Vapor Lock

Facts, Theories and Myths

By Armand Minnie with help from John Heslinga

What is Vapor Lock?

- Hot Fuel reaching its boiling point due to a combination of temperature and pressure (positive or negative)
- Prior to pump: bubbles in fuel can cause pump to lose its prime (the origin of term “lock”)
- After pump: bubbles in fuel cause problems in carburetor (“stumbling”)

Vapor Pressure

- Textbook: “Vapor pressure is defined as the pressure exerted by a vapor in thermodynamic equilibrium with its condensed phases (solid or liquid) at a given temperature in a closed system.”
- KISS: Heat increases the vapor pressure of gasoline and when the vapor pressure equals the pressure on the gasoline in the tank, fuel line, or carburetor, it boils (vaporizes).

Reid Vapor Pressure (RVP)

- RVP is a common measure of the volatility of gasoline (used by EPA)
- RVP of a fuel is measured at 100 °F (37.8 °C) in a vessel with a vapor/liquid volume ratio of 4:1
- In some areas (most of the country), EPA sets maximum RVP for Summer but none for Winter (atmospheric pressure is the only limit)
- Summer is June 1 – Sept. 15 for retail and May 1 to Sept. 15 at “terminals”

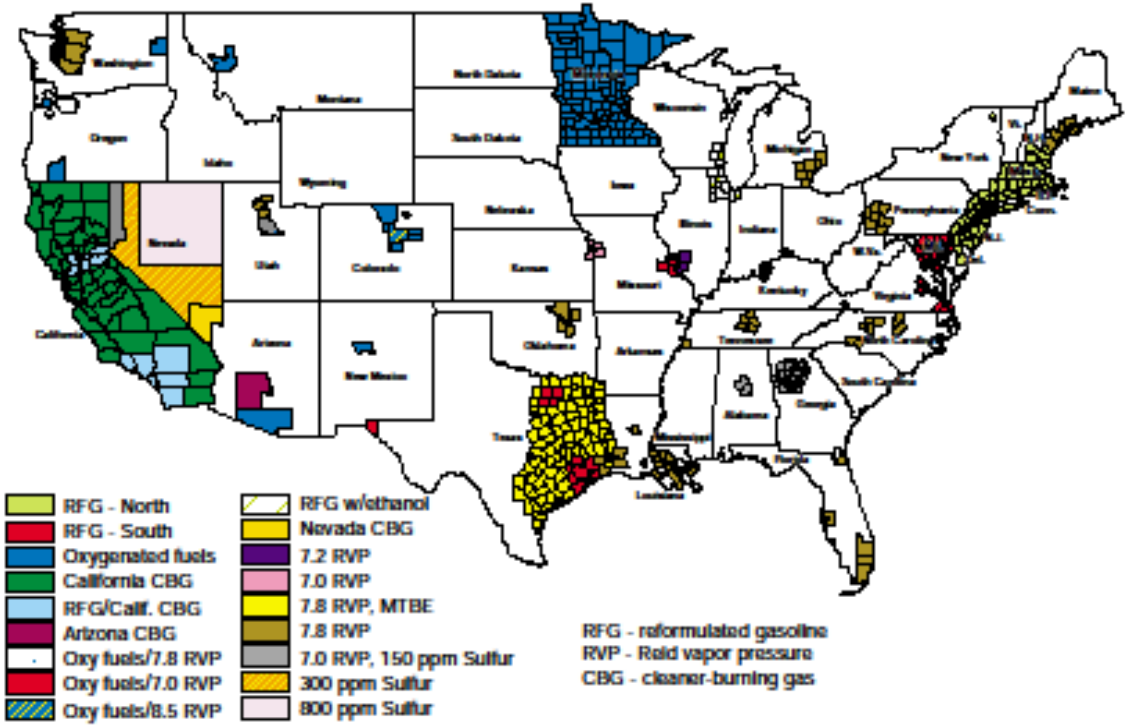
The Numbers

- RVP requirements set by EPA and individual cities and states
- EPA Summer Maximum (May 1 - Sept. 15) is set at 9.0 in “attainment areas” and 7.8 in “non-attainment areas” (may be lower)
- Ethanol (9%-10%) blend gets 1 PSI waiver in “attainment areas”
- Individual districts may set it lower (Phoenix area is 7.0 in Summer)
- EPA Winter Maximum (Sept. 15 – April 30) is not limited in most of the country

Ethanol Effects by National Renewable Energy Laboratory (part of DOE)

- 10% Ethanol increases RVP by 1 PSI but increase is waived for 9-10% mixtures in most areas of the country
- More ethanol has no additional effect on RVP until about 20% when it begins going down

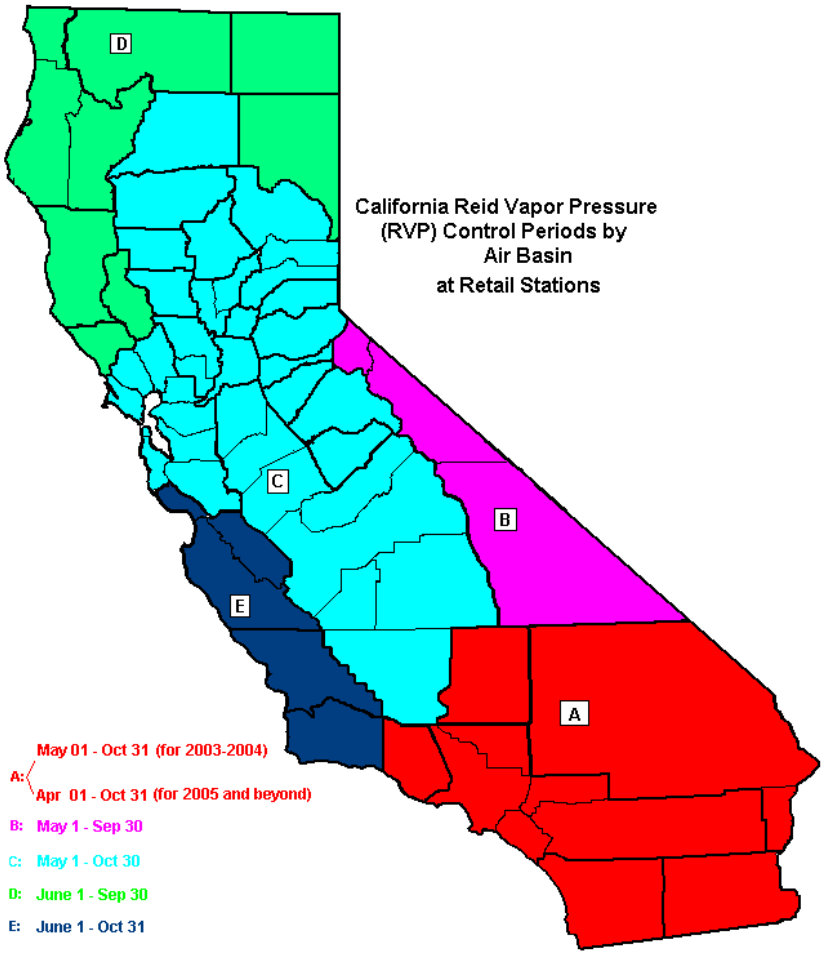
Boutique Fuel Requirements Across the U.S.



Graphic: Courtesy of NACS National Association of Convenience Stores
Source: ExxonMobil (used with permission)

Market-specific fuel requirements have fragmented the U.S. gasoline supply and distribution system. These are some of the regions that have unique fuel blend requirements.

RVP Control periods by location



Reid Vapor Pressure (RVP) Control Periods for California Air Basins and Counties

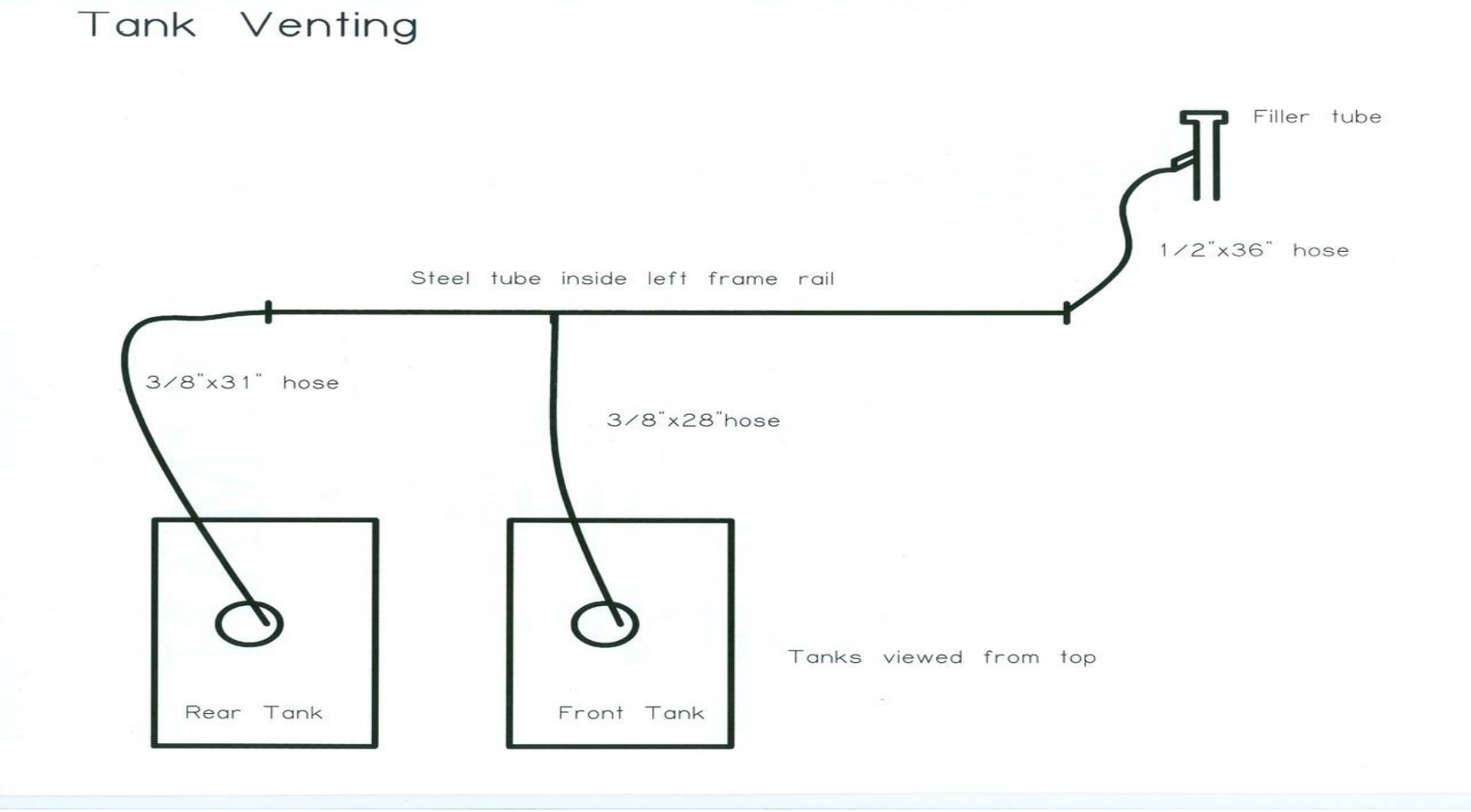
	Control Periods	Air Basins[1]	Counties included[1]
A	May 1 through Oct 31 (For 2003 and 2004) April 1 through October 31 (For 2005 and beyond)	South Coast Air Basin and Ventura County	*Ventura, Los Angeles, Orange, West of San Bernardino, and West of Riverside Counties*
		San Diego Air Basin	*San Diego County*
		Mojave Desert Air Basin	*East of Kern, North East of Los Angeles, San Bernardino, East of Riverside Counties*
		Salton Sea Air Basin	*Imperial, Central of Riverside Counties*
B	May 1 through September 30	Great Basin Valley Air Basin	*Alpine, Inyo, Mono Counties*
C	May 1 through October 31	San Francisco Bay Area Air Basin	*Santa Clara, San Mateo, Alameda, San Francisco, Contra Costa, Marine, Napa, South of Sonoma, and West of Solano Counties*
		San Joaquin Valley Air Basin	*West of Kern, Tulare, Kings, Fresno, Madera, Merced, Stanislaus, San Joaquin Counties*
		Sacramento Valley Air Basin	*Sacramento, East of Solano, Yolo, West of Placer, Sutter, Yuba, Colusa, Glenn, Butte, Tehama, and Shasta Counties*
		Mountain Counties Air Basin	*Amador, Calaveras, Greater of Eldorado, Mariposa, Nevada, Central Placer, Plumas, Sierra, and Tuolumne Counties*
		Lake Tahoe Air Basin	*Alpine, East of Placer, and East of El Dorado Counties*
D	June 1 through September 30	North Coast Air Basin	*Mendocino, Trinity, Humboldt, Del Norte Counties*
		Lake County Air Basin	*Lake County*
		Northeast Plateau Air Basin	*Siskiyou, Modoc, Lassen Counties*
E	June1 through October 31	North Central Coast Air Basin	*Monterey, San Benito, Santa Cruz Counties*
		South Central Coast Air Basin (except Ventura County)	*San Luis Obispo, Santa Barbara Counties*

[1] *Refer to this ARB web site for Air Basin and County Maps Boundaries:*
http://www.arb.ca.gov/desig/adm/basincnty.htm

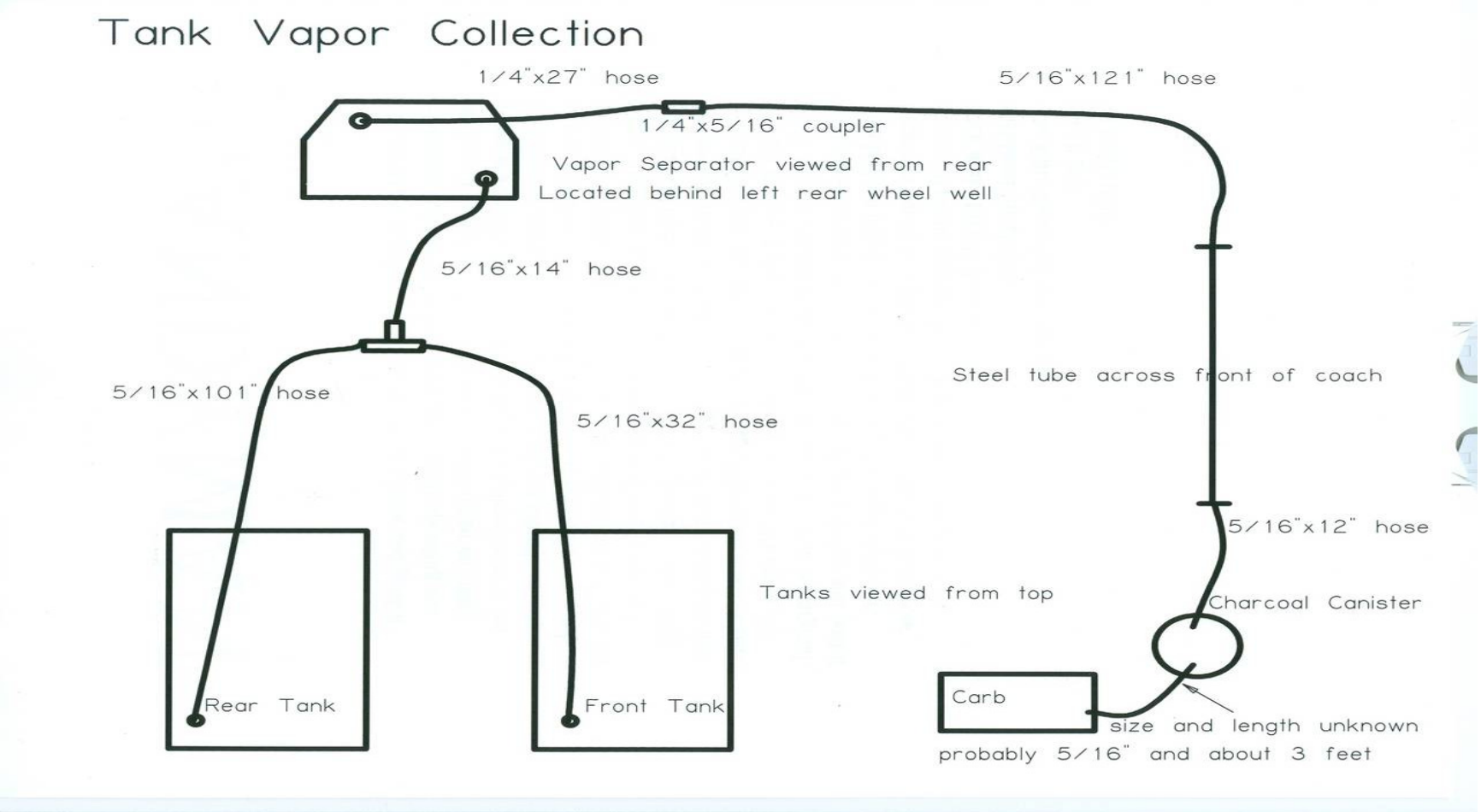
GMC Fuel Systems

- Fuel fill – cap, fill venting
- Fuel vapor capture
- Fuel delivery to engine

Venting During Fill



Fuel Vapor Capture



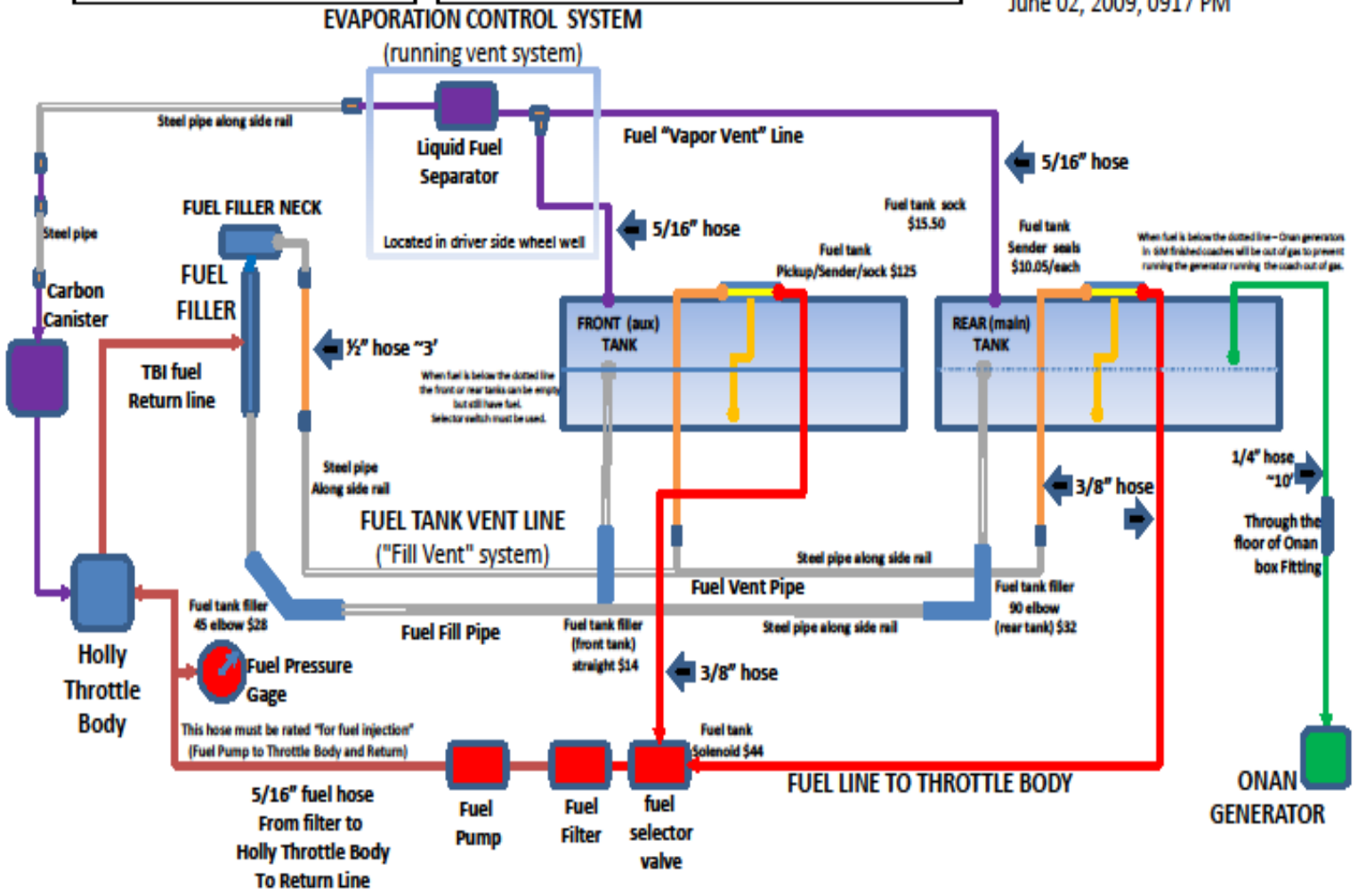
Fuel Injection but good overview anyway

You will need 4 different sizes of fuel line. They are as follows:
- 1/2" fuel hose - 3 feet
- 3/8" fuel hose - 24 feet
- 5/16" fuel hose - 25 feet
- 1/4" fuel hose - 10 feet.

You will need :
- 2- 25 foot rolls-for SAE SPEC R7 3/8 line.
- about 14 feet of SAE SPEC R7 1/4 inch line for the genset.
- 20 all SS clamps

ARCH

UPDATED:
June 02, 2009, 0917 PM



Gas Caps

- Designed to relieve vacuum and pressure
- Arizona ADEQ: gas cap must not leak more than 60cc per minute at 30 inches of water (1.08 PSI)
- Autozone/Stant: vacuum relief valve opens after a vacuum of -0.5 psi
- Autozone/Stant: pressure valve acts as a backup pressure relief valve in the event the normal venting system is overcome by excessive generation of internal pressure or restriction of the normal venting system. The pressure relief range is 1.6-2.1 psi

Fuel Temperatures

- Boiling point of gasoline can be as low as 100°F for Winter blend (unrestricted RVP)
- Tanks are heated by radiated heat from road and by air passing over exhaust components in front of tanks
- Fuel lines, pump and carburetor in engine compartment are heated by air, radiation and conduction from engine

From Chuck Garton's Seminar at GMCWS Rally – Fall 2011

Fuel temperatures

- fuel temperature senders in each (3) fuel tank and one outside the driver's side frame near the fuel tanks where 3 fuel pumps are mounted.
- hottest fuel temperature observed was 148 degrees - twice. Once on Baker Grade on I-15, and another time on I-84 east of Portland, OR. In both cases it was August and the outside temperature was 115 . The temperature outside the frame was 122 . On I-15 Baker Grade with two fuel tanks, the front tank was 5 degrees hotter than the rear tank. On I-84 with three tanks, the front tank was 5 degrees hotter than than both rear tanks.
- Generally his fuel temperatures run 30 warmer than outside temperatures.
- After installing heat shielding between the exhaust pipe and the fuel tanks, he could not detect any change in fuel temperatures.

Boiling Point Examples

(boiling point: RVP = atmospheric pressure)

Demonstrating that here is a difference between “Winter” and “Summer” gas:

- Watch Summer gasoline boil – Southern California gasoline boils at 160° in this youtube video https://www.youtube.com/watch?v=d7AkcjnCTVU
- Watch Winter gasoline boil – gasoline boils at 116° in this youtube video https://www.youtube.com/watch?v=xhbkx8iFvsk

Contributing/Mitigating Factors

- Location of fuel pump and lines: hot vs. cool, push vs. pull, long vs. short pull
- Insulating tanks and lines
- Pressure in tank: more pressure = higher boiling point (caps must maintain 1 PSI minimum – will vent at 2 PSI for safety)
- Effective air movement through engine compartment helps keep fuel lines cooler

More Contributing/Mitigating Factors

- Carburetor heated by exhaust crossover in standard intake manifold
- Mechanical fuel pump heated by conduction from engine
- Mechanical fuel pump old/worn check valves aggravated by vapor

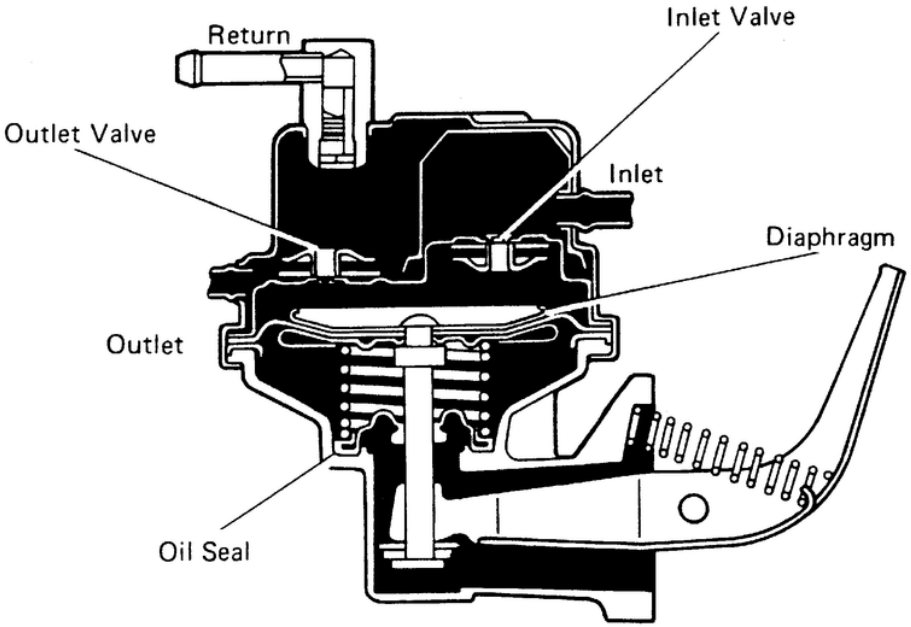
Countermeasures

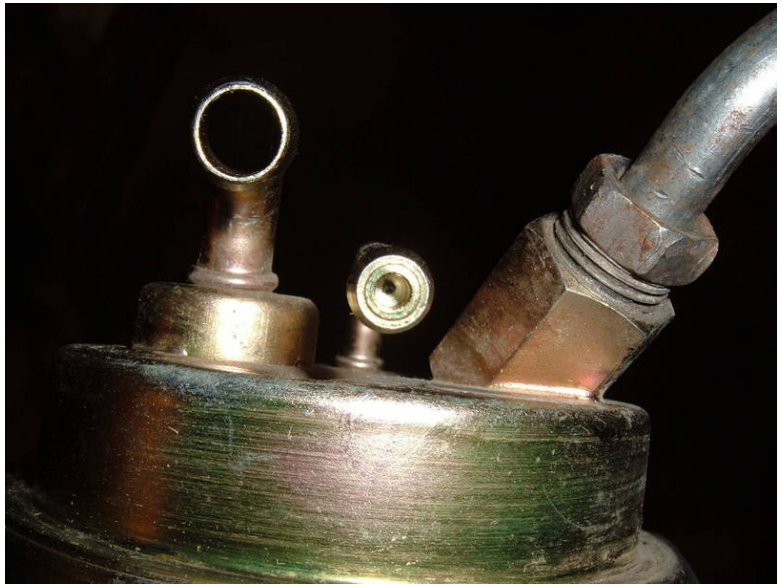
- Electric fuel pumps – near tank, in tank (along with fuel injection - today's solution)
- 3-Port fuel pump (GM's solution for many vehicles in the same era)
- 3-Port fuel filter (Ford's "Hot Fuel Option" in '70s and '80s pickups)
- 3-port fuel filter housing (Mike Morton)
- Block exhaust crossovers in intake manifold (reduce carburetor temperature)
- Use 3/8" insulating gasket under carburetor

Michael Morton's Solution

- A simple fuel return line. Tap and install a fitting in the top of the fuel filter housing at the carburetor. Install another one in the fuel filler neck, located in the engine compartment under the driver's seat. Connect the two with a 1/4 inch line. With the fuel constantly flowing there is little chance for vapor lock and if vapor does form it is routed back to the fuel tank.

3-Port Mechanical Fuel Pump



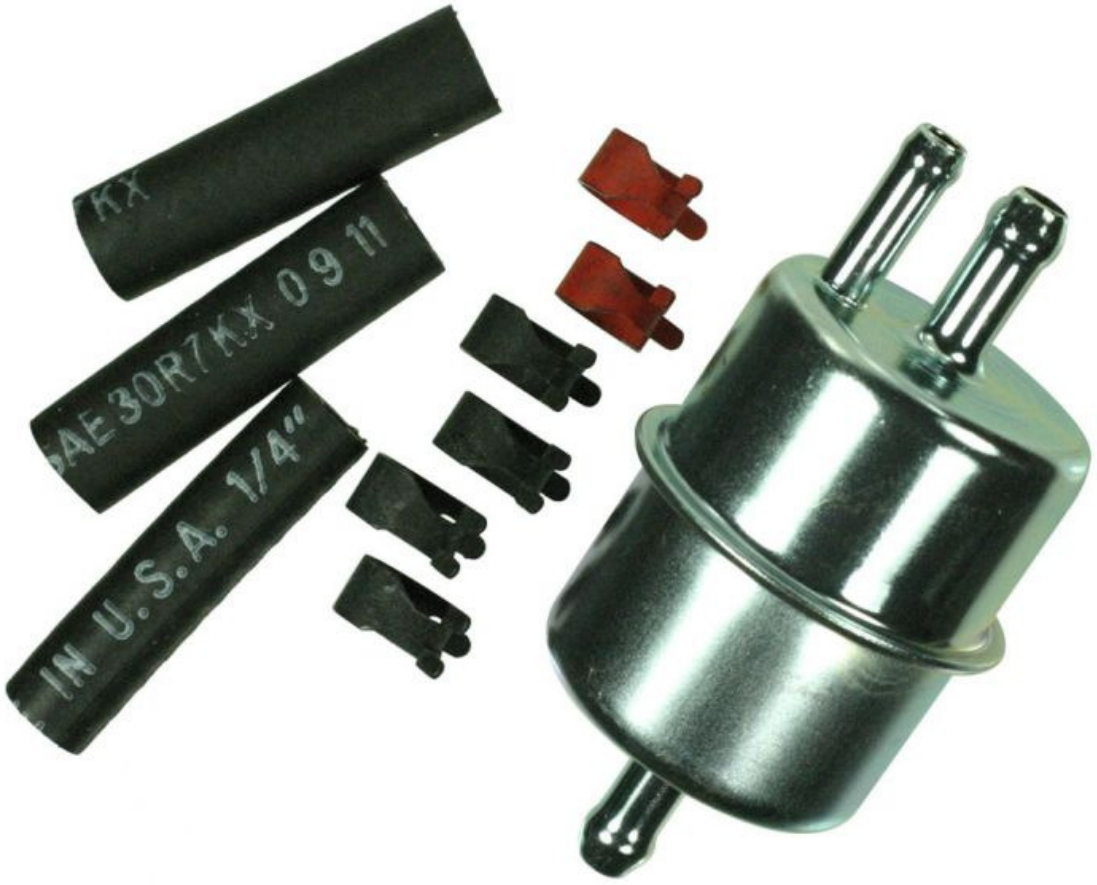


Airtex 40736
Bosch 68622
Carter M6109

Ask for a Pump for:
74-77 Olds Toronado Broughm 455 with Air
these will also fit the 403

3-Port Fuel Filter

3 port fuel filter with 3/8" In Port - 3/8" Out Port - 1/4" By Pass and Vapor Port



Wix-33941
ACDelco-GF98
Powerflow-95041
Balwin-BF887
NAPA-3041
Hastings-GF20
Fram-G18
Motorcraft-FG12
Purolator-GF1118

Michael Morton's 3-Port Fuel Filter

Routing 3-port pump or filter vent back to tanks

Myths

- Pressure in fuel tanks is contributor to vapor – no matter what the cause, increased pressure means a higher boiling point and less vapor
- Gas cap should be vented – it is vented. It allows air in and vapor out as designed
- Vacuum developing in the tanks – really? With two inlets (cap and canister)
- Higher octane rating will help – all levels have the same RVP requirements and need additives to meet them

A Good Plan

- Divide the fuel delivery system in two at the fuel pump and then:

1. Get the fuel pump as close to the tanks as possible and select a pump that can recover from lost prime
2. Recognize that fuel arriving at the carburetor may contain vapor despite all efforts so accept it or deal with it with a 3-port filter