MACS Service Reports

MOBILE AIR CLIMATE SYSTEMS ASSOCIATION ©

By Richard Hawkins, MACS Technical Correspondent

January 2022

Where are the service ports located? (And why does it matter?)

When approached by MACS about writing an MSR, one of my first thoughts was: What should the subject be? And the answer to that question was pretty easy: It should be on the importance of knowing the location of service ports on A/C systems and understanding the importance of applying that information to diagnostics. That was because I participated in a webinar with MACS' manager of service training on that very subject. To view the webinar, you can go to the following link: *https://youtu.be/KkOokPg7zeg*

Having worked on an A/C tech line for over 12 years, I've had the opportunity to have a lot of interesting conversations with technicians who were experiencing some extremely tough performance problems, sometimes with some really unusual pressure readings. When having these conversations, one of the first questions posed to them was: Where are the locations of the service ports? After asking this question a number of times and listening to the answers, it became obvious early on that a very large percentage of technicians didn't have any understanding of the importance of this question, hadn't given any thought to it and actually had trouble providing that information. To provide some insight into this, let's take a look at how a conversation might go.

Me: Those are some pretty usual pressure readings you just provided, and some detailed information is needed to dig in to this. Can you tell me where the service ports are located?

Technician: Sure, the high side service port is located on the high side hose, and the low side port is located on the low side hose.

Me: That's a start, but I need to know the PRECISE location of those ports.

Technician: OK. Let me go look under the hood (and a minute or so later he'd come back and say), the high side port is located on the high side line, up near the front of the car, and the low side port is located back near the firewall.

Me: That still doesn't provide the precise location of the service ports as you have a discharge line and a liquid line on the high side and sections of both can run along the front of this car. On the suction line, just knowing that it is located near the firewall doesn't tell us if it is closer to the block valve or the compressor and it also doesn't provide any information on whether there might be a rubber hose located between it and those components.

So, let's try approaching this a little differently. Let's forget about the car and focus on just the A/C system only. The A/C system is a closed loop system that has the major components connected to one another with hoses and lines. The compressor is connected to the condenser by the discharge line, and the condenser is then connected to the drier by the liquid line (and then another liquid line runs from the dryer to the block valve). Is that high side service port located on the discharge line or the liquid line?

Technician: The discharge line.

Me: OK. Now is it located closer to the compressor or the condenser?

Technician: Closer to the condenser.

Me: OK, so that means there is a rubber hose between the service port and the compressor. Approximately how long is that hose?

Technician: That's right. The hose is about 2 feet long.

Me: Is there any rubber hose between the service port and the condenser?

Technician: No, there is about a two-inch piece of metal line between the service port and the condenser.

Me: Now let's move on to the low side port. The suction line runs along the firewall and connects the block valve to the compressor. Is the low side service port closer to the block valve or the compressor?

Technician: It's located closer to the block valve.

Me: Is there any rubber hose between the service port and the block valve?

Technician: No. There is a short piece of metal line between the service port and the block valve. It's about 3 inches long.

Me: How long is the rubber hose from the service port to the compressor and is there just one section of rubber hose or maybe two?

Technician: The rubber hose is about 3 feet long and there is only the one section.

Me: So, to make sure that I have the information correct; the high side service port is located on the condenser end of the discharge line and there is about 2 feet of rubber hose between it and the compressor and there is about a two inch piece of metal line between the service port and the condenser.

Technician: Yes.

Me: OK, and the low side port is located on the block valve end of the suction line with about two inches of metal line between it and the block valve and there is about 3 feet of rubber hose between it and the compressor and there is only the one section.

Technician: Yes, that is correct. But why does it all of that matter?

Me: Because you could have a restriction in one or more of those hoses or one or more of the other components and what you're seeing on your gauges could be quite different from what the ACTUAL pressures are at the compressor. The further a service port is located from the compressor and the more components that are located between it and the compressor, the more likely it is for that to occur.

Technician: Hmm. I hadn't thought about that before. It makes sense.

Before continuing on, I need to mention that MACS members are the cream of the crop when it comes to A/C diagnostics and most will understand all of this, but they like other shops have to hire new technicians from time to time, so this MSR is more geared toward the less experienced technicians on the staff.

Near the beginning of the webinar, I was asked the following question: If you were an A/C engineer at one of the OEMs and you had unlimited resources (and of course unlimited funds to do this), where is the ideal location to install service ports on an A/C system, and is there ever a reason to have more than one (of each)? To address the first part of the question: My preference is as close to the compressor as possible. See Figure 1. That's because I want to know for SURE what the compressor head pressure is and also want to know for SURE the level the compressor is pulling the low side down to, and taking readings right at the compressor is the only way you can be sure.

NOTE: Even with being connected to service ports right at the compressor, there is always the possibility of a problem with a Schrader valve, hose connector, gauge or hose connected to the gauge. So, for that reason, always make sure that gauge movement corresponds to temperature changes of metal lines right at the compressor.

As indicated in the conversation with the technician, the further away service ports are located from the compressor, the more likely you are to see a pressure reading that is quite different from what it is at the compressor. When that occurs, it is the result of restrictions. Consider an expansion valve system with a restricted condenser and the high side service port located downstream of the drier. Because of the restriction in the condenser, you could be seeing a high side pressure on your gauge which might appear to be below normal, but the actual pressure at the compressor is highly elevated. Couple that with a low side pressure reading which is higher than normal (because the compressor is trying to pump against the elevated high side pressure) and the conclusion is that the compressor is weak and it ends up being replaced unnecessarily. There is no standard that exists in the industry on

Steve Schaeber

Figure 1: *Having the service ports located right at the compressor, such as on this manifold, ensures being able to get the actual pressures the compressor is producing (unless there is a problem with a Schrader valve, hose connector, gauge or hose connected to the gauge).*

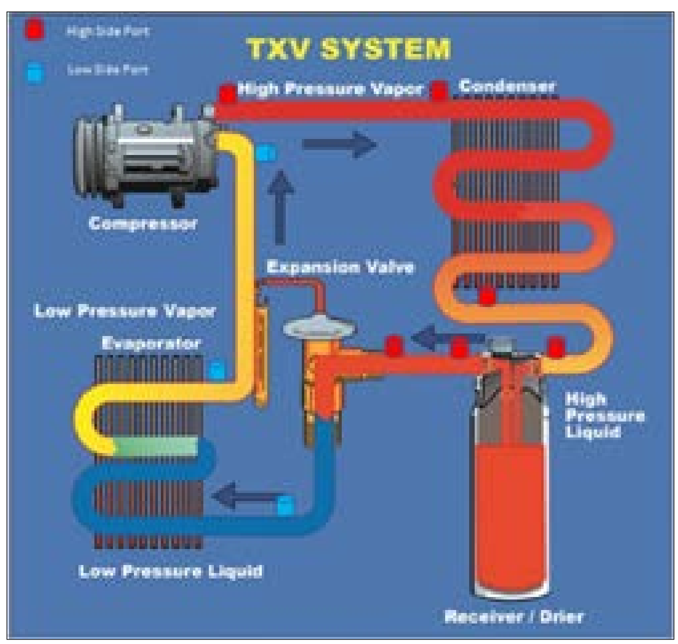

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Figure 2: *Expansion Valve System Service Port "Wish List".*

where service ports are located. Often, they end up being placed where they are just because of being in the most accessible places on vehicles.

To address the second part of the question about, "Is there ever a reason to have more than one of each", that would be a resounding YES! That's because multiple service ports would provide the capability to check pressures in multiple places and easily find restrictions. So, with unlimited resources and unlimited funds, I'd create a "service port wish list" which would involve a high side service port at the inlet and outlet of every major component and hose/line on the high side and also a service port at the inlet and outlet of each major component and line/hose on the low side. On a typical expansion valve system, this would involve 6 service ports on the high side and 3 on the low side. See Figure 2. On a typical orifice tube system, it would involve 4 service ports on the high side and 6 on the low side. See Figure 3. This would only occur on a prototype system such as used for testing in a wind tunnel or for training and discussion purposes and never make it to production vehicles, but I'm sure many of you have encountered a tough diagnostic situation and wished that you could have placed some service ports in some of the locations shown.

Now let's take one of these systems and simulate a restriction and see what the effect might be on pressure readings at different points. But before going further we need the proper information on the type of system we're dealing with; the type of compressor it uses and the ambient temperature and humidity, just as we'd be doing if we were working on it in a shop. Then we need to establish what the pressures are with the system operating properly and the vent temperature. That information is as follows:

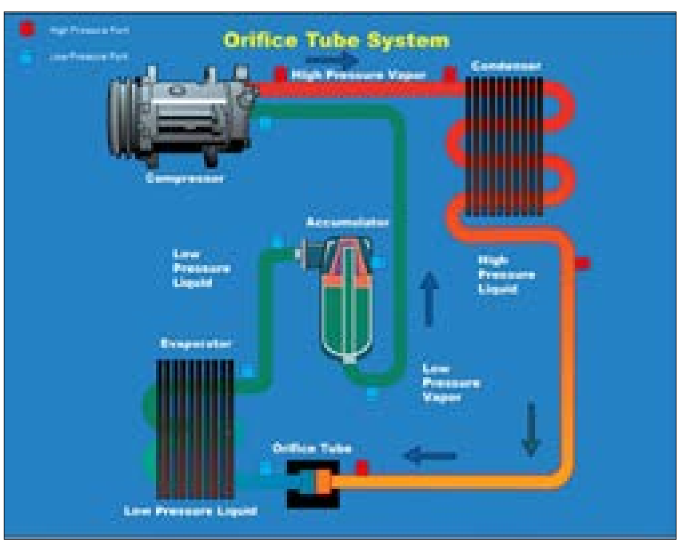

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Figure 3: *Accumulator/Orifice Tube System Service Port "Wish List".*

System Type: Single Expansion Valve System

Compressor Type: Fixed Displacement Piston Compressor
Ambient Temperature: 90°F
Humidity: 70%
High Side Pressure: 210 psi (at a slow idle)
Low Side Pressure: 35 psi (at a slow idle)
Center Vent Temperature: 48°F

A popular service port arrangement on a TXV system would be the following:

High Side Service Port Location: On the liquid line about 2 inches downstream of the drier.

Low Side Service Port Location: On the suction line about 2 inches from the evaporator outlet.

So, we'll start by showing an illustration with the ports in those locations and the pressure readings with everything operating properly. See Figure 4.

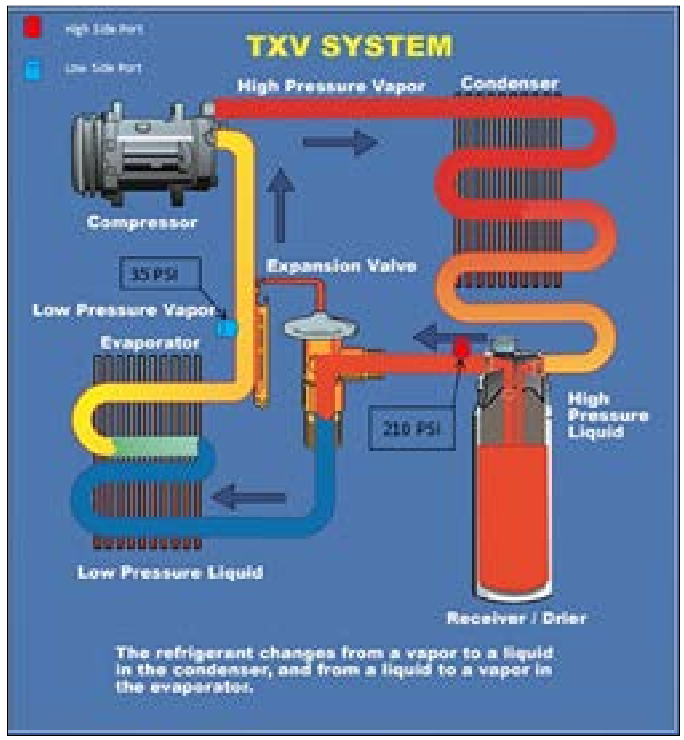

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Figure 4: *Properly functioning Expansion Valve System.*

The next step is to create a partial restriction in the upper portion of the condenser. This affects condenser efficiency dramatically and the combination of the reduced condenser efficiency and the compressor pumping against the restriction is going to cause the pressure at the compressor to increase significantly and the low side pressure will also increase as a result. However, the pressure at the original service port location is going to drop significantly because that service port is located downstream of where the restriction is. With the high side

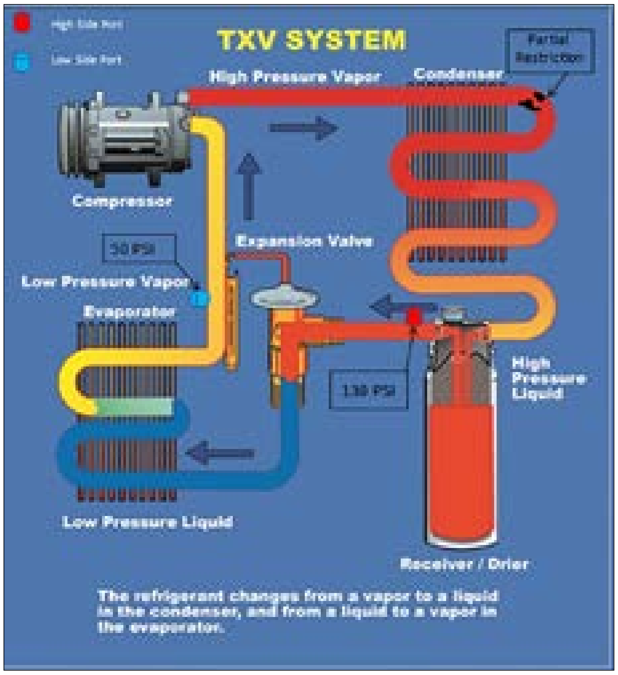

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Figure 5: *Expansion Valve System with a restricted condenser.*

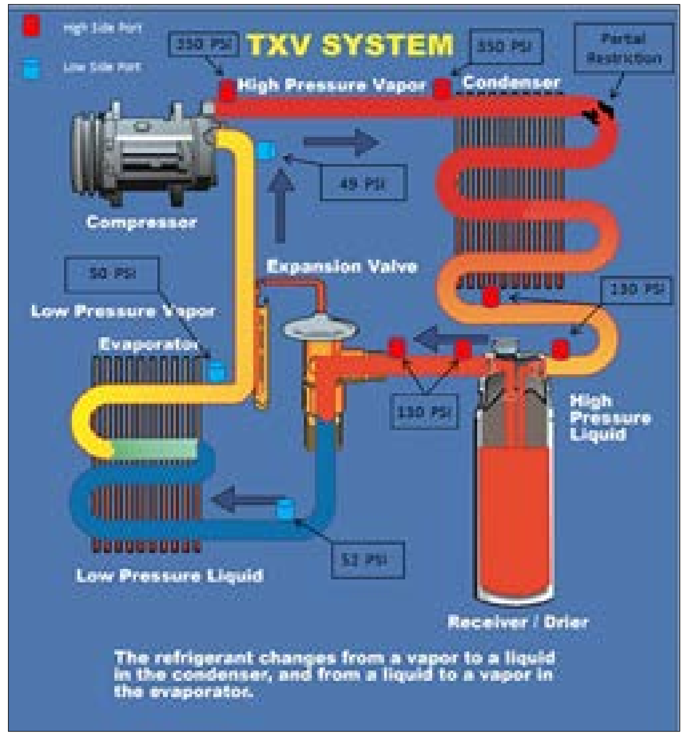

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Figure 6: *Expansion Valve System with restricted condenser shown with pressure readings in multiple places.*

pressure showing up as 130 and the low side at 50, someone could easily diagnose that as a weak compressor. See Figure 5.

Now let's take the expansion valve system illustration with the multiple service ports and utilize it to illustrate what the pressure readings would look like at other points in that system with the restriction present. As you can see, the high side pressure at the compressor is actually 350 psi. By comparing that reading to the one taken at the original high side service port, we find a difference of 220 psi and that indicates a significant restriction. If we check the pressure at the inlet and outlet of the condenser, we see that it is 350 going in and 130 coming out, so that would tell us for sure that the restriction is in the condenser. With all of those ports, we could also do further testing to verify that there weren't any other restrictions present. See Figure 6.

It would be great if we had systems configured like this with the multiple service ports, but we don't. However, we can use temperature testing to find restrictions, unless there is a total restriction, because pressure drops create temperature drops. *NOTE: Temperature drops don't occur with a total restriction because there is no refrigerant flow.*

In this case a 220 psi pressure difference between the inlet and outlet of the condenser would result in about a 75° temperature difference and that is way more than the typical 20° to 50° temperature difference we would expect to see on a system with a fixed displacement compressor. *NOTE: Vehicles utilizing parallel flow condensers with variable output compressors can experience temperature differentials far above 50 degrees, so be extremely careful when temperature testing them and condemning condensers.* If we were to further temperature test the lines and drier, there should be almost no difference in the inlet and outlet temperatures on those components. *CAUTION: You must use a contact type temperature reading tool to get accurate readings. Infrared temperature guns will result in inaccurate readings and an incorrect diagnosis. Infrared guns have their place in the shop when it comes to taking high temperature readings such as on an exhaust manifold when trying to find a misfiring cylinder but are just too inaccurate to use on lower temperature components such as those in an A/C system (Figure 7).*

Now let's take this information and apply it to a diagnostic situation I encountered a number of years ago. This involved an actual visit to a shop and not a tech call. The vehicle was a late 90s or early 2000s Honda with a Conventional valve system and a fixed output scroll compressor and this shop had been working on it for over a week, on and off. The warehouse had just sent out a second replacement compressor and after installation the system was still behaving the same way and the shop wanted to replace it with a third unit. I happened to be visiting the city where this warehouse was located, and the manager had asked if I could pay the shop a visit because he felt it was very unlikely that the two compressors that had already been installed were both bad. So, he provided me with all of the information that he had and I headed over to the shop.

After walking in and doing a short introduction, I was immediately met with a somewhat hostile, "How come you guys have so many problems with your compressors?" Then the conversation proceeded to go something like this:

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Figure 7: *This is a typical reading that can be expected when taking temperature readings on an A/C system with an infrared temperature gun. Both the infrared gun on the left and the contact type temperature reading tool on the right are reading the temperature on the same metal suction line about ½-inch apart. Before doing the test, I felt the suction line with my hand, and it felt like a glass of iced tea. The reading on the contact type temperature reading tool indicates a temperature that would be expected of a glass of iced tea. However, the infrared gun indicates a temperature that is almost 40° higher. This was despite numerous efforts to get an accurate reading with it and was the lowest temperature recorded.*

Me: Any parts supplier can have a problem with an A/C compressor, and we certainly aren't an exception, however we make efforts to ensure that our compressor suppliers furnish us with high quality product. I understand that you've had multiple compressors on that car and that usually is an indication of a problem with the system on the vehicle and not a compressor problem. Can you tell me what's going on with this car so I can get a good understanding of the problem?

Him: I really don't want to waste time talking about it. I just want another compressor and your warehouse manager doesn't want to send me one.

Me: The warehouse manager is fine with sending you another compressor if there is a problem with the current unit. But, he wants to be sure there is indeed a problem with it before doing so and I'm sure you don't want to spend time replacing a compressor unnecessarily. You've obviously spent a lot of time already working on this car, but maybe spending a few minutes explaining what is going on with it could be a good investment of time.

Him: Well, OK. This compressor just won't pump like it's supposed to. It will only create about 135 to 140 psi on the high side and will only pull the low side down to about 60 or 65 and it isn't doing much cooling.

Me: What was the ambient temperature when those pressure readings were taken?

Him: It was a little earlier today and it been about 90° most of the day. The high side pressure should be more along the lines of about 180 to 225 and the low side should be below 40.

Me: Yes, the pressures are not where they should be for sure. What were the pressure readings with the previous compressor?

Him: About the same.

Me: And what were the pressure readings with the original compressor?

Him: About the same.

Me: So, if I'm understanding this correctly, there have been 3 compressors on this car (including the original unit) and you've gotten the same results with all 3. Is that correct?

Him: Actually, there was one more. I got a unit from one of your competitors and it leaked, so I had to return it.

Me: What were the pressure readings with that one?

Him: Same thing.

Me: So, we're talking four compressors and they are all doing the same thing?

Him: Yes.

Me: What do you think the chances are of having 4 different compressors all with the same problem?

Him: Well, I'd have to say pretty unlikely.

Me: Exactly. I can almost guarantee you there is a system problem that is causing those readings and the cooling problem. Replacing the current compressor isn't going to fix the problem.

Him: But that compressor just won't pump properly. (SLAMMING HIS FIST ON THE DESK!)

Me: I understand your frustration and why those pressure readings were the reason you initially replaced the compressor, but here we are 2 additional compressors

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Figure 8: *Honda suction hose. The straight metal tubing on one end and almost straight metal tubing on the other end made it easy to see daylight when looking through it, but it didn't look perfectly round on the inside.*

later with the same results. There is another problem with that system and it's going to be necessary to diagnose it and fix it to ever get that system to cool properly.

Him: Well, what in the world could it be?

Me: Assuming that your charge is correct, most likely a restriction. Also, an expansion valve that is stuck wide open (which isn't all that common) can affect pressure readings.

Him: I've replaced the expansion valve twice and that didn't make any difference and it can't be a restriction because that would cause the high side pressure to be too high.

Me: Well with 3 different expansion valves and no difference, we can almost surely rule out an expansion valve issue. But a restriction isn't necessarily going to cause the high side pressure to be too high.

Him: Why?

Me: It depends on where the restriction is and also where the service ports are located in relation to the restriction. For example, it's very common to have a severely restricted expansion valve. It can happen because debris might become lodged in it or because it loses its charge and won't open. But when this occurs, the low side can go into a vacuum and the high side might only be 100 to 110. The reason the high side pressure is so low is because once the low side goes into a vacuum, there is very little refrigerant being pumped through the system. Also, most of the refrigerant is residing in the high side between the compressor and the expansion valve, where there is plenty of room for it, and the airflow through the condenser is keeping it pretty close to the temperature of that air.

Going a step further here, a restriction in the discharge line could definitely result in some very elevated high side pressure, but depending on the location of the high side service port, you may or may not see it on your gauge. If the service port is located between the compressor and the restriction, the gauge would read high. If the service port is between the restriction and the condenser, the gauge will read lower than the pressure at the compressor.

Him: So, you're saying I have a restricted discharge line?

Me: You could, if your service port was located after the restriction, but a restricted suction line could cause the same type readings as well as a restricted condenser or drier, again depending on the location of the high side service port.

Him: Well, we can rule out a restricted discharge line or suction line and liquid line too for that matter. I took air and flush and blew through all of them and they all flow just fine. Also, I replaced the condenser so there shouldn't be a problem with a new condenser.

Me: It's unlikely there is a problem with that new condenser, but any of those lines could have a restriction in them.

Him: How is that possible? I said I took air and flush and blew through them.

Me: If you have a TOTALLY restricted line or SEVERLY restricted line, you could likely find it by blowing air or flush through it. But it's possible for a hose to flow air or flush just fine when you have it off the system, but when you have it installed on the system and charge it up and try to flow refrigerant it can become restricted due to a problem with the internal liner.

Him: Wow. I hadn't thought about that. So how would you find a restriction like that?

Me: By temperature testing. When you have a pressure drop, you are going to have a temperature drop. You need to check the temperature on the inlet and outlet of each component that you're testing for a restriction. With the exception of the compressor, condenser and the expansion valve, there should be very little temperature difference from inlet to outlet on any of the other components in the system when it is operating. There are several im-

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Figure 9: *Cutting the hose in two at about the midway point revealed exactly what the problem was. The inner liner had come loose from the adjacent layer it had been attached to.*

portant things to remember when temperature testing. 1.) If a component has a total restriction, there will be no temperature drop as you have to have refrigerant flow in order to have a temperature drop. Also, a severe restriction might not be detected by temperature testing, because there is enough heat from the engine to offset what little cooling is taking place with a very small flow of refrigerant through the restriction. 2.) If you're temperature testing a hose you must take the reading on the metal ends as the rubber will act as an insulator and you might not be able to detect a temperature drop through it. 3.) Last but not least, you must use a contact type thermometer. Infrared guns are just too inaccurate and will lead to the replacement of parts unnecessarily. Can we go out into the shop and do some temperature testing on it?

Him: Unfortunately, I have it completely apart where I was blowing through those lines. But it does sound like I need to put it back together and charge it back up and do some temperature testing on it tomorrow.

Me: Yes, just be sure you get the correct charge in it. I would come over tomorrow when you temperature test it but, I'll be in a different city. I'll give you my phone number so you can call and let me know how things are going.

During the middle of the afternoon on the following day, he called and said he had it fixed. It was blowing 42° air from the vents and the high side pressure was just over 200 and the low side was in the high 20s and the customer had picked it up. I asked what he'd found and what he did to fix it and he said he'd replaced the suction hose. He went on to say that when he temperature tested it, there was a difference of about 50° from one end to the other. He thanked me and said he had never been so glad to get a car out of the shop. I asked what he'd done with the hose, and he said he'd thrown it in the trash can. I asked if I could possibly have the hose and he said he'd dig it out of the trash and set it aside for me. I went by and picked it up a couple of days later and I've taken it with me to just about every A/C clinic I've conducted since that time, and it's been used extensively to illustrate the effects that a restriction can have on pressure readings. See Figure 8.

Upon seeing the hose, the first thing I did was hold it up to the light and look through it. As you can see in the picture, it is only about 15 inches long and has straight metal tubing on one end and only a slight bend on the other end so it's very easy to look completely through it. The customer had indicated earlier that he had blown air through it and detected no restriction, and it was easy to see why. Looking through it, plenty of daylight could be seen at the other end. However, upon closer examination, something just didn't look right. Instead of being perfectly round all the way through on the inside, it had more of an elliptical shape to it toward the middle. To investigate further, the next step was to cut the hose apart. Once cut apart, it was easy to see what had happened. It is a barrier type hose and the inner liner had come loose as indicated in the picture. See Figure 9.

So, what was actually going on here? There were several inches of the internal liner that had come loose from

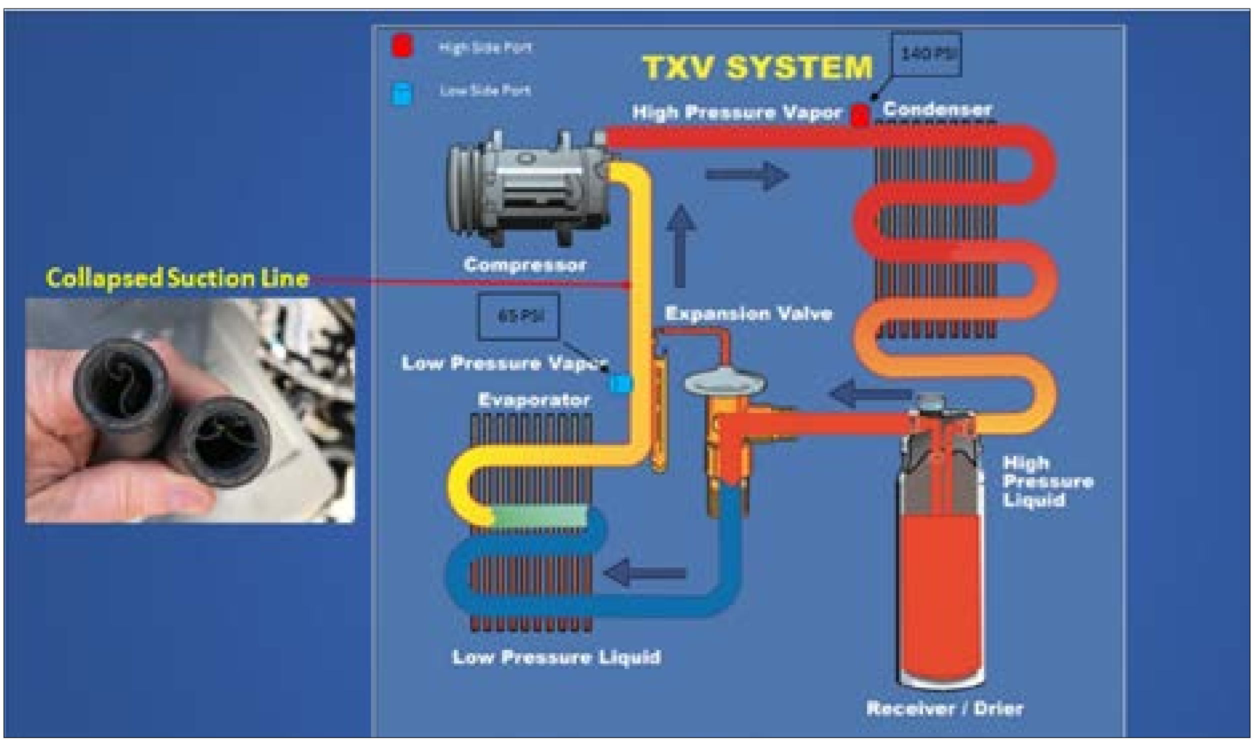

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Figure 10: *This illustration of the Honda A/C system shows the location of the service ports, location of the restriction and the pressures at those ports with the restriction in place.*

the layer that it attached to. With no refrigerant in it, there was no resistance encountered when trying to blow air or flush through. But with the system charged up and the compressor not running, the hose would have about 104 psi of static pressure inside (at 90°F). With the inner liner coming loose, there was also some damage that was allowing refrigerant to permeate through it and get to the area between the inner liner and the adjacent layer it was formerly attached to. When the compressor was turned on, it immediately started reducing the low side pressure. The higher pressure on the outer part of the inner liner caused the inner liner to collapse and caused a restriction. Based on the pressure readings of 135 to 140 on the high side and 60 to 65 on the low side, it wasn't a total restriction, but rather was a partial restriction (Figure 10). But the 60 to 65 on the low side gauge wasn't what the actual low side pressure was at the compressor. That's because the low side service port was located between the evaporator and where the collapsed area of the hose was located. It involves a bit of speculation, but if it had been possible to take a low side pressure reading there at the compressor it would have likely been in the low single digits or maybe even in slight vacuum. See Figure 11.

Many compressor companies report a large number of NTF (No Trouble Found) compressors when conducting warranty analysis on returned units. These are units which have been installed by shops and then determined to be defective because the systems won't function properly, and they are returned for warranty. In this case and in many others, a lot of that could be avoided and a lot of time and expense saved by utilizing more careful diagnostic procedures and temperature testing.

We've covered a lot of ground here and the three most import takeaways from this MACS Service Report are:

1. The further service ports are located away from the compressor, the more likely it is that what is being displayed on a gauge may not be the actual pressures at the compressor.

2. Temperature testing needs to be utilized to locate restrictions, but if there is a total restriction there will be no temperature drop because there is no refrigerant flow.

3. Contact type temperature testing devices must be used when doing temperature testing on A/C systems. ❖

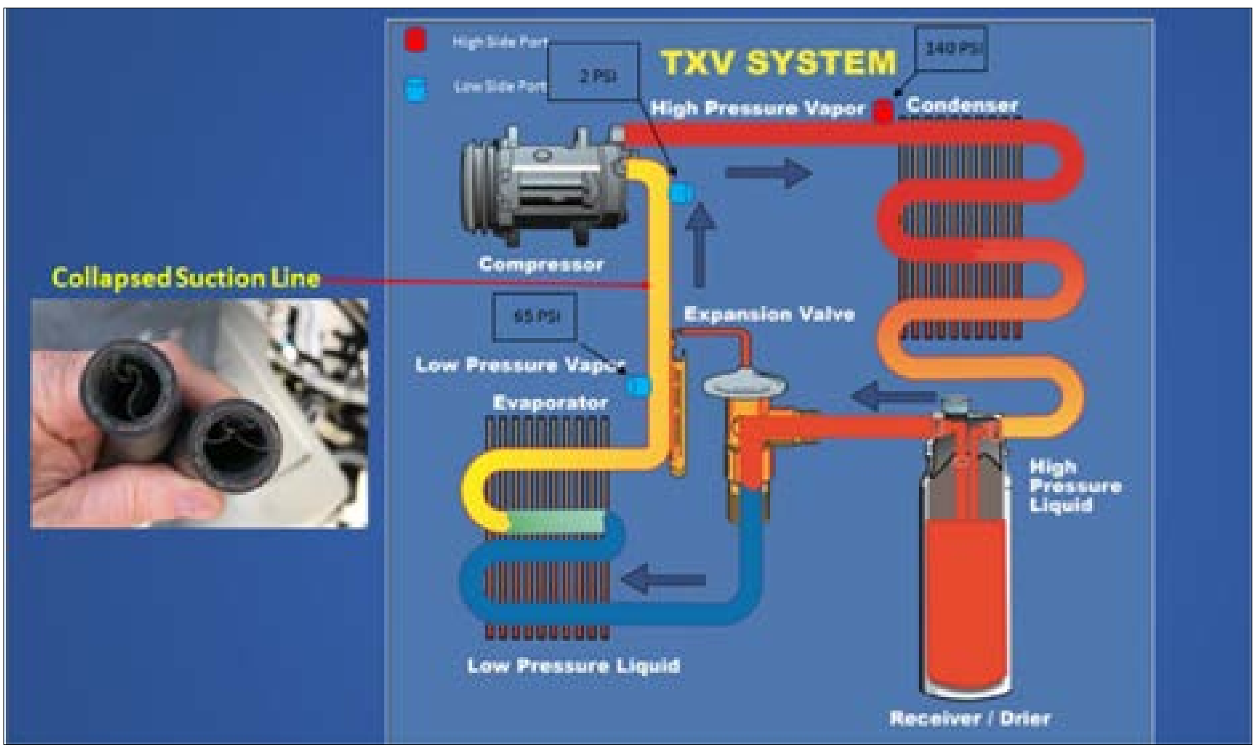

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Figure 11: *If a pressure reading could have been taken between the location of the restriction in the suction line and the compressor (extra port added near the compressor), it would have likely been in the low single digits or maybe a slight vacuum.*

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2.	A	B	C	D
3.	A	B	C	D
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8.	A	B	C	D
9.	A	B	C	D
10.	A	B	C	D

1. Internal combustion engines are only about 30-35% efficient as machines go. This translates to approximately _____ % of the heat of combustion is lost to the atmosphere.
- a. 15-20
- b. 35-40
- c. 65-70
- d. 95-100

2. Two technicians are discussing cooling and air conditioning system performance degradation. Technician A says that a good visual inspection should include a flashlight test across the entire section of the radiator surface area. Technician B says that any areas that are restricted can impede the efficiency of the electric cooling fans. Who is correct?
- a. Technician A
- b. Technician B
- c. Both technicians A and B
- d. Neither technician A nor B

3. Technician A says that the electric cooing fans on modern engines are usually controlled by the PCM (powertrain control module). Technician B says that the PCM monitors certain parameters such as engine coolant, vehicle speed, A/C on-off status, A/C pressure and others to determine engine cooling fan needs. Who is correct?
- a. Technician A
- b. Technician B
- c. Both technicians A and B
- d. Neither technician A nor B

4. Technician A says that when reading a schematic, interpreting the power flow is from left to right across the page. Technician B says that the function of a diode is to act as a two-way check valve in the electrical system. Who is correct?
- a. Technician A
- b. Technician B
- c. Both technicians A and B
- d. Neither technician A nor B

5. Two technicians are discussing diode function in a cooling fan circuit. Technician A says that each time the PCM disables the low fan control relay (to turn off the fans), this can create enough voltage spike in the electrical system to cause issues with high voltage electronics. Technician B says that the diode will dissipate this unwanted voltage to ground and prevent issues with low voltage electronics. Who is correct?
- a. Technician A
- b. Technician B
- c. Both technicians A and B
- d. Neither technician A nor B

6. Technician A says that if the diode is shorted, voltage from the fan control relay would be shorted directly to ground and blow the fuse. Technician B says that if the diode is open, there may be a popping noise heard through the audio system associated with the cooling fans turning off. Who is correct?
- a. Technician A
- b. Technician B
- c. Both technicians A and B
- d. Neither technician A nor B

7. True or False: The 2010 Ford Flex PCM controls the fan speed and operation using a duty cycle output on the fan control variable (FCV) circuit.
- a. True
- b. False

8. The Flex's fan controller has the capability to detect certain failure modes within the fan motors. If it detects a motor that is drawing excessive current, the fan controller will _____ the fans.
- a. Speed up
- b. Slow down
- c. Monitor
- d. Shut off

9. Technician A says that fan motor concerns will set a specific DTC that can be checked using a scan tool. Technician B says that with the fan motor disconnected from the fan controller, voltage may not be present at the fan controller, however the PCM will display FAULT-YES on the scan tool. Who is correct?
- a. Technician A
- b. Technician B
- c. Both technicians A and B
- d. Neither technician A nor B

10. Technician A says that bi-directional control of the cooling fans can be done with any OE-capable scan tool. Technician B says that this test provides a quick way to determine if the fans are functional, which can save a lot of diagnostic time. Who is correct?
- a. Technician A
- b. Technician B
- c. Both technicians A and B
- d. Neither technician A nor B