

Cracked Heat Exchangers—Legalities, Methods of Detection & Tools

Tech to Tech Column--December 07

“Make daily deposits to your box of knowledge, soon it will have many reference cards.”--Randal S. Ripley

This month we are going to focus on the importance of a company having a set procedure in place for checking a heat exchanger for cracks, plugged ports or any other signs that the integrity of the heat exchanger has been compromised and some of the tools and procedures available for the service technician to find these defects.

Because entire manuals have been written on this topic and we can only scratch the surface in three pages, this article should in NO WAY be considered anything other than the catalyst for companies and/or technicians to research tools and testing procedures that would best protect them from the liability for and the customer from, the heart break of a possible tragic situation.

To my knowledge there is no single check available that will find a crack in a heat exchanger 100% percent of the time and cracked heat exchangers result in less than 1 percent of carbon monoxide poisoning events.

The heat exchanger of a furnace separates the combustion side from the air side, keeping the flue gases from mixing with the supply air and transfers the heat from the combustion of the fuel to the air blowing over the heat exchanger. I know this is a simplified explanation of a heat exchanger but you can reference last months “Venting & Draining Condensing Gas Furnaces” column and other sources if you need further information on heat exchangers.

Henry Heatingman, a service technician for Heating is Us, goes out to Mr. & Mrs. Joe Q. Publics house to do a preventive maintenance call on their aging furnaces. After replacing the filter, verifying what type of gas he is dealing with, checking his inlet gas pressure with his manometer and then moving the manometer to the outlet side of the gas valve to check manifold pressure on start up, he fires up the unit. He immediately reads his gas pressure and then before the blower starts, he does a visual inspection of the flames noting that they are blue and firing straight down the tubes.

When the blower started he noticed an immediate change in the left burner flame. It was dancing and coming back out of the heat exchanger cell (this is a clam shell heat exchanger but could just as well be a tubular heat exchanger). Henry knows that flames should not come out of the heat exchanger when the blower starts or any other time and that this is better known as *flame rollout*.

Flame rollout can be caused by a few different things:

1. Inadequate combustion air that will cause the flame to rollout seeking oxygen
2. sooting from incomplete combustion that will eventually plug the tube or cell
3. A crack in the heat exchanger tube or cell that allows the higher positive blower pressure to enter the negative pressure heat exchanger, pushing the flame out of the cell or tube opening
4. The gasket material breaking down and allowing the blower pressure to leak into the exchanger

Because the rollout didn't occur until the blower motor came on, Henry knew this problem was a clear sign of a cracked heat exchanger, possible leak in a gasket or one or more of the pressed rings that help hold the clam shell style heat exchanger together, had let go. He also knew that the pressed rings were known to fall off and allow blower pressure into the heat exchanger on aging units.

Since the problem only started once the blower came on, Henry removed the blower motor assembly in order to get a better view of the heat exchanger and found two of the rings in the bottom of the heat exchanger area.

The manufacturer of the unit in question says to use a bright flashlight to visually check the heat exchanger tube(s) and if any sign of the heat exchanger being compromised is found the technician should shut down and disable the unit.

Even though Henry did not find a crack or breach of the heat exchanger, the flame rollout and the broken rings justified his shutting down of the unit according to the manufacturer's specifications.

He explained to the customer the situation and that the exchanger or the unit itself had to be replaced and duly noted this on his service invoice and asked the customer to sign that they had read his warning.

But what if the customer took you to court claiming you didn't need to shutdown the unit and traumatize him and his family by leaving them without heat for an evening? Would following the manufacturers instructions hold up in court?

NFPA 54, annex H says "If it is determined a condition that could result in unsafe operation exists, the appliance should be shut off and the owner advised of the unsafe condition." Note: The Annex section of NFPA 54 is not part of the code but is included for informational purposes.

Service technicians generally leave a legal document behind on every call, the service slip, and need to know that they must inform the customer on this document of any potential or definite problem with the equipment. Courts have ruled that failure to inform the customer in writing is telling the customer the equipment is operating properly. This not only opens you up to a possible negligence claim, but can also leave you liable for a potential tragedy.

In a court of law, tradesmen will get a quick and sometimes painful lesson in "standards", which is a customary practice or acceptable operating procedure; because with all equipment inspection there is an implied warranty, a company or technician needs to always ask themselves "would I be able to defend these inspection procedures in court?"

Because the court could possibly consider standards that have been generally accepted by trade associations or testing organizations, technicians and/or business owners should always be cognizant of the test procedures available to them and what some organizations have determined a proper heat exchanger inspection to entail.

For example, GAMA (Gas Appliance Manufacturer's Association) funded a study by the GRI (Gas Research Institute) in 1986 that was published in the RSES (Refrigeration Service Engineers Society) SAM for heat exchanger 630-92 9/86. This study determined that a three part procedure was necessary to determine the integrity of a heat exchanger.

1. Observe the flame before and after the blower motor comes on to see if there is any change to the flame characteristics when the blower comes on. If the flame characteristics change it could be an indication of a possible split seam, open crack, severe deterioration of the exchanger or gasket material or physical separation of the connected parts
2. Perform a visual inspection of the heat exchanger. Look for rust, warping, holes, cracks or other signs of deterioration. Visual inspection can be very limited in residential units because of evaporator coils or the shape the exchanger.
3. Perform a chemical test on the heat exchanger. This test is done by introducing a chemical into the exchanger and using a device that detects the chemical at the supply grills

Although no agency has approved or certified this three test inspection method, it encompasses all the necessary methods expected by RSES, GAMA and other trade organizations and is therefore a standard in the HVAC industry.

Before discussing some tools and methods used in heat exchanger inspection, I want to debunk a few myths about cracked heat exchangers:

1. That you can test for carbon monoxide at the register if there is a crack in the heat exchanger. This is a total waste of time in most cases because the blower motor of a residential furnace is positive and the combustion side of the heat exchanger is a negative, the much more powerful positive pressure is going to infiltrate this negative pressure and keep carbon monoxide from escaping into the air stream to the conditioned space except in severely open heat exchangers. Where carbon monoxide is more likely to show up is at the burner port of the cracked cells because the blower pressure is infiltrating the exchanger and pushing it out of the cell or tube openings or in the flue gasses going out of the vent.
2. A crack is open at all times, this is not true and a crack may only open up when the metal of the exchanger is hot
3. Heat exchanger failures are usually manufacturer defects. Factory testing of heat exchangers has shown that most field failures of cracking, burn-through and warping were not manufacturing quality or design related but the direct result of not following installation instructions or application related issues such as:
 - o Excessive temperature rise due to restricted airflow (blocked or restrictive filters),
 - o Poor duct design causing excessive static pressure and low airflow
 - o High manifold gas pressures resulting in over-firing
 - o Chemicals in the combustion air zone that cause corrosion when burned in the heat exchanger

Now let's look at some of the tools & procedures available today. Then after further research, you can draw your own conclusion as to what is best for you to protect your company and set a standard for your technicians.

Please follow all test equipment, manufacturers and/or company guidelines when testing any heat exchanger.

In the past there has been many different tests suggested with vary degrees of success such as the smoke bomb test, the winter green test, the salt test, the pressure test, the tracer gas test, the flame distortion test, the visual test, with the flame distortion test being the easiest and the visual the most reliable.

As we all know a residential furnace with an A/C coil is not visual inspection friendly like say most rooftop package units that you can pop the top off and look at the exchanger itself. That is why there are many different styles & shapes of telescopic mirrors available for viewing places otherwise not viewable.

Another way is to do a combustion analysis on the unit while paying particular attention to the O₂ (oxygen)/CO₂ (carbon dioxide) readings. These readings usually stabilize 30-60 seconds after ignition, using a combustion analyzer to monitor these readings when the blower comes on is a very reliable way of determining the possibility of a crack in the heat exchanger.

When the blower comes on if a crack is present, air at a constant 20% O₂ can be blown by the higher pressure blower motor into the heat exchanger **increasing the O₂ levels** (O₂ levels will usually be no higher than 5-10 percent because of usage in the combustion process) or **decreasing the CO₂ levels** that will be read on the analyzer.

This method only tells us of the possibility of a crack and now the technician must locate it. A visual inspection scope would come in handy at this time. These tools can have switch able low and high beam lights on the viewing lens, a 36" or longer flexible probe (expandable to 96" on some models) that allows you to insert it into the cell or tube of the heat exchanger you suspect of being compromised and viewing the cell or tube walls on a LED screen. Remember to pay special attention to rust spot or lines that can show to be small holes on close scrutiny.

When used together, these two detection methods are very reliable in determining if there is a crack in the heat exchanger and locating it. They are also much easier and less time consuming than many of the "old school test."

Right now a popular tool brand name is selling one of these scopes at the big box store with the orange signs for around two-hundred bucks. Think of the opposite of flexible and the tools brand name should quickly come to mind.

I have had a few technicians rave about it to me but please understand this is not an endorsement of the product but a lead for you to check into yourself.

Just like you would show the customer a broken part or the results of a combustion analysis, it is absolutely imperative that you show any cracks found to the customer, this leaves no doubt in their mind that the exchanger is indeed compromised.

Remember that whether you can find the crack or not, if any of the tests you perform indicate a possible cracked heat exchanger or any other potential problem with the vent, combustion air, safeties, etc, etc, you must put this in writing on the service slip. If the customer refuses to sign, note that also. In today's law suit happy society, you can never CYA enough.

I am not trying to favor any method over the other and if you are having success with the methods you are using, then you should certainly continue to use them. I would be very interested in hearing what methods and tools "work for you". You can reach me with any questions or comment at randal@totalairsupply.com or 603-889-0100.

Have a Merry Christmas & a safe New Year. Hopefully Santa will bring you some cool toys and/or tools instead of a lame tie or shirt.