White Paper

Report ID: 110810
Application Number: PF-50351-13
Project Director: Julia Clark
Institution: Abbe Museum
Reporting Period: 10/1/2013-3/31/2016
Report Due: 6/30/2016
Date Submitted: 6/30/2016

White Paper Report

Grant No. PF-50351-13

Implementing Sustainability Strategies for the Abbe Museum’s Collections Environment

Project Director: Ms. Julia (Clark) Gray

Grantee Institution: Abbe Museum

Date: June 30, 2016

Narrative

As a collecting institution, the Abbe Museum focuses on four Native American tribes in Maine: the Penobscot, Passamaquoddy, Micmac and Maliseet, collectively known as the Wabanaki. Operating from two public facilities, the mission of the Abbe Museum is *to inspire new learning about the Wabanaki Nations with every visit.* The Museum's collections, exhibitions, and programs focus on Native American history, culture, and contemporary issues in Maine and explore the broader context Native American experience, past and present. The Museum's collections management policy and collecting plan limit our permanent collection to Wabanaki related artifacts and archives, while we have more flexibility in exhibitions and programs to explore a broader range of Native American cultures and issues.

In September 2001, the new Abbe Museum in downtown Bar Harbor opened its doors to the public. There was a great deal of excitement about this new facility, a second location for the museum that was originally founded in 1928. One of the most exciting things about the new facility was that it provided for state-of-the-art collections storage and exhibits. From the original building with its old electric heat, portable dehumidifiers and fans, we were now in a brand new space with a big, complex HVAC system that would provide a level of temperature and humidity control not possible before. The goal was to achieve the 70˚F/50% RH that loan agreements from major museums around the country required to borrow objects. We were told that our well-lit, spacious collections storage space, with its preservation-quality compact storage system would provide ideal conditions for the long-term care of our collections! We updated our AAM Standard Facilities Reports with the new temperature and humidity parameters given to us by the environmental engineers, while the system was being completed.

Then we installed new HOBO data loggers and started to monitor conditions prior to moving collections into the space, and before we installed any exhibits with objects, especially loans. Our excitement about the new climate control system was short-lived. This was the beginning of almost a decade of frustrations, challenges, equipment failures, un-met expectations, high costs and much more learning about HVAC systems than we had ever expected. Rarely were we able to accomplish the treasured 70/50 the loan agreements asked for and our engineers told us the system would provide. While conditions in the below-grade, single-story and rarely occupied collections storage space were really close most of the time, the much larger main exhibit gallery, a two- story open space with many exterior walls and roof, brightly lit with halogen track lighting and populated with museum visitors, was almost never on target. And that was when all the components of the system were up and running. But then the chiller would break down, or a boiler, or the humidifier, or a fan in the air handler, and our data logger charts would shift from looking like the Appalachians to more like the Himalayas. Records many pages long were created documenting every problem, the attempted solutions, and follow-up.

Over the many years of trying to fix the climate control system, faulty or incorrect mechanical components of the system were identified and replaced, settings were constantly tweaked, new service providers would come in to learn the systems and become familiar with museum climate control goals and the expectations of Abbe staff. It was often a challenge to determine why our dataloggers were recording one set of temperature and humidity readings, when the system controls were telling us something different. In 2003, Facility Dynamics, an engineering firm specializing in building commissioning and controls consulting, did a partial evaluation of the HVAC system, identifying several problems and proposing solutions. Most of these solutions were carried out, with moderate success, but others were beyond the funding resources available at the time.

The other challenge we were facing throughout this time was that the cost of operating the system was much higher than we had expected. We were using almost as much heating oil in July (reheating air cooled to dehumidify it) as we were in January, and the chiller was running through much of the winter (to cool down the air heated by the steam humidification, or so we thought). The frequent breakdowns meant frequent visits from service providers, and often it took longer than we expected to fix problems, either because a new service tech was not familiar with the specifics of our system, or because parts were not locally available to make the necessary repairs. It was frustrating to be spending so much to maintain what was essentially a brand new facility, instead of focusing resources on exhibits, educational programs, and other mission-related activities.

In 2009, under new leadership, the Abbe identified the NEH's Sustaining Cultural Heritage Collections planning grant as an opportunity to take a more comprehensive look at our building systems, with the complementary goals of improving the performance of these systems while also making their operation more sustainable, both environmentally and financially. As a critical component of overall institutional health, these goals were included in the Abbe's 2010-2014 Strategic Plan: "Strategic Objective 10: Maintain and improve facilities and infrastructure to support essential programs and to promote long-term sustainability. Tactical Step (a) Analyze the existing climate control systems and examine passive and low-energy alternatives." To help accomplish this, the Abbe applied for a planning grant in 2009, and was awarded the grant in 2010. Planning grant activities were completed from 2010 through 2012, and an implementation plan was developed to carry out the wide range of recommendations.

Some of the recommendations could be carried out with little to no added operational costs, relying primarily on changes to organizational practices and staff behaviors. For the recommendations that required more of a financial investment, we began the Greening the Abbe campaign to engage individual donors, identified grant and foundation funding opportunities, and applied for a Sustaining Cultural Heritage Collections implementation grant, which we were awarded in 2013. This grant has allowed the Abbe Museum to implement several significant capital improvements that would not have been feasible otherwise, and we have already seen notable returns on these investments through both cost savings and reduced electricity and fuel consumption, and the reduced environmental impact that results.

Project Activities

Through the planning project, we had determined that our building systems were in fact doing a relatively good job of meeting the targets for Control Class A (Float RH), the second highest level of control as defined in Table 3, Chapter 21, *Museums, Galleries, Archives and Libraries* of the 2007 *Applications Handbook* of the American Society of Heating Refrigeration and Air Conditioning Engineers (ASHRAE). The key areas for improvement that were identified were in improving the reliability of various HVAC system components, identifying additional passive measures to protect collections, making changes to our lighting systems, and improving the environmental and financial sustainability of these systems. We have found that through this process we have not had to significantly change the targets for temperature and relatively humidity, other than being more proactive and deliberate about making seasonal adjustments to set points for Rh.

The goal of the NEH funded implementation project was the replacement/improvement of the Abbe Museum's exhibit lighting system, dehumidification system, and chiller in order to meet environmental preservation targets as well as implement economically and environmentally sustainable approaches to the building environment. The planned improvements at the time of the grant award were:

1. Refit exhibit spaces with museum-quality LED lighting

2. Reduced use chilled water dehumidification by adding dedicated dehumidification equipment for collections spaces.

3. Replace chiller unit with a new high-efficiency unit.

A number of recommendations coming out of the planning grant project were implemented prior to the grant period, or being carried out as the grant-funded components were underway.

- Airflow into and out of collections spaces was rebalanced to reduce the infiltration of unconditioned air into these spaces.
- Humidity sensors were replaced with more accurate and reliable sensors that also had an LCD display so that conditions could be quickly and easily assessed on site.
- A new digital controls system was installed with a graphic web interface, which now provides remote access to the system and is much easier for museum staff to understand and diagnose problems.
- A reverse osmosis-demineralized water treatment system was put in for the steam humidifier, something that was in the original system specifications but for some reason never installed. Additional changes to the set-up and piping for the humidifier were also made to improve its operation. As it turned out, these improvements were a little too late for the existing humidifier, which we ended up replacing as part of the grant funded project. More details can be found below. These updates are expected to support the proper function of the new system.
- The operation of the heat recovery unit, which handles the introduction of outside air into the system, was modified to improve efficiency. Instead of constantly taking in relatively large volumes of outside air, which required conditioning, the system now operates on a much more limited schedule, and only during the hours when the building is occupied. The installation of a CO_2 detector in the controls provides for additional outside air if it becomes necessary for safe human occupancy.

These improvements were completed under our operating budget or were funded by private donations made to the Greening the Abbe campaign. We have seen positive results in both the operation and efficiency of these systems. In addition, the staff as a whole has an increased awareness of how to more efficiently use the museum spaces, and is doing a great job of closing doors and turning off lights to reduce the demand on our systems.

During the course of implementing the changes proposed in our Sustaining Cultural Heritage Collections application, we encountered a variety of challenges and unexpected events that resulted in several changes in scope and several extensions of the project timeline. The willingness of the NEH to accommodate these changes and to provide thoughtful input throughout resulted in very positive outcomes despite the challenges.

The following measures were implemented with funding from the grant during the period from October 1, 2013 through March 31, 2016.

Gallery Lighting System

At the start of the grant period, we worked with lighting designer Peter Knuppel, MCM Electric (a local electrical contractor), and representatives from lighting controls and hardware companies to assess the lighting needs and determine the best solutions for our spaces.

During the month of January 2014, while the museum was closed to the public and our primary changing exhibit was being installed in the gallery, we worked with MCM Electric to remove the old lighting system and install the new system. A new controls/dimming system, wiring and switches were installed throughout the building, both to be compatible with the new gallery lighting system, and because the new gallery lighting wattage reduction allows for a smaller dimming rack.

In the main exhibit gallery, the existing halogen fixtures and track were removed. New track was installed, with a revised layout for increased flexibility. The new layout allows for better lighting of the exhibits in the space, and supports the use of fewer fixtures. Three types of new fixtures were purchased and installed (see Appendix A for specifications). To allow some flexibility in lighting exhibits, we selected 120 21W LED fixtures (Times Square LED1738 PAR38), 25 17.8W LED fixtures (Times Square X13), and 8 50W halogen mini-spotlights for detailed object lighting. The total number of fixtures was based on the 145 50W halogen MR16 fixtures that were in use before the lighting replacement.

Once the new system was installed, and Abbe Museum staff installed fixtures to light the current exhibits in the Main Gallery, we ended up using only 60 of the 21W fixtures, all 25 of the 17.8W fixtures, and all 8 of the mini-spots. Overall this works out to a shift from approximately 7,250W of total lighting before the replacement to a total of approximately 2,100W after. This is a roughly 70% reduction in wattage along with a notable reduction in heat load. We are currently seeing about a 3% reduction in our overall electrical consumption, and the daily temperature peaks we were recording in the gallery space have been significantly reduced or eliminated (depending on the other demands on the climate control system).

Furthermore, the quality of the lighting is greatly improved. The LED fixtures do not produce any UV light, and unlike the previous halogen fixtures, they exhibit no color shift when they are dimmed to reach acceptable lumens for light-sensitive materials. The fixtures are more attractive, and allow for more area to be lit with fewer fixtures.

Humidity Control

By August of 2014, we encountered the first of several system issues that led to changes in the scope of the grant-funded work, and delays in the overall implementation.

The planning process, production, and installation of the dedicated dehumidification system took longer than expected, and resulted in a different system recommendation than originally planned. An unexpected positive outcome of these changes, the project engineers determined that the installation of a high efficiency direct expansion dehumidifier, combined with the lighting improvements, would substantially reduce the cooling load on the present chiller. With smaller cooling loads, less cold weather cycling on the existing chiller as a result of the above improvements, our service contractor determined that we could extend the service life of the chiller with a more aggressive maintenance plan. As a result, it was determined that a chiller replacement was not required.

Working with our HVAC service provider, Mechanical Services, the new Nautica Air System DU4A0304 dehumidifier and neccesary duct work were installed. The installation was completed in December 2014, and the system was up and running for a period of several weeks to determine that all components were functioning. Following this initial start-up, the system was then idled until the dehumidification season started in the spring of 2015. At that time, Mechanical Services restarted and fine tune the system.

The initial plans for ducting for the dehumidification system would have required substantial activity in the museum’s collections storage space, and the use of a large section of our exhibit preparation space for equipment. Through careful onsight planning with Mechanical Services and their duct installation subcontractor, it was determined that the system could tie into the exisiting duct work to access the collections storage, collections lab, and main gallery, and disruption in these spaces was minimal. In addition, it was determined that the loading dock was a better location for the unit, and space in exhibit preparation space was not required.

Regular operation of the new Nautica Air System DU4A0304 dehumidification system began during May 2015, and was fine-tuned during the summer months. During this time, the programming was adjusted to enable the air-handling portion of the system to run only when dehumidification is being called for, both to limit the noise levels produced in the archaeology lab and to conserve electricity required to operate the fans. A couple of issues with the condensed water removal portion of the system were encountered and addressed. Overall the operation of the system was excellent, with relative humidity targets consistently maintained and the human comfort in the spaces significantly improved

During the grant implementation process, the poor and unreliable performance of the humidifier became a chronic problem. The humidifier had reached a point where repairs had become so costly and frequent that it made more sense to replace the unit than to continue to repair it. To provide for better future performance of the replacement humidifier, we had already installed a water treatment system for the humidifier water supply using non-grant funds. Michael Henry, our external technical advisor, recommended a new steam humidifier. Although other types of humidification systems have been reported to be more energy efficient, they have also proven to be a risk to the long-term care of museum collections. It was determined that the combination of a new humidifier, with the manufacturer's ongoing improvements in energy consumption, and the water treatment system, could reduce the cost of operation of this portion of the environmental management system for the collections, as well as result in better stability in relative humidity which is so critical to the RH sensitive materials particular to our collection. A change in scope was requested in order to use grant funds to replace the humidifier, and the request was granted.

A Dri-Steem VLC humidifier was installed to replace the rapidly failing equipment originally installed in 2001. The new equipment has shown much more reliable operations, and has generally been more effective at meeting the target set points. The new humidifier appears to be both more effective and more efficient, though some trouble-shooting continues. This element of the HVAC system has proven to be the most problematic through the course of the implementation project. Problems with reduced water flow through the previously installed reverse osmosis water treatment system as led to repeated instances of low water in the humidifier, resulting in its shut down, followed by significant drops in relative humidity in collections spaces for short periods of time. Our mechanical service provider continues to work to resolved this problem.

Heating System

An additional, unexpected development in our HVAC system occurred in the spring of 2015. One of our two cast iron oil-fueled boilers was found to have a cracked section. Our mechanical contractor determined that this could not be repaired, and that a boiler replacement would be needed. We initially considered replacing the failed boiler with a new, high efficiency Veissman propane gas boiler, which would serve the entire heating load of the building 99% of the time and lead to a 15% reduction in energy use, with the resulting reduction in environmental impact. We would keep the currently-functioning cast iron boiler as a back-up and for second-stage heating during extreme cold weather, and retrofit it with a propane burner (funded through non-grant sources). The NEH granted a change in scope request to include the cost of boiler replacement in the grant project.

With additional consultation with our mechanical contractor and other project consultants, we eventually decided that we would have a better long-term outcome from investing in the replacement of both boilers with new, efficient, propane-fired units. We worked with our mechanical contractor, Mechanical Services, to firm up the details for our new heating system. The specifics for venting the new propane boilers were confirmed, and a plan to manage the installation of the new system while keeping the current boilers operational was developed. This became critical when delays in the project meant that the conversion would be taking place during the fall months, when heating would be needed at all times in the building.

With this decision, the cost of the boiler replacement exceeded the remaining grant funds, so we worked with Mechanical Services to finance costs for the replacement that exceeded the grant and Greening the Abbe funds remaining. Abbe staff also worked with our fuel provider, Dead River Company, to put together a financing plan to cover the cost of converting to propane. Under this plan, the cost for installing the underground tanks and running the lines to the building will be built into our monthly propane bill over a fixed term.

Building Envelope

In the late fall of 2014, Sustainable Structures conducted both a a building air-barrier evaluation and infrared building shell evaluation. This was done to get a better handle on ongoing insulation/heat loss concerns in several parts of the building, and was funded through the ongoing Greening the Abbe initiative. This evaluation identified some areas of concern in the the main gallery space (see appendix A). During the course of what turned out to be a winter of record cold and snow, it was determined that both heat and moisture were being lost through a section of the gallery ceiling identified in these reports, where a large unnoccupied attic space exists. Condensation in this area ended up creating leaks back through the gallery ceiling. This appears to be the result of damage to insulation and the vapor barrier between the gallery and this unheated attic, and possibly inadequate amounts of insulation.

Abbe Museum staff worked with members of our building and grounds committee, the contractor who built the building, and an insulation contractor to determine the insulation and vapor barrier needs above the main gallery. It was decided that the most economical and efficient approach would be to leave the rigid foam insulation in place and apply the spray foam on top of this, thus keeping the insulation value of the current material while adding both the vapor barrier and insulating capacity of the spray foam. We also determined, in consultation with the Bar Harbor Fire Department, that this spray foam application does not require a fire-proofing coating, as the space is not regularly occupied, and is fully sprinklered and monitored with fire detection devices. Installation of the spray foam insulation took place during the late fall of 2015, when the museum is closed for part of the week. This prevented exposure of museum guests and staff to any potentially harmful material resulting from the process.

The NEH had granted a change in scope request to include the cost of the additional insulation in the grant. However, with the added cost of the boiler replacements described above, the cost of the insulation work exceeded remaining grant funds. It was instead paid for out of other Greening the Abbe funds.

Additional and Ongoing Sustainable Collections Care Efforts

Doors between collections spaces and non-collections spaces are now kept closed at all times, except when people are actively passing through them. In the past, these doors were often propped open for convenience.

The use of exhibit cases to buffer objects from fluctuations in temperature and RH while on exhibit is something that is already being done at the Abbe- most objects on exhibit are in closed cases. Evaluation of the effectiveness of various cases in buffering fluctuations was carried out by using HOBO dataloggers to log temperature and humidity inside cases and compare these to the conditions of the gallery as a whole. The results show that humidity fluctuations are greatly reduced or eliminated within our existing display cases, and these cases can be used when more vulnerable objects are exhibited.

Additional buffering or containerization of collections in our collections storage space has not proved necessary, as overall operations of the systems now in place are providing a consistent stable environment in collections storage, with some minor exceptions caused by ongoing challenges with our humidification equipment.

Accomplishments

The Abbe Museum is very pleased with the results of our Sustaining Cultural Heritage Collections grant project. We have also learned some valuable lessons that will serve us well moving forward, and can inform other organizations looking to carry out similar projects.

The combination of adjustments, upgrades, replacements, and fine-tuning of the lighting and HVAC systems in our collections storage and exhibition spaces have resulted in improved control, more reliable operations, new equipment that should last for a long time, and significant reductions in energy use and costs. Details are provided in the Evaluation section below.

It was not, however, a smooth and flawless process to reach these goals. Completion required at least two significant changes in scope, and three grant extensions. As plans for each component of the project were refined, costs and expectations changed. Almost every element of the implementation project took longer than expected, sometimes much longer. This was primarily the result of delays from contractors and changes required when plans were adjusted or unexpected hurdles were encountered. And during the implementation, both our humidification and heating systems suffered substantial failures that presented both challenges and opportunities. In the end, these failures led to the installation of new equipment that has meant an overall more positive outcome for the project.

The support of the SCHC grant has also provided the foundation for a variety of additional and ongoing work to make the Abbe Museum facilities more sustainable. The initial planning grant provided many recommendations that could be implemented as part of regular operations. The work that has been done so far has also strengthened the case for additional private and grant funding for ongoing work.

Shortly before we received word that we had been awarded this implementation grant, we launched the Greening the Abbe campaign, which by the conclusion of FY2014 had raised $37,693 from dozens of private donations. Additional donations to this fund continue to come in periodically. In 2015, the Abbe received funding from the Grants to Green program to carry out a detailed energy audit of the historic portion of our structure, which while it does not generally contain collections materials, certainly contributes to the energy use for the facility. We also funded an energy audit of our original 1928 building in Acadia National Park through the Greening campaign. Following the energy audit, we recently received additional grant funding from the same program to implement the recommendations of the audit.

Audiences

The Abbe Museum serves multiple audiences and communities through programs, educational outreach and in-reach, and partnerships with the four Maine tribes, Acadia National Park, and other regional and state-wide organizations. The locations in and near Acadia National Park, draws international visitation, as well as visitors from across the country during five months out of each year when the Park is open. In the off season, the Museum serves communities in Maine, primarily in Hancock County, but also from Washington, Penobscot, and Waldo Counties as well. The Museum has a close relationship with the four tribes in Maine, the Passamaquoddy, Penobscot, Micmac, and Maliseet, collectively known as the Wabanaki, and serves these rural communities through partnerships and programs.

Evaluation

Evaluation of this project is reflected primarily in the energy use and cost savings we have seen as a result of the work completed, and the ongoing data logger data documenting temperature and humidity levels in collections spaces.

For example, electricity usage was down 6.28% for 2015 compared to 2014. We also saw a summer (July and August) heating oil use reduction from 796 gallons in 2013 and 1,207 in 2014 to just 481 gallons in 2015. While the conversion to propane is relatively recent, we are already seeing a substantial cost savings: compared to $7,175 spent on heating oil from January-April 2015, only $4,756 was spent on propane to heat the building from January through April of 2016.

Some examples of comparison data logger charts can be found in Appendix B.

Continuation of the Project

As discussed above, the overall work to make the operations of the Abbe Museum more environmentally and financially sustainable continue. Some of the systems installed or modified as part of the project will continue to need fine-tuning and adjustments over time, and we expect to make additional updates and changes as technology improves and costs come down for newer technologies. We currently have funding in hand for other sustainability measures across the organization, and are seeking ways to accomplish other goals. The *Environmental Improvements Report* prepared by Michael Henry and Ronald Harvey as part of the planning grant remains a key guiding document in these efforts.

Furthermore, in the Abbe Museum current strategic plan, adopted in 2015, sustainability remains a key objective. As stated in goal F: Steward of All Entrusted Assets, the Museum is a responsible and ethical steward of all the assets entrusted to it. This includes the objective to implement environmentally sustainable practices throughout the Museum (read more at abbemuseum.wordpress.com).

Long Term Impact

The long-term impact of this project will be seen in improved sustainability in building systems operations along with the long-term maintenance of appropriate conditions for the care of the Abbe Museum's collections. Sustainability will be reflected in both cost savings and a reduction of the environmental impact of our operations. It is also important that, as a non-tribal Native American museum, we operate in ways that are consistent with the sovereignty and cultural

values of the Wabanaki communities we work with and represent. Sustainability, respect for the environment, and respectful care of our collections are all consistent with this approach.
We will be conducting long-term monitoring of temperature and humidity in collections spaces, as well as tracking energy consumption to assess the long-term impact of the project.

Grant Products

The primary grant products are the new systems now in place at the Abbe Museum that are providing appropriate and efficient care of our irreplaceable collections.

The Abbe also looks forward to continuing to share our experiences and lessons learned across the field through everything from conference presentations, publications, collaborative projects, and conversations with others in the field.

The Greening the Abbe initiative and fundraising campaign has been in many ways an outgrowth of this project. More about the Greening the Abbe can be found on the museum's website at http://abbemuseum.org/support/greening.html.

Appendices

Appendix A: Lighting Fixture Specifications
Appendix B: Data Logger Chart Comparisons
Appendix C: Building Envelope Reports

Appendix A: Lighting Fixture Specifications

Job Name: ______ **Fixture Type:** ______ **Qty:** ______

LED Series by Times Square Lighting

Manufactured in the USA - IBEW

c UL us LISTED · Pb lead-free · RoHS 2002/95/EC

Xicato

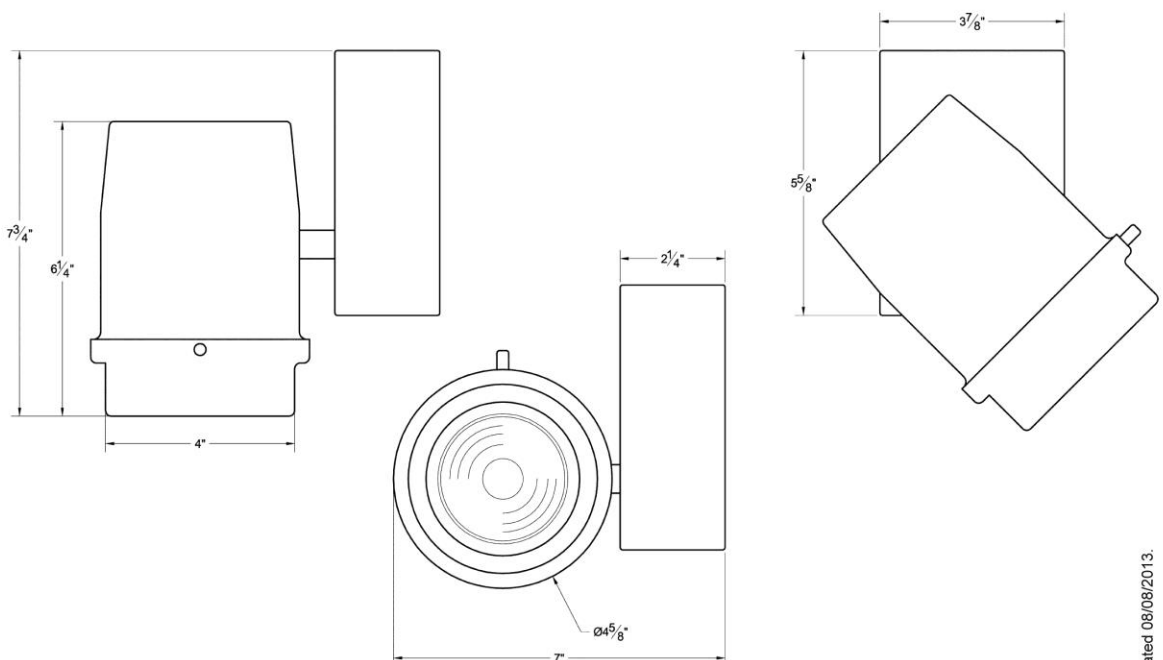
X13 17.8W, 1300 Lumen LED

The X13 is designed around the Xicato™ LED remote phosphor module. This module produces an even field of illumination for the most demanding applications. The X13 is ideal for museum and retail lighting where a low wattage, high output LED fixture would be required. Xicato™ LEDs exceed ANSI specifications by maintaining tight color consistency over the life of the LED module.

The X13 is available in standard black, white, or silver finishes. Custom colors are available upon request.

Features:

- 100-277 Volt available
- 17.8-Watt Xicato™ module
- 50,000 Hour life
- CRI ≥80 (≥95 as an option)
- Integral electronic driver
- 20º, 40º and 60º Field-changeable reflectors
- Choice of color temperature: 2700, 3000, 3500 or 4000.
- No UV or IR
- Dimmable (optional)
- Can accept 2-3 accessory elements



Last updated 08/08/2013.

Maximum ambient temperature: 35ºC
Maximum operating angle: 45º from vertical

TIMES SQUARE LIGHTING

5 Holt Drive • Stony Point, NY 10980
Phone: 845-947-3034 • Fax: 845-947-3047 • www.tslight.com
Specifications are subject to change without notice.

X13 17.8W, 1300 Lumen LED

Specify:	X13	-		-		-		-		-		-		-		-	
	Model		**CRI**		**Color Temp**		**Finish**		**Voltage**		**Reflector**		**Mounting ***		**Dimming**		**Accessories ***
Example:	X13	-	80	-	30	-	B	-	120	-	20	-	TA1	-	ND	-	LV6

** Optional*

Photometric Data

20º Spot Reflector

Distance	Beam Spread	Footcandles
5'	1.7'	200
7.5'	2.7'	89
10'	3.6'	50
12.5'	4.4'	32

40º Medium Flood Reflector

Distance	Beam Spread	Footcandles
5'	3.6'	108
7.5'	5.5'	48
10'	7.3'	27
12.5'	9.1'	17

60º Flood Reflector

Distance	Beam Spread	Footcandles
5'	5.7'	61
7.5'	8.7'	27
10'	11.6'	15
12.5'	14.4'	10

Voltage

100	100 Volt
120	120 Volt
240	230-240 Volt
277	277 Volt

LED Modules

8027 17.8W; 50,000Hrs; ≥80 CRI; 2700°K Color Temp

8030 17.8W; 50,000Hrs; ≥80 CRI; 3000°K Color Temp

8035 17.8W; 50,000Hrs; ≥80 CRI; 3500°K Color Temp

8040 17.8W; 50,000Hrs; ≥80 CRI; 4000°K Color Temp

9527 27.7W; 50,000Hrs; ≥95 CRI; 2700°K Color Temp

9530 27.7W; 50,000Hrs; ≥95 CRI; 3000°K Color Temp

9535 27.7W; 50,000Hrs; ≥95 CRI; 3500°K Color Temp

9540 27.7W; 50,000Hrs; ≥95 CRI; 4000°K Color Temp

Reflector

20	20º Reflector
40	40º Reflector
60	60º Reflector

Mounting Options

AD1
Track adapter for commercial grade 1 and 2-circuit track.

T1
Track adapter for commercial grade 1 and 2-circuit track.

TA1
Track adapter for E-Series specification grade 1-circuit track.

TE2
Track adapter for E-Series specification grade 2-circuit track.

TA2
Track adapter for G-Series specification grade 2-circuit track.

HTA2
Track adapter for G-Series specification grade 2-circuit 277-volt track.

TA3
Track adapter for G-Series specification grade 3-circuit track.

US1
Unistrut adapter.

MC
Medium duty pipe clamp for pipes up to 1 1/2" O.D.

MN
Medium duty pipe clamp for pipes up to 2" O.D.

CM4
6" Canopy for permanent mounting on standard 4" octagonal outlet boxes.

Dimming

ND	Non-Dimming
TE	Trailing Edge
LE*	Leading Edge
010**	0-10 Volt
IP	Integral Pot

** Not available in 277V*
*** Not available w/ track adapters or cord sets*

Accessories

LV6	Louver
XL6	Cross Baffle Louver
BD10	Barndoor
HD6	Hood
XH6	Cross Baffle Hood
X00517 *	Glass/Dichroic Holder
GF22	Glass Color Filter
DF22	Dichroic Color Filter
GF22-600	5ºx50º Linear Lens
GF22-601	Beam Softener
GF22-673	50ºx50º Spread Lens
CC18	Coiled Cord
SC-24	Safety Cable

** Required accessory when using glass or dichroic filters*

Finish

B	Black
W	White
S	Silver
CC	Custom Color

Notes on Dimming:

TE	This means the fixture will work on *MOST* quality Trailing Edge dimmers. These dimmer types are also known as Reverse Phase or Electronic Low Voltage (ELV), and are available as wall mount and rack mount modules.
LE	This means the fixture will work on *MOST* quality Leading Edge dimmers. These dimmer types are also known as Forward Phase, Incandescent, Halogen or Triac, and are available as wall mount and rack mount modules.
0-10	This means the fixture will work on *MOST* quality 0-10V or 1-10V dimmers. These dimmer types are also known as Fluorescent, and are available as wall mount and rack mount modules.
IP	This means the fixture has a dimmer *BUILT IN* to the fixture itself, and will dim to about 50%. It has an integral potentiometer located on the bottom of the driver housing. This fixture *WILL NOT* function with *EXTERNAL* wall or rack dimmers.

It is impractical to test every fixture type with every dimmer type, and some combinations work better than others, while some not at all.
It is advisable to pretest a particular fixture with an intended dimmer beforehand to insure that the combination will work as expected.
Some dimmers will allow for full-range dimming, while others will only dim to 50%.
Some dimmers will work well within a certain range, and perhaps flicker or shut off at the lowest settings, rendering that portion of the range unusable.
Most if not all dimmers have a maximum LED load that can be applied, often as little as 10% of its nominally rated value.
Dimming LEDs can actually extend their life expectancy, and will not affect the color temperature or CRI.

Job Name: ____________ **Fixture Type:** ____________ **Qty:** ______

Manufactured in the USA - IBEW

LISTED lead-free RoHS 2002/95/EC

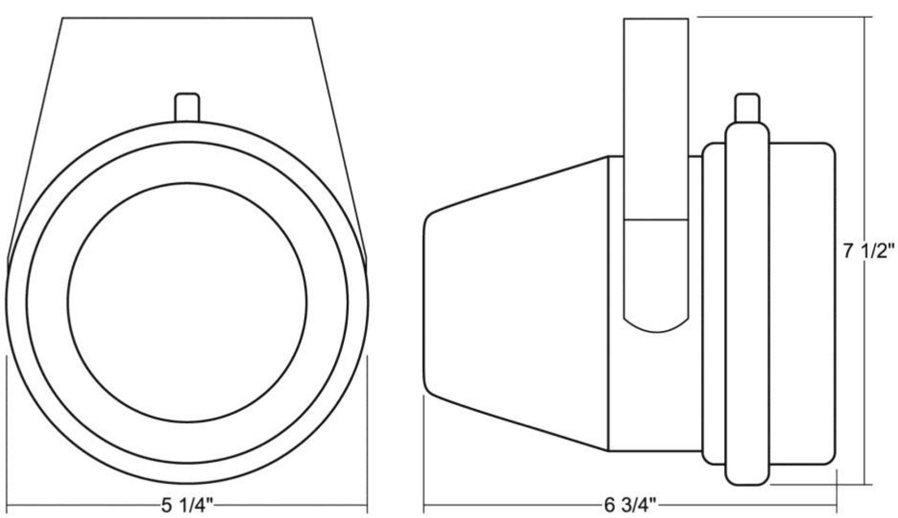
LED1738 PAR38 LED

The LED1738 is a specification grade LED fixture that is capable of replacing 75-watt line voltage and 39-watt metal halide fixtures. Its light weight and small size makes it ideal for interior spaces such as museums, exhibits, shops, residences; and areas where high-intensity light is needed.

Features include a three piece spinning set that allows full accessory rotation that locks in place. A rugged steel self-locking yoke, and internal accessory ring that can hold up to four accessories is also included. Available in standard black, white and silver finishes. Custom colors are available by request.

Features:

- Performance equivalent to 75W halogen PAR lamp
- 75% power savings over 75W halogen and > 10 times the service life
- Internal self-locking yoke
- Internal accessory holder
- Numerous mounting options
- Equipped with lens rotation and relamping handle
- Industry leading lumen maintenance and color point stability
- Dimmable



Last updated 01/17/2012.

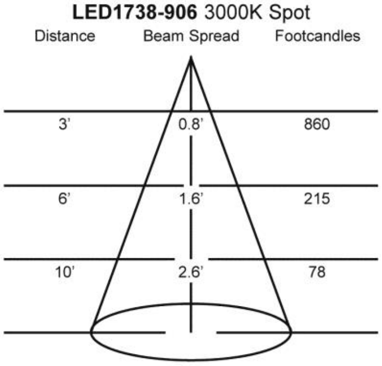
5 Holt Drive • Stony Point, NY 10980
Phone: 845-947-3034 • Fax: 845-947-3047 • www.tslight.com

Specifications are subject to change without notice.

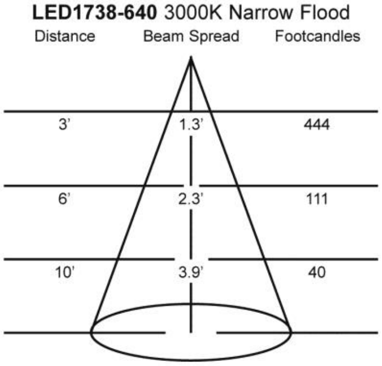
Specify:	LED1738-*XXXX*	-	-	-
	MODEL NUMBER	**FINISH**	**MOUNTING (optional)**	**ACCESSORIES (optional)**
Example:	LED1738-906	-B	-T1	-LV7

Photometric Data

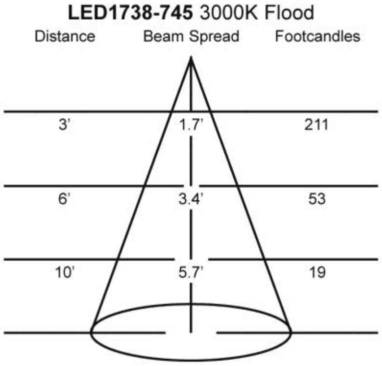
LED1738-906 3000K Spot



LED1738-640 3000K Narrow Flood



LED1738-745 3000K Flood



Fixture Types

LED1738-433 17W; 45,000Hrs; 10° Beam; 930 Lumens; 3000°K Color Temp

LED1738-516 17W; 45,000Hrs; 15° Beam; 880 Lumens; 2700°K Color Temp

LED1738-532 17W; 45,000Hrs; 15° Beam; 1080 Lumens; 4000°K Color Temp

LED1738-191 17W; 45,000Hrs; 22° Beam; 1050 Lumens; 4000°K Color Temp

LED1738-657 18W; 50,000Hrs; 25° Beam; 860 Lumens; 2700°K Color Temp

LED1738-658 18W; 50,000Hrs; 40° Beam; 860 Lumens; 2700°K Color Temp

LED1738-640 18W; 50,000Hrs; 25° Beam; 900 Lumens; 3000°K Color Temp

LED1738-641 18W; 50,000Hrs; 40° Beam; 900 Lumens; 3000°K Color Temp

LED1738-761 18W; 50,000Hrs; 40° Beam; 920 Lumens; 4000°K Color Temp

LED1738-906 21W; 50,000Hrs; 15° Beam; 1150 Lumens; 3000°K Color Temp

LED1738-745 21W; 50,000Hrs; 30° Beam; 1150 Lumens; 3000°K Color Temp

LED1738-806 24W; 50,000Hrs; 25° Beam; 1300 Lumens; 3000°K Color Temp

LED1738-807 24W; 50,000Hrs; 40° Beam; 1300 Lumens; 3000°K Color Temp

Mounting Options

T1
Track adapter for commercial grade 1 and 2-circuit track.

TA2S
Track adapter for specification grade 2-circuit track.

TA3
Track adapter for specification grade 3-circuit track.

US1
Unistrut adapter.

MC
Medium duty pipe clamp for pipes up to 1 1/2" O.D.

MN
Medium duty pipe clamp for pipes up to 2" O.D.

PC9M
Heavy duty pipe clamp for pipes up to 2" O.D.

CM4
6" Canopy for permanent mounting on standard 4" octagonal outlet boxes.

TB4
6" Portable wall mount/table base for floor, wall or table use.

Accessories

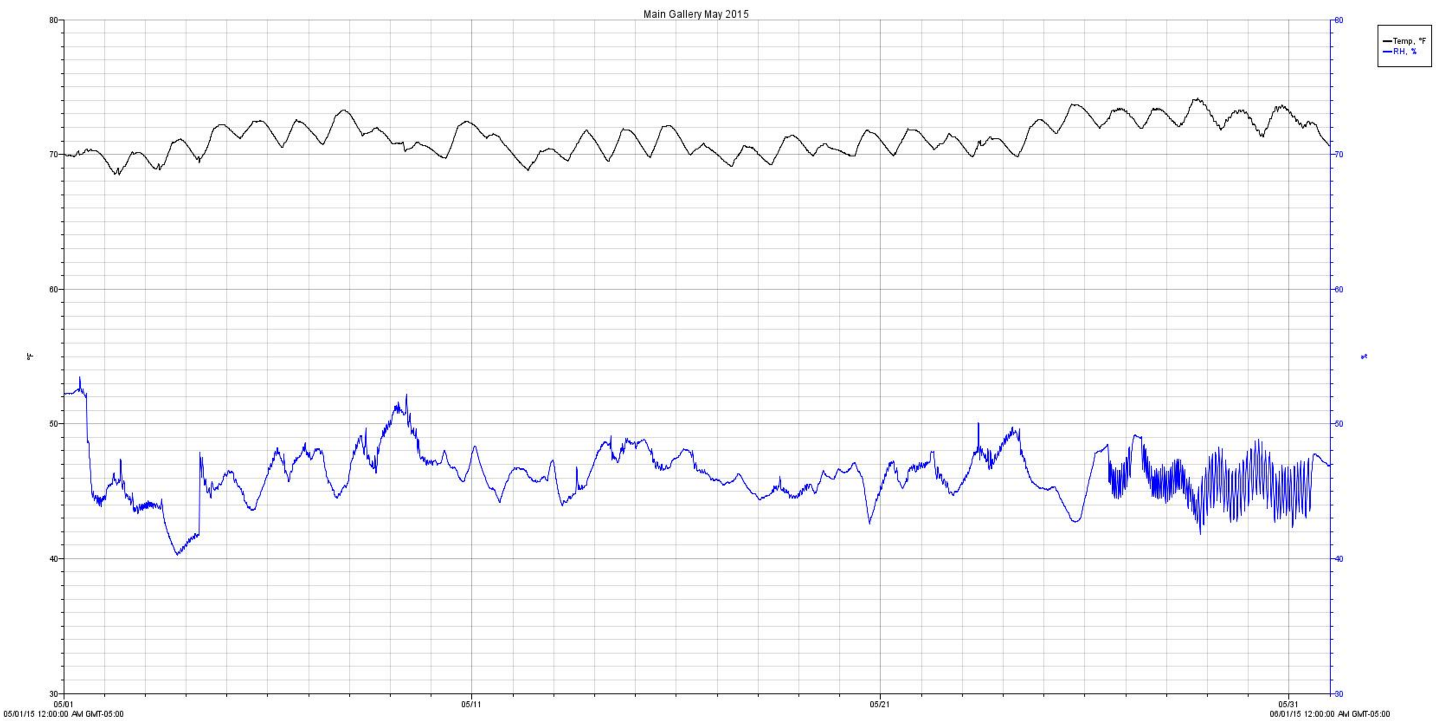
LV7	Louver
XL7	Cross Baffle Louver
BD7L	Barndoor
HD7	Hood
XH7	Cross Baffle Hood
SH7	Sparkle Hood
GFH8	Glass Filter Holder
GF7	Glass Color Filter
DF7	Dichroic Color Filter
GF7-600	5ºx50º Linear Lens
GF7-601	Beam Softener
GF7-673	50ºx50º Spread Lens
GF7-702	UV Blocking Filter
CC18	Coiled Cord
SC-24	Safety Cable
WL	Wrench Locking

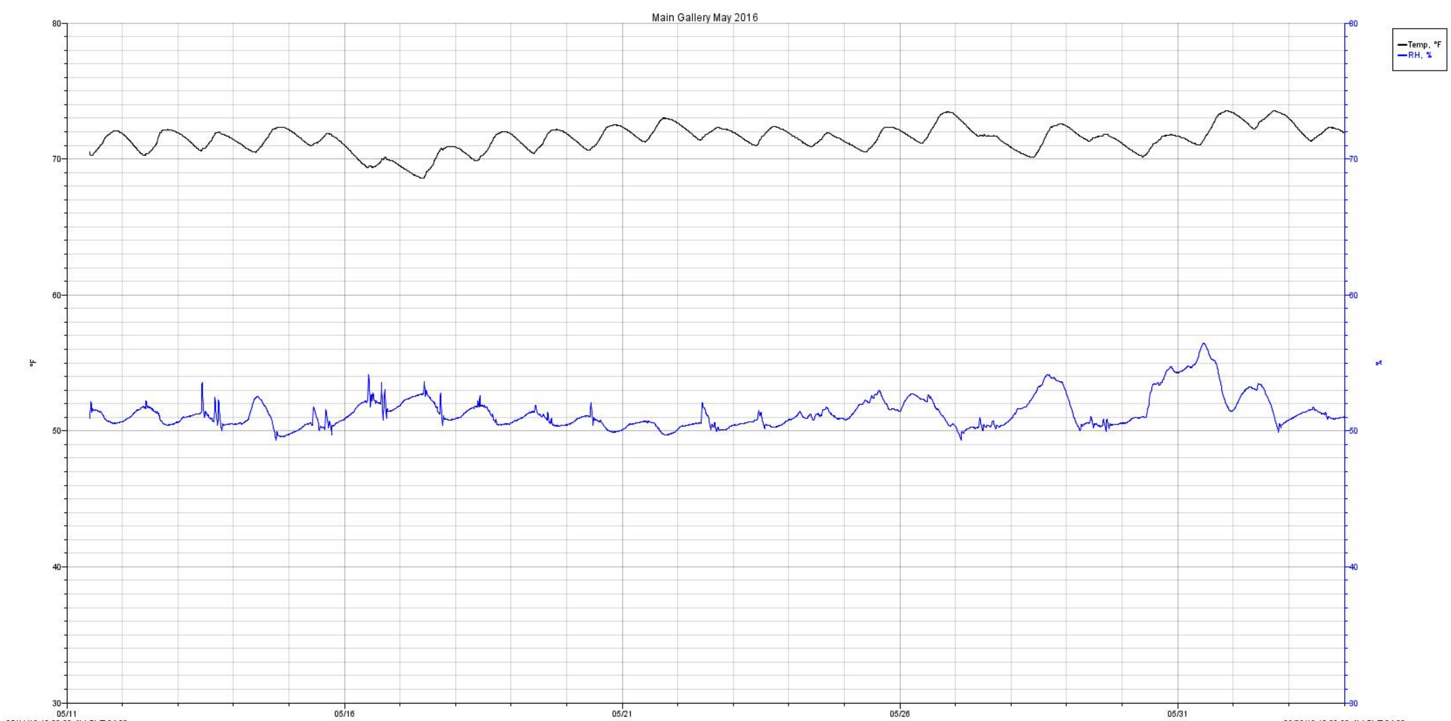
Finish

B	Black
W	White
S	Silver
CC	Custom Color

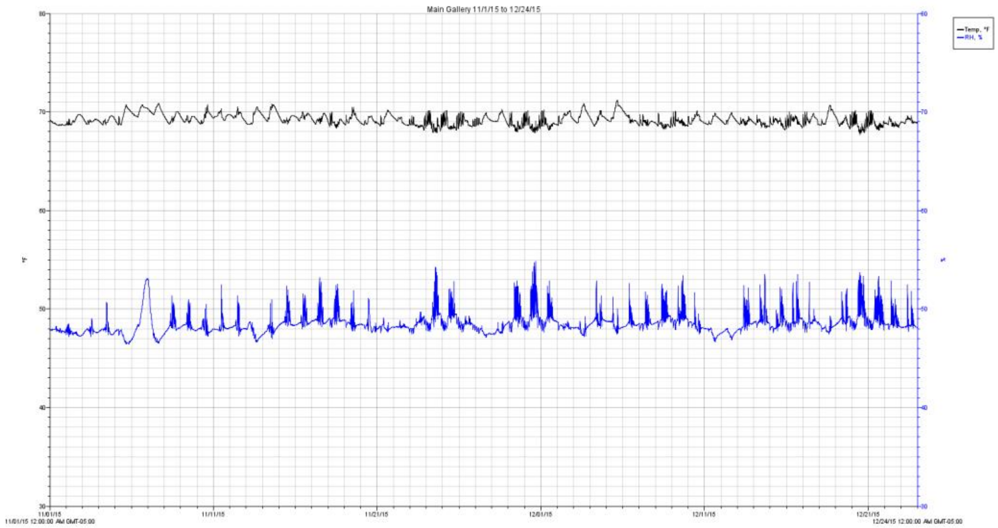
Appendix B: Data Logger Chart Comparisons

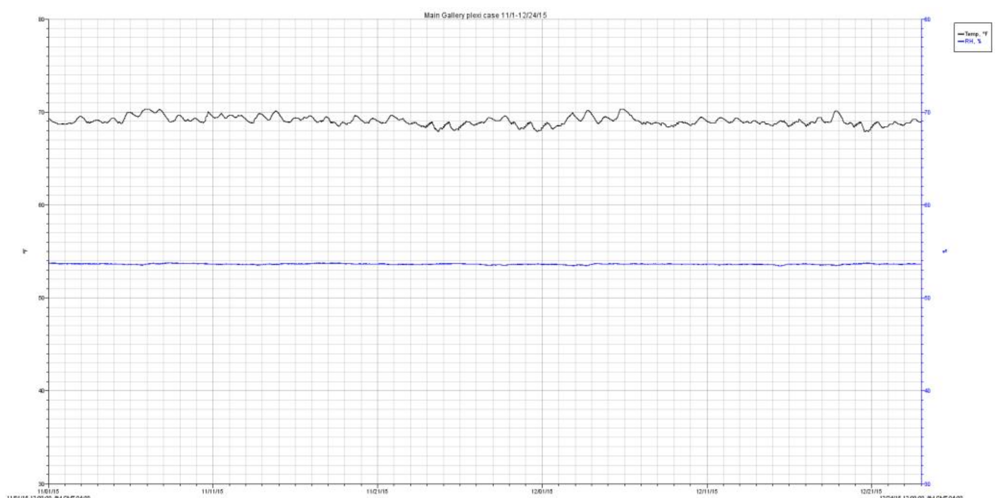
Main Gallery, May 2015 (top) compared to May 2016 (bottom), with new dehumidification system.

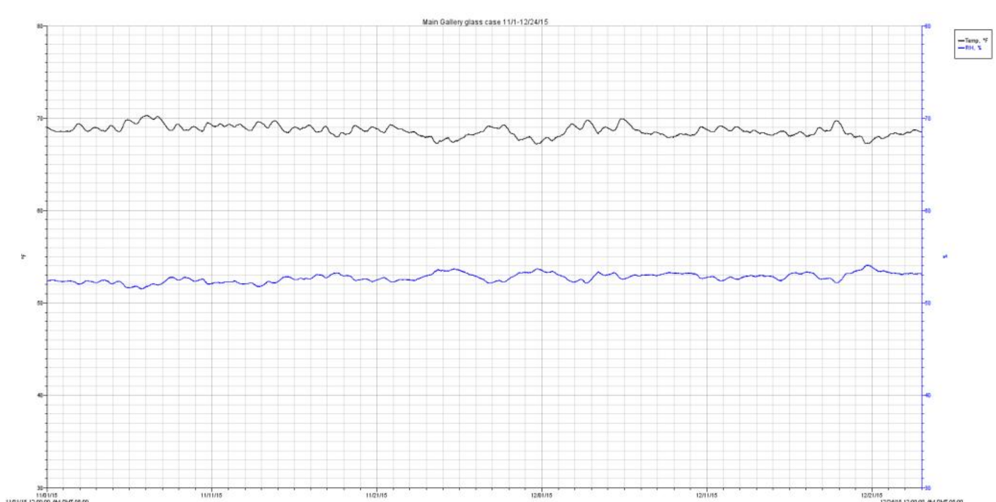




Main Gallery space (top) compared to inside a plexi case (middle) and inside a glass case (bottom) showing buffering effect of display cases.







Appendix C: Building Envelope Reports

BUILDING AIR-BARRIER EVALUATION REPORT—ABBE MUSEUM

PO Box 45, Hallowell, ME 04347 // (207) 446-7924 // currycaputo@savemaineenergy.com

Building-owner Information

Name: ***Abbe Museum***	Address: ***PO Box 286, 26 Mt Desert St, Bar Harbor, ME 04609***
Phone: ***207-288-3519***	
Email: ***info@abbemuseum.org***	

Date of Testing and Inspection: ***11/7/2014***
Ambient Temperature: ***38 F***
Date of Report: ***11/21/2014***

Shell-test Summary

Goals:

1. Determine the cause for undue condensation and subsequent leaking in the roof assembly of the Museum's main exhibit hall.
2. Recommend improvements to eliminate condensation and improve energy-efficiency.

Tools and testing:

1. Pressure-testing in the exhibit hall;
2. thermal imaging (see attached images);
3. and, non-toxic/non-corrosive smoke-testing.

Evaluation:

1. determine if exhibit hall is under positive pressure (i.e. air always being forced out of shell-leaks);
2. identify and document air-barrier breaches—especially those contributing to the condensation problem;
3. evaluate thermal boundary of the problems area(s) and the entire contiguous attic.

Background:

The environmental requirements in the exhibit hall push the limits of what is acceptable in a conventional building assembly. A constant temperature of 70-72°F, a relative humidity of 50-55%, and a positive pressure in the space-envelope places extra demands on the building assembly. The overall effect is warm, moist air being driven through all gaps, spaces, cracks and holes in the envelope. Ideally, air is forced out all leaks whether exposed to the interior or exterior, and ideally the leaks do not occur within a building assembly (like a wall or ceiling-structure.

The goal for performance in the space is to maintain the desired environmental conditions with a positive space-pressure with reference to adjacent spaces via return-air ducting to air-handler, and planned leaks to the adjacent hallway.

Though I didn't have access to the engineering drawings or specifications for the space, it is clear that a vapor-controlled building envelope was contemplated and attempted. Over time however, elevated relative humidity in the attic has reportedly caused periodic water leaks into the exhibit hall.

Current issue:

Julia Clark pointed out the 2 areas where ceiling leaks have occurred—at the HVAC supply duct penetrating the upper east sloped-ceiling, and along the east-eave at a steel roof-framing bracket, above the common wall with the adjacent hallway. These leaks occur during the heating season only.

To help alleviate the problem, an attic exhaust fan was installed. This system simply exhausts attic air via duct-work to the exterior at a south-east corner overhang.

Summary of findings:

The current condensation/infiltration issue is being caused by a number of problems:

1. Breaches in the air-barrier adjacent to surfaces which drop below the dew-point (i.e. cold surfaces directly contacting or close to warm, moist air-leaks).
2. Incomplete air-sealing and vapor-sealing at major roof assembly transitions (at valley rafters, ridge, and eave).
3. Inadequate attic ventilation—especially in problem area—allowing concentration of water vapor near ridge of exhibit hall.
4. Minimal positive pressure in exhibit hall with reference to the hallway, negative WRT exterior.

The overall effect is warm moist air forcing into a poorly ventilated attic, condensation occurring at specific air-leaks adjacent to metal (ductwork, steel-framing bracket) and at the roof-deck and framing, then either water leaking into the space where condensation occurs (ductwork/bracket), or water collecting, beading and draining down the surface of the exhibit hall ceiling insulation (foamboard), to leak at the eave above the common wall with the adjacent hallway.

Recommendation summary:

At a minimum the following should occur:

1. Create proper attic ventilation by creating large hole(s) in plywood ceiling of attic above exhibit hall. There are 2 layers of plywood (with 2x6 framing in between) between lower attic space and upper flat roof. The goal is to provide enough open area in the upper (currently inaccessible) flat roof-framing along either an edge-vent or roof vent to allow air-flow from soffit venting in the adjacent attic spaces to ventilate out the flat roof.
2. Remove enough ceiling foamboard to expose air-barrier breaches at east-facing exhibit hall sloped-ceiling. Then air-seal using caulking/canfoam, and re-insulated with field-applied closed-cell spray polyurethane foam (SPF).

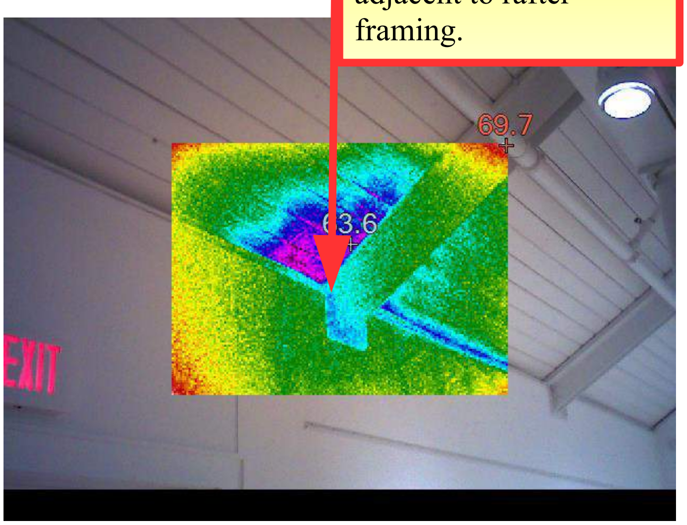
For a more comprehensive job:

1. Above the exhibit hall, along the sloped-ceiling, remove roughly the bottom 6-feet of foamboard insulation (corresponds with pitch change) and all other impacted foamboard, then replace with like foamboard (properly air-sealed).
2. Address opposing sloped ceiling (over hallways), by removing existing insulation, air-sealing and installing new insulation with an air-barrier.
3. Address attic-exposed walls and ceiling of the computer room, by removing existing insulation and debris, air-sealed all wall/ceiling penetrations, then re-insulating with loosefill cellulose.

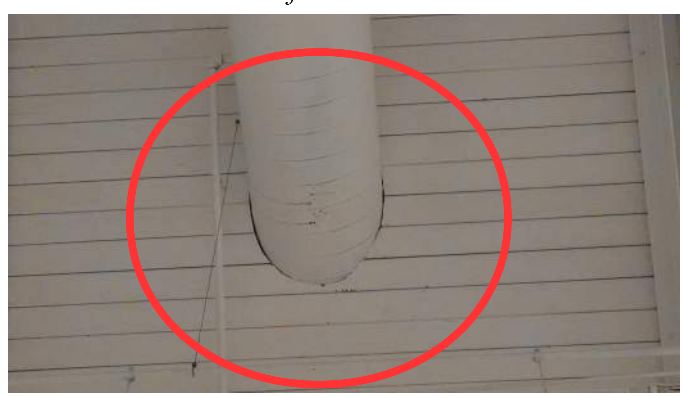
Thermal Boundary & Air Barrier Recommendations—Ductwork & Eave	
Priority	Retrofit/Air-sealing recommendations
High	***EAVE--In the attic, remove the lower 6-foot section of foamboard insulation (2 layers) to expose the membrane over the ceiling. Remove all debris and insulation at building assembly transition to opposing slope and wall of computer room. Seal all penetrations in the membrane with flexible adhesive sealant. Install new 6" polyisocyanurate foamboard (in 2 or 3" alternating layers) from pitch change to within 1-foot of transition above common-wall with hallway below. Install 4" SPF (in 2 applications of 2") to exposed ceiling membrane and building-assembly transition (to either wall or sloped-ceiling).*** ***SUPPLY DUCT—cut back existing insulation roughly 1-foot from edge of duct/duct-insulation. Air-seal duct penetration in the ceiling with flexible adhesive caulking. Be sure to remove insulation at the bottoms of the adjacent valley rafters, and air-seal all cracks/holes/seams with canfoam. Install 4" SPF (in 2 applications of 2") to exposed ceiling encasing rafter-bottoms/plate.***

This is one of the identified leak areas. Note metal adjacent to leak.

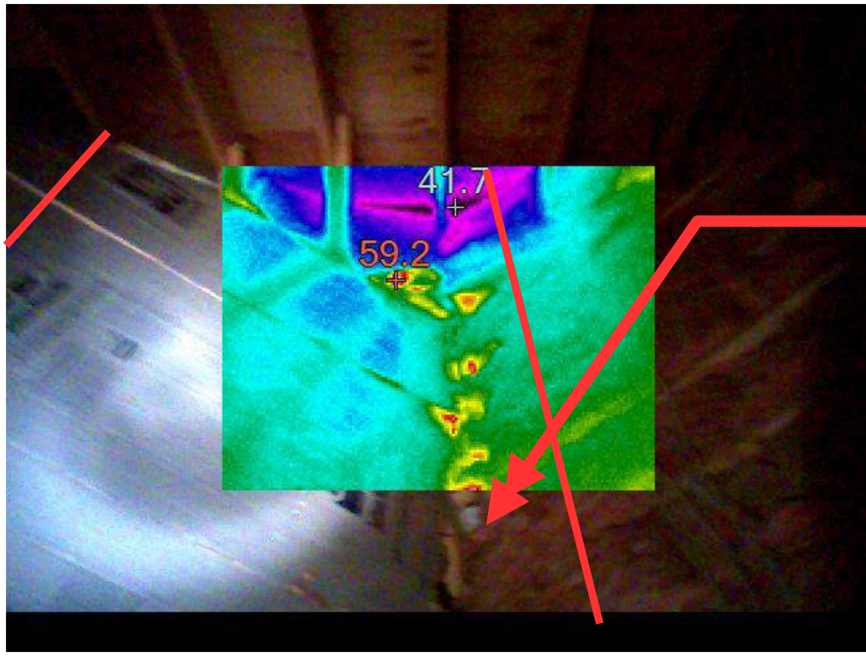
Thermal image showing impacted insulation at east-eave adjacent to rafter framing.



This is the attic-side of the same ductwork.



Site of ceiling leak at HVAC supply ductwork. Remove insulation inside of red-line in attic for proper air-sealing.

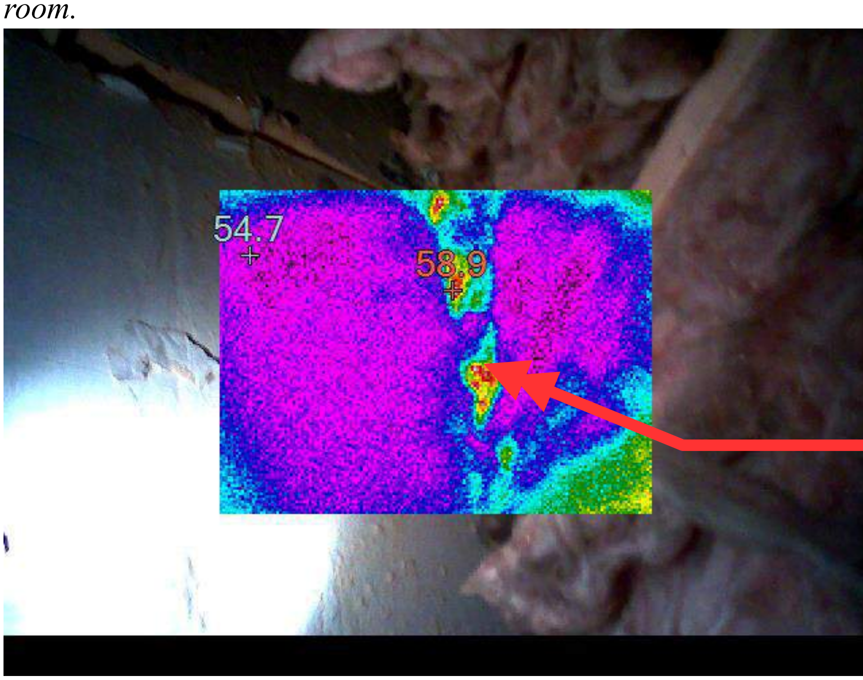


The eave-leak issue is both an air-barrier and thermal barrier breach. Therefore complete removal of foamboard to pitch change (at red-line left) and removal of fiberglass along reverse slopes (to the right red-line) followed by comprehensive membrane-sealing, air-sealing, and re-insulation should fix the water leaking in, and air leaking out.

East-facing eave of exhibit room, above common-wall with hallway.

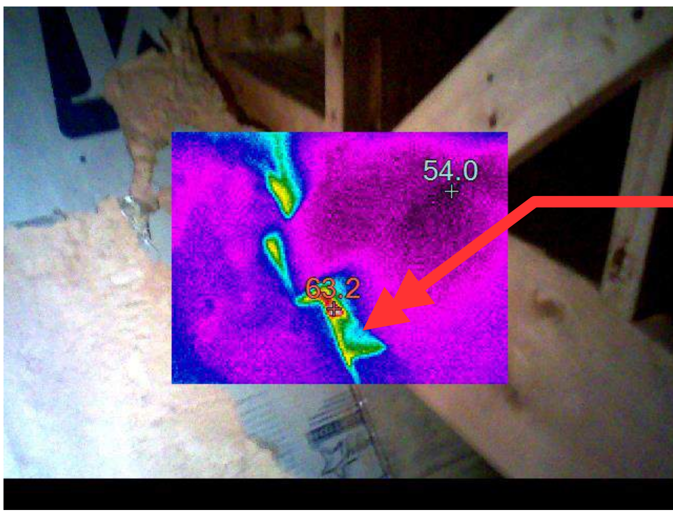
Location of pitch-change on east-facing exhibit room ceiling. Currently the 2 layers of foamboard are not contacting the ceiling surface because the sheets are spanning transition, instead of being cut/fit and sealed to ceiling. Note seams not sealed.

East-facing eave of exhibit room, adjacent to 2nd story computer room.



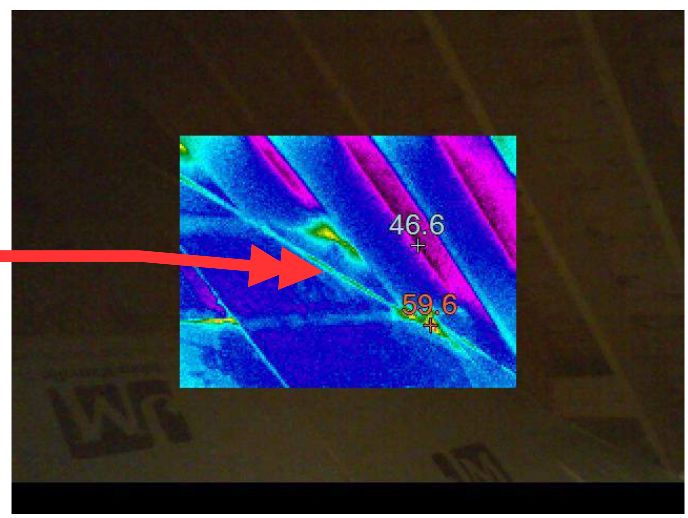
Location of "eave" at intersection with framed-wall of 2nd story computer room. This foamboard is heavily impacted, poorly air-sealed and is discontinuous where it intersects the wall framing. Remove foam up to the 6-foot mark, pulling the fiberglass and debris, then subsequent SPF installation should eliminate this problem.

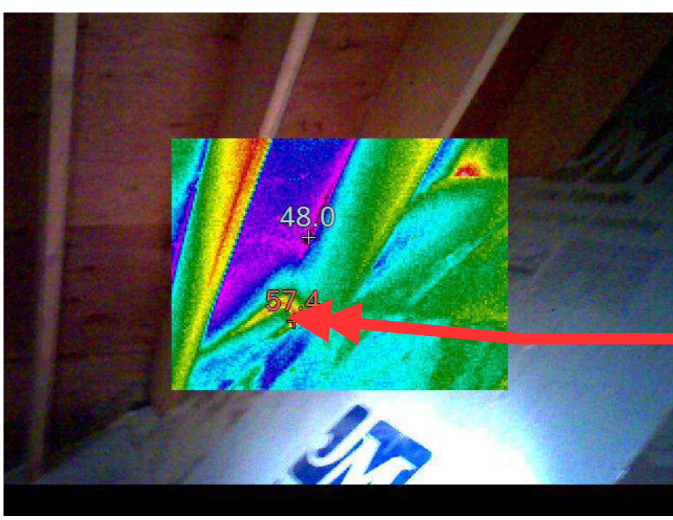
Thermal Boundary & Air Barrier Recommendations—Roof-supports & Valleys	
Priority	Retrofit/Air-sealing recommendations
High	***ROOF SUPPORTS--In the attic, atop and along both sides of the 2 roof-support structures, remove at least 1-foot of foamboard to expose ceiling membrane—from the ridge down to the eave (above the common-wall with hallway). Repair/seal membrane, air-seal any gaps/seams, then install 4" SPF (in 2 applications of 2") to exposed ceiling encasing bottom-plate of roof-support. VALLEYS—Along both north and south valleys—where perpendicular roof overlays/intersects the sloped-roof of the exhibit hall, cut back existing insulation roughly 2-feet from valley point. Air-seal holes drilled into bottoms of rafters (intended to connect the bottoms of the adjacent exterior-exposed slopes to the ridge vent, but are ineffective in their current location), air-seal all framing seams/gaps with canfoam. Install 4" SPF (in 2 applications of 2") to exposed ceiling encasing rafter-bottoms/plate.***



This image shows conditioned air exfiltrating through breaches in the membrane and the poorly air-sealed foamboard adjacent to and over the associated roof-support framing.

Looking west in the attic toward the northern valley which overlays the exhibit room. Yellow and reds show air-leaks associated with the framing intersection between the exhibit room ceiling/roof and the connector roof.





Looking south in the attic toward the southern valley which overlays the exhibit room. Again, yellow and reds show air-leaks associated with the framing intersection between the exhibit room ceiling/roof and the connector roof.

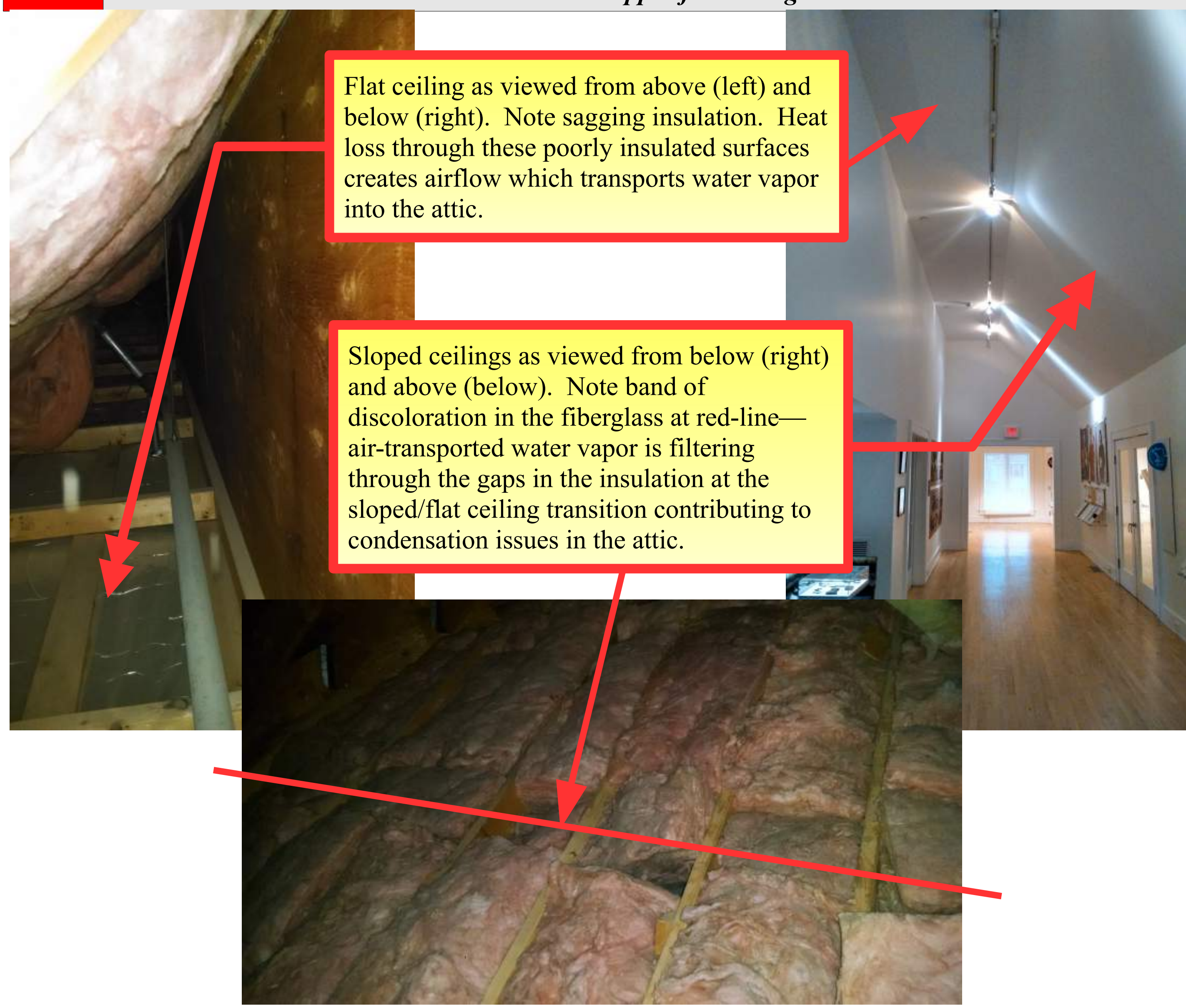
Looking west up one of the roof-support structures. Note the high concentration of seams in the foamboard. Remove existing foamboard to the red-line, seal membrane, air-seal gaps, cracks and seams, then install 4” SPF over exposed ceiling and bottom plate of the support-wall.

Close-up of bottom of roof-support showing seams, and insulation wear. SPF will effectively encase the framing to prevent air/vapor loss.

At the north end of the attic overlaying the east-facing exhibit room sloped-ceiling. North-facing valley rafter at top-right. Note the amount of condensate drool down the face of the foamboard. This north-facing roof is generally a lower temperature, that coupled with a restricted air-pathway (see below), creates a back-up of water vapor conducive to condensation. Cut back foamboard to red-line and treat as with the roof-support-wall.

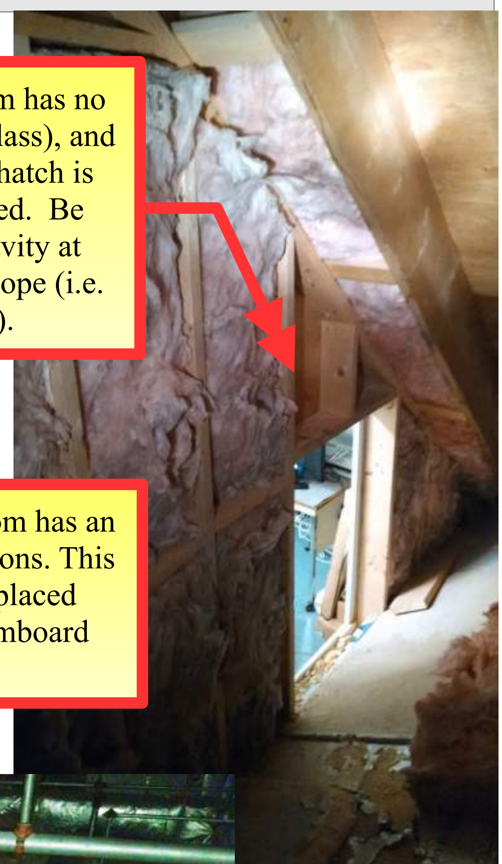
Close-up of after-the-fact venting into the adjacent overlaying roof assembly of exhibit room at very north end (same at south end). These holes are drilled all along the valley to connect and allow the stranded roof cavities exposed to the exterior to ventilate. However, moist attic air accumulates in these valley pockets, some of which exhausts into the adjacent sloped ceiling cavities through the drilled holes, condensing on it's way through the restricted, cold pathway. These holes should be sealed, and an alternative ventilation strategy proposed for the stranded slopes.

Thermal Boundary & Air Barrier Recommendations—Hallway ceilings	
Priority	Retrofit/Air-sealing recommendations
High	***HALLWA Y CEILINGS--In the attic, remove all existing fiberglass batt insulation from the sloped ceiling over the hallway. Note: this will expose a triangular space/void below created by the flat ceiling over a portion of the hallway. Because the existing fiberglass insulation has no air-barrier, air freely filters through the insulation, especially at gaps/edges. This improvement suggests maintaining the same thermal barrier, only creating an air and vapor barrier to the exterior using 2" Thermax foamboard.*** • ***Air-seal sloped-ceiling framing intersections at the eave, at both flat ceiling intersections above the hall, and at the intersection with the computer room wall at the south.*** • ***Install Insulweb netting to underside of sloped-ceilings/rafters,*** • ***install 2" foamboard to attic-side of rafters, air-sealed with foil-tape and canfoam, secured with strapping,*** • ***then install densepacked cellulose into the "rafter" cavities from the eave at the common-wall below to the intersection with the upper flat ceiling.***



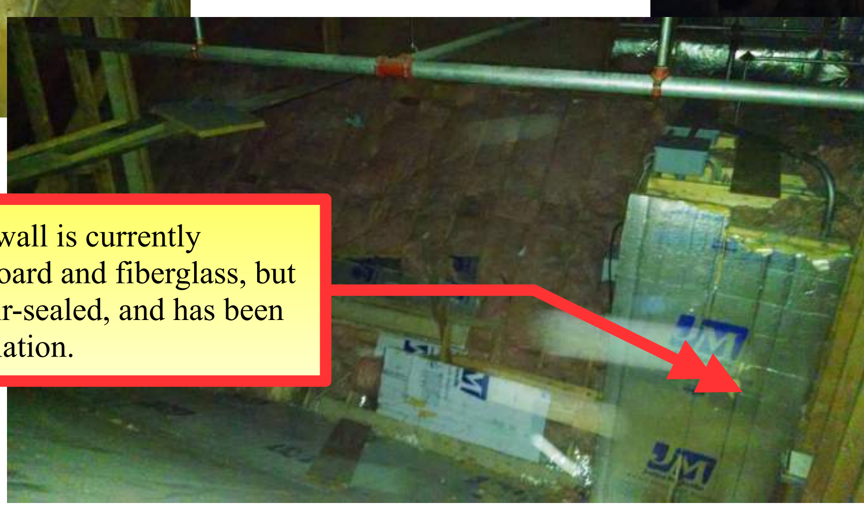
Thermal Boundary & Air Barrier Recommendations—Computer room walls

Priority	Retrofit/Air-sealing recommendations
High	***COMPUTER ROOM WALLS—These walls have many penetrations, poorly installed and incomplete insulation, and contribute to heat-loss to the adjacent attic space. In the attic, remove all existing fiberglass batt insulation from the west and north-facing wall cavities (north wall will require plywood-removal).*** • ***Air-seal penetrations in the walls with canfoam/caulking,*** • ***create insulation dam at tops of wall cavities (west-wall),*** • ***air-seal seams at ceiling drywall above, exterior corner of room, and at the bottom of wall (if not completed already in above recommendation).*** • ***Then, install 1" Thermax foamboard to the attic-side of wall cavities, with cap-nails/strapping to secure, and in-fill prepared wall cavities with densepacked cellulose (r-27).***



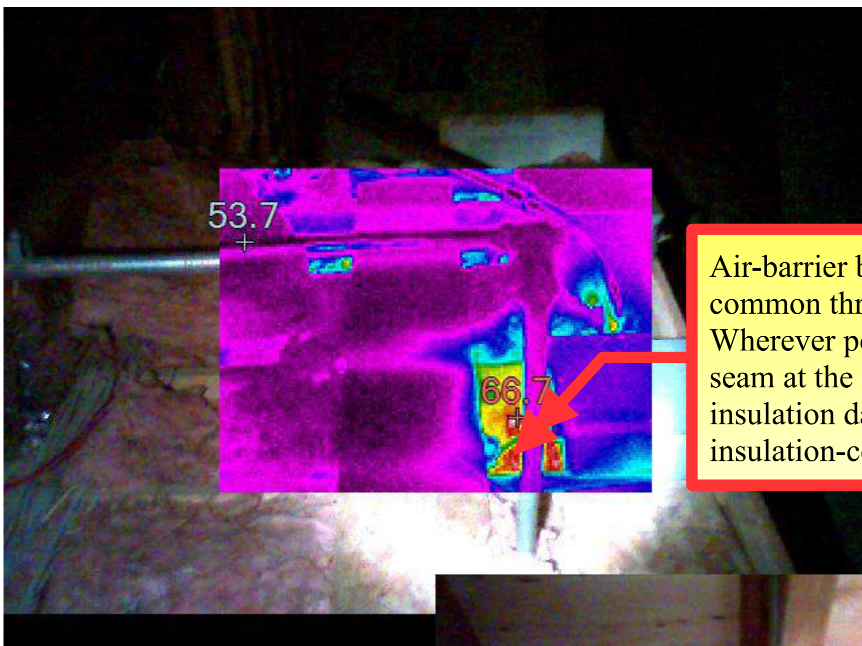
This west-wall of the computer room has no effective air-barrier (to cover fiberglass), and has missing insulation. The access hatch is also poorly air-sealed and uninsulated. Be sure to address the sloped ceiling cavity at the top plate of the wall under the slope (i.e. foamboard and densepack cellulose).

This north-wall of the computer room has an air-barrier but with many peneterations. This plywood should be removed and replaced (following air-sealing) with the foamboard and densepack cellulose treatment.



This section of west-wall is currently insulated with foamboard and fiberglass, but was never properly air-sealed, and has been impacted since installation.

Thermal Boundary & Air Barrier Recommendations—Computer room ceiling	
Priority	Retrofit/Air-sealing recommendations
High	***COMPUTER ROOM CEILING—The ceiling is barely insulated and riddled with air-barrier breaches. A comprehensive retrofit will reduce heat and vapor loss into the attic above the central part of the building. And due to the ceiling's proximity to the attic-exhaust fan (which tends to increase exfiltration), air-sealing will likely have a disproportionate improvement.*** • ***Remove all existing fiberglass insulation and debris*** • ***Air-seal all ceiling penetrations with canfoam and/or caulking*** • ***Build foamboard or drywall boxes over recessed ceiling fixtures (fans/lights), sealed at edges and to the ceiling (convert light fixtures to LED).*** • ***Install insulation dams at sloped ceiling intersection to south, and along the edge of ceiling to north and west to retain the proposed insulation.*** • ***Install 16" loosefill cellulose over prepared ceiling surface (R-60).***



Air-barrier breaches such as this one are common throughout the entire attic. Wherever possible air-seal the penetration seam at the ceiling. If necessary create an insulation dam over the fixture to prevent insulation-contact.

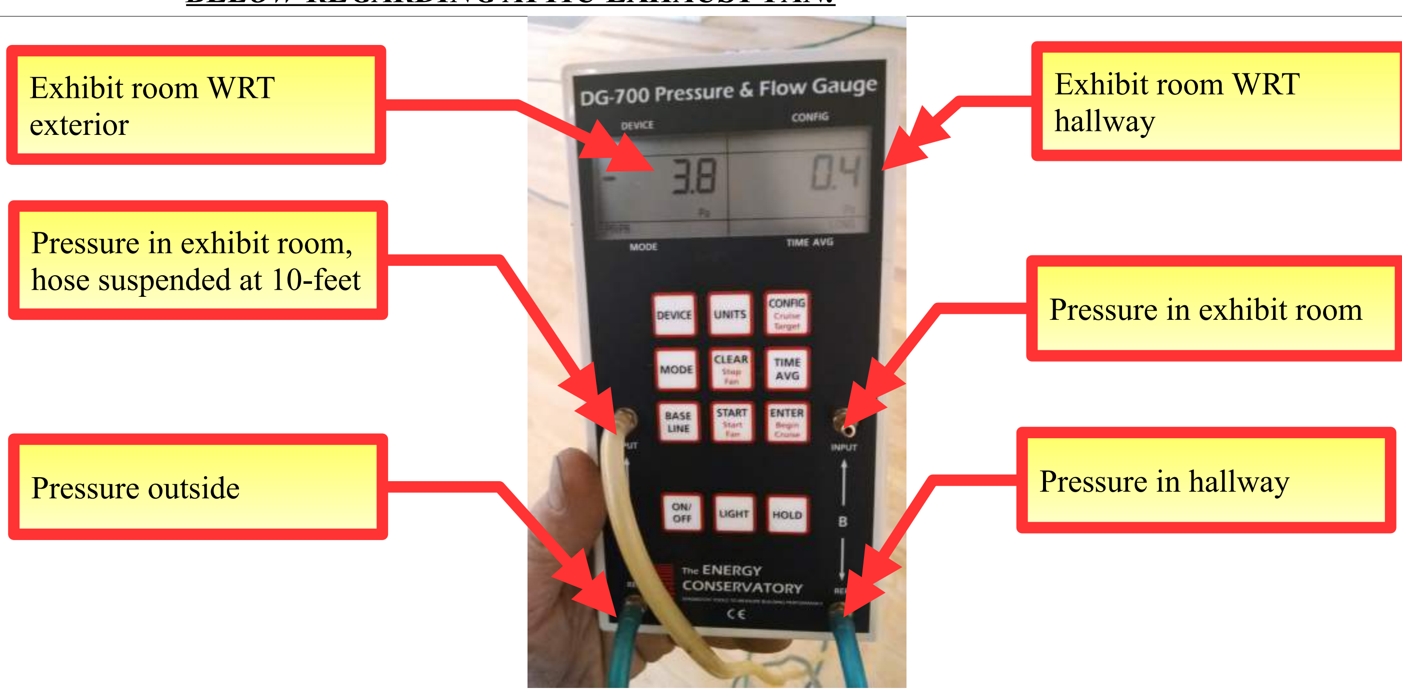
Gaps like these along the edges of the batt insulation allow convective looping in the air-space under the insulation—this accelerates heat-loss by increased air-flow through the insulation.

Zone Pressure Diagnostics—shows pressure in the exhibit room with reference to (WRT) adjacent spaces—exterior and hallway	
Pressure—exhibit room WRT hallway	***+0.4 pascals***
Pressure—exhibit room WRT exterior	***-3.8 pascals***

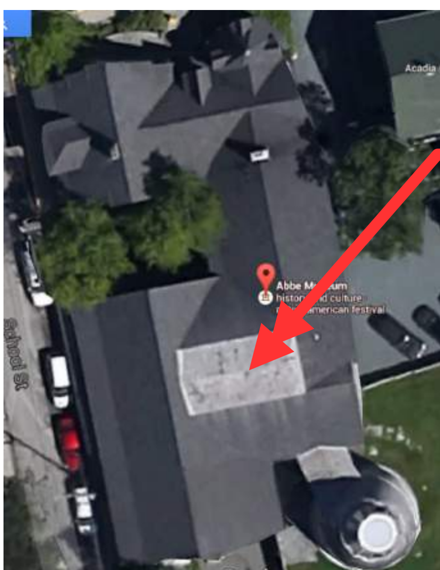
Interpretation and Discussion

The ideal scenario is to have positive pressure in the exhibit hall with reference to BOTH exterior and hallway.

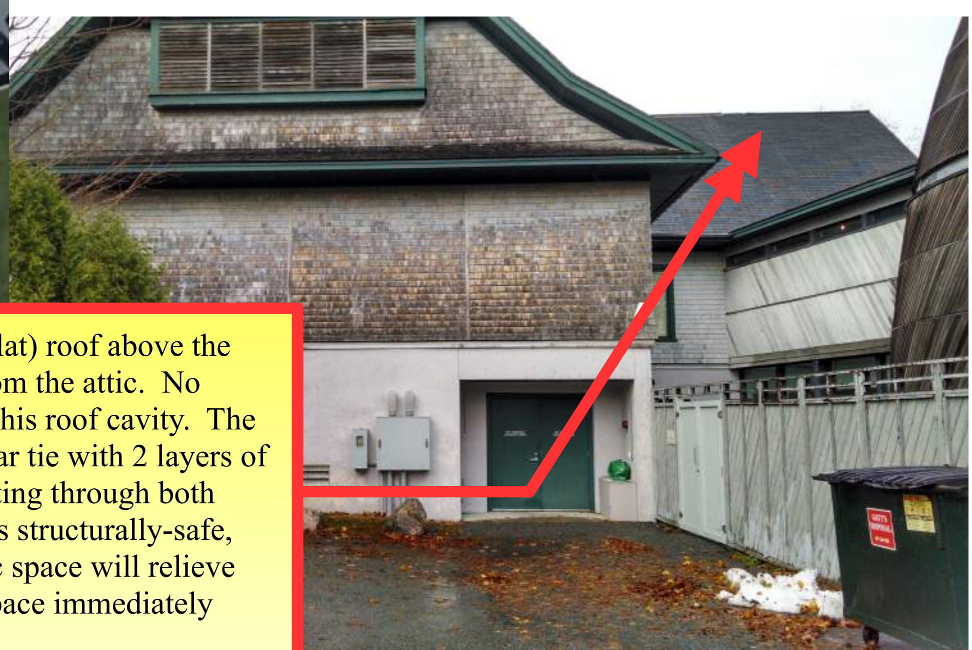
- ***Discussion:***
  - ***The <u>negative pressure WRT to the exterior</u> means that MORE air is infiltrating (leaking/ventilating in from the exterior), than is exfiltrating (leaking/ventilating to exterior).***
  - ***The slight <u>positive pressure WRT the hallway</u> suggests that the same, and even a greater-degrer of negative-pressure exists in the hallway causing exfiltration from the exhibit room into the hallway (mainly through wall/doors).***
- ***Interpretation:***
  - ***EITHER, the exhibit room ventilation system can't overcome the stack effect in the building and air-leaks from the exterior through the exhibit room and into the hallway with some slight reduction due to supply-air from the ventilation system.***
  - ***OR, the entire building's ventilation system is exhausting more than it's supplying, which would cause a negative <u>interior pressure WRT the exterior</u>. In this scenario, the exhibit room is set to get slightly <u>more supply than return WRT the hallway</u>.***
- ***Recommendations:***
  - ***with the help of your licensed HVAC technician/company:***
    - ***EITHER, greatly reduce return air from the exhibit hall to the central system with the goal to create a greater <u>positive pressure in the exhibit hall WRT both interior and exterior spaces</u>.***
    - ***AND/OR, greatly <u>reduce return air in the ENTIRE BUIDING'S ventilation system, with the goal of raising the interior pressure WRT the exterior</u>. AND/OR, complete comprehensive retrofit to attic spaces to reduce stack-effect throughout the entire building. AND/OR, <u>SEE BELOW REGARDING ATTIC-EXHAUST FAN.</u>***



Exhaust Fans and Attic Ventilation	
Type/ location	Recommendation
Attic	***1. Attic ventilation should be achieved through passive means rather than mechanical. Though no pressure-testing was done in the attic, it is quite possible that the exhaust fan, as it's set up, will pull outside air into the attic via the path of least resistance—or the larger open vents-areas. This means most outside air is pulled in through the soffit venting (east-facing), and likely some inside conditioned air is pulled through the larger holes in the air-barrier (chimney chase, kneewall spaces of original building).*** ***2. Unfortunately current attic ventilation, even with the exhaust fan doesn't likely pull enough air from the problem area (over the exhibit hall), mainly because there's no substantial supply of air to feed the exhaust fan.*** ***3. Ideally passive attic ventilation is designed to allow for a greater area of open venting down low throughout the attic, and a lesser amount at the very top of the attic. In this case the bottommost venting occurs in spots around the roof...some places unintentionally. While the uppermost venting occurs at the east eaves.*** ***4. Creating ventilation above the problem area is the ideal solution.*** ***5. Cut holes through the flat plywood decking/framing at the top of the attic space over the exhibit hall to allow airflow into roof cavities. Then either engineer ridge venting at the south-facing section of east/west ridge, or engineer/install a roof vent, built up through a curb to allow proper sealing with existing rubber roofing.***



This is the satellite image. Flat roof shows up as whitish.



There is low-pitch (essentially flat) roof above the flat plywood deck as-viewed from the attic. No venting currently occurs out of this roof cavity. The deck is essentially a double collar tie with 2 layers of sandwiched 1/2" plywood. Cutting through both layers—with as large a hole as is structurally-safe, and connecting to the small attic space will relieve the vapor pressure in the attic space immediately above the exhibit room.