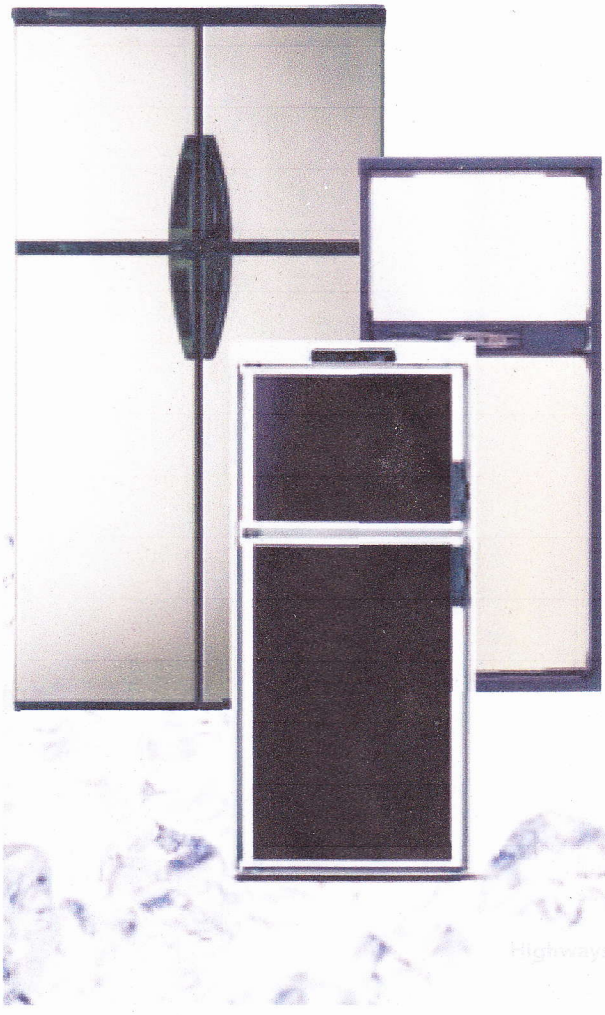
RV Absorption Refrigeration

The Technology of Refurbishing a Cooling Unit

by Gary Bunzer, the RV Doctor

The typical RV absorption refrigerator can truly be an enigma of sorts to many RV owners. It is also a workhorse, often taken for granted. Silent and void of moving parts, the RV refrigerator has seen many advances in technology since its inception.



From the early days of manually lit, constant flame units to today's fully automatic and energy efficient boxes, all RVers have enjoyed the benefits of on-board refrigeration during RVing forays. Execute a quick, rearward glance into history and you will find a heyday when the manufacturing of RV refrigerators was quite prolific with as many as eleven different makers in the field at the same time. Today, however, that number is reduced to two major players, Norcold and Dometic (though Atwood has entered the arena with a new type of helium-filled refrigerator). This article is not intended to convey operational differences between manufacturers; rather, its purpose is to bring to light their similarities and common issues regarding the very heart of the absorption system, the core cooling unit itself.

While the dynamics and the theory of absorption refrigeration have evolved little over time, the controlling of that absorption process has changed greatly with the advent of printed circuitry and automatic mode switching, but the actual application of the theory of absorption remains quite constant still today. It is the cooling unit that holds us vexed in understanding just how we can silently remove heat from inside the refrigerator and in its absence, realize cold. To gain a little understanding, let's review the processes taking place inside the RV absorption refrigerator.

The typical cooling core consists of four major components; the boiler, condenser, evaporators and absorber. Though some components of the cooling unit are hidden inside the refrigerator, portions are visible when viewed outside the RV through the exterior access panel.

1 The cooling unit is a weirdly constructed amalgamation of tubes within tubes connecting the four major components mentioned earlier. Many RVers may be surprised that cooling unit failure, regardless of the cause, always mandates a replacement. Not an inexpensive proposition for RV owners. This magnifies the importance of an annual and aggressive preventive maintenance program to ensure optimum performance of the refrigerator.

The contents of the sealed system include water, liquid ammonia (and associated vapors), hydrogen gas and sodium chromate, a rust inhibitor used to line the internal tubing to protect it from the corrosiveness of the ammonia.

During a typical cycle, heat is applied to the boiler by either an electric heating element or an open propane flame. Water and liquid ammonia begin to boil and ammonia vapor rises up to the condenser, the highest portion of the cooling unit. Any water molecules reaching the condenser are separated and returned to the boiler section. After passing through the condenser and turning back into a liquid, hydrogen gas is introduced to the liquid ammonia at the low temperature evaporator located in the freezer compartment. Heat from inside the freezer is transferred through the tubing of the low temperature evaporator and released to the exterior of the refrigerator.

2 Next, a remnant of mixed hydrogen vapor and liquid ammonia passes to the high temperature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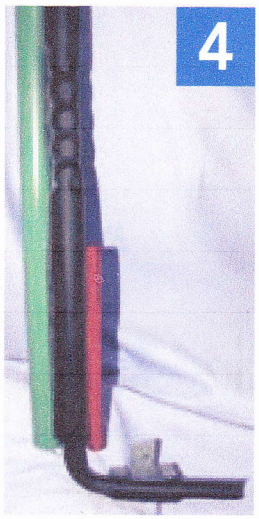
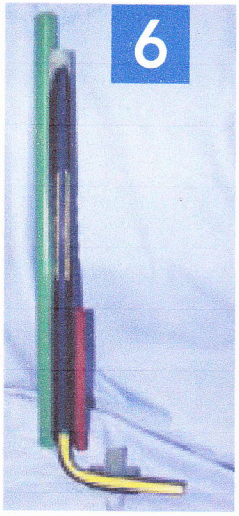
evaporator located behind the main food storage compartment fins and the process of removing the heat continues, albeit less assertively. The food storage compartment/high temperature evaporator becomes cold, but not as cold as the low temperature evaporator in the freezer.

Upon leaving the evaporator sections, the weakened ammonia liquid then flows through the absorber coils. Here the hydrogen gas rises back up to the evaporator sections while the liquid ammonia is mixed with water in the absorber vessel where it is held until flowing into the boiler as the next cycle begins.

From the point where liquid ammonia leaves the condenser until it reaches the absorber and re-mixes with the water, gravity provides the motivation. Off level operation slows the pace and causes overheating in the boiler section. Continued operation in an over-heated condition results in cooling unit blockage whereby the rust inhibitor becomes crystallized and blocks sections of the internal tubing in the boiler. Unfortunately, this process cannot be reversed. The only remedy for a blocked cooling unit is replacement, even though unfortunately, a lot of tales to the contrary are yet told around the campfire.

Let's take a detailed look at the boiler section and what can happen if the refrigerator is run off level while the coach is stationary. Keep in mind, the problems associated with off-level operation pertain to either forms of heat applied to the boiler, burning propane or electricity and only when the RV is not moving. Operating the refrigerator on battery power while driving, (optional on some refrigerators), eliminates the leveling issue altogether. In most cases, there is enough rocking motion while traveling down the highway to keep the contents flowing through the system without the fear of overheating.





3 A damaged boiler section. This unit was obviously overheated by either running off level or by a tubing breach that resulted in a refrigerant leak. These two heating elements were actually welded into their sleeve pockets due to the excessive heat.

4 A cutaway view of the boiler section, (black tubing). The green section is the flue pipe that is positioned directly over the propane burner flame. The red portion is the sleeve or pocket into which the electrical heating element slips. On three-way refrigerators there will be two separate heater pockets.

5 The percolator tube (blue/yellow tube) will be positioned inside the boiler tube. This is the tube that becomes plugged with the crystallized chromate when the refrigerator is chronically operated off level or when a leak develops; both conditions will overheat the boiler section.

6 Here, the cutaway percolator tube is nestled inside one half of the boiler section. Remember, there are quite a few "tubes within tubes" inside the cooling unit.

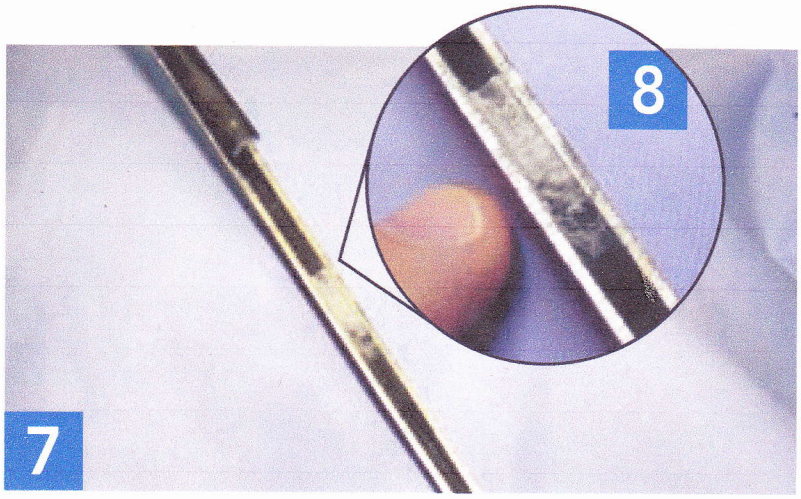
7 Here's a cutaway section of a blocked percolator tube.

8 Because of excess heat in the boiler section, the rust inhibitor crystallized, solidified and completely blocked the percolator tube.

A blocked percolator tube is but one cause of rendering a cooling unit faulty. By far the largest cause of unit failure today is due to leaks in the tubing, especially in those areas imbedded in the polyurethane foam block that surrounds the evaporator sections. It's been estimated that as many as 85% of cooling unit failures are due to leaks in these areas. Here's why.

Cooled tubing within the refrigerator attracts moisture in the form of condensation. This moisture envelops the tubing and is typically retained there because the insulating foam prohibits it from being evaporated. A rust pocket develops and eventually a leak or crack appears. The hydrogen inside the unit is pressurized to over 300 PSI, so any small rusted area is likely to rupture at some point, especially under that kind of pressure. The tiniest of cracks simply cannot hold back the internal pressure behind those small hydrogen molecules. When cracks do occur in visible sections, though infrequently, a yellowish residue will be present and the wondrous odor of ammonia will be quite evident. If ammonia is detected when the refrigerator door is opened, it's definitely time for a new cooling unit. Any crack or leak in the tubing renders the unit inoperable and replacement is, once again, the only fix.

It is this combination of blocked and leaking cooling units that keep many RV repair facilities standing at the ready to install a new or refurbished cooling unit into the RV absorption refrigerator. But are all



refurbished units created equal? The short answer is no.

A quality rebuilt cooling unit is the result of many detailed steps employing precise methodologies coupled with environmental awareness and safety precautions. Here's what happens to some of those faulty units removed from RVs today.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9 In the photo at right, faulty cooling units are staged and prepared for cleaning and flushing. The foam insulating blocks will first be stripped away to reveal all areas of the tubing prior to the start of the flushing process. It is important to purge and flush the cooling unit in order to rid the tubing of any attached deposits inside. It's common for deposits to adhere to the tubing walls, especially if that unit suffered a previous overheated condition.

10 Since refrigerant contains ammonia and sodium chromate, both quite hazardous, special precautions are employed during the flushing process to safely handle and dispose of them properly and responsibly.

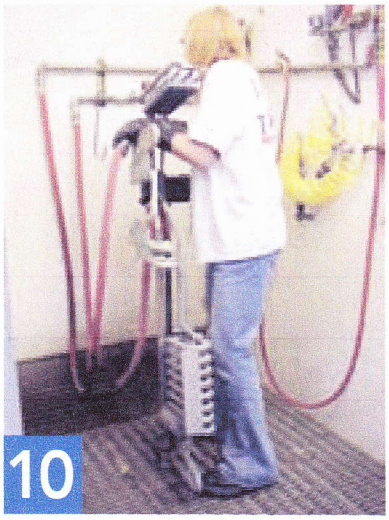
After flushing, any remaining residues are eliminated from the old cooling unit by injecting a high volume of dry compressed air. This rids the core of all hydrogen vapor as well as the remnants of ammonium hydroxide.

All contaminants flushed from the old unit are safely collected, separated and run through a sophisticated process all their own. Quality rebuilders will install environmentally sensitive rooms, just for collecting and processing waste by-products as they are removed from faulty units.

Next, each core is sandblasted so a detailed inspection can be better facilitated. The technician must be able to view every inch of tubing so all rust, scale, paint and dirt must first be removed, especially in the area usually surrounded by the foam pack.

11 As an example, shown to the right, this tiny rupture would not have been visible if the core had not been sandblasted first.

Damaged, rusted and leaking tubing is replaced and new tubes are welded into place. In another process called "sleeving," an overlayment of new tubing covers a damaged area. All tubes are then initially pressurized to about 150 PSI followed by a high-pressure leak test of almost 1000 PSI.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12 While pressurized, the revamped core is fully submerged to verify that no leaks are present. Compressed air molecules are substantially larger than those tiny hydrogen molecules soon to be injected, so in addition to pressurizing with compressed air, each core is subjected to more sensitive chemical leak detection methods. Heat stressing is also employed to locate potential leaks.

After passing all the leak tests, the tubing, which forms the low and high temperature evaporator coils as well as all tubing to be encased within the foam pack, is galvanized. This coats the tubing with 99% pure zinc. The zinc galvanizing contains an inherent cathodic protection


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characteristic that allows it to sacrificially degrade rather than the steel tubing. Remember, this is the area most prone to developing leaks due to moisture entrapment.

This is but one process that delineates a quality rebuilding facility from others. Not all rebuilders use such galvanizing techniques. This indeed adds to the life span of the cooling unit. Now the unit is ready to be recharged.

After being subjected to a deep vacuum, the cooling unit is connected to a charging station that monitors and regulates precise amounts of fresh ammonia, water, hydrogen gas and the rust inhibitor, all of which are injected into the core at a specific pressure as dictated by the size of the cooling unit.

13 Here, the pressure is monitored while the recharging process continues until the specified amount is fully contained inside the cooling unit.

After fully charging the cooling unit, the boiler section is temporarily insulated and a "shop" heating element is installed. Each unit is test run on 120-volt AC electricity to be sure the evaporators ice up, proving a successful recharge. All new welds are then hand tested with a burning sulfur stick that will detect even the slightest leak of ammonia.

After the quick performance test and the battery of leak tests, each rebuilt cooling unit is freshly painted. This is purely a cosmetic, although expected, step in the rebuilding process.

Next, the cooling unit is fitted with a new foam pack, encompassing the evaporator tube set. The new foam is injected into a specific mold affixed to the unit. Quality rebuilders will have foam molds for every brand and model refrigerator.

After the mold is removed, the new foam block is trimmed, cleaned and inspected.

Rebuilt cooling units are tagged and warehoused. They are then boxed and shipped to an RV parts distributor or directly to the service shop.

14 One sure-fire way to know if you need a new cooling unit is to periodically inspect all the exposed coils and piping for leaks. A yellowish-type stain will generally appear where a refrigerant leak exists. Here's an absorber vessel that shows signs of a definite leak. If you ever smell ammonia, inside the refrigerator or outside at the rear of the unit, immediately shut the refrigerator off; it's time for a new cooling unit.

15 Are cooling unit replacements common? It sure looks like this aftermarket shop had a busy week!

Though modern absorption refrigerators are more forgiving than some of the older designs, the best thing any RVer can do to protect the refrigerator is to always get it as level as possible when stationary and operating. Also, it's recommended to annually perform a set of cleaning and servicing procedures. A well-maintained and correctly operated absorption refrigerator can last a very long time. Personally, I have seen RV absorption refrigerators still performing well at 40 years old! And do remember that RVing is more than a hobby, it's a lifestyle!