Ammonia Absorption Refrigerators

I'm going to date myself here, but when I was a child, I remember the old refrigerator my aunt and uncle once had in the garage that had this tower on the top of it that put out a lot of heat. Being inquisitive, I asked my uncle what that was and he said it was "a cooling tower". I couldn't understand why a "cooling" tower put out so much heat! Well that old refrigerator was an ammonia absorption refrigerator, manufactured well before the days Freon was popular as a refrigerant. In fact, the first absorption principal refrigerator was invented in 1858 and in 1923 the first ammonia absorption refrigerator was available for sale to the public. They replaced the old "ice box" which used blocks of ice for cooling (that's where the nickname came from). Although Freon based refrigerators were available in the 1920's and 1930's, they didn't become common household appliances until 1940's, and has continued to be improved upon ever since.

So why are they not around anymore – well guess what, you probably have one in your RV right now. As a matter of fact, ammonia absorption technology is still widely used today in commercial cooling applications, like packing houses. Ammonia absorption refrigeration technology has come a long ways since the days of the old "cooling tower" model.

So why don't you have a Freon based refrigerator in your RV? Well, many higher end RV's do, but there are drawbacks I will discuss later. Basically it's a matter of energy consumption and efficiency.

All refrigerators are *heat exchangers*. How they exchange heat can differ depending on the type of refrigerant used, but the bottom line is they *remove heat* from food compartments and displace that heat to the outside environment thereby creating a cooling effect inside the food compartment.

The drawback to a Freon based refrigerator's use in an RV is the amount of energy it uses for the heat exchange. We all have one in our home, and no doubt you hear the compressor coming on and off during the cooling cycle. A *basic* Freon based refrigerator uses about 725 watts to operate (larger units with icemakers, dispensers, self-defrost and all the other goodies can significantly increase this number), or another RV friendly way of looking at it; it uses about 6.5 amps of your incoming shore power. No biggie, even a 30 amp system can handle that, right? Well, yes….but what about when you're on the road or out dry camping, where's that 6.5 amps going to come from?

Well, if you're driving down the road in a higher end RV, your genset or inverter can power it just fine. That's why some higher end RV's do have residential style refrigerators in them… and the inverter, battery bank and generator to operate it when dry camping.

The reason the residential refrigerator uses so much electricity is the compressor that is required to create the heat exchange. *Residential refrigerators have much better cooling efficiency over the ammonia absorption, but the ammonia absorption refrigerator has much better energy efficiency over a compressor driven system*.

For most of us RV'ers, a residential style refrigerator just wouldn't be feasible. They *always* have to have 110VAC power to operate. Enter the ammonia absorption refrigerator.

I could go on for quite a while about how the principal of ammonia absorption heat exchange works, but in reality there are only a few basics the RV'er should be concerned with:

1) Ammonia absorption refrigerators have no moving refrigeration parts; no pumps or compressors to circulate the refrigerant.
2) Ammonia absorption refrigerators use thermo-dynamics and gravity to operate (more on this later).
3) Ammonia absorption refrigerators can use different types of energy sources; 110VAC electricity, propane, or even 12VDC power to operate.
4) Ammonia absorption refrigerators use ammonia, hydrogen gas and water as the refrigerant.
5) Ammonia absorption systems are a closed system and never need recharging (unless a leak forms – more later).

A pictorial and complete explanation of how the ammonia absorption system operates for those who really want to understand the complex process is available at the end of this article

In a nutshell, the process begins with heat being applied to the "boiler". The heat source can be a flame (LPG), a 110VAC heating element (AC mode) or a 12VDC heating element (DC mode – found on 3 way refrigerators). The boiler heats the refrigerant and begins the circulation process. Throughout the process the refrigerant continues to circulate within the cooling unit absorbing heat from the freezer and refrigerator compartments and displacing it to the outside. The circulation process is never ending, requiring only the outside heat source, thermo-dynamics and gravity to operate.

The ***cooling unit*** is the “guts” of the ammonia absorption refrigerator. On most refrigerators, the cooling unit is replaceable, so in the event of a leak or failure of the cooling unit, the whole refrigerator does not need to be replaced, just the cooling unit.

LEVELING: The pipes visible on the cooling unit are set at an exact angle to earth level. This allows the refrigerant to flow back to the bottom thanks to gravity. This is the reason it is so important for your refrigerator to be level when parked. If parked off-level, the refrigerant cannot flow uphill, and since there are no pumps or compressors to maintain flow, the refrigerant flow comes to a standstill.

At this point, all sorts of maladies start to happen. The refrigerant in the boiler begins to superheat due to the lack of circulation. This can cause the boiler housing to crack and create a refrigerant leak. The super-heated mixture contains an anti-corrosive to protect the metal piping which can solidify and plug up the cooling unit. Continued use in an off-level condition can even cause a fire danger from the excessive heat in the boiler area. These issues start to happen rapidly, therefore it is very important that if the RV is going to be parked off-level for ANY length of time, turn the unit off. The interior will remain cold for a long time provided the doors are not opened.

During travel, the constant motion of the RV keeps the refrigerant from stagnating and this is one of the great benefits of the ammonia absorption refrigerator is its ability to continue to operate during travel using only a minimal amount of energy to operate.

It’s important to remember that although you may be operating your refrigerator in electrical mode or even LPG mode, the *control circuit* is powered by your 12VDC system. Therefore if you experience a problem with your 12VDC electrical or out dry camping and your 12VDC system voltage drops below 10.5VDC, your refrigerator control circuit can no longer function and the refrigerator will turn off.

The main drawback to the ammonia absorption refrigerator is the efficiency of the units. When compared to a residential refrigerator, the ammonia absorption refrigerator has much less cooling efficiency. This is the trade-off for being able to operate with minimal energy usage. Whereas a residential refrigerator will reach temperature within 1-2 hours of being turned on, the ammonia absorption refrigerator can, depending on ambient temperature take anywhere from 4 to 24 hours to reach temperature.

Ammonia absorption refrigerators are designed to keep cold food cold and frozen food frozen. When stocking your refrigerator, after it has reached temperature, it is important to put pre-refrigerated or pre-frozen items in it. Because of the limited efficiency of the units, if asked to bring room temperature items down to refrigerator temperature, you're asking the cooling unit to remove a lot of heat. As an example, if you put in a cold 6 pack of soda, there is relatively small amount of heat that the unit has to dissipate in order to bring the sodas to refrigerator temperature. On the other hand, if you put in a warm 6 pack of soda, there is a tremendous amount of heat the unit has to remove to bring the sodas to refrigerator temperature, and it may take 4 or more hours to perform this task. In the meantime, the heat radiating from the warm 6 pack to its surroundings will inevitably cause the entire refrigerator temperature to rise before the 6 pack cools. The same principal holds true for the freezer section. You should try to avoid putting warm or hot left-overs in the ammonia absorption refrigerator for the same reason. Small amounts of left-overs at room temperature are usually not too much of a feat to ask the refrigerator to cool down, but be attentive to this limitation.

Heat exchanger – what does that mean? Well, basically it is a device that moves heat from one location to another. Your air conditioner is one type of heat exchanger; it *removes* the heat from the interior of the vehicle and displaces it to the exterior of the vehicle. Once heat is removed, the resulting air feels cool, since the heat has been removed from it. That's why if you go to your air conditioner's exterior unit, you feel heat coming from it, that's the heat it absorbed from the interior and is now displacing to the exterior of the vehicle. Refrigerators operate in the same manner; heat is removed from the food compartments and their contents and displaced to the ambient air outside the refrigerator. The problem arises when the outside ambient temperature is warm or hot, it will only allow a little bit of the absorbed heat to dissipate. This can happen when there is a ventilation issue, or just high outside temperatures. Remember, your residential refrigerator sits in your nice and comfortable air conditioned kitchen and doesn't have to deal with high ambient outside temperatures. Your RV refrigerator is at the mercy of the ambient outside air temperature.

Proper, adequate ventilation of the refrigerator is imperative for proper operation. The best configuration for ventilation is the "chimney effect". This consists of the lower exterior sidewall access cover which doubles as the cool air intake for the ventilation system. The heat is exhausted by a roof mounted vent, and operates much like a fireplace chimney does; cool air goes in the lower vent, and the heat rising through the compartment causes the heat to exhaust through the roof vent creating a constant air flow pattern.

In recent years, RV manufactures have started installing refrigerators on slide-outs. This mounting configuration does not allow for a roof mounted exhaust vent. Instead, dual access covers are mounted on the exterior wall of the refrigerator compartment, upper and lower. Unfortunately, this configuration is not the optimum configuration for ventilation. Heat tends to accumulate in the upper cabinet and since there is little or no chimney effect, ventilation fans must be used with this configuration to aid in air circulation. The fan(s) are usually mounted on the rear of the refrigerator just below the condenser fins that are responsible for dissipating the heat. Proper baffling of the upper portion of the cabinet is a must to prevent eddies of air from hindering the hot air from escaping. Most lack of cooling complaints I receive are directly related to this type of installation. In some cases it is poor baffling installed by the manufacturer, in other cases just lack of air flow across the condenser fins which require additional fans to help circulate and exhaust the hot air from the compartment. If you find that your refrigerator temperature “chases” the outside temperature, in other words rises and falls with the ambient outside temperature, you may have a ventilation issue or a weak cooling unit. Exterior temperatures above 102 degrees will affect the operation of all ammonia absorption refrigerators as the air is already saturated with heat and makes the heat exchange process harder or even impossible and will affect the interior temperature of the refrigerator to some degree. Also take into consideration that sun beating on the exterior wall of the refrigerator compartment raises the interior cabinet temperature significantly.

Temperature regulation is based on the refrigerator compartment temperature. An electronic component called a thermistor (temperature variable resistor) is mounted in the refrigerator compartment and reports the refrigerator temperature to the control board which is responsible for cycling the cooling unit accordingly. The way the cooling unit is designed is that the refrigerant first goes to the freezer compartment then the refrigerator compartment. This is why during initial start of the unit, the freezer will feel cold and the refrigerator can still be warm. The refrigerant must first remove all the heat from the freezer compartment before there is left over refrigerant to remove heat (and thereby cool) the refrigerator compartment. Once the refrigerator temperature is satisfied, the control board will begin cycling the cooling unit on and off according to the refrigerator temperature. The normal or optimal temperature for the refrigerator compartment is 38-43 degrees. The freezer compartment will normally maintain its temperature at 0-15 degrees by design and requires no temperature monitoring to maintain.

Should you be unlucky enough to experience a cooling unit refrigerant leak, it is imperative that the refrigerator be turned off and taken out of service until repair can be made. A refrigerant leak can be identified by a smell of ammonia either inside the refrigerator or freezer compartment, or at the rear of the unit. It can also be identified by a yellowish-green liquid or powderish residue either in the food compartments or the rear of the refrigerator. Continued operation of the refrigerator with a leaking cooling unit poses a very high risk of fire. If in doubt as to the possibility of a leaking cooling unit, shut the unit off and call for service just to be on the safe side.

Replacement of the cooling unit is a labor intensive process, and unfortunately a costly repair. Cooling units vary in price depending on the refrigerator model and if you opt for a new cooling unit, or a rebuilt one. There are a lot of companies out there rebuilding (remanufacturing) cooling units, some good, some not so good – so if opting for a rebuilt unit, make sure it is from a reputable company. Sundance Custom RV always recommends new replacement cooling units from the refrigerators manufacturer as these units are a direct replacement and will restore the refrigerator to like new operation.

Cooling unit replacement is depicted in the pictures below, and shows in order the removal of the refrigerator from the compartment, removal of the control system, removal of the cooling unit, prepping for the replacement cooling unit, installation of the new cooling unit, reinstalling the control system and replacement of the unit in the cabinet. Most double door refrigerators take an average of 4 hours to complete this process.










In summary, your RV's ammonia absorption refrigerator is a complicated piece of equipment, and any ailment it may suffer requires a professional repair person to properly diagnose and repair. Given the information in this article, I hope you will better understand how these units are designed to operate and the do's and don'ts of using them properly, and what to realistically expect from them. As always, if you have any questions or problems with your unit, please call me.

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The Absorption System

The continuous absorption type of cooling unit is operated by the application of a limited amount of heat furnished by gas, electricity or kerosene. No moving parts are employed.

The unit consists of four main parts — the boiler, condenser, evaporator and absorber.

The unit can be run on either electricity, kerosene or gas. When the unit operates on kerosene or gas the heat is supplied by a burner which is fitted underneath the central tube (A) and when the unit operates on electricity the heat is supplied by a heating element inserted in the pocket (B).

The unit charge consists of a quantity of ammonia, water and hydrogen at a sufficient pressure to condense ammonia at the room temperature for which the unit is designed.

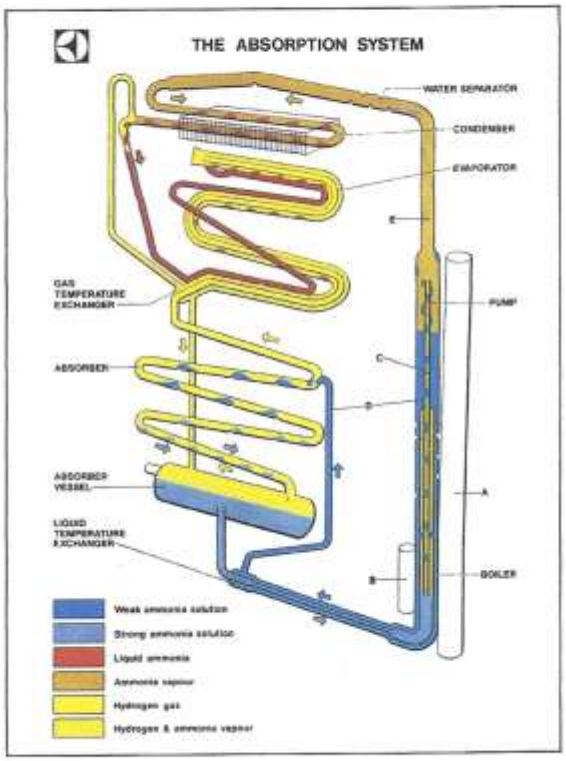
When heat is supplied to the boiler system, bubbles of ammonia gas are produced which rise and carry with them quantities of weak ammonia solution through the siphon pump (C). This weak solution passes into the tube (D), whilst the ammonia vapour passes into the vapour pipe (E) and on to the water separator. Here any water vapour is condensed and runs back into the boiler system leaving the dry ammonia vapour to pass to the condenser.

Air circulating over the fins of the condenser removes heat from the ammonia vapour to cause it to condense to liquid ammonia in which state it flows into the evaporator.

The evaporator is supplied with hydrogen. The hydrogen passes across the surface of the ammonia and lowers the ammonia vapour pressure sufficiently to allow the liquid ammonia to evaporate. The evaporation of the ammonia extracts heat from the evaporator which in turn extracts heat from the food storage space, as described above, thereby lowering the temperature inside the refrigerator.

The mixture of ammonia and hydrogen vapour passes from the evaporator to the absorber.

Entering the upper portion of the absorber is a continuous trickle of weak ammonia solution fed by gravity from the tube (D). This weak solution, flowing down through the absorber, comes into contact with the mixed ammonia and hydrogen gases which readily absorbs the ammonia from the mixture, leaving the



hydrogen free to rise through the absorber coil and to return to the evaporator, The hydrogen thus circulates continuously between the absorber and the evaporator.

The strong ammonia solution produced in the absorber flows down to the absorber vessel and thence to the boiler system, thus completing the full cycle of operation.

The liquid circulation of the unit is purely gravitational.

Heat is generated in the absorber by the process of absorption. This heat must be dissipated into the surrounding air. Heat must also be dissipated from the condenser in order to cool the ammonia vapour sufficiently for it to liquefy. *Free air circulation* is therefore necessary over the absorber and condenser.

The whole unit operates by the heat applied to the boiler system *and it is of paramount importance that this heat is kept within the necessary limits and is properly applied.*