Applying Dynamic Controls™ to Vapor Intrusion Mitigation Systems to Manage Pressure Differentials, Effluent Concentrations and Energy Conservation

Paper # 18

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ABSTRACT

This paper describes the development and applications of dynamic motor controls that have been designed to optimize the operational efficiencies of soil vapor intrusion mitigation systems (VIMS). The current generation of VIMS utilizes a combination of centrifugal, regenerative and radial blowers that are intended to achieve minimum sub slab pressure differentials that are usually specified by a regulatory agency's vapor mitigation guidance documents. Among the limitations of current technology is that after the blowers have been running for a few weeks, the soil moisture beneath the slab is reduced which often results in several adverse unintended consequences. They are: the development of preferential pathways that can draw source contaminants through the system thus exceeding exhaust effluent standards, the development of zones of excessive soil gas airflow yields and the creation of sub slab vacuum fields that exceed the pressure differentials that are required to mitigate the entrainment of soil vapors. All of these factors contribute to excessive power consumption. The paper demonstrate how the application of sensors and reactive circuitry can be implemented to achieve specified sub slab pressure differentials for the purpose of regulating the flow of source contaminants, exhaust effluent concentrations and improving energy conservation by as much as forty percent or more. Dynamic Controls™ and the associated electronic system management technology is a substantial improvement over the current technology in the areas of monitoring motor performance, reducing energy consumption, extending operating cost savings to building owners and providing system managers with advanced warning of potential motor failures thus protecting building occupants from unnecessary exposure to harmful vapors.

INTRODUCTION

Designing an effective and energy efficient Vapor Intrusion Mitigation System (VIMS) starts in the planning stage with a firm understanding of all the variables that are contributing to the problem.[1] Although there are many goals that are usually integrated into the design of a mitigation system such as aesthetics, ease of maintenance, cost to the client, etc., the primary focus should be on protecting human health followed by long term sustainability. Since no one really knows how far into the future these systems will need to operate, energy efficiency and performance monitoring need to be key components of the design. This paper presents a method of dynamically controlling VIMS systems to enhance energy efficiency and sustainability.

MITIGATION DESIGN PRINCIPLES

Migration of contaminant vapors into buildings most often occurs because air pressure inside of a building is lower than the pressure in the soil beneath the building. These lower indoor pressures draw soil gases into the building via pathways such as floor drains, sumps, cracks in the slab, open concrete block tops, and utility penetrations. Although adding outdoor dilution air can be integrated as part of a secondary solution, basic VIM technology functions by applying vacuum in the soil or air plenum beneath a building. This technology, first introduced in the 1980's to mitigate indoor radon, has demonstrated to be the most reliable and cost effective.

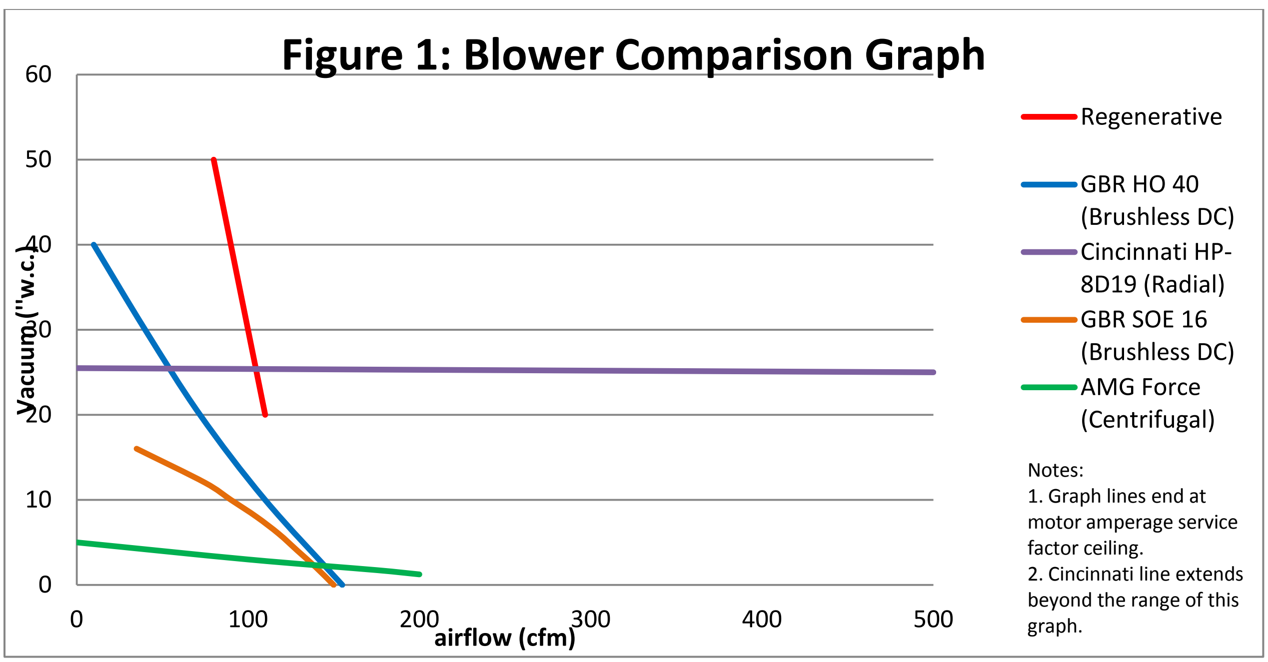
The Vapor Intrusion (VI) risk to building occupants depends on the toxicity of the individual chemical and the concentration of that chemical in the building. Unlike radon, there are no national standards for acceptable concentrations of VI compounds. Published standards for corrective measures and risk tables vary widely across federal and state environmental agencies. Since acceptable risk concentrations of many compounds has demonstrated to be a moving target in the direction of increasingly lower permissible levels of exposure as analytical technology improves, it is wise to design a vapor intrusion system with a goal of achieving non-detect for the Compounds of Concern (COC) for which the mitigation system is being designed.

Developing an effective VI mitigation plan depends on understanding and quantifying the relationship between three key factors that contribute to VI: (1) the properties and concentrations of the COC's; (2) the pressure differentials that draw contaminants from the soil and groundwater into the building; and (3) the number and size of the pathways that allow VI into the building.

After the mechanical components of the building that influence pressure are understood and the potential contaminant entry points have been catalogued, the next step is to understand exactly what will be required to create the desired pressure differential beneath the slab. Since most of the energy and costs required to mitigate the problem will be allocated as a result of the data collected during this phase of the investigation, it is critical to understand exactly how much vacuum needs to be applied and where to achieve the pressure differential goals. Achieving system effectiveness usually occurs when the objective of the design is to create a pressure differential between -0.016 and -0.008 inches of water column (in. w.c.) with a minimum cold weather performance standard of -0.004" w.c. (1 pascal). [2]

The pathways of soil gas entry need to be sealed. These are usually fairly obvious. The next step is to determine what is required to depressurize the slab. Pressure field testing of the soil beneath the slab will determine vacuum field extensions; this is accomplished by drilling suction test holes in the slab, auguring out some soil and applying vacuum to simulate future vacuum fields. The physical characteristics of the sub slab material should be noted and recorded. Applying different levels of vacuum to the test suction hole will determine the relationship between the vacuum applied and the pressure field extension needed for designing an effective soil depressurization system. The vacuum data from the pressure field testing and the measured volume of system exhaust are then extrapolated to project an expected radius of influence and soil gas yields in the form of airflow. Once this has been completed, several critical decisions need to be made with respect to the number and locations of suction points as well as the types and capacity of suction blowers to be used. There are centrifugal, small high speed brushless radial and 1-5 horse power (HP) regenerative and radial blowers to choose from. Each blower type has different performance characteristics and a best fit for the application.

All blowers have a common characteristic where vacuum is inversely proportional to airflow. Centrifugal blowers typically have low vacuum, high airflow and are used where the fill beneath a slab is highly permeable such as crushed stone or when depressurizing a crawlspace. Small high speed brushless radial blowers can be used on lower permeable soils that generally yield less than 120 cubic feet per minute (CFM). Regenerative blowers can develop relatively high vacuum levels, up to 80" w.c., and can be used where there is extremely low permeability and low airflow yields. Radial blowers, depending on the horsepower of the motor, width and diameter of the radial wheel, can sustain a wide range of vacuum and airflow. Because of the increased efficiency of radial blowers over multiple smaller blowers, they are usually well suited for mitigating large commercial buildings. The long, slightly arched performance curve of the radial blower enables multiple suction points, in some cases up to twenty, to be joined into a single blower system without a sharp decline in static vacuum. See graph below for details on the operation of the various blower types discussed. The success of the VIMS in terms of its operational life and the allocation of financial resources required to run and maintain the system depends heavily on correctly and accurately interpreting the diagnostic data and selecting the blower best suited to achieve the vacuum field objectives. The VIMS should be designed to function and meet pressure differential standards under a worst case scenario.



Different states have different standards of performance by which a mitigation system is designated as successful. For example, New Jersey's Vapor Intrusion Guidance Document classifies a system as successful if a minimum pressure differential of 0.004" w.c. (one pascal) is maintained between the floor slab and the building interior.[3] Massachusetts has a stated goal of 0.015″ w.c.[4] (almost four pascals) pressure differential. The higher pressure differential required by Massachusetts is typically not necessary to meet post mitigation Indoor Air objectives and results in higher energy costs.

DESIGNING VIMS FOR ENERGY EFFICIENCY

Up to this point, the large building VIMS design focus has been to create sufficient vacuum beneath the slab to facilitate achieving the pressure differential goals set forth by the state's regulatory agency and acceptable post mitigation indoor air quality tests. The result of this has been robust systems that have been effective in reducing indoor contaminants but inefficient in terms of energy consumption. Very little focus has been applied to power conservation and long term sustainability of VIMS. Integrating Dynamic Controls™ into a VIMS design will ensure that the goals of protecting human health and conserving energy for long term sustainability are achieved. There are two main categories of variables that influence the ongoing performance of a VIMS. They are the sub slab soil mechanics and a multiplicity of environmental variables that contribute varying pressures inside of buildings. Even though using Pressure Field Extension (PFE) modeling is the best way to project the radius of influence from a suction point and must be the starting point in the design phase; changes that occur once soil has been removed from the suction point and the moisture content of the soil beneath the slab has been reduced can alter the performance of a system to decrease the overall energy efficiency.

There are multiple variables that influence sub slab vacuum field extension and soil gas airflow yields throughout the year. VIMS are designed to continuously operate to accommodate the worst case scenarios that exist during the heating season. If energy efficiency and sustainability are goals of VIMS, then VIMS should have the ability to dynamically respond to changes from influencing factors. Integrating Dynamic Controls™ with VIMS design will enable the system to self adjust and change in response to influencing factors while maintaining a specific pressure field objective. The result could be that VIMS would not have to operate at continuous peak performance. Systems may actually only need to operate at fifty or sixty or less percent of peak performance to achieve vacuum goals. This would provide significant energy savings and extend longevity to the operation of the blowers. Designing energy efficient systems requires accurate pressure field extension data, efficient design, and Dynamic Controls™.

GREEN ENERGY AND SUSTAINABILITY CONSIDERATIONS

Since it has been demonstrated that using precision instruments during the diagnostic portion of the building investigation will yield data that will produce an efficient design, why not integrate the same level of instrumentation in the continuous operation of the system? EPA defines Green remediation as "considering all the environmental effects of a remedy implementation and incorporating options to maximize the net environmental benefit …" [5]. When designing VIMS, long term energy considerations need to be integrated into the design process. Greater design efficiency reduces operational costs and extends the time that an active venting program can be sustained for a fixed capital expenditure. Managing the application of sub slab vacuum to counterbalance the convective forces that draw soil gases into buildings will increase the efficiency of applied vacuum and reduce the energy required by the blower.

There are three main components that need to be considered when attempting to lower the operational energy costs of a radon or vapor intrusion mitigation system. They are: the cost of operating the blower(s) that will maintain the negative pressure field beneath the slab, the cost of the heated, cooled, and conditioned air that is being drawn out of the buildings, and the cost of replacing the blowers themselves.[6] Blowers operating at higher RPM and loads have a shorter life span than blowers that operate at lower RPM and lower loads. When a motor runs at partial capacity it does less work, runs cooler, and lasts longer, thus lowering operations and maintenance costs.

Previous studies have indicated that one of the greatest costs associated with operating a soil depressurization system is the loss of conditioned building air that is drawn down into the sub slab though slab openings such as floor wall joints, electrical conduits, slab cracks and other openings. When mitigating an existing building, many of these slab openings are not readily available for sealing. In some cases, replacing conditioned air that is drawn into mitigation systems can be a greater operational expense than the electrical cost to operate the blowers. The cost of replacing conditioned air can become the largest variable in reducing ongoing energy costs. It has been demonstrated that installing a tightly sealed vapor barrier system during new construction and optimizing the blower size can save up to $1,000.00 annually in heating, cooling and electric costs per 10,000 square feet of floor space [6] (using 2009 energy costs). The loss of conditioned air through slab openings inaccessible for sealing can be significant because existing buildings are typically constructed over low permeable indigenous fill. As a result, these buildings require fifteen or more times vacuum than newly constructed buildings with integrated crushed stone or aerated floor venting systems. Controlling the level of vacuum that is applied to the sub slab and the resulting loss of conditioned air is critical to the overall energy optimization of a mitigation system.

EFFICIENCY OF BLOWER TYPES AND PROBLEMS ASSOCIATED WITH UNCONTROLLED RADIAL BLOWER SYSTEMS

In 2009, an effort was started to examine the power efficiencies of centrifugal, high speed brushless small Direct Current (D.C.) radial blowers and multi-horsepower large radial blowers installed by Clean Vapor, LLC. Conclusions were reached that even though radial blowers required larger horsepower motors, greater efficiency was achieved because only a minor reduction in vacuum occurred when airflow was substantially increased by adding more suction points to the system. The higher the voltage and lower the amperage 3 phase used to power the larger radial blowers also contributed to the electrical efficiency.[6] Clean Vapor also noticed higher airflow yields over a period of a few months as soil moisture content was being reduced. This was a new phenomenon that had not occurred with the smaller brushless or centrifugal blowers since relatively small increases in airflow produce sharp declines in static vacuum that can be applied to extend the pressure field in those types of blower. An additional problem developed in unregulated systems where the riser pipe valves were left partially or completely open in that the increased airflow yields were causing the motor to overwork and exceed the electrical service factor. Motors were running hot and increased airflow was causing multiple point suction systems to become unbalanced. The first response was to manually dampen gate valves and reduce airflow to return motor performance to a range within the service factor. This created another unexpected problem, noise. Dampening gate valves created a nonlinear harmonic slide whistle effect with varying ranges of pitch and amplitude. This is not a problem in warehouse settings, where white noise is prevalent, but it became a serious problem when suction points were in office walls. Significant time was spent with micromanometers and pitot tubes achieving the best balance between pressure field extension and tolerable noise.

The next step in the evolution of trying to achieve greater efficiency and control was the introduction of frequency inverters more commonly known as variable speed drives. This enabled us to manually control the motor speed. This solved the service factor and noise problems and added a greater degree of power consumption efficiency to the systems.

Even though integrating variable speed drives was a large step forward, it still does not close the gap on a variety of system and energy management issues. The problems associated with manually balancing motor controls to adjust pressure field extension need to be solved. Manually balancing these systems requires mobilizing personnel, gaining building access and usually off hours work for experienced individuals.

Many of the subject properties where VIMS are installed have serious groundwater contaminant issues and the reality is that these systems are not going to be decommissioned any time in the near future. The need to automate VIMS to achieve system control and power efficiency for long term sustainability became apparent. In 2011, Vapor Dynamics, LLC started developing prototype circuitry to control and manage the effectiveness and efficiency of VIMS. Achieving a constant defined sub slab pressure differential is the largest variable that influences power consumption. The second is controlling the loss of conditioned air. Applying only the level of vacuum that is required to arrest the flow of vapors from the sub slab into the building is the most efficient mechanism to manage the energy required to operate a soil depressurization system.

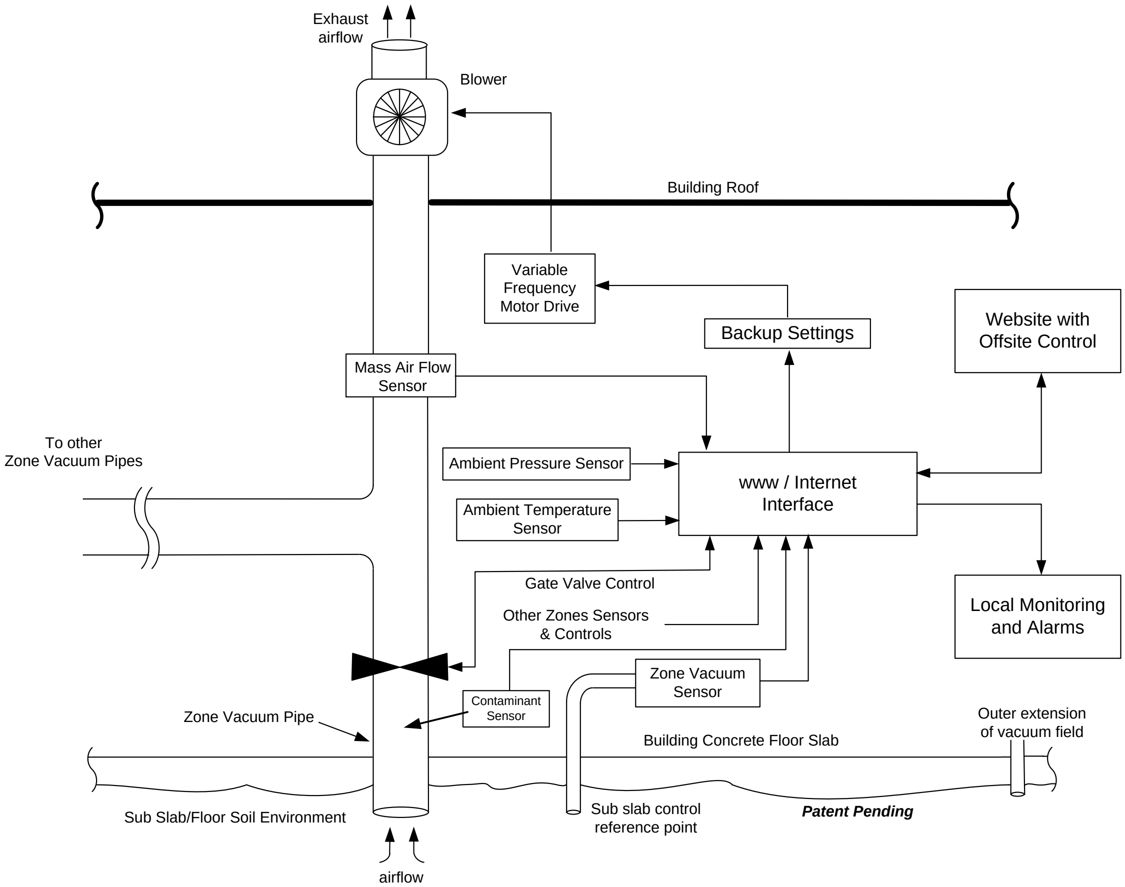
POWER CONSERVATION

In the past typical VIMS have been designed using fractional HP, single phase, 115 volt fans. Efficiency has been increased by increasing the number of suction points on a single system and using larger multi-horsepower radial and regenerative blowers. The 3 phase power associated with these blowers provides an approximate 33 percent energy savings over single phase. The use of this power also allows smaller gauge wire size to be routed long distances between the electrical source and the blowers.[7] To further conserve power, frequency inverters have been included so that vacuum applied to the sub slab can be controlled by adjusting the speed of the motor.

As part of our goal to overcome the negative pressure loads that are induced on the interior of the building by fume hoods and minimize the power required to achieve the specified sub slab pressure differentials, a decision was made to develop and pilot dynamic motor controls as part of the mitigation plan. It is common for commercial buildings and strip malls with exhaust blowers to be under a 0.25" w.c. internal negative pressure load. Development and prototype bench testing of pressure sensitive Dynamic Controls™ started in 2010. Several modifications to improve control stability had to be applied during the development process. After bench test performance goals had been achieved, the next step was to field test the controls. The photo to the right shows Dynamic Controls™ being bench tested.

The diagram below illustrates the basic concept of automated Dynamic Controls™ with integrated monitoring.

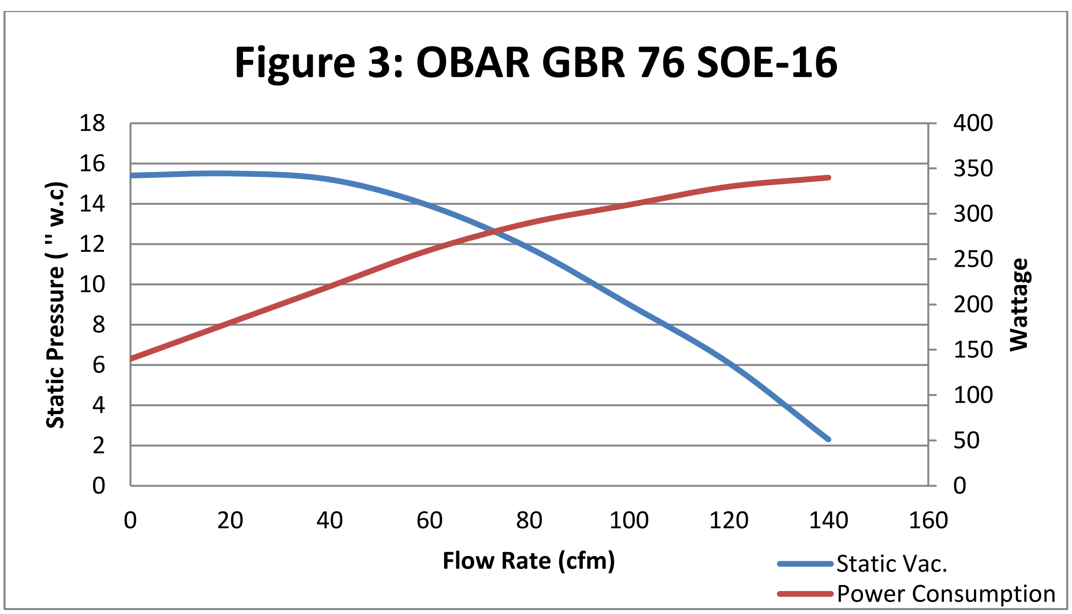
Figure 2: Dynamic Controls™ with Integrated Monitoring



CASE STUDY AT TWO BUILDINGS

The site selected for the Dynamic Controls™ pilot study is a New Jersey manufacturing site. There are several independent buildings on this site. The origin of the Vapor Concern is from a Carbontetrachloride plume that originated from a previous owner. Diagnostic and pressure field extension indicated that the sub slab fill material was indigenous low permeability sandy clay. Pressure field extension testing indicated that at most vacuum test hole locations, 35" w.c. of static vacuum was reduced to less than 0.01" w.c. with a radius of approximately twenty feet from the test suction hole. The VIMS was originally installed in November 2011. In August 2012, two of the buildings were revisited for the purpose of installing Dynamic Controls™.

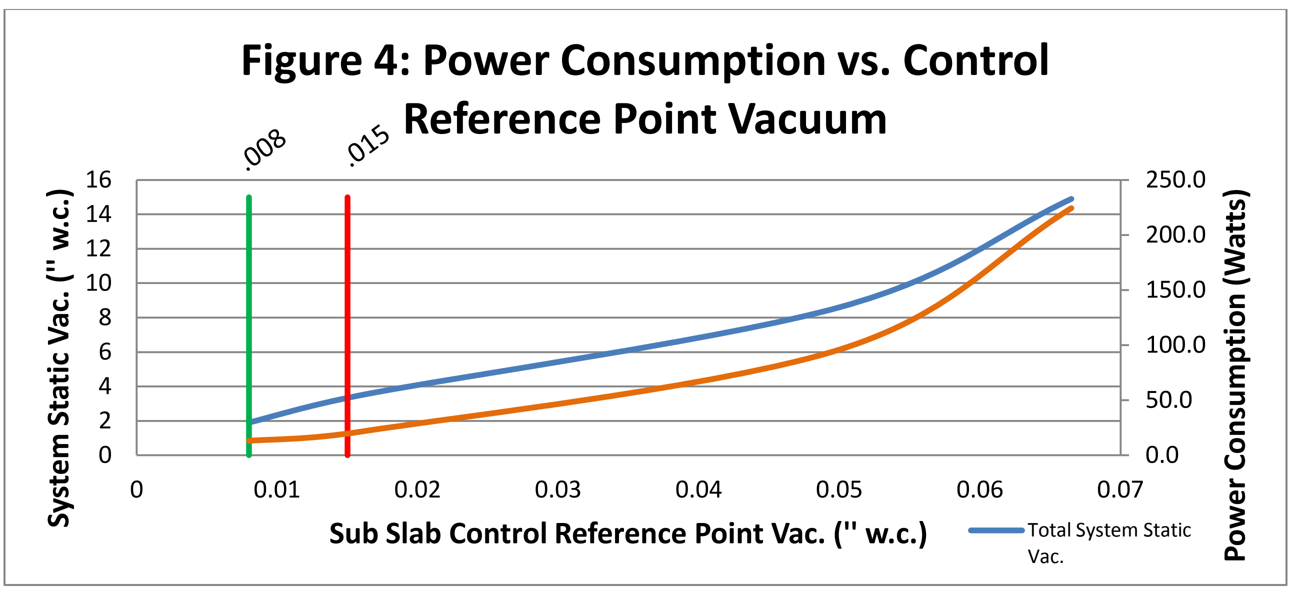
The first building is a three story engineering building with approximately 3,400 square feet of slab contact with the soil. Diagnostic tests indicated that a three point single blower system would be required to meet the design objective in creating a pressure differential between 0.016" and 0.008" w.c. with a minimum performance standard of 0.004" w.c. The blower selected was an OBAR GBR76 SOE 16 (shown on the right) which is a small brushless D.C. radial blower assembly that is designed to provide optimum performance between 5" and 15" w.c and 40 to 130 CFM. This blower was also selected because the circuitry is designed to accommodate remote control commands to vary the speed of the motor. Below is a graph displaying airflow, vacuum and power characteristics of the described blower.



Using Dynamic Controls™, the system was run using a variety of sub slab control reference point settings. The results of these tests are shown in the table below.

Sub Slab Control Reference Point (" w.c.)	Average Sub Slab PFE Vac. (" w.c.)	Weakest Sub Slab PFE Vac. (" w.c.)	Total System Static Vac. (" w.c.)	Total System Airflow (cfm)	Watts	Kw-H	Annual Cost (USD)	Percentage Savings
0.0665	-0.3491	-0.0644	14.9	46	224	1962.24	$ 337.51	-
0.0500	-0.4390	-0.037	8.6	31	96	840.96	$ 144.65	57%
0.0160	-0.2116	-0.014	3.5	15	21.6	189.216	$ 32.55	90%
0.0080	-0.046	-0.0067	1.9	10	13.2	115.632	$ 19.89	94%

The results of the tests on this building show that a cost savings of 94% can be achieved when using Dynamic Controls™ and a set sub slab vacuum reference point. The following graph illustrates the system static vacuum and power required to maintain consistent vacuum at a set sub slab control reference point. The green vertical line shows the lowest value the reference point was set to, which represents double New Jersey's standard, and the red line represents Massachusetts's vapor intrusion standard.



The second building that was selected for our study is a one story building that is an active laboratory. This building is approximately 22,000 square feet and is constructed over eight separate foundation areas. Sub slab vacuum field extension is contained within each foundation area; therefore, each of the slab areas must be treated independently as part of a total solution. There were open slab joints around the floor drains, expansion joints and floor wall joints that required sealing. Contributing to the vapor intrusion problem is the significant negative air pressure load that is placed on the interior of the building by the laboratory fume hoods.

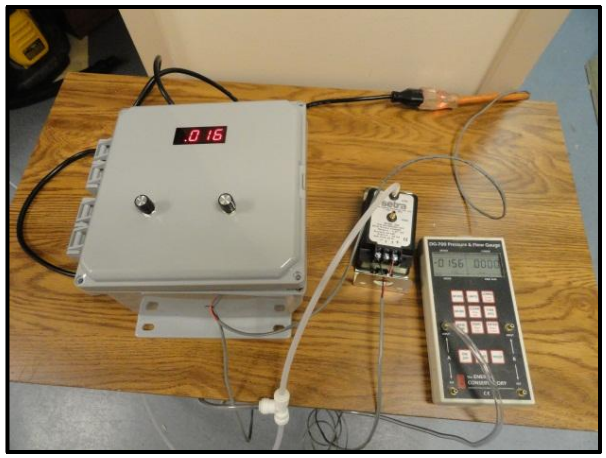
Introducing filtered conditioned outdoor air to offset the negative load induced by the fume hoods was an early consideration; however, the expense of heating, cooling and humidity stabilizing the large volume of air that would be drawn into the building would be cost prohibitive. Interior to exterior pressure differentials were measured at two areas to determine the negative load applied to the building interior. The first area tested was a side entrance corridor which measured an interior /exterior pressure differential of -0.41" w.c. The second area tested was the main entrance corridor and vestibule which served as a pressure buffer to the outside of the building. The total pressure differential from the inside corridor to outside the building measured at -1.29" w.c. The pressure differential from the corridor to the vestibule measured at -1.046" w.c. indicating that the vestibule provided a buffer between the two pressures. The average negative pressure differential induced by the fume hoods on the building interior at the time of our investigation was -0.85" w.c. It is anticipated that the pressure differentials that draw soil gas into the building will be slightly greater during the heating season when warm air escapes near the top of the building creating a greater vacuum at the slab level.

In order to determine blower requirements and suction point locations for the VIMS, sub slab soil permeability tests were conducted. The design objective is to create a negative pressure field between 0.016" w.c. and 0.008" w.c. with a minimum performance of 0.004" w.c. between the sub slab and indoor air at the outer area of the PFE. Pressure field projections were adjusted to accommodate an anticipated increased PFE that can occur when one cubic foot of soil is removed from beneath the slab at the suction point. A mitigation plan was developed that included the installation of 40 suction points and three radial blowers. Two of the radial blowers installed were 3.0 HP Cincinnati Fan model PB 12A's and the third blower was a 5.0 HP Cincinnati Fan model HP 6C-19. The 5.0 HP blower serviced 19 suction points that are in the central area of the building where fume hoods induce the greatest vacuum and shortest sub slab PFE was achieved during diagnostic testing. The combination of blowers specified were designed to maintain an operational performance range between 7.0" w.c. and 28.0" w.c. static vacuum and between 380 and 700 cubic feet per minute (CFM). The motors selected are 3 phase 480 volts.

Recognizing that there is a severe negative pressure load that was on the building, the owners attempted to minimize the load by making adjustments to the HVAC system. On the day of the pilot test, the average negative pressure load on the building was -0.211" w.c. which was an improvement over the -0.85" w.c. that was measured at the time of our initial design investigation. The outdoor temperature was between 80 and 90 degrees Fahrenheit on both the investigation and pilot study days so stack effect as a result of temperature differences was not an influencing factor.

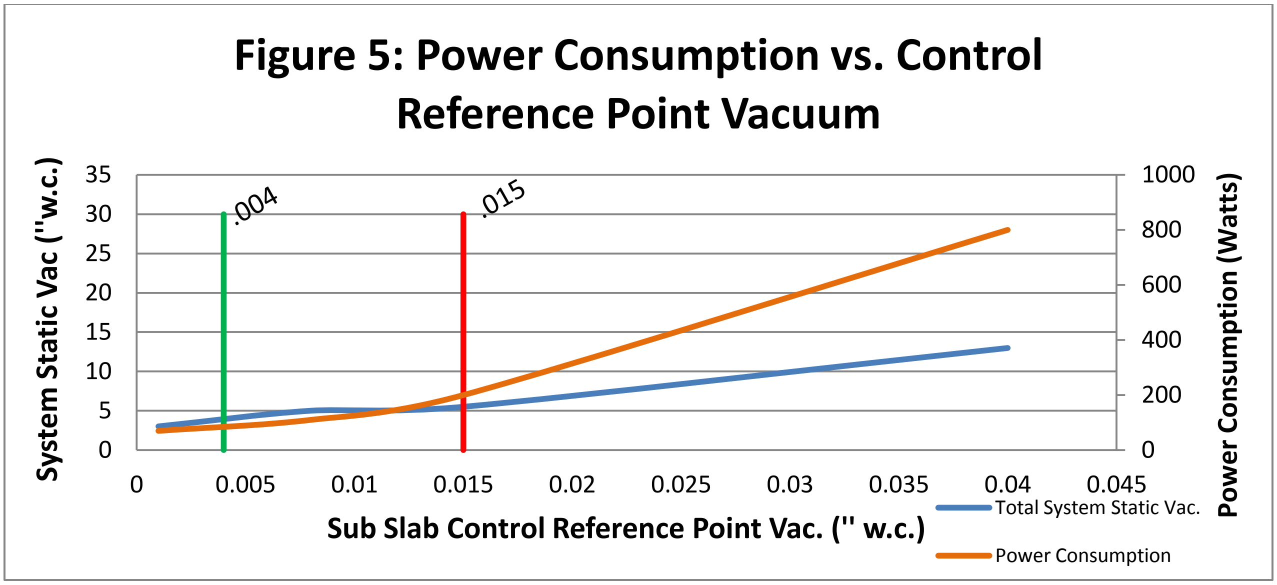
Prior to starting the Dynamic Controls™ experiment and making changes to the sub slab vacuum, a fresh round of sub slab pressure differential data was collected. There was approximately a 52 percent increase in the sub slab vacuum field data since the initial start up ten months prior. Once the location with the smallest pressure differential was identified, a sub slab control reference point was selected to provide the vacuum data that would drive the motor controls for the experiment. Locating the sub slab control reference point between the suction point and the lowest point in the vacuum field enables control adjustments to be made on a greater scale without being at the bottom of the sensor's effectiveness range. With the system operating at full capacity, the reference control point, T-5 measured -0.111" w.c. which is slightly more than twice the vacuum of the lowest test point that measured –0.0409" w.c with the blower system operating at full capacity.

Once the sensor driven controls were operational and the set points established, vacuum field and energy consumption testing was initiated. Throughout the pilot test, lab personnel were opening exterior doors to enter and exit the building. The rush of outdoor air into the building would cause the interior vacuum load to drop to near 0.0" w.c. Even though this occurred, the motor controls would react to maintain the set sub slab pressure differential demonstrating the ability of the controls to rapidly respond and maintain proscribed vacuum field objectives. The experiment was repeated at multiple sub slab vacuum set points. Sensor driven motor controls maintained a constant proscribed sub slab vacuum even though there was great variation of interior building pressures. The picture to the right shows a prototype unit dynamically adapting to the changes in building pressures. The results of these tests can be seen in the table below.



Sub Slab Control Reference Point (" w.c.)	Average PFE Vac. (" w.c.)	Weakest PFE Vac. (P-8) (" w.c.)	Total System Static Vac. (" w.c.)	Total System Airflow (cfm)	Watts	Kw-H	Annual Cost (USD)	Percentage Savings
0.111	-1.387	-0.041	26	392	2950	25842	$ 4,444.82	
0.04	-0.603	-0.0221	13	227	800	7008	$ 1,205.38	73%
0.015	-0.265	-0.013	5.5	131	200	1752	$ 301.34	93%
0.008	-0.193	-0.0078	5	99	110	963.6	$ 165.74	96%
0.001			3		70	613.2	$ 105.47	98%

The savings from using Dynamic Controls™ and setting a sub slab reference point at 0.008" w.c. (twice NJ's standard) were 96%. A graph showing the relationship between system vacuum, power consumption, and the control reference point is shown below.



USING DYNAMIC CONTROLS™ TO REGULATE CONTAMINANT DISCHARGE

A responsibility that is incumbent to the designer of a VIMS is to ensure that the system installed does not exceed the state's contaminant discharge emissions standards. Manufacturing facilities and dry cleaner sites are notorious for having "hot spots" of chlorinated solvents where soil gas concentrations can be in the hundreds of thousands ugl/m^3. Individual riser pipe soil gas samples should be collected from each riser pipe and from the main discharge pipe of the VIMS as part of startup and again after the system has been operating for thirty days. This is particularly important if "hot spots" are known to exist. Knowing COC concentrations along with the airflow in CFM from each contributing riser pipe zone, as well as the total system exhaust, will enable the consultant to calculate the total contaminant discharge from each contributing zone. If riser pipe COC concentrations are contributing to a potential emissions exceedance, the first control action is usually to manually dampen riser pipe airflow from the zones that are contributing to the discharge exceedance. Most large building VIMS operate between 10" w.c. and 25" w.c. of static vacuum and have between a 12 and 50 CFM contribution from each riser pipe. In most cases, riser pipe valves would need to be dampened over 70% before any appreciable reduction in airflow would be measured. Even though the permeability of the soil and resistance to airflow are usually the limiting factors in a VIMS, dampening airflow from selected zones will increase load on the motor and may contribute to excessive vacuum in other zones. A third and more energy efficient option is to use Dynamic Controls™ to command the motor speed to achieve minimum pressure differentials to ensure vacuum coverage and then re-measure riser airflow from the problem zones to determine if discharge volumes are still a problem. If discharge exceedances continue to be a problem, then dampening individual risers to decrease vacuum to problem zones would still be an option. Adding carbon filtration should be avoided as it always introduces some level of system inefficiencies. Conversely, if it is an objective that the VIMS contribute to the long term reduction of soil contaminants, motor speeds could be increased.

PERFORMANCE MONITORING

Since it has yet to be determined how far into the future that any VIM or Radon system will need to operate, each system should be delivered to the client with a solid Operations and Maintenance (O&M) plan as part of the post mitigation deliverables package. The same group of sensors and circuitry that are controlling performance commands can be integrated to supply information to monitoring systems that enables the consultant and owner to monitor a wide variety of performance parameters including, sub slab vacuum fields, total system vacuum and airflow, selected contaminant concentrations, power consumption, and the cost savings realized by Dynamic Controls™. The introduction of fresh outdoor air as required in daycare VIMS in California could also be integrated and monitored as part of the dynamically controlled system.[8] Monitoring motor performance characteristics can provide system managers with advanced warning of potential motor failures thus protecting building occupants from unnecessary exposure to harmful vapors. The days of time consuming building access issues and technicians traveling to sites with a clipboard only to find out that a critical system component is malfunctioning may soon be a problem of the past. Whether it is an existing building that has been retrofitted with a VIMS or new building that is constructed over a Brownfield site, property managers can now have continuous documented assurance that all vapor system components are functioning correctly and building occupants are safe from vapor intrusion concerns.

CONCLUSION

Integrating Dynamic Controls™ with VIMS design represents a departure from earlier technology where VIMS motors were designed to continuously operate at near peak performance in order to maintain sub slab pressure differential standards under worst case load conditions that are induced by severe weather or mechanical depressurization. There is a non linear relationship between change in sub slab pressure differentials and the electrical power required to achieve the proscribed pressure field benchmarks. An order of magnitude increase in sub slab pressure differentials, measured in inches of water column, can result in more than twenty times the power consumption and annual operational costs.

Through the use of Dynamic Controls™ VIMS will have the ability to automatically adjust vacuum levels to meet a pre-defined standard level. Maintaining the upper range of a state’s standards during the heating season can represent significant power consumption and cost which creates waste during the non heating season. Integrating dynamic controls™ to optimally designed VIMS can continuously maintain a match between a specified performance standard and the minimum energy required to meet that performance standard. The electrical information that controls the speed of the motor as well as other system critical information can be integrated into a remote monitoring system where the consultant can off site monitor and even alter the operational parameters further increasing efficiency. Dynamic Controls™ enable vapor intrusion mitigation systems to achieve year round standardized pressure field differentials that in turn provide significant cost savings, energy conservation and future system sustainability.

PATENT PENDING TECHNOLOGY

The technology described herein may be subject to one or more U.S. Patent Applications. Please contact Thomas E. Hatton of Clean Vapor, LLC or Michael D. Salcone of Vapor Dynamics, LLC for further information regarding the above technology.

ACKNOWLEDGEMENTS

Dan Nuzzetti, Paul Kearney, Kristin Hatton, Clean Vapor, LLC

John Kitchura, Jr., Esq., Proskauer Rose, LLP

REFERENCES

1. Naval Facilities Engineering Command, NAVFAC, 2011, *Vapor Intrusion Mitigation in Existing Buildings Fact Sheet.*

2. Sundquist, Jon A. Ph.D., Wertz, William E. PhD, Boyd, John H., September 2007, AWMA Symposium, Providence, RI. *Sub Slab Depressurization System Performance Evaluation.*

3. New Jersey Department Of Environmental Protection Site Remediation Program, January 2012, *Vapor Intrusion Technical Guidance.*

4. Commonwealth of Massachusetts, Executive Office of Energy &Environmental Affairs, Department of Environmental Protection, December 2011, *Interim Final Vapor Intrusion Guidance.*

5. United States Environmental Protection Agency, March 2008, *Brownfields Technology Primer: Vapor Intrusion Considerations for Redevelopment,* EPA 542-R-08-001.

6. Hatton, Thomas E., October 2010, AARST International Radon Symposium, Columbus, OH**,** *Designing Efficient Sub Slab Venting And Vapor Barrier Systems For Schools And Large Buildings.*

7. Brodhead, William P., Hatton, Thomas E., September 2010, AWMA Symposium, Chicago, IL. *High Vacuum, High Airflow Blower Testing and Design for Soil Vapor Intrusion Mitigation in Commercial Buildings.*

8. State of California, Department of Toxic Substances Control, California Environmental Protection Agency, October 2011, *Guidance for The Evaluation and Mitigation of Subsurface Vapor Intrusion to Indoor Air.*

KEY WORDS

Vapor Intrusion Mitigation System (VIMS)
Low Permeability Soils
Pressure Field Extension
Dynamic Controls™
Energy Efficiency
Remote Monitoring
Cost Savings