EnergyIdeas Clearinghouse

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Product & Technology Review

CA-1 Condenser Amplifier

An add-on mechanical device used to reduce compressor load and increase the efficiency of small- to medium-sized refrigeration systems.

Product
CA-1 *(formerly ArticMaster™ RMS)*

Manufacturer
Intelligent Motor Controls
3000 Business Park Circle, Suite 400
Goodlettsville, TN 37072

Telephone: (615) 855-3090
Fax: (866) 341-7631
Email: *info@imotorcontrols.com*
Website: *http://www.imotorcontrols.com/*

Distributor
At this time, all distribution in the Northwest is done through the manufacturer; see contact information above.

Product History
The product debuted in the U.S. (in California) in October 1996 as the Talon RMS. It was later called ArticMaster, and in 2006 was renamed the CA-1. Note that the CA-1 product is exactly the same as ArticMaster in technical operation, so information below relating to ArticMaster still applies to the CA-1.

As this *Product & Technology Review* is going to press, the manufacturer is in the process of making a new model available which they call the CA-2. It has some design changes, but the operating principles remain substantially the same. However, because of the design changes, we cannot be certain that all comments in this fact sheet apply directly to the CA-2.

Photograph courtesy of Intelligent Motor Controls

Product & Technology Reviews (PTR) are developed for Northwest electric utilities. *Energy*Ideas Clearinghouse engineers review published literature for objective, independent test results. No primary testing was conducted by the reviewer for the preparation of this document. PTR factsheets describe the technology, discuss available data, and suggest additional testing needed to verify energy saving claims.
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Product Function and Application

The following information was extracted from websites, sales literature, and patent documents. The manufacturer and the inventor provided further clarifications.

The manufacturer claims that the purpose of the CA-1 is to significantly reduce the energy consumption of modern air conditioners and refrigeration systems by reducing the compression ratio, enhancing the efficiency of the condenser, and contouring the flow of the liquid stream. It accomplishes these tasks by increasing the condensing volume by reducing the temperature of the liquid exiting the condenser, eliminating flash gas to the thermal expansion valve (TXV) and removing the boundary layer in the piping between the CA-1 and the TXV with a "vortical stream."

The CA-1 is installed between the condenser coil and the expansion device. The manufacturer requires that a CA-1-certified technician install the device.

A description of how the device works was given in a technical and installation manual for contractors developed when the product was called ArticMaster. A synopsis of how they interpret the process is given below:

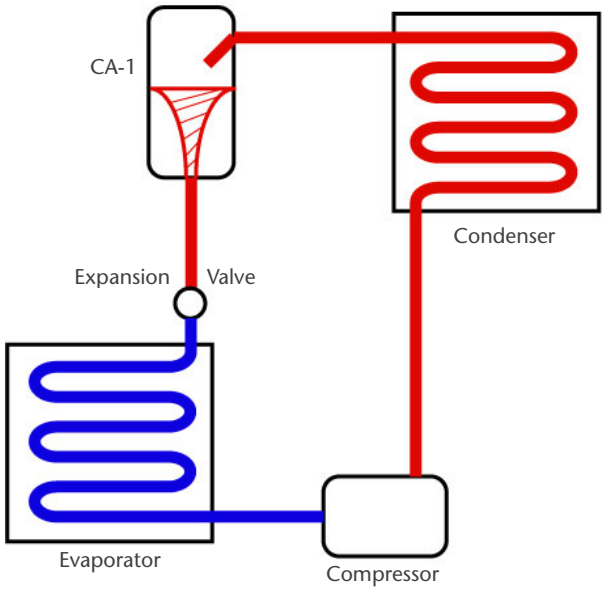
- The refrigerant enters near the top of the ArticMaster (see Diagram 1), at an angle, to induce a swirling action or vortex. The vortex induces a low-pressure area in the center of the liquid. This low pressure allows the refrigerant to expand and sub-cool. The cooler mass is pulled to the center and the warmer mass of fluid is pushed to the outside where heat is rejected through the surface, increasing the sub-cooling effect.

- A fixed impeller is attached to the bottom of the vessel. Instead of the impeller spinning to induce energy into the system to pump the refrigerant, the fluid is being spun into the fixed impeller to create a pumping effect.

- The impeller also creates a uniform turbulent flow that reduces the boundary layer associated with laminar flow in a pipe. This reduces the friction and further sub-cools the refrigerant as it flows toward the expansion valve.

Diagram 1

Location of CA-1 in a Refrigeration System



- Turbulent flow scrubs the sides of the pipe, helping to remove oil that collects on the sides. The oil acts as an insulator, so removing the oil aids in heat transfer.

- The sub-cooled refrigerant passes through the expansion valve with a greater swirling velocity where it expands even more. This added expansion absorbs more heat. Colder coil temperatures increase the condensation level of the air, removing latent heat and making the air drier (dehumidification).

- The compressor ratio reduces as the evaporator coil becomes colder and reaches freezing. The reduction in compressor ratio reduces the energy needed by the compressor.

- In order to prevent excessive frost buildup

on the evaporator coil, the flow out of the condenser slows down when it enters the ArticMaster canister, allowing refrigerant to back up into the condenser. This will cause the refrigerant level in the ArticMaster to drop, causing cavitation by taking warm gas vapor from the upper level of the vessel, which becomes entrained in the fluid to the expansion valve. This starves the evaporator momentarily and defrosts the coil similar to a hot gas defrost, without the need for additional controls.

- There is an increased volume of refrigerant added to the system to fill the ArticMaster. Depending on the application, this increase ranges from around 2-1/2 lbs. for a small system to 5-1/2 lbs. for a commercial system. An increase in refrigerant volume gives a greater capacity to reject heat. Since the ArticMaster is placed immediately after the condenser, it acts as an accumulator allowing increased heat rejection space to the condenser coil.

- Since the ArticMaster is larger than the pipe from the condenser, the velocity of the fluid will slow as it enters the vessel. The vessel is also not full of fluid; there is a gap of gas at the top. The presence of the gas allows the fluid to expand slightly as fluids are essentially incompressible. This decrease in pressure allows the refrigerant to cool (since refrigerant temperature is directly related to pressure).

Energy Saving Claims

Sales literature claims that "all CA-1 models work equally well to achieve a minimum of 20% energy savings on all air cooled equipment, and 8% to 12% on water cooled systems." However, an engineer from Smith Environmental Products, a company that previously had national marketing rights to the device, says that the ArticMaster (now CA-1) does not work well on rack systems similar to those found in large grocery stores. It does not appear to hurt these systems, but it doesn't help either. He recommended that an ArticMaster (now CA-1) certified technician analyze each application for appropriateness.

Non-Energy Benefits

The manufacturer claims that the unit combats the formation of mold and airborne spores and microorganisms, produces no emissions, and runs silently.

Independent Testing Results

This product was tested (as ArticMaster) by South Mountain Air Conditioning and Refrigeration Testing Labs, Phoenix, AZ.

Description of Testing:

The ArticMaster was added to a new 5-ton split system with a thermal expansion valve and a Copeland Scroll Compressor. All tests were performed in an independent test facility with calibrated instrumentation. Ratings test was performed according to ARI standard 210/240.

Test Results:

The 5-ton system was tested with and without the ArticMaster. At 95°F ambient temperature, the EER improved 14.3%, discharge pressure dropped 11.7%, watts decreased by 5.8%, and BTUH increased by 10%. At 82°F ambient, the EER improved 12.3%, discharge pressure dropped 11.1%, watts decreased 6.9%, and BTUH increased 7.1%.

Test Conclusions:

- Older systems should benefit from a decrease in oil film thickness in system piping.
- Increased BTUH should shorten operating cycle.
- Reduction in head pressure would normally extend compressor life.
- Decrease in watts and improved EER should result in operating cost savings.

*[**Reviewer's note:** This was a short test, and not well funded, so they did not come up with firm savings figures in realistic conditions over a period of time. The best measure of savings here is the EER calculation. Notice that both figures given (14.3% and 12.3%), while significant, are well below the advertised energy savings of 20%.]*

Cost

CA-1 *(Manufacturer's Suggested Retail Price)*	$700
Typical Installation *(provided by manufacturer)*	$400
Total	$1,100

Alternative Products and Strategies

No comparable products were found.

Case Studies

The previous manufacturer (Smith Environmental Products) provided information on a case study at Prince of Peace Lutheran Church in Carrollton, TX. TXU Energy in Texas performed an energy analysis on two 60-ton reciprocating chillers at this facility approximately four years ago. Data were collected during September 1999 for 19 days before installation and for 61 days after installation.

The report summary indicates that "Measured data calculates the cooling energy savings to be approximately 25% and a dollar savings of between $348 and $339 per month." However, observations listed in the report show that "very few days over the study months of September through November had the same temperatures and relative humidity," and that "Of those days... the change in kWh usage varied from –21 to +28 kWh." *[Note: Though this is a direct quote from the report, the table these numbers come from suggests that the range is actually -28 to +21, and the units should be kWh/hr.]* The report also states that "Monthly energy data did not provide significant results because of the various discrepancies between the months." *(Quotations are taken unedited from the case study report.)*

[Notes from a conversation with the senior utility engineer (a professional engineer and certified energy manager) who wrote the report: He has verified these results and indicated that the temperature setting was increased during the second month of testing to improve occupant comfort because the air coming from the registers was colder. Because of this, savings in the second month actually exceeded the 25% figure. He also indicated that they logged meter data from the building for an additional two years, during which time the savings indicated in the case study were maintained. In addition, he has data logged two other systems, the smallest being a 20-ton rooftop unit, with similar or better results. Unfortunately, none of these reports are public.]

Suggestions for Further Research and Testing

Although laboratory testing of this equipment has been performed as shown above, further testing is recommended. The laboratory testing only covered two temperatures and not all the variations in parameters. The test was performed on only one system for a short time, and the level of savings was not clearly quantified for a variety of operating conditions. This makes performance difficult to predict even for the system tested, and nearly impossible to generalize. Tests should be conducted so that performance can be predicted, or even carry out side-by-side tests of identical systems where one unit is equipped with a CA-1. Further, testing of the device under controlled conditions that allows for trending of pressure, fluid flow, and operational characteristics will allow pre-analysis of a system to determine benefits before installation.

Further testing should also be done in laboratory conditions to analyze the physical parameters of the device. These measured and observed parameters would be used to determine and prove the actual engineering principles under which this device operates. Documentation of pressure changes, flow characteristics, and temperature profiles would go a long way in convincing those interested in the validity of the device.

Because of the uncertainty of the technology and its benefits, prior to installing one it is advisable that energy pre- and post-logging be conducted by an independent auditor or utility to determine the effect of the device.

Additional Reviewer Comments

In our review, no negative effects of the equipment were noted. However, several questionable results were found, especially in calculations performed during installation. For example, in the documentation of a case study that the manufacturer provided, tested conditions for the condenser prior to installation showed high ambient temperatures, while tested conditions after installation showed low ambient temperatures. This alone would account for a decrease in energy use, even without installation of the product. The case study also showed changes in controls that would be a factor in reducing energy and that would obscure the actual effect of the device.

We conducted interviews with a refrigeration engineering consultant, utility energy conservation engineers, and a commercial/industrial refrigeration contractor. All questioned the claims made about how the device operates (shown in "Product Function and Application" above). In particular, the experts all agreed that the increase in refrigerant charge necessary due to the volume of the device, though helpful in maintaining liquid refrigerant to the thermal expansion device, is not the same as adding capacity to the condenser, which would be one possible explanation for how it benefits the refrigeration process.

Another aspect of the system that they thought might help explain benefits has to do with the common practice of maintenance personnel to "undercharge" a system and then boost the pressure to compensate, due to the high cost of some refrigerants. The extra charge necessary for the CA-1 to operate would correct this problem and allow for a lower pressure. This would show up as an energy savings, but may have nothing to do with the device. This device will also act as a receiver, which is commonly put on refrigeration systems to insure liquid to the thermal expansion valve (TXV). When new equipment is added, a good installer will tune up the system and adjust settings to be sure that all are operating properly. This alone will likely give significant savings.

Turbulent flow can cause a reduction in the boundary layer effect, but the liquid in the line is already turbulent. Turbulent flow is defined as a flow having a Reynolds number of greater than 2000. As an example, using R-22 as the refrigerant and a conservative temperature of 80°F in a ½ inch pipe, the Reynolds number is roughly 70,000. For these conditions to produce laminar (non-turbulent) flow, the pipe would have to have an inside diameter of less than 0.01 inches. In other words, the flow in the liquid line is already turbulent.

Another issue is the hot-gas defrost that purportedly occurs with the device. The thermal expansion valve is designed to handle fluid. When gas bubbles are entrained in the fluid, as they say it is during the hot-gas defrost, the thermal expansion valve "hunts." This hunting causes the valve to open and close quickly, creating several problems in the system. Gas bubbles usually occur with the existence of flash gas, which means that the liquid is expanding to vapor before it reaches the evaporator. The gas then must condense again before reaching the expansion valve, causing inefficiencies in the system.

One possible explanation of how the device works is that it sub-cools the refrigerant. However, the typical placement of this device is outside and above the condenser. This places the device in the same environmental temperature as the condenser. The ability of this device, a smooth metal painted canister, to transfer heat to the atmosphere would be greatly inferior to a typical finned condenser designed specifically to transfer heat, so it is unlikely that this is a cost-effective method of achieving sub-cooling.

Though these criticisms may seem severe, they are directed at the explanation of how the device actually works. It is possible that it works on some other principle than has been described and actually works better than the application of these principles suggest.

Conclusion

The good news is that we have heard no reports of the CA-1 causing any harm to a refrigeration system, so the risk of installing one is small, and it seems to save some energy in some applications. If nothing else, it should provide some benefit by assuring that a liquid stream of refrigerant is delivered to the thermal expansion valve. There may be other mechanisms at work that we do not fully understand.

The manufacturer of the CA-1 makes substantial claims of energy savings, but does not currently have tested results that definitively back these claims. There are many testimonials of satisfied customers, but the physical evidence that clearly demonstrates that the product was responsible for the claimed savings is lacking. In many of the trials, the evaluated conditions for data taken before and data taken afterward were substantially different and thus the results are inconclusive. The explanations given for how the device works do not follow established refrigeration theory, and do not justify the level of savings they claim. This is not to say that the device does not perform well, just that the explanation of how it performs the task does not support the level of savings claimed. This – and the lack of adequate testing– justify skepticism as to the validity of the savings claims.

The final issue is that (because of the uncertainty as to the principles on which it operates and the lack of comprehensive testing results) it is not clear in which circumstances it will work, and in which it will not. In addition, we have no means of calculating the expected savings in a given system.

Additional information

Northwest businesses and electric utilities can contact the *Energy*Ideas Clearinghouse for additional information on this or other energy technologies or products. Contact:

Phone: 1-800-872-3568
Email: *info@EnergyIdeas.org*
Website: *www.EnergyIdeas.org*

The *Energy*Ideas Clearinghouse is a technical assistance service managed by the WSU Extension Energy Program with support from the Northwest Energy Efficiency Alliance.

Reviewer

Craig Meredith, P.E.
WSU Extension Energy Program

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