Searching for new cool in older Porsches–A chilling adventure in three parts

By Bill Middleton

Part One: The Problem

As anyone knows who has owned an older 911 type Porsche in even a moderately warm climate, the design of the air conditioning system was not a priority of the Porsche engineers. For one thing, these cars are designed and built at latitudes far above Texas, the southern U.S., and most places that get any form of summer. For another, the typical sports car line of thinking is that any item that robs horsepower from the engine simply to provide creature comforts is an item to be considered only grudgingly. After all, the windows roll down, don't they?

This is the problem: inadequate air conditioning in the Porsche 911. Its result is an attempt at an air conditioning system that, on mild days in the Northeast, Midwest, or any latitude much above the Mason-Dixon line, will perform reasonably well. Anywhere south of these idyllic places with mild summers, forget it!

To begin with, in order to avoid having to create new space in the already legendary framework and body sheet metal of the 911, Porsche had to do some very creative component locating. The cooling coil (or evaporator), along with its fan, was too big an assembly to easily locate under the dash or anywhere in the passenger compartment, where short duct runs to the vents would require it to be. As a result, it wound up in the 'smugglers box', aka early gas heater location under the trunk deck. The condenser, a necessary evil, was not easily locatable in any air stream at the front of the car without either reconfiguring the front sheet metal (God forbid!) or placing it in a delicate position under the belly pan, exposing it to damage. Needing forced airflow at idle as well as while in motion; the only choice left was in the engine deck lid, using the cooling fan for the engine to draw air through the coil. A smaller secondary condenser was located in some editions behind the front valance panel with a pitifully small blower forcing whispers of air over it, and in some models inside the front fender well instead of behind the front valance.

With the compressor in standard location mounted direct to the engine, and the balance of the components scattered about the vehicle like stray puzzle parts, the real challenge began – plumbing all this together. With the condenser on a moveable panel – the rear decklid – and the balance of the components at some distance from the others, the length of tubing and fittings required to connect all this together bears no small resemblance to the transfusion apparatus from a Frankenstein movie. Add to all these lengths of hose an o-ring or flared fitting at each connection, and the total number of potential leak points increases to equal some bad autocross lap times.

The result of all this was a system consisting of an evaporator not much bigger than a ladies shoebox, a condenser located in a very compromising position for something that is supposed to be rejecting heat, not absorbing it from the hot engine directly below it, and over 40 feet of rubber hoses each with fittings that mustn't leak. And this is supposed to keep us cool in a Texas August? I don't think so!

Thus begins my adventure with this problem. I purchased a 1986 930 in early April of 2001. At the time, it still had its charge of R-12, and demonstrated a fairly good capacity for keeping the cabin comfortable – not freezing, but comfortable. Shortly after purchasing the vehicle, one of the plethora of fittings decided it was time to go to the great o-ring heaven in the sky, and bye-bye went the last charge of R-12.

Upon performing the conversion to R-134a, the limitations of the system became painfully obvious. While R134A is actually a more efficient refrigerant than R-12, it ONLY displays better performance characteristics in systems properly sized for it. With the early Porsche system really not properly sized for R-12, 134a would only yield what I call 'slightly less than warm' air from the vents. After a summer of only being able to drive the car at night after the sun was down, I decided it was time to pursue corrective action.

Before I begin to discuss the research that led to the correction of the problem, let's visit some of the basics of air conditioning. This may be redundant for some, but even for those who have a pretty good background some of the simple details somehow get missed.

An air conditioner is nothing more than a heat transference device. By circulating an exchange medium (the refrigerant), the system absorbs heat from one location (the interior of your car) and disposes of it at another location (the exterior of your car). In order to do this well, the system needs to have sufficient surface area where heat is being absorbed to effectively transfer heat from the interior of your car to the refrigerant. This is the evaporator coil. It also has to have enough surface area at the point it is disposing of all that heat, or the heat absorbed from the interior will never be completely disposed of. This is the condenser coil. The system also must have sufficient air flow over both coils so the heat exchange process can take place. Sufficient surface area, sufficient airflow, and sufficient circulating refrigerant – the three critical needs for an a/c system to work properly. While there are a lot of other parameters that play a role in design and functioning of a/c systems, these are the three paramount criteria that must be satisfied in every installation.

Unfortunately, Porsche failed in two out of three areas – surface area and airflow. In Part Two, we will engage in the daunting task of searching for the solution.

Part Two: Searching for large cool in small spaces

Upon starting to research a/c upgrades, it quickly became apparent that there were as many opinions on ‘how to fix it’ as there were opinion givers – and most of them had some sort of financial angle to push in the process. However, the bulk of the solutions readily available and installable without major alterations to the vehicle fell in to the following groups:

1. Increasing condenser efficiency.

   There are numerous options offered here, including adding auxiliary condensers at various locations about the car, changing some of the condenser side tubing from rubber to ‘rifled’ copper tubing, making the tubing itself a part of the condenser, adding fans to increase air flow through existing condensers, and so forth – all aimed at improving heat rejection of the system.

2. Increasing evaporator efficiency.

   There are few options available here without serious changes to equipment locations, and the best ones offered usually involve a more effective evaporator coil with larger surface area, and improving airflow through the evaporator. Along with these, better sealing of stray air loss points or stray hot air entry points take care of these problems.

3. Better utilization of ‘lost’ refrigerant effect.

   In a static refrigeration system, such as your household air conditioner or your refrigerator, the compressor runs at constant speed and fairly constant load. In an automobile, that is far from the case. The system needs to function at speeds from idle to several thousand rpm, and heat rejection demands vary from mild fall days to 140 degree interior temps in August. As such, the system design has built in an accumulator or receiver, which ‘holds’ excess liquid state refrigerant and helps balance system capacity with demand. In most cases this receiver/accumulator also contains a desiccant, which traps any moisture that has gotten in to the system to prevent it causing problems. You can feel this ‘lost’ refrigerant effect by seeing how cold the return line bringing refrigerant back to the compressor gets, even on fairly hot days – all this ‘cool’ is the result of refrigerant that was not fully expanded in the evaporator coil continuing to absorb heat. In essence, lost efficiency.

In reviewing the condenser upgrade options, the following issues became clear:

1. All options required some MAJOR re-piping of the system, involving addition of hoses and fittings.
2. Most options required placing an added condenser at some place where it was vulnerable to damage – either under the car, or in a fender well.
3. In the options where the added condenser was installed in a rear fender well, the condenser was to be located in one of the HOTTEST places in the car (for

a 930, at least) – in the right rear well, immediately adjacent to the turbo and wastegate. The likelihood of good air circulation becoming compromised by recirculating hot air trying to escape the fender well at low speeds or stop and go conditions was clearly present. Similarly, locating a static condenser on the belly pan of the car not only exposed it to severe damage potential, but also located it right above the pavement – and in stop and go traffic in summer, it could easily absorb heat rather than reject it.

4. Adding fans to the existing rear deck condenser, while helpful, did not completely solve the problem and added heat load to the engine at idle and lower rpm's.

While I felt it VERY necessary to improve the condenser rejection efficiency, simply adding another condenser in a compromising location did not seem viable, and presented lots of potential for future problems. I opted for adding a high velocity high volume PermaCool electric fan to the rear condenser as the first part of the total upgrade.

In reviewing the evaporator upgrades, the only one that made sense was the change out of the old style tube and fin evaporator for a more efficient serpentine design, with significantly larger surface area. Along with this change would go the prerequisite corrections of air leaks so that all the cooling effect generated by the more efficient evaporator would actually find its way in to the passenger compartment. In addition, reviewing all the vent paths, making SURE they were all clear of any debris, leaves; other objects that could block air flow, and revamping the nearly useless 'bowtie' vent on the firewall to a more efficient configuration, seemed like the ticket.

In considering other available items to improve efficiency, I ran across an item advertised as a 'sub cooler' specifically made for use in Porsche 911 applications. Being closely involved with commercial refrigeration applications while working with both Trane and Carrier commercial groups several years back, the principle was not new – but this application was. Could this be the 'magic bullet' I was looking for?

In principle, a sub cooler is simply a double walled refrigerant 'bottle', where hot near-liquid refrigerant going to the evaporator circulates through the inner bottle, and cold, expanded returning refrigerant coming from the evaporator back to the compressor circulates in the space between the inner bottle and the outer wall. By passing the two refrigerant paths in close proximity to each other, the following things happen:

1. the hot refrigerant in the inner chamber is cooled down substantially – reducing both head pressure required to produce liquid refrigerant, and reducing temperature at the evaporator inlet – thus improving refrigerant effect at the evaporator. If the refrigerant entering the evaporator is at a higher temperature, it must first dispose of the heat it is carrying

before it can produce any refrigerant effect by expanding. The cooler you can get the refrigerant as it approaches the evaporator, the better.

2. the returning, expanded refrigerant circulating in the outer shell has in it a fairly large proportion of only partially expanded refrigerant. This is the ‘lost’ refrigerant effect discussed earlier. By circulating it around the inner shell containing hot refrigerant en route to the evaporator, the returning refrigerant gives up most of the remainder of its refrigerating capacity – thus utilizing something that otherwise would be lost. NOTE that there is STILL enough remaining refrigerant effect in the flow returning to the compressor to assist in keeping the compressor properly cooled off!

At first, I thought this appeared too simple to be true – just another gimmick to separate me from my money, and not provide any substantial benefit in the process. In doing further reading, I found that this device, in a slightly different configuration, had actually been tested by the Texas A & M Mechanical Engineering department. I obtained a copy of the test data, now several years old, and was pleasantly surprised to see that this device actually seemed to do what it claimed. Based on heavily documented test data, the sub cooler installed on a standard Porsche 911 added over ½ ton – over 6000 btu’s – of cooling effect to the interior of the car!! Due to it being also reasonable in cost, I decided to try this as the third part of my upgrade. The device, called the **ProCooler**, became the integral part of my upgrade program.

Now that all the components were determined, it came time to actually put all this reading, studying, and comparing to work – time to spend the money, scrape the knuckles, and see if what I had come up with was actually capable of performing ‘as advertised’.

Part Three: Installation and 'trial by fire' – or is it 'by ice'?

In doing the installation, I carefully prepared for each step as an independent and unique module in the process. I felt this approach would provide for each step being manageable and workable in one day or less, keep each step understandable and not confuse work in one step with work in another step, and also help keep me from getting tired mentally or physically by trying to do too much at one time.

While I am sure that individuals both younger and more capable than I could do more than one, if not all, steps in a day or a weekend, I did not want to tackle that kind of effort – besides, by the time I acquired all the parts, it was the middle of the summer, and as such battling the heat along with battling the car made for a double chore.

Step one was the condenser fan addition. As this step did not require disconnecting any refrigerant lines, it was easily accomplished in a Sunday afternoon. My choice of fans was based on three parameters – air flow generated, fan durability and construction, and fan sizing to fit the space intended and clear other engine components. There are several models of PermaCool fans, used heavily by professional racing teams that fit the bill nicely. As each car is different depending on aftermarket components installed, compressor changes done, and so forth, this selection is best left to the individual. In my case, the fan selected was a metal frame, metal shroud, PermaCool Turbo Flex #19010. It has a high quality motor in all metal housing and mounts, a four-blade fan, and good air flow.

Installation was simple and involved loosening the condenser from its supports up inside the whale tail, fitting the fan support thru rods GENTLY through the fins of the coil, attaching the fan, and reinstalling the condenser to its supports. Be SURE that the fan is mounted forward enough that the shroud does not contact the a/c compressor. Also be SURE to relay the fan! The circuit that feeds power to the compressor clutch is not large enough in current capacity to handle the load of a high CFM fan, and I found out the hard way – relay kits are available from PermaCool that match the fan itself, and work quite well.

You can get the constant DC power from the engine compartment fuse block on the left side where the ignition module is located. Control the relay from the compressor clutch power lead. Adding the powered fan to the rear condenser dropped the refrigerant temperature leaving the rear condenser approximately 25 to 28 degrees compared to previous observation and reduced compressor head pressures by 30 to 35 psig from pre-fan pressures at similar ambient conditions. Discharge air temp at the dash vents also dropped by about 10 to 12 degrees. A good start, but still not a significant improvement – that was yet to come.

Step two was a combined effort of installing the new high efficiency serpentine evaporator and the ProCooler system. This was done simultaneously, as the refrigerant system had to be evacuated for both installations, and doing them together required only one evacuation and recharge cycle. Plan on a full weekend for this work, as while the work is not heavy labor, it is very time consuming and a fair amount of the work is in tight spaces.

The first work was replacing the evaporator coil, as this also required loosening the hoses that would eventually go to the ProCooler, and I could accomplish both the hose relocation and the coil replacement at the same time. This is a GOOD time to clean out the areas leading to the coil air intake, prevent any hidden 'dust bunnies' from causing later problems, and in general getting to places not easily gotten to otherwise. One of the 'sore spots' for air leakage that is also accessible during this process is the discharge airline from the evaporator fan to the distribution plenum. This is a fabric covered 'dryer' type hose, and mine was severely deteriorated and leaking air badly. Just fixing this hose improved airflow to the cabin noticeably. Observe ALL the precautions regarding evaporator installation, including handling, NOT bending certain tubing, and SEALING all possible air leaks in to the evaporator box – the time spent being careful is worth it!

During this process, the original return line from the evaporator to the compressor is NOT reconnected, but removed and left for the next process. In its place, the replacement hose that will connect the return of the evaporator to the ProCooler is installed and run through the lower suspension to its final location. Be SURE that this new hose is clear of operating suspension components and the rack & pinion steering travel clearances!

Once the evaporator was replaced, installation moved to the ProCooler. This work takes place in basically three steps – first, removing the factory receiver/drier and disconnecting/relocating existing hoses to be kept; then installing the added hoses required to plumb in the ProCooler, and finally fitting up the ProCooler and attaching to the old receiver/drier bracket.

Almost ALL this work takes place inside the drive side fender well and nearby areas, so it can be done either on the ground with jack stands under the driver side, or on a lift – whatever is easier. Again, the installation steps provided by the vendor were well laid out and easy to follow, but there were some minor issues with hose lengths. Be prepared to spend some time fitting hoses finger tight, checking clearances and fit, readjusting what hoses go where and what hoses go under or over other hoses (a total of four hoses will now go where only two went before), until everything fits. BEWARE tire clearances in the rear of the fender well! One hose in particular will most probably wind up running up the fender well wall near where the tire sidewall is during full left turns, and then over to the area where the ProCooler mounts.

NOTE that hose relocation from the evaporator to various parts of the ProCooler requires removal of the suspension protective pan. For those of you who have not done this, the pan is held in place by four bolts that do double duty – both holding up the pan, and ALSO holding the anti-sway bar bushing carrier plate in place! As such, loosening these bolts with any differential load on the front suspension, i.e. one side loaded, the other unloaded, is a VERY bad idea! While most of the work can be done with just one side raised and the left front tire removed, work under the suspension pan MUST be done with the entire front properly raised and the entire front suspension unloaded!

Also during the hose realignment process, the return line from the evaporator to the rear of the car is moved from the right side to the left side. This is done to most effectively utilize the existing hose length and fitting. The hose is disconnected from its several clamps attaching it to the underbody and under the rocker panel along the right side, then relocated to a run along the front edge of the engine compartment, along the left rocker panel where the high pressure a/c line is already located, then attached to the ProCooler with a short adapter hose. The kit was very complete, with all required o-rings, fittings, clamps, and accessories.

During removal of the original receiver, something you may not notice until it's too late was discovered – significant corrosion of body metal behind this component due to trapping of dirt, mud, etc in an inaccessible location. This is a good time to take on repair in this area if needed – mine did.

If you are performing this install yourself with little to no previous HVAC experience, and having someone else evacuate and charge the system, be advised that o-ring fittings take very particular assembly protocols, including torques required to make them seal without either cutting or over-compressing the sealing ring. If you are the least bit unsure of how to do this, get advice or have someone else do it. The time lost by having a leak due to not making up fittings correctly is not worth it, and the potential for damaging a fitting by not seating it properly or over tightening (the hose fittings are steel, the ProCooler is aluminum!) are very real. NOTE that ALL o-rings and fittings MUST be oiled with a refrigerant oil compatible with whatever refrigerant you will be charging the system with to properly seat and seal! Installing o-rings 'dry' does NOT work – for long at least – and leaks will result.

THE MOMENT OF TRUTH – STARTUP AND TESTING

Once installation was complete and all parts checked for clearances, proper torques, nothing loose hanging where it shouldn't, and all electricals reconnected, it was time for the final stages – system evacuation, leak testing, charging, and testing.

Following proper evacuation procedures, connect the system to a vacuum pump of proper design and capacity, and evacuate the system. It is recommended to insure a complete evacuation that the pump be run at least two hours, preferably three to four. This insures that any residual refrigerant, moisture, along with the air that has gotten in to the system, are thoroughly removed. The system, if properly sealed, should easily vacuum down to less than 500 microns within only a couple of minutes on a good pump, and then pull down to within 200 to 250 microns over the next hours. If the system is truly leak tight, closing off the gauges and shutting down the pump and leaving the system for at least a half hour should result in NO rise in pressure. If you have a leak, check all the fittings you disturbed including at the evaporator, and re-evacuate. IF your system was leak tight before this process, it should return to being leak tight. IF your system was leaky before this process, or its refrigerant fully discharged for some time and not used, there are two things to consider. First, this process will NOT fix other problems! Second, before this process can be successful, any other problems should be addressed FIRST, then this upgrade done!

Once my system was found to be leak tight, I charged it with the recommended charge of r-134a. Prior to introducing straight refrigerant, I added four ounces of oil to the system to make up for the oil lost with the replaced evaporator and receiver/drier. Oil circulates along with the refrigerant in an a/c system, and forms a thin film inside every component it circulates through. When components are replaced, that oil film is lost, is replaced from the remaining oil in the system, and can cause a low oil failure if it isn't replaced.

Be sure to use the correct oil that matches whatever is currently in your system. IF you are also refitting to an alternate refrigerant at the same time, allow for this extra oil charge when calculating how much oil to put back during the retrofitting process.

Once I had the initial charge of refrigerant in the system, it was time to start the ultimate test – and start the system up. Immediately on starting the system, I was amazed at the difference. With the engine running on about 2000 rpm's, and only about 75% charged, the air from the dash vents was actually COLD!

I completed the charging process, recorded my results, shut the system down, and disconnected gauges and refrigerant from the compressor.

Over the next few days, using an Omega Scientific multi sensor lab thermometer, I was able to document the performance change – but I didn't need to see the numbers to know what was going on. For the very first time, I was able to drive in Dallas rush hour on a hot August day, and actually had to turn the air down slightly as it was getting too cool! I had frost forming on the evaporator discharge fitting, and the ProCooler was developing an ice ring on it!

In conclusion, this multi-part approach – increasing efficiency at multiple sites throughout the system – seems to be the most efficient and effective method to achieving best system operation. Operating pressures, a clear indication of system efficiency, are down significantly and right in the optimum range for the refrigerant being used, and operating temperatures and temperature drops across various elements are significantly improved.

Further, this particular modification was carried out WITHOUT adding any major components to the existing system, i.e. added condensers, thus preserving most of the original system intact. Along with that, this particular conversion avoided installation of delicate components in locations where they would be subject to harm, such as added condensers either under the car or in a fender well, and also avoided drilling any added holes in body panels or other steel.

Another critical item is cost efficiency. The above conversion when you add the high efficiency serpentine evaporator, condenser auxiliary fan, and

ProCooler kit, totaled out under $1000 compared to over $2500 for 'all in one' kits that utilize added condensers. This cost is for the parts ONLY, with myself doing the complete installation. If you have to have someone install this for you, figure on at least 8 hours of labor if not 10 or 12, and add to that the refrigerant recycling costs, fees, and new refrigerant. If you are doing this in conjunction with a conversion to another refrigerant, that cost will also add on top of this.

In closing, this conversion and upgrade, like so many similar projects done to other systems of the car, is one where significant gains in performance and reliability are best gained through making moderate changes in several parts of the system, not applying the 'single magic bullet' theory and being disappointed in only partial improvement.

Test Data

Test data are as follows. NOTE that both sets of data are WITH the auxiliary condenser fan installed and operational, and charged with r134a. The only changes from the BEFORE and AFTER data sets are the installation of the serpentine evaporator and the ProCooler subcooler system. In both the before and after scenarios, the refrigerant charge was weighed with a charging cylinder to insure proper charge volume.

BEFORE
A/c set to full cold, high fan
Ambient air temp outside car: 99 deg. F
Ambient air temp inside car: 96 deg. F (sitting in shade)
Engine rpm: 2020 to 2070 rpm
Compressor head pressure: 265 to 270 psig
Compressor suction pressure: 37 to 42 psig
Compressor fitting discharge temperature: 225 deg. F
Rear condenser leaving fitting temperature: 175 deg. F
Liquid line in to evaporator entering temperature (after 2nd condenser at front of car): 135 deg. F
Suction line leaving evaporator temp: 48 – 52 deg. F
Compressor return line temp at compressor fitting: 54 – 56 deg. F
Air entering evaporator: 96 deg. F
Air leaving evaporator: 62 deg. F
Temp drop across evaporator: 34 deg. F

AFTER
A/c set to full cold, high fan
Ambient air temp outside: 96 deg. F
Ambient air temp inside car: 92 deg. F (sitting in shade)
Engine rpm: 2050 to 2110 rpm
Compressor head pressure: 210 to 212 psig
Compressor suction pressure: 14 to 16 psig
Compressor fitting discharge temp: 182 deg. F
Rear condenser leaving fitting temp: 135 deg. F
Inlet line to procooler temp (after 2nd condenser in front of car): 115 deg. F
Leaving liquid line from procooler to evaporator temp: 83 deg. F (inlet refrigerant temp to evaporator)
Suction line leaving evaporator: 28 deg. F
Suction line entering procooler @ procooler fitting: 30 deg. F
Return line to compressor at fitting leaving procooler: 56 – 60 deg. F
Return line to compressor at compressor fitting: 66 to 70 deg. F
Air entering evaporator: 92 deg. F
Air leaving evaporator: 41 deg. F

Temp drop across evaporator: 51 deg. F

The numbers speak for themselves – nearly a 20-degree improvement in temperature drop across the evaporator, when coupled with the airflow, yields added sensible capacity well over 6000 btu/h. For information, the system basic capacity is designed to be about a 2.5 ton system, or around 30,000 btu/h under ideal conditions. Per the Texas A & M study, the baseline system they tested was more around 26,000 btu/h, or slightly over 2 tons.