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THE INTERNAL HEAT EXCHANGER—ALSO KNOWN AS “IHX” OR “SLHX”

It’s hardly a new refrigeration system component, but when it comes to automotive air conditioning, the term “internal heat exchanger” – IHX – is something that most A/C service technicians are hearing about for the first time (Figures 1, 2). However, it has been around for some time in commercial refrigeration, and even in household refrigerators, certainly since the mid-1990’s, and in a few automobile R-134a systems too. More important: our best advance information is that it will be used in most R-1234yf-equipped systems.

Perhaps it’s an engineering test, perhaps it’s a validated way to improve a system that needed some boost, but the 2011-12 Toyota Sienna minivan is an example of a vehicle with an R-134a system and an IHX. However, the thermodynamic characteristics of R-1234yf mean that an IHX is more beneficial for this new refrigerant than for R-134a. On the Sienna, the IHX is called a “sub-cool accelerator type tube” (Figure 3). We’re not sure how this name was chosen, primarily the “accelerator” bit. We heard speculation that it might refer to “acceleration” in cooling efficiency, or that the use of helical (spiral) grooving on the IHX suction tube might convey a sense of acceleration. But whatever the reasoning, it’s an IHX. The purpose of the spiral grooves, which are on the inner tube wall, is so the tubes can be bent without being crushed in the bending process.

What is “thermodynamics?” To keep it simple, it’s the physics that deal with the relationships between heat and other forms of energy. In A/C, we use mechanical energy with a chemical refrigerant, with favorable properties to transfer heat from the passenger cabin to the great outdoors.

What is an IHX? Basically, it’s a heat exchanger that uses the cool refrigerant vapor from the low-pressure (suction) side of the system to “sub-cool” (further cool) the hot liquid refrigerant that is flowing from the condenser to the expansion device (orifice tube or thermal expansion valve). If that hot liquid refrigerant contains some vapor because the weather is hot and the condensation process was not completed, the IHX should finish the job. The IHX sub-cool effect may be in addition to the performance of the sub-cool section of many condensers, which as an example,

ALSO INSIDE THIS ISSUE:

TXV VS. THE ENTIRE EVAPORATOR ................................................................. 4
AMBIENT TEMPERATURE DISPLAY—A DIY SOFTWARE FIX .................................................. 5
SOME MORE ON SOFTWARE—“SMARTKEYS” ............................................................... 5
KEEPING YOUR RECOVERY MACHINE OPERATIONAL ................................................... 5
CLOSE BUT NO CIGAR ................................................................................................. 6
THOSE ON-BATTERY POWER DISTRIBUTION CENTERS ............................................... 7
DO YOU LIKE COPPER-BRASS? .................................................................................. 8

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is what we find on the Sienna (Figure 4). With a sub-cool condenser, there normally is minimal vapor. But the addition of the IHX’s sub-cooling effect on the liquid refrigerant means that the refrigerant will have even greater capacity to absorb heat when it flows into and through the evaporator, improving system efficiency. Sub-cooling the hot liquid refrigerant that’s flowing to the expansion device is the primary function of the IHX.

Because the low-pressure side is the “more active” side (providing the low-temperature refrigerant that vaporized in the evaporator and is on its way to the compressor), the IHX is often called an SLHX, for suction line heat exchanger.

Although the refrigerant absorbed heat from the passenger

![Diagram](image)

**Figure 3:** This is the internal heat exchanger arrangement used by DENSO on the Toyota Sienna R-134a system. Notice in illustration at left, the spiral grooves formed into the exterior of the inner tube, which in this case also is the low-pressure side (suction) line. The high-pressure liquid refrigerant flows through the space around that spiral-grooved tube. At right is the layout of the IHX in the complete A/C system.

![Diagram](image)

**Figure 4:** Although most systems have a sub-cool condenser section at the top or bottom (in this case at the bottom), the liquid refrigerant flowing to the IHX is further sub-cooled, which increases its capacity to absorb heat in the evaporator.
cabin when it passed through the evaporator, and emerged from the evaporator perhaps a couple of degrees warmer (called “superheat”) it’s still pretty cold, as you’ve learned when your hand touched the suction line at the evaporator outlet (Figure 5). So when low-side cold refrigerant vapor flows through the IHX, it can make a real contribution to heat transfer from the high-side liquid line.

Further, there also could be a benefit on the low-pressure side: as a practical matter, there’s always some liquid droplets in the vapor exiting the evaporator. By transferring heat from the liquid line, the IHX vaporizes any remaining liquid in the low-side line, so it doesn’t get to the compressor, where the liquid would vaporize, reducing compressor efficiency.

In real-world terms, designing and installing an IHX is a delicate balancing act for the OE integration engineers. Yes, any droplets of liquid refrigerant in the low-side vapor will evaporate, and the absence of liquid in the vapor going from the IHX to the compressor improves compressor volumetric efficiency. But if the temperature of the vapor were to rise too much, the vapor would become less dense. And the refrigerant exiting the compressor would be hotter, which could impact the condenser and durability of the compressor. So the condenser has to be designed to deal with this effect.

Although an OE engineer has to design the IHX to work well in the particular system from performance and efficiency standpoint, packaging considerations usually are factors too. However, an IHX itself can’t be just “whatever fits.” It has to allow low-side vapor flow with minimum pressure drop, and it has to be an efficient heat exchanger, but balanced with the rest of the system. So the compressor inlet vapor temperature and pressure don’t go up so much they affect system efficiency. Testing also indicates that for a particular refrigerant, there are IHX size limitations, particularly length.

The IHX has a lab-demonstrated value in system efficiency, perhaps up to 10-15% for R-1234yf, somewhat less for R-134a. An IHX offered an even more significant improvement in R-744 systems (carbon dioxide as a refrigerant), but other factors, particularly cost of robust components and thermal performance in hot climates, gave the edge to a chemical refrigerant. R-1234yf has different thermodynamic properties than R-134a, and on a straight exchange basis in an R-134a system, its performance and efficiency suffers. However, R-1234yf has inherently lower compressor discharge temperatures than R-134a, and with the increase in sub-cooling from the right IHX, an R-1234yf system will provide a bigger boost in thermal performance in the evaporator. So a well-tailored system can be an environmentally-acceptable replacement for an R-134a one.

As should be apparent, the IHX must provide a careful balance among such factors as heat exchange efficiency and low-side pressure drops. Therefore, a replacement IHX for any system must be at least the equal of the OE-engineered part in both areas. Specific condensers and high-strength evaporators (that meet SAE J2842) also will be of great importance. The suction line must be sized (usually larger diameter for R-1234yf than R-134a) to minimize pressure drop, as R-1234yf has greater density.

The shape of the IHX and its length both are key factors in its performance, and engineering tests have shown there are performance limits in the sizing, particularly as noted earlier, in shape and length (because after a certain point, the pressure drop can become an issue). Another factor may be the amount of oil in circulation with the refrigerant. Oil coats the walls of the tubing, which helps maintain a relatively uniform temperature on them throughout, and that is helpful. However, oil is an insulator, and can lower the effectiveness of the heat exchange process, possibly reducing IHX efficiency. Further, the more oil that is kept in circulation through an A/C system, the greater the effort that must be expended by the A/C compressor. So there is a modest trend we’ve noticed to sharply reduce the amount of oil used by the system, and keep most of that oil primarily within the compressor by use of baffles. Fortunately, it takes very little oil circulating through the system to mix with trace dyes, but with less oil in circulation, it may take somewhat longer for the dye to show a leak.

The effect of an IHX will vary according to the system and how well the IHX is designed for it. If someone comes up with a great balance, the temperature of the refrigerant exiting the compressor, even with an IHX, might be no higher. But if the temperature is much higher under peak operating conditions, that would not be unexpected for even a cool vapor going through an effective IHX. And as noted earlier in this report, that would call for an improved condenser.

These heat exchanger performance factors mean that for aftermarket parts manufacturers to compete, their engineers will have to design heat exchangers that not only fit, but provide the thermal and refrigerant flow performance required. The best price you’re quoted for an A/C heat exchanger – including as we’ve shown, the IHX – has to be way down on your list of requirements when parts orders are placed, certainly as both R-134a and R-1234yf systems are upgraded for efficiency.

There are two basic types of internal heat exchangers that have been designed for auto air conditioning systems. If it’s an accumulator/orifice tube type, the accumulator is likely to be modified to accept a liquid line loop, for packaging reasons. If it’s an expansion valve system, the IHX could be a cylindrical can type, like an accumulator. But the coil-within-a-coil design

Figure 5: Grasp the low-pressure side (suction) line at the evaporator outlet as shown. It’s certainly cold, and as the cold vapor flows through the IHX, it can absorb heat from the liquid refrigerant flowing to the evaporator.
(in some cases U-shaped), seems to be what the industry has chosen to use at this early stage. The tubing is round or multi-path, and may have dimpling to improve heat transfer. Or as on the 2011-12 Sienna, there are helical grooves embossed in the exterior of the inner (low-side vapor) tubing. The high-pressure liquid flows through the space between the grooves, which causes it to maintain contact with the wall of the inner tube for a longer period, increasing heat transfer.

Everything we’ve seen and heard about the IHX indicates that it will have a major impact on system performance with both refrigerants, and the efficiency improvements are likely to go up as the engineers learn more about this component in automotive applications. The IHX-provided increase in evaporator thermal performance already permits a reduction in the amount of refrigerant that one would otherwise expect might be needed with an additional heat exchanger. Which for R-1234yf, helps offset some of its higher cost. And if there’s less refrigerant required for the system – R-134a or R-1234yf – that equals less refrigerant to pump around (along with less oil), which translates to higher system efficiency. The Toyota Sienna, for example, has exactly the same R-134a charge on a 2011-12 model with an IHX as the 2010 without the IHX. In one European model Volkswagen, the IHX performance boost reportedly permitted the use of a smaller displacement (and less expensive) compressor than originally thought would be necessary, while maintaining the same cooling capacity.

Why is all this effort being expended to improve A/C efficiency? The answer is that A/C operation now is included in one of the Environmental Protection Agency’s test cycles for emissions and fuel economy. And EPA gives the car manufacturers “credits,” in carbon dioxide grams per mile, for both system efficiency improvements as well as improved sealing to reduce leakage. The use of an A/C refrigerant with low global warming impact, such as R-1234yf, carries a special credit. All these credits impact the Corporate Average Fuel Economy number (CAFE), which you should understand is not what’s on the window sticker. But it’s what the car manufacturers have to meet to satisfy Federal fuel economy mandates. In Europe, all new platform vehicles since January 1, 2011 were legally mandated to use a low-global-warming refrigerant, and R-1234yf was the choice. But lack of supply led to few installations and a moratorium on enforcement. However, the supply issue is expected to be solved by late Fall, and on January 1, 2013, European enforcement will begin.

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**TXV VS. THE ENTIRE EVAPORATOR**

Nissan says do not replace the evaporator or HVAC case just because the expansion valve is bad. The TXV is available as a detail part for 2002-10 Altima, 2004-10 Armada, Maxima and Titan, 2004-09 Quest minivan, and 2005-10 Pathfinder and Xterra. There’s no comparable bulletin for the Infiniti line, but the principle is the same. In fact, it’s applicable for just about every make of vehicle.

Okay, if the TXV is accessible under the hood, as it often is, there’s really not much of an argument. You replace just the TXV.

But when it’s mounted in the HVAC case with the evaporator, and you have to remove the case for access, a lot of shops will order a new case – with evaporator and TXV (Figure 6). Or if they call the dealer, they may be told that a complete case is all that’s available. The meaning of the word “available” can be “it’s all that the factory supplies to us” or “it’s all that we ever order and stock.” If a dealer parts department wants to limit its stock, a complete assembly is the easy way, certainly a more profitable approach if independents really will be able to convince the customer that the expensive assembly is the only way to get the system fixed.

Some independent shops may be reluctant to use aftermarket expansion valves, certainly if they’ve ever had problems with them (although we have reason to suspect that sometimes, “problems” with aftermarket TXVs may be related to diagnosis. That is, the TXV is not the actual problem, so replacing it doesn’t fix anything. Or there’s debris in the system, so the aftermarket TXV ends up serving as a filter, and soon plugs, with an OE replacement from the car dealer coming next and being “the right part at the right time” (yes, timing is everything).

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Figure 6: If the expansion valve is up against the firewall, you’d surely replace it alone if it were defective. But in this case, a 2008 Nissan Xterra, the TXV is in the evaporator case, which must be removed and disassembled for access. The repair should be the same: replace just the TXV, unless the evaporator is found to be leaking. Avoid the temptation to install a complete evaporator case.
The need to take apart the HVAC case for replacement of the TXV does make it tempting to just bolt up a new case, but an independent shop should be looking to develop its reputation for doing just the appropriate repair. And with OE (and aftermarket) expansion valves available, that’s only what should be installed. Yes, there’s likely to be debris on the evaporator core face and in the case, and you’ve got a legitimate reason to charge for cleaning. But unless there’s oil (or trace dye if there’s dye in the system) on the evaporator or on the inside surface of the case, indicating a leak, that’s as far as you should go.

Even if the TXV is available as a detail part only from an aftermarket source, obtain it from your most reliable one. If you’ve performed your diagnosis correctly and you come up with “change the expansion valve,” that’s what you do, and a major aftermarket supplier’s TXV will ever so rarely be a problem. If there’s any question about debris in the system, install an in-line filter for insurance. This approach still will be far cheaper than a new case.

**AMBIENT TEMPERATURE DISPLAY—A DIY SOFTWARE FIX**

Software engineers for automobiles have to cover a lot of possibilities with computer strategy, and sometimes they don’t get it right. But often, they have an objective, and think that the other possibilities are just too remote to try to cover with some algorithm. That’s when we periodically get the “it’s supposed to work that way,” even if the customer doesn’t like it.

General Motors’ full-size crossovers and SUVs have an ambient temperature strategy that can cause the A/C to fail to come on, and since the complaints, there’s at least a do-it-yourself fix. What you may hear from the motorist is “Very often the A/C doesn’t come on unless I drive it for a while.”

If you question the motorist carefully, you may find that it happens on a warm morning after a cold night, as is often something you’ll see in desert areas. Ask the motorist to read the ambient temperature display the next time this happens, and he may say, “It reads low, although eventually it catches up. But the A/C may come on sometimes, and the display reads the correct temperature.”

Well yes, that’s the way it works, because if the ambient drops to 36 degrees F or below, as can happen overnight in the desert, and the car is restarted in the morning, the ambient display will update immediately. But suppose a family member is out with the car until the wee hours, while it’s cold, and parks the car. Another family member arises and takes the car to work a couple of hours later, when ambient temperature has risen. The temperature display will not immediately update, and if the motorist turns on the A/C, it won’t go on.

At this time, there’s no new software to address this issue, but the motorist can simultaneously press and hold the RECIRC and A/C buttons on the control head, and the temperature display should update within a few seconds. After that, the A/C should work.

**SOME MORE ON SOFTWARE—“SMARTKEYS”**

Nissan encountered the “smartkey” issue with its new Juke sporty crossover, and with all the smartkeys in use, and just so many suppliers, it’s certainly is possible across other makes—no one can tell you it can’t happen (and we have heard anecdotal reports on other cars): the customer drove the car into the shop, left the key with you, and now it won’t start. The cause: you have smartkeys from other cars in your pocket, and one is sending a false signal to the vehicle electronics, which “thinks” that maybe someone is trying to start the wrong car, perhaps even a thief.

Many of us have encountered a situation where we think we’ve arrived at our car in a parking lot, and we get into the wrong car (or we can’t get into what we think is our car). But the intelligent key miscommunications on unlocked cars are another matter, and the Juke is an example that says they do happen, as unlikely as some software engineer who’s written the rolling code for one of these keys may think it is. So hanging up all the keys on a pegboard and taking just the one for the car you’re going to work on should become a work habit (and maybe don’t forget the smartkey for your own car in the process).

**KEEPING YOUR RECOVERY MACHINE OPERATIONAL**

When your recovery/recycle/recharge (R/R/R) machine is misbehaving, and it isn’t just a matter of a used up filter locking it out, a defective power cord plug or another obvious issue, you may figure you’re out of A/C service until you can get it fixed. But although not required, the machines that meet SAE J2788 (and the upcoming SAE J2843 for R-1234yf R/R/R machines), have a lot of on-board electronics, including diagnostics.

We saw some of the procedures for the Ritchie Yellow Jacket 37880, and the first two are ones you’ll see for most machines, in the operator’s manual. One is a troubleshooting chart for mechanical problems and simple electrical issues. So keep the operator’s manual in a location where you store all service equipment manuals, warranty data, etc., including consumable parts (calibration bottles, filters and perhaps sensors for your electronic leak detectors, filters for your refrigerant identifier, replacement filters for the recovery machine, etc.).
Okay, we’ve been making the point that (a) electronic parts substitution frequently doesn’t work on late-model cars, and could cause an electronic “mess”; (b) you’ve got to get the right part, and today that includes using the VIN. But there seems to be the impression that on older cars, particularly before CAN (Controller Area Network) started (coming on strong around 2004, and mandatory by MY 2008), you had much more flexibility. Maybe not.

The 2002 Audi S6 Avant Wagon is over 10 years old, and the A/C clutch won’t engage. The technician checks the wiring diagram (logical move) and finds that Audi (like VW) uses “track type” diagrams, which may be the most annoying we’ve seen. First, no parts are labeled with actual names, just numbers, so you have to keep referring to a legend; second, the numbers appear only on one diagram “track,” and if you’re on another, you have to find the one with the ID. So we’ve labeled everything (Figure 8) and you can see it’s a pretty straightforward clutch circuit with a relay and fuses.

Second, the machine’s digital display may produce one or more error messages, and you’ll find explanations (with recommended repair) for them, also in the operator’s manual, possibly also on a coated card you can store in a machine drawer.

Still no solution? If you call the tech support department at the manufacturer of your machine, the people there can talk you through a more sophisticated troubleshooting procedure using the onboard diagnostics, and ship the needed repair part via an overnight delivery service.

The Yellow Jacket machine offers an additional possibility: it is capable of being remotely diagnosed (and having update software installed) by the Ritchie tech support department, via a USB connection from the machine to a PC with an internet connection (Figure 7). The Yellow Jacket refrigerant system analyzer, which was designed for commercial refrigeration but also usable for auto A/C, also can get software updates from the Yellow Jacket website.

Figure 7: Like most other J2788-spec R/R/R machines, the Yellow Jacket 37880 has extensive onboard diagnostics, and also has a USB port to connect to a personal computer, for remote diagnostics by company’s tech support department.

Figure 8: One of the “tracks” in the Audi S6 track-type diagram. We’ve labeled the parts so you can see it’s basically a straightforward A/C clutch circuit from the A/C control head to the clutch relay and the clutch itself. It’s tough to fit in all the labels, which is why you won’t find them on the VW/Audi track diagrams, but it does make it more difficult to identify parts, as even the numbers that are used will appear on only one of the entire series of tracks.

CLOSE BUT NO CIGAR
The technician grounded relay terminal 86 (labeled 4/86 in the diagram), the clutch engaged, and the system produced cold air and normal pressures. He decided that the A/C control head was not providing the relay ground, so he got a used one. He cleared codes, but a code for the coolant temperature sensor circuit appeared. He could find no circuit problem, so he replaced the sensor, which he was told was a common failure. The code returned.

He tried the old control head, and the coolant temperature code went away (indicating an issue with the used control head), but he still had the A/C clutch problem. At that point, he checked the part numbers of the two control heads. They were close, but not the same (and the used head didn’t provide recirculation in Auto). Yes, we’ve occasionally heard about the used part that fit, that “came close” to working right (key functions were operative), and because of the $$$ saving, was worth it. But as with many things, there are unintended consequences.

Also, sometimes there are “superseding” part numbers, but unless you can confirm them, “close” is never good enough. Ask the technicians who have worked on Ford Escorts for examples with the CCRM (Constant Control Relay Modules).

THOSE ON-BATTERY POWER DISTRIBUTION CENTERS

If you’re a MACS member who reads this newsletter regularly, you may remember our April 2010 article on power distribution centers (PDCs) mounted on the tops of the batteries on late-model VW Golfs and Beetles, and Audi TTs. Knowing about these PDCs is important, because they’re a high-failure rate item, and one of the three European plug-in fuses (S-180) is for the radiator electric fan, and one of the fusible links (S-164) is a 40-amper for the fan control module.

However, the PDC “box” itself is a sealed sandwich design, and usually you need the whole thing, not just a fuse or fusible link, because under hood heat causes one of the fuses to not just fail, but melt and damage the box. However, in one of those contrasts with our earlier comments about dealers stocking complete HVAC cases and complete compressors rather than the detail parts you need, the VW situation seems to be different: the box is a blank, and you have to order all the fuses and fusible links separately — or change over the usable ones from the old box. An aftermarket company (actually an offshoot of Standard Motor Products – SMP—the company that includes Four Seasons) is selling a new line of problem solvers. The product line is “TechSmart by SMP” (techsmartparts.com).

It’s a pretty broad line, including such things as EGR repair kits, turbocharger oil drain tubes, and taillight circuit boards — and it includes that VW/Audi PDC as a complete assembly — with all the European fuses and fusible links neatly installed with the studs and nuts, and the connecting red (positive) cable (Figure 9). We first saw a variation on this type of PDC on a Toyota product about 11 years ago, and haven’t seen it since. But its appearance on VW/Audi probably indicates it’s something you’ll be seeing more of. So if you’re looking for an aftermarket source with a convenience factor, this is it.

We should point out that the VW/Audi one includes three fuses, whereas the Toyota one did not—the Toyota application was just a series of fusible links. And on the VW/Audi, it is the melting of the box around the fuse from a fuse failure that creates the need for replacing the box. So when you’re changing the complete box, also check current draw in the circuit to help avoid a repeat failure.

TechSmart also is marketing a line of HVAC actuators that SMP has found have a high failure rate, which depending on the vehicle mix in your shop, might seem to be “all of them.” The replacement actuators...
are physically stronger, and although the company has 43 actuators available as this MACS Service Reports goes to press, the first four released – blend-air actuators to meet special demand (Figure 10)—are for these vehicles (we’re not including part numbers; get them from the website or your parts supplier):

- Jeep Grand Cherokee – 1999-2004 for Automatic Temperature Control systems. This is the only Chrysler application. All others in the TechSmart parts line are for General Motors and Ford products.

DO YOU LIKE COPPER-BRASS?

Many shops that encounter heater core failures in this era of aluminum cores blame them on electrolysis (and sometimes it is), but they recall fewer problems with copper cores. If you’re one of those shops, you’ll be happy to know that once more, there is copper-brass in the U.S. aftermarket (for some Ford products at this time), from ProSource (www.prosourceheatercores.com). These heater cores, exhibited at the 2012 MACS trade show, are Asian imports, and sorry, they’re not sold directly to shops, but through manufacturers looking to supplement their lines. So if you’re looking for a wholesale source, you’ll have to call the company’s Fort Worth, TX headquarters at 817-546-6528 or e-mail from the website. At present, the company has five copper-brass heater cores for certain Ford products covering model years 1995-2005.

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