Measurement and Verification of Heating Energy Savings Resulting From the Installation of Heat Reflector Panels

"Reflector Panels"

Site 1 Report:
Centre Calixa-Lavallée, Montreal

Project No.: 218204

Presented to:

Energy Efficiency Fund (EEF)

8 July 2004

RIGHTS AND RESPONSIBILITIES

EXECUTIVE SUMMARY

According to various academic studies and laboratory tests, installing heat reflector panels on the wall behind heat distribution equipment, such as cast-iron radiators or hot water baseboards (finned tubes), would lead to average energy savings of 10% during the heating period.

Thus, the EEF mandated the NGTC to verify the effect of these reflector panels by taking measurements on actual installations. First, two sites were selected, the Centre culturel Calixa-Lavallée in the city of Montreal and Habitations L'Équerre, a housing cooperative in Sherbrooke. The Montreal site uses a cast-iron radiator heat distribution system, whereas the Sherbrooke site uses baseboard heating. This document discusses the results obtained at Centre Calixa-Lavallée, while the series of measurements from the second site (Sherbrooke) have not yet been completed.

At Centre Calixa-Lavallée, the effect of the heat reflector panels was only measured in one room of the building, although panels were installed behind every radiator in the building. The overall effect of the panels could not be evaluated due to a wrong setting on the boiler system and the subsequent opening of windows by tenants during the winter months. This last element in effect rendered it impractical to complete an energy assessment on the entire building.

In the room of the building that was measured an average energy savings of 24% was observed. The majority of these savings was realized by the insulating properties of the heat reflector panels, which reduced heat losses through the exterior walls behind the radiators. However, these results come from a room in the building where the ratio of surface area of the wall behind the radiator over the total surface area of the wall is larger, therefore showing elevated energy savings for this part of the building. An overall analysis of the entire building should reveal more realistic results. Nevertheless, it is possible to affirm at this stage that the effect of the heat reflector panels seems positive.

A survey asking the difference of comfort levels of the tenants at Centre Calixa-Lavallée after the installation of the heat reflector panels was carried out. Due to the fact that there was no adjustment carried out on the controls of the boiler system, the comments obtained related mainly to the lack of initial comfort, connected to an inequality of the temperatures in the building, more than with the effect of the panels, which were pretty much unperceived.

Since the Sherbrooke site represents a different type of heating system, it would be interesting to add another test site to the project which has a cast-iron radiator heating system, similar to that of Centre Calixa-Lavallée, but where the boiler system controls were properly adjusted and the windows would remain closed during the winter. This additional site analysis would allow us to bring validity and completeness to the results obtained at Centre Calixa-Lavallée.

FACT SHEET

1.Title and Subtitle

Measurement and Verification of Heating Energy Savings Resulting From the Installation of Heat Reflector Panels – "Reflector Panels", Site 1 Report: Centre Calixa-Lavallée, Montréal

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10. Summary (maximum of 200 words)

This first report presents the measurement results as well as the analysis of the energy savings associated with the installation of heat reflector panels in the first site, which has cast-iron radiator heating system. This site is the Centre cultural Calixa-Lavallée, located in Montreal. There were two measurement periods, the first from January and February 2004, before the installation of the heat reflector panels, and the second in March 2004, following the installation of the panels.

A survey evaluating the comparative comfort of the occupants was carried out before and after the installation of the heat reflector panels and the results of this survey are present in the following document.

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1.0 BACKGROUND

The EEF established a program for natural gas users to install reflector panels behind hot water or steam radiators.

According to various sources, it has been demonstrated that installing these panels leads to energy savings of 10%, depending on the type of radiator and building in question. However, these demonstrations were performed in a laboratory or by modeling. As of yet, no on-site measurements seem to have been taken in an actual use situation. In addition, the community of specialized professionals is slow to recommend using these panels in institutional and commercial settings.

2.0 OBJECTIVE

Within this context, the NGTC proposed taking on-site measurements to verify the forecast performance for these heat reflector panels and to thereby establish some case studies.

This document presents the measurement results obtained for a first site of measurement, the Centre culturel Calixa-Lavallée in the city of Montréal.

3.0 APPROACH

The approach used in this measurement project can be summarized in five steps:

Task 1: Site identification and validation

The EEF used its various contacts to identify potential sites, conducive to the installation of reflector panels and to the taking of measurements. Initially, two sites were identified: the Centre culturel Calixa-Lavallée in Montréal, which is the subject of this report, and Habitations L'Équerre, a housing cooperative in Sherbrooke.

In the case of the Centre culturel Calixa-Lavallée, Patrice Leroux, from the City of Montréal, helped with the location of the site and carried out the questionnaires for the residents of the Centre.

Task 2: Installation of the instrumentation and definition of the protocol

Once the sites were identified, instrumentation was put in place so that measurements could be taken to analyze the effects of the reflector panels.

The measuring equipment was selected and installed subsequently to the development of a measurement plan combined with an analysis protocol that would make it possible to estimate the extent of the energy savings attainable as a result of the reflector panels. This document has been validated by the EEF and Gaz Métro.

In addition, a survey was prepared for occupants of the equipped sites, for the purpose of conducting a qualitative analysis of the impact of the reflector panels, in terms of the occupants' comfort. This document was intended to complement the analysis conducted through measurement.

Task 3: First series of measurements

Before the reflector panels were installed, an initial measurement period was used to establish the comparison reference to analyze the effect of these panels on heating energy consumption.

Boiler measurements were taken in the overall comprehensive analysis of the entire building; measurements were also taken in a single room in a single suite with the radiators. In the case of the Centre Calixa-Lavallée, the suite where the measurements took place was the office of the maintenance engineer, adjacent to the entrance hall.

Task 4: Second series of measurements

The second series of measurements took place at the same measurement points as the first, subsequent to the installation of the reflector panels, to determine their impact.

In the case of complaints of discomfort of occupants (too hot) resulting from the installation of reflector panels, the second series of measurements was taken at two different times and a third series of measurements was then taken following certain adjustments to the heating control systems, such as lowering of the set thermostat temperatures and/or removing water from the boiler. This third series of measurements was not taken in the case of the Centre Calixa-Lavallée, the temperature of the water in the heating system was already lowered close to the minimum temperature which is assured that no condensation would occur in the exhausts of the boilers.

The comparative survey of the before and after effect of the reflector panels was submitted to the occupants of Centre Calixa-Lavallée, after the second series of measurements.

Task 5: Data Analysis

The data collected before and after the installation of the reflector panels was analyzed to assess the energy savings attained as a result of the panels. This data was adjusted for the HDD, the sum of which differs during the two measurement periods.

4.0 DATA MEASUREMENT AND ANALYSIS

Evaluating the impact of the reflector panels on the consumption of energy necessary to produce a similar level of comfort in one suite or one building is realized by two approaches. These approaches are based on two hypotheses connected to the utilization of these types of panels, they are:

- The reflector panels permit the modification of the conditions of operation of the radiators, by reflecting the radiant heat emitted from the radiator and by reheating the water in circulation (recuperation of energy otherwise lost to the wall behind the radiator);
- The reflector panels play a role in insulating the wall behind the radiator, therefore diminishing any loss of heat and the consumption of energy for heating purposes, not necessarily from any importance of the reflection effect of the panels to reheat the water of the radiator in any fashion.

4.1 MODIFICATION OF THE CONDITIONS OF OPERATION OF THE RADIATORS

The reflector panels permit the return (reflection) of a large part of radiant energy coming from the radiators towards this and the "reheating" therefore of the water or vapor that circulates within. This energy is otherwise lost through the wall behind the radiator. Therefore the difference in temperature between the entrance and exit of the radiator would be reduced, for a similar transfer of heat to the suite/room. In other terms, there would be a reduction of the net energy emitted from the radiator to generate a similar comfort level (the same temperature in the suite/room).

Also, the observation of the effect of the reflector panels on the conditions of exchange of heat from the radiator is realized with by the average difference of mean temperature of the water between the entrance of the radiator and the exit of the radiator ($\Delta T_{radiator}$), before and after the installation of the reflector panels, for similar conditions of operation (temperature of the room (T_{room}), temperature of the water entering the radiator ($T_{entering\ radiator}$), exterior temperature ($T_{exterior}$)). The following measurements have to therefore be calculated:

- Temperature of the water entering the radiator: $T_{entering\ radiator}$
- Temperature of the water leaving the radiator: $T_{leaving\ radiator}$
- Temperature of the room: T_{room}

The exterior temperature ($T_{exterior}$) is evaluated from the given daily climatic conditions taken from Environment Canada.

By the same method, the effect of the reflector panels on the conditions of the operation of the radiators can be observed in an overall way, by using the difference between the average temperature of the water entering the boiler (return water) and of that leaving the boiler (ΔT_{boiler}), before and after the installation of the reflector panels, for similar conditions of operation (internal temperature of the building ($T_{building}$), temperature of the water leaving the boiler ($T_{leaving\ boiler}$), exterior temperature ($T_{exterior}$)).

The effect of the reflector panels on the effectiveness of the boiler is equally evaluated by the intermediary of the temperature of the exhausts ($T_{exhausts}$) tied to the residual oxygen percentage they contain. For example, if the water in the heating circuit comes back at a

higher temperature to the boiler, the effectiveness of the boiler can be diminished. This measure therefore allows the establishment of various effects of the reflector panels on the heating system and helps in the planning of system adjustments, such as the reduction of the temperature of the water leaving the boiler.

The following measurements therefore have to be calculated:

- Temperature of the water returning to the boiler: $T_{\text{entering boiler}}$
- Temperature of the water leaving the boiler: $T_{\text{leaving boiler}}$
- Temperature of the exhausts: T_{exhausts}

The internal temperature of the building (T_{building}) is measured in each room or suite only (T_{room}) and is judged equally to the temperature of this suite, or at the very least in proportion with this one, for buildings where the heat controls are not by room or suite. In this last case, an overall analysis is impractical.

The percentage of residual oxygen in the boiler exhausts ($\%O_2$) is measured in a timely manner. Also, this percentage is considered stable enough in that time.

Equation [1] is used to determine the percentage of savings arising from the modification of the conditions of the exchange of the radiator ($\%_{\Delta T\ \text{radiator}}$). The second term of the equation permits for a correction of a light difference at the level of the conditions of operation of the radiator, be it at the level of temperature of the water entering the radiator ($T_{\text{entering radiator}}$) and at the level of the temperature of the room (T_{room}).

Equation [2] is used for the overall evaluation using the conditions of operation of the boiler ($\%_{\Delta T\ \text{boiler}}$)

$$\%_{\Delta T\,rad} = \left[1 - \left(\frac{(T_{e\,rad} - T_{s\,rad})_{après}}{(T_{e\,rad} - T_{s\,rad})_{avant}} * \frac{(T_{e\,rad} - T_{pièce})_{avant}}{(T_{e\,rad} - T_{pièce})_{après}}\right)\right] * 100\% \qquad [1]$$

$$\%_{\Delta T\,chaud} = \left[1 - \frac{(T_{s\,chaud} - T_{e\,chaud})_{après}}{(T_{s\,chaud} - T_{e\,chaud})_{avant}}\right] * 100\% \qquad [2]$$

NOTE: These equations can *only* be used as long as similar average conditions can be found when measuring without panels and measuring with panels, these are the temperature of the room (T_{room}), the exterior temperature (T_{exterior}), the temperature of the water entering the radiator ($T_{\text{entering radiator}}$) and the temperature of the water leaving the boiler ($T_{\text{leaving boiler}}$). It is thus necessary to locate among the accumulated data, those that correspond to periods (days) present similar average conditions.

4.2 INSULATION OF THE WALL BEHIND THE RADIATORS

The reflector panels permit the insulation of a part of the walls in a room/building, reducing therefore the losses through the walls, behind the radiators, and by the same the consumption of energy for the room/building, always with a similar comfort level. The overall energy provided to a room/building in the measured time period would be reduced, thus generating energy savings.

The energy exchanged to the room or the building in the measured time period is evaluated in part by the sum of the time period ($\sum_{period}$) of energy exchange to the radiator(s) situated in the room and, in part, by the consumption of gas energy to the boiler. Also, the energy exchanged during these periods must be the object of a correction making it possible to bring back a comparison to similar heating loads, so to say the base same number of heating degree days (HDD).

To enable this analysis, the following measurements must be collected during the measurement period:

Around the radiator:

- Temperature of the water entering the radiator(s) in the room: $T_{entering\ radiator}$
- Temperature of the water leaving the radiator(s) in the room: $T_{leaving\ radiator}$
- Temperature of the Room: T_{room}
- Temperature of the wall behind the radiator in the room: T_{wall}

Around the boiler:

- Consumption of natural gas at the boiler: V_{gas}

The temperature of the wall behind the radiator is raised (T_{wall}) to an indicative basis, for a qualitative appreciation of the reduction of energy lost directly to the wall in the absence of the heat reflectors.

Equations [3] and [4] are used to evaluate the percentage of energy savings observed in the room ($\%_{Q\ room}$) and in the entire building ($\%_{Q\ building}$), by the reduction of the consumption of energy used to heat in the measured time period, connected to the insulation of part of the walls.

$$\%_{\Delta Q\ pièce} = \left[1 - \left(\left(\frac{\sum_{période}(T_{e\,rad} - T_{s\,rad})_{après}}{\sum_{période}(T_{e\,rad} - T_{s\,rad})_{avant}}\right) * \frac{d - j_{\ avant}}{d - j_{\ après}}\right)\right] * 100\% \qquad [3]$$

$$\%_{\Delta Q\ bâtisse} = \left[1 - \left(\left(\frac{\sum_{période}\left(V_{gaz}\right)_{après}}{\sum_{période}\left(V_{gaz}\right)_{avant}}\right) * \frac{d - j_{\ avant}}{d - j_{\ après}}\right)\right] * 100\% \qquad [4]$$

The daily degree days (HDD), taken from Environment Canada, are used in equations [3] and [4] to calculate the correction for the level of heating during the period studied.

NOTE: Equations [3] and [4] can *only* be used if the average room temperature (T_{room}) and building temperature ($T_{building}$) in their entirety are similar when measuring without panels and when measuring with panels. The interior temperature of the building ($T_{building}$) is measured in one room only (T_{room}) and is judged to be equal to the temperature of this room, or at the very least variable in proportion to this one, for buildings where the heating control system is not located in each room. In this last case the overall building analysis is much more complex.

4.3 INSTRUMENTATION

The various temperatures are measured using surface thermocouples and collected on an ongoing basis using micro data loggers (MDL). The volume of gas consumed is measured using a gas meter and is also collected using these MDL. Data is recorded every five minutes.

For the measurement of the consumption of gas the Gaz Métro gas meter is used. Where the gas meter does not measure just the boiler, a supplementary gas meter, specifically for the boiler, is installed for the measurement period with consent from the client.

The percentage of residual oxygen is measured in the boiler exhausts with help from a portable gas analyzer, in a punctual way, at the time of displacements on site of a technician, that is to say at the time of the installation of the instrumentation, following the installation of the reflecting panels and at the time of the dismantling of the measurement system.

5.0 SITE 1: CENTRE CALIXA-LAVALLÉE, MONTRÉAL

The first case study site was the Centre culturel Calixa-Lavallée, situated in Montréal at 3819 on Calixa-Lavallée road (Lafontaine Park). It consists of a cultural vocation building, where the hydronic heating system is carried out with two Smith boilers (Model 19-series-7), each one equipped with a Fuel Master burner with a power of 275 kW (942 BTU/h). These boilers work either together or alternately depending on the heating needs of the building.

The heat distribution is realized by cast iron radiators, which are not temperature controlled by room. The only point of control is situated at the site of the boilers, therefore the temperature of the water leaving the boiler is dependant upon the outside temperature (this is the “indoor-outdoor” control type). Figure 5-1 shows one of the radiators located in this building, to be exact the one the measurements were carried out on (described below).

Figure 5-1 Cast Iron Radiator, Centre Calixa-Lavallée

Also, with *the heat distribution system being badly calibrated* in this building, certain occupants were too hot while others were too cold. It is consequently not very easy to carry out an analysis based on comfort. *Many of the occupants who were too hot opened their windows in the winter thus making an overall analysis of the building impractical*.

For this reason, although measuring was carried out according to the plan envisaged, only the analysis of the instrumented room could be carried out. It was the maintenance engineer's office, adjacent to the entrance hall. It was a room with reduced dimensions (about 7.5 m^2 (80 ft^2) by a minimum of 2.5 m (9 ft) in height), heated (and usually over-heated) by a cast iron radiator.

5.1 DATA ANALYZED: ROOM

A first period of measurement was carried out from January 21, 2004 to February 17, 2004, before the installation of the heat reflector panels. Then, following the installation of the panels, which lasted approximately two weeks, the second series of measurements were started Mach 5, 2004 and ended March 24, 2004. Figures 5-2 and 5-3 show a section of reflector panels installed at Centre Calixa-Lavallée and a view of a radiator with the panels installed in place, respectively.

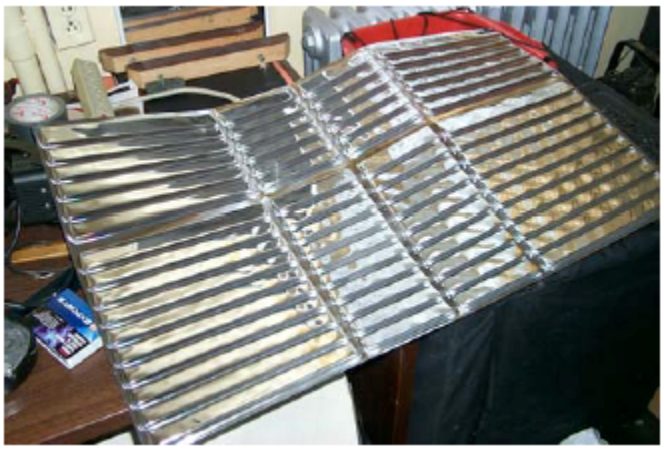

Figure 5-2 Reflector Panels

Figure 5-3 Reflector Panels behind a Radiator

5.1.1 Modification of the conditions of operation of the radiator

During the two periods of measurement, equivalent days could be located in terms of similar average conditions:

- temperature of the room (T_{room})
- exterior temperature ($T_{exterior}$)
- temperature of the water entering the radiator ($T_{entering}$)

During these days, the conditions of exchange of the radiator were compared using equation [1]. Table 5-1 presents the percentage of savings realized as a result of the modification of the conditions of exchange of the radiator ($\%_{\Delta T\ radiator}$), calculated for these days. Detailed calculations are presented in appendix 1.

Table 5-1 Modification of the conditions of exchange to the radiator (office of the maintenance engineer)

Comparable Days (Winter 2004) Before panels vs. After panels	Modification of the conditions of exchange to the radiator
03/02 vs 17/03	3.47%
04/02 vs 14/03	4.05%
09/02 vs 09/03	2.95%
09/02 vs 14/03	2.96%
10/02 vs 08/03	4.06%
10/02 vs 12/03	-5.11%
10/02 vs 15/03	1.12%
08/02 vs 22/03	-4.46%
03/02 vs 18/03	6.52%
13/02 vs 18/03	-1.98%
09/02 vs 19/03	3.08%
04/02 vs 21/03	-4.81%
09/02 vs 21/03	-6.00%
Average:	0.45%

We can see from table 5-1 that the modification of the conditions of exchange to the radiator is on the one hand rather random, and on the other hand, it is of smaller amplitude. Also, on average, the observed effect is close to zero, that is to say of no marked effect.

Therefore, according to the data collected in the maintenance engineer's office at the Centre Calixa-Lavallée, the effect of the reflector panels at the level of the conditions of operation of the radiator is not visible, not seeming to, in this case, have been reheated in a notable fashion by the radiant heat reflected by the panels.

5.1.2 Insulation of the wall behind the radiator

In order to judge the effect of the panels on the heating load of the instrumented room, by the insulation of a part of the wall located behind the radiator, the data making it possible to calculate the energy exchanged from the radiator to the room for a period of time were used in combination with equation [3]. This equation uses the difference in temperature between the entering and leaving of the radiator ($\Delta T_{radiator}$) to estimate the amount of energy exchanged. These differences are accumulated over a certain time period, as long as the heating circuit is functioning, so to say as long as water is running through the radiator.

Hypothesis: The data of the temperature being measured at a continuous rate at the entrance and exit of the radiator, it is necessary to determine the periods when the heating circuit is functioning and when it is stopped. Also, as long as the system is working, $\Delta T_{radiator}$ is elevated. A limit was thus posed in a hypothetical kind of way to be able to consider the energy exchanged with the radiator during the working periods of the heating circuit. $\Delta T_{radiator}$ varies on average between 1.1 ˚C, as long as the circuit is working, and close to zero as long as the system is stopped since a certain time (about 30 minutes). As long as the system is working or stopped, a reading is observed. Also, with this observation, and considering the data is recorded every five minutes, the system is considered working during this five minute period as long as the $\Delta T_{radiator}$ recorded is higher than 0.75 ˚C.

The comparable days presented in the preceding section were used for the second series of calculations because the temperature of the room was similar. Two lengthened periods, for which the average temperature observed in the room was comparable, were equally used as points of comparison. Such as defined in equation [3], all the comparisons made were corrected to reflect an equivalent number of heating degree days (HDD). Table 5-2 presents, for these various periods, the percentages of energy savings observed in the room ($\% Q_{room}$) for the reduction of the consumption of energy used for heating. Detailed data can be consulted in appendix 1.

Table 5-2 Energy savings realized from the insulation of a part of the wall.

Comparable Days (Winter 2004) before panels vs after panels	% of savings realized from insulation of the wall	Extended period (Winter 2004)	% of savings realized from insulation of the wall	
		Before panels: 28 to 26 January + 22 January + 2 to 16 February Vs After panels: 5 to 24 March	26.83%	
03/02 vs 17/03	22.53%			
04/02 vs 14/03	41.23%			
09/02 vs 09/03	0.56%			
09/02 vs 14/03	22.14%			
10/02 vs 08/03	8.47%			
10/02 vs 12/03	35.75%			
10/02 vs 15/03	37.32%			
08/02 vs 22/03	16.64%			
03/02 vs 18/03	35.81%			
13/02 vs 18/03	-2.94%			
09/02 vs 19/03	11.95%			
04/02 vs 21/03	39.17%			
09/02 vs 21/03	19.41%			
Average:	Daily 22.16%		Extended 26.83%	Overall 24.49%

Whether it is for a daily comparison or a comparison of an extended period, the percentages in table 5-2 are all around 24% energy savings. According to these results, there is therefore a positive effect from the panels on the necessary energy consumption to heat the building.

On a purely qualitative basis, the average temperatures measured on the wall behind the radiator, before and after the installation of the panels, show equally a reduction in the loss of heat through this wall. These temperatures are presented in table 5-3.

Table 5-3 Average temperature of the wall behind the radiator, before and after the installation of the reflector panels

Comparable Days (Winter 2004) before panels vs after panels	Average temperature of wall behind radiator	Difference (˚C)	Extended Period (Winter 2004)	Average Temperature of wall behind radiator	Difference (˚C)
03/02 vs 17/03	27.23 vs 15.69	11.54	Before panels: 28 to 26 January + 22 January + 2 to 16 February	29.73˚C	12.20
04/02 vs 14/03	27.51 vs 17.77	9.74			
09/02 vs 09/03	27.19 vs 16.88	10.31			
09/02 vs 14/03	27.19 vs 17.77	9.42			
10/02 vs 08/03	24.63 vs 17.64	6.99			
10/02 vs 12/02	24.63 vs 17.04	7.59			
10/02 vs 15/03	24.63 vs 17.49	7.14	vs	vs	
08/02 vs 22/03	33.63 vs 20.26	13.37			
03/02 vs 18/03	27.23 vs 15.14	12.09	After panels: 5 to 24 March	17.53˚C	
13/02 vs 18/03	27.88 vs 15.14	12.74			
09/02 vs 19/03	27.19 vs 15.49	11.70			
04/02 vs 21/03	27.51 vs 17.90	9.61			
09/02 vs 21/03	27.19 vs 17.90	9.29			
	Average:	10.12 ˚C			

Table 5-3 presents an average fall in temperature to the order of 10˚C on the wall behind the radiator, following the installation of the reflector panels. The insulation effect of the panels therefore becomes quite evident.

However, a line must be drawn to the quantification of the potential of the energy savings realized by the use of the reflector panels. It's great that the percentages obtained in the maintenance engineer's office of the Centre Calixa-Lavallée are up around 24%, but it is important to note that this room's dimensions are quite reduced. Thus, the ratio of the surface of the wall "insulated" by the panels over the total surface area of the walls in the room is elevated, being greater than that of a room of larger dimensions. The percentage of savings, probably all positive for the overall building or a larger room, should be however less.

5.2 COMFORT OF THE OCCUPANTS

In order to judge the effect of the panels on the comfort of the occupants, a survey was submitted to the occupants of Centre Calixa-Lavallée. The questionnaire used can be consulted in appendix 2.

A total of six people responded to the questionnaire. Also, of these six people, five mentioned not being comfortable in their place of work during the winter, due to the

inequality of temperatures in the building and it being too hot in some rooms and too cold in others. Also, in the rooms where it is too hot, people open the windows thus adding cold air currents to the uncomfortable situation.

Related to the major problem of calibration (adjustment) of the distribution of heat in the building, on a overall scale, the effect of the panels passed unappreciated by the occupants. Only two of the six people who responded to the questionnaire mentioned having felt a slight difference following the installation of the panels, being an increase in the ambient temperature.

6.0 CONCLUSIONS AND RECOMMENDATIONS

The tests carried out in the Centre culturel Calixa-Lavallée seem to show that the installation of the reflector panels behind the cast-iron radiators generated energy savings during periods of heating, by the reduction of thermal losses through the walls behind the radiators. However, the energy savings measured on this first site cannot be used as a basis of reference, given the following elements:

- Due to a lack of calibration of the heating system, certain occupants of the Centre had to open windows in winter, invalidating the data measured for the overall building and rendering an overall analysis of the building impractical.
- Also, the analysis realized at the level of the office of the maintenance engineer showed extremely elevated data for energy savings (24%), which can be misleading because they are probably realized from this room's reduced dimensions.

For these reasons, and because the obtained results were positive, the addition of a supplementary test site to the project would be interesting. This additional site should, like the Centre Calixa-Lavallée, have a hydronic heat distribution system with cast-iron radiators. Also, it is very important that the heating system of this building is properly calibrated, so the occupants can keep the windows closed during winter.

The Sherbrooke site, which constitutes the second site of measurement envisaged for this project for which measuring was started in the Winter of 2004 and will end the Winter of 2005, cannot be directly compared to the site "Calixa-Lavallée" because at the Sherbrooke site, the heating distribution system is different: we are speaking of finned-tube baseboard and not cast-iron radiators.

In an other order of thought, at the time of installation at Centre Calixa-Lavallée, the possibility of painting the reflectors was discussed. The goal of this operation would be to blend them in to the décor. The manufacturer of the reflector panels mention that they can be painted. In first thought, the painting of the panels would reduce their reflecting effect enormously. However, if it is discovered that the insulating effect of the panels attain and are linked in large part to the energy savings, because of the vapor barrier between the wall and the reflector panel and not because of the reflective surface, then painting the panels would not greatly reduce the energy savings potential.

In the case where a supplementary site is added to the project, this point in particular can be verified by painting one panel following the completion of the measurements and observing the incurred effect on the temperature of the wall behind the panel. An increase in the temperature of the wall would signify that the reflector panels should not be painted.

APPENDIX 1

Appendix 1 – Average Data

BEFORE PANELS

Average data for the period	Temperature of the water entering the radiator	Room Temperature	Difference of radiator temperature	Sum of the $DT_{radiator}$ for the period	Exterior Temperature	Degree Days
	$T_{entering\ radiator}$ ˚C	T_{room} ˚C	$(T_{entering\ radiator} - T_{leaving\ radiator}) = DT_{radiator}$ ˚C	˚C	T exterior ˚C	HDD
03/02/2004	48.84	16.94	1.10	115.92	-5.60	23.60
04/02/2004	48.97	19.23	1.09	92.32	-4.30	22.30
08/02/2004	60.47	23.09	1.12	111.36	-12.20	30.20
09/02/2004	47.46	19.32	1.02	68.12	-3.80	21.80
10/02/2004	43.88	17.52	1.01	65.96	-1.00	19.00
13/02/2004	50.19	18.87	0.99	73.20	-5.90	23.90
28 to 26 January + 22 January + 2 to 16 February	54.82	20.48	1.11	2074.56	-10.77	546.60

AFTER PANELS

Average data for the period	Temperature of the water entering the radiator	Room Temperature	Difference of radiator temperature	Sum of the $DT_{radiator}$ for the period	Exterior Temperature	Degree Days
	$T_{entering\ radiator}$ ˚C	T_{room} ˚C	$(T_{entering\ radiator} - T_{leaving\ radiator}) = DT_{radiator}$ ˚C	˚C	T exterior ˚C	HDD
08/03/2004	46.25	19.32	0.99	62.60	-1.70	19.70
09/03/2004	46.42	19.13	0.96	64.60	-2.70	20.70
12/03/2004	42.27	20.17	0.89	41.04	-0.40	18.40
14/03/2004	48.08	21.64	0.93	53.28	-3.90	21.90
15/03/2004	43.53	20.57	0.87	40.04	-0.40	18.40
17/03/2004	49.84	17.10	1.09	91.32	-6.00	24.00
18/03/2004	50.07	17.81	1.04	75.04	-5.80	23.80
19/03/2004	47.16	18.69	1.00	58.88	-3.40	21.40
21/03/2004	46.82	21.57	0.97	56.16	-4.30	22.30
22/03/2004	57.80	24.89	1.03	93.44	-12.40	30.40
5 to 24 March	46.85	20.78	0.97	1174.72	-3.15	423.00

APPENDIX 2

Appendix 2 – Survey on the comfort of the occupants: questionnaire

QUESTIONNAIRE:

COMFORT OF THE OCCUPANTS

Site 1: Centre Calixa-Lavallée, Montréal

1.0 SITUATION *BEFORE* THE INSTALLATION OF THE REFLECTOR PANELS:

1. In a direct way, say that you are or are not comfortable in the winter in your place of work?

   Yes No

If No:

2. To what do you attribute your discomfort? (You can check more than one)

   Too Hot Puffs of heat

   Bad distribution of heat in rooms

   Too Cold Air Currents

2.0 SITUATION *AFTER* THE INSTALLATION OF THE REFLECTOR PANELS:

1. Since the installation of the reflector panels have you noticed a difference in the heating level and in you comfort?

   Yes No

If Yes:

2. Which?

   Warmer Other: _____

   Colder

3. Do you have control over the level of heating in your work place? (eg: thermostat, valve,…)?

   Yes No

If Yes:

a. Have you made an adjustment to the temperature since the installation of the panels?

   Yes No

If No:

b. Have you taken actions to receive more or less heat (eg: open windows)?

   Yes No

   If Yes:

   What are these actions? _____