NATIONAL RENEWABLE ENERGY LABORATORY

JULY 5, 2017

From: Dane Christensen
National Renewable Energy Laboratory
15013 Denver West Parkway Golden, CO 80401

To: Buzz Eaves. Ref. S. Sart Inc, TDS_CP200
Pradditive Corp, SL
C/ Munt, 33
08392 - S. A. Llavaneres
Barcelona (Spain)

Dear Mr. Eaves:

This letter is to confirm our finding that NREL's recent laboratory study of the TDS_CP200 additive in a 10-ton rooftop air conditioning unit (RTU) showed an increased flowrate in the R-410A primary circuit after the additive was installed. The mass flow in the primary refrigerant circuit was observed to increase by approximately 14% when the test article was operated at comparable environmental conditions before and after TDS_CP200 was installed. This relative increase was consistent, with minor variation, across several measurement points and appeared independent of which stage the test article was operating in.

NREL was not tasked with diagnosing the cause behind the measured flow rate change, and the finding was not clearly indicated or explained by other experimental observations or results. However the increase is statistically significant based on the measurement accuracy of the Micro-Motion Coriolis flow meter used.

We appreciated the opportunity to work with your team.

Sincerely,

Dane Christensen

Why NREL?

A fortune 10 company requested that TDS_CP200 test a 10 ton RTU (Roof Top Unit) at NREL (National Renewable Energy Lab — US Department of Energy). It was agreed that the company would provide a 6-year old RTU from one of their stores, and TDS_CP200 manufacturer would pay for the test. The analysis of that test follows below.

NREL Testing of 10 ton RTU with TDS_CP200 Additive

Recently a 10 ton RTU refrigeration unit was tested at NREL's Thermal Test Facility to evaluate the performance of the air conditioning unit with the addition of TDS_CP200 additive. The results of the tests showed an increase in the refrigerant flow rate of approximately 14% when TDS_CP200 was added to the primary circuit 1.

Table 1:

NREL Stage 1 Test Results

	PRE	POST	% Change
Refrigerant Flow Rate (kg/s)	0.11	0.13	+15.4% (avg. 14%)

These findings confirm the analysis done previously on the effects of TDS_CP200 in A/C units.

The performance of a refrigeration unit depends on how efficiently the unit converts the compressor input power to cooling, Btu/hour, in the evaporator. The cooling rate is a function of mass flow rate, di (kg/sec), since the cooling rate is:

$$0 = Ai\ Ah \qquad (1)$$

where Ah is the change in enthalpy across the evaporator.

Table 2:

Change in EER using TDS_CP200 Additive from NREL Stage 1 Test Results

	Stage 1					
	MA DB 751; MA WB 67 OA DB 95F		MA DB 80F; MA WB 67			
	Pre	Post	Pre	Post	Pre	Post
		11-May	7-Mar	10-May		10-May
P1(kPa)	1156.03	1109.04	1124.6	1113.89	1152.95	1147.29
T1©	20.49	22.48	21.24	22.37	20.7	21.5
hl (kJ/kg)	293	296	294	296	293	294
P3 (kPa)	2639	2593.56	2335.4	2311.9	2637.8	2604.29
T3 ©	40.94	40.57	35.64	35.41	40.96	40.56
h3=h4	126	126	117	116	126	126
rh (kg/s)	0.11	0.12	0.11	0.13	0.11	0.13
Q=rh(h1-h4)	18.59	20.4	19.47	23.4	18.37	21.84
Power(kW)	5.18	5.132	4.778	4.744	5.192	5.13
EER=QJP	12.1	13.56	13.9	16.724	12.07	14.53
Percent change (%)		10.8 % increase in		16.89% increase		**16.9% increase EER**

Table 2 shows an average 14.86% increase in EER after the additive is used. The Post EER values increase because of the increase in the cooling rate of the refrigerator (a), as shown in Equation 1, with little change in the total input power.

When the mass flow rate increases, the cooling rate will increase providing more refrigeration to the unit. As shown in Table 1 (see previous page), the NREL tests showed that by adding the TDS_CP200 additive to the 410A refrigerant, the flow rate increased by approximately 14% which would then increase the cooling rate for the unit.

It is known that a refrigerant typically exhibits substantial lubricating properties. Removing oil fouling and the resultant improvement in heat transfer in the evaporator are other aspects of improving efficiency in A/C and refrigeration units. TDS_CP200 is a patent-pending polymer that permanently bonds to all metal surfaces within the system and provides benefits other than the removal of oil fouling.

The addition of the polymer allows the flow of the refrigerant to occur with less flow friction resistance which results in an improved performance of the evaporator coils and reduced power consumption by the unit. Additional benefits of friction reduction occur throughout the system. The molecular structure of the polymer provides friction reduction within the compressor, particularly within reciprocating compressors. This friction reduction shows in the reduced power for the compressor during the first minute of operation and throughout the life of the system.

The reduction in flow friction results because of the increased refrigerant flow velocity and Reynolds Number (Re) that occurs with the addition of the additive to the refrigerant. As shown in the Moody Diagram (Figure 1) the friction factor, f, decreases with increased Reynolds Number for both laminar and turbulent pipe flow. For turbulent flow in a smooth pipe, a 15% increase in the Reynolds Number of the refrigerant with polymer additive results in approximately a 25% reduction in flow friction. This decrease in friction results because of the interaction of the polymer with the flow of refrigerant. The addition of polymer solution in the flow of refrigerant dampens the turbulence next to the wall of the pipe and reduces the flow friction and reduces drag.

The reduction in drag as a result of an increase in Reynolds Number is significant for lower, laminar flows. These types of flows occur during startup and with the addition of the TDS_CP200 additive, the friction drops significantly as shown in the left side of Figure 1. This will again provide significant reduction in the power required to start and operate the system.

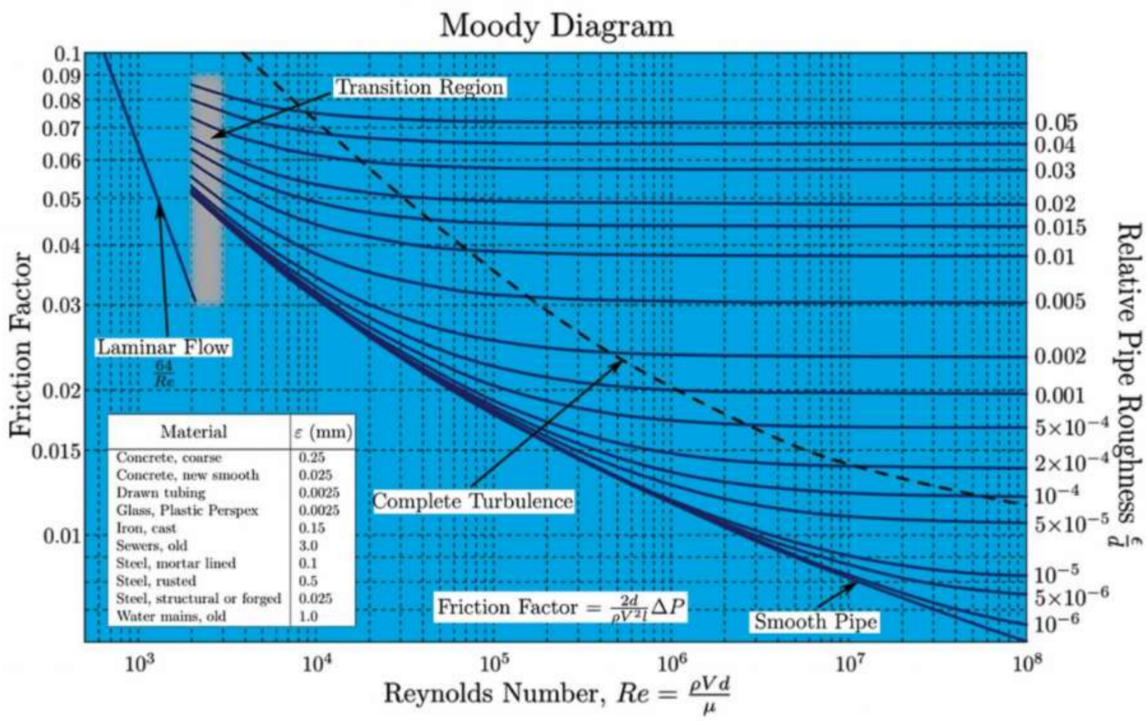

Figure 1 - Moody Diagram for Friction Factor for Pipes

The flow of refrigerant through the compressor tends to remove a lubricant from the compressor surfaces that it contacts. The lubricant remains dispersed in the refrigerant, but when the lubricant reaches the relatively low temperature evaporator its viscosity increases. The lubricant thus tends to accumulate in the evaporator and starve the compressor of lubricant. If the amount of lubricant returning to the compressor is insufficient, the compressor lubrication cannot be maintained relatively constant over time. This condition negatively affects the compressor's operating life, raising the compressor frictional forces and requiring the motor to supply additional power to drive the compressor.

TDS_CP200 and its PTFE boundary lubrication helps to eliminate this problem. The boundary lubrication is caused by the unique properties of the polymers composed of PTFE particles of various sizes that are designed to permanently bond to metal contact surface. This bonding is maintained for the life of the system and provides for long term efficiency and reduced maintenance.

The friction drag is directly related to the flow velocity and Reynolds Number, and as the flow velocity increases with the addition of the PTFE additive, the resulting flow friction, f, is reduced. This reduction in flow friction results because of the way the polymer interacts with flow boundary layer and turbulence in the pipes. As a result of this reduction in friction and drag, the refrigerant flow rate increases and the cooling rate increases with little change in power requirements which results in an overall improvement in the system efficiency and an increase in EER.

•

PE Jenkins,
PhD, PE June
16, 2017