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REPORT ON MOISTURE CONDITIONS TOBIAS LEAR HOUSE PORTSMOUTH, NEW HAMPSHIRE

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This report is based on a brief inspection of the Tobias Lear House on the afternoon of April 28, 2009, by Benjamin H. Wilson of the Bureau of Historic Sites in the New Hampshire Department Resources and Economic Development and James L. Garvin of the Division of Historical Resources in the New Hampshire Department of Cultural Resources. The purpose of the inspection was to ascertain the internal conditions of the house as a means of addressing concerns about mold in the building, and to make recommendations for the future treatment of existing mold.

Mold is visible on some surfaces in the house, including wall plaster and organic materials such as book bindings. The presence of mold and mold spores has been verified by UCA Microbial Investigations. As reported by Ron Tuveson, however, UCA utilized a “non-viable” testing methodology, employing spore traps and tapes that confirmed the presence of mold but did not permit its specific identification.

Moisture conditions: The presence of mold in the Tobias Lear House is a symptom of an underlying condition of excessive moisture. Mold spores, which are virtually everywhere, require three resources to mature and propagate: proper temperatures, nutrients, and moisture. With these three needs met, mold will grow. If one or more of these resources is denied, mold will cease to flourish.

The exterior skin in the lower regions of the Lear House and the interior surfaces on all levels of the building were monitored for moisture content with a Tramex® non-destructive moisture meter. Such a meter operates by transmitting alternating current pulses from two soft, flat rubber electrodes that do not penetrate or abrade the tested materials. When the tested material is dry, electrical resistance is high and signals from the electrodes are insulated from one another. When the tested material contains water in varying degrees, conductivity increases and the flow of electrical current is visually indicated by an analog meter, providing an accurate reading of moisture content from 10% to 20%.

Wood is considered to be relatively dry in an indoor environment when such a meter fails to detect moisture content of 10%, which is the lowest reading on the meter. Wood is considered relatively dry in an outdoor environment when it has a moisture content of 14% or less. Exterior woodwork at this level of moisture content will accept and retain house paint. Moisture content above 14% may result in paint failure. The higher the moisture content above 14%, the more severe or rapid will be the paint failure.

Moisture readings on the lower clapboards of the Lear House generally exceeded 20%, the maximum reading on the meter's dial. Moisture meter readings on the interior frame in the basement and on the finish woodwork and wooden furniture on the first floor of the house also exceeded 20%. Generally, moisture readings on the second floor and attic of the house were lower, although some of the paneled breastwork adjacent to chimneys on the second floor also exceeded 20%.

Collectively, these readings indicate that the fabric of the Lear House and the contents of the house are saturated with moisture. As shown by a digital hygrometer that had recently been placed in the basement of the house, the atmosphere in the basement was also heavily laden with moisture, yielding a hygrometer reading of 85% relative humidity. This reading means that the basement air was holding 85% of the moisture it could hold, without condensation occurring, at the existing basement air temperature. The outside atmosphere on the day of inspection was relatively cool and dry. It is safe to say that on a humid summer day, simply due to infiltration of water vapor from outside air, the basement air would approach 100% relative humidity, with condensation occurring on cool surfaces. That this has occurred consistently is suggested by the fact that the greater part of the first floor frame and subflooring of the Lear House have been replaced by modern joists and plywood, presumably because of the decay of the original materials.

The current moisture conditions in the Lear House are unhealthy for the house and its contents. Moisture content above 20% in organic materials like wood, leather, and textiles can result not only in the flourishing of mold, but also in wood decay and insect infestation. Rapid drying of materials that are saturated to this degree, although unlikely in an unheated building, can result in cracking, splitting, and warping.

The Association is taking steps to moderate the excessive moisture levels in the Lear House through installation of electric dehumidifiers and other straightforward means. This will have a beneficial result. Dehumidification, combined with other steps to eliminate liquid water from penetrating the envelope of the house and cellar, will probably stabilize the interior conditions to the degree that only simple treatment for mold will be necessary. These steps will also likely improve the moisture content of the clapboards to the degree that the house will retain its exterior paint much longer than under present conditions.

Origins of moisture: The Association has already identified some of the sources of moisture in the Lear House. These sources include the walls, sashes, and flashings of the roof dormers; the chimneys; possible roof leaks; the basement walls and windows; and condensation on the single-glazed windows of the house.

Except for condensation on single-glazed windows, these are what are called “point sources” of water—sources of liquid water infiltration that can be traced to certain points of entry through the envelope of the house or foundation. Most of these sources of water probably contribute to the problem of pervasive moisture in the house. Current inspections and repairs by John Schnitzler will undoubtedly reduce direct infiltration of liquid water.

Because the high moisture content detected by moisture meter suffuses the entire house, however, and is especially pervasive in the basement and first story, there is a more general presence of moisture than would be contributed by individual points of entry of liquid water from outside the house. Fortunately, this more general source of moisture will be alleviated by the electric dehumidification that is already underway.

When a building reveals uniformly high moisture content both in the structure and its contents, most of the moisture that pervades the interior atmosphere may be assumed to have its origins in the basement. The basement of the Lear House extends under the main house, and has a concrete floor. The cellar walls of the house are laid in glacially-fragmented local stone, and the natural shape of this stone provides for considerable stability and for a plumb inner face of the walls. The walls were originally laid nearly dry, with little or no pointing between the stones except at and above grade. Subsequently, the walls have been fairly extensively pointed with mortar in an effort to exclude moisture, dirt, and vermin.

Even when pointed, such a foundation wall is highly pervious to water, especially to the concentrated rainwater that drops from the eaves of the house. The house has no gutters on the eaves of its hipped roof, and probably has never had. Much of the water that falls from the slopes of the roof therefore finds its way into the cellar through the walls. Capillary action in the soil also draws water upward from the soil directly under the house. Although this source of moisture is less apparent in a cellar with a concrete floor than in a dirt-floored cellar, moisture is likely to penetrate the concrete through various gaps unless the concrete was poured over an impermeable vapor barrier.

The surfaces in such a cellar seldom cool below freezing except in the coldest weather; this is why cellars were used for storage of root crops, cider, and other food. The unfrozen cellar therefore acts as a source of water vapor year-round. During the daytime in winter, the warmer air in the upper rooms, being heated by the sun, is capable of absorbing some of the water vapor generated in the basement. Being a gas, this vapor migrates into the upper parts of the house by vapor pressure, penetrating wooden floors and plaster walls with ease. At night, when the house cools, this water vapor condenses on all cold surfaces. It is not uncommon in unheated houses to find hoarfrost covering all walls and furnishings at night or on especially cold days in winter. Such frost is especially common in attics, which tend to become the warmest areas in any old house during sunny winter days, but to cool most quickly at night. On warmer days, this frost melts, often inviting the flowering of mold or creating damaging condensation on furniture finishes or behind the glass of framed pictures.

This cycle of migration and condensation of water vapor slowly saturates all the building materials of the house. At the Lear House, as noted above, moisture meter readings on all wooden joists or subflooring in the basement, and in most woodwork on the first story, were above the high end of the calibrated scale—above 20% moisture content. Moisture levels this high are conducive to decay in the wood, and nourish mold spores and wood-destroying insects. The evaporation of this accumulated moisture during warmer weather is a chief cause of paint failure on the clapboards.

In addition to evaporation from a damp cellar, there is a second source of moisture that is commonly encountered in houses with no central heating. This is condensation. Members of the Association have already identified condensation on cold window panes as a source of the moisture in the house. But condensation may become a still more serious problem, and a source of much liquid water, during the humid summer months.

Typically, an unventilated basement or crawl space under a house remains cool during the summer. When the outdoor humidity is high, the cool areas under the building are frequently below the dew point. In such a situation, water vapor in the humid air from the outdoors finds its way into the building through vapor pressure, and condenses as liquid water droplets on all surfaces, including wooden floor joists. Sometimes, a stratum of water droplets forms in the still air, creating a layer of visible fog in the cellar. Even with the cellar floor sealed against moisture, the infiltration of outside air can introduce damaging amounts of water that will saturate the first floor frame and eventually cause decay. Water from this saturated wood eventually finds its way into the upstairs rooms as well. Evidence of this process is provided in the Lear House by the fact that most of the first floor framing and subflooring have been replaced, while the baseboard in the central stair hall shows signs of decay from the excessive levels of moisture that have migrated upward from the basement.

Treatment of moisture problems: The Lear House has clearly suffered for years from conditions that were detrimental to the health of the building. The house was closed to public visitation at the outbreak of World War II. The building remained closed, and poorly maintained, through the 1980s. During much of that time, it suffered from broken windows on the second story and general neglect and lack of surveillance that probably invited leaks around dormers, chimneys, and other penetrations in the outer envelope of the building.

The Association is now focusing again on these issues. The ongoing checking of the dormers for tightness against leaks, the replacement of the cellar windows, and the proposed double glazing of the house windows with Lexan (a polycarbonate resin with ultraviolet light-excluding capability), will all exclude liquid water.

Benjamin Wilson made some excellent points regarding the interception of roof water at ground level to prevent its infiltration through the dry-laid cellar walls. The simple changing of the gradient of soil outside the cellar walls will cause a portion of the roof water to flow away from the house instead of toward it. A simple, shallow trench at the drip line, lined with polyethylene and sloped to some point away from the house, will be still more effective than merely changing the slope of the ground.

As an alternative, a more elaborate in-ground collection trough may be placed along the drip lines of the building. Perforated PVC (polyvinyl chloride) pipes or pierced flexible drain conduits may be buried in the soil, usually cradled in a trough created by digging a trench, lining the trench with 6 mil black polyethylene, and filling it with crushed stone or gravel. The perforated collection pipes are usually connected to solid PVC piping that conducts the run-off to a distant point of discharge such as a dry well or an open-ended outfall.
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As was reiterated during the inspection, no substantial excavations should be undertaken on the Lear House property without an archaeologist in attendance.

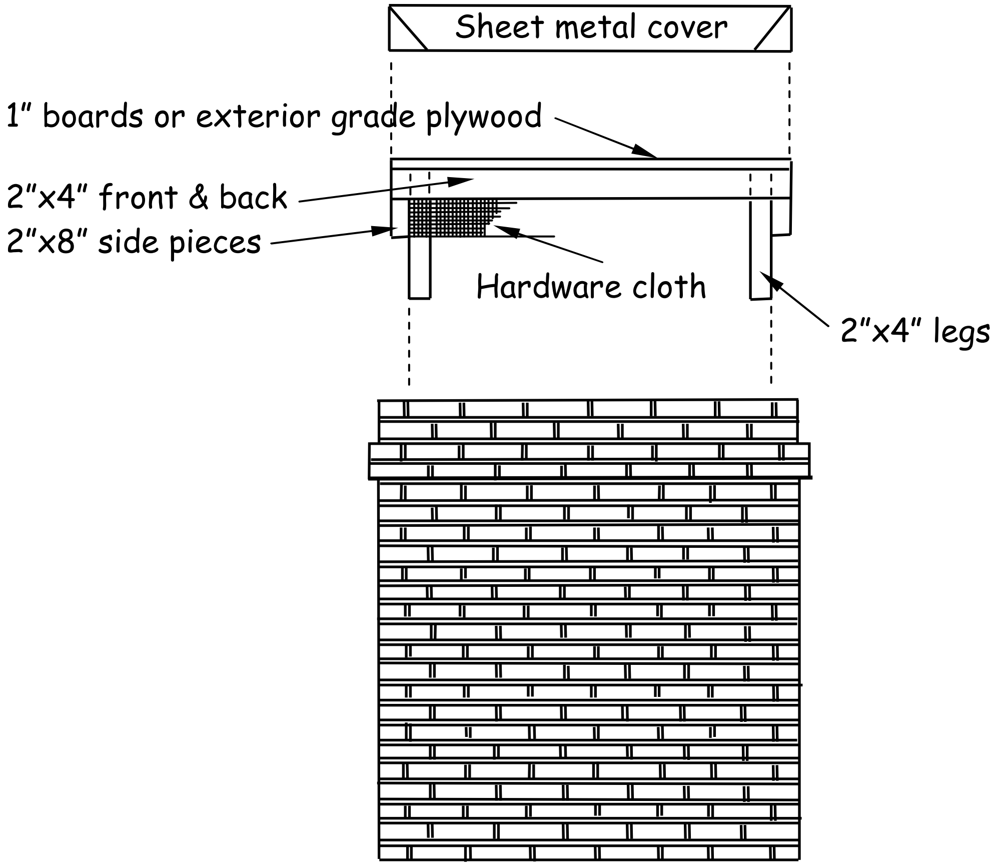
As indicated above, the second stage of moisture management, following the exclusion of liquid water, will be the reduction of infiltration of water vapor and the capture and disposal of water vapor that does find its way into the building. The most direct and effective method of doing this is the one that the Association is now following: after sealing the house against infiltration of liquid water and water vapor as much as possible, install dehumidifiers and monitor their effectiveness. As noted during the inspection, the cooling coils of dehumidifiers may be prone to icing if ambient temperatures are 55ºF. or cooler, so humidifiers in basements need to be monitored, even in midsummer. The presence of a dehumidifier in a closed basement actually cools the surrounding air below its normal summertime temperature due to the forced passage of air over cold surfaces, and this cooling effect contributes to icing of the coils.

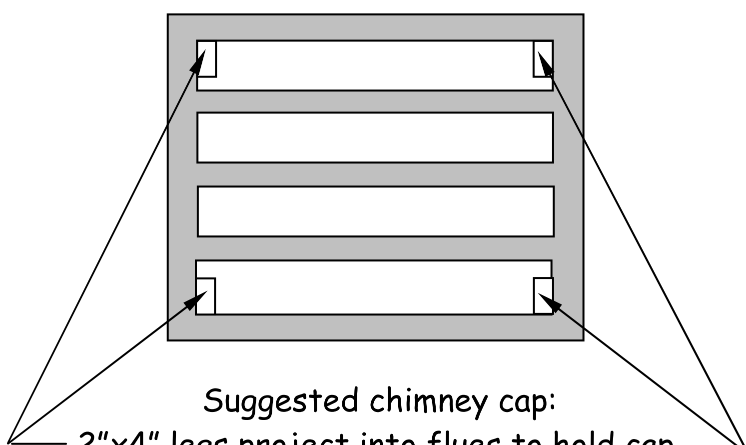
While moisture readings in the woodwork were predictably lower on the second floor and in the attic of the Lear House than at or below ground level, readings in the woodwork near the chimneys showed an elevated moisture content in some areas. This suggests (as is common) that moisture is entering the chimney stacks through the open flues, saturating the brickwork, and migrating to adjacent framing or woodwork. This effect may be especially pronounced in older chimneys, where the bricks below the roof are typically laid in a clay-sand mortar. When mason John Wastrom rebuilt the two Lear House chimneys in 2001, he deliberately reused or replicated the traditional soft mortar below the roof. Thus, these chimneys remain as pervious to water saturation as they have always been.

While it is beneficial to exclude rainwater and snow from the chimney flues, it is likewise beneficial to encourage natural, drying convection currents to continue to rise through the flues and to carry off moisture in the brickwork and in the internal atmosphere of the rooms that are served by the fireplaces.

The drawing on page 7 offers one suggestion (of many that might be devised) for a low-profile wooden cap that would exclude rain and snow from the flues while permitting some degree of air flow upward through the chimney flues.

One point about moisture management should be reiterated: *simple is better*. Many organizations, including Historic New England (formerly the Society for the Preservation of New England Antiquities) have invested in complicated and expensive climate control systems, only to find them hard to regulate, costly to operate, difficult to maintain, and quick to break down. The lesson to be learned from these experiments is that it is best to begin with straightforward steps like those already undertaken by the Association, and to monitor the effects of each step before advancing to the next. Traditional approaches such as tightening the building envelope, monitoring internal conditions, beginning dehumidification and logging its results, and controlling rainwater and groundwater, will yield better results in the long run than committing to complex systems. Eighteenth-century houses were built with natural materials and were expected to endure the effects of the New England climate. With watchful help and simple means, buildings like the Lear House can attain and maintain equilibrium with the environment and can continue to remain in stable condition through a future of undetermined duration.





Suggested chimney cap:
2"x4" legs project into flues to hold cap.
2"x8" side pieces elevate cap to provide
ventilation at front and rear of chimney.
Cap should be wired to nails embedded in mortar joints.