

## The Lease Pumper's Handbook

### Chapter 11 Motors, Engines, Pumps, and Compressors

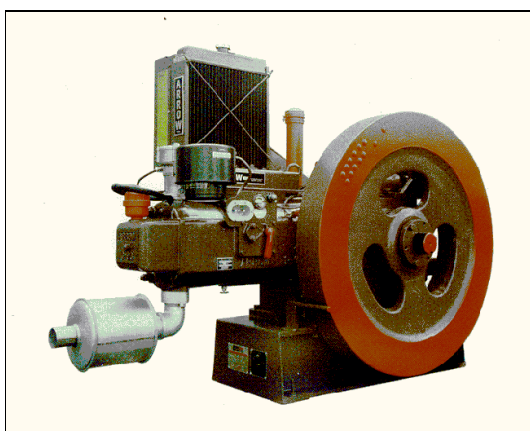
#### Section B

#### ENGINES

##### B-1. Introduction to Engines.

Engines have been used as prime movers since the first wells were drilled. Since they continue to play a major role today, the pumper must have a basic knowledge of how to operate and maintain many types of engines.

When no electricity is available to a new well that has insufficient gas pressure to flow, a mechanical pumping unit with a natural gas engine will probably be installed, at least temporarily. This is especially true for a wildcat well where the only knowledge available is that it produces enough oil to justify completing it. Regardless, the pumper must operate and maintain an engine that will run 24 hours a day, probably using casing gas as fuel (Figure 1).



**Figure 1. A single-cylinder engine with a flywheel, typical of many engines used in oilfields.**

(courtesy Arrow Specialty Co., Inc.)

##### B-2. Two- and Four-Cycle Engines.

Engines typically used on the lease site are called internal combustion engines because the fuel is burned inside the engine. The fuel is burned in a hollow area of the engine called a *cylinder*. Fuel is allowed into the cylinder through an intake valve and the byproducts of fuel combustion are removed from through an exhaust valve. A piston moves up and down within the cylinder to compress the fuel for more powerful combustion. When the compressed fuel explodes, the piston is driven back down the cylinder. It is this downward movement of the piston that actually produces the power generated by an engine so that it can be used to do work. This whole process is described as a series of four strokes. A stroke is the movement of the piston along its full travel in one direction. The strokes of an internal combustion engine are:

- **Intake stroke.** With the exhaust valve closed and the intake valve open, the piston moves down or away from the cylinder head, drawing a mixture of air and fuel into the cylinder. As the piston reaches bottom, the intake valve closes.
- **Compression stroke.** With both valves closed, the piston moves up or toward the cylinder head, compressing the fuel/air mixture into 1/10 or less of the volume.
- **Power stroke.** With the intake and exhaust valves closed, the spark plug

ignites the fuels, an explosion occurs. The resulting power pushes the piston down or away from the cylinder head.

- **Exhaust stroke.** The exhaust valve opens and as the piston returns to the top or toward the cylinder head, it pushes the byproducts of combustion gas out of the cylinder.

The combustion process just described is called a *four-cycle process* because there are four strokes for each ignition event. Some engines, called *two-cycle* engines, have an ignition event every time the piston comes to the top of the cylinder. With two cycle engines, used in some outboard engines and motorcycles, lubricating oil must be added into the gasoline. With a four-cycle engine, oil circulates outside of the combustion chamber. Almost all field engines are four-cycle. The events of the four-cycle process must occur at the correct time in relation to each other. For example, during the ignition event, the fuel mixture must be compressed and the valves must be closed. This is called *engine timing*.

### B-3. What Makes an Engine Run?

The three things that make up the firing triangle of the gasoline or natural gas engine are a heat source, fuel, and compression. For an engine to run, it must have the correct amount of all three with correct timing. When troubleshooting an engine, these are items that must be checked. Additionally, an engine includes two safety systems, one to lubricate moving parts and one to help remove heat from the engine. The lease pumper is expected to have a working knowledge of these systems in order to keep engines operating dependably, including the ability to change and service basic engine components and properly time engines.

**A heat source.** The usual heat source for an internal combustion engine is electricity—specifically, a spark jumping across the gap of a spark plug. Other electrical components may include a battery, voltage regulator, generator (or alternator), starter, distributor, coil (or low-tension coils), spark plugs, and appropriate wiring. Spark plugs must be the correct size, have the proper gap setting, and be of the correct temperature range, which generally include cold, standard, and hot. Some engines have a magneto electrical system with the coil, distributor, condenser, and points built into the magneto. Some engines have low-tension magnetos, which cost more but can greatly reduce magneto problems. Newer engines may have solid-state ignition systems. Battery maintenance includes ensuring that service-free batteries are not left outside in a rundown condition in freezing weather.

Because engines remain in service for several years, the lease pumper must know how to service all types of heat sources.

**Fuel.** The fuel system includes a fuel supply, air filter, carburetor, and mixing chamber. Fuel may be gasoline, natural gas, butane, or diesel. The gasoline system requires a carburetor with a float and fuel filter or a fuel injection system. Natural gas and butane systems require a gas or a combination carburetor. Diesel systems use a fuel distributor and a injector system. Pumper duties include air and fuel cleaning systems maintenance, adjustments, and minor repair.

**Compression.** This involves mechanical parts such as the engine block, pistons, rings, valves, and timing system. Maintenance performed by the pumper in this area depends upon job duties, available time, experience, tool and support availability, and many other factors.

**Safety systems.** Safety systems to protect the engine include the *lubricating safety system* and the *cooling safety system*. These safety components shut down an engine without damage in the event of emergency conditions. A medium-sized engine will cost several thousand dollars, thus representing a substantial investment. The safety systems must always be kept in operating condition.

The lubricating system circulates oil over moving parts to reduce friction and wear. The two critical aspects of the lubricating system are oil level—that is, that there is enough oil in the system—and oil pressure, which is a measure of whether there is enough pressure from the oil pump to move oil throughout the engine. The oil level safety system uses a float to measure how much oil is in the lubricating system. If the oil gets low, the float falls and makes contact with the engine block to ground the ignition and shut down the engine. The oil pressure safety system has a contact that will ground the ignition if the pressure drops too low.

The cooling system circulates coolant—normally a mixture of water and antifreeze—around the engine parts to remove the heat produced by engine operation. The coolant passes through a radiator, where moving air removes heat from the coolant. A temperature gauge monitors coolant temperature, with a contact that moves with changes in coolant temperature. If the temperature rises to a predetermined level, such as 212° F, the contacts grounds the ignition system and shuts down the engine.

#### **B-4. Engine Oils and Oil Additives.**

The lubricating system is filled with oil. The oil must be suited for the engine and operating conditions in terms of viscosity and additives. The term *viscosity* refers to the how quickly a given oil will pour when

the oil is cold and when it is hot. Viscosity can be thought of as the thickness of oil and is referred to as weight, such as 10 weight, 30 weight, and 50 weight, with the higher number representing a thicker or higher viscosity oil. Engine oils are available in multiple viscosities, such as 10-40, which means that at a cold temperature, it will flow as quickly as a 10 weight, but when it is hot it will flow as slowly as a 40 weight oil.

Although oils may be similar in appearance, they can vary greatly in contents, especially in the additives they contain. Additives are chemicals that are added to the oil to overcome potential problems. Some of the more common additives include:

- **Sulfur neutralizer** to prevent the elements in the crankcase from combining and forming acids.
- **Anti-wear agents** to reduce engine wear, especially during the warm-up period which is when the most wear occurs.
- **Rust inhibitors** to reduce rust and sludge when the engine is either running or off. Sensitive metals can rust, even below the oil level.
- **Viscosity index improvers** to maximize the ability of oil to adhere to the metal so that components above the oil line retain lubrication for start-up and while running to reduce wear.
- **Homogenizing agents** retain carbon and other foreign agents in suspension so that they are carried to the filter system. While these agents cause the oil to be darker, they actually keep the engine cleaner.

As oil circulates through the engine and is exposed to heat, byproducts of combustion, and the elements, it breaks down, losing its lubricating abilities, and the additives break down. For these reasons, the engine oil and

filter must be changed periodically. The replacement oil must be of the proper viscosity and contain the additives recommended by the engine manufacturer.

### B-5. Gasoline and Gasoline Additives.

When purchasing gasoline, care must also be taken to obtain the correct grade and quality of product. When selecting quality fuels, considerations include:

- **Sulfur neutralizers** are added to reduce engine wear caused from acids being created within the system through fuels and water condensation.
- **Carburetor cleaners** reduce the varnish buildup that causes carburetor parts to stick and the jet holes to narrow or plug.
- **Water absorbents** break down and remove water that otherwise will accumulate in the gas tank, lines, and carburetor, causing rust and occasionally freezing.
- **Anti-glow agents** prevent carbons deposited in the engine heads from becoming hot (glowing) enough to ignite the fuel. These hot spots can ignite the fuel ahead of the power stroke (knocking) or, after the ignition system has been shut off, keep the engine running (dieseling).
- **Octane improvers.** These improve engine performance and burn slower to reduce rod bearing wear and dramatically extend the life of the engine. The higher the octane, the slower the gasoline will burn. With slower burning high octane fuel, the initial impact on the piston is less severe. This results in more miles per gallon, less damage to the engine, and a cleaner engine inside. It is not unusual to have a lower cost per mile and better performance on an engine when using a higher octane than with regular fuel.

### B-6. Antifreeze and Radiators.

There are many benefits to running a good antifreeze in an engine, including:

- **Prevention of rust and corrosion.** Ethylene glycol is a natural rust inhibitor.
- **Lubrication of the water pump.** Ethylene glycol is also a natural lubricant and lubricates the water pump.
- **Transfer of heat more easily.** By transferring heat more easily, the engine runs warmer in the winter and cooler in the summer. The boiling point of antifreeze is 263° F.
- **Prevention of water from freezing.** The primary reason for adding antifreeze to the water is obviously to prevent the water from freezing.

Antifreeze should be maintained in most engines year-round because of the additional protection it gives to the engine other than cold weather protection.

When mixing antifreeze, the basic method is to mix two gallons of water and one gallon of antifreeze, or a 1/3 mixture. This gives protection down to 0° F., or 32 degrees below freezing. In colder climates a 1:1 mixture may be more appropriate.

#### Antifreeze mixing ratios.

Parts Water	Parts Anti-freeze	%	Freezes at °F	Boils at °F
3	1	25	+10	
2	1	33	0	
20	7	35	-3	
5	2	40	-12	258
20	9	45	-22	
1	1	50	-34	263
20	11	55	-48	266

### B-7. Single- and Multiple-Cylinder Engines.

Single-cylinder oilfield engines (Figure 2) are used extensively on circulating pumps (vertical cylinder small engines), and as the prime mover (horizontal cylinder, medium to large engines) for shallow and medium depth oil wells. Engines that are large enough to operate pumping units are slow-running engines with large flywheels that rotate at a speed of 300-500 revolutions per minute. The large flywheels store energy in their movement, which allows the engine to run smoothly. Instead of having several spark plugs and an electrical distributing system, the system is reduced to a magneto, one wire, and a spark plug. This greatly reduces electrical maintenance requirements. The sheave is almost twice as large as those on multiple-cylinder engines, and belts move much slower across the engine sheave. The starting system is usually composed of a portable starter and a pair of jumper cables. It uses a vehicle starting battery.



**Figure 2. Single-cylinder four-cycle engine using marginal casing gas for power.**

Multiple-cylinder engines are more complex, have a large number of parts, and run at speeds of 900-1600 rpm. The electrical system may require a battery,

starter, voltage regulator, distributor, possibly a coil for each cylinder, and more spark plugs. Since it does not have large flywheels to store energy, the engine must rotate much faster to run smoothly.

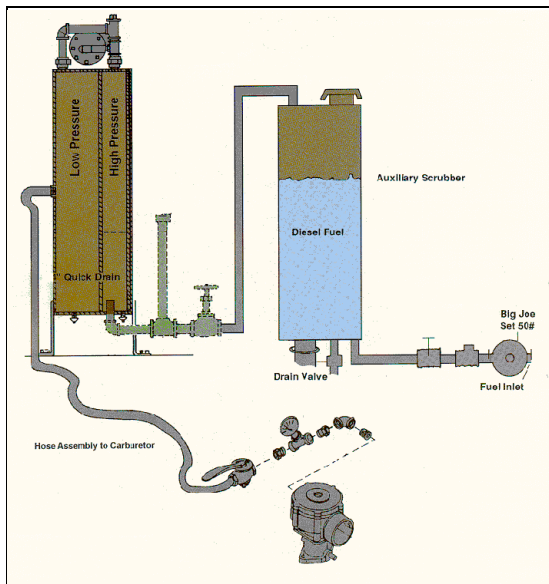
### B-8. Diesel Engines.

Diesel engines do not use a spark to ignite the fuel on each power stroke. Instead, the heat generated by engine compression is enough to ignite the fuel. Thus, the compression stroke compresses only air, and as the piston approaches the top of its stroke, diesel fluid is injected into cylinder, and it ignites instantly. Because of the extreme heat generated, diesel fuel contains a lubricant for the cylinder, rings, and valve stems.

Diesel engines are assembled with looser clearances than gasoline engines. Steel expands as it gets hot, and diesel engines generate more heat than gasoline types. As a result, the diesel engine makes more noise when it is first started but grows quieter as it gets warm. If the engine is going to be used again in a short time after becoming idle, the engine is left running. To start the engine in cold weather, the cylinders have *glow plugs* that are turned on a few minutes before the engine is cranked in order to provide ignition heat.

### B-9. Natural Gas Fuel Systems.

Natural gas engines can be a very economical way to drive pumps, especially when gas is drawn from a well where a gas engine may be pumping. Figure 3 illustrates the components of a typical gas system. A scrubber and volume tank are installed just ahead of each facility whenever gas is wet. With dry gas, the scrubber is either not required or is much smaller and used simply to trap rust out of the system.



**Figure 3. Natural gas supply system including pressure regulators, scrubber, volume tanks, and line system.**

*(courtesy Arrow Specialties, Co., Inc.)*

The system begins with a regulator that reduces the gas pressure to protect the downstream system, followed by a scrubber or wash tank. With small engines this is the complete system, except for an ounce gauge

and a flexible connecting hose. Engines will need a fuel pressure of 6-8 ounces.

For larger engines requiring a high volume of gas, a second tank is needed as illustrated in Figure 3 to maintain a sufficient reserve supply volume. The riser between the pictured tanks acts as a shock absorber to protect the vessels and regulators.

**Problems with wet gas containing water vapor.** When the natural gas supply line contains water vapor and is connected to the casing, problems can be encountered in the winter in keeping the system operational.

In cold weather, warm gas gets cold after it leaves the wellhead, and the vapor condenses into free water. This water collects in the line and, because of slow movement, accumulates and freezes in the riser as the line turns up into the scrubber.

Each night in the winter, this moisture may freeze and shut down the system. A small shop-made blow-down tank can be installed on the inlet line to act as a drip pot to collect this moisture. It will be necessary to occasionally blow down this system as it gets full.