Re-circulation or Pressurization for Electrical Rooms

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1.0 Overview

The goal is to provide clean air inside a space where corrosion, temperature, humidity and dust is not a factor in equipment reliability. Filtration works with air conditioning to provide such an environment if sized correctly and the space and equipment are maintained.

Pressurization requires introduction of outside air either through inducement or fan forced, and the intent is that the air being introduced is very clean, and all air entering the room is through the pressurizer, and all leakage is "out". By dilution, the air is cleaned. It is like pouring clear liquid into a glass of colored liquid, until the liquid becomes clear "enough". The clear liquid is expensive, and a lot is discarded to achieve this goal.

Re-circulation involves filtering the air inside the room to remove contaminants. Essentially filtering the "color" out of the "colored liquid". This is a far more cost effective way to achieve a clean environment, and we will endeavor to prove the point mathematically in the following calculations.

As the basis for the calculations, we will assume a room 60' long x 30' wide x 20' high, and a starting concentration of 2 ppm H_2S. The room volume is 36,000 ft^3, or 1,019 m^3. The contaminant level of 2 ppm, is 2.8 mg/m^3 (ppm x 1.4= mg/m^3). The mass of H_2S in the room is 2.85 grams, or 0.09 oz. Based on a standard impregnated carbon, nothing special, with a capacity of 25% by weight, this room would require 0.36 oz of media. Not even a handful.

A dollar bill is 0.104 ft^2. A football field, including end zones, is 57,240 ft^2. If the surface of a football filed were covered by dollar bills, there would be 550,385 bills on the ground. 1 in 1 million, ppm, would be about 55c; 2 ppm would be $1.10.

2.0 Pressurization

We will assume a flow of 5% of the room volume per minute (1,800 cfm) for pressurization and an outside level of 2 ppm, a one pass removal efficiency of 99%. In real life, we consider this a fairly optimistic figure.

There is usually some leakage- allow some wind/personnel/opening doors etc. Based on this scenario, the inside level would be 0.022 the level of the outside, or 46 times cleaner, but still at 43.9 ppb. From ISA Standard S-71-1985, Table 3 or 2013 Table B1, this would still be a G3- Harsh environment, which is any concentration between 10 and 50 ppb. The accuracy of the correlation between contaminant levels on these tables is debatable- A G1 environment is listed at less than 3 ppb! A far bigger contributor will be unconditioned air and additional moisture from the outside air.

If we assume a constant challenge of 2 ppm, and 1800 cfm 24/7/365, the filtration system would be required to remove 165 lbs of H_2S per year, and will consume approximately 660 lbs of media based on 25% capacity by weight.

For every 10 degree temperature difference between outside and inside in heating, each 1800 cfm will require 19,000 Btu/hr, or 5.6 kW of heating. In cooling, the energy requirement will be higher due to latent loads etc.

Rarely do pressurization scrubbers have heating on the intake side of the media. Therefore, once the temperature drops below approximately 35 ^{o}F, the reaction and removal efficiency will most likely be slow to non existent. Therefore contaminated air will be forced into a room and will warm up and react. The one thing that slows this down will be lack of humidity in very cold weather, plus the heat inside the room is all sensible. We are unsure of the performance of the newer, higher capacity “Catalytic” carbons at low temperatures.

	Gas Phase Model	
Site ID	Typical Chemical Plant	
	Pressurization only	
Variable	**Description**	**Value**
C	outside air contaminant concentration, ppb	2000
Q1	intake air quantity into room, cfm	1800
η1	intake filter efficiency, %	99
QL	air leakage around intake filter, cfm	10.80
QR	recirculation filter airflow, cfm	0
ηR	recirculation filter efficiency, %	0
QW	wind quantity infiltration into room, cfm	10.80
Result		
Pen	ratio of inside contamination to outside	0.022
x	inside air contaminant concentration, ppb	43.9
PF	Protection factor, Co/Ci	46
	Input Table	
	Space volume, ft3	36000
	Pressurization air, % volume per minute	5
	Re-circulation air, % volume per minute	0
	Wind entrance, % volume per minute	0.03
	Filter bypass, % outside air per minute	0.03

The room has a “Protection Factor” of 46, indicating by the model an environment 46 times cleaner than the outside.

3.0 Re-Circulation

This is passing the space or room air through re-circulation scrubbers to clean up what is in the room. It covers the introduction of contaminants through doors, personnel etc.

If we take the same room, increase the amount of outside air leakage into the space, we drop the removal efficiency but double the filtration rate, and allow for approximately 45 cfm of outside air leaking into the room, the inside level would be 0.009 the level of outside, and level would be 17.6 ppb. The inside would be 114 times cleaner than the outside.

From ISA Standard S-71-1985, Table 3, and 2013 Table B1, this would still be a G3- Harsh environment, which is any concentration between 10 and 50 ppb. Again, the accuracy of the correlation between contaminant levels on that table is debatable- A G1 environment is listed at less than 3 ppb!

The inside contaminant levels reduce further with higher turn rates and less infiltration from outside.

A re-circulation system is:

1. Far less of an energy consumer;
2. Far more forgiving as media has been consumed and removal efficiency drops;
3. Will operate at standard room temperatures and not add load to the climate control system;
4. Use a fraction of the media and provide cleaner air;
5. Typically have removable media containers, thereby eliminating the need for vacuum trucks and refilling adventures.

	Gas Phase Model	
Site ID	Typical Chemical Plant	
	Recirculation only	
Variable	**Description**	**Value**
C	outside air contaminant concentration, ppb	2000
Q1	intake air quantity into room, cfm	9
η1	intake filter efficiency, %	0
QL	air leakage around intake filter, cfm	18.00
QR	recirculation filter airflow, cfm	3600
ηR	recirculation filter efficiency, %	85
QW	wind quantity infiltration into room, cfm	18.00
Result		
Pen	ratio of inside contamination to outside	0.009
x	inside air contaminant concentration, ppb	17.6
PF	Protection factor, Co/Ci	114

Input Table	
Space volume, ft3	36000
Leakage air, % volume per minute	0.025
Re-circulation air, % volume per minute	10
Wind entrance, % volume per minute	0.05
Filter bypass, % outside air per minute	0.05

4.0 Re-circulation and Pressurization

A combined system that has pressurization and re-circulation will further lower contaminant levels. The air leakage into a room through poor seals, wind, access doors etc. will reduce, so more of the air entering the room will be clean.

The emphasis is on having the media in operating condition, and climatically being capable of working. In cold climates, this requires pre heat or mixing with room return air. The latter is not a bad option as the contaminant challenge levels are evened out and the scrubber does not run the risk of uneven contaminant levels passing through a media bed and therefore uneven media consumption and breakthrough.

The table below is the model for a mixed flow situation. The amount of pressurization air is reduced to only 1% of the room volume.

Under this model, the inside level would be further reduced to approximately 12.6 ppb.

	Gas Phase Model	
Site ID	Typical Chemical Plant	
	Pressurization and Recirculation	
Variable	**Description**	**Value**
C	outside air contaminant concentration, ppb	2000
Q1	intake air quantity into room, cfm	360
η1	intake filter efficiency, %	99
QL	air leakage around intake filter, cfm	9.00
QR	recirculation filter airflow, cfm	3600
ηR	recirculation filter efficiency, %	85
QW	wind quantity infiltration into room, cfm	9.00
Result		
Pen	ratio of inside contamination to outside	0.006
x	inside air contaminant concentration, ppb	12.6
PF	Protection factor, Co/Ci	159

Input Table	
Space volume, ft3	36000
Pressurization air, % volume per minute	1
Re-circulation air, % volume per minute	10
Wind entrance, % volume per minute	0.025
Filter bypass, % outside air per minute	0.025

Here the room ends up with a “Protection Factor” of 159.

5.0 Conclusion

The best situation is a small amount of pressurization with significant re-circulation. What is introduced from outside has to be clean and that means the scrubber has to be capable of removing the contaminant by having enough media, the air must be at a condition that removal can occur and the media needs to be monitored for life and replaced before the removal efficiency has dropped. Otherwise the situation could be far worse for the room.

Probably one thing saving industrial sites on pressurization only systems is that contaminant levels are typically much lower in winter.

Tremendous results can be achieved by re-circulation filtration only. These are much easier to install, have a much lower cost to operate and do not create worse problems if media is spent as in straight pressurization systems.

A swimming pool is kept clean by filtering the water in the pool, not by exchanging the water 3 to 5 times per hour.