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MEMORANDUM

DATE: 07/18/2011

TO: Dean Charter (Town of Acton)

FROM: Bob Quitadamo (RDK Engineers)

SUBJECT: HVAC Budget Pricing

PROJECT NO.: 20100701.00

COPIES TO: Mike Travers (RDK Engineers)

RDK Engineers (RDK) was retained by the Town of Acton to review and report on the existing conditions of the Mechanical, Electrical, Plumbing and Envelope base building systems, as well as recommend replacements or upgrades of the aforementioned systems to reduce energy costs and improve comfort levels of staff and visitors at The Acton Town Hall at 472 Main Street in Acton, Massachusetts. RDK issued the report, "Energy Analysis/Due Diligence Report – Acton Town Hall, Acton, Massachusetts," April 18, 2011, later revised June 1, 2011. The Town of Acton requested additional information, specifically budget prices, on the following measures listed in the report:

- Make-Up Air (negative building pressure correction)
- Chilled Water Pump Piping Re-Arrangement
- New Chiller (end of useful life replacement)

Make-Up Air

As mentioned in the report, RDK recommends adding a new air handling unit for make-up air near the mechanical room, where there is an abandoned fan coil and outside air duct in place. The estimated cost for this unit is $4,700. Additionally, removal and sealing of the existing building exhaust fans is an estimated $1,100 per fan.

Chilled Water Pumping

The chilled water primary pumping measure to include two new pumps with ecm motors, piping and labor, as stated in the report, carries an estimated budget cost of $5,000.

New Chiller

As stated in the "Existing Conditions & Facility Description" portion of the report, the existing chiller is approaching the end of its useful life. As requested, RDK has provided a budget cost of $47,000 for its replacement with a new "package" air cooled chiller.

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ENERGY ANALYSIS/DUE DILIGENCE REPORT – ACTON TOWN HALL, ACTON, MASSACHUSETTS

Submitted to: **TOWN OF ACTON**

April 18, 2011

Submitted by: RDK ENGINEERS

RDK ENGINEERS

TABLE OF CONTENTS:

SECTION 1	Introduction/Executive Summary
SECTION 2	Existing Conditions & Facility Description
SECTION 3	Recommendations, Economics, Energy Conservation Measures, and Occupant Comfort Measures
SECTION 4	Appendices

1.0 INTRODUCTION/EXECUTIVE SUMMARY

RDK Engineers (RDK) was retained by the Town of Acton review and report on the existing conditions of the Mechanical, Electrical, Plumbing and Envelope base building systems, as well as recommend replacements or upgrades of the aforementioned systems to reduce energy costs and improve comfort levels of staff and visitors at The Acton Town Hall at 472 Main Street in Acton, Massachusetts. RDK has also presented various energy conservation opportunities that presented themselves as a result of the building survey. Utility bills for the base building meters were reviewed in general for anomalies and are reported on. A detailed utility bill analysis was performed and can be found in the recommendation portion of this report. RDK visited the site on several occasions throughout the months of November 2010 through January 2011. During each of the visits, RDK toured the property with a facilities staff member (Dayle MacGillivary) of the Town of Acton. Thermographic analysis of the building was performed by William Rundle of Infra-red Analyzers, Inc. An HVAC balancing survey was conducted by E.L. Barrett Company, Inc. The entirety of the study took place during the heating season.

The Acton Town Hall is a multistory municipal office building built in 1864 and renovated in 1987 with an addition to the ground floor. The building consists of approximately 22,000 conditioned square feet, 11,000 of which are on the ground floor and include the 1987 addition. The building is occupied from 8 AM to 5 PM Monday through Friday, and Meeting Room 204 (Faulkner Room) holds meeting nightly until 9PM or 11PM Monday through Thursday. The most recent building upgrades have been storm window installations, repair of exhaust fans and new lamps, ballasts and lighting within the last five years. These past installations were not measured or verified by RDK, with the exception of the building envelope components, which inherently became part of the thermal imaging study.

2.0 EXISTING CONDITIONS & FACILITY DESCRIPTION

HVAV Existing Conditions

HVAC General

Note: System median useful life is an ASHRAE suggested value.

In general, the building is heated and cooled by a boiler and chiller located on the ground floor. A new gas fueled hot water forced draft cast iron sectional boiler was installed in 2008. The chilled water infrastructure for the building consists of an air-cooled chiller. The condensing section is located outdoors by Woodbury Lane. The unit appears to be between fifteen and eighteen years old. The hot and chilled water each feed to a changeover loop which sends the water to two pipe fan coil units throughout the facility. In some cases, employees supplement the heating with electric space heaters. Open office space on the ground floor is served by an overhead fan coil which is designed to provide fresh air from an intake in the mezzanine. Perimeter zones are equipped with operable windows to provide fresh air and ventilation during swing seasons. During heating and cooling seasons, no ventilation is provided in these zones. Several exhaust fans are installed throughout the building, primarily exhausting the ground floor.

Hot Water Boiler/Burner System

The gas fired cast iron boiler is a Weil-McLain (Model 80 Series 1 – 480) with a Carlin burner. The boiler was installed new in 2008 and is in good condition. These type of boilers have an expected median useful life of thirty five (35) years if properly maintained. The input/output gas rating of the boiler is 491/396 MBH respectively. This boiler technology can yield efficiencies of 80% thermal efficiency is operated correctly, which meets current energy codes (ASHRAE 90.1-2007; MA 780 CMR 8th Edition, Chapter 13).

Figure 1 - Weil-McLain HW Boiler

The heating primary loop is controlled by a secondary manual changeover loop. When it is determined that the heating season is to start, the heating loop will be enabled via the end use/operator through the "Tekmar" boiler controller. The boiler control loop is enabled via an outdoor air temperature sensor and outdoor air reset schedule as well as a hot water return reset strategy which is employed on a call for heat. The boiler is currently without any temperature modulation, such as a three way valve or modulating burner, and only utilizes firing on or off to control loop temperature

Figure 2 - HW Primary Loop Pump

Piping insulation has noticeable thermal breaks which have lead to deterioration of the insulation over time. Wicking has occurred throughout lengths of the insulation, leaving the batten insulation compromised. Through these thermal breaks, the pipe begins to sweat and through capillary action soaks the batten through to its vapor barrier, which in this case is a kraft bonded vapor barrier type. Once the batten insulation becomes compromised, its thermal resistance properties become near zero.

Figure 3 - Thermal Breaks in Piping Insulation

Chilled Water Generation/Cooling Systems

Chilled water is generated by an air-cooled 40 ton nominal Trane reciprocating chiller. The chiller consists of an outdoor condensing section with interconnecting buried refrigerant lines that feed the indoor compressors and evaporator located in the building's mechanical room. The chiller was installed as part of the 1987 renovation project. Although this chiller is beyond its estimated median useful service life of 20 years, there were no outward physical deficiencies observed. The chilled water loop is activated by the secondary manual changeover loop when switched into cooling mode.

Fan Coil Units

All spaces are heated and cooled via two-pipe fan coil units, either wall mounted or horizontal ceiling concealed type. Time-clock controls are installed to deactivate the fan coil fans in some spaces where the fan coils are not used regularly during business hours. Fan coil set points are determined manually on the wall units or via a manual thermostat on the wall. A certified balancer was contracted to determine airflow through several of the fan coil units and ceiling diffusers. The balancer's survey data (Appendix C) shows several units are not delivering the designed air flow, or in particular instances any at all. This can result in unmet heating and cooling loads and poor temperature gradients throughout the space. This is elaborated in the recommendations portion of this report.

Figure 4 - Typical Wall Mounted Fan Coil Unit

Exhaust Fans

There are eight exhaust fans serving the first floor spaces. The location and operation of these fans were part of the renovation design of 1987. The designed airflow on these exhaust fans range from 90 cfm to 760 cfm each. In the last year, many of these exhaust fans have been replaced as regular maintenance. The balancer tested several of the exhaust fans and determined some of which were exhausting more air than originally designed.

Figure 5 - REF-9 Exhaust Duct

Seven exhaust fans run on a time clock operation and are on during all business hours. REF-9 located in the plan and print room is manually operated as needed for printing. This exhaust has an additional local capture device targeting the noxious chemicals, but has no significant airflow. Due to the configuration, as seen in Figure 4, it is apparent the air would take the path around the small duct perimeter and yield the local capture device ineffective.

Some of these exhaust fans are required by code (restrooms, plan and print room), but many are used as a means of ventilation in office spaces. As noted in the balancer's report, when examined the outside air dampers were closed, and FCU-1 which serves the north wing of the first floor was deactivated. This is significant, as there are no other means of providing fresh outdoor air to these office spaces and can cause heating and cooling problems as well as thermal comfort concerns. As a result, the building has been confirmed by the balancer to be negatively pressurized. This means the static pressure inside the building is less than the static pressure outside and the outside air has a tendency (driven also by outdoor climatic conditions) to come in the building to maintain static equilibrium. As an industry standard in commercial type buildings, we, as a norm, design the airside systems to maintain a slight positive static pressure inside the building. RDK observed this effect when opening the main entrance door. As the door is opened slightly, we observed the outside air rushing in the entrance way. The negative effects of this are potential problems with choking the supply fans in the fan coil units, infiltration of unconditioned outside air leaking in through the envelope, and exhausting conditioned air.

Balancing Report

A certified balancer was obtained to measure current operating conditions of selected equipment and building spaces. The balancer's complete report is attached as Appendix C.

Measurements taken were as follows:

- Airflow measurements were taken at several fan coil units and ceiling diffusers as well as return registers.
- Building pressure differential was measured through windows at two locations.
- Hot water and system pumps were examined for differential pressure.

The balancer noted that several of the supply air flow readings were very low when compared with the design values from the 1987 renovation plans. Upon further examination, many of the air filters were clogged. After changing the air filters, the readings were taken again and were significantly higher, but still well below the design values. Regular air filter changes are recommended as part of regular maintenance.

Of the exhaust fans measured, three of the seven fans were noted as operating with higher airflow than originally designed. This, coupled with the lack of outdoor air to make up for the exhausted air, leads to the negative pressurization of the building.

Both the boiler pump and system (changeover loop) pump tested operate at a lower flow than designed. Hot water flow has not been seen as an issue in operation.

Life Safety Concerns/ Code Violations

The mechanical room contains multiple life safety concerns. Current codes prohibit refrigerant to be in the same room as equipment with open flames (ASHRAE 15-2007, IMC 2009). Additionally, per current code, the door of the mechanical room must be equipped with a tight fitting door that opens out of the room and self-closes. As a life safety measure, current codes also require a refrigeration leak detector which triggers an emergency exhaust system in the machinery room. Adding exhaust in this room is not practical because the boiler is located in the same room and uses the room air for combustion, but is a life safety issue if ignored and a refrigerant leak occurs. The current chiller utilizes R-22 as a refrigerant, which is not flammable at ambient temperatures and atmospheric pressure, but is oxygen depleting. A refrigerant leak detection can be installed and tied to the boiler, to deactivate the burner in the case of a refrigerant leak. Most manufacturers have phased out the use of R-22 refrigerant per the Montreal Protocol to reduce ozone-depleting refrigerants. This should be investigated further when planning to replace the current chiller.

The combustion air intake should also be tied to the boiler. This is to ensure that combustion air is provided at all times when the boiler is operational.

As a historic building, Acton Town Hall is exempt from the energy code (MA 780 CMR 13) but must comply with other chapters of Massachusetts State Building Code (780 CMR) upon changes to the building (mechanical, electrical, envelope, etc.) as dictated in the building code.

Electrical Existing Conditions

Power

The building power distribution consists of a 600 amp, 480Y/277V, 3 phase, and 1 wire main switchboard located in the main electrical room near the emergency generator. A transformer is also located in the main electrical room for step down to 208V, 1 phase, 60 hertz power. There were no major deficiencies noted relative to the normal power distribution.

Figure 6 - Main Switchboard

Emergency Power

Emergency power for the facility is via a 50 kW diesel generator located in room 12. The emergency generator is exercised regularly on Sundays due to exhaust air complaints when run during business hours. A discussion relative to re-entrainment of noxious gases and run time can be found in the recommendation portion of this report.

Figure 7 - Emergency Diesel Generator

Lighting

A lighting retrofit, including new lamps and ballasts, was completed in the last five years. RDK observed most of the lighting fixtures to be equipped with efficient equipment. Some closets still use incandescent light bulbs, as noticed in storage room 04. Several offices, conference rooms, rest rooms, and closets do not utilize occupancy sensors. During site visits, RDK observed many of those rooms to be unoccupied with lights on.

Figure 8 - Open Office 05 Lighting

Lighting foot-candle levels were measured in the open offices in the south wing of the first floor as well as a private office in that wing. IESNA (Illuminating Engineering Society of North America) publishes recommended lighting levels in different work spaces. IESNA foot-candle recommendations for office space range from 35 foot-candles to 55 foot-candles, depending on the office use. In the open office section, RDK measured a 57 foot-candles along the windows, and 40 foot-candles in the center of the office.

In the private office (Assessor - 10), readings measured 130 foot-candles with the lights on and 75 foot-candles with the lights off. During the readings, outdoor conditions were sunny and window blinds were open.

Building Envelope Existing Conditions

The core building at 472 Main St. was originally constructed in 1864. A 1987 project on the building included a major renovations and first floor additions. Most of the building is constructed with insulated wood frame walls, but also includes some poured concrete walls. The town hall has several single pane, double hung, operable windows located throughout the building. New storm windows have recently been placed in many of these window openings.

Since the 1987 project completion, The Acton Town Hall has become considered an historic building and part of the town's historic district by the local historical society. The implications of this prohibit changing the outward physical appearance of the building as seen from Main Street. Existing building conditions were analyzed in more depth via a thermal imaging study. The certified thermographer's report can be found in Appendix D.

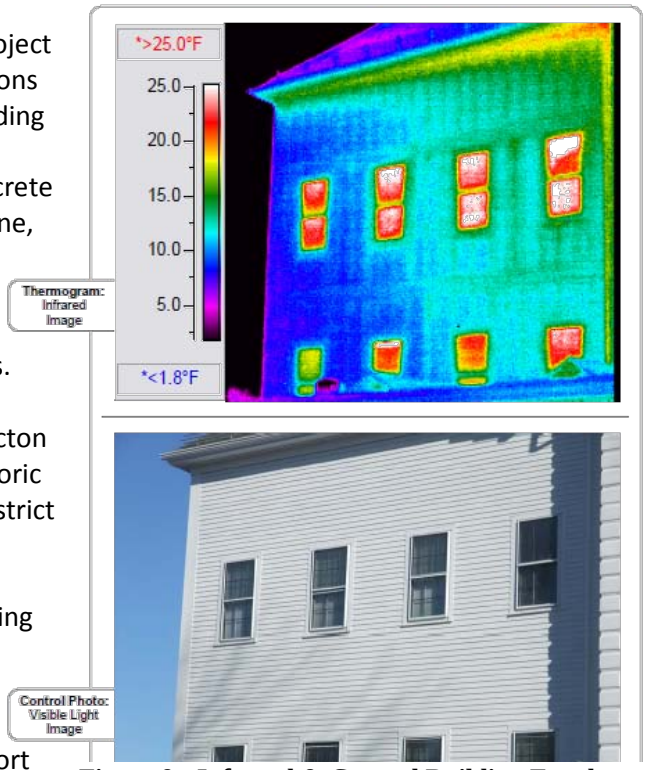


Figure 9 - Infrared & Control Building Envelope Images by Infra-red Analyzers

Envelope Component	Existing Thermal Properties (Estimated)	Current Code Required Thermal Properties (ASHRAE 90.1-2007)
Cementious Wall Construction	U-Value - .15	U-Value - .090
Wood Wall Construction	U-Value - .05	U-Value - .064
Roof	U-Value - .086	U-Value - .027
Fenestration/Windows	U-Value/SHGC - .66/.59	U-Value/SHGC - .35/.40

Thermographic Analysis

Infra-red Analyzers performed a full thermographic study of the building envelope and roof. In the report, stack effect is observed repeatedly in several spaces of the building and the attic. This occurs as heated air is relieved through the roof and attic of the building and often leads to infiltration at the lower elevations. This stack effect is directly related to the exhaust fan analysis in both the balancer's report and the recommendation portion of this report.

Additionally, notable heat losses were observed through windows, the perimeter of the slab on grade floor, and compromised insulation. Upon further investigation of the slab on grade heat loss, RDK took temperature readings via a noncontact infrared thermometer (model Raytek Raynger ST). RDK observed temperatures in the 50-55 degree range along the slab floor at the perimeter. As the readings were taken further away from the perimeter, the temperature of the slab approached room temperature. This occurred 4-5 feet from the perimeter. The heat loss associated with a slab-on-grade is most significant at the perimeter of the building and it is often magnified by poor wall, window construction and infiltration. Down drafts from the perimeter assemblies will cool the slab surface and transfer it towards the center if not insulated. However, heat transfer from the ground to the slab at the center is negligible. This is why the energy/building codes require slab insulation for only a short distance in from the perimeter of the building and not the underside of the slab in its entirety.

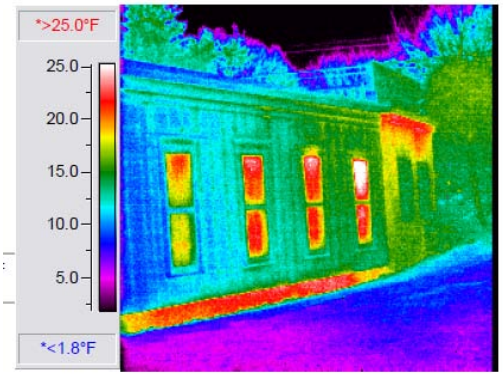


Figure 10 - Notable Envelope Heat Losses

3.0 RECOMMENDATIONS, ECONOMICS, ENERGY CONSERVATION MEASURES, AND OCCUPANT COMFORT MEASURES

General

The base case for all analysis is the existing system as described in the Existing Building & Facility Description portion of this report and in the interview document found in Appendix F. Any construction cost estimates stated herein are RDK's opinion of cost.

RDK interviewed the Client and has included this interview/report at the end of this document. Based on this interview and discussion with the Municipal Properties Director, Town Manager, and Assistant Town Manager, RDK offers the following recommendations, energy conservation measures, and occupant comfort measures.

Utility Bill Analysis

A utility bill analysis can provide a good, first look at the large picture of the building's energy use. Utility bills also provide an easy way to benchmark a building's utility use and track changes and upgrades to the building. The Town of Acton provided RDK Engineers three years history of both electricity and natural gas billing data. The Department of Energy's Energy Information Association (EIA) publishes energy usage averages from the 2003 Commercial Buildings Energy Consumption Survey (CBECS). This published data is a great tool for benchmarking building performance by usage, size, location, year constructed, or several other categories. CBECS data can be looked at in a variety of ways, i.e. by building size, use, construction year, region, etc.

The Energy Usage Index (EUI) is a measure of total energy used per square foot of floor area per year. The calculated EUI of The Acton Town Hall is 69.7 kBtu/ft^2/year. This compares similarly while compared to the average building of its size. Compared to the national average building 10,001 to 25,000 square feet (Acton town hall ~ 22,000 square feet), The Acton Town Hall EUI falls just behind the average building of 67.3 kBtu/ft^2/year. The town of Acton paid an average of $0.20 per kilowatt-hour electricity, and $1.57 per therm natural gas in the bill analyzed. The EIA reported Massachusetts' commercial average electricity and natural gas rates in 2008 to be $0.16 per kilowatt-hour and $1.53 per therm, respectively.

RDK recommends the Town of Acton utilize the Energy Star Portfolio Manager to further benchmark and continuously track utility expenditures. Portfolio Manager is a free online tool provided by Energy Star. RDK, as a complimentary service, will train your staff in implementing this tool.

Utility bills were analyzed further to identify any unusual trending in the data. Typically, a heated and cooled building will experience seasonal peaks and valleys for both electricity and natural gas consumption. Electricity should typically peak during the summer season as the mechanical cooling equipment is run, while natural gas consumption should fall close to zero consumption during the cooling season, to meet domestic hot water needs. Variations from this can indicate simultaneous heating and cooling, poor control strategies, or unique operation not typical of an office building. Upon examination, the Acton Town Hall utility data trends very well

from a seasonal perspective and is also readily apparent in the natural gas consumption on the following page.

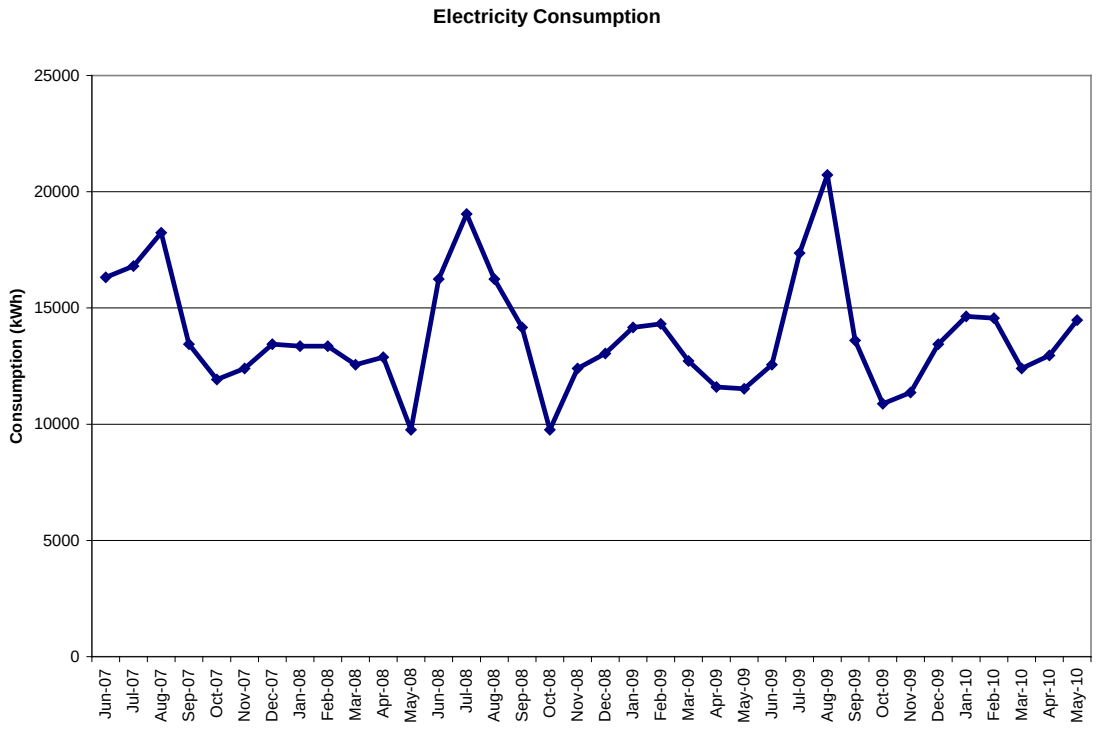


Figure 11 - Building Electricity by Month

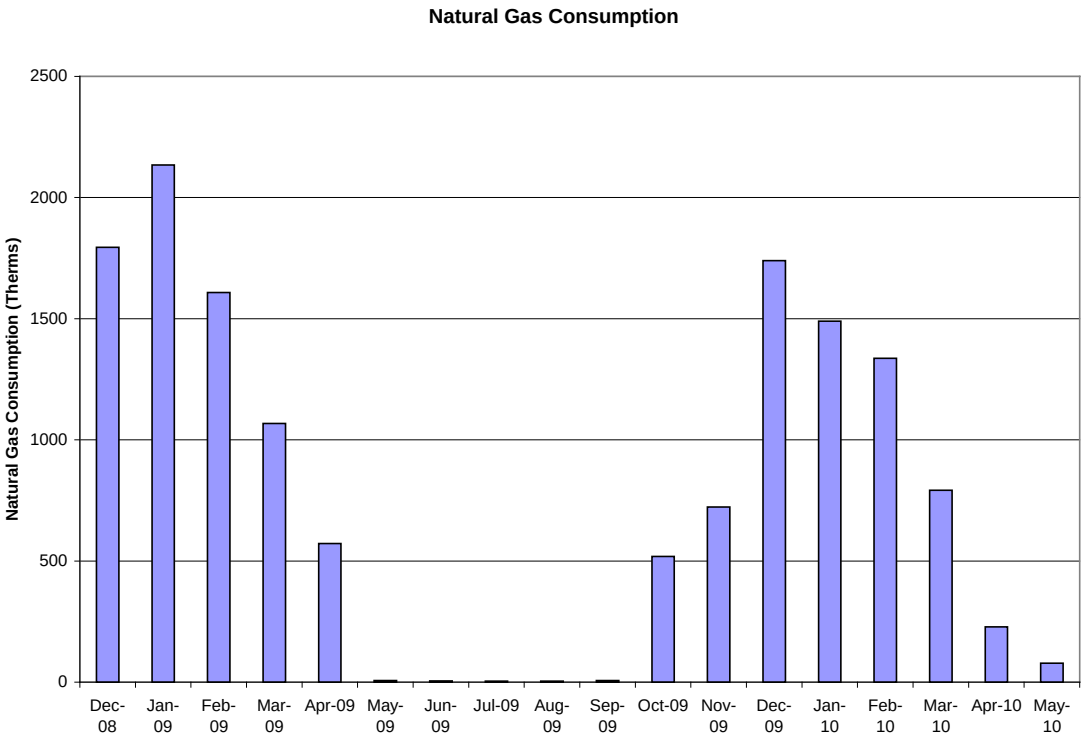


Figure 12 - Building Natural Gas Consumption by Month

Measure 1 - Radiant Heating

One measure requested by the town of Acton is an investigation of an underfloor hydronic radiant floor heating system. RDK investigated this and found to be impractical, expensive and without significant energy savings. Because the town hall is a registered historical site, it intrinsically further prohibits this potential opportunity due to disruption of the physical architectural attributes. Radiant heating in retrofit applications is often times cost prohibitive and disruptive during a long installation process, especially while installed underfloor. One possible scenario RDK investigated includes installation of overhead radiant heat overhead on the ground and first floors along the perimeter. The ceiling height and construction on the second floor, led RDK to investigate underfloor radiant heating in this location. Underfloor radiant hydronic heating in this floor can be installed in between the floor joists along the perimeter.

According to load calculations performed by RDK using hourly weather data, radiant heating along the perimeter should be sized to a capacity of 370 Btu/h per lineal foot. The Acton Town Hall contains approximately 680 lineal feet of conditioned perimeter space. From past projects and experiences, RDK estimates the cost for such an installation at approximately $30,000. In addition to the panels, piping, valves, and installation, a new condensing boiler would need to be factored in as well. Traditional natural gas boilers similar to the installed boiler are unable to handle a return water temperature at the required low temperatures used in a radiant system. A condensing boiler, which is able to operate at these low return temperatures, also can boast an increase of overall efficiency up to 92%. A new condensing boiler with full modulation capabilities costs approximately $15,000 installed.

Installing a radiant heating system will improve employee comfort, but RDK does not recommended one as energy conservation measure at this time. The current boiler installed is 2-3 years old and has an estimated median useful service life of 35 years (ASHRAE suggested values) with proper maintenance. With a lifecycle cost analysis in mind, a replacement of the boiler at this stage is not economical. A new condensing boiler, operating at its peak efficiency, will save less than $2,000 per year at this capacity. There is also some fan savings seen in radiant heating systems. In addition to the poor economic affects, relocation of employees could become a factor as a potential system is installed. A schematic drawing of this radiant heating measure can be found in Appendix E.

Measure 2 - New Split System Air Conditioner

RDK engineers utilized Carrier Hourly Analysis Program (HAP) for energy modeling and zone loading purposes. The second floor meeting room (Faulkner 204) is not currently designed to meet the full cooling load purposes. Currently the fan coils are designed to provide a total of 4 tons refrigeration (48MBH) of cooling capacity to the room. The cooling load in this room without any ventilation air (current design) is 5.9 tons refrigeration 71MBH. Current ventilation codes offer two methods of acceptable ventilation. Natural Ventilation is an acceptable means of ventilating as long as there is at least four percent of the floor area in openable area to the outdoors (operable windows). The current design meets this criterion and does not need to be updated to meet code. While this is acceptable by code, meeting and assembly rooms often

operate at high occupancy, and the inside air can get stale quickly. During hot and cold ambient outdoor air conditions, windows are not frequently opened and the problem worsens. Additionally, when the windows are opened, the entering outside air is untreated and can cause uncomfortable space temperatures. This problem is worsened by the fact the room does not have ample cooling capacity.

RDK recommends adding a new split system condenser and air handler. RDK also recommends mechanically ventilating the space for occupant comfort and to improve indoor air quality. ASHRAE standard 62.1-2010 - Ventilation for Indoor Air Quality serves as an industry standard for mechanical ventilation minimum flows. Utilizing the recommended 5 cfm outside air per person and .06 cfm outside air per square foot, the room requires a cooling load of 10 tons. This new unit would be used in lieu of the fan coils in the room for cooling, and in conjunction with them for heating. While this may actually increase electricity consumption, it is recommended as an occupant comfort measure. Cooling efficiency will increase as the current design utilizes the air cooled chiller, and often times during occupancy of the meeting room, there are no other cooling loads in the building. Air cooled chillers generally operate at poor efficiencies during low load conditions. A split system utilizes direct expansion cooling (DX) via a condenser to be located outdoors and DX coils located in the air handler. Ideally the condensing unit will be located on the roof of either the north or south wings, but could present a problem with the town's historical society. In this scenario, the air handler would be located in the attic space above the room and deliver air through diffusers in the ceiling. An energy simulation was run for this measure through forward modeling and the new proposed system yields a predicted annual energy cost increase of $3,860. RDK recommends the install of a ten ton unit such as the Trane Odyssey TTA. A schematic drawing of this new cooling measure can be found in Appendix E.

Measure 3 - Photovoltaic (Solar) Renewable Energy

RDK was requested to investigate implementation of renewable energy to the Acton Town Hall. One source considered was photo voltaic cells as a source to provide electricity to the town hall. Photo voltaic cells are arranged together into modules and wired into panels. The photo voltaic cells capture energy from the sunlight to create DC electricity. This DC electricity travels to an inverter, where it is changed to AC electricity to use for electric appliances.

RDK investigated three opportunities to utilize photo voltaic panels as an electric source. The first of the potential opportunities utilizes photovoltaic panels sized at a capacity of 100% of the building's peak demand. This system is a grid-tie system, meaning no batteries are installed and when there is not enough electricity provided by the photovoltaic panels, it is taken from the utility. This occurs often as there are a limited amount of solar hours (hours where solar energy capture is possible with PV cells) in this region. This strategy will often times overproduce electricity as well, as the building's electric load is often less than the peak demand. The inefficiencies of the photovoltaic cells combined with the difference in sunlit hours and operational hours yield disappointing economic results. See below for summary of economic results.

The next two photovoltaic opportunities are similar systems to the previous layout, but with downsized capacities. A smaller system can become advantageous when sized to a capacity where 100% of its electricity generated goes to the building, without wasting any back to the grid. These two opportunities have been evaluated at half of the peak electric load and a quarter of the electric load.

Size	Capital Cost	Annual Savings	Simple Payback	Area Required
63.2 kW	$402,100	$10,275	39 Years	4,676 s.f.
31.6 kW	$202,800	$7,190	28 Years	2,338 s.f.
15.8 kW	$105,300	$3,602	29 Years	1,199 s.f.

While some of the economic terms may look enticing for long term occupants, they do not paint a full picture. The reality is the photovoltaic panels degrade at one to two percent annually and typically have an estimated useful service life of 25 years. The building's historic designation may prevent installation of photovoltaic arrays from installation on the building's roof. Shading also plays a major role in photovoltaic application, and performance as well as corresponding paybacks suffers in those cases. The state of Massachusetts offers some incentive programs for installation of photovoltaic through its RPS Solar Carve-Out program and through the Massachusetts CEC (Clean Energy Center) Commonwealth Solar rebate program. RDK does not recommend installation of photovoltaic panels at this time.

Measure 4 - Solar-Thermal Renewable Energy

As an additional renewable energy measure, RDK investigated the possibility of utilizing solar-thermal power for water heating. Solar thermal devices capture and utilize the sun's heat. In this case RDK analyzed a system using a solar collector to heat water. This solar collector would heat water pumped through a loop of pipes to and from a new thermal storage tank. This tank would then be connected to a heat exchanger to pre-heat the domestic hot water load. A new domestic hot water boiler would need to be installed. Additionally, when there is no demand for domestic hot water the stored hot water can be used to preheat the boiler return water. RDK utilized RETScreen for energy modeling purposes. RETScreen is a Software for evaluating energy production and savings, costs, emission reductions, financial viability and risk for various types of Renewable-energy and Energy-efficient Technologies (RETs). Results of the model show value in installing the solar thermal collector and heating system. Similar to the results of the photovoltaic study, a major issue in installing a solar thermal collector is the location of the equipment. Due to the building's classification as a historic building, installation of the array may be problematic. The other special concern lies in the boiler room. Currently, there is no space available in the boiler room to account for the additional infrastructure, including the thermal storage tanks. The analysis was performed using a Viessman Vitosol 300 as the proposed solar collector. This particular solar collector would occupy 31.52 square feet in operation.

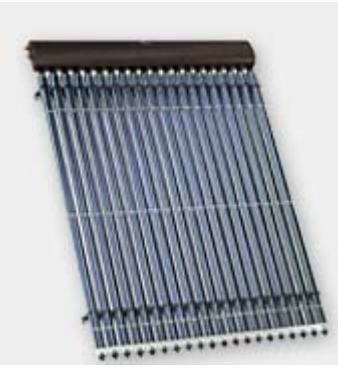


Figure 13 - Viessman Vitosol 300 Solar Collector

Arrays	Capital Cost	Annual Savings	Simple Payback	Area Required
1	$12,374	$2,196	5.6 years	31.52 s.f. (collector only)

Measure 5 - Balancing

As discussed, The balancing report confirmed RDK's analysis of negative pressurization in the building. The two largest contributors of this are the exhaust fans and lack of makeup air. Simply put, to obtain a positive building pressurization, the building needs to take in more air than it takes out. Air naturally wants to create pressure equilibrium with the adjacent space. As is the case in this building there are no air handling units or fans forcing outside air into the building. There are, however, seven exhaust fans removing air from the building. As a result of this, outside air is forced in via infiltration in the envelope. This outside air enters the building untreated at ambient outdoor conditions. This can cause of draft of untreated air, especially along the perimeter of the building.

To improve this infiltration of untreated air, RDK recommends exhaust fans should be removed and exhaust ducts sealed. Additionally, A makeup air fan should be installed to force air into the building. A makeup air unit often consists of a fan and a heating coil (and often a cooling coil) to pre-treat the outside air entering the space.

The balancer also observed several low air flow conditions across the fan coils. Temperature readings were measured by RDK engineers in the board of health room (47) at the supply diffuser and exhaust register with a noncontact infrared thermometer (model Raytek Raynger ST). Readings indicated an entering temperature of 136ºF and exhaust temperature of 89 ºF. The problem that occurs when entering at a high temperature is the treated (warm air) doesn't disperse throughout the room. Due to the fact that hotter air is more thermally buoyant than colder air, the hot air generally will stay at the higher levels of the room. When introduced to the large infiltration air discussed, the temperature differential between the floor and ceiling increases, potentially leading to occupant discomfort. Additionally, the exhaust fan in the room is essentially exhausting the conditioned air at the ceiling level to outside. Ideal design values target the entering temperature 15ºF-20ºF above temperature set point to achieve proper temperature gradient in positively pressurized spaces.

Measure 6 - Weather Stripping

During a survey, RDK Engineers noted there was significant air space both between the two doors and between the doors and the floor. Currently, that space is a source for infiltration air and allows untreated outdoor air into the building. Adding weather stripping is a low cost solution which will decrease the heat transfer through the doorways. Weather stripping will also further seal the building from infiltration either in or out.

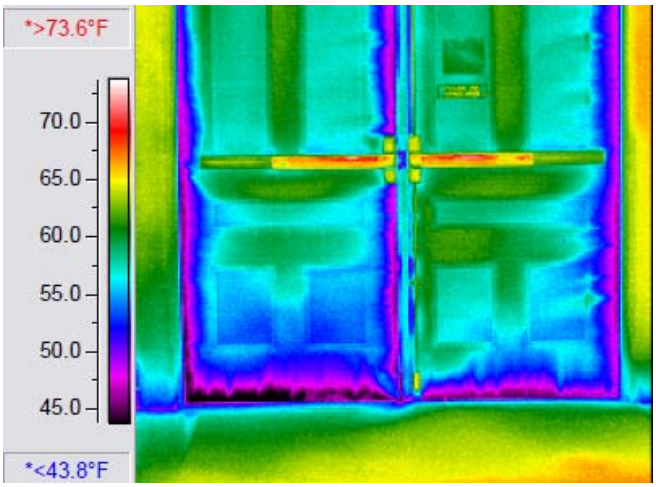


Figure 14 - Infrared Image of Entry Doors at Parking Lot Entrance Taken by Infra-red Analyzers

Measure 7 - Chilled Water Pump Operation

Figure 15 - Chilled Water Pumps

The chilled water loop performance was not studied for active performance during this analysis, as it was not active. One observation made was the two primary chilled water pumps are operated in series. This can cause a variety of problems. If both pumps are simultaneously run, both pumps must maintain the same flow to avoid any issues. If these pumps are run in a run-standby operation, flow through the deactivated pump can cause heat gain and reduced efficiency of the active pump. RDK recommends adding a bypass around the second pump, or consider arranging the pumps in parallel to avoid decreased pump performance, efficiencies, and useful life.

Measure 8 – Lighting Controls

As mentioned, many lighting fixtures, ballasts, and bulbs have been upgraded within the last five years as an energy efficiency measure in the building. RDK did not investigate the recently replaced lighting. During RDK's surveys, many lights were observed to be on in unoccupied rooms and closets. Many of the rooms utilized simple light switches and were not equipped with occupancy sensors of any kind.

Figure 16 - Men's Room 133. Single Light Switch Observed On While Unoccupied

Figure 17 - Plan and Print Room 44. Single Light Switch Observed On While Unoccupied

Figure 18 - Storage Room 04. Incandescent Bulb Observed On During Walkthrough

Current energy codes require many of these spaces to switch off via occupancy sensors, or a similar measure. While current energy codes are not applicable to this building, the Massachusetts' energy code requires a mandatory method of light reduction controls. One option is to provide occupancy sensors to control lighting. Based on RDK's observation of lights on in unoccupied restrooms, conference rooms, offices and closets, RDK recommends installing occupancy control switches, to turn off lights in areas that have been unoccupied for a half hour.
Lighting levels taken indicate some areas are over lit on a sunny day. Many office buildings implement a daylight dimming system to take advantage of the sun's natural light. A daylight dimming system involves a control system, photocells and dimming ballasts. While this type of system may not make economical sense in this instance due to the high upfront capital costs, and minimal fixtures affected, RDK recommends signage or internal correspondence is utilized to educate the end user/occupants on turning lights off when unnecessary. Local utilities offer incentives through the MassSave program for retrofitting lighting controls and range from $35 through $85 for occupancy sensors.

Measure 9 - Piping Insulation

As mentioned in the existing conditions portion of this report, much of the hydronic piping insulation has been compromised in both the primary loops and the system loop. Re-insulating the piping does not yield significant energy savings to economically justify the replacement, but RDK recommends re-insulation to increase the performance of both the heating and cooling systems. The insulation should consist of batten insulation, ideally with a PVC vapor barrier.

Measure 10 - Emergency Generator Air Quality

The emergency generator has had problems with the re-entrainment of noxious gases and exhaust negatively affecting the indoor air quality when operated. This has become a problem

as the generator cannot be exercised regularly while the building is occupied. This re-introduction of the generator's exhaust to the building is likely an affect of the building's negative pressurization. As discussed, the constant exhaust of air from the building tends to drive air from outside the building in through infiltration. In the scenario when the generator operates, the generator exhaust is located outside the building and infiltrates in to the spaces.

Measure 11 - Air Eliminator

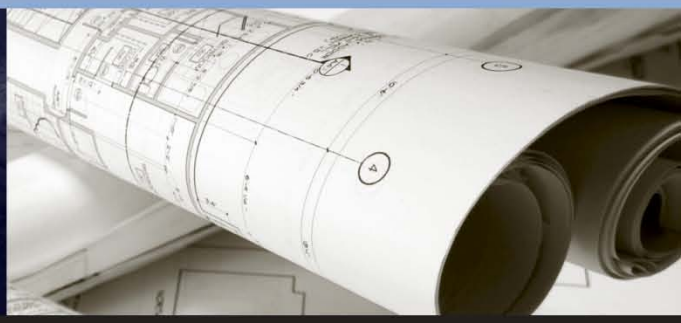
According to town staff, seasonal air purging is a repeated maintenance bear. The current air purging maintenance involves bleeding the air from the system loop at every fan coil unit during both heating and cooling seasons. An air eliminator such as the "Spyrotherm Spyrovent" can remove this regular maintenance task from practice. While no energy savings or increase will occur, this can potentially reduce maintenance costs. RDK recommends installing an air eliminator on the system loop to remove air from water flow during both heating and cooling operation.

Conclusion

Although the facility performs average relative to the national data base of buildings of the same size, age and use, RDK has concluded through site observation and several means of measurement, that a large majority of the human comfort concerns can be attributed to an air imbalance in the facility. The inefficiencies are well documented within the report and should be prioritized as such to mitigate both comfort and reduce energy end use consumption. As state, federal, and local utility energy efficiency incentives are continuously changing, dsireusa.org and the local utilities (MassSave) are great resources to obtain up to date information on the programs.

RDK ENGINEERS

APPENDIX A: BOILER EQUIPMENT DATA SHEETS



RDK ENGINEERS

BUILDING SYSTEM ASSESSMENT
LOW PRESSURE STEAM BOILER

Unit Tag

BUILDING: _____ **FLOOR:** _____ **DATE:** _____

SYSTEM TYPE: _____ **YEAR INSTALLED:** _____ **INSP. BY:** _____

MANUFACTURER: _____ **MODEL:** _____

SIZE: _____ **HP** _____ **V** _____

SERIAL # _____

SYSTEM DETAILS:

☐	Steel Water-Tube	☐	Oil	☐	Combustion Air
☐	Steel Fire-Tube	☐	Steam	☐	___% Redundancy
☐	Cast Iron	☐	Hot Water	☐	Positive Rm Pressure
☐	Electric	☐	Absorption	☐	F.O. Heater
☐	Gas	☐	Condensing	☐	Emergency Power

SERVICED: ☐ IN HOUSE ☐ CONTRACTOR

EQUIP. DATA SHEETS AVAILABLE: Y ☐ N ☐ **COLLECTED:** Y ☐ N ☐

Equipment Location:		Observations/Deficiencies:		Comments:
☐	Equipment Room	☐	In need of repair or service:	FCI = _____(Repair $ ÷ Replace $)
☐	Within Space Served	☐	End of Useful Service Life:	
☐	Penthouse	☐	Code Violation	
☐	Remote Plans	☐	Energy Conservation:	
☐		☐		

WHAT TO LOOK FOR:
EXISTING CONDITIONS & DEFICIENCIES

Y	N	N/A		Y	N	N/A		Y	N	N/A	
☐	☐	☐	Rust on Equipment	☐	☐	☐	Poor External Lining	☐	☐	☐	Oper/Dmpr/Valves working?
☐	☐	☐	Excessive Vibration	☐	☐	☐	Balancing Valve Set	☐	☐	☐	Flue stack ___F
☐	☐	☐	Fan in poor condition	☐	☐	☐	Valves Set & Locked	☐	☐	☐	Boiler Log
☐	☐	☐	Bare Pipe/No Insulation/Sweating	☐	☐	☐	Damper Linkage Connected	☐	☐	☐	
☐	☐	☐	Controls in Poor Condition	☐	☐	☐	Control Valve Operation	☐	☐	☐	
☐	☐	☐	Gauges and Thermometers	☐	☐	☐	Condensate Leaks	☐	☐	☐	
☐	☐	☐	Access Door Leaks	☐	☐	☐	Tube Failures	☐	☐	☐	
☐	☐	☐	Poor Fire Lining	☐	☐	☐		☐	☐	☐	

END OF USEFUL EQUIPMENT LIFE: See Table Below

Unit is	years old vs.	25	year benchmark	Controls are	years old vs.	16	year benchmark
Motor is	years old vs.	17	year benchmark	Tubes are	years old vs.	16	year benchmark

CODE ISSUES: See Notes Below

Y	N	N/A		Y	N	N/A		Y	N	N/A	
☐	☐	☐	Backflow Preventer	☐	☐	☐	Fuel Oil Curbing	☐	☐	☐	
☐	☐	☐	Emergency Shut-Off	☐	☐	☐		☐	☐	☐	

ENERGY CONSERVATION: See Table Below

Y	N		Y	N		Y	N	
☐	☐	Preheat Makeup Water	☐	☐	Economizer Cycle in use?	☐	☐	24/day operation
☐	☐	3 Way CHW ATC Valve	☐	☐	Heat Recovery in Flue Stack	☐	☐	

NOTES

1)
2)
3)
4)
5)
6)
7)

RDK ENGINEERS

BUILDING SYSTEM ASSESSMENT
LOW PRESSURE HOT WATER BOILER

Unit Tag B-1

BUILDING: Acton Town Hall **FLOOR:** Ground Floor **DATE:** 01/24/11

SYSTEM TYPE: Hot Water Heating Boiler **YEAR INSTALLED:** 2008 **INSP. BY:** MWT

MANUFACTURER: Weil Mclain **MODEL:** 80 Series - 480

SIZE: 480 MBH **HP** **V** 208

SERIAL # 082900001 - Carlin 301 Burner

SYSTEM DETAILS:

☐	Steel Water-Tube	☐	Oil	☑	Combustion Air
☐	Steel Fire-Tube	☐	Steam	☐	___% Redundancy
☑	Cast Iron	☑	Hot Water	☐	Positive Rm Pressure
☐	Electric	☐	Absorption	☐	F.O. Heater
☑	Gas	☐	Condensing	☐	Emergency Power

SERVICED: ☑ IN HOUSE ☐ CONTRACTOR

EQUIP. DATA SHEETS AVAILABLE: Y ☐ N ☑ **COLLECTED:** Y ☐ N ☑

Equipment Location:		Observations/Deficiencies:		Comments:
☑	Equipment Room	☐	In need of repair or service:	FCI = _____(Repair $ ÷ Replace $)
☐	Within Space Served	☐	End of Useful Service Life:	
☐	Penthouse	☐	Code Violation	
☐	Remote Plans	☐	Energy Conservation:	
☐		☐		

WHAT TO LOOK FOR:
EXISTING CONDITIONS & DEFICIENCIES

Y	N	N/A		Y	N	N/A		Y	N	N/A	
☐	☐	☐	Rust on Equipment	☐	☐	☐	Poor External Lining	☐	☐	☐	Oper/Dmpr/Valves working?
☐	☐	☐	Excessive Vibration	☐	☑	☐	Balancing Valve Set	☐	☐	☐	Flue stack ___F
☐	☐	☐	Fan in poor condition	☐	☑	☐	Valves Set & Locked	☐	☑	☐	Boiler Log
☐	☐	☐	Bare Pipe/No Insulation/Sweating	☐	☐	☐	Damper Linkage Connected	☐	☐	☐	
☐	☐	☐	Controls in Poor Condition	☐	☑	☐	Control Valve Operation	☐	☐	☐	
☐	☐	☐	Gauges and Thermometers	☐	☐	☐	Condensate Leaks	☐	☐	☐	
☐	☐	☐	Access Door Leaks	☐	☐	☐	Tube Failures	☐	☐	☐	
☐	☐	☐	Poor Fire Lining	☐	☐	☐		☐	☐	☐	

END OF USEFUL EQUIPMENT LIFE: See Table Below

Unit is years old vs. 4 year benchmark — Controls are years old vs. 4 year benchmark

Motor is years old vs. na year benchmark — Tubes are years old vs. na year benchmark

CODE ISSUES: See Notes Below

Y	N	N/A		Y	N	N/A		Y	N	N/A	
☑	☐	☐	Backflow Preventer	☐	☐	☐	Fuel Oil Curbing	☐	☐	☐	
☐	☑	☐	Emergency Shut-Off	☐	☐	☐		☐	☐	☐	

ENERGY CONSERVATION: See Table Below

Y	N		Y	N		Y	N	
☐	☐	Preheat Makeup Water	☐	☑	Economizer Cycle in use?	☑	☐	24/day operation
☐	☑	3 Way ATC Valve	☐	☑	Heat Recovery in Flue Stack	☐	☐	

NOTES

1) Recommend Air Eliminator as Mfr'd by Spirotherm
2) Recommend Check Valves on Primary Pumps (Discharge)
3)
4)
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7)
8)
9)

80 Commercial Boiler
Weil-McLain

Gas, Oil & Gas/Oil
Water or Steam
MBH: 346-1,674
Combustion Eff.: 85%

80 BOILER

- Weil-McLain captured seal design
- For Light Oil, Gas and Dual Fuel Combustion
- Packaged, Assembled Block or Knock-down
- Available for Water and Steam Heating Systems
- Available as Forced or Chimney draft venting

WEIL-McLAIN
www.weil-mclain.com

MADE IN THE USA

WEIL-McLAIN

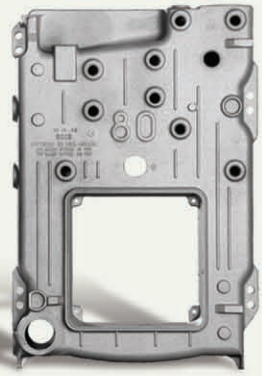
Presenting...

the Weil-McLain Model 80 – commercial boiler-burner units for light oil, gas or gas/light oil firing, available with high-capacity tankless heaters, with the features installers have asked for – Outstanding performance...innovative design...easier to install and service...top or back venting...just a few of the advantages that make the Model 80 boiler the industry's best value. And best of all, the Model 80 boiler is made by Weil-McLain, America's leading name in cast iron boilers for over a century.

The Model 80 is available packaged or knockdown, for water or steam, with or without burner. Burners are ordered and shipped separately – to give you maximum flexibility.

Factory assembled available

In addition to individual sections, the Model 80 boiler is also available with factoy assembled sections. Burner plate, flue collector and flue collar are also assembled. Individual sections as well as the assembled unit are hydrostatically tested before shipping.



Lifting cables are attached to the block so the assembled boiler can be lifted by crane or hoist. Steel skids on the bottom of the boiler permit moving the unit with pipe rollers.

The Model 80 boiler is also available as a factory fire-tested package unit. Consult a Weil-McLain representative for details.

Wide selection of burners

Burners for the Model 80 are designed and engineered to match the firing characteristics of the boiler. Major brands of advance-design burners are available for firing light oil, gas, or combination gas-light oil, including Beckett, Carlin, Riello, Gordon-Piatt, Power Flame, and Webster. All burners are flame-retention type, ensuring optimum control of the fuel and air mixture for outstanding operating performance and maximum efficiency.

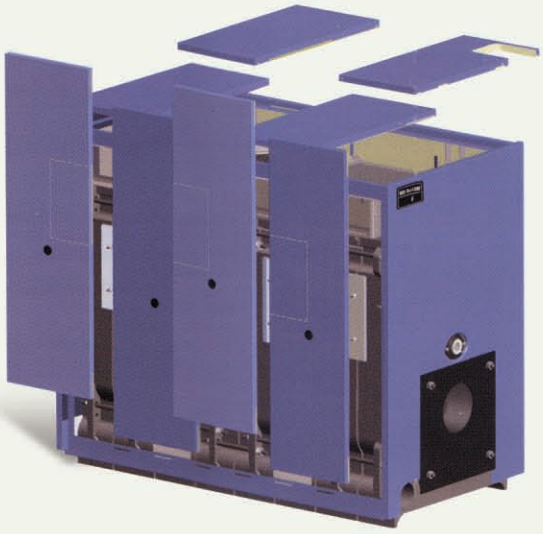
Model 80 ratings are certified by I=B=R when used with burners listed on page 4.

All burners are certified by Underwriters Laboratories, and can be furnished with optional controls to meet all insurance specifications and state and local code requirements.

Refer to the Weil-McLain burner specification sheets for complete details or consult a Weil-McLain representative.

Unique, easy-access jacket for – no tools needed to remove panels

This is the product you've been asking for – a boiler with a sturdy jacket that is quick and simple to assemble.



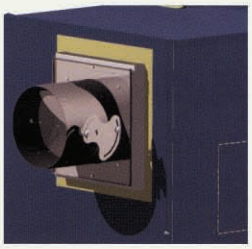
The Model 80's unique jacket design does that and more.

- Jacket support brackets slide onto section tie rods and secure with 5/8" nuts.
- Jacket assembly requires only 10 screws for smaller models and 16 screws for larger models.
- Jacket side panels require no screws – just slide onto upper support rail and into lower support channel.
- Jacket side panels are easy to handle – never wider than 24 inches.
- Jacket top panels just drop into place, secured in position by support rails and adjacent panels.
- Jacket trim gives a clean, finished look to the jacket corners.

Rear or top flue

Model 80 boilers are available with either rear flue or top flue. Save valuable floor space with the top flue option.

And the flexible design of the Model 80 allows simple field conversion of the flue location using a flue conversion kit.



Rear flue (standard)

Top flue (optional)

Easy inspection and cleaning

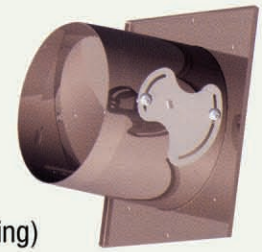
The Model 80 boiler can be inspected by lifting off a jacket side panel and removing a cleanout plate.

To clean the boiler, simply lift off a left side jacket panel and remove the cleanout plates. Replace the plates and jacket panel and continue down the boiler.

Steel flue collar

The Model 80 flue collar is made from heavy-guage galvanized steel, designed and constructed for long and reliable life.

For maximum flexibility, the flue collar can be installed on either the top or rear of the boiler. (Specify location when ordering)



Hydro-wall design

The Model 80 boiler has a water-backed combustion are with water circulating completly around the firebox. The crown sheet, sidewalls, and heat pins on the flue passages enlarge prime heating surface for maximum operating efficiency.

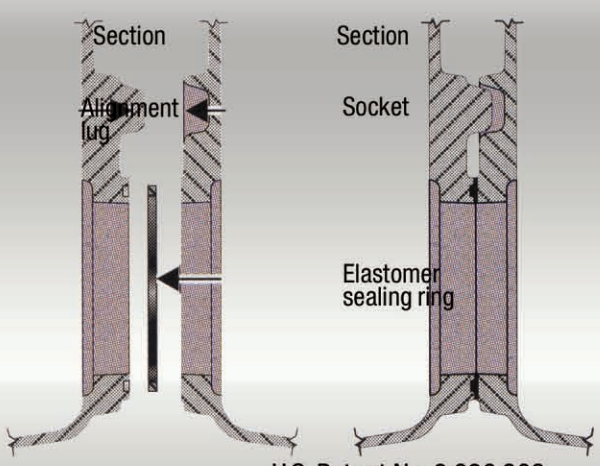
In addition, Hydro-Wall design permits lower height, reduces heat loss through the bottom of the boiler, and allows installation on any floor.

The cast iron sections are not face-ground; the tough outer skin is retained to protect against corrosion. Sealing rope between sections assures the gas-tight seal required for forced draft firing.

W-M captured seal

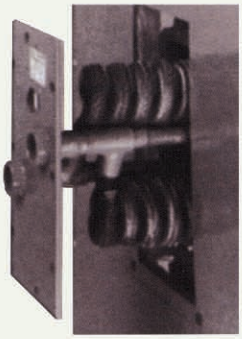
Boier sections want room to move as they heat and cool. Modern elastomer seals provide the ultimate freedom for the cast iron to flex (unlike rigid metal push nipples), preventing leaks caused by expansion contraction.

The precision-machined port grooves secure the seals in place and protect them from constaminants in the water.



U.S. Patent No. 3,626,908

Mutiple tankless heaters

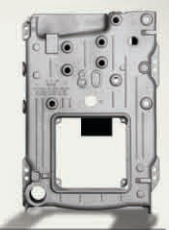


Model 80 tankless heaters (Number 78-24) have a continuous draw rating (40o to 140oF, with 200oF boiler water) of 6.5 GPM per heater. Replace intermediate sections with tankless heater sections to provide up to 4 tankless heaters, depending on boiler size. See page 4 for a complete listing for each boiler size. Multiple heaters are another feature of the Model 80 flexibility, allowing (1) Increased domestic water capacity; (2) Multiple domestic water supply temperatures; (3) Use of a tankless heater for snow melting.

80 Output 278-1348 MBH (8-40 HP)

- Top or Rear outlet flexibility
- Easy access jacket

	Oil	Gas
Combustion	85%	82%
Thermal	83%	80%



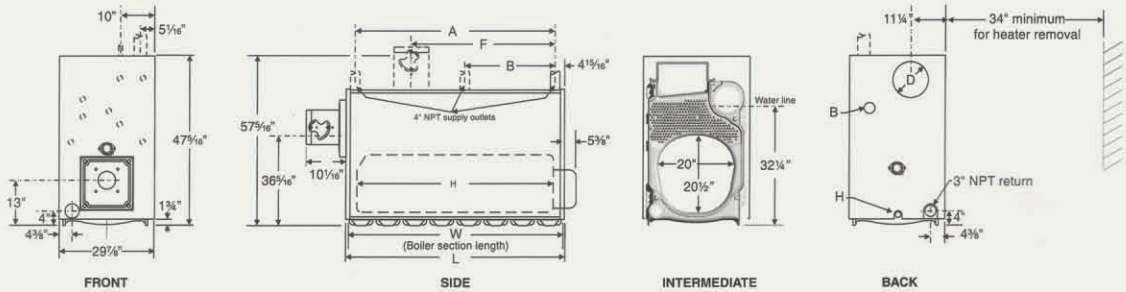
Ratings

Boiler Model	I=B=R Oil Input GPH	I=B=R Gas Input MBH	I=B=R Gross Output MBH	Boiler H.P.	I=B=R Net Rating Steam MBH	Steam Sq. Ft.	Water MBH	Flue Outlet Dia.	Net Firebox Volume Cu/Ft	Stack Gas Volume CFM	Positive Pressure in firebox	Water Boiler Content Gallons	Operating Weight Pounds
380	2.4	346	278	8.3	208	867	242	8	2.61	139	0.28	37.5	1170
480	3.4	491	396	11.8	297	1238	344	8	3.97	198	0.28	49	1411
580	4.45	639	515	15.4	386	1608	448	8	5.33	259	0.28	60.5	1752
680	5.5	787	634	18.9	476	1983	551	8	6.69	320	0.27	72	2093
780	6.5	935	753	22.5	565	2354	655	10	8.05	378	0.27	83.5	2434
880	7.5	1082	872	26	654	2725	758	10	9.41	436	0.27	95	2774
980	8.5	1230	991	29.6	743	3096	862	10	10.77	494	0.27	106.5	3115
1080	9.6	1378	1110	33.2	833	3471	965	10	12.13	558	0.26	118	3456
1180	10.6	1526	1229	36.7	922	3842	1069	10	13.49	616	0.26	129.5	3697
1280	11.6	1674	1348	40.3	1018	4242	1172	12	14.85	675	0.26	141	4038

Notes
- Burner input based on maximum of 2,000 feet altitude. For higher altitudes consult local Weil-McLain representative.
- NO.2 fuel oil Commercial Standard Spec. CS75-56. Heat value of oil-140,000 Btu/Gal.
- Consult Weil-McLain Burner Specifications and Data Sheet for gas pressures required. Gross I=B=R ratings have been determined under the I=B=R provision forced draft boiler-burner units.
- Net I=B=R ratings are based on net installed radiation of sufficient quantity for the requirements of the building and nothing need be added for normal piping and pickup. Water ratings are based on a piping and pickup allowance of 1.15. Steam ratings are based on the following allowances: 380 thru 1180 - 1.333; 1280 - 1.321. An additional allowance should be made for gravity hot water systems or for unusual piping and pickup loads. Consult local Weil-McLain representative.
- Stack gas volume at outlet temperature.
- With 0.10" W.C. positive pressure at flue collar.

Dimensions

Boiler Model	Supply Tappings Qty - Size Water	Supply Tappings Qty - Size Steam	Return Tappings Qty - Size Water	Return Tappings Qty - Size Steam	Dimensions (Inches) - Reference Drawings A	B	D	F	H	L	W
380	2 - 4"	2 - 4"	2 - 3"	2 - 3"	13-1/8	-	8	12-7/16	13-1/2	21-5/8	20-3/8
480	2 - 4"	2 - 4"	2 - 3"	2 - 3"	20-1/8	-	8	13-5/8	20-1/2	28-5/8	27-3/8
580	2 - 4"	2 - 4"	2 - 3"	2 - 3"	27-1/8	-	8	13-5/8	27-1/2	35-5/8	34-3/8
680	2 - 4"	2 - 4"	2 - 3"	2 - 3"	34-1/8	-	8	13-5/8	34-1/2	42-5/8	41-3/8
780	2 - 4"	2 - 4"	2 - 3"	2 - 3"	41-1/8	-	10	27-5/8	41-1/2	49-5/8	48-3/8
880	2 - 4"	2 - 4"	2 - 3"	2 - 3"	48-1/8	-	10	27-5/8	48-1/2	56-5/8	55-3/8
980	2 - 4"	2 - 4"	2 - 3"	2 - 3"	55-1/8	-	10	41-5/8	55-1/2	63-5/8	62-3/8
1080	2 - 4"	3 - 4"	2 - 3"	2 - 3"	62-1/8	27-9/16	10	41-5/8	62-1/2	70-5/8	69-3/8
1180	2 - 4"	3 - 4"	2 - 3"	2 - 3"	69-1/8	34-9/16	10	55-5/8	69-1/2	77-5/8	76-3/8
1280	2 - 4"	3 - 4"	2 - 3"	2 - 3"	76-1/8	34-9/16	12	55-5/8	76-1/2	84-5/8	83-3/8



Standard Equipment

All Boilers
- Cast iron sections
- Insulated steel jacket
- Flame retention burner (except H-80)
- Burner mounting plate with refractory (except H-80)
- Aluminized steel flue collector assembly
- Steel flue collar and breeching damper
- Observation ports on front and rear sections
- Refractory blanket and target wall in combustion area
- Side cleanout plates
- Flue brush

Water Boilers
- 30 PSIG ASME safety relief valve (sections tested for 80 PSIG maximum working pressure)
- Combination high limit/low limit control
- Combination pressure/temperature gauge
- Built-in air eliminator

Steam Boilers
- 15 PSIG ASME safety valve (side outlet)
- Low limit and high limit pressure controls
- Steam pressure gauge
- Gauge glass. gauge cocks and gauge guards

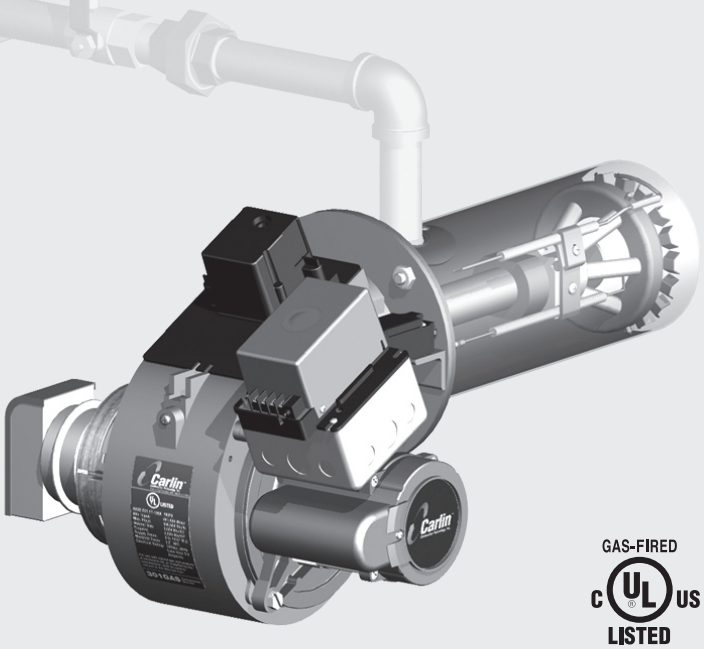
Optional Equipment
- Low water cut-offs (probe or float type)
- Tankless heaters
- Burner mounting plate (for H-80 boilers)
- Factory-assembled sections
- Fire-tested packaged boiler (with low water cut-off)

WEIL-McLAIN
www.weil-mclain.com

MODEL **301GAS™**

Gas burner

Instruction manual



GAS-FIRED
C UL US
LISTED

Ratings

Input:	401,000 to 1,100,000 Btuh
Fuels:	Natural gas or propane gas
	Max. supply pressure 14 inches w.c.
	Min. supply pressure 5 inches w.c.
	Manifold pressure 3.5 inches w.c.
Electrical:	Power 120V/60 Hz/1-Phase
	Motor 1/6 HP, 3450 RPM, 1.8 amps
	Total Current Approx. 2.5 amps
Ignition:	Carlin Model 41800 solid state ignitor
Control:	Carlin Model 60200FR microprocessor control
Agencies:	UL Listed

WARNING **Installer/servicer** — Except where specifically stated otherwise, this manual must be used only by a **qualified service technician**. (In the state of Massachusetts, this product must be installed by a licensed Plumber or Gas Fitter.) Failure to comply with this or other requirements in this manual could result in severe personal injury, death or substantial property damage.

WARNING **User** — Refer only to **User's Information** booklet for information regarding operation of this burner. The burner **Instruction Manual** is intended only for your service technician. The burner and heat exchanger must be inspected and started at least annually by your service technician.

Contents

PLEASE read this first 2
Codes and standards 2
301GAS burner at-a-glance 3
Prepare site • prepare burner • mount burner 4
Install gas piping 10
Wire burner 11
Check system • start-up burner/appliance 12
Perform checkout procedures • fill out certificate 14
Maintenance and service procedures 16
Troubleshooting 17
Dimensions and mounting information 19
Replacement parts 20

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PLEASE read this first . . .

Special attention flags

Please pay particular attention to the following when you see them throughout this manual.

DANGER Notifies you of hazards that **WILL** cause severe personal injury, death or substantial property damage.

WARNING Notifies you of hazards that **CAN** cause severe personal injury, death or substantial property damage.

CAUTION Notifies you of hazards that **WILL or CAN** cause minor personal injury or property damage.

NOTICE Notifies you of special instructions on installation, operation or maintenance that are important, but are not normally related to injury or property damage hazards.

General information

Burner applications

Follow all instructions in this manual and the appliance manual. Where appliance instructions differ from this manual, follow the appliance instructions. Read the label attached to the burner air tube to verify the burner is correct for the appliance being used. See page 8 for procedures.

Damage or shortage claims

The consignee of the shipment must file damage or shortage claims immediately against the transportation company.

When calling or writing about the burner . . .

Please provide us with the UL serial number and burner model number to assist us in locating information. Enter this information on the Installation Certificate in this manual. The certificate information can be helpful when troubleshooting or obtaining replacement parts.

Fill out burner adjustment label

Fill out the burner adjustment label, located on the housing above the rating label after completing installation and burner setup.

WARNING Should overheating occur: (1) shut off the manual gas control to the appliance, (2) do not shut off the control switch to the pump or blower.

WARNING Follow the guidelines below to avoid potential severe personal injury, death or substantial property damage.

Installer/service technician . . .

- Read all instructions before proceeding. Perform all procedures, and in the order given to avoid potential of severe personal injury, death or substantial property damage.
- Before leaving the site after start-up or service, review the **User's information** manual with the user. Make the user aware of all potential hazards and perform the training outlined below.

Train the user . . .

- To properly operate the burner/appliance per this manual and the appliance instructions and the **User's information manual.**
- To keep this manual at or near the burner/appliance for ready access by the user and service technician.
- To contact the service technician, gas supplier or fire department should the user smell gas.
- To keep the appliance space **free of flammable liquids or vapors and other combustible materials**.
- Do not use laundry products, paints, varnishes or other chemicals in the room occupied by the burner/appliance.
- To contact the service technician at least annually for start-up and burner/appliance service.

When servicing the burner . . .

- **Disconnect electrical supply** to burner before attempting to service to avoid electrical shock or possible injury from moving parts.
- Burner and appliance components can be extremely hot. **Allow all parts to cool** before attempting to handle or service to avoid potential of severe burns.

Codes and standards

NOTICE The installer/servicer is solely responsible for compliance with all applicable codes and standards.

Burner listings

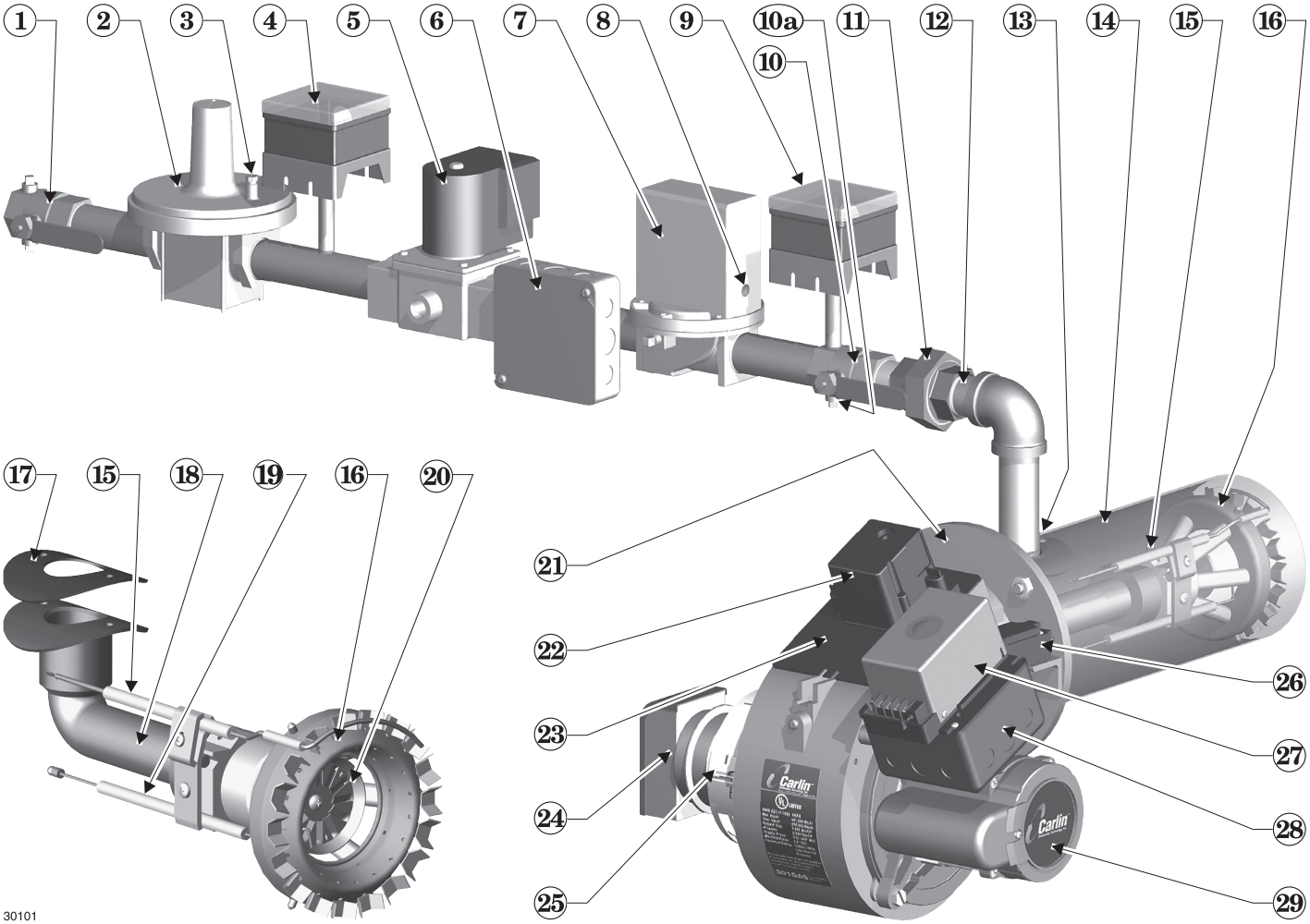
Carlin 301GAS burners are tested and approved under standards UL795 and CGA 3.4-latest edition.

Codes

Burner/appliance installations must comply with all applicable local codes and, where applicable, with the National Fuel Gas Code, ANSI Z223.1/NFPA 54-latest edition, and the National Electrical code, ANSI/NFPA 70-latest edition for U. S. installations or B149.1/B149.2 Installation Code, and CSA C22.1 Canadian Electrical Code Part 1 for Canadian installations.

Where appliance instructions differ from this manual, follow the appliance instructions.

301GAS burner at-a-glance



1 Manual gas valve (wtih two test tappings) –Gas supply entrance — 1" NPT; 5" w.c. min; 14" w.c. max; natural gas or propane

2 Gas pressure regulator

3 Gas pressure regulator vent port (fitted with fixed orifice; vent to outside where required by applicable codes)

4 Low gas pressure switch

5 Automatic gas valve

6 Junction box

7 Automatic gas valve (diaphragm type)

8 Diaphragm gas valve bleed port (fitted with fixed bleed orifice) – installer must provide vent piping from this tapping to outside

9 High gas pressure switch

10 Manual gas valve

10a Burner gas manifold pressure test port, 1/4" NPT

11 Union

12 Orifice nipple (burner gas orifice plug located inside)

13 Burner gas connection, 1" NPT

14 Air tube (flange omitted for clarity), with powder coat paint finish

15 Flame rod/insulator assembly

16 Combustion head assembly

17 Gas saddle connection gasket

18 Gas manifold

19 Ignition electrode/insulator assembly

20 Static disk assembly (low input range shown)

21 Hinged burner flange door – for access and removal of combustion head/gas manifold assembly

22 Ignitor (Carlin Model 41800 solid state electronic ignitor — 9,000 volts, continuous duty rated)

23 Hinged cover plate (for access to blower wheel & electrodes)

24 Airflow proving switch — Prevents burner from firing if air is not moving

25 Air band — Only a single adjustment required for setting combustion air; see page 7 for starting setting based on input

26 Door interlock switch — prevents burner operation if flanged door is open

27 Primary control — Carlin Model 60200FR microprocessor-based interrupted ignition flame supervisory control (flame rectification); Flame current test jack is located to right of control terminal strip

28 Burner junction box (installer electrical entrance)

29 Motor (with permanently-lubricated bearings and thermal overload protection)

1. Prepare site • prepare burner • mount burner

Vent system

Inspect, repair and/or replace vent system

WARNING Do not install this burner unless you have verified the entire vent system and the appliance are in good condition and comply with all applicable codes. And . . .

The vent and chimney must be sized and constructed in accordance with all applicable codes. If intended for use with an oil burner as well, the vent system must comply with relevant codes for both gas and oil firing.

The vent system must not be pressurized unless the vent piping and vent system are designed accordingly. The vent must provide draft at all times (negative pressure in vent).

Do not install or use an existing manual damper in the vent connector or vent.

Do not connect the appliance vent connector to a chimney or vent serving a fireplace, incinerator or solid-fuel-burning apparatus.

In a cold climate, do not vent into a masonry chimney that has one or more sides exposed to the outside. Install a listed stainless steel liner to vent the flue products.

A defective vent system could result in severe personal injury, death or substantial property damage.

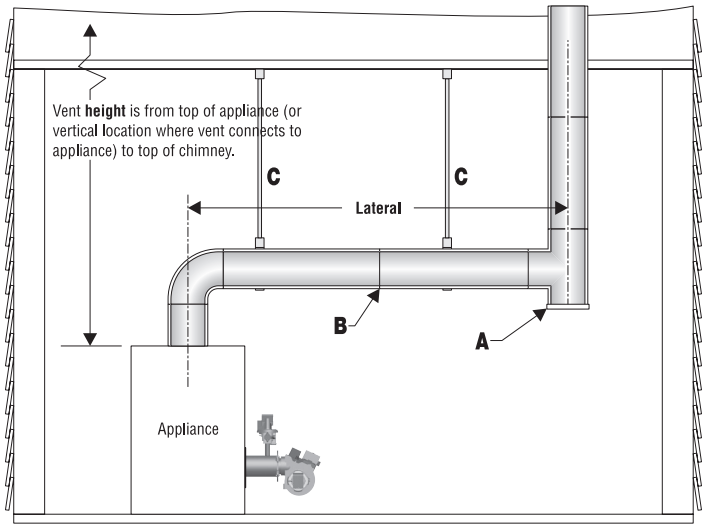
Vent/chimney sizing

- Follow all local codes when sizing the vent and chimney.
- Refer to the appliance manufacturer's manual, when available, for venting recommendations.

Prepare vent/chimney

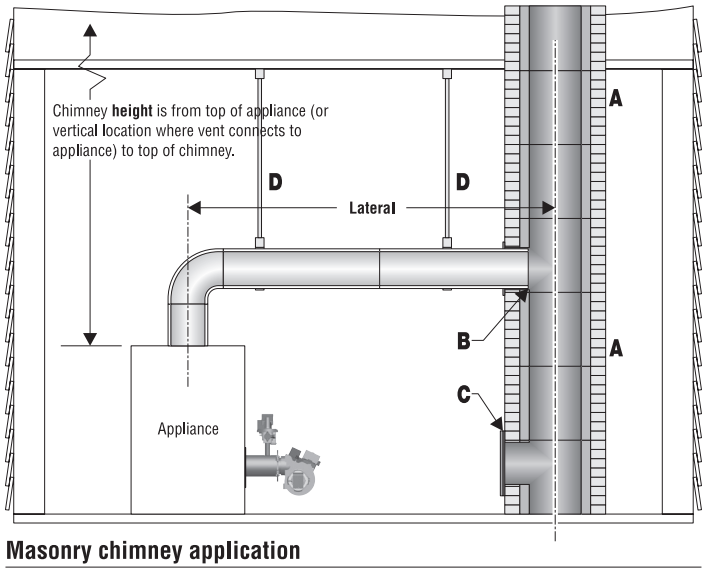
- Secure all metal vent joints with screws, following the vent manufacturer's instructions. Seal all joints in the vent system and chimney. Repair masonry chimney lining and repair all mortar joints as needed.
- Where draft fluctuations are likely, install a double-acting barometric draft regulator in the vent piping. (The damper must be located in the same space as the appliance.) Install a manual reset spill switch in the top of the draft regulator outlet. Wire the switch into the appliance limit circuit to shut off the appliance/burner if sustained downdraft should occur. Refer to the appliance manufacturer's instruction manual for recommendations regarding the need for a barometric draft regulator.
- Provide support for the vent piping. Do not rest the weight of any of the vent piping on the appliance flue outlet.

Figure 1 *Vent and vent connector installations, typical*



Metal vent application

A Connect to vertical with tee, if possible, to provide inspection/cleanout opening in vent.
B Seal all joints and access openings tightly to prevent draft loss.
C Support vent pipe so no weight of vent connector rests on appliance.



Masonry chimney application

A Tile-lined interior masonry chimney only; with all tile and joints in good condition.
B Vent pipe should be almost flush, but ***not extending into***, inside surface of liner.
C Seal all access openings tightly to prevent draft loss.
D Support vent pipe so no weight of vent connector rests on appliance.

30102

1. Prepare site • prepare burner • mount burner *(continued)*

Combustion air/ventilation openings

General

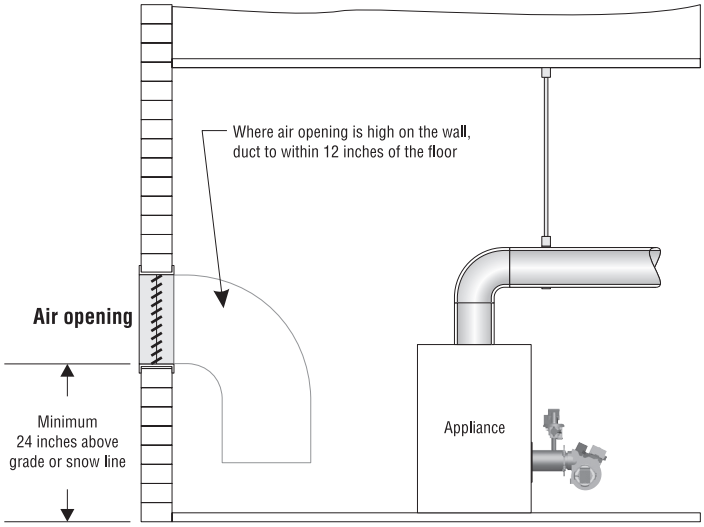
WARNING Installing the burner/appliance in a space that does not provide enough air for combustion and ventilation can result in severe personal injury, death or substantial property damage. Follow all applicable codes and guidelines below to ensure space has sufficient air openings.

WARNING Exhaust fans and negative pressure conditions — Isolate the boiler room from areas subject to negative pressure. Size combustion air openings to ensure neutral air pressure in the boiler room whenever the burner operates.

WARNING Make sure the space provides enough ventilation to prevent overheating of the appliance, burner and controls. If there is risk of overheating, you must install ventilation air openings sized large enough to provide air for cooling the equipment. Failure to provide ventilation can result in severe personal injury, death or substantial property damage.

WARNING The space and combustion air supply must not contain corrosive contaminants, such as laundry products, paints, varnishes or other chemicals.

Figure 2 *Locating combustion air/ventilation openings*



A Tile-lined interior masonry chimney only; with all tile and joints in good condition.
B Vent pipe should be almost flush, but ***not extending into***, inside surface of liner.
C Seal all access openings tightly to prevent draft loss.
D Support vent pipe so no weight of vent connector rests on appliance.

30103

Sizing air openings

Follow all applicable codes and the appliance instruction manual (when available) to size combustion air openings. Use the following guidelines when appliance instructions are not available.

- All air from inside building (building must be well-ventilated):

  Size air openings for a free area (after louver deduction) of at least 1 square inch per 1,000 Btuh input of all appliances in the space.
- All air through openings to outside:

Locating air openings

Follow all applicable codes and the appliance instruction manual (when available) to size combustion air openings. Refer to Figure 2 when appliance instructions are not available.

Free area estimating

When specific information on the free area of louvers is not available, estimate free area as:

- wood louvers — free area = area times 0.25.
- metal louvers or grilles — free area = area times 0.60.
- screens, when used must be no smaller than ¼ inch mesh.

Motorized vent dampers

Wire the vent damper end switch to prevent operation of the burner until the air opening louvers are fully open.

Combustion air/ventilation opening checklist

- Verify that openings are unobstructed.
- Verify that appliance space and air source spaces are free of:
  - Gasoline or other flammable liquids or vapors.
  - Combustible materials.
  - Air contaminants, such as laundry products, paint, thinner, varnish, etc.
- Confirm with user that the area will be kept free of these materials at all times.

Verify clearances

- Verify that the burner/appliance will maintain all clearances to combustible walls or floor and all clearances required for service/maintenance as required in the appliance manual and applicable codes.

1. Prepare site • prepare burner • mount burner *(continued)*

Prepare the appliance

WARNING

Burner input: Install a gas burner sized for the normal input rating of the appliance. Do not install a burner with a higher firing rate than the appliance rating. Do not install a burner with a firing rate more than 10% lower than the appliance rating. The appliance and vent system could be damaged due to condensation.

Clean the appliance: Clean the appliance thoroughly and seal all joints. Test all electrical components and verify the relief valve works (boilers only).

Verify combustion chamber dimensions comply with the minimum dimensions shown in Figure 3, page 7. Install or replace chamber liner if required by the appliance manufacturer. The burner must not extend into the combustion chamber. The end of the burner air tube must be within ¼" of the inside face of the chamber. If the space around the burner air tube is more than ¼", wrap the burner air tube with minimum 2300-°F-rated ceramic fiber blanket to seal off the gap.

Repair or replace damaged appliance components. Inspect the appliance thoroughly. Follow appliance manufacturer's guidelines for repair or replacement of any component found defective.

When cleaning the appliance or working with **ceramic fiber refractories or fiberglass insulation**, see **WARNING** on this page.

Failure to comply with the above could result in severe personal injury, death or substantial property damage.

Prepare appliance for burner mounting

WARNING

Positive overfire pressure applications: When firing with positive overfire pressure, do not exceed the pressure specified in the appliance manual.

Positive overfire pressure reduces maximum burner capacity. See Table 1 notes for estimated reduction in burner capacity with pressurized firing.

Failure to comply could result in severe personal injury, death or substantial property damage.

Check bolt locations

Verify that the burner flange bolt layout matches that of the appliance. See page 19 for required dimensions and bolt locations.

Ceramic fiber or Fiberglass insulation

WARNING

Ceramic fiber materials, such as chamber liners, may contain carcinogenic particles (chrystobalites) after exposure to heat. Airborne particles from fiberglass or ceramic fiber components have been listed as potentially carcinogenic by the State of California. Take the following precautions when removing, replacing and handling these items.

Avoid breathing dust and avoid contact with skin or eyes. Wear long-sleeved, loose-fitting clothing, gloves and eye protection. Use a NIOSH N95 certified respirator. This respirator meets requirements for protection from chrystobalites. Actual job requirements or NIOSH regulations may require other or additional protection. For information, refer to the NIOSH website, http://www.cdc.gov/niosh/homepage.html.

Ceramic fiber removal: To prevent airborne dust, thoroughly wet ceramic fiber with water before handling. Place ceramic fiber materials in a plastic bag and seal to dispose.

Avoid blowing, tearing, sawing or spraying fiberglass or ceramic fiber materials. If such operations are necessary, wear extra protection to prevent breathing dust.

Wash work clothes separately from other laundry. Rinse clothes washer thoroughly afterwards to prevent contamination of other clothing.

NIOSH First aid procedures:

Eye exposure — irrigate immediately

Breathing — fresh air.

1. Prepare site • prepare burner • mount burner *(continued)*

Prepare burner and components

WARNING Do not install or operate the burner if any component is damaged or if burner does not comply with the specifications of Table 1 and other guidelines in this manual.

Combustion head/air tube configurations

- 301GAS burners are supplied with either an "B" or "C" head and air tube combination. The "B" head/tube is designed for the low range from 401 to 700 MBH. The "C" head/tube is for the high range from 550 MBH to 1,100 MBH.

Air tube insertion length (UTL)

- Usable air tube length (UTL) is the distance from mounting flange to end of air tube. Verify that the end of the air tube will be flush with, or no more than ¼ inch short of, the inside of the appliance combustion chamber front wall when the burner is mounted. See Figure 3 and Table 1 for further information.

Figure 3 *Chamber dimensions & tube configurations*

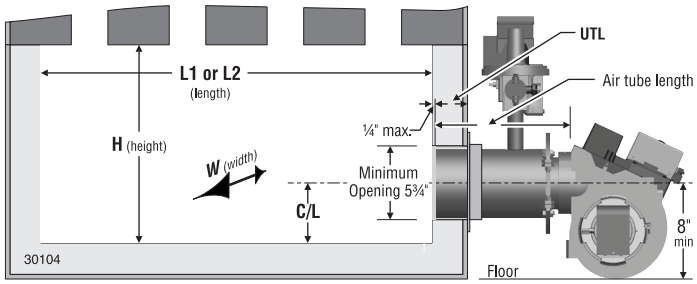


Table 1 *Burner orifice sizing, air settings and minimum combustion chamber dimenions (see Figure 3)*

Input Note 1	Burner orifice drill size Inches		Approximate air settings Notes 1 & 2		Air tube & Head	Minimum chamber dimensions Inches (Notes 3, 4, 5) (VC = min. diam. of vertical cylinder chamber)						UTL Air tube insertion length		
Btuh	Natural gas	Propane gas	% open	Air shutter		C/L	L1	L2	W	H	VC			
401,000	7/16	11/32	20	Blank	B	6.0	20	24	15	13.5	17	Welded flange: Burners with ***welded flange*** have fixed usable tube length (UTL) set for the appliance application. Verify length is correct for the application. Adjustable flange: Burners with ***adjustable flange***: Usable tube length (UTL) varies with air tube length (see below).		
450,000	15/32	23/64	30	Blank	B	6.5	22	26	16	14.5	19			
500,000	31/64	25/64	35	Blank	B	7.0	23	27	16	15.5	20			
550,000	17/32	27/64	40	Blank	B	7.0	23	27	16	15.5	20			
			20	Center	C									
600,000	35/64	7/16	50	Blank	B	7.5	23	27	17	16.5	20			
			25	Center	C									
650,000	37/64	29/64	60	Blank	B	8.0	24	28	18	17.5	21			
			30	Center	C									
700,000	19/32	15/32	70	Blank	B	8.5	24	30	19	19.5	21			
			35	Center	C									
750,000	5/8	31/64	40	Center	C	8.5	30	36	19	19.5	27	Nominal air tube length	UTL min.	UTL max.
800,000	21/32	1/2	50	Center	C	8.5	35	41	19	19.5	32			
850,000	11/16	33/64	60	Center	C	9.0	38	44	20	20.0	35			
900,000	23/32	17/32	70	Center	C	9.0	39	45	20	20.0	35			
950,000	25/32	35/64	80	Center	C	9.0	40	46	20	20.0	36	14" B 14" C	1 ¾" 0"	9" 7 ½"
1,000,000	13/16	9/16	65	None	C	9.5	41	47	21	21.0	37			
1,050,000	15/16	37/64	85	None	C	9.5	41	47	21	21.0	37			
1,100,000	1	19/32	100	None	C	10.0	42	48	21	22.0	38			
Note 1	Ratings: • The maximum burner inputs at sea level are 700,000 Btuh for the "B" tube/head, 1,100,000 Btuh for the "C" tube/head. • Altitude ratings: Reduce maximum capacity by 4% per 1,000 feet above sea level. — Example: The maximum "B"-tube/head capacity at 5,000 feet altitude is 560,000 Btuh instead of 700,000, a 20% reduction. Positive overfire pressure effects: • Maximum burner input decreases with increasing overfire pressure. • Assume a reduction in maximum burner input of approximately 5% at 0.1 inches w.c. and 10% at 0.2 inches w.c. • You will have to increase the air band opening to compensate for the increased pressure. • Follow the procedures given in this manual to check combustion with instruments to determine the correct air band setting. • Never fire at a higher overfire pressure than recommended by the appliance manufacturer.														
Note 2	Use this as the starting setting only. Adjust air band setting, if necessary, after performing combustion testing (see page 14).													
Note 3	Some tested appliances may operate satisfactorily with dimensions less than the above.													
Note 4	Horizontal cylindrical chambers — diameter must be no less than column "W" above Horizontal stainless steel cylindrical chambers — diameter at least 1 to 4 inches larger than column "W" above. VC is the minimum diameter for vertical cylindrical chambers (refractory or refractory-lined chambers only).													
Note 5	A corbel may help heat transfer in a larger boiler or furnace, provided it is recommended by the appliance manufacturer.													

1. Prepare site • prepare burner • mount burner *(continued)*

Inspect/correct flame rod/electrode

- Before installing the burner in the appliance, inspect the flame rod and electrode.
- Verify the dimensions shown in this page.
- If the flame rod or electrode is damaged or not in the correct position, follow the procedure below to access and adjust.

To access the flame rod or electrode

1. If the burner is not installed in an appliance, you can inspect the flame rod and electrode from the front of the burner. To change the position of the flame rod or electrode, you must remove the combustion head/gas manifold assembly from the burner. See “D” thru “H” below.
2. To remove the combustion head/gas manifold assembly, you must disconnect the gas piping and swing the burner flange door open. See Figure 4, and proceed to:
   a. Turn off all power to the burner and appliance before proceeding.
   b. Close the manual gas valve on the gas supply line.
   c. Disconnect the burner gas train union.
   d. Remove the gas pipe at the burner air tube.
   e. Remove the four nuts securing the burner hinged door flange.
   f. Swing the burner open at the door flange.
   g. Remove the two screws holding the gas manifold saddle to the air tube. (Save the gasket.)
   h. Disconnect electrode and flame rod wires then slide the burner combustion head/gas manifold assembly out the end of the open air tube.
3. Position Electrode first — Make sure the electrode is placed according to the dimensions shown in Figure 6. To adjust the electrode, loosen the electrode clamp screw and slide/rotate into position.

   Tighten the electrode clamp screw after positioning. The shim rod welded in the clamp’s v-groove aligns the bracket when tightening.
4. Position Flame rod after setting electrode — Make sure the flame rod is located as shown in Figure 7. To adjust, loosen the flame rod clamp screw. Tighten the screw to secure the flame rod in place.
5. Replace the combustion head/manifold in the air tube.

Figure 4 *Removing combustion head/gas manifold*

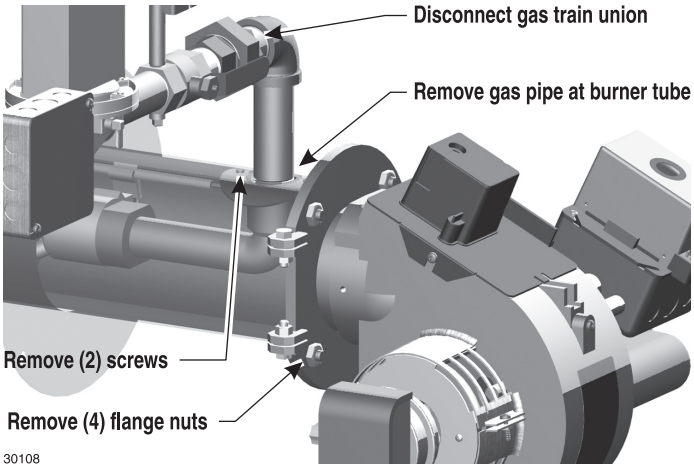


Figure 5 *Combustion head/manifold assembly*

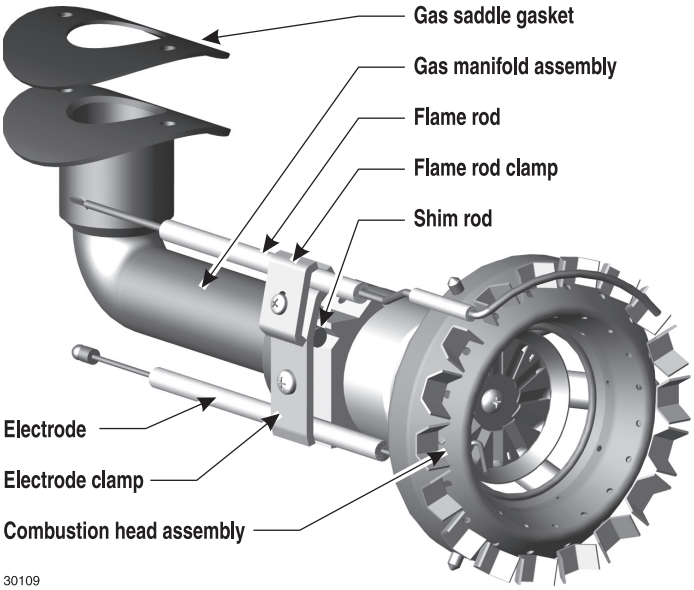


Figure 6 *Electrode location*

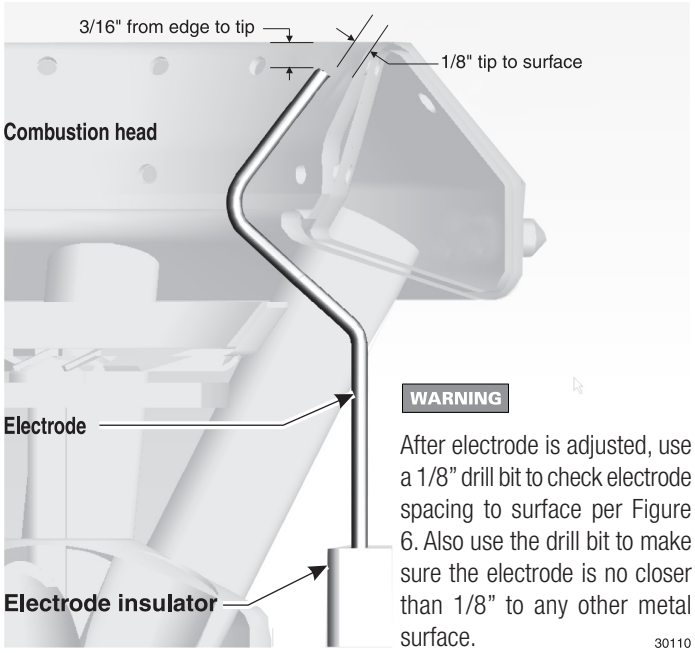


Figure 7 *Flame rod location*

1. Prepare site • prepare burner • mount burner *(continued)*

Mount burner in appliance

- Verify appliance burner front plate dimensions and bolt locations.
- Slide gasket supplied with burner over end of air tube.
- Insert burner into appliance opening and bolt in place.
- Level the housing if necessary by loosening the set screws securing the housing to the air tube. Retighten the set screws.

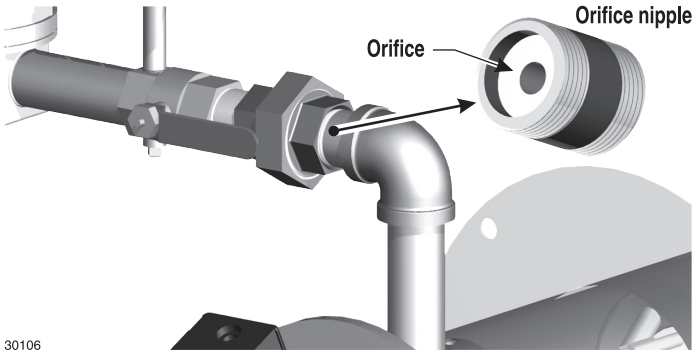
Inspect/redrill gas orifice

WARNING If the burner is installed, you must disconnect power to burner and close main manual gas valve before proceeding. Failure to do so could result in severe personal injury, death or substantial property damage.

WARNING In the state of Massachusetts, when lever-type gas shutoffs are used, they must be T-handle type only.

1. Turn off power to the burner/appliance before proceeding.
2. Close main manual gas valve in gas supply line to burner.
3. Disconnect the burner gas train union if the burner/gas train is installed. See Figures 8 and 9.
4. Locate the correct orifice drill size in Table 1, page 7 (or appliance manual). Then check actual orifice size using that size drill bit.
5. **If the gas orifice is smaller than required,** unscrew the orifice nipple from the elbow. Then redrill the orifice to the correct size. Replace the gas train, using only pipe dope listed for use with liquefied petroleum gases.
6. **If the gas orifice is larger than required,** remove the orifice nipple from the elbow. Obtain a replacement orifice nipple. If necessary, drill the correct orifice hole in the new orifice to the correct size.
7. Replace gas train. Seal pipe joints with a small amount of pipe dope. Use only pipe dope approved for use with propane gas.

Figure 8 *Gas orifice location*



Install gas train on burner

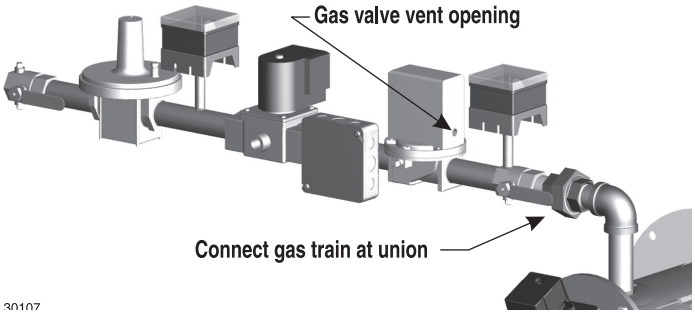
1. The standard burner gas train is shipped fully assembled, with the piping disconnected at the gas train union. See separate instructions if installing an optional knocked down gas train.
2. Connect the gas train at the union (Figure 9).

WARNING To avoid damage to gas train components, do not hold components with a pipe wrench or overtighten. Use only a crescent wrench or other means. Failure to comply could result in severe personal injury, death or substantial property damage.

3. Connect the flexible conduit, pre-attached to the primary control J-box, to the gas train J-box, and attach the wires to the terminal strip inside the gas train J-box.
   a. Match wire colors of the incoming wires to those pre-wired to the terminal strip inside the gas train J-box.
   b. See the label in the burner junction box or the wiring diagram on page 11.

NOTICE Gas valve vent opening — The V48 diaphragm gas valve is fitted with a factory-installed vent liminting orifice in the vent connection. Do not remove or change the size of this orifice. If local codes require, install piping from the vent connection to outside, sized and installed as required by codes.

Figure 9 *Gas train installation*



Inspect components and wiring

- Visually inspect all burner components and wiring.
- Verify that wiring is intact and leads are securely connected.
- Verify that all burner components are in good condition.
- Check gas pressure switch settings. Set the low gas pressure switch at manifold setting minus 50%. Set the high gas pressure switch at manifold setting plus 50%.

2. Install gas piping from meter to combination gas train

Code compliance

The burner/appliance installation must comply with codes listed on page 2 and any other locally applicable codes.

Piping from gas meter to burner

WARNING Connect from the gas supply to the burner gas train inlet using new, clean black iron pipe and malleable iron fittings only. Do not use copper, brass, cast iron or galvanized pipe or fittings.

Provide support for gas piping. Do not rest the weight of the gas piping on burner gas train.

Provide a support for the burner gas train.

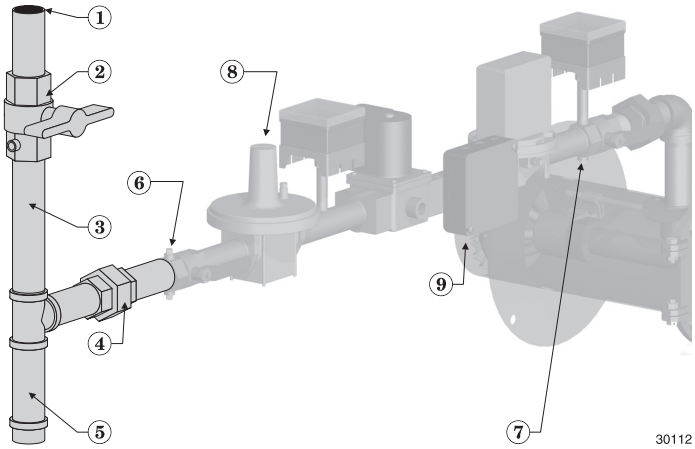
Apply pipe dope sparingly at all joints. Use only pipe dope listed for use with propane gas. Do not use pipe sealing tape.

Do not hold the gas valve with pipe wrench. Use crescent wrench or other smooth-jawed device. Do not overtighten.

Failure to comply with above could result in severe personal injury, death or substantial property damage.

1. If possible, install a new gas line directly from the gas meter. If you are using an existing gas line, verify it is clean and in good condition, and verify it is large enough to handle the load of all connected appliances.
2. When branching from a common gas line, do not tap off from the bottom of horizontal sections — only from the side or top.
3. Install a main manual shutoff valve, sediment trap and ground joint union near the burner combination gas valve connection as shown in Figure 10.
4. If the burner is installed inside an appliance jacket, install the main manual gas valve and sediment trap external to the jacket.
5. Size piping (or verify size) using Table 2. You will find additional information on gas line sizing in the National Fuel Gas Code, NFPA 54/ANSI Z223.1, or B149.1/B149.2 Installation Code for Canadian Installations.

Figure 10 *Connecting gas supply piping to burner*



1 Pipe to meter or branch
2 T-handle main manual gas valve
3 Use clean, burr-free black iron pipe and malleable iron fittings
4 Ground joint union
5 Sediment leg
6 Upstream pressure tap, 1/4"
7 Outlet pressure tap, 1/4"
8 Gas regulator access screw
9 Gas valve wire junction box

Table 2 *Capacities of black iron pipe, cubic feet gas/hour*

NATURAL GAS Capacities in ***Cubic feet per hour*** for Schedule 40 metal pipe					
Pipe size (inches)	Total length of gas piping, from meter to burner connection (feet)				
	20	40	60	80	100
Natural gas @ .60 specific gravity, pressure drop 0.3 in. w.c. (note 1)					
1¼	730	500	400	350	305
1½	1,100	760	610	530	460
2	2,100	1,450	1,150	990	870
2½	3,300	2,300	1,850	1,600	1,400
Natural gas @ .60 specific gravity, pressure drop 0.5 in. w.c. (note 1)					
1	465	320	260	220	195
1¼	950	660	530	460	400
1½	1,460	990	810	690	620
2	2,750	1,900	1,520	1,300	1,150
2½	4,350	3,000	2,400	2,050	1,850

Note 1	For natural gas with specific gravity other than 0.60, consult National Fuel Gas Code, NFPA 54/ANSI Z223.1, or Canadian B149.1/B149.2 for correction factor.

PROPANE GAS Capacities in ***Btuh*** for Schedule 40 metal pipe					
Propane gas @ 1.5 specific gravity, pressure drop 1 psi					
½	1,684	1,157	929	795	705
¾	3,521	2,420	1,943	1,663	1,474
1	6,632	4.558	3,660	3,133	2,776
Propane gas @ 1.5 specific gravity, pressure drop 0.5 in. w.c.					
1	735	506	411	348	308
1¼	1502	1043	838	727	632
1½	2308	1565	1281	1091	980

Gas supply pressure — *natural or propane*

- Maximum supply pressure: **14 inches** w.c.
- Minimum supply pressure: **5 inches** w.c.

WARNING Do not expose the gas train to gas pressure in excess of 14 inches water column. Higher pressure could damage the valve seat, resulting in potentially hazardous condition. When pressure testing piping at higher pressures, disconnect burner from gas line before testing.

If the gas supply pressure can exceed 14 inches water column at any time, you must install a lockup type gas pressure regulator in the gas supply piping, ahead of the main manual gas valve installed at the burner.

Test and purge gas line

Read WARNING above.

Pressure test and purge the line. Pressure testing should be done by the gas supplier or utility, following all applicable codes.

3. Wire burner

Code compliance

The burner/appliance installation must comply with codes listed on page 2 and any other locally applicable codes.

General wiring requirements

WARNING **Read and follow the guidelines below**. Failure to comply could result in severe personal injury, death or substantial property damage.

Electrical shock hazard — Disconnect electrical supply to the burner before attempting to service.

Electrically ground burner — The burner must be grounded in accordance with local codes or, in the absence of local codes, with the National Electrical Code, ANSI/NFPA 70, or CSA C22.1/CSA C22.2 Canadian Electrical Code for Canadian installs.

Label all wires before removing for servicing. Wiring errors could result in unsafe appliance/burner operation.

NOTICE Read appliance manufacturer's instructions completely before wiring burner.

The 60200FR control requires a constant 120 VAC power source from the appliance as well as power from the appliance limit circuit. See Figure 11. Check polarity carefully. If hot and neutral wires are reversed at appliance power source, the control will lockout on flame failure.

If replacing any of the wire supplied with the burner, use minimum #18 AWG 125°C or better.

Verify power supply

1. The burner requires a 120 VAC/60 HZ/single-phase power supply, with at least a 10-amp fuse. The current draw will be (when equipped with typical motor and Carlin 41800 electronic ignitor) approximately:

Approximate amp draw	
Motor →	1/6 HP
During ignition	2.5 AMPS
Steady operation	2.0 AMPS

2. The 120 VAC power connections to the black and red/white wires of the 60200FR must be the same polarity **from the same power source**. DO NOT attempt to supply separate power sources. Check the power from the appliance with a voltmeter. Verify that the supply to the black and red/white wires are from the 120 VAC HOT side and that the power is no less than 102 VAC nor more than 132 VAC.

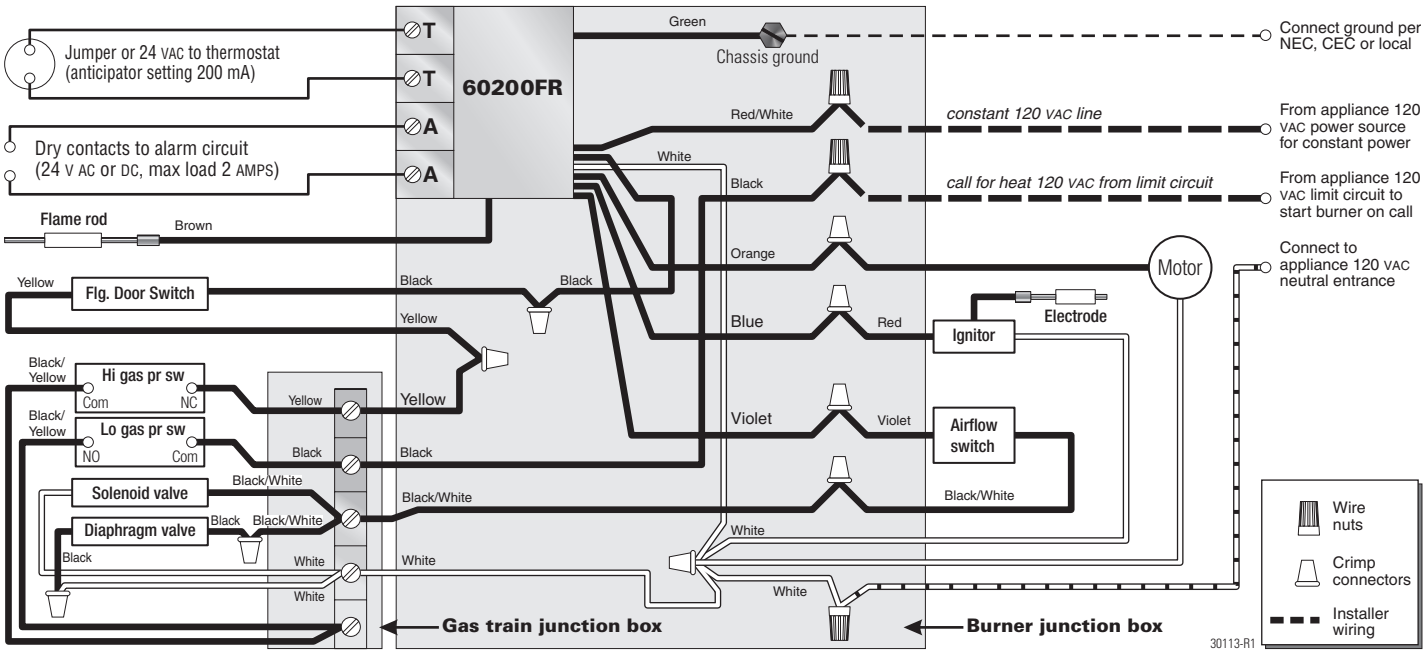
Checking burner flame signal

The 60200FR uses flame rectification to detect the flame. Because the grounded metal surface area near the flame rod is much larger than the surface of the flame rod, current flows through the flame more easily in one direction than the other. This causes an AC voltage applied to the flame rod to result in a DC current. (Note that, if the flame rod should touch a grounded metal part, the current would be AC, not DC, and the control would not sense flame causing a flame failure.)

The 60200FR control has a 3 mm flame signal test jack (next to the terminal block) that can be used with a flame signal meter, such as the Honeywell W136. Or you can use a standard 3 mm stereo plug fitted with two leads (Carlin part number 99017). Connect these leads in series with your ammeter leads to read DC microamps.

The minimum flame signal needed to satisfy the 60200FR sensing circuit is 0.8 microamps. The control will register flame failure at any lower signal.

Figure 11 *Wiring diagram — 301GAS burner with 60200FR primary control*



4. Check system • start-up burner/appliance

Inspect/check system

Before starting the burner and appliance, verify the system has been installed as directed by this manual and the appliance instructions.

Check gas piping for leaks

WARNING Disconnect the burner from the gas supply line if gas line test pressure will exceed 14 inches w.c. Exposing the burner gas train to pressure higher than 14 inches w.c. can damage the valve seat, resulting in potentially unsafe operation.

You can usually test the gas piping by allowing the line to fill with gas to main regulator outlet pressure.

1. Shut off gas flow to all equipment connected to the meter.
2. If test pressure will be less than 14 inches w.c., close the gas train manual gas valve. If test pressure will be higher than 14 inches, remove the burner gas train from the gas line by shutting off the main manual gas valve installed near the burner (per Figure 10, page 10) and disconnecting the ground joint union. See WARNING above.
3. Watch the gas meter dial. For a one half cubic foot per revolution dial, there should be no movement of the dial for at least 5 minutes. For larger volumes per revolution, increase this time proportionately.
4. If you detect a gas leak, locate the leak with a soap suds mixture and repair it. Then test the system for leaks again.

WARNING Do not test for leaks with an open flame. And do not use oxygen as a test gas. Either of these could cause an explosion, resulting in severe personal injury, death or substantial property damage.

Bleed gas line

Purge all air from the gas line. Purge to outside of the building, NEVER into the appliance or burner.

Leak test near-burner gas piping

If piping near burner has not already been pressure tested, open main manual gas valve on supply to burner and smell around area for any signs of gas. Apply a soap suds mixture to all gas piping joints near burner and check for any leaks. If any leaks appear, repair before proceeding and retest.

Set burner air band

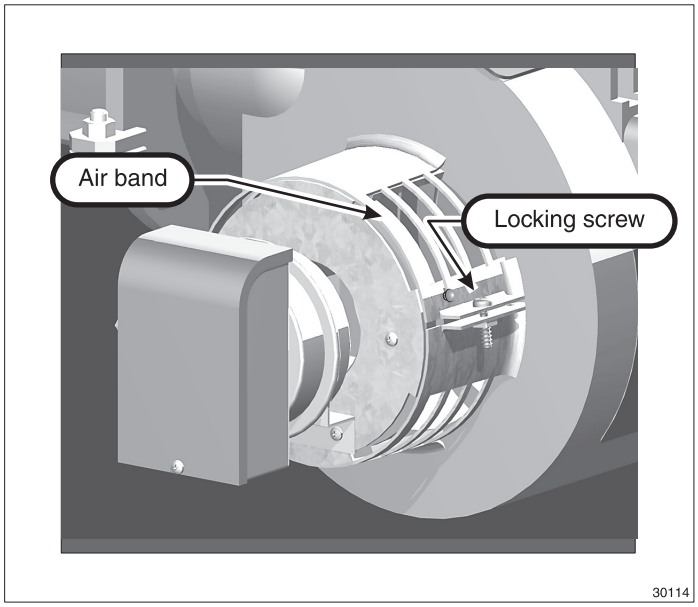
See Figure 12. Loosen air band locking screw. Then rotate band until it is open to the setting given in Table 1 page 7. Tighten air band locking screw.

The Table 1 setting will probably be satisfactory without change. If the combustion test indicates a need for more or less air, however, you will have to adjust the band accordingly.

Check burner and primary control

Inspect burner thoroughly. Verify that hinged ignitor cover plate is closed and screw is tight. Verify all wiring is in place and all components are secure and in position.

Figure 12 *Air band adjustment*



WARNING Do not start the burner if you smell gas or if there may be gas present in the appliance combustion chamber, appliance or the vent system. An explosion could occur, causing severe personal injury, death or substantial property damage.

WARNING During initial start-up, you must be constantly alert for emergency conditions such as fuel leaks, electrical malfunctions, etc. Familiarize yourself with the location of manual shutoff valves and switches so you can quickly use them if needed.

WARNING If the burner fails to ignite, NEVER attempt to manually bypass the normal sequence of the control, which provides purging of the combustion chamber.

Verify flame failure Lockout of 60200FR control

1. Install a hose barb fitting in the manual gas valve pressure tap (item 10a, page 3) and connect with a hose to a U-tube manometer.
2. Close the main manual gas valve and turn the combination gas valve knob to ON.
3. Turn on power to appliance and set appliance limit(s) to call for heat.
4. Burner motor will start. The 60200FR will run for its prepurge timing, then start the ignitor. Approximately one second later, the gas valves will open. (The manometer should show almost no pressure, because the main manual gas valve is closed.)
5. After the Trial for Ignition Period, the 60200FR will lockout and turn on the red LED. The ignitor will shut off and the gas valve will close. Turn off power and set controls to stop call for heat.
6. If Lockout does not occur, replace the 60200FR control.

4. Check system • start-up burner/appliance *(continued)*

WARNING Should overheating or an emergency occur, immediately:

- Shut off main manual gas valve.
- Shut off control switch to burner.

Under some circumstances power should remain on for circulating blowers or other equipment. Determine proper response before attempting start-up.

If burner fails ignition on several attempts, close gas valve and use burner blower to purge appliance before restart.

Model 60200FR diagnostic LED's

Ⓐ – Amber **OFF** Ⓡ – Red **OFF** Ⓖ – Green **OFF**
Ⓐ – Amber **ON** Ⓡ – Red **ON** Ⓖ – Green **ON**
Ⓐ – Amber **FLASHING** Ⓡ – Red **FLASHING**
Ⓐ – Amber **BLINKING** (blinks off momentarily every 3 to 4 seconds)

NOTICE Please see 60200FR control label for trial for ignition (TFI) and purge timings.

Start-up & operation

WARNING Do not start the burner if the combustion chamber contains residual gas. Allow gas to disperse.

NOTICE Per UL requirements, the control will not turn on if the flame rod senses flame during the self-test. If the flame rod senses flame, the green LED turns on. The control will remain in self-test mode until the flame rod no longer senses flame. The amber LED will remain on, but blink off momentarily Ⓐ every 3 to 4 seconds.

Ⓐ Ⓡ Power ON Open all manual gas line valves. Close the line switch. (If Red LED turns on constant Ⓡ, control is in lockout. See below to reset.)

Ⓐ Ⓡ Self-test 1 The control performs a "boot-up" test to verify internal operation each time power is applied to the red/white wire. About 4 seconds after power application, the amber LED turns on. The test continues for about 6 more seconds. If the test fails, the control turns the amber LED off and repeats this test sequence until successful.

Ⓐ Ⓡ Stand-by (No call for heat) If Self-test 1 is successful, amber LED turns off and control waits for heat call.

Ⓐ Ⓡ Call for heat Set operating control and all limit controls to call for heat. The 60200FR thermostat circuit must be closed (jumpered) and power coming to black wire from limits.

Self-test 2 The amber LED turns on. For the first 3 to 4 seconds, the control performs a self-test. If the flame rod senses flame, the green LED turns on. The control repeats the self-test until flame is no longer detected (green LED would turn off). During this time, the amber LED will remain on, but blink off momentarily Ⓐ every 3 to 4 seconds. If the control detects motor contacts closed or power to the gas valve, lockout occurs.

Ⓐ Ⓡ Burner on After the self-test, the amber LED turns off. The ***motor*** starts.

Ⓐ Ⓡ Pre-purge The ***ignitor*** starts after the pre-purge period. Two seconds later, the ***gas valve*** opens. The 2-second delay (ignition establishment period) helps ensure a stable spark is in place when the gas valve opens (to compensate for sluggish response of some AC ignition transformers).

Ⓐ Ⓡ TFI After gas valve opens, the flame rod must sense flame within the TFI time limit (trial for ignition). The green LED turns on Ⓖ at the end of the TFI if the flame rod senses flame.

Ⓐ Ⓡ Ⓖ Run The burner continues firing during call for heat if the flame rod senses flame. Amber and red LED's are off and green LED is on during normal running.

Ⓐ Ⓡ Ⓖ Lockout If the flame rod does not sense flame within the TFI time limit after gas valve activation, **lockout** occurs. The control turns the red LED on constant, and closes the ***alarm*** contact. Green LED is off.

To **Reset** Push in and hold reset button for 1 second, then release.

Ⓐ Ⓡ Ⓖ Latch-up If the control locks out **3 times** during a single call for heat, **latch-up** occurs. The control turns on both the amber and red LED's constant. You must use the special procedure below to reset the control after latch-up.

WARNING **Reset from latch-up — *Only a qualified service technician should attempt to reset the control after latch-up. The problem that caused the repeated burner problems must be corrected before returning the burner to normal operation.***

Ⓐ Ⓡ Ⓖ Push in and hold the reset button for about 10 seconds. The red and amber LED's will flash alternately.

Ⓐ Ⓡ Ⓖ After the LED's begin flashing, continue to hold the reset button for about another 20 seconds. The LED's will turn off. Release the reset button and the control will restart. (Releasing the button before the LED's turn off will cause the control to remain in latch-up.)

NOTICE The 60200FR control will not reset from lockout or latch-up if power is interrupted.

Ⓐ Ⓡ Flame failure If the flame rod loses flame signal during operation (after the TFI), the red LED flashes. The ***gas valve*** closes within 2 seconds. The ***motor*** remains on for the post-purge period, then shuts off. **Recycle**: Control waits for 65 seconds (with red LED flashing), then begins again at **Self-test 2**. Red LED goes off Ⓡ.

(NOTE: Controls with non-recycle feature will lock out on flame failure.)

Ⓐ Ⓡ Post-purge Set operating control(s) and limit(s) to stop call for heat. The ***gas valve*** will turn off within 2 seconds. The ***motor*** remains on for the post-purge period, then turns off.

Ⓐ Ⓡ Stand-by Control remains in stand-by mode until limit circuit sends power to the black wire and thermostat circuit closes (or jumpered) — (call for heat).

5. Perform checkout procedures • fill out certificate

Installer/servicer

Please check off and fill in certificate

❑ After completing start-up and testing or service, fill out the certificate on page 24.

WARNING Should overheating or an emergency occur, immediately:

- Shut off main manual gas valve.
- Shut off control switch to burner.

Under some circumstances power should remain on for circulating blowers or other equipment. Determine proper response before attempting start-up. If appliance fails ignition on several attempts, close gas valve and use burner blower to purge appliance before restart.

Preparation before checkout

❑ Burner/appliance installed per appliance instruction manual?

❑ Burner components verified against Table 1, page 7?

❑ Burner/appliance installed per all applicable codes?

❑ Installation site has adequate ventilation openings and vent system?

❑ Gas supply line in good condition and sized correctly?

❑ All gas line joints sealed with pipe dope listed for use with liquefied petroleum gases?

❑ Gas supply pressure to gas valves checked?

❑ Regulator installed if pressure can exceed 14 inches w.c.?

❑ Air purged from gas line?

❑ Gas piping checked for leaks?

❑ Wiring installed per burner manual and appliance instructions?

❑ Burner inspected and primary control flame failure lockout checked?

❑ Start-up sequence performed (page 13)?

Make final burner adjustments

Check for leaks in gas piping

❑ Smell around burner to make sure there is no gas leak in near-burner piping. Verify integrity of gas line joints between combination gas valve and burner gas inlet tapping using soap suds mixture.

Check/adjust gas valve outlet pressure

❑ With burner running, check manometer reading for combination gas valve outlet pressure. Adjust valve regulator if necessary so the reading is 3.5 inches w.c. for either natural gas or propane gas.

Make final burner adjustments *(continued)*

Inspect flame

❑ Look at flame through appliance observation port. The flame should be a soft blue with well-defined orange and yellow tips for natural gas, or well-defined yellow tips for propane gas. (If you make air or gas pressure changes later, inspect the flame again.)

Check the firing rate

❑ Natural gas only — Turn off all other gas appliances connected to the gas meter. Use a stopwatch to time the number of seconds for a flow of one cubic foot of gas (two revolutions for a one half cubic foot per revolution dial, for example). You will also need to know the gas heat content in Btu per cubic foot. Determine the actual input from: INPUT = (3600 x Btu per cubic foot) ÷ (number of seconds for one cubic foot), for firing rate in Btuh. For example, for 1050 Btu per cubic foot natural gas, with meter timed at 15.1 seconds for one cubic foot of gas: INPUT example = (3600 x 1050) ÷ (15.1) = 250,500 Btuh. Firing rate should be within ± 5% of rated input for the appliance. Adjust the combination gas valve pressure regulator if necessary to obtain the correct firing rate. Valve outlet pressure must not be lower than 3.2 inches w.c. nor higher than 3.8 inches w.c.

❑ For propane gas, contact your propane supply for procedure to verify firing rate.

Check combustion using instruments

WARNING Do not attempt to confirm combustion simply by inspecting the flame visually. You must use combustion test instruments. Failure to properly verify/adjust combustion could allow unsafe operation of the burner, resulting in severe personal injury, death or substantial property damage.

❑ Insert a test probe into appliance vent outlet to sample flue products. The results should show CO_2 or O_2 as follows:

Fuel	CO_2		O_2	
	Minimum	Maximum	Maximum	Minimum
Natural Gas	8.5%	10.0%	6.2%	3.5%
Propane Gas	9.5%	11.2%	6.0%	3.5%

❑ If the combustion results are outside the range above, and the firing rate of the burner is within 5% of rated input, open or close the air band until the CO_2 (or O_2) are acceptable.

WARNING After CO_2 (O_2) tests are completed satisfactorily, measure flue products for carbon monoxide (CO) concentration. The CO must not exceed 50 ppm adjust to “air free”, or other if specified by local codes.

❑ Check overfire pressure in the appliance. Refer to the appliance manual for recommended reading and barometric damper instructions for proper setting of damper, when used.

5. Perform checkout procedures • fill out certificate *(continued)*

Verify burner/appliance operation

Check burner/appliance/controls operation

❑ Test operating and limit controls on appliance as specified in appliance instruction manual.

❑ Check operation of the 60200FR primary control by forcing Latch-up (three consecutive lockouts during the same call for heat): Close the main manual gas cock. Temporarily jumper the low gas pressure switch. Then cycle the burner. Press the reset button to reset when the 60200FR control locks out on flame failure. Do this two times and the control should enter Latch-up. See page 13 to reset control. Remove the jumper from the low gas pressure switch.

❑ Check the airflow switch

Cycle the burner off with the appliance controls. Then turn off power to the appliance. Remove both of the sensing lines from the airflow switch by loosening the plastic sealing nuts and pulling the aluminum sensing tubes out of the socket.

With the sensing line removed, turn on power to the appliance and set the controls to call for heat. Watch the manometer on the manual gas valve outlet pressure tap. After the control performs its pre-purge, it will try to turn on the gas valves. The gas valves should not open with the airflow sensor line removed. Set the controls to stop the call for heat and turn off power to the appliance. If the airflow switch operates correctly (gas valves don't open), continue with normal operation. If the ariflow switch fails to operate correctly, replace the switch and retest.

WARNING NEVER attempt to adjust the air pressure switch setting. This could allow unsafe operation of the burner, resulting in potential of severe personal injury, death or substantial property damage.

❑ Check gas pressure switches

❑ High gas pressure switch —

Cycle the burner off with the appliance controls and turn off power to the appliance/burner.

Attach a manometer to the manifold-side manual gas valve test port.

Turn on power and cycle the burner on with the appliance controls.

Measure the manifold gas pressure with the manometer.

Set the high gas pressure switch to a pressure less than actual manifold pressure. The high gas pressure switch should shut the burner down. Replace the switch if necessary.

Turn off power to the appliance/burner; remove the manometer and replace the plug in the gas valve test port.

❑ Low gas pressure switch —

Cycle the burner off with the appliance controls and turn off power to the appliance/burner.

Close the main manual gas valve.

Cycle the burner on.

The low gas pressure switch should shut the burner down. Replace the switch if necessary.

Turn off power to the appliance/burner.

Open the main manual gas valve.

❑ Check flange door switch

Cycle the burner off with the appliance controls and turn off power to the appliance/burner.

Remove the nuts securing the hinged flange and swing the flange open.

Attempt to cycle the burner with the appliance controls.

The flange door switch should prevent the burner from operating. Replace the switch if necessary.

Close the flange door and replace the nuts.

Verify burner operation

❑ Start and stop the burner several times, allowing the primary control to sequence through normal operation. Verify correct operation of burner and controls throughout, including the burner door switch and high and low gas pressure switches.

Verify vent system operation

❑ Verify vent is operating correctly and flue products are properly exhausted from building.

❑ Check operation of barometric damper and spill switch.

❑ If the building contains any exhaust fans or conditions that could affect vent performance, check burner/appliance/vent operation with exhaust fans (or other conditions) operating.

Prepare the burner for normal operation

❑ Cycle burner off with appliance controls. Then turn off power to the appliance.

❑ Close the main manual gas valve.

❑ Verify all components and wires are in place and burner is ready for operation.

❑ When all tests and checks are completed, restore the burner and appliance to normal condition for operation.

❑ Start the burner again to verify proper operation before leaving.

Train the user

❑ Train the user to operate the burner and appliance under normal conditions. Explain procedure to shut down burner/appliance when required.

❑ Review the user information manual (and the appliance instructions) with the user.

❑ Verify the user is aware of all procedures specified in the manual.

❑ Verify user will not store or use combustible liquids or materials or contaminants in the vicinity of the burner/appliance.

6. Maintenance and service procedures

Annual start-up & service

WARNING This burner should be started and serviced at least annually by a qualified service technician. Failure to properly maintain and service the burner could result in severe personal injury, death or substantial property damage.

WARNING Turn off power to appliance and close main manual gas valve when servicing burner. See warnings on page 2 and elsewhere in this manual regarding correct procedures. Failure to comply could result in severe personal injury, death or substantial property damage.

Annual start-up and service procedures

- ❑ Discuss burner/appliance operation with user to determine any problems that may have occurred during the previous season and to verify user is aware of proper operation and care of the burner/appliance.
- ❑ Turn off power to appliance and close main manual gas valve.
- ❑ Remove the burner from the appliance and inspect the combustion head assembly, ignitor electrode and flame rod (see page 8). Adjust if necessary as described on page 8.

NOTICE If the air tube or combustion head needs to be cleaned, clean with a vacuum cleaner with brush attachment with the combustion head assembly assembly out of the burner.

- ❑ Verify that the hinged ignitor cover plate is closed and the screw is tight.
- ❑ Verify that the air tube flanged door is securely closed and the bolts are tightened.
- ❑ Check the burner flange gasket. It must be in good condition. Replace gasket on burner flange and mount burner in appliance, securing to mounting studs.
- ❑ Perform the complete checkout procedures of pages 12 through 15, including system inspection and checks.

Maintenance/service procedures

Cleaning blower wheel

1. The blower wheel accumulates dust and debris from normal operation. You will need to clean the wheel blades periodically to prevent reduction in airflow. To clean blades, remove the two bolts securing the motor to blower housing.
2. Slide the motor out and rotate to remove and access blower wheel.
3. Use a brush and vacuum to clean each blade and the blower housing interior.
4. Replace motor/wheel in blower housing and secure with the two bolts.
5. Push wire slack back into junction box.

Replacing blower motor or wheel

1. If either the blower wheel or motor must be replaced, remove the two bolts securing the motor to housing.
2. Disconnect the motor wires in the burner junction box.
3. Loosen the Allen screw securing the blower to the motor shaft and remove the wheel.
4. When assembling the replacement assembly, slide the wheel onto the motor shaft and use feeler gauges to set a space of 1/8 inch between the blower wheel and the motor face.
5. Replace the motor/wheel assembly in the housing, wire the motor leads and secure the motor with the two bolts.

Motor maintenance

The motor is constructed with permanently-lubricated bearings, and requires no oiling. Should you replace the original motor with another type of motor, occasional oiling may be required, depending on motor design and manufacturer's recommendations.

WARNING Any time you replace a component or disassemble any part of the burner for service/maintenance, perform a complete operational test after reassembly to verify the burner operates correctly. Failure to verify operation could result in severe personal injury, death or substantial property damage.

7. Troubleshooting

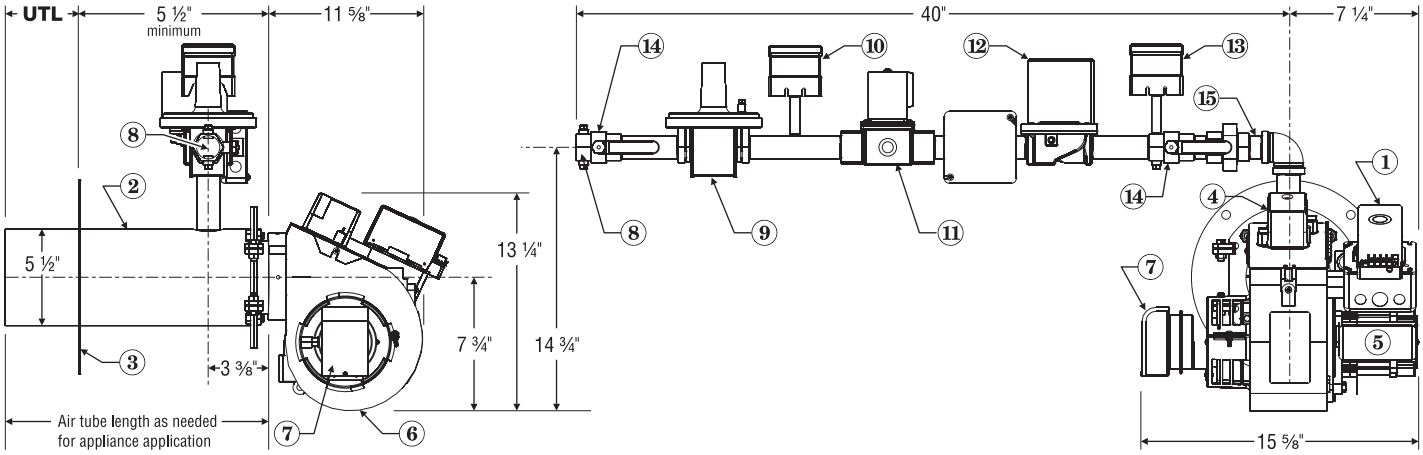
Problem	Possible cause	Corrective action
WARNING		These procedures must only be performed by a qualified service technician. Use care when performing tests on electrically or mechanically live parts. Disconnect power to burner/appliance and close main manual gas valve when removing components for service. Failure to comply could result in severe personal injury, death or substantial property damage.
Burner motor will not start	120 VAC power circuits	Check voltage and polarity at entrance to appliance and burner. Check fuse or breaker protecting circuit. Check appliance limit circuit — are controls calling for heat? Check electrical connections.
	Primary control is in Lockout	Red LED will be on. Press the reset button for 1 second. If red LED comes back on in a couple of seconds, probably either there is voltage present to the gas valve or the motor relay contacts are stuck in the closed position. The Safety Monitoring Circuit causes lockout if this occurs. If there is no voltage present at the gas valve (using a voltmeter), replace the control. If there is voltage at the gas valve, check all wiring for accuracy. Replace the control if the 60200FR gas valve wire shows 120 VAC when disconnected from the burner wiring.
	Primary control is in Latch-up	Red and amber LED's will both be on. See page 13 for the procedure to handle this condition. When resetting the 60200FR control from Latch-up, be sure to investigate what caused the repeated failures. Correct the condition.
	Incorrect wiring	Check wiring against appliance and burner wiring diagrams. Verify all connections are secure.
	Defective motor	Remove motor leads from the burner junction box and apply power directly. If motor fails to operate, then replace.
	Defective primary control	If control receives power to both the black and red/white wires, but doesn't start the motor, the control may be defective. Replace control.
	Flange door switch	Make sure flange door is closed securely and that door switch is closed.
	Gas pressure	Check low gas pressure switch. If it is open, gas supply may be too low or no gas flow — check supply line and manual valves. Gas train inlet pressure should be at least 5" w.c. when burner is operating. Check high gas pressure switch. It should be closed. If it is open, gas pressure to manifold may be too high.
Repeated flame failures — burner won't light	Airflow problem	Check air band setting against Table 1, page 7. Reposition to correct setting if necessary. Check blower wheel to verify it is turning.
	Gas orifice	Check gas orifice size. See Table 1, page 7.
	Manifold pressure	Check gas manifold pressure — should be between 3.2 and 3.8 inches w.c.
	Ignition — no spark or poor spark	Check wire connections to ignitor electrode at primary control and electrode end. Check position of ignitor electrode per page 8. Adjust if needed. Check voltage to ignitor. If ignitor receives 120 VAC and doesn't generate spark, replace ignitor.
	Gas valves not opening	Check gas supply pressure to gas train. Pressure in excess of 14 inches w.c. will cause valves to lockup. Check voltage to gas valves. Are gas valves receiving 120 VAC? If gas valves are receiving 120 VAC and not opening, and gas supply pressure is below 14 inches w.c., replace gas valve(s).
	Airflow switch	Check electrical connections and sensing connections to airflow switch. If blower operates, check across switch to see if it makes. If switch is correctly connected, but won't close, replace airflow switch. To verify switch is receiving signal, connect a manometer across the sensing lines.
	Primary control defective	Check voltage to gas valves during TFI. If no voltage to valves, replace the primary control.

7. Troubleshooting *(continued)*

Problem	Possible cause	Corrective action
WARNING		These procedures must only be performed by a qualified service technician. Use care when performing tests on electrically or mechanically live parts. Disconnect power to burner/appliance and close main manual gas valve when removing components for service. Failure to comply could result in severe personal injury, death or substantial property damage.
Burner lights, but locks out after TFI	Insufficient flame signal	The flame signal at the 60200FR test jack must be at least 0.8 microamps. Check following if signal is lower. Flame rod may be touching ground, insulator may be broken, or contamination may cause a path to ground. Inspect and clean if necessary. See page 8 for more information. Check the flame rod position in burner per page 8. Adjust if necessary. The flame rod must be correctly positioned for best flame signal.
	Airflow	Check air band setting against Table 1, page 7.
	Orifice size	Check gas orifice size. See Table 1, page 7.
	Manifold pressure	Check gas manifold pressure — should be between 3.2 and 3.8 inches w.c.
	Low gas supply pressure	Check line pressure at gas train entrance. Gas pressure must be at least 5 inches w.c. — If other appliances are on the same line or regulator, and burner pressure drops when they are on, the line is undersized. Contact your gas supplier. If gas pressure is always low, check the supply regulator setting and adjust if necessary. Inlet gas pressure must not exceed 14 inches w.c.
	Improper draft	Over-fire draft should not be higher than specified in the appliance manufacturer's instructions. Follow the appliance manual instructions to troubleshoot excess overfire pressure or poor draft problems if necessary.
	Flame rod grounded	Check flame rod and insulator. If the flame rod is grounded in any way, the control will lockout after the trial for ignition.
	120 VAC polarity	Check the power supply polarity. If hot and neutral wires are reversed, the flame rod circuit cannot sense flame correctly. The 60200FR control will lockout after the trial for ignition.

8. Dimension and mounting information

Figure 13 *Dimensional data*



1	Carlin 60200 primary	6	Cast aluminum housing	11	Secondary gas valve
2	Air tube	7	Air flow switch	12	Primary gas valve
3	Flange (welded shown)	8	Gas connection, 1″ NPT	13	High gas pressure switch
4	Carlin 41800 ignitor	9	Gas pressure regulator	14	Manual gas cocks
5	Carlin PSC motor	10	Low gas pressure switch	15	Orifice nipple

Mounting burner to appliance

WARNING Positive overfire pressure applications: When firing with positive overfire pressure, do not exceed the pressure specified in the appliance manual.

Positive overfire pressure reduces maximum burner capacity. See Table 1 notes for estimated reduction in burner capacity with pressurized firing.

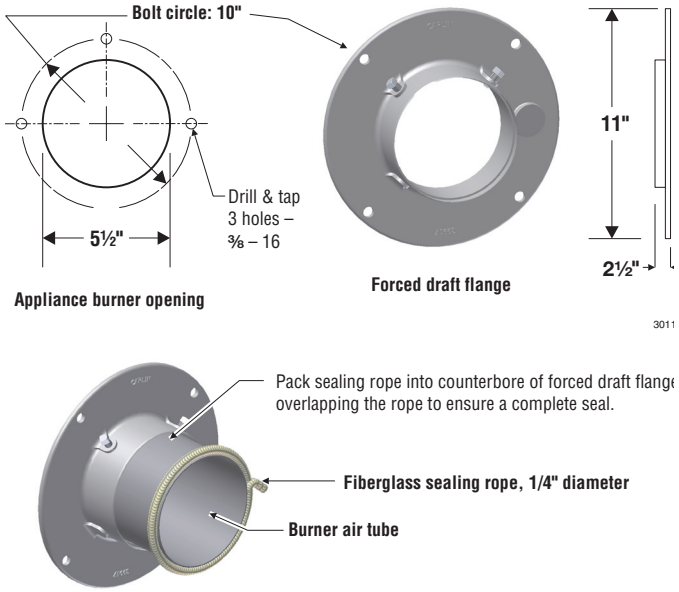
When using the adjustable flange, follow the steps in Figure 14 to prepare for pressurized firing.

Failure to comply could result in severe personal injury, death or substantial property damage.

When using a welded flange burner, verify the insertion depth on the appliance and burner (see page 7).

If using the adjustable flange (Figure 14), measure the appliance insertion depth to the set the position of the flange on the air tube. Tighten the flange locking screws firmly. Prepare the appliance opening to the dimensions shown in Figure 14. Also read page 7.

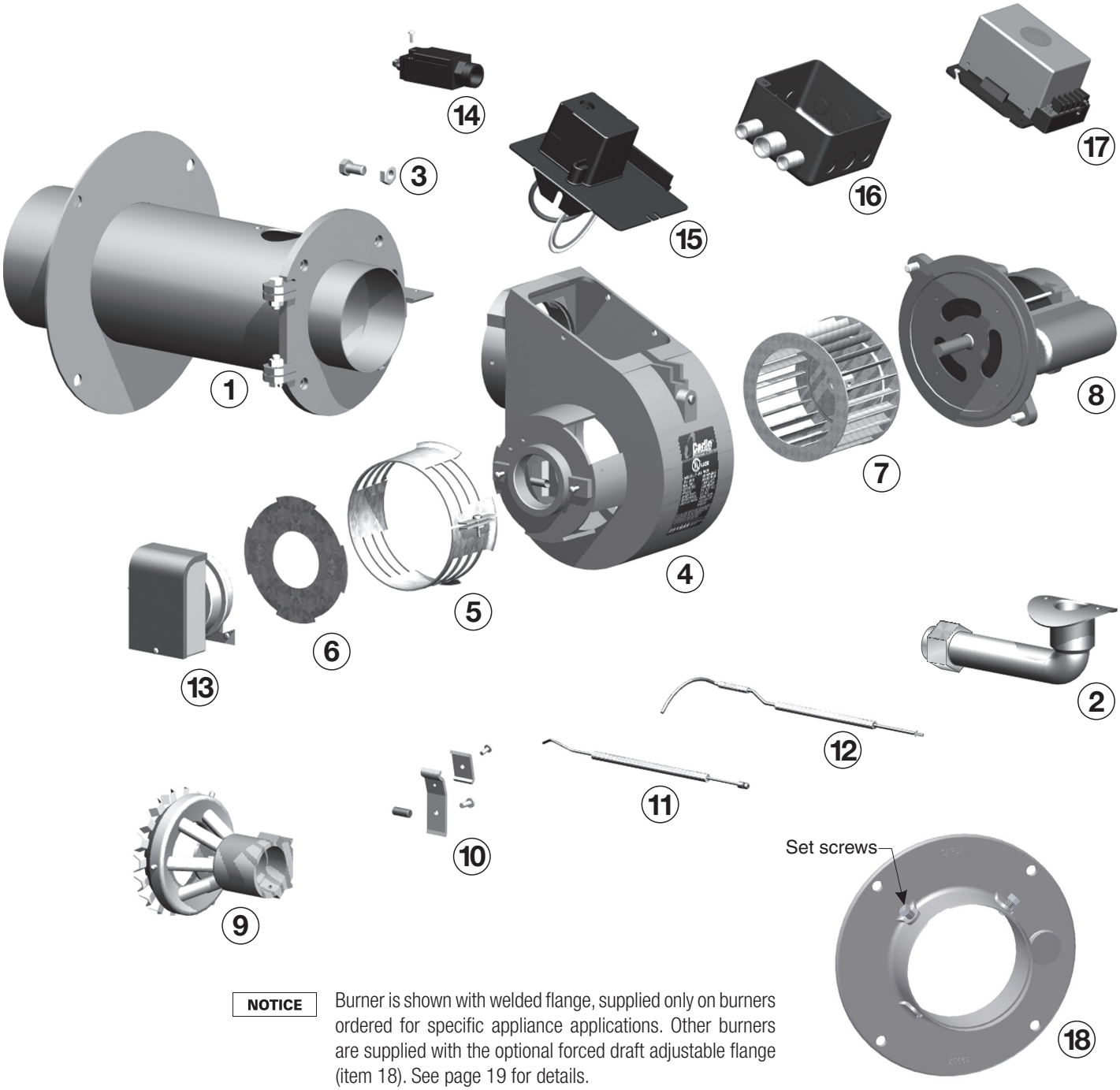
Figure 14 *Adjustable flange mounting information*



9. Replacement parts – Burner

Item number	Description	Part number
1	Air tube with gasket and flanged door assembly; welded appliance flange shown (specify appliance application and overall length of air tube) — “B” and “C” combustion head/tube assemblies available	Consult factory
2	Gas manifold (specify overall length of air tube and input range required)	Consult factory
3	Flanged door nuts (four required)	28357
4	Blower housing (with scroll extension and pressure augmenter)	NA
5	Air band (four-slot)	47001S
6	Air shutter, low input range (“B” head/tube) Air shutter, mid input range (“C” head/tube)	99254 99278
7	Blower wheel, 5¾“ diameter x 4“ deep	28563S
8	Motor, Carlin PSC, 1/6 hp, 3450 RPM	98611S
9	Combustion head assembly, “B” head Combustion head assembly, “C” head	99164 99277
10	Electrode/flame rod bracket assembly	99153KIT
11	Ignitor electrode	99158
12	Flame rod	99161
13	Airflow switch and mounting plate assembly (sensing lines not shown, but included with kit)	98521KIT
14	Door interlock switch and mounting screws	99261KIT
15	Ignitor, Carlin electronic Model 41800	4180002C
16	Burner junction box, 4" x 4", with grommet, lock washer, conduit nipples (to burner housing)	99198KIT
17	Primary control, Carlin 60200FR microprocessor flame rod control	602002FR943S
18	Optional adjustable forced draft flange	99255

9. Replacement parts – Burner *(continued)*

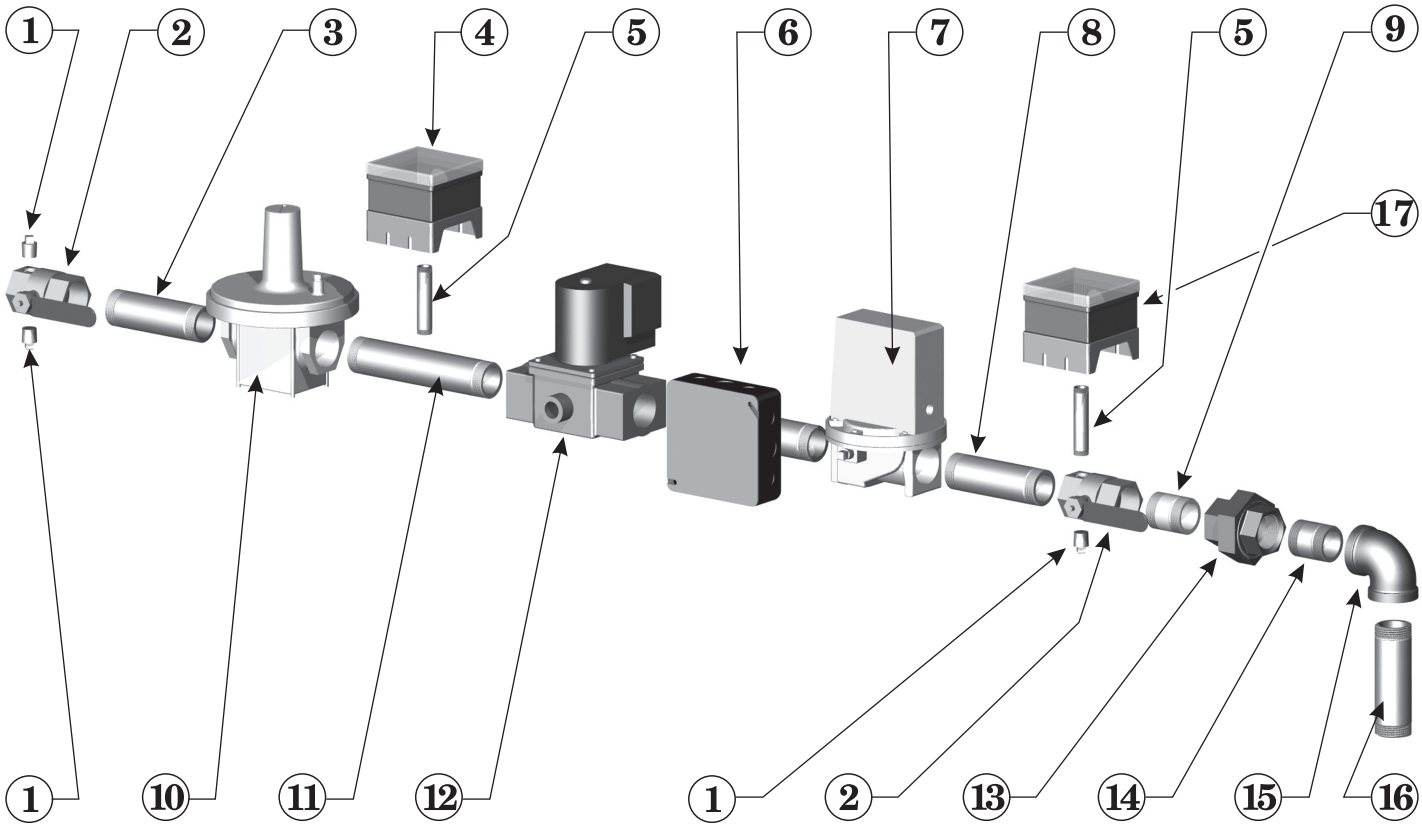


NOTICE Burner is shown with welded flange, supplied only on burners ordered for specific appliance applications. Other burners are supplied with the optional forced draft adjustable flange (item 18). See page 19 for details.

9. Replacement parts – Gas train

Item number	Description	Part number
1	Pipe plug, 1/4″ NPT (3 required)	Obtain locally
2	Gas cock, 1″ NPT	99225
3	Pipe nipple, schedule 40 steel, 1″ NPT x 2″ long	Obtain locally
4	Low gas pressure swtich	99234
5	Pipe nipple, schedule 40 steel, 1/4″ NPT x 2″ long	Obtain locally
6	Pipe nipple, schedule 40 steel, 1″ NPT, with 4 x 4 junction box	99517
7	Primary gas valve, Honeywell V48A, 1″ NPT Bleed restrictor, fixed	99227 99228
8	Pipe nipple, schedule 40 steel, 1″ NPT x 4″ long	Obtain locally
9	Pipe nipple, schedule 40 steel, 1″ NPT x 2″ long	Obtain locally
10	Gas pressure regulator, 1″ NPT, Maxitor RV-61 Vent limiting orifice	99233 Apply local codes
11	Pipe nipple, schedule 40 steel, 1″ NPT x 6″ long, with 1/4″ NPT tapping	99239
12	Secondary gas valve, Honeywell V4295A, 1″ NPT	99229
13	Union, black iron, 1″ NPT	Obtain locally
14	Orifice nipple: 1″ NPT schedule 40 steel x 2″; with orifice plug (with starter orifice, 9/32″ drill)	9925020
15	Pipe elbow, 90° black iron, 1″ NPT	Obtain locally
16	Pipe nipple, schedule 40 steel, 1″ NPT x 3″ long	Obtain locally
17	High gas pressure switch	99235

9. Replacement parts – Gas train *(continued)*



Installation/service certificate

Installation data

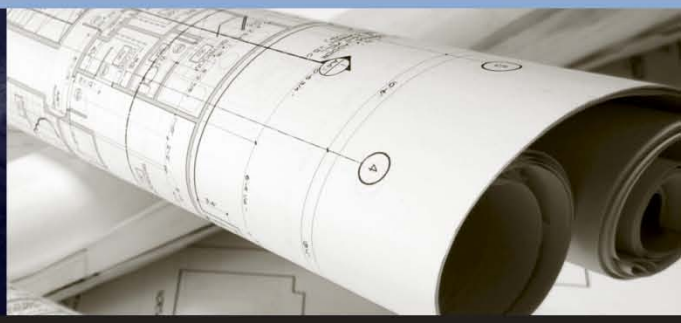
Burner model	Serial number	Measured firing rate, Btuh	Gas orifice drill size	Manifold gas pressure, IWC	Inlet gas pressure, IWC
CO2%	O2%	Fuel (natural or propane)	Were are controls tested?		
Comments about installation/start-up:					
Installer's name:	Company name:		Company address:		Phone:

Service history

Date	Technician	Company/address	Describe work performed

RDK ENGINEERS

APPENDIX B: CHILLER EQUIPMENT DATA SHEETS



RDK ENGINEERS

BUILDING SYSTEM ASSESSMENT
AIR COOLED CHILLER

Unit Tag CH-1

BUILDING: Acton Town Hall **FLOOR:** Ground Flr **Date** 01/24/11

SYSTEM TYPE: Air Cooled Chiller/Split **YEAR INSTALLED:** 1987 **INSP. BY:** MWT

MANUFACTURER: Trane **MODEL** CCACC-M-1-306

SIZE 40 tons **HP** **V** 208/3ph

SERIAL # L87J04483

SYSTEM DETAILS:

☑ Reciprocating	☐ To AHU	☐ Compressor Heater
☐ Centrifugal	☐ To Heat Pump	☐ Refrigerant
☐ Axial	☐ To Chiller	☐ Condenser Water
☐ Blow-thru	☐ Head Pressure Control	☐
☐ Draw-thru	☐ 3-Way By Pass	☐

SERVICED: ☑ IN HOUSE ☐ CONTRACTOR

EQUIP. DATA SHEETS AVAILABLE: Y ☐ N ☑ **COLLECTED:** Y ☐ N ☑

Equipment Location:	Observations/Deficiencies:	Comments:
☑ Equipment Room	☐ In need of repair or service:	FCI = _____(Repair $ ÷ Replace $)
☐ Within Space Served	☑ End of Useful Service Life: 20+yrs	
☐ Rooftop Equipment	☐ Code Violation	
☐ Tunnel	☐ Energy Conservation:	
☐ At grade		

WHAT TO LOOK FOR:

EXISTING CONDITIONS & DEFICIENCIES

Y	N	N/A		Y	N	N/A		Y	N	N/A	
☐	☐	☑	Rust on Equipment	☐	☐	☐	Control valve open?	☐	☐	☑	
☐	☐	☑	Excessive Vibration	☐	☐	☐	Coil condition poor/rust	☐	☑	☐	
☐	☐	☑	Fan Belt in poor condition	☐	☐	☐	Temp of Cond. Pipe _____F	☐	☐	☑	
☐	☑	☐	Bare Pipe/No Insulation/Sweating	☐	☐	☐		☐	☐	☐	
☐	☐	☑	Ambient noise Ok?	☐	☐	☐		☐	☐	☐	
☐	☑	☐	Access door leaks?	☐	☐	☐		☐	☐	☐	
☐	☑	☐	Balancing valve set?	☐	☐	☐		☐	☐	☐	
☐	☐	☑	Operators (valves) working?	☐	☐	☐		☐	☐	☐	

END OF USEFUL EQUIPMENT LIFE: See Table Below

Unit is	years old vs.	20	year benchmark	Controls are	years old vs.	16	year benchmark
Motor is	years old vs.	17	year benchmark	Coil is	years old vs.	0	year benchmark

CODE ISSUES: See Notes Below

Y	N	N/A		Y	N	N/A		Y	N	N/A	
☐	☑	☐	Refrigerant Management Records	☐	☐	☐		☐	☐	☐	
☐	☐	☐		☐	☐	☐		☐	☐	☐	

ENERGY CONSERVATION: See Table Below

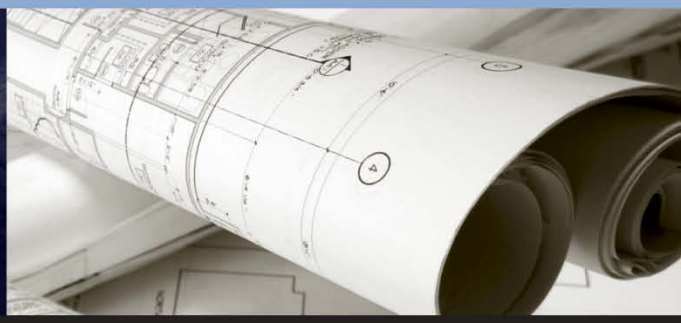
Y	N		Y	N		Y	N	
☐	☑	Low ambient in use	☑	☐	Constant volume fan	☐	☑	Retrofit to CHW
☐	☑	Waterside Economizer Cycle in use?	☑	☐	24 hr/day operation	☐	☐	

NOTES

1)
2)
3)
4)
5)
6)
7)
8)

RDK ENGINEERS

APPENDIX C: BALANCING REPORT



E. L. BARRETT
COMPANY, INC.

HVAC TESTING & BALANCING
SURVEYS & EVALUATIONS
CONSULTING SERVICES

SURVEY

PROJECT: ACTON TOWN HALL
472 MAIN STREET
ACTON, MA

ENGINEER: RICHARD D. KIMBALL CO., INC.
BOSTON, MA

CONTRACTOR: RICHARD D. KIMBALL CO., INC.
BOSTON, MA

ELB CO. JOB #: 3701

1147 HANCOCK STREET ● SUITE 201 ● QUINCY, MA 02169
TELEPHONE (617) 770-9990 ● FAX (617) 770-9075

E. L. BARRETT
COMPANY, INC.

HVAC TESTING & BALANCING
SURVEYS & EVALUATIONS
CONSULTING SERVICES

March 31, 2011

Richard D. Kimball Company, Inc.
70 Fargo Street, Suite 800
Boston, MA 022101964

Attn: Mr. Michael Travers
Sr. HVAC Energy Engineer

Re: Survey: Acton Town Hall
472 Main Street
Acton, MA

Gentlemen:

Enclosed please find one (1) copy of the data obtained during our recent survey performed at the above referenced project. We have also enclosed annotated drawings.

The following items were noted during the survey and are to supplement the report.

1. The building differential pressures were measured several times at two locations. The readings were consistent throughout each day of testing.

   Ground Floor, Engineering Dept: -0.051 in wg.
   Second Floor, Meeting Hall: -0.025 in. wg.

2. FCU-A: Ground Floor North: The fan coil unit that is ducted to the north side of the ground floor is shut down. The connected supply and return duct work is not being used. The outside air damper in the attic remains closed.

3. FCU-A: Ground Floor South: The initial supply and return airflow readings were very low. The filters were found to be clogged and were changed by facilities personnel. The readings were taken again and were significantly higher but still not near original design values.

   Duct pitot traverse readings for total airflow were not possible for the supply and the return. All of the connected supply outlets and return inlets were read and used as unit totals.

   The outside air damper in the attic remained closed throughout both days of testing. The outside air temperature range was 32° F. to 43°F. Information on the operation of the outside air damper was not available from facilities personnel.

1147 HANCOCK STREET ● SUITE 201 ● QUINCY, MA 02169
TELEPHONE (617) 770-9990 ● FAX (617) 770-9075

4. Planning Department: Ground Floor, Room 40: The ceiling mounted fan coil unit (Recirc. only) was tested with the fan at high speed and the following results were noted. The airflows for the first two outlets are too low to measure and the airflow for outlet #3 is only 52 CFM. There are no closed dampers. The appropriate corrective measures should be taken including filter replacement.

5. The filters for all of the ceiling mounted fan coil units should be checked and replaced if necessary.

6. As advised the toilet exhaust fan for the second floor nurse's area discharges above the ceiling in the attic.

7. The chilled water system is off for the winter so the pumps could not be tested.

8. Please note the following conditions for the hot water heating system.

   There are no calibrated balancing valves or flow stations installed. Differential pressure readings were taken at the suctions and discharges of the system pump and the boiler pump. One of each is on at any time. A calibrated Shortridge digital meter was used for the readings.

Boiler pump: B&G, 2", 1/6 HP, 1725 RPM
P in= 9.03 P.S.I., P out= 13.0 P.S.I., DP 3.97 P.S.I.: " 9.2' "

System pump: B&G, 3", 1/3 HP, 1725 RPM
P in= 5.02 P.S.I., P out= 10.5 P.S.I., DP 5.48 P.S.I.: " 12.7' "

Design G.P.M. and TDH not listed on pumps.
Original documents: Boiler pumps: 45 GPM@ 5' Hd.
System pumps: 90 GPM @ 9' Hd.

E. L. BARRETT
COMPANY, INC.

HVAC TESTING & BALANCING
SURVEYS & EVALUATIONS
CONSULTING SERVICES

An invoice for services rendered will follow under separate cover.

If there are any questions or we can be of further assistance, please call.

Sincerely,

E.L. BARRETT COMPANY, INC.

Edward L. Barrett, Jr./bb

Enclosures

1147 HANCOCK STREET ● SUITE 201 ● QUINCY, MA 02169
TELEPHONE (617) 770-9990 ● FAX (617) 770-9075

E. L. BARRETT
COMPANY, INC.

SURVEY:
ACTON TOWN HALL
472 MAIN STREET
ACTON, MA

3/31/2011
FLOOR: GROUND
SYSTEM: FCU-A

OUTLET NO.	LOCATION	TYPE	SIZE	AREA	DESIGN C.F.M.	ACTUAL C.F.M.	ACTUAL C.F.M.
	FCU-A-SOUTH					**INITIAL**	**FINAL**
	SUPPLY						
1	HALL-24	SD	6 X 6	*	100	31	78
2	OPEN OFC. 05	SD	6 X 6	*	100	0	27
3	OPEN OFC. 05	SD	6 X 6	*	100	0	25
4	COMP. RM. 06	SD	6 X 6	*	100	25	48
5	OPEN OFC. 05	SD	10 X 10	*	150	29	54
6	OPEN OFC. 05	SD	10 X 10	*	150	52	97
7	OPEN OFC. 05	SD	10 X 10	*	150	33	76
8	OPEN OFC. 05	SD	10 X 10	*	150	44	100
9	OPEN OFC. 05	SD	6 X 6	*	100	27	64
10	OPEN OFC. 05	SD	10 X 10	*	150	35	93
11	OPEN OFC. 05	SD	6 X 6	*	100	33	73
12	HALL 24	SD	6 X 6	*	100	26	65
13	OPEN OFC. 05	SD	10 X 10	*	150	40	86
14	HALL	SD	6 X 6	*	100	46	69
15	CONF. RM. 46	SD	10 X 10	*	150	41	102
					1850	**462 (1)**	**1057 (2)**

ELB CO. JOB #: 3701

COMMENTS:

* NO FACTOR REQUIRED. DIRECT C.F.M. READING FLOW HOOD USED.

1. INITIAL READINGS PRIOR TO FILTER CHANGE.
2. FINAL READINGS AFTER FILTER CHANGE.
3. DESIGN CFM BASED ON ORIGINAL DOCUMENTS DATED: 4/6/87. ORIGINAL UNIT HAS BEEN REPLACED.
4. SUPPLY DUCT CONNECTIONS NOT SEALED.
5. REFER TO ATTACHED LETTER AND DRAWINGS.

E. L. BARRETT COMPANY, INC.

SURVEY:
ACTON TOWN HALL
472 MAIN STREET
ACTON, MA

3/31/2011
FLOOR: GROUND, 1ST
SYSTEM: FCU-A

OUTLET NO.	LOCATION	TYPE	SIZE	AREA	DESIGN C.F.M.		ACTUAL C.F.M.	ACTUAL C.F.M.
	FCU-A-SOUTH						**INITIAL**	**FINAL**
	RETURN							
16	OPEN OFC. 05	RG	24 X 18	*	---		70	191
17	OPEN OFC. 05	RG	24 X 18	*	---		191	517
					---		**261 (1)**	**708 (2)**
	O.A.							
17	1ST FL. RM. 117	PITOT	25 X 15 I.D.	2.60	---	S.P. -0.46	VEL: 41	107 **(4)**

ELB CO. JOB #: 3701

COMMENTS:

1. INITIAL READINGS PRIOR TO FILTER CHANGE.
2. FINAL READINGS AFTER FILTER CHANGE.
3. DUCT CONNECTIONS AT RETURN INLETS NOT SEALED.
4. O.A. CONTROL DAMPER IN ATTIC REMAINS CLOSED.

E. L. BARRETT COMPANY, INC.

SURVEY:
ACTON TOWN HALL
472 MAIN STREET
ACTON, MA

3/31/2011
FLOOR: GROUND, 1ST
SYSTEM: EXHAUST

INLET NO.	LOCATION	TYPE	SIZE	AREA	DESIGN C.F.M.	REQUIRED VELOCITY	ACTUAL VELOCITY	ACTUAL C.F.M.
	REF-1							
1	COMP. RM. 06	EG	24 X 24	*	350			640
	REF-2							
1	OPEN OFC. 05	EG	24 X 24	*	760			618
	REF-3							
1	CONF. RM. 46	EG	12 X 12	*	550			272
	REF-4							
1	RECREATION OFC. 27	OED	12 X 12	*	500	500	425	425
	REF-5							
1	JANITOR	EG	6 X 6	*	60			68
2	WOMEN'S RM. 25	EG	24 X 24	*	200			97
3	HP TOILET	EG	6 X 6	*	60			56
4	MEN'S RM. 26	EG	24 X 24	*	200			66
					520			**287**
	REF-9							
1	PLAN & PRINT: 44	OED	10 X 10	0.69	350	507	621	428

ELB CO. JOB #: 3701

COMMENTS:

1. REF-9 TURNS ON WITH WALL SWITCH. ALL OTHER FANS RUN CONTINUOUSLY WHEN BUILDING IS OCCUPIED.
2. DESIGN CFM VALUES BASED ON ORIGINAL DOCUMENTS DATED 4/6/87.

E. L. BARRETT COMPANY, INC.

SURVEY:
ACTON TOWN HALL
472 MAIN STREET
ACTON, MA

3/31/2011
FLOOR: 1ST
SYSTEM: EXHAUST

INLET NO.	LOCATION	TYPE	SIZE	AREA	DESIGN C.F.M.	REQUIRED VELOCITY	ACTUAL VELOCITY	ACTUAL C.F.M.
	CEF-6							
1	MEN'S RM. 133	EG	12 X 12	*	150			196
2	WOMEN'S RM. 132	EG	12 X 12	*	150			227
					300			**423**

ELB CO. JOB #: 3701

COMMENTS:

1. DESIGN CFM VALUES BASED ON ORIGINAL DOCUMENTS DATED 4/6/87.

E. L. BARRETT COMPANY, INC.

SURVEY:
ACTON TOWN HALL
472 MAIN STREET
ACTON, MA

3/31/2011
FLOOR: GROUND, 2ND
SYSTEM: FCU

INLET NO.	LOCATION	TYPE	SIZE	AREA	DESIGN C.F.M.	REQUIRED VELOCITY	ACTUAL VELOCITY	ACTUAL C.F.M.
	FCU-D-4							
1	OPEN OFC. 05	SG	28 X 5	*	300			221
	FCU-D-5							
1	OPEN OFC. 05	SG	28 X 5	*	300			236
	FCU-E-40							
1	MTG. HALL 204	SG	32 X 5	*	400			407
	FCU-E-44							
1	MTG. HALL 204	SG	32 X 5	*	400			412

ELB CO. JOB #: 3701

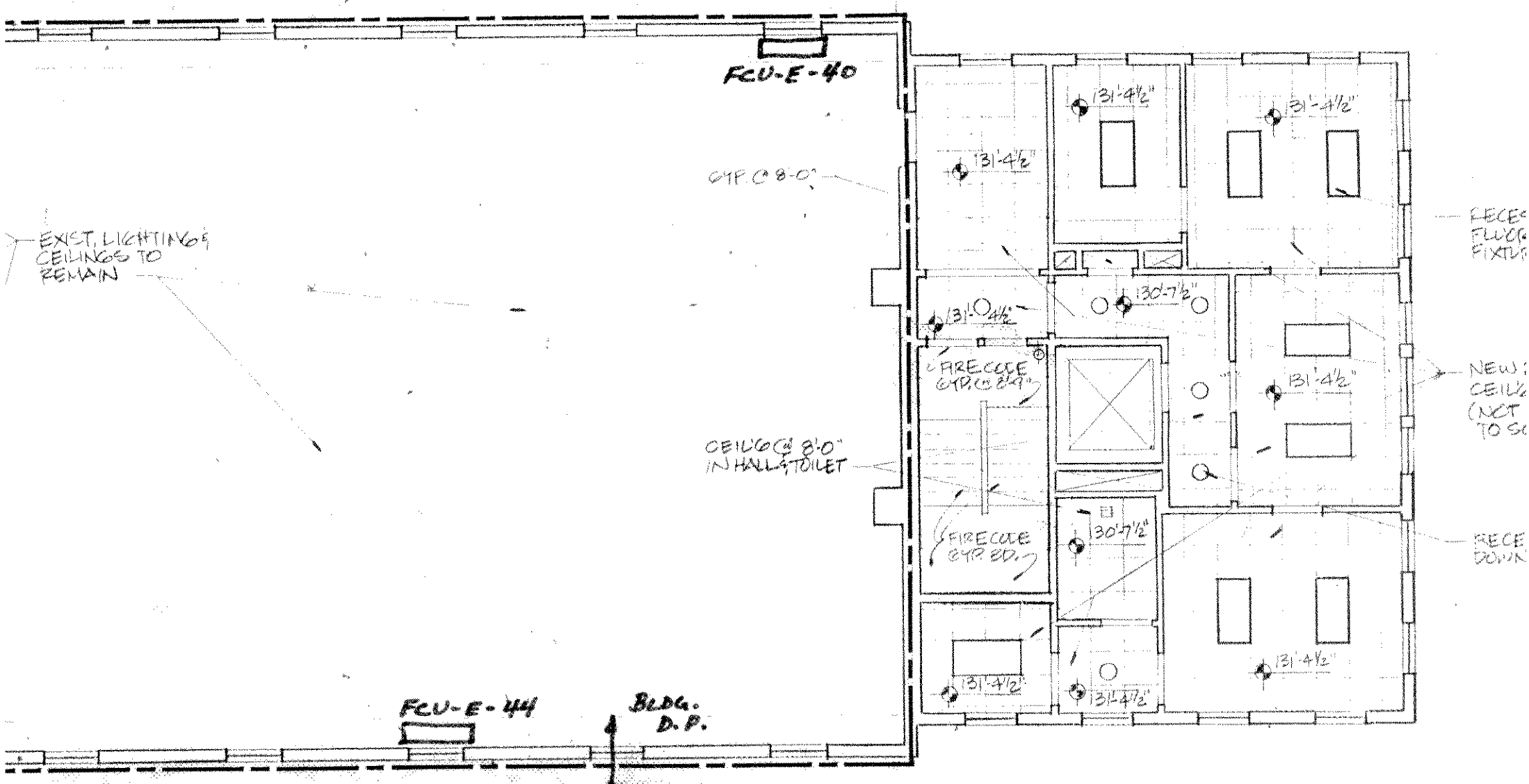
COMMENTS:

1. FCU-D-4: HIGH SPEED, E.A.T.=71°F L.A.T. = 110°F
2. FCU-D-5: HIGH SPEED, E.A.T.=71°F L.A.T. = 102°F
3. FCU-E-40: HIGH SPEED, E.A.T.=68°F L.A.T. = 103°F
4. FCU-E-44: HIGH SPEED, E.A.T.=69°F L.A.T. = 105°F

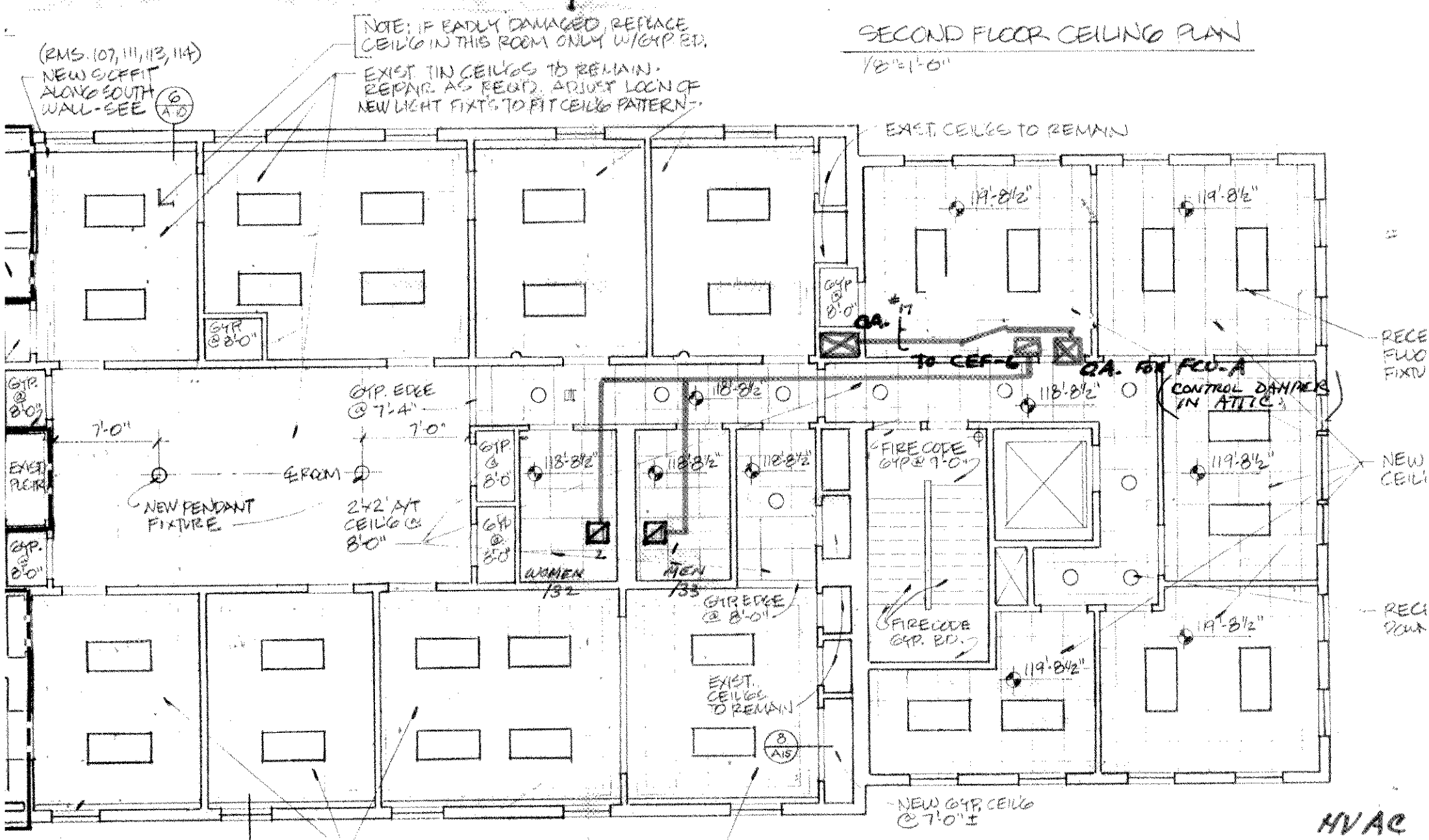
CEILING @ 1-5 (NOT DRAWN TO SCALE)

ATTIC CEILING PLAN
1/8"=1'-0"

BALCONY CEILING PLAN
1/8"=1'-0"



SECOND FLOOR CEILING PLAN
1/8"=1'-0"



NOTE: ALL FLUORESCENT FIXTURES @ EXIST. TIN OR PLASTER CEILINGS TO REMAIN SHALL BE SURFACE MOUNTED.

FIRST FLOOR CEILING PLAN
1/8"=1'-0"

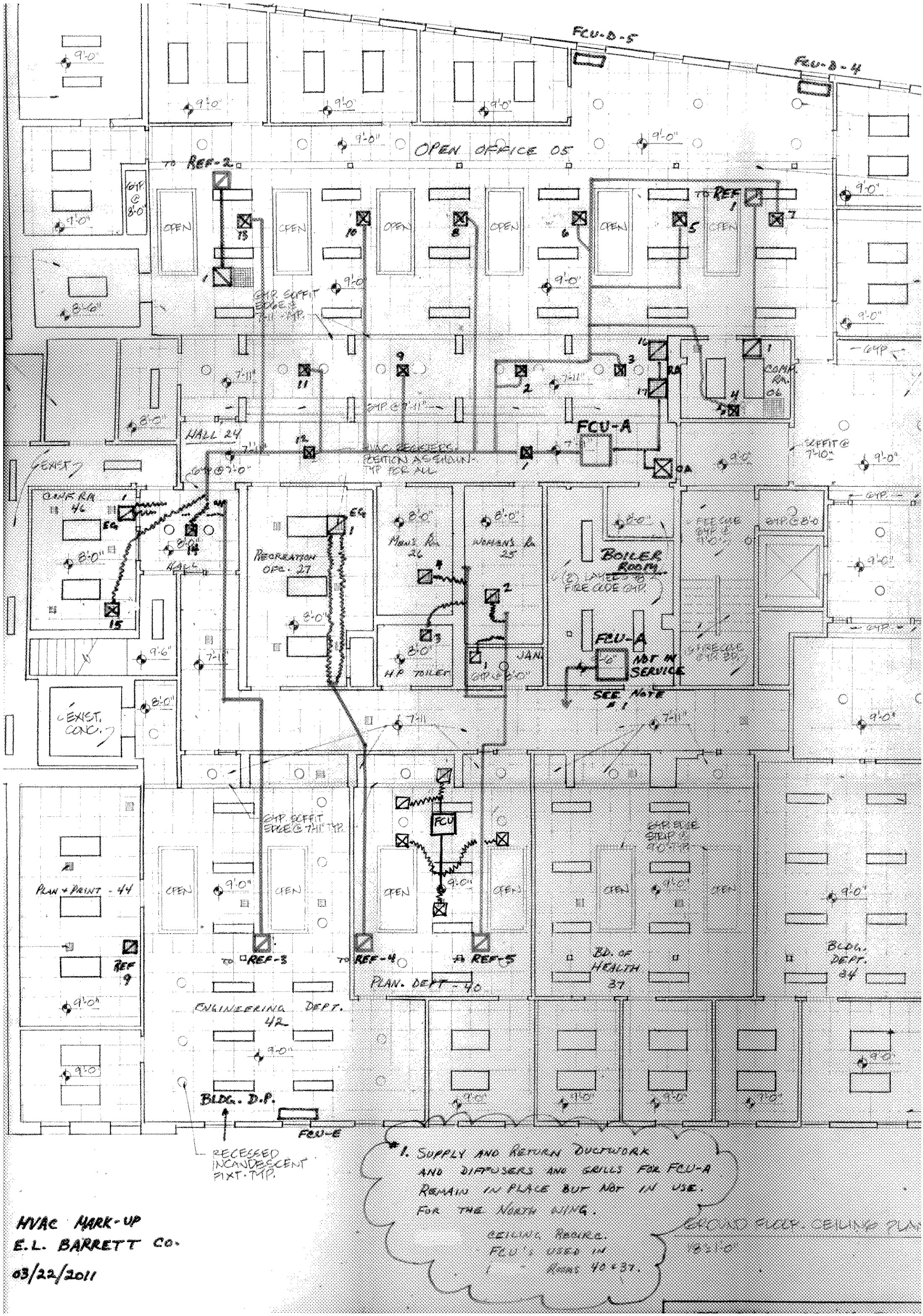
HVAC
E.L. BAR
03/22/2

ditions and Renovations to
ACTON TOWN HALL
Acton, Massachusetts

title REFLECTED CEILING PLAN

ROBERT G. NEILEY ARCHITECT
286 Congress Street, Boston MA 022

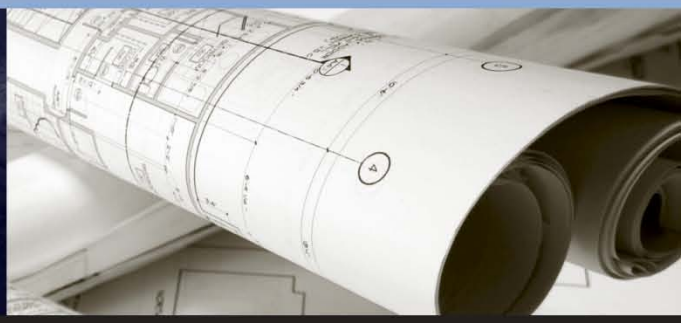
drawn by MF	job 0323	scale NOTED	date



HVAC MARK-UP
E.L. BARRETT CO.
03/22/2011

RDK ENGINEERS

APPENDIX D: THERMOGRAPHIC ANALYSIS REPORT



Infrared Thermographic Building Envelope Analysis

PERFORMED FOR:	**RDK Engineers** **70 Fargo Street** **Suite 800** **Boston, MA 02210**
LOCATION:	**Acton Town Hall** **Acton, MA**
CONDUCTED ON:	**January 4, 2011**
REQUESTED BY:	**Michael Travers**
PERFORMED BY:	**William Rundle, Certified Thermographer**

Infra-red Analyzers, Inc.
237 Commerce Street, Suite 260
Williston, VT 05495
(800) 879-1964

INFRARED ANALYZERS INC
Certified Thermographers

Table of Contents

I. Introduction

II. Infrared Thermography

III. Instrumentation

IV. Thermographic Documentation

V. Summary

January 21, 2011

Michael Travers
RDK Engineers
70 Fargo Street
Suite 800
Boston, MA 02210

Dear Michael,

This report summarizes the findings of the Infrared Building Envelope Analysis performed at the Acton Town Hall in Acton, MA on January 4, 2011.

INFRARED THERMOGRAPHY

All objects emit heat (i.e. infrared radiation). This radiation is constantly being absorbed and re-emitted by ourselves and everything around us. "Infrared scanning" and "thermography" are the terms used to describe the process of making this thermal radiation visible and capable of interpretation.

Infrared Building Envelope Analysis locates and documents building heat loss and moisture damage problems. Infrared Thermography is the only non-destructive and complete system for locating and documenting causes of frozen pipes, ice dams, damaged or missing insulation, moisture damaged building materials, warm air exfiltration, cold air infiltration, and high heating costs. Infrared Building Envelope Surveys provide valuable information for trouble-shooting building envelope problems, evaluating energy retrofits, and developing practical and cost-effective energy solutions.

Our Infrared cameras can also be used in a variety of other Non-Destructive testing applications:

- Infrared Electrical/Mechanical Inspections pinpoint developing problems in power delivery systems. The infrared scanner can "see" hot spots where there are going to be failures before they happen. This Predictive Maintenance approach provides for time to repair these problem areas before they cause equipment damage, unscheduled outages, and expensive down time. Problem areas are pinpointed, prioritized and fully documented.

- Infrared Steam System Inspections pinpoint failing steam traps, malfunctioning heat exchangers and boiler problems. These surveys can save thousands of dollars by reducing energy usage.

- Infrared Roof Moisture Surveys pinpoint moisture damage within roofing systems to help you target problem areas and wet insulation for more cost-effective repairs or roof replacement. Our roof moisture surveys provide independent, objective information about the real condition of your roof system so you can make sound decisions and sift through conflicting opinions and advice.

INSTRUMENTATION

Infra-red Analyzers uses top-quality instruments when performing your Building Envelope Analysis. The portable, high-resolution ThermaCAM Pm390 is one of the most sensitive and sophisticated scanners available. It is capable of resolving temperature differences as small as 0.1 degree Centigrade. The system consists of an infrared camera unit, equipped with PCMCIA Flash Card, video output and image storage capable of storing multiple high resolution 12 BIT images. The stored information is brought to our offices and downloaded to thermal imaging analysis software.

The camera unit receives infrared radiation from the object being surveyed and converts it to an electrical signal that is instantaneously displayed on the color viewfinder. This high-resolution thermal image is then interpreted by Infra-red Analyzers' Certified Thermographers.

THERMOGRAM INTERPRETATION AND DOCUMENTATION

Hard copy documentation of the survey findings is provided through Thermograms and Control Photos. In the Thermograms, temperatures are indicated in various colors. The following is a chart illustrating the hierarchy of colors that the Inframetrics ThermaCAM 390 uses to represent the relative temperature differences of the surface temperatures:

When viewing thermograms that were recorded on the warm side of the thermal envelope (inside the building), the colors that represent cooler temperatures (black, purple & blue) generally represent heat loss problems. When viewing images recorded on the cold side of the thermal envelope (outside of building) surface areas represented by warmer colors (white, red, yellow & green) represent areas of heat loss from the building. Typically heat loss occurs due to reduced insulation value in a wall system and/or air leakage into or out of the heated space.

When scanning from the outside in the cooler months, thermal imagers are limited in their radiometric (temperature measurement) functions. In order to maintain consistent qualitative information, occasionally the scale in the thermogram will be converted to a luminance reading rather than a temperature calibrated output. This allows the thermal imager to provide accurate high-quality thermal imagery at low temperatures. The luminance scale may also be employed at lower Delta T's (inside vs outside) to improve consistency in the thermographic imagery.

The next section of the report contains the forty-one sets of thermograms and control photos that were generated during the inspection.

Key to Thermogram Explanations

Thermogram #: 1,2,3,4 etc

Facility: Building being surveyed.

Location of Target: Floor and/or room being surveyed.

Target Shown: Building elevation and/or specific area being surveyed.

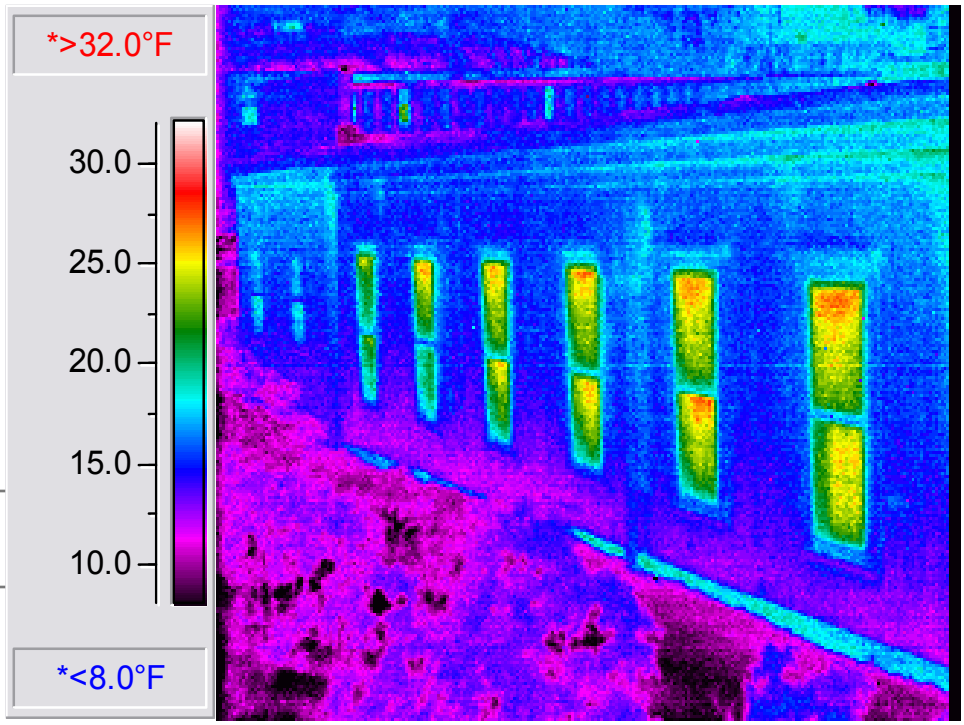
Position/Location Taken From: Thermographer's location when recording the thermogram.

Camera Direction: Direction the camera was facing when the thermogram was taken.

Building Component: The actual component being documented: wall, window, door etc.

Problem Category: Typically the types of problems documented will be Conduction Losses, Air Leakage Losses (infiltration/exfiltration), and Moisture Damage.

Recommendation: These are general guidelines for practical and cost-effective ways to correct the problem.



Thermogram: Infrared Image

Control Photo: Visible Light Image

Thermogram # 1

Thermogram #: 1

Facility/Building: Acton Town Hall

Location of Target: North Elevation – Ground Floor

Target Shown: East End

Position/Location of Thermographer: Outside

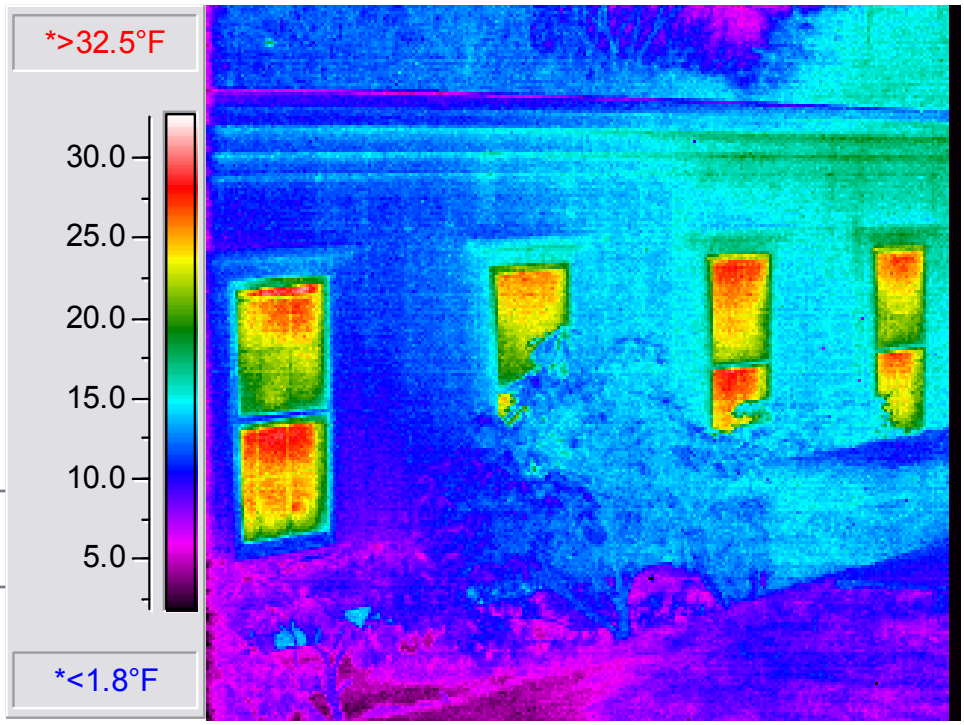
Camera Direction: Southeast

Building Component: Window, Foundation

Problem Category: Conduction Loss

Recommendation: The glazing in these units appears to be less resistant to heat loss (have lower R-value/higher U-value) than newer high efficiency glazing. Retrofitting with new high efficiency glazing will substantially reduce these conduction losses, but would involve significant expense. It would be prudent to perform a complete cost/benefit analysis to determine the cost effectiveness and return on investment (ROI) of retrofitting these units.

The foundation in this area is exhibiting significant conduction loss and may be uninsulated. Typically, retrofitting a foundation wall with insulation involves substantial cost. It may be prudent to perform a comprehensive cost-benefit analysis to determine the return on investment (ROI) and advisability of any retrofits designed to reduce these conduction losses.



Thermogram: Infrared Image

Control Photo: Visible Light Image

Thermogram # 2

Thermogram #: 2

Facility/Building: Acton Town Hall

Location of Target: North Elevation – Ground Floor

Target Shown: West End

Position/Location of Thermographer: Outside

Camera Direction: Southwest

Building Component: Window

Problem Category: Air Leakage – exfiltration & Conduction Loss

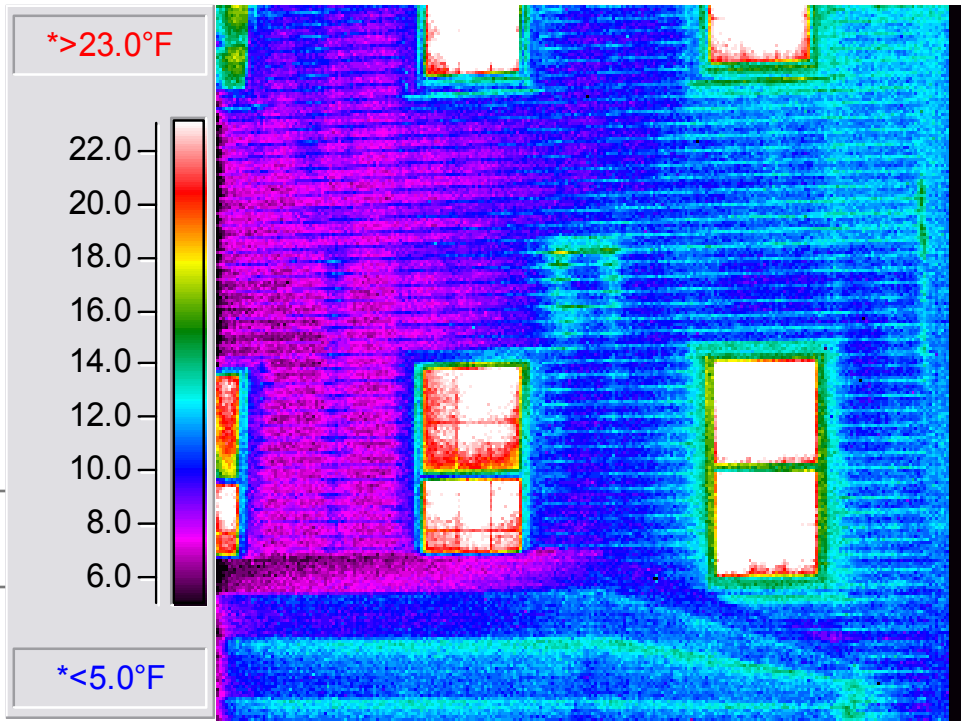
Recommendation: The glazing in these units appears to be less resistant to heat loss (have lower R-value/higher U-value) than newer high efficiency glazing. Retrofitting with new high efficiency glazing will substantially reduce these conduction losses, but would involve significant expense. It would be prudent to perform a complete cost/benefit analysis to determine the cost effectiveness and return on investment (ROI) of retrofitting these units.

In a number of areas of the building, we noted significant conduction losses through the window frames. Typically, these metal frames conduct a substantial amount of heat. The metal is an excellent conductor of heat and cold, and they are often either uninsulated or minimally insulated. We also noted areas where certain portions of the metal frames are warmer than others. This could be caused by uneven heat delivery in the room. We are not aware of a simple, cost-effective retrofit for these window units.

It is also possible that some of these warmer frames may be experiencing air leakage caused by deteriorated, damaged or missing gaskets where the glazing is installed in the frame. Deteriorated, damaged or missing gaskets can allow significant warm air exfiltration from the building. These areas should be carefully examined to determine the condition of the gaskets, and repairs should be made as needed.

Thermogram #2 (continued)

Where excessive heat is noted around any moveable sash, an inspection should be made to determine the condition of the weather stripping, and repair or replacement should be made as needed.



Thermogram: Infrared Image

Control Photo: Visible Light Image

Thermogram # 3

Thermogram #: 3

Facility/Building: Acton Town Hall

Location of Target: North Elevation – 1st Floor

Target Shown: Wall between the 1st & 2nd windows from the west

Position/Location of Thermographer: Outside

Camera Direction: South

Building Component: Window, Wall

Problem Category: Air Leakage – exfiltration & Conduction Loss

Recommendation: Some sections of the building may be fitted with fiberglass batt insulation. Variations in the thermal patterns can indicate significant differences in the performance of the insulation. When viewed from the inside, warmer interior temperatures indicate better performance of fiberglass insulation while cooler temperatures indicate increased cold penetration of the envelope and elevated heat losses. When viewed from the outside, cooler exterior temperatures indicate better performance of the fiberglass insulation while warmer temperatures indicate elevated heat losses.

Fiberglass insulation must be properly installed and protected in order to perform well. Before the insulation is installed, it should be expanded to its designed thickness. Care must be taken in the installation process to ensure that the fiberglass maintains as much of its designed thickness as possible, because compressed areas of fiberglass insulation will have reduced R-value. The insulation must also be installed snugly against studs, joists and rafters in order to prevent warm air bypassing the insulation and transferring heat to the exterior of the building.

The effectiveness of fiberglass insulation can also be reduced by air movement through the material from either the interior or the exterior of the building. Fiberglass must be protected on the inside of the of the building envelope by a continuous air/vapor barrier to prevent warm air from escaping the heated spaces, moving into the envelope and creating warm spots on the exterior. On the cold side of the fiberglass there should be a continuous and vapor permeable air barrier to reduce the potential for cold air infiltration

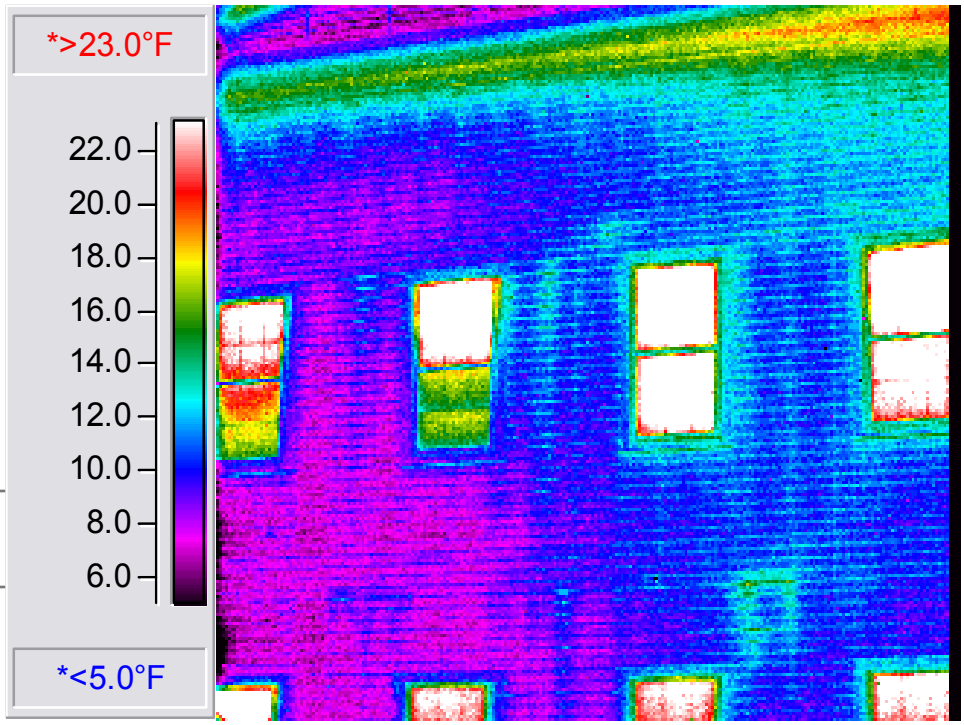
Thermogram #3 (continued)

into the insulation. Any cold air moving through the fiberglass disturbs the tiny air pockets that create the insulating value and can seriously reduce the insulation's R-value.

Overall, this section of the building appears to be insulated, but has significant variations in thermal performance that may indicate areas of missing, disturbed, or poorly installed insulation, or insulation whose effectiveness has been compromised by air movement. If the insulation in this area is easily accessible, repair or replacement should be made as needed. If the insulation in this area is not accessible due to constraints of interior or exterior finish, retrofitting these areas will involve substantial cost. It may be prudent to perform a comprehensive cost-benefit analysis to determine the return on investment (ROI) and advisability of any retrofits designed to reduce these heat losses, if these areas are not readily accessible.

The glazing in these units appears to be less resistant to heat loss (have lower R-value/higher U-value) than newer high efficiency glazing. Retrofitting with new high efficiency glazing will substantially reduce these conduction losses, but would involve significant expense. It would be prudent to perform a complete cost/benefit analysis to determine the cost effectiveness and return on investment (ROI) of retrofitting these units.

Portions of the wall surface in this thermogram display a thermal signature that appears to indicate a build-up of moisture in the wall system. Water damaged materials will have lower R-values than sound, dry materials and appear as colder temperatures on the inside of the envelope and warmer temperatures on the exterior of the envelope. Some of the areas of warmer temperature in the thermogram may indicate moisture damage. It may be prudent to perform some invasive testing in these areas to absolutely determine the presence or absence of moisture.



Thermogram: Infrared Image

Control Photo: Visible Light Image

Thermogram # 4

Thermogram #: 4

Facility/Building: Acton Town Hall

Location of Target: North Elevation – 2nd Floor

Target Shown: West side windows & wall

Position/Location of Thermographer: Outside

Camera Direction: South

Building Component: Window, Wall, Soffit

Problem Category: Air Leakage – exfiltration & Conduction Loss

Recommendation: Some sections of the building may be fitted with fiberglass batt insulation. Variations in the thermal patterns can indicate significant differences in the performance of the insulation. When viewed from the inside, warmer interior temperatures indicate better performance of fiberglass insulation while cooler temperatures indicate increased cold penetration of the envelope and elevated heat losses. When viewed from the outside, cooler exterior temperatures indicate better performance of the fiberglass insulation while warmer temperatures indicate elevated heat losses.

Fiberglass insulation must be properly installed and protected in order to perform well. Before the insulation is installed, it should be expanded to its designed thickness. Care must be taken in the installation process to ensure that the fiberglass maintains as much of its designed thickness as possible, because compressed areas of fiberglass insulation will have reduced R-value. The insulation must also be installed snugly against studs, joists and rafters in order to prevent warm air bypassing the insulation and transferring heat to the exterior of the building.

The effectiveness of fiberglass insulation can also be reduced by air movement through the material from either the interior or the exterior of the building. Fiberglass must be protected on the inside of the of the building envelope by a continuous air/vapor barrier to prevent warm air from escaping the heated spaces, moving into the envelope and creating warm spots on the exterior. On the cold side of the fiberglass there should be a continuous and vapor permeable air barrier to reduce the potential for cold air infiltration

Thermogram #4 (continued)

into the insulation. Any cold air moving through the fiberglass disturbs the tiny air pockets that create the insulating value and can seriously reduce the insulation's R-value.

Overall, this section of the building appears to be insulated, but has significant variations in thermal performance that may indicate areas of missing, disturbed, or poorly installed insulation, or insulation whose effectiveness has been compromised by air movement. If the insulation in this area is easily accessible, repair or replacement should be made as needed. If the insulation in this area is not accessible due to constraints of interior or exterior finish, retrofitting these areas will involve substantial cost. It may be prudent to perform a comprehensive cost-benefit analysis to determine the return on investment (ROI) and advisability of any retrofits designed to reduce these heat losses, if these areas are not readily accessible.

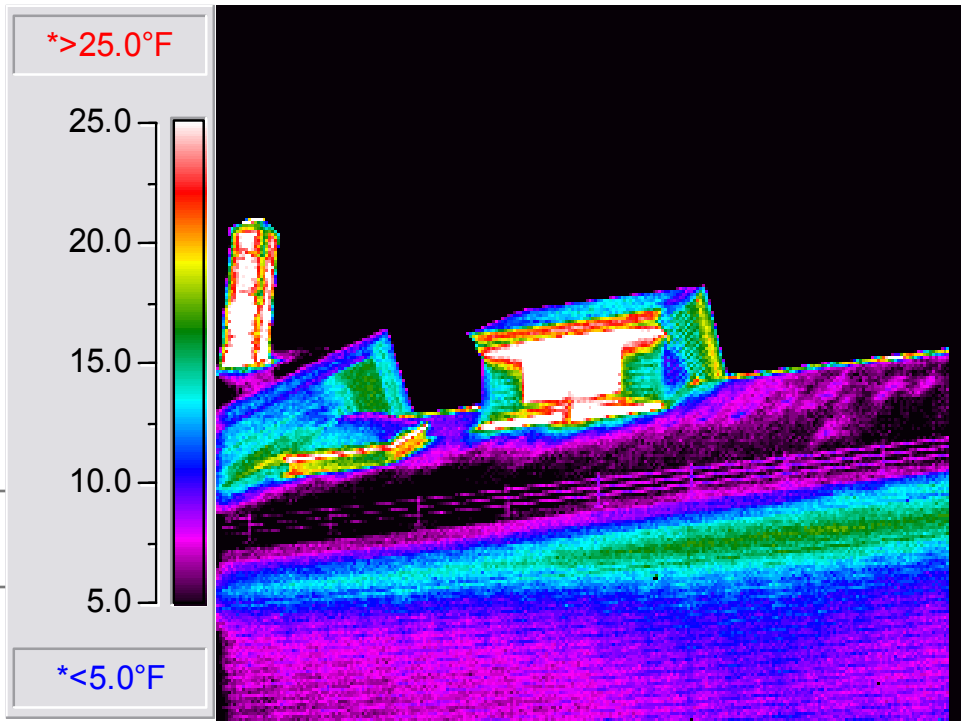
The glazing in these units appears to be less resistant to heat loss (have lower R-value/higher U-value) than newer high efficiency glazing. Retrofitting with new high efficiency glazing will substantially reduce these conduction losses, but would involve significant expense. It would be prudent to perform a complete cost/benefit analysis to determine the cost effectiveness and return on investment (ROI) of retrofitting these units.

In this area of the building, the roof soffit is significantly warmer than the adjacent wall system. Ideally, the roof soffit should be no warmer than the exterior ambient air temperature. Elevated temperatures at the soffits typically indicate excess heat in the roofing system or attic and poor air flow in the roof venting system. Typically, this excess heat in the attic can lead to the formation of ice dams. Even if ice dams are not forming, these heat losses contribute to increased heating costs, and warm air exfiltration into the attic can add to "stack effect" problems. Stack effect happens when warm air escaping near the top of the building creates the need for cold air to be drawn in near the bottom of the building to replace it. This cycle of air movement from the bottom to the top of the building is called "stack effect" and contributes significantly to heating costs as

Thermogram #4 (continued)

well as reduces occupant comfort. The insulation near the sofftits should be examined to be sure that it is properly installed and creates a “blanket” that extends out to the outside edge of the vertical stud wall. The air/vapor barrier should also be examined throughout the attic and repaired or replaced as needed. The insulation blanket should fit snuggly against ceiling joists and other structural members, and be installed full thickness to take advantage of all possible R-value. A thorough physical examination will need to be made of the condition of the insulation and air/vapor barrier throughout the attic, and repairs should be made as needed.

Portions of the wall surface in this thermogram display a thermal signature that appears to indicate a build-up of moisture in the wall system. Water damaged materials will have lower R-values than sound, dry materials and appear as colder temperatures on the inside of the envelope and warmer temperatures on the exterior of the envelope. Some of the areas of warmer temperature in the thermogram may indicate moisture damage. It may be prudent to perform some invasive testing in these areas to absolutely determine the presence or absence of moisture.



Thermogram: Infrared Image

Control Photo: Visible Light Image

Thermogram # 5

Thermogram #: 5

Facility/Building: Acton Town Hall

Location of Target: North Elevation – West End Roof

Target Shown: Elevator cupola

Position/Location of Thermographer: Outside

Camera Direction: Southeast

Building Component: Cupola, Skylight, Ridge Vent, Soffit

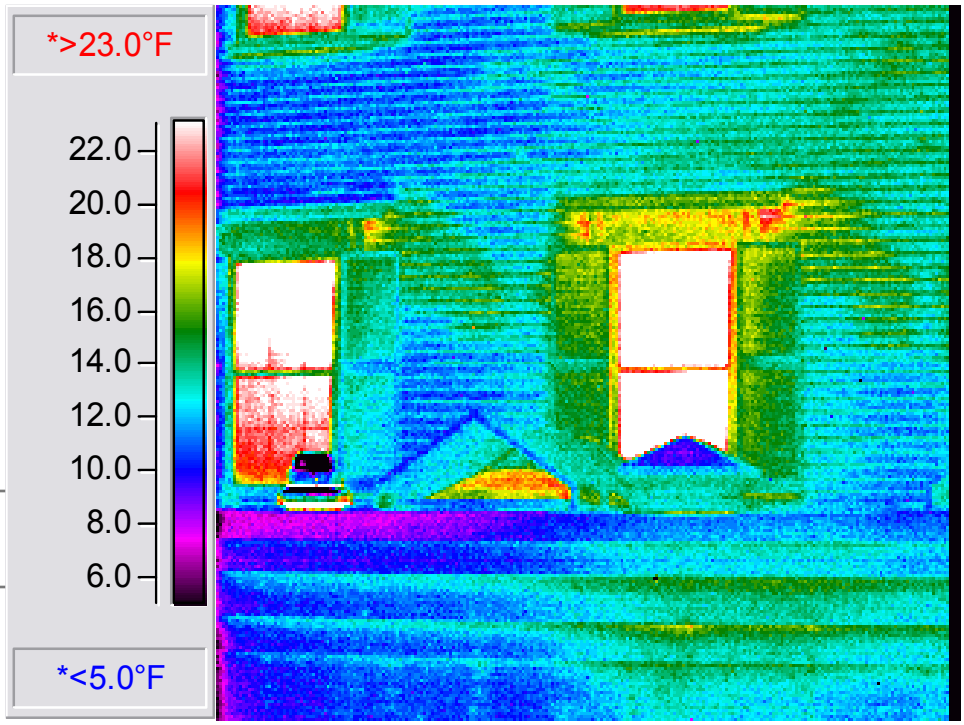
Problem Category: Air Leakage – exfiltration & Conduction Loss

Recommendation: Ideally, the attic air temperature should be as close to the exterior ambient air temperature as possible. The temperatures in the attic appear to be significantly higher than the exterior temperatures. A thorough physical examination of the attic floor air/vapor barrier and insulation should be made to locate areas where there are deficiencies and repairs should be made as needed. Correcting these deficiencies should reduce heat losses from the interior of the building into the attic and reduce the overall ambient air temperature in the attic.

In this area of the building, the roof soffit is significantly warmer than the adjacent wall system. Ideally, the roof soffit should be no warmer than the exterior ambient air temperature. Elevated temperatures at the soffits typically indicate excess heat in the roofing system or attic and poor air flow in the roof venting system. Typically, this excess heat in the attic can lead to the formation of ice dams. Even if ice dams are not forming, these heat losses contribute to increased heating costs, and warm air exfiltration into the attic can add to “stack effect” problems. Stack effect happens when warm air escaping near the top of the building creates the need for cold air to be drawn in near the bottom of the building to replace it. This cycle of air movement from the bottom to the top of the building is called “stack effect” and contributes significantly to heating costs as well as reduces occupant comfort. The insulation near the sofftits should be examined to be sure that it is properly installed and creates a “blanket” that extends out to the outside edge of the vertical stud wall. The air/vapor barrier should also be examined throughout the attic and repaired or replaced as needed. The insulation blanket should fit snuggly

Thermogram #5 (continued)

against ceiling joists and other structural members, and be installed full thickness to take advantage of all possible R-value. A thorough physical examination will need to be made of the condition of the insulation and air/vapor barrier throughout the attic, and repairs should be made as needed.



Thermogram: Infrared Image

Control Photo: Visible Light Image

Thermogram # 6

Thermogram #: 6

Facility/Building: Acton Town Hall

Location of Target: North Elevation – 1st Floor

Target Shown: 4th & 5th windows from east

Position/Location of Thermographer: Outside

Camera Direction: South

Building Component: Window, Wall

Problem Category: Air Leakage – exfiltration & Conduction Loss

Recommendation Some sections of the building may be fitted with fiberglass batt insulation. Variations in the thermal patterns can indicate significant differences in the performance of the insulation. When viewed from the inside, warmer interior temperatures indicate better performance of fiberglass insulation while cooler temperatures indicate increased cold penetration of the envelope and elevated heat losses. When viewed from the outside, cooler exterior temperatures indicate better performance of the fiberglass insulation while warmer temperatures indicate elevated heat losses.

Fiberglass insulation must be properly installed and protected in order to perform well. Before the insulation is installed, it should be expanded to its designed thickness. Care must be taken in the installation process to ensure that the fiberglass maintains as much of its designed thickness as possible, because compressed areas of fiberglass insulation will have reduced R-value. The insulation must also be installed snugly against studs, joists and rafters in order to prevent warm air bypassing the insulation and transferring heat to the exterior of the building.

The effectiveness of fiberglass insulation can also be reduced by air movement through the material from either the interior or the exterior of the building. Fiberglass must be protected on the inside of the of the building envelope by a continuous air/vapor barrier to prevent warm air from escaping the heated spaces, moving into the envelope and creating warm spots on the exterior. On the cold side of the fiberglass there should be a continuous and vapor permeable air barrier to reduce the potential for cold air infiltration

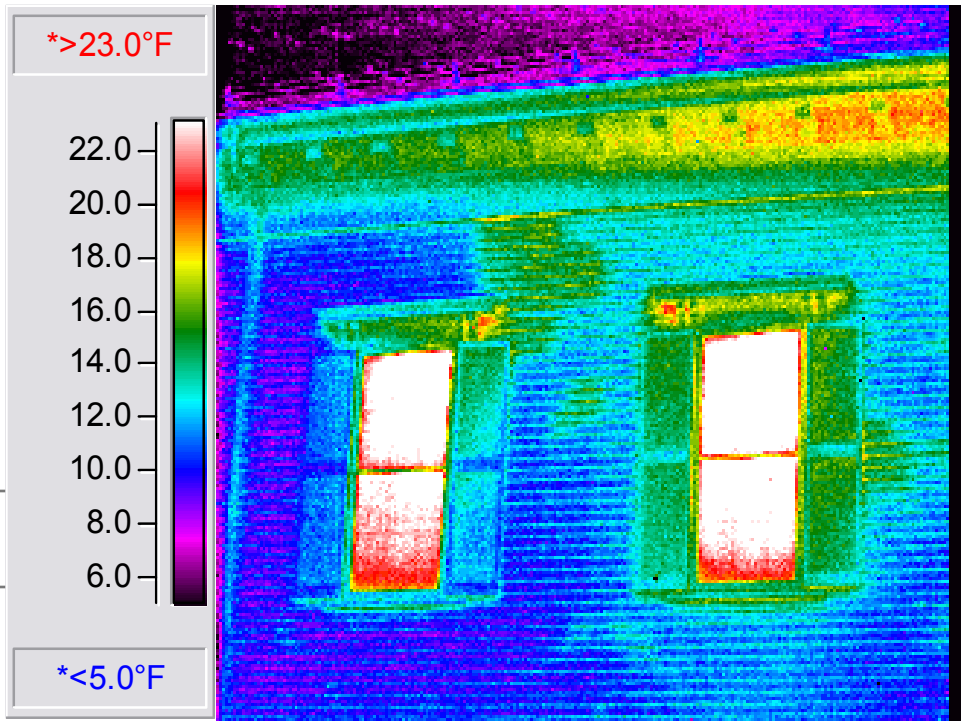
Thermogram #6 (continued)

into the insulation. Any cold air moving through the fiberglass disturbs the tiny air pockets that create the insulating value and can seriously reduce the insulation's R-value.

Overall, this section of the building appears to be insulated, but has significant variations in thermal performance that may indicate areas of missing, disturbed, or poorly installed insulation, or insulation whose effectiveness has been compromised by air movement. If the insulation in this area is easily accessible, repair or replacement should be made as needed. If the insulation in this area is not accessible due to constraints of interior or exterior finish, retrofitting these areas will involve substantial cost. It may be prudent to perform a comprehensive cost-benefit analysis to determine the return on investment (ROI) and advisability of any retrofits designed to reduce these heat losses, if these areas are not readily accessible.

The glazing in these units appears to be less resistant to heat loss (have lower R-value/higher U-value) than newer high efficiency glazing. Retrofitting with new high efficiency glazing will substantially reduce these conduction losses, but would involve significant expense. It would be prudent to perform a complete cost/benefit analysis to determine the cost effectiveness and return on investment (ROI) of retrofitting these units.

Portions of the wall surface in this thermogram display a thermal signature that appears to indicate a build-up of moisture in the wall system. Water damaged materials will have lower R-values than sound, dry materials and appear as colder temperatures on the inside of the envelope and warmer temperatures on the exterior of the envelope. Some of the areas of warmer temperature in the thermogram may indicate moisture damage. It may be prudent to perform some invasive testing in these areas to absolutely determine the presence or absence of moisture.



Thermogram: Infrared Image

Control Photo: Visible Light Image

Thermogram # 7

Thermogram #: 7

Facility/Building: Acton Town Hall

Location of Target: North Elevation – 2nd Floor

Target Shown: 4th & 5th windows from east

Position/Location of Thermographer: Outside

Camera Direction: South

Building Component: Window, Wall, Soffit

Problem Category: Air Leakage – exfiltration & Conduction Loss

Recommendation Some sections of the building may be fitted with fiberglass batt insulation. Variations in the thermal patterns can indicate significant differences in the performance of the insulation. When viewed from the inside, warmer interior temperatures indicate better performance of fiberglass insulation while cooler temperatures indicate increased cold penetration of the envelope and elevated heat losses. When viewed from the outside, cooler exterior temperatures indicate better performance of the fiberglass insulation while warmer temperatures indicate elevated heat losses.

Fiberglass insulation must be properly installed and protected in order to perform well. Before the insulation is installed, it should be expanded to its designed thickness. Care must be taken in the installation process to ensure that the fiberglass maintains as much of its designed thickness as possible, because compressed areas of fiberglass insulation will have reduced R-value. The insulation must also be installed snugly against studs, joists and rafters in order to prevent warm air bypassing the insulation and transferring heat to the exterior of the building.

The effectiveness of fiberglass insulation can also be reduced by air movement through the material from either the interior or the exterior of the building. Fiberglass must be protected on the inside of the of the building envelope by a continuous air/vapor barrier to prevent warm air from escaping the heated spaces, moving into the envelope and creating warm spots on the exterior. On the cold side of the fiberglass there should be a continuous and vapor permeable air barrier to reduce the potential for cold air infiltration

Thermogram #7 (continued)

into the insulation. Any cold air moving through the fiberglass disturbs the tiny air pockets that create the insulating value and can seriously reduce the insulation's R-value.

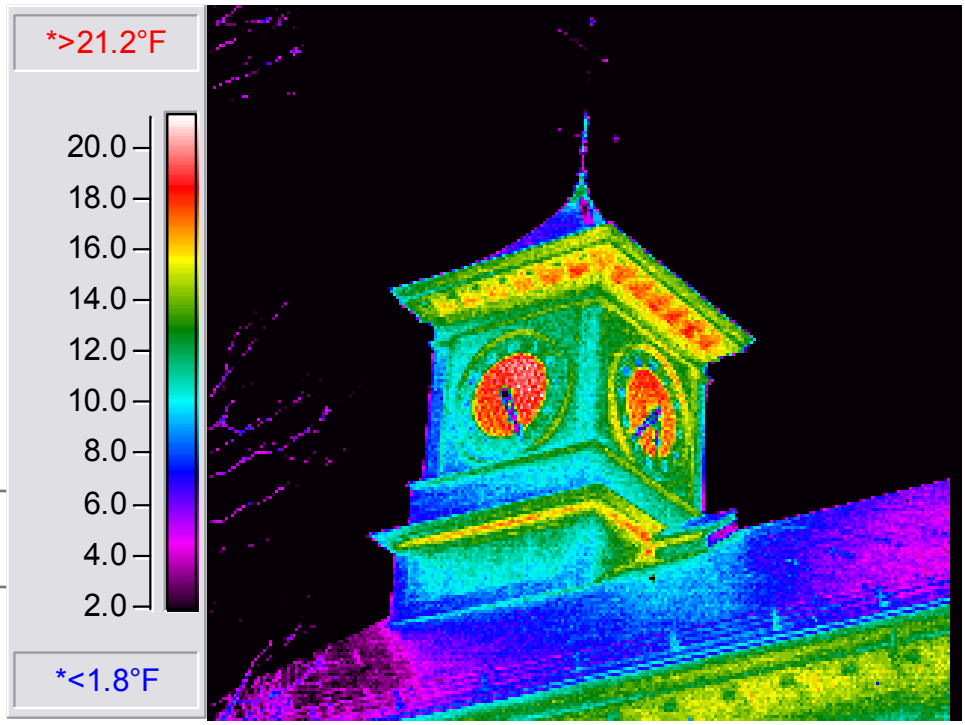
Overall, this section of the building appears to be insulated, but has significant variations in thermal performance that may indicate areas of missing, disturbed, or poorly installed insulation, or insulation whose effectiveness has been compromised by air movement. If the insulation in this area is easily accessible, repair or replacement should be made as needed. If the insulation in this area is not accessible due to constraints of interior or exterior finish, retrofitting these areas will involve substantial cost. It may be prudent to perform a comprehensive cost-benefit analysis to determine the return on investment (ROI) and advisability of any retrofits designed to reduce these heat losses, if these areas are not readily accessible.

The glazing in these units appears to be less resistant to heat loss (have lower R-value/higher U-value) than newer high efficiency glazing. Retrofitting with new high efficiency glazing will substantially reduce these conduction losses, but would involve significant expense. It would be prudent to perform a complete cost/benefit analysis to determine the cost effectiveness and return on investment (ROI) of retrofitting these units.

Portions of the wall surface in this thermogram display a thermal signature that appears to indicate a build-up of moisture in the wall system. Water damaged materials will have lower R-values than sound, dry materials and appear as colder temperatures on the inside of the envelope and warmer temperatures on the exterior of the envelope. Some of the areas of warmer temperature in the thermogram may indicate moisture damage. It may be prudent to perform some invasive testing in these areas to absolutely determine the presence or absence of moisture.

Thermogram #7 (continued)

In this area of the building, the roof soffit is significantly warmer than the adjacent wall system. Ideally, the roof soffit should be no warmer than the exterior ambient air temperature. Elevated temperatures at the soffits typically indicate excess heat in the roofing system or attic and poor air flow in the roof venting system. Typically, this excess heat in the attic can lead to the formation of ice dams. Even if ice dams are not forming, these heat losses contribute to increased heating costs, and warm air exfiltration into the attic can add to “stack effect” problems. Stack effect happens when warm air escaping near the top of the building creates the need for cold air to be drawn in near the bottom of the building to replace it. This cycle of air movement from the bottom to the top of the building is called “stack effect” and contributes significantly to heating costs as well as reduces occupant comfort. The insulation near the sofftits should be examined to be sure that it is properly installed and creates a “blanket” that extends out to the outside edge of the vertical stud wall. The air/vapor barrier should also be examined throughout the attic and repaired or replaced as needed. The insulation blanket should fit snuggly against ceiling joists and other structural members, and be installed full thickness to take advantage of all possible R-value. A thorough physical examination will need to be made of the condition of the insulation and air/vapor barrier throughout the attic, and repairs should be made as needed.



Thermogram: Infrared Image

Control Photo: Visible Light Image

Thermogram # 8

Thermogram #: 8

Facility/Building: Acton Town Hall

Location of Target: North & West Elevations

Target Shown: Clock Tower

Position/Location of Thermographer: Outside

Camera Direction: Southeast

Building Component: Clock Face, Soffit

Problem Category: Air Leakage – exfiltration & Conduction Loss

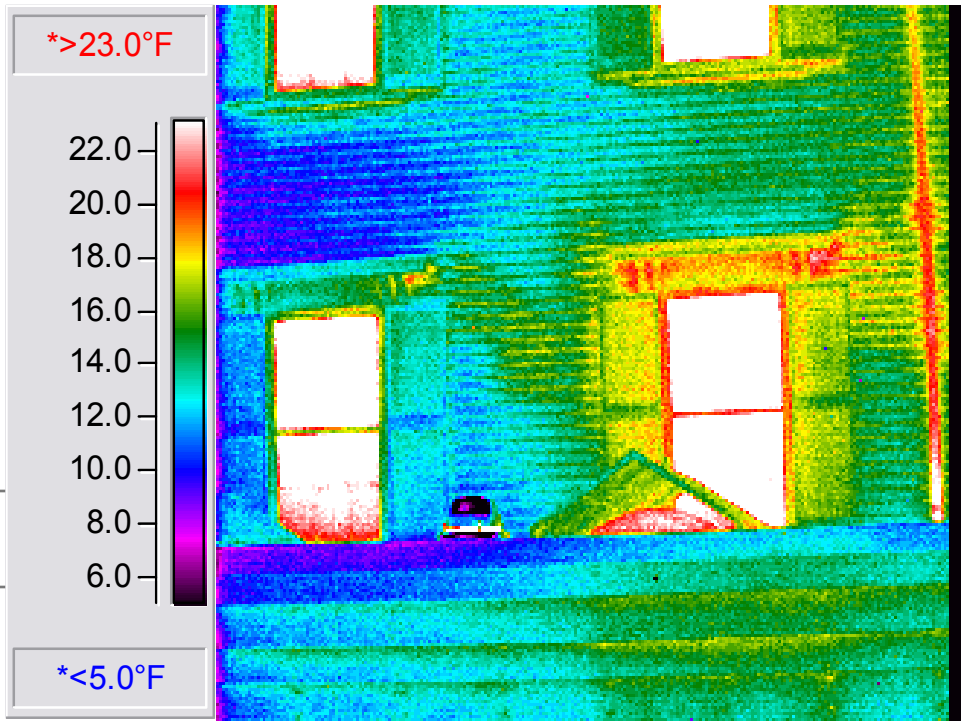
Recommendation: The building appears to be experiencing significant "stack effect". The warm thermal patterns in the thermogram are typical of warm air exfiltration. Poorly sealed joints and penetrations near the top of the building will allow warm air to continuously leave the building. As the warm air is lost, cold air must be drawn in to replace it, typically near the bottom of the building. This cycle of warmer, lighter and more humid air escaping near the top and colder, heavier and drier air being pulled in near the bottom is called stack effect. It substantially increases heating costs and decreases occupant comfort. Continuously heating air that will eventually leak out the top of the building is costly, while at the same time the cold drafts coming in near the bottom make people uncomfortable.

In order to devise a practical and cost-effective retrofit, a thorough physical examination of the leaky joints and penetrations near the top of the building should be performed. High-quality long-lasting materials (e.g. caulking, backer rod, expanding foam insulation, etc.) should be employed to reduce or eliminate this warm air exfiltration. Reducing these air leakage losses will result in increased occupant comfort and lowered heating costs.

In this area of the building, the roof soffit is significantly warmer than the adjacent wall system. Ideally, the roof soffit should be no warmer than the exterior ambient air temperature. Elevated temperatures at the soffits typically indicate excess heat in the roofing system or attic and poor air flow in the roof venting system. Typically, this excess heat in the attic can lead to the formation of ice dams. Even if ice dams are not

Thermogram #8 (continued)

forming, these heat losses contribute to increased heating costs, and warm air exfiltration into the attic can add to “stack effect” problems. Stack effect happens when warm air escaping near the top of the building creates the need for cold air to be drawn in near the bottom of the building to replace it. This cycle of air movement from the bottom to the top of the building is called “stack effect” and contributes significantly to heating costs as well as reduces occupant comfort. The insulation near the sofftits should be examined to be sure that it is properly installed and creates a “blanket” that extends out to the outside edge of the vertical stud wall. The air/vapor barrier should also be examined throughout the attic and repaired or replaced as needed. The insulation blanket should fit snuggly against ceiling joists and other structural members, and be installed full thickness to take advantage of all possible R-value. A thorough physical examination will need to be made of the condition of the insulation and air/vapor barrier throughout the attic, and repairs should be made as needed.



Thermogram: Infrared Image

Control Photo: Visible Light Image

Thermogram # 9

Thermogram #: 9

Facility/Building: Acton Town Hall

Location of Target: North Elevation -1st Floor

Target Shown: 2nd & 3rd windows from east

Position/Location of Thermographer: Outside

Camera Direction: South

Building Component: Window, Wall

Problem Category: Air Leakage – exfiltration & Conduction Loss

Recommendation: Some sections of the building may be fitted with fiberglass batt insulation. Variations in the thermal patterns can indicate significant differences in the performance of the insulation. When viewed from the inside, warmer interior temperatures indicate better performance of fiberglass insulation while cooler temperatures indicate increased cold penetration of the envelope and elevated heat losses. When viewed from the outside, cooler exterior temperatures indicate better performance of the fiberglass insulation while warmer temperatures indicate elevated heat losses.

Fiberglass insulation must be properly installed and protected in order to perform well. Before the insulation is installed, it should be expanded to its designed thickness. Care must be taken in the installation process to ensure that the fiberglass maintains as much of its designed thickness as possible, because compressed areas of fiberglass insulation will have reduced R-value. The insulation must also be installed snugly against studs, joists and rafters in order to prevent warm air bypassing the insulation and transferring heat to the exterior of the building.

The effectiveness of fiberglass insulation can also be reduced by air movement through the material from either the interior or the exterior of the building. Fiberglass must be protected on the inside of the of the building envelope by a continuous air/vapor barrier to prevent warm air from escaping the heated spaces, moving into the envelope and creating warm spots on the exterior. On the cold side of the fiberglass there should be a continuous and vapor permeable air barrier to reduce the potential for cold air infiltration

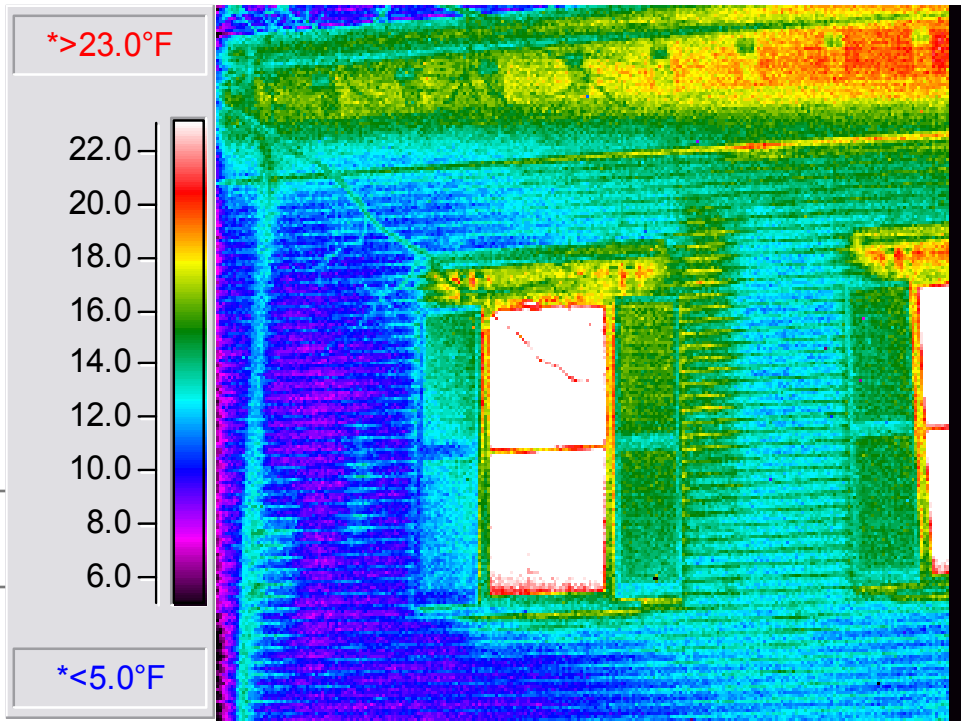
Thermogram #9 (continued)

into the insulation. Any cold air moving through the fiberglass disturbs the tiny air pockets that create the insulating value and can seriously reduce the insulation's R-value.

Overall, this section of the building appears to be insulated, but has significant variations in thermal performance that may indicate areas of missing, disturbed, or poorly installed insulation, or insulation whose effectiveness has been compromised by air movement. If the insulation in this area is easily accessible, repair or replacement should be made as needed. If the insulation in this area is not accessible due to constraints of interior or exterior finish, retrofitting these areas will involve substantial cost. It may be prudent to perform a comprehensive cost-benefit analysis to determine the return on investment (ROI) and advisability of any retrofits designed to reduce these heat losses, if these areas are not readily accessible.

Portions of the wall surface in this thermogram display a thermal signature that appears to indicate a build-up of moisture in the wall system. Water damaged materials will have lower R-values than sound, dry materials and appear as colder temperatures on the inside of the envelope and warmer temperatures on the exterior of the envelope. Some of the areas of warmer temperature in the thermogram may indicate moisture damage. It may be prudent to perform some invasive testing in these areas to absolutely determine the presence or absence of moisture.

The glazing in these units appears to be less resistant to heat loss (have lower R-value/higher U-value) than newer high efficiency glazing. Retrofitting with new high efficiency glazing will substantially reduce these conduction losses, but would involve significant expense. It would be prudent to perform a complete cost/benefit analysis to determine the cost effectiveness and return on investment (ROI) of retrofitting these units.



Thermogram: Infrared Image

Control Photo: Visible Light Image

Thermogram # 10

Thermogram #: 10

Facility/Building: Acton Town Hall

Location of Target: North Elevation -2nd Floor

Target Shown: 2nd window from the east

Position/Location of Thermographer: Outside

Camera Direction: South

Building Component: Window, Wall, Soffit

Problem Category: Air Leakage – exfiltration & Conduction Loss

Recommendation: Some sections of the building may be fitted with fiberglass batt insulation. Variations in the thermal patterns can indicate significant differences in the performance of the insulation. When viewed from the inside, warmer interior temperatures indicate better performance of fiberglass insulation while cooler temperatures indicate increased cold penetration of the envelope and elevated heat losses. When viewed from the outside, cooler exterior temperatures indicate better performance of the fiberglass insulation while warmer temperatures indicate elevated heat losses.

Fiberglass insulation must be properly installed and protected in order to perform well. Before the insulation is installed, it should be expanded to its designed thickness. Care must be taken in the installation process to ensure that the fiberglass maintains as much of its designed thickness as possible, because compressed areas of fiberglass insulation will have reduced R-value. The insulation must also be installed snugly against studs, joists and rafters in order to prevent warm air bypassing the insulation and transferring heat to the exterior of the building.

The effectiveness of fiberglass insulation can also be reduced by air movement through the material from either the interior or the exterior of the building. Fiberglass must be protected on the inside of the of the building envelope by a continuous air/vapor barrier to prevent warm air from escaping the heated spaces, moving into the envelope and creating warm spots on the exterior. On the cold side of the fiberglass there should be a continuous and vapor permeable air barrier to reduce the potential for cold air infiltration

Thermogram #10 (continued)

into the insulation. Any cold air moving through the fiberglass disturbs the tiny air pockets that create the insulating value and can seriously reduce the insulation's R-value.

Overall, this section of the building appears to be insulated, but has significant variations in thermal performance that may indicate areas of missing, disturbed, or poorly installed insulation, or insulation whose effectiveness has been compromised by air movement. If the insulation in this area is easily accessible, repair or replacement should be made as needed. If the insulation in this area is not accessible due to constraints of interior or exterior finish, retrofitting these areas will involve substantial cost. It may be prudent to perform a comprehensive cost-benefit analysis to determine the return on investment (ROI) and advisability of any retrofits designed to reduce these heat losses, if these areas are not readily accessible.

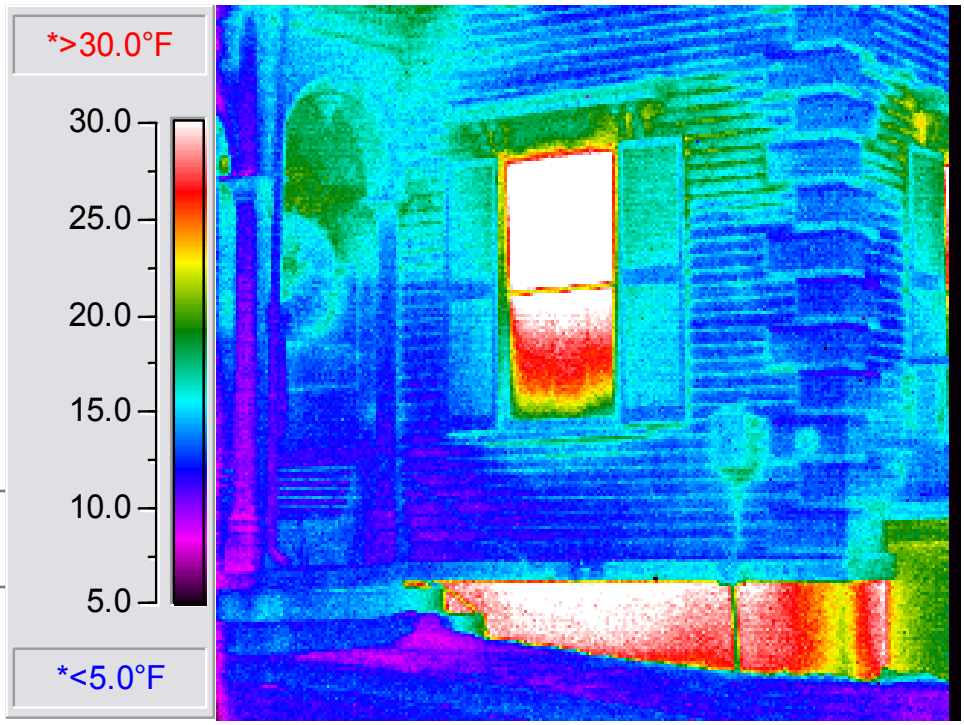
Portions of the wall surface in this thermogram display a thermal signature that appears to indicate a build-up of moisture in the wall system. Water damaged materials will have lower R-values than sound, dry materials and appear as colder temperatures on the inside of the envelope and warmer temperatures on the exterior of the envelope. Some of the areas of warmer temperature in the thermogram may indicate moisture damage. It may be prudent to perform some invasive testing in these areas to absolutely determine the presence or absence of moisture.

The glazing in these units appears to be less resistant to heat loss (have lower R-value/higher U-value) than newer high efficiency glazing. Retrofitting with new high efficiency glazing will substantially reduce these conduction losses, but would involve significant expense. It would be prudent to perform a complete cost/benefit analysis to determine the cost effectiveness and return on investment (ROI) of retrofitting these units.

In this area of the building, the roof soffit is significantly warmer than the adjacent wall system. Ideally, the roof soffit should be no warmer than the exterior ambient air

Thermogram #10 (continued)

temperature. Elevated temperatures at the soffits typically indicate excess heat in the roofing system or attic and poor air flow in the roof venting system. Typically, this excess heat in the attic can lead to the formation of ice dams. Even if ice dams are not forming, these heat losses contribute to increased heating costs, and warm air exfiltration into the attic can add to “stack effect” problems. Stack effect happens when warm air escaping near the top of the building creates the need for cold air to be drawn in near the bottom of the building to replace it. This cycle of air movement from the bottom to the top of the building is called “stack effect” and contributes significantly to heating costs as well as reduces occupant comfort. The insulation near the sofftits should be examined to be sure that it is properly installed and creates a “blanket” that extends out to the outside edge of the vertical stud wall. The air/vapor barrier should also be examined throughout the attic and repaired or replaced as needed. The insulation blanket should fit snuggly against ceiling joists and other structural members, and be installed full thickness to take advantage of all possible R-value. A thorough physical examination will need to be made of the condition of the insulation and air/vapor barrier throughout the attic, and repairs should be made as needed.



Thermogram: Infrared Image

Control Photo: Visible Light Image

Thermogram # 11

Thermogram #: 11

Facility/Building: Acton Town Hall

Location of Target: East Elevation – 1st Floor

Target Shown: North side window and foundation

Position/Location of Thermographer: Outside

Camera Direction: West

Building Component: Window, Wall, Foundation

Problem Category: Air Leakage – exfiltration & Conduction Loss

Recommendation: Some sections of the building may be fitted with fiberglass batt insulation. Variations in the thermal patterns can indicate significant differences in the performance of the insulation. When viewed from the inside, warmer interior temperatures indicate better performance of fiberglass insulation while cooler temperatures indicate increased cold penetration of the envelope and elevated heat losses. When viewed from the outside, cooler exterior temperatures indicate better performance of the fiberglass insulation while warmer temperatures indicate elevated heat losses.

Fiberglass insulation must be properly installed and protected in order to perform well. Before the insulation is installed, it should be expanded to its designed thickness. Care must be taken in the installation process to ensure that the fiberglass maintains as much of its designed thickness as possible, because compressed areas of fiberglass insulation will have reduced R-value. The insulation must also be installed snugly against studs, joists and rafters in order to prevent warm air bypassing the insulation and transferring heat to the exterior of the building.

The effectiveness of fiberglass insulation can also be reduced by air movement through the material from either the interior or the exterior of the building. Fiberglass must be protected on the inside of the of the building envelope by a continuous air/vapor barrier to prevent warm air from escaping the heated spaces, moving into the envelope and creating warm spots on the exterior. On the cold side of the fiberglass there should be a continuous and vapor permeable air barrier to reduce the potential for cold air infiltration

Thermogram #11 (continued)

into the insulation. Any cold air moving through the fiberglass disturbs the tiny air pockets that create the insulating value and can seriously reduce the insulation's R-value.

Overall, this section of the building appears to be insulated, but has significant variations in thermal performance that may indicate areas of missing, disturbed, or poorly installed insulation, or insulation whose effectiveness has been compromised by air movement. If the insulation in this area is easily accessible, repair or replacement should be made as needed. If the insulation in this area is not accessible due to constraints of interior or exterior finish, retrofitting these areas will involve substantial cost. It may be prudent to perform a comprehensive cost-benefit analysis to determine the return on investment (ROI) and advisability of any retrofits designed to reduce these heat losses, if these areas are not readily accessible.

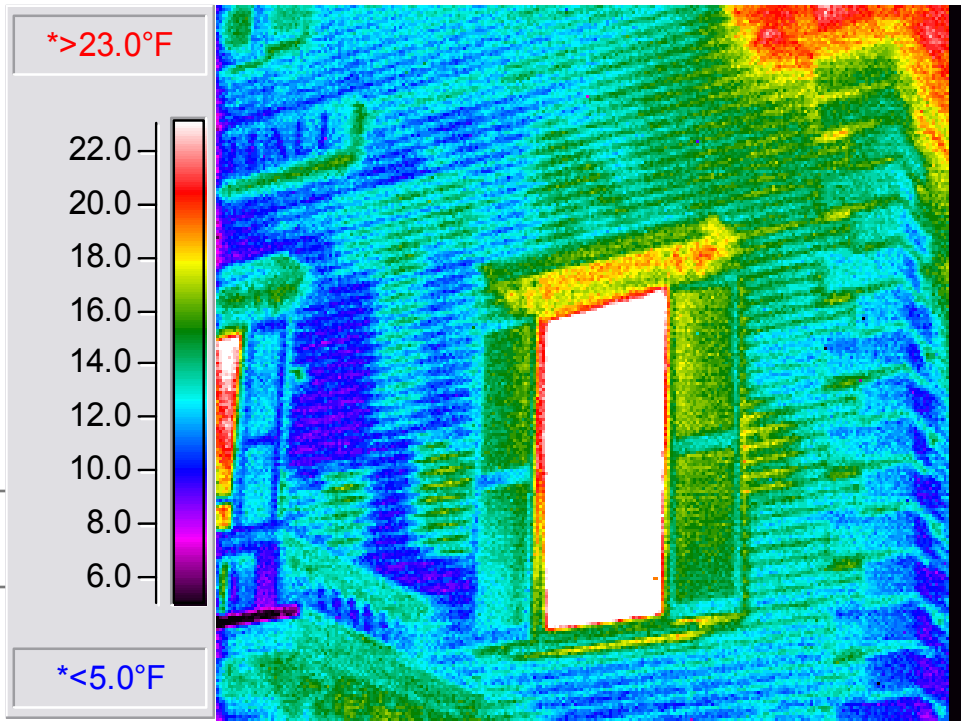
Portions of the wall surface in this thermogram display a thermal signature that appears to indicate a build-up of moisture in the wall system. Water damaged materials will have lower R-values than sound, dry materials and appear as colder temperatures on the inside of the envelope and warmer temperatures on the exterior of the envelope. Some of the areas of warmer temperature in the thermogram may indicate moisture damage. It may be prudent to perform some invasive testing in these areas to absolutely determine the presence or absence of moisture.

The glazing in these units appears to be less resistant to heat loss (have lower R-value/higher U-value) than newer high efficiency glazing. Retrofitting with new high efficiency glazing will substantially reduce these conduction losses, but would involve significant expense. It would be prudent to perform a complete cost/benefit analysis to determine the cost effectiveness and return on investment (ROI) of retrofitting these units.

The foundation in this area is exhibiting significant conduction loss and may be uninsulated. Typically, retrofitting a foundation wall with insulation involves substantial

Thermogram #11 (continued)

cost. It may be prudent to perform a comprehensive cost-benefit analysis to determine the return on investment (ROI) and advisability of any retrofits designed to reduce these conduction losses.



Thermogram: Infrared Image

Control Photo: Visible Light Image

Thermogram # 12

Thermogram #: 12

Facility/Building: Acton Town Hall

Location of Target: East Elevation -2nd Floor

Target Shown: North window and wall

Position/Location of Thermographer: Outside

Camera Direction: West

Building Component: Window, Wall, Soffit

Problem Category: Air Leakage – exfiltration & Conduction Loss

Recommendation: Some sections of the building may be fitted with fiberglass batt insulation. Variations in the thermal patterns can indicate significant differences in the performance of the insulation. When viewed from the inside, warmer interior temperatures indicate better performance of fiberglass insulation while cooler temperatures indicate increased cold penetration of the envelope and elevated heat losses. When viewed from the outside, cooler exterior temperatures indicate better performance of the fiberglass insulation while warmer temperatures indicate elevated heat losses.

Fiberglass insulation must be properly installed and protected in order to perform well. Before the insulation is installed, it should be expanded to its designed thickness. Care must be taken in the installation process to ensure that the fiberglass maintains as much of its designed thickness as possible, because compressed areas of fiberglass insulation will have reduced R-value. The insulation must also be installed snugly against studs, joists and rafters in order to prevent warm air bypassing the insulation and transferring heat to the exterior of the building.

The effectiveness of fiberglass insulation can also be reduced by air movement through the material from either the interior or the exterior of the building. Fiberglass must be protected on the inside of the of the building envelope by a continuous air/vapor barrier to prevent warm air from escaping the heated spaces, moving into the envelope and creating warm spots on the exterior. On the cold side of the fiberglass there should be a continuous and vapor permeable air barrier to reduce the potential for cold air infiltration

Thermogram #12 (continued)

into the insulation. Any cold air moving through the fiberglass disturbs the tiny air pockets that create the insulating value and can seriously reduce the insulation's R-value.

Overall, this section of the building appears to be insulated, but has significant variations in thermal performance that may indicate areas of missing, disturbed, or poorly installed insulation, or insulation whose effectiveness has been compromised by air movement. If the insulation in this area is easily accessible, repair or replacement should be made as needed. If the insulation in this area is not accessible due to constraints of interior or exterior finish, retrofitting these areas will involve substantial cost. It may be prudent to perform a comprehensive cost-benefit analysis to determine the return on investment (ROI) and advisability of any retrofits designed to reduce these heat losses, if these areas are not readily accessible.

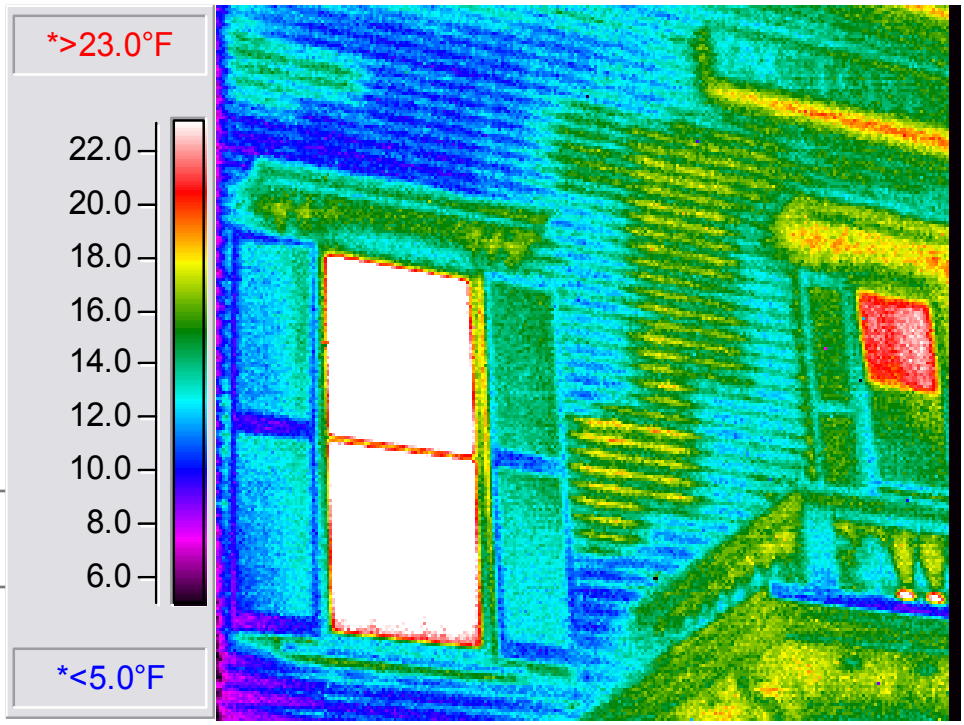
Portions of the wall surface in this thermogram display a thermal signature that appears to indicate a build-up of moisture in the wall system. Water damaged materials will have lower R-values than sound, dry materials and appear as colder temperatures on the inside of the envelope and warmer temperatures on the exterior of the envelope. Some of the areas of warmer temperature in the thermogram may indicate moisture damage. It may be prudent to perform some invasive testing in these areas to absolutely determine the presence or absence of moisture.

The glazing in these units appears to be less resistant to heat loss (have lower R-value/higher U-value) than newer high efficiency glazing. Retrofitting with new high efficiency glazing will substantially reduce these conduction losses, but would involve significant expense. It would be prudent to perform a complete cost/benefit analysis to determine the cost effectiveness and return on investment (ROI) of retrofitting these units.

In this area of the building, the roof soffit is significantly warmer than the adjacent wall system. Ideally, the roof soffit should be no warmer than the exterior ambient air

Thermogram #12 (continued)

temperature. Elevated temperatures at the soffits typically indicate excess heat in the roofing system or attic and poor air flow in the roof venting system. Typically, this excess heat in the attic can lead to the formation of ice dams. Even if ice dams are not forming, these heat losses contribute to increased heating costs, and warm air exfiltration into the attic can add to “stack effect” problems. Stack effect happens when warm air escaping near the top of the building creates the need for cold air to be drawn in near the bottom of the building to replace it. This cycle of air movement from the bottom to the top of the building is called “stack effect” and contributes significantly to heating costs as well as reduces occupant comfort. The insulation near the sofftits should be examined to be sure that it is properly installed and creates a “blanket” that extends out to the outside edge of the vertical stud wall. The air/vapor barrier should also be examined throughout the attic and repaired or replaced as needed. The insulation blanket should fit snuggly against ceiling joists and other structural members, and be installed full thickness to take advantage of all possible R-value. A thorough physical examination will need to be made of the condition of the insulation and air/vapor barrier throughout the attic, and repairs should be made as needed.



Thermogram: Infrared Image

Control Photo: Visible Light Image

Thermogram # 13

Thermogram #: 13

Facility/Building: Acton Town Hall

Location of Target: East Elevation -2nd Floor

Target Shown: South window and wall

Position/Location of Thermographer: Outside

Camera Direction: West

Building Component: Window, Wall

Problem Category: Air Leakage – exfiltration & Conduction Loss

Recommendation: Some sections of the building may be fitted with fiberglass batt insulation. Variations in the thermal patterns can indicate significant differences in the performance of the insulation. When viewed from the inside, warmer interior temperatures indicate better performance of fiberglass insulation while cooler temperatures indicate increased cold penetration of the envelope and elevated heat losses. When viewed from the outside, cooler exterior temperatures indicate better performance of the fiberglass insulation while warmer temperatures indicate elevated heat losses.

Fiberglass insulation must be properly installed and protected in order to perform well. Before the insulation is installed, it should be expanded to its designed thickness. Care must be taken in the installation process to ensure that the fiberglass maintains as much of its designed thickness as possible, because compressed areas of fiberglass insulation will have reduced R-value. The insulation must also be installed snugly against studs, joists and rafters in order to prevent warm air bypassing the insulation and transferring heat to the exterior of the building.

The effectiveness of fiberglass insulation can also be reduced by air movement through the material from either the interior or the exterior of the building. Fiberglass must be protected on the inside of the of the building envelope by a continuous air/vapor barrier to prevent warm air from escaping the heated spaces, moving into the envelope and creating warm spots on the exterior. On the cold side of the fiberglass there should be a continuous and vapor permeable air barrier to reduce the potential for cold air infiltration

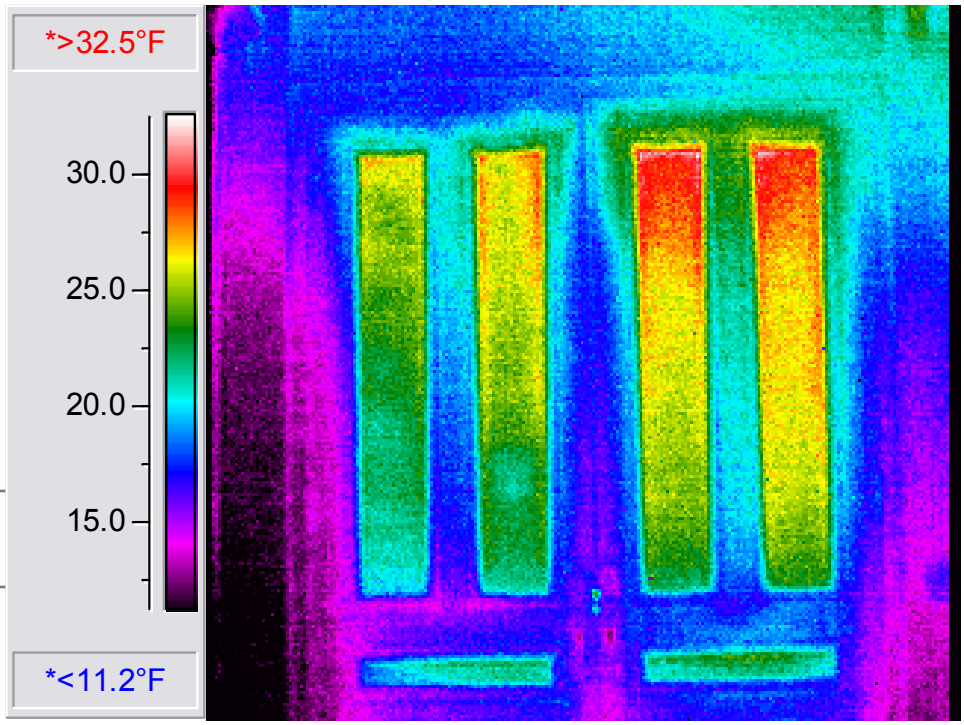
Thermogram #13 (continued)

into the insulation. Any cold air moving through the fiberglass disturbs the tiny air pockets that create the insulating value and can seriously reduce the insulation's R-value.

Overall, this section of the building appears to be insulated, but has significant variations in thermal performance that may indicate areas of missing, disturbed, or poorly installed insulation, or insulation whose effectiveness has been compromised by air movement. If the insulation in this area is easily accessible, repair or replacement should be made as needed. If the insulation in this area is not accessible due to constraints of interior or exterior finish, retrofitting these areas will involve substantial cost. It may be prudent to perform a comprehensive cost-benefit analysis to determine the return on investment (ROI) and advisability of any retrofits designed to reduce these heat losses, if these areas are not readily accessible.

Portions of the wall surface in this thermogram display a thermal signature that appears to indicate a build-up of moisture in the wall system. Water damaged materials will have lower R-values than sound, dry materials and appear as colder temperatures on the inside of the envelope and warmer temperatures on the exterior of the envelope. Some of the areas of warmer temperature in the thermogram may indicate moisture damage. It may be prudent to perform some invasive testing in these areas to absolutely determine the presence or absence of moisture.

The glazing in these units appears to be less resistant to heat loss (have lower R-value/higher U-value) than newer high efficiency glazing. Retrofitting with new high efficiency glazing will substantially reduce these conduction losses, but would involve significant expense. It would be prudent to perform a complete cost/benefit analysis to determine the cost effectiveness and return on investment (ROI) of retrofitting these units.



Thermogram: Infrared Image

Control Photo: Visible Light Image

Thermogram # 14

Thermogram #: 14

Facility/Building: Acton Town Hall

Location of Target: East Elevation -1st Floor

Target Shown: Doorway

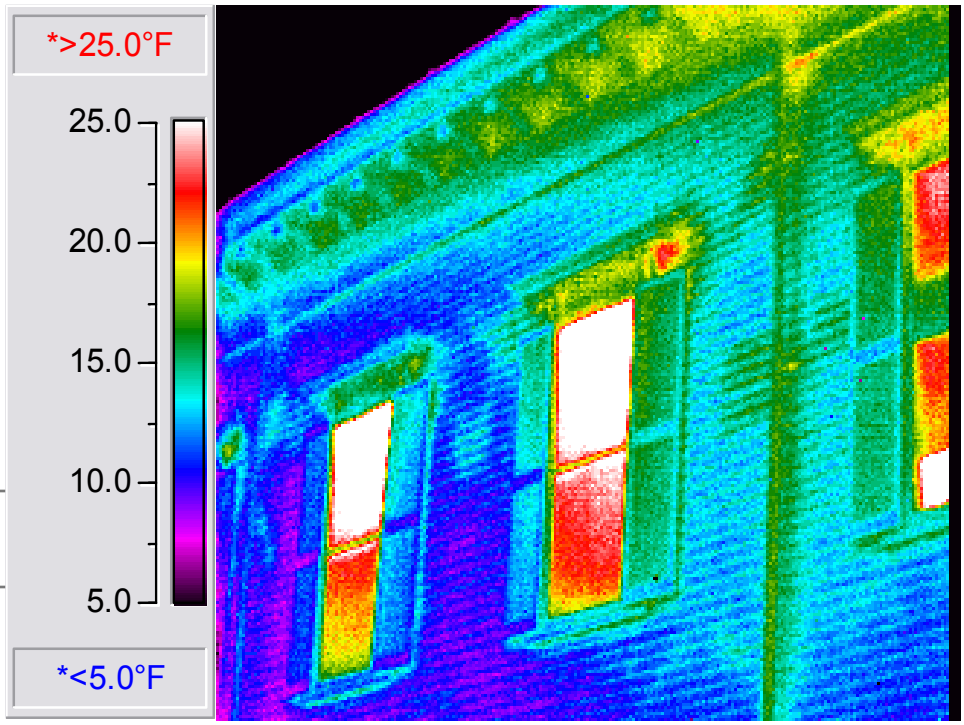
Position/Location of Thermographer: Outside

Camera Direction: West

Building Component: Door

Problem Category: Conduction Loss

Recommendation: Wood door units often have substantial conduction losses. Wood has an R-value of approximately 1 per inch. Therefore, a 1.5" thick door only has an R-value of approximately of 1.5. In addition, any edges of the raised panels on wood doors can be thinner and have even lower R-values. Typically, replacing a wood door with a new energy-efficient unit will involve considerable expense. It may be prudent to perform a comprehensive cost-benefit analysis to determine the return on investment (ROI) and advisability of any retrofits designed to reduce these conduction losses.



Thermogram: Infrared Image

Control Photo: Visible Light Image

Thermogram # 15

Thermogram #: 15

Facility/Building: Acton Town Hall

Location of Target: South Elevation -2nd Floor

Target Shown: 1st, 2nd & 3rd windows from east

Position/Location of Thermographer: Outside

Camera Direction: Northwest

Building Component: Window, Wall, Soffit

Problem Category: Air Leakage – exfiltration & Conduction Loss

Recommendation: Some sections of the building may be fitted with fiberglass batt insulation. Variations in the thermal patterns can indicate significant differences in the performance of the insulation. When viewed from the inside, warmer interior temperatures indicate better performance of fiberglass insulation while cooler temperatures indicate increased cold penetration of the envelope and elevated heat losses. When viewed from the outside, cooler exterior temperatures indicate better performance of the fiberglass insulation while warmer temperatures indicate elevated heat losses.

Fiberglass insulation must be properly installed and protected in order to perform well. Before the insulation is installed, it should be expanded to its designed thickness. Care must be taken in the installation process to ensure that the fiberglass maintains as much of its designed thickness as possible, because compressed areas of fiberglass insulation will have reduced R-value. The insulation must also be installed snugly against studs, joists and rafters in order to prevent warm air bypassing the insulation and transferring heat to the exterior of the building.

The effectiveness of fiberglass insulation can also be reduced by air movement through the material from either the interior or the exterior of the building. Fiberglass must be protected on the inside of the of the building envelope by a continuous air/vapor barrier to prevent warm air from escaping the heated spaces, moving into the envelope and creating warm spots on the exterior. On the cold side of the fiberglass there should be a continuous and vapor permeable air barrier to reduce the potential for cold air infiltration

Thermogram #15 (continued)

into the insulation. Any cold air moving through the fiberglass disturbs the tiny air pockets that create the insulating value and can seriously reduce the insulation's R-value.

Overall, this section of the building appears to be insulated, but has significant variations in thermal performance that may indicate areas of missing, disturbed, or poorly installed insulation, or insulation whose effectiveness has been compromised by air movement. If the insulation in this area is easily accessible, repair or replacement should be made as needed. If the insulation in this area is not accessible due to constraints of interior or exterior finish, retrofitting these areas will involve substantial cost. It may be prudent to perform a comprehensive cost-benefit analysis to determine the return on investment (ROI) and advisability of any retrofits designed to reduce these heat losses, if these areas are not readily accessible.

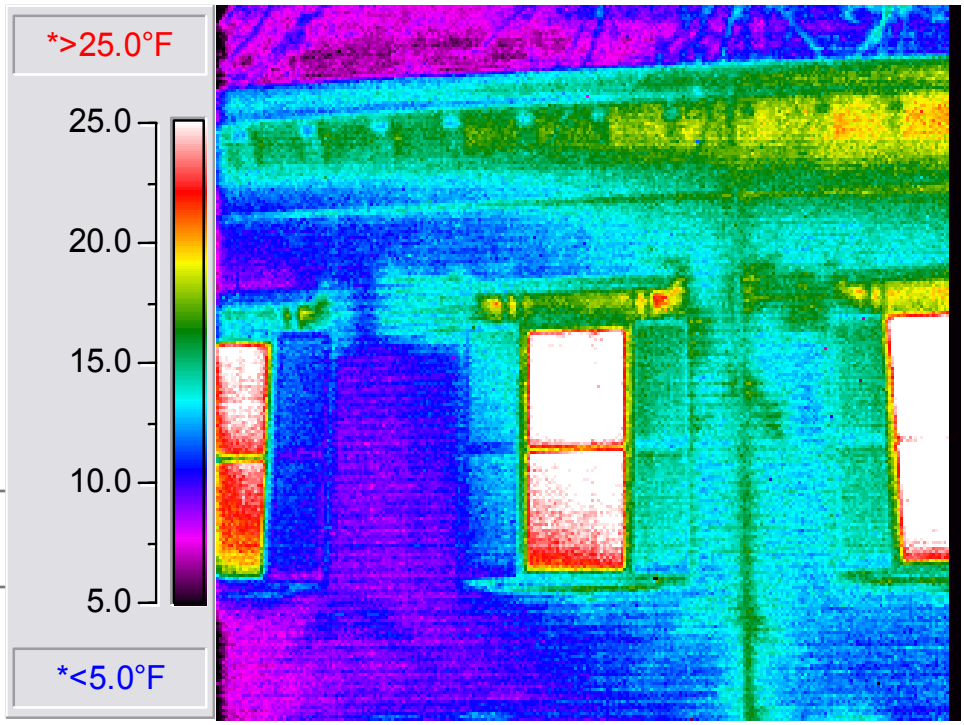
Portions of the wall surface in this thermogram display a thermal signature that appears to indicate a build-up of moisture in the wall system. Water damaged materials will have lower R-values than sound, dry materials and appear as colder temperatures on the inside of the envelope and warmer temperatures on the exterior of the envelope. Some of the areas of warmer temperature in the thermogram may indicate moisture damage. It may be prudent to perform some invasive testing in these areas to absolutely determine the presence or absence of moisture.

The glazing in these units appears to be less resistant to heat loss (have lower R-value/higher U-value) than newer high efficiency glazing. Retrofitting with new high efficiency glazing will substantially reduce these conduction losses, but would involve significant expense. It would be prudent to perform a complete cost/benefit analysis to determine the cost effectiveness and return on investment (ROI) of retrofitting these units.

In this area of the building, the roof soffit is significantly warmer than the adjacent wall system. Ideally, the roof soffit should be no warmer than the exterior ambient air

Thermogram #15 (continued)

temperature. Elevated temperatures at the soffits typically indicate excess heat in the roofing system or attic and poor air flow in the roof venting system. Typically, this excess heat in the attic can lead to the formation of ice dams. Even if ice dams are not forming, these heat losses contribute to increased heating costs, and warm air exfiltration into the attic can add to “stack effect” problems. Stack effect happens when warm air escaping near the top of the building creates the need for cold air to be drawn in near the bottom of the building to replace it. This cycle of air movement from the bottom to the top of the building is called “stack effect” and contributes significantly to heating costs as well as reduces occupant comfort. The insulation near the sofftits should be examined to be sure that it is properly installed and creates a “blanket” that extends out to the outside edge of the vertical stud wall. The air/vapor barrier should also be examined throughout the attic and repaired or replaced as needed. The insulation blanket should fit snuggly against ceiling joists and other structural members, and be installed full thickness to take advantage of all possible R-value. A thorough physical examination will need to be made of the condition of the insulation and air/vapor barrier throughout the attic, and repairs should be made as needed.



Thermogram: Infrared Image

Control Photo: Visible Light Image

Thermogram # 16

Thermogram #: 16

Facility/Building: Acton Town Hall

Location of Target: South Elevation -2nd Floor

Target Shown: 4th window from east

Position/Location of Thermographer: Outside

Camera Direction: North

Building Component: Window, Wall, Soffit

Problem Category: Air Leakage – exfiltration & Conduction Loss

Recommendation: Some sections of the building may be fitted with fiberglass batt insulation. Variations in the thermal patterns can indicate significant differences in the performance of the insulation. When viewed from the inside, warmer interior temperatures indicate better performance of fiberglass insulation while cooler temperatures indicate increased cold penetration of the envelope and elevated heat losses. When viewed from the outside, cooler exterior temperatures indicate better performance of the fiberglass insulation while warmer temperatures indicate elevated heat losses.

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Thermogram #16 (continued)

into the insulation. Any cold air moving through the fiberglass disturbs the tiny air pockets that create the insulating value and can seriously reduce the insulation's R-value.

Overall, this section of the building appears to be insulated, but has significant variations in thermal performance that may indicate areas of missing, disturbed, or poorly installed insulation, or insulation whose effectiveness has been compromised by air movement. If the insulation in this area is easily accessible, repair or replacement should be made as needed. If the insulation in this area is not accessible due to constraints of interior or exterior finish, retrofitting these areas will involve substantial cost. It may be prudent to perform a comprehensive cost-benefit analysis to determine the return on investment (ROI) and advisability of any retrofits designed to reduce these heat losses, if these areas are not readily accessible.

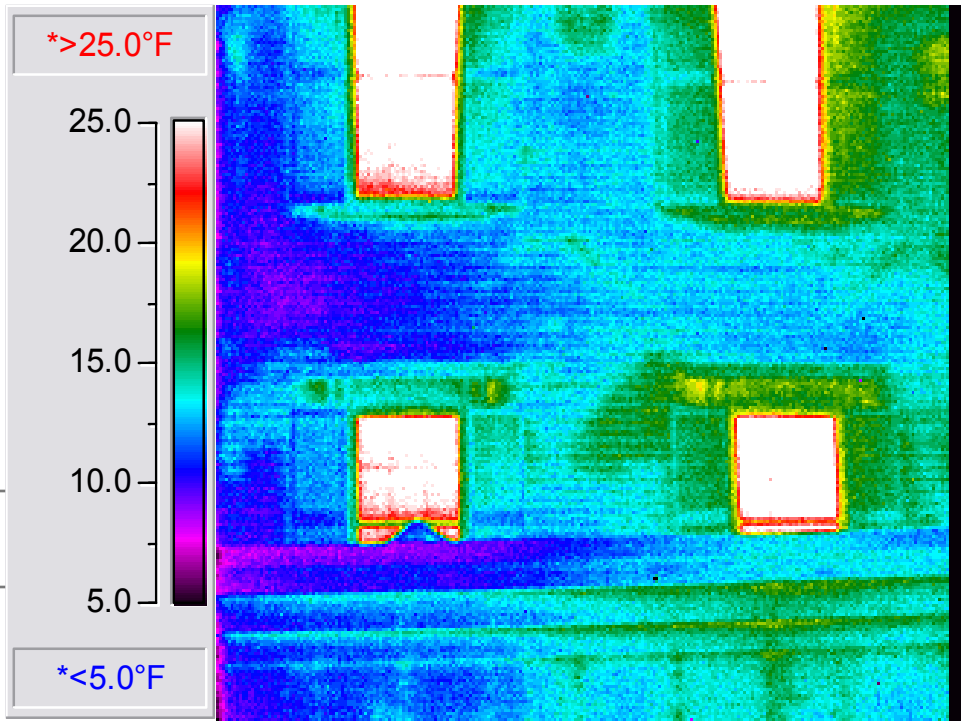
Portions of the wall surface in this thermogram display a thermal signature that appears to indicate a build-up of moisture in the wall system. Water damaged materials will have lower R-values than sound, dry materials and appear as colder temperatures on the inside of the envelope and warmer temperatures on the exterior of the envelope. Some of the areas of warmer temperature in the thermogram may indicate moisture damage. It may be prudent to perform some invasive testing in these areas to absolutely determine the presence or absence of moisture.

The glazing in these units appears to be less resistant to heat loss (have lower R-value/higher U-value) than newer high efficiency glazing. Retrofitting with new high efficiency glazing will substantially reduce these conduction losses, but would involve significant expense. It would be prudent to perform a complete cost/benefit analysis to determine the cost effectiveness and return on investment (ROI) of retrofitting these units.

In this area of the building, the roof soffit is significantly warmer than the adjacent wall system. Ideally, the roof soffit should be no warmer than the exterior ambient air

Thermogram #16 (continued)

temperature. Elevated temperatures at the soffits typically indicate excess heat in the roofing system or attic and poor air flow in the roof venting system. Typically, this excess heat in the attic can lead to the formation of ice dams. Even if ice dams are not forming, these heat losses contribute to increased heating costs, and warm air exfiltration into the attic can add to “stack effect” problems. Stack effect happens when warm air escaping near the top of the building creates the need for cold air to be drawn in near the bottom of the building to replace it. This cycle of air movement from the bottom to the top of the building is called “stack effect” and contributes significantly to heating costs as well as reduces occupant comfort. The insulation near the sofftits should be examined to be sure that it is properly installed and creates a “blanket” that extends out to the outside edge of the vertical stud wall. The air/vapor barrier should also be examined throughout the attic and repaired or replaced as needed. The insulation blanket should fit snuggly against ceiling joists and other structural members, and be installed full thickness to take advantage of all possible R-value. A thorough physical examination will need to be made of the condition of the insulation and air/vapor barrier throughout the attic, and repairs should be made as needed.



Thermogram: Infrared Image

Control Photo: Visible Light Image

Thermogram # 17

Thermogram #: 17

Facility/Building: Acton Town Hall

Location of Target: South Elevation -1st Floor

Target Shown: 2nd & 3rd windows from east

Position/Location of Thermographer: Outside

Camera Direction: North

Building Component: Window, Wall

Problem Category: Air Leakage – exfiltration & Conduction Loss

Recommendation: Some sections of the building may be fitted with fiberglass batt insulation. Variations in the thermal patterns can indicate significant differences in the performance of the insulation. When viewed from the inside, warmer interior temperatures indicate better performance of fiberglass insulation while cooler temperatures indicate increased cold penetration of the envelope and elevated heat losses. When viewed from the outside, cooler exterior temperatures indicate better performance of the fiberglass insulation while warmer temperatures indicate elevated heat losses.

Fiberglass insulation must be properly installed and protected in order to perform well. Before the insulation is installed, it should be expanded to its designed thickness. Care must be taken in the installation process to ensure that the fiberglass maintains as much of its designed thickness as possible, because compressed areas of fiberglass insulation will have reduced R-value. The insulation must also be installed snugly against studs, joists and rafters in order to prevent warm air bypassing the insulation and transferring heat to the exterior of the building.

The effectiveness of fiberglass insulation can also be reduced by air movement through the material from either the interior or the exterior of the building. Fiberglass must be protected on the inside of the of the building envelope by a continuous air/vapor barrier to prevent warm air from escaping the heated spaces, moving into the envelope and creating warm spots on the exterior. On the cold side of the fiberglass there should be a continuous and vapor permeable air barrier to reduce the potential for cold air infiltration

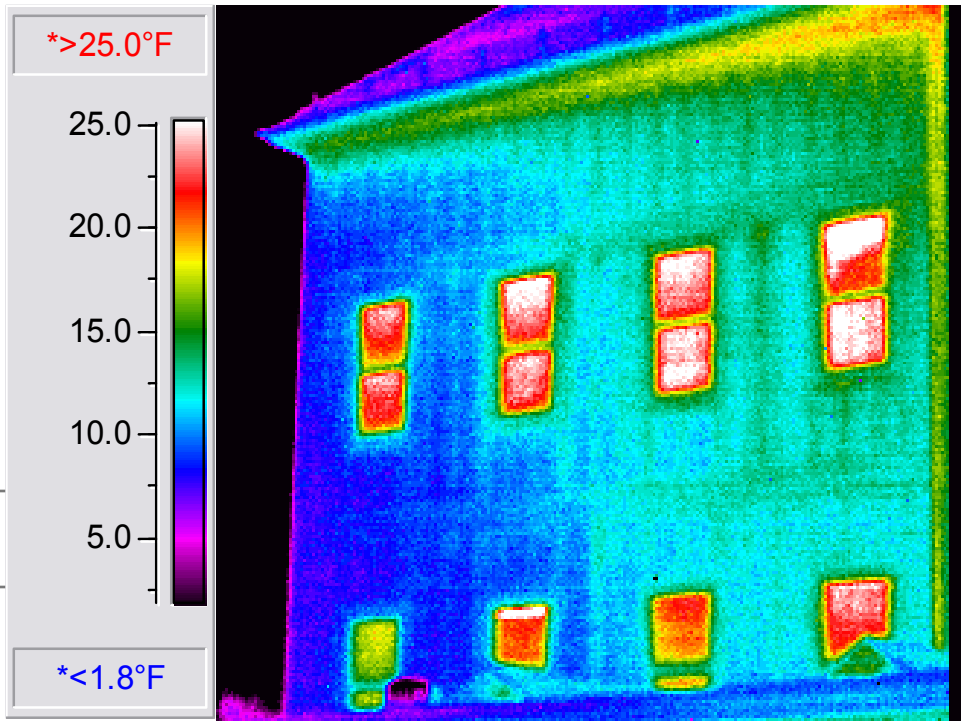
Thermogram #17 (continued)

into the insulation. Any cold air moving through the fiberglass disturbs the tiny air pockets that create the insulating value and can seriously reduce the insulation's R-value.

Overall, this section of the building appears to be insulated, but has significant variations in thermal performance that may indicate areas of missing, disturbed, or poorly installed insulation, or insulation whose effectiveness has been compromised by air movement. If the insulation in this area is easily accessible, repair or replacement should be made as needed. If the insulation in this area is not accessible due to constraints of interior or exterior finish, retrofitting these areas will involve substantial cost. It may be prudent to perform a comprehensive cost-benefit analysis to determine the return on investment (ROI) and advisability of any retrofits designed to reduce these heat losses, if these areas are not readily accessible.

Portions of the wall surface in this thermogram display a thermal signature that appears to indicate a build-up of moisture in the wall system. Water damaged materials will have lower R-values than sound, dry materials and appear as colder temperatures on the inside of the envelope and warmer temperatures on the exterior of the envelope. Some of the areas of warmer temperature in the thermogram may indicate moisture damage. It may be prudent to perform some invasive testing in these areas to absolutely determine the presence or absence of moisture.

The glazing in these units appears to be less resistant to heat loss (have lower R-value/higher U-value) than newer high efficiency glazing. Retrofitting with new high efficiency glazing will substantially reduce these conduction losses, but would involve significant expense. It would be prudent to perform a complete cost/benefit analysis to determine the cost effectiveness and return on investment (ROI) of retrofitting these units.



Thermogram: Infrared Image

Control Photo: Visible Light Image

Thermogram # 18

Thermogram #: 18

Facility/Building: Acton Town Hall

Location of Target: South Elevation -1st & 2nd Floors

Target Shown: West side windows and wall

Position/Location of Thermographer: Outside

Camera Direction: Northwest

Building Component: Window, Soffit

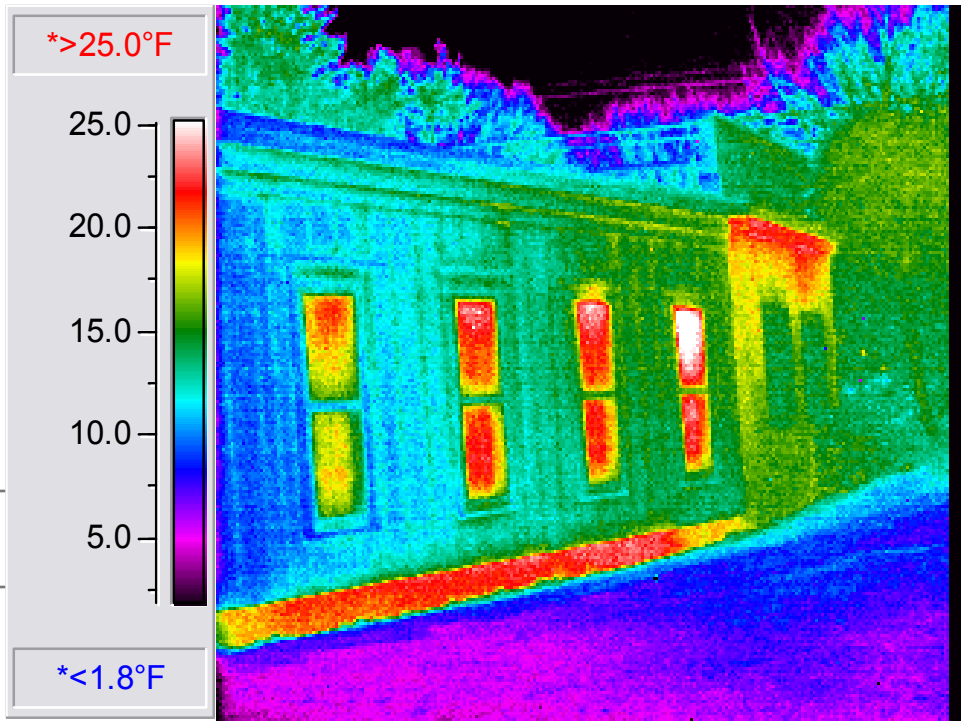
Problem Category: Air Leakage – exfiltration & Conduction Loss

Recommendation: In this area of the building, the roof soffit is significantly warmer than the adjacent wall system. Ideally, the roof soffit should be no warmer than the exterior ambient air temperature. Elevated temperatures at the soffits typically indicate excess heat in the roofing system or attic and poor air flow in the roof venting system. Typically, this excess heat in the attic can lead to the formation of ice dams. Even if ice dams are not forming, these heat losses contribute to increased heating costs, and warm air exfiltration into the attic can add to "stack effect" problems. Stack effect happens when warm air escaping near the top of the building creates the need for cold air to be drawn in near the bottom of the building to replace it. This cycle of air movement from the bottom to the top of the building is called "stack effect" and contributes significantly to heating costs as well as reduces occupant comfort. The insulation near the sofftits should be examined to be sure that it is properly installed and creates a "blanket" that extends out to the outside edge of the vertical stud wall. The air/vapor barrier should also be examined throughout the attic and repaired or replaced as needed. The insulation blanket should fit snuggly against ceiling joists and other structural members, and be installed full thickness to take advantage of all possible R-value. A thorough physical examination will need to be made of the condition of the insulation and air/vapor barrier throughout the attic, and repairs should be made as needed.

The glazing in these units appears to be less resistant to heat loss (have lower R-value/higher U-value) than newer high efficiency glazing. Retrofitting with new high efficiency glazing will substantially reduce these conduction losses, but would involve

Thermogram #18 (continued)

significant expense. It would be prudent to perform a complete cost/benefit analysis to determine the cost effectiveness and return on investment (ROI) of retrofitting these units.



Thermogram: Infrared Image

Control Photo: Visible Light Image

Thermogram # 19

Thermogram #: 19

Facility/Building: Acton Town Hall

Location of Target: South Elevation – Ground Floor

Target Shown: East end

Position/Location of Thermographer: Outside

Camera Direction: Northeast

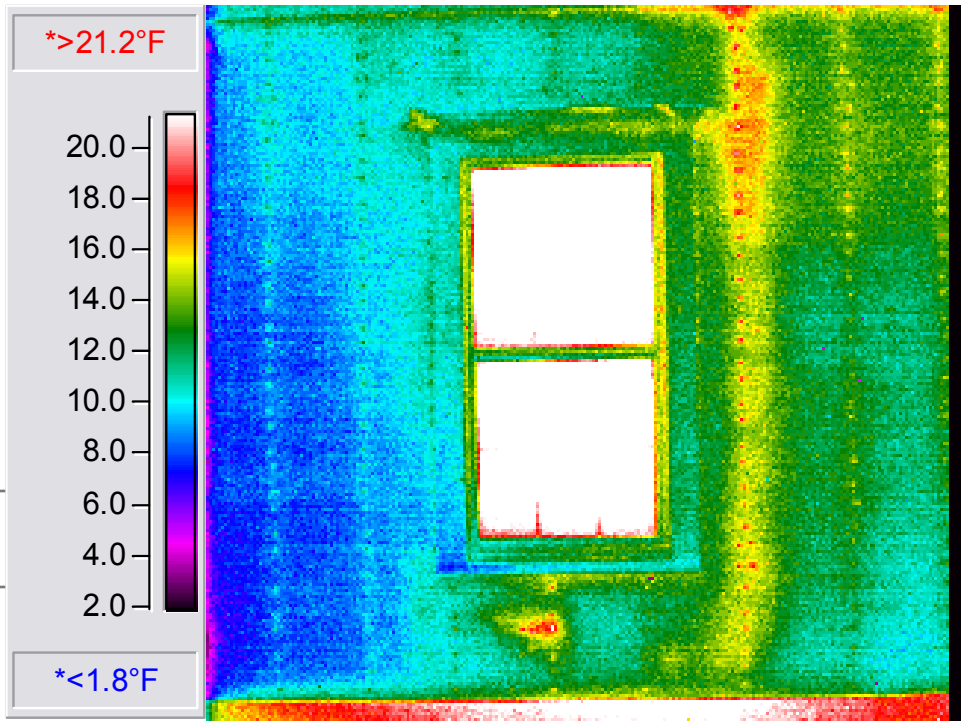
Building Component: Window, Wall, Foundation

Problem Category: Air Leakage – exfiltration & Conduction Loss

Recommendation: The glazing in these units appears to be less resistant to heat loss (have lower R-value/higher U-value) than newer high efficiency glazing. Retrofitting with new high efficiency glazing will substantially reduce these conduction losses, but would involve significant expense. It would be prudent to perform a complete cost/benefit analysis to determine the cost effectiveness and return on investment (ROI) of retrofitting these units.

The foundation in this area is exhibiting significant conduction loss and may be uninsulated. Typically, retrofitting a foundation wall with insulation involves substantial cost. It may be prudent to perform a comprehensive cost-benefit analysis to determine the return on investment (ROI) and advisability of any retrofits designed to reduce these conduction losses.

It appears that there is both significant air leakage and some conduction loss in this area. In order to devise a practical and cost-effective retrofit, a thorough physical examination of the leaky joints and penetrations near the top of the building should be performed. High-quality long-lasting materials (e.g. caulking, backer rod, expanding foam insulation, etc) should be employed to reduce or eliminate this warm air exfiltration. Reducing these air leakage losses will result in increased occupant comfort and lowered heating costs. Any areas of poorly installed or insufficient insulation could also be addressed at this time.



Thermogram: Infrared Image

Control Photo: Visible Light Image

Thermogram # 20

Thermogram #: 20

Facility/Building: Acton Town Hall

Location of Target: South Elevation – Ground Floor

Target Shown: 2nd window from west

Position/Location of Thermographer: Outside

Camera Direction: North

Building Component: Window, Wall, Foundation

Problem Category: Air Leakage – exfiltration & Conduction Loss

Recommendation: Some sections of the building may be fitted with fiberglass batt insulation. Variations in the thermal patterns can indicate significant differences in the performance of the insulation. When viewed from the inside, warmer interior temperatures indicate better performance of fiberglass insulation while cooler temperatures indicate increased cold penetration of the envelope and elevated heat losses. When viewed from the outside, cooler exterior temperatures indicate better performance of the fiberglass insulation while warmer temperatures indicate elevated heat losses.

Fiberglass insulation must be properly installed and protected in order to perform well. Before the insulation is installed, it should be expanded to its designed thickness. Care must be taken in the installation process to ensure that the fiberglass maintains as much of its designed thickness as possible, because compressed areas of fiberglass insulation will have reduced R-value. The insulation must also be installed snugly against studs, joists and rafters in order to prevent warm air bypassing the insulation and transferring heat to the exterior of the building.

The effectiveness of fiberglass insulation can also be reduced by air movement through the material from either the interior or the exterior of the building. Fiberglass must be protected on the inside of the of the building envelope by a continuous air/vapor barrier to prevent warm air from escaping the heated spaces, moving into the envelope and creating warm spots on the exterior. On the cold side of the fiberglass there should be a continuous and vapor permeable air barrier to reduce the potential for cold air infiltration

Thermogram #20 (continued)

into the insulation. Any cold air moving through the fiberglass disturbs the tiny air pockets that create the insulating value and can seriously reduce the insulation's R-value.

Overall, this section of the building appears to be insulated, but has significant variations in thermal performance that may indicate areas of missing, disturbed, or poorly installed insulation, or insulation whose effectiveness has been compromised by air movement. If the insulation in this area is easily accessible, repair or replacement should be made as needed. If the insulation in this area is not accessible due to constraints of interior or exterior finish, retrofitting these areas will involve substantial cost. It may be prudent to perform a comprehensive cost-benefit analysis to determine the return on investment (ROI) and advisability of any retrofits designed to reduce these heat losses, if these areas are not readily accessible.

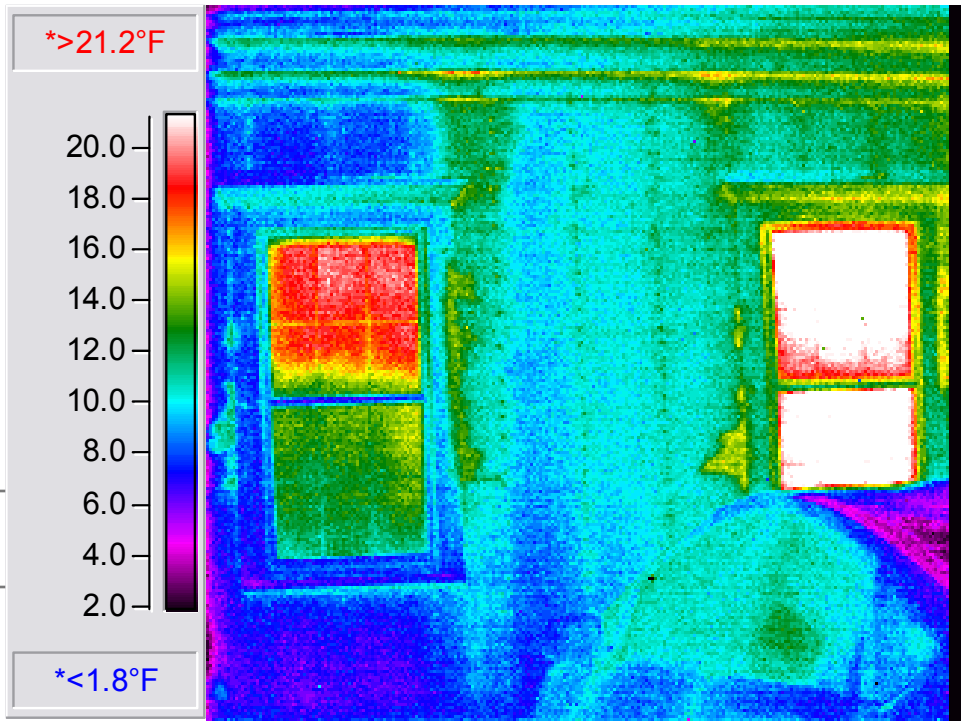
Portions of the wall surface in this thermogram display a thermal signature that appears to indicate a build-up of moisture in the wall system. Water damaged materials will have lower R-values than sound, dry materials and appear as colder temperatures on the inside of the envelope and warmer temperatures on the exterior of the envelope. Some of the areas of warmer temperature in the thermogram may indicate moisture damage. It may be prudent to perform some invasive testing in these areas to absolutely determine the presence or absence of moisture.

The glazing in these units appears to be less resistant to heat loss (have lower R-value/higher U-value) than newer high efficiency glazing. Retrofitting with new high efficiency glazing will substantially reduce these conduction losses, but would involve significant expense. It would be prudent to perform a complete cost/benefit analysis to determine the cost effectiveness and return on investment (ROI) of retrofitting these units.

The foundation in this area is exhibiting significant conduction loss and may be uninsulated. Typically, retrofitting a foundation wall with insulation involves substantial

Thermogram #20 (continued)

cost. It may be prudent to perform a comprehensive cost-benefit analysis to determine the return on investment (ROI) and advisability of any retrofits designed to reduce these conduction losses.



Thermogram: Infrared Image

Control Photo: Visible Light Image

Thermogram # 21

Thermogram #: 21

Facility/Building: Acton Town Hall

Location of Target: West Elevation – Ground Floor

Target Shown: 1st & 2nd windows from the south

Position/Location of Thermographer: Outside

Camera Direction: East

Building Component: Window, Wall

Problem Category: Air Leakage – exfiltration & Conduction Loss

Recommendation: Some sections of the building may be fitted with fiberglass batt insulation. Variations in the thermal patterns can indicate significant differences in the performance of the insulation. When viewed from the inside, warmer interior temperatures indicate better performance of fiberglass insulation while cooler temperatures indicate increased cold penetration of the envelope and elevated heat losses. When viewed from the outside, cooler exterior temperatures indicate better performance of the fiberglass insulation while warmer temperatures indicate elevated heat losses.

Fiberglass insulation must be properly installed and protected in order to perform well. Before the insulation is installed, it should be expanded to its designed thickness. Care must be taken in the installation process to ensure that the fiberglass maintains as much of its designed thickness as possible, because compressed areas of fiberglass insulation will have reduced R-value. The insulation must also be installed snugly against studs, joists and rafters in order to prevent warm air bypassing the insulation and transferring heat to the exterior of the building.

The effectiveness of fiberglass insulation can also be reduced by air movement through the material from either the interior or the exterior of the building. Fiberglass must be protected on the inside of the of the building envelope by a continuous air/vapor barrier to prevent warm air from escaping the heated spaces, moving into the envelope and creating warm spots on the exterior. On the cold side of the fiberglass there should be a continuous and vapor permeable air barrier to reduce the potential for cold air infiltration

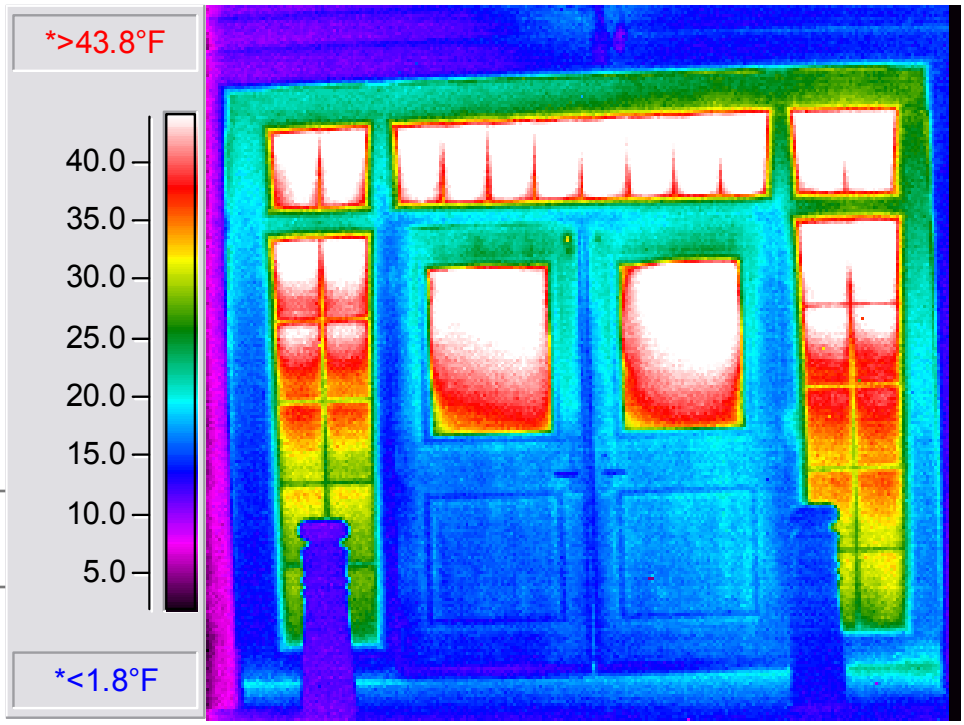
Thermogram #21 (continued)

into the insulation. Any cold air moving through the fiberglass disturbs the tiny air pockets that create the insulating value and can seriously reduce the insulation's R-value.

Overall, this section of the building appears to be insulated, but has significant variations in thermal performance that may indicate areas of missing, disturbed, or poorly installed insulation, or insulation whose effectiveness has been compromised by air movement. If the insulation in this area is easily accessible, repair or replacement should be made as needed. If the insulation in this area is not accessible due to constraints of interior or exterior finish, retrofitting these areas will involve substantial cost. It may be prudent to perform a comprehensive cost-benefit analysis to determine the return on investment (ROI) and advisability of any retrofits designed to reduce these heat losses, if these areas are not readily accessible.

Portions of the wall surface in this thermogram display a thermal signature that appears to indicate a build-up of moisture in the wall system. Water damaged materials will have lower R-values than sound, dry materials and appear as colder temperatures on the inside of the envelope and warmer temperatures on the exterior of the envelope. Some of the areas of warmer temperature in the thermogram may indicate moisture damage. It may be prudent to perform some invasive testing in these areas to absolutely determine the presence or absence of moisture.

The glazing in these units appears to be less resistant to heat loss (have lower R-value/higher U-value) than newer high efficiency glazing. Retrofitting with new high efficiency glazing will substantially reduce these conduction losses, but would involve significant expense. It would be prudent to perform a complete cost/benefit analysis to determine the cost effectiveness and return on investment (ROI) of retrofitting these units.



Thermogram: Infrared Image

Control Photo: Visible Light Image

Thermogram # 22

Thermogram #: 22

Facility/Building: Acton Town Hall

Location of Target: West Elevation – Ground Floor

Target Shown: Main entrance

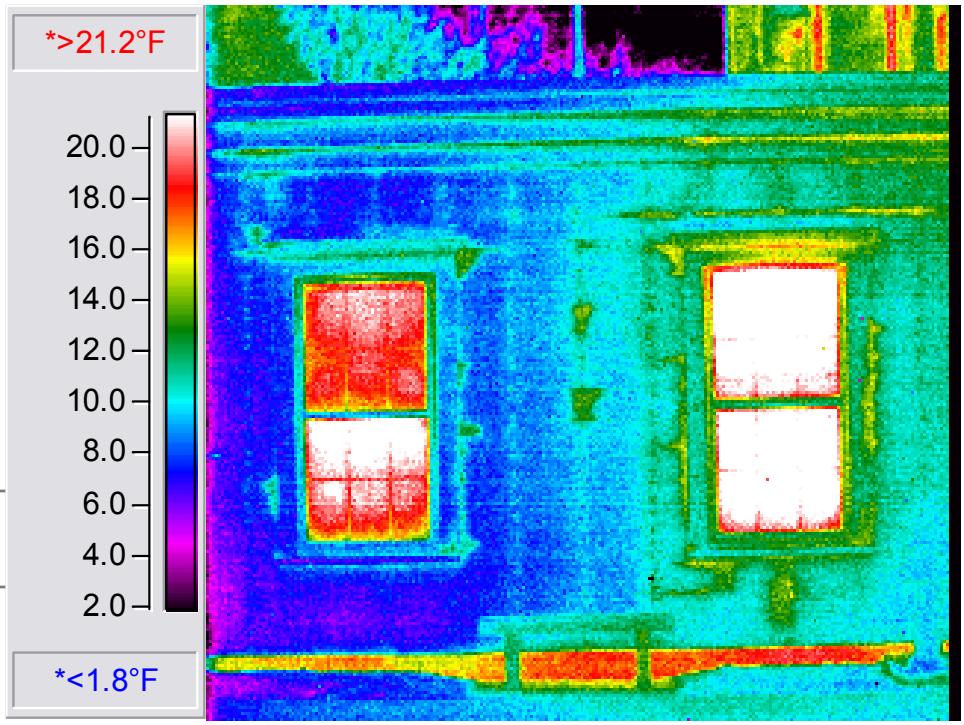
Position/Location of Thermographer: Outside

Camera Direction: East

Building Component: Window, Door

Problem Category: Conduction Loss

Recommendation: The glazing in these units appears to be less resistant to heat loss (have lower R-value/higher U-value) than newer high efficiency glazing. Retrofitting with new high efficiency glazing will substantially reduce these conduction losses, but would involve significant expense. It would be prudent to perform a complete cost/benefit analysis to determine the cost effectiveness and return on investment (ROI) of retrofitting these units.



Thermogram: Infrared Image

Control Photo: Visible Light Image

Thermogram # 23

Thermogram #: 23

Facility/Building: Acton Town Hall

Location of Target: West Elevation – Ground Floor

Target Shown: 3rd & 4th windows from the north

Position/Location of Thermographer: Outside

Camera Direction: East

Building Component: Window, Wall, Foundation

Problem Category: Air Leakage – exfiltration & Conduction Loss

Recommendation: Some sections of the building may be fitted with fiberglass batt insulation. Variations in the thermal patterns can indicate significant differences in the performance of the insulation. When viewed from the inside, warmer interior temperatures indicate better performance of fiberglass insulation while cooler temperatures indicate increased cold penetration of the envelope and elevated heat losses. When viewed from the outside, cooler exterior temperatures indicate better performance of the fiberglass insulation while warmer temperatures indicate elevated heat losses.

Fiberglass insulation must be properly installed and protected in order to perform well. Before the insulation is installed, it should be expanded to its designed thickness. Care must be taken in the installation process to ensure that the fiberglass maintains as much of its designed thickness as possible, because compressed areas of fiberglass insulation will have reduced R-value. The insulation must also be installed snugly against studs, joists and rafters in order to prevent warm air bypassing the insulation and transferring heat to the exterior of the building.

The effectiveness of fiberglass insulation can also be reduced by air movement through the material from either the interior or the exterior of the building. Fiberglass must be protected on the inside of the of the building envelope by a continuous air/vapor barrier to prevent warm air from escaping the heated spaces, moving into the envelope and creating warm spots on the exterior. On the cold side of the fiberglass there should be a continuous and vapor permeable air barrier to reduce the potential for cold air infiltration

Thermogram #23 (continued)

into the insulation. Any cold air moving through the fiberglass disturbs the tiny air pockets that create the insulating value and can seriously reduce the insulation's R-value.

Overall, this section of the building appears to be insulated, but has significant variations in thermal performance that may indicate areas of missing, disturbed, or poorly installed insulation, or insulation whose effectiveness has been compromised by air movement. If the insulation in this area is easily accessible, repair or replacement should be made as needed. If the insulation in this area is not accessible due to constraints of interior or exterior finish, retrofitting these areas will involve substantial cost. It may be prudent to perform a comprehensive cost-benefit analysis to determine the return on investment (ROI) and advisability of any retrofits designed to reduce these heat losses, if these areas are not readily accessible.

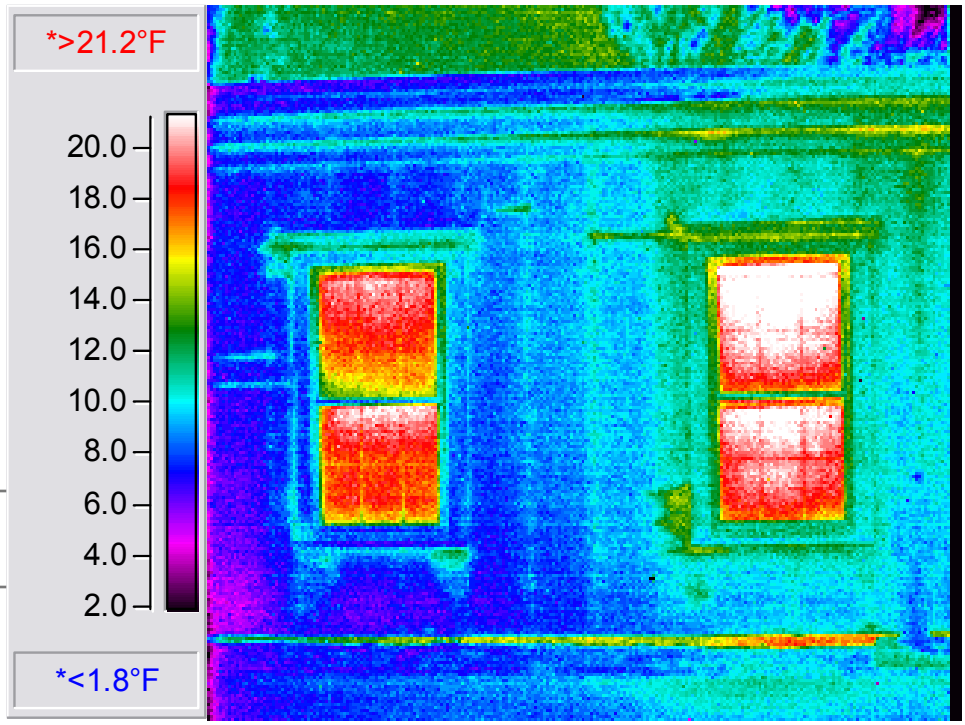
Portions of the wall surface in this thermogram display a thermal signature that appears to indicate a build-up of moisture in the wall system. Water damaged materials will have lower R-values than sound, dry materials and appear as colder temperatures on the inside of the envelope and warmer temperatures on the exterior of the envelope. Some of the areas of warmer temperature in the thermogram may indicate moisture damage. It may be prudent to perform some invasive testing in these areas to absolutely determine the presence or absence of moisture.

The glazing in these units appears to be less resistant to heat loss (have lower R-value/higher U-value) than newer high efficiency glazing. Retrofitting with new high efficiency glazing will substantially reduce these conduction losses, but would involve significant expense. It would be prudent to perform a complete cost/benefit analysis to determine the cost effectiveness and return on investment (ROI) of retrofitting these units.

The foundation in this area is exhibiting significant conduction loss and may be uninsulated. Typically, retrofitting a foundation wall with insulation involves substantial

Thermogram #23 (continued)

cost. It may be prudent to perform a comprehensive cost-benefit analysis to determine the return on investment (ROI) and advisability of any retrofits designed to reduce these conduction losses.



Thermogram: Infrared Image

Control Photo: Visible Light Image

Thermogram # 24

Thermogram #: 24

Facility/Building: Acton Town Hall

Location of Target: West Elevation – Ground Floor

Target Shown: 1st & 2nd windows from the north

Position/Location of Thermographer: Outside

Camera Direction: East

Building Component: Window, Wall, Foundation

Problem Category: Air Leakage – exfiltration & Conduction Loss

Recommendation: Some sections of the building may be fitted with fiberglass batt insulation. Variations in the thermal patterns can indicate significant differences in the performance of the insulation. When viewed from the inside, warmer interior temperatures indicate better performance of fiberglass insulation while cooler temperatures indicate increased cold penetration of the envelope and elevated heat losses. When viewed from the outside, cooler exterior temperatures indicate better performance of the fiberglass insulation while warmer temperatures indicate elevated heat losses.

Fiberglass insulation must be properly installed and protected in order to perform well. Before the insulation is installed, it should be expanded to its designed thickness. Care must be taken in the installation process to ensure that the fiberglass maintains as much of its designed thickness as possible, because compressed areas of fiberglass insulation will have reduced R-value. The insulation must also be installed snugly against studs, joists and rafters in order to prevent warm air bypassing the insulation and transferring heat to the exterior of the building.

The effectiveness of fiberglass insulation can also be reduced by air movement through the material from either the interior or the exterior of the building. Fiberglass must be protected on the inside of the of the building envelope by a continuous air/vapor barrier to prevent warm air from escaping the heated spaces, moving into the envelope and creating warm spots on the exterior. On the cold side of the fiberglass there should be a continuous and vapor permeable air barrier to reduce the potential for cold air infiltration

Thermogram #24 (continued)

into the insulation. Any cold air moving through the fiberglass disturbs the tiny air pockets that create the insulating value and can seriously reduce the insulation's R-value.

Overall, this section of the building appears to be insulated, but has significant variations in thermal performance that may indicate areas of missing, disturbed, or poorly installed insulation, or insulation whose effectiveness has been compromised by air movement. If the insulation in this area is easily accessible, repair or replacement should be made as needed. If the insulation in this area is not accessible due to constraints of interior or exterior finish, retrofitting these areas will involve substantial cost. It may be prudent to perform a comprehensive cost-benefit analysis to determine the return on investment (ROI) and advisability of any retrofits designed to reduce these heat losses, if these areas are not readily accessible.

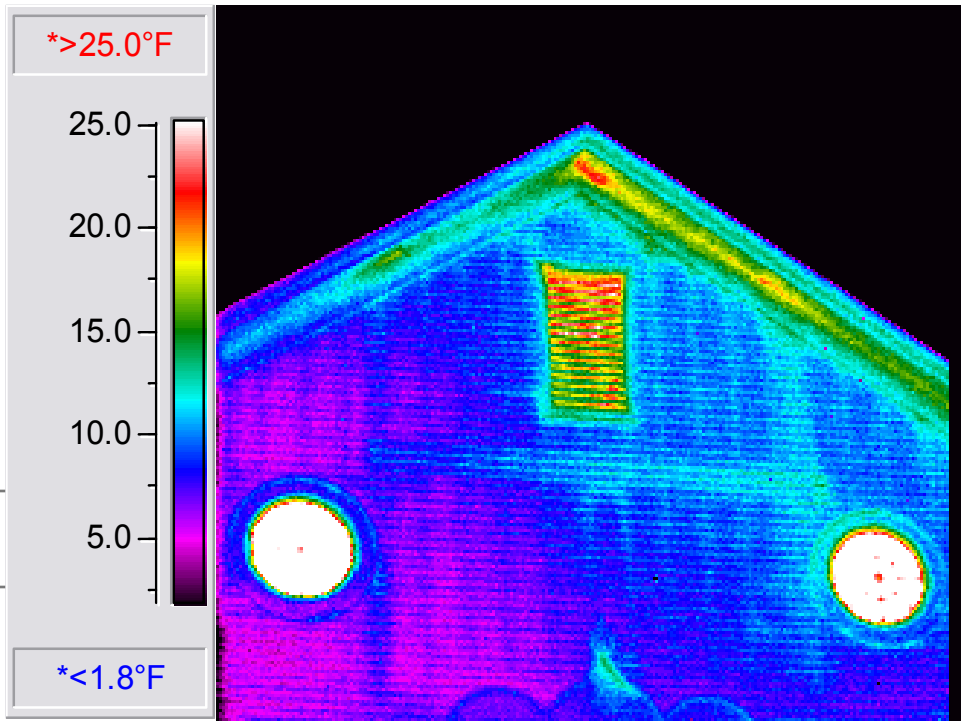
Portions of the wall surface in this thermogram display a thermal signature that appears to indicate a build-up of moisture in the wall system. Water damaged materials will have lower R-values than sound, dry materials and appear as colder temperatures on the inside of the envelope and warmer temperatures on the exterior of the envelope. Some of the areas of warmer temperature in the thermogram may indicate moisture damage. It may be prudent to perform some invasive testing in these areas to absolutely determine the presence or absence of moisture.

The glazing in these units appears to be less resistant to heat loss (have lower R-value/higher U-value) than newer high efficiency glazing. Retrofitting with new high efficiency glazing will substantially reduce these conduction losses, but would involve significant expense. It would be prudent to perform a complete cost/benefit analysis to determine the cost effectiveness and return on investment (ROI) of retrofitting these units.

The foundation in this area is exhibiting significant conduction loss and may be uninsulated. Typically, retrofitting a foundation wall with insulation involves substantial

Thermogram #24 (continued)

cost. It may be prudent to perform a comprehensive cost-benefit analysis to determine the return on investment (ROI) and advisability of any retrofits designed to reduce these conduction losses.



Thermogram: Infrared Image

Control Photo: Visible Light Image

Thermogram # 25

Thermogram #: 25

Facility/Building: Acton Town Hall

Location of Target: West Elevation

Target Shown: Attic

Position/Location of Thermographer: Outside

Camera Direction: East

Building Component: Window, Wall

Problem Category: Air Leakage – exfiltration & Conduction Loss

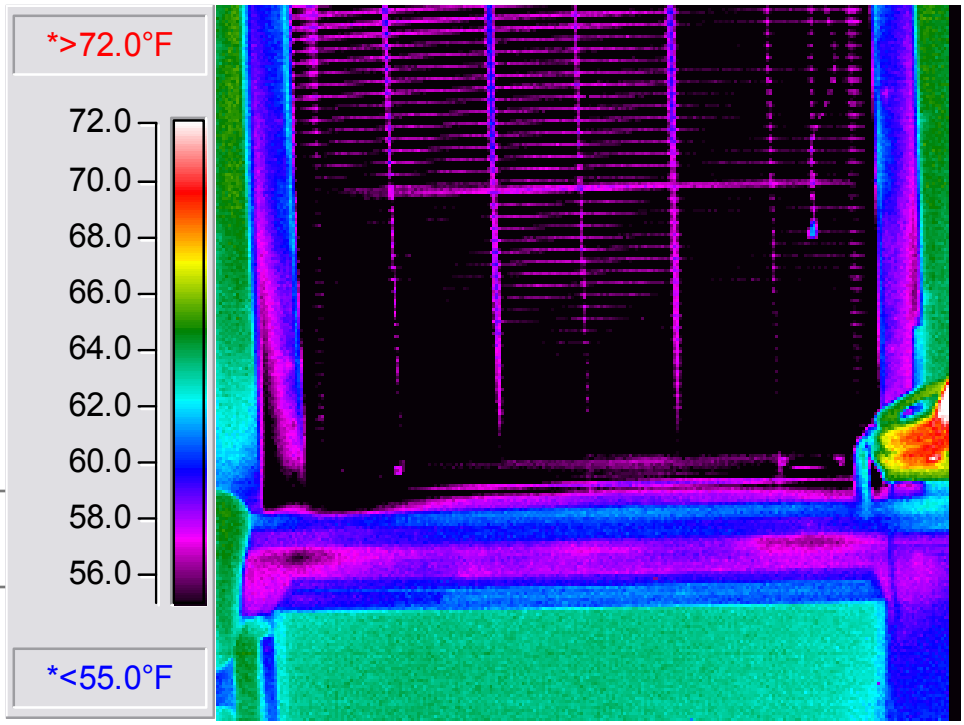
Recommendation: The building appears to be experiencing significant "stack effect". The warm thermal patterns in the thermogram are typical of warm air exfiltration. Poorly sealed joints and penetrations near the top of the building will allow warm air to continuously leave the building. As the warm air is lost, cold air must be drawn in to replace it, typically near the bottom of the building. This cycle of warmer, lighter and more humid air escaping near the top and colder, heavier and drier air being pulled in near the bottom is called stack effect. It substantially increases heating costs and decreases occupant comfort. Continuously heating air that will eventually leak out the top of the building is costly, while at the same time the cold drafts coming in near the bottom make people uncomfortable.

In order to devise a practical and cost-effective retrofit, a thorough physical examination of the leaky joints and penetrations near the top of the building should be performed. High-quality long-lasting materials (e.g. caulking, backer rod, expanding foam insulation, etc.) should be employed to reduce or eliminate this warm air exfiltration. Reducing these air leakage losses will result in increased occupant comfort and lowered heating costs.

The glazing in these units appears to be less resistant to heat loss (have lower R-value/higher U-value) than newer high efficiency glazing. Retrofitting with new high efficiency glazing will substantially reduce these conduction losses, but would involve significant expense. It would be prudent to perform a complete cost/benefit analysis to

Thermogram #25 (continued)

determine the cost effectiveness and return on investment (ROI) of retrofitting these units.



Thermogram: Infrared Image

Control Photo: Visible Light Image

Thermogram # 26

Thermogram #: 26

Facility/Building: Acton Town Hall

Location of Target: Room 126 – north wall

Target Shown: East window

Position/Location of Thermographer: Inside

Camera Direction: North

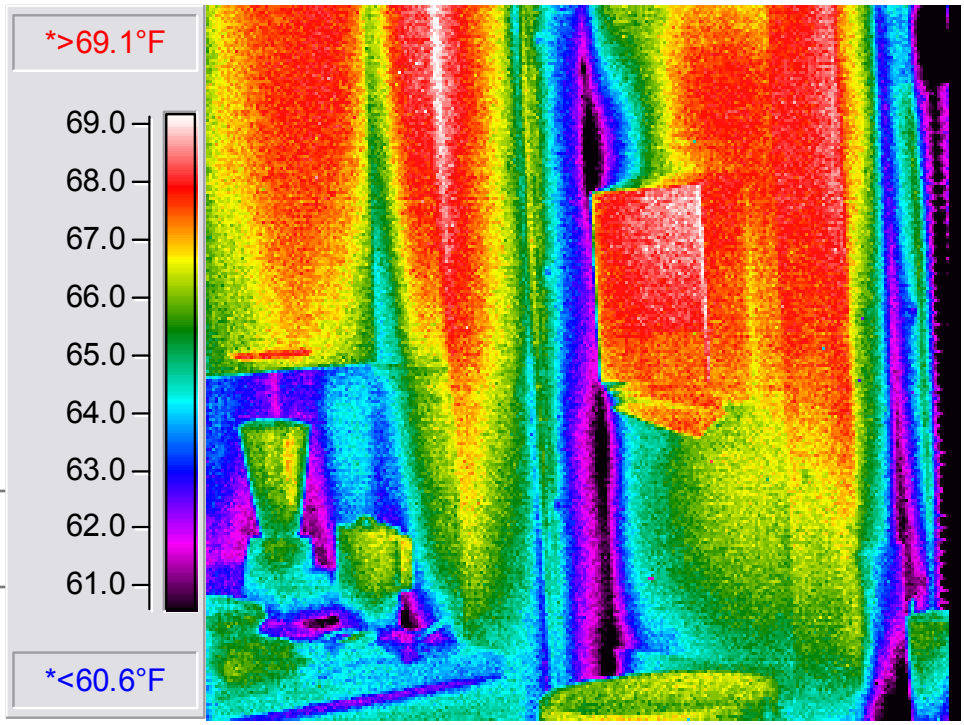
Building Component: Window

Problem Category: Air Leakage – infiltration & Conduction Loss

Recommendation: It appears that there may be significant air movement through some of the windows. In some instances, the windows may be open, or partially open. Windows exhibiting air leakage should also be examined for proper operation to ensure that they close completely and that all hardware is functioning properly. All the meeting surfaces of moveable sashes should be checked to determine if the weather strips are worn, damaged or missing. Repairs should be made as needed. The joints between the glazing and the frames should be checked for gaskets or sealants that are deteriorated, damaged, or missing. Repairs should be made as needed.

The window trim should also be visually examined for gaps that can allow air leakage. Any significant gaps between the window frame and the window trim, or between the window trim and the wall should be sealed utilizing high-quality caulking compounds.

The glazing in these units appears to be less resistant to heat loss (have lower R-value//higher U-value) than newer high efficiency glazing. Retrofitting with new high efficiency glazing will substantially reduce these conduction losses, but would involve significant expense. It would be prudent to perform a complete cost/benefit analysis to determine the cost effectiveness and return on investment (ROI) of retrofitting these units.



Thermogram: Infrared Image

Control Photo: Visible Light Image

Thermogram # 27

Thermogram #: 27

Facility/Building: Acton Town Hall

Location of Target: 1st Floor – Lunch Room – north wall

Target Shown: West corner

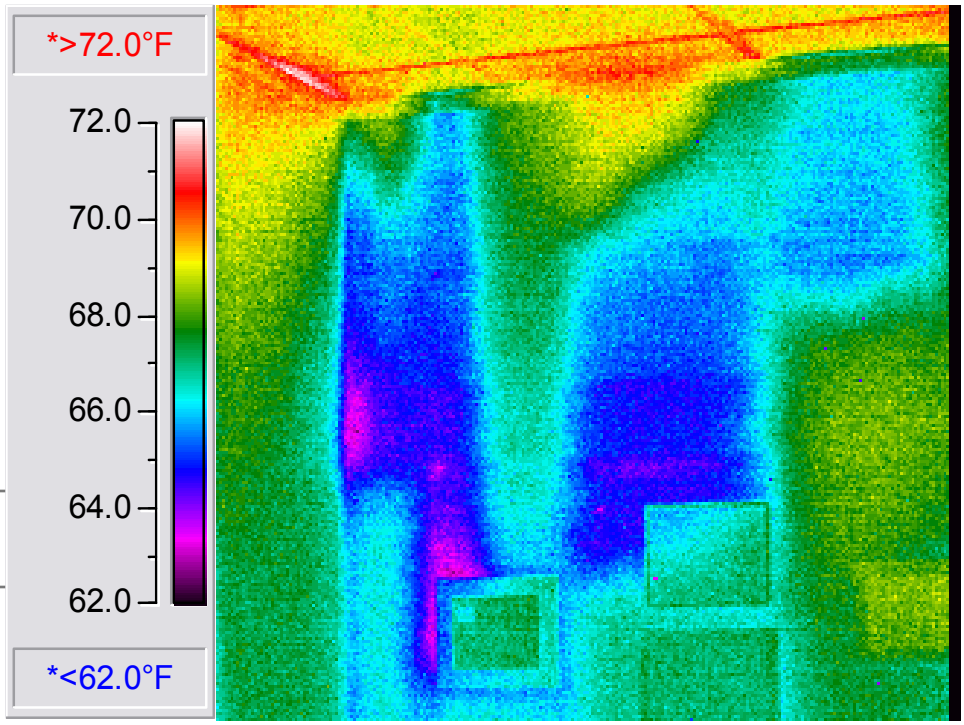
Position/Location of Thermographer: Inside

Camera Direction: Northwest

Building Component: Wall

Problem Category: Air Leakage – infiltration & Conduction Loss

Recommendation: When viewed from the inside, cold air infiltration into the wall system from leaky building joints and penetrations will appear as cooler temperatures in the thermogram. Cold air appears to be entering the cavity behind the interior finish in this area. It will be necessary to visually inspect the outside and inside wall components in this area to locate openings that could allow air flow. These sources of cold air infiltration should be sealed to reduce heating costs and improve occupant comfort. Air movement through narrow gaps can often be corrected with the careful application of high-quality long-lasting caulking compounds. To seal large gaps, it may be necessary to retrofit any joints or penetrations with expanding foam insulation.



Thermogram: Infrared Image

Control Photo: Visible Light Image

Thermogram # 28

Thermogram #: 28

Facility/Building: Acton Town Hall

Location of Target: 1st Floor – Room 121 – north wall

Target Shown: Wall west of window

Position/Location of Thermographer: Inside

Camera Direction: North

Building Component: Wall

Problem Category: Air Leakage – infiltration & Conduction Loss

Recommendation: Some sections of the building may be fitted with fiberglass batt insulation. Variations in the thermal patterns can indicate significant differences in the performance of the insulation. When viewed from the inside, warmer interior temperatures indicate better performance of fiberglass insulation while cooler temperatures indicate increased cold penetration of the envelope and elevated heat losses. When viewed from the outside, cooler exterior temperatures indicate better performance of the fiberglass insulation while warmer temperatures indicate elevated heat losses.

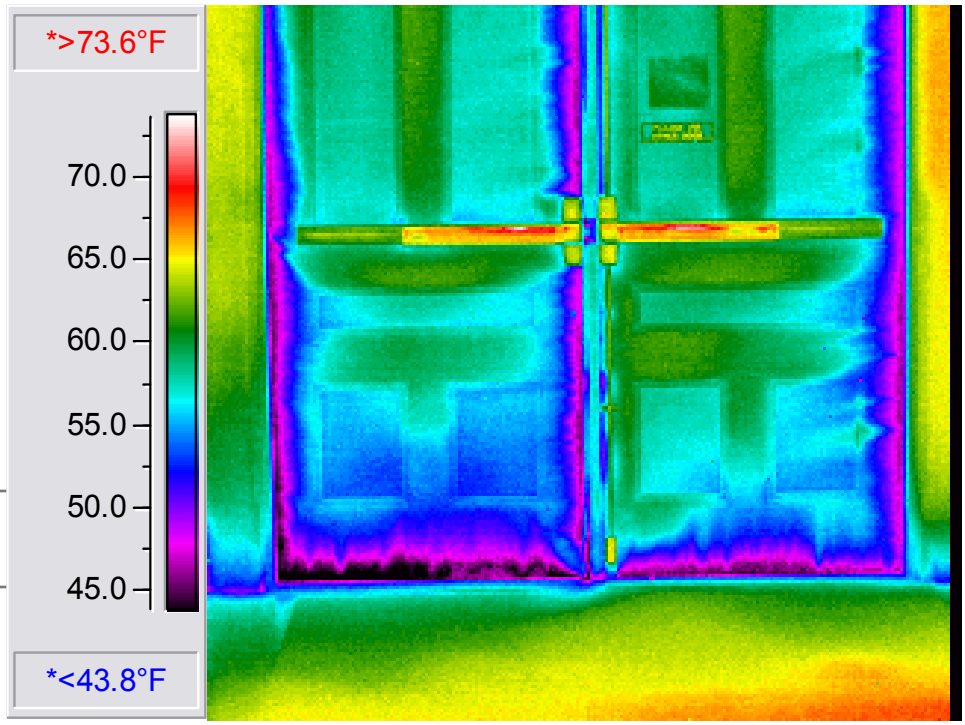
Fiberglass insulation must be properly installed and protected in order to perform well. Before the insulation is installed, it should be expanded to its designed thickness. Care must be taken in the installation process to ensure that the fiberglass maintains as much of its designed thickness as possible, because compressed areas will have reduced R-value. The insulation must also be installed snugly against studs, joists and rafters in order to prevent warm air bypassing the insulation and transferring heat to the exterior of the building.

The effectiveness of fiberglass insulation can also be reduced by air movement through the material from either the interior or the exterior of the building. Fiberglass must be protected on the inside of the of the building envelope by a continuous air/vapor barrier to prevent warm air from escaping the heated spaces, moving into the envelope and creating warm spots on the exterior. On the cold side of the fiberglass there should be a continuous and vapor permeable air barrier to reduce the potential for cold air infiltration

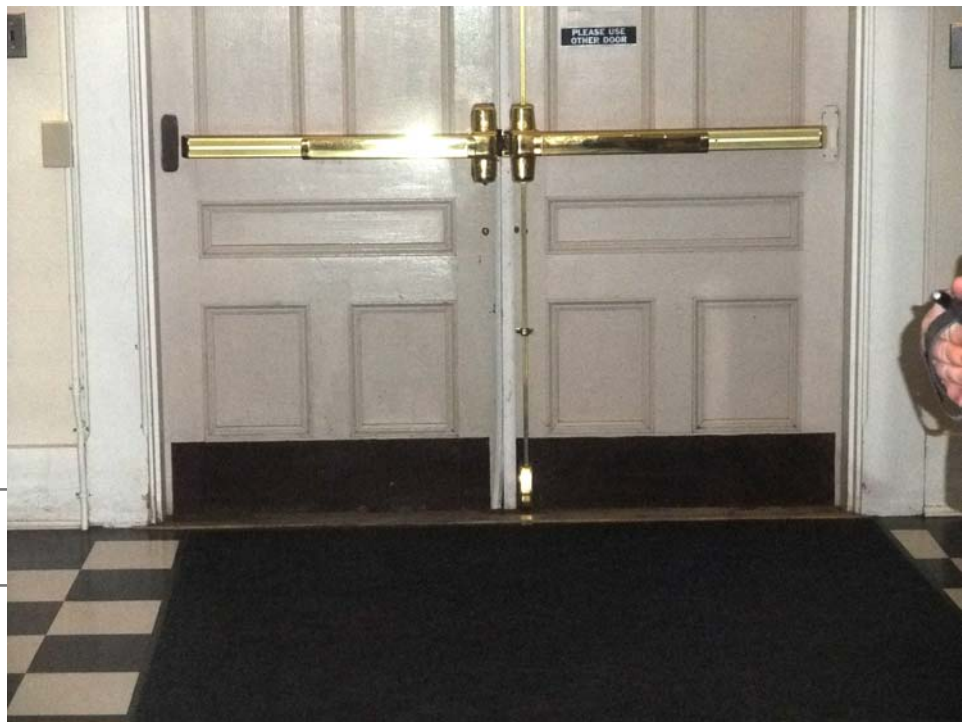
Thermogram #28 (continued)

into the insulation. Any air moving through the fiberglass disturbs the tiny air pockets that create the insulating value and can seriously reduce the insulation's R-value.

Overall, this section of the building appears to be insulated, but has significant variations in thermal performance that may indicate areas of missing, disturbed, or poorly installed insulation, or insulation whose effectiveness has been compromised by air movement. If the insulation in this area is easily accessible, repair or replacement should be made as needed. If the insulation is not accessible due to constraints of interior or exterior finish, retrofitting these areas will involve substantial cost. It may be prudent to perform a comprehensive cost-benefit analysis to determine the return on investment (ROI) and advisability of any retrofits designed to reduce these heat losses, if these areas are not readily accessible.



Thermogram: Infrared Image



Control Photo: Visible Light Image

Thermogram # 29

Thermogram #: 29

Facility/Building: Acton Town Hall

Location of Target: 1st Floor – east wall

Target Shown: East entrance door

Position/Location of Thermographer: Inside

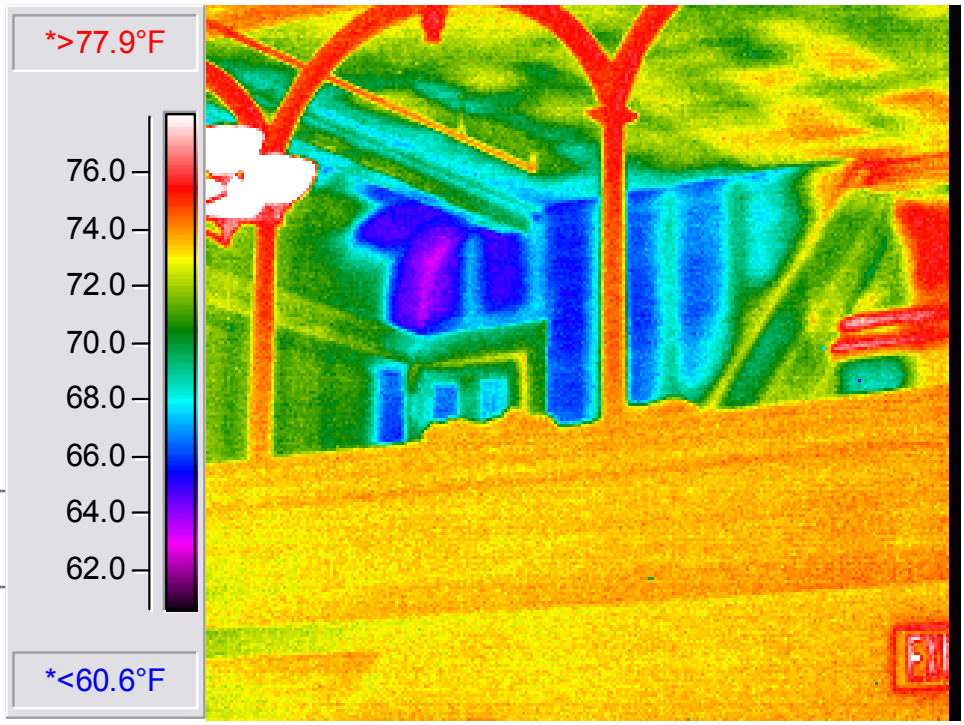
Camera Direction: East

Building Component: Door

Problem Category: Air Leakage – infiltration & Conduction Loss

Recommendation: There appears to be substantial air leakage around the door unit illustrated in this thermogram. The hardware should be inspected to ensure that it is in good operating order, and that it provides for proper closure. All door sweeps and weather stripping should be carefully examined for wear, damage and adjustment. Repairs, adjustments or replacement should be made as needed to reduce this air leakage.

Wood door units often have substantial conduction losses. Wood has an R-value of approximately 1 per inch. Therefore, a 1.5" thick door only has an R-value of approximately of 1.5. In addition, any edges of the raised panels on wood doors can be thinner and have even lower R-values. Typically, replacing a wood door with a new energy-efficient unit will involve considerable expense. It may be prudent to perform a comprehensive cost-benefit analysis to determine the return on investment (ROI) and advisability of any retrofits designed to reduce these conduction losses.



Thermogram: Infrared Image

Control Photo: Visible Light Image

Thermogram # 30

Thermogram #: 30

Facility/Building: Acton Town Hall

Location of Target: 2nd Floor – Faulkner Room – east wall

Target Shown: Attic doorway

Position/Location of Thermographer: Inside

Camera Direction: Northeast

Building Component: Wall, Ceiling

Problem Category: Air Leakage – infiltration & Conduction Loss

Recommendation: Some sections of the building may be fitted with fiberglass batt insulation. Variations in the thermal patterns can indicate significant differences in the performance of the insulation. When viewed from the inside, warmer interior temperatures indicate better performance of fiberglass insulation while cooler temperatures indicate increased cold penetration of the envelope and elevated heat losses. When viewed from the outside, cooler exterior temperatures indicate better performance of the fiberglass insulation while warmer temperatures indicate elevated heat losses.

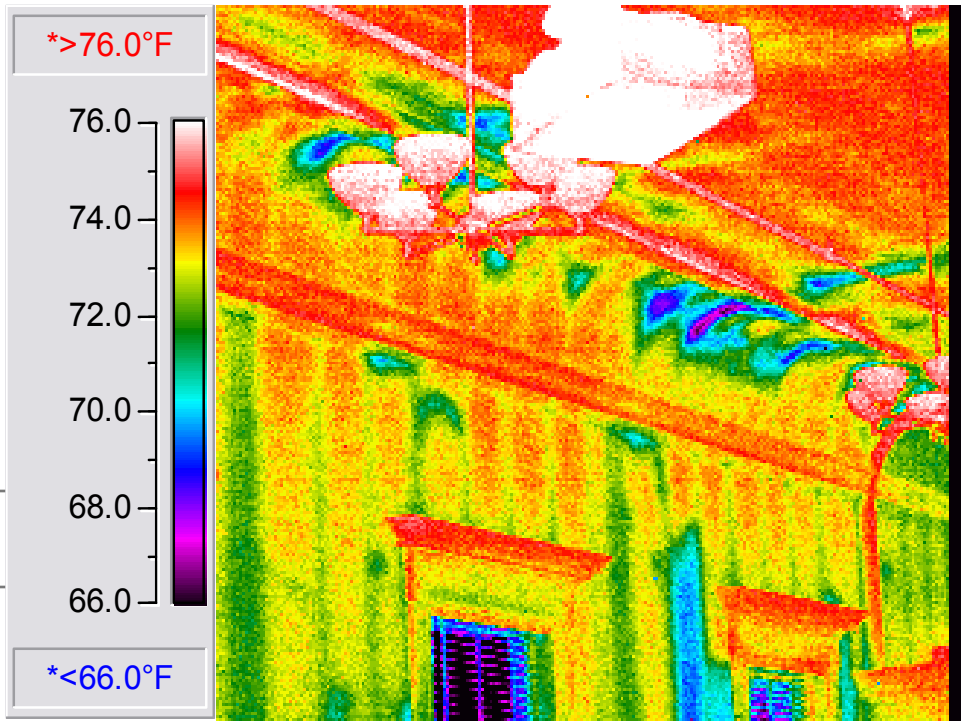
Fiberglass insulation must be properly installed and protected in order to perform well. Before the insulation is installed, it should be expanded to its designed thickness. Care must be taken in the installation process to ensure that the fiberglass maintains as much of its designed thickness as possible, because compressed areas will have reduced R-value. The insulation must also be installed snugly against studs, joists and rafters in order to prevent warm air bypassing the insulation and transferring heat to the exterior of the building.

The effectiveness of fiberglass insulation can also be reduced by air movement through the material from either the interior or the exterior of the building. Fiberglass must be protected on the inside of the of the building envelope by a continuous air/vapor barrier to prevent warm air from escaping the heated spaces, moving into the envelope and creating warm spots on the exterior. On the cold side of the fiberglass there should be a continuous and vapor permeable air barrier to reduce the potential for cold air infiltration

Thermogram #30 (continued)

into the insulation. Any air moving through the fiberglass disturbs the tiny air pockets that create the insulating value and can seriously reduce the insulation's R-value.

The insulation "cap" in this area appears to be insulated with fiberglass batt insulation. There are a number of areas that are exhibiting heat losses. Fiberglass batt insulation can be difficult to properly install around truss rafter components, and building envelope penetrations. There appear to be gaps in this insulation that are allowing cold to be conducted into the warm interior space. There may also be bypasses where cold air on the exterior side of the insulation is dropping down through the insulation to the interior of the building. In addition, occasionally extremely cold areas will be the result of moisture damage in the insulation. These areas should be physically inspected to determine if improvements can be made to the fit and thickness of the insulation, and to locate and replace any areas of water damaged insulation. Heat losses like these will raise the interior temperature of the attic. The goal of any cold attic space is to keep the air temperature as close to the ambient outside temperature as possible.



Thermogram: Infrared Image

Control Photo: Visible Light Image

Thermogram # 31

Thermogram #: 31

Facility/Building: Acton Town Hall

Location of Target: 2nd Floor – Faulkner Room – north wall

Target Shown: Northeast section over 1st & 2nd windows from the east

Position/Location of Thermographer: Inside

Camera Direction: Northeast

Building Component: Wall, Ceiling

Problem Category: Air Leakage – infiltration & Conduction Loss

Recommendation: Some sections of the building may be fitted with fiberglass batt insulation. Variations in the thermal patterns can indicate significant differences in the performance of the insulation. When viewed from the inside, warmer interior temperatures indicate better performance of fiberglass insulation while cooler temperatures indicate increased cold penetration of the envelope and elevated heat losses. When viewed from the outside, cooler exterior temperatures indicate better performance of the fiberglass insulation while warmer temperatures indicate elevated heat losses.

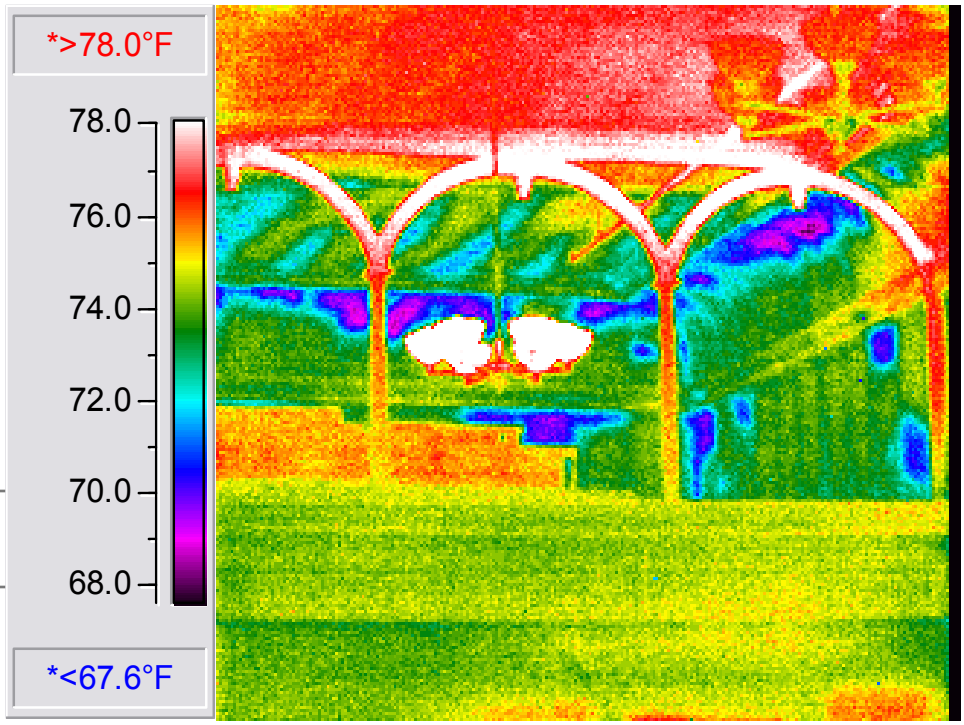
Fiberglass insulation must be properly installed and protected in order to perform well. Before the insulation is installed, it should be expanded to its designed thickness. Care must be taken in the installation process to ensure that the fiberglass maintains as much of its designed thickness as possible, because compressed areas will have reduced R-value. The insulation must also be installed snugly against studs, joists and rafters in order to prevent warm air bypassing the insulation and transferring heat to the exterior of the building.

The effectiveness of fiberglass insulation can also be reduced by air movement through the material from either the interior or the exterior of the building. Fiberglass must be protected on the inside of the of the building envelope by a continuous air/vapor barrier to prevent warm air from escaping the heated spaces, moving into the envelope and creating warm spots on the exterior. On the cold side of the fiberglass there should be a continuous and vapor permeable air barrier to reduce the potential for cold air infiltration

Thermogram #31 (continued)

into the insulation. Any air moving through the fiberglass disturbs the tiny air pockets that create the insulating value and can seriously reduce the insulation's R-value.

The insulation "cap" in this area appears to be insulated with fiberglass batt insulation. There are a number of areas that are exhibiting heat losses. Fiberglass batt insulation can be difficult to properly install around truss rafter components, and building envelope penetrations. There appear to be gaps in this insulation that are allowing cold to be conducted into the warm interior space. There may also be bypasses where cold air on the exterior side of the insulation is dropping down through the insulation to the interior of the building. In addition, occasionally extremely cold areas will be the result of moisture damage in the insulation. These areas should be physically inspected to determine if improvements can be made to the fit and thickness of the insulation, and to locate and replace any areas of water damaged insulation. Heat losses like these will raise the interior temperature of the attic. The goal of any cold attic space is to keep the air temperature as close to the ambient outside temperature as possible.



Thermogram: Infrared Image

Control Photo: Visible Light Image

Thermogram # 32

Thermogram #: 32

Facility/Building: Acton Town Hall

Location of Target: 2nd Floor – Faulkner Room

Target Shown: Southeast corner

Position/Location of Thermographer: Inside

Camera Direction: Southeast

Building Component: Wall, Ceiling

Problem Category: Air Leakage – infiltration & Conduction Loss

Recommendation: Some sections of the building may be fitted with fiberglass batt insulation. Variations in the thermal patterns can indicate significant differences in the performance of the insulation. When viewed from the inside, warmer interior temperatures indicate better performance of fiberglass insulation while cooler temperatures indicate increased cold penetration of the envelope and elevated heat losses. When viewed from the outside, cooler exterior temperatures indicate better performance of the fiberglass insulation while warmer temperatures indicate elevated heat losses.

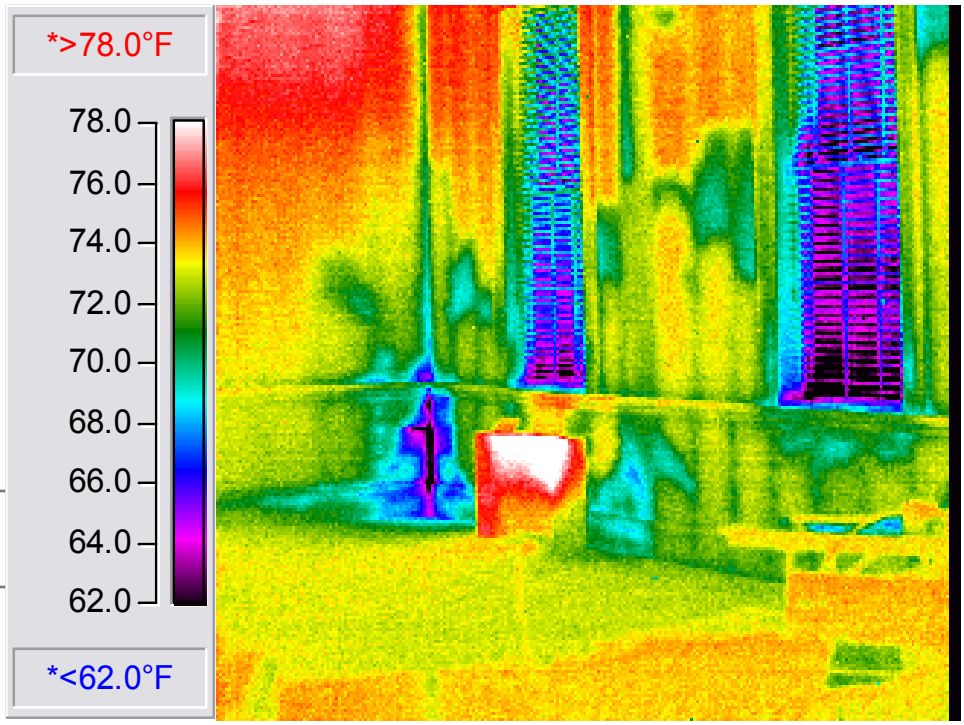
Fiberglass insulation must be properly installed and protected in order to perform well. Before the insulation is installed, it should be expanded to its designed thickness. Care must be taken in the installation process to ensure that the fiberglass maintains as much of its designed thickness as possible, because compressed areas will have reduced R-value. The insulation must also be installed snugly against studs, joists and rafters in order to prevent warm air bypassing the insulation and transferring heat to the exterior of the building.

The effectiveness of fiberglass insulation can also be reduced by air movement through the material from either the interior or the exterior of the building. Fiberglass must be protected on the inside of the of the building envelope by a continuous air/vapor barrier to prevent warm air from escaping the heated spaces, moving into the envelope and creating warm spots on the exterior. On the cold side of the fiberglass there should be a continuous and vapor permeable air barrier to reduce the potential for cold air infiltration

Thermogram #32 (continued)

into the insulation. Any air moving through the fiberglass disturbs the tiny air pockets that create the insulating value and can seriously reduce the insulation's R-value.

The insulation "cap" in this area appears to be insulated with fiberglass batt insulation. There are a number of areas that are exhibiting heat losses. Fiberglass batt insulation can be difficult to properly install around truss rafter components, and building envelope penetrations. There appear to be gaps in this insulation that are allowing cold to be conducted into the warm interior space. There may also be bypasses where cold air on the exterior side of the insulation is dropping down through the insulation to the interior of the building. In addition, occasionally extremely cold areas will be the result of moisture damage in the insulation. These areas should be physically inspected to determine if improvements can be made to the fit and thickness of the insulation, and to locate and replace any areas of water damaged insulation. Heat losses like these will raise the interior temperature of the attic. The goal of any cold attic space is to keep the air temperature as close to the ambient outside temperature as possible.



Thermogram: Infrared Image

Control Photo: Visible Light Image

Thermogram # 33

Thermogram #: 33

Facility/Building: Acton Town Hall

Location of Target: 2nd Floor – Faulkner Room – north wall

Target Shown: Lower western section and corner

Position/Location of Thermographer: Inside

Camera Direction: Northwest

Building Component: Window, Wall

Problem Category: Air Leakage – infiltration & Conduction Loss

Recommendation: Some sections of the building may be fitted with fiberglass batt insulation. Variations in the thermal patterns can indicate significant differences in the performance of the insulation. When viewed from the inside, warmer interior temperatures indicate better performance of fiberglass insulation while cooler temperatures indicate increased cold penetration of the envelope and elevated heat losses. When viewed from the outside, cooler exterior temperatures indicate better performance of the fiberglass insulation while warmer temperatures indicate elevated heat losses.

Fiberglass insulation must be properly installed and protected in order to perform well. Before the insulation is installed, it should be expanded to its designed thickness. Care must be taken in the installation process to ensure that the fiberglass maintains as much of its designed thickness as possible, because compressed areas will have reduced R-value. The insulation must also be installed snugly against studs, joists and rafters in order to prevent warm air bypassing the insulation and transferring heat to the exterior of the building.

The effectiveness of fiberglass insulation can also be reduced by air movement through the material from either the interior or the exterior of the building. Fiberglass must be protected on the inside of the of the building envelope by a continuous air/vapor barrier to prevent warm air from escaping the heated spaces, moving into the envelope and creating warm spots on the exterior. On the cold side of the fiberglass there should be a continuous and vapor permeable air barrier to reduce the potential for cold air infiltration

Thermogram #33 (continued)

into the insulation. Any air moving through the fiberglass disturbs the tiny air pockets that create the insulating value and can seriously reduce the insulation's R-value.

Overall, this section of the building appears to be insulated, but has significant variations in thermal performance that may indicate areas of missing, disturbed, or poorly installed insulation, or insulation whose effectiveness has been compromised by air movement. If the insulation in this area is easily accessible, repair or replacement should be made as needed. If the insulation is not accessible due to constraints of interior or exterior finish, retrofitting these areas will involve substantial cost. It may be prudent to perform a comprehensive cost-benefit analysis to determine the return on investment (ROI) and advisability of any retrofits designed to reduce these heat losses, if these areas are not readily accessible.

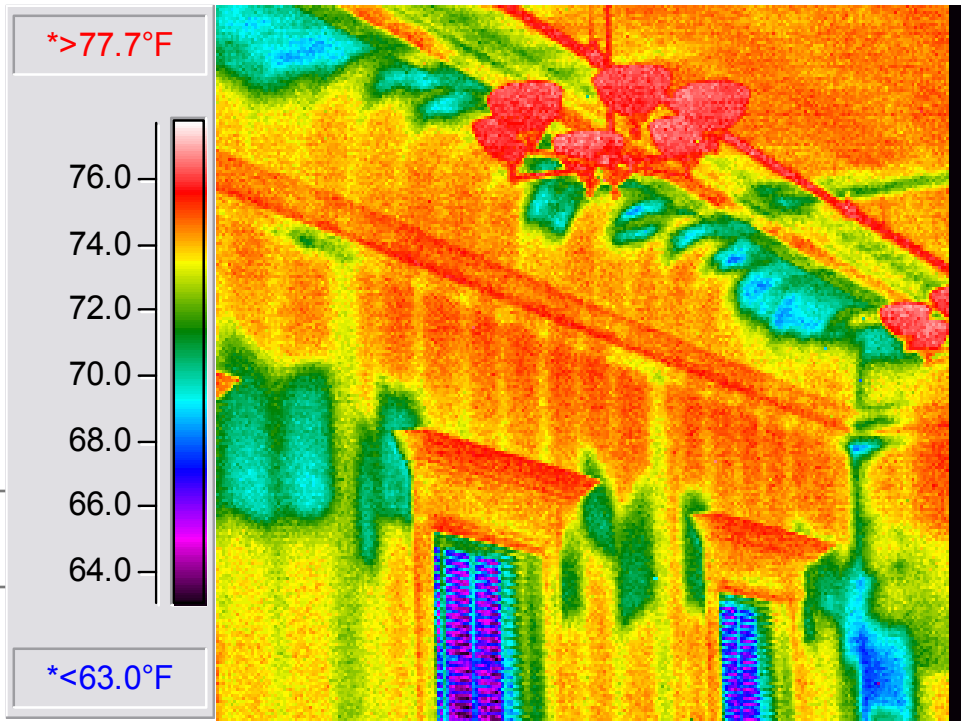
Significant amounts of cold air may be entering the building through leaky joints in this area. The best course of action to reduce this air movement is to seal any visible interior gaps. Smaller gaps can be treated with high-quality caulking compounds, while larger gaps may need to be filled with expanding foam insulation. If possible, the exterior of the building should be visually examined for gaps between the exterior siding materials, and between the exterior siding and the trim, and any gaps on the outside of the building should also be sealed. Reducing this cold air infiltration will result in lower heating costs and greater occupant comfort.

It appears that there may be significant air movement through some of the windows. In some instances, the windows may be open, or partially open. Windows exhibiting air leakage should also be examined for proper operation to ensure that they close completely and that all hardware is functioning properly. All the meeting surfaces of moveable sashes should be checked to determine if the weather strips are worn, damaged or missing. Repairs should be made as needed. The joints between the glazing and the frames should be checked for gaskets or sealants that are deteriorated, damaged, or missing. Repairs should be made as needed.

Thermogram #33 (continued)

The window trim should also be visually examined for gaps that can allow air leakage. Any significant gaps between the window frame and the window trim, or between the window trim and the wall should be sealed utilizing high-quality caulking compounds.

The glazing in these units appears to be less resistant to heat loss (have lower R-value//higher U-value) than newer high efficiency glazing. Retrofitting with new high efficiency glazing will substantially reduce these conduction losses, but would involve significant expense. It would be prudent to perform a complete cost/benefit analysis to determine the cost effectiveness and return on investment (ROI) of retrofitting these units.



Thermogram: Infrared Image

Control Photo: Visible Light Image

Thermogram # 34

Thermogram #: 34

Facility/Building: Acton Town Hall

Location of Target: 2nd Floor – Faulkner Room – south wall

Target Shown: Upper western corner

Position/Location of Thermographer: Inside

Camera Direction: Southwest

Building Component: Window, Wall, Ceiling

Problem Category: Air Leakage – infiltration & Conduction Loss

Recommendation: Some sections of the building may be fitted with fiberglass batt insulation. Variations in the thermal patterns can indicate significant differences in the performance of the insulation. When viewed from the inside, warmer interior temperatures indicate better performance of fiberglass insulation while cooler temperatures indicate increased cold penetration of the envelope and elevated heat losses. When viewed from the outside, cooler exterior temperatures indicate better performance of the fiberglass insulation while warmer temperatures indicate elevated heat losses.

Fiberglass insulation must be properly installed and protected in order to perform well. Before the insulation is installed, it should be expanded to its designed thickness. Care must be taken in the installation process to ensure that the fiberglass maintains as much of its designed thickness as possible, because compressed areas will have reduced R-value. The insulation must also be installed snugly against studs, joists and rafters in order to prevent warm air bypassing the insulation and transferring heat to the exterior of the building.

The effectiveness of fiberglass insulation can also be reduced by air movement through the material from either the interior or the exterior of the building. Fiberglass must be protected on the inside of the of the building envelope by a continuous air/vapor barrier to prevent warm air from escaping the heated spaces, moving into the envelope and creating warm spots on the exterior. On the cold side of the fiberglass there should be a continuous and vapor permeable air barrier to reduce the potential for cold air infiltration

Thermogram #34 (continued)

into the insulation. Any air moving through the fiberglass disturbs the tiny air pockets that create the insulating value and can seriously reduce the insulation's R-value.

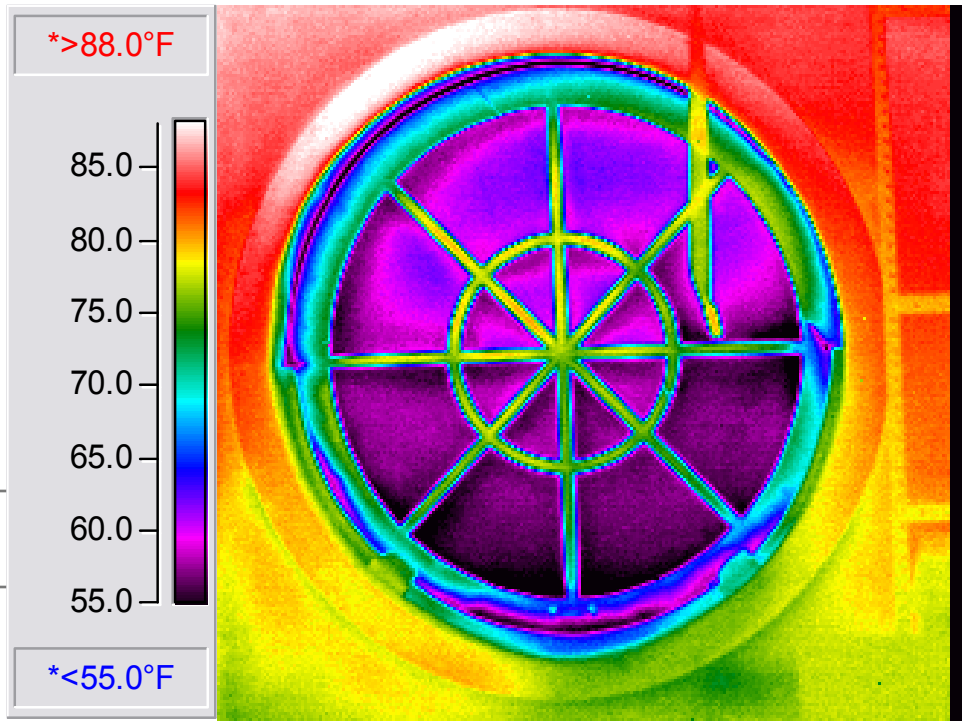
Overall, this section of the building appears to be insulated, but has significant variations in thermal performance that may indicate areas of missing, disturbed, or poorly installed insulation, or insulation whose effectiveness has been compromised by air movement. If the insulation in this area is easily accessible, repair or replacement should be made as needed. If the insulation is not accessible due to constraints of interior or exterior finish, retrofitting these areas will involve substantial cost. It may be prudent to perform a comprehensive cost-benefit analysis to determine the return on investment (ROI) and advisability of any retrofits designed to reduce these heat losses, if these areas are not readily accessible.

The insulation "cap" in this area appears to be insulated with fiberglass batt insulation. There are a number of areas that are exhibiting heat losses. Fiberglass batt insulation can be difficult to properly install around truss rafter components, and building envelope penetrations. There appear to be gaps in this insulation that are allowing cold to be conducted into the warm interior space. There may also be bypasses where cold air on the exterior side of the insulation is dropping down through the insulation to the interior of the building. In addition, occasionally extremely cold areas will be the result of moisture damage in the insulation. These areas should be physically inspected to determine if improvements can be made to the fit and thickness of the insulation, and to locate and replace any areas of water damaged insulation. Heat losses like these will raise the interior temperature of the attic. The goal of any cold attic space is to keep the air temperature as close to the ambient outside temperature as possible.

The glazing in these units appears to be less resistant to heat loss (have lower R-value//higher U-value) than newer high efficiency glazing. Retrofitting with new high efficiency glazing will substantially reduce these conduction losses, but would involve

Thermogram #34 (continued)

significant expense. It would be prudent to perform a complete cost/benefit analysis to determine the cost effectiveness and return on investment (ROI) of retrofitting these units.



Thermogram: Infrared Image

Control Photo: Visible Light Image

Thermogram # 35

Thermogram #: 35

Facility/Building: Acton Town Hall

Location of Target: Heated Attic – west wall

Target Shown: North round window

Position/Location of Thermographer: Inside

Camera Direction: West

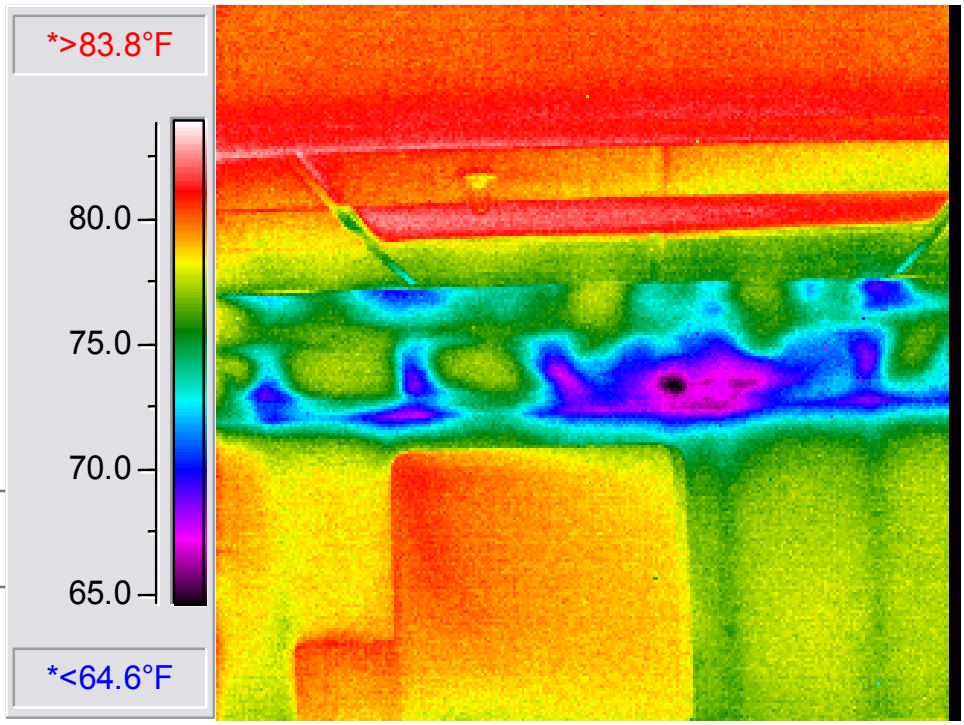
Building Component: Window

Problem Category: Air Leakage – infiltration & Conduction Loss

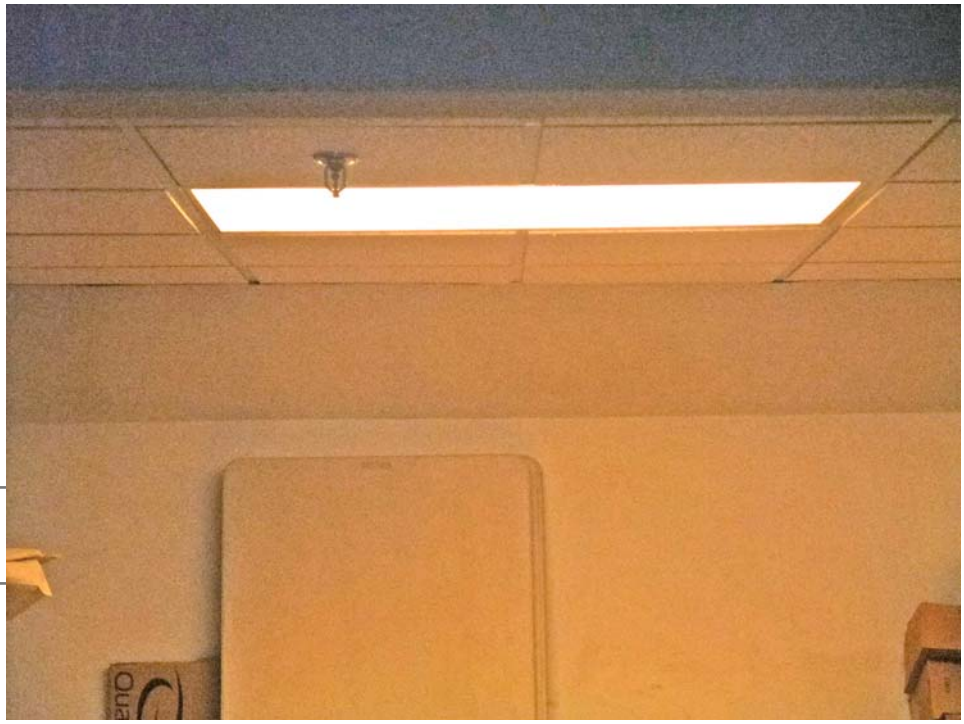
Recommendation: It appears that there may be significant air movement through some of the windows. In some instances, the windows may be open, or partially open. Windows exhibiting air leakage should also be examined for proper operation to ensure that they close completely and that all hardware is functioning properly. All the meeting surfaces of moveable sashes should be checked to determine if the weather strips are worn, damaged or missing. Repairs should be made as needed. The joints between the glazing and the frames should be checked for gaskets or sealants that are deteriorated, damaged, or missing. Repairs should be made as needed.

The window trim should also be visually examined for gaps that can allow air leakage. Any significant gaps between the window frame and the window trim, or between the window trim and the wall should be sealed utilizing high-quality caulking compounds.

The glazing in these units appears to be less resistant to heat loss (have lower R-value//higher U-value) than newer high efficiency glazing. Retrofitting with new high efficiency glazing will substantially reduce these conduction losses, but would involve significant expense. It would be prudent to perform a complete cost/benefit analysis to determine the cost effectiveness and return on investment (ROI) of retrofitting these units.



Thermogram: Infrared Image



Control Photo: Visible Light Image

Thermogram # 36

Thermogram #: 36

Facility/Building: Acton Town Hall

Location of Target: Heated Attic – north wall

Target Shown: Western side

Position/Location of Thermographer: Inside

Camera Direction: North

Building Component: Wall

Problem Category: Air Leakage – infiltration & Conduction Loss

Recommendation: Some sections of the building may be fitted with fiberglass batt insulation. Variations in the thermal patterns can indicate significant differences in the performance of the insulation. When viewed from the inside, warmer interior temperatures indicate better performance of fiberglass insulation while cooler temperatures indicate increased cold penetration of the envelope and elevated heat losses. When viewed from the outside, cooler exterior temperatures indicate better performance of the fiberglass insulation while warmer temperatures indicate elevated heat losses.

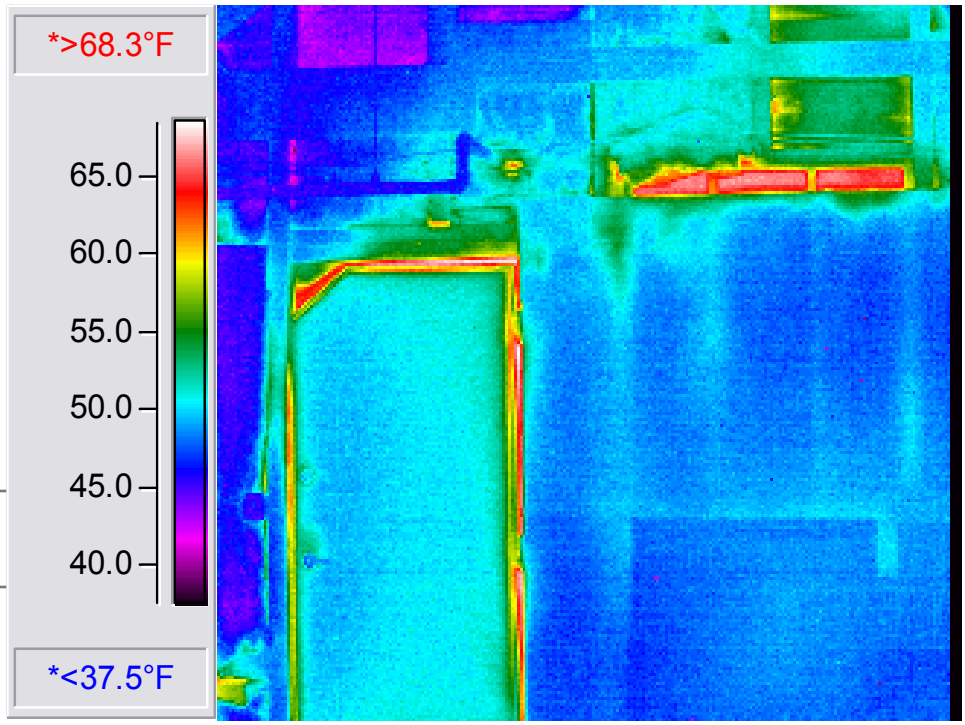
Fiberglass insulation must be properly installed and protected in order to perform well. Before the insulation is installed, it should be expanded to its designed thickness. Care must be taken in the installation process to ensure that the fiberglass maintains as much of its designed thickness as possible, because compressed areas will have reduced R-value. The insulation must also be installed snugly against studs, joists and rafters in order to prevent warm air bypassing the insulation and transferring heat to the exterior of the building.

The effectiveness of fiberglass insulation can also be reduced by air movement through the material from either the interior or the exterior of the building. Fiberglass must be protected on the inside of the of the building envelope by a continuous air/vapor barrier to prevent warm air from escaping the heated spaces, moving into the envelope and creating warm spots on the exterior. On the cold side of the fiberglass there should be a continuous and vapor permeable air barrier to reduce the potential for cold air infiltration

Thermogram #36 (continued)

into the insulation. Any air moving through the fiberglass disturbs the tiny air pockets that create the insulating value and can seriously reduce the insulation's R-value.

Overall, this section of the building appears to be insulated, but has significant variations in thermal performance that may indicate areas of missing, disturbed, or poorly installed insulation, or insulation whose effectiveness has been compromised by air movement. If the insulation in this area is easily accessible, repair or replacement should be made as needed. If the insulation is not accessible due to constraints of interior or exterior finish, retrofitting these areas will involve substantial cost. It may be prudent to perform a comprehensive cost-benefit analysis to determine the return on investment (ROI) and advisability of any retrofits designed to reduce these heat losses, if these areas are not readily accessible.



Thermogram: Infrared Image

Control Photo: Visible Light Image

Thermogram # 37

Thermogram #: 37

Facility/Building: Acton Town Hall

Location of Target: Attic – west wall

Target Shown: Doorway and wall to heated attic

Position/Location of Thermographer: Outside

Camera Direction: West

Building Component: Door, Wall

Problem Category: Air Leakage – exfiltration & Conduction Loss

Recommendation: Some sections of the building may be fitted with fiberglass batt insulation. Variations in the thermal patterns can indicate significant differences in the performance of the insulation. When viewed from the inside, warmer interior temperatures indicate better performance of fiberglass insulation while cooler temperatures indicate increased cold penetration of the envelope and elevated heat losses. When viewed from the outside, cooler exterior temperatures indicate better performance of the fiberglass insulation while warmer temperatures indicate elevated heat losses.

Fiberglass insulation must be properly installed and protected in order to perform well. Before the insulation is installed, it should be expanded to its designed thickness. Care must be taken in the installation process to ensure that the fiberglass maintains as much of its designed thickness as possible, because compressed areas of fiberglass insulation will have reduced R-value. The insulation must also be installed snugly against studs, joists and rafters in order to prevent warm air bypassing the insulation and transferring heat to the exterior of the building.

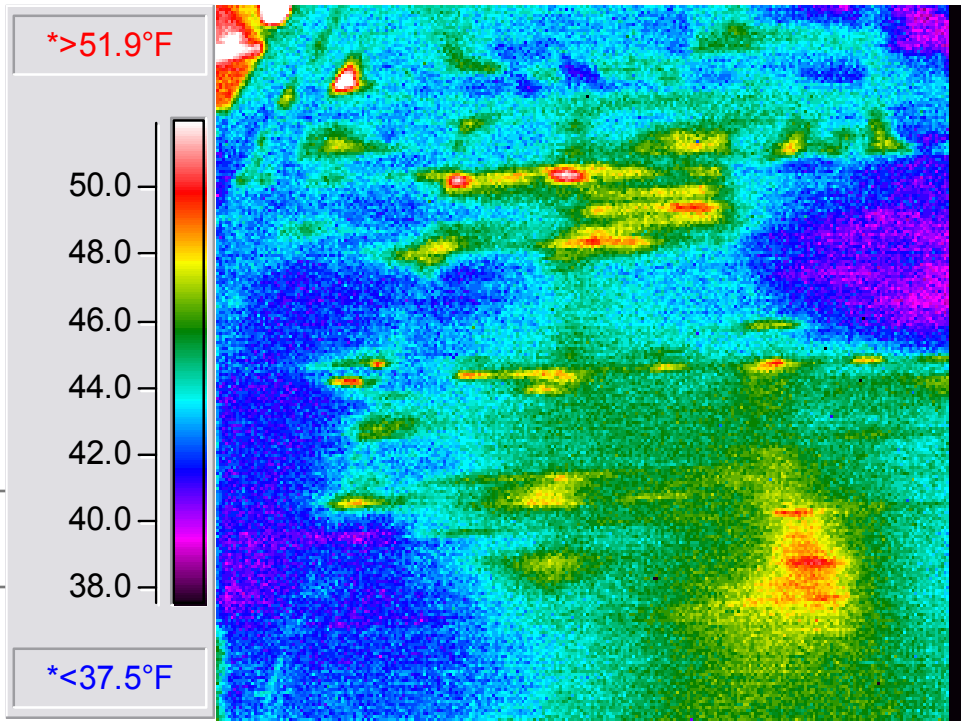
The effectiveness of fiberglass insulation can also be reduced by air movement through the material from either the interior or the exterior of the building. Fiberglass must be protected on the inside of the of the building envelope by a continuous air/vapor barrier to prevent warm air from escaping the heated spaces, moving into the envelope and creating warm spots on the exterior. On the cold side of the fiberglass there should be a continuous and vapor permeable air barrier to reduce the potential for cold air infiltration

Thermogram #37 (continued)

into the insulation. Any cold air moving through the fiberglass disturbs the tiny air pockets that create the insulating value and can seriously reduce the insulation's R-value.

Overall, this section of the building appears to be insulated, but has significant variations in thermal performance that may indicate areas of missing, disturbed, or poorly installed insulation, or insulation whose effectiveness has been compromised by air movement. If the insulation in this area is easily accessible, repair or replacement should be made as needed. If the insulation in this area is not accessible due to constraints of interior or exterior finish, retrofitting these areas will involve substantial cost. It may be prudent to perform a comprehensive cost-benefit analysis to determine the return on investment (ROI) and advisability of any retrofits designed to reduce these heat losses, if these areas are not readily accessible.

There appears to be substantial air leakage around the door unit illustrated in the thermogram. The hardware should be inspected to ensure that it is in good operating order, and that it provides for proper closure. All door sweeps and weather stripping should be carefully examined for wear, damage and adjustment. Repairs, adjustments or replacement should be made as needed to reduce this air leakage.



Thermogram: Infrared Image

Control Photo: Visible Light Image

Thermogram # 38

Thermogram #: 38

Facility/Building: Acton Town Hall

Location of Target: Attic – north side

Target Shown: Central section of floor

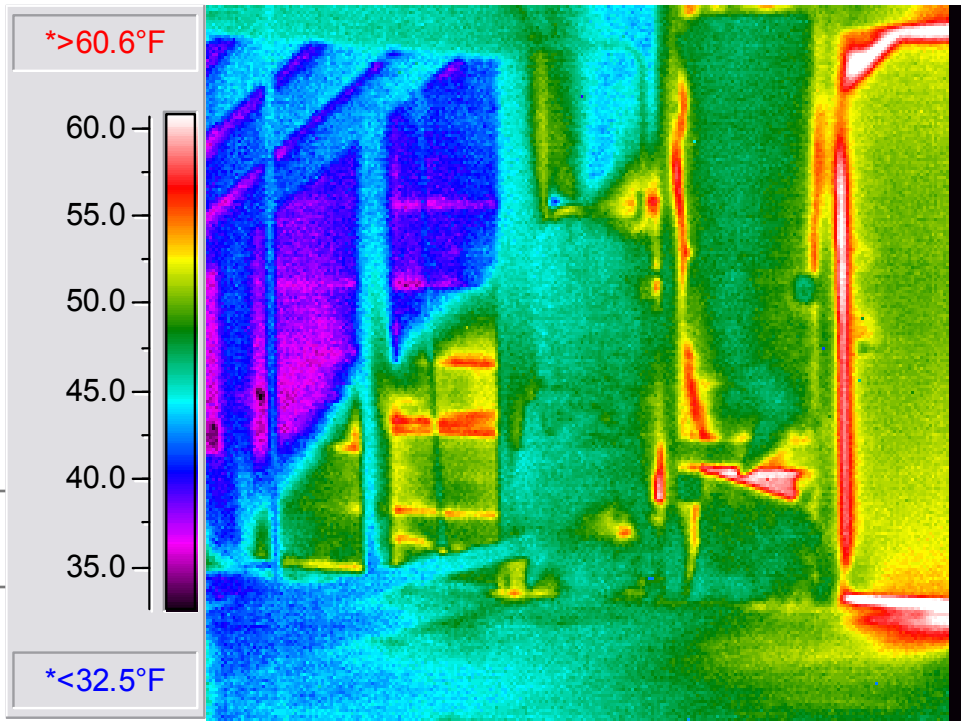
Position/Location of Thermographer: Outside

Camera Direction: West

Building Component: Floor

Problem Category: Air Leakage – exfiltration & Conduction Loss

Recommendation: The insulation "cap" in this area appears to be insulated with fiberglass batt insulation. There are a number of areas that are exhibiting heat losses. Fiberglass batt insulation can be difficult to properly install around truss rafter components, and building envelope penetrations. There appear to be gaps in this insulation that are allowing heat to be conducted into the cool exterior space. There may also be bypasses where warm air on the interior side of the insulation is rising up to the exterior of the building envelope. These areas should be physically inspected to determine if improvements can be made to the fit and thickness of the insulation. Heat losses like these will raise the interior temperature of the attic. The goal of any cold attic space is to keep the air temperature as close to the ambient outside temperature as possible.



Thermogram: Infrared Image

Control Photo: Visible Light Image

Thermogram # 39

Thermogram #: 39

Facility/Building: Acton Town Hall

Location of Target: Attic – west wall

Target Shown: Southwest corner

Position/Location of Thermographer: Outside

Camera Direction: Southwest

Building Component: Door, Wall

Problem Category: Air Leakage – exfiltration & Conduction Loss

Recommendation: Some sections of the building may be fitted with fiberglass batt insulation. Variations in the thermal patterns can indicate significant differences in the performance of the insulation. When viewed from the inside, warmer interior temperatures indicate better performance of fiberglass insulation while cooler temperatures indicate increased cold penetration of the envelope and elevated heat losses. When viewed from the outside, cooler exterior temperatures indicate better performance of the fiberglass insulation while warmer temperatures indicate elevated heat losses.

Fiberglass insulation must be properly installed and protected in order to perform well. Before the insulation is installed, it should be expanded to its designed thickness. Care must be taken in the installation process to ensure that the fiberglass maintains as much of its designed thickness as possible, because compressed areas of fiberglass insulation will have reduced R-value. The insulation must also be installed snugly against studs, joists and rafters in order to prevent warm air bypassing the insulation and transferring heat to the exterior of the building.

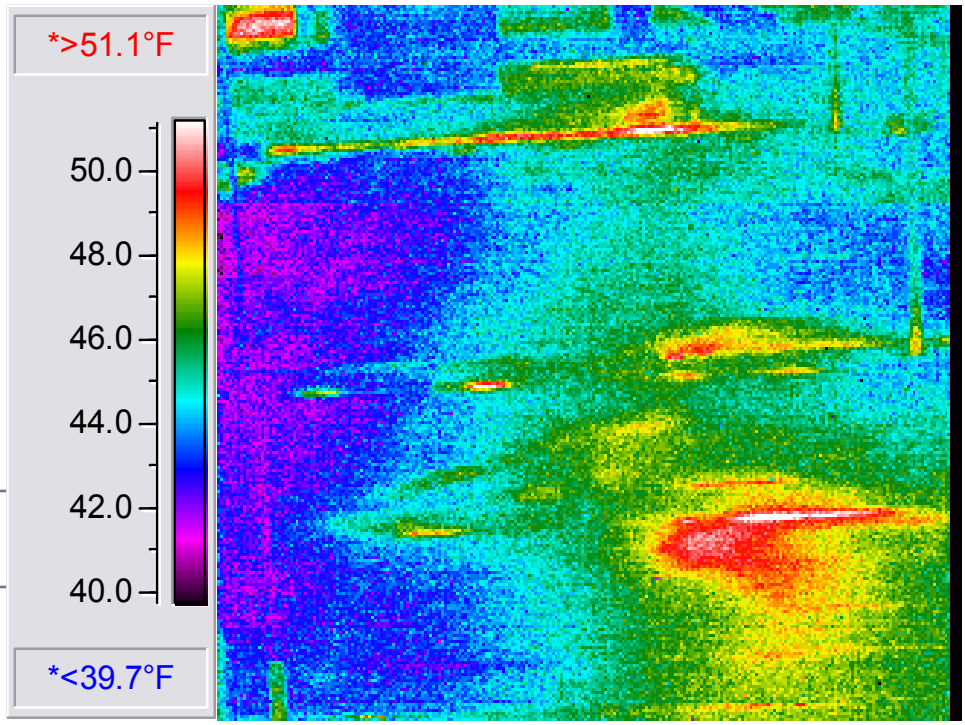
The effectiveness of fiberglass insulation can also be reduced by air movement through the material from either the interior or the exterior of the building. Fiberglass must be protected on the inside of the of the building envelope by a continuous air/vapor barrier to prevent warm air from escaping the heated spaces, moving into the envelope and creating warm spots on the exterior. On the cold side of the fiberglass there should be a continuous and vapor permeable air barrier to reduce the potential for cold air infiltration

Thermogram #39 (continued)

into the insulation. Any cold air moving through the fiberglass disturbs the tiny air pockets that create the insulating value and can seriously reduce the insulation's R-value.

Overall, this section of the building appears to be insulated, but has significant variations in thermal performance that may indicate areas of missing, disturbed, or poorly installed insulation, or insulation whose effectiveness has been compromised by air movement. If the insulation in this area is easily accessible, repair or replacement should be made as needed. If the insulation in this area is not accessible due to constraints of interior or exterior finish, retrofitting these areas will involve substantial cost. It may be prudent to perform a comprehensive cost-benefit analysis to determine the return on investment (ROI) and advisability of any retrofits designed to reduce these heat losses, if these areas are not readily accessible.

There appears to be substantial air leakage around the door unit illustrated in the thermogram. The hardware should be inspected to ensure that it is in good operating order, and that it provides for proper closure. All door sweeps and weather stripping should be carefully examined for wear, damage and adjustment. Repairs, adjustments or replacement should be made as needed to reduce this air leakage.



Thermogram: Infrared Image

Control Photo: Visible Light Image

Thermogram # 40

Thermogram #: 40

Facility/Building: Acton Town Hall

Location of Target: Attic

Target Shown: Central section of floor

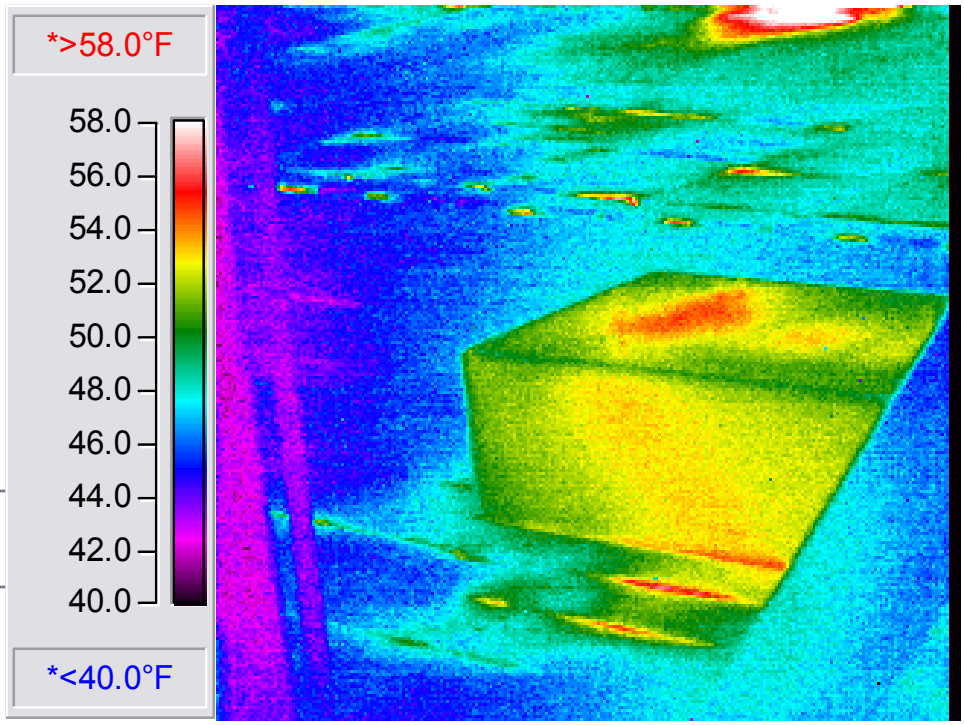
Position/Location of Thermographer: Outside

Camera Direction: East

Building Component: Floor

Problem Category: Air Leakage – exfiltration & Conduction Loss

Recommendation: The insulation "cap" in this area appears to be insulated with fiberglass batt insulation. There are a number of areas that are exhibiting heat losses. Fiberglass batt insulation can be difficult to properly install around truss rafter components, and building envelope penetrations. There appear to be gaps in this insulation that are allowing heat to be conducted into the cool exterior space. There may also be bypasses where warm air on the interior side of the insulation is rising up to the exterior of the building envelope. These areas should be physically inspected to determine if improvements can be made to the fit and thickness of the insulation. Heat losses like these will raise the interior temperature of the attic. The goal of any cold attic space is to keep the air temperature as close to the ambient outside temperature as possible.



Thermogram: Infrared Image

Control Photo: Visible Light Image

Thermogram # 41

Thermogram #: 41

Facility/Building: Acton Town Hall

Location of Target: Attic

Target Shown: Central west portion of floor

Position/Location of Thermographer: Outside

Camera Direction: Southwest

Building Component: Floor

Problem Category: Air Leakage – exfiltration & Conduction Loss

Recommendation: The insulation "cap" in this area appears to be insulated with fiberglass batt insulation. There are a number of areas that are exhibiting heat losses. Fiberglass batt insulation can be difficult to properly install around truss rafter components, and building envelope penetrations. There appear to be gaps in this insulation that are allowing heat to be conducted into the cool exterior space. There may also be bypasses where warm air on the interior side of the insulation is rising up to the exterior of the building envelope. These areas should be physically inspected to determine if improvements can be made to the fit and thickness of the insulation. Heat losses like these will raise the interior temperature of the attic. The goal of any cold attic space is to keep the air temperature as close to the ambient outside temperature as possible.

SUMMARY

The testing at the Acton Town Hall uncovered some significant areas of heat loss, and they are documented in this report. Typically, when addressing heat loss issues the air leakage problems are assigned higher priorities. While most buildings have both conduction and air leakage losses, addressing the air leakage problems is usually the simplest and most cost-effective way to improve the thermal performance of the building envelope. Air movement through the building envelope can often be reduced or eliminated using simple, inexpensive and easily applied materials. While conduction losses through the solid materials in the structure may also be significant, it is typically more expensive and disruptive to reduce the conduction losses by retrofiiting walls, windows and doors. It may be prudent to perform a complete cost/benefit analysis before undertaking retrofits designed to reduce any conduction losses.

The issues documented during the testing are listed below in approximate priority order, i.e the recommendations at the beginning of the summary appear to constitute the most practical and cost-effective actions, while those at the end will probably require greater expense and result in a longer return on investment (ROI).

It appears that there may be significant air movement through some of the windows. These issues are recorded in Thermograms # 26, 33 & 35. In some instances, the windows may be open, or partially open. Windows exhibiting air leakage should also be examined for proper operation to

ensure that they close completely and that all hardware is functioning properly. All the meeting surfaces of moveable sashes should be checked to determine if the weather strips are worn, damaged or missing. Repairs should be made as needed. The joints between the glazing and the frames should be checked for gaskets or sealants that are deteriorated, damaged, or missing. Repairs should be made as needed.

The window trim should also be visually examined for gaps that can allow air leakage. Any significant gaps between the window frame and the window trim, or between the window trim and the wall should be sealed utilizing high-quality caulking compounds.

Portions of the wall surface in this Thermograms #3, 4, 6, 7, 9-13, 15-17, 20, 21, 23 & 24 display a thermal signature that appears to indicate a build-up of moisture in the wall system. Water damaged materials will have lower R-values than sound, dry materials and appear as colder temperatures on the inside of the envelope and warmer temperatures on the exterior of the envelope. Some of the areas of warmer temperature in the thermogram may indicate moisture damage. It may be prudent to perform some invasive testing in these areas to absolutely determine the presence or absence of moisture.

The glazing in some of the window units appears to be less resistant to heat loss (have lower R-value//higher U-value) than newer high efficiency glazing. Retrofitting with new high efficiency glazing will substantially reduce these conduction losses, but would involve significant expense. It would be prudent to perform a complete cost/benefit analysis to determine the cost effectiveness and return on investment (ROI) of retrofitting these units. Please refer to Thermograms # 26 & 33-35.

The building appears to be experiencing significant “stack effect”, as noted in Thermograms #8 & 25. The warm thermal patterns are typical of warm air exfiltration. Poorly sealed joints and penetrations near the top of the building will allow warm air to continuously leave the building. As the warm air is lost, cold air must be drawn in to replace it, typically near the bottom of the building. This cycle of warmer, lighter and more humid air escaping near the top and colder, heavier and drier air being pulled in near the bottom is called stack effect. It substantially increases heating costs and decreases occupant comfort. Continuously heating air that will eventually leak out the top of the building is costly, while at the same time the cold drafts coming in near the bottom make people uncomfortable.

In order to devise a practical and cost-effective retrofit, a thorough physical examination of the leaky joints and penetrations near the top of the building should be performed. High-quality long-lasting materials (e.g. caulking, backer rod, expanding foam insulation, etc.) should be employed to reduce or eliminate this warm air exfiltration. Reducing these air leakage losses will result in increased occupant comfort and lowered heating costs.

Some sections of the building may be fitted with fiberglass batt insulation. The thermal patterns are uneven, indicating significant differences in the performance of the insulation. When viewed from the outside, cooler exterior temperatures indicate better performance of the fiberglass insulation while warmer temperatures indicate elevated heat losses. Apparent differences in the performance of the insulation are recorded in Thermograms # 3, 4, 6, 7, 9-13, 15-17, 20, 21, 23, 24, 37 & 38.

Fiberglass insulation must be properly installed and protected in order to perform well. Before the insulation is installed, it should be expanded to its designed thickness. Care must be taken in the installation process to ensure that the fiberglass maintains as much of its designed thickness as possible, because compressed areas of fiberglass insulation will have reduced R-value. The insulation must also be installed snugly against studs, joists and rafters in order to prevent warm air bypassing the insulation and transferring heat to the exterior of the building.

The effectiveness of fiberglass insulation can also be reduced by air movement through the material from either the interior or the exterior of the building. Fiberglass must be protected on the inside of the of the building envelope by a continuous air/vapor barrier to prevent warm air from escaping the heated spaces, moving into the envelope and creating warm spots on the exterior. On the cold side of the fiberglass there should be a continuous and vapor permeable air barrier to reduce the potential for cold air infiltration into the insulation. Any cold air moving through the fiberglass disturbs the tiny air pockets that create the insulating value and can seriously reduce the insulation's R-value.

Overall, these sections of the building appear to be insulated, but have significant variations in thermal performance that may indicate areas of missing, disturbed, or poorly installed insulation, or insulation whose effectiveness has been compromised by air movement. If the insulation in these areas is easily accessible, repair or replacement should be made as needed. If the insulation is not accessible due to constraints of interior or exterior finish, retrofitting these areas will involve substantial cost. It may be prudent to perform a comprehensive cost-benefit analysis to determine the return on investment (ROI) and advisability of any retrofits designed to reduce these heat losses, if these areas are not readily accessible.

The glazing in some of the window units appears to be less resistant to heat loss (have lower R-value//higher U-value) than newer high efficiency glazing. Retrofitting with new high efficiency glazing will substantially reduce these conduction losses, but would involve significant expense. It would be prudent to perform a complete cost/benefit analysis to determine the cost effectiveness and return on investment (ROI) of retrofitting these units. Please refer to Thermograms # 1-4, 6, 7 & 9-25.

Ideally, the attic air temperature should be as close to the exterior ambient air temperature as possible. The temperatures in the attic in Thermogram #5 appear to be significantly higher than the exterior temperatures. A thorough physical examination of the attic floor air/vapor barrier and insulation should be made to locate areas where there are deficiencies and repairs should be made as needed. Correcting these deficiencies should reduce heat losses from the interior of the building into the attic and reduce the overall ambient air temperature in the attic.

In Thermograms #4, 5, 7, 8, 10, 12, 15, 16 & 18 the roof soffit is significantly warmer than the adjacent wall system. Ideally, the roof soffit should be no warmer than the exterior ambient air temperature. Elevated temperatures at the soffits typically indicate excess heat in the roofing system or attic and poor air flow in the roof venting system. Typically, this excess heat in the

attic can lead to the formation of ice dams. Even if ice dams are not forming, these heat losses contribute to increased

heating costs, and warm air exfiltration into the attic can add to “stack effect” problems. Stack effect happens when warm air escaping near the top of the building creates the need for cold air to be drawn in near the bottom of the building to replace it. This cycle of air movement from the bottom to the top of the building is called “stack effect” and contributes significantly to heating costs as well as reduces occupant comfort. The insulation near the sofftits should be examined to be sure that it is properly installed and creates a “blanket” that extends out to the outside edge of the vertical stud wall. The air/vapor barrier should also be examined throughout the attic and repaired or replaced as needed. The insulation blanket should fit snuggly against ceiling joists and other structural members, and be installed full thickness to take advantage of all possible R-value. A thorough physical examination will need to be made of the condition of the insulation and air/vapor barrier throughout the attic, and repairs should be made as needed.

The insulation “cap” in some areas appears to be insulated with fiberglass batt insulation. There are a number of areas that are exhibiting heat losses, and this is recorded in Thermograms #38, 40 & 41. Fiberglass batt insulation can be difficult to properly install around truss rafter components, and building envelope penetrations. There appear to be gaps in this insulation that are allowing heat to be conducted into the cool exterior space. There may also be bypasses where warm air on the interior side of the insulation is rising up to the exterior of the building envelope. These areas should be physically inspected to determine if improvements can be made to the fit and thickness of the insulation. Heat losses like these will raise the interior temperature of the attic. The goal of any cold attic space is to keep the air temperature as close to the ambient outside temperature as possible.

Some sections of the building may be fitted with fiberglass batt insulation. Variations in the thermal patterns can indicate significant differences in the performance of the insulation. When

viewed from the inside, warmer interior temperatures indicate better performance of fiberglass insulation while cooler temperatures indicate increased cold penetration of the envelope and elevated heat losses. When viewed from the outside, cooler exterior temperatures indicate better performance of the fiberglass insulation while warmer temperatures indicate elevated heat losses. Apparent differences in the performance of the insulation are recorded in Thermograms # 28, 30-34 & 36.

Fiberglass insulation must be properly installed and protected in order to perform well. Before the insulation is installed, it should be expanded to its designed thickness. Care must be taken in the installation process to ensure that the fiberglass maintains as much of its designed thickness as possible, because compressed areas will have reduced R-value. The insulation must also be installed snugly against studs, joists and rafters in order to prevent warm air bypassing the insulation and transferring heat to the exterior of the building.

The effectiveness of fiberglass insulation can also be reduced by air movement through the material from either the interior or the exterior of the building. Fiberglass must be protected on the inside of the of the building envelope by a continuous air/vapor barrier to prevent warm air from escaping the heated spaces, moving into the envelope and creating warm spots on the exterior. On the cold side of the fiberglass there should be a continuous and vapor permeable air barrier to reduce the potential for cold air infiltration into the insulation. Any air moving through the fiberglass disturbs the tiny air pockets that create the insulating value and can seriously reduce the insulation's R-value.

Overall, these sections of the building appear to be insulated, but have significant variations in thermal performance that may indicate areas of missing, disturbed, or poorly installed insulation, or insulation whose effectiveness has been compromised by air movement. If the insulation in these areas is easily accessible, repair or replacement should be made as needed. If the insulation is not accessible due to constraints of interior or exterior finish, retrofitting these areas will involve substantial cost. It may be prudent to perform a comprehensive cost-benefit analysis to

determine the return on investment (ROI) and advisability of any retrofits designed to reduce these heat losses, if these areas are not readily accessible.

When viewed from the inside, cold air infiltration into the wall system from leaky building joints and penetrations will appear as cooler temperatures in the thermogram. This is illustrated in Thermogram #27. Cold air appears to be entering the cavity behind the interior finish in this area. It will be necessary to visually inspect the outside and inside wall components in this area to locate openings that could allow air flow. These sources of cold air infiltration should be sealed to reduce heating costs and improve occupant comfort. Air movement through narrow gaps can often be corrected with the careful application of high-quality long-lasting caulking compounds. To seal large gaps, it may be necessary to retrofit any joints or penetrations with expanding foam insulation.

Significant amounts of cold air may be entering the building through leaky joints. This is illustrated in Thermogram #33. The best course of action to reduce this air movement is to seal any visible interior gaps. Smaller gaps can be treated with high-quality caulking compounds, while larger gaps may need to be filled with expanding foam insulation. If possible, the exterior of the building should be visually examined for gaps between the exterior siding materials, and between the exterior siding and the trim, and any gaps on the outside of the building should also be sealed. Reducing this cold air infiltration will result in lower heating costs and greater occupant comfort.

There appears to be substantial air leakage around the door units in Thermograms #37 & 39. The hardware should be inspected to ensure that it is in good operating order, and that it provides for proper closure. All door sweeps and weather stripping should be carefully examined for wear, damage and adjustment. Repairs, adjustments or replacement should be made as needed to reduce this air leakage.

It appears that there are both significant air leakage and some conduction losses in some areas near the top of the building. This is documented in Thermogram #19. In order to devise a practical and cost-effective retrofit, a thorough physical examination of the leaky joints and

penetrations near the top of the building should be performed. High-quality long-lasting materials (e.g. caulking, backer rod, expanding foam insulation, etc) should be employed to reduce or eliminate this warm air exfiltration. Reducing these air leakage losses will result in increased occupant comfort and lowered heating costs. Any areas of poorly installed or insufficient insulation could also be addressed at this time.

In a number of areas of the building, we noted significant conduction losses through the window frames. This is recorded in Thermogram #2. Typically, these metal frames conduct a substantial amount of heat. The metal is an excellent conductor of heat and cold, and they are often either uninsulated or minimally insulated. We also noted areas where certain portions of the metal frames are warmer than others. This could be caused by uneven heat delivery in the room. We are not aware of a simple, cost-effective retrofit for these window units.

It is also possible that some of these warmer frames may be experiencing air leakage caused by deteriorated, damaged or missing gaskets where the glazing is installed in the frame. Deteriorated, damaged or missing gaskets can allow significant warm air exfiltration from the building. These areas should be carefully examined to determine the condition of the gaskets, and repairs should be made as needed.

Where excessive heat is noted around any moveable sash, an inspection should be made to determine the condition of the weather stripping, and repair or replacement should be made as needed.

There appears to be substantial air leakage around some of the door units. This is illustrated in Thermogram #29. The hardware should be inspected to ensure that it is in good operating order, and that it provides for proper closure. All door sweeps and weather stripping should be carefully examined for wear, damage and adjustment. Repairs, adjustments or replacement should be made as needed to reduce this air leakage.

The wood door units in Thermograms #14 & 29 have substantial conduction losses. Wood has an R-value of approximately 1 per inch. Therefore, a 1.5" thick door only has an R-value of approximately of 1.5. In addition, any edges of the raised panels on wood doors can be thinner and have even lower R-values. Typically, replacing a wood door with a new energy-efficient unit will involve considerable expense. It may be prudent to perform a comprehensive cost-benefit analysis to determine the return on investment (ROI) and advisability of any retrofits designed to reduce these conduction losses.

Thermograms #1, 11, 19, 20, 23 & 24 record sections of foundation that are exhibiting significant conduction losses and may be uninsulated. Typically, retrofitting a foundation wall with insulation involves substantial cost. It may be prudent to perform a comprehensive cost-benefit analysis to determine the return on investment (ROI) and advisability of any retrofits designed to reduce these conduction losses.

Mike, thank you for using our Infrared Services. Please call me if you have any questions regarding this report, or if I can help in any way.

Sincerely,

J.P. Phillips
Director of Operations

Infrared Thermographic Roof Moisture Analysis

PERFORMED FOR: RDK Engineers
70 Fargo St., Suite 800
Boston, MA 02210

LOCATION: Acton Town Hall
Acton, MA

CONDUCTED ON: 1-4-2011

REQUESTED BY: Michael Travers

PERFORMED BY: Bill Rundle, Certified Thermographer

Infra-red Analyzers, Inc.
237 Commerce Street, Suite 260
Williston, VT 05495
(800) 879-1964

Nashua, NH • Worcester, MA • New Haven, CT • Burlington, VT

INFRA RED ANALYZERS INC

Table of Contents

I. Introduction

II. Weather Conditions

III. Infrared Thermography

IV. Instrumentation

V. Survey Procedures

VI. Findings

VII. Appendix A: Thermographic Documentation

VIII. Roof Maps

1/21/2011

Michael Travers
RDK Engineers
70 Fargo St., Suite 800
Boston, MA 02210
Acton Town Hall

Dear Michael,

This report summarizes the findings of our Infrared Roof Moisture Analysis at Acton Town Hall, Acton, MA, performed on 1-4-2011.

Included in this report are AutoCAD® maps of the inspected roofing. All suspected water-damaged areas are marked on the maps. The suspected wet areas are marked directly on the roof with long-lasting spray paint. This report also includes descriptions of Infrared Thermography, as well as survey procedures and the weather conditions on the date of the infrared testing.

WEATHER CONDITIONS

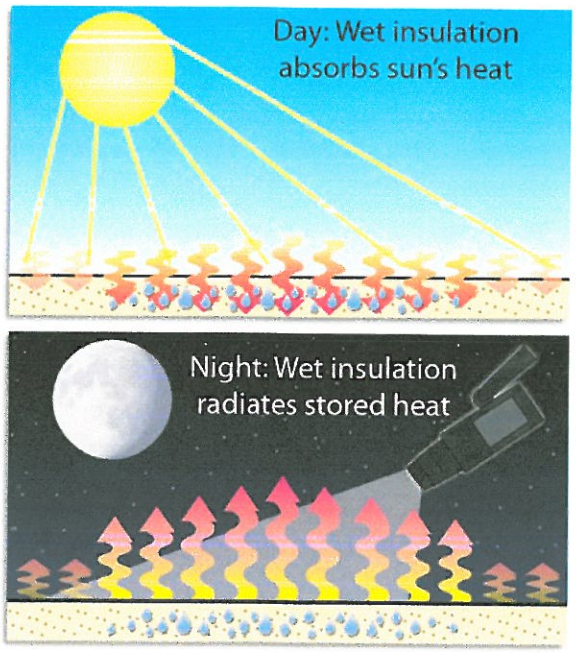
The Infrared Roof Moisture Analysis was performed during the night of 1-4-2011. During the day on 1-4-2011, the weather was sunny, with calm winds and a high temperature of approximately 35 °F. At night the sky was clear, with calm winds and an ambient nighttime temperature of approximately 25 °F.

INFRARED THERMOGRAPHY

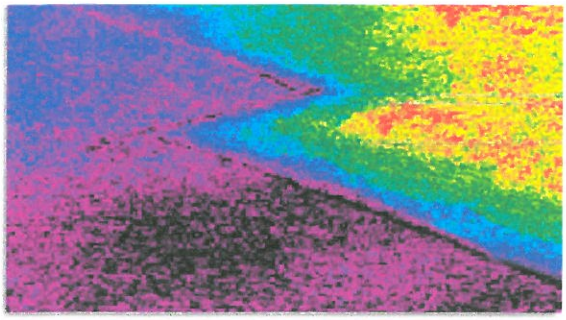
All objects emit heat (i.e. infrared radiation). This radiation is constantly being absorbed and re-emitted by ourselves and everything around us. "Infrared scanning" and "thermography" are the terms used to describe the process of making this thermal radiation visible and capable of interpretation.

Infrared Roof Moisture Analysis locates areas of wet insulation within a flat roofing system. These areas of wet insulation can be pinpointed with the infrared scanner because wet and dry insulations have different abilities to absorb, conduct and retain heat. The thermal differences between wet and dry insulation are especially evident under two sets of circumstances.

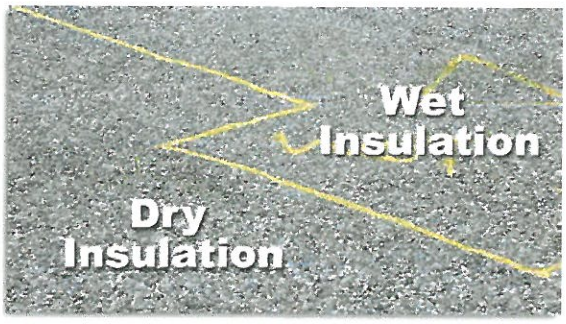
First, wet roof insulation absorbs much more heat than dry insulation. Moisture-damaged insulation also stores more heat over a longer period of time than intact, dry materials. During the day, the sun's heat raises the temperature of wet insulation in the roofing system. As the roof cools off at night, the areas of wet insulation will stay warm longer than the dry areas. During the evening, this stored "solar gain" is released as radiant heat that is detectable with the infrared camera. As the evening progresses, areas of wet insulation will appear warmer to the camera than adjacent dry roofing.



Second, when there is a significant difference in ambient temperature between the interior and exterior of the building, heat losses from inside the building will be greater through the wet areas due to the reduced R-value of the wet insulation. This is especially true during the heating season. In both instances, when viewed from the roof side, wet insulation will show up as warmer in the infrared image. Often these two phenomena work together, creating strong, long-lasting thermal images that clearly illustrate the differences between wet and dry insulation.



Thermographic image from infrared camera



Control image, wet sections marked for removal

Our Infrared cameras can also be used in a variety of other Non-Destructive testing applications:

- Infrared Electrical/Mechanical Inspections pinpoint developing problems in power delivery systems. The infrared scanner can "see" hot spots where there are going to be failures, before they happen. This Predictive Maintenance approach provides for time to repair these problem areas before they cause equipment damage, unscheduled outages, and downtime. Problem areas are pinpointed, prioritized and fully documented.
- Infrared Steam System Inspections pinpoint failing steam traps, malfunctioning heat exchangers and boiler problems. These surveys can save thousands of dollars by reducing energy usage.
- Infrared Building Envelope Analysis locates and documents building heat loss problems, including sources of mold, drafts, and excess moisture. Infrared thermography is the only non-destructive and complete system for locating the causes of frozen pipes, ice dams, missing or wet insulation and high heating costs. Infrared Building Envelope Surveys provide valuable performance data for newly constructed buildings and energy retrofits.

INSTRUMENTATION

Infra-red Analyzers uses top-quality instruments when performing your Roof Moisture Analysis. The portable, high-resolution ThermaCAM® PM390 is one of the most sensitive and sophisticated scanners available. It is capable of resolving temperature differences as small as 0.1 degree Centigrade. The system consists of a digital infrared camera unit with a color viewfinder and captures images and temperature data to digital videotape and/or flash memory cards.

The camera unit receives infrared radiation from the object being surveyed and converts it to an electrical signal that is instantaneously displayed on the color viewfinder. This high-resolution thermal image is then interpreted by Infra-red Analyzers' Certified Thermographers.

Your Thermoplastic roof was inspected with a ThermaCAM® PM390 Short Wave System. At Infra-red Analyzers, we use scanners that operate in both Short Wave (3-5.6 microns) and Long Wave (8-12 microns) segments of the infrared spectrum. Due to the reflectivity of the Thermoplastic membrane on your roof, a Short Wave Scanner was used in order to provide high quality, accurate readings. While other consultants may use Long Wave imaging systems on these types of roofs, in our experience the highest quality information can only be provided by using a Short Wave Scanner.

ThermaCam® PM390 Specifications

Detector	PtSi/CMOS 256 x 256 FPA with variable integration (> 65,000 image elements)
Spectral band	3.4 to 5 µm
Sensitivity (NETD @ 30°C)	< 0.1°C
Temperature measurement range	-10 to 1500°C
Focus range	9" to infinity
FOV (DEG) 16 degree lens, f/1.5	17 horizontal x 16 vertical

SURVEY PROCEDURES

The Infra-red Analyzers Certified Thermographers followed defined survey procedures when inspecting your roof.

GUIDELINES: Every square foot of roofing in the contract was scanned a minimum of two times.

This roof is under a manufacturer's warranty. Therefore, to avoid any possibility of jeopardizing this warranty, the Certified Technician did not take core samples or moisture probes of the roof to verify presence of water. The non-destructive detection equipment used to test your roofing systems is extremely sensitive and accurate when locating areas of wet insulation. However, as with any non-destructive testing technique, there exists a slight possibility that false positives or false negatives may occur. Due to the lack of absolute physical verification, the areas marked on your roof and on the maps should be considered to represent suspected or probable areas of wet insulation, rather than verified areas of wet insulation.

BOUNDARIES: Every effort is made to have the lines painted on the roof indicate accurately the boundaries of the wet insulation. However, the non-destructive nature of the testing can sometimes result in small inaccuracies. Therefore, the Technician will generally mark outside the wet area by about 6" to 12" to provide a reasonable margin of error. In other instances, it may be advisable to calculate a slightly larger area of insulation than what is actually painted on the roof. Additionally, the way water migrates through insulation may not be homogeneous, and it may happen that there are a few square feet of dry insulation within the boundaries of the larger wet area. As a practical matter, these small dry spots are not significant, and the Technician will just define the overall boundaries of the wet area.

MAPPING: After all the scanning and verification were completed, the roofs were mapped. A draft copy of your drawing was made at the site, documenting all the information generated during the inspection. A final copy of the map was plotted in the office using an AUTOCAD® system. Please note that the measurements displayed in these maps should not be used as a substitute for as-built drawings.

FINDINGS

As per our survey procedures, the entire roof area in the contract was scanned a minimum of two times. A total of 3 areas of suspected wet insulation were detected in the inspected roofing.

The total size of the inspected roofing is approximately 6,218 square feet. The total amount of suspected wet insulation equals approximately 63 square feet. The amount of suspected wet insulation is approximately 1 % of the total inspected roof area. These areas of suspected wet insulation are marked directly on the roof and on the maps provided. Please refer to these maps when reviewing the report.

The table below represents the findings by roof section and total area tested.

Table of Findings

Roof Section	Approx. Roof Area (sf)	Approx. Wet Area (sf)	Approx. Wet Area (%)
Acton Town Hall: South roof	2,843	53	1.9 %
Acton Town Hall: North roof	3,375	10	< 1%
Totals:	6,218	63	1 %

The next section of the report contains the 8 sets of thermograms and control photos that were generated during the inspection.

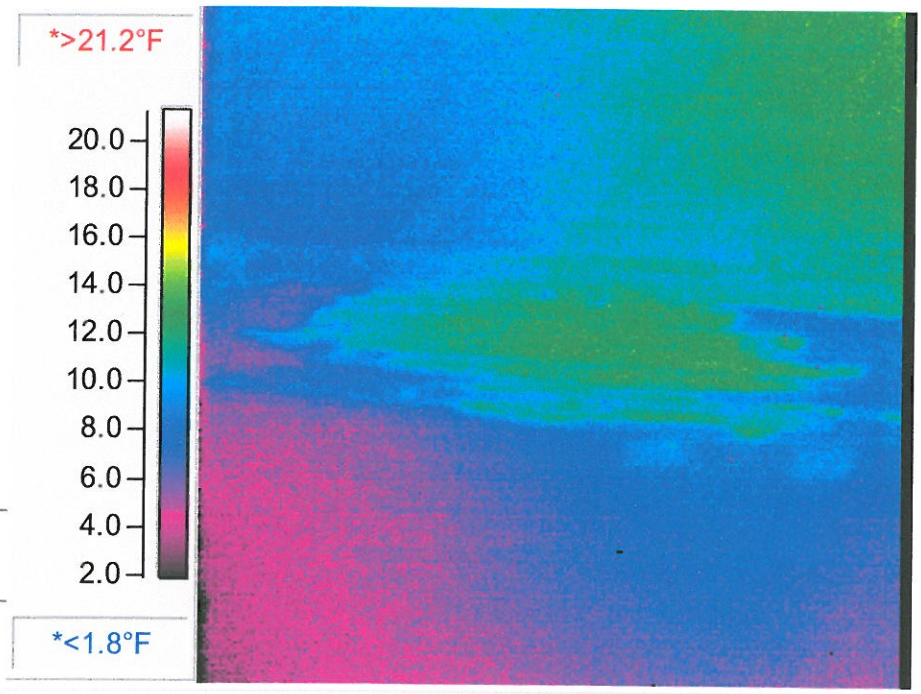
Control Photo 1

Control Photo: Visible Light Image

Wet Area #1

Thermogram 1

Thermogram: Infrared Image



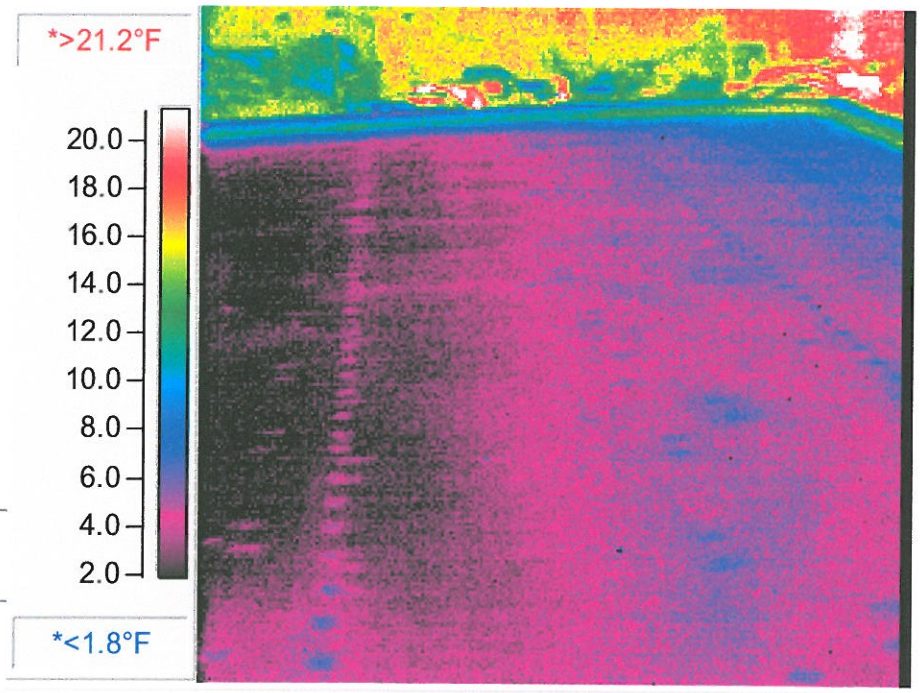
Control Photo 2

Control Photo: Visible Light Image

Dry area of roofing

Thermogram 2

Thermogram: Infrared Image



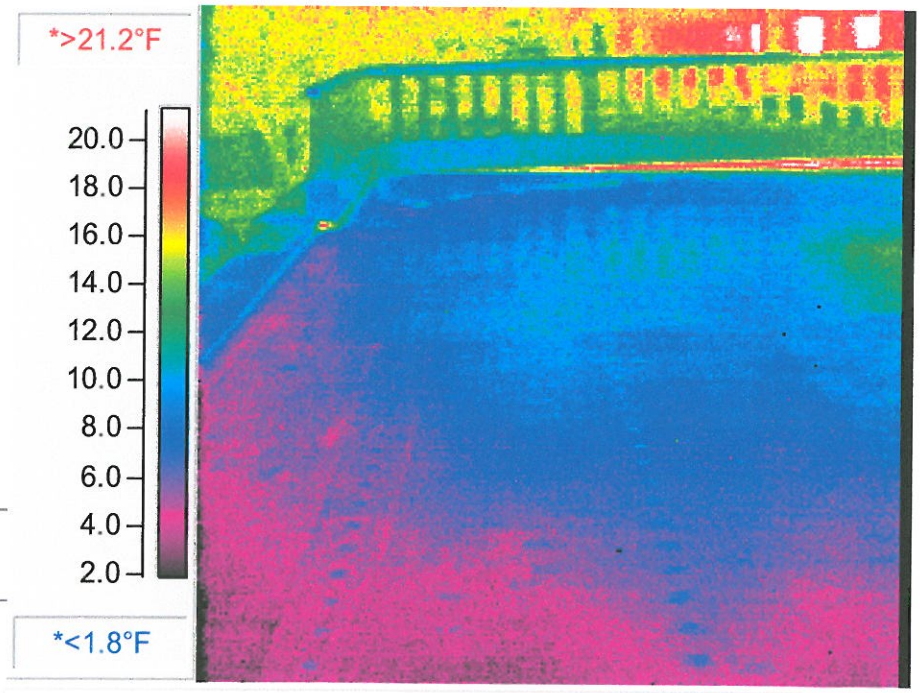
Control Photo 3

Control Photo: Visible Light Image

Dry area of roofing

Thermogram 3

Thermogram: Infrared Image



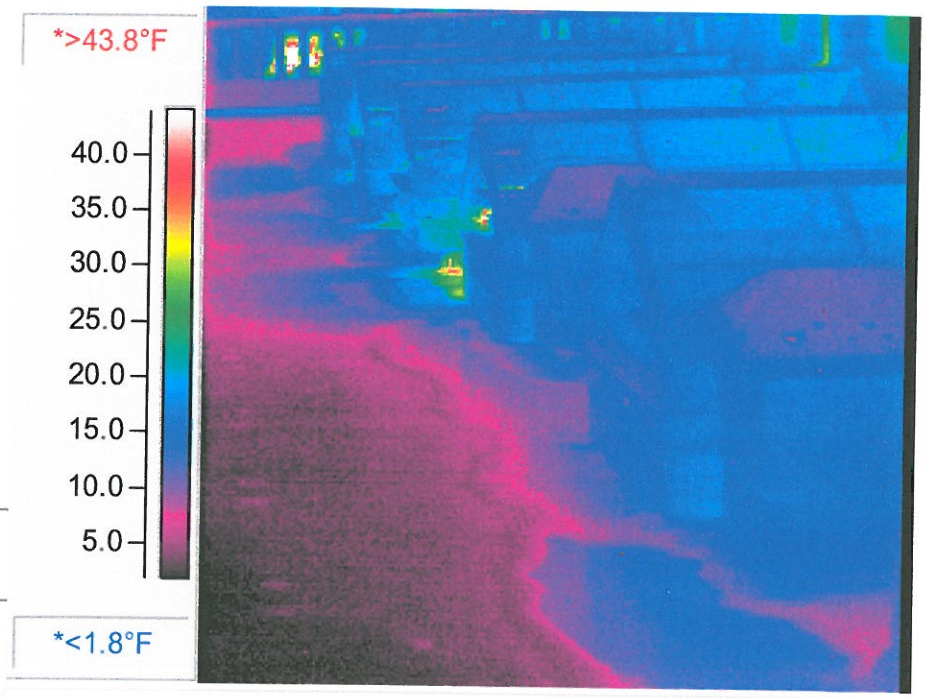
Control Photo 4

Control Photo: Visible Light Image

Dry area of roofing

Thermogram 4

Thermogram: Infrared Image



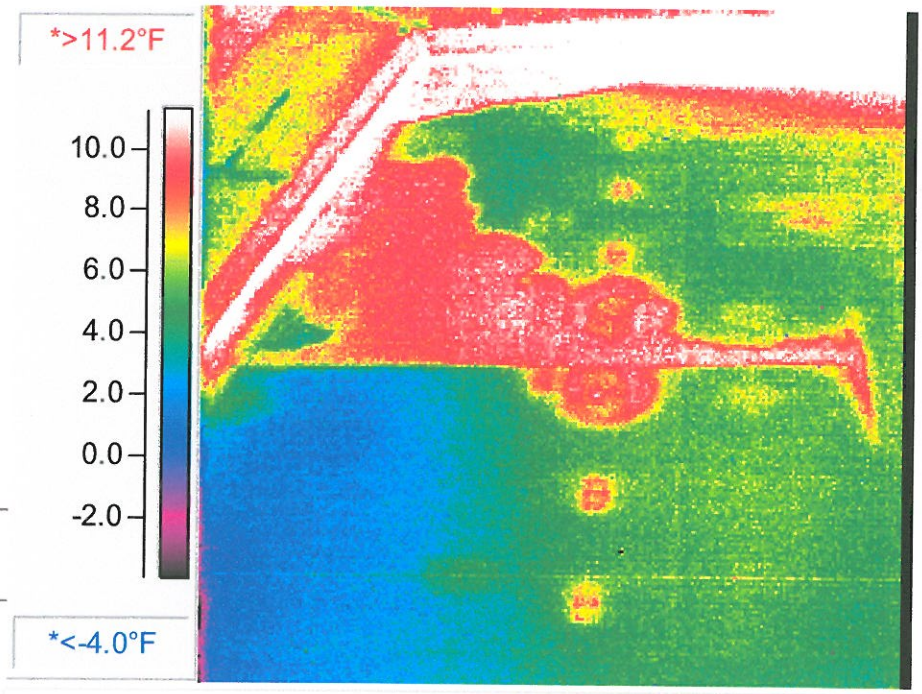
Control Photo 5

Control Photo: Visible Light Image

Wet Area #2

Thermogram 5

Thermogram: Infrared Image



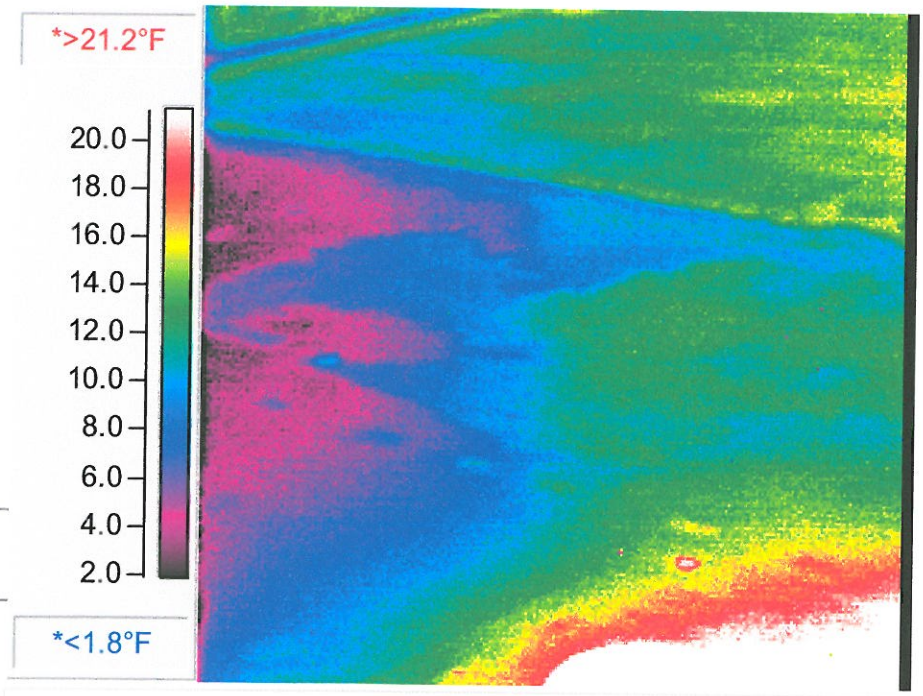
Control Photo 6

Control Photo: Visible Light Image

Wet Area #3

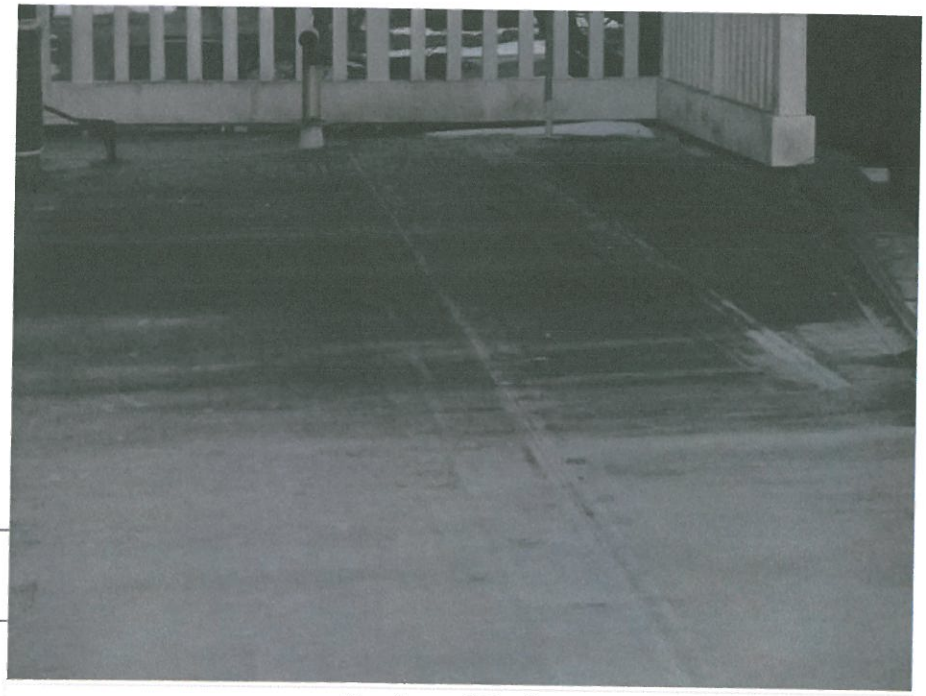
Thermogram 6

Thermogram: Infrared Image



Control Photo 7

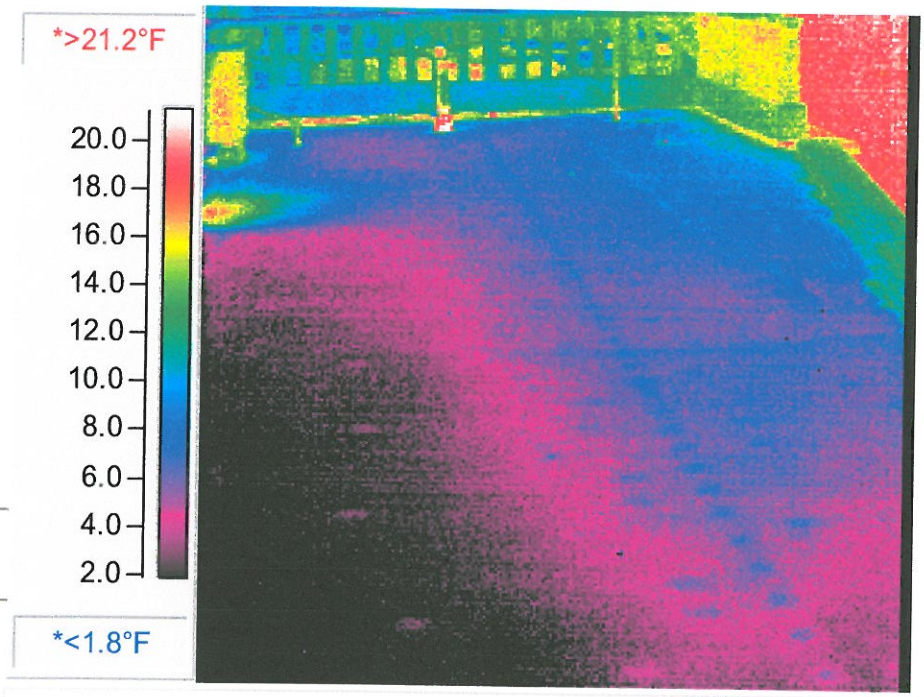
Control Photo: Visible Light Image



Dry Area of Roofing

Thermogram 7

Thermogram: Infrared Image



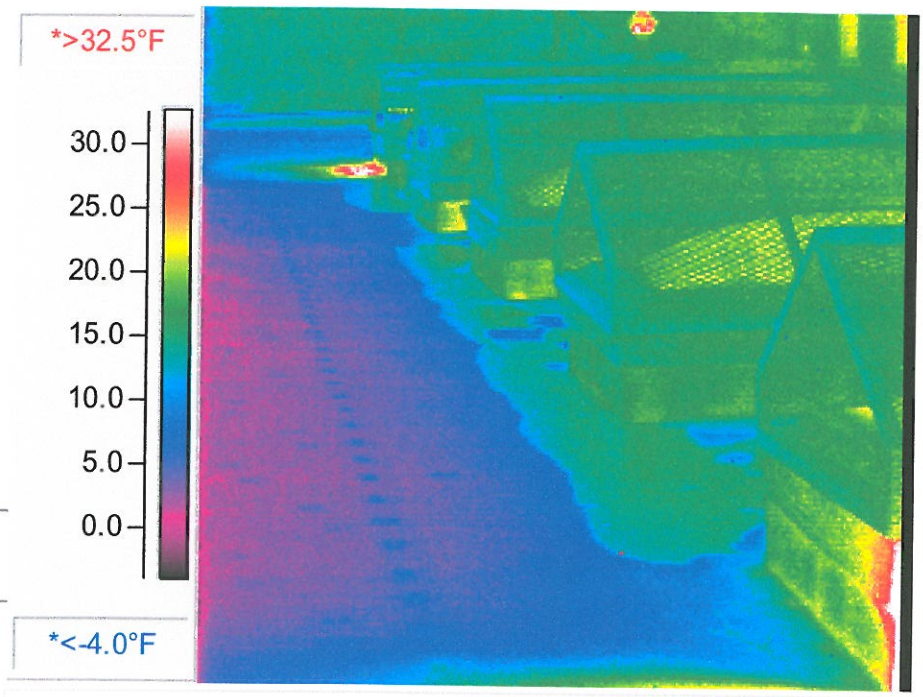
Control Photo 8

Control Photo: Visible Light Image

Dry Area of Roofing

Thermogram 8

Thermogram: Infrared Image



ROOF MAPS

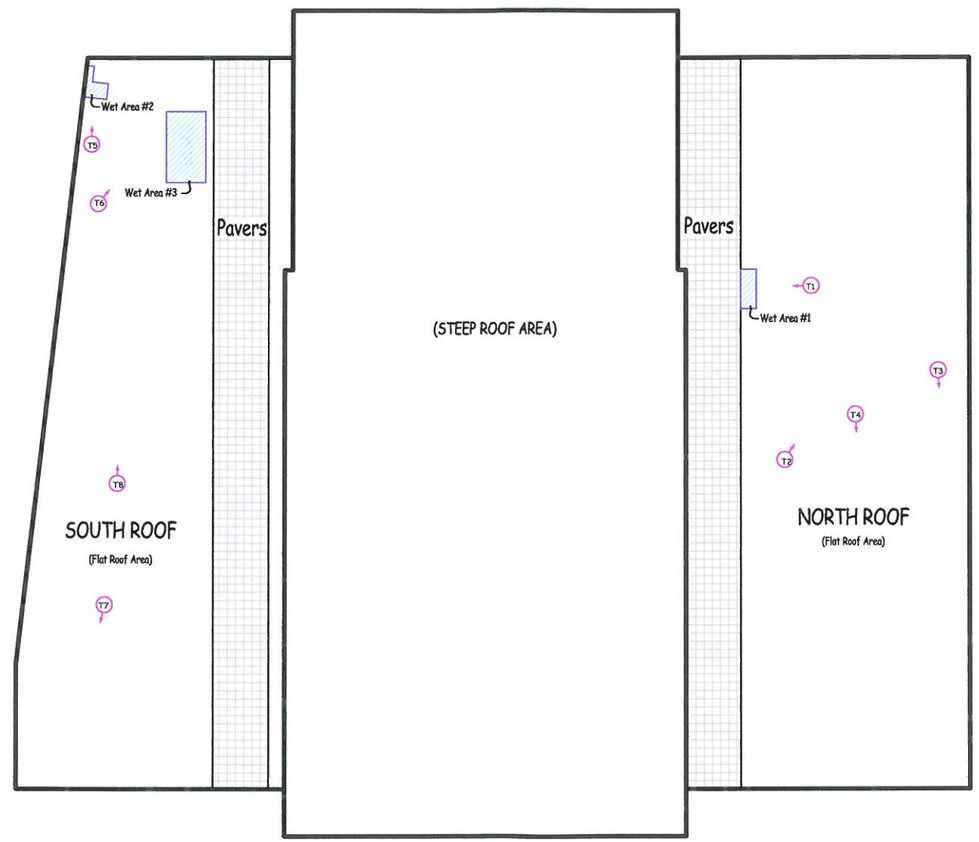
The last part of this report contains four copies each of a map of the roofs. These scaled drawings were plotted on an AUTOCAD® System and complete the documentation of the findings of the survey.

This report documents the locations and extent of suspected wet insulation at the time of the inspection. No information regarding the integrity of the roofing system or building is provided or implied in this report. Many factors, including sunlight, precipitation, wind, foot traffic, and building movement and the like can affect a roof over a short period of time. Regular inspections ensure early detection of problems and can extend the life of a roof membrane.

Michael, thank you for using our services. Please call me if you have any questions regarding this report, or if I can help in any way.

Sincerely,

J.P Phillips
Director of Operations



Legend

T3 THERMOGRAM

SUSPECTED WET INSULATION

Areas: SOUTH ROOF
(In approximate square feet)

Square Footage of Roof Inspected:	2,843
Square Footage of Suspected Wet Area:	53
Percentage of Suspected Wet Area:	1.9%

Areas: NORTH ROOF
(In approximate square feet)

Square Footage of Roof Inspected:	3,375
Square Footage of Suspected Wet Area:	10
Percentage of Suspected Wet Area:	<1%

Areas: TOTAL OF BOTH ROOFS
(In approximate square feet)

Square Footage of Roof Inspected:	6,218
Square Footage of Suspected Wet Area:	63
Percentage of Suspected Wet Area:	1.0%

INFRA-RED ROOF MOISTURE ANALYSIS

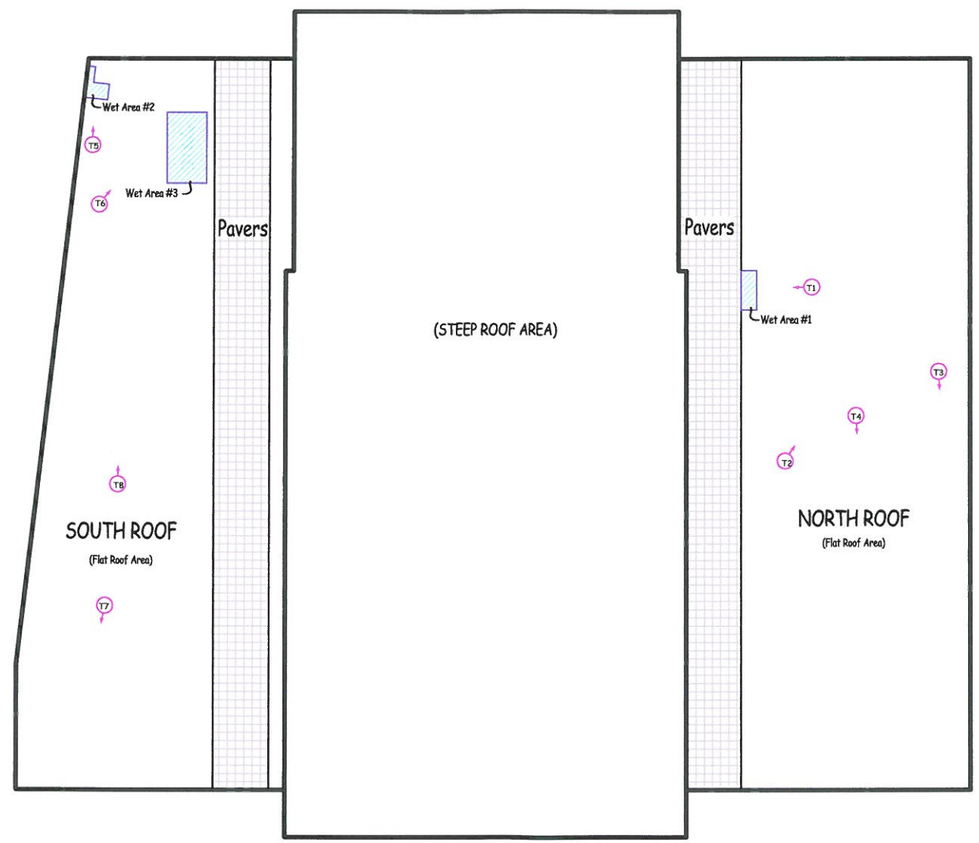
INFRA RED ANALYZERS
CERTIFIED THERMOGRAPHERS
237 COMMERCE ST., SUITE 260
WILLISTON, VERMONT 05495
Phone: (800) 879-1964
NASHUA, NH - NEW HAVEN, CT - ORLANDO, FL

NORTH

RDK ENGINEERS
BOSTON, MA

ACTON TOWN HALL
ACTON, MA

SCALE: N.T.S
DATE: 01-12-11
PAGE: 1 OF 1
DRAWN BY: DMR
JOB#: 11019ACT



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T3 THERMOGRAM

SUSPECTED WET INSULATION

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Square Footage of Suspected Wet Area:	10
Percentage of Suspected Wet Area:	<1%

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DRAWN BY: DMR
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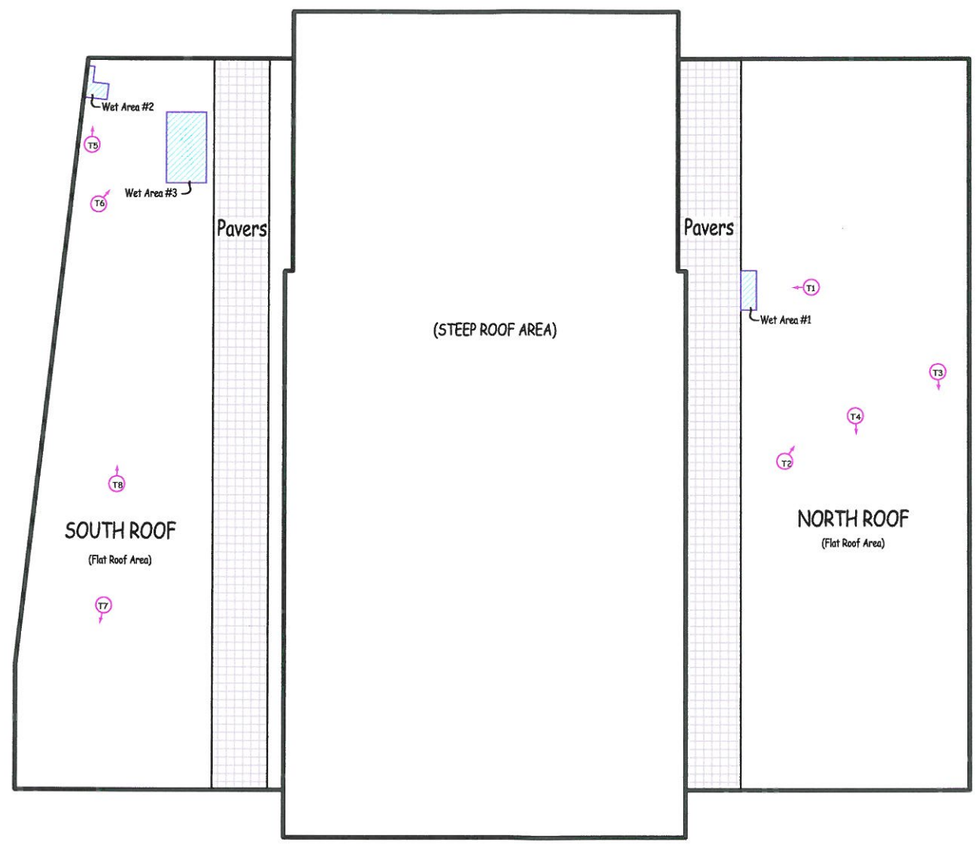

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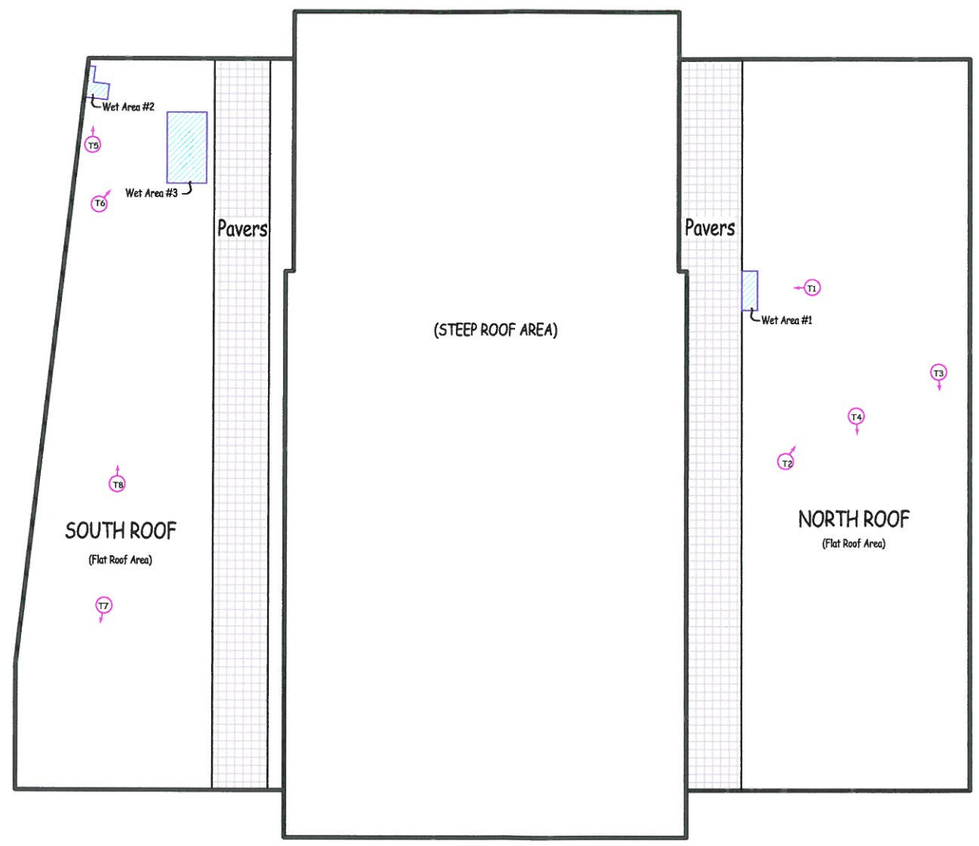

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T3 THERMOGRAM

SUSPECTED WET INSULATION

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Square Footage of Roof Inspected:	2,843
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Percentage of Suspected Wet Area:	<1%

Areas: TOTAL OF BOTH ROOFS (In approximate square feet)	
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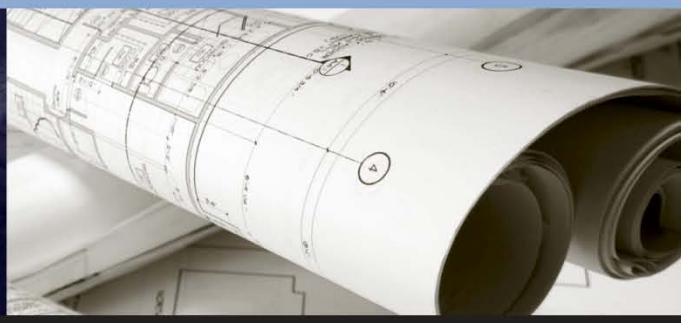
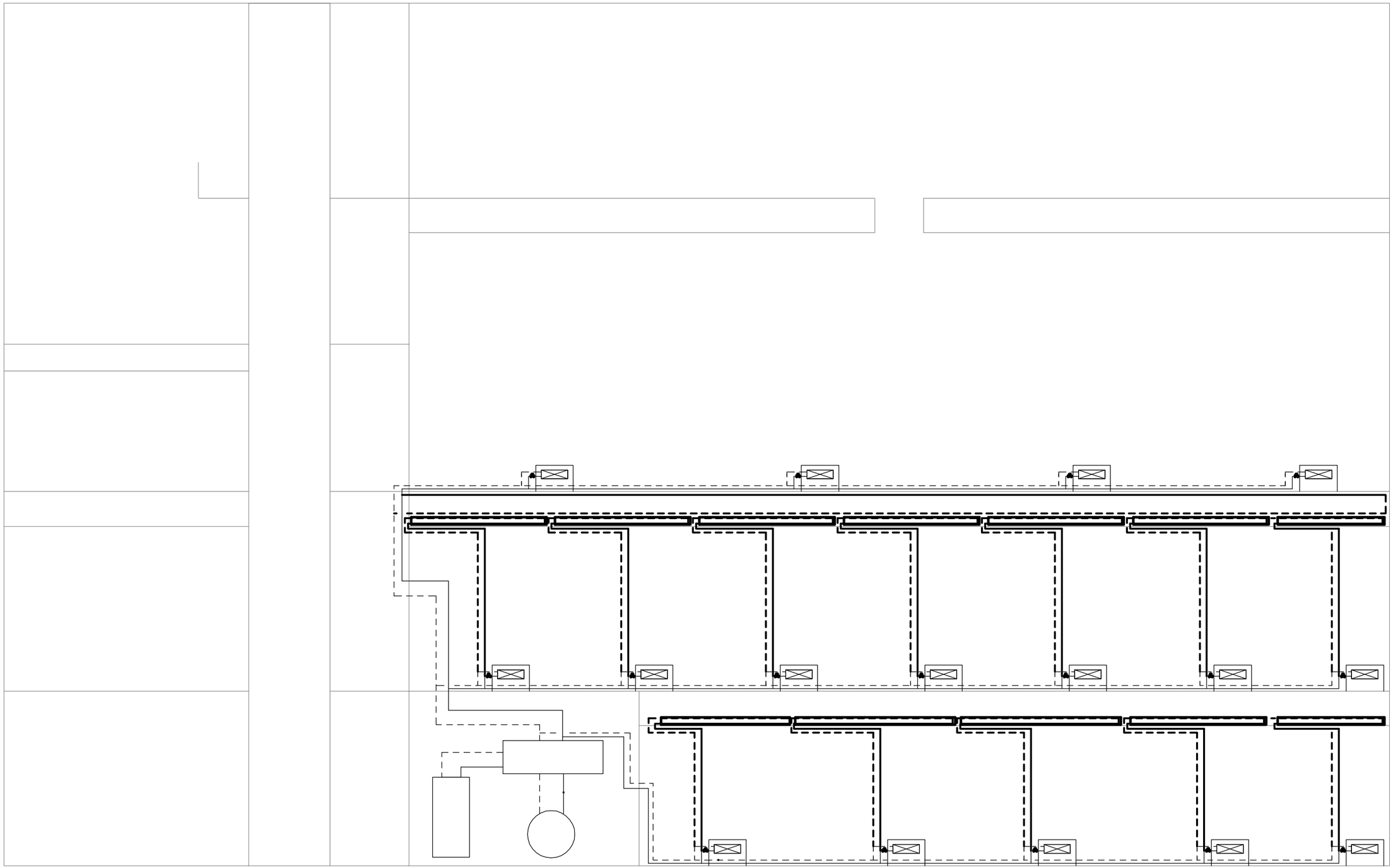
DATE: 01-12-11
PAGE: 1 OF 1
DRAWN BY: DMR
JOB#: 11019ACT

RDK ENGINEERS

APPENDIX E: SCHEMATIC DRAWINGS





RDK ENGINEERS

Andover, MA - Boston, MA - Amherst, MA

Durham, NC - Charlotte, NC

RDK Engineers - Seaport Center
70 Fargo Street, Suite 800
Boston, MA 02210

T.617-345-9885
F.617-345-4226
W. www.rdkengineers.com

PROJECT

NUMBER

DATE

REVISION

DRAWING

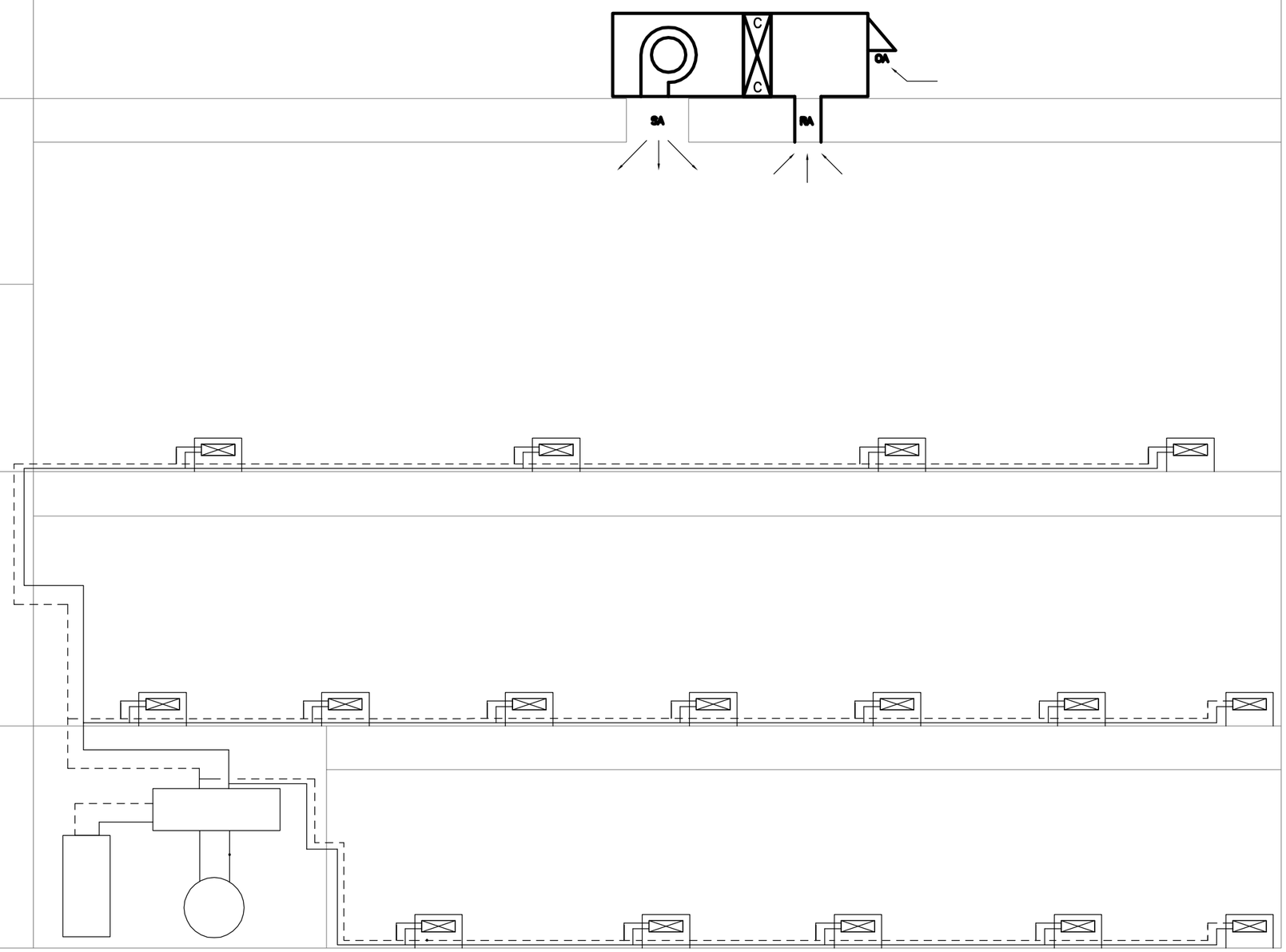
DRAWN BY

CHECKED BY

SCALE

REFERENCE DRAWING

RADIANT HEATING
SCHEMATIC DESIGN



RDK ENGINEERS

Andover, MA - Boston, MA - Amherst, MA

Durham, NC - Charlotte, NC

RDK Engineers - Seaport Center
70 Fargo Street, Suite 800
Boston, MA 02210

T.617-345-9885
F.617-345-4226
W. www.rdkengineers.com

PROJECT

NUMBER

DATE

REVISION

DRAWING

DRAWN BY

CHECKED BY

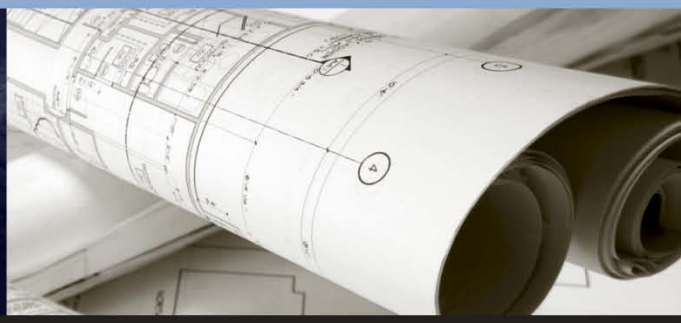
SCALE

REFERENCE DRAWING

NEW SPLIT SYSTEM
SCHEMATIC DRAWING

RDK ENGINEERS

APPENDIX F: ENERGY ANALYSIS INTERVIEW



Project Name: Acton Town Hall energy study **Submitted By:** Dean Charter

Job Number: **Date Verified:**

Energy Service Provider: NSTAR/CNE (electric), NGRID/Direct (gas)

	Item	Response/Action
1.0	**General Information**	
1.1	What is your expectation of an Energy Audit/Analysis?	A list of possible improvements to factor into long term capital plan
1.2	What is your company's investment philosophy directly related to energy savings? i.e.; MARR, Simple Payback yrs.	
1.3	Are your current annual energy bills a larger percentage of your operating cost than you would like?	Bills for this building do not seem to be out of line, but we are always looking for savings
1.4	What kind of percentage energy reduction is your company/firm targeting? Short term/Long term	10%
1.5	Is your firm interested in sustainability?	Yes. Political considerations are very important
1.6	Are you willing to use innovative technologies to achieve your short/long term goal? Examples; solar, wind, geothermal, bio-fuel etc…	Yes
1.7	Is LEED Certification a priority?	Nice to have, but not essential
1.8	Have any building modifications or projects been implemented recently? If so, explain	New storm windows in historic portion of the building, window restoration on one floor, new gas boiler, attic insulation
2.0	**Pre-Audit Information**	
2.1	What are your building operating hours? From___to ____	7-5 office, 5-11 meeting rooms
2.2	Does the building utilize a "state of the art" control system for lighting and HVAC? If so, please describe	No, very low-tech
2.3	Does the facility perform there own maintenance or is it contracted to a third party?	Routine work by in-house (filters, etc.) larger jobs contracted out

	Item	Response/Action
2.4	What are the major energy consuming equipment/functions in your building (e.g., heating/cooling systems)	Summer cooling, computers/copiers

3.0 Office Equipment

3.1	Are PC monitors shut off, or in sleep mode at the end of the day?	Not shut down
3.2	Are copying machines shut off, or in sleep mode at the end of the day?	Sleep mode
3.3	Are fax machines shut off at the end of the day?	One fax, not shut down
3.4	Does your firm utilize any unique office equipment? If so, please describe	
3.5	General Comments	

4.0 Lighting

4.1	Does the facility utilize incandescent lamps?	no
4.2	Are there any immediate/future plans to upgrade lamps, ballasts or lighting?	None at this itme
4.3	How is your lighting system controlled?	Individual switches, motion detectors in meeting rooms
4.4	Is lighting only used when needed?	Some lights left on in hallways at night
4.5	What percentages of lights are being shut off after hours/weekends?	85-90%
4.6	What is the extent of outdoor lighting? And does it currently meet your needs?	Parking lot lights, some perimeter CFL coach lights
4.7	What do you hear most often regarding lights in this building? To dark, to bright etc..	No comments, seems ot be OK

	Item	Response/Action
4.8	Are occupants reminded to turn off lights if automated control is not currently available?	yes

5.0 Heating/Cooling

5.1	Is heating/cooling control accomplished from a central computer and does the computer schedule match your occupancy?	No central computer, some time clocks
5.2	Are heating thermostats set to maintain 70 degrees or lower?	68
5.3	Are cooling thermostats set for 73-75 degrees and shut down during unoccupied hours?	72
5.4	Is a setback strategy employed for unoccupied conditions?	Yes, on weekends and after midnight
5.5	Are there any fans or portable electric heaters used by occupants?	A few electric heaters
5.6	Are heating/cooling system pipes insulated?	yes
5.7	Are fans shut off during unoccupied hours? Such as Toilet exhaust	We are installing time clocks
5.8	What is heard most often regarding the building heating/cooling comfort from occupants?	Cool spots at ankle level, too warm in upper levles
5.9	Are there any large motors operating in the building?	no
5.10	General Comments	

6.0 Building Envelope

6.1	Are doors/windows kept closed during heating and cooling season?	Windows are used for ventilation in appropriate season
6.2	Is weather stripping found to be adequate around windows and doors? Is there any noticeable leakage? Please explain	Some leakage around entrance doors
6.3	Are windows in need of solar film to reduce/block the sun?	no

	Item	Response/Action
6.4	Are exterior walls too hot/cold?	Not noticed
6.5	General Comments	

7.0 Water

7.1	Is domestic hot water at lowest possible setting for general purpose?	yes
7.2	Are there any leaking faucets?	no
7.3	Do lavatories and sinks utilize low flow fixtures?	no
7.4	General Comments	

8.0 Miscellaneous

8.1	Do currently you receive utility usage and cost reports for your building? Please provide if available	Yes, have forwarded spread sheets
8.2	Are any energy awareness materials displayed throughout the building? Pamphlets, signage etc…	no
8.3	Are there other major energy usage, issues in your building that would not be covered by this audit? If so, please describe/list	
8.4	Would you like any additional energy conservation educational materials within your building? (e.g.; posters, usage data, light stickers, etc…)	

	Item	Response/Action
8.5	How many food or drink vending machines are in your building? Are they on all the time or do they go to "sleep"?	1
8.6	Is there a cooking/servery space within the building?	no