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# ADVANCED COOLING TECHNOLOGY, Inc.

## QUARTERLY TECHNICAL PROGRESS REPORT

July 29, 1992

U. S. Department of Energy

Grant Project No. 01-91CE 15525


Homer S. Myers
Project Director


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## PROJECT DESCRIPTION

Advanced Cooling Technology (ACT), Inc., will perform the following tasks in order to develop an improved, more reliable and more marketable version of their ACT Evaporative Subcooling System.

1. Develop a more stable pump by reducing vibration levels.

2. Design and develop a drainage mechanism that will protect the coil.

3. Apply for Underwriters Laboratories approval and perform follow-up and coordination work to complete task to insure product is safe, within its intended applications.

4. Test invention's performance to demonstrate energy savings and long term resistance to scale and corrosion.

5. Contract with the American Refrigeration Institute to perform engineering tests under controlled laboratory conditions. Tests to incluse pressure and temperature data throughout the refrigeration cycle.

6. Organize data, and develop technical manual for helping purchasers determining energy savings and invention's merits.

7. Perform a field test in a cooperating supermarket, where utility usage can be measured on a before and after basis.

8. Submit progress and financial reports at the end of each calendar quarter. Submit a final report at the end of the grant period that summarizes the technical accomplishments and next steps to make this technology a commercially viable option. The final report will estimate the energy and other benefits of using this system.

Essentially all of the mechanical design improvements proposed for the Evaporative Subcooler having been completed and the production of pilot quantities of the improved parts was done. An effort was made to have some of these installed in field units where difficulties have been observed in the past. Major attention was focussed during this period on the performance of controlled third party tests of the effectiveness of the unit in improving energy efficiency.

In addition, during this Quarter a second or "Continuation Patent" was granted by the U. S. Patent Office allowing much broader claims than was the case of the first patent which was granted in December, 1991.

Task No. 1
Pump Design

This task has now been completed. Tests of the improved pump in the laboratory, as reported last period, were highly successful. During this period a number of these improved units were sent to the field both on new subcooler units and also as replacement parts for old pumps which had failed in service because of vibration problems. No reports of difficulties with the new pumps have been received.

Task No. 2
Drainage Mechanism

This task has now been completed from the design standpoint. Ten subcooler units with coated coils were sent to a Florida area where the most severe corrosion problems have been encountered. Attempts will be made to follow the results of this treatment in affecting coil corrosion.

Task No. 3
Underwriters Laboratories Approval

This task has been abandoned for the reasons described in the previous Quarterly Report.

## Task No. 5
## American Refrigeration Institute Tests

Copies of the reports of the ARI tests performed by ETL Testing Laboratories are included herewith as Appendix A (Refrigeration) and Appendix B (Air Conditioning).

Refrigeration:

A Copeland 5 HP Refrigeration unit was rented and shipped to ETL Testing Laboratories for these tests and was returned to us at their completion. The results showed that at 95° F and at 41% Relative Humidity, the Evaporative Subcooler increased the capacity of the system by 7.86%. At 99.7° F and at 43% Relative Humidity, the increase was 12.48%.

Air Conditioning:

A Carrier Unitary 10 Ton Air Conditioner unit which was being tested for other characteristics at ETL Testing Laboratories was made available by the Carrier Corporation for use in our Evaporative Subcooler tests. The results showed that at 99.4° F and at 43% Relative Humidity, the Evaporative Subcooler improved the Energy Efficiency Ratio (EER) of the system by 8.31%.

Several considerations must be kept in mind in the interpretation of these results:

1. The ambient conditions under which the tests were carried out were rather normal summer temperatures and humidities. In many areas of the country, higher temperatures and lower humidities often prevail, both of which promote greater evaporative cooling.

2. The systems were both well "balanced", i.e., the capacities of the compressor and the condenser were well matched. The Copeland refrigeration components were selected by our engineer to achieve this balance. The Carrier air conditioner system is described as "unitary", with components selected and assembled by the manufacturer at the factory. These considerations along with the fact that the systems were properly charged with the correct amount of refrigerant by ETL Laboratories engineers before testing means that they were operating at top efficiency for the "base-line" tests before the Evaporative Subcoolers were installed. The conclusion that can be drawn from this is that the observed

improvements are the minimum that can be expected for installation on systems operating under these ambient conditions.

3. In contrast, however, much larger improvements are frequently obtained in field installations. If, for example, a system is unbalanced because it has an undersized condenser, the addition of a subcooler, even without any evaporative cooling, will improve the performance of the system by increasing the condenser capacity bringing it nearer to balance with the compressor capacity. Add the effect of evaporative cooling and much more improvement is obtained. Similarly, if a system is not properly charged with refrigerant and, as a part of the subcooler installation, the refrigerant charge is brought to the proper level, additional improvement over that attributable to evaporative subcooling may be observed. While these are not true efficiency improvements achieved by evaporative subcooling, they are real energy efficiency gains resulting from the whole process of installing an evaporative subcooler.

APPENDIX A

# REPORT
# ETL TESTING LABORATORIES, INC.

INDUSTRIAL PARK CORTLAND, NEW YORK 13045

Order No. 64670-410 Date: May 4, 1992

REPORT NO. 517055
RENDERED TO
ADVANCED COOLING TECHNOLOGY INC.
PERFORMANCE TESTS OF A
"ACTEC" MODEL 10
EVAPORATIVE SUBCOOLER
(REFRIGERANT R-12)

## General

This report gives the results of Performance Tests of an "ACTEC" Model 10 Evaporative Subcooler coupled to a "Copeland" Model CBAM-0500-TFC-001 condensing unit for refrigeration.

The samples were selected and submitted by the client and received at ETL on March 18, 1992. The work was authorized by client's letter dated February 26, 1992. Testing was coordinated through Mr. Ira Marsh representing the client.

## Test Method

The test was performed in general accordance with the following standards published by the American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc.

ASHRAE 41.9-88 A Standard Calorimeter Test Method for Flow Measurement of a Volatile Refrigerant

ASHRAE 20-70 Methods of Testing for Rating Remote Mechanical-Draft Air-Cooled Refrigerant Condensers

## Description of Test Setup

The evaporative subcooler and the refrigeration system condensing unit were installed in a temperature controlled environment. The refrigerant leaving the condensing unit was valved to go through or to bypass the "ACTEC 10" evaporative subcooler. The test system was coupled to a Secondary Refrigerant Calorimeter. Calibrated precision pressure gauges were used to determine refrigerant pressures throughout the system. Calibrated RTD's and thermocouples were used to measure refrigerant and ambient air temperatures. Refrigerant flow was determined by a turbine-type flow meter.

Calorimeter heat input was determined by a watthour transducer measuring the watt input to the evaporator heaters.

Refrigerant flowrate for the primary measurement was determined as the quotient of the heat input to the calorimeter and the enthalpy change of the refrigerant passing through it. The confirming method of the refrigerant flow was the turbine flow meter.

Checked by: MY

## Description of Sample, Physical and Nameplate Data

1. General Description of Sample

The subcooler consisted of an aluminum finned copper heat exchanger coil, a down draft fan and a cone pump.

The refrigerant condensing system unit consisted of a compressor, condenser coil, fan and two receivers.

The refrigerant was R-12.

2. Nameplate Data

Subcooler

"Advanced Cooling Technology
ACTEC Evaporative Subcooler
Model No. 10 Serial 543
Voltage 230 Hz 60 0.4 Amps"

Condensing Unit

"Copeland
Model CBAM-0500-TFC-001
208/230 Volt 3 Ph 60 Hz"

Compressor

"Copeland
Model 9RA1-0500-TFC"

## Description of Tests

Conditions

| | | |
|---|---|---|
| Ambient, °F | 95 | 100 |
| Saturation Suction, °F | -10 | -10 |
| Return Gas, °F | 65 | 65 |

Test Runs 1 and 3 were with the refrigerant bypassing the evaporative subcooler.

Test Runs 2 and 4 were with the evaporative subcooler energized and supplied with city water.

Checked by: My

| Test Conditions | Test Run 1 | Test Run 2 |
|---|---|---|
| Saturated Suction, F | -10 | -10 |
| Return Gas, F | 65 | 65 |
| Ambient of Condenser, F | 95 | 95 |
| **Results of Tests** | | |
| Condenser Ambient | | |
| Air Inlet, F | | |
| dry-bulb | 95.2 | 95.0 |
| wet-bulb | 74.7 | 75.1 |
| Barometer, in. Hg. | 28.73 | 28.84 |
| Calor'meter Side | | |
| Electric Input to Heaters, Whrs | 4,584 | 4,944 |
| REFRIGERATING CAPACITY, BTUH | 15,640 | 16,870 |
| Calculated Refrigerant Flow, lbs/hr | 283.9 | 283.9 |
| Refrigerant Side | | |
| Refrigerant Temperature, F | | |
| Liquid at Condenser | 107.5 | 107.0 |
| Liquid Entering Subcooler | - | 106.5 |
| Liquid Leaving Subcooler | - | 83.5 |
| Liquid at Calorimeter | 101.4 | 82.6 |
| Suction at Calorimeter | 61.6 | 61.4 |
| Suction at Compressor | 65.0 | 65.0 |
| Refrigerant Pressures, PSIG | | |
| Liquid at Condenser | 173.5 | 173.0 |
| Liquid at Calorimeter | 172.0 | 171.5 |
| Suction at Calorimeter | 6.0 | 6.0 |
| Suction at Compressor | 4.5 | 4.5 |
| Refrigerant Enthalpy, Btu/lb | | |
| Entering Calorimeter | 31.438 | 26.972 |
| Leaving Calorimeter | 86.512 | 86.407 |
| Difference Across Calorimenter | 55.072 | 59.435 |
| Refrigerant Flow Rate, lbs/hr | 278.6 | 277.7 |
| Electrical Characteristics | | |
| Voltage, volts | | |
| Phase A-B | 230 | 230 |
| Phase B-C | 230 | 230 |
| Phase C-D | 230 | 230 |
| Current, amps | | |
| Phase A | 13.8 | 13.9 |
| Phase B | 15.2 | 15.1 |
| Phase C | 14.2 | 14.2 |
| Total Power Input, watts | 3,895 | 3,953 |

Checked by: MY

| Test Conditions | Test Run 3 | Test Run 4 |
|---|---|---|
| Saturated Suction, F | -10 | -10 |
| Return Gas, F | 65 | 65 |
| Ambient of Condenser, F | 100 | 100 |
| **Results of Tests** | | |
| Condenser Ambient | | |
| Air Inlet, F | | |
| dry-bulb | 99.9 | 99.5 |
| wet-bulb | 78.4 | 79.5 |
| Barometer, in. Hg. | 28.41 | 28.45 |
| Calorimeter Side | | |
| Electric Input to Heaters, Whrs | 4,039 | 4,543 |
| REFRIGERATING CAPACITY, BTUH | 13,780 | 15,500 |
| Calculated Refrigerant Flow, lbs/hr | 258.8 | 262.3 |
| Refrigerant Side | | |
| Refrigerant Temperature, F | | |
| Liquid at Condenser | 115.9 | 115.6 |
| Liquid Entering Subcooler | - | 114.8 |
| Liquid Leaving Subcooler | - | 83.9 |
| Liquid at Calorimeter | 107.4 | 81.6 |
| Suction at Calorimeter | 59.5 | 60.3 |
| Suction at Compressor | 64.7 | 65.2 |
| Refrigerant Pressures, PSIG | | |
| Liquid at Condenser | 198.5 | 196.0 |
| Liquid at Calorimeter | 197.5 | 195.0 |
| Suction at Calorimeter | 6.0 | 6.0 |
| Suction at Compressor | 4.5 | 4.5 |
| Refrigerant Enthalpy, Btu/lb | | |
| Entering Calorimeter | 32.894 | 27.183 |
| Leaving Calorimeter | 86.139 | 86.255 |
| Difference Across Calorimenter | 53.245 | 59.072 |
| Refrigerant Flow Rate, lbs/hr | 254.6 | 254.8 |
| Electrical Characteristics | | |
| Voltage, volts | | |
| Phase A-B | 230 | 230 |
| Phase B-C | 230 | 230 |
| Phase C-D | 230 | 230 |
| Current, amps | | |
| Phase A | 13.7 | 13.8 |
| Phase B | 14.9 | 14.7 |
| Phase C | 14.2 | 14.1 |
| Total Power Input, watts | 3,820 | 3,879 |

Checked by: WY

Dates of Tests: April 22 - 24, 1992

Report Approved by:

Mark W. Paquette

Mark W. Paquette, Manager
Applied Products

Tests Supervised by:

Robert J. Hill

Robert J. Hill
Project Engineer

Checked by: MY
Copy by:kn

APPENDIX B

# REPORT
# ETL TESTING LABORATORIES, INC.

INDUSTRIAL PARK CORTLAND, NEW YORK 13045

Order No. 64672-420 Date: June 11, 1992

REPORT NO. 518483

RENDERED TO

ADVANCED COOLING TECHNOLOGY, INCORPORATED

PERFORMANCE TESTS

OF A "CARRIER" UNITARY AIR CONDITIONER

MODEL 38AFC0085 CONDENSING UNIT

WITH MODEL 40RR008 BLOWER COIL

WITH AND WITHOUT AN "ACTEC" EVAPORATIVE SUBCOOLER

## General

This report gives the results of Performance Tests of a "Carrier" Unitary Air Conditioner Model 38AFC0085 Condensing Unit With Model 40RR008 Blower Coil, with and without an "ACTEC" Evaporative Subcooler manufactured by Advanced Cooling Technology, Incorporated, Lexington, Kentucky 40503.

The sample used to test the evaporative subcooler was provided by Carrier Corporation.

Authorization for the tests was by client's letter dated February 26, 1992, signed by Mr. Homer S. Myers, President. The work was coordinated through Mr. Ira Marsh, Chief Engineer, representing the client.

The tests were conducted in accordance with ARI Standard 210/240-89, "Standard For Unitary Air-Conditioning And Air-Source Heat Pump Equipment," published by the Air-Conditioning and Refrigeration Institute, and ASHRAE Standard ANSI/ASHRAE 37-88, "Methods of Testing for Rating Unitary Air Conditioning and Heat Pump Equipment," published by the American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc.

Notes: (1) The results contained herein are for technical evaluation only and are applicable only to the specific test specimen referenced herein.

(2) The tests herein reported have not been performed at the request of the Air-Conditioning and Refrigeration Institute, and use of these findings by Advanced Cooling Technology, Inc. in any advertising or other literature shall state therein that the test is not part of the ARI Certification Program.

## Description of Unit, Nameplate Data, etc.

### 1. General Description of Unit

The sample was a split-system air-cooled air conditioner. The condenser air w drawn through the condenser coil on three sides and discharged vertically by a f from the top of the section. The evaporator air was drawn through the front openin air filters and diagonal evaporator coil, and discharged vertically by a blower through two openings at the top of the section. The sections were connected by 25 f of 1-1/8-in. O.D. suction line (insulated) and 1/2-in. O.D. liquid line. The refrigerant control device contained in the unit was an expansion valve.

### 2. Nameplate Data

Condensing Unit

Model No. 38AFC008510 Serial No. 0792G78198

| | Qty | Volts AC | Ph | Hz | RLA | LRA |
|---|---|---|---|---|---|---|
| Compressor | 1 | 208/230 | 3 | 60 | 32.5 | 183 |
| | | | | | FLA | HP |
| Fan | 1 | 208/230 | 1 | 60 | 2.9 | .50 NEC |

Power Supply 208/230 V 3 Ph 60 Hz
R-22 Design Test Pressure High 477 Low 150
Permissible Voltage At Unit 253 Max. 187 Min.
Min. Circuit Amp 44.4 60 Fuse Only

Compressor

Copeland
Model No. BRE2-0750-TFC-214
Serial No. 92A 15605 00015
Customer No. GB30TN010A U019 Oil - 128
Volts 208/230 Ph 3 Hz 60 LRA 183
Volts 200/240 Hz 50 Pro T MO-C

Condenser Fan Motor

G.E. Model 5KCP39PGH806S
V 208/230 Hz 60 Ph 3 Amps 1.7
Cap 10.00/370 Rot. → RPM 1050
Mfg. No. HC44VL603A

Blower Coil Unit

Model No. 40RR-008-530 Serial No. 1292F91201
Design Test Pressure High 410 HP 1 Kw Out 0.75
Power Supply 208/230-460 Volts 3 Ph 60 Hz
I.D. Motor 230/460 Volts 3 Ph 60 Hz 3.8/1.9 FLA

Evaporator Blower Motor

Inaccessible

Description of Unit, Nameplate Data, etc. (cont'd)

3. Description of Coils

| | Evaporator | Condenser |
|---|---|---|
| Number of Coils | 1 | 1 |
| Fin Material | Aluminum | Aluminum |
| Tubing Material | Copper | Copper |
| Style | Staggered | Staggered |
| Type of Fins | Rippled | Rippled |
| Number of Fins per Inch | 13 | 15 |
| Diameter of Tubing (OD), in. | 1/2 | 3/8 |
| Number of Tubes per Row | 20 | 32 |
| Center-to-Center Distance Between Tubes, in. | 1.25 x 1.25 | 1.0 x 0.866 |
| Number of Rows Deep | 3 | 2 |
| Coil Height, in. | 25.0 | 32.0 |
| Coil Length, in. | 42.0 | 77-1/2 |
| Face Area (Total), sq. ft. | 7.29 | 17.22 |

| Results of Tests | W/Out Subcooler | | W/ Subcooler | |
|---|---|---|---|---|
| | Test Run | | | |
| | 1A* | A | 1A* | A |
| **Evaporator Side** | | | | |
| Air Temperature, F* | | | | |
| Evaporator Inlet, dry-bulb | 79.90 | 80.00 | 79.95 | 79.80 |
| wet-bulb | 67.10 | 67.30 | 67.25 | 67.20 |
| Evaporator Outlet, dry-bulb | 63.45 | 63.50 | 62.25 | 62.10 |
| wet-bulb | 59.60 | 59.80 | 58.85 | 58.70 |
| Static Pressure at Unit Outlet, in. W.G. | 0.31 | 0.31 | 0.30 | 0.30 |
| Standard Air Flow, cfm | 2985 | 2985 | 2985 | 2985 |
| TOTAL COOLING EVAPORATOR SIDE, Btu/hr | 74630 | 74930 | 83320 | 84160 |
| **Condenser Side** | | | | |
| Air Temperature, F* | | | | |
| Condenser Inlet, dry-bulb | 99.40 | 99.50 | 99.50 | 99.30 |
| wet-bulb | 78.80 | 78.90 | 79.50 | 79.50 |
| Condenser Outlet, dry-bulb | - | 127.30 | - | 127.90 |
| Static Pressure at Unit Outlet, in. W.G. | - | -0.03 | - | -0.04 |
| Standard Air Flow, cfm | - | 3555 | - | 3365 |
| TOTAL COOLING CONDENSER SIDE, Btu/hr | - | 74330 | - | 70200 |
| **Miscellaneous** | | | | |
| Electrical Characteristics of Motors | | | | |
| Compressor, Condenser Fan & Evaporator Blower | | | | |
| Voltage, volts | | | | |
| Phase A-B | 231 | 231 | 230 | 230 |
| Phase B-C | 229 | 229 | 230 | 229 |
| Phase A-C | 230 | 230 | 230 | 229 |
| Current, amps | | | | |
| Phase A | 29.5 | 29.5 | 30.3 | 30.2 |
| Phase B | 31.4 | 31.5 | 32.5 | 32.4 |
| Phase C | 29.8 | 29.6 | 30.6 | 30.5 |
| Power Input, watts | | | | |
| Phase A-N/A | 3330 | 3340 | 3500 | 3470 |
| Phase B-N/B | 3490 | 3500 | 3650 | 3640 |
| Phase C-N/C | 3210 | 3200 | 3300 | 3300 |
| Total Power Input, watts | 10030 | 10040 | 10450 | 10410 |
| Energy Efficiency Ratio, EER | - | 7.46 | - | 8.08 |
| **Refrigerant-Circuit Temperatures, F** | | | | |
| Discharge at Compressor | 237.5 | 238.5 | 233.5 | 233.0 |
| Liquid at Condenser | 110.5 | 111.5 | 112.5 | 113.0 |
| Liquid at Evaporator | 109.0 | 110.0 | 95.5 | 95.0 |
| Suction at Evaporator | 58.5 | 59.0 | 55.5 | 55.5 |
| Suction at Compressor | 61.0 | 61.0 | 61.0 | 61.0 |
| Liquid at Subcooler In | - | - | 113.0 | 112.5 |
| Liquid at Subcooler Out | - | - | 96.0 | 96.0 |
| **Refrigerant-Circuit Pressures, psig** | | | | |
| Liquid at Condensing Unit | 304.0 | 304.0 | 310.0 | 310.0 |
| Suction at Condensing Unit | 77.0 | 77.0 | 72.0 | 72.0 |

Note: Air temperatures are recorded to 0.05°F; this value is estimated and is valid only for obtaining temperature differentials as may be required to determine enthalpies.

*Preliminary Test Run - Condenser Side Free Air Discharge.

Remarks

In the absence of specified requirements, no conclusion has been drawn. The test results are furnished for the client's information and evaluation.

Dates of Tests: May 21-27, 1992

Report Approved by:

Reginaldo I. Romero
Program Administrator

Test Supervised by:

Byron F. Horak, Manager
Unitary Products

Copied by: mb

END

DATE FILMED

9/21/92