

# Fuelie Facts & Fiction: Mechanical Fuel-Injection Systems

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01 While Ramjet FI systems came in a variety of configurations, they all operated in basically the same manner. Properly maintained, they were a big improvement over the carburetors of the time.

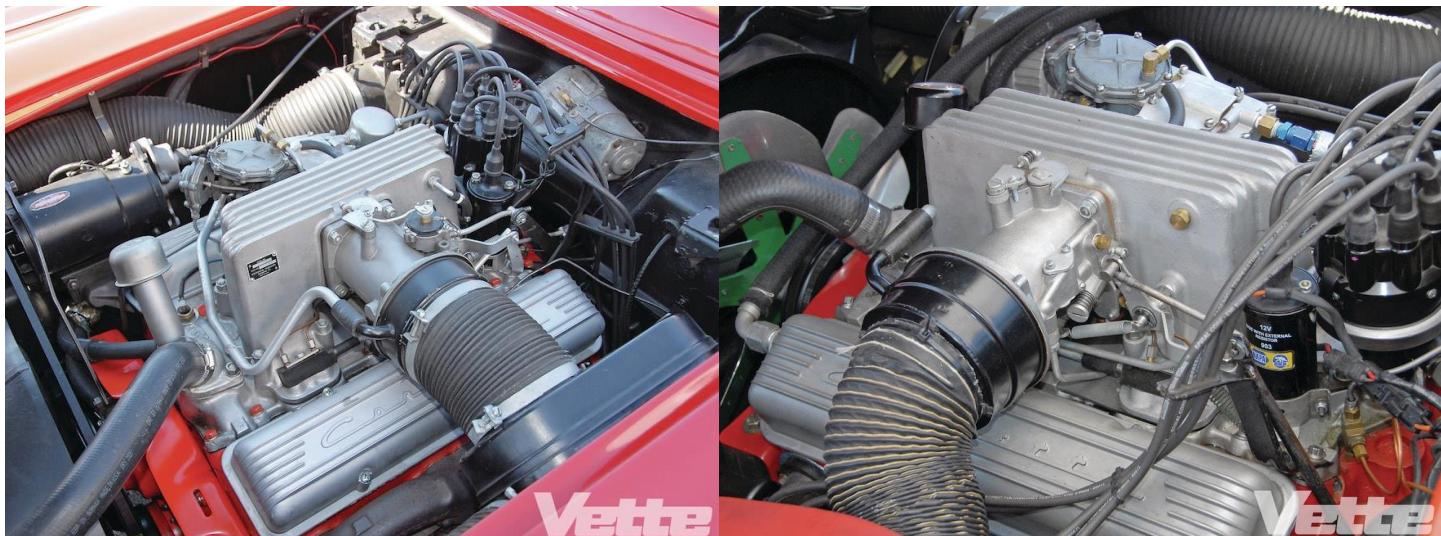
More than five-and-a-half decades have passed since the first mechanical fuel-injection system appeared on the C1 Corvette and full-size Chevy sedans, but it is remarkable how well the system worked in its day. Developed by Zora Arkus-Duntov and John Dolza, the Rochester Ramjet FI still stands a breakthrough feat of engineering, long before the advent of computer-controlled induction in the early 80s.

With the 20/20 hindsight supplied by modern EFI LS engines, the Rochester unit might at first glance seem somewhat rudimentary. After all, it had just three basic components: a fuel meter, an air meter, and an intake manifold. Yet they kept a continuous supply of fuel accumulating behind the intake valves, ready and waiting for the valves to open, avoiding the fuel sloshing common to carburetors back then.

In contrast with the computer-controlled, sequential firing of individual injector nozzles used on LS engines, on the Ramjet, an air metering unit measures how much air is flowing into the intake manifold, then instructs the fuel-metering unit as to how much fuel should be sent to the engine. Mixing of the air and fuel begins within the nozzles themselves and continues in the cylinder head, in the path between the nozzles and the intake valves.

There is a basic visual difference as well. The Ramjet is known for a tall, thin aluminum intake manifold nicknamed the doghouse. Keeping this unit in tune today, though, requires teaching an old dog a few new tricks.

We will not dwell on the engineering intricacies of the design, as that would literally take an entire book. (See *The History of GM's Ramjet Fuel Injection on the Chevrolet V-8 and its Corvette Racing Pedigree*, by Kenneth Kayser, for a comprehensive treatment of the topic.) What is of more practical value to owners of these rare, vintage Ramjets is how to keep them running smoothly.



02 These two views show the “doghouse” of the Ramjet system: the tall, thin intake manifold. The appearance of the doghouse changed somewhat over the years, but not the essentials of system’s operation.



03 This particular '57 Corvette needed a quick swap-out of the fuel-injection unit in the pits, in time for race day

After all, this sort of expertise is not exactly common knowledge. Many carburetor-centric mechanics will not even touch a fuelie. That is understandable, since in 1957, FI was a then-pricey \$480 option, and out of all the 57 Corvettes made, only 16 percent (1,040 units; 284 – 250hp, 713 – 283hp, 43 – 283hp - airbox) were fuel injected, according to the National Corvette Restorers Society (NCRS).

So do not expect to find a warehouse stocked with FI components. (We have even heard of some Corvette collectors buying an entire car just the fuel-injection system.) As often as not, replacement parts must be hand-fabricated by technically proficient experts, who can be hard to find.

Fortunately, we came across one in the person of Jim Lockwood, an electrical engineer by training, and an avid Corvette collector by nature, who works on older fuel-injection systems as a hobby of sorts. He generously shared some of his in-depth knowledge with us, apparently out of goodhearted appreciation for the design of the unit, as he was quick to indicate that other fuelie experts can be

found who will be of assistance. Presently, he can barely handle the volume of work he has now.



04 Take note of the spring inside the enrichment housing. Both its inherent strength, and the adjustable tension on it, control when the FI unit switched between a lean, cruising mixture and a rich, power mixture. Three different springs were used between '57 and '65, reflecting increasing experience with FI and the introduction of more-modern cam designs. Install the wrong spring, or improperly adjust even the right spring, and you could end up with a lean stumble or an overly rich bog when accelerating.



05 Here's the high-pressure pump, disassembled. Inspect the pump shaft for wear, especially near the squared-off end where the lip of a rubber seal typically wears a groove. If there's any question about the condition of the shaft, replace it, also inspect the end plate (right) for circular patterns created by gear rotation. Lap the end plate of n600-grit sandpaper on a surface plate to remove wear due to gears. Unfortunately, replacement parts vary in quality, so it is important to take note of small details. For instance, a replacement shaft should have a shiny finish, and be exactly the right size. Even a shaft undersized by 0.001" can cause free-play and allow the tips of the gear to hit the cavity wall.

In addition to providing tech and troubleshooting tips, we will touch on how to repair and/or update specific areas that tend to suffer from wear and tear. That is obviously an issue for anything that is more than 55 years old and keeping this system in proper tune is essential for enjoying a classic Corvette.

While speaking with Lockwood, we also came away with a profound realization of just how sophisticated the Ramjet FI is as a milestone of mechanical engineering. As he put it, it is the most wonderful mechanical gadget, and does an amazingly good job of metering fuel in a broad range of conditions.

Even so, some basics on the care and feeding of this elusive system are in order. For instance, both the air and fuel meters are sensitive to contamination. A clean fuelie is a happy one.

In addition, as doctors recommend to anyone whos middle-aged, exercising a fuelie on a regular basis is probably the best thing you can do for it. Since its a vented system, sitting still for extended periods of time can allow the fuel inside the fuel meter to evaporate and deposit a film of varnish. This buildup will eventually gum up the works. Also, it goes without saying that proper assembly and adjustment are essential. (The accompanying photos and captions illustrate what happens when these principles are not followed assiduously.)

At this point, things can get complicated, as there were several variations on the FI theme, which well also highlight in the captions. As Rochester Products gained familiarity with the FI system, manufacturing methods were simplified (sand castings became die castings, for example).

Also, the subsystem that provides for cold-weather enrichment was improved, and the one that initiates fuel flow for engine starting was refined as well. Eventually attempts were made to increase the FI systems tolerance for hot weather. Even with all these changes, the fundamental operating principles remained unchanged for as long as mechanical fuel injection was in production.

Lockwood feels that it's very important to mount the anti-siphoning solenoid valve on a bracket. If the copper fuel lines are used to support the valve, its

weight and engine vibration can combine to "work harden" the copper, causing it to fail and resulting in a serious fuel leak.

In addition, the axle pin must be free to rotate, with no resistance whatsoever. That means no Loctite or epoxy at the ends that could add friction.



06 Pump-rebuild kits are available from multiple sources. Lockwood recommends the high-quality kits sold by John DeGregory. Editor confirms the quality.

In view of these changes, Lockwood points to the preferred original parts to use, along with some modern ones that can be integrated into the system to improve both its function and reliability, all without hurting the car's collectability.

Based on his years of experience, he notes out that there are two types of fuel-injection systems: those that have failed, and those that are going to fail. He attributes this eventuality to three aspects: wear, engineering flaws, and Bubbas (his term for general-purpose mechanics who are not familiar with the specifics of a Ramjet). Lockwood's basic advice: Look for damage and do not assume it does not matter.

Even when new, the Ramjet system was difficult to service, and few mechanics had the experience or

tools to properly adjust it. (As a result, one unusual source for FI parts is from mechanics who replaced the system with a more familiar carb setup, and simply left the stock hardware on the shelf!) Despite this initial disdain by the uninitiated, the Rochester FI is now recognized as a classic design, seriously sought after by collectors of C1 Corvettes.

That is in part because the Ramjet was a major improvement over the carburetors of the day. Unlike a carb, in which the venturi signal directly pulls fuel into the air stream, the venturi signal of the fuel injection tells the fuel meter how much fuel to push or, more accurately, inject into the air stream. Because this fuel-metering scheme was so much better than that of conventional carburetors, the problem of erratic mixture changes due to fuel slosh during hard cornering was eliminated.

Carburetors also suffered from a limited manifold size, due to the requirements of the operating range and the need for a hot spot during engine warm-up. The front cowl, carburetor, and air cleaner had to be low for clearance, and that height restriction interfered with achieving the ideal combination of driveability and high performance.

The Ramjet FI had none of these problems, but it had other issues. Being mechanical, it lacks the sensors that allow modern EFI systems to compensate for a wide range of operating conditions, such as changes in temperature and altitude. In spite of this drawback, it does a remarkably good job of adjusting fuel flow in response to changes in air density. Vintage racers looking for every advantage might find a reason to make minor adjustments on race day, but for normal street driving, the FI system can be calibrated once and then just left alone.

And when that Ramjet is working properly, the throttle response can make for a thrilling ride down memory lane.

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