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Docket Number:	21-BSTD-01
Project Title:	2022 Energy Code Update Rulemaking
TN #:	238584
Document Title:	Rheia LLC Comments - 2022 Energy Code Update Rulemaking - Rheia 06-30-2021
Description:	N/A
Filer:	System
Organization:	Rheia LLC
Submitter Role:	Public
Submission Date:	6/30/2021 1:56:30 PM
Docketed Date:	6/30/2021

Comment Received From: Rheia LLC
Submitted On: 6/30/2021
Docket Number: 21-BSTD-01

2022 Energy Code Update Rulemaking - Rheia 06-30-2021

Additional submitted attachment is included below.

Dear Commissioners,

Re: Docket # 21-BSTD-01, 2022 Energy Code Update Rulemaking

Subject: Rheia, LLC, comment on insulation requirements for ducts in conditioned space

As a manufacturer of HVAC distribution systems using uninsulated ductwork, our position is that the proposed requirement for insulation on ducts in conditioned space (2022 Express terms Section 150.0(m)1B) is unnecessary and based on an overly conservative position on the risk of condensation and the impact of duct losses on distribution efficiency.

Rhiea's uninsulated duct solution enables builders and contractors to locate the air handler and supply air ducts inside the thermal envelope of the home, increasing energy efficiency, removing the need for trades to work in the attic and homeowners and service providers to no longer have to access the attic to conduct routine maintenance or replacement of the air handler. Additionally, the simplicity of our quick connect component system requires minimal trade training and reduces total system install times by as much as 50% when compared to standard insulated duct distribution systems, clearly helping trades resolve the shortage of skilled workers.

Our design and commissioning software ensures that the design airflows to each room are correctly calculated and confirmed by our commissioning process, ensuring both system efficiency and homeowner comfort.

The reports appended below summarize data from both laboratory and field testing of the Rheia distribution system. The field tests show that in normal use in a climate typically more humid than California (Kissimmee, FL) there was no observed condensation on the ducts. The lab tests show that even under operating conditions that would be more likely to suffer from condensation than would be encountered in a properly installed system, with excessive leakage into the duct cavity, there is no condensation found on the ducts.

Over the past year Rheia's uninsulated duct solution has been installed in single-family and townhomes in the following markets: Pittsburgh, Baltimore, Orlando, Indianapolis, Portland, and Phoenix. We have no reported issues of moisture on the ducts.

In the next 3-4 months Rheia will be installed in the following markets, Denver, Minneapolis, Chicago, Detroit, Columbus, Cleveland, Cincinnati, Jacksonville, Washington DC, and Houston. The designs are completed, the communities selected, and start dates established.
Furthermore, we have been specified as the duct solution for a modular builder in Denver and are in design discussions with the leading manufactured housing company in the country.
Lastly, we are engaged with the leading Geo-Thermal provider in the North-East to enable their expansion into the segment of the retrofit market that does not have pre-existing duct work.

Based on this test data, and a history of trouble-free installations in multiple climates, we respectfully request that the requirement for insulation on ducts in cavities within the building's thermal envelope be removed from the 2022 standards.

Duct Condensation Testing

Prepared for: California Energy Commission
By: Rheia LLC ., 4636 S 35th Street, Suite 2, Phoenix, AZ, 85040
June 29th, 2021

Introduction

During the summer of 2020, Rheia conducted laboratory testing to assess the relationship between the amount of outside air leaking into a duct chase from a hot-humid attic and the associated condensation potential of uninsulated ducts running through the chase.

In the Rheia test facility in Phoenix, AZ, a test rig (Figure 1) was constructed to simulate the hot-humid attic conditions that were being observed in a Pulte pilot home in Kissimmee, Florida in which a complete Rheia air distribution system was installed. The test rig comprised an air sealed and insulated representative 'attic' space above a representative duct 'chase' containing a bundle of uninsulated Rheia ducts connected to an air conditioning unit, and a method to control the humidity level within the 'attic' space.

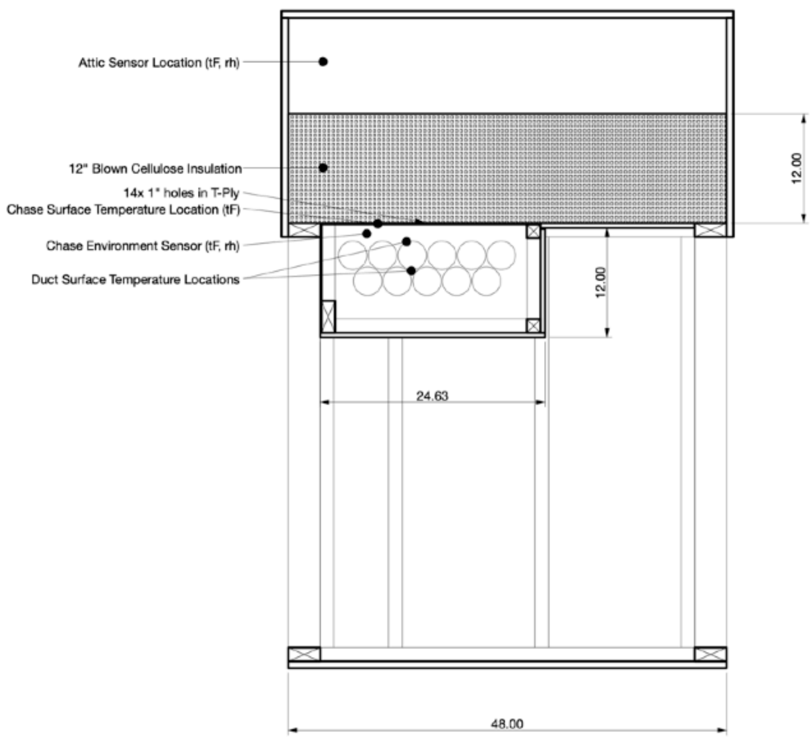


Figure 1. Photo and Illustration of Test Setup

Duct Condensation Testing

Test Results

A series of tests were run that controlled the temperature and humidity in the attic and the amount of air leakage and from the attic into the chase. The air conditioner cycled on and off for various test intervals while a series of environment and surface sensors monitored the system.

For each test, the attic was brought to a dew point of approximately 80-90 degrees Fahrenheit. This condition approximates monitored real-world conditions of the pilot home. Secondly, air flow was induced from the attic into the chase by depressurizing the chase beginning at observed field conditions—about 1 pascal positive pressure in the attic relative to the chase—and increasing in pressure from that baseline. 14-1" holes were then

drilled in the chase surface to provide a leakage path from the attic into the chase to simulate imperfections in construction. These holes were located immediately adjacent to the bundle of ducts near the manifold to draw the moist air in at the point where the duct surfaces were the coldest. The air conditioner was cycled on for approximately one hour per test to give the system time to cool to a steady state.

Surface and environmental sensors were installed to monitor the temperatures relevant to duct condensation. In addition, a viewing window was installed to observe any condensation forming in the event the sensors did not capture all microclimates within the system. The figure 2 illustrates the data gathered at the sensors, with groupings at the start (worst case) and end of the chase. Note the uninsulated ducts reached approximately 55 deg. F surface temperature as expected. 3.6 Pa and 14-1" holes simulate a scenario far worse than any monitored in the real world pilot home, and still showed zero risk of condensation.

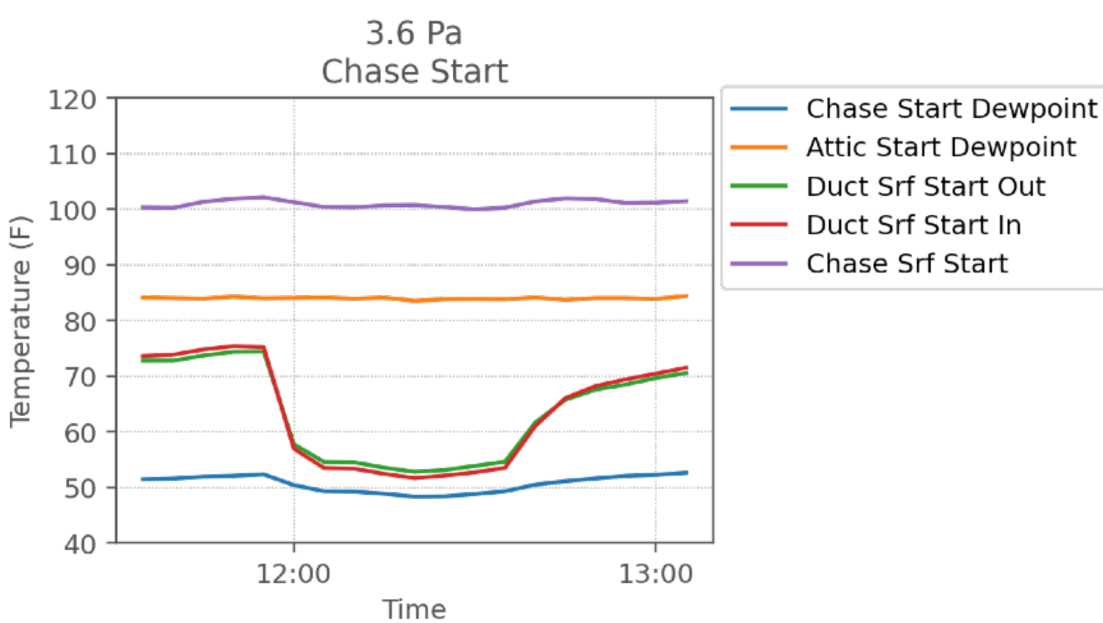


Figure 2. Test case with condensation occurring.

Duct Condensation Testing

Conclusion

Condensation on the ducts was not observed in any scenario at or even beyond any real-world environment.

The test rig was set up to simulate the most extreme weather observed at the pilot home near Orlando FL, where the outdoor weather conditions are far more severe than any climate in California.

The table below shows a comparison of Orlando and several other cities where Rheia has been installed, and California. Installations in California will have less risk of condensation since there is far less moisture present.

		ASHRAE Climatic Design Conditions - 2013		
	City	Cooling 1% - Dry Bulb (Deg. F)	Cooling 1% - Mean Coincident Wet Bulb (Deg. F)	Dew Point at Design Condition (Deg. F)
California	Burbank	93.8	66.7	49.5
	Fresno	100.8	69.3	50.4
	Sacramento	98.2	69.6	53.2
	Los Angeles	80.4	63.6	53.0
Cities with Rheia Installations	Orlando, FL	92.5	76.2	69.5
	Fort Myers, FL	92.6	76.8	70.4
	Indianapolis, IN	88.7	74.0	67.6
	Portland, OR	87.5	66.5	54.0
	Baltimore, MD	91.3	74.1	66.5
	Pittsburgh, PA	86.6	70.7	62.9
	Phoenix, AZ	108.3	69.4	43.9

Rheia System Pilot Home Summary

Prepared for: California Energy Commission
By: Rheia LLC ., 4636 S 35th Street, Suite 2, Phoenix, AZ, 85040

June 29th, 2021

Introduction

The Rheia air distribution system was installed and commissioned in a pilot test home in March 2020. The intent of this pilot home was to assess the condensation risk of uninsulated ducts in chases, bulkheads, and enclosed spaces in a challenging climate zone. A newly-constructed, unoccupied Pulte Homes' house was used for the pilot installation, the two-story, slab-on-grade home is located in the East Lake Preserve neighborhood in Kissimmee, Fl. Monitoring equipment was installed to measure the chase, ductwork, and house conditions through the duration of the test program from May through October 2020.

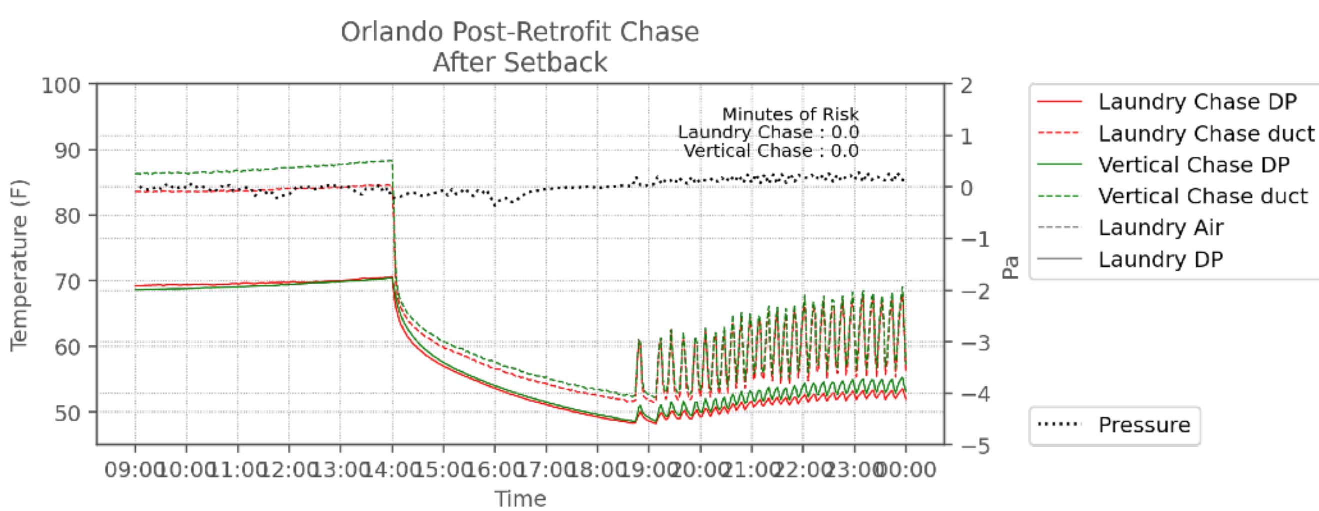
Cases where significant amounts of hot humid air that leak into the home and condense on cold surfaces are common knowledge in the building industry. For that reason, Rheia provides construction details that need to be followed to create leak-free chases and bulkheads that are adjacent to unconditioned spaces of the home. After an initial test period in the Pulte pilot home, the chases and bulkheads containing Rheia's uninsulated ductwork were air-sealed and insulated per Rheia's best practice requirements. These practices that ensure air tight installations are common knowledge and are ratified by whole house leakage tests as required by energy codes in many US markets

Assessing Duct Condensation Risk

After an initial assessment period, a series of 'stress tests' were conducted to evaluate the risk of condensation in extreme cases. The tests were; a power outage simulation, low thermostat set point, and leaving windows open throughout the home. These scenarios were run with the newly constructed chases and bulkheads.

Power Outage Scenario

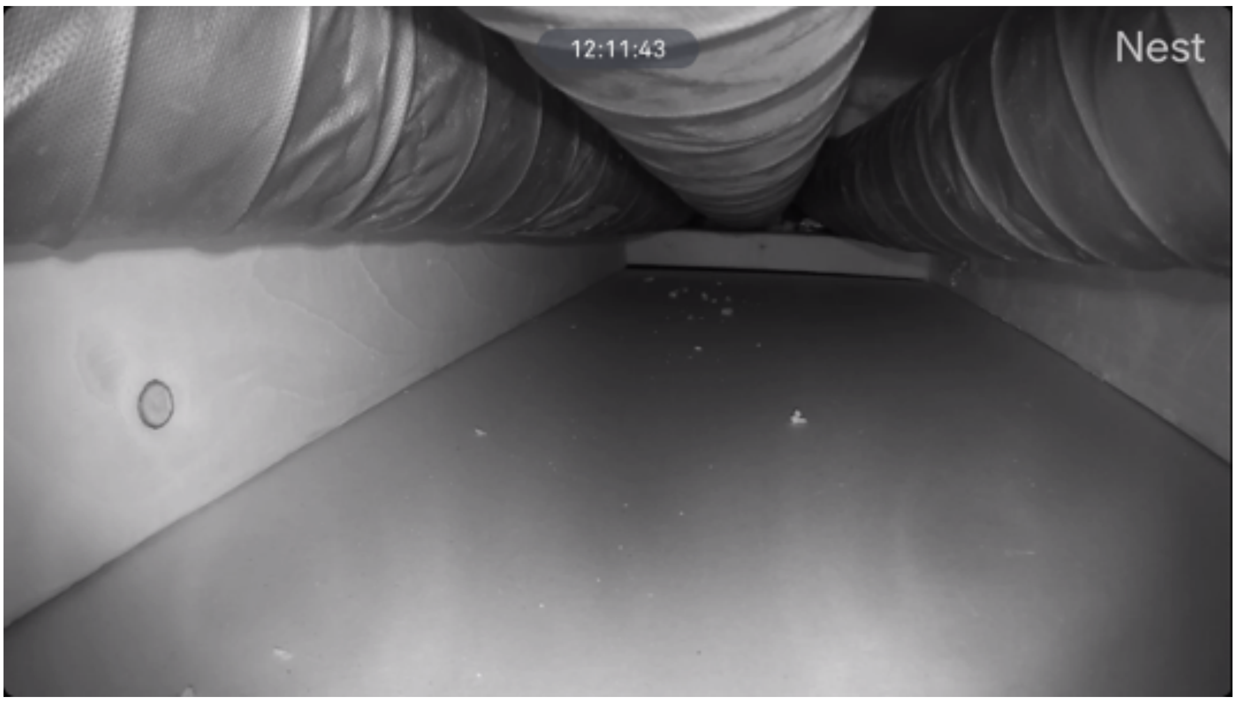
To simulate a power outage, which is a common occurrence in Orlando due to hurricanes and thunderstorms, the cooling equipment was shut off for 48 hours, allowing the indoor conditions to become hot and humid. There was a long runtime once the unit was turned back on. The data indicates the surface temperature of the ducts never fell below the dew point of the surrounding air in the chases, and not in a condition where condensation could occur. Video footage capturing the condition in the case over the test period confirmed the ducts remained dry.



When the air conditioner ran after the shut off period, it dehumidified the air more quickly than lowering the dry bulb temperature. This forced the dew point of the air within the home to never exceed the duct surface temperature

Low Temperature Set Point Scenario

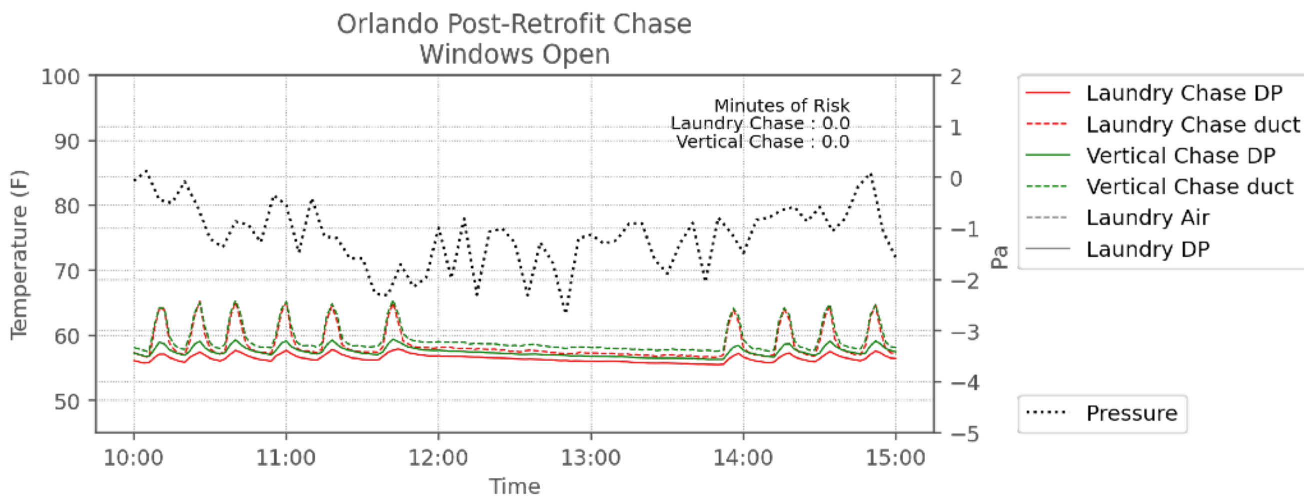
Tests were run with a thermostat set point at 68°F to simulate the lowest temperature a homeowner would realistically set the interior temperature. The duct surface temperature got colder at lower set points. However, with the small amount of air infiltration from the attic into the chase, a condensation issue did not occur. The data did not show any points where the duct surface temperature was lower than the dew point. Video footage capturing the condition in the case over the test period confirmed the ducts remained dry. The following image is of ducts in a chase directly below the attic during the test period. Although the duct surface temperature was lower at the lower set point, the dew point was also lower, preventing any issues



Windows Cracked Scenario

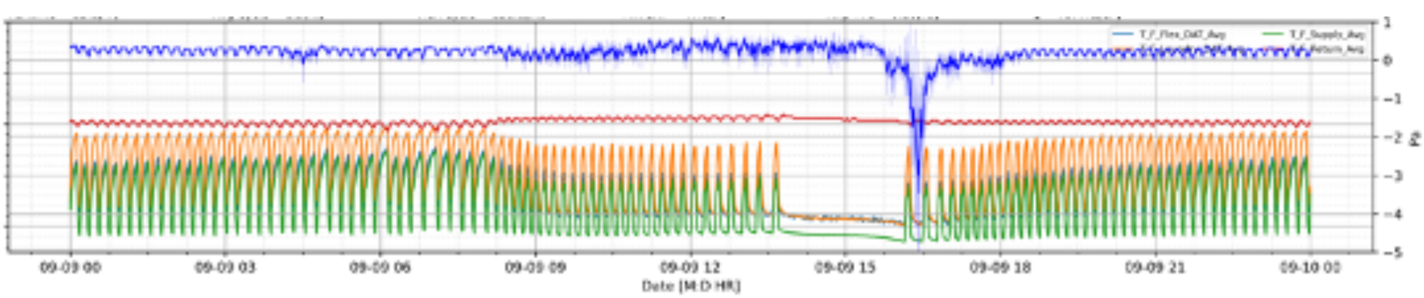
The third scenario tested was with windows left open throughout the home. A total of four windows, two on the first floor and two on the second, were opened about 1" each. Showers, laundry, cooking, occupants, pets, plants and other factors introduce humidity into the home when the home is occupied which this test simulated. Since testing was done on an unoccupied home, windows were cracked to a point that would simulate extreme indoor usage. The chases are not completely air-sealed from the living space, so when the indoor humidity raises, so does the humidity in the chase. Higher humidity means a higher dew point.

The increased indoor humidity drew the chase dew point and duct surface temperature towards one another. The chart below shows one of the days where the windows were open. The duct surface temperatures were close to the dew points (within about a degree F) but never crossed over. Since the chases were well-sealed to the attic, the increased indoor humidity alone was not enough to create condensation.



Attic Pressure Evaluation

During the test period, a pressure transducer was installed to measure the pressure difference between the attic and laundry room chase. This was done to confirm that higher pressure differentials will produce increased airflow through any small gap in the air barrier between the attic and a chase. The data from the transducer typically showed low values between 0 and 1 pascals, with the attic at a higher pressure than the chase. This pressure differential occurs naturally due to stack effect. Since the attic was at a slightly higher pressure, air would slowly flow from the attic into the chase through small gaps potentially bringing moisture with it. There were times each day when that value would drop to as low as -5 Pascals. This is assumed to be due to external wind. Testing took place during the stormy season in Orlando. Wind creates a negative pressure in the attic, pulling air from the chase into the attic. Air flowing into the attic does not cause any issues. The chart below shows a typical day during the monitoring period.



The blue line represents the pressure differential. Understanding the pressure differential is important because there is a direct relationship between pressure and airflow into a chase. Since the pressure differential is relatively low, any gaps in the air barrier must be large to create a substantial amount of airflow into the chase.

Conclusion

In September 2020, the chases, bulkheads, and duct system, were given a final inspection before handing back to Pule Homes to sell. Even with some air leakage due to minor construction defects from the attic into the chases, there were no indications of condensation accumulation on the ducts or chase surfaces. This indicates that an imperfect installation, where the chase is not perfectly air-sealed, and a small amount of air leakage into the chase occurs does not create a condensation issue. The house has been owner-occupied since October 2020.

These tests were done near Orlando, Fl where the outdoor weather conditions are far more severe than any climate in California.

The table below shows a comparison of Orlando and several other cities where Rheia has been installed, and California. Installations in California will have less risk of condensation since there is far less moisture present.

		ASHRAE Climatic Design Conditions - 2013		
	City	Cooling 1% - Dry Bulb (Deg. F)	Cooling 1% - Mean Coincident Wet Bulb (Deg. F)	Dew Point at Design Condition (Deg. F)
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	Sacramento	98.2	69.6	53.2
	Los Angeles	80.4	63.6	53.0
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