105 Series Alfa Fuel Tanks

By John Hoard

Fuel tanks are not likely to be the thing that decides which car you buy. Actually, one probably doesn't think much about them at all, other than as a small hole into which a large amount of money is poured. Like most things in a car, there is a lot more to the technology than readily meets the eye. Also, when your car gets to be 40 years old there are some new issues to deal with.

Safety

One of the first things that come to mind when we think of fuel tanks is safety, or perhaps one should say the potential for lack thereof. We have all seen TV and movie crashes where the car bursts into a ball of fire, and so we are pretty sensitive to that stuff – think Pinto. The reality is much less frightening than you probably think. A Society of Automotive Engineers (SAE) paper was published some years ago by the Insurance Institute for Highway Safety (a Ralph Nader front group) where they studied automotive crash related fires. The bottom line: you are more likely to be injured by someone putting a fire bomb in your car, than by a crash related fire. This was true even though they attributed every injury and fatality in a crash where there was a fire. They acknowledge this is a pessimistic assumption, since crashes with fire are usually very bad crashes where the occupants may well have died due to impact and not fire.

Nonetheless, gasoline is a flammable liquid, and leaks can be a problem. In more modern cars, fuel tanks are carefully mounted mid-ships, often under the rear seat and always with floor pan sheet metal between you and the tank. In older cars including 105 series Alfas, the tank was most often "drop in" – dropped into the trunk floor through an opening, with a flange on the tank to keep it from falling through. Thus, the top of the tank is in the trunk. It is also behind the major vehicle structure, being behind the real axle and ahead of the bumper. On my cars ('69 Spider and '68 GTA 1300 Junior), the bumpers are of the top-speed variety – i.e., they go the same speed as the rest of the car. I would not describe them as "10 mph bumpers" since in each case the sheet metal bumper is bolted to a sheet metal structure.

Now, if you hit a car with a drop in tank fairly hard from behind, the rear of the car collapses. In a rear barrier impact, the bumpers move forward with respect to the rest of the car until the spare tire hits the rear axle and begins to take up some load. If you keep pushing, or if the spare tire is missing, it becomes the fuel tank which helps slow the collapse. As a result, the tank acts rather like a water balloon. You get big internal pressure, and the tank deforms a lot. This isn't as bad as it sounds, unless there is something sharp to cut the metal. This was the problem with the Pinto; the rear axle sheet metal cover had sharp edges that cut the tank. Alfas have cast differentials so that's not so much a problem. By the way, this logic is why I always autocross and time trial with my spare tire in and fully inflated.

On my GTA, I had some structural problems a few years back – common to the aluminum body cars. The rear is cantilevered out a long way behind the rear axle, and loads over the years cause metal fatigue. After making repairs, we put in a pair of steel braces from the rear bumper mount to the top of the wheel arches. These also serve to help transfer some load in the event of a rear crash (I hope).

On the Spider, I moved the battery to the trunk, and while looking for a good way to mount it Dean Russell suggested adding in the fuel tank reinforcement from a later Alfa. Late in the life of the 105 series, rear impact standards came in. Part of Alfa's answer was a thick metal reinforcement that goes over the fuel tank in the trunk. Again, it helps transfer loads in a crash and protects the tank. It also makes a good strong surface to mount a rear battery!

I hasten to add that I have not crash tested these modifications and certainly don't plan to do so! If there ever is an unintended test, we

will find out how good my engine engineer's intuition is for body-engineering issues.

Spider fuel tank area. Note battery mounted to reinforcement.

Fuel Tank Fundamentals

A fuel tank has a number of functions. Of course, it has to hold fuel. But, it also has to let fuel out – on demand. And these days, it has to prevent fuel vapor from escaping into the air. To put it in perspective, evaporative emission of fuel from your fuel tank on a '60s vintage Alfa is several times the total hydrocarbon emission of a modern car.

Fuel pick up from a tank requires some design effort. It wasn't so hard with carburetors: they have a float bowl and so there is a bit of fuel already at the engine when you go into a corner. But fuel injection systems have to have a steady flow of pressurized fuel to operate correctly. If the fuel level is very low and you corner hard, the fuel can slosh away from the center of the tank. Our '71 Berlina was an example of what happens. If you had less than ¼ tank of fuel and turned right hard, the low fuel pressure light came on and shortly after that the engine quit.

Another problem can arise due to vapor lock. Now, you can bring fuel out of the tank several ways. You can make a tube stick out the bottom of the tank and connect a hose to it. This gets fuel from the low part of the tank and works fine. Until you ground on a driveway or rock and knock the little widget off, creating really bad fuel economy and drastically reduced driving range. Most companies pull the fuel out the top of the tank. This also means that the gaskets and seals are at the top where they are least likely to leak, and in the case of our Alfas puts them in the relatively dry and protected trunk and not out in the salt splash.

Now, if the fuel pump is under the floor and the tank exit is at the top of the tank, you have to siphon fuel over the top. Typical gasoline breaks into a rolling boil at about 120°F and sea level pressure. This is not an uncommon temperature in Death Valley and the like. So, if the fuel boils in the tube from tank to pump you get vapor lock and the engine stops. This was also known to happen on some of the early Spica injected cars.

GTA fuel tank, out of the car

About '74, Alfa added baffles in the tank, and an in-tank pump to solve these problems. The baffles keep fuel close to the pick up, and the fuel return line dumps fuel into the baffle region so you can get more reliable fuel delivery. The in-tank pump means the "siphon" hose is pressurized and so less likely to boil.

Where the GTA fuel tank resides

The driver may also have some slight interest in knowing how much fuel is in the tank. The sender assembly shown in the picture is typical for pre-injection cars. You can see the pick up tube and inlet screen, and a float connected to a potentiometer. As the fuel level drops, the float drops and the gas gauge goes down. If your gauge is really inaccurate, you can try bending the rod and see if you can get better accuracy.

About 1975 manufacturers had to capture fuel evaporation. While most American companies put in carbon canisters and systems to purge them, Alfa used a crankcase storage method. The gas cap had its vent removed, and vent tube ran from the fuel tank up to the engine crankcase. This worked nicely… most of the time.

Fuel sender from GTA

If you drove in very cold weather for a long time, two related things occur. The vapor pressure of gasoline gets rather low, so as you use the liquid you have to let "air" into the tank. With the new system, this "air" was in fact crankcase vapors, having quite a lot of water in them. When the tube runs under the car in cold weather, the water condenses and eventually freezes – creating an ice plug in the vent line. As you use more fuel, you get a vacuum in the tank.

I was driving the Berlina home from work one night when the fuel pressure light came on, and shortly after that the engine stopped. Since I wasn't turning right, I was surprised. After checking several things, I noticed that the fuel gauge seemed to say we had been making fuel. I opened the gas cp and there was a loud hiss as the vacuum in the tank was released. Looking under the car, the tank had collapsed into itself. Surprisingly, the car now started and ran just fine.

When I got home I estimated I now had about a 1 gallon fuel tank. After some serious head scratching, and figuring there wasn't much to lose, I drained the fuel tank, removed the sender and all hoses and plugged the holes, and then took an air hose with a hand nozzle, and blew it though a piece of 2x4 with a hole drilled in it, and held against the fuel filler. This rather small pressure caused the tank to re-inflate. In fact, the original 11 gallon tank then held about 12 gallons and has a slightly convex top surface.

There was a recall from Alfa that installed a check valve near the fuel tank so this failure couldn't happen; no one had done that on my car!

Even newer cars now have systems to capture refueling vapors. These also have self-diagnostics so that it can even warn you if you have a loose gas cap. These really reduce hydrocarbon emissions but certainly make things more complex. This is the story of cars – what used to be simple gets better but more complicated. Maybe that's why I still play with these old ones!

Leaks

Another issue, much more likely for most owners, is fuel leaks. The vast majority of auto fires start with fuel leaks, and usually result not in

spectacular explosions, but rather in smelling smoke, pulling off the side and watching your Alfa burn to the ground. This unfortunate event happened to an AROC member who, having just won the National Meeting Concours at Aspen was driving home. His letter to the Owner probably sold a good many fire extinguishers – including my purchase of several, one for each car.

Leaks can happen when rubber fuel lines get old and crack. Crawl around under your car and make sure the rubber is nice and flexible. Always use real auto fuel line hose, and not just any old flex tubing that happens to be lying around. Gasoline has many compounds that eat or soften many hose materials.

Leaks can also happen when the factory metal fuel lines get rusty. For a number of years, Alfa used steel lines with a rubber covering. The rubber was probably there in part to protect the fuel line from stone chipping, and partly to isolate the rather loud humming noise of early electric fuel pumps. Unfortunately, salty water gets under the rubber and sits there encouraging the tin worm to eat your fuel lines. If you smell gas, inspect carefully! Better yet, periodically crawl under and be sure the lines are solid and intact.

Obviously, loose fittings can cause fuel leaks. Various models have various fuel filters, some of which have gaskets that can be leaky.

Crud

Over the years, annoying stuff whose technical description is "crud" can get into fuel tanks. In the early '70s I worked at Ford as part of a team developing electronic fuel injection systems, and we ran tests of durability. We took old fuel filters after these tests and cut them open to see what was in them. These were test cars refueled at ordinary gas stations, no obvious problems. We found small bits of glass, metal, salt, wood, sand. Amazing. Imagine what is in your 40 year old tank…

Another bit of crud (sometimes a lot of it) comes from rust inside the tank. Now, fuel tanks in the 105-series days were made of terncoat steel. That is, steel coated with lead. Remember that lead – be careful if you sand, grind, weld around the tanks because you don't really want to transport that lead into your body. Lead makes a very good anti-corrosion coating for fuel tanks. Unlike zinc (used to make galvanized steel), auto fuels do not attack lead. However, over a long period of time you may use up the lead, or even rust from the outside in.

I bought my Spider for $200 and spent a couple years putting metal back in the salt-generated ventilation locations. When she was back on the road she ran beautifully ….. most of the time. If you drove a long time, especially on rough roads or with enthusiastic cornering, eventually the engine would die as if of fuel starvation. You'd spend 30 minutes checking this and that without finding anything and then miraculously it restarted and ran fine. This happened several times before someone suggested a likely solution.

The fuel pick up in your tank has around it a screen. This is very fine metal screen, much finer than window screen. Its job is to let fuel through but not the little bits of crud mentioned above. My Spider had a good bit of rust on the inside, and when you stirred it up it clogged the screen. After 30 minutes of sitting, the crud settled off the screen and it would run again.

I removed the fuel tank, sent it to a place that put it in a rust stripping vat until clean, and then coated the interior with sloshing compound. This is essentially a paint or epoxy-like coating, but made specifically for fuel tank interiors. Most paints are not sufficiently immune to the solvency and chemistry of fuel, and if you use the wrong stuff you will make your tank scrap. With the right stuff, my tank has been fine for about 20 years now.

Why did it rust? Probably a combination of cheap gas (not containing the right "dry gas" additives to dissolve water and carry it out of the tank), and too much sitting around. If you car sits a lot in cool, humid weather then you can get water condensation inside the tank. Fuel floats on water, so you can gradually get a layer of water in the bottom and that can lead to rust.

As I said, a primary solution is to use high quality gas because people like Mobil, Shell, BP put quality additives in. Yes, I know the one about the guy who saw the cheap station's truck leaving the major brand refinery. Did that guy go inside and watch while they filled the truck? The refinery can quite easily turn off the additives for things like water, valve cleaning, and oxidation stability. There is a reason why cheap gas is cheap – those additives cost a few cents per gallon, and the buyer won't know if they are there or not. When your tank rusts, or your valves get deposited and cause drivability problems, you will blame the car maker and not the gas station most likely. Having been around the business for nearly 40 years, I use only major brand gasoline in all my vehicles (regular grade if it doesn't knock, but the 105 Alfas really need premium for the octane).

Other Damage

I managed to create yet another fuel tank failure mode. Ever since our kids came along and we needed to take crib, stroller, diapers, food, tent top, kitchen sink, and of course baby to autocrosses and time trials and therefore didn't fit in a small car any more, we have put the car on a trailer from time to time. I know that the car is rather annoyed by this, being a car and liking to drive, but there are times it just happens.

On one trip to the race track, I arrived at the leading end of a rather long streak of liquid smelling suspiciously like gasoline. A brief inspection showed that one of the hold down chains was right below the front of the fuel tank, and apparently a large bump cause s the car to move enough that the chains dented the tank resulting in a pin hole leak.

If you own a Ford or Chevy you can go to a dealer or junk yard and easily procure a replacement fuel tank. GTA tanks are somewhat less readily available it seems. So, after some consideration, I decided to fix it.

Now, the local auto parts store sells a goop called fuel tank repair. This purports to be an epoxy paste you can knead up and wad, rather like bubble gum under a school desk, onto the leaking spot. I imagine that if you are fantastically lucky this might actually work and staunch the leak for at least a few hours so you can quickly sell the car to someone who may not have a functional olfactory system.

Rubber boot; the fuel filler goes through the big hole. The tube goes through the trunk floor to drain refueling spills.

I thought I might like a somewhat more permanent solution. The fuel tank can be removed with relative ease. Get the fuel out of the tank; I used the car's fuel pump, disconnected the hose at the carburetors, and pumped it into gas cans where I transferred it into the spider. I hope the Spider will feel some added muscle from the transfusion of GTA fluids…

Once empty, disconnect the hoses and wires, remove the fill cap (put a paper towel in to keep crud from finding its way in, or perhaps tape it over). There is a large rubber boot around the filler neck. Unsnap it from the fender, pull the drain out of the floor, and work it off the filler neck. This is lots of fun, especially since the rubber is now nice and old and rock hard. You might be able to get the tank out with it in place but not me!

Inside the trunk, around the edges you will find 6 or 8 screws that go down through the tank flange into the trunk floor. Remove these. The tank sits on a rubber gasket in the hole. I found I needed a block of wood and a jack to get enough force to break everything loose the first time, but be careful not to dent the tank bottom.

One of my favorite sections in the Alfa shop manual for the engine is the part where they describe the actual engine/transmission removal from the vehicle saying "remove the engine and transmission as a unit by tilting conveniently". On several occasions, I have wondered what Italian word was translated into English as "conveniently". The fuel tank presents a somewhat similar conundrum. You can't just go straight up; the filler neck runs into the fender. You can't tilt enough to raise the side opposite the filler and clear the trunk floor. Although I have now done it about ten or twelve times, I can't really describe it. Some Anglo Saxon language, ignoring the back pains and a bit of effort will eventually find it out of the car. Enjoy!

Now, you might be tempted to set the tank on the ground with the leak up, and weld or braze it. If you do this without appropriate preliminaries, let me know so I can be a long way away. Even though you think you have thoroughly drained the interior, you can easily have a flammable mixture and make a rather satisfactory bomb of it (satisfactory, that is, if you are an Iraqi insurgent).

To avoid this syndrome, fill the tank with water. In my case, I could balance it such that there was only a very small air volume in the tank near the damage. With that, I could weld for braze. I like brazing since it will fill pin holes and coat the surface. As mentioned above, you need very good ventilation and proper respiratory gear so you don't breathe lead vapors.

Will it be as good as new? Not unless you have a lead coating facility. You may want to get the sloshing compound in there at this point.

Clean and paint the outside. I like to use rubber trim adhesive (available at any auto parts store) to stick the gasket to the tank flange before installation. The gasket is not just window dressing; it spreads the loads evenly over the surfaces. Without it, high points would meet high points and put a lot more stress on the sheet metal bits. Also, the gasket keeps water from leaking though the joint.

Installation is, as they say, the reverse of removal. I have always found it necessary to touch up the paint after scraping it liberally on the trunk floor in the process of putting it back in. Tighten the screws holding the tank in uniformly and go around several times. As you compress the gasket, other screws will become looser so keep going until they are all snug.

Now, fill the tank and enjoy emptying it again!