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FUELS AND LUBRICANTS IN AGRICULTURE 1/

by

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Contents

INTRODUCTION

The object of this paper is to review the fundamentals of fuel and lubricant storage and handling under agricultural conditions, and to describe the results obtained from a practical application.

Well organised maintenance keeps machinery in working order and saves valuable time. The less time the farmer spends on repairing his machines the more time he will have to get on with his real job of growing crops and the greater will be the profitability of his operations. Towards this end equipment manufacturers argue that correct routine servicing increases the life and overall output of farm machinery; oil companies point out the considerable benefits that accrue from the correct storage and handling of fuels and lubricants.

The opportunity of determining the actual benefits that can be achieved by practicing the precautions and procedures advocated by equipment manufacturers and oil companies has been provided by participation in a scheme in Scotland where seven neighbouring farms, covering a total of 37,000 acres, were amalgamated under one management (Ref. 1). The scheme embodied the re-organisation of the machinery and servicing arrangements to obtain maximum benefit from a planned maintenance programme. By the installation of appropriate, yet cheap and simple, facilities the extent to which lost farming time, mechanics' effort and spare-part costs can be reduced were clearly demonstrated.

PRINCIPLES OF FUEL STORAGE

During the 20th century, tractor designers have made use of almost every kind of internal combustion engine. At first gasoline and kerosine-fuelled engines were the most popular, and in certain areas of the world they still are. But after World War II the diesel engines took an increasingly prominent place, first in Europe and then in America. Today almost all the current British tractor production is diesel powered, with only a few gasoline-engined tractors being built for some Middle East countries where there is a low tax on gasoline used for agricultural purposes. In North America, the diesel engine has grown in popularity to the point where it now accounts for more than 50% of the tractor production, in competition with gasoline, and LPG fuelled engines, used mainly in the smaller tractors (Ref. 2).

Consequently in most developing areas of the world the diesel engine is the most common form of agricultural power unit and the following comments on storage and handling refer to diesel fuel.

The rules for the correct storage of fuel for tractors are so simple that when written down they appear to do no more than state the obvious. Yet the number of cases in which the simple rules are ignored or overlooked, are so frequent that there is ample justification, without apology, for presenting them again.

1. Tanks should be designed and positioned to allow periodic draining of accumulated sludge and water.

   Essential features being:

   a) An outlet in the base of the tank close to the end opposite the draw-off point.

   b) Tank to slope downwards towards drain valve - 1 in 20 (Fig. 1).

2. Fuel outlet pipe to protrude into the tank a few inches above the base, to ensure that water and sludge on the base of the tank are not drawn-off into the tractors' fuel tanks (Fig. 2).

3. Air ventilation pipes should be designed and positioned to avoid ingress of rainwater and from being blocked by birds' nests (Fig. 3).

4. Tanks should be elevated and positioned so that machinery can be gravity-fed by flexible hose direct from the storage tank without resorting to pumps or intermediate containers (Figs. 4 & 5).

5. Storage tanks should be filled by a coupled hose and fixed stand-pipe, not by free discharge from an open hose through an inspection cover.

6. A dipstick or suitable contents gauge must be provided (Fig.1).

7. Galvanized tanks should <u>not</u> be used because acids sometimes formed with certain types of diesel fuel and water may attack the zinc coating. Corrosion of the zinc coating can cause filter blocking and fuel system failure.

8. Cylindrical tanks are better than rectangular tanks because all contaminents, including the water condensed from the atmosphere onto the tank walls, will collect in the bottom sector of the cylindrical tank to facilitate ready draining. The ideal fuel storage tank, based on the above rules, will be:

Cylindrical

Made of steel

Elevated above the level of tractor tanks

Tilted to facilitate proper draining of water

Fitted with drain tap

Capable of accepting a dipstick (or fitted with a contents gauge)

Filled by standpipe, (not an open-ended hose)

Vented to atmosphere

Easily accessible for both filling and discharging

Fitted with a flexible discharge pipe and trigger cut-off nozzle; the nozzle when not in use should be clipped in a suitable holder

Farm fuel tanks of any size designed with the foregoing features incorporated will guarantee complete freedom from tractor fuel system problems arising from the ingress of dirt and water.

Rectangular tanks without draining facilities are most undesirable especially if open man-hole filling is adopted and if they are placed close to the ground so that cans or buckets have to be used to transfer fuel to the machines. Unfortunately it is the latter which are most frequently found in agricultural locations in all parts of the world.

PRINCIPLES OF LUBRICANT STORAGE

All tractors require an oil supply for three basic compartments, the engine, the transmission (gear box and final drive) and hydraulics, whilst all slow-moving parts such as wheel bearings and steering mechanisms must be lubricated with grease. Whichever grades and quality of oil and grease are selected principles of storage and handling remain the same.

During the storage period, while oil is not being drawn from the drums, they should be stored in the horizontal position with the bungs in the positions corresponding to 3 o'clock and 9 o'clock on the clock face. Storing the drums horizontally ensures that rainwater or any other possible form of contaminant is not able to accumulate in the drum ends; positioning the bungs at 3 o'clock and 9 o'clock ensures that moist air is not drawn through the seals when the contents of the drums expand and contract due to changes in ambient temperature. Once a tap is fitted and the drum is brought into use it should be held horizontally in a cradle high enough off the ground to allow a can to be placed easily beneath the tap (Fig. 6).

Alternatively, drum pumps that fit into the large bung in the end of the drum can be used for transfering the oil into dispensing cans. In this way man-handling of the drums is reduced and there is less risk of waste due to spillage. Where a large fleet of tractors is to be serviced and a workshop is justified, then dispensing can be improved considerably by the use of compressed-air operated drum pumps coupled with a simple dispensing bar. An example of a lubrication bay in ar agricultural workshop is shown in Fig. 7

45-gallon or 25-gallon drums can be handled by those methods but 5-gallon drums, which are sometimes the most economical way of buying oils in smaller quantities can stand vertically on a suitable bench or plinth. The tap is positioned in the side of the drum, protruding out over the edge of the stand to allow a suitable container to be placed underneath it for drawing-off the lubricant.

Oil in use should always be kept under cover and it is also preferable for drums awaiting use to be stored under cover, protected from the sun and rain.

It is desirable, wherever possible, to allocate a specific place for storing and dispensing lubricants if contamination by dust and dirt is to be avoided. A simple dividing partition is all that is necessary to separate the oilstorage area from the rest of the floor space, but the floor of the oil storage area should, whenever possible, be made of concrete or timber. To complete the oil storage facilities a shelf or rack should be fitted, thus avoiding the temptation to leave cans laying on the floor.

The storage of greases presents no problems as they are packed in sealed drums or buckets but once the grease bucket is opened the problem of handling and loading the grease into the guns arises. Figure 8 illustrates only too clearly what happens on many farms, yet by the use of a gun that mounts directly on to the container all the problems of dirt and moisture ingress can be overcome. In addition, the farm worker does not have to face the messy job of loading the hand-operated grease gun - a task that must make him reluctant to use it. Figure 9 illustrates a typical, direct-mounted grease gun.

A new approach to the handling of grease on the farm is currently being fostered in Europe by the introduction of cartridge loaded grease-guns and pre-packed grease. With this system it is only necessary to remove the end caps from the grease cartridge, load it into the gun which is then ready for immediate use. Figure 10 shows a typical example of this type of gun. It cannot be emphasised too strongly that dirt and moisture must be kept out of grease otherwise considerable damage, particularly to ball and roller bearings, will occur.

PRACTICAL FARMING EXERCISE

Before the scheme mentioned in the Introduction was inaugurated the seven farm units supported 35 tractors, together with an extensive range of field implements. Each farm had its own allocation of machinery with the driver or operator responsible for day-to-day servicing.

Two fitter/mechanics were fully employed in maintaining and servicing this equipment from a primitive, dirty and overcrowded workshop, while each farm unit had a dark and dirty shed in which a multitude of oil drums and tins, grease pails and grease guns were spread in an untidy array - usually on the ground! As the conditions were certainly no better, and in many respects were worse than those encountered by the Authors in many parts of the world including West Africa, South-East Asia, North Africa and the Middle East, it is reasonable to conclude that the failures, difficulties and expense incurred in trying to operate a fleet of mechanical equipment under these conditions were not significantly different from those problems encountered, and frequently not recognized as easily avoidable, in many developing areas of the world. It is therefore worth considering the exercise in Scotland in some detail.

Before the new scheme started minor tractor engine failures were frequent, poor starting being the biggest single problem. This was partly due to complete disregard of any attention to batteries, battery leads and terminals. Fuel system failures were however a major secondary cause of failure; in many cases resulting in a repair with the tractor out of service for several days.

All too frequently water and dirt were detected in the fuel lines, filters and pumps. Reports from the mechanics confirmed that fuel system failures, including expensive seizure of the fuel injection pumps were a continual source of disruption to profitable farm work. In spite of repeated problems no steps had been taken to improve the fuel storage facilities. The shape, position and location of the tanks made it impossible to drain them. Consequently, the water and sludge accumulated over more than ten years of use was stirred up into the tank every time a new charge of fuel was delivered. Extreme fuel system troubles could have safely been predicted merely from an examination of the elementary storage arrangements.

It was therefore necessary to install new fuel tanks at convenient points adjacent to each farm and provide storage facilities for lubricants, grease & filter elements along with suitable oil and grease dispensing equipment.

Each 750 gallon fuel tank rests on brick piers at a height of eight feet, thus allowing direct gravity filling into the tractors' fuel tanks. For the purpose of recording fuel consumption the fuel is dispensed through gravity flow meters. (Fig. 11).

A steel walk-way provides easy access to the tank, especially for using the dipstick. Filling is effected through a down-pipe terminating some 18" from ground level. A concrete hard-standing in front of the tank is used by the farm tractors for refuelling and for minor service work such as checking oil levels and changing lubricating oil.

The space under each tank has been filled-in and fitted with lockable doors to provide a storage place for oil and grease. Spare fuel and oil filter elements are kept in this store in which shelves have been fitted (Fig. 12).

The fuelling units are successful in completely overcoming tractor breakdowns due to the ingress of dirt. Waste due to spillage, which in the past was considerable when tractors were filled from poor dispensing equipment, has been reduced to nil.

Spare parts and repair work costs were not carefully recorded in the period before the exercise started, but it is safe to estimate that the parts bill saved merely by clean fuel amounted to some £350 to £500 per year. Lost production time was also unrecorded so no objective comparison can be made. The outstanding feature is that the two fitters, who previously spent their working days attending to minor breakdowns are now free to carry out machinery overhauls and maintenance that previously had to be passed to manufacturers' approved service depots. With reduced overtime, and a proportion of their time now allocated to a simple programme of preventive maintenance, the improvements appear to have saved something in the order of 1,000 mechanics' man-hours and at least an equivalent amount in productive farm work.

Before the operation commenced each farm unit stocked a multitude of different grades of lubricant in a variety of different-sized containers. Considerable difficulty, coupled with a high risk of dirt contamination, was involved in the sheer task of dispensing the lubricant into the appropriate part of the tractor. Under such conditions it is needless to say that the risk of putting the wrong oil in the wrong part of the tractor was great. Therefore, one of the first tasks of the operation was to consider carefully the possibility of lubricant rationalisation. A study of the machines on the Estate - including tractors, general farm implements, lorries, vans and cars - showed that considerable rationalisation could be achieved so the following arrangements were made.

1. Each fuelling installation would carry one grade of Universal Oil of Supplement 1 quality and SAE 10W/30 viscosity. (See Appendix). This would be used in the engine, transmissions and hydraulic systems of the tractors and in any other agricultural machinery allocated to that farm. Only one grade of grease was made available - a moderately thick (Number 2) lithium type that could act as a Universal Grease for all machinery.
2. The main workshop was responsible for looking after the Estate's fleet of vans, lorries and cars in addition to a wide range of agricultural machinery. The workshop was therefore supplied with Universal Oil and an Extreme Pressure type gear oil for use in the transmissions and rear axles of the cars, vans and commercial vehicles. The one Universal Grease was adopted for use throughout the complete range of machinery although it was necessary to carry a small tin of special purpose grease for use when overhauling water pumps. The wisdom of adopting rationalisation of this type may be questioned by many manufacturers but it is significant that only the grades mentioned have been used on the farms for the past five years and no problems have arisen. A list of machinery currently in use on the Estate is given below:

<u>Tractors</u>

1 Massey Ferguson MF 178
1 " " " 175
15 " " " 65
3 " " " 35
1 " " " 203 (industral tractor)
6 Fordson Majors
1 Ford County (four wheeled drive)

<u>Combine Harvesters</u>

5 Massey Ferguson types MF 500, 510 and 515 models.

Farm Vehicles

4 Petrol-engined Land Rovers

3 Diesel-engined Land Rovers

3 Haflingers

Miscellaneous

24 Cars and light commercial vehicles

2 10-ton Ford commercial vehicles.

TRACTOR SERVICE BENCH

As an alternative to the fuelling stations described earlier consideration has been given to the design of a work bench, for use in existing buildings, fitted with the equipment and material needed to carry out routine tractor maintenance. the basic idea being to encourage the drivers to carry out routine maintenance at a focal point to which all machinery should be brought for servicing.

A survey of tractor Handbooks was carried out to determine the nature of work which manufacturers expect drivers to carry out. From this study it was concluded that the following equipment and materials would be required:-

1. Oil for engines and transmissions; dispensing pumps and measuring cans.
2. Grease and grease gun.
3. Compressed air for tyres.
4. Anti-freeze and hydrometer for checking Anti-freeze concentration.
5. Distilled water for battery, hydrometer and battery-charger.
6. Tools for adjusting valve clearances and fan belt tension etc.
7. A convenient working surface.
8. Cupboard space for storing Handbooks, tools etc.

Figure 13 illustrates a design of bench that has been put into service on several farms. The main working surface is at waist height; to one side is a low shelf for storing batteries on charge. Underneath the bench is a small electrically driven air compressor, a keg of grease and a 45-gallon drum of oil. Above, and mounted on a backboard, are cupboards for tools. A vice was not fitted to the working surface because operations likely to require it were not regarded as part of the bench's function and might tempt fitters to cut and file metal, giving rise to a dangerous source of contaminant.

To minimise the accumulation of dust and dirt it was found necessary to site the benches in outbuildings fitted with doors. The siting also allowed for the tractor to be driven indoors in the bad weather and to provide an additional incentive to the driver to carry-out the required maintenance. The cost of the prototype bench was £210 - £110 for the basic bench and £100 for associated equipment. This figure must be compared with the considerable capital value of the machinery and vehicles being serviced. An even cheaper bench could be designed having a hand-operated grease gun and a power take-off compressor in place of the electrically operated unit.

The bench was well received by the drivers and soon became used for all routine maintenance. It provided what the majority of small farms lack - a central point where all equipment and material for servicing can be stored.

MANUFACTURERS CONTRIBUTION TO SIMPLIFIED MAINTENANCE.

Servicing farm machinery should be a simple operation that can be carried out quickly and without special tools. Unfortunately this is not the case with the majority of farm machinery. While manufacturers go to considerable trouble to place the fuel filler caps in an accessible place the filler for the hydraulic oil system is frequently located in such a position that it is necessary to have a special shaped funnel available before it is possible to add oil to this system. Similarly, drain plugs have to be removed by spannering a rough cast square or hexagon that always fails to conform to a known spanner size. These plugs soon become rounded by the repeated use of pipe wrenches of adjustable spanners with the result that the plug becomes difficult to remove and the farmer loses interest in changing the oil.

It should be relatively simple to modify the design of the drain, filling and level plugs and adopt one standard size hexagon (or square) head. The nuts and bolts on filters that have to be undone to change elements should also be standardised. A suitable spanner of robust construction could then be incorporated in the tool kit.

Reference to the servicing chart in the operator's handbook presents a further problem, particularly when different manufacturers equipment is being serviced side-by-side. Several independent bodies allied to farm machinery have realised this problem and have drawn up a proposed standardised lubrication chart for use by agricultural machinery manufacturers. A typical example of a chart drawn up by the American Society of Agricultural Engineers is shown in Figure 14. Manufacturers appear reluctant to adopt these charts. This is unfortunate because the use of standard colours or characters, coupled with a chart having a standard layout would be of considerable value, particularly in Developing Countries.

Manufacturers could further assist maintenance by rationalising the grades of lubricant recommended. Earlier in this Paper we referred to the use of Universal Oils which go a long way towards meeting this requirement. In our experience it is possible to lubricate the majority of farm machinery with two grades of oil.

Namely, a Universal Oil for engines, transmissions and hydraulic systems and an EP gear oil for the use in heavily-loaded rear axles and final reduction gears. With the introduction into Europe of more sophisticated tractors incorporating semi-automatic transmissions and brakes immersed in the rear-axle oil, it will be necessary to introduce a third grade for these special requirements. It may however be some time before these machines find their way into developing countries where two grades of lubricant should suffice for many years to come.

THOUGHTS ON LUBRICATING OIL RATIONALIZATION*

As the tractor is the mainstay of farm machinery it is usual to give it first consideration when selecting oils for the machinery on a farm. With one notable exception (that will be dealt with later) one oil and one grease will lubricate all wheeled tractors. The oil and grease must be carefully chosen, but once selected they can be used in a wide variety of mechanical farm equipment. Rationalization makes the storage and handling arrangements extremely simple; and considerably reduces the possibility of using the wrong grade of oil.

Practical experience has shown that the majority of agricultural tractor engines can be lubricated satisfactorily with an oil of MIL-L-2104B quality. This quality can also be used in engines in agricultural tractors when Series 3 or DS oils are called for, providing the oil change periods are reduced by half. Diesel oils of MIL-L-2104B quality can also be used in petrol, TVO and LPG engines that often work alongside diesel tractors.

The use of a multigrade oil also assists rationalisation and overcomes the need to change the oil with every change of season. The selection of the appropriate viscosity depends on several factors including the country and climate. However, the local oil supplier will be pleased to advise on this matter.

*Note: Simple designation of lubricants will be used in this section of the paper. For full explanations of the various categories, qualities and viscosities of lubricating oils consult References 2 and 3 or the Appendix to this paper.

TRANSMISSION & HYDRAULICS

The important aspect of tractor transmission lubrication revolves round whether or not there is a separate reservoir of fluid for the hydraulic system or whether the hydraulic pump draws oil from the transmission and employs the transmission oil as the hydraulic fluid. The separate system offers the opportunity of selecting an oil to meet specific requirements of the hydraulic system without consideration for the other lubrication requirements of the tractor. The combined transmission-hydraulic reservoir offers a number of distinct practical engineering advantages which have led to the adoption of the combined system by most European tractor manufacturers. The oil quality recommended for the combined systems was originally dictated by the requirements of the transmission units. Consequently, simple gear oils of SAE 80, SAE 90 and SAE 140 viscosity were used in the majority of cases and it was soon found that such oils were far too thick for the successful operation of the hydraulic equipment.

During the late 1950's tests were carried out which showed that the transmission units could be satisfactorily lubricated with a diesel-engine oil which had viscosity characteristics more suited to hydraulic systems than the thicker, conventional gear oils. As a result it has become common practice to use a good quality engine oil in combined tractor transmission and hydraulic systems. However, as transmission loads increased and the requirements of hydraulic systems became more severe, it became necessary to improve the performance of the engine oil to make it more suitable for this type of duty. This lead to the introduction of 'Universal Tractor Oils' which are essentially high quality engine oils that have:-

1) Additional load-carrying additives to protect the gears;
2) Increased resistance to oxidation and oil-film breakdown, to suit hydraulic system requirements;

3) **Ability to** protect gears and hydraulic system components from rusting during periods when the machine is layed-up.

The popularity of these oils among the farmers of Europe has been such that there are now many different Branded products sold as "Universal Tractor Oils". The range of Branded products available is not important. What is important is that any one of these oils will lubricate all tractors; engines, transmissions, hydraulics and any other auxillaries and sundry equipment around the farm.

The Exception to the Rule

Special Transmission Lubricants

Some tractor transmission systems require Extreme Pressure oils of various viscosities - usually described as SAE 80 EP; SAE 90 EP and SAE 140 EP. These oils are not only damaging if used in engines, they can also cause severe damage to hydraulic pumps if inadvertantly used in conventional transmission/hydraulic systems. Tractors and other farm machinery needing EP oils should be made easily identifiable to minimise the risk or misuse of these very active oils that can lead to severe corrosion and wear if used in the wrong machines or in the wrong components of certain machines. Furthermore, manufacturers should not specify these oils unless they are absolutely necessary.

ACKNOWLEDGEMENT

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APPENDIX

SAE VISCOSITY CLASSIFICATIONS FOR ENGINE AND GEAR OILS

The need for a reliable classification of engine-oil viscosities was recognized in 1926 when, to replace previous vague terms such as "light, medium and heavy", the American Society of Automotive Engineers (SAE) adopted an arbitrary scale of numbers corresponding to viscosity brackets. Today there are seven single-grade numberings, each spanning a range of viscosities at a certain temperature: the most viscous or thickest is SAE 50, and the least viscous or lightest is SAE 5W. The suffix W denotes a thin oil recommended for winter use, when engine-starting would be difficult with thicker oils. Viscosity numbers for the winter grades are specified at a temperature of $0^{o}F$, but those for other grades are specified at $210^{o}F$, which is nearer the normal running temperature for an engine oil.

(Note: SAE numbers for gear oils bear no relation to those for engine oils.)

In the latest revision of the SAE viscosity classification (1967) the official values are quoted at $0^{o}F$ in Centipoise and at $210^{o}F$ in Centistokes. In the table below, these values are underlined. Corresponding values in other units are approximate and are for information only.

	Centipoise		Centistokes		Saybolt		Redwood		Engler	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
	VISCOSITY AT 0°F									
5W 10W 20W	- 1200 2400	1200 2400 3600	- 1300 2600	1300 2600 10500	- 6000 12000	6000 12000 48000	- 5200 10500	5200 10500 42500	- 172 343	- 172 1386
	VISCOSITY AT 210°F									
20 30 40 50	5.1 8.6 11.6 15.1	8.6 11.6 15.1 [illegible].4	5.7 9.6 [illegible] [illegible]	9.6 12.9 16.8 22.7	45 58 70 85	58 70 85 110	41 52 62 75	52 62 75 98	1.45 1.80 2.12 2.52	1.80 2.12 2.52 3.19
Note A	[illegible]		3.9		39		36		1.31	
Note B	[illegible]		4.2		40		37		1.34	

A) SAE Recommended Practice J300 specifies that the viscosity of all oils included in the classification shall not be less than 3.9 centistokes at 210°F.

B) SAE Recommended Practice J300 specifies that the minimum viscosity at 0°F of SAE 10W may be waived, provided that viscosity at 210°F is not below 4.2 centistokes.

S.A.E. Transmission Oils Classification

S.A.E. Viscosity Number	Viscosity Range: Saybolt Universal Seconds		Consistency must not Channel in Service at
	at 0°F	at 210°F	
75	15,000 max	-	-40°F
80	15,000/000,000	-	-20°F
90	-	75/120	-10°F
140	-	120/200	20°F
250	-	200 min	-

API Service Classifications for Engine Oils

In and around 1958 it was becoming obvious that there was a need for gradings or standards for engine oils, so that engine manufacturers could safely recommend any oils that conformed to the desired standard, and so that users could select the oils best suited to their requirements. The American Petroleum Institute (API) drew up a series of service classifications to cover the conditions under which engines operate, with three types of service for diesel engines and three for gasoline engines. In the diesel category they are: Service DS, the most severe standard, followed by DM and DG, which are progressively less severe in their requirements. Gasoline engines are covered by Service MS, the most severe; Service MM, catering for moderately severe operating conditions; and Service ML, catering generally for light and favourable conditions in engines with no special requirements.

Since their introduction these classifications have been widely used by industry. However, changes in engine design and operating conditions have outdated the original definitions as applied to gasoline engines and as a result the API have recently announced revisions of its service classifications for motor oils. The changes are as follows:-

Service MS will now designate motor oils which meet the car manufacturer's warranty requirements for engines, including those with emission control devices. The official designation reads as follows:-

"Service MS - Service typical of gasoline and other spark-ignition engines where there are special lubrication requirements for deposit, wear or corrosion control. The severity of these special lubrication requirements varies with engine design factors, which in themselves may vary with makes and models, with fuel characteristics, and particularly with engine operating conditions. Service MS represents the severe conditions of modern gasoline engines including those equipped with emission control devices, operating under manufacturer's warranty."

Service MM will now designate additive-type oils intended for moderate service. The official designation reads as follows:-

"Service MM - Service typical of gasoline and other spark-ignition engines used under moderate operating conditions, but presenting problems of deposit or bearing corrosion control when crankcase oil temperatures are high."

Two-cycle classifications have recently been announced as follows:-

"For Service TC-1 - Service typical of two-cycle, crankcase scavenged engines operating under moderate power conditions, which present no special problems for deposit control.

"For Service TC-2 - Service typical of two-cycle engines operating near or at highest power conditions and requiring greatest protection against scuffing and wear, lacquer and carbon formations and deposits of combustion and their related problems."

The classifications for diesel lubricants DS, DM and DG remain unchanged. Service ML is now absolute (from May 1st 1969).

From the above it will be appreciated that the classifications define engine operating conditions and not oil quality. In order to provide a means of assessing oils as suitable for MS classification, the American motor manufacturers developed a series of engine test methods which have been adopted and published by the ASTM as Standard Methods. These are known as MS Test sequences I to V.

Each Sequence evaluates a particular aspect of an oil's behaviour. Prominence is given to the demands imposed on an oil by modern gasoline engines with hydraulic tappets and closed systems of positive crankcase ventilation. Among the factors assessed are wear of components, deterioration of cams and cam-followers, formation of deposits in pistons and other parts, formation of sludge, corrosion of bearings and, finally, general rusting. Thus is set a minimum performance standard covering all operating conditions, whether encountered singly or together. An oil that withstands these tests successfully can be said to have passed through the most searching and rigorous test conditions so far devised for crankcase oils.

DIESEL ENGINE OIL QUALITIES IN CURRENT USE

SUPPLEMENT 1 (OFTEN REFERRED TO AS S1)

This is an abbreviation for US Army Ordinance Department oil specification 2-104B Supplement 1. Although frequently referred to by manufacturers and oil companies this specification is now out-of-date having been superseded by MIL-L-2104B specification.

The Supplement 1 oil (S1) specification requires an oil to be tested in a Chevrolet L4 gasoline engine and in a Caterpillar L1 diesel engine. On completion of the tests the engines are inspected and rated in terms of deposits, wear and corrosion. An S1 oil can be classified as suitable for service DG by the API rating system.

MIL-L-2104B.

This US Army specification was introduced in 1964 and was developed to fulfil the performance requirements of a lubricant for use in Military vehicles equipped with gasoline or diesel engines and operating under light duty stop - and - go as well as under continuous moderately-high output conditions. For civilian applications today's MIL-L-2104B (often referred to as MIL-B) is generally thought of more as a diesel engine oil, although it is equally suitable for the gasoline engines found in commercial vehicles and agricultural tractors.

The MIL-B specification requires an oil to be tested in four different engines to evaluate the following performance factors.

1) <u>High temperature deposit control</u>. This is assessed in a Caterpillar 1H diesel engine which provides a more severe test than the Caterpillar L1 used for approving S1 quality oils. It is however, less severe than the Caterpillar 1G test used for Series 3 oil evaluations.

2) <u>Low temperature deposit control</u>. This evaluates the ability of the oil to control low temperature deposits in gasoline engines. In this test a single cylinder engine is operated on a low-moderate temperature cycle using a low quality, regular-grade gasoline. On completion of the test the engine is rated for sludge and varnish deposits on engine components.

3) <u>Rust Protection</u>. This test is carried out in a gasoline engine running under low-speed, low-temperature conditions and is designed to simulate short trip winter journeys. After the test the engine is inspected and rated for rust, corrosion, varnish and sludge deposits.

4) <u>Copper/Lead Bearing Corrosion Protection</u>. This test is carried out in a gasoline engine operated at high temperature. It assesses the oil's ability to resist oxidation, corrosion and the formation of varnish. On completion of the test the copper/lead small-end bearing is checked for weight loss, while the pistons are rated for skirt varnish. A MIL-B oil would be classified as suitable for service DM and MM by the API rating system.

<u>SERIES 3</u>. A series 3 lubricant is one that meets the requirements of the Caterpillar Tractor Company's Superior Lubricants - Series 3, which was introduced in 1956. To qualify under this specification it is necessary for the oil to demonstrate satisfactory detergency in the super-charged Caterpillar 1G and 1D single cylinder diesel test engines. The 1G test evaluates the deposit control characteristics of the lubricant under high load using low-sulphur fuel. The 1D test demonstrates an oil's ability to control deposits formed under less thermal stress, but in the environment of a high sulphur fuel. The US military equivalent of Series 3 is MIL-L-45199B which, in addition to the Caterpillar 1G and 1D test, calls for a bearing corrosion test similar to that required in the MIL-L-2104B specification. A Series 3 oil is classified as "suitable for service DS" by the API rating system.

TRACTOR FUELLING UNIT

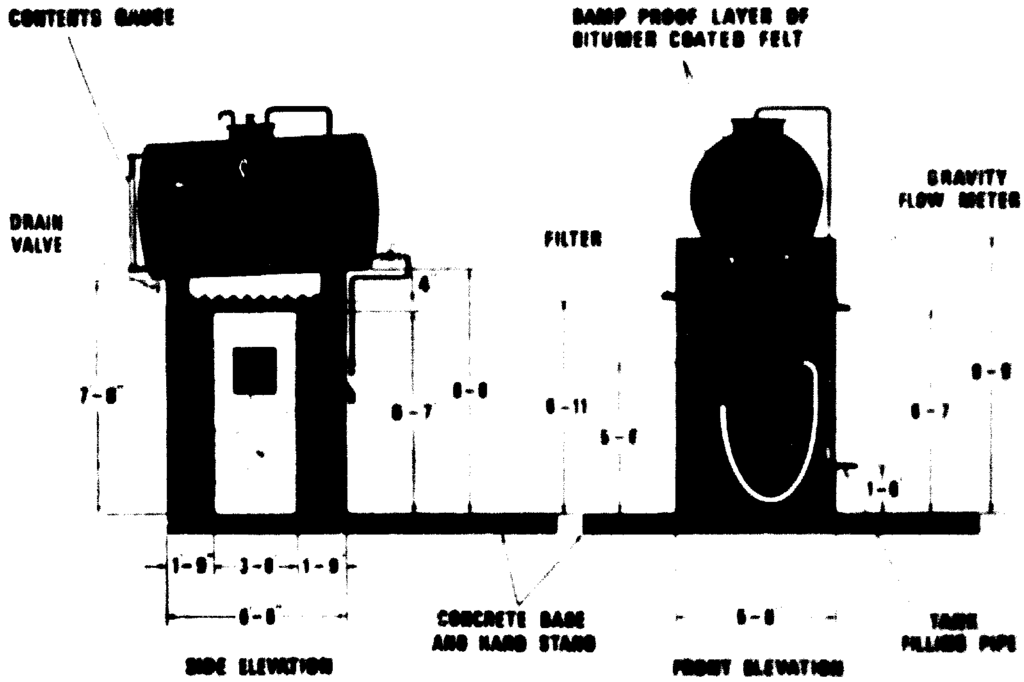


Fig. 1.

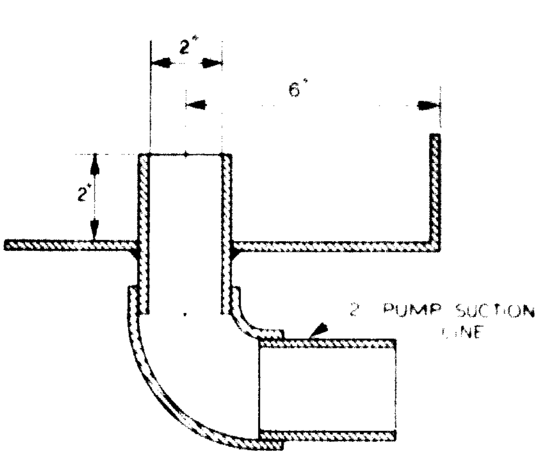


Fig. 2.

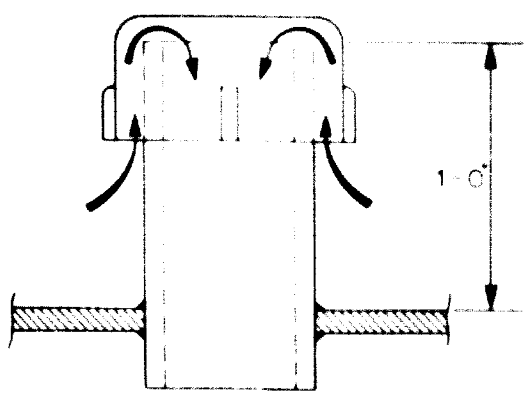
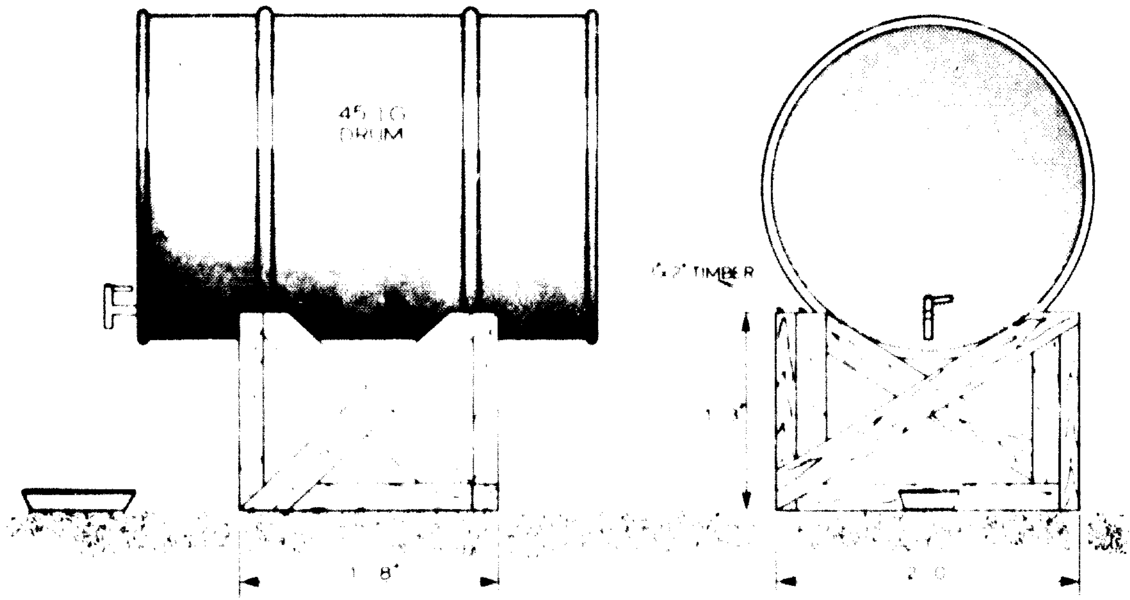


Fig. 3.

Fig. 4.

Fig. 5.



SIMPLE DRUM STAND

Fig. 6.

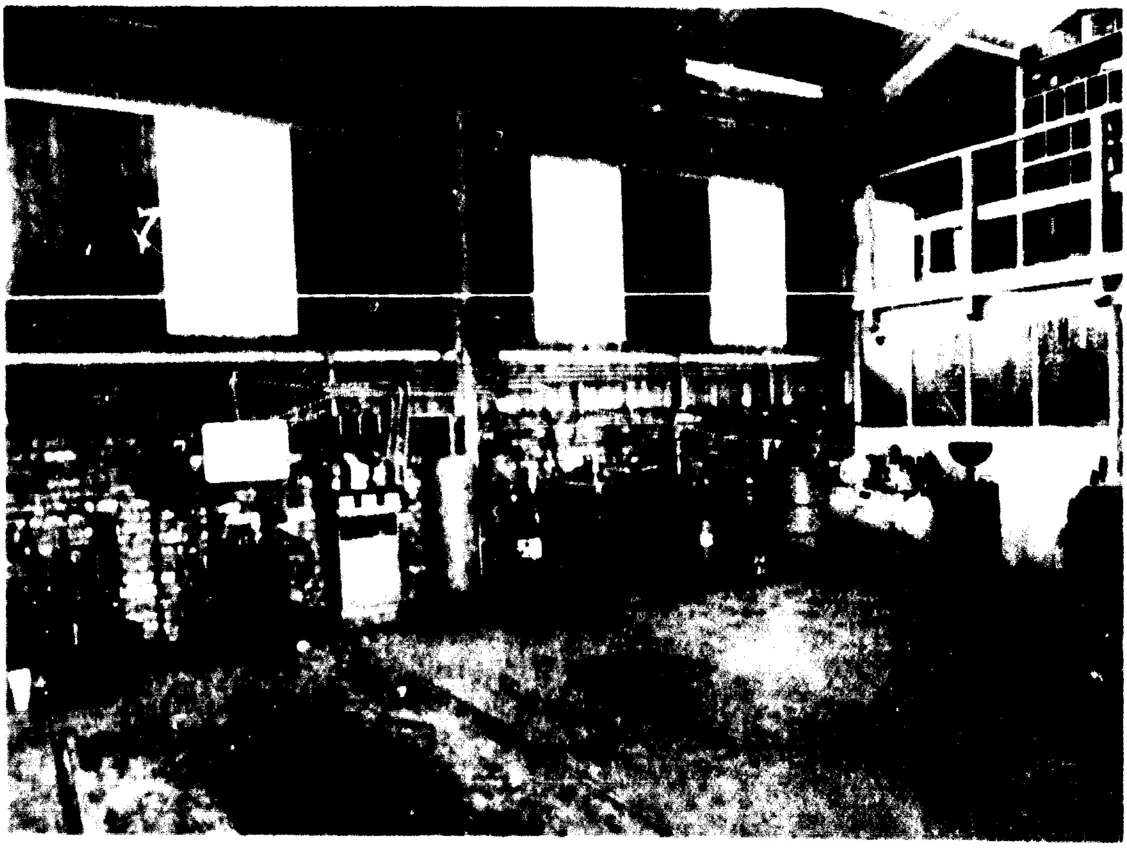


Fig. 7.

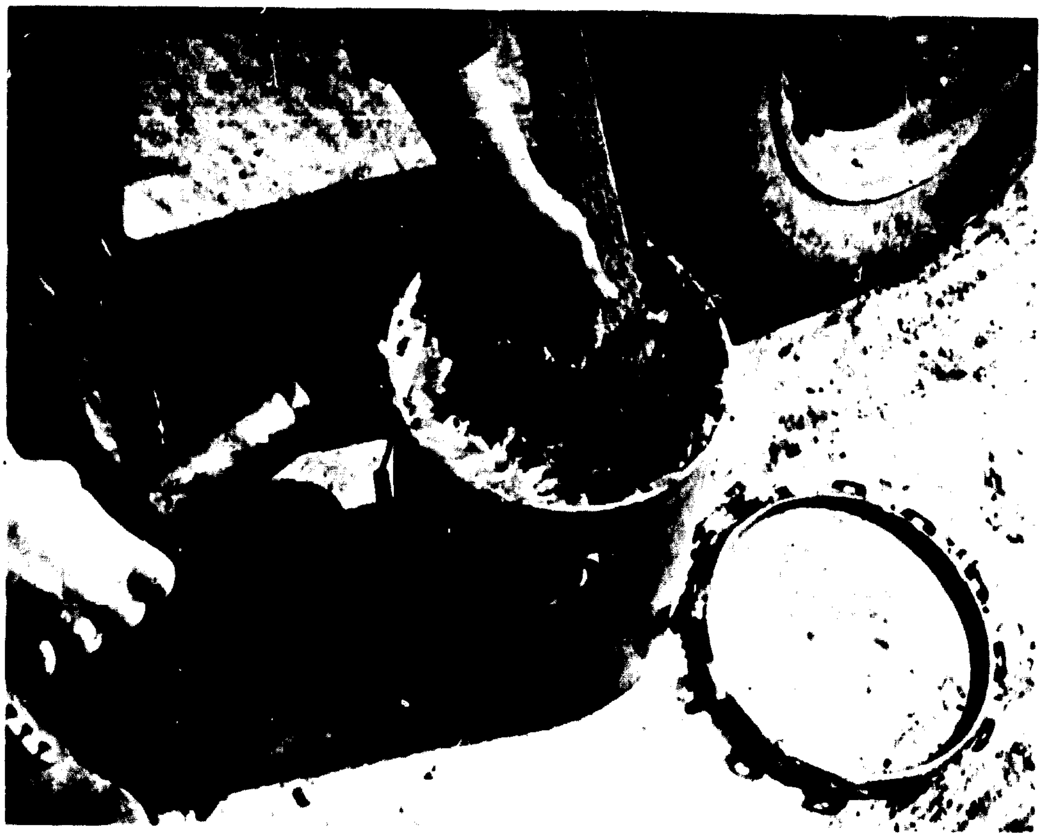


Fig. 8.

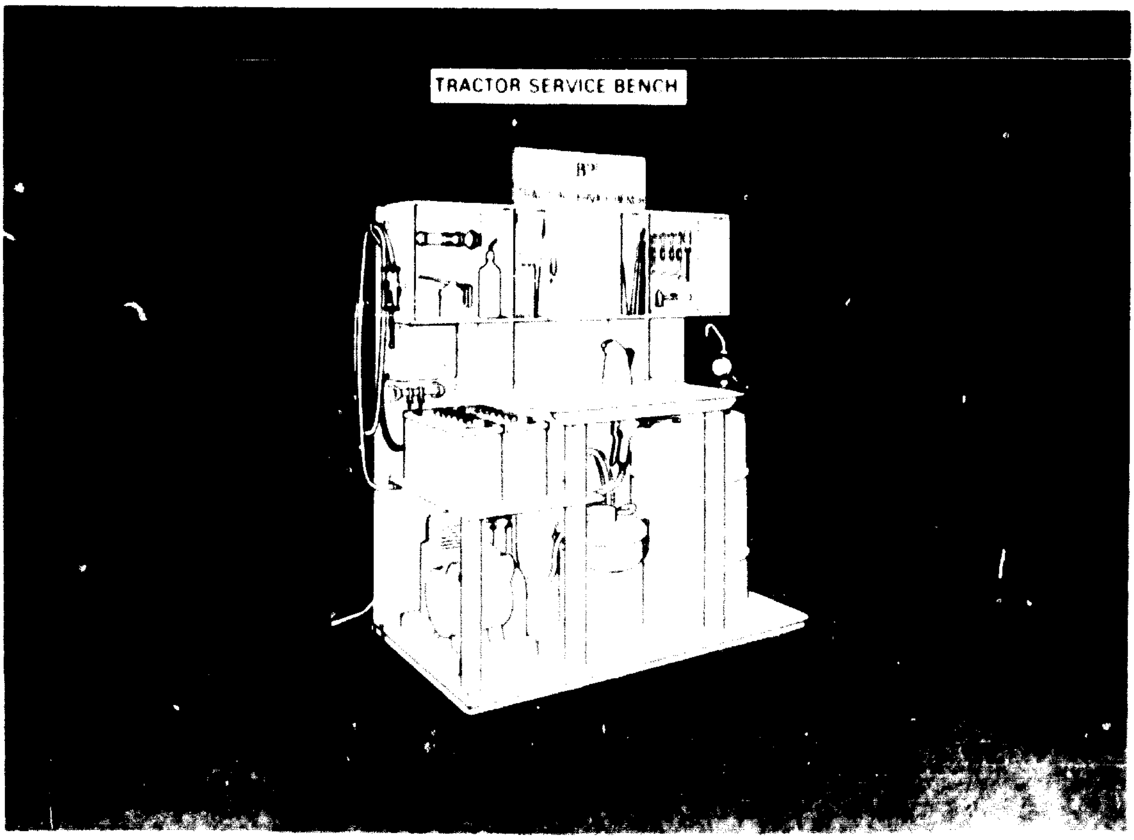
Fig. 9.

Fig. 10.

Fig. 11.

Fig. 12.

Fig. 13.



ASAE RECOMMENDATION:

Lubrication Intervals For Tractors And Farm Machinery

LUBRICATION INTERVAL	SYMBOL*	[illegible]*
5 HOURS	△	ORANGE
10 HOURS	○	RED
50 HOURS	□	YELLOW
100 HOURS	◡	GREEN
250 HOURS	▱	BLUE
500 HOURS	▭	WHITE
1000 HOURS	⬡	BROWN
2000 HOURS	⏢	BLACK

*OPTIONAL

Recommendation approved by ASAE Power and Machinery Technical Committee, J. H. Hodges Chairman, Adopted, 1962

This is a recommended schedule for use in preparing periodic lubrication or service instructions. Use with *ASAE Recommendation Lubrication Chart for Tractors and Farm Machinery*. Charts may be used either with or without symbols and/or colors.

ASAE RECOMMENDATION:

Lubrication Chart And Diagram For Tractors And Farm Machinery

Recommendation approved by ASAE Power and Machinery Technical Committee, J. H. Hodges Chairman, Adopted, 1962

This is a recommended format for periodic lubrication and service charts that will be affixed to the machine or to be used in the service area. A separate chart for each major assembly of a complicated machine may be desirable. Charts are to be of waterproof and greaseproof material. For preparing chart use ASAE *Recommendation Lubrication Intervals for Tractors and Farm Machinery*.

TABLE 1 LUBRICATION CHART*

TRACTOR [illegible] TYPE

INTERVAL HOURS	POINT	LOCATION	LUBRICANT
[illegible]	1 ORANGE	AIR CLEANER	[illegible]
[illegible]	2 RED	STEERING MECHANISM [illegible] MECHANISM	M.P. [illegible]
[illegible]	3 YELLOW	CLUTCH THROW OUT BEARING	M.P. [illegible]
[illegible]	4 GREEN	ENGINE OIL CHANGE	E.O.
[illegible]	BLUE	[illegible] GENERATOR BEARING [illegible]	[illegible]
[illegible]	6 WHITE	[illegible] FRONT WHEEL BEARINGS	M.P.G.
[illegible]	BROWN	TRANSMISSION [illegible] CHANGE [illegible] OIL CHANGE POWER STEERING RESERVOIR	M.P. [illegible] E.O. ATF

LUBRICANT ABBREVIATIONS

E.O.	ENGINE OIL
M.P.G.	MULTIPURPOSE TYPE GREASE
M.P. [illegible]	MULTIPURPOSE TYPE GEAR LUBRICANT
ATF	AUTOMATIC TRANSMISSION FLUID TYPE A

*1 Entries in body of Table 1 are typical examples only and are not part of the recommendation practice.
2 Chart (Table 1) can be used either with or without machine diagram (Figure 1). When used, the diagram should be either below or to the right of Table 1.
3 Chart can be used either with or without the symbols or color schedule.

FIG. 1 LUBRICATION CHART DIAGRAM

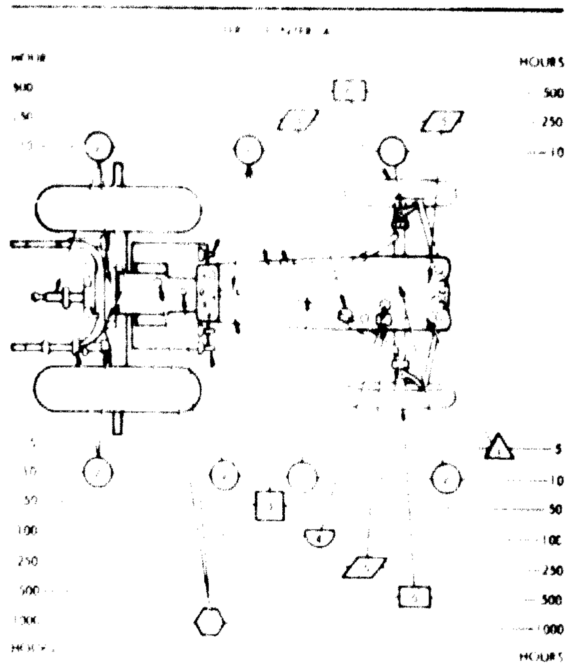


Fig. 14.

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