What's Wrong With SU Carbs?

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Many people who own Volvos equipped with SU carbs tolerate them, but secretly long to replace them with something "better." I've been guilty of this myself -- but perhaps I've been doing the old carbs an injustice. Skinner Unions are not the end-all and be-all of carburetors, but Uncle Olaf did not design his cars to run badly, and SUs are OE on a variety of models. If a Volvo does run badly, it's generally due to breakage, wear, misadjustment or poorly executed modifications, not because the factory equipped these cars with substandard components.

Let me introduce the first two in a series of VClassics Obvious Principles (OPs). OP #1: *A properly tuned car runs better than one that isn't*. OP #2: *Good parts work better than worn out parts*. And there's a corollary: *Worn out parts cannot be properly tuned*. I've owned worn out SUs that wouldn't tune right -- no mystery there. And I've bolted good SUs onto a worn out motor (I didn't realize just how worn out, at the time), and they wouldn't tune right either. In the latter case, it's all too easy to abandon the most obvious of principles, go into denial, declare that SUs are junk and spring the big bucks for a Weber downdraft conversion (money that would be better spent overhauling the worn out motor. It will still be worn out, even with a shiny new air cleaner).

Lately, though, my own 1800S sports a fresh set of SUs on a perfectly healthy B18B motor, and I find this combination can deliver excellent performance and a lovely, smooth idle. You too might wish to take a fresh look at these venerable old British gas pots -- they might surprise you.

How they work:
Any carburetor does two things: it regulates the rate of airflow into the motor, and it meters fuel into the airflow. The first function is almost universally accomplished by use of a throttle butterfly in the body of the carb -- a flat plate opened via some sort of linkage by pressure on the accelerator pedal and closed by spring tension -- and SUs are no exception. It's in the fuel metering function that carb designs vary greatly. The SU scheme is relatively simple, elegant and easily understood.

Before we examine how that works, let me state the following fact: Any gasoline-fueled motor delivers the most efficiency when the air/fuel mixture is at what's known as the stoichiometric ratio (measured as the ratio of air to fuel by weight). Under ideal laboratory conditions, that ratio is 15:1. In actual practice, the ratio for maximum power is 12.5:1 (5.3% CO on an exhaust gas analyzer, failing smog in most states); anything richer produces less power. (As a note: In later, fuel-injected Volvos with catalytic converters, the only acceptable ratio is 14.7:1 -- this is the "Lambda" point.) For now, it's enough to understand that the carb must precisely regulate delivery of fuel in direct proportion to airflow. Here's how an SU does that:

The car's fuel pump supplies gasoline to the float bowl on the carb. The level of fuel in each bowl is kept fairly constant by use of an aptly-named float, which actuates a fuel valve. When the fuel reaches the proper level, the float closes the valve; when the level drops, the valve is permitted to open. The bottom of the float bowl is connected by a small hose to a tube that goes up into the bottom of the carb body, known as a jet. Inside the jet, fuel rises to the same level as in the float bowl. It's just gravity -- the fuel in the bowl and jet is at ambient air pressure, and SU carbs use no internal pumps of any sort. Air flowing through the carb body is *not* at ambient pressure, however -- it's at a somewhat lower pressure (commonly referred to as "vacuum" for simplicity). Fuel in the jet is therefore sucked into this area of lower pressure, where it is swept along into the combustion chambers to make the motor run.

If that seems too simple, well, it is. Remember, we want the fuel flow to be proportional to the airflow rate, not the level of vacuum. We might easily have the same vacuum level at 2000 RPM as at 6000 RPM, and the motor will pump far more air through its cylinders (and need more fuel) at the higher revs -- but it's only vacuum that's making the fuel flow in the first place. An additional mechanism is needed to keep the mixture at the stoichiometric ratio -- and that's what the dome-and-piston affair on top of the carb is all about.

Into the top of each jet is inserted a precisely tapered needle, thin end down. When the thick, top part of the needle is down blocking most of the jet, little fuel gets sucked into the airflow; when the needle is lifted so the skinny part presents less obstruction, more fuel is delivered. The dome is ported from the front (the upper two holes in the face of the carb body) and the piston is ported at the bottom in such a way that the pressure in the dome drops in proportion to airflow through the carb. In a nutshell, this arrangement makes its own vacuum separately from the manifold vacuum, thereby drawing the piston up into the dome and pulling the attached needle up out of the jet. Upward movement of the piston is dampened by oil (in a dashpot in the center of the dome) to prevent overshoots and oscillations. Fuel flow is therefore affected by both engine-generated vacuum in the carb body and airflow-generated vacuum in the dome. If the needle's taper is properly matched to the airflow characteristics of the motor, the resulting mixture will be close to correct across a wide range of throttle openings and RPM. It works pretty well when it's working right.

What goes wrong:

Worn bores: Volvo motors last longer than SU designers ever anticipated. After 100,000 miles of cycling a throttle shaft open with linkage pushing on one end and pulling it closed again with a spring on the opposite end, the shaft will wear the bores where it passes through the carb body, which is, after all, only soft aluminum. When a shaft no longer fits snugly in its bores, undesired outside air will leak through -- air which won't be registered correctly by the piston-and-dome setup. The leakage will vary with throttle position, and there's no guarantee that it will be similar in both carbs. There is no trick needle taper or anything else that can compensate -- carbs in this condition cannot be properly tuned (which doesn't stop owners from spending years trying and cussing anyway).

It's normal to have a bit of play in the long axis of the shaft, but if you can feel perceptible movement of the shaft in any other direction, the bores are wearing out. In many cases, it's possible to rattle them around audibly. The only solution is to rebuild the carbs with harder metal bushings in the egg-shaped holes -- once fitted with these, they essentially will not wear out again.

Damaged jets or needles: When a jet is installed, it must be correctly centered so there's no contact with the needle. Fortunately, they tend to stay that way, but if contact does occur, both needle and jet will wear rapidly. These are precision parts and any wear is unacceptable; replacement is the only recourse. It is usually safe to install thinner needles for tuning purposes without recentering the jet; if going the other way, exercise caution. Also take great care not to dink the needle whenever working on a carb.

Float bowl problems: Fuel valves eventually wear from use, and they may also get sticky deposits from fuel running through them. If a valve leaks or sticks open, fuel will pump out the overflow in the bowl cover (conveniently dripping onto the hot exhaust) and out the jet (conveniently flooding half your motor). If it sticks closed, you're out of gas on two cylinders. Fuel valves are easy to clean (carb cleaner), inexpensive and not hard to replace. In-line fuel filters are also cheap. In emergency situations, a sharp rap on the offending float bowl with a roadside rock will generally unstick the valve temporarily. Consider this a warning that further attention will soon be required.

Early carbs used soldered metal floats that are prone to corrosion and leakage. A sinking float cannot actuate a fuel valve. The later plastic floats rarely cause problems after initial adjustment to the specified level.

Dirt: British wire mesh air filters were mostly useful for keeping objects the size of large insects or small pine cones out of the motor. Paper filters (or the K&N type, or oiled foam socks on velocity stacks, etc.) do a better job, but some dirt will eventually accumulate on the inside walls of the dome. There's a designed-in clearance between dome and piston edge, and dirt in that gap is not a good thing. In severe cases, it can cause the piston to rub, hang and wear. Once in a great while, take the dome off, pull the piston out and clean everything. See previous caveat about not dinking the needle.

Dashpot out of oil: Oil is essential for damping and lubricating the pistons, so keep the dashpots filled to the proper level. I prefer to use a light oil (hydraulic jack oil is nice and comes in handy small bottles; many others swear by ATF), but regular motor oil is adequate. Here's my scheme for putting in the correct amount: Pour in some oil, refit the plunger and tighten the cap. Hold a rag around the cap and lift the piston all the way up, hopefully pumping a bit of excess oil out the cap's vent hole and into the rag. If not, repeat. An overfilled dashpot will squirt oil clear across the engine compartment when the throttle is opened -- I'd rather just get it into the rag right at the start.

Owner-induced problems: On carbs with two-bolt air cleaners, it's possible to put them on upside down. Don't do that -- they'll block off the dome ports.

Tuning:
The only thing that makes tuning SUs more tricky than some other carbs is that there's two of them. Both carbs must operate identically. In order for that to happen, we must first match the airflow through the carbs, and before that can happen, the forward two cylinders in the motor have to pump air exactly like the rearmost pair. Before doing any carb tuning, therefore, ensure your valve adjustment, ignition timing and dwell are all as good as they can be, and that there are no vacuum leaks (PCV hose, brake booster...). Fill the dashpots as noted above. Ensure the motor is at full operating temperature, then:

1) Inspect the carbs and prepare them for tuning. Remove the air cleaners. Make sure the choke mechanisms are completely off and the fast idle adjusting screws are not touching their cams. Loosen the two cranks on the intermediate shaft between the carbs so they are free to rotate on the shaft. Lift the pistons, open each throttle fully by hand and verify that the butterflies are parallel to the direction of airflow when the wide open throttle stop is contacted. Crank each jet upwards until the top is flush with the bridge of the carb body, then crank back down 1-½ turns (count 9 flats on the adjusting nut). Leave the cranks loose for the moment.

2) Start the motor -- yes, I know the accelerator doesn't do anything right now. Adjust the idle speed screws to balance airflow in both carbs. If you don't have a carb synchronizing gauge of some sort, good results can be obtained by listening to the intake of each carb through a short length of hose and adjusting the idle screws so both sound the same.

3) Raise (or lower) the jets in equal amounts, one flat at a time, until the fastest idle is obtained. Readjust the idle speed screws -- also in equal amounts; count the flats -- for the desired idle speed. Recheck the airflow for balance with your gauge or hose.

4) Tighten the intermediate shaft cranks against the throttle forks so both throttles open equally when pulling on the top of the threaded interconnecting rod by hand. I like to fine tune by readjusting one of the cranks if necessary, so that both pistons begin to rise at the same instant while pulling the linkage.

5) Shut off the motor. Gently press the accelerator to the floor and hold it there with a heavy object of some sort (like an assistant's foot, if you have one lying around). If this does not open the butterflies wide, adjust the threaded linkage rods so that it does. Make sure there is no possible pedal travel left over, or damage to linkage or carbs can occur when you tromp on it.

6) Double-check for proper linkage operation and for positive throttle return before starting the motor. Reinstall air cleaners.

Needles and more:
If machines were perfect, your carbs should now be able to produce a stoichiometric mixture under all normal conditions. In fact, that is just more than any simple carburetor can do, which is why more modern cars have sensors to monitor mixture and computers to control it. Therefore, the above tuning

procedure is only a close approximation -- you will need to optimize by reading spark plugs after driving in various situations and carefully fine-tuning the jet adjustments until they look right most of the time (a tan color is desirable). To further complicate matters, SU carbs are sensitive to changes in air density -- settings that are good for a cool day at sea level are wrong for a hot day in Denver. To a large extent, when traveling, you can quickly compensate by adjusting the jets up or down a flat or two when stopping for gas.

Ultimately, though, it's the taper of the needles that determine how well fuel tracks airflow in varying conditions and throttle/RPM combinations. SU carbs were OE on B18 motors equipped with three different cams, and on B20 motors with two different cams (before we even get into any of the R-Sport stuff), all with different "breathing" characteristics. We commonly see three tapers of needle in use in these motors: the ZH in the mildest, the SM in the mid-performance and the KD in the higher-performance motors. Anything that modifies how a motor flows air -- different cam grind, larger valves, a big overbore, for instance -- means that the standard needles may or may not be appropriate. There were literally hundreds of others produced, and many are still available -- charts exist which show their diameters, measured at 1/8-inch increments along the length of the needle. There's a lot of potential for experimentation, and, depending on the mods done, possibly a real requirement for it.

If that sounds scary, you might once again be tempted to spring for that tinker-free, "one size fits all" Weber downdraft conversion. I own one, and it's a very trouble-free unit -- but not suitable for high-performance use, even on a B18. There's no manifold on the market for this carb that has equal-length runners to all cylinders, and the fact that it's a downdraft carb means the airflow has to make a sharp 90-degree bend upon entering the manifold. Both factors add up to something like a 10% power reduction at high RPM compared to the SU's "straight shot into the head" configuration. And that's probably not what you want, after spending lots of bucks on all those other engine mods, is it? The alternative is to go to a pricey 2x2 throat setup (Weber, Dellorto, Solex) or aftermarket programmable injection like the Weber Alpha system -- well, if setting up SUs sounds tough to you, don't even consider those. Trust me on this.

So, maybe SUs aren't so bad after all. The way they're laid out inherently promotes performance and economy, they're simple to tune once you know them, a sound set doesn't require much tinkering, and you can have a pair expertly rebuilt to better-than-new condition for considerably less that the cost of a Weber downdraft kit. If you really need to go faster than SUs permit, there's a steep price to be paid, both financially and in increased complexity. Take another look -- Uncle Olaf was no fool.