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To: Randy Foose and John Delemarre, VLS
From: Marc Rosenbaum, PE
Subject: VT Law School New Classroom Building Design Intent
cc: Mike Hulbert and Jim Svendsen, HPC; Rolf Kielman and Tom Warner, TCP; Dan Lewis and Roy Swain, K&L; Brian Browning and Mary Benoit, Hallam; Gene Elmore, TCVT.

At our meeting on the topic of the building handover on Tuesday, I was asked to set down a description of the design intent on the NCB, as a document that could be used to train the people who will take care of the building, and the people who will use the building, and the people who seek to learn from the building. Here is a first draft. Each of you has had special responsibility for some portion of the building and I welcome your additions, deletions, and edits.

Introduction

Overall goals were set to create a project that was:

- safe, healthy, and comfortable - a place that nurtures those who use it
- durable
- efficient in the use of resources - energy, water, materials, land, capital
- adaptable to the future needs of VLS, future technologies, and future resource availability, all of which increases the useful life of the building.

The consequences of satisfying these goals produce benefits for the users, the institution, society, and the health of the planetary environment. The document entitled, Vermont Law School New Classroom Building - An Environmental Building for an Environmental Law School, dated February 1998, covers the building's environmental features, grouping them by the goals cited above. The document entitled, Environmental Aspects of Materials for VT Law School New Classroom Building, dated November 1997, covers material and finish choices. This document has a different intent, which is to describe whole systems and how they are intended to function. Therefore, it is organized by system. These systems are included:

- building envelope
- mechanical systems

- lighting and daylighting
- water and waste systems
- materials and finishes

Building Envelope

The intent of the building envelope design was to create a building that was durable, comfortable, healthful, and energy efficient. Unusual attention was paid to creating an envelope in which the insulation layer is continuous and not punctured by highly conductive structural elements such as steel or concrete. The air barrier is similarly continuous. Both of these strategies drastically reduce the chance of common building failures such as frozen pipes or ice dams, as well as minimize heat loss. Specific envelope components are the roof, walls, foundation, windows, and interior finish materials.

The roof is a durable, factory-painted 24 gauge standing seam steel, installed over 30 pound felt paper on plywood sheathing, which is over a 1-1/2 inch roof ventilation space, over a 10-3/4 inch thick stressed-skin roof panel. The panel provides a high level of continuous insulation (R-37). The ventilation space, which runs from soffit to ridge, keeps the roof surface below freezing during the winter months, so that snow will not melt on the roof and form destructive ice dams.

The walls are clad on the exterior with durable fiber-cement siding, installed over 3/4 inch wood furring strips which create a vented air space behind the siding. This space, called a vented rain-screen, allows the siding to dry more easily when wetted by rain. Both the siding material chosen and the installation detail used promote longer paint life, by providing a more stable substrate with smaller swings in moisture content. The air space is backed by a layer of 15 pound felt paper to act as a drainage plane for water which does get into the space, over a 7-1/8 inch thick stressed-skin panel (R-24.)

The concrete foundation is insulated on the inside with foam insulation which laps slightly onto the stressed-skin wall panels above. The floor slabs are completely thermally isolated from both the ground and the foundation walls with rigid foam. This minimizes heat loss and also keeps the surface temperature of the floor up, preventing condensation and possible mold growth.

The windows are made of pultruded fiberglass, a durable and stable material. Both the sash and frame are hollow and are filled with expanded polystyrene foam insulation. This more than doubles the insulation level of the opaque portions of the windows over wooden windows. The glazing used is a triple glazing, with the two gaps filled with argon gas, and one glazing layer has a low emissivity coating (R-6). The spacers used are non-metallic, which reduces heat loss at the edge. The overall window insulating value is almost double typical windows, which minimizes heat loss, eliminates condensation, and increases comfort near the windows. Durability is enhanced by a design in which failed glazing can be easily replaced.

Mechanical Systems

The intent of the mechanical system design was to create a building that was durable, comfortable, healthful, and energy efficient. The largest thermal energy load in the building was the fresh air required for ventilation, so this received unusual attention. The fundamental design intent is that unoccupied spaces do not receive ventilation air (which generally needs to be heated or cooled), and occupied spaces receive 100% fresh, filtered outdoor air, with no recirculated air. This maximizes indoor air quality in occupied spaces, and minimizes energy consumption in unoccupied spaces.

Installed capacity for both heating and cooling has been sized to meet the expected loads rather than the maximum possible loads. Expected loads have been calculated by carefully studying the way the Law School will occupy the building. If all classrooms were to be occupied simultaneously the building would seat over 500 people, but the expected maximum occupancy is just over 300 people, based on the maximum number of classrooms which will be occupied at the same time. The terminal units in each room have the full capacity needed to heat or cool that room at full occupancy, but the chiller, which produces the chilled water for cooling, has been sized based on the maximum number of occupied classrooms, so it is smaller than it would have been if it were to be sized to cool all of the classrooms simultaneously. The indoor heat exchanger for the chiller has been sized for the maximum possible occupancy, so if additional cooling capacity is required, a second chiller can be added outdoors with minimal cost and disruption. Similarly, four modular boilers have been installed to heat the classroom building and Whitcomb, but a provision has been made to add a fifth boiler if necessary. This strategy has kept initial cost of the mechanical system down.

The system components include the four modular boilers (also heating Whitcomb, located in the Whitcomb basement); the chiller; the variable speed ventilation air handling unit (AHU) with enthalpy recovery wheel (ERW) and an economizer design; a smaller heat recovery ventilator; a two pipe space conditioning coil and a recirculation fan for each classroom, the courtroom, and the lounge; a system of pumps and piping to circulate either heated or chilled water to the space conditioning coils and packaged fan coil units; a corridor ventilation cooling system; and a system of motorized dampers and controls, along with a direct digital control system (DDC).

The central ventilation air handling unit has a supply blower and an exhaust blower. Both are driven by variable speed motor drives, enabling the AHU to provide the amount of ventilation air required by the occupied spaces, which will vary as more or fewer rooms are occupied. The AHU serves all of the classrooms, the courtroom, and the lounge. There are motorized dampers which close off each room's ductwork from the central supply and exhaust ducts, and these are opened when the room is occupied and closed when room is unoccupied. When the room is occupied, its dampers open, and fresh outdoor air, filtered inside the AHU, is supplied to the room. The air first goes through a space conditioning coil, consisting of copper tubing with aluminum fins, which is being supplied with hot water (from the boilers) in the heating season and chilled water (from the chiller). The coil heats or cools the air as needed, and the air is delivered to the room through ceiling-mounted air diffusers. Stale air is removed from the room through the ceiling-mounted exhaust grilles, and returned to the AHU to be exhausted outdoors. No stale air is recirculated inside the room, all supply air has come directly from the outdoors to maximize indoor air quality. The coil system is called a two pipe system, because there is only one coil, with its supply and return pipes (two). A four pipe system has a separate coil for heating and one for cooling, each having supply and return piping, thus the term four pipe. Four pipe systems can supply heat to one room while cooling another. Two pipe systems are less flexible, in that the whole building is in either heating mode or cooling mode. The changeover is made manually, and there is always the possibility that unusual weather patterns might cause some occupant discomfort. This possibility is minimized by the high grade building envelope, and the economizer (see below).

When the room is unoccupied, the motorized dampers close, and the supply and return ductwork within the room are connected by a short section of ductwork containing a small fan which can be energized to recirculate the air within the room, thus allowing the room to be heated or cooled if needed when unoccupied. The control intent for the building is to not cool rooms unless they are occupied, so the temperature will be allowed to float upwards during unoccupancy. The heating temperature setpoint is lowered during unoccupied periods, so the fan only comes on if the lower setpoint is reached.

There is an enthalpy recovery wheel (ERW) in the AHU. This seven foot diameter, aluminum wheel is located in the ventilation air ductwork. It rotates between the incoming fresh air and the outgoing air exhausted from the building. The wheel has a tremendous amount of surface area to transfer heat, and it is coated with a substance which adsorbs and re-releases water vapor (moisture). As it rotates, it transfers heat and water vapor from the warmer, more humid airstream to the other airstream, recovering as much as 85% of the heat and moisture in the air. This keeps the NCB from becoming too dry in the winter or too humid in the summer. Combined with a cooling system designed to maximize humidity removal in the summer, the enthalpy wheel keeps the humidity level below that needed to support mold and dust mite growth. If the outdoor air in spring or fall is bringing too much moisture in with it, the wheel rotation speed will be slowed down automatically by the DDC system, which makes it less effective at recovering humidity in the exhaust air stream, thereby keeping indoor humidity from rising to unsafe levels. The heat and moisture recovery aspect of the ERW greatly reduces the energy used to heat or cool the ventilation air, and it also enabled the capacity of the heating and cooling system to be greatly reduced (which pays for the ERW!)

The AHU is set up with an economizer design. This allows the building to use outdoor air to provide cooling when the outdoor temperature and relative humidity are sufficiently below the room temperature setpoint. Since all the supply air to the building is already from the outdoors (no recirculated air), the economizer function is obtained merely by reducing the rotational speed of the ERW. As the ERW slows down, its ability to recover heat decreases, so less heat is transferred from the exhaust air to the supply air, and the supply air temperature drops below the comfort temperature, providing cooling.

The design intent of the control strategy is to give the users as much control as is possible, and to make it easy for them by having clearly labeled controls in each room. When the switch labeled Push for Ventilation is pushed, it tells the DDC system that the room is occupied. This opens the motor dampers and speeds up the AHU, so fresh air is supplied to the room. If the building is in the unoccupied mode set at the DDC system (i.e., nights and weekends), the switch also overrides the temperature setbacks and begins to bring the room to occupied comfort settings. In this way, users who wish to use a space out of normal occupied hours should be able to avoid the typical problems of inadequate ventilation air and uncomfortable temperatures.

Once the room is vacated, the occupancy sensor (motion detector) will sense that there is no motion in the room, and, after a suitable time delay (which is adjustable), will return the room to unoccupied mode. **Room temperature setpoint will return to the setback temperature if the building as a whole is in unoccupied mode, otherwise it remains at the occupied setpoint.** The lights will be automatically turned off also.

The lower level toilet rooms, and all three main corridors, are ventilated by the smaller heat recovery ventilator. Stale air is exhausted from the lower level toilet rooms and the corridors, and fresh air is supplied to the corridors.

One unusual feature of the space conditioning design is that each of the four large classrooms has two separate, identical space conditioning coils. This serves two purposes. In the cooling season, when the room experiences peak cooling load, both coils receive ~45F water from the chiller. As the cooling load drops, the supply water to one of the coils is mixed with return water from the coil, so that coil runs at a higher water temperature, providing less cooling. The other coil still receives fully chilled water. This strategy keeps most of the dehumidification potential of the cooling system (the colder the water in the coil, the more moisture is condensed out of the room air) while dropping the total amount of cooling supplied to the room. Maintaining humidity control at off-peak conditions improves comfort for the occupants. The DDC system switches which coil is mixed and which coil is fully chilled every 20 minutes.

The second reason for the two coils is to allow future partitioning of any of the large classrooms into two smaller rooms with very little mechanical changes.

Audio/visual rooms are heated and cooled by packaged two pipe fan coils. **Corridors are heated by packaged two pipe fan coils. Both can receive heated and chilled water from the central distribution piping. Auxiliary spaces, toilet rooms, entries, and stairs are heated by heating-only terminal units, which are only set up for heating.** Design intent is that the circulation not be mechanically cooled by the chilled water system. Instead, the two upper corridors are cooled using outdoor air and a 6000 CFM ventilation fan located in the mechanical attic space, which connects to the corridors through a large louver with a motorized damper mounted high on the wall in the upper corridor. The upper level corridor and the main level corridor are connected by the stairway between them. Make-up inlet air to replace air exhausted by the fan comes through four power-operated windows, two in the main level corridor and two in the upper level corridor. When the corridor temperature rises to the cooling setpoint, the dampers are opened, the windows are opened, and the fan is started. Obviously, outdoor air can't cool the corridors to the same comfort level as the classroom spaces when it is 85F outdoors! The design intent is that the corridors are circulation spaces which have a lower comfort requirement, and that the energy savings is worth the decreased comfort in circulation spaces. Doors between the classrooms and the circulation spaces will need to be kept closed to maintain comfort conditions in the classrooms, which are mechanically cooled. It is anticipated that this is desirable from a noise control standpoint in any case. It is also anticipated that on days when it is quite hot, occupants will choose to be outdoors once they leave class. Because these spaces have fan coils, they can be mechanically cooled if the ventilation cooling proves unsatisfactory.

The oil-fired boilers are four identical, highly efficient (86%) 200,000 BTU/hour units located in the Whitcomb basement. They provide heat for both the NCB and Whitcomb, as well as domestic hot water for Whitcomb. They replace the aging, inefficient boiler previously heating Whitcomb. They use the existing chimney, and require a variable speed draft inducer to ensure adequate boiler draft as different numbers of boilers are firing. The boilers are low-mass (only 3-1/2 gallons of water in each) and therefore are operated as cold start boilers, only firing when there is a call for heat, in which case they reach operating temperature in a little over one minute. By staging the boilers to come on one-by-one as the building heating load increases, the heat wasted by having one or two larger high mass boilers instead is eliminated. Additional savings are made by lowering the temperature of the heating loop from 200F at outdoor temperatures of 0F and below to 140F when the outdoor temperature reaches 60F. This strategy is called temperature reset, and these setpoints are adjustable at the DDC system.

The air-cooled chiller is a 24 ton (288,000 BTU/hour) unit. A chiller is a refrigeration machine which has electrically-driven compressors and fans, and it produces chilled water (~45F) to supply to the space conditioning coils during the cooling season. It is located on a pad to the east of the building. This particular chiller is a split barrel design, which separates the chiller, comprised of the compressors and the air-cooled condenser, from the evaporator, which is the portion of the chiller in which the refrigerant evaporates from the liquid state to the vapor state. The evaporator contains the heat exchanger which cools the chilled water to be used for cooling in the building. By locating the evaporator in the building (lower level mechanical room), all of the water used for building cooling remains indoors, eliminating the necessity to protect the system from freezing with anti-freeze. The evaporator is oversized for the chiller, which will allow for the possibility of adding another chiller should the cooling requirements change in the building. **The over-sized evaporator provides increased efficiency at the installed chiller capacity.**

Lighting and Controls

The interior lighting is a combination of compact fluorescent and linear tube fluorescent light sources, powered by electronic ballasts. Phillips lamps were specified because, at the time design was occurring, Phillips was manufacturing fluorescent lamps with a mercury content which was several times lower than other manufacturers. This is desirable environmentally, since mercury is a significant toxin.

The design intent is that the occupants have control over the lighting in the classrooms, and that control is facilitated by installing the switching in a consistent layout from room to room, and labeling all switches. In the classrooms, the general lighting is provided by 2' x 4' fixtures which contain three lamps. In larger classrooms, additional lighting is provided by recessed fixtures. In all rooms, the first switch (from the door) controls the two outer lamps in each fixture. The second switch controls the inner lamp of each fixture. In this way, occupants can select any of four lighting levels - all lamps off, one lamp/fixture on, two lamps/fixture on, or all three lamps/fixture on.

The lighting in the classrooms is designed to be turned on manually and set to the occupants preference. For maximum energy savings, occupants should be encouraged to consciously choose a lighting level appropriate to the task. Occupants should also be encouraged to turn the lights off manually when they leave the room. The back-up system for turning lights off uses an occupancy sensor in each room, which will turn all lights off after a pre-set (and adjustable) time delay, once no motion is detected. If any light switch is left in the on position, then whenever the occupancy sensor senses motion, the lamps controlled by that switch will be turned on.

Occupancy sensors are also used in toilet rooms and corridors.

In the main level and upper level corridors, photocell sensors sense the available natural light, and turn off the lights when a preset (adjustable) level is reached.

Exterior lighting is controlled by photocell sensors which turn the lights on as natural light level drops (adjustable.) The DDC system is programmed to turn those lights off after hours of expected occupancy (adjustable.) Exterior fixtures at entries to the building adjacent to Whitcomb are not under DDC control, and are designed to be on all night, controlled by a local photocell.

The Grafic Eye system, installed in the 50 seat classroom used for distance learning, allows owner-designed preset scenes which allow two or four lighting zones to be adjusted to a variety of options including dimming and switching. Once programmed, one push of the button will operate all lighting groups connected to the Grafic Eye to respond to the preset level. For example: An Entering preset may turn the 2x4 fixtures with dimming to be at 20% light, the wall wash lights to be full on and lecture area to be off. A Lecture preset may increase the dimmed 2x4's to 60%, the lecture area full on and the wall wash lights to be off.

<u>Water and Waste Systems</u>

The primary design intent was to use the new building to actually reduce the Law School's total demand on the South Royalton municipal water system, which is severely limited in its capacity. The main level and the upper level toilet rooms are served by two <u>composting toilet systems</u>. Since the composter tanks are located on the lower level, the lower level toilet rooms could not be connected to the composters (the composters must be below the toilets.) These use conventional flush-type toilets, which are connected to the town sewer system. The rooms served by the composters are ventilated through the toilet stools to the composters, which each have an exhaust fan rated at over 200 CFM. Make-up air to these rooms comes through grilles in the doors.

The composters rely on microbial action, similar to what occurs in nature, to decompose the human waste, and convert it into a nutrient-rich, pathogen-free end product. A collection area at the bottom of the composter is where the compost fluid ends up. This fluid has been significantly altered by its passage through the compost pile. In most cases, it is pumped to a holding tank, where it can be removed and used as a liquid fertilizer on plantings. In the case of the Law School, the state regulators allowed the composting units on condition that the compost fluid be disposed of to the town sewer. This wastes a nutrient-rich resource, but the permit conditions may be alterable in the future as more enlightened regulators reach positions of responsibility.

Domestic hot water is provided by a 50 gallon electric water heater located in the lower level mechanical room. Water delivered to the lavatory faucets is mixed to 105F.

Materials

Design intent on material and finish selection included satisfying the following criteria to the greatest extent possible:

- durability
- low toxicity
- produced from recycled materials
- produced from waste byproducts
- produced from renewably harvested plant materials
- zero ozone depletion potential

The materials following are only noted if they replace what is typically a less environmentally friendly product.

Durable materials include: fiberglass window frames, concrete floors, linoleum floors, steel roofing, fiber-cement siding, and composite wood exterior trim.

Low toxicity materials include: linoleum floors, zero volatile organic compound interior paint, water-based clear finishes, latex-based paint, and nylon carpet with an impermeable backing and peel-and-stick adhesive.

Materials with recycled content include: toilet compartment partitions, gypsum board drywall, and acoustical ceiling tiles and track.

Materials with waste byproduct content include: concrete with fly ash, acoustical ceiling tiles, and straw-based Wheatboard for the wainscoting.

Materials produced from renewably harvested plant materials include: white cedar shingles and interior hardwood trim from certified sustainable forests.

Materials with zero ozone depletion potential include: the expanded polystyrene foam in the stressed-skin panels used on the walls and roof, and the spray-in-place foam used for insulating much of the foundation walls and the steel-framed exterior walls.

Greater detail is obtainable from the documents mentioned in the Introduction.