Articmaster Test Report

Animatics Server Room 33.4% Savings

April 2, 2009

Summary: The Articmaster and MicroPlug combined to reduce average daily electricity consumption by 33.4%, from 47.4 kWh to 31.6 kWh (See Fig. 1). An Articmaster™ condenser control unit and a MicroPlug motor controller unit were installed on a Carrier 2-1/2 Ton condenser unit at Animatics of Santa Clara by Valence Energy, Inc. The power consumption was metered and the project was monitored by Silicon Valley Power energy efficiency representatives. This project will save the customer a projected 5770.95 kWh per year, and it earned the customer a rebate from Silicon Valley Power.

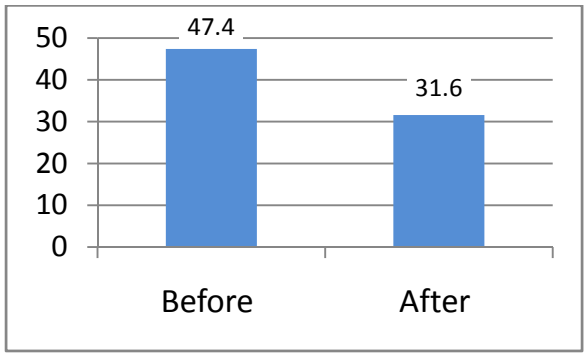


Fig. 1 Daily Energy Use (kWh)

Air-Conditioning Equipment. The system that cools the Animatics server room is a split system made up of a Carrier 2 ½ - Ton Residential Condensing unit and a General Electric Heat Pump Evaporator Coil. The condenser unit is a Carrier Model 38CKC030340 (Fig. 2) with 4.25 lbs. of R-22 refrigerant, 208-230VAC 60Hz single phase power. The evaporator unit is GE Model # BWE730C100A0, and the evaporator unit was clearly older than the condensing unit.

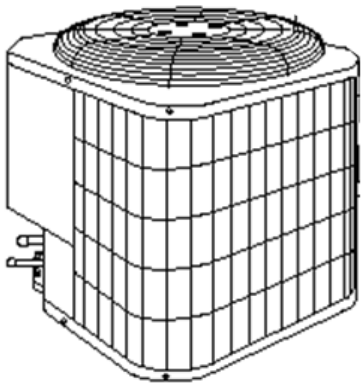


Fig. 2 Carrier 2-1/2 Ton Condenser

Energy Efficiency Equipment Being Evaluated: The equipment being evaluated was an Articmaster Model TSA 1-1/8 U (Fig. 3) and a MicroPlug Model Number MPC30A (Fig. 4). The Articmaster is plumbed in line to the refrigerant circulation loop after the condenser. The MicroPlug is wired in to the power supply line to the condenser.

Articmaster Principal of Operation: The Articmaster is a variable condenser control unit. It controls the amount of refrigerant held in the condenser for heat rejection. The hotter it gets, the less refrigerant is held back in the condenser. The colder it gets, the more refrigerant is held back in the condenser. Refrigerants work most efficiently within a

narrow band of pressure and temperature. The Articmaster allows the refrigerant level in the condenser to adjust and remain closer to the most efficient band of temperature and pressure. The Articmaster is a simple device that employs complex principles (such as fluid mechanics, vortex, refrigerant turbulence, and thermodynamics) to optimize refrigerant efficiency and reduce energy consumption.

Fig. 3 Articmaster™ Model TSA 1-1/8 U Variable Condenser Control Module

The Articmaster is mounted 6" above the top of the condenser coils. Because the compressor is now pumping refrigerant into the partially empty Articmaster vessel, the compressor head pressure is reduced compared to normal. To partially compensate for the loss of pressure and still deliver refigerant to the evaporator, a fixed impeller is incorporated into the base of the Articmaster (See Fig. 4). This fixed impeller imparts a swirling motion to the refrigerant as it exits the Articmaster, and this resulting gravity-assisted turbulent flow ensures adequate velocity of refrigerant en route to the evaporator unit. In addition, the turbulent flow theoretically reduces the boundary layer within the refrigerant piping, and it serves to distribute lubricant back to the condenser.

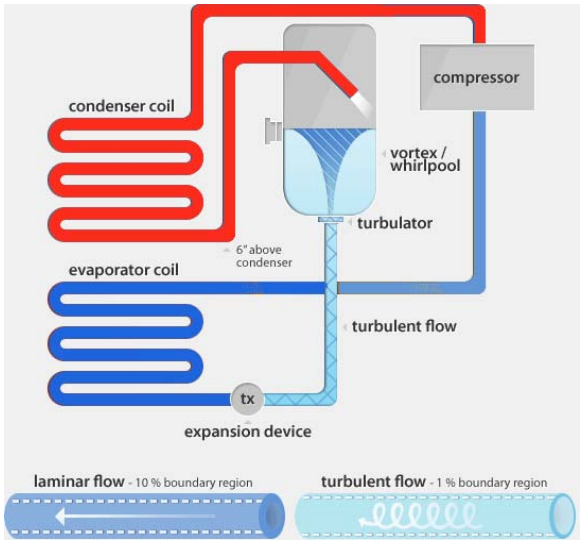


Fig. 4 Articmaster System Schematic

MicroPlug Principal of Operation: The µPlug (Micro Plug) Power Saver is a solid-state motor controller designed to improve the efficiency of a single-phase induction motor. The Plug especially purportedly saves electricity in applications where the motor is not under full load. The µPlug Motor Controller uses a microprocessor and circuitry to sense the energy requirements of a motor. By monitoring both voltage and current being fed to the motor, it can precisely calculate the power that is instantaneously required by the motor and to instantly provide the exact amount of energy the motor needs. Depending on the application, the µPlug reportedly can reduce power consumption by 8 to 15%. (See Fig. 5).

Fig. 5 MicroPlug MPC30A

One test in the MicroPlug Literature indicated that a ½ horsepower induction motor run with no load increased from room temperature to a maximum temperature of 103^{o}F in 10 minutes. (See Fig. 6) Then the MicroPlug was plugged in and the motor cooled off by 10 degrees in 10 minutes.

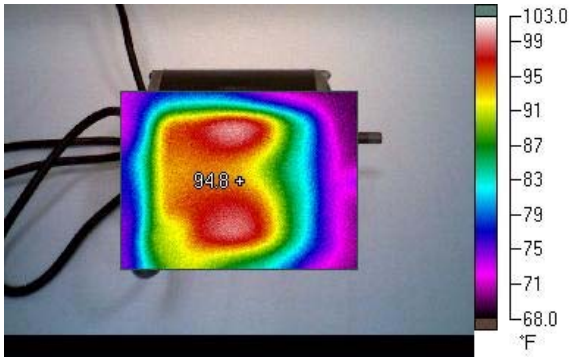


Fig. 6 Thermal Image of Induction Motor

Area being cooled: The area being cooled by this split unit is the Animatics computer server room and two adjacent rooms. The set point temperature in the server room was 74^{o}F. One of the rooms served by the air-conditioner unit houses several large transformers that generate a fairly constant heat load. The reason this particular air conditioner was chosen for this evaluation project is that the unit is cooling a dedicated space, a fact which enabled a more accurate measurement of the efficacy of the Articmaster and motor controller. If the split unit were cooling a large space that is also cooled by other air conitioning units, it would be more difficult to determine the efficiency gains caused by the Articmaster and motor controller, because the thermostat would stop all units at the same time.

Test Equipment: To measure the energy consumption of the unit before and after installation of the Articmaster, a TED (The Energy Detective) Model 1101 kilowatt-hour meter was installed onto the circuit that supplies power to the split unit. (See Fig. 6).

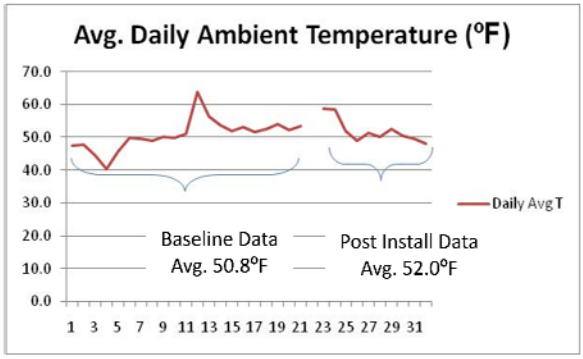
Fig. 6 The Energy Detective Meter

Evaluation Procedure: The evaluation procedure consisted of the following steps:

1. Establish baseline energy consumption.
2. Install the efficiency devices.
3. Monitor energy consumption .

Establishing Baseline energy consumption. The energy consumption was monitored, and the unit consumed a total of 980 kWh over a period

of 20.69 days for an average baseline daily consumption of 47.4 kWh per day. The average daily ambient temperature during this baseline period was 50.8°F (10°C) (See Fig. 7).



Ambient Temperature Increased by 1.2°F

Fig. 7 Average Daily Ambient Temperature

Applying for a utility rebate. Silicon Valley Power (SVP), Santa Clara's municipal utility offers a Customer Directed Rebate for HVAC efficiency devices, and will pay a rebate of $0.17 per each kilowatt-hour saved during the first year of operation. Projects must be pre-approved prior to installation. Lockheed Martin manages the energy efficiency program under contract to SVP. The representatives from SVP and Lockheed Martin made sure that the data was being collected properly, and they were very helpful during the entire process.

It is interesting to note that the amount of rebate that any one company can receive in one year is limited, but it is limited to $1,000,000. SVP has some of the lowest electric rates in the region, with a base rate less of approximately $0.077/kWh. As a result of the low electric rates, Santa Clara has attracted a number of data center companies who are building new facilities.

Installing Articmaster and the MicroPlug. The Articmaster and the MicroPlug were installed on the unit. The original refrigerant was removed, and the system was charged with new refrigerant. Prior to installation, the GE evaporator had ice built up on the one branch of the evaporator coils as shown in Fig. 8.

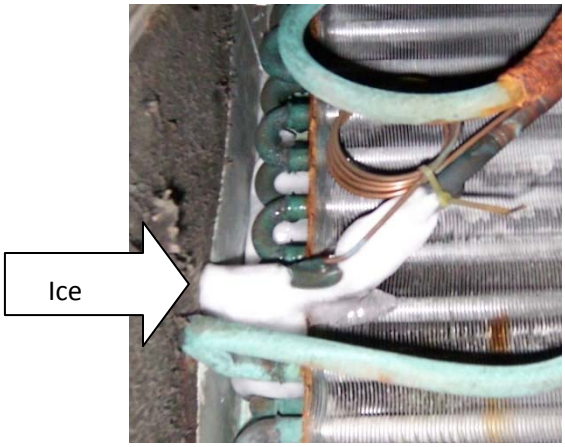


Fig. 8 Ice at the Evaporator Coils

Fig. 9 Articmaster installation

The Artimcaster was mounted per the installation instructions so that the Articmaster's base is 6" above the top of the condenser coils, as shown in Fig. 9.

Project Results: 33.4% reduction in energy consumption. After installation of the Articmaster and MicroPlug, the average daily electricity consumption of the air-conditioning unit during a 10-day period was 31.6 kWh per day compared to the baseline of 47.4 kWh per day. The Articmaster and MicroPlug efficiency devices combined to deliver a 33.4% reduction in electricity consumption. Head pressure was measured to be about 200 psi prior to installation and about 175 psi after the installation. With a measured savings of 15.8 kWh per day, this retrofit is calculated to save 5771 kWh each year. Animatics earned an SVP rebate of $980.06.

Observations and Analysis: Prior to the installation of the Articmaster and MicroPlug it was observed that the air-conditioning unit was cycling constantly, running 24 hours per day. After installation , the air-conditioning unit would reach the set point temperature and then the unit would cycle off for a period of time. Allowing the compressor motor to cycle off periodically will result in less time at elevated temperature and is likely to lengthen the life of the compressor motor.

Given that the evaporator unit is not made by the same manufacturer as the condenser unit and that the condenser unit is newer than the evaporator unit, one can surmise or at least speculate that the original condenser unit failed and was replaced by the existing Carrier unit. A 1999 Purdue University report on "Automated Fault Detection and Diagnostics for Vapor Compression Cooling Equipment" indicates that 70% of condenser failures are caused by compressor motor failures. The report also indicates that motor failures are often caused by thermal system faults. Thermal system faults can be exacerbated by heat build up from running the compressor motor continuously.

Another consideration for future study is to understand the effect of the MicroPlug motor controller on compressor motor life. If the MicroPlug results in a cooler motor, then it is likely that there will be a net positive effect on compressor life as a result of the lower operating temperatures. Motor operating temperatures were not part of this study.

One open question is regarding the cause of the ice observed on the evaporator coils prior to installation. It is theorized that the ice buildup could have been caused by blocked or partially blocked capillary tubes. It is interesting to note that the Articmaster literature claims that the Articmaster is effective in reducing or eliminating ice build up on the condenser coils. This icing problem occurs sometimes during the colder months. During the colder months, the Articmaster will have less refrigerant in it. Theoretically, when ice builds up on the evaporator coil, then the differential temperature of the evaporator coil and the ambient is very low and the heat transfer is very inefficient at that point.

Conclusions: The Articmaster and MicroPlug motor controller units worked together to deliver a 33.4% reduction in electricity consumption for this Carrier 2-1/2 Ton air-conditioning system. The testing was audited by Lockheed Martin under contract to Silicon Valley Power, and the customer received a rebate from Silicon Valley Power for this project.