoky exhaust, dilution of lubricating oil, excessive wear, and fuel pump and injector troubles are some of the penalties of using fuel oil which does not meet recommended specifications.

Fuel must be delivered to the combustion chamber in the right quantity. The horsepower developed depends upon the amount of fuel being burned. Overfueling causes overspeeding and failure of turbochargers. In the naturally-aspirated engine, it causes all the troubles associated with smoky exhaust and crankcase dilution. Underfueling decreases horsepower output.

Proper fuel combustion depends upon air supply as well as fuel. When intake air is restricted, the engine loses horsepower. The exhaust will be smoky, and some of the unburned fuel will get by the piston rings and dilute the lubricating oil.

4. CONTROL OPERATING TEMPERATURES -- Combustion temperature is high enough to melt the engine. Complete failure of the cooling system will ruin the engine within a few minutes. Nobody purposely operates an engine without water, but many engines are being damaged slowly by cooling systems that are only 50% to 75% efficient. Engine coolant temperatures should be maintained at 160 F to 190 F. This ideal temperature range for all operating conditions requires that every part of the cooling system be maintained in top condition. The cooling system must do its best job under the most adverse conditions. As outside air temperatures or engine loads increase, the coolant temperature tends to rise. At the same time, it is expected to do <u>more</u> cooling of oil and of iron masses.

When coolant temperature is below 160 F, fuel may not burn readily or produce its full power. When water temperature exceeds 190 F and the engine is operating under full load, lubricating oil may get so hot and thin that it cannot lubricate effectively.

Every part of the cooling system requires attention:

Water jackets lose ability to absorb heat when they become coated with scale, rust or dirt.

Water pumps circulate less coolant as impellers wear, or as belts slip.

Thermostats fail to control water flow accurately after long periods of service.

When radiators and oil coolers get dirty they lose ability to absorb and radiate heat.

Water hose, gaskets and piping may develop leaks.

5. GUARD AGAINST CORROSION -- Many engine owners have been shocked to find water in the crankcase and to learn that it got there through "pin holes" or "worm holes" that started on the water side of the cylinder liners. This "eating away of metal" or corrosion, as it is commonly called is likely to occur in any heating or cooling system where the coolant is not treated. Corrosion may or may not be associated with iron rust. Corrosion may even take place in a system that is protected against rust.

Research has shown there are many causes of corrosion. Among the most serious are acid, salt or air in the coolant, which can create conditions favorable to electrolysis and the resultant erosion of metal. Corrosion can be controlled or prevented entirely by the use of corrosion resisters.

Rust and scale decrease the efficiency of the cooling system by retarding conduction and radiation of heat and restricting the flow of the coolant. Rust acts as an insulator against heat. Pockets in the system get clogged with rust or scale deposits.

Cracked cylinder heads are a common result of poor cooling. The same maintenance that prevents corrosion will prevent rusting.

6. LET THE ENGINE BREATHE -- The diesel engine requires about

12,000 gallons of air (1 gallon = 231 cubic inches) for every gallon of fuel it burns. For the engine to operate efficiently, the air system must meet the following requirements:

The engine must breathe freely; the intake and exhaust must not be restricted.

Valves, pistons and rings must seal properly against compression and combustion pressures.

The amount of fuel which can be burned and the power developed are as dependent upon air as on fuel. If there is too little air to burn all the fuel, the excess fuel causes a smoky exhaust -- a sign of wasted money and lost horsepower.

Unfortunately, wasted fuel is not the only loss caused by incomplete combustion. The excess fuel washes lubricating oil off cylinder walls, resulting in seized pistons and bearing failures. Carboned injector cup spray holes and stuck piston rings are other troubles which result from insufficient air. Dirty air cleaner elements, leaky valves, worn rings, damaged mufflers, and air piping that is too small, or with sharp bends, are common causes of air restriction.

7. PREVENT OVERSPEEDING -- Engines must not be operated beyond the maximum rated rpm for which they were designed. Cummins diesels are protected against overspeeding during normal operation by governors, which are correctly adjusted when they leave the factory. Increasing rpm by changing governors or by allowing a vehicle on a down grade to push the engine beyond its rated rpm, leads to damage. Overspeeding may cause turbocharger damage or failure.

Overspeeding often causes pistons to strike and break valves. Cam lobes and valve seats and faces are also damaged by overspeeding, which prevents tappets or cam followers from following cam lobes. Injectors may stick as a result of overspeeding when the governor shuts off the fuel and deprives the injector of lubrication.

8. KNOW YOUR ENGINE'S CONDITION -- The engine constantly provides signs of its condition for the operator or the maintenance mechanic to interpret. In many cases, the operator is the first to detect signs of trouble. Unless he reports these conditons, they may be missed until after real trouble develops. Interpretation of the signs is a very important part of maintenance. As an example, from low indicated oil pressure the mechanic knows to check the following conditions for correction:

A faulty gauge
Low oil level
Diluted lubricating oil
Worn bearings
A bearing failure

It never pays to run an engine until it fails, because one part failure usually ruins other good parts. Some examples of approaching failure are:

Bearing metal found in the lube oil filter which, if not corrected at the source, may cause the loss of a crankshaft.

Excessive crankcase pressure, or blow-by, which indicates conditions that may lead to a stuck piston, broken rod and ruined cylinder block.

Leaks in the air system may permit entrance of enough dirt to wear out the engine within a few hours.

9. CORRECT TROUBLES WHILE THEY ARE SIMPLE -- An engine is made of many parts -- each closely related to many others. Each part has its own function. Failure to perform that function places additional strain on other parts. As overloaded parts fail, they add to the overload on still other parts, until the progressive failures put the engine out of commission.

Preventive maintenance is a series of simple checking, service and repair operations intended to forestall progressive damage. Delaying a maintenance job that needs to be done is a reckless gamble. Very few engine failures occur which are not preceded by warning signs that can be detected before major damage takes place.

10. SCHEDULE AND CONTROL YOUR MAINTENANCE -- The objective of preventive maintenance is to correct unfavorable conditions that develop during engine usage before they get serious enough to cause damage. The value of the program is dependent upon having the equipment available for maintenance following a well-planned schedule.

Preventive maintenance performed on schedule is the easiest, as well as the least expensive, type of maintenance. It requires less work and material to prevent failures than to fix them. Maintenance must not be relegated to a position of secondary importance for the sake of a temporary increase in production. Preventive maintenance permits the maintenance department to do the work on schedule rather than out on the job under poor working conditions and at unusual and inconvenient hours.

DIDACTOR PLATES FOR AM 1-20D

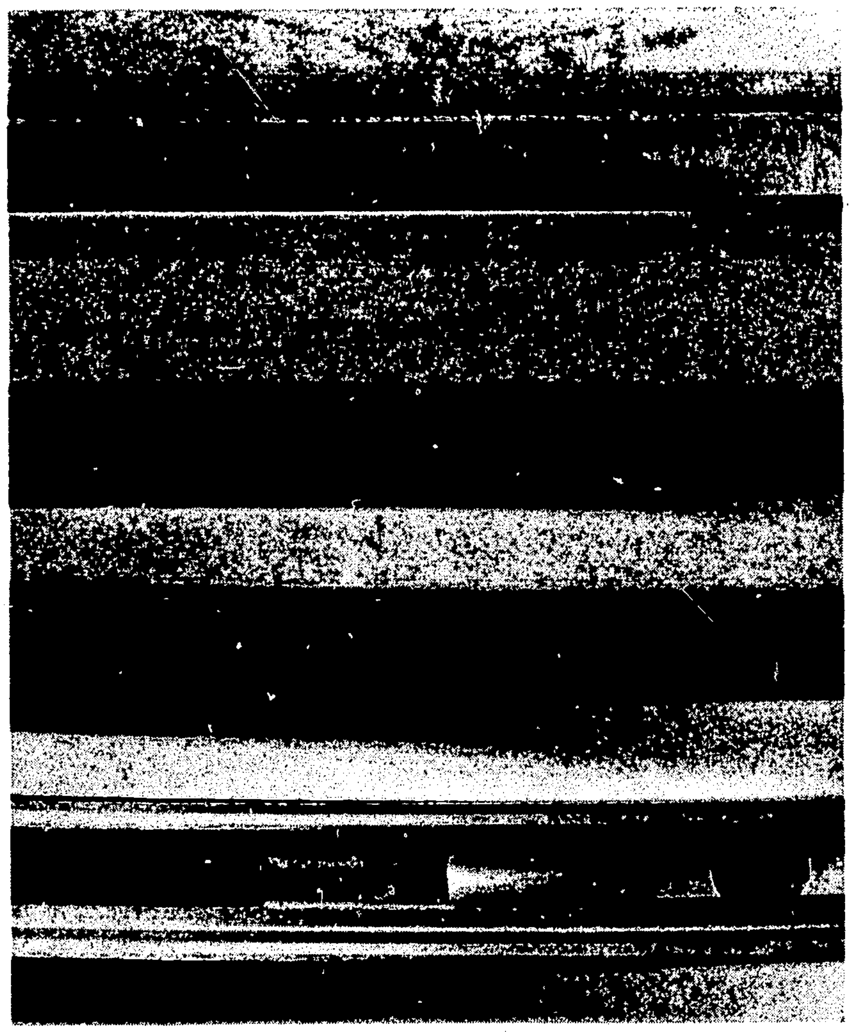


Plate I New rings installed on pistons

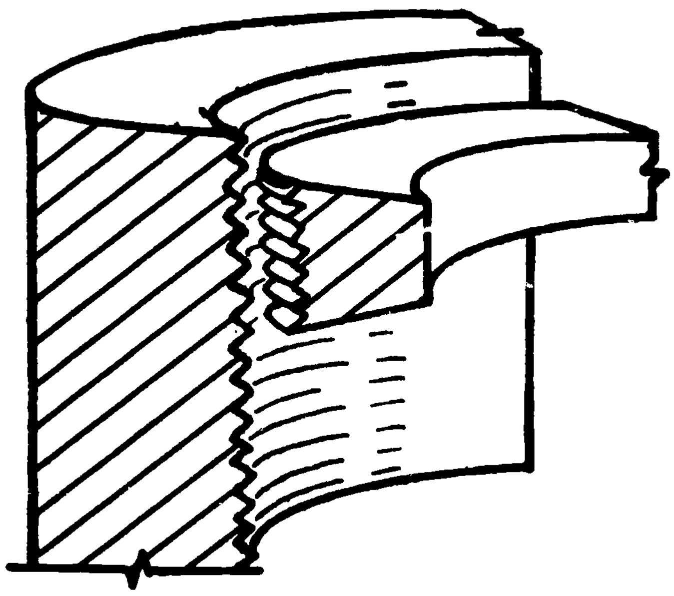


Plate II Cross section, new surfaces

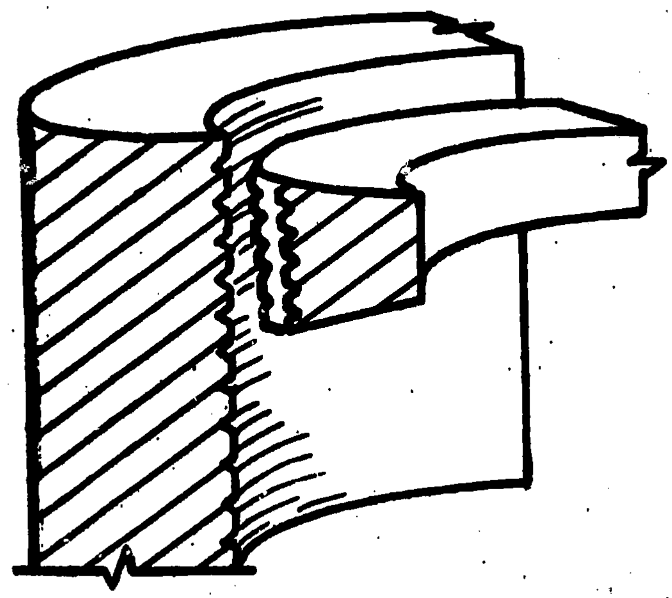


Plate III Cross section, surface after breaking

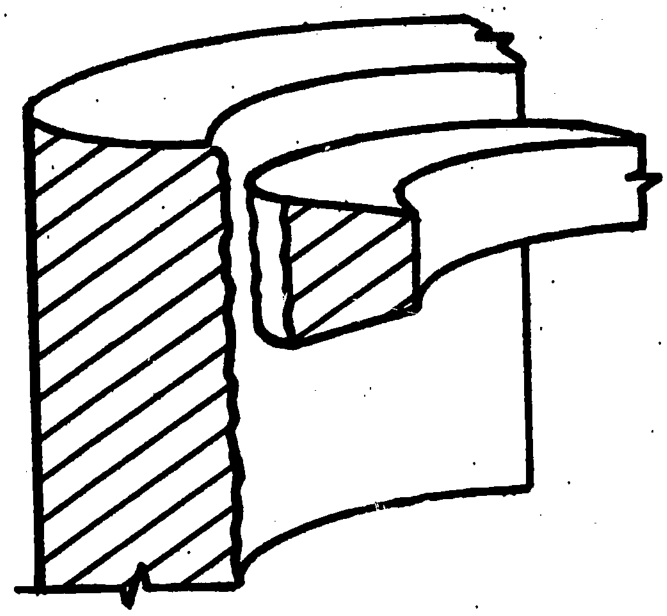


Plate IV Cross section, closed wall

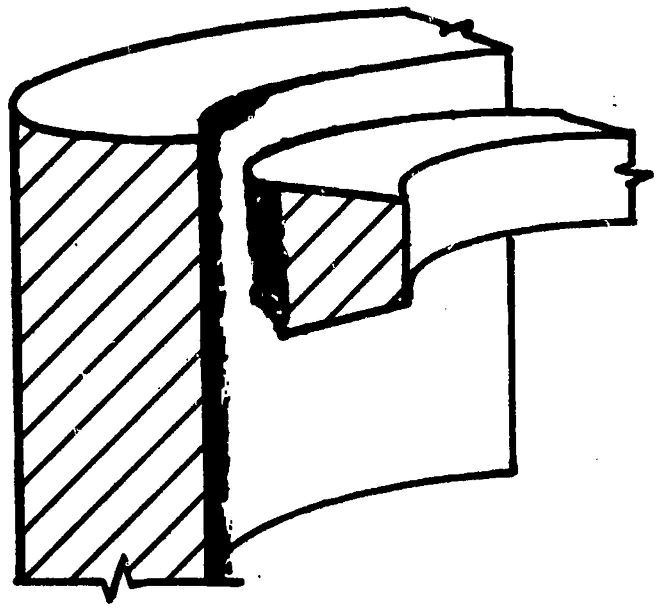


Plate V Cross section, walls filled with carbon

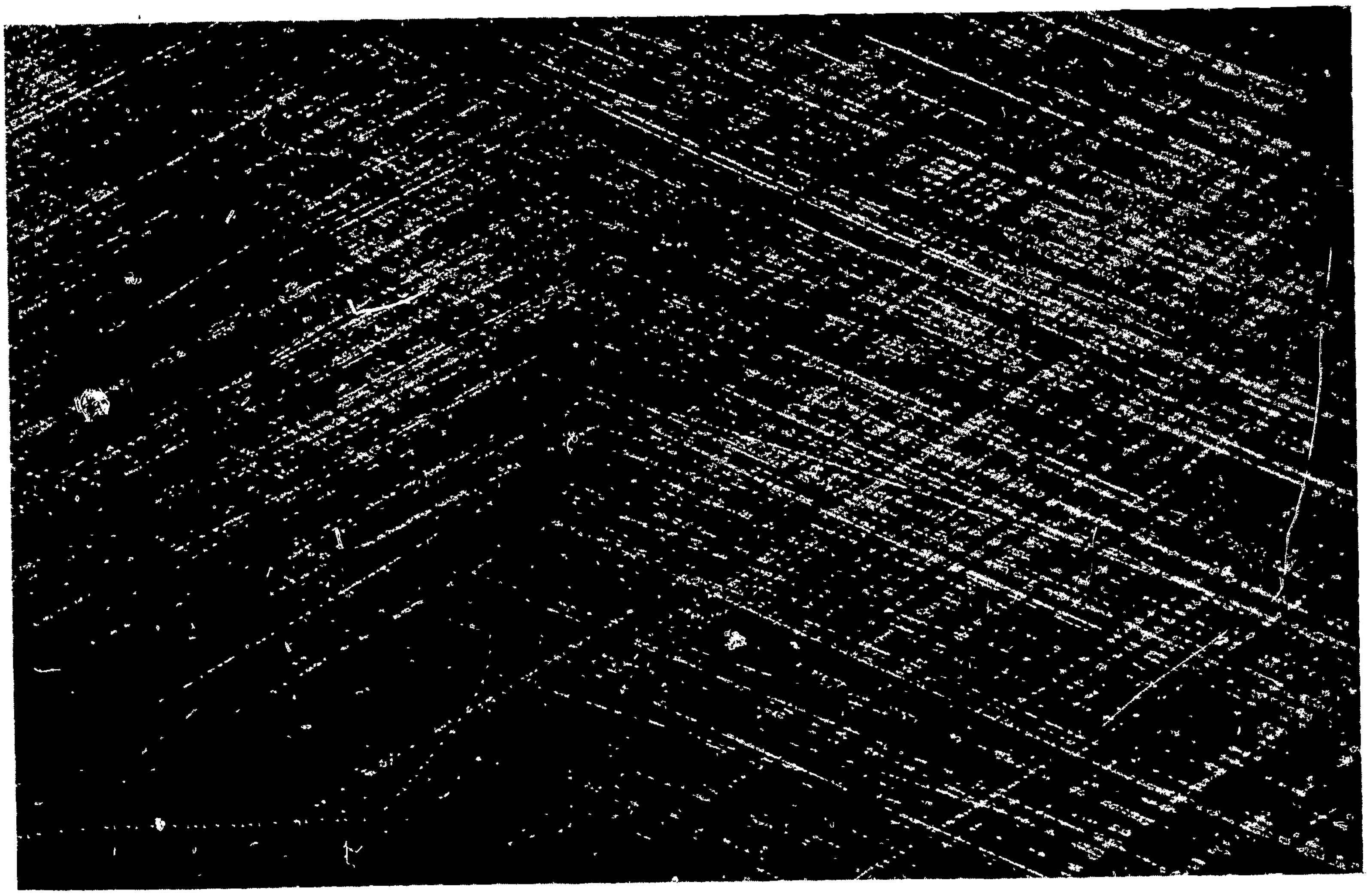


Plate VI Recommended liner finish

0

AM 1-20D
7/26/66

CUMMINS DIESEL ENGINE MAINTENANCE SUMMARY

Human Engineering Institute - Minn. State Dept. of Ed. Vocational Education

ess A — 1 Check to see that timer is off.

1

In this lesson we will review some of the factors of diesel engine oil consumption, covering piston rings and cylinder liner finishes and contours of mating surfaces, after repair operation and during the engine break-in period. In addition, there will be a coverage of the template method of torquing bearings and a review of safety precautions.

Press A — 2

2

A great deal has been written on the subject of engine "break-in." Oil consumption in miles per quart, gallons per hour, or qts. per hour, are universally used criteria, for determining when an engine is "broken-in."

The condition of cylinder and piston ring surfaces is the primary factor in oil consumption, even though oil may be lost or consumed in many other ways. By "condition" we refer to the finish and contour of the mating surfaces, after repair operations and during the engine operating period.

Press A — 3

3

Piston rings have several important functions which must be performed under extremely varying conditions of heat and pressure:

1. Provide a seal between the piston and the cylinder wall.
2. Conduct heat from the piston to the cylinder.
3. Guide the piston in its up and down motion in the cylinder.
4. Control the lubricating film on the cylinder wall.
5. Provide a self-cleaning action to prevent accumulation of combustion products on the rings and in the grooves.

Press A — 4

4

The five functions previously mentioned must be carried out ______________.

A. during the power stroke — 5
B. during the intake stroke — 5
C. continuously — 6

5

No. It is important that the five functions mentioned be carried out on all four cycles of a four cycle engine and both cycles of a two cycle engine (intake, compression, power, and exhaust) continuously.

Press A — 6

6

OK. In a typical four cycle engine, a complete range of pressures, temperatures and forces occurs sixteen times every second (at 2100 rpm).

The compression temperature may reach as high as _____.

A. 750 F. — 7
B. 2500 F. — 7
C. 1000 F. — 8

7

No. On the compression stroke, temperatures may reach as high as 1000 F.

On the power stroke the cylinder temperatures go above 1000F when the fuel is burned.

Press A — 8

8

OK. Piston rings are special in relation to the position each occupies. The top ring must seal against the highest pressure in the highest temperature zone with the least lubrication. Intermediate rings are designed to distribute and control oil as well as to seal against pressure.

One of the rings shown on Plate I of the Didactor reference sheets for AM 1-20D has a grooved finish, sometimes called a "threaded" finish, to facilitate break-in.

Which of the above mentioned piston rings has the grooved finish?

A. Compression rings — 9
B. Oil rings — 9
C. Intermediate rings — 10

9

No, See Plate I. You will notice the two center (intermediate) rings have grooves or a thread-like finish referred to in the last statement to assist in the break-in operation.

Press A — 10

10

OK. During the manufacturing process some stock must be left on the ring surfaces to permit mating adjustment by wear in the first few hours of operation. This adjustment period is called ________________.

A. break-through. — 11
B. break-in or run-in. — 12
C. break-out. — 11

11

No. See Plate II. Notice the enlarged view of the mating surfaces. The wear stock or ridges must have the proper form to make possible a reducing wear rate as break-in or run-in progresses.

Press A — 12

12

OK. Let's review some of the material that has been covered to this point. Plate I shows a magnified view of the face of a set of piston rings. Notice the coarse thread-like pattern of the different ring faces. This pattern provides the break-in or run-in surface of the rings.

What effect, if any, does the surface shown in Plate I have on the seal efficiency of a "green" engine?

A. The "new" engine's seal efficiency is not affected. — 12-1
B. The "new" engine has more blow-by. — 14

(c) — 13

12-1

You said the "new" engine's seal efficiency is not affected. This is not true; a "new" engine's seal is very critical, because blow-by is excessive and the engine must be run-in according to recommended procedures.

Press A — 14

13

You have answered one or more of the questions in this sequence of material incorrectly. Let's review this again. Read carefully and take your time in answering.

Press A — 3

14

OK. Yes, the "new" or re-built engine has more blow-by and is more easily damaged by excessive loading than a broken-in engine.

Chrome plated top rings do not present a patterned face to the cylinder wall, since they are lapped to a fine matte (dull) finish. They are closer to a perfect fit, and only a polishing action is required for break-in; see Plate III.

Press A — 16

(no #15)

16

While any worn but undamaged cylinder wall presents a smooth, shiny appearance, only two conditions deserve to be called glazed, meaning glass-like.

A. The "closed" wall and the open wall. - 17
B. The "closed" wall and the straight wall. - 17
C. The "closed" wall and the filled wall. - 18

17

No. The closed wall and the filled wall are the correct answers, see Plates IV and V.

The "closed" wall is caused by hot combustion gases that have softened the hone pattern, and the metal has smeared and wiped the pattern.

The "filled" wall valleys of the hone pattern are filled with carbon from burned oil, gum and varnish, from unsuitable fuel and oil, coolant or anti-freeze residues from internal leaks, or any combination of these.

Press A — 18

18

Most manufacturers specify that hone marks make a helical pattern on the cylinder wall. Thirty to 45 degrees is desired, since the ring face should shear or peel the sharp ridge points. If the pattern is too near horizontal, some pattern engagement and tearing occurs, which either closes the valleys or leaves uneven gaps in the wall, neither of which is desirable. (See Plate VI).

A. Vertical scratches form a path for combustion gases to blow by. — 19
B. Vertical scratches cause the oil film to be burned off. — 19
C. Both A and B are true. — 20

19

No. Both A and B are correct. Vertical scratches form a path for combustion gases to blow by, and for burning off the oil film.

Press A — 20

20

OK. Experience indicates that the best break-in for most used cylinder liners is obtained when the finished wall is between 20 and 30 RMS.

The amount of wear stock in the form of a honed pattern must be such that the wear rate reduces to a low value at about the same time the rings are worn just enough to fit the cylinder and seal effectively.

A — 21

21

OK. Conditions in the first hour of operation of new parts will determine their performance of useful life.

Normal engine temperatures ______________________

A. must be maintained, to permit good oil flow both to and around the sealing surfaces. — 24
B. have little or no effect on oil flow. — 22

X (C) — 23

22

No. As you recall in our previous discussions on lubrication, engine temperatures do have an effect on the flow of oil. If the engine is too cold, oil will not flow freely, causing poor lubrication. The answer we wanted here was that normal engine temperatures must be maintained.

Press A — 24

23

You have answered one or more of the questions incorrectly. Before advancing to new material, let's review the last few frames. Read carefully, take your time and pick the right answers to all the questions so that you will be given a chance to move along.

Press A — 14

24

OK. Since oil supply to the rings and cylinders is dependent on oil thrown from the rod bearings and mains engine speeds must be kept high enough to provide an adequate supply. Some load is required to assist ring pressure; however, loading must be held below the point where high blow-by burns off the oil film and permits surface damage.

Press A — 25

25

During the recommended break-in procedure, as outlined in AM 1-20 and the maintenance manuals, the following principle should be remembered:

A. do not accelerate sharply. — 27

B. do accelerate sharply, several times, to insure proper lubrication. — 26

C. accelerating sharply does little or no harm, as long as maximum (governed) speed is not held for a long period of time. — 26

(choose one only)

26

No. Never accelerate a new or recently overhauled engine. Besides over-fueling the cylinders and the damage caused, the wear rate of surfaces during a cold start is up to 100 times as great as after the engine is warmed up to normal operating temperature.

Press A — 27

27

After 10 or 15 minutes of no load running is complete, operate the machine with a light load for 1/2 to 1 hour. During this period, do not idle for long periods of time, avoid lugging, and do not operate at governed speed longer than necessary. Average engine speed should be 1/2 to 3/4 rated speed. Coolant temperature should be at least __________.

A. 190 F. — 28
B. 140 F. — 29
C. 210 F. — 28

28

No. The coolant temperature should be at least 140 F. during this light load part of the break-in period.

Press A — 29

29

OK. If operation is normal at this point, the unit should be stopped and the final valve and injector adjustment made. A close inspection of all parts visible during this operation should be made. If all is well, release the unit with instructions to avoid lugging, sustained full load, idling over 5 minutes, and extreme engine temperatures. These are valid instructions at anytime, and are particularly important during break-in.

Press A — 31

(no #30)

31

TORQUING BEARINGS (Template method) -- The template method is used almost exclusively with Cummins engines. It is a method of tightening bearing caps in steps, then loosening and retightening to a specified amount of torque, then advancing the bolt or nut 30° (half-hex)

Press A — 32

32

According to the instructions in the N-NH Series shop manual, a main bearing should be torqued to 300 foot-pounds of torque, then loosened to 150 foot-pounds, then advanced 30° (half-hex)... ?

A. True — 33
B. False — 34

33

O. According to the maintenance manual bearing caps hould be torqued to the specified amount of foot-pounds o "set" the shells, caps and lockplates. The next step to loosen completely, then retighten to the proper torque. he final step is to advance the capscrews 30° (half-hex).

ress A - 34

34

Main bearing capscrews need not be tightened evenly, as they will align themselves. The only precaution is; the marks should be on the same side (camshaft side).

A. True - 35

B. False - 36

35

o. The text also states, "Tighten each capscrew a little a time and as evenly as possible until reaching operating nsion."

ress A - 36

36

A cylinder block must be cleaned before any attempted inspection is made. Inspect upper cylinder liner counterbore, lower cylinder liner bore, and main bearing bore diameters.

Main bearing caps have an interference fit to block of .002 to .004 inch and must fit in the block with no perceptible clearance or "shake." Main bearing bores should be carefully inspected. Assemble main bearing caps, tighten capscrews to operating tension, gauge main bearing bore horizontally, vertically and diagonally with dial bore gauge. Check manual for proper diameter.

Press A - 37

37

heck main bearing bores with an ST 136, or comparable ool. This closely ground checking bar will pass through l bores and turn freely unless caps are not tightened to roper tension, burrs etc. have not been removed, or if ps are distorted.

ain bearing caps are tightened by the ________ method.

A. tension method. - 38

B. variation method - 38

C template method. - 39

38

No. The template method is used on Cummins engines for torquing bearings.

Press A - 39

39

. What type of cylinder liner is used in Cummins gines? ____________

A. Dry type. - 40

B. Integral type. - 40

C. Wet type. - 41

40

No. The wet type cylinder liner is used in Cummins Engines. It is surrounded by the circulating water (coolant) that passes through the engine.

Press A - 41

-11

OK. The most accurate tool to use in checking an out-of-round cylinder is the ______________.

A. inside micrometer. - 12
B. plug gauge - 12
C dial indicator - 13

-12

No. The dial indicator is the proper tool for checking the bore (out-of-round) of a cylinder liner.

Example of this is shown in Plate VII.

Press A — 13

-13

OK. Which of the following is an indication that there is a blow-by of hot gases between the cylinder liner and the face of the rings?

A. Darkened area in the ring groove. — 14
B. Darkened area on the cylinder liner. — 15
C. Extreme wear on the cylinder liner. — 14

-14

No. Darkened area on the cylinder liner is the correct answer. Eventually, there would be extreme wear on the ring face and the cylinder liner, and even burned piston ring lands if this condition was allowed to continue.

Press A — 15

-15

OK. Which of the following forces holds the piston rings in the sealing position (against the cylinder walls) during the power stroke?

A. Tension of the rings only. — 16
B. Tension of the rings and pressure of the combustion gases. — 17
C. Tension of the rings and air pressure. — 16

-16

No. Tension of the rings and the pressure of the combustion gases tend to hold the rings against the cylinder liner to increase sealing efficiency.

Press A — 17

-17

OK. Lugging an engine is considered very bad practice. Which of the following is most descriptive of lugging?

A. Failure to supply sufficient fuel to meet the load. *
B. Overloading the engine beyond the rated horsepower capacity at given engine speed. — 19

x(C) - 18

* does not move

(You must select the correct answer to this question to move the film).

-18

OK. The rings are held in the sealing position against the cylinder walls by ring tension and pressure of the combustion gases.

You have answered one or more of the last few questions incorrectly. Before going on to new material, let's review the last few frames. Read carefully and take your time.

Press A — 39

49

OK. The most critical period for a rebuilt engine that is being run-in is ______________

A. beginning of operation under load. — 50
B. during preliminary warm-up. — 50
C. the very beginning of the run-in period. — 60

50

No. The very beginning of the run-in period is the most critical period of the rebuilt engine. The engine can be damaged by rapid acceleration, and by several other negligent or careless operations during this period.

Press A — 60

(no #51-59) 60

OK. NEED FOR MAINTENANCE.

Engine owners' and manufacturers' research departments have worked together and found positive ways of extending engine life. All their recommendations can be reduced to ten maintenance steps which will result in:

Increased equipment availability
Decreased operating expense
Improved working conditions

Press A — 61

61

Extension of engine life mentioned in frame 60 applies to ______________

A. a certain series model of Cummins Engines. — 62
B. any model or series of Cummins Engines. — 62
C. any model or series Cummins Engines and to other engines. — 63

62

No. Several engine manufacturers have worked together and found positive ways of extending engine life not just Cummins: and these procedures apply to all the engines that Cummins (and the others) build.

Press A — 63

63

OK. The first of the ten maintenance steps is: KEEP DIRT OUT OF THE ENGINE. Why is it so important to keep dirt out of the engine?

A. It makes the engine difficult to work on. — 64
B. Dirt is the cause of most of the wear in an engine. — 65
C. The statement is false and should be disregarded, as the engine can be steam cleaned. — 64

64

No. Statements "A and C" from the previous frame are incorrect.

Statement "B" is correct: dirt causes most of the wear in an engine.

It does little good to steam clean an engine after it is worn out and in need of repair.

Press A — 65

65

OK. Maintenance step number two states: MAINTAIN A LUBRICATING FILM ON ALL SURFACES. It also states that lubricating oil performs four important functions in the engine:

1. Reduces friction
2. Scavenges
3. Cools
4. Completes the seal at sealing surfaces.

Information in this section states that downtime and overhaul expense for one engine failure may cost as much as ______ oil changes.

A. 100 — 66
B. 1000 — 67
C 10,000 — 66

66

No. Maintenance step number two states that downtime and overhaul expense for one engine failure may cost as much as 1,000 oil changes. This is a considerable expense and can be reduced through proper preventive maintenance and proper repair procedures.

Press A — 67

67

OK. Maintenance step number three has to do with regulating the engine's fuel, and states: FUEL MUST BE DELIVERED TO THE COMBUSTION CHAMBER AT THE RIGHT TIME AND IN CONDITION TO BURN.

Fuel injection must be complete and occur at precisely the right ____________________

A. degree of crankshaft rotation. — 68
B. time. — 68
C. (both of the above). — 69

68

You are not entirely wrong; both "A and B" are correct. The degree of crankshaft rotation controls time of fuel injection.

Press A — 69

69

OK. Hard starting, decreased horsepower, smoky exhaust, dilution of lubricating oil, excessive wear, and fuel pump and injector troubles are some of the penalties for using fuel oil which does not meet recommended specifications.

Diesel fuel has an ignition quality that is rated very much like gasoline, and is called its ________________ rating number?

A. octane — 69-1
B. cetane — 71
C. viscosity index — 70

x (c) - 70

69-1 [redacted]

No. Octane rating refers to gasoline rather than diesel fuel oil. The answer we wanted here is cetane rating.

Press A — 71

70

You have missed one or more of the questions in this section and you should have the opportunity for a review. Read carefully and take your time in answering the questions.

Press A — 60

71

OK. Cetane number is the ignition quality of diesel fuel. Cetane number 40 is usually the minimum recommended.

Proper fuel combustion depends upon air supply as well as on fuel. When intake air is restricted, the engine loses horsepower. The exhaust will be smoky and some of the unburned fuel will get by the piston rings and will dilute the lubricating oil.

Diluted lubricating oil may increase the ________________

A. probability of crankcase explosion. — 72
B. possibility of damaging main and connecting rod bearings. — 72
C. damage to piston rings and scored cylinder walls, (plus A & B) — 73

72

No. All three items mentioned in the previous frame are possible if crankcase fuel dilution is allowed to continue unchecked.

Remember, this condition can cause :

1. crank case explosion
2. main and connecting rod bearing damage
3. rings and cylinder wall scoring

Press A — 73

73

OK. Combustion temperature is high enough to melt the engine. Failure of the cooling system will ruin the engine within a few minutes. Nobody purposely operates an engine without water (coolant), but many engines are being damaged slowly by cooling systems that are only 50% to 75% efficient.

Engine coolant temperature should be maintained at _____.

- A. 260 F to 290 F. — 74
- B. 72 F to 140 F. — 74
- C. 160 F to 190 F. — 75

74

No. 160 to 190 F. is the correct level for engine coolant.

In most trucks and heavy duty equipment the proper operating temperature is maintained with the aid of thermostats and shutterstats.

Press A — 75

75

OK. The cooling system must do its best job under the most adverse condition. As atmospheric temperatures or engine loads increase, the coolant flow in the radiator _______________.

- A. remains the same. — 76
- B. increases. — 77
- C. decreases. — 76

76

No. As atmospheric temperatures increase, more coolant is circulated through the radiator and less through the by-pass tube to keep coolant temperature at the proper level.

Press A — 77

77

OK. When coolant temperature is allowed to remain for long periods of time below the recommended minimum of 160 F, fuel may not burn completely or produce its full power. Other unwanted conditions are also developing: _______________.

- A. Carbon is building up in the combustion space and around the piston rings and ring grooves. — 78
- B. Unburned fuel is getting past the piston rings and diluting the lubricating oil. — 78
- C. Undue wear is occurring on bearing surfaces due to poor lubrication, (as well as "A" and "B"). — 79

78

No. The correct answer is "C" which states: Undue wear is occurring on bearing surfaces due to poor lubrication, plus "A" and "B", which states: Carbon is building up in the combustion space and around the rings and grooves, unburned fuel is getting past the rings and diluting the lubricating oil. Diluted lubricating oil, by the way, contributes to the undue wear on bearing surfaces.

Press A — 79

79

OK Research has shown there are many causes of corrosion and among the most serious are: acid, salt or air in the coolant. Corrosion can be controlled or prevented entirely.

Rust and scale decrease the efficiency of the cooling system by retarding conduction and radiation of heat and flow of the coolant.

What is the most common failure as a result of poor cooling?

- A. Cracked cylinder heads. — 81
- B. Burned pistons and valves. — 80
- C. Scored cylinder liners. — 80

80

No. Cracked cylinder heads (especially valve seats) are the most common failures as a result of poor cooling. Burned pistons and valves, and scored cylinder liners, will also result if engine is run unchecked for long periods of time with cooling system in poor condition.

Press A — [redacted] 81

81

OK The diesel engine requires about 12,000 gallons of air for every gallon of fuel it burns. For the engine to operate efficiently, the engine must breathe freely, and the intake and exhaust systems must not be restricted. The amount of fuel which can be burned and the power developed is dependent upon ________________.

A. amount of fuel injected. — 71-1
B. amount of air in relation to the fuel. — 73
C. neither of these. — 72

x(c) - 72

71-1

No. Remember, we said the power developed and the amount of fuel burned are dependent upon the amount of air that is available in the cylinder for the fuel to mix with.

Press A — 73

82

No. You have missed one or more of the questions in this section and should have the opportunity for a review. Read carefully and take your time in answering the questions.

Press A — 71

73

OK. Unfortunately, wasted fuel is not the only loss caused by insufficient air and incomplete combustion. The excess fuel washes lubricating oil film off cylinder walls, resulting in seized pistons and bearing failures. In most cases, the one single item responsible for the restriction in the intake air system is ________________.

A. air piping too small or with sharp bends in it. - 84
B. damaged or packed mufflers, - 84
C. dirty air cleaner element. — 85

84

No. Air piping too small or with sharp bends in it, and the damaged mufflers do contribute to engine air restriction; but in most cases the air cleaner element is the cause of most of the restriction in the engine intake system.

Press A — 85

85

OK. Diesel engines are protected against overspeeding by governors, which are correctly adjusted when they leave the factory. Increasing rpm beyond the rated rpm leads to damage.

Overspeeding may cause one or more of the following:

A. Cam lobes and valve seats may be damaged. - 86
B. Injectors may stick when the governor shuts off the fuel, depriving the injectors of lubrication. - 86
C. Pistons may strike and bend or break the valves, plus all of the above mentioned possibilities. - 87

86

No. You are not entirely wrong but, in all probability more than one single item would be damaged if the engine were allowed to run above the manufacturers' recommended rpm.

Press A — 87

87

OK. The engine constantly provides signs of its condition for the operator or the maintenance mechanic to interpret. In many cases, the operator is the first to detect signs of trouble. Interpretation of the signs is a very important part of maintenance.

For instance, the mechanic knows to check one of the following from low indicated oil pressure. ________________.

A. Worn bearings. - 88
B. Diluted lubricating oil and missing air filter. - 78
C. A check for faulty gauge should be made first. - 79

88

No. The mechanic may be able to save himself a lot of trouble, time, and expense by checking the oil pressure gauge first.

Always keep in mind the rule stated in the next frame.

Press A — 89

89

OK. A good rule to follow is: check the simple things first and work up to the more difficult. Example: don't disassemble the fuel pump if the engine won't start; first check the fuel supply.

Also correct troubles while they are small and simple. Preventive maintenance is a series of simple checking, service and repair operations intended to forstall progressive damage.

Schedule and control your maintenance. Maintenance performed on schedule is the easiest, as well as the least expensive.

It is also important to remember that paper work is useful, only as it reduces work instead of contributing to it.

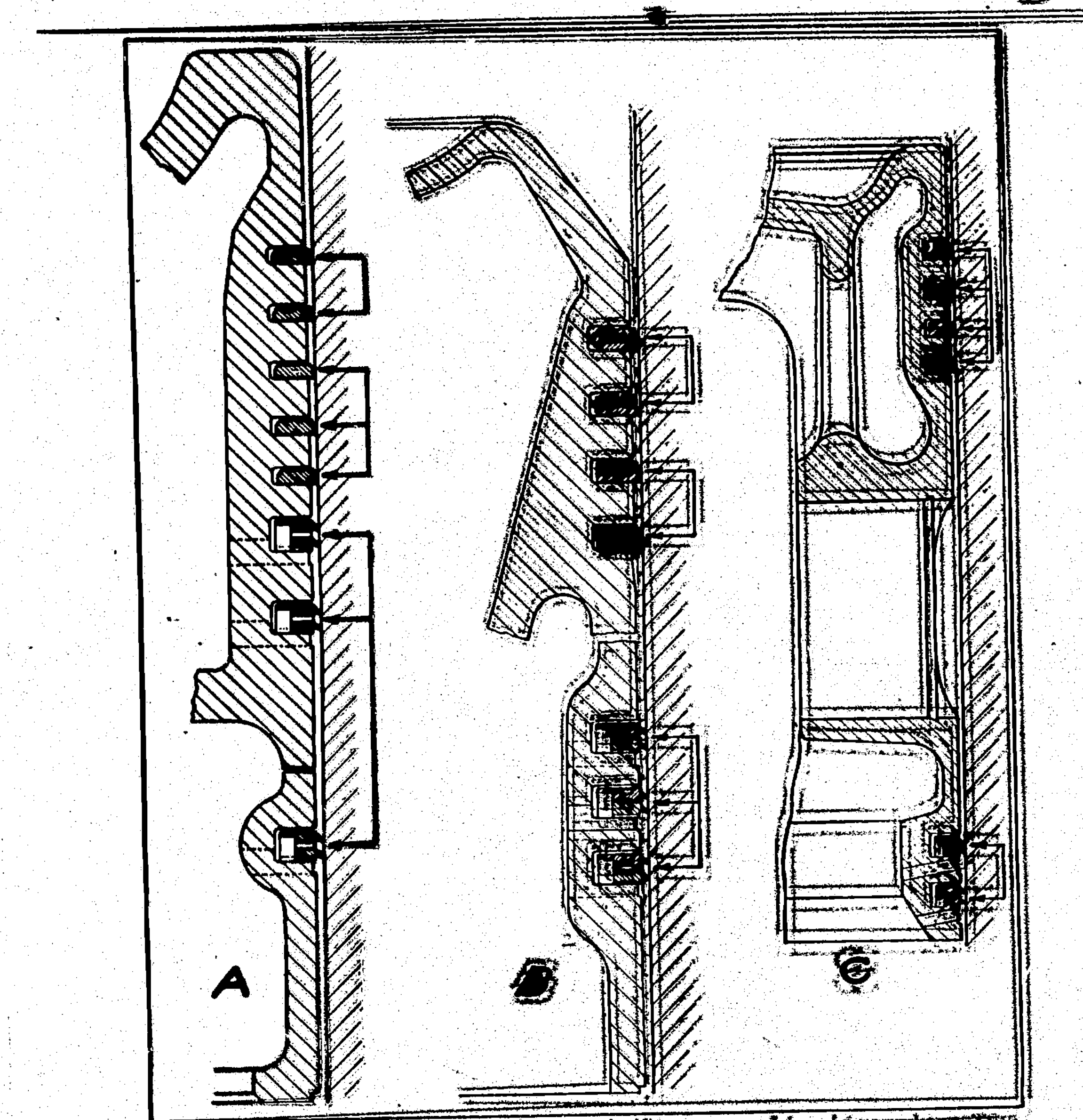
Press A — 90

90

Congratulations, you have completed Unit AM 20D which winds up the lessons on the Cummins engine. More will be said about Cummins later on in the program.

PRESS REWIND

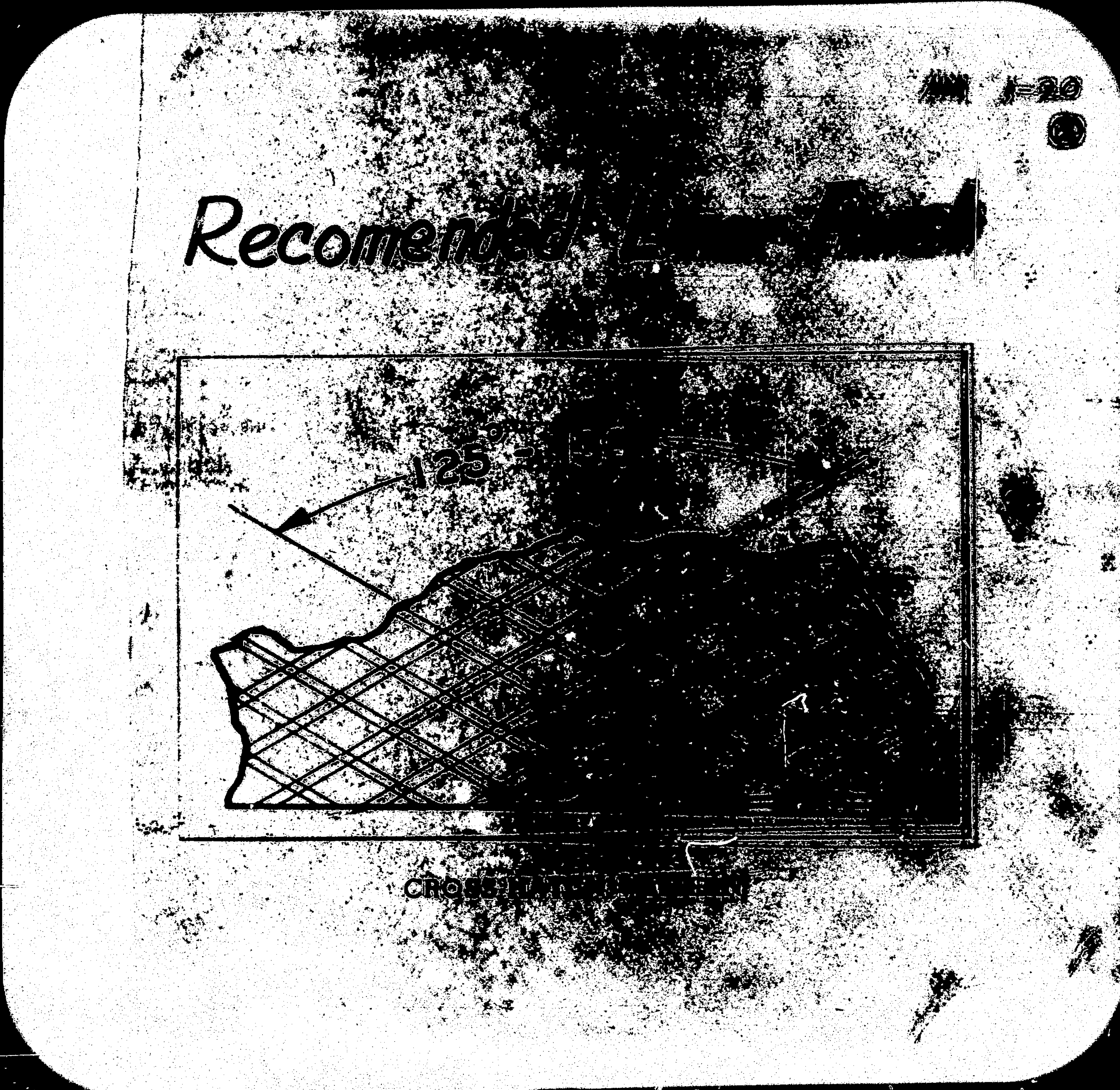
AM = 1-20



A—Typical ring installation on a 4-cycle engine. Two top compression rings are chrome plated. Next three compression rings and [illegible] oil control rings are unplated. B—Typical ring installation on large 2-cycle, supercharged engine. Again only the two top compression rings, subjected to the highest heat, are chrome plated. C—In GM Series 71 engine piston, all compression rings are chrome plated, oil rings unplated.

HUMAN
ENGINEERING
INSTITUTE

2341 Carnegie Ave
Cleveland Ohio 44115



HUMAN
ENGINEERING
INSTITUTE

INSTRUCTOR'S GUIDE

AM 1-20

Title of Unit: Cummins Diesel Engine Maintenance Summary 7/21/66

OBJECTIVES for This Unit:

1. To familiarize the student with maintenance procedures of the Cummins Engine.
2. To give the student some REASONS for maintenance, not just procedures, even though some procedures are necessary.
3. To explain break-in and break-in recommendations.
4. To explain the need for maintenance and also some recommendations.

LEARNING AIDS suggested:

VU - GRAPH CELLS:	AM 1-8 (9) (scored pistons)
	AM 1-20 (1) (new rings installed on pistons)
	AM 1-20 (2) (recommended liner finish)
MODELS:	Engine components, such as cylinder liner (whole or cut in half), pistons and rings.

DISCUSSION IDEAS AND QUESTIONS: (Designed to get participation and involvement of as many people in the class as possible.)

1. What does engine break-in mean?
2. What are some of Cummins Engine Company's recommendations for engine break-in?
3. Why do we have the "crosshatch" pattern in cylinder liners?
4. What are some of the functions of piston rings?
5. What are some of the forces occurring in the engine? What effects on operation and maintenance?
6. Why are chrome piston rings never used with chrome cylinder liners?
7. When is the most critical time of engine break-in?
8. Why is the need for maintenance different on different applications?