TESTS OF ADSIL COATING

Final Report

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Prepared for:
Bob Suggs

Florida Power & Light Company
9250 W. Flagler street
Miami, Florida 33174

Principal Investigator
Dr. Charles J. Cromer P.E.

Appliance Laboratory (ALT)
Florida Solar Energy Center
1679 Clearlake Road
Cocoa, Florida 32922

EXECUTIVE SUMMARY

Adsil, a company in Palm Coast Florida, has developed a chemical and system to deposit this chemical on to a substrate such as the fins and coil of AC evaporators and condensers. The chemical contains a high proportion of silica and the coating is thus referred to as a “glass” or “pre-ceramic.” In addition to corrosion protection, the company claims that the coating provides an extremely thin layer (5 microns) that is strongly bonded and provides a 1% to 2% heat transfer improvement by wicking into sub-micron crevices and joints, where other coatings typically cause a 4 to 5% reduction in heat transfer. Because this coating may reduce HVAC related demand and consumption, especially units exposed to degradation of the condenser, and it may prevent an increase in demand over time caused by corrosion and degradation of HVAC coil surfaces, it was of interest to determine under controlled tests if a demand or energy use savings is provided by the product.

This research project, funded by Florida Power & Light Company, to test the Adsil product included five separate tests of air conditioning equipment conducted within the controlled environmental chambers of the Appliance Laboratory at the Florida Solar Energy Center, University of Central Florida. Two additional tests, were conducted on units outside the Appliance Laboratory. All tests included a determination of baseline of operational performance for each test unit after being washed with a hose. Then the Adsil cleaning and application was performed per standard AD1115-01 dated Nov. 15, 2000, and the operational performance was again determined to quantify the potential improvement due to the Adsil cleaning and application process. In addition, the two outside units, one without the Adsil treatment (control) and one with the treatment, were exposed to a salt spray to produce accelerated aging and degradation of the condenser coils while performance was measured.

Both the control unit and the Adsil unit showed degraded performance EER in a slow, linear fashion during the first part of their % life. The control unit demonstrated this linear drop for about 0 to 30% of its life, while the Adsil coated unit degraded more slowly for the 0 to 50% portion of life. At about 30% and 50% life for the control and Adsil respectively, both units showed a more rapid degradation over time that became worse as time went on. The difference in measured performance for the outside units ranged from no change in performance when they were new, to an 11% improvement in performance at an estimated 77% of useful life. The % improvements found in the before-after tests showed that EER improved after treatment with Adsil and this improvement was significant at the 95% confidence level. This measured improvement increased with the estimated life of the unit at treatment. The difference in measured performance on the before-after tests ranged from no change on the new unit to 11.9% improvement on the unit estimated at 85% of its useful life.

If a utility were to create a program to accelerate the application of this product, after a time, the estimated average impact on the utility from a large number of treated units in the field (average new EER = 12) is summarized in the table below.

Ave. % Life @ change-out	Ave. Years @ change-out	New Units Ave. KW Saved/ton	New Units Ave. KWh Saved/ton	Retrofit Units Average KW Saved/ton	Retrofit Units Average KWh Saved/ton
66.7	10	0.0414	435	0.071	723
66.7	15	0.0414	652	0.071	1085
85	10	0.0591	600	0.104	1087
85	15	0.0591	900	0.104	1630

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PURPOSE OF THIS REPORT

This is the Final Report for the TASK entitled "TESTS OF ADSIL COATING," under contract from FPL with FSEC/UCF, contract titled "FPL - Blanket for Task Evaluations", FPL enabling DWAs for this task, Nos. 48501 and 48550 under FPL PO No. B92139-00078, and UCF control number 26-56-891.

This research task, funded by Florida Power & Light Company, to test the Adsil product includes five separate tests (A1 - A5) of air conditioning equipment to be conducted within the controlled environmental chambers of the Appliance Laboratory at the Florida Solar Energy Center, University of Central Florida. The contract calls for an Update Report to be written after each of the five tests. These Reports are included in the Appendix. Two additional before/after tests, A6 and A7 were conducted on units located just outside the Appliance Laboratory, A6 on one new unit and test A7 after test B was completed on a second outside unit.

Test B was a long term side by side test with two five ton Carrier units installed next to each other. The condensers for the two units were installed side by side outside of the Appliance Laboratory and the evaporator and air handler units were installed on a side by side basis within one of the environmental control chambers inside the Appliance Laboratory. The air presented to the condensers was treated with a salt mist to enhance corrosion and provide accelerated aging of the condenser units. The test was run for 248 days and data on the performance of the units was taken for 5759 hours. The Update Report containing detail of this test is also provided in the Appendix of this report.

The purpose of this report is to summarize the findings of tests A1-A7 and Test B as these findings apply to average potential demand (Kw) and KWh savings of the Adsil product that would accrue to a utility due to a program supporting this application.

INTRODUCTION

Adsil, a company in Palm Coast Florida, has developed a chemical and system to deposit this chemical on to a substrate such as the aluminum fins of AC evaporators and condensers. The chemical contains a high proportion of silica and the coating is thus referred to as a "glass" or "pre-ceramic." In addition to corrosion protection, the company claims that the coating provides an extremely thin layer (5 microns) that is strongly bonded and provides a 1% to 2% heat transfer improvement by wicking into sub-micron crevices and joints, where other coatings typically cause a 4 to 5% reduction in heat transfer.

It is possible that this coating may significantly reduce HVAC related demand and consumption, especially on older units and units exposed to degradation of the condenser such as in salt spray environments. Further, the coating may prevent an increase in demand over time caused by corrosion and degradation of HVAC coil surfaces. It is therefore of interest to determine under controlled, reproducible tests if a demand or energy use savings is provided by the product.

TEST METHOD

Two test types were conducted: (A) Demand Reduction Test (Bam test) and (B) Demand Prevention Test (Long term test). The test types were set up and conducted at the UCF-FSEC Appliance Laboratory (ALT).

Test A, Demand Reduction Test: Three air conditioner units were provided by FSEC for lab test. Four units were provided by Adsil (two for lab test and two for the outdoor test). The five lab test units: tests A1 through A5, were configured sequentially for operation between two control chambers, one to control indoor conditions and one to control outdoor conditions. They were instrumented for the monitoring of their energy use and the temperature and relative humidity (air conditioning) contribution of each unit was recorded per ARI/ASHRAE steady state test procedures. The tests were conducted over a constant inside temperature, 80 degree, 51%RH indoor condition, and three outdoor conditions, 75, 85, and 95 degrees Fahrenheit (F). The air-enthalpy test method was employed to determine operational energy use. All units were run for a minimum of three (3) ARI test runs as baseline - each run conducted at the designated outdoor temperature. The units' condenser was then cleaned as per normal maintenance (washing down good with a hose) and a second baseline obtained. Then the Adsil washing and coating process was applied to the condenser and a minimum of three additional test runs completed under the same operating conditions.

Test A6 was conducted on the outdoor unit designated for long term testing that received the Adsil coating. The unit was run continuously and data was taken for two hours prior to the Adsil application, then after the Adsil was applied, the unit was run for an hour to dry the Adsil, then two hours of "after" Adsil application data was taken on operational EER. Test A7 was conducted on the outdoor unit designated for long term testing that did not receive the Adsil coating. At the end of the long term testing, the Adsil treatment was applied to this unit. For the test, the unit was run continuously and data was taken for two hours prior to the Adsil application, then after the Adsil was applied, the unit was run for an hour to dry the Adsil, then two hours of "after" Adsil application data was taken on operational EER for the unit.

For two units inside the test chambers with untreated evaporators, (evaporators provided by FSEC), the Adsil coating was applied to the evaporator and an additional three test runs completed on each evaporator (tests E1 and E2).

Test B, Demand Prevention Test: Two new units were installed on a side by side basis. They were installed with air handlers in an indoor control chamber to assure equivalent load on the two units and the condensers were installed outside on a side by side basis. The units were instrumented for monitoring of performance as stated above. One unit had the Adsil coating applied and the other unit did not have the Adsil coating. The condensers were installed within an enclosure to provide a uniform salt spray (fog) applied to the condensers. The salt (NaCl) for the spray was mixed as per ASTM B117-97, Standard Practice for Operating Salt Spray (FOG) Apparatus. The units were operated for at least eight hours each day and for a total of 248 days. The demand for each unit was measured at 100% duty cycle, each day. Periodic photos were taken of the units during the test. The trend of performance degradation over time was regressed from the daily data and an estimate of demand savings due to the application of the Adsil coating on a new unit was determined.

ANALYSIS OF TEST DATA

Statistics were used for data analysis. Simply comparing the average performance of before and after data is inappropriate in making a determination as to the effectively of a treatment, as simple averages do not take into consideration inherent variability in the data. For these analyses, paired t-tests were used with the hypothesis that the before/after data showed no difference vs. the alternative that the before/after data showed an improvement with washing and then the Adsil treatment. All tests were completed using the Minitab Statistical Software Package and conducted at the 95% confidence level. A detail description of the analysis procedure and evaluation techniques is provided on pages 6 - 8 of the Test A1 Update provided in the Appendix.

SAVINGS ASSOCIATED WITH THE ADSIL COATING ON NEW UNITS

Page 7 of the Test B Report (Appendix) provides a plot of the two test units EERs over the time of the test. This plot is reproduced here as Figure 1. The two units start out with equal EERs, but as the condensers degrade over time, the Adsil coated condenser visibly degrades less rapidly. This less rapid degradation of the Adsil condenser is also represented in a less rapid reduction in the measured EER over time. The un-coated unit begins to use more energy than the Adsil coated unit to provide the same cooling, and this difference in energy use (savings) increases over time.

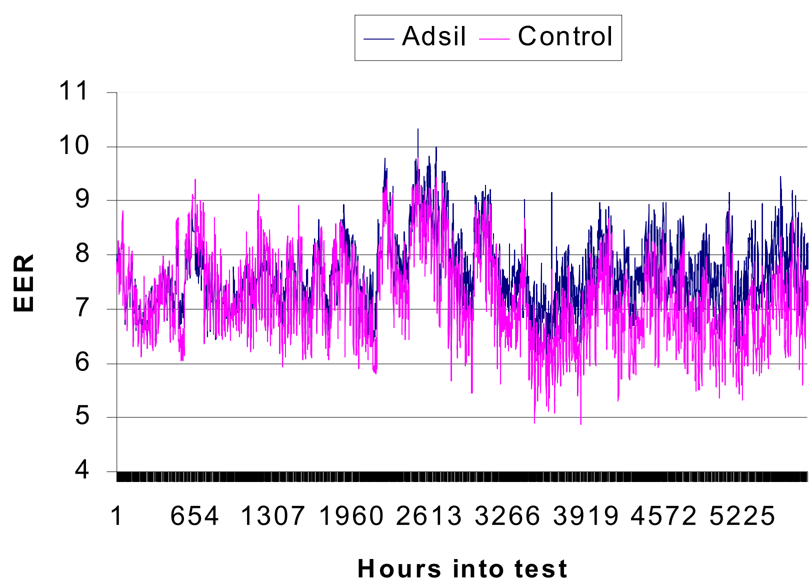

Figure 1. Plot of EERs Over Time of Test.

Development of Degradation Curves

The data of Test B -Figure 1 includes the variability in EER associated with the outdoor temperature so the trend over time, though apparent, is difficult to discern. When the effect of temperature on EER is removed from the test data, the smoothed EER performance curves over time for the test units can be determined by least square regression. Also, the difference in the performance curves (savings) can be regressed from the paired data. It should be noted that the test units were not operated to failure and it was estimated that the control unit would be at least three fourths (75%) of its useful life. It should be understood that the extension of the degradation curves beyond this point up to 100% life, is an extension of the regressed curve equations, and does not include actual data. The regressed degradation curve found for the control unit was:

$$y = E + .0042834\,x - .00029649\,x^2 \qquad [1]$$

Where y is performance EER, E is the starting EER, and x is test hours converted to % life.

The regressed degradation curve for the treated unit was found to be:

$$y = E - .2200 + .0173997\,x - .00033049\,x^2 \qquad [2]$$

Figure 2 provides a plot of this regressed curve for the untreated unit, and the plot of the treated unit curve. The difference between the two data sets provides the projected savings curve in EER that is also shown. The slight rise of the Adsil curve around 25% life was not apparent in the raw data. It is a result of fitting all the data to a second order smooth curve.

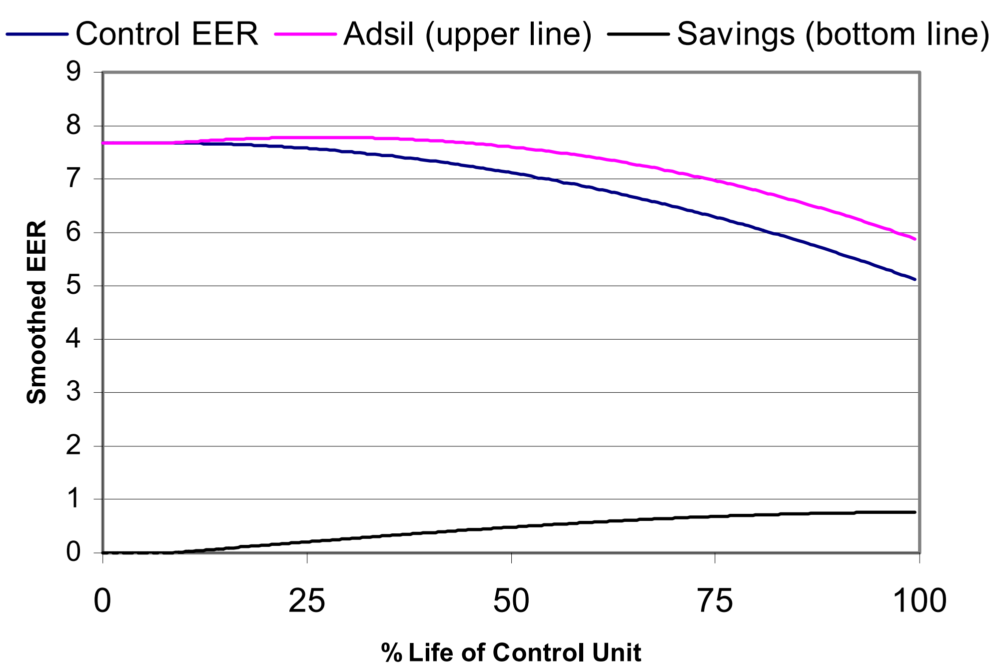

Figure 2. Smoothed Test EER Curves Over Time And Difference of Adsil Unit.

It was concluded that the difference in measured performances at the 95% confidence level are significant. Details of these statistics are provided in the Test B report, p.10. Review of the savings curve (the bottom line of Figure 2) provides some information and explanation in what is found when anticipated savings is calculated. It should be noted that the test data indicated that there is no immediate anticipated savings of the Adsil coating on a new unit up to 10 to 14% in age and the saving is smaller during the early life of the unit. The anticipated difference comes over time as the treated unit degrades less. Also note that because the test unit was not run to 100% life (to failure) the anticipated savings for the right hand one fourth of the graph is an extension of the regression line beyond the actual data of the test.

It is possible to interpret the data taken on the test units in two ways. One could assume that the reduction in EER over time that occurred on the two units (more rapidly on the untreated unit) would drop for the same value of EER regardless of the starting EER of the unit. Or one could assume that the drop of EER occurs as a percentage (%) of the starting EER. Because most energy saving analyses use the % savings assumption, that assumption will be used here also. There is evidence that this assumption is more correct, as the measured % improvement was similar for tests A1, A3, and A4 and their EERs range from 8 to 13 (see Table 3). Never the less, the assumption that a % savings improvement in EER found on a lower EER unit will translate to the same % savings on a higher EER unit, or visa versa, is not proven by this work. This is mentioned here because this is an important assumption for the evaluation of projected energy savings.

The EER performance over time due to condenser degradation is plotted from the test data as a % in Figure 3.

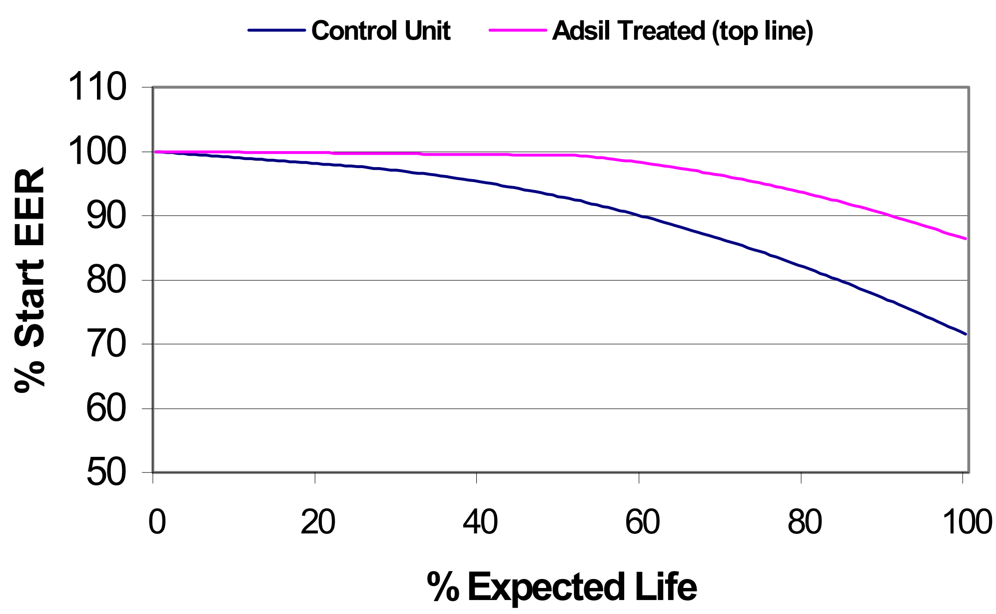

Figure 3. Plot of % EER Degradation vs. Unit % Life

After fitting several sets of equations to the smoothed curves, both polynomial and negative exponential, it was found that the best curve fits for the plots of Figure 3 incorporated two functions to describe these curves. Both the control unit and the Adsil unit degraded in a slow, linear fashion during the first part of their % life. The control unit demonstrated this linear drop for about 0 to 30% of its life, while the Adsil coated unit degraded more slowly for the 0 to 50% portion of life. At these two points, 30% and 50% life for the control and Adsil respectively, both units showed a degradation over time that became worse as time went on. This segment of the curves could both be represented well by second order quadratic equations.

The equations found for the control unit were:

For $x = 0$ to 30 $\quad y = 100.0 - 0.09737\ x$ [1]

and,

for $x = 30$ to 100 $\quad y = 98.28 + 0.0538\ x - 0.0032159\ x^2$ [2].

Where y is the % EER of its starting EER, and x is the % life of the unit at that time.

For example, assume an untreated unit is at its 50% life. Evaluating using the lower equation, then y = 98.28 + 0.0538 (50) - 0.0032159 (50)(50) = 92.93 %. Assuming the unit was at an EER of 12 when new, then at 50% its EER would be 12 * 0.9293 = 11.15, a 7.1% reduction in performance.

The equations found for the Adsil unit were:

For $x = 0$ to 50 $\quad y = 100.0 - 0.01179\ x$ [3]

and,

for $x = 50$ to 100 $\quad y = 96.71 + 0.02188\ x - 0.0032274\ x^2$ [4].

The curve fits of these equations to the smoothed EER % data are provided in the Appendix. All fits provide an adjusted r^2 of over 99%.

Expected Utility Demand Savings (KW) For Applying Treatment to New Units

With the development of equations [1] thru [4] above, it is possible to estimate expected demand savings per unit if this treatment has been applied to new units. Even though the **rate** of degradation of AC units by % is assumed to be the same for units of various EERs, because the actual performance EER of the units (and therefore demand) at any particular time in their life is dependent on its initial EER, it will be assumed that the average EER of new units that this will be applied to, is 12. In addition, for this analysis, it is necessary to select a potential portion of useful life for a time when the units will be replaced - for clearly, when the unit is replaced, the demand benefit is no longer available. This analysis will compare potential demand per ton for units replaced at 67%, 85% and 100% of their maximum useful life.

Assuming a program is in place that has treated a large number of units over time. To determine the anticipated demand savings to the utility requires estimating the average EER for the life of all units that have received the treatment. Given this large number of units in the field is assumed to be of all ages and evenly distributed, then one could use the bin method to evaluate the average expected EER for all units in the field. To find this average, one could segment the curves of Figure 2 into segments, say 10 segments of the x axis going from 0 to 67% (for the 67% life calculation), then find the EER at the center of each one of those segments by evaluating the equations, and then average the values. A more accurate technique to find the average y value over an f(x) (sometimes called the centroid) is to evaluate the integral of f(x)/dx. The integral finds the exact average of EER for an evenly distributed large group of units for the two alternatives.

For example, using equations [1]and [2]:

For [1](x<30) $\int y_1 = 100.0\,x + .048685\,x^2$ [5]

and for [2](x>30), $\int y_2 = 98.2785\,x + .00269\,x^2 - .00107196\,x^3$ [6]

And, with E = 12, evaluating for a large number of units who's change-out life is 85%, then using dx = 0 to 30 equation [5] and 30 to 85 equation [6], the average lifetime %EER calculates as $\int y / dx = (\int y_1 + \int y_2)/ dx = 0.929$. Thus, 0.929 * 12 = 11.15. Using the expected average EER for a large number of units found from $\int y / dx$ of equations [1] thru [4], and by the mathematical definition of EER,

$$\text{KW/ton} = 12 / \text{EER} \qquad [7]$$

the potential demand savings (KW)/ton to the utility can be found for an Adsil treatment program on new units. These values are provided in Table 1.

Table 1. Potential Demand Savings Per Ton for Adsil Coated Unit When New

Average % Life @ Change-out	Start EER	Uncoated EER Ave. All Units	Coated EER Ave. All Units	Uncoated KW Per Ton	Coated KW Per Ton	Savings KW Per Ton
66.7	12	11.45	11.92	1.048	1.006	0.0414
85	12	11.15	11.80	1.076	1.017	0.0591
100	12	10.84	11.64	1.107	1.031	0.0757

Here the anticipated demand savings to the utility from a program on new units can be determined. As an example, if 10,000 units in the field were 5 tons and all running on the system peak, using the 85% change-out estimate, Adsil applied to these 10,000 units when they were new would provide an estimated demand savings to the grid of 10,000 * 5 * 0.0591 = 2955 KW.

Expected Utility Energy Savings (KWh) for Applying Treatment to New Units

The amount of energy savings over the life of a single piece of equipment, given that the treatment was applied when the equipment was new, depends on the estimated average % life at change-out (as in the demand calculation,) but it also depends on the estimated years of service the equipment has provided at this change-out % life. This analysis will consider the estimated years of service to be either 10 years, or 15 years at change-out.

In addition to the number of years the unit operates over its lifetime, the estimated number of hours that a unit operates each year needs to be estimated. This estimate can be found by assuming that the sizing of the air conditioner unit is provided to the load of the space as would be suggested by design criteria similar to ASHRAE Manual J. This is another way of saying that with a thermostat setting of 78 F, and in West Palm Beach, an outdoor temperature of 98 F, (2 standard deviation extreme annual value), the system will be operating at 100% duty cycle and be at its maximum capacity while delivering the cooling required. Clearly, field units may be oversized to their load, never the less, this relationship provides a good mechanism to estimate KWh per year for a weather location such as West Palm Beach, recognizing that an oversized unit will operate with a reduced duty cycle, but the oversized unit will use more energy for each hour that it is run.

Using TMY (Typical Meteorological Year) weather data from NOAA, and assuming the thermostat set at 78 degrees F, typical operational hours for an air conditioning unit located in West Palm Beach can be calculated by using the air conditioner load as a function of temperature difference between the thermostat set-point and the outdoor temperature. This is the basis for the much used bin method of load calculation. However, a more accurate measure of load can be obtained by using a computer program that reads TMY hourly weather data and calculates the Btu load from the space, then determines the run time of the ac unit needed to deliver that cooling on an hourly basis and then totals the energy used.

A program titled HOUSSIM that does these calculations has been written by the author under DOE contract and a copy of the code is provided in the Appendix. Thus the anticipated load from a space can be generated from detailed hourly weather data, however to calculate the energy use of an air conditioner system to meet that load requires the input of the EER of the unit.

To find the energy use of the two alternatives (untreated or treated) over their lives requires knowing the average EER for each alternative over their lives. To find this average, one could segment the x axis of Figure 2 into yearly segments, say 15 segments for a 15 year life, then find the EER at the center of each one of those segments, and average them. Similar to the "many units in the field" problem, a more accurate technique to find the average y value over an f(x) is to evaluate the integral of f(x)/dx. From equations [1] thru [4], this finds the exact average of EER over the defined life of the two alternatives. Using this method, the average lifetime EERs for the untreated and treated units were determined (see Table 1) for the assumed lives of 66.7, 85 and 100%. These EERs were entered into the TMY weather based computer program to calculate the projected energy use for a five ton ac system in West Palm Beach starting with EER = 12. Six runs were completed, three for the untreated unit and three for the treated unit, each at 66.7, 85 and 100% respectively. Copies of the computer output for these six runs are provided in the Appendix. The calculated KWh/year, KWh/lifetime use and estimated treatment savings are provided in Table 2.

Table 2. Estimated Lifetime KWh Savings of Adsil on EER= 12, New 5 Ton Unit

Ave. Life	Ave. Years	Untr. EER	Adsil EER	Untr. KWh/yr	Adsil KWh/yr	Lifetime Untr KWh	Lifetime Adsil KWh	Lifetime KWh Sav.
66.7	10	11.45	11.92	4455.6	4238.1	44556	42381	2175
66.7	15	11.45	11.92	4455.6	4238.1	66834	63572	3262
85	10	11.15	11.80	4581.8	4281.7	45818	42817	3001
85	15	11.15	11.80	4581.8	4281.7	68727	64226	4502
100	10	10.84	11.64	4780.8	4361.4	47808	43614	4194
100	15	10.84	11.64	4780.8	4361.4	71712	65421	6291

The lifetime savings associated with the Adsil treatment will vary with the EER of the equipment. Higher EERs use less energy to meet the same load, and thus there is less potential for savings. In other words, Adsil applied to a new unit starting with an EER of 10 would save more KWh over its lifetime than the table values given, and likewise, a unit starting with an EER of 14 would save less than the table values.

The Table 2 column "Lifetime Kwh Savings" provides estimates of average lifetime energy savings that would be seen by the utility from a program for the application of the Adsil product on new units. For example, assume a group of units (five ton EER = 12) do not have Adsil applied when they are new, and they are installed one a year for an extended period of years. These units are changed-out when each reaches 10 years of age and at that point, each has degraded to 85% of its useful life. The expected KWh average lifetime energy savings for the same set of units treated with Adsil when new, and also changed-out at 10 years, would be 3001 KWh per unit. It should be noted that these are energy savings only. No consideration has been taken to the value which might accrue to an owner associated with the potential for extended % life due to the Adsil coating. It should also be noted however, that any savings from extending the change-out period of an Adsil coated unit (say to 12 years), accrues to the owner from differing the purchase of a new unit, not from energy savings - as the Adsil treated unit with extended life would use more energy than the alternative changed out unit - even when changed out with the same EER rating.

SAVINGS ASSOCIATED WITH THE ADSIL COATING ON RETROFIT UNITS

Seven separate tests were conducted on air conditioner units whereby before-after performance data were obtained. These units were in various stages of their useful lives including tests on two new units. Details of the test set-up and the statistical evaluation for determination of reduction in EER measured for the units after the Adsil treatment are provided in the individual test reports in the Appendix. Table 3 summarizes these findings.

Table 3. Summary of Before - After Performance Test Data.

Unit	Tons	Est.%Life	Test	Old EER	Adsil EER	Delta EER	% Improvement
Bryant	5	75	A1	13.333	14.691	1.36	10.2
Carrier	2.5	New	A2	14.02	13.98	-0.04*	0*
Bard	5	85	A3	8.10	9.06	0.96	11.9
Rheem	5	67	A4	10.57	11.16	0.59	9.5
Lennox	5	40	A5	13.97	14.22	0.25	1.8
Carrier 1	5	New	A6	7.66	7.66	0.0*	0*
Carrier 2	5	77	A7	7.49	7.35	-.14*	0*

*Change too small for significance @ 95% confidence level.

When the % Improvements found in the Before-After tests are plotted on the graphs of Figure 2 vs. the estimated % life of each unit at test, apparently the performance of the treated unit is brought up very close to the performance level as if the unit were treated with Adsil when it was new. This is shown on Figure 3. Prior to the plots, it was not known where the retrofit improvement would show up compared to Adsil application when new. Even though the % life estimation was done knowing that a higher % change is expected for an older unit, and a lower % change is expected on a newer unit, the % life estimations were made before the values shown on Figure 3 were calculated and the plots were made.

The one point that does not follow the pattern of the others is the before/after test on the outdoor test unit (Carrier 2). This unit showed no measurable change when the unit was treated at about 77% life. One can speculate that this occurred because there were fins missing from the condenser that produced holes through which the air could be drawn (bypass air) - effectively reducing the air that was drawn through the fins that remained on the condenser. When the Adsil was applied, due to the washing and application process, these holes became even larger causing more bypass air. This additional bypass air could have compensated for any improvement in heat exchange that was a result of the Adsil cleaning and application on the remaining fins.

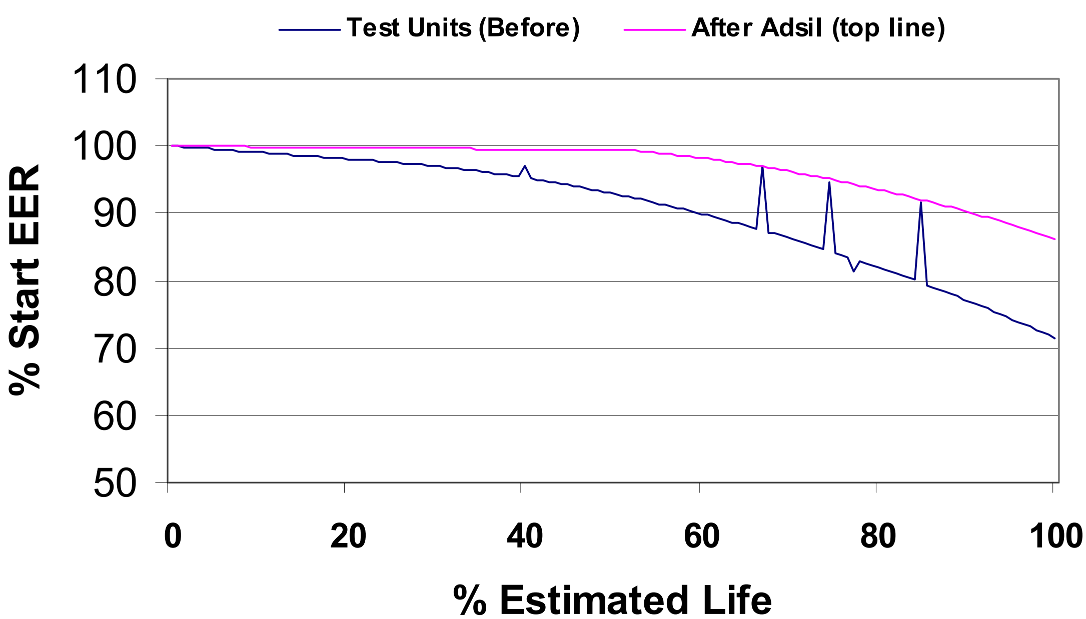

Figure 3. Plot of Before/After Performance % Improvement vs. % Estimated Life

Estimated Utility Demand Savings (KW)From Applying Treatment to Retrofit Units

As in the previous demand calculations on new treated units, for retrofit units, their will be no reduction in demand due to the retrofit when the unit is changed-out, so the change-out lives of 67, 85 and 100% will be considered. Also, when units are retrofitted in a program, the utility does not see any improvement in demand until the retrofit is made. If the retrofits are evenly distributed across estimated total life, then the average improvement of all retrofitted units is provided by the double integral of the function equations , [1] -[4], evaluated from 0 to the change-out lives. The average EER values for units starting with EER = 12 were calculated by spread sheet and are shown in Table 4. The average demand of a large group of retrofitted units may be then found by equation [7]. These values are also shown in Table 4.

Table 4. Potential Demand Savings Per Ton for Group of Adsil Retrofitted Units

Average % Life @ Change-out	Start EER	Uncoated EER Ave. All Units	Coated EER Ave. All Units	Uncoated KW Per Ton	Coated KW Per Ton	Savings KW Per Ton
66.7	12	11.07	11.85	1.084	1.013	0.071
85	12	10.51	11.56	1.142	1.038	0.104
100	12	9.93	11.21	1.208	1.071	0.138

Here the anticipated demand savings to the utility from a retrofit program on older units can be determined. As an example, if 10,000 units in the field were 5 tons and all running on the system peak, and their ages when retrofitted ranged uniformly from almost new to almost 85% life (change-out), Adsil applied to these 10,000 units would provide an estimated average demand savings to the grid of 10,000 * 5 * 0.104 = 5200 KW.

Estimated Utility Energy Savings (KWh)From Applying Treatment to Retrofit Units

The average energy savings that can be expected from applying the Adsil treatment to a large number of units, as in the example for treatment on new units, requires an estimate of the number of years the units are in operation and the % life the units attain at change-out. As in the previous example, the same values of 10 or 15 years of age, and 66.7, 85 and 100% of life will be used. Also, the same operational load as found by the TMY - NOAA weather data will also be used to project unit operation and resultant annual energy use. Outputs from the six computer runs, given the determined average retrofit operational EERs, are provided in the Appendix. The results are summarized in Table 5.

Table 5. Estimated Average Retrofit KWh Savings for Group of EER= 12, 5 Ton Units

Ave. Life	Ave. Years	Untr. EER	Adsil EER	Untr. KWh/yr	Adsil KWh/yr	Lifetime Untr KWh	Lifetime Adsil KWh	Lifetime KWh Sav.
66.7	10	11.07	11.85	4625.0	4263.4	46250	42634	3616
66.7	15	11.07	11.85	4625.0	4263.4	69375	63951	5424
85	10	10.51	11.56	4935.3	4392.0	49353	43920	5433
85	15	10.51	11.56	4935.3	4392.0	74030	65880	8150
100	10	9.93	11.21	5258.2	4556.2	52582	45562	7020
100	15	9.93	11.21	5258.2	4556.2	78873	68343	10530

The Table 5 column “Lifetime Kwh Savings” provides estimates of average lifetime energy savings that would be seen by the utility from a program for the application of the Adsil product on retrofit units. For example, assume a large group of units (five ton EER = 12) range in age from almost new to almost 85% life. They do not have Adsil applied. These units are changed-out when each reaches 10 years of age and at that point, each has degraded to 85% of its useful life. The expected KWh average lifetime energy savings for the same set of units treated with Adsil at their various existing ages, would be 5433 KWh per unit.

CONCLUSIONS

Both the control unit and the Adsil unit showed degraded performance EER in a slow, linear fashion during the first part of their % life. The control unit demonstrated this linear drop for about 0 to 30% of its life, while the Adsil coated unit degraded more slowly for the 0 to 50% portion of life. At these two points, 30% and 50% life for the control and Adsil respectively, both units showed a more rapid degradation over time that became worse as time went on. The difference in measured performance for the aged units ranged from no change in performance when they were new, to an 11% improvement in performance at an estimated 77% of its useful life. The % improvements found in the before-after tests showed that the performance of the treated units were brought up very close to the performance level as if the units were treated with Adsil when they were new. The difference in measured performance on the before-after tests ranged from no change on the new unit to 11.9% improvement on the unit estimated at 85% of its useful life.

Clearly, the process used in cleaning the condenser coils and applying the Adsil was important in obtaining these results. It should be noted that all units of these tests were coated with Adsil grade AD423 and the treatment process was completed to specification: AD1115-01 dated Nov. 15, 2000.

If a utility were to create a program to accelerate the application of this product, after a time, the estimated average impact on the utility from a large number of treated units in the field (average new EER = 12) is summarized in the table below.

Ave. % Life @ change-out	Ave. Years @ change-out	New Units Ave. KW Saved/ton	New Units Ave. KWh Saved/ton	Retrofit Units Average KW Saved/ton	Retrofit Units Average KWh Saved/ton
66.7	10	0.0414	435	0.071	723
66.7	15	0.0414	652	0.071	1085
85	10	0.0591	600	0.104	1087
85	15	0.0591	900	0.104	1630

APPENDIX

A1. Curve Fit of Control %EER Drop Over % Life (0 - 30%)

A2. Curve Fit of Control %EER Drop Over % Life (30 - 100%)

A3. Curve Fit of Adsil %EER Drop Over % Life (0 - 50%)

A4. Curve Fit of Adsil %EER Drop Over % Life (50 - 100%)

A5. Program Code for Calculating Energy Use from NOAA TMY Weather Data

A6. Monthly Energy Use Tables for West Palm Beach, given EER inputs

A7. Test A1 Update Report

A8. Test A2 Update Report

A9. Test A3 Update Report

A10. Test A4 Update Report

A11. Test A5 Update Report

A12. Test B - Long Term Test Report