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IDENTIFIERS	*Automotive Cooling Systems; *Lubrication Systems

ABSTRACT

This correspondence course, originally developed for the Marine Corps, is designed to provide new mechanics with a source of study materials to assist them in becoming more proficient in their jobs. The course contains four study units covering automotive cooling system maintenance, cooling system repair, lubricating systems, and lubrication system repair. Each study unit begins with a general objective, which is a statement of what the student should learn from the study unit. The study units are divided into numbered work units, each presenting one or more specific objectives, and illustrated unit texts. At the end of the unit text are study questions with answers. (KC)

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35.13a
1 Oct 1984

1. ORIGIN

MCI course 35.13a, Automotive Cooling and Lubricating Systems, has been prepared by the Marine Corps Institute.

2. APPLICABILITY

This course is for instructional purposes only.

J. M. D. HOLLADAY
Lieutenant Colonel, U. S. Marine Corps
Deputy Director

ACKNOWLEDGEMENT

The Marine Corps Institute, Marine Barracks, Washington, D.C. gratefully acknowledges the important contributions provided by the following MCI personnel in developing and publishing the revision of this course:

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The Marine Corps Institute gratefully acknowledges the assistance of Motor Transport Schools, Marine Corps Service Support Schools, Camp Lejeune, N.C. in the formal review of this course.

INFORMATION

FOR

MCI STUDENTS

Welcome to the Marine Corps Institute training program. Your interest in self-improvement and increased professional competence is commendable.

Information is provided below to assist you in completing the course. Please read this guidance before proceeding with your studies.

1. MATERIALS

Check your course materials. You should have all the materials listed in the "Course Introduction." In addition you should have an envelope to mail your review lesson back to MCI for grading unless your review lesson answer sheet is of the self-mailing type. If your answer sheet is the pre-printed type, check to see that your name, rank, and social security number are correct. Check closely, your MCI records are kept on a computer and any discrepancy in the above information may cause your subsequent activity to go unrecorded. You may correct the information directly on the answer sheet. If you did not receive all your materials, notify your training NCO. If you are not attached to a Marine Corps unit, request them through the Hotline (autovon 288-4175 or commercial 202-433-4175).

2. LESSON SUBMISSION

The self-graded exercises contained in your course are not to be returned to MCI. Only the completed review lesson answer sheet should be mailed to MCI. The answer sheet is to be completed and mailed only after you have finished all of the study units in the course booklet. The review lesson has been designed to prepare you for the final examination.

It is important that you provide the required information at the bottom of your review lesson answer sheet if it does not have your name and address printed on it. In courses in which the work is submitted on blank paper or printed forms, identify each sheet in the following manner:

DOE, John J. Sgt 332-11-9999
08.4g, Forward Observation
Review Lesson
Military or office address
(RUC number, if available)

Submit your review lesson on the answer sheet and/or forms provided. Complete all blocks and follow the directions on the answer sheet for mailing. Otherwise, your answer sheet may be delayed or lost. If you have to interrupt your studies for any reason and find that you cannot complete your course in one year, you may request a single six month extension by contacting your training NCO, at least one month prior to your course completion deadline date. If you are not attached to a Marine Corps unit you may make this request by letter. Your commanding officer is notified monthly of your status through the monthly Unit Activity Report. In the event of difficulty, contact your training NCO or MCI immediately.

3. MAIL-TIME DELAY

Presented below are the mail-time delays that you may experience between the mailing of your review lesson and its return to you.

	TURNAROUND MAIL TIME	MCI PROCESSING TIME	TOTAL NUMBER DAYS
EAST COAST	16	5	21
WEST COAST	16	5	21
FPO NEW YORK	18	5	23
FPO SAN FRANCISCO	22	5	27

You may also experience a short delay in receiving your final examination due to administrative screening required at MCI.

4. GRADING SYSTEM

LESSONS			EXAMS	
GRADE	PERCENT	MEANING	GRADE	PERCENT
A	94-100	EXCELLENT	A	94-100
B	86-93	ABOVE AVERAGE	B	86-93
C	78-85	AVERAGE	C	78-85
D	70-77	BELOW AVERAGE	D	65-77
NL	BELOW 70	FAILING	F	BELOW 65

You will receive a percentage grade for your review lesson and for the final examination. A review lesson which receives a score below 70 is given a grade of NL (no lesson). It must be resubmitted and PASSED before you will receive an examination. The grade attained on the final exam is your course grade, unless you fail your first exam. Those who fail their first exam will be sent an alternate exam in which the highest grade possible is 65%. Failure of the alternate will result in failure of the course.

5. FINAL EXAMINATION

ACTIVE DUTY PERSONNEL: When you pass your REVIEW LESSON, your examination will be mailed automatically to your commanding officer. The administration of MCI final examinations must be supervised by a commissioned or warrant officer or a staff NCO.

OTHER PERSONNEL: Your examination may be administered and supervised by your supervisor.

6. COMPLETION CERTIFICATE

The completion certificate will be mailed to your commanding officer and your official records will be updated automatically. For non Marines, your completion certificate is mailed to your supervisor.

7. RESERVE RETIREMENT CREDITS

Reserve retirement credits are awarded to inactive duty personnel only. Credits awarded for each course are listed in the "Course Introduction." Credits are only awarded upon successful completion of the course. Reserve retirement credits are not awarded for MCI study performed during drill periods if credits are also awarded for drill attendance.

8. DISENROLLMENT

Only your commanding officer can request your disenrollment from an MCI course. However, an automatic disenrollment occurs if the course is not completed (including the final exam) by the time you reach the CCD (course completion deadline) or the ACCD (adjusted course completion deadline) date. This action will adversely affect the unit's completion rate.

9. ASSISTANCE

Consult your training NCO if you have questions concerning course content. Should he/she be unable to assist you, MCI is ready to help you whenever you .eed it. Please use the Student Course Content Assistance Request Form (ISD-1) attached to the end of your course booklet or call one of the AUTOVON telephone numbers listed below for the appropriate course writer section.

PERSONNEL/ADMINISTRATION	288-3259
COMMUNICATIONS/ELECTRONICS/AVIATION	
NBC/INTELLIGENCE	288-3604
INFANTRY	288-3611
ENGINEER/MOTOR TRANSPORT	288-2275
SUPPLY/FOOD SERVICES/FISCAL	288-2285
TANKS/ARTILLERY/INFANTRY WEAPONS REPAIR	
LOGISTICS/EMBARKATION/MAINTENANCE MANAGEMENT/	
ASSAULT AMPHIBIAN VEHICLES	288-2290

For administrative problems use the UAR or call the MCI HOTLINE: 288-4175.

For commercial phone lines, use area code 202 and prefix 433 instead of 288.

AUTOMOTIVE COOLING AND LUBRICATION SYSTEMS

Course Introduction

AUTOMOTIVE COOLING AND LUBRICATION SYSTEMS has been designed to provide new mechanics with a source of study materials to assist them in becoming more proficient in their jobs. The course stresses maintenance, malfunction diagnosis, and repair of the cooling and lubrication system.

ADMINISTRATIVE INFORMATION

ORDERS OF STUDIES

Study Unit Number	Study Hours	Subject Matter
1	2	Cooling System Maintenance
2	2	Cooling System Repair
3	2	Lubrication Systems
4	2	Lubrication System Repair
	2	REVIEW LESSON
	2	FINAL EXAMINATION
	12	

RESERVE RETIREMENT CREDITS: 4

COLLEGE CREDIT: American Council on Education (ACE) has awarded 35.13, Automotive Cooling and Lubricating Systems, 1 semester hour toward lower division Baccalaureate/Associate Degree.

EXAMINATION: Supervised final examination without textbook or notes; time limit 2 hours.

MATERIALS: MCI 35.13a, Automotive Cooling and Lubrications Systems, review lesson and answer sheet.

RETURN OF MATERIALS: Students who successfully complete this course are permitted to keep the course materials.

Students disenrolled for inactivity or at the request of their commanding officer will return all course materials.

SOURCE MATERIALS

TM9-8000	Principles of Automotive Vehicles, Jan 1956
TM9-2320-211-20	Truck, Chassis, 5-Ton, 6x6, Jan 1973 w/ch A Jan 1975
TM9-2320-211-35	DS and GS Maintenance for Truck Chassis, 5-Ton, 6x6, Sept 1974 w/ch 1 Jan 1965
TM9-2320-218-20	Truck, Utility, 4x4, M151, M151A1, M151A2, Sept 1971 w/ch 3 Oct 1974
TM9-2320-218-34	DS and GS Maintenance, Truck Utility, 4x4, 1/4-Ton, Jan 1972 w/ch 2 Oct 1973

HOW TO TAKE THIS COURSE

This course contains 4 study units. Each study unit begins with a general objective which is a statement of what you should learn from the study unit. The study units are divided into numbered work units, each presenting one or more specific objectives. Read the objective(s) and then work the unit text. At the end of the work unit text are study questions which you should be able to answer without referring to the text of the work unit. After answering the questions, check your answers against the correct ones listed at the end of the study unit. If you miss any of the questions, you should restudy the text of the work unit until you understand the correct response. When you have mastered one study unit, move on to the next. After you have completed all study units, complete the review lesson and take it to your training officer or NCO for mailing to MCI. MCI will mail the final examination to your training officer or NCO when you pass the review lesson.

TABLE OF CONTENTS

MARINE CORPS INSTITUTE

STUDY GUIDE

Welcome to the Marine Corps Institute correspondence training program. By enrolling in this course, you have shown a desire to improve the skills you need for effective job performance, and MCI has provided materials to help you achieve your goal. Now all you need is to develop your own method for using these materials to best advantage.

The following guidelines present a four-part approach to completing your MCI course successfully:

1. Make a "reconnaissance" of your materials;
2. Plan your study time and choose a good study environment;
3. Study thoroughly and systematically;
4. Prepare for the final exam.

I. MAKE A "RECONNAISSANCE" OF YOUR MATERIALS

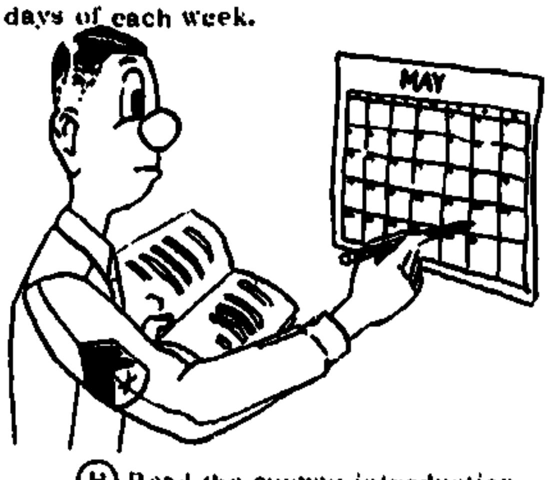
Begin with a look at the course introduction page. Read the COURSE INTRODUCTION to get the "big picture" of the course. Then read the MATERIALS section near the bottom of the page to find out which text(s) and study aids you should have received with the course. If any of the listed materials are missing, see Information for MCI Students to find out how to get them. If you have everything that is listed, you are ready to "reconnoiter" your MCI course.

Read through the table(s) of contents of your text(s). Note the various subjects covered in the course and the order in which they are taught. Leaf through the text(s) and look at the illustrations. Read a few work unit questions to get an idea of the types that are asked. If MCI provides other study aids, such as a slide rule or a plotting board, familiarize yourself with them. Now, get down to specifics!

II. PLAN YOUR STUDY TIME AND CHOOSE A GOOD STUDY ENVIRONMENT

From looking over the course materials, you should have some idea of how much study you will need to complete this course. But "some idea" is not enough. You need to work up a personal study plan; the following steps should give you some help.

(A) Get a calendar and mark those days of the week when you have time free for study. Two study periods per week, each lasting 1 to 3 hours, are suggested for completing the minimum two study units required each month by MCI. Of course, work and other schedules are not the same for everyone. The important thing is that you schedule a regular time for study on the same days of each week.



(B) Read the course introduction page again. The section marked ORDER OF STUDIES tells you the number of study units in the course and the approximate number of study hours you will need to complete each study unit. Plug these study hours into your schedule. For example, if you set aside two 2-hour study periods each week and the ORDER OF STUDIES estimates 2 study hours for your first study unit, you could easily schedule and complete the first study unit in one study period. On your calendar you would mark "Study Unit 1" on the appropriate day. Suppose that the second study unit of your course requires 3 study hours. In that case, you would divide the study unit in half and work on each half during a separate study period. You would mark your calendar accordingly. Indicate on your calendar exactly when you plan to work on each study unit for the entire course. Do not forget to schedule one or two study periods to prepare for the final exam.

(C) Stick to your schedule.

Besides planning your study time, you should also choose a study environment that is right for you. Most people need a quiet place for study, like a library or a reading lounge; other people study better where there is background music; still others prefer to study out-of-doors. You must choose your study environment carefully so that it fits your individual needs.

III. STUDY THOROUGHLY AND SYSTEMATICALLY

Armed with a workable schedule and situated in a good study environment you are now ready to attack your course study unit by study unit. To begin, turn to the first page of study unit I. On this page you will find the study unit objective, a statement of what you should be able to do after completing the study unit.

DO NOT begin by reading the work unit questions and flipping through the text for answers. If you do so, you will prepare to fail, not pass, the final exam. Instead, proceed as follows:

(A) Read the objective for the first work unit and then read the work unit text carefully. Make notes on the ideas you feel are important.

(B) Without referring to the text, answer the questions at the end of the work unit.

(C) Check your answers against the correct ones listed at the end of the study unit.

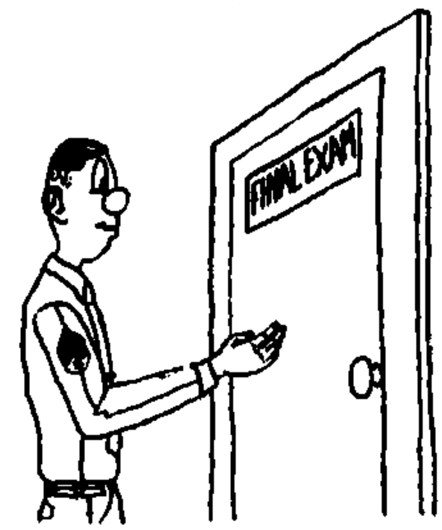
(D) If you miss any of the questions, restudy the work unit until you understand the correct response.

(E) Go on to the next work unit and repeat steps (A) through (D) until you have completed all the work units in the study unit.

Follow the same procedure for each study unit of the course. If you have problems with the text or work unit questions that you cannot solve on your own, ask your section OIC or NCOIC for help. If he cannot aid you, request assistance from MCI on the Student Course Content Assistance Request included with this course.

When you have finished all the study units, complete the course review lesson. Try to answer each question without the aid of reference materials. However, if you do not know an answer, look it up. When you have finished the lesson, take it to your training officer or NCO for mailing to MCI. MCI will grade it and send you a feedback sheet listing course references for any questions that you miss.

IV. PREPARE FOR THE FINAL EXAM



How do you prepare for the final exam? Follow these four steps:

(A) Review each study unit objective as a summary of what was taught in the course.

(B) Reread all portions of the text that you found particularly difficult.

(C) Review all the work unit questions, paying special attention to those you missed the first time around.

(D) Study the course review lesson, paying particular attention to the questions you missed.

If you follow these simple steps, you should do well on the final. GOOD LUCK!

12

STUDY UNIT 1

COOLING SYSTEM MAINTENANCE

STUDY UNIT OBJECTIVES: WITHOUT THE AID OF REFERENCES, YOU WILL IDENTIFY THE PURPOSE OF THE MAIN COMPONENTS OF THE AUTOMOTIVE COOLING SYSTEM, HOW IT IS CONSTRUCTED, AND COOLING SYSTEM PROCEDURES.

Work Unit 1-1. PURPOSE

STATE THE PURPOSE OF THE LIQUID COOLING SYSTEM.

Purpose. Tremendous heat is generated by an automotive engine--enough to keep an average-size house warm in the winter! So, unless this heat is quickly removed after it has done its job, it could cause great damage to the engine by ruining lubricating oil or melting and warping metal parts. The liquid-cooled engine has a better control over the engine temperature than the air-cooled engine does. Since engines in military vehicles are normally equipped with a liquid-cooled system, the air-cooled engine will not be discussed in this study unit. The liquid in the liquid-cooled system is circulated throughout the system--around the hot cylinders and back through the radiator (fig 1-1), where the liquid is cooled before it is returned to the engine to pick up more heat.

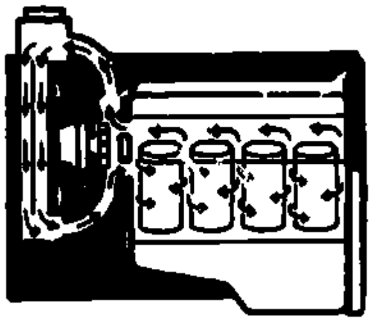


Fig 1-1. Coolant flow in liquid-cooled engine.

Now that the basic principle of coolant flow has been explained to you, take a look at the main parts of the cooling system (fig 1-2).

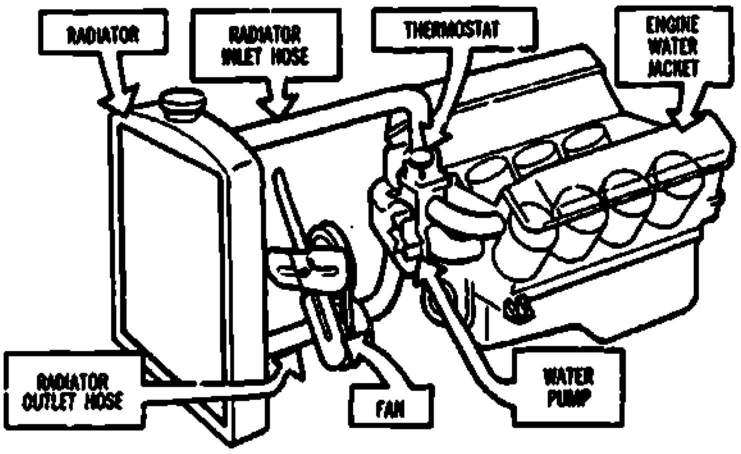


Fig 1-2. Main parts of the cooling system.

The purpose of the cooling system is to act as an indirect medium to carry the heat from inside the engine and transfer it into the air. The most common type of cooling system makes use of a liquid such as water. Such a cooling liquid is called a coolant. Liquid-cooled systems are used for the engines in most military-wheeled vehicles.

EXERCISE: Answer the following question and check your response against the one listed at the end of this study unit.

1. State the purpose of the liquid cooling system.

Work Unit 1-2. COMPONENTS OPERATION

NAME THE COOLING SYSTEM COMPONENT THAT PROVIDES A PASSAGEWAY FOR THE COOLANT AROUND THE HOT CYLINDERS OF THE ENGINE.

NAME THE COOLING SYSTEM COMPONENT THAT STORES AND COOLS THE LIQUID COOLANT.

NAME THE LIQUID USED IN COOLING SYSTEMS.

Engine water jacket (fig 1-3). An important part of the liquid-cooled system is the engine water jacket. The water jacket is located in the engine block. The water jacket is made up of many channels and passages which surround the combustion chambers and the cylinders. These channels are filled with liquid coolant.

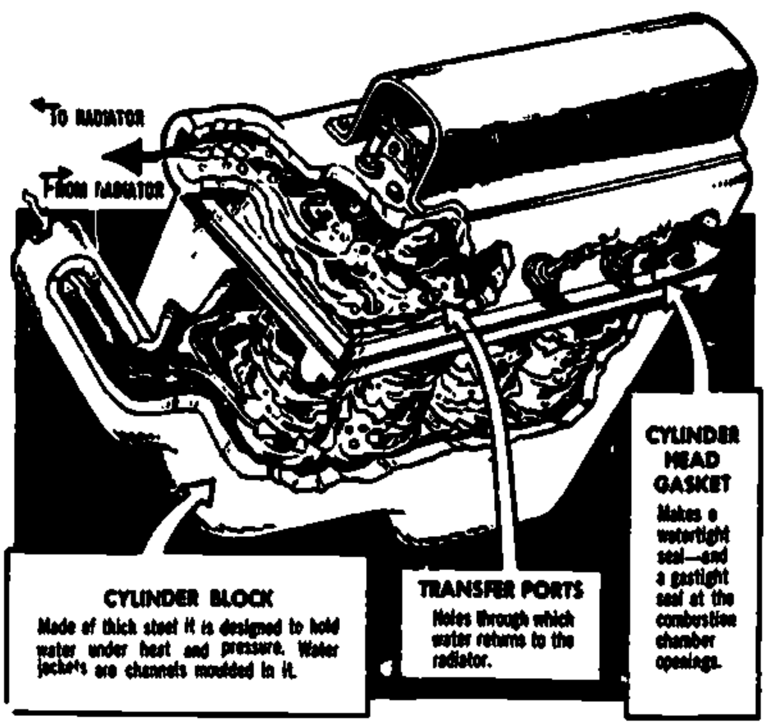


Fig 1-3. Engine water jacket.

Radiator (fig 1-4). Another important part of the liquid-cooled system is the radiator. The radiator has two purposes. First, it acts as a storage tank for the liquid coolant. Second, the radiator cools the liquid as it flows from top to bottom in the core. The air stream flowing through the radiator carries heat away from the core.

14

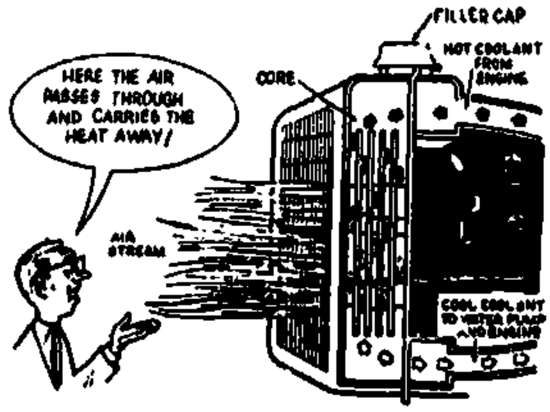


Fig 1-4. Radiator.

Some radiators are equipped with cooling coils, located in the bottom or side tank. Here the transmission lubricant circulates removing the heat from the lubricant, and then returning to the transmission (fig 1-5). This is accomplished by transmission lubricant being pumped from the automatic transmission through metal tubing, which is connected to a fitting on the bottom tank of the radiator, then through cooling coils inside the bottom tank. At this point, the radiator coolant cools the transmission lubricant. After the lubricant is cooled, it circulates out of the radiator back through the metal tubing and the transmission.

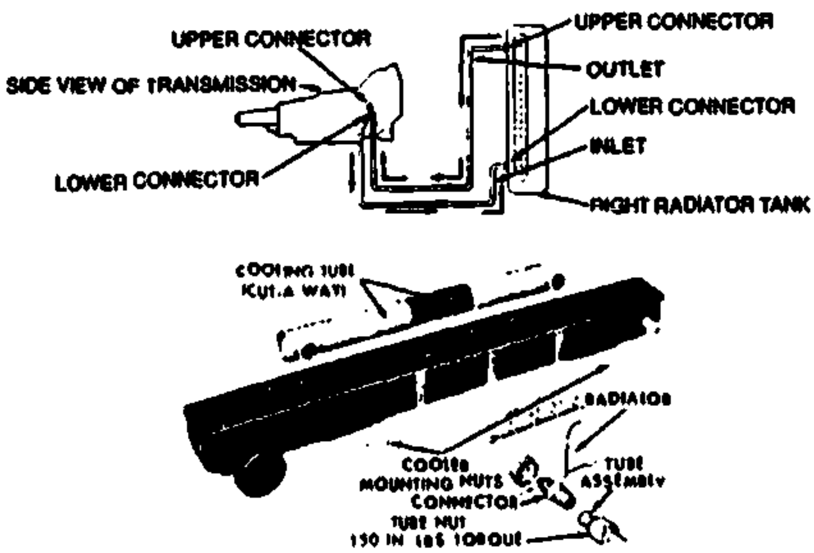


Fig 1-5. Automatic transmission oil cooler.

Water pump (fig 1-6). The water pump keeps the coolant moving through the cooling system. After the engine has been warmed up, the water pump sends the coolant from the engine to the radiator. Then the water pump sends the coolant back to the engine.

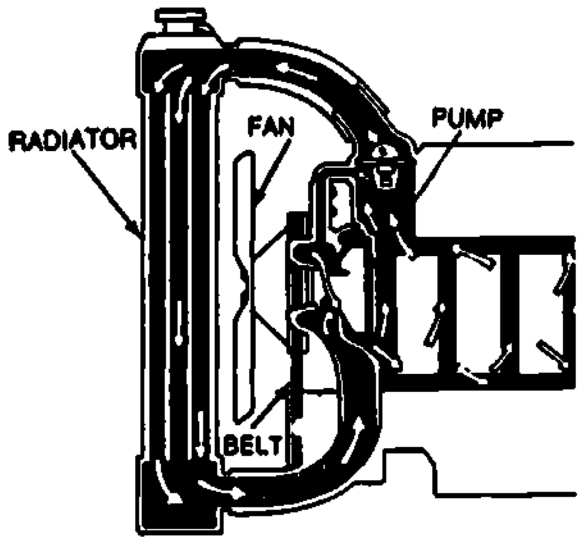
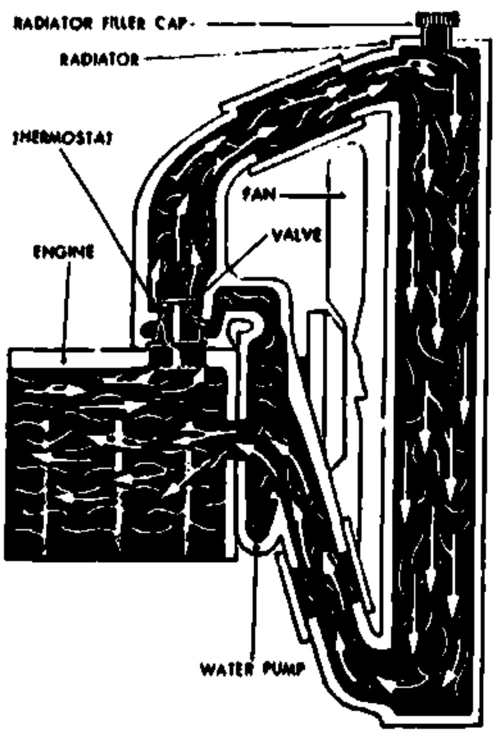
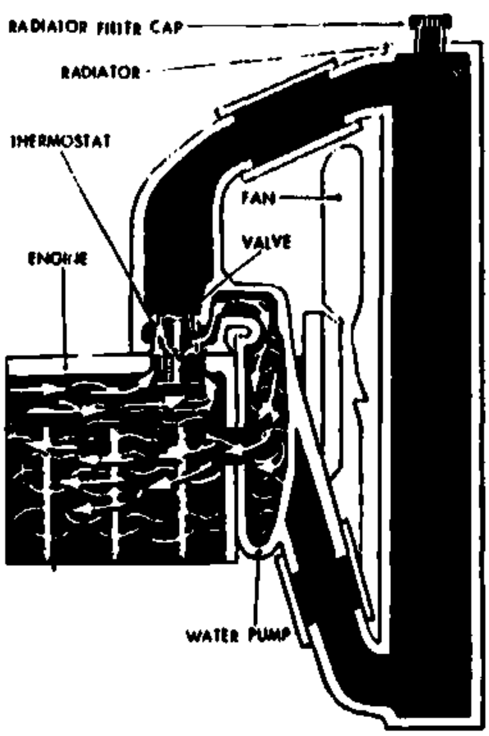


Fig 1-6. Pump circulates coolant from engine to radiator.

Thermostat (fig 1-7). When an engine is NOT warmed up, coolant flows only through the engine. The thermostat is the valve that controls coolant flow. After the engine has been started, heat builds up. As the engine gets hotter, so does the coolant. The thermostat controls the amount of coolant going to the radiator. In this way, the thermostat keeps the engine at just the right temperature.



Engine warm - valve opened by thermostat allows water to circulate through the engine and the radiator.



Engine cold - valve closed by thermostat allows water to circulate through the engine but not the radiator.

Fig 1-7. Thermostat function.

16

Fan (fig 1-8). The last important part of the liquid-cooled system is the fan. When a vehicle is moving fast, air naturally flows through the radiator; however, vehicles are also driven slowly or stand still with the engine running. It is at these times that the fan is needed to draw air through the radiator. A fan belt from the crankshaft provides the power to turn both the radiator fan and the water pump.

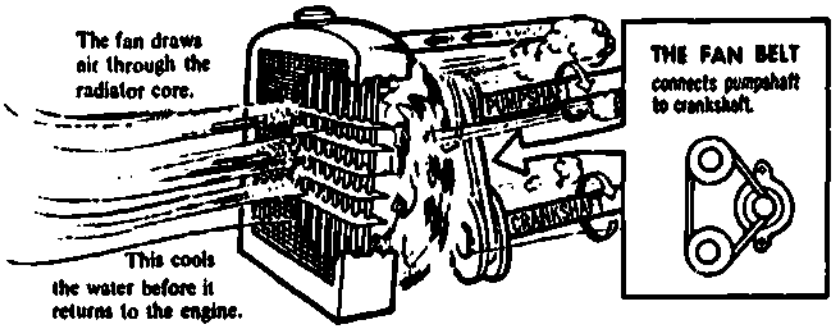


Fig 1-8. Fan and "V" belt.

Overflow/surge tank system (fig 1-9). When the cooling system is equipped with an overflow tank, the pressure cap is placed on the tank instead of on the radiator, and a plain cap is used on the radiator.

Overflow or surge tanks are special equipment for operation in hot or dry climates. The coolant expands as it is heated and contracts as it cools; consequently, the level of coolant in the radiator is constantly changing as the engine's operating temperature changes. This condition is further aggravated when the temperature becomes high enough to change the water to steam. Not only is the expansion much greater, but the pressure also increases.

The overflow tank makes it possible to keep the radiator full at all times. Overflow from the radiator, caused by the expansion or surging of steam vapor within the cooling system, passes through a tube to the overflow tank. The pressure cap on the overflow tank controls the pressure within the system. The plain cap on the radiator effectively seals the radiator opening so that the only vent to the atmosphere is through the cap on the overflow tank. When the coolant cools off, it contracts and the pressure in the upper part of the radiator drops below atmospheric pressure. The pressure in the overflow tank, which is maintained above atmospheric pressure by the pressure cap, forces the liquid to return to the radiator for recirculation through the engine.

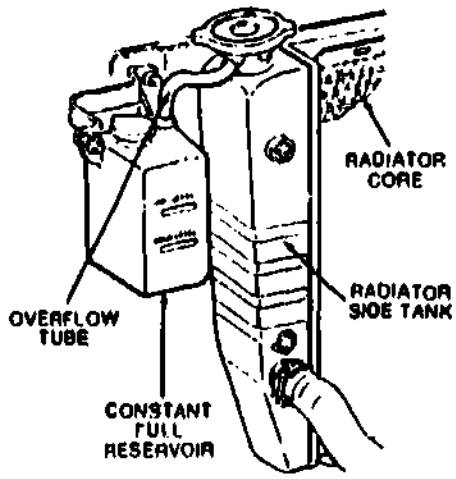


Fig 1-9. Overflow/surge tank.

As you have seen, the liquid-cooled system has several jobs. It assists in the initial engine warm-up by retaining the heated liquid around the engine and it keeps the engine from getting too warm or too cool by adjusting the amount of liquid that goes to the radiator. The liquid-cooled system controls engine heat in all kinds f weather.

EXERCISE: Answer the following questions and check your responses against those listed at the end of this study unit.

1. Which cooling system component provides a passageway for the coolant around the hot cylinders of the engine?

____

2. Which cooling system component stores and cools the liquid coolant?

____

3. Liquid cooling systems use a liquid called ______________________.

Work Unit 1-3. COOLANTS

STATE WHY WATER IS SELDOM USED ALONE IN A COOLING SYSTEM.

NAME THE SOLUTION USED TO PREVENT FREEZING, RUST AND CORROSION IN THE COOLING SYSTEM.

NAME A CHEMICAL SOLUTION USED TO PROTECT YOUR COOLING SYSTEM IF YOU ARE LOCATED IN A WARM CLIMATE.

Certain coolants are prescribed for the liquid-cooled engine; however, you may deviate from these coolants in case of an emergency. We will discuss proper coolants used to maintain the system and touch on liquids which may and may not be used.

Water. The basic coolant for the automotive cooling system is water. Water alone may freeze in cold climates, causing engine damage, and does not contain properties which prevent rust and corrosion of the system.

Antifreeze, a mixture of chemicals, is added to engine water to prevent freezing, rust, and corrosion. There is also on the market an antifreeze product which contains chemicals able to prevent minor cooling systems leaks.

Since you have no control over the ingredients used in antifreeze, they will not be discussed. However, since you can control the amount of antifreeze used in a given quantity of water, we will discuss the preparation of this antifreeze and water solution.

You must first know the capacity of the cooling system in order to protect it properly. This information may be found in the operator's manual, usually in the tabulated data tables. In some cases, you may find it listed in the specifications. In either case, it will be in the first chapter or major section of the technical manual (TM). An example is the TM for 2 1/2-ton trucks (TM 9-2320-209-10/1, Operator's Manual). In this particular manual, the cooling system is located in chapter 1, section 4, Tabulated Data. Although it is true that this is an operator's function, in some cases, you, as the mechanic, may be called upon to supervise or even do this task. The table below is a handy reference for mixing an antifreeze solution:

Table 1-1. Antifreeze Protection

Protection to Fahrenheit	Number of pints of antifreeze per gallon of cooling system capacity
+10	2
0	2-3/4
-10	3-1/4
-20	3-1/2
-30	4
-40	4-1/2

18

Now, let's simulate mixing a solution of antifreeze. Use a cooling system of 22-quart capacity and mix a solution for -30°F for this exercise. First, convert the number of quarts into gallons. Since there are 4 quarts in a gallon, divide 4 into 22 (the number of quarts in the cooling system capacity). The answer should be 5 1/2 gallons. According to the antifreeze solution table, each gallon requires 4 pints of antifreeze to protect the cooling system to -30°F. Since there are 5 1/2 gallons of antifreeze solution required, you will need 22 pints (4 x 5.5) of antifreeze. The simplest method of mixing this solution would be to drain the system and pour 22 pints of antifreeze into the radiator. When this is accomplished, finish filling the radiator with water, put the radiator cap in place and tighten it, then start the engine and let it run for 10 to 15 minutes. The circulation of the coolant will mix the antifreeze with the water, and the result is an antifreeze solution.

Remember, whether mixing the solution in the cooling system or in a separate container, always pour the required amount of antifreeze first to produce the desired amount of solution. Do not pour in a gallon of water and then add 4 pints of antifreeze. This results in 1 1/2 gallons of weak solution instead of 1 gallon of the proper mixture. Test yourself by simulating the mixing of a solution which will protect a cooling system to +10°F. Choose a cooling system that you already know the coolant capacity of. Remember the steps: (1) check the operator's manual, (2) convert to gallons, (3) figure the amount of antifreeze needed (pints per gallon x cooling system capacity), and (4) procedure for mixing.

The antifreeze solution used in the winter may remain in the cooling system all year. This serves as protection against rust and corrosion in warm weather. However, the solution may be changed once a year, preferably just prior to the winter season.

How do you protect your cooling system if you are located in an area where the climate is warm all year and antifreeze is not required? In this case, you may use a cooling system corrosion inhibitor available through the supply system. This is a dry compound, and may be mixed directly in the radiator. Here again, you must determine the capacity of the cooling system. Add one ounce of inhibitor for every two quarts of the system's capacity. A word of caution--be sure to drain enough water from the system to allow space for the dry inhibitor. The inhibitor will mix with the water when the radiator cap is tightened and the engine is operated. Remember that corrosion inhibitor is only a preservative and will not protect against freezing temperatures.

As was mentioned earlier, poor maintenance can leave you "high and dry." If your cooling system happens to "run dry" due to poor maintenance or radiator damage and clean water is not available, you may use any liquid available except those which contain acid such as electrolyte. Petroleum-based liquids may even be used as a last resort provided the system is thoroughly cleaned and flushed as soon as possible. If you must use a petroleum-based liquid, then you must change the hoses as soon as possible to prevent their deterioration.

EXERCISE: Answer the following questions and check your responses against those listed at the end of this study unit.

1. Why is water seldom used alone in a cooling system?

____

2. Name the chemical solution used to prevent freezing, rust, and corrosion in the cooling system.

____

3. What is used to protect your cooling system if you are located in an area where the climate is warm year-round and antifreeze is not required?

____

Work Unit 1-4. METHODS USED TO CLEAN AND CHECK THE COOLING SYSTEM

STATE HOW TO REDUCE CLOGGING AND OVERHEATING OF THE COOLING SYSTEM.

STATE WHY A CLEANING COMPOUND IS USED IN THE RADIATOR.

NAME THE METHOD USED TO FORCE WATER INTO THE OUTLET, AND OUT THE INLET HOLES OF THE RADIATOR.

General. Sometimes it is recommended that you flush the cooling system. You might do this when antifreeze is added or when the antifreeze is drained. Other times flushing may be done only when the coolant is contaminated. At any rate, regular flushing by you, as a mechanic, will reduce clogging and overheating. However, if you notice that the cooling system is clogged, take it in for repairs.

Cleaning materials. An authorized cleaning compound should be used. The cleaner is a very strong acid that will loosen rust, scale, and sludge. The acid will damage cooling system parts if it is allowed to stay in the system, so be sure you apply a neutralizer to stop the action of the cleaner. The cleaner and the neutralizer normally come packed in separate compartments of the same container. Always read and follow the instructions printed on the cleaner container and in the TM for the vehicle you are working on. The following instructions apply to most cleaning compounds and vehicles:

> Run the engine at a fast idle until the normal operating temperature is reached to stir up any loose rust or scale. Stop the engine and remove the radiator cap (5, fig 1-10). (When a radiator overflow tank is used, the radiator cap is referred to as an overflow tank pressure cap.) Open the drain cock on the radiator and the cylinder block drain plug (16 & 8, fig 1-10). Allow the cooling system to drain completely. (This is important as the cleaning action of the cleaner is reduced if any antifreeze or rust inhibitor remains in the cooling system.) Close the radiator drain cock and cylinder block drain plug. Make sure that the engine temperature is below 200 degrees before you fill the cooling system. If the engine is too hot, pouring cool liquid into the system could cause the engine block to crack. Pour the required amount of cleaner into the radiator and then finish filling the system with water. You must be very careful with the acid cleaner. The acid could cause burns on your skin and damage the painted parts of the vehicle. If any is spilled, pour clean water over the affected area immediately. When the cooling system is full, install the radiator cap and start the engine. Continue to run the engine at the 180-200 degree temperature range for at least 30 minutes; then stop the engine and drain the cooling system as before. Close the drain cocks and pour the neutralizer into the radiator. Stop the engine and drain the cooling system.

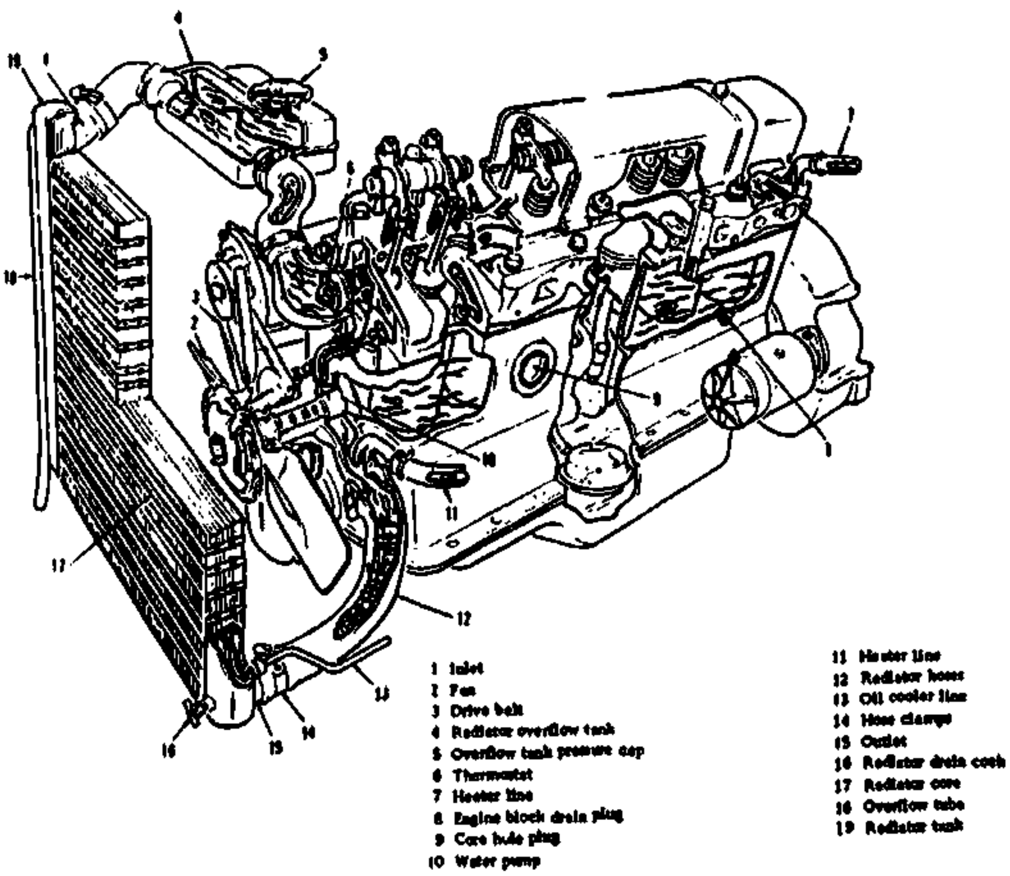


Fig 1-10. Cooling components location.

Now that you have neutralized the acid, you should flush the system to remove any loose particles or residue that remain in the system.

Flushing. There are two basic means of flushing the cooling system.

Normal flushing. Make sure you have closed the drain cocks, and the engine temperature is below 200 degrees. Fill the cooling system with clean, fresh water. Install the radiator cap. Start the engine and allow it to run for about 5 minutes. When the engine has reached normal operating temperature, stop the engine and drain the cooling system. If the water is discolored, repeat this flushing process until it drains clear.

Pressure flushing (fig 1-11). The pressure method is the best for flushing the cooling system, provided you have a flushing gun on hand. This method is more effective for removing rust and scale from the cooling system. Pressure through the system should be opposite the normal coolant flow. This allows the flushing pressure to get behind the deposits, forcing them out.

Pressure flushing of radiator. To pressure flush the radiator, proceed as described below:

Remove both upper and lower hoses connecting the radiator to the engine block. To carry away flushing stream, connect the proper length of hose to the radiator core inlet and another to the radiator outlet opening (lower). At this time, you want to connect the flushing gun to a compressed air source. Connect the water line to a suitable water source. Now you are ready to attach the flushing gun. Clamp the nozzle of the gun into the end of the hose that is attached to the radiator outlet opening (lower). You are ready now to proceed. Tighten the radiator cap. Turn the water on and fill the radiator core. Turn the compressed air on in short blasts. The purpose for this is to prevent core damage. Now turn off the compressed air, allowing the radiator to fill with water. Again, you will apply air pressure as before. Repeat this process until the water comes out clear.

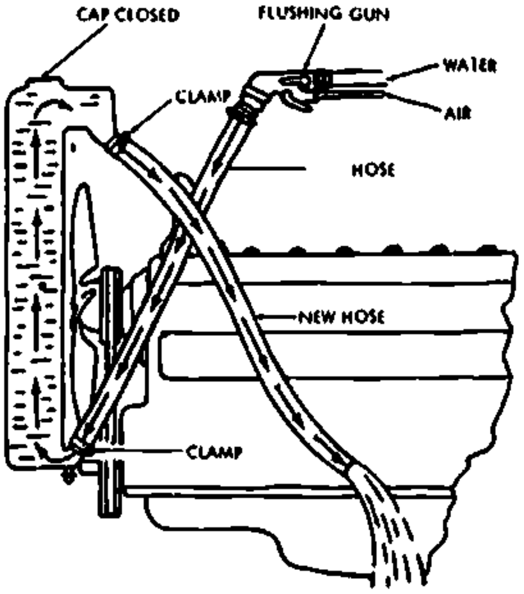


Fig 1-11. Pressure flushing radiator.

Pressure flushing of engine block (fig 1-12). You know that the coolant flows through the engine block also. To flush the engine block, you would proceed as follows: having removed the radiator hoses, remove the water outlet elbow by removing the two bolts that hold it to the block and take out the thermostat (inset, fig 1-12). Then install the water outlet without the thermostat. Connect the flushing gun to the water outlet with a hose. Turn on the water to fill the engine water jacket. You will have to cover the inlet partially on the water pump before the water jacket will fill up. This is because the water pump inlet is lower than the water outlet. Turn on the compressed air to blow out loosened rust and scale with the water. Repeat the process of filling the engine with water and blowing it out with compressed air until the water comes out clean.

Remove the flushing equipment. Inspect, clean, and test the thermostat. (We will discuss the thermostat in a later paragraph.) Install the thermostat, connect the hoses, and close the drain cocks. Fill the cooling system with water and check for leaks. Follow this procedure because the cleaning solution may have uncovered leaks that existed before cleaning but were plugged by rust or corrosion.

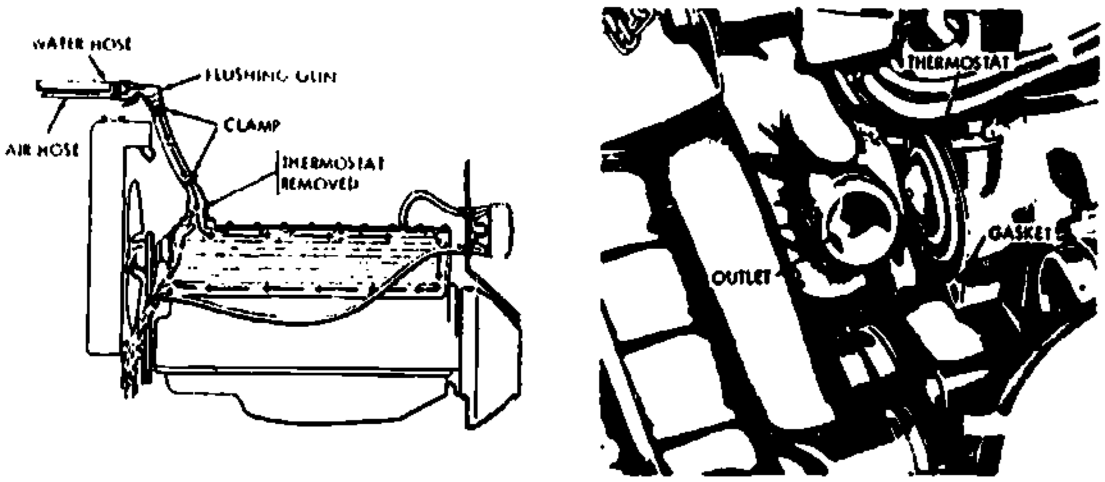


Fig 1-12. Pressure flushing the engine.

EXERCISE: Answer the following questions and check your responses against those listed at the end of this study unit.

1. How can you, as a mechanic, reduce clogging and overheating of the cooling system?

___

2. Why is an authorized cleaning compound used in the radiator?

___

3. Name the method used to force water into the outlet and out the inlet holes of the radiator.

___

Work Unit 1-5. CHECKING COOLANT LEVEL

STATE THE MOST COMMON CAUSE OF OVERHEATING IN THE COOLING SYSTEM.

NAME A COMPONENT THAT MINIMIZES THE LOSS OF COOLANT THROUGH EVAPORATION.

STATE A COMMON CAUSE OF COOLANT LOSS THROUGH THE OVERFLOW OUTLET.

General. The level of coolant in the radiator is the starting point for proper preventive maintenance of the cooling system. Coolant level should be checked accurately as well as frequently for three separate purposes:

To make sure the system always contains enough coolant

As a guide to cooling system condition

To avoid overfilling

Coolant shortage. If the most common cause of overheating is to be avoided, it is important to make sure that the system contains a sufficient quantity of coolant at all times. A low coolant level would prevent proper circulation, especially at lower engine speeds. At higher engine speeds, a low coolant level allows a large volume of air to become mixed with the liquid.

22

Air bubbles in the coolant not only reduce the capacity of the coolant to carry away heat, but also promote rapid rust formation and corrosion, and may cause excessive foaming and coolant loss through the overflow pipe. In any case, coolant shortage leads to overheating, operating difficulties, and engine damage. Having sufficient coolant in the system at all times is especially important in military operations, due to the necessity of being prepared for all possible operating emergencies.

Coolant level as an indicator of the cooling system condition. The third reason for checking the coolant level is generally less understood. In the military, vehicle cooling systems are equipped with a radiator pressure cap allowing very little coolant to escape through evaporation or from any other cause if the system is clean, leakproof, and in proper working order. Therefore, any unusual coolant loss over a period of normal operation may indicate an improper condition within the system. Any such condition should be located and corrected before it causes serious trouble. The operator can assist greatly in the early detection of irregular conditions inside the cooling system by keeping track of the amount of coolant he has to add to keep the coolant at the required level in the radiator. The coolant level should always be checked prior to operation. You should understand that the coolant level will rise as the engine warms up and fall as the engine cools down. Any unusual increase in the amount of coolant needed to bring the level up to that required should be investigated. The operator should add the correct amount of coolant and then report the matter to the proper individual as a possible indication of trouble developing in the system.

Overfilling. If the radiator is continually filled above the specified level or if the engine is not up to normal operating temperature, any changes in the level of coolant will be of little value as an indicator of the cooling system condition. Both water and antifreeze expand when heated, and if there is not enough air space left in the radiator for this expansion, some coolant will be lost through the overflow. Overfilling the radiator while using water results in dilution and weakening of the corrosion inhibitor and/or the antifreeze solution. Unnecessary additions of water increase water scale deposits which interfere with removal of heat from the engine. Overfilling not only wastes antifreeze, but when a system containing antifreeze is overfilled with water, it may lead to a freezeup. The upper diagram in figure 1-13 shows a radiator at 30°F which seems to be underfilled. The bottom diagram shows that it is actually overflowing when the coolant reaches the normal operating temperature of the engine at 160°F.

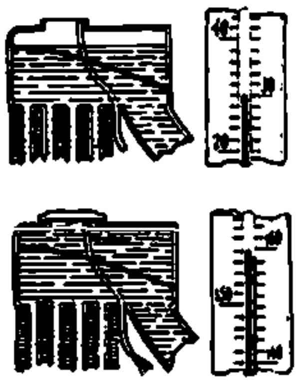


Fig 1-13. Loss of coolant through expansion by heat when radiator is overfilled.

Operator's responsibility. The operator is responsible for keeping the coolant at the proper level so that when the engine is at normal operating temperature the coolant will not overflow. This, then, provides the operator with a reliable indication of possible trouble in the cooling system.

EXERCISE: Answer the following questions and check your responses against those listed at the end of this study unit.

1. What is the most common cause of overheating in the cooling system?

____

2. In military vehicles, what component minimizes the loss of coolant through evaporation?

____

3. Why is it important to check the coolant level prior to vehicle operation?

____

Work Unit 1-6. HYDROMETER

STATE WHY ANTIFREEZE SOLUTIONS ARE TESTED.

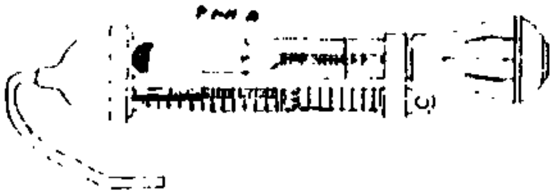
STATE HOW THE FREEZING PROTECTION OF THE SOLUTION IS DETERMINED WHEN USING AN ANTIFREEZE HYDROMETER.

DETERMINE THE POINT AT WHICH ANTIFREEZE AND BATTERY TESTER READINGS ARE REFLECTED.

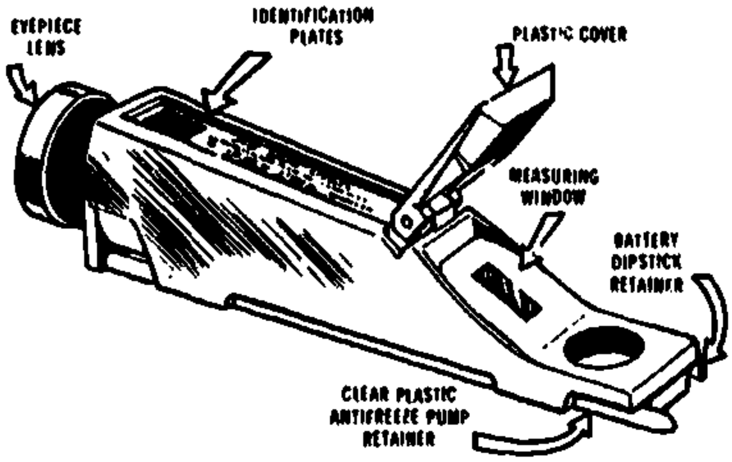
Testing antifreeze. The freezing protection of a solution should be tested at least weekly and more often if the need is indicated because of water addition or weather conditions. This is done to be sure that the antifreeze will give protection at the coldest temperature to which the engine is likely to be exposed and to avoid overheating difficulties from slush freezeup (ice forming in the radiator). Only hydrometers designed for testing ethylene glycol type of antifreeze will give an accurate reading. Check the accuracy of the antifreeze tester occasionally by taking readings on a prepared solution of a known freezing point. If a sample mixture of one part of antifreeze and two parts of water is tested with a hydrometer, a freeze protection down to 0°F should be indicated. One part antifreeze and one part water should indicate a freeze protection down to -30°F. The instructions put out by the manufacturers of the hydrometers should be followed for proper use and care of the hydrometers. We will describe two different models with which you should be familiar. The first is called an antifreeze hydrometer and consists of a glass barrel with a rubber bulb at one end and a rubber tube at the other end, plus a float gage inside the barrel (fig 1-14A). The second is called an antifreeze and electrolyte tester and consists of a plastic housing with an eyepiece at one end and a measuring window at the other end (fig 1-14B).

Use of the antifreeze hydrometer. Before trying to take a reading, make sure that the float gage and the inside of the glass barrel are clean or the accuracy of the reading will be affected. Also, you should fill and empty the barrel several times in order to equalize the temperature of all the parts before you try to take a reading. The first number or letter on the float above the surface of the liquid is read first and the solution temperature is then noted from the first division or number above the top of the thermometer column. These two readings should be made at the same time and as soon as possible after drawing the solution into the hydrometer. The freezing protection of the solution is determined by comparing the float and thermometer readings to the protection chart on the hydrometer (fig 1-14C). Tests will be inaccurate if made immediately after adding either water or antifreeze. Run the engine 5-10 minutes so that the solution reaches a temperature of around 110°F. Even with hydrometers designed to be read at solution temperatures below 0°F, tests should be made with the coolant at a temperature of 60°F, if possible, because the solution is more viscous (thicker) when cold. This condition prevents the float from finding its true level quickly and may result in a false floating reading.

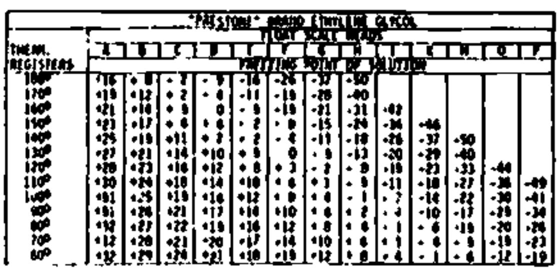
Use of the antifreeze and electrolyte tester. As suggested by the name, the tester serves a dual purpose, that of measuring the degree of antifreeze protection and that of measuring the specific gravity of the electrolyte in the battery. Before using this tester you should make sure that all parts are clean and dry, paying particular attention to the plastic cover and measuring window (be sure to leave it clean and dry when you are finished with it). To test the antifreeze, insert the tip of the clear plastic antifreeze pump into the radiator (without removing the pump completely from the tester housing), making sure that the end is well below the surface of the coolant. Press and release the bulb to draw up a sample of the coolant. Bend the plastic tube around the tester so that you can insert the tip into the opening of the plastic cover. Then press the bulb and eject a few drops of coolant onto the surface of the measuring window. (Do not open the plastic cover when taking readings as evaporation of water from the coolant sample being tested can affect the reading.) Hold the tester up to the light and look through the eyepiece. The scale you see through the eyepiece will be divided into a light area and a dark area (fig 1-14D). At the point where the two areas meet on the scale will be the degree of antifreeze protection. If the edge of the dark area is fuzzy, it indicates that the measuring surface is dirty. Clean it and do the test over again. As was the case with the hydrometer described in the preceding paragraph, you can get an inaccurate reading if you have added water to the coolant just prior to the test. So, run the engine for 5-10 minutes and then make the test.



A. Antifreeze hydrometer.



B. Antifreeze and electrolyte tester.



C. Scale of antifreeze hydrometer.

D. Scale of antifreeze and electrolyte tester.

Fig 1-14. Hydrometers.

EXERCISE: Answer the following questions and check your responses against those listed at the end of this study unit.

1. Why is it important to test the antifreeze solution?

____

2. Antifreeze should be tested ______________________

   a. daily.
   b. once a month.
   c. twice a week.
   d. at least weekly.

3. When using the antifreeze hydrometer, how is the freezing protection of the solution determined?

____

Work Unit 1-7. FILLING AN OVERHEATED COOLING SYSTEM

STATE THE CAUSE OF AN UNUSUAL CHANGE IN THE COOLANT LEVEL IN THE RADIATOR.

Improper coolant level. Check the level of the coolant in the radiator against the level known to be correct. If the level is low, it is possible that a defect or malfunction has occurred in the cooling system. You would fill the cooling system as follows:

Remove the radiator cap slowly, especially if the engine is hot. Turn the cap in the direction of the arrow until it reaches the vent position. Remember always to keep your body away from the radiator cap opening to avoid possible injury. If escaping steam or air is heard, take your hand away from the cap until the noise stops. If the engine is overheated, it is better to run the engine at a fast idle than to turn it off. This will allow the radiator to do its job. If you turn the engine off, some engine parts might seize up. After the pressure is released, turn the cap as far as it will go and lift it off. Add coolant slowly with the engine running at a fast idle.

Caution: Never add coolant to an overheated engine until boiling has stopped and the temperature gage reads under 200°F (fig 1-15).

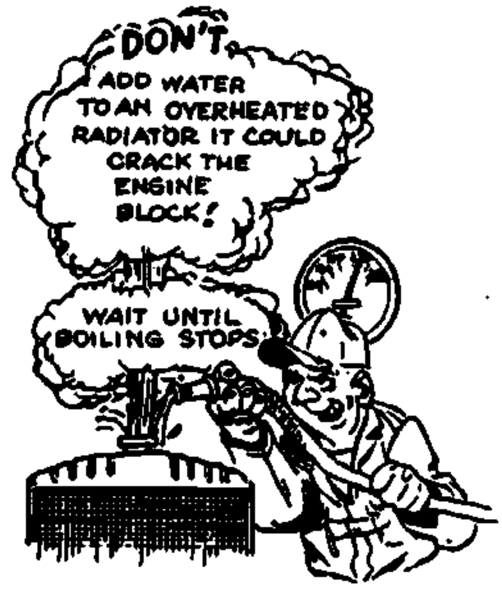


Fig 1-15. Overheating radiator.

Run the engine until it warms up to a point where the thermostat opens and releases trapped air. If necessary, add more coolant to bring the level up to the proper point.

Note: Be sure to allow the engine to cool before you attempt to add any coolant.

EXERCISE: Answer the following question and check your response against those listed at the end of this study unit.

1. An unusual change in the level of coolant in the radiator from the one normal level would indicate what?

____

Work Unit 1-8. HOSE DETERIORATION

STATE THE CAUSE OF A PUFFED OUT RADIATOR HOSE.

STATE THE CAUSE OF A RADIATOR HOSE THAT WRINKLES OR FOLDS INWARD WHILE THE VEHICLE ENGINE IS RUNNING.

Hose deterioration (fig 1-16). Bad hoses and overheated engines just naturally go together. If you see any water around the hoses, then you know something is wrong. But even before hoses start to leak, watch out for these DANGER SIGNS.

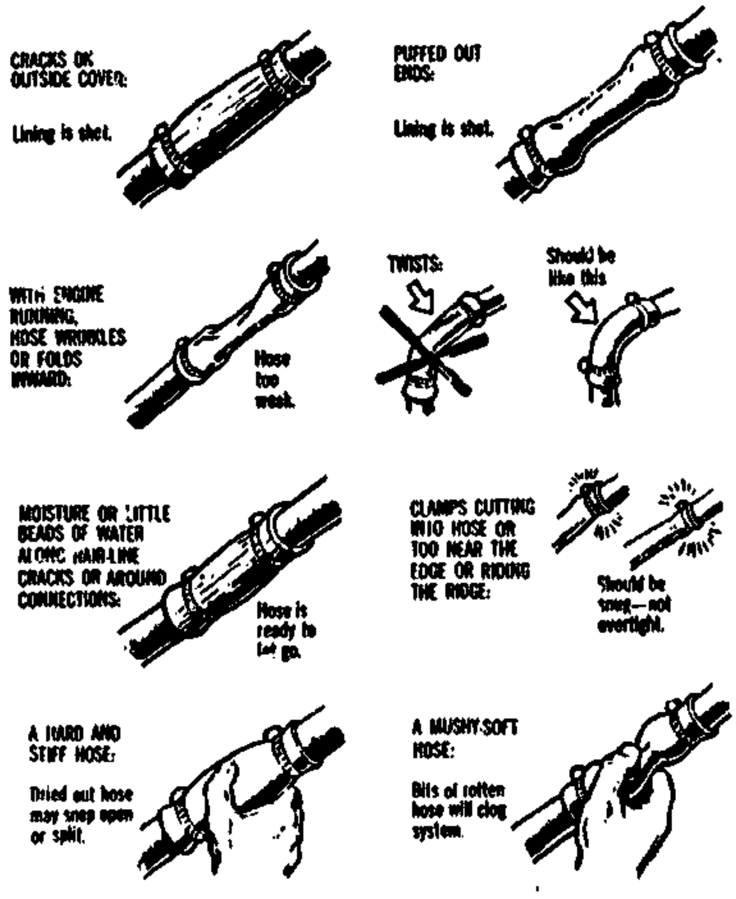


Fig 1-16. Hose deterioration.

EXERCISE: Answer the following questions and check your responses against those listed at the end of this study unit.

1. What could cause the ends of a radiator hose to puff out?

____

2. If a radiator hose wrinkles or folds inward while the vehicle engine is running, what could be the problem?

____

Work Unit 1-9. DRIVE BELT REPLACEMENT

GIVEN A SITUATION IN WHICH ONE OF THE TWO DRIVE BELTS OF THE COOLING SYSTEM BECOMES FRAYED, STATE THE CORRECTIVE ACTION.

Drive belt deterioration (fig 1-17). Drive belts (also referred to as "V" belts or fan belts) must be checked often to make sure that they are in good condition and properly adjusted. Belts that are badly frayed, worn, or cracked should be replaced before they break in operation and cause the engine to overheat. When more than one belt is used, they must be replaced in matched sets. Belts will stretch with use, thus making adjustment difficult if used with a new belt.

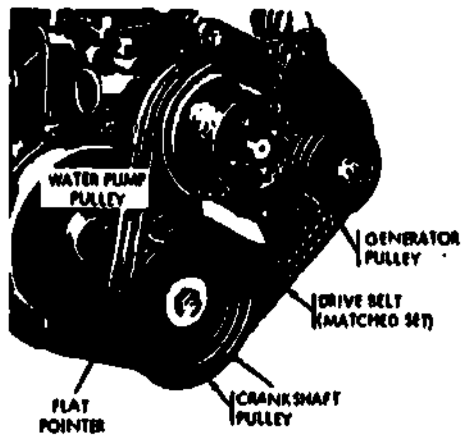


Fig 1-17. Drive belts.

EXERCISE: Answer the following question and check your response against the one listed at the end of this study unit.

1. Your cooling system has two drive belts. One becomes frayed and must be replaced. What should you do with the other belt?

___

Work Unit 1-10. METAL DETERIORATION

STATE THE RESULT OF EXCESSIVE AIR IN THE COOLING SYSTEM.

STATE THE CAUSE OF EXCESSIVE FOAMING, COOLANT LOSS, AND ENGINE OVERHEATING.

Metal deterioration (fig 1-18). Because there is moving water going through the cooling system, dirt and bits of crud are left in the passages. These are called scale or rust deposit. These deposits will collect in the cooling system over a period of time. If these deposits are not removed, they will eventually clog water passages in the cooling system.

Rust causes leaks and builds up sludge that slows down circulation and retards cooling. Rust is caused by water reacting chemically with metal. Air enters the system through the overflow pipe or through leaks in the system. The radiator cap is the normal source of air in the radiator. Rust also comes from a damaged, leaky head gasket that allows exhaust gases to be blown into the cooling system. These gases contain strong acids that tend to cause rust.

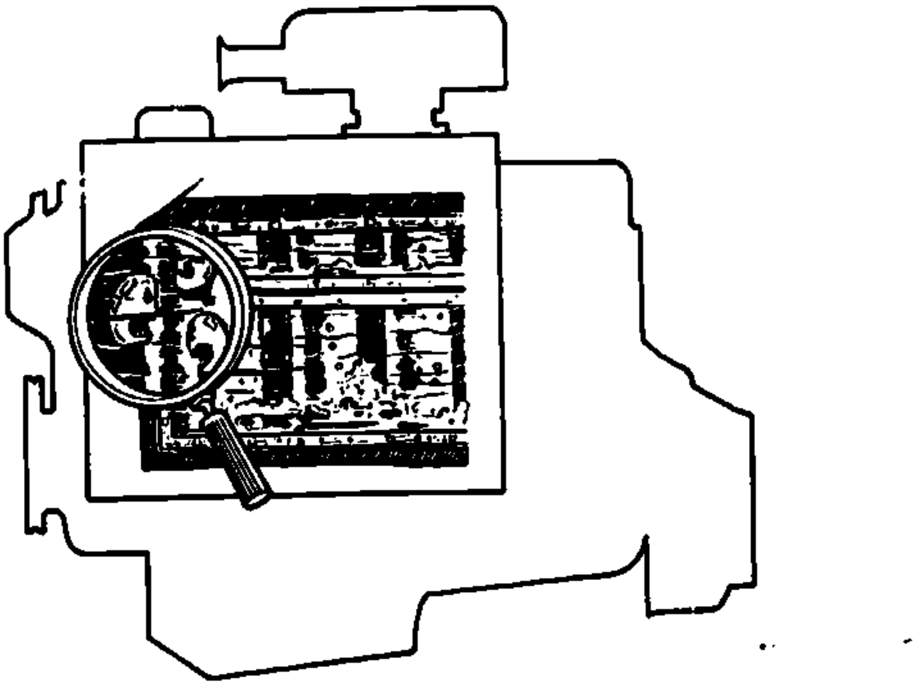


Fig 1-18. Metal deterioration.

Air in coolant (fig 1-19). Air mixed with water can increase the corrosion of iron by as much as 30 times. Normal aeration in the cooling system takes place in the radiator top tank where air that enters the system is trapped. At higher engine speeds, the rush of coolant into the radiator is great enough to drive air into the liquid and carry air bubbles down through the water tubes. The normal expansion of the coolant as it is heated up will force most air out of the system. However, if the coolant level is allowed to drop as low as the top of the water tubes, the suction of the water pump will draw air in through the overflow pipe and down through the water tubes, causing excessive foaming and additional coolant loss.

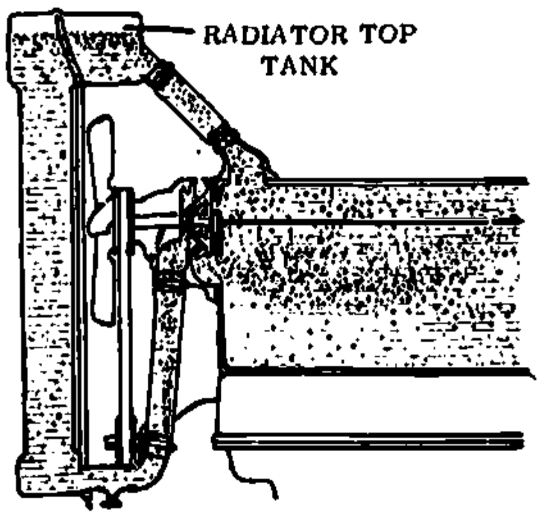


Fig 1-19. Air in coolant (aeration).

EXERCISE: Answer the following questions and check your responses against those listed at the end of this study unit.

1. Scale or rust deposits caused by excessive air in the cooling system may result in

____.

2. Excessive foaming, coolant loss, and engine overheating may be caused by what?

____

Work Unit 1-11. CRACKED BLOCKS

STATE THE RESULT IF LEAKAGE IN THE COOLING SYSTEM IS NOT REPAIRED.

STATE THE RESULT OF WATER FREEZING IN THE ENGINE'S COOLING SYSTEM.

Leakage (fig 1-20). Leakage is common in the cooling system, due to stresses and strains around the various connections. Engine vibration, road shock, and deterioration of metal parts are causes of leakage. These conditions are often severe in military operations. Radiator pressure caps, used on military vehicles, create pressure in the system increasing leakage at various connections. Accidental damage can occur without your knowledge. Small coolant leaks may not be noticed when the engine is hot because of the rapid evaporation of the coolant after it leaves the cooling system. Antifreeze leakage is easier to find because it evaporates more slowly than water. Grayish-white stains at connections or joints indicate leakage. Small leaks should be repaired right away or you may suffer a sudden, major breakdown when you least expect it. Leakage of any kind in the cooling system that is not corrected will result in overheating. This neglect could cause the failure of your mission.

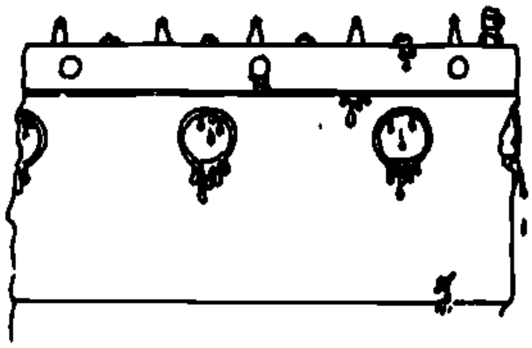


Fig 1-20. Outside leakage of engine water jacket.

Cracked block (fig 1-21). Another cause of coolant loss could be a cracked block or water jacket. This damage is usually caused by allowing water to freeze in the cooling system. A cracked block could also result from an overheated engine or by adding water to an overheated radiator.

30

Fig 1-21. Cracked engine block.

EXERCISE: Answer the following questions and check your responses against those listed at the end of this study unit.

1. Leakage of any kind in the cooling system that is not corrected will result in ______________________.

2. What is the result of water freezing in the engine cooling system?

____

Work Unit 1-12. CRACKED CYLINDER HEAD OR LEAKING HEAD GASKET

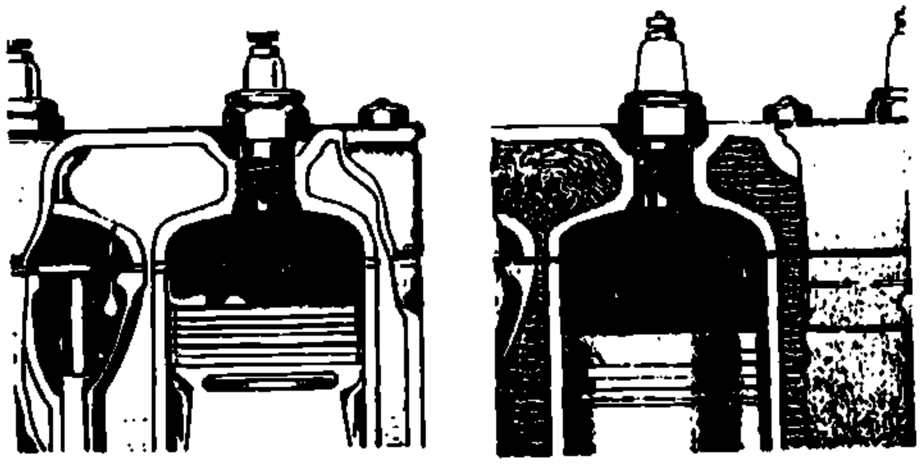
STATE THE CAUSE OF COOLANT IN THE ENGINE OIL AND EXHAUST GASES.

STATE A CAUSE OF AN OVERHEATED ENGINE DUE TO IRREGULAR COOLANT FLOW.

DETERMINE WHEN THE THERMOSTAT SHOULD BE REMOVED.

NAME THE PART OF THE RADIATOR DESIGNED TO CONTROL THE PRESSURE IN THE COOLING SYSTEM.

Cracked cylinder head or leaking head gasket (fig 1-22). Leakage around the head gasket or leakage from a cracked cylinder head will affect coolant level. The joints are subject to extreme pressures, which may reach as high as 600 pounds per square inch (psi). These coolant leaks usually cannot be detected from outside the engine. There is a good chance that coolant will leak into the engine oil, where it may cause serious damage. Even though the gasket is tight enough to prevent coolant leakage, exhaust gasses can be forced into the cooling system (fig 1-22). This can force the coolant out the overflow pipe.



A. Cracked head and leaking head gasket-coolant leakage.

B. Exhaust gas leakage.

Fig 1-22. Leakage.

Defective components. The loss of coolant will greatly increase the engine temperature and is the most common cause for an overheated engine. In the last paragraph, you were able to see some of the reasons for coolant loss. Now you will have a chance to look at other factors that can cause excessive engine temperatures without involving the loss of coolant.

Thermostat (fig 1-23). The function and operation of the thermostat is such that this indispensable unit does not have an indefinite service life and can fail with little or no advance warning. It is the valve that controls coolant flow in the engine. The valve and operating mechanism are subjected to extreme temperature changes, corrosion, and also to wear and bending movement. Rust or foreign matter in the coolant interferes with proper thermostat operation, and overheating from any cause may damage it. Defective thermostats may stick open or closed or they may leak. The thermostat should be removed only when necessary for testing or replacement.

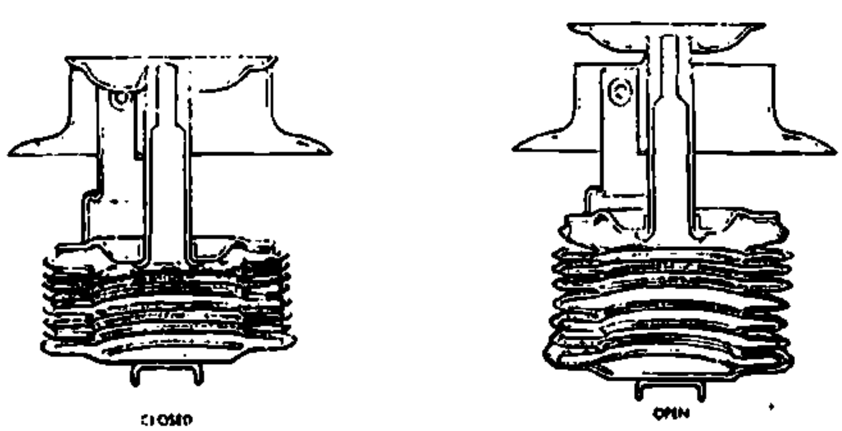


Fig 1-23. Thermostat.

Radiator cap (fig 1-24). Military vehicles are equipped with a pressure radiator cap (fig 1-34). This type of cap allows the coolant to reach a higher temperature before boiling; thus the engine can operate at a higher temperature before overheating (more efficient operation). The boiling point for water is 212°F. Using a pressure-type radiator cap that has a pressure release of 4 psi (pounds per square inch) will increase the boiling point to 225°F. Some radiator caps are designed to withstand a much higher psi to allow the engine to operate at a higher temperature. An air leak above the liquid level in the radiator, such as at the radiator cap gasket or pressure valve, will prevent pressure from building up, and benefits of the pressure cap will be lost. Coolant may boil in some cooling systems even at normal operating temperature if the cap is not pressure-tight. On the other hand, if the pressure release (blow-off) valve fails to open, undesirable excess pressure may build up in the system and break the radiator seams or blow off the hose connections. Failure of the vacuum valve to open when the system cools may cause collapse of hoses and other parts which have no internal support.

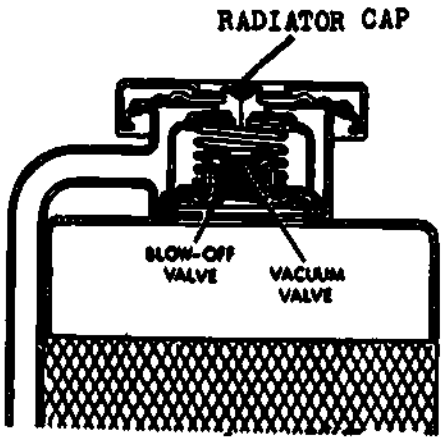


Fig 1-24. Radiator cap.

EXERCISE: Answer the following questions and check your responses against those listed at the end of this study unit.

1. What could cause coolant in the engine oil and exhaust gases?

____

2. Engine overheating caused by irregular coolant flow may be due to _______________

_______________.

3. When should the thermostat be removed?

____

4. Which part of the radiator is designed to control the pressure in the cooling system?

____

Work Unit 1-13. WATER PUMP

STATE WHY AN ENGINE OVERHEATS WHEN THERE IS A LACK OF COOLANT CIRCULATION.

Water pump (fig 1-25). The water pump is the only power driven unit in the cooling system. Pump failures are most often caused by broken or loose drive belts. Because the water pump is driven by the belt(s), any slippage of the belt(s) on the pump pulley or a broken belt not turning the pulley will prevent the pump from circulating the coolant. Edge wear of impeller blades and wear of the pump housing also reduce pumping capacity. Sand, rust, and other abrasive foreign matter in the coolant have a tendency to wear away impeller blades. Corrosion of impeller blades and pump housing may result from the failure to add a corrosion inhibitor to the water or to discard rusty antifreeze solution.

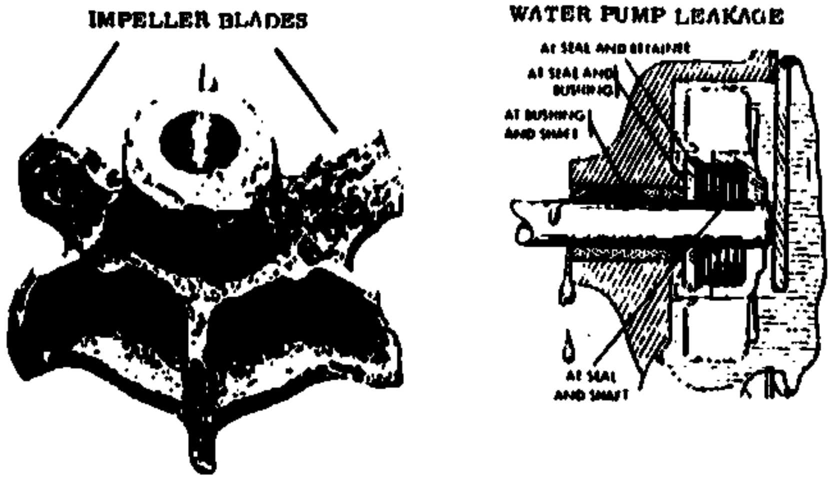


Fig 1-25. Causes of water pump failure.

Drive belts (fig 1-26). The fan and water pump receive their propelling motion from the drive belt which is connected to a pulley on the crankshaft. Normally, this belt also drives the generator. Other vehicles may have separate belts for one or two of these units, or two belts to drive a single unit. In any case, proper operation of the water pump drive belt ("V" belt) is most critical. When the water pump stops during engine operation, overheating of the engine follows almost immediately. Several things can happen to drive belts. They stretch, wear out, or sometimes break while in service. Adjustment of belt tension is by movable mountings on one or more units driven by the belts.

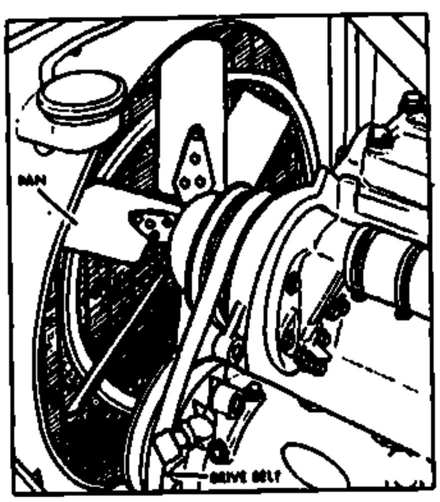


Fig 1-26. Drive belt.

EXERCISE: Answer the following questions and check your responses against those listed at the end of this study unit.

1. Engine overheating caused by lack of coolant circulation may be caused by__________

____

2. Broken or loose drive belt(s) will cause ________________.

   a. water pump failure
   b. air bubbles in the system
   c. the thermostat to fail
   d. diluted coolant due to improper mixing

SUMMARY REVIEW

In this study unit, you have learned the purpose of the engine's cooling system and its main components. You have also learned how to identify trouble shooting indicators and how to maintain the cooling system.

In the next study unit, you will learn how to remove and repair a damaged or worn cooling system component.

Answers to Study Unit #1 Exercises

Work Unit 1-1.

1. To act as an indirect medium carrying the heat from inside the engine and transferring it into the air

Work Unit 1-2.

1. Engine water jacket
2. Radiator
3. Coolant

Work Unit 1-3.

1. Because it does not have any properties that prevent rust and corrosion of the system
2. Antifreeze
3. A cooling system corrosion inhibitor

Work Unit 1-4.

1. By regularly flushing the cooling system
2. To loosen rust, scale, and sludge
3. Pressure flushing

Work Unit 1-5.

1. Shortage of coolant
2. The radiator cap
3. Because the coolant will rise as the engine warms up and an accurate reading cannot be obtained

Work Unit 1-6.

1. To ensure that the coolant provides protection against freezing temperatures
2. d.
3. By comparing the float and the thermometer readings with the protection chart on the hydrometer

Work Unit 1-7.

1. A defect or malfunction in the cooling system

Work Unit 1-8.

1. The hose lining could be worn out.
2. The radiator hose could be too weak.

Work Unit 1-9.

1. You should replace it along with the one that is frayed.

Work Unit 1-10.

1. the cooling system passages becoming clogged
2. Aeration

Work Unit 1-11.

1. engine overheating
2. A cracked block

Work Unit 1-12.

1. A loose or leaking cylinder head gasket
2. a damaged thermostat
3. When it is necessary for testing or replacing only
4. Radiator cap

Work Unit 1-13.

1. a water pump failure
2. water pump failure

STUDY UNIT 2

COOLING SYSTEM REPAIR

STUDY UNIT OBJECTIVE: WITHOUT THE AID OF REFERENCE, YOU WILL IDENTIFY COOLING SYSTEM REPAIRS AND REBUILD PROCEDURES.

Work Unit 2-1. RADIATOR HOSE REMOVAL/REPLACEMENT PROCEDURES

STATE AN ACTION THAT WOULD ALLOW COOLANT TO FLOW MORE FREELY OUT OF THE RADIATOR DRAIN COCK.

STATE WHY CARE IS TAKEN WHEN DISCONNECTING THE UPPER RADIATOR HOSE FROM THE RADIATOR INLET.

DETERMINE THE TYPE OF RADIATOR HOSE TO BE USED UPON REPLACEMENT.

The inspection procedures for the cooling system are similar for all vehicles but the repair of the parts varies a great deal. You should always refer to the technical manual for specific procedures and specifications concerning the vehicle you are working on. You should inspect the complete cooling system of a vehicle before making any repairs to the cooling system. We will discuss the inspection, testing, repair, and replacement of the parts of the cooling system one part at a time.

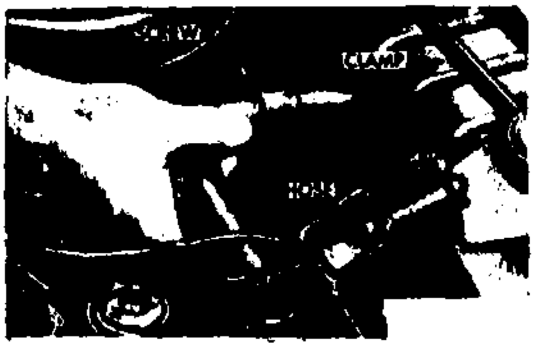
Draining the system (fig 2-1). It is a good practice to allow the cooling system to cool down before you attempt to drain the coolant. Always loosen the radiator cap before you open the radiator drain cock. This will allow the coolant to flow out more freely. Open the radiator drain cock to drain the coolant. If the coolant is going to be reused, catch it in a clean container.

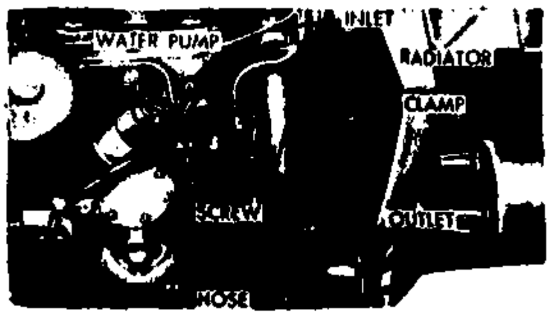
Fig 2-1. Radiator drain cock.

Hose removal (fig 2-2).

Upper hose. Disconnect the upper radiator hose from the radiator inlet. This is done by loosening the hose clamp screw and pulling the hose off the inlet pipe. Use care when pulling the hose off as the inlet pipe is made of thin metal and is easy to damage. Repeat the procedure at the engine end of the hose.

Lower hose. Disconnect the lower radiator hose from the radiator outlet in the same manner that you disconnect the upper hose (radiator and engine).





Upper Lower

Fig 2-2. Hose removal.

Hose replacement. Use the hose specified in the TM. Hoses have different shapes and the one specified in the TM has been manufactured with the special demands of your pumps and engine in mind. You should try to get a new hose; old ones can be dangerous. Follow the removal procedures in reverse when replacing the radiator hose. Hose clamps must be properly positioned and securely tightened to insure a watertight seal. Refer to figure 2-3 for some good tips on installing a hose. If you follow them, you will save time and effort and get a better installation.

Fig 2-3. Hose replacement.

38

EXERCISE: Answer the following questions and check your responses against those listed at the end of this study unit.

1. When you open the radiator drain cock, the coolant flows out at a very slow rate. To allow the coolant to flow more freely, you would ______________________________

____

2. When disconnecting the upper radiator hose from the radiator inlet, care must be taken so as NOT to do what? ______________________________

____

3. When replacing radiator hoses how would you determine which type of hose to use?

____

Work Unit 2-2. RADIATOR REMOVAL/REPLACEMENT PROCEDURES

NAME THE COMPONENT PART REMOVED AFTER THE RADIATOR SHROUD IS REMOVED.

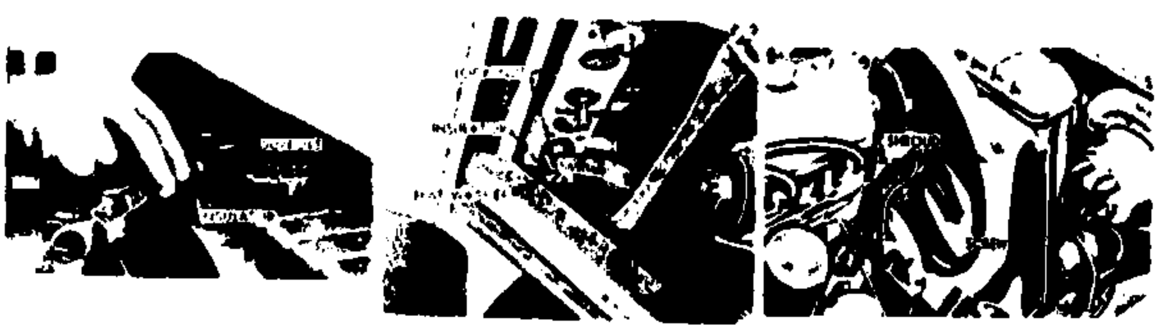
STATE HOW TIGHT THE LOWER RADIATOR BOLTS SHOULD BE WHEN REPLACING THE RADIATOR.

Removal procedures (fig 2-4). Since there are many different radiator designs, it would be impossible to explain all of the methods of removal. Removal procedures are basically the same so we will talk about the radiator removal procedures for a vehicle which you are familiar with, the M151 1/4-ton. You should begin by following the steps explained in paragraph 2-1. Now you are ready to complete the final steps of removal.

Step 1. Disconnect radiator insulator assembly from radiator support and engine lifting eye.

Step 2. From the underside of the vehicle, remove two radiator mounting back nuts, flat washers, and insulator.

Step 3. The radiator is now loose, but before it can be lifted out, the shroud will have to removed. The shroud acts as a hood placed around the fan to improve the fan action, directing the flow of air to the engine. The shroud is secured to the radiator mounting by six screws, three on each side. After removing the six screws, slide the shroud toward the engine and flip over the fan, and remove the radiator.



Step 1 Step 2 Step 3

Fig 2-4. Radiator removal.

Replacement procedures. Reverse the removal procedures for installing the new radiator. Using a torque wrench, tighten the two lower radiator mounting nuts and the two nuts on the ends of the upper insulator to the required torque given in the vehicle's TM.

EXERCISE: Answer the following quostions and check your responses against those listed at the end of this study unit.

1. The radiator shroud must be removed before the ______________ can be removed.

2. How tightly should the lower radiator bolts be tightened when replacing the radiator? ____

Work Unit 2-3. RADIATOR TESTING PROCEDURES

STATE THE PURPOSE OF A FLO-TESTER.

NAME THE PERCENTAGE OF CLOGGING IN A RADIATOR, IF THE GALLONS PER MINUTE (GPM) READING IS 15 AND THE GPM SPECIFIED IS 30.

RADIATOR REPAIR PROCEDURES

Flo-Tester (fig 2-5). An accurate, portable Flo-Tester will quickly determine the percent of plugging (how much is clogged up) without the radiator being removed from the vehicle. The Flo-Tester requires a water pump, a gallons per minute (GPM) flow gage, a reservoir tank and connecting hoses and adapters. The water pump must have the required capacity in rated gallons per minute and the delivery rate must be controllable. The flow gage must accurately measure and indicate the flow in GPM. Radiator manufacturers measure the GPM flow of new radiators to establish performance specifications. The Flo-Tester measures the gravity flow rate of the radiator by maintaining the wat r level constant in the upper tank while the gravity force drains the radiator through the bottom outlet neck. The measured rate is compared to the manufacturer's specification. Percentage of restricted flow may be determined by the following formula:

$$\% \text{ plugged} = 100\% - \frac{(\text{GPM reading} \times 100\%)}{\text{GPM specified}}$$

Example: GPM reading = 15
GPM specified = 20

$$\% \text{ plugged} = 100\% - \left(\frac{15}{20} \times 100\%\right)$$
$$= 100\% - (.75 \times 100\%)$$
$$= 100\% - 75\%$$

$$\% \text{ plugged} = 25\%$$

Performance charts for most radiator flow gages show that they are accurate at only one GPM rate.

a. Flo-Test procedure (radiator not removed from the vehicle).

(1) Remove the radiator cap and drain the cooling system. (If the antifreeze solution is clean and free from rust, it may be saved for subsequent use.)

(2) Disconnect the radiator inlet and outlet hoses at the radiator necks.

(3) Connect the Flo-Tester discharge hose to the radiator inlet (top) neck. Make sure that the connection is tight and that test pressure will not blow the hose from the neck connection.

(4) Examine the lower outlet neck making sure that discharged water will not flow on vital engine parts. Use a deflector made from sheet metal, canvas, or rubber.

(5) Start the Flo-Tester pump and gradually increase the water delivery rate until the water level appears in upper tank. Adjust the water delivery rate until the water level remains constant in the base of the filler neck. The water level should be slightly below the overflow opening; otherwise, an inaccurate reading will result.

(6) Record the flow gage reading and determine the percentage from the preceding formula.

(7) If the reading is acceptable, reconnect the hoses to the radiator and refill with coolant. Run the engine for about 10 minutes to remove air pockets in the cooling system and fill again to proper level.

(8) If the reading is unacceptable, the radiator should be either back-flushed or removed for vat cleaning and possible rodding.

(b) Flo-Test procedure (radiator removed from vehicle).

(1) Remove the radiator cap and place the radiator in normal operating position in the Flo-Tester rack.

(2) Position the radiator so that the lower outlet neck of the radiator will discharge back into the Flo-Tester tank.

(3) Connect the Flo-Tester output hose to the upper inlet neck of the radiator. Start the Flo-Tester pump and gradually increase the pump delivery rate until the water level is raised to the base of the radiator filler neck. Maintain water at this raised level. Make sure water is not discharging from the small overflow in filler neck. Observe and record the GPM gage reading. This test should be made prior to any radiator repairs.

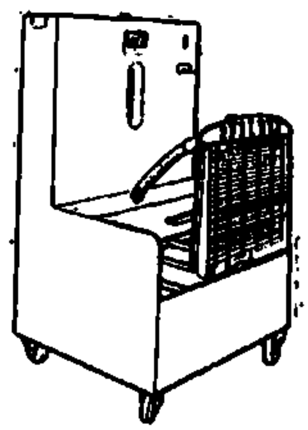


Fig 2-5. Flo-Tester.

EXERCISE: Answer the following questions and check your responses against those listed at the end of this study unit.

1. What is a Flo-Tester used to determine? ______________________________

____

2. You are testing a radiator with a Flo-Tester. The GPM reading is 15, but the GPM specified is 30. What is the percentage of clogging in the radiator? __________

____

Work Unit 2-4. CLEANING THE RADIATOR

STATE WHAT MUST BE DONE PRIOR TO TESTING OR REPAIRING THE RADIATOR.

STATE THE REQUIRED ACTION WHEN PREPARING TO AIR LEAK TEST A RADIATOR, IF YOU SEE OBVIOUS LEAKS.

STATE THE MAINTENANCE ACTION PERFORMED TO ENSURE THAT THE RADIATOR CAP FUNCTIONS PROPERLY.

Cleaning. There are various methods used in cleaning the radiator. We spoke of the normal flushing and the pressure flushing method earlier in the course. If you recall, these two methods were accomplished with the radiator in the vehicle. A radiator should be cleaned prior to testing or extensive repairs. This will assist you in locating leaks that otherwise may go unnoticed. We will now cover some of the procedures used in cleaning the radiator when it is out of the vehicle.

Spray cleaning. Spray cleaning requires the same equipment as pressure flushing. The spray of water under air pressure forces out dirt, bugs, and other material lodged between the fins so that free circulation of air around all parts of each tube and fin is restored (fig 2-6).

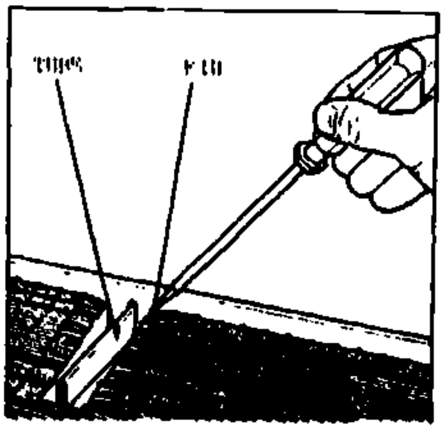


Fig 2-6. Radiator tube and fin.

Boiling out radiator (fig 2-7). Sediment which is so firmly packed in the radiator that pressure flushing will not remove it must be boiled out. Suitable chemical solution is used in a radiator test and repair stand. The stand is made so that the radiator may be lowered beneath the surface on a lever-controlled rack. Leave it there long enough to loosen the scale, rust, and other foreign matter and then rinse it with clean water.

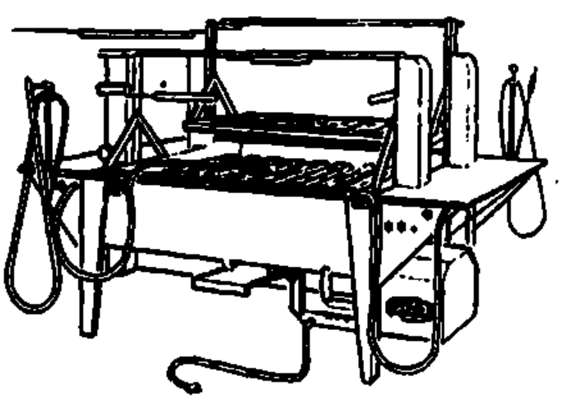


Fig 2-7. Radiator test and repair stand.

Vat cleaning preparation (fig 2-8). A heated vat with a cleaning solution is the most effective method of cleaning a radiator when it is out of the vehicle. Before vat cleaning all radiators should be Flo-Tested. The gallons per minute (GPM) flow should be recorded to be compared with the GPM reading after cleaning. The vat must be large enough to contain the entire radiator. It should be constructed of material that is unaffected by the caustic action of the cleaning compound. You must have a method of heating the solution and a means of controlling and regulating the temperature. You need a drain on the vat for changing the solution when it becomes dirty from use.

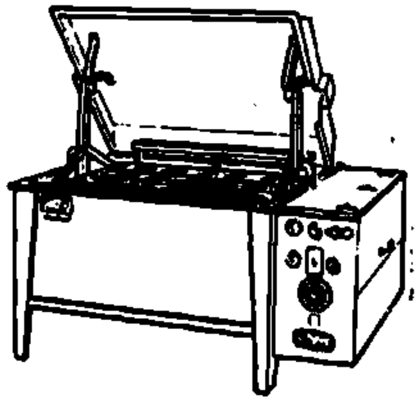


Fig 2-8. Radiator vat cleaner.

Vat solution. The vat should contain a solution of water and radiator cleaning compound. It should be maintained at the proper temperature when in use. Cleaning compound is normally used in a quantity of 5 to 8 ounces per gallon of water. The most effective solution temperature is 190°F to 200°F. When you are working with the hot cleaning solution in the vat you should wear safety goggles, a rubber apron, and gloves as protection against the hot vat solution. The new vat solution becomes most effective after being maintained at operating temperature for a short period of time. This enables the chemicals in the compound to react and come to balance.

Warning: If hot cleaning vat solution, muriatic acid, or flux gets in your eyes, flush them with clean water and then seek medical attention as soon as possible.

When you mix a new solution, add the cleaning compound gradually in small amounts to cold water, then heat and maintain the solution temperature at about 195°F. To bring a weak cleaning solution up to strength, start with the addition of one ounce of compound per gallon of the existing vat contents. A solution that is too strong decreases the cleaning effectiveness because the mixture is not at an even balance with the liquid, thereby losing its effect. When adding small amounts of compound, the vat should be at operating temperature to achieve the best results.

Caution: Adding large amounts of cleaning compound to a hot vat will cause violent boiling. You should slowly add only small amounts. Never add water to the dry compound but instead add the compound to the water.

Placing the radiator in the vat. The length of time required to clean the radiator will be governed by the condition of the radiator and the thickness of deposits that have accumulated inside the radiator. You should remove material such as insects from the outside of the radiator with an air gun before vat cleaning. This reduces contamination of the vat solution. Place the radiator flat on the rack in the vat (fig 2-8). You would normally leave the radiator in the vat for about one hour. If the radiator has oil cooler openings you would seal them with a plug or a suitable device.

Caution: Aluminum radiators should not be cleaned with caustic-base cleaning agents.

After following the above procedures, you are now ready to lower the radiator into the vat. Do this slowly until the radiator is completely covered with the hot solution. If violent boiling occurs when the radiator comes in contact with the solution, immediately remove the radiator and flush it with clean water. Violent boiling indicates that the radiator or some of its parts are made of aluminum. After you remove the radiator from the hot cleaning vat, immediately flush it with water both internally and externally. This to remove any foreign matter that was loosened by the vat cleaning process and to prevent the formation of troublesome oxides which could interfere with soldering that might be required on the radiator.

Your next step now would be to Flo-Test the radiator again. If the GPM rate is not up to specifications, repeat the vat cleaning and flushing procedures.

If repeated cleaning does not do the job, then you would remove the tanks for rod cleaning.

Rod cleaning (rodding). If boiling or cleaning is inadequate, clean the inside surfaces of the water passages with a bristle brush or a cleaning rod. A cleaning rod is a round wire with its end rounded to avoid puncturing the water tubes inside the radiator.

Drying procedures. A dry radiator will show every leak, no matter how small. If all leaks are exposed and repaired while on your workbench, the reliability of the radiator can be assured. Seal all openings on the radiator (except the inlet and outlet passages) with push-on rubber test plugs (fig 2-9). Using a hot air blower with suitable adapters and hoses, connect a forced air hose to the radiator inlet neck. Allow the air to circulate through the water passages and discharge from the outlet neck until the radiator is completely dry internally.

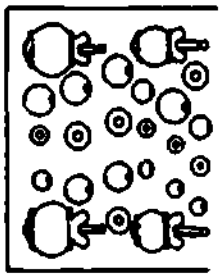


Fig 2-9. Rubber test plugs.

Testing for radiator leaks. Check the radiator for any visible leaks before you start your testing procedures. Visible leaks should be soldered promptly so that the test will be sensitive enough to reveal less obvious defects.

Air leak test (fig 2-10).

Examine the radiator tanks, core and fittings for physical damage and for large obvious leaks. Repair these obvious leaks before air testing.

Attach a filler neck adapter plug (Filler Neck Tester with air connection) to the filler neck of radiator. The adapter must seal the filler neck opening the same as the radiator cap but must provide a means of applying compressed air through a hose connection in the filler neck adapter.

To leak test a radiator and locate leaks, the radiator is submerged in a tank of water. Most radiators are tested at approximately 15 psi. An air pressure regulator and a low pressure gage are required for air pressure control.

Seal all other radiator openings with push-on rubber caps or plugs (fig 2-9).

Apply regulated air pressure to the radiator before submerging it in the test tank.

With test air pressure applied, lower the radiator slowly into the test tank while looking for bubbles.

Mark the source of the leak with a scribe or other satisfactory means.

Some leaks are difficult to locate because of bubble deflections by the core fins. Lowering and raising slowly or reducing air pressure will have advantages for locating some difficult leaks.

To find very small leaks, place the bench light in back of the radiator so that the interior of the core can be seen. Stand the radiator on the bench, and spread the supposed leak with flux or soapy water from an eyedropper, oilcan, acid brush or swab. Compressed air seeping through the leak will cause the liquid to foam.

The number of leak' d their location and general condition of the radiator will determine the advisability of repairing.

The leak test is conducted many times during most repairs and requires raising and lowering the radiator each time.

In some cases a new core may be recommended when there are a large number of leaks or the core shows deterioration.

Warning: The operating pressure of cooling systems is being progressively increased and some exceed 15 psi. When testing at pressures of more than 15 psi, the push-on rubber caps and plugs may blow off. To prevent this danger, clamps or wires should be used for holding those plugs or caps firmly.

Caution: Never attempt to air test a radiator with a direct air hose from the usually available 125 psi air source. Always use regulated air pressure.

Note: The inside of the radiator should be thoroughly dry before leaking testing.

Note: Pressure is applied to radiator before submerging to prevent water from entering the inside of radiator through any leak.

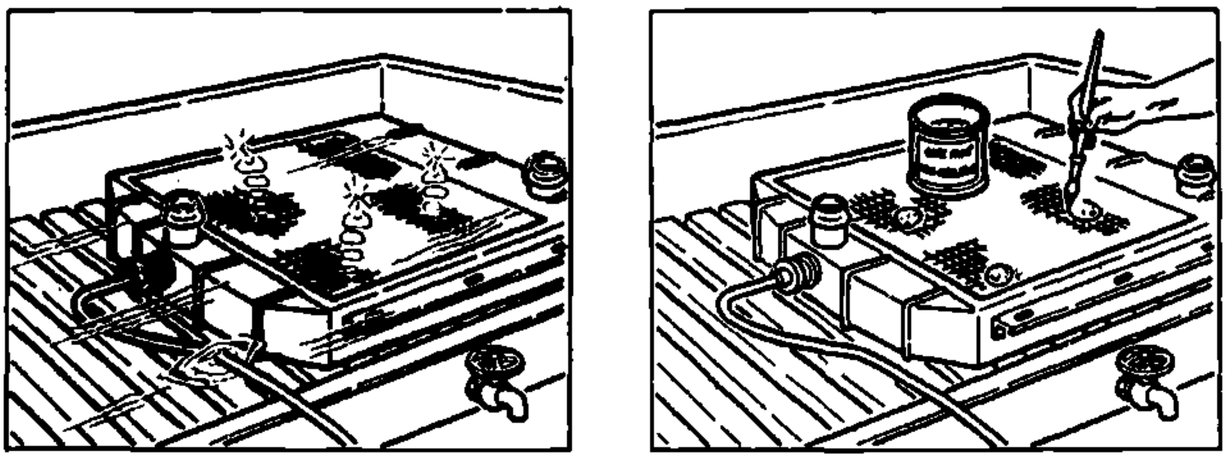


Fig 2-10. Leak testing a radiator.

Combustion leak test (fig 2-11). For combustion leak testing, a combustion leak tester is recommended. This tester can be used on all types of vehicles and operates on a chemical color change indication. With the engine running, remove the radiator cap and draw a sample of coolant in a similar manner to the way it is done in t , antifreeze test. When doing each sample, remove each spark plug wire in sequence. When the wire has been removed from the cylinder which leaks, a noted color change will take place on the float chart. The combustion leak will be located and then you would proceed to the correct leak. In most cases, the leak has been caused by a leaking head gasket or a crack in the head or block.

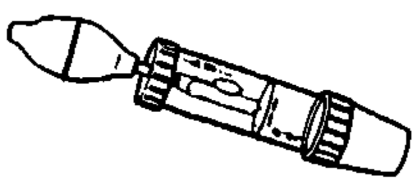


Fig 2-11. Combustion leak tester.

Radiator cap test (fig 2-12). Radiator caps should be tested periodically for proper operation. A defective cap can cause loss of coolant, over-pressure damage or a rupture of a cooling system component. When testing radiator caps, the pressure seal on both the cap seating surface and the radiator filler neck should be carefully inspected. A cooling system tester should be used. These testers make use of a hand pump, a pressure gage, and adapter fittings for attaching to various types of caps. The radiator cap seals should be moistened to assure that the test results are equal to operating conditions. The manufacturer's specifications should be consulted to determine the relief valve opening pressure. In some instances, the pressure is stamped on the cap. Be sure that the cap operates at the specified pressure. The vacuum protection valve can be tested by visually checking that the valve spring operates and that the seal is good.

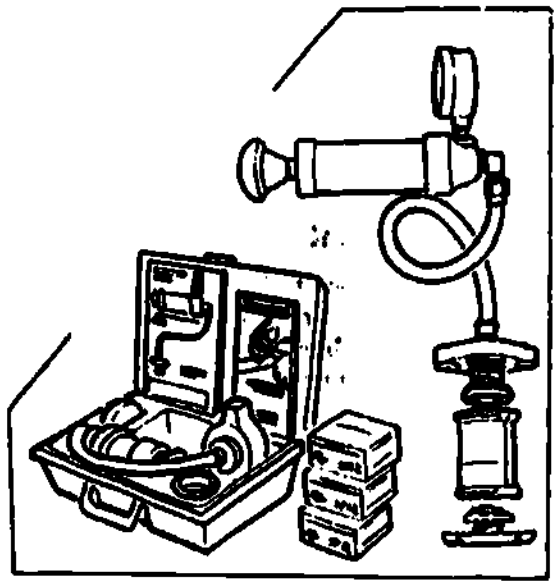


Fig 2-12. Radiator cap tester.

EXERCISE: Answer the following questions and check your responses against those listed at the end of this study unit.

1. Prior to testing or repairing a radiator, what must you do to the radiator?

____

2. You are preparing to air leak test a radiator and you see very obvious leaks on the radiator top tank. What should you do? ____________________

____

3. To insure that the radiator cap functions properly, it should be ____________

____.

Work Unit 2-5. DISASSEMBLY OF THE RADIATOR

STATE A REQUIRED PROCEDURAL STEP IF THE REPEATED VAT CLEANING FAILS TO REMOVE RESTRICTIONS IN THE RADIATOR.

STATE WHY COMPONENTS ARE CODE-MARKED WHEN DISASSEMBLING THE RADIATOR.

Disassembly. After vat cleaning, if the Flo-Test shows excessive water passage restrictions, vat clean again. If repeated vat cleaning will not remove flow restrictions, the top tank should be removed for rodding of tubes. To rod clean the tubes, insert a flat steel cleaning rod through each tube. When making certain types of repairs, it may be necessary to remove both tanks. The method used for removing the tank will vary in accordance with the type of header and tank attachment. The following procedure may be used for removing the tank:

Code-mark all components to be removed with a scribe so that they will be replaced correctly. A sketch may also be drawn of the core-tank-bracket assembly. Remove all necessary brackets and anchorages.

Apply heat to lip of header and when solder is molten, scrape away with a wire brush. Continue around the lip until solder is removed from lip channel.

While tank and header are still hot, heat one side of the header seam. Move torch alternately from one end to the other. (This requires more heat and it may be necessary to increase the torch flame for more heat distribution.) A larger torch tip may be required.

When the entire side is heated, place a wire brush handle or similar prying device inside one of the tank opening necks. Carefully pry the side loose. A small opening along the seam is all that is necessary. A slight jiggling motion with very little force should be used. The tank may be easily cracked when hot. The neck joint of the opening may become loose or bent from too much force.

When the side seam is loosened, repeat the procedure with the other side and ends until the tank is removed.

Remove the bottom tank, if required, in the same manner and perform the necessary repairs.

Warning: Wear safety equipment when soldering.

Caution: Exercise extreme care to avoid flowing solder inside header tank. Excessive solder could block the tubes.

EXERCISE: Answer the following questions and check your responses against those listed at the end of this study unit.

1. If repeated vat cleaning fails to remove restrictions in the radiator, your next step would be to ____
____.

2. When disassembling the radiator, you will see that the components are code-marked. Why are they code-marked? ______________________
____

Work Unit 2-6. REPAIRS OF DAMAGED AREA

NAME A CLEANING AGENT USED TO PREPARE A DAMAGED AREA ON A RADIATOR.

NAME A COMPONENT PART USED TO HOLD THE TANK TO THE HEADER FOR SOLDERING WHEN ASSEMBLING THE RADIATOR.

Resoldering header (fig 2-13). After you have removed the upper tank or both tanks, you can proceed with further repairs if needed. Before making repairs to the header, you should clean and tin the area to be repaired in the following manner:

If necessary, with a heating torch, heat and raise the fins in the area you wish to repair. Heat the fins slowly in the repair area (fig 2-14).

Raise the unbound fins in the repair area no more than 1/2 inch. Do not force the fins but pry them only while solder bond is melted.

Next, clean the entire area by heating and removing the hot solder from the tube-header junctions with wire brush.

After you have removed the solder, flush and clean the area to be repaired by squirting muriatic acid on the repair area. Use a syringe-type squirt bulb for this purpose. Apply flux with a large flux brush and clean between the tubes with a radiator brush.

Apply the thinning mixture with a swabbing brush and heat the base of the tubes along the edge of the header. You want to alternate the use of flux and tinning mixture for the best results. Continue tinning until entire fin side of header is bright and clean.

If you experience difficulty in cleaning the tube-header fin-side area, repeat the use of muriatic acid, heat, and flux. Dirt and oxides are washed away by brushing with this method.

When the area to be repaired is cleaned and tinned, position the radiator so that the header is level and the fin side to be soldered is facing upward.

Begin heating and flowing solder about the header and tube joints. If the radiator has three or more rows of tubes, begin with the innermost tubes. Withdraw the torch slightly to control the heat. Solder the outer tubes in a similar manner.

Continue air testing and repairing until all leaks are repaired. Wash the area thoroughly to remove acid and flux residue.

The tube reinforcements that are added to the unit add rigidity to the tube-header junctions. These clips are formed from copper wire and can be replaced around the tubes at the tube-header junctions and soldered in place. They are more necessary around the corner tubes wh re stress is greatest. The possibility of leaks occurring again is further reduced by using these clips.

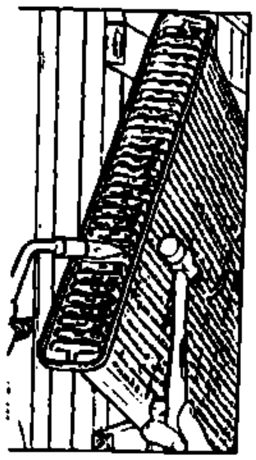


Fig 2-13. Resoldering header.

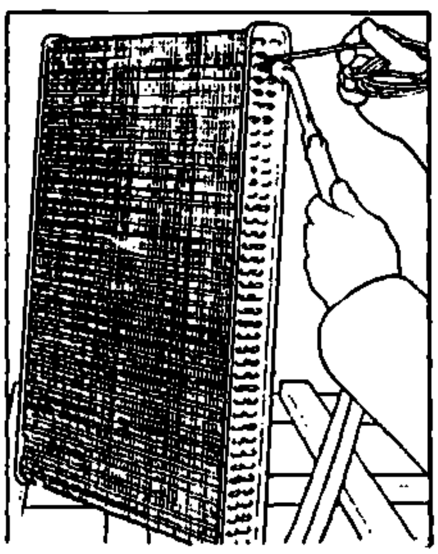


Fig 2-14. Header and tube removal.

Patching headers and tanks. Cracks occur in headers and tanks from temperature and changes. Other causes are mechanical stresses and vibrations during normal operation. These cracks, if repaired by solder alone, are likely to recur because solder alone contributes very little to the structural rigidity and strength of the radiator. If a copper patch (a thin patch cut from 16 oz. copper sheet) is soldered over a crack, the bonding area of the solder is greatly increased. This strengthens the crack area. A patch usually results in a repair of sufficient strength to prevent recurrence of the crack. When a header is cracked in between tubes, a notched patch may be used. Cracks that are located on a multiple contoured surface are usually brazed or silver soldered.

Patching headers (fig 2-15). You would clean the area to be repaired by alternately using heat and muriatic acid utilizing a procedure similar to the one that you used for resoldering headers. If the area is extremely dirty, then you may use a wire brush and muriatic acid. Tin an area at least 1 inch larger than all points of the crack. Cut a patch from 16 oz. copper sheet (this material is approximately .21 inches thick) to a size that covers the crack with the surface contour and the proper overlap. Remove the patch and position the radiator so the surface to bo repaired is level. Heat and apply a thin layer of solder over the crack and tinned area. Position tho patch, then hoat and flow additional solder around the edges of the patch and cool with water. Wash the patch area thoroughly and leak test at proper air pressure.

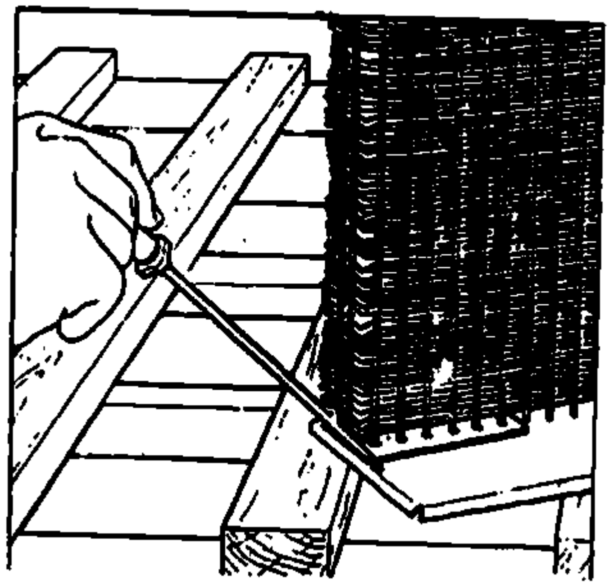


Fig 2-15. Header repair using a notched patch (before soldering).

Tank patch repair (fig 2-16). The repair procedure for the tank is the same as for the header patching. The only difference is that the header would have a notched patch.

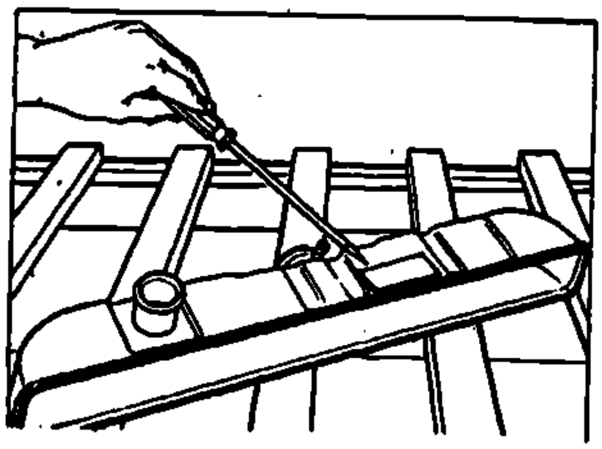


Fig 2-16. Tank patch repair (before soldering).

Removing and replacing overflow pipes (fig 2-17). Using the needle flame of a torch, heat the overflow pipe at the filler neck joint until the solder becomes melted. Then, from the outside, pull the ovorflow pipe free.

Note: If the overflow pipe is pulled first, it will probably break.

Prior to installing the pipe, clean, tin, and flux the upper end and insert it into the filler neck. Putting flame to the joint, touch the pipe with a solder rod. When the solder begins to flow into the joint, remove the torch quickly and let the solder harden. Unless the fusing metal enters the joint, it will give little strength. After you have completed this, attach the lower end of the overflow pipe to the lower tank or radiator side members.

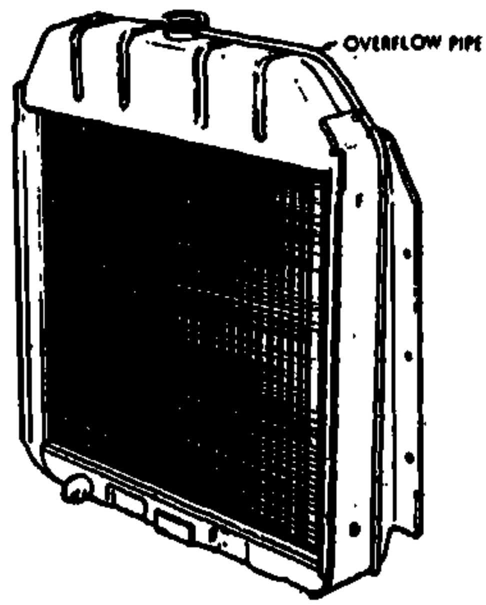


Fig 2-17. Overflow pipe.

Radiator opening neck repair (fig 2-18). A crack at the base of the filler neck, inlet neck or outlet neck may be repaired in the same manner as the tank repair procedures with the exception of shaping the copper patch which is cut and formed for soldering to both the tank and the neck. Cut a number of slits along the center hole radius of the patch and bend them to a 90° angle for soldering to neck. The 90° bends provide reinforcement to the neck base. The flat section of the copper patch is soldered to the tank.

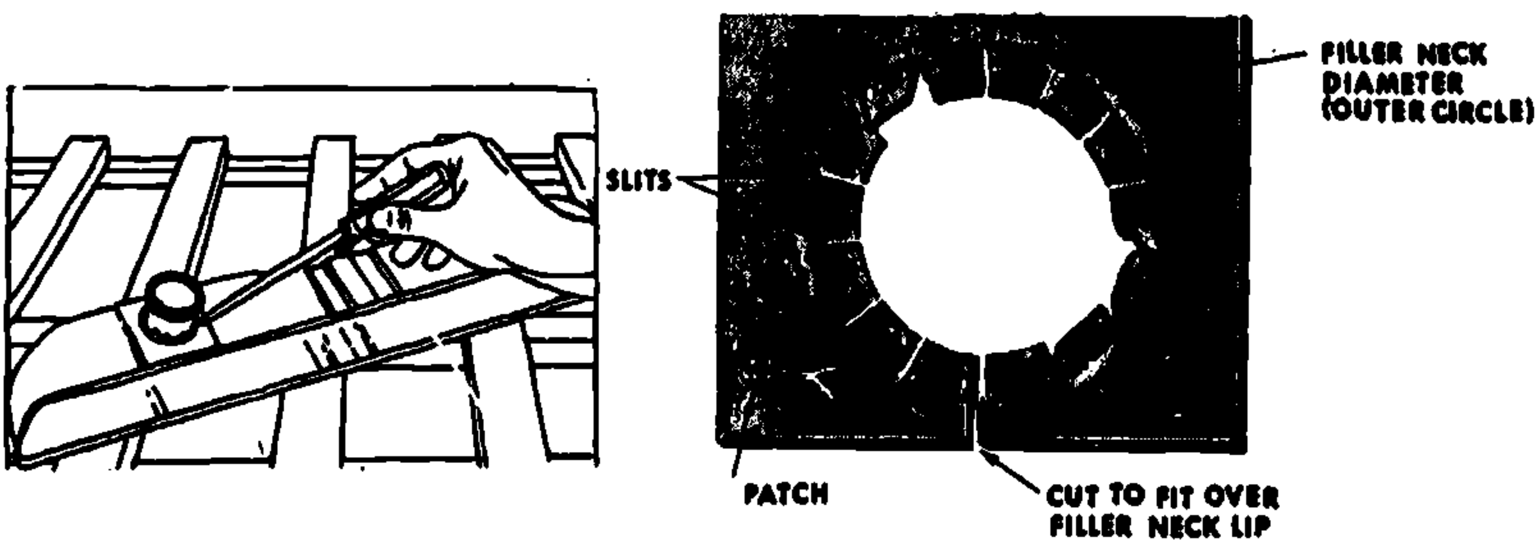


Fig 2-18. Inlet neck repair.

Reassembly (fig 2-19). After you have made all necessary repairs to the radiator, you are ready to install the tank. To do this follow the steps listed below:

Before replacing the tank, check both header and tank for proper fit and alinement.

Clean and tin the seam portion of the header in preparation for soldering the tank. Carefully inspect for cracks and other defects that might have occurred without your knowledge.

Clean and tin the tank on both sides of the rim portion in preparation for soldering the header. Inspect for defects such as cracks.

Place the core assembly in a vertical position with the header rim surface level. Fit the tank to the header and clamp it in position using a header clamp. Heat the solder and allow it to flow into the lip channel until the entire lip is completely soldered.

After testing the radiator, replace all brackets and anchorages that were removed. Use appropriate radiator clamps and radiator side notches. Soldering the brackets will require cleaning, tinning, and clamping before soldering.

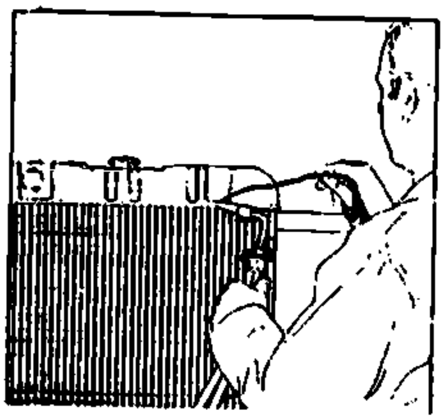


Fig 2-19. Header assembly.

EXERCISE: Answer the following questions and check your responses against those listed at the end of this study unit.

1. When repairing a damaged radiator, you would prepare the area to be repaired by cleaning it with what? ______________________________

____

2. When assembling the radiator, the tank is held to the header for soldering by a

____

Section II. COMPONENT PART REPAIR PROCEDURES

Work Unit 2-7. WATER PUMP REMOVAL/REPLACEMENT PROCEDURES

STATE HOW YOU WOULD CHECK FOR FAULTY WATER PUMP BEARINGS.

STATE WHY THE GASKET AREA IS CLEANED AFTER REMOVING THE WATER PUMP.

Testing. A water pump may be defective due to faulty bearings or leaks. The pump may fail to operate due to a loose or broken fan belt. The water pump should be checked with the engine stopped and then again with the engine running. With the engine stopped, check the pump bearings for looseness by attempting to move one of the fan blades back and forth lengthwise with the pump shaft. Do not exert enough force to bend the fan. Since the fan is bolted to the hub on the water pump shaft any slack felt on the fan is caused by loose bearings on the pump shaft. Unless the water pump leaks badly enough to drip, a leak can be hard to locate. The coolant usually leaks past the pump shaft seal and escapes through a drain hole in the pump housing.

The drain hole is located on the bottom of the housing and on most vehicles is covered by the belt pulley. It can usually be viewed by using a small mirror or a flashlight. Any dampness or water stains left by evaporation around the drain hole indicate a coolant leak. When the engine is running, listen for any noises in the water pump. If the pump is noisy and equipped with a grease fitting, lubricate it according to the lubrication order to see if this stops the noise. Noises that cannot be stopped by lubrication are caused by faulty bearings or seals. On some vehicles you can look in the radiator filler neck to see if the pump is operating. If you can see the coolant circulating, the pump is operating. If the radiator inlet or baffles in the radiator tank prevent you from seeing the circulation of coolant, squeeze the upper radiator hose until the sides almost meet. Next, you should accelerate the engine. If the pump is operating, you can feel the coolant force its way through the hose. The water pump should be replaced if it leaks, has loose bearings, is noisy or does not operate. Remove the radiator before replacing the water pump on the M151 1/4-ton truck. Then the lower radiator hose can be removed by disconnecting it from the water pump inlet.

Water pump replacement. Install the water pump in the reverse order of removal. Use a new water pump gasket and tighten according to the TM. Adjust the fan belts and fill the cooling system.

EXERCISE: Answer the following questions and check your responses against those listed at the end of this study unit.

1. With the engine stopped, how would you check for faulty water pump bearings?

____

2. When removing the water pump, why is it important to clean the gasket area?

____

Work Unit 2-8. THERMOSTAT REMOVAL/REPLACEMENT PROCEDURES

NAME THE COOLING SYSTEM COMPONENT THAT AUTOMATICALLY CONTROLS THE AMOUNT OF COOLANT FLOWING THROUGH THE RADIATOR CORE.

STATE THE REQUIRED PROCEDURAL STEPS AFTER YOU HAVE REMOVED THE THERMOSTAT.

STATE WHEN A NEW THERMOSTAT GASKET SHOULD BE INSTALLED.

General. Full-length engine water jackets; large, efficient radiator cores; and rapid coolant circulation on the system provide the extra cooling required for engine operation under heavy loads or hot weather. The same amount of cooling would remove too much heat from the engine under lighter engine loads and cool weather. Overcooling of the engine results in waste of fuel, loss of power, and rapid wear of moving parts; therefore, the amount of heat removed from the engine must be controlled for different operating conditions and air temperatures. This is a done by thermostat which regulates engine temperature by automatically controlling the amount of coolant flowing through the radiator core.

The thermostat consists of a valve and a heat-operated unit which moves the valve. One type of thermostat-operated unit is a closed bellows which contains a special liquid designed to boil at a certain temperature. When the temperature is reached, the boiling liquid creates gas pressure which expands the bellows and opens the thermostat valve. When the liquid cools and condenses, the pressure is reduced, allowing the bellows to contract and close the valve. In another type of thermostat, the valve is operated by a bimetallic coil which depends for its operation upon the difference of the coefficients of expansion of the two metals. The thermostat is located between the engine water jacket and the radiator, usually in the housing at the cylinder head water outlet. Automatic operation of the thermostat valve holds the coolant temperature within proper limits by controlling the flow of coolant through the radiator. When the engine is cold, the thermostat valve stays closed and shuts off practically all the circulation to the radiator. As the engine warms up, the valve opens slowly allowing some coolant to flow. In actual operation, the valve may move frequently to regulate coolant flow into the radiator in accordance with variations in heat output from the engine.

Testing (fig 2-20).

Hang the thermostat by its frame in a container of water so that the thermostat unit does not touch the bottom of the container.

Heat the water and measure the temperature with a thermometer.

If the valve opens at a temperature of more than 10° to 15° above the specified opening temperature, the thermostat should be replaced.

If the valve can be pulled or pushed off its seat with slight effort when the thermostat is cold, the thermostat may be considered defective.

Whenever the thermostat is removed for any reason, it should be cleaned, tested, and examined carefully.

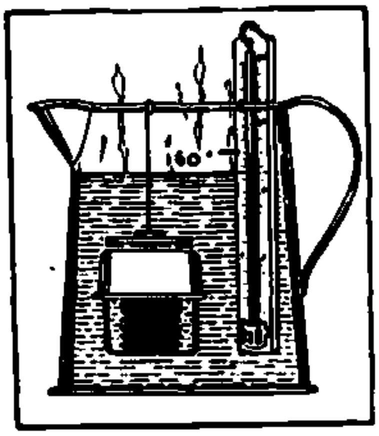


Fig 2-20. Testing thermostat.

Replacement. When replacing the thermostat, make sure that the thermostat has been properly cleaned and that a new thermostat housing gasket has been installed.

EXERCISE: Answer the following questions and check your responses against those listed at the end of this study unit.

1. Which cooling system component automatically controls the amount of coolant flowing through the radiator core? ______________________________

____

2. After removing the thermostat from the thermostat housing assembly on the M35 2 1/2-ton truck what would be your next step? ______________________________

____

3. The thermostat you are testing opens at 200°F but the TM calls for an opening temperature of 180°F. What should you do? ______________________________

____

4. When should a new thermostat gasket be installed? ______________________________

____

Work Unit 2-9. TEMPERATURE SENDING UNIT REMOVAL/REPLACEMENT PROCEDURES

STATE THE CAUSE IF AFTER ENGINE WARM UP THE TEMPERATURE GAGE DOES NOT REGISTER BUT WHEN THE SENDING UNIT WIRE IS GROUNDED THE GAGE REGISTERS.

STATE THE REQUIRED STEP BEFORE REMOVING THE TEMPERATURE SENDING UNIT.

IDENTIFY THE REQUIRED ACTION BEFORE INSTALLING A NEW TEMPERATURE SENDING UNIT.

Testing. The electric temperature sending unit is checked in the same manner on all military type vehicles. To test the sending unit, first run the engine the until it warms up. If no reading is indicated on the gage, remove the wire from the sending unit and momentarily ground the wire to the engine block with the ignition switch in the ON position. If the gage now indicates, the temperature sending unit is faulty and must be replaced. If the gage still does not indicate, the gage or wiring is probably defective.

Removal (fig 2-21). Normally the sending unit is located to the rear of the engine and requires very little time to replace. When replacing the temperature sending unit, drain the coolant until it is below the sending unit. Unscrew the old temperature sending unit and discard it.

Replacement. Coat the threads of the new sending unit with a nonhardening gasket cement before installing it. This will prevent coolant leakage and will make the unit easier to remove the next time. Use a box or socket wrench to tighten the sending unit. An open-end wrench is likely to distort the unit causing it to fail.

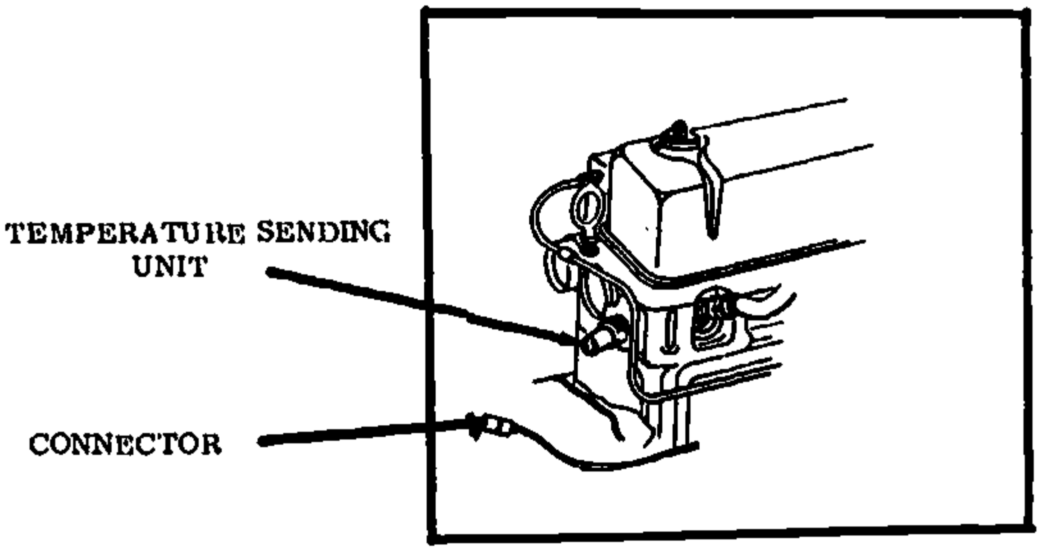


Fig 2-21. Temperature sending unit.

EXERCISE: Answer the following questions and check your responses against those listed at the end of this study unit.

1. The engine has had time to warm up but the temperature gage is not registering. You remove the wire from the sending unit and momentarily ground the wire to the engine block. If the gage registers what should you do? ____________________

____

2. To remove the temperature sending unit, you should do what? ____________________

____

3. Before installing a new temperature sending unit, you should

a. test it to insure it is operative.
b. waterproof the connections.
c. coat the threads with a nonhardening gasket cement.
d. make sure it is pressure tested to 15-20 psi.

Work Unit 2-10. TROUBLESHOOTING THE COOLING SYSTEM

STATE THE RESULT OF COMBUSTION GAS LEAKAGE INTO THE COOLANT SYSTEM.

Purpose. When you are asked to locate a problem in a cooling system, it will most likely be because of one or more complaints: engine overheats, coolant is being lost, or the engine fails to reach operating temperature. The cause of these complaints may vary because of the differences in the design of different vehicles. For this reason you should always refer to the troubleshooting section of the TM for the vehicle you are working on.

Procedures. If a specific trouble, test, and remedy are not covered, proceed to isolate the system in which the trouble occurs and then locate the defect. Use any test equipment that you may have available. Question the vehicle operator because he will be able to inform you of the symptoms of malfunctions in the vehicle. The greater the number of malfunctions that can be evaluated, the easier it will be for you to isolate the defect. Table 2-1 below contains some problems which may develop in the cooling system.

Table 2-1. Troubleshooting Chart

Malfunctions	Probable causes	Corrective action
1. Overheating	a. Clogged coolant passages	a. Flush cooling system.
	b. Disintegrated radiator hose	b. Replace radiator hose.
	c. Clogged or bent radiator fins	c. Spray clean, splice, or replace radiator fins.
	d. Shortage of coolant	d. Check for leaks. Tighten clamps. Replace coolant to proper level.
	e. Defective thermostat	e. Replace thermostat (see pertinent maintenance manual).
	f. Dirty radiator	f. Drain coolant, clean radiator, add fresh coolant.
2. Overcooling	a. Faulty thermostat	a. Replace thermostat (see pertinent maintenance manual).
	b. Improper coolant	b. Test coolant mixture. Add or remove mixture to bring coolant to proper level.
	c. Extreme cold weather	c. Partly cover radiator. close hood louvers.
3. Loss of or abnormally high radiator pressure	a. Defective or improper radiator cap	a. Replace radiator cap.
4. Loss of coolant	a. Loose radiator hose	a. Tighten hose clamps.
	b. Defective or improper radiator cap	b. Replace radiator cap.
	c. Rupture of radiator tube	c. Repair, splice, or replace radiator tube(s).
	d. Unsoldered joints, cracked	d. Solder (epoxy) aluminum radiators or patch defective areas.
	e. Open drain cock	e. Close drain cock.

Table 2-1. Troubleshooting Chart con't

Malfunctions	Probable causes	Corrective action
5. Corrosion	a. Air in coolant	a. Keep coolant level above radiator tubes.
	b. Impurities in coolant	b. Change coolant frequently.
	c. Contamination coolant	c. Drain and clean radiator. add fresh coolant. Check coolant frequently for cleanliness.
6. Foaming of coolant	a. Combustion gas leakage into the coolant	a. Drain coolant. Add water, then run the engine. If foaming continues, conduct combustion g.s and air suction test.
	b. Air suction into the cooling system	b. See a. above.

EXERCISE: Answer the following questions and check your responses against those listed at the end of this study unit.

1. Loss of or abnormally high radiator pressure would be the result of

    a. air in the system.
    b. a defective or improper radiator cap.
    c. coolant level to high.
    d. cold water.

2. What would a combustion gas leakage into the coolant cause? ____________________

____

SUMMARY REVIEW

After have completed this study unit, you have learned how to repair cooling systems. You should now, if given a cooling system requiring repairs, be able to troubleshoot it and make the appropriate repairs.

Answers to Study Unit #2 exercises

Work Unit 2-1.

1. Loosen the radiator cap
2. Damage the 'ilet pipe
3. Check the TM that pertains to the vehicle you are working on

Work Unit 2-2.

1. radiator
2. To the specific torque given in the TM

Work Unit 2-3.

1. The percentage of plugging in a radiator
2. 50%

Work Unit 2-4.

1. You must clean the radiator.
2. You should repair the leaks.
3. periodically tested and visually inspected

Work Unit 2-5.

1. remove the top tank for rodding of the tubes
2. So they can be replaced correctly

Work Unit 2-6.

1. Muriatic acid
2. header clamp

Work Unit 2-7.

1. By attempting to move one of the fan blades back and forth lengthwise with the pump shaft
2. To ensure a water tight seal

Work Unit 2-8.

1. Thermostat
2. Inspect the thermostat seal and then test the thermostat.
3. Replace the thermostat.
4. Each time the thermostat is removed and replaced.

Work Unit 2-9.

1. Defective sending unit.
2. Drain the coolant until it below the sending unit.
3. c

Work Unit 2-10.

1. b
2. The coolant to foam

STUDY UNIT 3

LUBRICATING SYSTEMS

STUDY UNIT OBJECTIVE: WITHOUT THE AID OF REFERENCES, YOU WILL IDENTIFY THE PURPOSE OF THE ENGINE LUBRICATING SYSTEM, THE TYPES OF LUBRICATING SYSTEMS, THE MAIN COMPONENTS OF THE AUTOMOTIVE LUBRICATING SYSTEMS AND THE MAINTENANCE PROCEDURES.

Work Unit 3-1. PURPOSE

STATE THE PURPOSE OF THE ENGINE LUBRICATING SYSTEM.

Most lubricants are made from crude oil pumped from the ground. Crude oil is unusable in this form. The process of refining enables hundreds of usable products such as gasoline, diesel fuel, kerosene, asphalt, lubricating oil and grease to be made from crude oil. It is important for you to be able to identify various refined products so that you will use them properly.

Almost every piece of military machinery that has moving parts needs lubrication--OIL and GREASE (fig 3-1). The lubricating system supplies all of the moving parts of an engine with oil. Oil aids in reducing friction, cleaning the moving parts, and cooling these parts by carrying off part of the heat. Oil also helps to seal off the combustion chamber in the case of the pistons and rings.

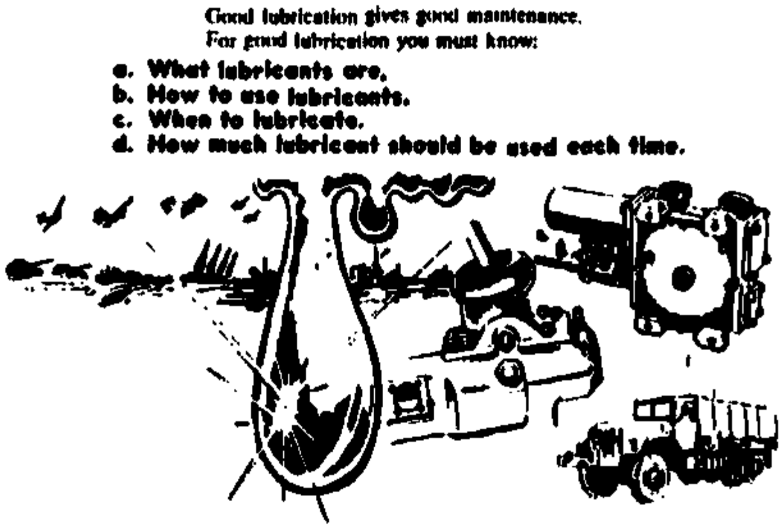


Fig 3-1. Lubrication.

EXERCISE: Answer the following questions and check your responses against those listed at the end of this study unit.

1. What is the purpose of the engine lubricating system? ____________________
____

Work Unit 3-2. LUBRICANTS

STATE HOW LUBRICANTS ARE KEPT CLEAN PRIOR TO BEING USED.

STATE THE PURPOSE OF LUBRICATION.

<u>Types</u>. First we will discuss oils, then grease.

<u>Oils</u>

<u>Function</u>. We use oils to slow down the wear between metal surfaces that rub together. The primary function of engine lubrication is to reduce friction between the surfaces. Friction (fig 3-2) is the resistance or drag between two surfaces in contact. All surfaces, no matter how smooth they feel or look, are rough when seen under a microscope. Friction produces heat, absorbs power, and causes wear.

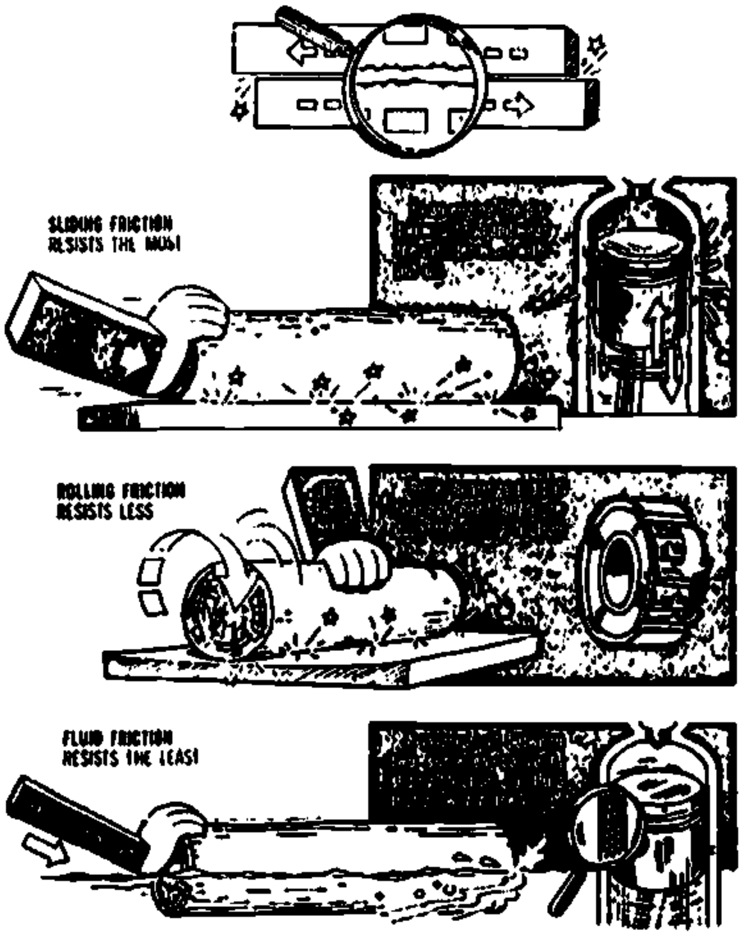


Fig 3-2. Friction.

When we place an oil film between rubbing surfaces, we call it lubrication (fig 3-3).

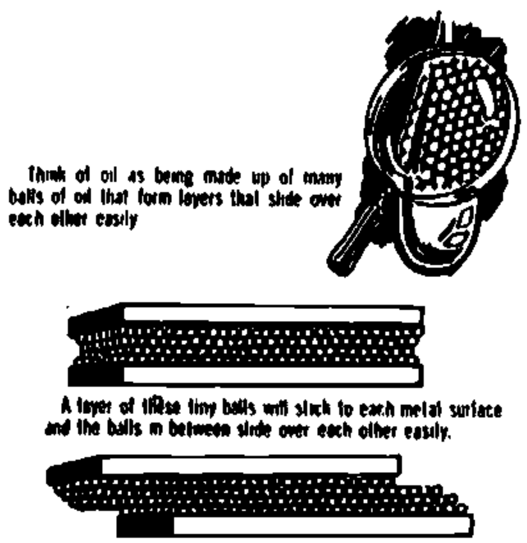


Fig 3-3. Lubrication.

Viscosity of oil (fig 3-4). A simple definition of viscosity is "the resistance of a liquid (any liquid) to pour or flow." Over the years engineers have developed very precise methods for measuring the viscosity of liquids. The Society of Automotive Engineers (SAE) has established the viscosity grades of oils, for example SAE 10, SAE 20, and SAE 30. The higher the number, the thicker (more viscous) the oil. However, as oils get hot, they get thinner. There are chemicals that are added to make oil last longer, and to keep the metal surfaces clean. All of the various chemicals that improve oils are called additives.

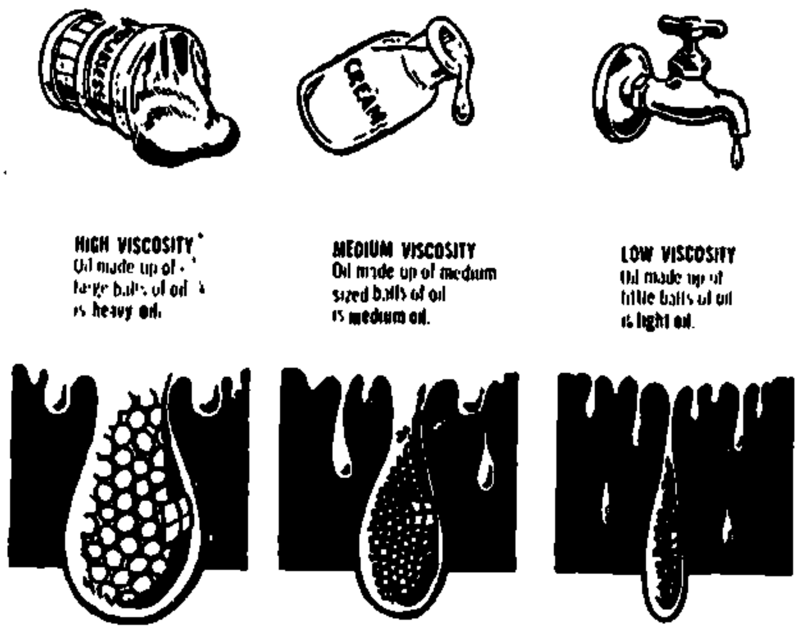


Fig 3-4. Viscosity of oil.

Grease. In some areas that need lubrication, oil cannot be used because it would flow out from the place where it must be stored. Grease is used to provide lubrication in areas where the use of oil would be impractical. There are many kinds of grease. Some grease is light such as vaseline while another is heavy such as axle grease. Some greases melt in water while others are waterproof. There are many types of grease just as there are many different types of oil. Scientists have not been able to devise one kind of grease for every purpose. The best one is GAA (Grease Automotive and Artillery) for military use. It is used in many places and in all climates ranging from -65° F. to +125° F (see figure 3-5).

Some lubricants do not come from crude oil. These are called synthetic lubricants, because they are made by just putting various chemicals together.

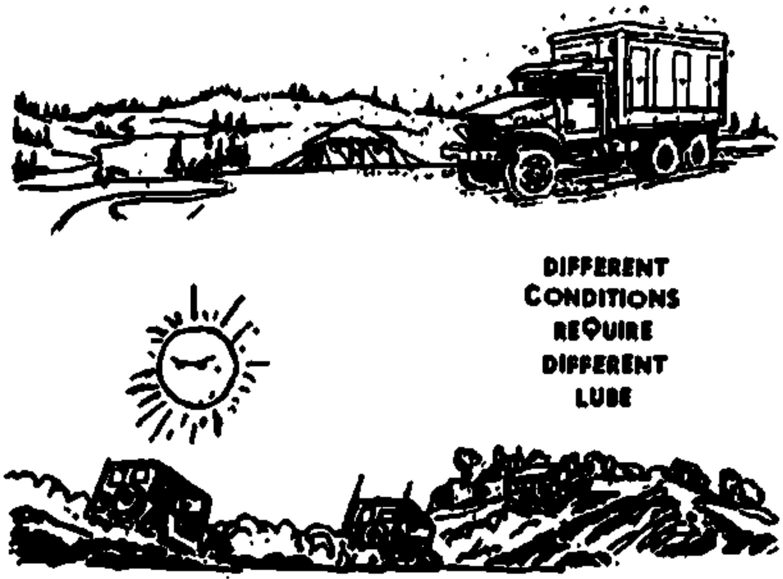


Fig 3-5. Lubrication requirements.

Cleanliness. One of the big problems in lubrication is to keep the lubricant clean. A grain of sand, a little dust from the air, or water will damage a bearing. Lubricants must always be kept covered when stored as shown in figure 3-6.
The paragraphs below describe some precautions and good practices.

Fig 3-6. Covered lubricant.

Dirty spout (fig 3-7). We obtain clean oil in sealed containers. A dirty spout or dispenser used by a careless mechanic will take dirt, dust, and grit directly into your engine.

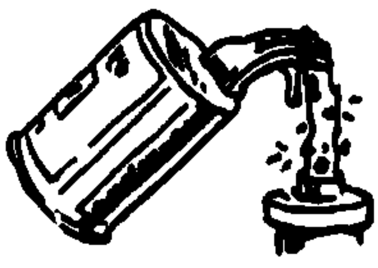


Fig 3-7. Dirty spout.

Water leakage (fig 3-8). Watch out for water leaking into drums and containers. You should wipe filler caps before removing them and clean hand pumps before inserting them into drums. Weather is the enemy! Store things properly. Cover and protect small cans.

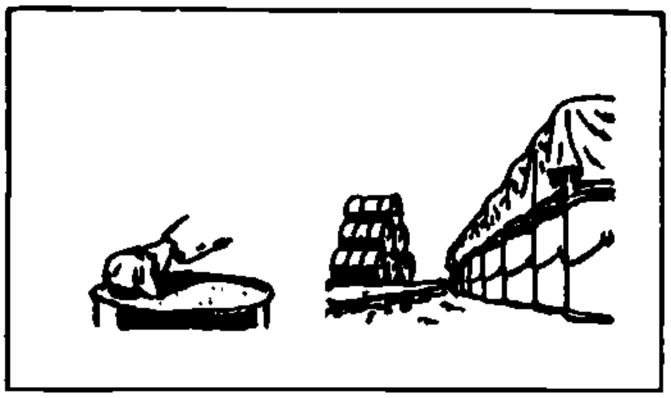


Fig 3-8. Weather protection.

The effects of mud (fig 3-9). Mud on a lubrication fitting will be pumped in with the next shot of grease if the fitting is not wiped off first.

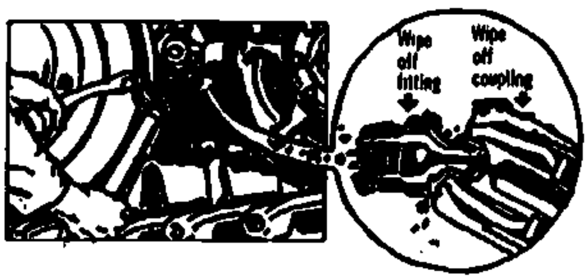


Fig 3-9. The effects of mud.

The amount, type and quantity of lubricant to be used and the frequency used is contained in the Lubrication Order (LO) pertaining to the vehicle.

Grease fittings (fig 3-10). Grease fittings are provided to those components requiring lubrication. These fittings screw directly into the component or into an adapter such as an elbow or an extension which connects the fittings to the component. The locations of all fittings are shown on the lubrication chart (LO) for each vehicle.

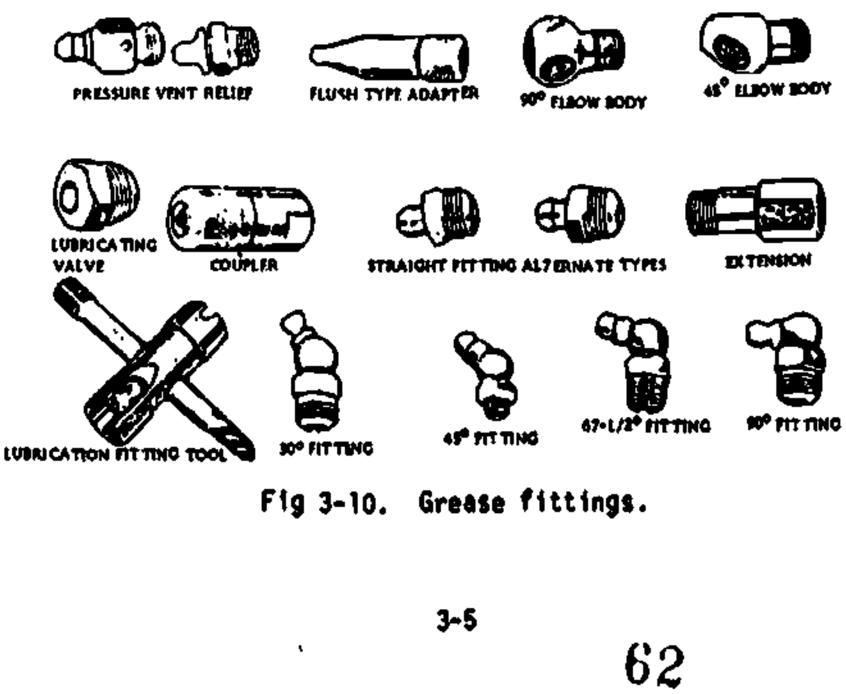


Fig 3-10. Grease fittings.

EXERCISE: Answer the following questions and check your responses against those listed at the end of this study unit.

1. How are lubricants kept clean prior to being used

____

2. What is the purpose of lubrication? ____

____

Work Unit 3-3. TYPES OF LUBRICATION SYSTEMS

NAME THE LUBRICATION SYSTEMS IN WHICH THE MAIN BEARINGS ARE FORCE-FED FROM THE OIL PUMP.

NAME THE LUBRICATION SYSTEMS THAT LUBRICATES THE CONNECTING ROD BEARINGS THROUGH DRILLED HOLES.

Several methods are used to transfer oil from the reservoir to the lubrication points. Although these methods are more or less similar, different mechanical means are used to obtain the desired results.

Splash feed (fig 3-11). Splash lubrication is the simplest system. The moving parts of the mechanism (generally the connecting rods) dip into or strike the oil and splash it into various parts requiring lubrication. Most modern engines do not rely on the splash system alone.

Fig 3-11. Splash feed.

Dip feed (fig 3-12). In dip lubrication, some of the rotating parts are partially submerged in oil. The oil adheres to the part as it rotates and is carried directly to the surfaces to be lubricated. Typical examples are timing gears or chains. Dip feed is often used in combination with other circulating systems.

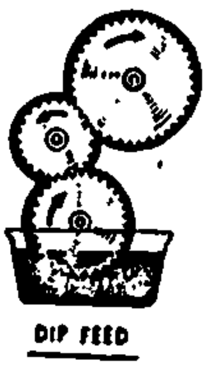


Fig 3-12. Dip feed.

Gravity feed (fig 3-13). Gravity feed is similar to the systems of splash and dip feed in that it does not use an oil pump as the source of oil pressure. In this system, the natural law of gravity is used to conduct oil from an elevated source of supply to the various parts to be lubricated. This is accomplished by having a supply tank located well above the level of the bearings to be lubricated. Oil is conducted from this tank through various lines or passages to the desired points; some type of metering arrangements to give the desired rate of flow is usually included. Sometimes such a system is accompanied by a recovery unit which is simply a sump or reservior where the surplus or used oil is collected after having performed its lubricating function. From this sump the oil can be returned to the elevated reservior by means of a pump.

Fig 3-13. Gravity feed.

Splash and force-feed system (fig 3-14). In this system the splash lubrication is not relied upon completely. The main bearings camshaft bearings, lifters and rockers are force-fed oil by pressure through passages from the oil pump. The connecting rods, pistons, piston pins, and cylinder walls are lubricated by splash.

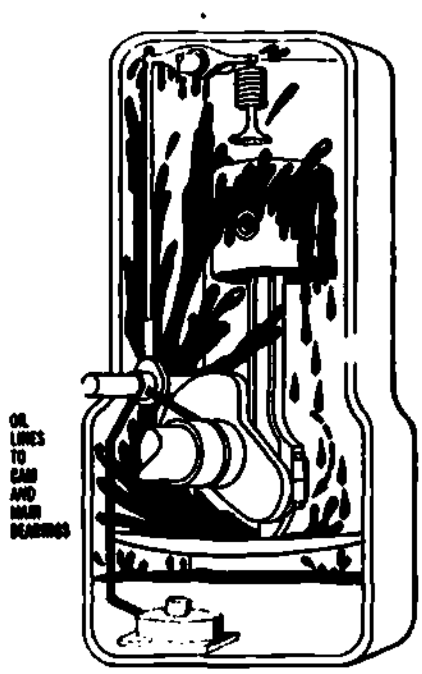


Fig 3-14. Splash and force-fed system.

Force-feed system (fig 3-15). The force-feed system does not depend on splash for the lubrication of connecting rod bearings. The oil pump forces oil directly to the main bearings and through oil holes in the crankshaft to the connecting rod bearings. Piston pins and cylinder walls are lubricated by oil being thrown up by the rotating of the crankshaft.

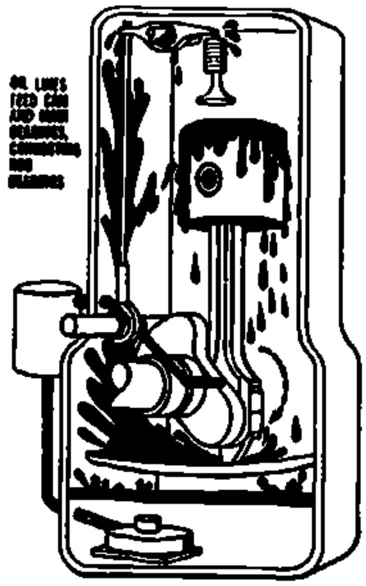


Fig 3-15. Force-feed system.

Full-force-feed system (fig 3-16). In the full-force-feed system the all bearing surfaces are force-fed by oil pressure from the oil pump.

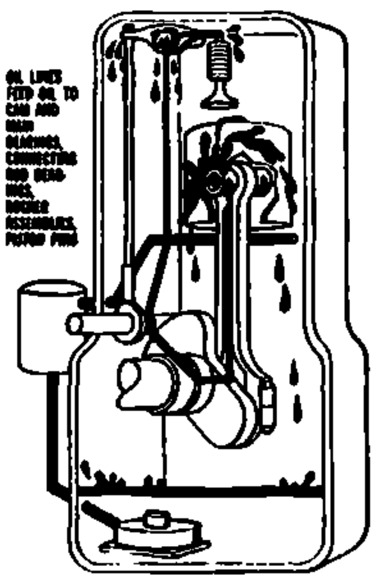


Fig 3-16. Full-force-feed system.

EXERCISE: Answer the following questions and check your responses against those listed at the end of this study unit.

1. In which type of lubrication systems are the main bearings force-fed from the oil pump?
   a. ______________________________
   b. ______________________________
   c. ______________________________

2. Name the lubrication systems that lubricates the connecting rod bearings through drilled holes in the crankshaft.
   a. ______
   b. ______

Work Unit 3-4. COMPONENTS OPERATION

STATE HOW IMPURITIES ARE REMOVED FROM THE OIL.

General. In order to get the lubrication to all the parts of the engine, in modern engine, a pump picks up the oil in the oil pan and sends it through the filter under pressure before the oil can lubricate the bearing surfaces. Oil galleries, drilled passages in the crankshaft, engine block and camshaft route the oil to the areas needing lubricating (See Work Unit 3-2).

Oil pump (fig 3-17). The oil pump circulates oil under pressure through drilled passages and oil lines to the engine parts which require lubrication the most used type of oil pump is the gear type.

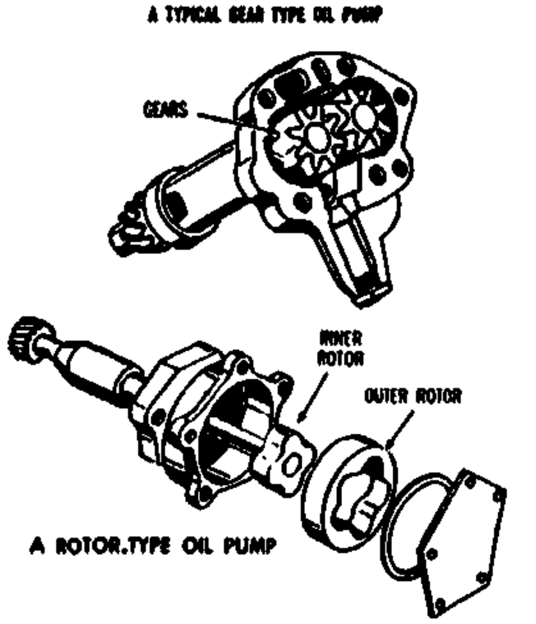


Fig 3-17. Oil pumps.

Oil inlet and screen (fig 3-18). The oil inlet and screen is a unit with a screen covering the opening that first filters the oil being drawn from the pan. The screen strains out the larger particles which may be in the oil. Usually this unit is hinged to the oil pump inlet so that it floats on top of the oil in the pan, drawing from the cleaner oil at the top and avoiding the sludge that settles to the bottom. Sludge can be kept to a minimum by draining the oil in accordance with the Lubrication Order or manufacturers recommendations.

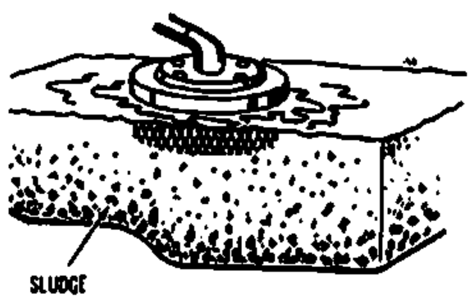


Fig 3-18. Oil inlet and screen.

Oil filter (fig 3-19). The oil picks up impurities as it circulates through the engine. The filter is designed to remove most of them. The filter is placed along the oil line so that the pump will force all of the oil to pass through it. This type is called a "full flow" filter. The filter consists of filtering material. When the filter becomes clogged, it must be replaced.

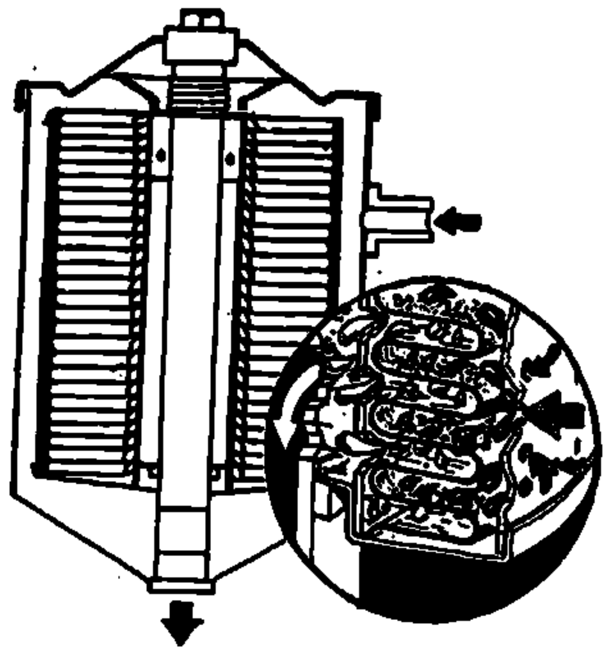


Fig 3-19. Oil filter.

Oil pan (fig 3-20). Most oil pans have a fairly deep section called the sump. The sump serves several purposes. First, it increases the amount of oil that the oil pan can hold. Second, it provides a pocket into which dirt, water, and metal particles can settle. Third, it decreases the sloshing back and forth of the oil. Fourth, the pickup screen for the oil pump is located in the sump and assures the delivery of oil to the pump as long as there is any in the oil pan. Finally, the sump insures that oil will be available at the pickup screen when the vehicle is climbing or going down steep grades. If the oil pan were shallow and had a flat bottom, all of the oil would run to the front or rear of the oil pan when the vehicle was traveling over steep grades. The deep sump guarantees that part of the oil will always be present in the sump so that the oil pump can pick it up. Some oil pans also have baffle plates which help to reduce the sloshing of the oil as the vehicle travels over rough roads or across country.

Excessive sloshing is undesirable because it tends to keep dirt and water mixed with the oil instead of letting them settle to the bottom of the sump.

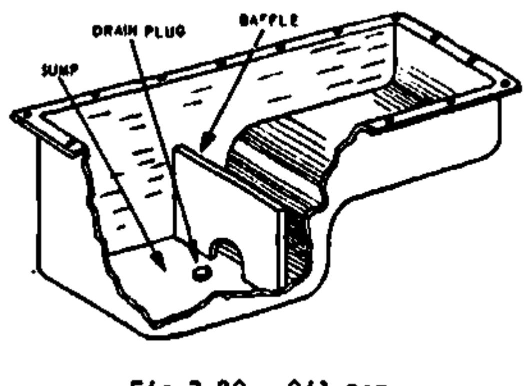


Fig 3-20. Oil pan.

oil dipstick or gage (fig 3-21). The dipstick or oil level gage is used to measure the level of the oil in the pan.

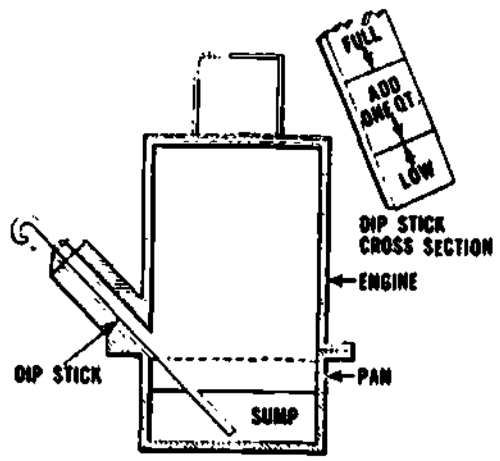


Fig 3-21. Dipstick.

EXERCISE: Answer the following questions and check your responses against those listed at the end of this study unit.

1. How are impurities removed from the oil?

Work Unit 3-5. MAINTENANCE METHODS

STATE THE CAUSE OF HIGH OIL LEVEL IN THE CRANKCASE.

STATE A NECESSITY WHEN ADDING OR CHANGING ENGINE OIL.

STATE HOW TIGHT THE FULL FLOW OIL FILTER SHOULD BE UPON INSTALLATION.

General. The major problem that you, the automotive repairman, will have with the engine lubricating system will be oil leaks. Such leaks are usually visible so be thorough when looking for them. When oil leaks are found, look for the causes. An oil leak is almost certain to develop if such things as the oil pan bolts or valve cover bolts are loose. Other major causes for oil leaks are oil levels which are too high and excessive crankcase pressure.

Maintaining lubricant level (fig 3-22). The majority of engines use a bayonet-type dipstick for checking engine oil level. Some of these dipsticks are the screw-in type and the manufacturer's recommendations must be followed on the method for checking.

First, with the engine off, check the level and condition of the oil. If you find the oil level is too high, check the level of coolant in the radiator. Unless the vehicle driver put too much oil in the crankcase, the most likely cause of a high oil level is water leaking from the cooling system into the crankcase. Leaking is the most common cause of low oil; however, an engine with worn internal parts (piston rings, valves) will result in oil entering the combustion chamber and being burned with the fuel. In checking for oil leaks, look for drops of oil on the floor under the engine. Then examine all possible places where the oil could leak out, including such places as the oil pan, timing gear cover, valve push rod cover, and valve rocker arm cover gaskets. Oil can leak out from the oil filter, vacuum booster pump, oil gage, and any external oil lines. The crankshaft oil seals can also leak. Oil leaking from the front crankshaft oil seal will probably be thrown all over the front of the engine by the crankshaft pulley. Oil leaking from the rear main bearing oil seals usually drips out through the drain hole in the bottom of the engine flywheel housing. If oil has to be added to an engine too often but no leaks are found, oil is being burned. The most likely causes of oil burning are worn or broken rings, worn or scored pistons or cylinder walls, worn intake valve guides or leaking valve seals, and a leaking vacuum booster pump diaphragm. If an engine is burning oil, it usually shows up in the exhaust as bluish smoke.

Note: Because the procedures for checking engine oil level may vary due to the type of vehicle, it is recommended that applicable technical literature be consulted for instructions that apply to specific models of vehicle.

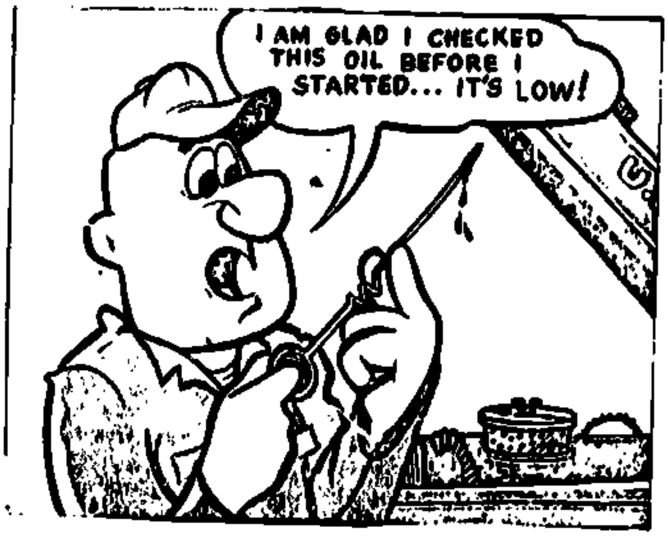


Fig 3-22. Maintaining lubricant level.

Changing engine lubricant. Drain crankcase oil and change filter in accordance with LO and TM.

EXERCISE: Answer the following questions and check your responses against those listed at the end of this study unit.

1. What is the likely cause of a high oil level in the crankcase? ________________

2. What is important to remember in adding or changing engine oil? ________________

SUMMARY REVIEW

You have now learned the purpose of the engine lubricating system. You have also learned the types of lubricating systems, the main components of the automotive lubricating systems and their maintenance procedures.

Answers to Study Unit #3 Exercises

Work Unit 3-1.

1. To lubricate, to reduce friction, and increase engine efficiency

Work Unit 3-2.

1. By keeping them covered
2. To reduce friction

Work Unit 3-3.

1. a. Splash and force-feed
   b. Force-feed
   c. Full force-feed
2. a. Full force-feed
   b. Force-feed system

Work Unit 3-4.

1. Through an oil filter

Work Unit 3-5.

1. The cooling system is leaking coolant into the oil
2. The cleaness of the oil

STUDY UNIT 4

LUBRICATION SYSTEM REPAIR

STUDY UNIT OBJECTIVE: WITHOUT THE AID OF REFERENCES, YOU WILL IDENTIFY LUBRICATION SYSTEM REPAIR AND REBUILD PROCEDURES.

Work Unit 4-1. TYPES OF OIL PUMPS

GIVEN A LIST OF ENGINE COMPONENTS, SELECT AN OIL PUMP.

The oil pump circulates oil under pressure through the drilled passages and oil lines to the engine parts which require lubrication. Oil pumps are mounted inside or outside the crankcase and are usually driven by a worm or spiral gear from the camshaft. There are four types of oil pumps: gear, rotor, vane, and plunger. Since the gear or rotor types (fig 4-1) are the usual automotive oil pumps, these two types will be discussed in detail in the following paragraphs.

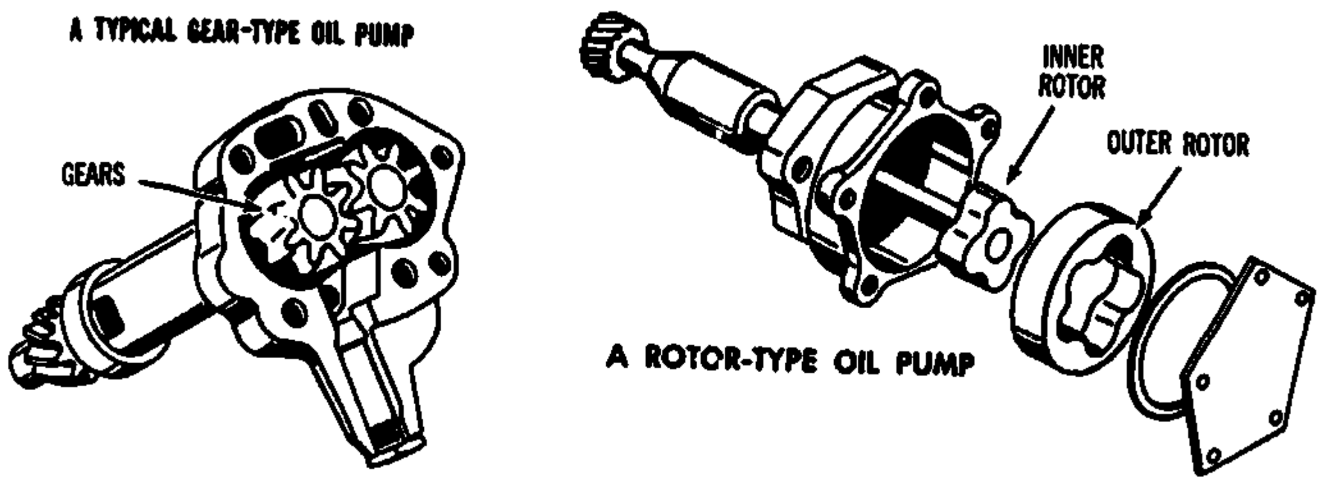


Fig 4-1. Gear- and rotor-type oil pumps.

Gear-type oil pump (fig 4-2). In figure 4-2 a top view and a side view of a gear-type pump are shown. In B of figure 4-2 the gear on the right is the driving gear and the driven gear is on the left. The gears revolve in the direction indicated by the arrows in A of figure 4-2. On the inlet side of the pump the teeth on the driving and driven gears are moving away from each other. Oil is picked up at the inlet and is carried between the gear teeth and the housing to the outlet side of the oil pump. The gear teeth come back to mesh (engagement) at the outlet side of the pump. The oil cannot pass through with the teeth of both gears meshing in the middle. The oil that enters around the outside of each gear is thus forced into the outlet (discharge) of the pump.

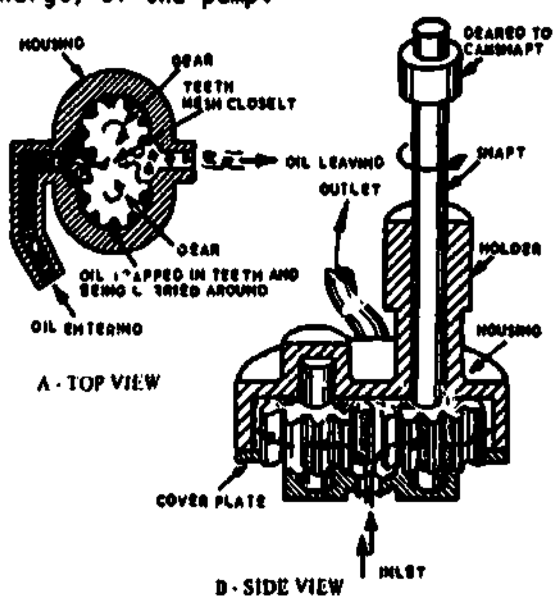
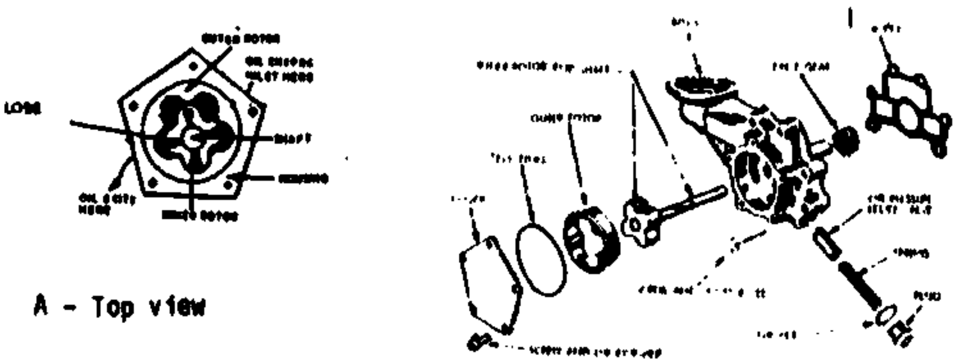


Fig 4-2. Gear-type oil pump operation.

Rotor-type oil pump (fig 4-3). The rotor-type pump uses an inner rotor with lobes that move in and out of mesh with an outer rotor. The inner rotor is keyed to, and driven by, a shaft similar to the gear in figure 4-2. As the inner rotor rotates, it carries the outer rotor with it in the same direction. Notice that the inner rotor is not centered in the outer rotor. The lobes of the two rotors are in mesh only at the bottom. As the two rotors turn to the left (counterclockwise), their lobes separate and the space between the rotors fills with oil (note inlet in figure 4-3A). As the rotors continue to turn, the lobes start coming back together. As the lobes come together, oil is squeezed out from the discharge side of the pump. An exploded view of the rotor pump is shown in figure 4-3B.



A - Top view

B - Exploded view of a rotor-type oil pump.

Fig 4-3. Rotor-type oil pump operation.

The two pumps we have discussed are capable of pumping oil under high pressure. In fact, the pressure such pumps can produce is too high for the lubricating systems used in automotive engines. An oil pressure relief valve is used to control the oil pressure at a desired amount (usually 60 psi or less). The relief valve (fig 4-4), which is also called a pressure regulator valve, is usually placed in the main oil line (also called the oil gallery) leading from the pump or built into the discharge side of the pump itself. The relief valve is usually a spring-loaded ball or plunger type (fig 4-4). Oil under pressure is delivered through the main oil line to the parts that are pressure lubricated. The oil exerts pressure on the plunger in the pressure relief valve. When the oil pressure exceeds the plunger spring pressure, the plunger is forced off its seat and oil can flow by the plunger into the oil outlet and from there to the sump. The plunger is held off of its seat by the oil pressure in the main oil line until the pressure drops to the point at which the spring can seat the plunger. The oil pressure from the pump is controlled by the strength of the plunger spring.

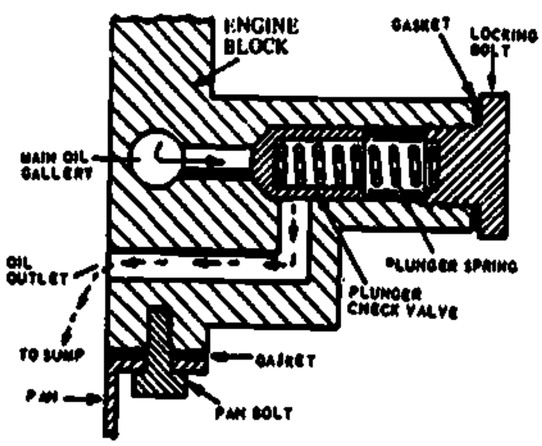


Fig 4-4. Pressure relief valve operation.

Figure 4-5A shows an exploded view of a typical oil pressure relief valve. Figure 4-5B is a cutaway view of a gear-type oil pump with the relief valve in the discharge side of the pump. It is common practice for many engine manufacturers to place the relief valve in the pump.

A - Exploded view B - Cutaway view

Fig 4-5. Pressure relief valve.

EXERCISE: Answer the following question and check your response against the one listed at the end of this study unit.

1. Which item listed below is an oil pump?

   a. Syphon type
   b. Rotor type
   c. Gravity type
   d. Crank type

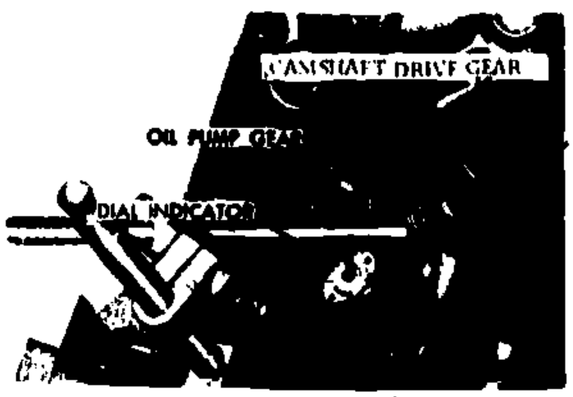
Work Unit 4-2. OIL PUMP TESTING PROCEDURE

NAME THE TEST TAKEN PRIOR TO REMOVAL OF THE OIL PUMP.

STATE THE CAUSE OF NOISY OPERATION AND LOSS OF OIL EFFICIENCY WHEN TESTING OIL PUMP FLOW (GPM).

There are various ways in which oil pumps are removed from engines. You should refer to the TM for a particular vehicle concerning the specific maintenance instructions and procedures for that vehicle.

Gear backlash check (fig 4-6). Check and record backlash between the oil pump drive gear and the drive gear on the camshaft by placing a dial indicator with the plunger bearing on one tooth of the pump drive gear prior to removing from the engine.



4-6. Measuring distributor and oil pump backlash.

Testing. Any oil pump removed from an engine should be tested for proper operation before further work is done. Test specifications are established for the oil pump (B, fig 4-7) without the strainer, lines, and fittings. Since intake vacuum may cause noisy operation and loss of efficiency, the inlet hose must be as short as possible. Use a 5/8-inch inside diameter hose (not more than 24 inches long) connected to a 3/8-inch pipe nipple in the pump inlet port. Since test stands normally measure oil flow by weight, use care in converting the results obtained with the test oil at the temperature used during the test to gallons per minute. Be sure to have the engine oil (OE-10) at 150°F temperature and run the pump at 1,500 revolutions per minute (rpm). The discharge should be approximately 8.5 gallons per minute (gpm) at 35 pounds per square inch (psi).

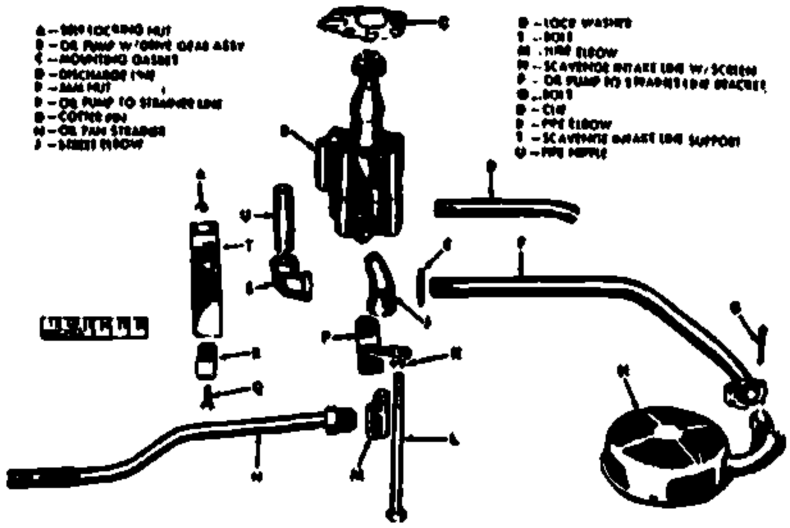


Fig 4-7. Exploded view of oil pump.

If the backlash is not correct or flow test is not sufficient replace the oil pump.

EXERCISE: Answer the following questions and check your responses against those listed at the end of this study unit.

1. What should you do prior to removing the oil pump? ____________________

____

2. When testing the oil pump flow (GPM), there is noisy operation and there is a loss of oil pump efficiency. This would be an indication of what? ____________________

____

3. How does an oil pump test normally measure oil flow? ____________________

____

Work Unit 4-3. OIL GAGES AND SENDING UNITS

NAME THE TYPE OF OIL PRESSURE GAGE NORMALLY USED ON MILITARY VEHICLES.

GIVEN A SITUATION WHERE A JUMPER WIRE ATTACHED TO THE TERMINAL END OF THE SENDING UNIT WHILE GROUNDED, AND THE RECEIVING UNIT REGISTERS WITH THE IGNITION SWITCH ON, STATE THE TROUBLESHOOTING PROBLEM.

Types of oil gages. Normally there are two types of oil gages in an engine: one indicates the pressure of the oil in the lubricating system; and the other indicates the oil level in the oil pan.

Oil pressure gage (fig 4-8). The pressure gage is mounted on the instrument panel. It is calibrated in pounds per square inch or in some other comparative system to indicate the pressure in the lubrication system. There are two types of oil pressure gages, mechanical and electrical; however, since most military vehicles use the electrical type, this will be the one described. In the electrical oil pressure gage operates a signaling device known as the sending unit. Immediately the gage on the dash indicates the oil pressure. The instructions concerning the pressure to be maintained may be found in pertinent technical manuals. If some part of the engine lubricating system becomes clogged, the pressure indicated on the gage will rise abnormally. New or cold oil also will produce a high oil pressure reading.

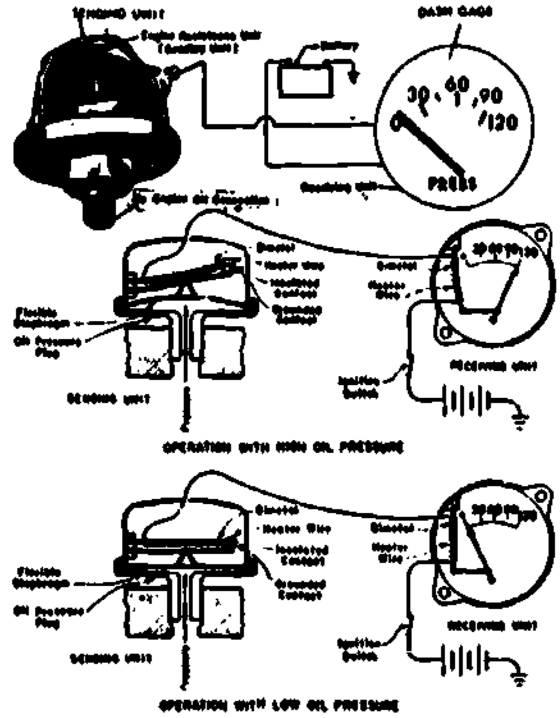


Fig 4-8. Electrical oil gage.

Warning lights. Electrically operated warning lights for indicating oil pressure are being used in military vehicles. These lights are called low oil pressure warning lights.

Oil-level gage (fig 4-9). The oil-level gage, also known as the dipstick, is usually the bayonet type. It consists of a small rod which extends into the oil pan through a small hole in the side of the crankcase. In most cases it is marked to show "LOW," and "FULL" oil levels.

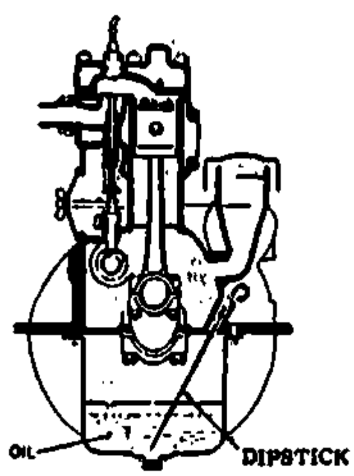


Fig 4-9. Oil-level gage.

Readings are taken by pulling the gage out from its normal place in the crankcase, wiping it clean, dipping it back fully into the crankcase, and then removing it again noting the height of the oil on the lower or marked end.

Oil sending unit. The oil sending unit operates under pressure from the engine oil supply. Normally it is connected directly to an oil connection where the oil is forced into it causing a flexible diaphragm to lift off its seat. This electrically actuates an oil pressure gage on the dash.

Testing procedures. If the gage fails to register, it is necessary to determine whether the sending unit, the receiving unit (gage), or the wiring which connects the two units is at fault. The test necessary to locate the cause of trouble may be performed in two ways. The first method involves shorting the sending unit and the second method requires the use of test equipment.

Testing by shorting out sending unit (fig 4-10). Use a jumper wire for this purpose (a wire of sufficient length with clip terminals on each end). Attach one end of the jumper to the terminal end of the sending unit with the wire attached and the other end to a good ground on the engine or frame. Turn on the ignition switch. If the receiving unit registers (show movement), install a new sending unit.

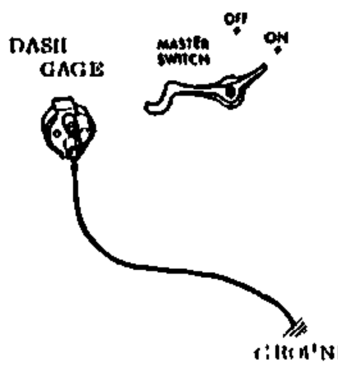


Fig 4-10. Testing by shorting out.

Testing with ohmmeter (fig 4-11). When using the ohmmeter, connect the negative lead to ground and the positive lead to tne terminal end of the sending unit (engine should be running). The meter should register a given resistance in ohms. To convert the ohms to psi (the measure of oil pressure read on the oil pressure gage on the instrument panel), use the chart in figure 4-11.

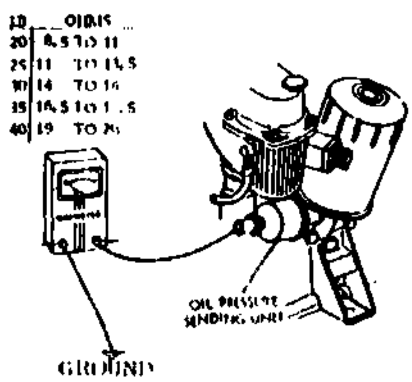


Fig 4-11. Using an ohmmoter to test sending unit.

EXERCISE: Answer the following questions and check your responses against those listed at the end of this study unit.

1. There are two types of oil pressure gages used in the lubricating system. Which type is primarily used in military vehicles? ____________________

____

2. When testing a sending unit, the jumper wire is attached to the terminal end of the sending unit and to ground. If the receiving unit registers with the ignition switch on, what would you suspect? ______________________________

____

Work Unit 4-4. TROUBLESHOOTING

STATE THE MOST COMMON TROUBLE EXPERIENCED WITH THE ENGINE LUBRICATING SYSTEM.

STATE WHAT EFFECT TIGHT ENGINE BEARINGS WOULD HAVE ON ENGINE OIL.

General. Failure to use the proper grade of oil and failure to keep oil at the proper level are the two most common causes for trouble in the lubricating system of an engine. Using oil of incorrect viscosity will contribute to engine problems such as bearing wear which in turn will cause the engine to overheat. Oil must be kept at a proper level or the final result will be a damaged engine. A troubleshooting table has been inserted to assist you in isolating problems you may have in the lubricating system.

Troubleshooting table

Table 4-1. Troubleshooting the Lubricating System

Malfunction	Probable causes	Corrective action
	LUBRICATION SYSTEM	
1. Low oil pressure	a. Worn bearings in engine	a. Overhaul engine if pressure is too low (10 psi)
	b. Defective or stuck oil pressure relief valve	b. Repair and replace oil pressure relief valve.
	c. Diluted engine oil	c. Locate source and repair. Drain crankcase and refill with proper grade oil for prevailing temperature.
	d. Defective or clogged oil pickup tube and screen assembly	d. Remove oil pickup tube and screen assembly. Clean and repair.
	e. Loose or defective oil plug in camshaft assembly	e. Disassemble engine and replace loose or defective oil plug in camshaft assembly.
2. High oil pressure	a. Improper grade engine oil	a. Drain crankcase and refill with proper grade oil. Refer to pertinent lubrication order.
	b. Defective or stuck oil pressure relief valve	b. Repair or replace oil pressure relief valve.

Table 4-1. Troubleshooting The Lubrication System--contd

3. Fluctuating oil pressure.	a. Low crankcase oil level.	a. Add oil to bring proper level.
	b. Clogged oil filter.	b. Replace oil filter. Refer to pertinent lubrication order.
	c. Defective or clogged oil pickup tube and screen assembly.	c. Remove oil pickup tube and screen assembly. Clean and repair
	d. Damaged oil pan restricting oil pickup tube inlet	d. Remove and repair oil pan.
	e. Defective oil pressure relief valve	e. Repair or replace oil pressure relief valve.
4. High oil temperature.	a. Improper grade engine oil or low oil level	a. Drain crankcase and refill with proper grade oil. Refer to pertinent lubrication order.
	b. Tight engine bearing.	b. Oversized bearings used on standard sized bearing journals upon overhaul. Engine must turn freely prior to initial start after overhaul. If not free, disassemable and install proper size bearings.
5. High oil consumption.	a. Improper grade engine oil	a. Drain crankcase and refill with proper grade oil. Refer to pertinent lubrication chart.
	b. Engine oil leaks	b. Repair engine oil leaks.
	c. Failure of vacuum pump	c. Repair or replace vacuum pump as necessary.
	d. Worn piston rings or cylinders	d. Overhaul engine.
	e. Worn valve stems, valve guides, or defective valve seal	e. Remove cylinder head and replace worn valves or defective intake valve seals.

EXERCISE: Answer the following questions and check your responses against those listed at the end of this study unit.

1. What is the most common trouble experienced with the engine's lubricating system?

____

____

2. What effect would tight engine bearings have on the engine oil? ______________

____

SUMMARY REVIEW

You have now learned those procedures required to repair and rebuild an engine's lubrication system.

Answers to Study Unit #4 Exercises

Work Unit 4-1.

1. b

Work Unit 4-2.

1. check gear backlash
2. That the oil pump inlet hose is too long
3. By the weight of the oil

Work Unit 4-3.

1. Electrical gages
2. That the sending unit is bad and must be replaced

Work Unit 4-4.

1. Failure, to use the proper grade of oil and maintain proper level
2. A higher oil temperature

AUTOMOTIVE COOLING AND LUBRICATION SYSTEMS

Review Lesson

Instructions: This review lesson is designed to aid you for your final exam. You should try to complete this lesson without the aid of reference materials, but if you do not know an answer, look it up and remember what it is. The enclosed answer sheet must be filled out according to the instructions on its reverse side and mailed to MCI using the envelope provided. The questions you miss will be lised with the references on a feedback sheet (MCI-R69) which will be mailed to your commanding officer with your final exam. You should study the reference material for the questions you missed before taking the final exam.

A. Multiple Choice: Select the one answer which BEST completes the statement or answers the question. After the corresponding number on the answer sheet, blacken the appropriate circle.

Value 1 point each

1. What is the purpose of the liquid cooling system?

a. To control the engine rpm by removing heat
b. To act an an indirect medium to carry the heat from inside the engine and transfer it into the air
c. To assist in removing vapors from the crankcase by dissipating heat from the engine
d. To remove heat by regulating the air flow around the hot cylinders

2. Which cooling system component provides a passageway for the coolant around the hot cylinders of the engine?

a. Combustion chambers
b. Engine water tubes
c. Radiator
d. Engine water jacket

3. Which cooling system component stores and cools the liquid coolant?

a. Cylinder block
b. Water jacket
c. Water pump container
d. Radiator

4. Liquid cooling systems make use of liquid which is called

a. coolant.
b. petroleum.
c. a heat retardant.
d. a solution.

5. Water is the basic coolant used in the cooling system, but is very seldom used alone because it

a. has no properties to prevent rust and corrosion of the system.
b. evaporates too rapidly and has to be checked continuously.
c. has a low boiling point.
d. requires more protective maintenance than other liquids.

6. What chemical is used to prevent freezing, rust, and corrosion in the cooling system?

a. Alcohol
b. Petroleum
c. Antifreeze
d. Cleaning solvent

7. What is used to protect your cooling system if you are located in an area where the climate is warm year-round and antifreeze is not required?

a. Cooling system corrosion inhibitor
b. A special coolant that can be ordered through supply
c. A petroleum-base liquid
d. Replace radiator hoses of grayish stains are noticed around the expansion plugs

8. How can you, as a mechanic, reduce clogging and overheating of the cooling system?

a. By keeping the "V" belts tight
b. Lubricating the water pump twice a year
c. Regular flushing of the cooling system
d. Replace radiator hoses if grayish stains are noticed around the expansion plugs

9. An authorized cleaning compound is used in the radiator to

   a. neutralize any acid.
   b. stop the action of a neutralizer.
   c. loosen rust, scale, and sludge.
   d. prevent engine freeze up.

10. Forcing water into the outlet and out the inlet holes of the radiator is known as

   a. pressure flushing.
   b. normal flushing.
   c. block flushing.
   d. flow testing.

11. What is considered to be the most common cause of overheating in the cooling system?

   a. High engine speeds
   b. Shortage of coolant
   c. Tropical driving
   d. Loose fan belts

12. In military vehicles what component minimizes the loss of coolant through evaporation?

   a. The water pump which circulates the coolant
   b. The top tank of the radiator
   c. The radiator core
   d. The radiator cap

13. What is the common cause of coolant through the overflow outlet?

   a. Low engine temperature
   b. Excessive water pump pressure, forcing coolant out the overflow pipe
   c. Overfilling the radiator
   d. Inoperative thermostat valve

14. Why is it important to test the antifreeze solution?

   a. To insure that the coolant provides protection against freezing temperatures
   b. To determine the amount of evaporation
   c. A weak antifreeze solution will cause aeration in the system
   d. To avoid rapid boiling out the overflow pipe

15. When using antifreeze hydrometer, the freezing protection of the solution is determined by comparing the

   a. light and the shadowed areas.
   b. float and thermometer readings to the protection chart on the hydrometer.
   c. level of the float after running the engine.
   d. drops on the measuring window to the protection chart on the hydrometer.

16. The antifreeze and battery tester that is considered a dual purpose type reflects its reading

   a. on the line where the light and shadowed area meet.
   b. at the top of the dark line.
   c. at the bottom of the light line.
   d. in the middle of the dark area.

17. An unusual change in the level of coolant in the radiator would indicate

   a. a defect or malfunction in the cooling system.
   b. frayed fan belts.
   c. the thermostat is not allowing coolant through the engine.
   d. the water pump is not circulating the coolant through the engine.

18. What is the cause of a puffed out radiator hose?

   a. The hose clamps are too tight
   b. Air is in the system
   c. The wrong size hose has been used
   d. The hose lining is worn out

19. What is the cause of a radiator hose that wrinkles or folds inward while the vehicle engine is running?

   a. The engine is overheated
   b. The coolant in the cooling system is low
   c. There is excessive air in the system
   d. The radiator hose is too weak

20. Your cooling system has two drive belts. One becomes frayed and must be replaced. What should you do with the other belt?

   a. Adjust it tighter to match the new belt tension.
   b. Replace it along with the new belt as a set.
   c. Replace the new belt and adjust it to match the old belt tension.
   d. Remove it and use the new belt temporarily by itself.

21. Scale or rust deposits which are caused by excessive air in the cooling system may result in

   a. a rapid circulation of water.
   b. a loss of antifreeze.
   c. clogging the cooling system water passages.
   d. clearing the cooling system water passages.

22. Excessive foaming, coolant loss, and overheating may be caused by

   a. excess coolant in the system.
   b. defective drive belts.
   c. aeration.
   d. worn impeller blades.

23. Engine vibration, road shock, deterioration of metal parts, and strain on and around various connections cause

   a. a weak coolant solution.
   b. excessive pressure in the cooling system.
   c leakage in the cooling system.
   d. sludge and foam to build up in the cooling system.

24. Leakage of any kind in the cooling system that is not corrected will result in

   a. engine overheating.
   b. engine overcooling.
   c. weak hoses.
   d. rust and corrosion.

25. Coolant in the engine oil and exhaust gases may be caused by

   a. a faulty radiator cap.
   b. a faulty thermostat.
   c. excess coolant in the radiator.
   d. a loose or leaking cylinder head gasket.

26. Engine overheating caused by irregular coolant flow may be due to

   a. a damaged radiator cap.
   b. a broken hydrometer.
   c. excess coolant in the radiator.
   d. a damaged thermostat.

27. When should the thermostat be removed?

   a. Once a year
   b. For summer driving
   c. When necessary for testing or replacing only
   d. During combat operations

28. Which part of the radiator is designed to control the pressure in the cooling system?

   a. Radiator cap
   b. Thermostat
   c. Overflow pipe
   d. Water jacket

29. Engine overheating caused by lack of coolant circulation may be due to

   a. a water pump failure.
   b. a broken radiator cap.
   c. excess coolant in the system.
   d. an improper coolant mixture.

30. When you open the radiator drain cock, the coolant flows out at a very slow rate. To allow the coolant to flow more freely, you would

a. loosen the radiator cap.
b. close the radiator cap.
c. run the engine at high idle.
d. loosen the radiator hoses.

31. When disconnecting the upper radiator hose from the radiator inlet, care must be taken not to

a. damage the inlet pipe.
b. mix hose clamps.
c. drop clamps into the radiator inlet.
d. damage the thermostat valve.

32. When replacing radiator hoses how would you determine which type to use?

a. Compare the replacement hose with the old one.
b. Check the slack of each hose before installing.
c. Check the TM for the vehicle your are working on.
d. You would determine the length and cut the size you needed.

33. The radiator shroud must be removed before the _________ can be taken out.

a. water pump
b. fan belts
c. thermostat
d. radiator

34. When replacing the radiator, you would reverse the removal procedures and tighten the radiator bolts

a. handtight so engine vibration will not break them loose.
b. to a specified torque given in the TM.
c. with a socket wrench to a snug fit.
d. with an open end wrench until the lock washers are meshed together.

35. A Flo-Tester is used to determine

a. percentage of plugging in a radiator.
b. freezing point of coolant.
c. radiator pressure.
d. water pump pressure.

36. You are testing a radiator with a Flo-Tester. The gpm reading is 15, but the gpm specified is 30. What is the percentage of clogging in the radiator?

a. 15%
b. 40%
c. 50%
d. 75%

37. Prior to testing or extensive repairs, a radiator should be

a. removed from the vehicle.
b. tagged and allowed to stand for 24 hours.
c. cleaned.
d. rodded.

38. You are preparing to air leak test a radiator and you see a large obvious leaks on the radiator top tank. You would

a. plug these holes with rubber plugs and make the test.
b. repair these obvious leaks before air testing.
c. mark the leaks with chalk and repair them after the air test.
d. add the pressure lost from the leak to the gpm reading.

39. To insure that the radiator cap functions properly it should be

a. replaced every 3 months.
b. periodically tested and visually inspected.
c. replaced if overheating occurs.
d. temperature tested to at least 200°F.

40. If repeated vat cleanings fail to remove restrictions in the radiator your next step would be to

a. discard the radiator and replace with a new one that has no restrictions.
b. remove top tank for rodding.
c. disassemble radiator for a thorough inspection.
d. remove the radiator core, making sure safety goggles and rubber gloves are worn.

41. When disassembling the radiator, components are code-marked for what purpose?

a. So that they will be replaced correctly
b. For easier cleaning
c. To identify defective parts
d. For ease of handling

42. When repairing a damaged radiator, you would prepare the area to be repaired by cleaning it with

a. muriatic acid.
b. gasoline.
c. soap and water.
d. an abrasive to aid the hot solder.

43. When assembling the radiator, the tank is held to the header for soldering by using a

a. radiator side notcher.
b. wedge vice and block of wood.
c. header clamp.
d. header and tank adapter.

44. With the engine stopped, how would you check for faulty water pump bearings?

a. Shake the pulley up and down.
b. Exert excessive pressure on one of the fan blades.
c. Attempt to move one of the fan blades back and forth lengthwise with the pump shaft.
d. Slack in the drive belts will cause noise in the bearings.

45. When removing the water pump, why is it important to clean the gasket area?

a. To ensure a water tight seal
b. To prevent evaporation of the antifreeze
c. To aid in detection of early coolant leak
d. To prevent contamination of the coolant through the gasket

46. When replacing the water pump on the M151 1/4-ton truck, the mounting bolts should be tightened to

a. 5-10 lb-ft torque.
b. 10-20 lb-ft torque.
c. the specified torque in the TM .
d. 5-15 lb-ft torque.

47. Which cooling system component automatically controls the amount of coolant flowing through the radiator core?

a. Water pump
b. Fan and belt unit
c. Thermostat
d. Water jacket

48. After removing the thermostat from the thermostat housing assembly on the M35 2 1/2-ton truck, you would next

a. conduct a Flo-Test on the cooling system.
b. back flush the radiator and block.
c. inspect the thermostat seal and proceed to test the thermostat.
d. discard the thermostat and install a new one.

49. When should a new thermostat gasket be installed?

a. Quarterly
b. Each time the antifreeze is checked
c. Each time the thermostat is removed
d. When the operator determines it needs replacing

50. The engine has had time to warm up and the temperature gage does not indicate. You remove the wire from the sending unit and momentarily ground the wire to the engine block. If the gage now indicates, you would

a. replace the sending unit.
b. replace the wiring from the gage to the sending unit.
c. replace the temperature gage.
d. check the ignition switch for a short circuit.

51. To remove the temperature sending unit, you should

a. run the engine until it is warm.
b. use an open end wrench.
c. drain coolant level until it is below the sending unit.
d. use a spanner wrench.

52. Before installing a new temperature sending unit, you should

a. test it to insure it is operative.
b. waterproof the connections.
c. coat the threads with a nonhardening gasket cement.
d. make sure it is pressure tested to 15-20 PSI.

53. A combustion gas leakage into the coolant would cause

a. foaming of coolant.
b. overcooling.
c. thermostat to fail.
d. loss of pressure.

54. What is the purpose of the engine lubricating system?

a. To act along with the positive-type ventilating system to cool the engine
b. To lubricate, to reduce friction, and increase engine efficiency
c. To increase engine torque and speed
d. To allow blowby gases to circulate oil vapors through the engine

55. Which type of lubrication system are the main bearings force-fed from the oil pump?

a. Splash system
b. Splash and force-fed system
c. Dipper type of system
d. Drip system

56. What type of lubrication system lubricates the connecting rod bearings through drilled holes in the crankshaft?

a. Splash system
b. Splash and force-fed
c. Full-force system
d. Drip system

57. To remove impurities from the oil is an operation that is performed by the

a. oil filter.
b. road draft system.
c. positive ventilation system.
d. air cleaner

58. How are lubricants kept clean?

a. By checking them frequently
b. By keeping them covered
c. By storing them in cool areas
d. By changing them quarterly

59. What is the purpose of a lubrication order (LO)?

a. It tells you at what temperatures you should change the oil.
b. It explains step by step procedures used in the combat lubrication.
c. It orders you to change lubricants once a month.
d. It tells what kind of lubricants to use and how much and how often to use it.

60. What is the likely cause of a high oil level in the crankcase?

a. Oil pump pressure too high
b. Improper lubricant being used in the crankcase
c. Cooling system leaking coolant into the oil
d. The ventilating system not relieving pressure

61. What is important to remember when adding or changing engine oil?

a. Cleanliness of the oil
b. Changing the oil ventilator valve
c. Changing the oil filter
d. The engine oil is cold

62. Which item listed below is a type of oil pump?

a. Syphon type
b. Rotor type
c. Gravity type
d. Crank type

63. When disassembling the oil pump, the pickup tube gasket should be

a. discarded, and a new one obtained to replace it.
b. code-marked so it can be re-installed in the same manner.
c. coated with a light coat of oil so it does not dry out.
d. cleaned of all carbon deposits and marked for proper installation.

64. While testing the oil pump flow (gpm), noisy operation and loss of oil pump efficiency occurs. This would be an indication that

a. the oil pump inlet hose is too short.
b. the rpm of the pump is too low.
c. the oil pump inlet hose is too long.
d. the oil pump has not reached normal operating temperature.

65. What is the [illegible] indicator used for when assembling the oil pump?

a. It is used to check gear back lash.
b. It is used to check the pressure relief valve.
c. It is used to check end clearance.
d. It is used to check the rotor end play in the pump.

66. There are two types of oil pressure gages used in the lubricating system. Which type is primarily used in military vehicles?

a. Electrical gages
b. Manual gages
c. Mechanical gages
d. Positive type gages

67. When testing a sending unit, the jumper wire is attached to the terminal end of the sending unit and to ground. If the receiving unit registers with the ignition switch on, you would suspect the

a. sending unit is bad and replace it.
b. receiving unit is bad and replace it.
c. wiring is bad and repair it.
d. ignition switch is bad and replace it.

68. What is the most common trouble experienced with the engine lubrication system?

a. Contamination of the lubricating system
b. Clogged oil filters and lines due to sludge
c. Failure to use the proper grade of oil
d. Defective or stuck oil pressure relief valves

69. What effect would tight engine bearings have on the engine oil?

a. High oil consumption
b. High oil temperature
c. Fluctuating oil pressure
d. Fluctuating pressure relief valve operation

Total Points: 69

* * *

TAE-1

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1. Did you find inaccurate or outdated information in this course? ☐ Yes ☐ No

   List the areas you found inaccurate or out of date. Give page or paragraph if possible.

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2. How long did it take you to finish the course?

   ☐ 1-5 hours ☐ 11-15 hours ☐ More than 20 hours
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3. Were the procedures taught in this course understandable and useful? ☐ Yes ☐ No

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   ☐ Almost all ☐ Very little ☐ None
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   If "Yes,", explain ______

6. Were the illustrations in this course helpful? ☐ Yes ☐ No

   If "No," how could they be improved? ______

7. Put an "X" in a box on the scale below to show how well you feel the lessons and the course materials prepared you for the final examination. (On this scale "10" indicates that the material prepared you very well, a "5" indicates adequate preparation, and a "1" indicates very poor preparation.)

   Very Poor | Adequate | Very Well

1	2	3	4	5	6	7	8	9	10

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   ☐ Yes ☐ No ☐ No questions sent to MCI

9. Please list below any suggestions you may have to improve this course. Try to be specific; give page or paragraph numbers. (You may also use the space on the back or attach additional sheets.)

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