FUEL SETUP GUIDELINES FOR ARROW ENGINES

CONTENTS

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Arrow natural gas engines will operate on a wide range of fuels including pipeline quality natural gas, wellhead gas, and propane. Arrow engines are designed for use in pumping unit, power generation, gas compression, irrigation and other stationary mechanical drive applications.

One of the most overlooked aspects of commissioning the engine is properly setting up the fuel delivery system based on engine and application type. This Fuel Setup Guideline will provide a better understanding of a properly arranged fuel delivery system for the Multi-cylinder and C-Series Arrow engines. Adherence to these guidelines will ensure trouble-free commissioning, providing the engine optimal fuel flow required for peak performance, and, in some cases, emissions compliance.

MULTI-CYLINDER ENGINES

Arrow offers a range of multi-cylinder engines that use various air/fuel controls systems requiring unique fuel delivery setups. Whether the engine is a legacy model or EPA Certified, there are some common key components required for proper fuel delivery to the engine.

KEY COMPONENTS

Gas Regulator(s)

- Depending on starting wellhead gas pressure, you may need one or multiple gas regulators to achieve the low pressure required at the inlet of the engine's fuel system which is typically measured in inches of water column (INWC), ounces per square inch (oz/in^2) or kilopascals (kPa).

- A Primary regulator (also referred to as First Stage or First Cut regulator) is the first regulator to manage the high-pressure wellhead gas (i.e. 100 psig reduced to 30 psig).

- A Secondary regulator (also referred to as Second Stage or Second Cut regulator) is installed after the Primary regulator to further reduce the pressure (i.e. 30 psig reduced to 15 psig).

- A Tertiary regulator (also referred to as Third Stage or Final Cut regulator) is the final regulator installed before the engine's fuel inlet. This regulator reduces pressure from psig to INWC (i.e. 15 psig to 8 INWC) and must be sized appropriately to feed the engine enough low-pressure gas. When selecting the final cut regulator, ensure a minimum 3/8" orifice is maintained, otherwise there will not be enough fuel flow to sustain operation of the engine.

    - Refer to ***Table 1. Fuel Pressure Range for Multi-Cylinder Engine*** for a listing of required fuel pressures for Multi-Cylinder Engines.

NOTE

A typical symptom of an undersized regulator orifice is engine flare after cranking, followed by engine stall within seconds of start up.

Fuel Scrubber and Coalescing Filter

- When running an engine on wellhead natural gas, a fuel scrubber and in some cases, a coalescing filter are essential to ensure reliable and efficient operation. Wellhead gas often contains contaminants such as water vapor, liquid hydrocarbons, and other particulates which can damage engine components and reduce performance.

A scrubber removes bulk liquids and larger particulates (>5 µm), preventing corrosion and wear, while a coalescing filter captures fine aerosols and submicron particles (0.01–0.5 µm), ensuring clean fuel delivery to the engine.

IMPORTANT

No liquids are permitted at the inlet of the engine's fuel system.

- Wellhead gas varies greatly from site to site. It is imperative to understand the condition of the wellhead gas (BTU, water content, liquid hydrocarbon content, and H2S presence, to name a few). The condition of the wellhead gas dictates the equipment type and size required to properly treat the gas and what derates or adjustments may be required at the engine for proper operation.

IMPORTANT

If H2S is present in the wellhead gas, refer to the document "H2S Fuel Limit and Guideline for Arrow Engines" for further information.

Propane Vaporizer

- A propane vaporizer is a device that converts liquid propane into gaseous form by utilizing heat from the engine's coolant circuit, ensuring a consistent vapor supply for the engine.

NOTE

A vaporizer should only be used when drawing liquid propane off the bottom of the tank. Vapor propane is drawn off the top side of an LPG tank or cylinder. Only a gas regulator (not a vaporizer) is required for vapor propane, however, the LPG tank/cylinder must have enough internal surface area to vaporize (boil) LPG at the rate required by the engine.

Fuel Filter

- If a coalescing filter is not used in the fuel supply setup, it is still strongly recommended to install a 10-micron inline fuel filter with 99% efficiency upstream of the engine's fuel inlet. The following fuel filters are recommended:
  - **Raw natural gas:** Oxion, Inc. Model M150 or equivalent.
  - **Pipeline quality natural gas or vapor propane:** Maxitrol GF60-1-88 or equivalent.

Fuel Piping and Low-Pressure Hose

- NG and Vapor Propane Piping should be 1-inch minimum inside diameter, avoiding excessive turns and long runs. Teflon tape is NOT RECOMMENDED as a pipe thread sealant due to loose ends coming free and plugging the fuel system or filter screens. Instead, use a natural gas safe brush-on pipe sealant for threaded connections.

- Low pressure fuel hose should be 1-inch minimum inside diameter, as short as possible from the final cut regulator to the engine (8 feet maximum length) and be free from sharp bends or kinks.

Manual Shut-off Valve(s)

- Install appropriately sized shut-off valves at the fuel source and at the engine's fuel inlet port, at minimum. This allows for maintenance of the fuel supply system, provides a means to positively shut off the engine, and ensure the fuel is shut off during routine maintenance of the engine.

    - Refer to ***Figures 1, 3, and 4*** for Reference Fuel Setup Diagrams applicable to Multi-Cylinder Engine applications.

C-SERIES ENGINES

The C-Series engine is a large-displacement, single-cylinder, slow-speed engine that requires a unique fuel delivery system to ensure a high volume of low-pressure gas is available for each big “gulp” of the engine.

Many key fuel delivery components needed for multi-cylinder engine applications are also needed for large, single-cylinder engines like the C-Series. One very significant addition to the system is the Volume Tank. Volume tanks are what provide the instantaneous high volume of low-pressure gas as the engine goes through the large intake stroke. A simple 1” fuel line connected directly to the outlet of the gas regulator cannot handle this quick fuel demand and will result in fuel starvation at the engine.

KEY COMPONENTS

Gas Regulator(s)

- See comments in previous section
- Refer to ***Table 2. Fuel Pressure Range for C-Series Engines*** for a listing of required fuel pressures for Arrow C-Series engines.

Fuel Scrubber and Coalescing Filter

- *See comments in previous section.*

Volume Tank

- A volume tank is a critical component in the fuel delivery system for C-Series engines, ensuring a consistent supply of wellhead natural gas to meet the engine's demands. It consists of high and low-pressure cylinders separated by a gas regulator. The high-pressure side facilitates liquid dropout, capturing moisture and contaminants, while the regulator reduces the gas pressure (i.e. 15 psig to 8 INWC). The low-pressure chamber maintains an adequate volume of low-pressure gas to support the large intake stroke of the C-Series engine, preventing fuel starvation and ensuring reliable operation.

NOTE

If you are using a single-cylinder volume tank with no integrated gas regulator, you must install the final cut gas regulator just upstream of the volume tank.

Fuel Filter.

- *See comments in previous section*.

Fuel Piping and Low-Pressure Hose.

- *See comments in previous section*.

Manual Shut-off Valve(s).

- *See comments in previous section*.

    - Refer to ***Figures 2, 3, and 4*** for Reference Fuel Setup Diagrams applicable to C-Series Engine applications.

TABLES

	Fuel Pressure Range for Multi-cylinder Engines (INWC)			
	Legacy Configuration (Carburetor)[A]		EPA Certified Configuration (PG+)[B]	
Engine	NG[C]	Propane[D]	NG[E]	Propane[D]
A54	5"-8"	2"-4"	8"-16"	8"-16"
KP3	-	-	8"-16"	8"-16"
KP3S	-	-	8"-16"	8"-16"
KP3TA	-	-	8"-16"	8"-16"
KP3TAS	-	-	8"-16"	8"-16"
KP4	5"-8"	2"-4"	-	-
KP6	5"-8"	2"-4"	8"-16"	4"-8"
KP6TA[F]	-	-	8"-16"	4"-8"

***Table 1**. Fuel Pressure Range for Multi-Cylinder Engines*

A. Field adjustment to the gas regulator and/or carburetor power valve may be necessary for optimum performance.

B. Refer to the Emissions Related Installation Instructions (ERII) provided with your engine for the ultimate fuel pressure requirement. You must operate within this fuel pressure range to maintain EPA compliance.

C. Recommended starting fuel pressure setting based on 900 Btu/scf LHV.

D. Based on HD5 grade propane at approximately 2,350 Btu/scf.

E. For EPA Certified models, your engine is certified to run on wellhead NG that has at least 45% methane content and energy content of 700-1,600 Btu/scf LHV.

F. KP6TA is currently only offered as Site-Certifiable, not EPA Certified.

	Fuel Pressure Range for C-Series Engines (INWC)			
	Non-Certified		EPA Certified[A]	
Engine	NG[C]	Propane[D]	NG[B]	Propane
C-46	5"-8"	2"-4"	6"-14"	-
C-66	5"-8"	2"-4"	5"-12"	-
C-96	5"-8"	2"-4"	4"-5"	-
C-101	5"-8"	2"-4"	5"-6"	-
C-106	5"-8"	2"-4"	-	-

***Table 2**. Fuel Pressure Range for C-Series Engines.*

A. For EPA compliance, the carburetor is non-adjustable. Fuel pressure at the inlet of carburetor must be adjusted per the Operations Manual to maintain EPA compliance.

B. Fuel pressure settings listed in the Operations Manual must be followed for EPA compliance. Factors including engine speed, load, and altitude determine the required fuel pressure setting. The values in table 2 are provided only as reference.

C. Recommended starting fuel pressure setting based on 900 Btu/scf LHV. Carburetor power valve or gas regulator adjustments may be required for optimum performance.

D. Based on HD5 grade propane at approximately 2,350 Btu/scf. Carburetor power valve or gas regulator adjustments may be required for optimum performance.

FIGURES

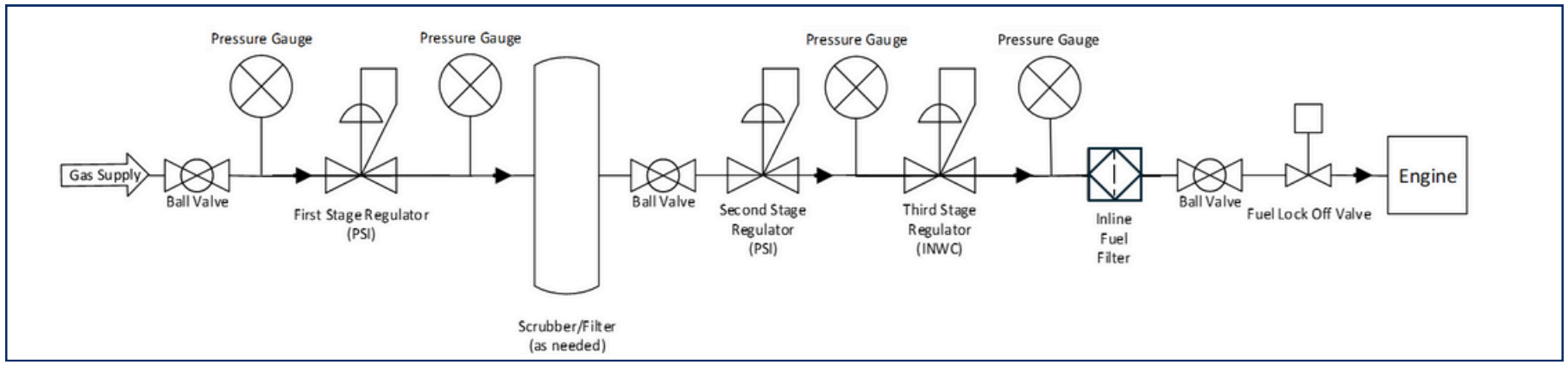

Figure 1. *NG Reference Fuel Setup Diagram for Multi-Cylinder Engines*

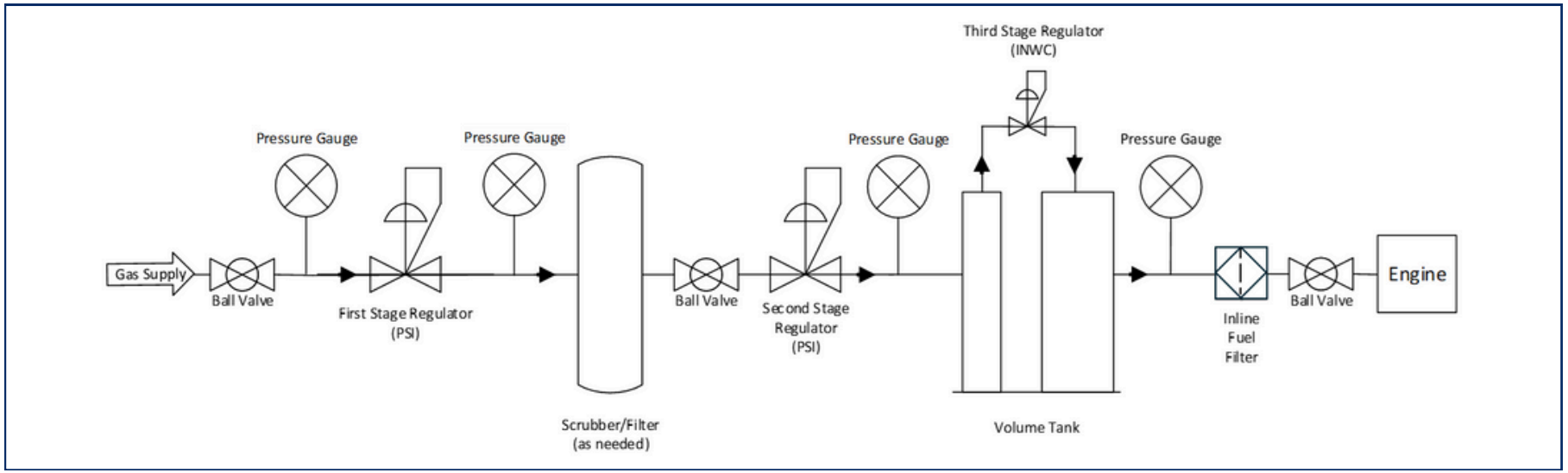

Figure 2. *NG Reference Fuel Setup Diagram for C-Series Engines.*

NOTE

The fuel setup diagrams are provided as general reference only. Each application requires a unique setup tailored to specific requirements.

FIGURES

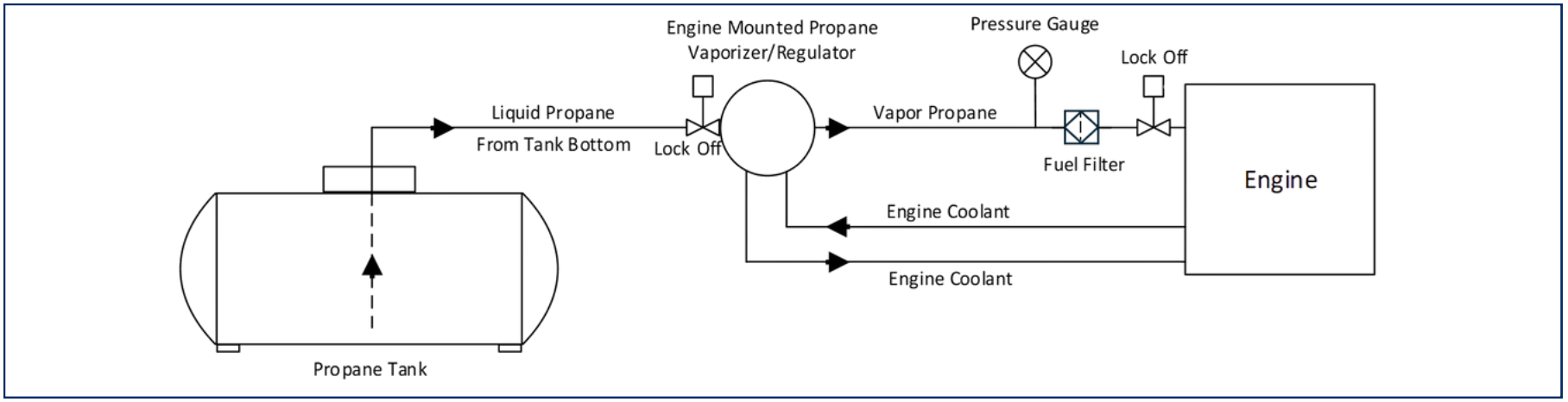

Figure 3 . *Liquid Propane Reference Fuel Setup Diagram.*

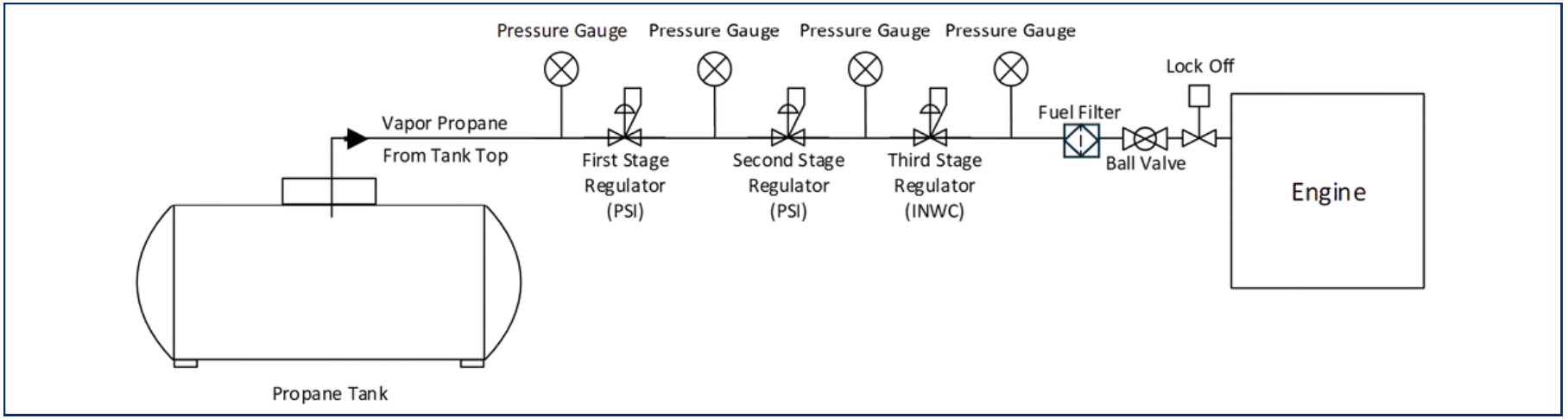

Figure 4 . *Vapor Propane Reference Fuel Setup Diagram.*

NOTE

The fuel setup diagrams are provided as general reference only. Each application requires a unique setup tailored to specific requirements.

FAQ

Frequently Asked Questions

Do I need a Volume Tank for my engine?

For C-Series engines, yes, a volume tank is required for normal operation of the engine. For multi-cylinder engines, it is application dependent. In steady-state applications, a volume tank is not required for multi-cylinder engines, but in cyclical load applications or applications where very large load swings are typical, it is recommended to use a volume tank to prevent momentary fuel starvation.

Can I make fueling adjustments to my EPA Certified engine?

No, all ignition and fueling parameters are non-adjustable on EPA certified engines. If your engine is site-certifiable (not EPA certified), then the engine is equipped with the necessary engine control systems to tune the engine into compliance on site.

Will my EPA certified engine run on any wellhead natural gas?

No, not all natural gas is permitted for use with your EPA certified engine. Your engine is certified to run on natural gas of pipeline-quality and most grades of non-pipeline-quality. Specifically, your engine is certified to run on natural gas that has at least 45% methane content by volume AND an energy content of 700 to 1,600 Btu per SCF. If your natural gas supply does not meet both of these specifications, your engine is operating as a noncertified engine.

FAQ

Frequently Asked Questions

Should I be concerned about the temperature of the natural gas fueling my engine?

Yes, low temperatures can cause condensation of liquids leading to performance, lubrication, corrosion and detonation problems. They can also cause hardening and embrittlement of elastomers in the fuel system. High temperatures can affect regulator performance and cause deterioration of elastomers found in regulators or fuel systems in addition to increasing knock tendencies of the engine.

The minimum allowable fuel temperature is at least 20°F above the dewpoint of any liquids in the fuel or -20°F, whichever is greater. The maximum allowable fuel temperature is 140°F.