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1/7/2025
Building Moisture Investigation at Elvehjem Arts Center

There are several problems at the Elvehjem Arts Center.

Part of the problem is understanding that there are several problems and how they are related to each other.

My goal here is to conclude with an explanation of these finer details of these issues.

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1/7/2025

Building Moisture Investigation at Elvehjem Arts Center

Problems at the Elvehjem Arts Center

1. The top floor of the building, the Penthouse Mechanical Room, is annually pressurized to be slightly positive by 0.05 inches of water column.

2. Moisture condensing on the roof below the Penthouse Mechanical Room on the outside of the building.

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1. The top floor of the building, the Penthouse Mechanical Room, is annually pressurized to be slightly positive by 0.05 inches of water column.

The Elvehjem Arts Center is unique from most buildings on the planet because of what is inside of the facility.

Expensive artwork and artifacts that require warm, moist and clean air for proper preservation that MUST stay within defined temperature and moisture parameters throughout the year and are the driving design force for the Art Center.

These parameters have presented multiple challenges for building architects and engineers since mankind has identified them in the preservation of materials and attempted to successful manage those conditions for thousands of years and it is extremely more challenging in this situation because of the harsh climate surrounding the Arts Center because it is located in Madison, Wisconsin.

Fortunately, mankind has developed multiple types of Heating, Ventilating and Air Conditioning equipment and systems to maintain these yearly changing conditions and, in the late 1960's, installed them in this facility and campus FP&M has done a nice job of "maintaining" this equipment and systems.

Please keep in mind that the atmospheric conditions outside of the Madison center vary.

1. Be as low as -25 F, in the winter months, with very little moisture
2. Be as high as 110 F, in the summer months, with very large amounts of moisture
3. Vary from intermittent and unpredictable inclement weather during the Spring and Fall

This stresses the barrier between the inside of the building and exterior, where these two conditions meet, and this last project has shown where the of wear and tear has presented itself.

Please also note, there has never been a condition where there is both a constant temperature and moisture content for more than a few minutes, on ANY given day, since the building was constructed some nearly 60 years ago, in the late 1960's, so the barrier is constantly being attacked by temperature and moisture changes throughout the day, every day, since it was built, thus all this damage has occurred.

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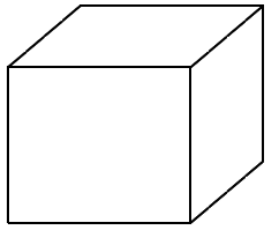
1/7/2025
Building Moisture Investigation at Elvehjem Arts Center

In the image next to this paragraph, there is a simple and basic "theoretical" Building Pressure diagram of a building pressure with no outside air entering it. The building is completely neutral and a single story in height and no wind blowing on the building.

A simple "theoretical" Building Pressure with no openings; just recirculated air.



Neutral

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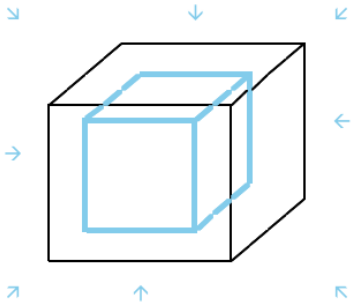
1/7/2025
Building Moisture Investigation at Elvehjem Arts Center

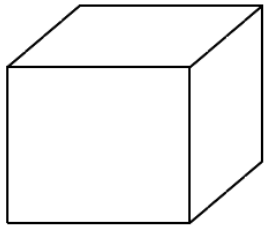
The current understanding of the three (3) states of Building Pressurization Conditions. This is how the current UW Direct Digital Controls computer views the Elvehjem Arts Center.

ONE SINGLE PRESSURE

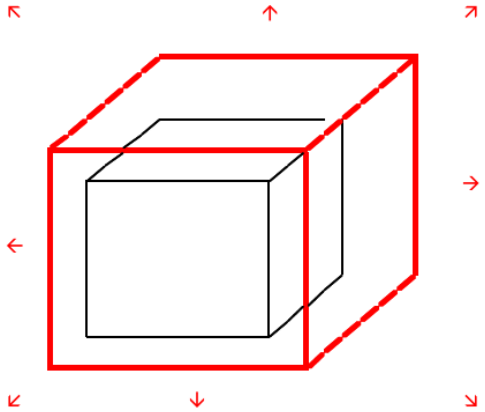
In the three images next to this paragraph, there are three “realistic” images of taller buildings that the building pressures are discovered to be at and are found in real life, outside of theory.
Please note the when the wind blows, it effects one side of the building more than the other and it causes multiple problems “measuring and defining” the “true building pressure”.



Negative



Neutral



Positive

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An excellent example of building pressure can be explained by using a simple hot air balloon and the pressures it exhorts while it is inflated.
Please note that it is affected when the wind is blowing and can be viewed by simply watching the ballon's shape while it is in flight.

The current understanding of a hot air balloon pressures.

Positive at the top

Neutral in the middle

Negative at the bottom

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1/7/2025

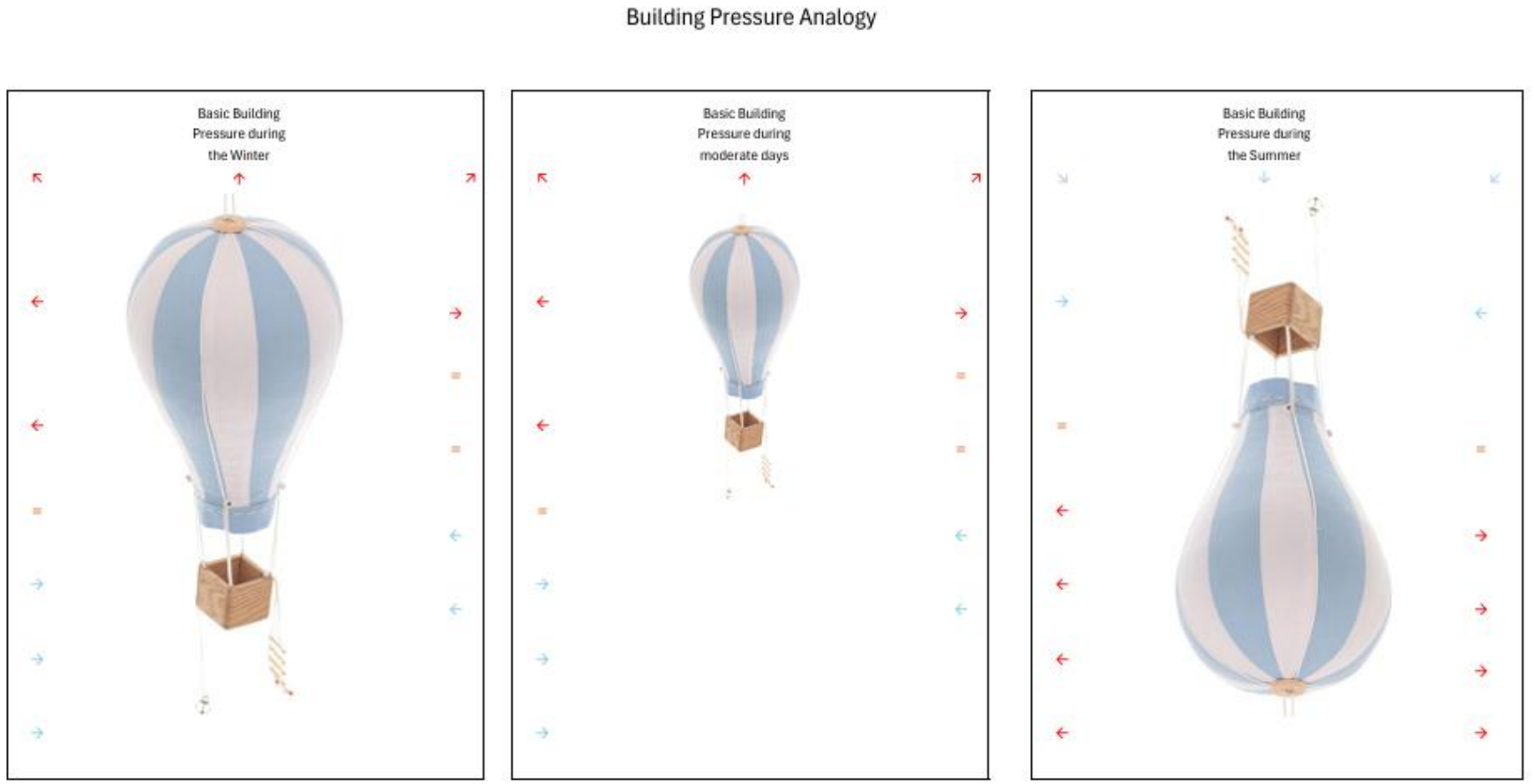
Building Moisture Investigation at Elvehjem Arts Center

The current understanding of the three (3) states of Building Pressurization Conditions

The only difference here is that the pressures characteristics will change as the outside conditions change.

Think of the building as a “hot air balloon” bolted to the ground.

Once secured, think of how it is affected by wind and the small penetrations in the vapor barrier or general construction force air into one side of it and out the other.



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1/7/2025
Building Moisture Investigation at Elvehjem Arts Center

In the illustration next to this paragraph, there are three “realistic” images of the Elvehjem Arts Center, found in real life, outside of theory.

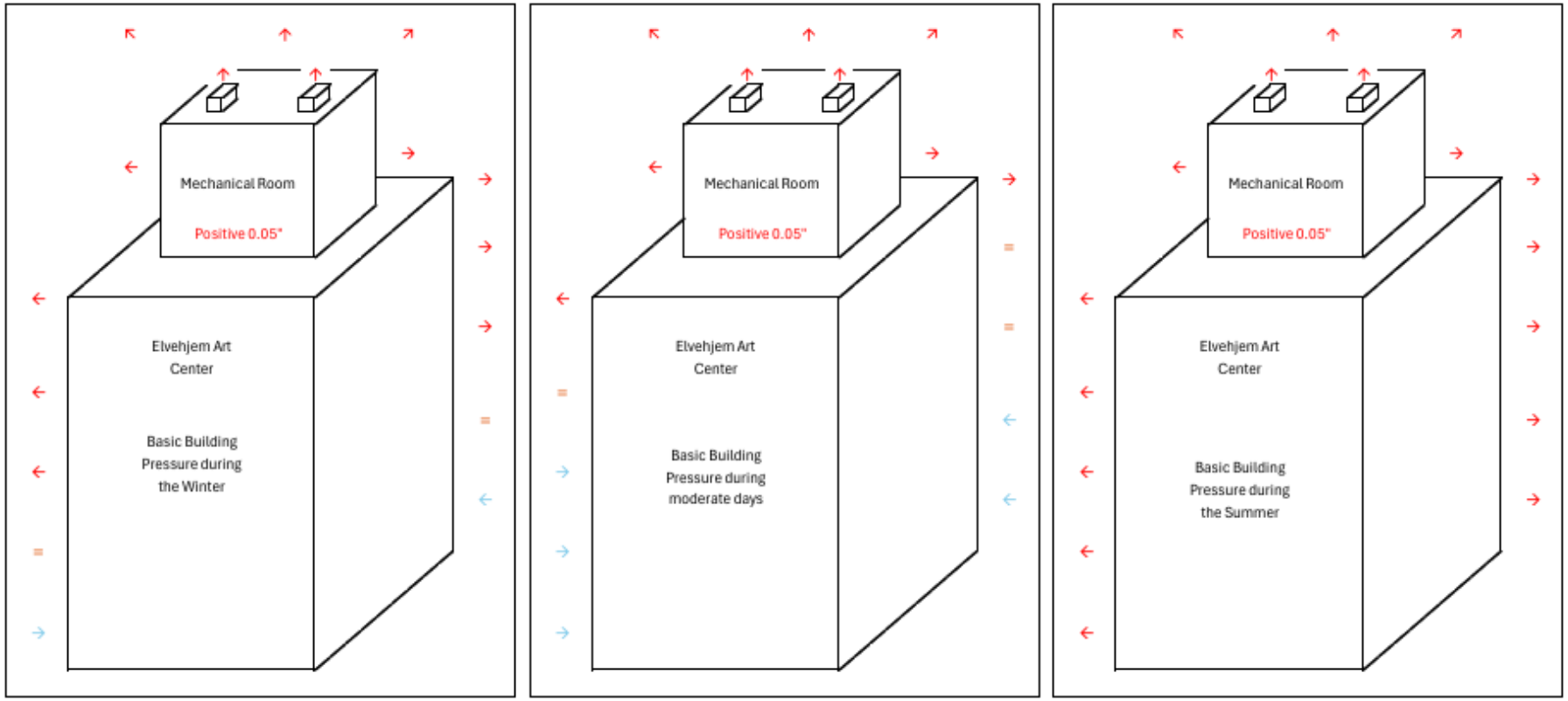
The point of these illustrations is to show that there are at least “TWO” pressurized area present at any one time in the art center.
The mechanical room and the entire Elvehjem Art Center.
The first condition is in the Winter, the second condition is in the Spring and Fall and the third condition is in the Summer.

The State of WI occupancy code requirements mandate that an annual minimum amount of outside air be brought into the building for both the people that both occupy and visit the Art Center replace all the restroom exhaust air volume.

My conclusion is that there is fundamental problem with the way that air volume is managed removing it from the building.

The building is thought of as ONE SPACE and not TWO SPACES and the positive (and negative) pressurization problems on the building are the source of the moist internal air escaping through the existing perimeter / envelope and that moisture accumulation are the source of our envelope problem.

The current understanding of the three (3) states of Building Pressurization Conditions



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1/7/2025
Building Moisture Investigation at Elvehjem Arts Center

Please note the constant excessive pressure built up in the upper mechanical room.

The value is always positive 0.05” of water pressure because it was designed to be 0.05” of water pressure.

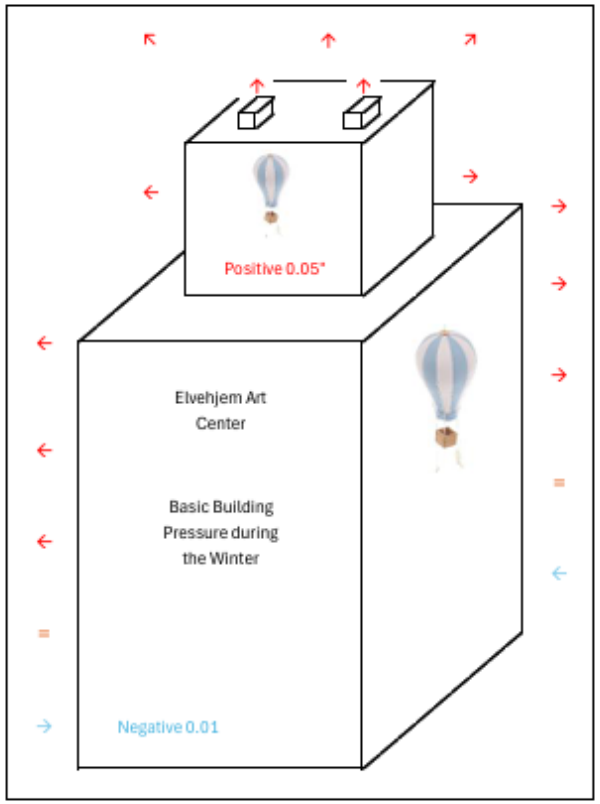
The building is designed to never go below this value because of the mandated minimum outside air quantities AND there is no “powered” exhausted” through two building pressure relief roof penetrations.

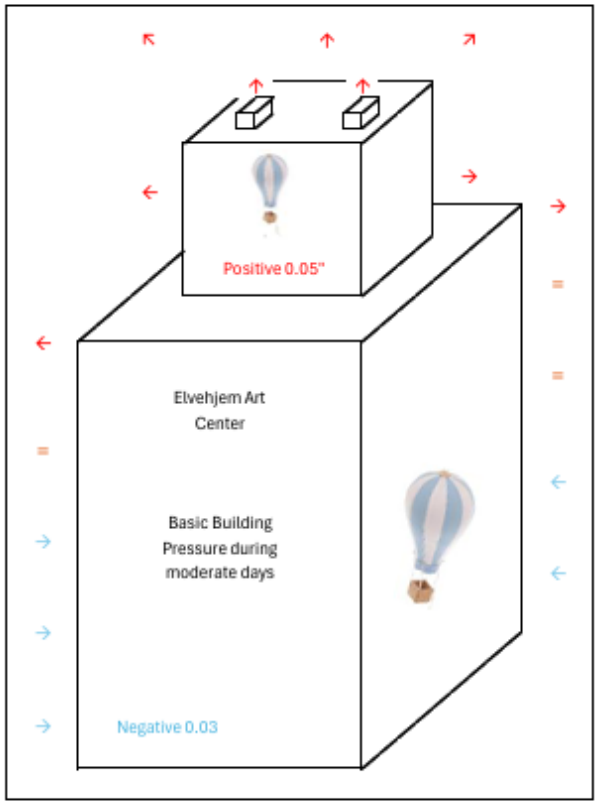
The air can only leave the building by non-mechanical means. In other words, two big dampers at the top of the mechanical room to the outside.

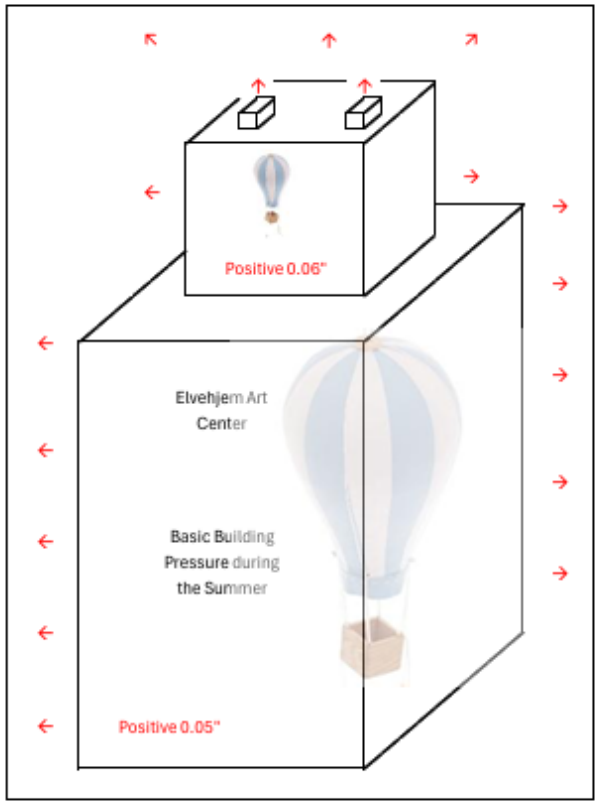
Those dampers are controlled by the two pressure relief dampers located at the top of the building’s Mechanical Room.

Please note that the pressure exceeds 0.05” of water when all the equipment is driven to 100% outside air during “ideal free-cooling conditions” on cooler days when the units try to economize and take advantage of the cool air outside.

The current understanding of the three (3) states of Building Pressurization Conditions







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1/7/2025
Building Moisture Investigation at Elvehjem Arts Center

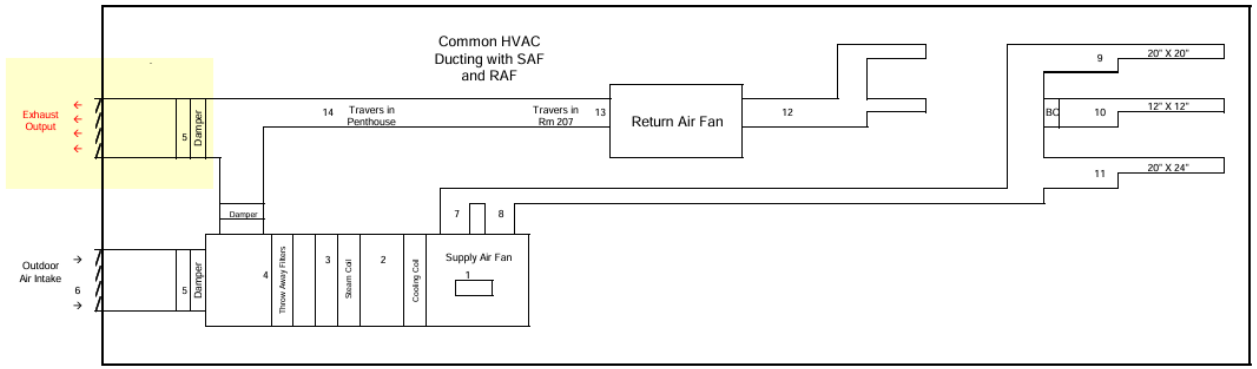
The mechanical room pressurization is also due to a fundamental basic design concept for “exhausting” excessive return air in the building.

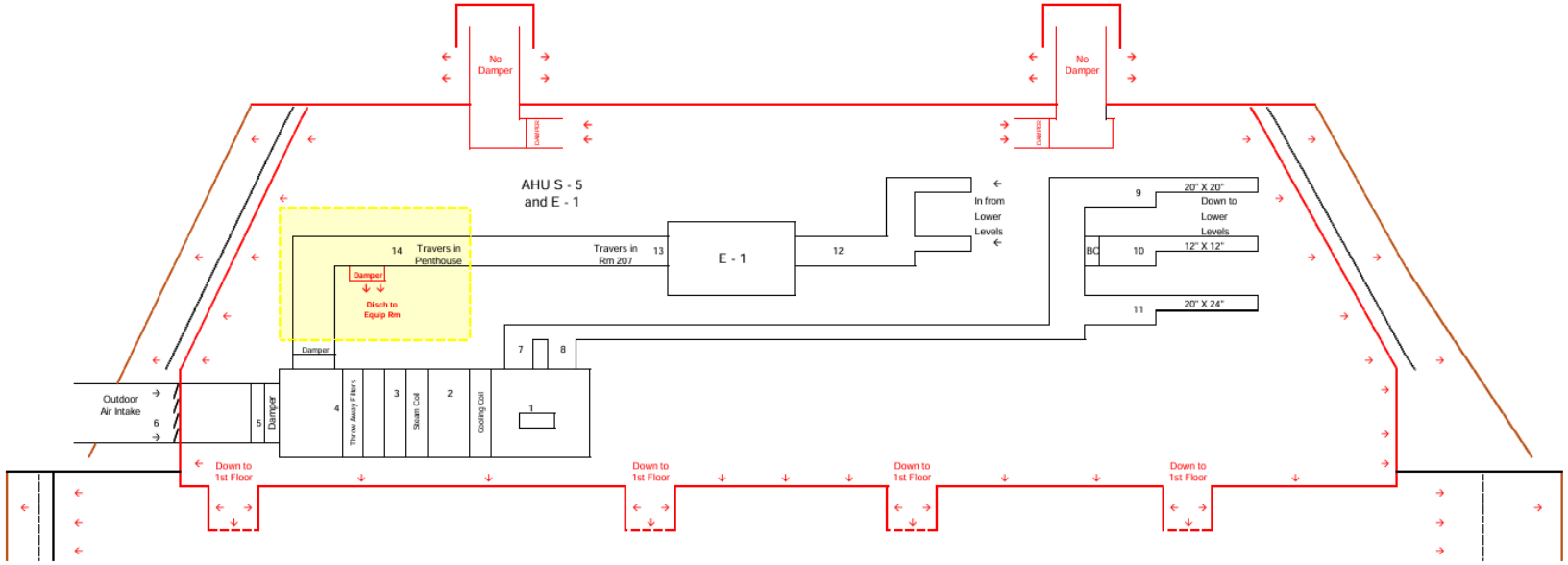
The upper diagram shows most mechanical room design fundamentals found in most buildings in Wisconsin.

The lower diagram shows how the Elvehjem Arts Center (and parts of Humanities next door) are ducted.

Note the differences highlighted in yellow. The upper system directly ducts the air outside while the lower system “pressurizes” the mechanical room (and the whole building) and attempts to “force” the air out the two large building pressure relief ducts at the top of the Penthouse.

You can either change the ductwork configuration or install pressure relief fans to the equipment room.





2. Moisture condensing on the roof below the Penthouse Mechanical Room on the outside of the building.

I stated earlier that the Elvehjem Arts Center is unique from most buildings on the planet because of what is inside of the facility.

Expensive artwork and artifacts that require warm, moist and clean air for proper preservation that MUST stay within defined temperature and moisture parameters throughout the year and are the driving design force for the Art Center.

My explanation of the mechanical room ALWAYS being positive to the outside of the building and the daily variations of the rest of the building pressure leads us to the root of the cause of moisture issue on both the outside of the building and in the hidden pathways the air is escaping through the exterior of the building.

Fortunately, we can control how much moisture each block of air in the building each block can receive from each air handler. All ten of them.

Unfortunately, we can not control where the moisture goes after it leaves the ductwork.

The airborne moisture acts as if it were any other type of gas in our atmosphere. It is highly volitive and is free to roam and mix as it pleases in the building. It can even leave the building if the building is not negative enough. This is explained in Daltons Gas Law of Partial Pressure. I'll leave it at that because I don't want to go down that discussion.

In other words, once the moisture is introduced in the building, the moisture is going to be present everywhere, and it will be in equal parts everywhere.

IF this statement about the moisture is true, any of the air that is escaping the building it going to contain that moisture and therefor condense wherever it strikes a surface that is cold enough to condense on.

In the illustration my next to the next paragraph, there are several readings taken throughout the building.

Please note that the moisture content is nearly THE SAME everywhere I the building.
It has been like this for 60 years.

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1/7/2025
Building Moisture Investigation at Elvehjem Arts Center

The readings from these two instruments show that the moisture content is uniform throughout the Art Center and there is very little moisture present outside. Therefor, the moisture on the roof MUST BE COMING FROM INSIDE THE FACILITY!

1/7/2025 - Summary of the moisture readings at the Elvehjem Art Center.

These readings were taken in the Elvehjem Arts Center, inside the Mechanical Penthouse Room, by the stairwell.

Below are the charactristics of the air inside "the 12"by 12" by 12" box of air.

29.8	Inches of Hg	Atmospheric Pres.	No Change
83.1	**Fahrenheit**	**Dry - Bulb**	**Standard**
59.4	Fahrenheit	Wet - Bulb	Standard
23.0	**%**	**Relative Humidity**	**Standard**
41.5	Fahrenheit	Dew Point	Standard
38.6	Grains / Lbs	Water Vapor Content	Standard
26.0	Btu/lb	Enthapy	Standard
13.80	Cu.Ft. / lbs	Specific Volume	Standard

These readings were taken on the upper Artium floor, outside the stairwell and elevator.

Below are the charactristics of the air inside "the 12"by 12" by 12" box of air.

29.8	Inches of Hg	Atmospheric Pres.	No Change
73.8	**Fahrenheit**	**Dry - Bulb**	**Standard**
56.4	Fahrenheit	Wet - Bulb	Standard
33.0	**%**	**Relative Humidity**	**Standard**
43.0	Fahrenheit	Dew Point	Standard
40.8	Grains / Lbs	Water Vapor Content	Standard
24.1	Btu/lb	Enthapy	Standard
13.57	Cu.Ft. / lbs	Specific Volume	Standard

These readings were taken on the "trolley platform" located in the Mezzanine below the glass.

Below are the charactristics of the air inside "the 12"by 12" by 12" box of air.

29.8	Inches of Hg	Atmospheric Pres.	No Change
75.9	Fahrenheit	Dry - Bulb	Standard
57.0	**Fahrenheit**	**Wet - Bulb**	**Standard**
30.0	**%**	**Relative Humidity**	**Standard**
42.3	Fahrenheit	Dew Point	Standard
39.8	Grains / Lbs	Water Vapor Content	Standard
24.4	Btu/lb	Enthapy	Standard
13.62	Cu.Ft. / lbs	Specific Volume	Standard

These readings were taken outside the building of the Elvehjem Arts Center.

Below are the charactristics of the air inside "the 12"by 12" by 12" box of air.

29.8	Inches of Hg	Atmospheric Pres.	No Change
25.1	**Fahrenheit**	**Dry - Bulb**	**Standard**
20.5	Fahrenheit	Wet - Bulb	Standard
42.0	**%**	**Relative Humidity**	**Standard**
7.4	Fahrenheit	Dew Point	Standard
8.02	Grains / Lbs	Water Vapor Content	Standard
7.3	Btu/lb	Enthapy	Standard
12.24	Cu.Ft. / lbs	Specific Volume	Standard

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1/7/2025
Building Moisture Investigation at Elvehjem Arts Center

Please observe the red arrows on the diagrams.
Wherever there is air leaving the building, there is moisture.
Mathematically, if we take the square root of the velocity pressure and multiple it by 4005, a gas constant, it yields our air velocity as if it were measured with a Pitot Tube (like an airplane measures its speed).
The square root of .05 times 4005 indicates that the air leaving the building is at a velocity close to 896 feet per minute or 10.18 miles per hour.
That is why you can feel the air pressure through the roof hatch and why there is moisture raining out from under the panels and metal decking.
IF we can lower that pressure down to nearly zero, we should be able to nearly eliminate the moisture problem; however, in the world of pressure management, zero is nearly impossible to achieve so you have to decide if you want it either negative or positive and by how much.