Second Strike

The Newsletter for the Superformance Owners Group

November 23, 2015 Volume 9 Number 2

Chapter 2: Curing the Gasohol/Winter Gas Blues

A Quick Review

The story continues from Second Strike, Volume 9 Number 1 (V9N1). If you haven't read it, you should before continuing.

Many thoughts about the problems with gasohol and suggestions for solutions have been offered. To sort through it, the project needed a rigorous approach. Second Strike projects follow the Engineering Method, a variation of the Scientific Method.

The **problem** in general terms is that SP 218 and other carbureted cars have begun to perform badly since the introduction of gasohol.

Background research indicates that the source of the problem was the low boiling point (173F) and corrosive effects of the ethanol in gasohol.

The **specified requirement** is that these cars should be able to perform normally on the available pump gasohol.

Brainstorming and gathering of data was done here at Second Strike and at gatherings of Superformance owners at such events as SSR 2012 and Superfest 2013. Three gasohol related problems were identified: boiling gasohol in the carburetor causing flooding, boiling gasohol in the fuel line before the mechanical fuel pump causing vapor lock, and damage to components from gasohol and/or the gasohol/water mix.

A variety of solutions that owners have implemented were reviewed in V1N9. In **evaluating and choosing a solution**, these solutions were combined into two proposed solutions – **A Comprehensive Solution** and **A Quick Fix**.

The **Comprehensive Solution** basically replaced everything in the fuel system for SP 218 except the fuel tank. After some careful thought, it seemed that it was absolutely the right solution for a new car being built. However for an existing car with a mechanical fuel pump and other components already in place, the **Quick Fix** looked faster and less expensive.

The next step was to **prototype** the solution, **test** it rigorously to see if it worked and **make design changes** if need be. Once resolved the results are **communicated** to others with V9N1 and this newsletter V9N2.

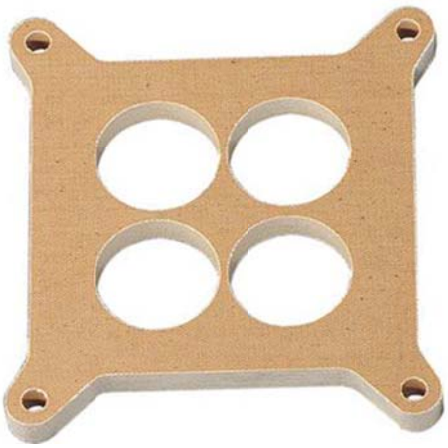
The Test Subject

SP 218 is an excellent test subject for investigating the effects of ethanol. Built in 1997, it is one of the oldest Superformance Mk III's. It has been driven 54,000 miles under all conditions from track to long distance road trips in all kinds of weather. It was built before the introduction of gasohol and has been subjected to the effects since the beginning. It has the effects of age, use, and gasohol. The pertinent configuration details for the test subject are:

- Superformance Mk III S/C SP 218
- 427 CID Windsor engine
- Standard 3/8" plated steel fuel line passing within 8" of the left side headers.
- Mechanical fuel pump (primary)
- Electric fuel pump (backup only).
- Rubber fuel line from mechanical fuel pump to chrome plated copper fuel log.
- Holley HP 750 double pumper carburetor
- CV Products CV1511 14" x 3" low profile air cleaner

The Quick Fix

In V9N1 the implantation and results of the phenolic spacer and rebuild of the carburetor with modern components were presented. The phenolic spacer is an effective, inexpensive, and easy to install solution to prevent engine heat from boiling the fuel in the carburetor. Thousands of miles of testing have proved its effectiveness.



Summit Racing SUM-G1402 four-hole 1/2” phenolic spacer

The Holley HP 750 was rebuilt with new gasohol resistant components in the model specific Holley Renew Kit. The needle and seat in the Renew Kit were not the correct ones for the carburetor. The correct needle and seat were purchased separately and installed with the rebuild.

Additional Solutions Required

These two changes met some but not all of the requirement. The vapor lock problem persisted. An additional solution was required.

Testing was done to determine which under hood heat source was capable of boiling the gasohol in the fuel line. Testing was done at low speeds which allowed a quick stop and engine shutdown to get accurate temperature measurements with a non-contact infrared thermometer.

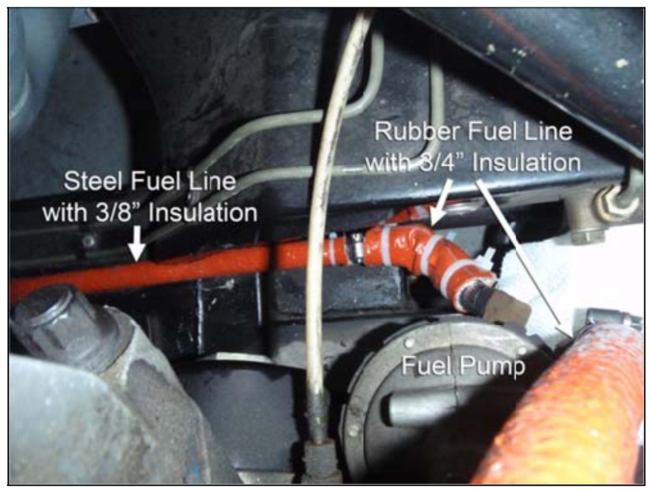
SP 218 was driven at slow speeds until the oil and water temperatures reached 100C. Temperature measurements were taken at multiple places under the hood. Even at low speeds, the headers were 260F. The frame next to the steel fuel line was 200F, clearly hot enough to boil the gasohol. There was no other heat source under the hood with a temperature near 200F and therefore capable of heating the frame to 200F. The hypothesis that the headers were the heat source was confirmed.

The remaining task was to insulate the fuel line to prevent boiling the gasohol in the fuel line and causing vapor lock in the mechanical fuel pump.

Earl’s Flame Guard Insulation is a tubular slip-on insulation available in a range of internal diameters and lengths. Earl’s Flame Guard Tape is a self-adhesive tape to finish the job.

Earl’s Flame Guard Insulation

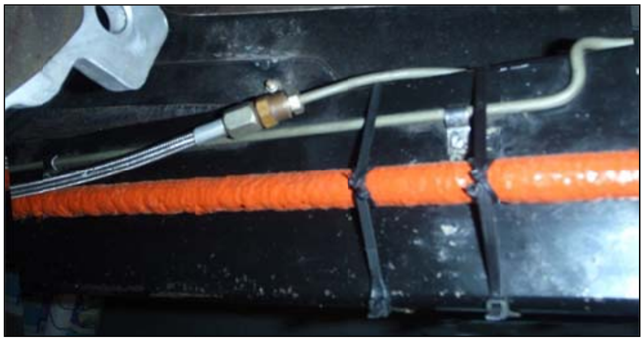
Before you start, run the fuel tank to almost empty. Then jack up the front end to keep the fuel from running out when you remove the rubber fuel line connecting the steel fuel line to the mechanical fuel pump.



Insulated Fuel Lines

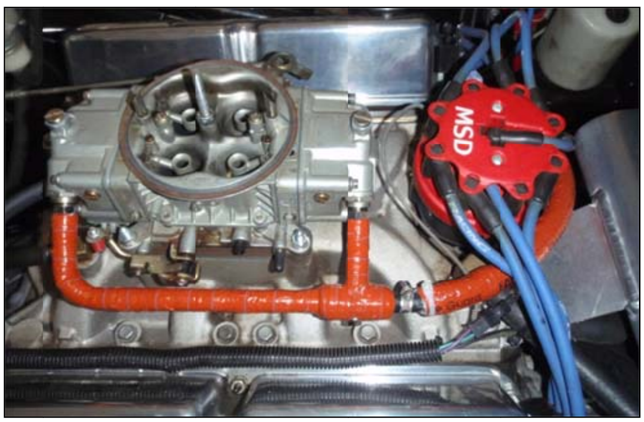
Insulate the 3/8” steel fuel line from the mechanical fuel pump back to the transmission cross member with Earl’s 3/8” insulation. The steel fuel line is attached with plastic clips pop riveted to the frame. It is not necessary to drill out the pop rivets. Simply cut the plastic clip at the base with a sharp wood chisel. Slip the insulation over the forward end of the steel fuel line and work it back toward the transmission tunnel. When you get an inch from the end, cut the insulation at the fuel pump end, and then slip it down the final inch. This will leave an inch of the steel fuel line exposed to connect the rubber fuel line from the steel fuel line to the fuel pump. Seal both ends of the insulation with a small white cable tie.

Secure the insulated steel fuel line to the frame using two of the large black cable ties. Secure the insulated steel fuel line to the large black cable ties with crossed small black cable ties. This arrangement keeps from pressing the insulation against the hot frame, but secures it from movement. And it avoids putting load on other lines in the area.



Secure Insulated Steel Fuel Line to Frame with Cable Ties

Replace the rubber fuel lines with new. Insulate the rubber fuel line from the steel fuel line to the fuel pump and from the fuel pump to the fuel log with Earl's 3/4" insulation. Seal the ends with small white cable ties.



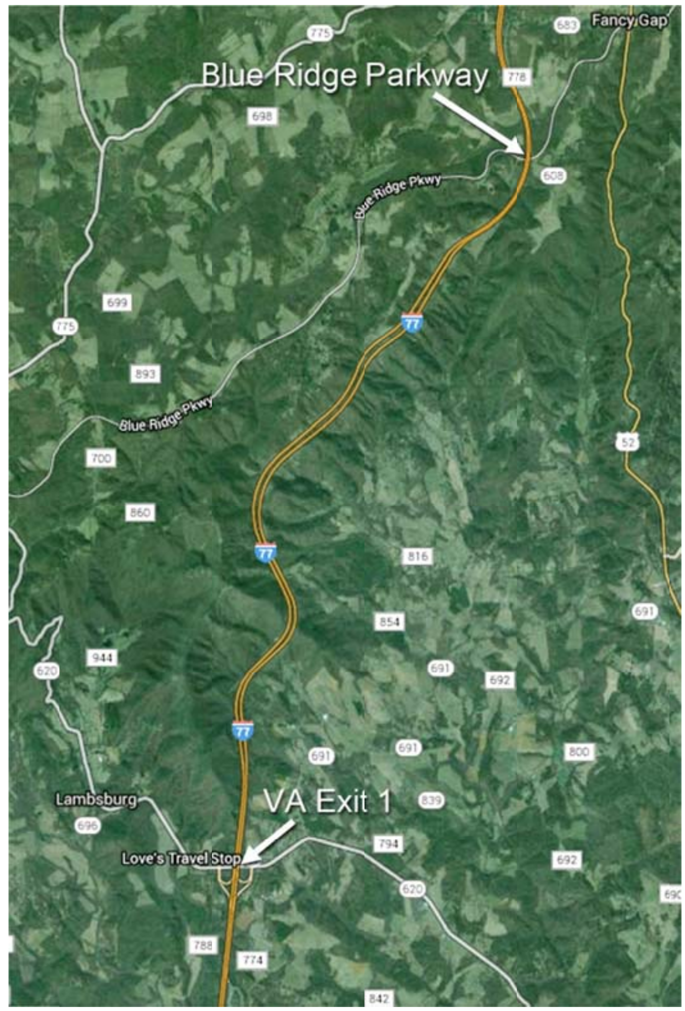
Insulted Fuel Log and Rubber Fuel line

If you have a metal fuel log, insulate it with Earl's 3/8" insulation. Slit the insulation end to end to get it around the tubing and tape it closed with Earl's tape.

Final Testing

The need for fuel line insulation has already been confirmed. The question remaining is if the insulation selected is up to the job. Testing will determine that. The most predictable and repeatable way to produce vapor lock was found to be a long fast climb up a steep hill. I-70 West from Idaho Springs to Georgetown in Colorado rises 950 feet in 11.4 miles, a 1.6% average grade. I-70 East from Polk Springs to Vail Pass rises 1037 feet in 5 miles, a 3.9% average grade. Both grades produced sufficient heat to cause vapor lock. A short hill in South Carolina produced vapor lock on a 110F day.

North Carolina isn't Colorado but it has plenty of steep mountain roads. The selected test area was the stretch of I-77 North where it crosses the Blue Ridge Parkway just north of the NC-VA border. The road runs diagonally up the side of the ridge and climbs 1332 feet in six miles from VA Exit 1 at the bottom to the Blue Ridge Parkway on the ridge. On the lower three miles the grade is 2.8%, fairly steep. On the upper three miles the grade is 5.7%, close to the interstate maximum of 6% for mountains and steeper than Route 6 over Loveland Pass in Colorado. Speed was maintained at a constant 75 mph for the 5 minute run. Climbing the upper section provided a constant heavy load for 2.5 minutes equal to 185% of the horsepower required for 75 mph on level ground. The test provided sufficient load for sufficient time to have the headers get hot enough to boil the gasohol in the fuel line.



Test Area. Up the Side of the Mountain on I-77

On the first test, SP 218 made it almost to the top before fuel starvation. If it were vapor lock, it would have happened much sooner so it was something else. A check of under hood temperatures showed that the mechanical fuel pump was 100F at entry and 108F at exit. The carburetor fuel bowl was 109F. The insulation was working. This was a new problem somewhere else. The higher fuel flow up the hill (185% of the level cruise fuel flow) indicated a partial fuel blockage.

The Holley Red fuel pump was disassembled and found to be contaminated with crud, probably a result of gasohol/water contamination. The fuel pump and integral pressure regulator were cleaned and returned to normal operation. At the same time the 18 year old fuel filter was replaced with a Holley Billet Fuel Filter 162-551 before the electric fuel pump. The rubber fuel lines were 18 years old and in bad shape. They were replaced as well.

Holley Billet Fuel Filter 165-551

The repair of the fuel pump and addition of the new high volume fuel filter resolved the fuel obstruction problem. On the next test SP 218 soared up the hill without a problem. Good news indeed. The second good news is that the electric fuel pump is fully functional again with a working pressure regulator.

It took three loops through the Engineering Method to get all issues identified, solutions implemented and tested. The process worked. With these fixes in place, I can run gasohol without difficulty. Bye-bye **Gasohol Blues**. Reliability is restored. Time for more road trips.

Quick Fix Bill of Materials

As promised, the bill of materials.

Part	Part No.	Qty	Cost
Phenolic spacer	SUM-G1402	1	29.95
Holley Trick Kit	Model specific	1	55.50
Holley Needle and Seat	Model specific	2	29.50
Earl’s 3/8 x 6 insulation	730606ERL	6 ft	41.97
Earl’s 3/4 x 3 insulation	730310ERL	3 ft	31.97
Earl’s 1 x 12 tape	731001ERL	12 ft	29.97
Holley Billet Fuel Filter	HLY-165-551	1	70.30
3/8” NPT to 3/8” hose	SUM-G3116	2	5.97
Total			295.13

All parts can be purchased from Summit Racing. I also used some shop supplies.

- 3/8” rubber fuel line
- 1/4” - 5/8” hose clamps
- Teflon tape – always use on NPT fittings
- Micro Plastic weather resistant cable ties in these sizes
  - Large - black, 3/16” x 14.5”
  - Small - black and white, 3/32” x 4”

The materials cost of the **Quick Fix** was about 20% of the estimated cost of the **Comprehensive Solution**.

Summary and Conclusions

In general, the objective was to determine the impact of gasohol on carbureted cars and what could be done to eliminate the impact. This objective has been achieved.

The three principal impacts of gasohol were found to be:
(1) Boiling gasohol in the carburetor causing flooding.
(2) Boiling gasohol in the fuel line causing vapor lock for mechanical fuel pumps.
(3) The ethanol/water mix causing corrosion of metal parts, degradation of rubber and soft parts, and clogging of fuel passageways.

To eliminate boiling gasohol in the carburetor, the carburetor must be insulated from intake manifold heat.

To eliminate boiling gasohol in the fuel line, the fuel line must be insulated from header heat or rerouted to avoid header heat.

Eliminating the effect of corrosion, degradation, and contamination will be an ongoing effort. These things should be done as often as every five years.

- Metal parts including carburetors, fuel lines, fuel filters, fuel pumps, and fuel regulators should be disassembled and cleaned and/or rebuilt on a regular basis.
- Rubber and soft materials such as fuel lines, O-rings, and gaskets should be replaced on a regular basis.
- Fuel flow path items such as fuel pumps, fuel filters, fuel regulators, fuel lines, and carburetors should be cleaned or purged periodically to remove ethanol/water caused sludge and contamination restricting fuel flow.

Cars that are driven regularly work better. This is particularly important when the fuel is gasohol which degrades over time.

When storing a car for a significant period of time, run through a couple of tanks of ethanol free gasoline to clear the ethanol out of your fuel system and/or add a fuel stabilizer. The fuel tank should be either full or empty to reduce fuel surface area and water absorption.

The specific objective for SP 218 was to make modifications so that it could survive on the pump gas readily available anywhere including gasohol. If possible the solution was to be quick, inexpensive and simple enough to be implemented by a reasonably competent home mechanic. This objective was accomplished by:

- Installing a phenolic spacer to insulate the carburetor
- Rebuilding the carburetor
- Insulating the fuel lines.

Comprehensive testing has verified the solution.

Footnotes

Fuel Pump and Fuel Filter Sizing

Fuel pumps and fuel filters are sized in gallons per hour (gph) by this equation:

$$gph = \frac{Horsepower \times BSFC}{Weight\ of\ gasoline} \times Safety\ Factor$$

where

gph = fuel flow in gallons per hour
BSFC= brake specific fuel consumption = .55 (lb/hour)/hp
Weight of gasoline = 6.3 lb/gallon
Safety factory = 1.7 to 2.1, average 1.9

Safety factors were deduced from ratings for a number of fuel pumps. For fuel pumps, the safety factor takes into account overly rich mixtures, the pressure losses in the fuel filter, fuel line, and carburetor entry, and of course the huge cost of going lean at maximum power. For fuel filters the safety factor allows for continued performance with some contamination. Given the range of safety factors, the exact size calculated is not critical. Close is close enough.

The engine in SP 218 makes 550 horsepower. For 550 horsepower, the flow needed is:

$$gph = \frac{550 \times .55}{6.3} \times 1.9 = 91$$

Fuel Filer Selection

The fuel filter selected is a Holley Billet Fuel Filter 165-551. It is rated at 100 gph and provides the desired pre-pump 100 micron filtration.

Fuel Pump Selection

Most owners only have one fuel pump so this is a personal quirk which is included only because the repair or replacement or elimination of the electric fuel pump became necessary. As odd as it may sound, I decided to keep both fuel pumps. Yeah, yeah, belt and suspenders. My primary use of SP 218 is now road trips and reliability is a primary concern. Both fuel pumps have malfunctioned, but never both at once. The vapor lock problems with the mechanical fuel pump were always easily resolved with the electric fuel pump. When the fuel pressure regulator on the electric fuel pump stuck and flooded the carburetor, I switched it off and went on the mechanical fuel pump alone. I do not want to give up the redundancy that I have enjoyed for the past 13 years.

The options were to repair the Holley Red or replace it. To avoid plumbing for an external pressure regulator, the replacement would have to have 7 psi internal pressure regulator.

The two candidates found are:

Pump	Max psi	gph	HP	Amps	Cost
Holley Red 12-801-1	7	71 gph at 4 psi	425	2	None
Aeromotive 11209	7	90 gph at 5 psi	600	5	212.97

The Aeromotive meets the flow and horsepower requirements and the Holley Red does not. However the Aeromotive draws 5 amps vs. 2 amps for the Holley Red, heats the fuel more, is quite a bit louder, and isn't free. I decided to keep the Holley Red when I decided to keep both fuel pumps. The mechanical fuel pump meets the flow requirements by itself. The Holley Red is just insurance.

Under Hood Air Temperature

A good deal of temperature monitoring was done in the course of this investigation. A side benefit of the data gathering was an observation about radiator exit air temperature. The radiator exit air temperature depends on a number of things and changes as circumstances change. However, a reasonable rule of thumb for cruise conditions is that the radiator exit air temperature is the average of the ambient (outside) temperature and the water temperature. The radiator exit air is the major source of under hood air. Hence in very general terms:

$$Under\ Hood\ Temp = \frac{Ambient\ Temp + Water\ Temp}{2}$$

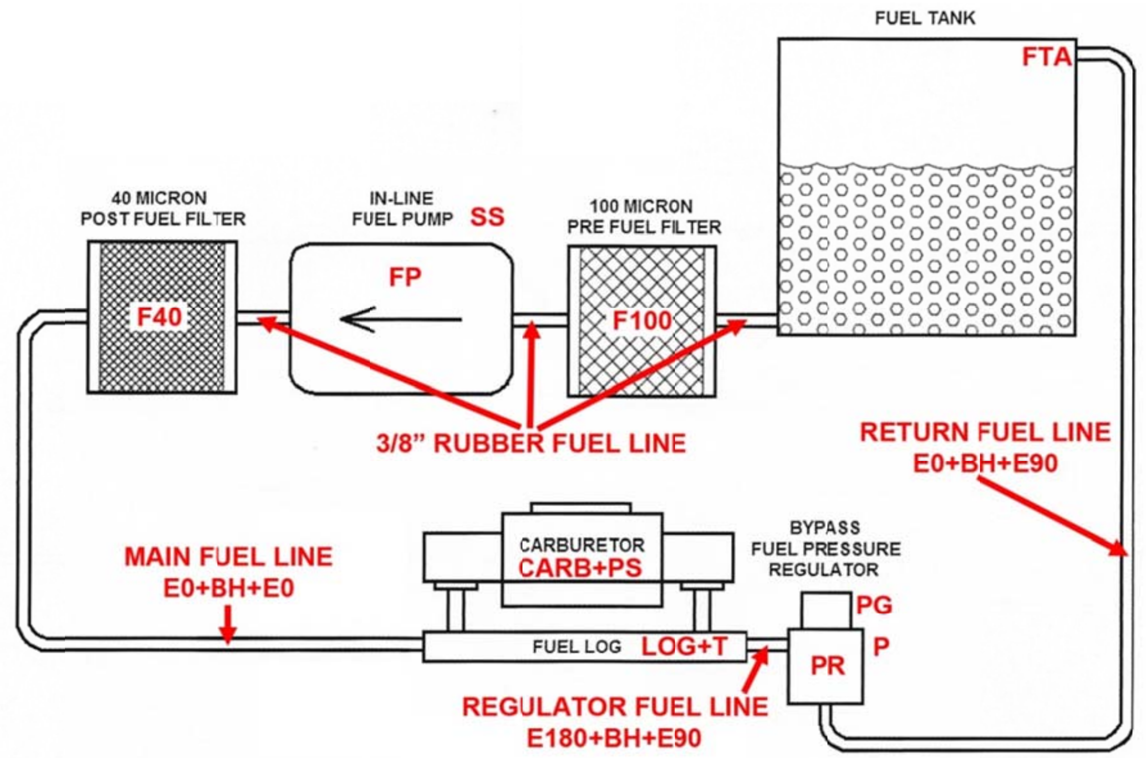
For example, if the outside temperature is a typical 80 degrees and the water temperature is the normal 180 degrees, the under hood temperature is 130 degrees.

$$Under\ Hood\ Temp = \frac{80 + 180}{2} = 130$$

Under hood air at 130 degrees going into the engine will drop a 550 horsepower engine to 505 horsepower, a loss of 45 horsepower. This would indicate that too much attention is paid to squeezing a few ponies from oversized carburetors and other minor tweaks and not enough to getting cool outside air into the engine. The next project is starting to appear on the horizon.

Comprehensive Solution

Bill of Material



Legend	Part #	Description	MSRP	Qty	Ext
Carburetor, Pressure Regulator, Fuel Pump, Filters from Holley					
CARB	0-80802HBX	Carburetor - 650 Ultra XP Hard Core Grey	$848.95	1	$848.95
PR	12-841	Billet Bypass Fuel Pressure Regulator	$106.02	1	$106.02
PG	26-504	Mechanical Fuel Pressure Gauge, 0-15 psi, Under Hood, 1.5"	$60.24	1	$60.24
FP	12-812-1	Blue Electric Fuel Pump 110 GPH	$143.95	1	$143.95
SS	12-810	Fuel Pump Pressure Safety Switch	$33.44	1	$33.44
F40	162-562	100 GPH Billet Fuel Filter 40 Micron	$78.11	1	$78.11
F300	162-551	100 GPH Billet Fuel Filter 100 Micron	$78.11	1	$78.11
	12-813	Mechanical Fuel Pump Mounting Pad Cover SB Ford	$12.27	1	$12.27
		Subtotal			$1,361.09
Fuel Line and Fittings from Earl's					
LOG	AT104195ERL	Single Inlet Fuel Log for Holley XP, Ano-Tuff , -6AN	$101.95	1	$101.95
T	AT982406ERL	Ano-Tuff Male Tee -6AN	$11.01	1	$11.01
BH	410006ERL	PERFORM-O-FLEX Stainless Steel Braided Hose, -6AN, 10 ft.	$87.30	2	$174.60
NPT	981666ERL	Straight Male -6AN to 3/8" NPT Adapter	$4.48	4	$17.92
E0	800106ERL	Swivel–Seal Hose End Straight -6AN Female to -6AN Hose	$7.70	3	$23.10
E90	809106ERL	Swivel–Seal Hose End 90^0 -6AN Female to -6AN Hose	$21.30	2	$42.60
E180	818006ERL	Swivel–Seal Hose End 180^0 -6AN Female to -6AN Hose	$25.70	1	$25.70
P	993303ERL	3/8" NPT Hex-Head Plug (package of 2)	$3.20	1	$3.20
		Subtotal			$400.08
Additional Parts					
PS	SUM-G1402	Summit Racing Phenolic Spacer	$29.95	1	$29.95
NPTH	SUM-G3116	Summit 3/8" NPT to 3/8" hose (package of 3)	$5.97	2	$11.94
FTA	Custom	Fuel Tank Adapter (see text)	$6.95	1	$6.95
		Subtotal			$48.84
		Total			$1,810.01

The **Comprehensive Solution** is a good choice for an initial installation where parts are being purchased for the first time. The **Comprehensive Solution** is very similar to the fuel system design used for electronic fuel injection.

As promised in V9N1, this is a sample bill of materials for the **Comprehensive Solution**. The manufacturer's suggested retail prices (MSRP) for Holley and Earl's are directly from the Holley website on the date of this newsletter. Discounts around 17% are available from Holley and others. The total price with discounts is $1508.

The bill of materials does not include shop materials including rubber fuel line hose, hose clamps, Teflon tape, and cable ties used to secure the fuel lines. Always use Teflon tape on NPT fittings.

This sample bill of materials is an illustrative example only. This specific configuration has not been installed and tested but the design elements have been successfully installed by other Mk III owners as seen in V9N1. It is designed for a 550 horsepower engine and uses 6AN. It uses components from Holley and Earl's (part of Holley). Other components and sizes may be substituted to suit personal preferences. As always, it is the responsibility of the person installing any hardware to determine if it is appropriate for their use.

The braided hose (BH) is natural stainless steel. The fitting colors are blue and red except the Ano-Tuff which are black.

The AN number specifies the inside diameter in 1/16". AN6 is 6/16" or 3/8". AN8 is 8/16" or 1/2". With a good fuel system design, the AN6 is good to about 600 horsepower. There are good reasons to use 6AN. The stock Mk III steel fuel line is 3/8" which is equivalent to 6AN. The fittings on the fuel tank, filters, fuel pump, and pressure regulator are 3/8". Fuel flows about 80% faster through the smaller 6AN than the larger 8AN. The 6AN has 25% less surface area than 8AN. For both these reasons the 6AN picks up less heat in transit than 8AN.

Implementation

The drawing shows where the components identified by "Legend" are placed in the system drawing above. The following suggestions follow the flow from the fuel tank to the carburetor and back to the fuel tank.

Fuel Pump and Fuel Filters: The fuel pump and filters are located together in the right rear next to the fuel tank. The 100 micron pre fuel filter (F100) is fitted with NPTH fittings in and out. The standard 3/8" rubber fuel line connects the standard 3/8" fuel tank fitting to F100. See photo page 4.

The electric fuel pump (FP) is rated at 110 gph, which is just above the calculated 91 gph required for 550 horsepower. See **Footnotes**. The fuel pump (FP) is fitted with NPTH fittings in and out. The 3/8" rubber fuel line connects F100 to FP.

Holley Blue Electric Fuel Pump

The optional safety switch (SS) cuts power to the fuel pump if the oil pressure falls below 5 psi. It is plumbed into the oil pressure port on the engine along with the oil pressure gauge sender which requires an adapter to support both. It also requires wiring from the Superformance wiring harness at the fuel pump forward to the SS and back to the FP. These items are not included in the bill of materials.

The 40 micron post fuel filter (F40) is fitted with a NPTH fitting in and a NPT fitting out. The 3/8" rubber fuel line connects FP to F40.

Main Fuel Line: The main fuel line goes from F40 to the fuel log (LOG+T). It is made from stainless steel braided hose (BH) cut to appropriate length and fitted with a straight hose end (E0) on each end. The main fuel line is routed away from the left header, up over the bell housing, and enters the engine compartment at the rear center of the engine. It connects directly to the rear of the fuel log.

Holley Ultra XP Hard Core Grey

Carburetor and Fuel Log: The carburetor (CARB) is a Holly Ultra XP Hard Grey 650 cfm double pumper. The Ultra XP is Holley's most sophisticated 4-barrel and provides the best performance from idle to wide open throttle. The chokeless design provides superior airflow entry. The 650 is the correct size for 550 horsepower. Double pumper is the correct configuration. It is anodized for corrosion resistance. See the help function on Carburetor Calculator on www.SecondStrike.com for full details. The phenolic spacer (PS) insulates the carburetor from intake manifold heat.

Holley Single Inlet 6AN Fuel Log for Ultra XP Carburetor

All Holley Ultra XP carburetors (CARB) have a longer 9.75" spacing between inlets requiring a special fuel log (LOG). The only 9.75" 6AN fuel log (LOG) available from Holley is the Ano-Tuff single inlet. The Male Tee (T) converts it to dual inlet.

Billet Bypass Fuel Pressure Regulator

Fuel Pressure Regulator: The fuel pressure regulator (PR) is the bypass style recommended in V9N1. As recommended, the regulator is located after the carburetor (CARB) which provides for more fuel flow through the fuel log (LOG), keeping it cooler. The regulator is mounted on the firewall away from engine heat. The PR is fitted with NPT fittings on one I/O port and the RET port. The other I/O port is not used and is plugged with a 3/8" NPT plug (P). The pressure gauge (PG) fits on the 1/8" NPT gauge port above the Holley logo on the regulator.

Regulator Fuel Line: The regulator fuel line goes from the front of LOG+T to the input port of PR. It is made from stainless steel braided hose (BH) cut to appropriate length and fitted with a 180^0 hose end (E180) on the LOG+T end and a 90^0 hose end (E90) on the PR end. The E180 and E90 provide the correct departure and approach angles respectively.

Return Fuel Line: The return fuel line must be the same size as the main fuel line since most of the fuel is always returned. The return fuel line goes from the return port of PR to the FTA. It is made from stainless steel braided hose (BH) cut to appropriate length and fitted with a straight hose end (E0) on the PR end and a 90^0 hose end (E90) on the fuel tank adapter (FTA) end. The E90 provides the correct approach angle. The regulator fuel line is routed away from the right header, down over the bell housing, and along the right side frame rail to the FTA

Fuel Tank Adapter: The Superformance factory offers a fuel tank adapter for a return line built into the fuel tank as an option. It is typically ordered for cars that will be fuel injected. If your car has one, use it. If you are ordering a car, be sure to include this option.

Tank Vent Line

Fuel Tank Adapter

If your car does not have one, this is one way you can make one. Purchase a 3/8" NPT by 3.5" galvanized steel pipe nipple and a 3/8" NPT galvanized steel Tee. Cut the nipple in half, clean it up, and thread the halves into the arms of the Tee. Use Teflon tape.

On the right side of the gas tank in the rear wheel well is the 5/8" rubber vent tube for the gas tank. Cut this vent tube about 2" above where it exits the gas tank. It would be a good idea to have the gas tank completely full when doing this to avoid explosive vapors in the gas tank.

Insert the custom Fuel Tank Adapter (FTA) into the cut line and secure it with 7/8" hose clamps. The NPT adapter (NPT) threads into the remaining port on the Tee.