

Module 12: Basic Fuel Systems and Components

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Terms and Definitions

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- Atomize is to break down into small particles.
- Cetane number is the relative measure of the time delay between the beginning of fuel injection and the start of combustion.
 - Note:** In cold engine starting, a low cetane number will cause difficult starting and white exhaust smoke until the engine warms up, and in engines with charge air cooling, a low cetane number fuel may also cause white exhaust smoke during light load operation.
- Flash point is when fuel is heated to a point where it gives off a flammable vapor.
- Governor is a device that controls engine speed under various load conditions by changing fuel delivery.
- Ignition is the combustion of fuel mixture in the combustion chamber.
- Ignition delay is the period of time from injection to actual ignition.
- Injection is the method of forcing fuel into a chamber for combustion.
- In-line is having the parts arranged in a straight line.
- Misfiring injector is an injector that fails to inject and atomize sufficient fuel to support combustion.
- Nozzle is a short tube with a tapered end or constriction used to speed up or direct the flow of fluid.
- Prime is to completely fill the system with fuel oil.
- Purge is to eliminate air in the fuel system by flushing with clean fuel.
- Restriction is a condition that reduces the volume of fuel flow, but increases the pressure.
- Specific gravity is the weight of a liquid or solid compared with the weight of an equal volume of water at 60°F.
- Unit fuel injector is a component with the pump and nozzle combined, which performs all the fuel injection functions.

Major Functions of Fuel Systems

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- Supplies the correct quantity of fuel
- Times the fuel delivery
- Controls the delivery rate
- Atomizes the fuel
- Distributes the fuel evenly throughout the combustion chamber

Major Parts of a Fuel System

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- A fuel tank stores fuel, and there are usually two on heavy equipment.
- A fuel transfer pump moves fuel at low pressure from the fuel tank to the fuel injection pump.
- A primer or primer pump bleeds air from the fuel system.
- A fuel injection pump times, measures, and delivers fuel under pressure to the injection nozzles.
- Fuel lines connect the fuel system.
- Fuel filters clean the fuel by removing impurities.
- A water separator allows water to settle out of the fuel so it can be drained off.
- A fuel heater raises the temperature of the fuel for correct flow and firing.
- An injection nozzle atomizes and distributes fuel evenly into the combustion chamber.

- A unit injector performs functions of both the injection pump and nozzle as one unit.

- A governor controls the amount of fuel required to hold the engine speed reasonably constant during load fluctuations.

Parts of Fuel Tanks

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- Vent
- Supply
- Return
- Mounting brackets
- Tank housing
- Tank inlet
- Supply outlet
- Screen
- Cap

Types of Fuel Transfer Pumps

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- Piston type (serviceable)
- Diaphragm type (non-serviceable)
- Gear or rotary type
- Electric vane type

Types of Primer Pumps

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- Mounted on the primary filter
- Mounted on the piston type fuel transfer pump
- Mounted in-line

Types of Fuel Injection Systems

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- The distributor-type (rotary pump) combines a single pumping unit in a housing with a head outlet to a high pressure line to each injection nozzle, and is mounted as a separate unit on the engine.
- The in-line pump combines pumping units into a single housing that is mounted on the engine and driven by the accessory drive, and delivers fuel through high pressure lines to injection nozzles.
- The pressure-timed (PT) pump combines a gear pump and a governor in a housing that is mounted on the engine, and delivers fuel through a common line to the injectors (Cummins rail system).
- The unit injector combines a pump and an injection nozzle into a single unit that is mounted on the top of each cylinder of the engine, and delivers fuel to each cylinder.

Methods of Injecting Fuel

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- Injection nozzles
 - Used in high pressure fuel systems
 - The nozzle and pump are separated and connected with a high pressure line.
 - Commonly used on in-line and distributor-type injection pumps
- Injectors
 - Used in high pressure fuel systems
 - The nozzle and pump are separated and connected with a high pressure line.
 - Commonly used on in-line and distributor-type injection pumps

Types of Controls on Fuel Systems

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- Mechanical
 - Uses governor flyweights to control the amount of fuel delivered to the injection nozzles or injectors (PT)
 - Unit injectors use a mechanical governor through linkage to control the amount of fuel that the injection delivers.
- Electronic
 - Uses electric solenoids and electronic control modules (ECM) to control and govern the amount of fuel delivered to the unit injector
 - In-line and distributor pumps can have electronic governors mounted on the pump to control the fuel.
 - PT systems may also use an electronic device on top of the pump to control the fuel to the injectors.
 - Electrohydraulic systems use engine oil raised to high pressure to the injector unit, which is controlled by an electronic solenoid and ECM.

Note: Most companies are using more electronic controls, often combining them with mechanical and hydraulic systems.

Types of Fuel Lines and Functions

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- Supply low pressure lines deliver fuel from the tank to the fuel injection pump.
- Schedule 80 high pressure lines deliver fuel from the in-line or distributor-type pump to the injection nozzles.
- Return low pressure lines deliver leak-off fuel from the injection nozzles to the tank.

Types of Fuel Filters

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- Primary filter
 - Filters out initial impurities such as dirt particles and insoluble gums in the fuel
 - Is located on the suction side of the transfer pump
 - Has little resistance to flow
 - Sometimes has a water separator with a drain at the bottom
- Secondary filter
 - Removes minute particles that may pass through the primary filter
 - Is located on the pressure side of the transfer pump
 - Usually is the final filter

Types of Governors

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- Mechanical governor
 - Uses mechanical weights (flyweights) to move the fuel control device (metering valve or control rack), which changes the engine speed
 - The weights sense the centrifugal force created by the engine speed.
- Hydraulic governor
 - Uses oil pressure or fuel pressure and mechanical weights to move the metering valve or control rack
 - Hydraulic action is transmitted by oil admitted under pressure from the engine lubricating system to an auxiliary oil pump in the governor.
- The auxiliary pump then develops the oil pressure necessary to actuate the governor mechanism.
- Electric governor
 - Uses electronic sensors to detect engine speed changes that results in new signals to change the throttle position
 - Typically used on stationary engines such as generators
- The pneumatic governor uses a vacuum created by air pressure differences to move the fuel control and change the engine speed.

Classes of Governors

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- Limiting speed (road speed)
 - Restricts (limits) the maximum speed of the engine and controls the engine idling speed
 - Used on engines requiring minimum and maximum speed control, together with manually controlled intermediate speeds
- Variable speed
 - Controls engine idle speed, restricts maximum no-load speed, and holds the engine at any constant speed (between idle and maximum) as desired by the vehicle operator
- Used on engines subjected to varying load conditions that require an automatic fuel compensation to maintain a near constant engine speed, which may be changed manually by the operator, and it is commonly used for construction and agriculture applications
- Constant speed
 - Maintains engine speed at constant revolutions per minute (RPM)
 - Used on stationary engines such as generators

Operation of a Mechanical Governor

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- Step 1: When more vehicle speed is desired, the operator's foot moves the foot feed, which is connected through linkage (cable or rod) to the pump's throttle shaft.
- Step 2: The throttle shaft moves the governor spring and linkage to open the metering valve or move the control rack.
- Step 3: After engine speed responds (more fuel is delivered, so the engine speeds up), centrifugal force on the governor weights moves them outward, which compresses the governor spring and cuts back fuel delivery.
- Step 4: Compressed governor spring linkage now limits the maximum speed of the engine.

Common Maintenance Problems on Fuel Systems

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- Clogged filters
- Leaking lines
- Tank problems, leaks, water, dirt, or a clogged vent
- Excessive fuel consumption
- Fuel line restrictions

Factors That Affect Fuel Consumption

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- Road conditions—gravel, bumpy, smooth, etc.
- Weather conditions—rain, snow, windy, extremely high or low temperatures, etc.
- Gross vehicle weight—vehicle plus payload
- Road speed
- Idle time
- Amount of time cruising versus changing gears and speeds
- Type of tires
- Wind drag
- Axle alignment
- Fuel system leaks
- Brake drag
- Fuel rate, pressure, or temperature
- Fuel system restrictions—inlet, drain, vent
- Air inlet or exhaust restrictions
- Fuel temperature