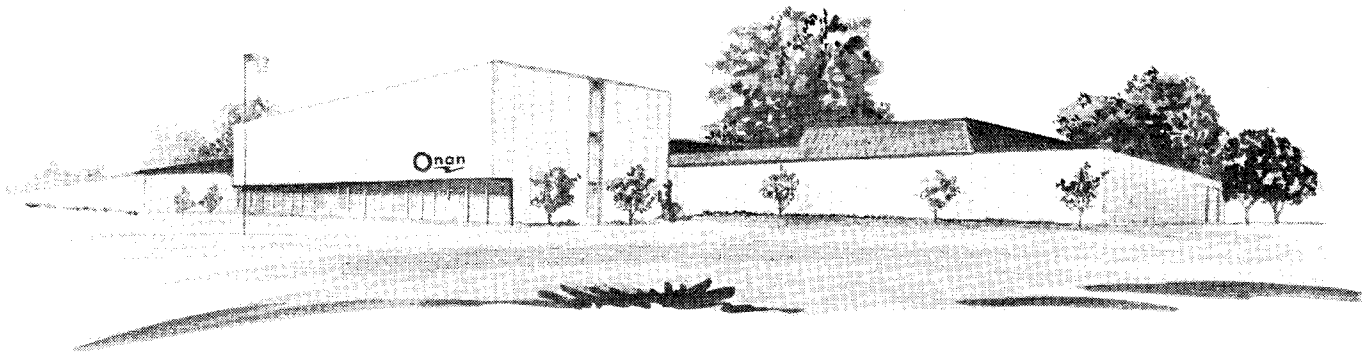
T-015

technical bulletin

USE OF GASEOUS FUEL
WITH
ONAN ELECTRIC GENERATING SETS



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A DIVISION OF ONAN CORPORATION

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SAFETY PRECAUTIONS

The following symbols in this manual signal potentially dangerous conditions to the operator or equipment. Read this manual carefully. Know when these conditions can exist. Then, take necessary steps to protect personnel as well as equipment.

WARNING **Onan uses this symbol throughout this manual to warn of possible serious personal injury.**

CAUTION **This symbol refers to possible equipment damage.**

Fuels, electrical equipment, batteries, exhaust gases and moving parts present potential hazards that could result in serious, personal injury. Take care in following these recommended procedures.

- **Use Extreme Caution Near Gaseous Fuels. A constant potential explosive or fire hazard exists.**

  Do not fill fuel tank near unit with engine running. Do not smoke or use open flame near the unit or the fuel tank.

  Be sure all fuel supplies have a positive shutoff valve.

  Do not use naked flame or weld in the vicinity of fuel installations or systems until the fuel has been evacuated and the tank or system purged.

  Keep all fuel line connections tight and check system frequently to prevent leaks.

  Have a fire extinguisher nearby. Be sure extinguisher is properly maintained and be familiar with its proper use. Extinguishers rated ABC by the NFPA are appropriate for all applications. Consult the local fire department for the correct type of extinguisher for various applications.

- **Guard Against Electric Shock**

  Remove electric power before removing protective shields or touching electrical equipment. Use rubber insulative mats placed on dry wood platforms over floors that are metal or concrete when around electrical equipment. Do not wear damp clothing (particularly wet shoes) or allow skin surfaces to be damp when handling electrical equipment.

  Jewelry is a good conductor of electricity and should be removed when working on electrical equipment.

  Always use an appropriately sized, approved double-throw transfer switch with any standby generator set. DO NOT PLUG PORTABLE OR STANDBY SETS DIRECTLY INTO A HOUSE RECEPTACLE TO PROVIDE EMERGENCY POWER. It is possible for current to flow from generator into the utility line. This creates extreme hazards to anyone working on lines to restore power.

  Use extreme caution when working on electrical components. High voltages cause injury or death.

  Follow all state and local electrical codes. Have all electrical installations performed by a qualified licensed electrician.

- **Do Not Smoke While Servicing Batteries**

  Lead acid batteries emit a highly explosive hydrogen gas which can be ignited by electrical arcing or by smoking.

- **Exhaust Gases Are Toxic**

  Provide an adequate exhaust system to properly expel discharged gases. Check exhaust system regularly for leaks. Ensure that exhaust manifolds are secure and not warped.

  Be sure the unit is well ventilated.

- **Keep The Unit And Surrounding Area Clean**

  Remove all oil deposits. Remove all unnecessary grease and oil from the unit. Accumulated grease and oil can cause overheating and subsequent engine damage and may present a potential fire hazard.

  Do NOT store anything in the generator compartment such as oil cans, oily rags, chains, wooden blocks etc. A fire could result or the generator set operation may be adversely affected. Keep the floor clean and dry.

- **Protect Against Moving Parts**

  Avoid moving parts of the unit. Loose jackets, shirts or sleeves should not be permitted because of the danger of becoming caught in moving parts.

  Make sure all nuts and bolts are secure. Keep power shields and guards in position.

  If adjustments *must* be made while the unit is running, use extreme caution around hot manifolds, moving parts, etc.

  Do not work on this equipment when mentally or physically fatigued.

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SCOPE

Information in this bulletin applies to natural gas, manufactured (city) gas and LP (liquefied petroleum) gas. This bulletin is not intended to be an installation manual, but rather a design guide.

All types of installation problems cannot be covered because of the variety of requirements. Illustrations of installations are only typical and do not represent actual installations. They do represent recommendations of the manufacturer.

CODES AND REGULATIONS

Gaseous fuel installations are governed by various local codes and NFPA (National Fire Protection Association) Pamphlet 58. Because of local variations, consult the local gas distributor for the particular gaseous fuel regarding the installation.

EXCERPTS FROM NFPA PAMPHLET 58

ONAN recommends that the installer or architect become familiar with the current NFPA Standard 58.

1. All piping, tubing, fittings and valves for use with vapor LP gas shall be suitable for a working pressure of 125 psig (862 kPa).
2. LP gas vapor at pressures exceeding 20 psig (138 kPa) shall not be piped into any building for fuel purposes, except buildings or separate fire divisions of buildings, used exclusively for housing internal combustion engines and for research and experimental laboratories.
3. Cast iron pipe fittings (ells, tees, crosses, couplings, flanges or plugs) shall not be used.
4. Flexible connectors, or hose complying with section 235 of NFPA 58 may be used between the container and regulator, or between the regulator and the gas-air mixer, with the approval for this application, of any of the authorities listed in section 1200 of NFPA 58.
5. All piping, tubing and hose shall be tested after assembly and proved free from leaks at not less than normal operating pressures. Tests shall not be made with a flame.
6. Piping outside buildings may be buried, above ground, or both, but shall be well supported and protected against physical damage. Where soil conditions warrant, all piping shall be protected against corrosion. Where condensation may occur, the piping shall be pitched back to the container or suitable means shall be provided for vaporization of the condensate.
7. Provisions shall be made for expansion, contraction, jarring, vibration, and settling. This may be accomplished by flexible connections.

NFPA requires that all standby generator sets be installed in a fireproof room or separate building. Fuel line sizes are determined by individual unit requirements and must include approved shutoff devices. All hardware, such as lines and fittings, must meet local codes.

GAS AS A FUEL

Gas is a desirable fuel for internal combustion engines even though there may be a slight loss in power. Although gaseous fuels generally have higher octane ratings than gasoline, some manufactured "city" gases have a lower octane rating. You can increase the combustion efficiency of an engine without producing more heat by increasing the compression ratio. The type of fuel limits the compression ratio of an engine. However, natural gas and propane generally allow higher compression ratios.

Gaseous fuels have a low residue content and generally build up minimum carbon deposits. Gaseous fuels mix more thoroughly with air to produce a mixture which burns more completely than gasoline mixtures.

Advantages of Gaseous Fuel Operation:

1. Minimum carbon formation.
2. Less sludge in oil.
3. Less valve burning.
4. No wash down of cylinder wall lubrication during engine starting.
5. No tetra-ethyl lead to foul spark plugs and other engine parts.
6. Excellent antiknock qualities.
7. Small amount of contaminating residues.
8. A nearly homogeneous mixture in cylinder.

TYPES OF GASEOUS FUELS

The selection of a particular gas fuel depends on (1) availability, (2) efficiency required, (3) engine application (mobile or not), (4) initial cost, and (5) cost of operation.

Basic fuel structure determines the amount of heat a fuel can produce. Dry gases vary in heat content as do gasoline, diesel fuel or other fuels. For example, propane and butane have considerably higher heat values than do methane and ethane.

Amount of heat a fuel can produce is usually expressed in the unit BTU (British Thermal Unit). Manufactured gas, composed primarily of methane (marsh gas), has a heat content of approx. 500-550 BTU/cu ft (18.6-20.5 MJ/m³). An engine fueled with this gas would produce about 10 percent less power than the same engine fueled with gasoline. The heat content of butane, a minor component of LP gas is about 3260

BTU/cu ft (121.4 MJ/m³). No derating would be necessary with this fuel. Refer to Technical Bulletin T-017 for "Rating Factors for Electric Generating Sets." If propane is used, type HD-5 propane is recommended.

POWER COMPARISON

A generator set using butane, propane, or a commercial mixture of both will deliver nearly the same power as if using gasoline.

1. Using 1100 BTU (41 MJ/m³) gas, a unit will deliver 80 to 95 percent of its gasoline rated power.
2. Using 850 BTU (32 MJ/m³) gas, a unit will deliver 80 to 85 percent of its gasoline rated power.
3. Using 600 BTU (22 MJ/m³) gas, a unit will deliver 70 to 75 percent of its gasoline rated power.
4. Using 450 BTU (17 MJ/m³) gas, a unit will deliver 50 to 60 percent of its gasoline rated power.

Natural gas is composed primarily of methane and varying amounts of other dry gases with a heat content of about 1000 BTU/cu ft (37.25 MJ/m³). It is piped from the source to points of consumption. In localities situated far from the source, natural gas is comparatively expensive as a fuel. Localities not serviced by natural gas frequently have a manufactured gas system.

Manufactured gas is not greatly adaptable as a fuel for generator sets if efficiency is important because its heat value is so low you must derate the engine as much as 50 percent. While gas manufacturing cost is usually higher than for other types of fuels, there are no storage problems such as with LP gas. Ambient temperature also has no effect on supplies.

LP gas (liquefied petroleum gas) is a commercial mixture of propane and butane. The ratio between the two varies with local temperatures and user requirements. While propane vaporizes at a lower temperature than butane, butane has a higher heat content. Stored and transported under pressure in tanks, LP gas at normal temperatures is a vapor. By increasing pressure and lowering the temperature, it remains in a liquefied state until withdrawn from its storage tanks.

TEMPERATURE AND PRESSURE

Temperature and pressure are interdependent. If gas temperature is changed, the pressure will change proportionally. You can change a gas at room temperature, for example, to a liquid by compression and store it in a closed container.

You can change a liquid at atmospheric pressure to a gas by raising the temperature to the liquid's boiling point such as boiling water. Vaporizing LP gas builds pressure within the container.

Working Pressure

The fuel system components must operate at various working pressures depending on the kind of gas, size and length of fuel lines, number of generator sets supplied by a given source, ambient temperature, etc. Components must have the strength to function properly under anticipated or calculated maximum working pressures. LP gas tanks, for example, must withstand a working pressure of 250 psi (1720 kPa) as specified in Pamphlet 58, National Fire Protection Association. Regulators must conform to the applicable specifications of the same agency in addition to performing the functions for which they are designed. The final regulator in a system must be able to maintain a constant pressure within a prescribed range which may be from 3 ounces (1.3 kPa) to 5 pounds (35 kPa) at the inlet.

Some codes prohibit the use of high pressure accumulator tanks within the building or high pressure fuel supply piping to natural gas units of 350 kW and larger. For these installations, the gas supply must enter the building under low pressure and be "boosted" by the generator set.

There are several ways of measuring and expressing pressure. Pressure measured with a manometer is expressed in inches or millimetres of water or mercury. Pressure measured with a gauge is expressed in ounces, pounds per square inch (psi) or kilopascals (kPa). Because both systems are used, refer to the pressure equivalents in Table 1.

TABLE 1. PRESSURE EQUIVALENTS

1 inch water column = 0.58 ounces/in.²	10 mm water column = 98.4 Pa
11 inch water column = 6.38 ounces/in.²	280 mm water column = 2755 Pa
11 inch water column = 0.4 lb/in.²	280 mm water column = 2.76 kPa
1 lb/in.² = 27.71 inch water column	1 kPa = 102 mm water column
1 lb/in.² = 16 ounces/in.²	1 Pa = 0.1 mm water column
1 lb/in.² = 2.04 inch mercury column	10 mm mercury column = 1.33 kPa
1 inch mercury column = 0.49 lb/in.²	1 kPa = 7.5 mm mercury column
1 standard atmosphere = 14.73 lb/in.²	1 mm mercury column = 13.59 mm water column
1 ounce/in.² = 1.73 inch water column	1 standard atmosphere = 102 kPa
1 inch mercury column = 13.59 inch water	

TABLE 2. AVERAGE FUEL CONSUMPTION AT FULL LOAD IN CU FT/HR (m^3/HR)

MODELS	RPM	NATURAL GAS	LPG*
1.0AJ	1,800	33 (0.93)	13 (0.37)
2.5AJ	3,600	62 (1.76)	25 (0.71)
2.5LK	1,800	54 (1.53)	23 (0.65)
4.0CCK	1,800	90 (2.55)	40 (1.13)
5.0CCK	1,800	115 (3.26)	47 (1.33)
6.5NH	1,800	150 (4.25)	60 (1.70)
7.5JB	1,800	126 (3.57)	63 (1.78)
10.0CCKB	3,600	200 (5.66)	100 (2.83)
12.5JC	1,800	230 (6.51)	92 (2.60)
12.5RJC	1,800	230 (6.51)	92 (2.60)
15.0JC	1,800	255 (7.22)	110 (3.11)
15.0RJC	1,800	255 (7.22)	110 (3.11)
30.0EK	1,800	600 (17.0)	245 (6.94)
45.0EM	1,800	690 (17.0)	290 (8.21)
55.0EN	1,800	890 (25.2)	355 (10.0)
55.0KB	1,800	840 (23.8)	330 (9.34)
70.0KR	1,800	1,000 (28.3)	— —
85.0KR	1,800	1,400 (39.6)	400 (11.3)
115.0WA	1,800	1,800 (51.0)	730 (20.7)
140.0WE	1,800	1,450 (41.0)	730 (20.7)
150.0WE	1,800	1,450 (41.0)	730 (20.7)
170.0WB	1,800	2,500 (70.8)	1,000 (28.3)
250.0FT	1,800	3,000 (84.9)	— —
350.0WF	1,800	3,850 (109.0)	— —
400.0WK	1,800	4,200 (118.9)	— —

***LPG:** 1 gallon = 36.5 cu ft, 1 lb = 8.5 cu ft, 1 litre = 0.273 m^3, 1 kg = 0.53 m^3.

SYSTEM COMPONENTS

Components depend on individual requirements. However, the following components are usually standard.

Regulators

Gaseous fuel is metered to the carburetor on a demand basis. A regulator (demand or secondary type) is supplied with fuel at an inlet pressure only slightly above atmospheric pressure. If supply pressures are high (above 6 ounces or 2.6 kPa), an additional primary regulator is used to reduce the supply pressure to a suitable level. Two primary regulators used in series are referred to as a "two-stage" regulation system.

The demand regulator in most systems regulates the gas flow by responding to pressure changes in the intake system of the engine. When the engine is shut down and there is no demand for fuel, the regulator prevents gas flow. A high pressure shutoff device [illegible]

Regulators are not always separate units. They may be integrated with a converter or carburetor but their function remains the same.

Onan recommends venting regulators in buildings to the outside. Gas leakage could occur if the regulator has diaphragm failure. Heavy industrial line regulators with a relief valve definitely need a vent.

CAUTION **A separate regulator must never be used between the tank and converter in a liquid withdrawal system.**

Regulators are designed to do a particular job in a particular system. A regulator designed for use in a vapor gas system cannot be used in a liquid gas system without modification. Regulators should be mounted where they will receive least vibration. They should not be in areas of extreme heat.

On most late model systems using IMPCO gaseous fuel carburetors, the recommended pressure to the carburetor is 5 ounces (8.6 kPa). A THERMAC regulator [illegible] regulate this pressure. The THERMAC regulator is suitable for

TABLE 3. REGULATOR SELECTION

MODELS	IF SOURCE PRESSURE IS:				
	6 to 11 Oz. (2.6 to 4.7 kPa)	11 Oz. to 1 Lb. (4.7 to 6.9 kPa)	1 to 2 Lbs. (6.9 to 14 kPa)	2 to 4 Lbs. (14 to 27 kPa)	4 Lbs. to Over (27 kPa or Over)
AK, AJ, LK	1	1	1	1	1
CCK, JB, CCKB, NH	5	5	5	5	5
JC, RJC	2	2	2	2	2
*EK	None	3	3	3	3
*EM, 55.0EN	None	4	3	3	3
*KB	None	4	3	3	3
*KR	None	4	4	3	3
*WA, WE	**	4	4	4	4
*WB	**	6	4	4	4
*FT	None	6	4	4	4

*Thermac regulator standard on EK, EM, EN, KB, KR, WA, WB, WE and FT gas fuel IMPCO system. Maximum supply pressure to Thermac is 12 ounces (5.2 kPa). Thermac outlet pressure is 3 ounces for 1000 BTU gas (1.3 kPa for 3.7 MJ/m³ gas).

**Combination natural gas-gasoline systems can use regulator in next column. For natural gas, no regulator is needed up to 11 ounces (4.7 kPa).

NOTE: Code numbers refer to KEY column in Table 5 for regulator part number and identification.

pressures up to 12 ounces (5.2 kPa). For regulator selection of higher supply pressures, see Table 3.

Models WF and WK shouldn't require an additional regulator for natural gas. The WF and WK require a 20 psi (138 kPa) natural gas supply and therefore do not use a THERMAC valve.

CAUTION **WF and WK models only: If utility gas pressure is below 20 psi (138 kPa), a gas booster must be furnished. However, the booster (optional item) supplied by Onan requires that inlet pressure (to booster) be no greater than 2 psig (13.8 kPa), 45 inches (1143 mm) H2O, and no less than 0.5 psig (3.45 kPa), 13.9 inches (352 mm) H2O. Should gas pressure not fall between these limits, some system redesign will be necessary.**

Converter (Vaporizer)

These components, used only in LP gas liquid withdrawal systems, provide heat for vaporizing liquefied fuel. Vent all LP gas converters to outside of building.

TABLE 4. INLET PRESSURE TO SECONDARY REGULATOR (Straight Gaseous Fuel Only)

MODEL	PRESSURE
AJ, AK, NH, CCK, CCKB, JB, JC, RJC (Begin Spec P)	2 to 6 oz. (0.9 to 2.6 kPa)
JC, RJC (Spec A through N)	6 oz. to 5 psi (2.6 to 34 kPa)
EK, EM, EN, KB, KR, WA, WB, WE	12 oz. (5.2 kPa) maximum (to thermac)
WF, WK*	20 psi (138 kPa)

*Usually only require one regulator (see text).

TABLE 5. PRIMARY GASEOUS FUEL REGULATORS

KEY	PART NUMBER	FUNCTION	ORIFICE	INLET SIZE	OUTLET SIZE	INLET PRESSURE	OUTLET PRESSURE	MAXIMUM CAPACITY
1	148-0033	Pressure Reducing	9/64 in.	1/4 in.	1/2 in.	250 lb (1725 kPa)	11 in. (280 mm) wc	190 cfh (5.38 m³/hr)
2	148-0034	Pressure Reducing	1/4 in.	3/4 in.	3/4 in.	200 lb (1380 kPa)	11 in. (280 mm) wc	680 cfh (19.2 m³/hr)
3	148-0343	Pressure Reducing	1/2 in.	1-1/4 in.	1-1/4 in.	35 lb (240 kPa)	11 in. (280 mm) wc	1,800 cfh (50.96 m³/hr)
4	148-0363	Pressure Reducing	1 in.	1-1/2 in.	1-1/2 in.	25 lb (170 kPa)	11 in. (280 mm) wc	7,750 cfh (219.4 m³/hr)
5	148-0523	Pressure Reducing	1/4 in.	1/2 in.	3/4 in.	200 lb (1380 kPa)	11 in. (280 mm) wc	330 cfh (9.34 m³/hr)
6	148-0605	Pressure Reducing	2 in.	2 in.	2 in.	5 lb (35 kPa)	11 in. (280 mm) wc	35,600 cfh (1007.8 m³/hr)

Heat is usually supplied by the engine coolant, thermostatically controlled at about 170 F (77 C), maintaining a rather constant fuel temperature. This positive method of vaporizing liquefied fuel allows a constant fuel-air mixture despite changes in withdrawal rates and atmospheric temperature.

Where ambient temperatures fall below freezing, generator sets of 50 kW and higher capacity should employ a vaporizer which has a gas-fueled burner to supply heat for vaporization. An adequate supply of vaporized fuel will then be assured for starting and permitting the set to immediately carry the load.

Install a burner-type vaporizer outdoors and as close as permissible to the point of consumption. You can use it with either surface or subsurface tanks. The rate of vaporization is automatically controlled to meet vapor demands. Generated gas, storage gas or both can be supplied on demand. An anti-overflow valve prevents liquid fuel from reaching the service line.

The capacity of a converter is defined in terms of rate of flow and volume of water, horsepower it serves, the volume of gas it can vaporize, etc. A converter should have a 20 percent reserve capacity for peak load operation.

The water flow through the converter must be great enough to vaporize enough fuel for peak demands. If water lines are obstructed or too small, so much heat loss can occur that it freezes. Moreover, if the fuel mixture becomes too lean, efficiency is lost and engine valves can burn. Not only does this apply to converters but to the size of fuel tanks in vapor withdrawal systems as well. Many converters have the primary and secondary regulator built into them.

Fuel Strainer

Foreign substances can cause failure of sensitive components in gaseous fuel systems. Natural gas contains a gummy substance with a sulfur base which is one of the chief contaminants. Rust, scale, etc., eventually find their way into the fuel system and damage valves and orifices.

TABLE 6. FUEL STRAINERS

PART NUMBER	PIPE SIZE (in.)	TYPE	TYPE OF FUEL
149-0558	3/4	Y	Natural or LP Gas Vapor
149-0624	1-1/4	Y	Natural
149-0625	1/4	Cone	LP Gas Liquid
149-0751	2	Y	Natural
149-0752	1	Y	Natural
149-1241	3	Y	Natural

Moisture, usually present to some degree, must be eliminated or freezing may occur at the regulators or carburetor during peak loads. Mount the filter slightly lower than the regulator, between the tank and first system component (refer to typical installation illustrations).

Electric Shutoff Valve

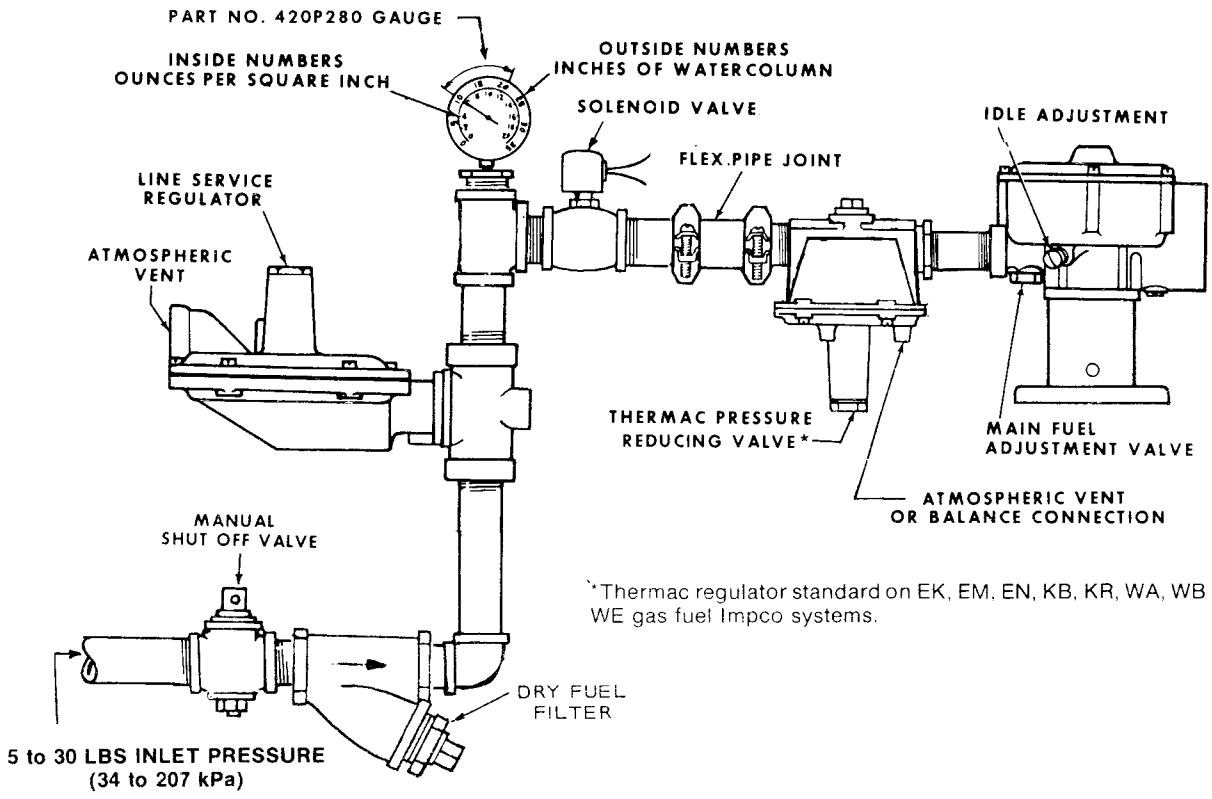
Most local codes require the use of an electric fuel shutoff (solenoid) valve which shuts off the gas supply when the engine is stopped. Check applicable agency code requirements for electric lockoff valves for protection against potential fire hazards.

The final regulator in some instances is an acceptable shutoff valve, but a more positive lockoff is usually desired and may be required. See the shutoff valve selection Table 7 for characteristics and usage.

A solenoid valve should be installed at the carburetor intake to prevent fuel in the converter leaking out to the exhaust system when the set stops. A liquid solenoid valve is required at the inlet to the converter.

TABLE 7. ELECTRIC SHUTOFF VALVES

MODEL OR UNIT SIZE	LINE PRESSURE	12 VOLT	24 VOLT	MAXIMUM OPERATING PRESS	PIPE SIZE (in.)
15 kW and Smaller	Under 8 oz (3.4 kPa)	307-0312		8 oz (3.4 kPa)	3/4
15 kW and Smaller	To 25 lb (170 kPa)	307-0834	307-0863	25 lb (170 kPa)	3/4
EK, EM	15 lb (100 kPa)	307-0836	307-0865	25 lb (170 kPa)	1
EN, KB, KR	15 lb (100 kPa)	307-0837		25 lb (170 kPa)	1-1/4
WA, WE	15 lb (100 kPa)	307-0840		15 lb (100 kPa)	2
WB, FT	15 lb (100 kPa)		307-0841	15 lb (100 kPa)	2
FT	15 lb (100 kPa)		307-1048	5 lb (35 kPa)	3
WF, WK	20 lb (140 kPa)		307-0866	25 lb (170 kPa)	1-1/4
Liquid Fuel		307-0268	307-0757		1/4



*Thermac regulator standard on EK, EM, EN, KB, KR, WA, WB and WE gas fuel Impco systems.

IMPCO VAPOR WITHDRAWAL GAS FUEL SYSTEM

VAPOR WITHDRAWAL

LP gas vapor withdrawn from the tank for consumption carries away a certain amount of heat from the liquid. This heat loss causes the temperature and pressure of the liquid within the tank to fall. Heat is normally absorbed through the tank wall to replace the lost heat. If heat can be replaced, the system will function as intended. If fuel consumption is high and ambient temperatures are low, for example, so much heat is lost that it cannot be replaced from around the tank and the system will not function efficiently.

There are two methods to assist heat transfer (tanks in vapor withdrawal systems absorb heat through only the portion which is in direct contact with the liquefied gas):

1. Use a suitable vaporizer for positive vaporization (liquid withdrawal).
2. Use a tank large enough to meet peak engine demands.

Surface and Subsurface LP Gas Tanks

Select and size the LP gas tanks according to the following requirements:

1. Type of withdrawal system.
2. Atmospheric (or design) temperature.
3. Vaporization characteristics of fuel.
4. Consumption.

LP gas temperature is critically important and imposes several limitations. Full power cannot be obtained from generator sets fueled by vapor withdrawal systems in which the fuel tanks are too small for the prevailing temperature. In many cases, it may be less expensive to purchase a vaporizer for positive vaporization than to purchase a larger tank to merely provide a greater area for heat transfer.

Burying tanks below the frost line where temperatures never go below 35 F (2 C) is all right if adequate allowances are made for year-to-year variations. In northern climates, the frost line might be four feet (about one metre) one year and eight feet (over two metres) the next year, depending on snow cover, etc.

The following tables apply only to propane, the major component of LP gas. The vaporization rates are based on the average temperature over an eight-hour period. The column temperatures heading represent the lowest average winter temperature which is the average of the daily winter low temperatures. Use the table which pertains to the type of container used.

Determining Number of 20-Gallon (75 Litre) Cylinders Required

Assume that a model 5.0CCK generator set is installed using propane gas. The lowest average outdoor temperature is -10 F (-23 C). No other gas appliances will be used.

1. Refer to fuel consumption Table 2. Note that a series CCK uses approximately 50 cubic feet (1.4 m^3) of fuel per hour at full-rated load.
2. Refer to cylinders required in Table 8. Note that at -10 F (-23 C), four cylinders will provide 50 cubic feet (1.4 m^3) of vapor fuel per hour. This will be sufficient for unit operation.

Combination Gaseous Fuel and Gasoline Systems

The combination fuel system can use either a gaseous fuel or gasoline to run the generator set. Conversion from one fuel to the other usually consists of shutting off one fuel supply and allowing the other fuel to flow to the carburetor. Most combination carburetors contain fuel shutoff valves and float locking devices for simple conversion. Idle and power adjustments for either fuel are also included in the carburetor for ease of maintenance. Refer to the generator set operator manuals and technical bulletins for installation techniques.

Gasoline supply lines and tanks are conventionally designed, installed and serviced as on straight gasoline fuel generator sets. The gaseous fuel (natural gas, LPG) installation is essentially the same as on straight gas fuel units. The selection of valves, regulators, filter, and other components is the same as in the preceding sections of this bulletin with the exception of the inlet pressure differences.

TABLE 8. 20-GALLON (76-LITRE) PROPANE CYLINDERS REQUIRED FOR INDICATED TEMPERATURES WHEN KEPT AT LEAST 1/2 FULL

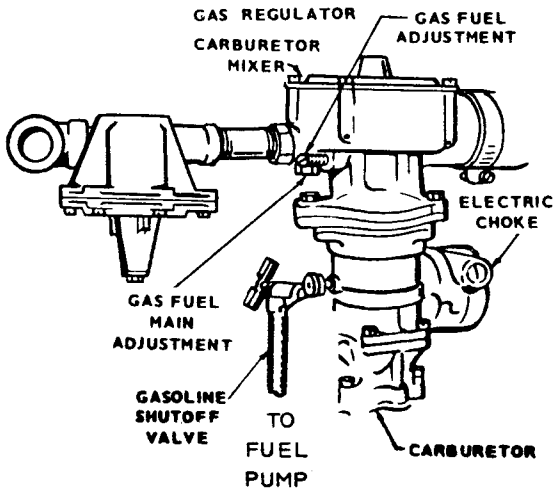
WITHDRAWAL RATE	LOWEST AVERAGE WINTER TEMPERATURE						
	32 F (0 C)	20 F (-7 C)	10 F (-12 C)	0 F (-18 C)	-10 F (-23 F)	-20 F (-29 C)	-30 F (-34 C)
10 cfh-25,000 BTU/hr (0.28 m^3/hr-26.4 MJ/hr)	1	1	1	1	1	1	2
25 cfh-62,500 BTU/hr (0.71 m^3/hr-65.9 MJ/hr)	1	1	1	2	2	3	4
50 cfh-125,000 BTU/hr (1.4 m^3/hr-131.9 MJ/hr)	2	2	3	3	4	5	9
100 cfh-250,000 BTU/hr (2.8 m^3/hr-263.8 MJ/hr)	4	4	5	6	7	10	20

TABLE 9. REQUIRED PROPANE TANK SIZE IN GALLONS (LITRES) FOR INDICATED TEMPERATURES WHEN KEPT AT LEAST 1/2 FULL

WITHDRAWAL RATE	LOWEST AVERAGE WINTER TEMPERATURE						
	32 F (0 C)	20 F (-7 C)	10 F (-12 C)	0 F (-18 C)	-10 F (-23 C)	-20 F (-29 C)	-30 F (-34 C)
50 cfh-125,000 BTU/hr 1.4 m^3/hr-131.9 MJ/hr	115 (435)	115 (435)	115 (435)	250 (945)	250 (945)	400 (1515)	600 (2270)
100 cfh-250,000 BTU/hr 2.8 m^3/hr-263.8 MJ/hr	250 (945)	250 (945)	250 (945)	400 (1515)	500 (1890)	1000 (3785)	1500 (5675)
150 cfh-375,000 BTU/hr 4.2 m^3/hr-395.6 MJ/hr	300 (1135)	400 (1515)	500 (1890)	500 (1890)	1000 (3785)	1500 (5675)	2500 (9460)
200 cfh-500,000 BTU/hr 5.7 m^3/hr-527.5 MJ/hr	400 (1515)	500 (1890)	750 (2840)	1000 (3785)	1200 (4540)	2000 (7570)	3500 (13250)
300 cfh-750,000 BTU/hr 8.5 m^3/hr-791.2 MJ/hr	750 (2840)	1000 (3785)	1500 (5675)	2000 (7570)	2500 (9460)	4000 (15140)	5000 (18925)

FUEL LINE SIZE

Fuel line size depends on the amount of fuel needed to run a unit at full load and the distance the fuel must be moved. See Tables 10 through 13.



TYPICAL COMBINATION FUEL SYSTEM

TABLE 10. PROPANE FUEL TWO STAGE REGULATION (2 REGULATORS)
(5 to 15 lb or 34 to 103 kPa — Allowing Pressure Drop of 1 psi or 6.9 kPa)
DIAMETER OF FUEL LINE IN INCHES FOR THE VARIOUS LENGTHS OF PIPE

UNIT	kW	CFH (m^3/hr)	15 FT (4.6 m)	25 FT (7.6 m)	50 FT (15 m)	75 FT (23 m)	100 FT (30 m)	150 FT (46 m)	200 FT (61 m)	300 FT (91 m)
AJ	1	13 (0.37)	1/4*	1/4*	1/4*	1/4*	1/4*	1/4*	1/4*	1/4*
AJ	2.5	25 (0.71)	1/4*	1/4*	1/4*	1/4*	1/4*	1/4*	1/4*	1/4*
LK	2.5	23 (0.65)	1/4*	1/4*	1/4*	1/4*	1/4*	1/4*	1/4*	1/4*
CCK	4	40 (1.13)	1/4*	1/4*	1/4*	1/4*	1/4*	1/4*	3/8£	3/8£
CCK	5	47 (1.33)	1/4*	1/4*	1/4*	1/4*	1/4*	1/4*	3/8£	3/8£
NH	6.5	60 (1.70)	1/4*	1/4*	3/8£	3/8£	3/8£	3/8£	3/8£	3/8£
JB	7.5	63 (1.78)	1/4*	1/4*	3/8£	3/8£	3/8£	3/8£	3/8£	3/8£
CCKB	10	100 (2.83)	3/8£	3/8£	3/8£	1/2†	1/2†	1/2†	1/2†	1/2†
JC, RJC	12.5	92 (2.60)	3/8£	3/8£	3/8£	1/2†	1/2†	1/2†	1/2†	1/2†
JC, RJC	15	110 (3.11)	3/8£	3/8£	3/8£	1/2†	1/2†	1/2†	1/2†	1/2†
EM	45	290 (8.21)	3/8£	1/2†	1/2†	1/2	1/2	3/4	3/4	3/4
EK	30	245 (6.94)	3/8£	3/8£	1/2†	1/2†	1/2	1/2	1/2	3/4
EN, KB	55	330 (9.34)	1/2†	1/2†	1/2	1/2	3/4	3/4	3/4	3/4
KR	85	400 (11.3)	1/2	1/2	3/4	3/4	1	1	1	1-1/4
WA	115	730 (20.7)	1/2	3/4	3/4	1	1	1	1	1-1/4
WE	140	730 (20.7)	3/4	3/4	1	1	1	1-1/4	1-1/4	1-1/4
WE	150	730 (20.7)	3/4	3/4	3/4	1	1	1	1-1/4	1-1/4
WB	170	1,000 (28.3)	3/4	3/4	1	1	1-1/4	1-1/4	1-1/4	1-1/4

* 3/8 outside diameter tubing can be used.
£ 1/2 outside diameter tubing can be used.
† 5/8 outside diameter tubing can be used.

TABLE 11. LPG VAPOR—11 INCH (280 mm) WATER COLUMN, 0.5 INCH (13 mm) PRESSURE DROP DIAMETER OF FUEL LINE IN INCHES FOR THE VARIOUS LENGTHS OF PIPE

UNIT	kW	CFH★ (m^3/hr)	15 FT (4.6 m)	25 FT (7.6 m)	50 FT (15 m)	75 FT (23 m)	100 FT (30 m)	150 FT (46 m)	200 FT (61 m)	300 FT (91 m)
AJ	1	13 (0.37)	1/2*	1/2*	1/2*	1/2£	1/2£	1/2†	1/2†	3/4†
LK	2.5	25 (0.71)	1/2+	1/2+	1/2+	1/2£	1/2£	3/4£	3/4	3/4
CCK	4	40 (1.13)	1/2£	1/2†	3/4†	3/4†	3/4	3/4	1	1
CCK	5	47 (1.33)	3/4£	3/4†	3/4†	1	1	1	1	1-1/4
NH	6.5	60 (1.70)	3/4	3/4†	3/4	1	1	1	1-1/4	1-1/4
CCKB	10	100 (2.83)	3/4	1	1	1	1-1/4	1-1/4	1-1/2	1-1/2
JB	7.5	63 (1.78)	3/4	3/4†	3/4	1	1	1	1-1/4	1-1/4
JC	12	110 (3.11)	3/4	1	1	1	1-1/4	1-1/4	1-1/2	1-1/2
EM	45	290 (8.21)	1	1-1/4	1-1/4	1-1/4	1-1/2	1-1/2	2	2
EK	30	245 (6.94)	1	1	1	1-1/4	1-1/4	1-1/4	1-1/2	1-1/2
EN, KB	55	330 (9.34)	1	1-1/4	1-1/4	1-1/2	1-1/2	1-1/2	2	2
KR	85	400 (11.3)	1-1/2	1-1/2	1-1/2	2	2	2	2-1/2	2-1/2
WA	115	730 (20.7)	1-1/2	2	2	2	2	2-1/2	2-1/2	2-1/2
WB	170	1000 (28.3)	2	2-1/2	3	3	4	4	4	4
WE	150	730 (20.7)	2	2-1/2	2-1/2	3	3	3	4	4

★ These values are only representative; refer to Table 2 for all specific values.
* 1/2 outside diameter tubing may be used.
£ 5/8 outside diameter tubing may be used.
\+ These engines require 15 psi (103 kPa) natural gas fuel supply.
† 3/4 outside diameter tubing may be used.

Note: Never use smaller than 1/2 inch outside diameter tubing.

TABLE 12. NATURAL GAS — 11 INCH (280 mm) WATER COLUMN, 0.5 INCH (13 mm) PRESSURE DROP DIAMETER OF FUEL LINE IN INCHES FOR THE VARIOUS LENGTHS OF PIPE

UNIT	kW	CFH* (m^3/hr)	15 FT (4.6 m)	25 FT (7.6 m)	50 FT (15 m)	75 FT (23 m)	100 FT (30 m)	150 FT (46 m)	200 FT (61 m)	300 FT (91 m)
AJ	1	33 (0.93)	1/2	1/2	1/2	3/4	3/4	3/4	1	1-1/4
LK	2	54 (1.53)	1/2	3/4	3/4	3/4	3/4	1	1	1-1/4
CCK	4	90 (2.55)	3/4	3/4	3/4	1	1	1	1-1/4	1-1/4
CCK	5	115 (3.26)	3/4	3/4	3/4	1	1	1-1/4	1-1/4	1-1/4
NH	6.5	150 (4.25)	1	1-1/4	1-1/4	1-1/4	1-1/2	1-1/2	1-1/2	2
CCKB	10	200 (5.66)	1	1-1/4	1-1/4	1-1/4	1-1/2	1-1/2	1-1/2	2
JB	7.5	126 (3.57)	3/4	3/4	3/4	1-1/4	1-1/4	1-1/4	1-1/4	1
JC	15	255 (7.22)	1	1-1/4	1-1/4	1-1/4	1-1/2	1-1/2	1-1/2	2
EK	30	600 (17.0)	1-1/4	1-1/4	1-1/4	1-1/2	1-1/2	2	2	2
EM	45	690 (19.5)	1-1/4	1-1/2	1-1/2	2	2	2	2-1/2	2-1/2
EN, KB	55	840 (23.8)	1-1/2	1-1/2	2	2	2	2-1/2	2-1/2	2-1/2
KR	70	1,000 (28.3)	2	2	2	2	2-1/2	2-1/2	2-1/2	3
KR	85	1,400 (39.6)	2	2	2	2	2-1/2	2-1/2	2-1/2	3
WA	115	1,800 (51.0)	2	2-1/2	2-1/2	3	3	3	3-1/2	3-1/2
WE	150	1,450 (41.0)	2	2-1/2	2-1/2	3	3	3	3-1/2	3-1/2
WB	170	2,500 (70.8)	2-1/2	2-1/2	3	3	3-1/2	3-1/2	3-1/2	4
FT	250	3,000 (84.9)	2-1/2	3	3	3	4	4	4	5
WF†	350	3,850 (109.0)	1-1/4	1-1/4	1-1/4	1-1/4	2	2	2	2
WK†	400	4,200 (118.9)	1-1/4	1-1/4	1-1/4	1-1/4	2	2	2	2
WF††	350	3,850 (109.0)	2-1/2	3	3	4	4	4	4	6
WK††	400	4,200 (118.9)	3	4	4	4	4	6	6	6

* These values are only representative; refer to Table 2 for all specific values.
† These engines require 20 psi (138 kPa) natural gas fuel supply.
†† Generator sets with gas boosters on engines . . . for low pressure incoming fuel line.

TABLE 13. LINE SIZING CHART FOR LIQUID PROPANE
Based on Pressure Drop of 1 PSI (6.9 kPa)

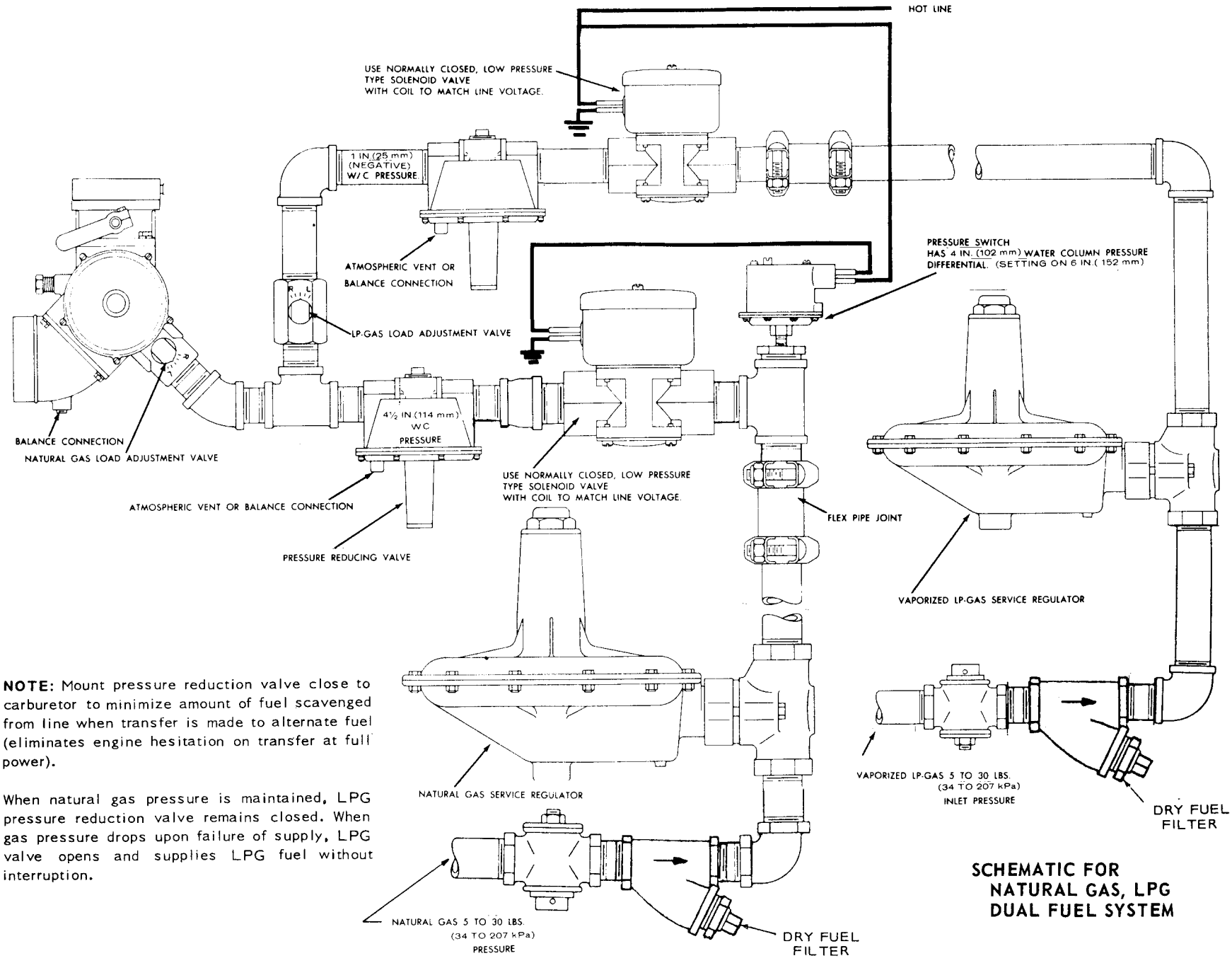
Liquid Propane Flow CFH (m^3/hr)	Liquid Propane Flow GPH (litre/hr)	PIPE LENGTH - FEET (m)															
		1/4 IN.		3/8 IN.		1/2 IN.		3/4 IN.		1 IN.		1-1/4 IN.		1-1/2 IN.		2 IN.	
		Schedule		Schedule		Schedule		Schedule		Schedule		Schedule		Schedule		Schedule	
		40	80	40	80	40	80	40	80	40	80	40	80	40	80	40	80
360 (10.2)	10 (38)	729 (222)	416 (127)														
540 (15.3)	15 (57)	324 (98)	185 (56)														
720 (20.4)	20 (76)	182 (55)	104 (32)	825 (251)	521 (159)												
1440 (40.8)	40 (152)	46 (14)	26 (8)	205 (62)	129 (39)	745 (227)	504 (154)										
2160 (61.1)	60 (227)	20 (6.1)	11 (3.4)	92 (28)	58 (18)	331 (101)	224 (68)										
2880 (81.5)	80 (303)	11 (3.4)	6 (1.8)	51 (16)	32 (10)	187 (57)	127 (39)	735 (224)	537 (164)								
3600 (101.9)	100 (378)	7 (2.1)	4 (1.2)	33 (10)	21 (6.4)	119 (36)	81 (25)	470 (143)	343 (105)								

TO USE CHART:

1. Having determined the required flow at point of use, locate this flow in the left hand column. If this falls between two figures, use the larger of the two.
2. Determine total length of piping required from source to point of use.
3. Read across chart from left (required flow) to right to find the total length which is equal to or exceeds the distance from source to use.
4. From this point read up to find the correct size of pipe required.

TABLE 14. INLET PRESSURE TO SECONDARY REGULATOR OR THERMAC REGULATOR
(Combination Fuel with Impco System)

UNIT	PRESSURE
EK, EM, EN	12 oz (5.2 kPa)
WA, WB, WE	12 oz (5.2 kPa)
KB, KR	12 oz (5.2 kPa)

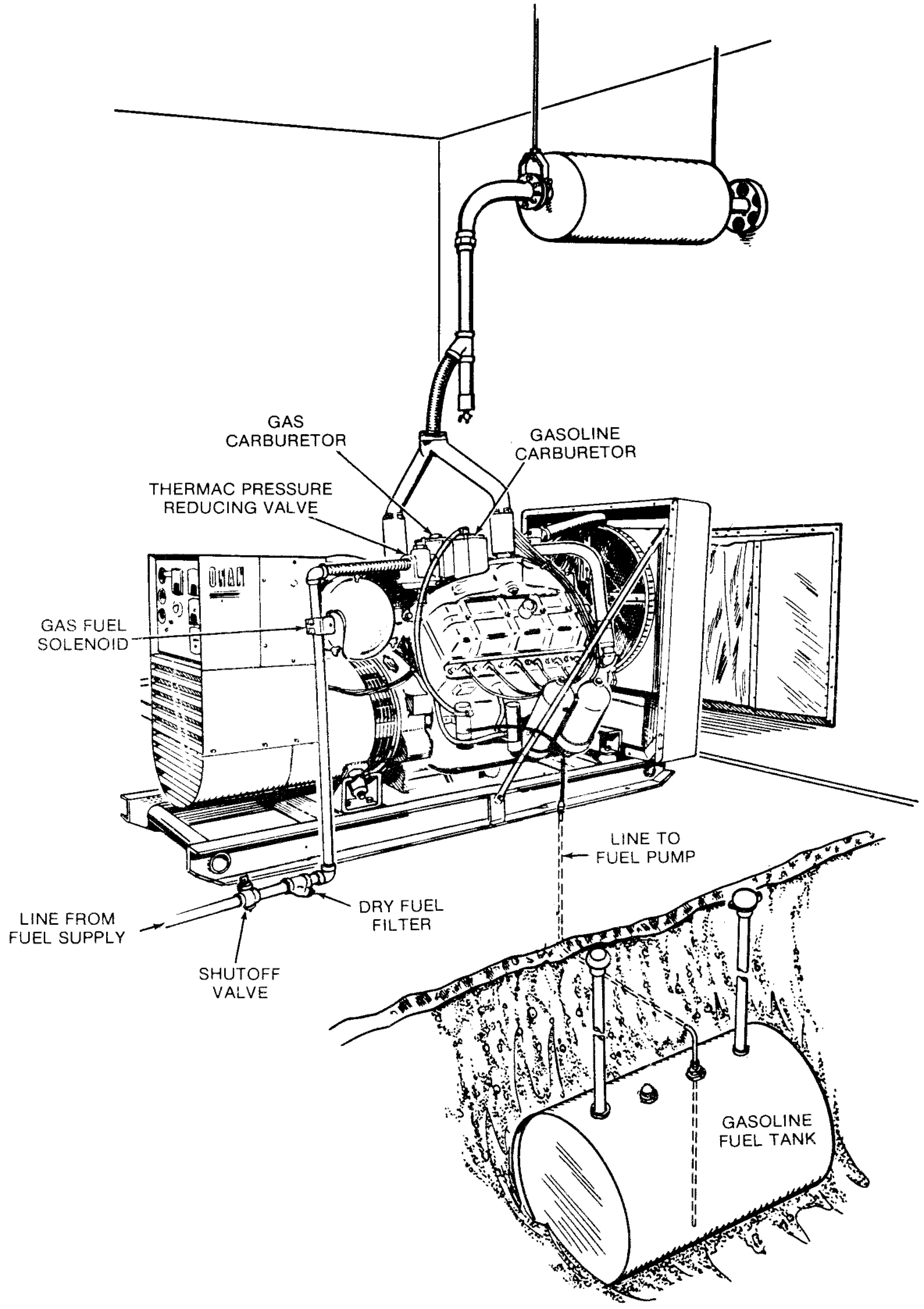


NOTE: Mount pressure reduction valve close to carburetor to minimize amount of fuel scavenged from line when transfer is made to alternate fuel (eliminates engine hesitation on transfer at full power).

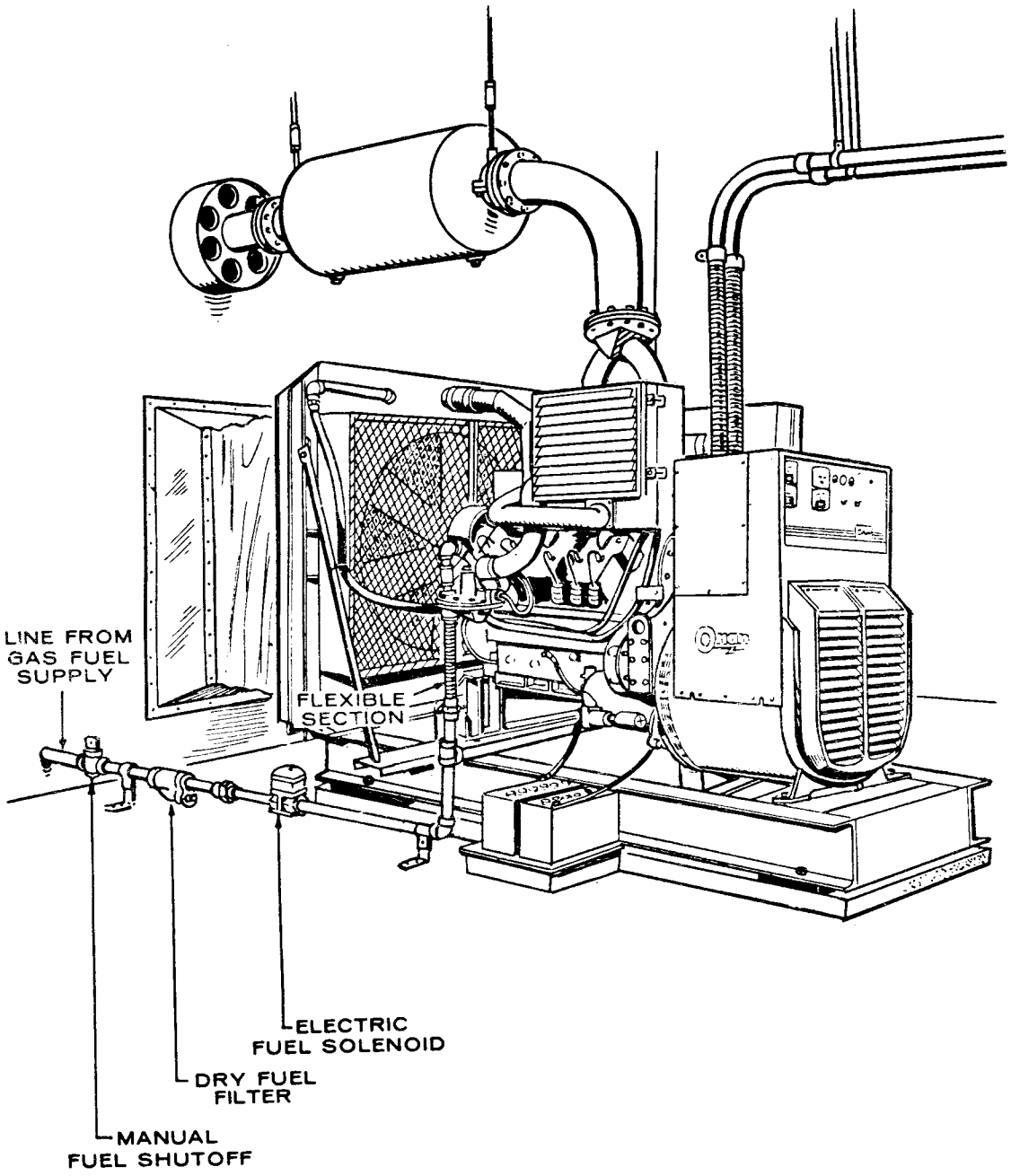
When natural gas pressure is maintained, LPG pressure reduction valve remains closed. When gas pressure drops upon failure of supply, LPG valve opens and supplies LPG fuel without interruption.

SCHEMATIC FOR NATURAL GAS, LPG DUAL FUEL SYSTEM

TYPICAL GAS-GASOLINE FUEL SYSTEM

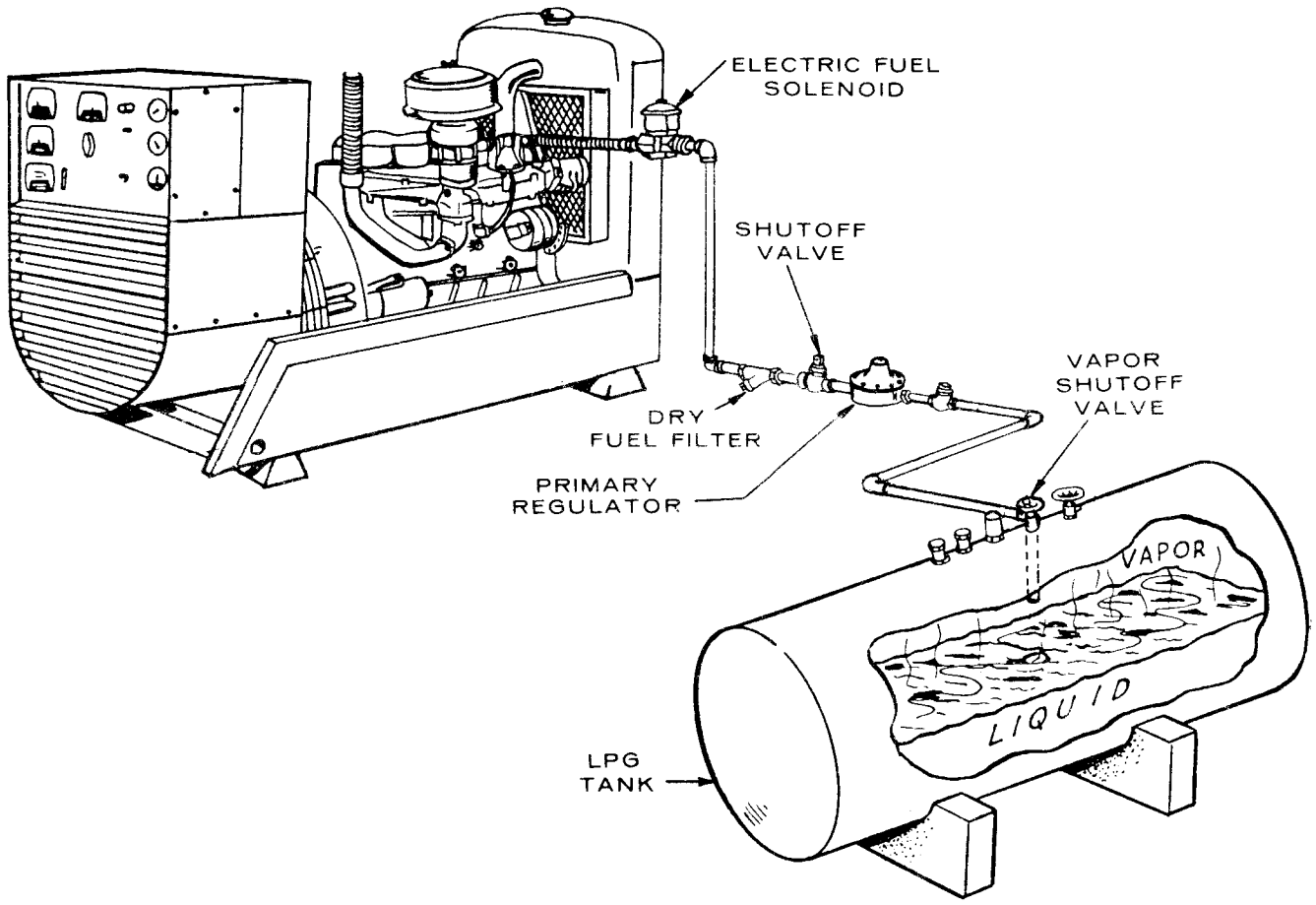


TYPICAL NATURAL OR MANUFACTURED CITY GAS SYSTEM

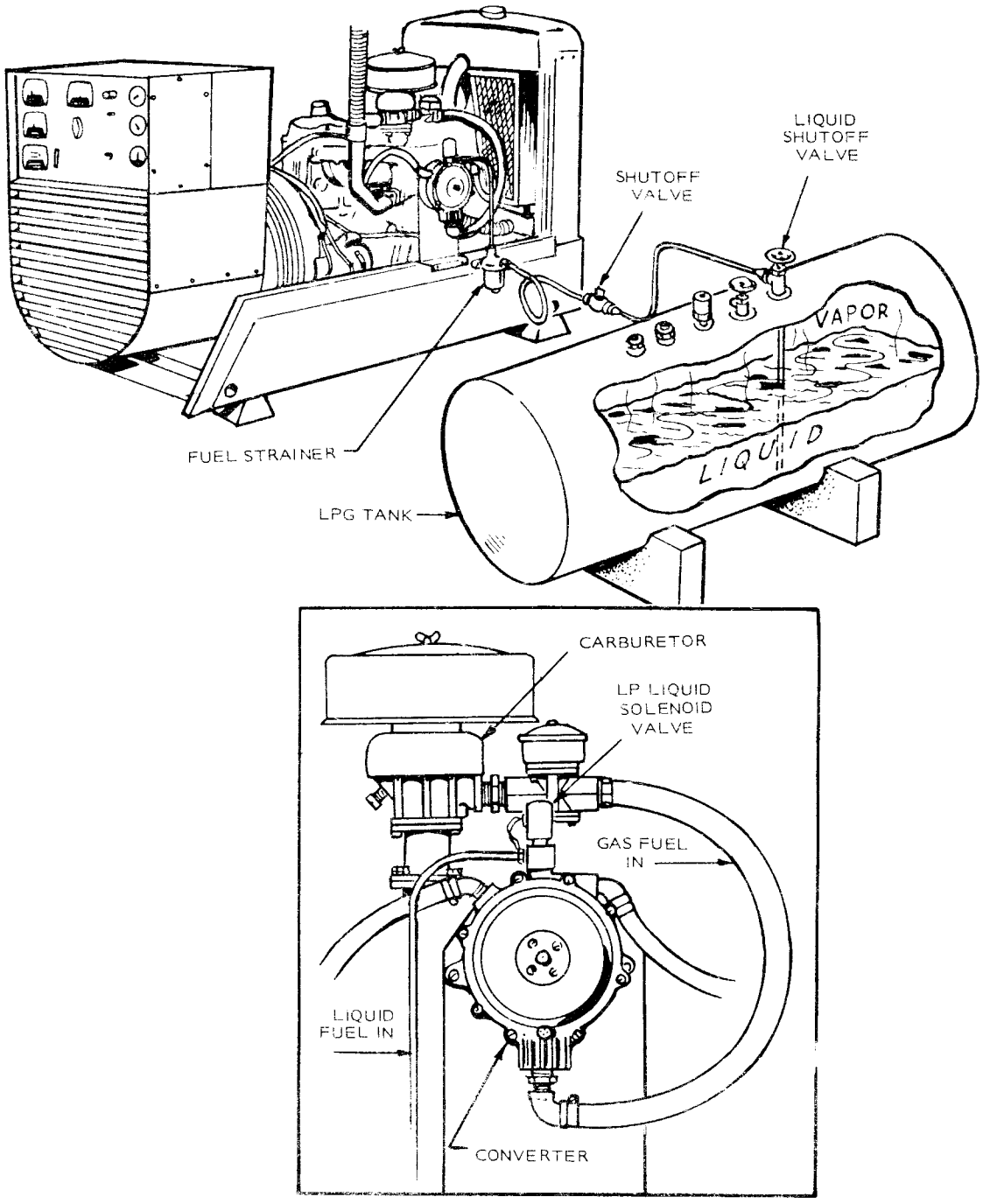


NOTE: WF and WK do not use two-step regulation.

TYPICAL LPG VAPOR WITHDRAWAL SYSTEM

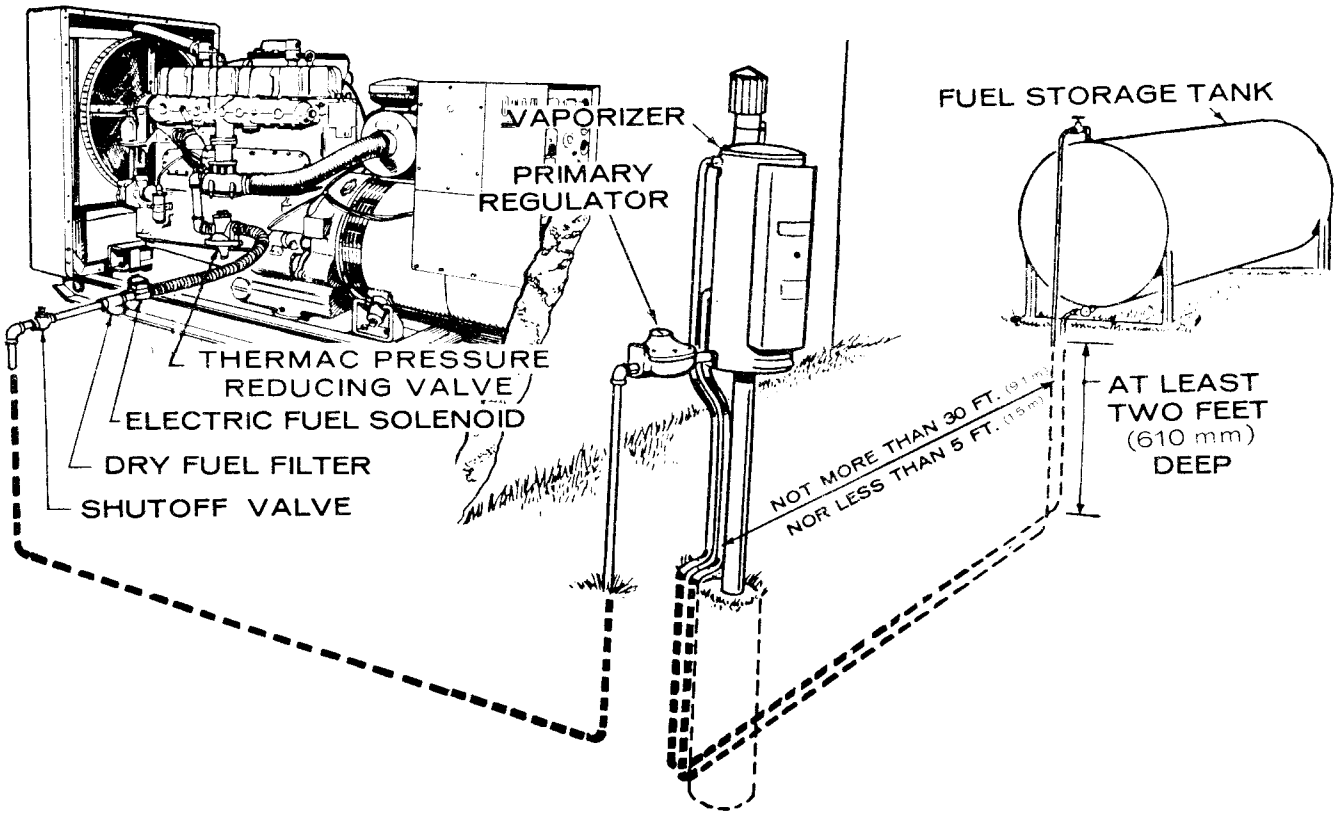


TYPICAL LPG SYSTEM WITH LIQUID WITHDRAWAL



NEVER INSTALL REGULATOR BETWEEN TANK AND CONVERTER IN LIQUID WITHDRAWAL.

TYPICAL LPG SYSTEM WITH GAS BURNER VAPORIZER



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