MOORE ENGINEERING & ASSOCIATES
MICHAEL W. MOORE PE
1680 DEERFIELD RD.
NORRISTOWN, PA 19403
610-952-1691/610-530-6251 FAX

February 14, 2006

Mr. Walter Krolman
The Lauren Condominium
1301 20th St NW
Washington, DC 20036

RE: Preliminary Report- Professional Engineering Assessment-HVAC Issues,
The Lauren Condominium.

In response to the site visit and meeting at 'The Lauren' on January 24, 2006

Technical Background

The Lauren Condominium has an HVAC system that dates from approximately 1972, and this equipment is part of the original building as constructed. The HVAC system is based on local convective heating/cooling air units manufactured by Whalen, Inc., each condo unit equipped with at least one of these units. The local air units are served by a centrally boiler/chiller water system installed in the 11th floor penthouse. Temperature control is by a local thermostat hard mounted to each Whalen Unit. The local Whalen units are built into the walls of the condo units and are not ducted units.

The heating/chilling water is distributed via 19 vertical distribution riser set-ups (tiers). Each riser set-up is comprised of a single supply down comer and a single return riser, i.e. a 'two pipe system'. Since it is a two pipe system the overall HVAC system as presently configured can be operated either in the heating mode, or in the cooling mode; there being the requirement to change over the system from heating and cooling. Twice a year the system is changed from heating to cooling in early summer and then back to heating from cooling in early winter.

The distributed water is heated by a 240 HP Cleaver Brooks boiler, approximately 1970 vintage; the boiler originally utilized #2 fuel oil as its fuel. At some point the boiler was modified to fire natural gas via a power burner unit. A smaller boiler is also available for operation during extremely low load heating situations. For chilling the water during the warmer months there is a twin compressor McQuay R-22 chiller and roof mounted cooling tower, the chiller is approximately 8 years old.

There are a total of 168 condominium units, with each condominium unit having at least one Whalen Vertical Fan Coil unit sized for the particular condo unit application. These fan coil units are built in units, completely enclosed with gypsum drywall, the only ready access to the unit internal components is via the supply or return grilles. The fan coil units are comprised of a housing, blower, convective coil and internal baffles, and integral thermostat for control. Twenty of the condo units, two per floor, are served by two Whalen Vertical Fan Coil units rather than a single large unit. The total number of Whalen Vertical Fan Coil units is 190.

Domestic hot water is handled by a separate system and is a self contained system.

In addition to the above there are several other systems of interest to this report. Of particular is the corridor air handling system which serves the common corridors located on each of the ten floors of the building. This system has a supply blower in the penthouse, equipped with heating and cooling coils. A supply trunk feeds each of the ten corridors located on each floor via a single register located on each floor, and an exhaust riser trunk that has a single inlet grille located in each corridor. The inlet registers and exhaust grilles are not located at the extreme ends of the corridors but rather each is at an approximate 25% distance from the extreme end of the corridor. This system as presently installed is not well designed to insure full and even air changes and conditioning of the corridor spaces over the full length of the corridor. There are dead air circulation spaces at the extreme ends of each corridor.

General Issues

In the broad sense there are three major issues associated with the HVAC system. Each of these issues can be further broken down in more specific considerations. The issues are:

1. Specific HVAC performance issues of the present systems.
2. Potential future upgrade of HVAC system in light of technological advancements and economic considerations.
3. How and what should be implemented on item 1 in light of item 2, i.e. the 'bridging issue' between 1 & 2.

General Issue #1

Presently there is an effort to deal with specific performance and/or design issues of the existing HVAC system. This effort is being led by Mr. Jack McNabb PE of J.G. McNabb, Consulting Engineers. Mr. McNabb has studied the various problems being experienced by the Laurens' tenants and has submitted specific recommendations for remediation of these problems. The most salient are as follows:

A. Lack of adequate heating or cooling performance in specific condo units.
B. Condensation problems on specific units.
C. Condensate drain pan failures.
D. Piping noise and water balancing issues.
E. Common corridor ventilation issues.

General Issue #2

A. Future HVAC upgrade options.
B. Other equipment upgrades.

Bridging Issue #3

Compatibility of short term repairs in lieu potential future HVAC or equipment upgrades.

General Issue #1 Status

As noted there is an effort presently underway to define the various short term HVAC issues. This effort has made considerable progress in defining specific problems with the existing HVAC system and has tendered some specific recommendations for remediation.

A. Inadequate Heating/Cooling

It would seem a most serious issue associated with the performance of the Lauren's HVAC system is the inadequate heating/cooling performance of certain specific condo units; a most notable example is the HVAC equipment in unit 1004. A successful resolution of the problems in 1004 will provide guidance in a more global approach to any other unit experiencing marginal HVAC performance. Presently there is a recommendation to replace the 300 cfm living room unit with a unit rated at 800 cfm.

Physical inspection of the units in 1004 was conducted on 1-24-06 by me and Mr. Jack McNabb PE. It obvious that air flow through both the 300 cfm unit as well as the 500 cfm unit is clearly well below the designed values. Before any modifications or replacement of existing units are implemented it is imperative that the actual performance of these units be established. Air flow through both units should be ascertained using an anemometer/hood as well as measuring air-in and air-out temperatures. This data will enable the design professional to compare actual equipment performance against original design parameters. (Note-During recent investigative work on a Whalen unit in condominium #711 it was determined that the convective fin-tube assembly was almost 100% plugged with hardened gypsum. This unit, using an anemometer/hood, was found to have extremely low airflow thus precipitating this in depth investigation. Manual cleaning of the convective heat exchanger has improved the performance of this unit. Unit is scheduled to be retested with an anemometer/hood to determine the effectiveness of the cleaning and actual performance against original design.)

The above is important to note well. The problems associated with poor HVAC unit performance may not be design related but rather simply a case of improper use of the unit sometime in the past. The strongest candidate for improper use would be operation of the equipment during the construction phase of The Lauren where the units would have been exposed to extreme amounts of construction dust, dirt in general, and high humidity. Given the fact that the Whalen units are built into the walls the Whalen units would have been operable well before the dry-wall workers would have completed their work. Given human nature it is highly probable the Whalen units would have been turned on during construction. This would have subjected the HVAC units to inordinate amounts of airborne dust, dirt, and humidity. This is the perfect scenario to create an environment that would clog an HVAC unit. Once clogged, the unit will not perform to its design capabilities.

B. Condensation/Moisture Removal Performance

According to Mr. Walter Krohlman there is strong evidence that the units associated with tier 04 may be piped in reverse. If this is truly a fact this could result in problems with moisture removal by the Whalen HVAC units. Convective coils are typically designed to have pre-cooling section and then a moisture removal section. Typically the pre-cooling section should be piped with the warmer return water in a series piped system; the coolest water should be piped to the moisture removal section. This is a subtle point in the design and operation of this type of HVAC unit but under the right circumstances improper piping could result in failure to remove moisture from the air, condensation problems, and moisture accumulation on grilles and other surfaces.

The aforementioned issue that the Whalen units may have been operated in conditions of extreme air borne contamination can have long term ramifications condensate piping. The piping can be highly restricted and prone to plugging if the condensate handled has been carrying a high particulate burden over the years.

C. Condensate Drain Pan Failures

There have been sporadic and unpredictable condensate drain failures. These failures result in damage to the affected condo unit as well as condo units below. There is a temporary fix that can be implemented to reline the condensate drain pans with an epoxy coating. According to Walter Krohlman a drain pan can be coated with an epoxy material for approximately $100.00 a HVAC unit. Given there is 190 units the total cost to reline all pan would be $19,000. I recommend that this be performed as soon as possible since there is already an unpredictable history of pan failures and the failure rate is likely to increase as time progresses. This repair should be implemented by a competent epoxy installer and under the guidance of a Whalen representative. However this type of repair has its limitations, it is only a temporary fix at best.

D. Piping Noise and Water Balancing

Progress in identifying the cause of the noise has resulted in specific and valid recommendations for remediation. Significant progress has been made in improving the noise problems.

E. Common Corridor Ventilation.

Two disparate issues are at work in this aspect of The Lauren's HVAC issues. The movement of air in the various common corridors is severely limited by the present design of the corridor ventilation system. There is a powered and temperature controlled supply of air to the corridors via a vertical trunk running the height of the building, with inlet registers located at approximately 25% of the total corridor length, nearest to the North fire tower. Air is removed by a powered exhaust air trunk, with an inlet grille located at each floor level, approximately at the opposite 25% location of corridor length. This system as presently designed results in only about 50% of the corridor experiencing any effective air exchange and ventilation. As designed the 25% of the corridors at each end, as well as the dog leg section at the South end of each corridor receives little or no air change from the corridor ventilation system.

It has been recognized by your consultant, Jack McNabb PE, that a significant source of problems associated with common corridor ventilation is the condo units themselves are the major contributors of odors. Most significant is cooking odors but anything that produces an odor in a unit can create a problem in a corridor. Presently the kitchen exhaust system in each unit is a fixed draft unit rated at approximately 25 to 30 cfm. The kitchen exhaust systems, as well as the bathroom exhaust systems, are powered systems without on off control and as noted somewhat limited in capacity. An exhaust capacity rating of 25 to 30 cfm is hardly adequate to remove cooking odors in a timely manner when for example one is cooking mussels or ham and cabbage.

The fundamental question is how to eliminate a problem in a common area that emanates from the units themselves. Exacerbating the situation is limited mixing of air in the corridors due to the aforementioned location of the supply and exhaust air registers and grilles in the corridor. Both ends of each common corridor are fundamentally unventilated by the existing system.

The strategy proposed by Mr. McNabb of creating a slight positive pressure in the common corridors is sound. However, the corridor ventilation system performs an extremely important function in an emergency; and that is smoke removal in the event of a fire. As such, modification of this system by blanking the corridor exhaust registers may not be the best solution. Pressurization of the corridors is absolutely the right approach, but displacement of the air out through the individual condo units, is in my opinion, a low cost practicable approach but not necessarily the best approach. Modifications to the corridor system to effect better air distribution, and unbalanced draft* within the corridor envelope proper might be the more sound approach from the standpoint of environmental engineering as well as safety. Furthermore it would be less invasive of the individuals' personal space.

* In this case unbalanced draft would be to intentionally redesign with a corridor air supply fan of greater capacity than the exhaust side can handle. This would effectively increase the corridor static pressure, thus creating a significant impediment to corridor air contamination from the condo units themselves. Should this approach be adopted I recommend that an energy recovery device (enthalpy wheel) be added to the system. These energy recovery devices have a very high "return on investment".

General Issue #2 Status

A. Future HVAC Upgrade Options.

The latest technology provides for various ways for an individual to achieve the level of environmental comfort tailored to his/her desires and lifestyle. However, wholesale adoption of any new technology has an economic cost that must be accepted and borne by each tenant. Options that should drive the decision making process associated with wholesale HVAC equipment replacement or system upgrade are as follows:

Note: The estimated costs shown herein are based on two similar projects presently in progress in Southern New Jersey. These estimates are based on work being performed by experienced non-union contractors. If the work is performed by experienced union contractors the costs will probably be higher. These are broad brush estimates at this point and should be used as a springboard for discussion by the HVAC committee and the Board.

Two Pipe Whalen System Renewal

The future development of the Lauren HVAC hinges on many factors. The technology of the present Whalen 2 pipe convective units has not appreciably changed in 30 years. The convection units are relatively efficient and provide satisfactory performance. The major uncertainty to the continued use of the existing Whalen units is the condition of the convective water tubing in the units. Once failure of the convective elements commences it would in all probability signal the need to begin a wholesale change-out of the units. Assuming approximately $4,000 per unit the cost would approximate $760,000 for the entire condo complex.

Two Pipe Whalen Unit with Electric Heat Upgrade

To upgrade to a 2 pipe Whalen convective unit with electric heat option would increase the upgrade cost to approximately $5,500 per unit for a total project cost of $1,004,500. The added cost would represent the Whalen unit upgrade plus providing for electric service to drive the electric resistance heating element in each Whalen unit. For this additional cost however the occupant of each unit would have greater flexibility in heating his/her particular unit especially during the bubble months where an occupant might desire heat but the overall system is in the cooling configuration. This upgrade could also be limited to specific units that are most subject to requiring heating during the 'bubble' months, whilst other units, especially on the South and West facing might operate fine with simply a new Whalen two pipe unit.

Four Pipe Whalen System Upgrade

The next level of upgrade would be to go to a Whalen convective unit system using a 4 pipe system. This system has significant advantages over the previous systems since it provides full heating/cooling flexibility in each unit. Each condo unit owner can choose to heat or cool his/her unit at anytime. There is no change over from heating to cooling.

The ringer in this proposal is the cost and expense of installing the second set of coolant riser/down comers. The challenge of this proposal is that in order to provide for a chase for the new insulated riser and down-comer for each tier is the need to core-drill the concrete floor slabs at each floor level. This will necessitate having the building structure analyzed, specifically the pre-stressed concrete floor elements, by a qualified structural engineer. Only subsequent to the approval of the structural Engineer could we then implement the work of installing the new pipe chase. I would estimate that the upgrade cost would approximate $6,000 per HVAC unit replaced. Total for the building would be $1,200,000 with the engineering costs/mechanical conversion costs of $60,000 a general expense.

Water Cooled Heat Pump Upgrade

Water cooled heat pump technology is near the apex of technical development that would be applicable for The Lauren. Each individual condominium will have complete control of his/her respective unit environment. The quality of the conditioned air will approximate that of a hot water system with an attendant overall improvement in efficiency since heat and cooling will be based on the highly efficient heat pump cycle. The existing hot water boiler can be utilized in the winter months to augment and improve the efficiency of the heat pumps as well as the quality of the heated air delivered to the conditioned space. The cost to convert a unit will approximate $5,500 including upgrade electric service to each unit. The central chiller could also augment cooling performance of the heat pumps in conditions of extreme high outside ambient temperatures. Total costs to implement the heat pump project could approximate $1,015,500. These costs include the requirement to install additional electric power to each condo unit and some penthouse control upgrades. It does not include the costs for additional primary power from the utility if so required.

Mitsubishi City-Multi Variable Refrigerant Flow Zoning System.

For a comparison to the circulated chilled/heated water HVAC system I am providing information on what may be the most efficient and advanced heat pump technology available. This is the City-Multi System manufactured by Mitsubishi.

This technologically advanced HVAC system is extremely efficient, does not require a central boiler, cooling tower, pumps, or chiller. Multiple condo units can be connected to large roof top units. The existing pipe chases in each tier could be used to connect the air handler in each condo unit to the roof top units. Additionally new style air handlers could be integrated into the units with better air distribution the result. There would be no need to install additional electrical service in each condo. A central circulating water system is no longer required thus eliminating the attendant potential for catastrophic leaks.

This system is extremely sophisticated. It uses variable speed roof top compressor/condensing units, dual linear expansion valves, and shared refrigerant branch distribution. For The Lauren this will translate into very high efficiency system with low operating and maintenance costs; extremely robust and flexible heating and cooling units in each condo unit. The estimated cost would be approximately $2,700,000, including conversion work in each individual condo unit.

Conversion to this system will eliminate the need for the McQuay chillers and the Cleaver Brooks boiler, all pumps and piping associated with the present Whalen system. This in turn will result in significant reduction in yearly maintenance and operating costs to The Lauren.

B. Other Equipment Upgrades.

Cleaver Brooks Boiler Upgrade

The present main heating boiler is a 34 year old 100% capacity boiler. It presently uses natural gas as the primary combustion fuel via a conversion burner. Originally the boiler was designed to

burn #2 fuel oil. There is no redundancy with the system as presently installed during the period of maximum heating demand.

Results of recommended boiler performance testing in all probability will show it is cost effective to replace the boiler with a more efficient unit or units. Present boiler technology now provides boilers that operate at 90% thermal efficiency or greater. Additionally smaller boilers operating in sequenced parallel operation will increase overall thermal efficiency and lower operating costs as well as fuel costs.

The estimated cost to replace the Cleaver Brooks boiler with smaller sequentially staged natural gas units would be approximately $200,000.

Common Corridor Ventilation System Upgrade

Any improvement to the common corridor ventilation should include the application of an energy recovery unit and unbalanced draft. Additionally, the system should be integrated into the fire protection system. To improve air circulation and eliminate dead air spaces installation of ducts with additional registers and grilles might be a possible solution.

General Issue #3-"Bridging Issue"

The cost for future HVAC system upgrades far outweighs any short term unit specific repair. The specific causes of poor unit performance in certain condo units have yet to be determined with certainty. However, resolution of HVAC performance problems in a specific unit needs to be borne by the respective tenant. This includes the global relining of all condensate drain pans since the cost of failure of a drain pans far outweighs the potential costs of repairing damage caused by a drain pan failure, even in the short term.

Long Term Overview

The existing Whalen units have been in service for over 34 years. In all probability the Whalen units are reaching the end of their useful operational life. It is probable that the convective water tubing in the Whalen units could begin to experience failures and should this happen significant water damage could result. At present the fact that there have been condensate drain pan failures is indicative of the fact that the Whalen unit life expectancy may have been reached or exceeded. Your consultant, Mr. Jack McNabb, has noted this in his reports and has provided some guidance in response to the aging of the Whalen units.

Recommendation-Short Term

It is my opinion that the following steps should be followed in the short term by the Lauren HVAC committee

1. Conduct baseline performance testing on all Whalen units that are underperforming. Data taken should include air in and air out temperature measurements, air flow using an anemometer or hood. (A condo dweller that is not satisfied with his/hers HVAC system performance can be assumed to have an underperforming unit.)
2. Verify the proper piping configuration of each water supply/return tier to the Whalen units. Reverse the piping configuration if it is determined that the piping is reversed.
3. Those underperforming Whalen units that demonstrate significant low airflows in relation to manufacturer performance data should have their convective heat exchangers cleaned out. Units should then be retested.
4. Conduct performance testing on the Cleaver Brooks boiler.
5. Blanket relining of all condensate drain pans.
6. Destructive testing of one Whalen unit.*
7. Refine the plan for resolving the corridor ventilation issue.

* Should an existing Whalen unit be removed from service that unit could be taken apart and thoroughly examined. Of significant value would be to perform a metallurgical examination on the copper convective water tubing for pitting, cracking, hardening, or any other factor that could result in future tube failures and coolant leakage.

Recommendation-Long Term

In my conversations with the Whalen representative, Tom Brown, the concept of predicting the true life expectancy of the Whalen units was discussed. Generally, failure of the convective tubing would be the most serious problem anticipated, especially if the failure occurred on the higher or highest floors. The damage caused by the coolant (water) leaking would be extensive. However, The Whalen Company has no definitive predicative information on the total hours to failure of the convective tubing.

The Whalen representative noted that once failure of drain pans is experienced then it should be assumed that all pans of the same age are in jeopardy of failure over the short term. Also experience in other sites with temporary epoxy pan repairs has been less than successful unless extreme care is taken by the applicator. This type of repair should be performed under the guidance of a Whalen representative

The Lauren HVAC committee should work with your design professional in the development of a long term HVAC system upgrade plan. The implementation of the short term and temporary repairs will buy the time necessary for the HVAC committee team to look at and evaluate the best HVAC system upgrade. Fortunately available future HVAC system upgrades are not limited to a single system or concept, and some upgrade options have been duly presented previously in this report. Now the challenge is to decide which technology is the overall most cost effective/comfort effective HVAC system for the future of The Lauren Condominium.

Summary

The efforts underway by your consultant, Mr. Jack McNabb PE, have made significant progress in identifying many issues associated with the existing HVAC system at The Lauren. His work is very thorough and professional and he will deliver an excellent final product.

Respectfully:

Michael W. Moore PE
Moore Engineering & Associates