THERMOSTATIC RADIATOR VALVE (TRV) DEMONSTRATION PROJECT

NEW YORK STATE ENERGY RESEARCH AND DEVELOPMENT AUTHORITY

The New York State Energy Research and Development Authority (NYSERDA) is a public benefit corporation created in 1975 by the New York State Legislature. F. William Valentino is President and Chief Operating Officer.

NYSERDA's primary mission is to carry out a broad program of energy research, development and demonstration projects designed to develop and apply efficient technologies to help ensure that New York has secure and economical future supplies of energy, while protecting environmental values and promoting economic growth.

NYSERDA derives its basic research revenues from an assessment levied on the intrastate sales of New York State's investor-owned electric and gas utilities. Additional research dollars come from limited corporate funds and a voluntary annual contribution by the New York Power Authority.

In its research program, NYSERDA stresses consultation and collaboration with other organizations, including utilities, universities, industries, private engineering and scientific research firms, local governments, and State and federal agencies. These efforts stretch NYSERDA's limited research funds and ensure the involvement of those who can use the results of the research.

In its federally funded Energy Services program, NYSERDA provides technical assistance to improve the energy and environmental performance of businesses and institutions, helps secure energy-project funding from private and public sources, and converts fleet vehicles to alternative fuels. The Energy Analysis program focuses on using energy, regulatory, and environmental policies to help New York State businesses grow and to meet the needs of New York State's energy consumers.

NYSERDA also has responsibility for:

- Managing the 3,300-acre Western New York Nuclear Service Center at West Valley 35 miles south of Buffalo, the site of a former commercial nuclear fuel reprocessing plant and a low-level radioactive waste disposal area. These responsibilities include:

  — Participating in the West Valley Demonstration Project, a joint federal/State effort to solidify the high-level radioactive wastes left over from the reprocessing operation and to clean up the facilities used.

  — Maintaining the portion of the site not being used in the Demonstration Project, including the shut-down low-level radioactive waste disposal area.

- Issuing tax-exempt bonds to finance facilities for electric and gas utilities and energy projects for private companies.

- Constructing and operating facilities for disposal of low-level radioactive wastes produced in New York State, once the State makes disposal method and site decisions and approvals have been issued by State regulatory agencies.

- Managing a 365-acre portion of a Superfund clean-up site in Malta, 20 miles north of Albany. Part of the site was once owned by the federal government. Portions of it have been used by the federal government and its contractors since the 1940s for activities that have included rocket engine and fuel testing, weapons testing, and space research.

For more information, contact the Technical Communications unit, NYSERDA, 2 Empire State Plaza, Suite 1901, Albany, New York 12223-1253, (518) 465-6251.

New York State
Energy Research and Development Authority
Two Empire State Plaza, Suite 1901 • Albany, New York 12223-1253
(518) 465-6251 Fax: (518) 432-9474

A NYSERDA Report in Brief

Report: **Thermostatic Radiator Valve (TRV) Demonstration Project**
Report No. 95-14

Project Manager: **Norine H. Karins**

Contractor: **EME Group, New York, New York**

Background: This report describes the results of a multiyear research project that investigated the energy savings attributable to thermostatic radiator valves (TRVs) installed on one-pipe steam distribution systems. The experiment involved the installation of TRVs in eight New York City multifamily buildings ranging in size from 15 to 26 apartments. .The buildings were monitored for three years.

Objectives: The project had three objectives: to determine whether fuel consumption was lower in buildings using TRVs; to determine if occupants would accept TRVs; and to determine if apartment overheating could be eliminated using TRVs.

R&D Results: U.S. Energy Control Fuel computers recorded apartment and outdoor temperatures, boiler fuel and domestic hot water (DHW) consumption, incoming City water and DHW supply temperatures, boiler make-up water flow, and boiler flue-gas temperatures, in eight low- and middle-income multifamily buildings. The project included three sets of two buildings: two pairs in Brooklyn, and one pair in Manhattan. Two similarly constructed Bronx apartment buildings also were monitored.

Each building owner was required to upgrade the heating plants and maintain the systems in good operating condition throughout the three-year project. Following the installation of these measures, the buildings' fuel consumption, DHW use, and apartment temperatures were recorded for 12 months to record baseline consumption. TRVs were installed in two phases. In the first phase, four buildings were equipped with TRVs with a 72°F setpoint in half the apartments. In the second phase, three buildings were equipped with TRVs in the remaining apartments and a fifth building was equipped with TRVs in half the apartments.

The average room temperature of an overheated apartment using TRVs was reduced, and the buildings' space heating energy use decreased an average 9.45% with partial installation. Space- heating energy use decreased an average of 15.5% with full installation. The higher the average apartment temperature before TRV installation, the greater the energy savings. In addition, if an apartment's average winter temperature was already maintained at 72°F by the existing boiler control system, there were no energy savings. Simple payback averaged 3.1 years based on an installed price of $50 per TRV.

Copies Available: A limited number of copies of the full report are available from the New York State Energy Research and Development Authority, 2 Empire State Plaza, Suite 1901, Albany, New York 12223-1253; (518) 465-6251, ext. 241.

THERMOSTATIC RADIATOR VALVE (TRV) DEMONSTRATION PROJECT

Final Report

Prepared for

THE NEW YORK STATE
ENERGY RESEARCH AND DEVELOPMENT AUTHORITY

Project Manager
Norine Karins

Prepared by

EME GROUP
135 Fifth Avenue
New York, NY 10010

Project Manager
Michael McNamara

1545-EEED-BES-91

NYSERDA
Report 95-14

September 1995

NOTICE

DISCLAIMER

ABSTRACT

This research measured the energy savings associated with installing thermostatic radiator valves (TRVs) on one-pipe low-pressure steam systems in New York City multifamily buildings. There were three primary objectives: to determine whether fuel consumption was lower in buildings using TRVs; to determine if occupants would accept the TRVs; and to determine if overheating in apartments could be eliminated using TRVs.

Eight buildings, ranging in size from 15 to 26 apartments, were monitored for three years. Each building was audited to determine fuel history and quick-payback energy conservation measures. The project covered three phases; phase-1 consisted of installing low-cost energy conservation measures such as pipe insulation, air vents and burner tune-ups; determining each building's baseline energy use; and recording baseline apartment temperatures. TRV installations occurred in phases 2 and 3. In phase-2, TRVs were installed in half the apartments in four buildings. In phase-3, TRVs were installed in the remainder of the apartments.

Experimental results were conclusive. Buildings with overheated apartments achieved energy savings through the installation of TRVs. Our research shows an average reduction of 9.45% in space heating energy use occurred with partial installation of TRVs, and savings of 15.5% were achieved after full installation. Buildings with the highest average apartment temperatures during the base year showed the greatest energy savings. Simple payback, based on an installed price of $50 per TRV, averaged 3.1 years.

Keywords:
steam heating
thermostatic radiator valves
multifamily heating systems
one-pipe steam

TABLE OF CONTENTS

Section	Page
SUMMARY	S-1
1. INTRODUCTION	1-1
Research Objectives	1-1
Experimental Design	1-1
2. RESEARCH DESIGN	2-1
Building Selection	2-1
Building Audits and Improvements	2-3
Boiler Monitoring and Control Equipment	2-3
Data Collection	2-4
TRV Installation	2-6
3. ANALYSIS OF RESULTS	3-1
Cost/Benefit Analysis of Pre-TRV Retrofit Energy Conservation Measures	3-1
Apartment Temperature Findings	3-2
Energy Savings from TRV Installation	3-4
Cost/Benefit Analysis of TRV Installation	3-5
4. EQUIPMENT OPERATING PERFORMANCE AND CHARACTERISTICS	4-1
Steam Distribution System - Purpose of the Air Vent	4-1
Functions of a TRV	4-3
TRV Performance	4-4
Monitoring Equipment Performance	4-4
Occupant and Building Staff Responses to TRVs	4-4
5. CONCLUSIONS AND RECOMMENDATIONS	5-1
When Does It Make Sense to Install TRVs	5-1
How To Install TRVs	5-1
APPENDIX	
A. Site Audits	A.1

LIST OF TABLES

Table		Page
2-1	Building Characteristics	2-2
2-2	Heating Plant Characteristics	2-2
2-3	TRV Installation	2-3
3-1	Summary of Building Improvements	3-1
3-2	Average Apartment Temperatures During Heating Season	3-2
3-3	Summary of Monthly Average Apartment Temperatures During Heating Season	3-3
3-4	DHW Use and Energy Consumption	3-4
3-5	Savings in Annual Heating Energy Using TRVs	3-5
3-6	Cost Benefit Analysis of TRV Installations	3-5

LISTS OF FIGURES

2-1	The DMC Monitoring System	2-4
4-1	Components of a Float Diaphragm Air Vent	4-2
4-2	Components of a Danfoss-Type TRV	4-3

SUMMARY

Space heating in multifamily buildings with low pressure steam boilers is often controlled with a central indirect monitoring control (IMC) system that uses an outdoor temperature sensor and time clock. IMC systems operate on a limited number of inputs and will overheat apartments if not properly calibrated and adjusted, leading to the classic open-window syndrome often seen in the winter months in New York City. Thermostatic Radiator Valves (TRVs) have been used to control steam flow in radiators for decades; however, most steam-heated multifamily buildings in New York City are not outfitted with TRVs.

This three year research project investigated the use of TRVs on one-pipe low pressure steam systems. The project determined TRVs effectiveness in eliminating overheated apartments, resultant energy savings, and cost effectiveness. EME also assessed occupant reception to TRVs and identified pitfalls in their installation and maintenance. US Energy Control Fuel computers recorded apartment temperatures, boiler fuel consumption and hot water use in eight low- and middle- income buildings ranging in size from 15 to 26 units. Three sets of twin buildings were monitored: two pairs in Brooklyn, and one pair in Manhattan. Another two buildings monitored in the Bronx, although not twins, were similar in construction and located near each other. The data were collected and stored by the fuel computer hourly and downloaded through a modem to EME's office.

To participate in the project, each building owner had to upgrade the heating plants and maintain them in good condition throughout the three-year project. Upgrades included insulating bare steam pipes, tuning burners, making minor repairs to the steam distribution system, and replacing inoperative or undersized air vents on radiators and steam mains. After installing these measures, the building's fuel consumption, domestic hot water use and apartment temperatures were recorded for 12 months. This became the base year for comparing TRV energy savings.

The research project encompasses three phases. Phase-1 determined each building's base year energy use after the installation of low-cost energy conservation measures. In phase-2 four buildings were outfitted with TRVs with a 72°F setpoint in half of the apartments ("partial installation"). In phase-3, three of the four buildings were outfitted with TRVs in the remaining apartments ("full installation"), and a fifth building was outfitted with TRVs in half of the apartments.

The average room temperature of an overheated apartment using TRVs was reduced, and the building's space heating energy use decreased an average of 9.45% with partial installation and 15.5% with full installation. The higher the average apartment temperature before TRV installation, the greater the energy savings. This research showed that if an apartment's average winter temperature was already

maintained at 72°F by the existing boiler control system no energy savings would be achieved through the installation of TRVs.

During the two years the TRV apartments were monitored, there were only a few complaints. Most occurred during phase-2, and came from tenants accustomed to average room temperatures ranging from 74°F to 78°F before TRV installation. The TRVs had no mechanical problems. The main problem, as in most steam systems, occurred with wet steam distorting air vents. This occurred in one building and was repaired by attaching a different manufacturer's air vent to the TRV.

Many factors influence a multifamily building's energy use, including the condition of the boiler and burner, upkeep and maintenance of the boiler and steam distribution system, and the building's DHW load. The researchers conclude that TRVs are a cost effective energy conservation measure, and that comfortable room temperatures and reduced fuel use are achievable when properly installed.

Section 1
INTRODUCTION

RESEARCH OBJECTIVES

This research was undertaken by the New York State Energy Research and Development Authority to investigate using TRVs on one-pipe low pressure steam systems to prevent apartments from overheating. Research objectives included determining whether TRVs can prevent overheated apartments without compromising occupant comfort; determining if energy savings can justify TRV installation; and determining if TRVs are reliable.

EXPERIMENTAL DESIGN

The research took three years. A fuel computer, fuel oil and water meters, and temperature sensors (RTDs) were installed in eight buildings to monitor the heating and domestic hot water (DHW) systems. These data were collected and stored by the monitoring system hourly and down-loaded via modem to EME's office every third day.

Data collected from the fuel computer included:

- Fuel consumption (gallons of oil or therms of natural gas);
- Outdoor temperature (°F);
- Apartment temperature (°F);
- Boiler run-time (hours/minutes);
- Boiler flue gas temperature (°F);
- DHW consumption (gallons);
- DHW supply temperature (°F);
- Incoming city water temperature (°F); and
- Boiler make-up water flow (gallons).

Each owner was first required to upgrade the building's heating plant to an efficient system. Owners had to insulate bare steam piping, repair leaks in the steam distribution system, and tune the burner. After implementing these measures, the building's fuel consumption, DHW use and apartment temperatures were recorded for 12 months. These data were used as the base-line to determine the effects of TRVs. Throughout the project, periodic steady state efficiency tests were done by EME to ensure that building owners maintained heating plants in good condition.

The experiment had three phases:

- Phase-1: Base year;
- Phase-2: Partial TRV Implementation; and
- Phase-3: Full TRV Implementation.

After recording energy consumption for winter 1991, TRVs were installed in half the apartment units in four buildings. TRV locations were selected based on these criteria:

- South-facing apartments with solar gain;
- Chronically overheated apartments; and
- Top floor apartments.

EME held an evening workshop at each building to explain the TRV program. These workshops were well received by the tenants and helped them accept TRVs.

TRVs were partially installed during July and August, 1992. Quality control of monitoring and metering equipment was maintained through bi-monthly inspections. Remote monitoring of each building's heating plant provided additional quality control; data were downloaded every third day and reviewed for anomalies, so EME could immediately respond to malfunctions in monitoring or metering equipment.

Section 2

RESEARCH DESIGN

BUILDING SELECTION

Names and addresses of multifamily building owners and management firms were solicited from a number of sources, including advertisements such as "NY Habitat" and "New York Cooperator", New York City based multifamily building publications; EME's contacts with building owners; and US Energy Controls Inc., the manufacturer of the fuel computer.

The experiment required eight privately owned multifamily buildings. All buildings were to be approximately the same size with similar fuel use and occupancy levels. Other selection criteria included:

- One-pipe low pressure steam distribution system
- Boiler equipment in good operating order
- Building envelope in good condition
- Even steam distribution
- Absence of water hammer and wet steam

The project required building owners to make all necessary low cost improvements to their heating plants; to maintain the heating plants in good condition during the three-year study; and to allow EME to monitor energy consumption for three years. As an incentive for participating in the experiment, the building owner would keep all monitoring equipment and TRVs. This monitoring equipment had an estimated value of $15,000 per building.

More than twenty building owners and management agents were interested in participating; however, many of the buildings did not meet all of the criteria. Twelve buildings were eventually selected to be inspected and eight were chosen for participation.

Table 2-1 on the following page summarizes the characteristics of each building.

Table 2-1. BUILDING CHARACTERISTICS

Building	No. of Apartments	No. of Occupants	No. of Stories	Building Pairing *	Fuel Type	Location
1710	23	36	4	A	#2 oil**	Brooklyn
1722	25	48	4	A	#2 oil**	Brooklyn
256	25	81	5	B	#2 oil	Brooklyn
260	25	80	5	B	#2 oil	Brooklyn
123	15	18	5	C	gas	Manhattan
125	15	19	5	C	gas	Manhattan
173	20	84	5	D	#4 oil	Bronx
3044	26	68	5	D	gas	Bronx

* Building pairing refers to the adjacent similar building used for comparison. The buildings in pair D were not immediately adjacent or "twin" buildings.

** Changed to dual-fuel boiler after phase-2.

The boiler capacity, fuel type, steam distribution system, and installed radiation load for the eight buildings are summarized in Table 2-2.

Table 2-2. HEATING PLANT CHARACTERISTICS

Building	Boiler (hp)	Boiler hp per Apt.	Radiation EDR (sq.ft.)	EDR/Apt. (sq.ft.)	No. of Radiators	No. of Rad/Apt.
1710	40	1.74	1,494	65	52	2.3
1722	44	1.76	1,515	61	60	2.4
256	40	1.60	1,443	58	72	2.9
260	40	1.60	1,859	74	72	2.9
123	22	1.47	1,097	73	40	2.7
125	22	1.47	1,185	79	40	2.7
173	50	2.50	1,485	74	50	2.5
3044	50	1.92	2,092	80	60	2.3
Average		1.8		71		2.6
Standard Deviation		0.337		8.2		0.25

BUILDING AUDITS AND IMPROVEMENTS

A detailed energy audit was performed to determine minor improvements that would make the buildings equally energy efficient, using these data:

- One to three years of historic fuel bills;
- Condition of steam and DHW piping and insulation;
- Condition of radiators;
- Condition and combustion efficiency of the boiler/burner;
- Condition and settings of the control system;
- Inventory of hot water fixtures and occupancy of apartments;
- Inventory of washing machines and dishwashers;
- Condition and contents of fuel tank;
- Envelope measurements to calculate heat loss; and
- Condition of windows and doors.

These data were used to develop each building's baseline fuel use before monitoring. A heat loss calculation estimated the degree of overheating by comparing installed radiation with calculated values.

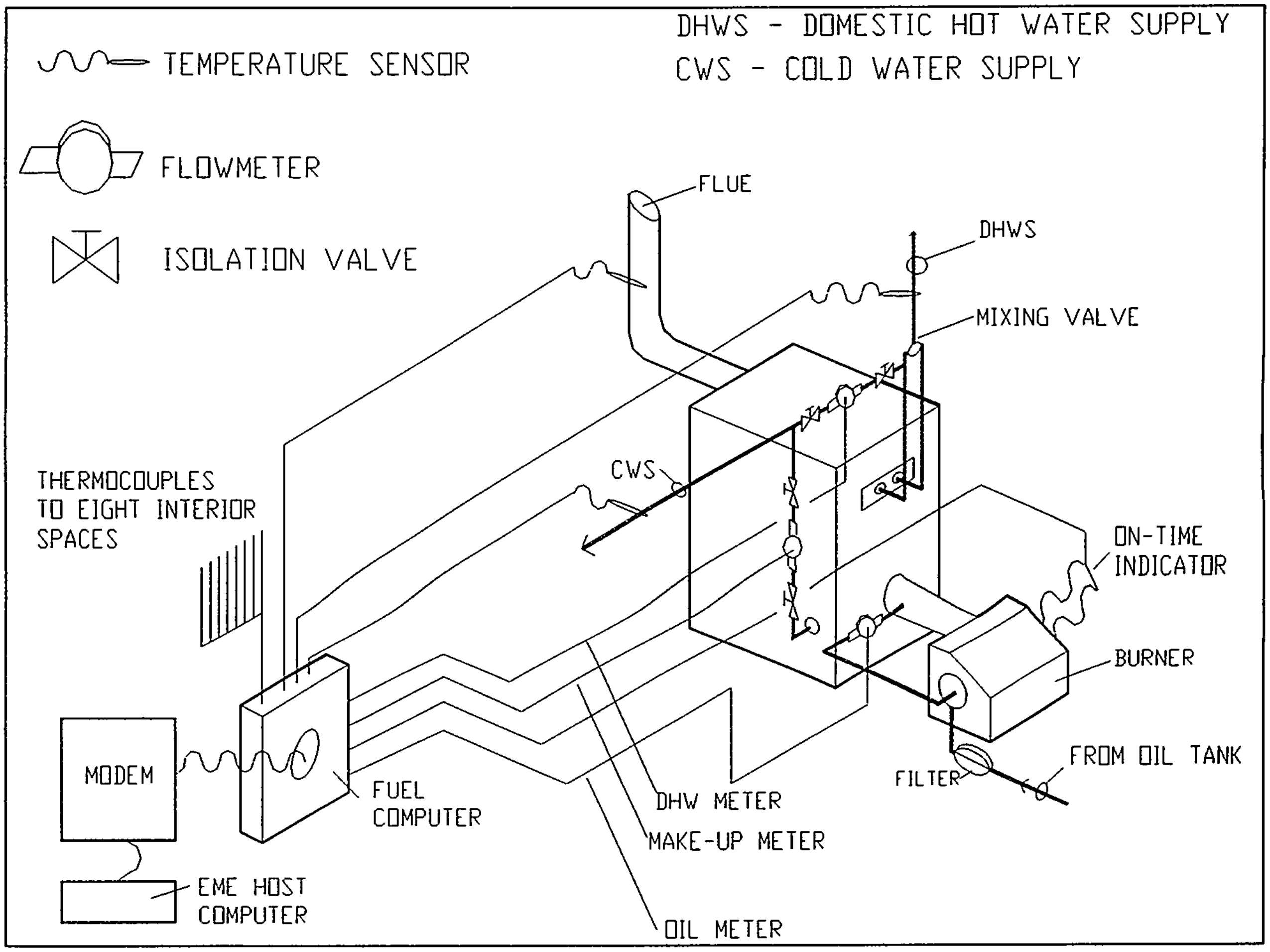
Building improvements included quick payback items such as pipe insulation, burner tunings, radiator repairs, and leaking air vent replacement. All the audited buildings required some of these measures. Original building audits are included in Appendix A.

BOILER MONITORING AND CONTROL EQUIPMENT

Heating plants in most multifamily buildings in New York City are controlled by an indirect monitoring control (IMC) system that monitors outside temperature in conjunction with boiler steam pressure or condensate return temperature. This equipment is tailored to meet the New York City Multiple Dwelling Law requirement which mandates a daytime indoor temperature of 68°F when the outside temperature drops below 55°F, and a nighttime indoor temperature of 55°F when the outside temperature drops below 40°F. Most IMC equipment in the New York City metropolitan area is manufactured by Heat-Timer; other manufacturers include Fuel Watchman and American Steam Timer.

More than a decade ago direct monitoring control (DMC) systems were introduced to multifamily building owners as an alternative to IMC. DMC provides full monitoring and boiler system control and presents, in a report format, specific operating data on the heating system. This project used DMC equipment manufactured by US Energy Controls, called the Fuel Computer. Although the Fuel Computer is designed to control and monitor the heating plant, in this experiment the Fuel Computer was used only to monitor the equipment; the boilers were controlled through existing IMC equipment.

FIGURE 2-1 THE DMC MONITORING SYSTEM.



DATA COLLECTION

The monitoring system included a modem and central processing unit that recorded data from eight apartment temperature sensors, boiler aquastat for hot water temperature, flue gas temperature probe, DHW meter, cold water temperature probe, hot water temperature probe, and boiler make-up water meter.

The US Energy fuel computer, a microprocessor based system, monitors apartment temperatures, and stores, on an hourly basis, the high, low, and average apartment temperatures using these inputs:

- pulse inputs from three of the meters (fuel oil or gas, DHW meter, and make-up water);
- RTD temperature sensors mounted in 8 apartments;
- 2 RTDs for the DHW output and cold water input temperatures;
- 1 high temperature RTD for recording stack temperature;
- 1 outdoor air temperature RTD;
- 1 burner on-time input; and
- 1 boiler aquastat input.

The fuel computers and apartment temperature sensors were installed by US Energy as part of their cofunding contribution. Bidding and installation of data collection and monitoring equipment was based on EME's specifications. The successful bidder was a licensed plumber with experience in multifamily building heating systems. Gas-heated buildings had their main gas meters equipped with a pulse output by Con Edison and Brooklyn Union Gas. Using the pulse output from the gas meter eliminated the need to install a separate gas meter installation, significantly reducing the price of the monitoring system.

DHW gallons consumption, and DHW supply and cold water inlet temperatures were measured. Space heating energy use was determined by subtracting DHW energy (corrected for boiler efficiency) from total energy use. Boiler make-up water was measured to ensure that no boiler had excessive leakage; none did. Outdoor air temperature was measured to compute heating degree days to normalize fuel consumption.

The original experiment called for installing TRVs that were fixed to maintain a room temperature of 72°F on all the radiators in half the apartments during phase-2. TRVs were to be installed on the radiators in the remaining apartments during phase-2. In buildings 1710 and 1722, however, phase-3 was revised because the owner replaced the oil-fired burner with a new dual-fuel unit after phase-1. It was, therefore, decided to install the remaining TRVs in this building's companion building and measure the change in apartment temperatures and building energy consumption in a pre- versus post- TRV test (as seen in Table 3-4).

Another modification was made in the experimental design in building 3044. After implementing phase-2 there was no change in the average apartment temperature and no energy savings, because this building's average apartment temperature was 73°F during phase-1 and appeared well balanced in terms of even steam distribution. TRVs that allowed tenants to manually lower the temperature setpoint were installed in this building.

Energy consumption in each building was computed based on metered data and compared to actual fuel and gas use records for each phase in the project: (phase-1) base-year, (phase-2) 50% TRVs, and (phase-3) 100% TRVs. Fuel consumption data were corrected for DHW fuel consumption and normalized for weather and the number of apartments for comparison. Annual energy savings, cost savings and simple paybacks were computed based on a natural gas cost of $0.70 per therm and $50 for each installed TRV.

TRV INSTALLATION

During phase-2, TRVs were installed on radiators in rooms with excessive solar gain; on radiators in top floor apartments; on radiators where apartment temperature sensors were located; and on radiators in apartments identified as overheated. In phase-3, TRVs were installed in the remainder of apartments in the buildings. Table 2-3 summarizes the number of TRVs installed in phase-2 and phase-3. Note that full installation of TRVs was not possible in building 1710 due to a major change in its heating plant and resulting experimental design modification. TRVs were subsequently installed in its sister building, building 1722, in half the apartments.

TABLE 2-3. TRV INSTALLATION

Building	No. of Apts.	Total TRVs Phase-2	Total TRVs Phase-3
1710	23	26	26
1722	25	0	26
260	25	36	72
125	15	20	40
3044	26	30	60
Total:	NA	112	224

One hundred ninety-four Danfoss type RAE 2000 PPS TRV packaged units were purchased in bulk directly from the factory for $35 each in late 1991. A second purchase of 30 identical units was made two years later from a local distributor for $46.50 each. The packaged units came unassembled and included one 1-PS valve, one air vent and one built-in sensor. The units were assembled in-house, taking about five minutes per TRV to assemble.

The original experimental design called for a licensed plumber to install the TRVs; however, after assembling the unit it was apparent research technicians working with building superintendents could do the installations without a licensed plumber.

Section 3

ANALYSIS OF RESULTS

COST/BENEFIT ANALYSIS OF PHASE-1 RETROFITS
ENERGY CONSERVATION MEASURES

The computed energy savings associated with the selected energy conservation measures were based on standard engineering savings analysis. Energy conservation measures included improving burner efficiency, insulating bare steam and hot water pipes, replacing inoperative radiator and steam main air vents, and reducing DHW supply temperature. Table 3-1 summarizes the items identified in each building, estimated cost, computed savings, savings measured in terms of reduced fuel consumption, and simple economic payback based on the first year's measured energy savings.

Table 3-1. SUMMARY OF BUILDING IMPROVEMENTS

Bldg.	Fuel	Description of Measure	Cost ($)	Computed Savings (MMBtu)	Measured Savings (MMBtu)	Measured Payback (Yrs.)
1710	#2 oil, then gas	Tune burner, replace leaking radiator vents, steam main vents and insulate bare piping.	1,000	206	134	1.4
1722	#2 oil, then gas	Tune burner, replace leaking radiator vents, steam main vents and insulate bare piping.	1,100	147	290	0.7
256*	#2 oil	Tune burner, clean boiler, replace leaking radiator vents, insulate bare piping, and reduce DHW supply temperature.	1,400	414	0	∞
260	#2 oil	Tune burner, clean boiler, repitch radiators, replace radiator vents, insulate bare piping,	850	239	43	3.7
123	gas	Replace radiator vents, insulate bare piping, repair leaking valve.	930	43	64	2.0
125	gas	Replace radiator vents, insulate bare piping.	1,650	165	158	1.5
173	#4 oil	Tune burner, clean boiler, replace radiator vents, insulate bare piping,	1,500	210	86	5.1
3044	gas	Replace radiator vents, reduce DHW supply temperature.	150	57	96	0.2

* Six apartments in building 256 underwent major renovations so that pre- versus post- energy conservation results were not directly comparable and most likely contributed to the lack of energy savings.

Buildings where savings were much less than expected all had oil-fired boilers. This may be attributed to gas burning cleaner than oil .

APARTMENT TEMPERATURE FINDINGS

A building's average apartment temperature was computed based on installing hard-wired RTD sensors in eight apartments, representing 30 to 50% of the apartments in each building in this experiment. The sensors were installed by US Energy Controls Inc. and located five feet above floor level in either a living room or bedroom, away from any windows, radiators or risers.

The sensors recorded the apartment's temperature on a real-time basis. Every hour the maximum, minimum, and average temperature for the hour would be recorded and stored in the fuel computer. An average temperature was computed for each day and used in the analysis. Tables 3-2 and 3-3 summarizes monthly average apartment temperatures.

Table 3-2: AVERAGE APARTMENT TEMPERATURE (°F) DURING HEATING SEASON

		Nov.			Dec.			Jan.			Feb.			Mar			Apr.	
Bldg.	'91	'92	'93	'91	'92	'93	'91	'92	'93	'91	'92	'93	'91	'92	'93	'91	'92	'93
1710	73	73	74	75	72	73	77	73	73	75	73	73	75	74	74	76	74	74
1722	75	73	72	76	72	71	76	73	74	75	73	72	76	74	73	73	72	73
260	76	73	74	76	72	73	76	72	73	74	73	74	76	73	74	75	72	71
256	76	75	76	78	76	76	77	76	77	74	77	77	78	75	76	75	73	72
125	78	74	73	76	74	72	77	74	73	74	75	74	75	75	76	74	73	74
123	77	75	75	75	76	78	76	77	78	75	77	77	75	77	78	76	73	76
3044	73	71	72	72	71	72	73	71	72	73	72	72	72	72	72	72	72	73
173	76	76	75	76	74	78	75	73	77	74	74	75	76	72	76	76	73	75

Note: Shading indicates TRV buildings

Table 3-3. SUMMARY OF MONTHLY AVERAGE APARTMENT TEMPERATURES (°F) DURING HEATING SEASON

Phase -1 = Baseline year = 1991-1992 heating season
Phase -2 = 1992-1993 heating season
Phase -3 = 1993-1994 heating season

	Average	Apt.	Temp.	Temperature	Drop
Address	Phase-1	Phase-2	Phase-3	Phase-2:1	Phase-3:1
1710	75	73	73*	2	2*
1722	75	73*	72*	2*	3*
260	76	73	73	3	3
256	76	75	76	1	0
125	76	74	74	2	2
123	76	76	77	0	-1
3044	73	72	72	1	1
179	75	74	76	1	0

Note: Shading indicates TRV buildings. TRVs were not installed in buildings 256, 123, and 179.

Phase-1 corresponds to baseline (pre-TRV installation) data taken during the 1991-1992 heating season. For buildings 1710, 260, 125, and 3044, phase-2 corresponds to installation of TRVs in half the apartments. As noted previously, building 1710 did not have a full TRV installation and building 1722, originally a control building, had TRVs installed in phase-3. These temperatures cannot be directly compared with the others in its phase and are therefore marked with an asterisk (*). Refer to table 2-3 for TRV installation information.

Table 3-3 shows that overheating was reduced in all buildings where TRVs were installed except for building 3044. All control group buildings remained significantly overheated.

ENERGY SAVINGS FROM TRV INSTALLATION

Energy savings were calculated using differences in space heating energy use for each TRV building. Fuel use for space heating was isolated from total energy use using metered DHW data due to uncertainty about variations in DHW consumption.

DHW in each building is generated by a combination space-heating boiler and tankless coil system. Combination low-pressure steam boilers and tankless coils are the predominant means of supplying space heat and DHW in multifamily buildings in New York City. DHW use can represent a significant percentage of total energy consumption in a multifamily building, ranging from 15 to more than 50 percent of annual fuel use. Since TRVs affect only space heating energy use, it is essential to extract DHW energy use from each building's total fuel use. Table 3-4 lists DHW energy consumption for the eight buildings.

Table 3-4: DHW USE AND ENERGY CONSUMPTION

Building	No. of Units	Measured Average* Gal/Day-Apt	ASHRAE Standard Gal/Day-Apt	Annual DHW Energy Consumption as a Percent of Total Energy Use		
				Phase-1	Phase-2	Phase-3
1710	23	65	40	30.1	30.1	22.8
1722	25	102	40	34.1	39.5	34.5
256	25	124	40	56.2	57.3	51.2
260	25	147	40	59.5	61.0	52.9
123	15	27	42	25.3	14.5	14.6
125	15	59	42	16.5	17.3	22.2
173	20	160	42	24.5	26.2	30.1
3044	26	139	40	44.7	44.5	43.1
Average	21.8	102.9	40.8	36.4	36.4	33.9
Std. Dev.		44.8		14.6	16.2	13.2

* Compared with an average 111 gal/apt./day measured in multifamily buildings in New York City in a previous NYSERDA study conducted by EME Group.

Table 3-5 lists the energy savings achieved with TRV installation. The largest energy savings occurred from the partial installation phase. Additional energy savings, averaging 15.5% occurred with complete TRV installation in buildings 260 and 125. These buildings' average temperature with partial TRV installation was still above the desired setpoint of 72°F.

Table 3-5. SAVINGS IN ANNUAL HEATING ENERGY USING TRVs

Building	Energy Consumption BTU/DD-APT			Savings in Annual Heating Use (Percent)	
	Phase-1	Phase-2	Phase-3	Partial	Full
1710	12,872	12,391	NA	3.7	NA
1722	10,361	9,913	NA	4.3	NA
260	8,563	8,047	7,699	6.0	10.1
125	13,756	11,983	10,876	12.9	20.9
3044	14,633	14,694	14,807	-0.4	-1.2
Average*	11,388	10,584	9,288	9.45	15.5
Std. * Deviation	2,369.9	2,009.1	2,246.5	4.2	7.6

* Buildings 1710 and 1722 do not have full data and are not included in the average and standard deviation. Also the average and standard deviation do not include the effects of building 3044

COST/BENEFIT ANALYSIS OF TRV INSTALLATION

The cost/benefit analysis used the difference between normalized base-year space heating energy use and space heating energy use after installing the TRVs. All TRV buildings were heated with natural gas or #2 fuel oil. Since #2 oil and firm service natural gas are similarly priced in New York City, the cost savings analysis is based on $7.00 per MMBtu, the average price of each commodity.

The cost/benefit analysis in Table 3-6 illustrates the payback for the TRVs. Installed cost is based on $50 per unit, since costs for superintendent labor were minimal.

Table 3-6: COST/BENEFIT ANALYSIS OF TRV INSTALLATION

	Partial: Phase-2			Full: Phase-3		
Building	Cost Savings ($)	Installed Cost ($)	Payback (Yrs)	Cost Savings ($)	Installed Cost ($)	Payback (Yrs)
1710	357	1,300	3.6	--	--	--
1722	391	1,300	3.3	--	--	--
260	418	1,800	4.3	769	3,600	4.7
125	810	1,000	1.2	1,518	2,000	1.3
3044	-46	1,500	∞	-160	3,000	∞
Average *	494.0	1,350.0	3.1	1,144	2,800	3.0
Std. * Deviation	212.1	331.7	1.3	529.6	1,131.4	2.4

* The average and standard deviation do not include the effects of building 3044

The payback period for buildings 1710 and 1722 is 3.6 and 3.3 years respectively; in building 260 the payback increases to 4.3 years for partial installation and 4.7 years for full installation. Note that payback time increased only slightly for full TRV implementation compared to partial TRV installation. Also, building 260 had unusually high DHW consumption and energy use which may have increased boiler on-time and reduced relative energy savings, increasing the payback period. Building 125 shows a very short payback period for both partial and full TRV installation. This building had a significant overheating problem (see table 2-2) which was reduced by the TRVs.

Building 3044 showed no savings in energy; therefore, there was no payback for installing TRVs. This building's average temperature before TRV installation was 73°F indicating minimal overheating. In phase-2, TRVs were installed in building 3044 which could be adjusted downward, (i.e. providing a fixed maximum temperature of 72 °F, but capable of being manually adjusted downward to a minimum of 64 °F by the tenants). Phase-2 results, however, did not show apartment temperature reduction. This finding is important. If a building is not overheated, it does not pay to install TRVs.

SECTION 4

EQUIPMENT OPERATING PERFORMANCE AND CHARACTERISTICS

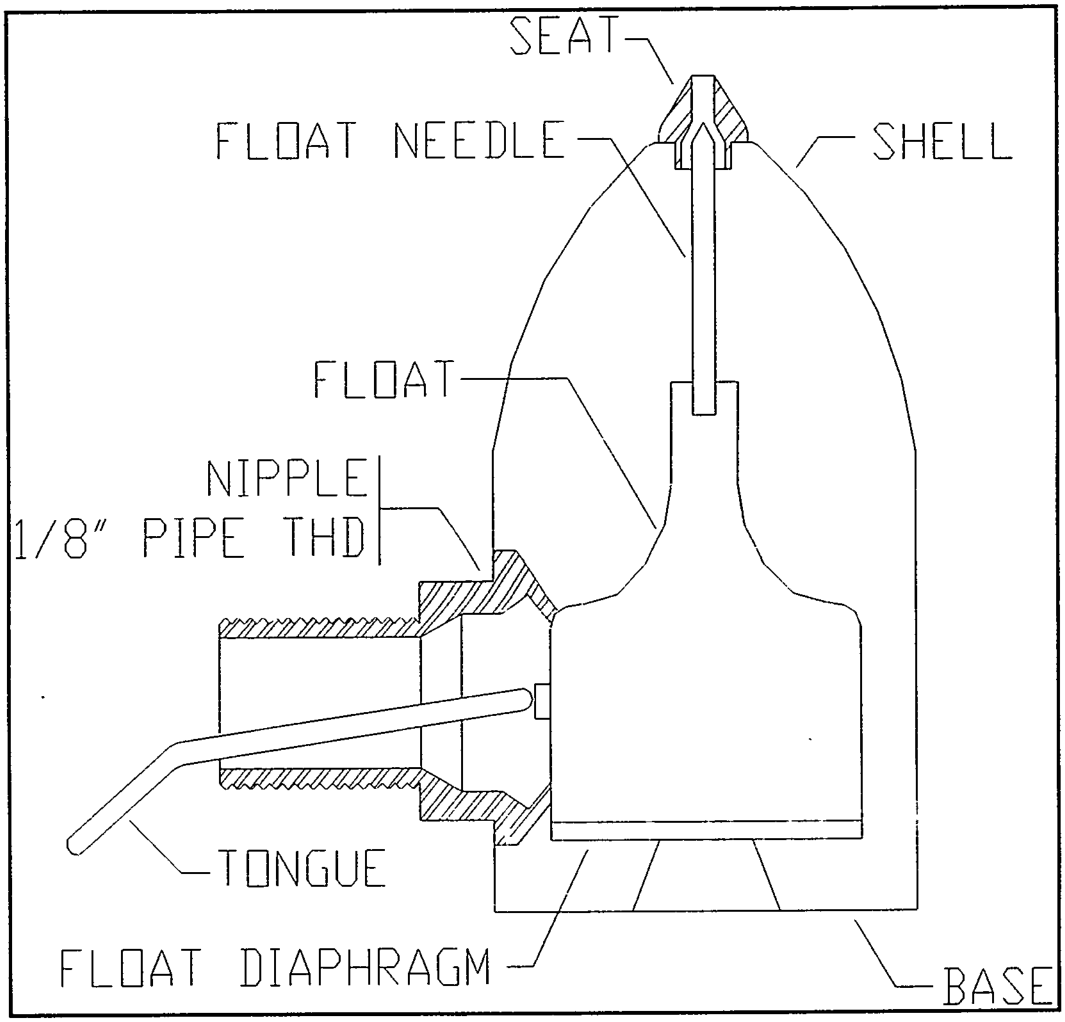
STEAM DISTRIBUTION SYSTEM - PURPOSE OF THE AIR VENT

The most common steam distribution system in multifamily buildings in New York City is the low pressure, one-pipe gravity return system. Other steam distribution systems include one-pipe forced return, two-pipe gravity return, two-pipe forced return, and two-pipe vacuum return. Steam distribution systems are closed-loop systems. The steam generated in the boiler and distributed to the radiators returns in the form of condensate back to the boiler, thereby completing the cycle.

The air vent permits air to enter and leave the steam distribution system as it is pressurized or depressurized. There are two types of air vents, a float diaphragm type and a bi-metallic type. Both permit air to escape so the radiators can fill with steam, close when the radiators fill with steam, and reopen when the radiator pressure drops. Problems occur in steam distribution systems when air becomes trapped in the radiators, preventing the steam from entering.

Since air has limited compressibility, it will displace steam flowing in the pipe. This property of air can control steam flow through radiators. The air vent controls air pressure in the radiator, indirectly regulating the radiator's temperature. A faulty air vent reduces radiator steam flow; a significant number of faulty radiator air vents will create an imbalance steam system. Figure 4-1 illustrates components of a float diaphragm air vent.

Figure 4-1. COMPONENTS OF A FLOAT DIAPHRAGM AIR VENT

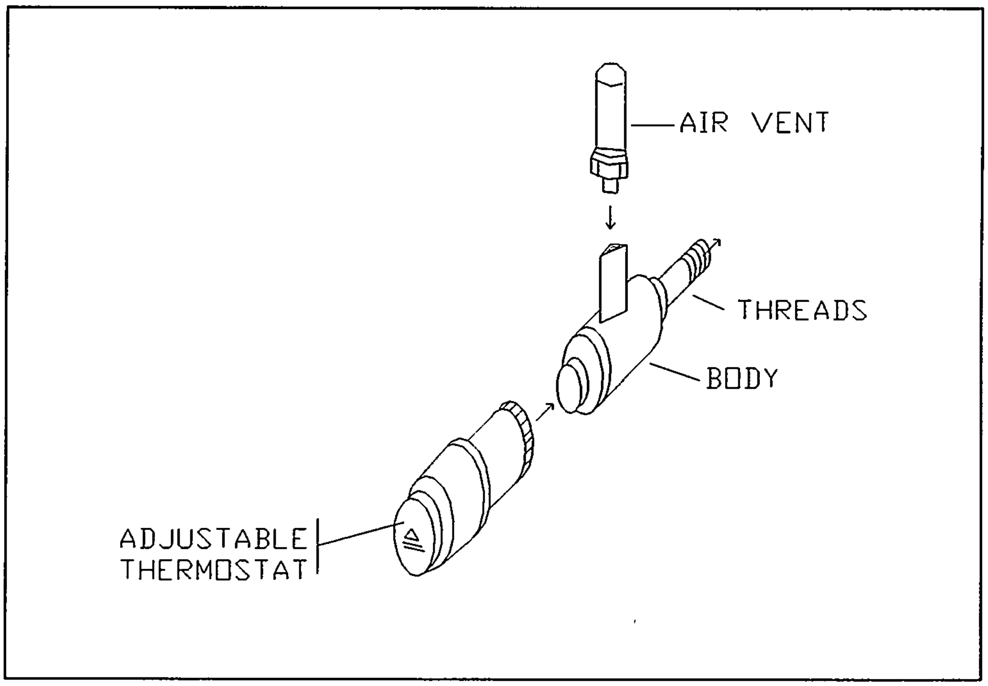


FUNCTIONS OF A TRV

The TRV is a temperature-regulated control valve that functions like an adjustable air vent. A TRV can maintain a lower room temperature by restricting the air flow through the vent during the steaming cycle. A TRV can also maintain a high room temperature by not restricting the air flow from the radiator allowing it to fill with steam quickly. The rate that the air flows through the vent is controlled by the adjustable temperature setting knob, an integral component of the TRV.

TRVs are available with either remote temperature bulbs or unit-mounted temperature bulbs. The remote bulb was installed on recessed radiators; both types were used in this project. Figure 4-2 illustrates the main components of a Danfoss-type TRV.

Figure 4-2. COMPONENTS OF A DANFOSS-TYPE TRV



TRV PERFORMANCE

No major problems were encountered with TRV performance in the two years that were monitored. The TRVs were installed by EME staff and superintendents. A plumber was required to re-thread the vent access port on one radiator because the stem of the air vent snapped off in the radiator while being removed. We had problems with the air vents that were supplied as a package with the TRVs. They would almost all fail immediately if they came into contact with wet steam. We therefore installed Hoffman type #40 air vents on the problem TRVs. This air vent appears to be more rugged and worked well in problem areas.

MONITORING EQUIPMENT PERFORMANCE

At the beginning of the project, the US Energy monitoring equipment performed inadequately. Their standard unit is designed to provide both control and monitoring features. This project required the system to perform monitoring functions only, so significant modifications had to be made to the base system's software. Unfortunately, the modified software had some bugs. The most significant problem was that the software could not total hourly DHW consumption and record the maximum, low and average DHW supply temperatures. When the bugs were fixed the monitoring equipment worked well and continues to provide reliable data three years later.

OCCUPANT AND BUILDING STAFF RESPONSES TO TRVS

The project goals, length of the study, and equipment were presented to tenants in a workshop held in the evening at each TRV building. Snacks were provided to encourage participation. A single-page diagram illustrating the monitoring equipment and meters was given to each tenant. Actual TRVs were passed around so tenants could become familiar with them before they were installed.

Tenant meetings reduced occupant objections to TRV installation. Apartment occupants were familiarized with the project, the project's objectives and equipment. Many tenants in apartments not receiving TRVs were disappointed. As noted earlier in this report, the only problems encountered with tenant satisfaction were in apartments that were usually overheated (to 76° to 78°F) and in apartments where wet steam caused the TRV to malfunction.

SECTION 5

CONCLUSIONS AND RECOMMENDATIONS

WHEN DOES IT MAKE SENSE TO INSTALL TRVS?

The readers should be aware that all conclusions and subsequent recommendations are based on a small sample number of buildings.

This research showed TRVs can cost-effectively achieve energy savings and reduce the incidence of overheating in apartments that average three or more degrees above 72°F Where as, TRVs installed in buildings that maintain an average temperature of 72°F will not result in any energy savings and is not cost effective.

Based on the research results and our observations we recommend installing TRVs on one-pipe steam systems serving multifamily buildings:

- In apartments that are heated above 72°F
- In apartment buildings where the existing control system does not maintain 72°F; and
- In specific rooms that may have chronic overheating problems associated with oversized radiators due to the installation of thermal pane windows.

HOW TO INSTALL TRVS

TRV installation for most applications is no different than replacing a radiator air vent. Superintendents who are shown how to assemble the TRVs can install them with little problem. It takes about five minutes to assemble the TRV and 15 minutes to install it.

The most difficult part of the installation was assembling the TRV and installing the temperature setpoint plugs. The key to installing setpoint plugs is to use the set-point plug tool, a $5.00 item available from the manufacturer. The set-point plug tool made installing setpoint plugs relatively easy.

The TRVs that we purchased required assembly and came in three pieces: TRV body, TRV sensing bulb and air vent. The three pieces are easily put together. After learning how to install the temperature setpoint plugs, the most difficult task at first, assembling each TRV required no more than five minutes each.

TRV installation on the radiator is easily performed without incident if the installer is careful. First, a plumber's wrench should be used to remove the air vent from the radiator. Several air vents that had been installed many years ago were difficult to remove. Spraying a lubricant like WD-40 around the vent chamber facilitated removal of some of the more stubborn air vents. We recommend cleaning the threads on the radiator air vent chamber with a thread-tap the size of the opening, usually 1/8" NPT. We also recommend wrapping the TRV air vent threads with teflon tape to reduce leaks.

Once the threads on the radiator sleeve are cleaned and TRV threads wrapped with teflon tape, the TRV should carefully be screwed into the radiator. We recommend first tightening the valve by hand. **DO NOT TIGHTEN THE TRV BY GRABBING ONTO THE AIR VENT VALVE; IT WILL BEND AND BREAK OFF**. Hand tighten until tight. Using a pipe wrench carefully tighten the TRV until the air vent is fully upright.

APPENDIX A: BUILDING AUDITS

BUILDING ENERGY AUDIT

at

1710 West Fourth Street
Brooklyn, New York 11223

Sponsored by:

NEW YORK STATE ENERGY RESEARCH AND DEVELOPMENT AUTHORITY

In Connection With The:

THERMOSTATIC RADIATOR VALVE RESEARCH PROJECT

Performed By

EME Group

135 Fifth Avenue
New York, New York 10010

February 26, 1991

I . SUMMARY OF FINDINGS

This building energy audit is part of a four-year research project sponsored by the New York State Energy Research And Development Authority (NYSERDA) to demonstrate the cost-effectiveness of installing thermostatic radiator valves (TRVs) on one-pipe steam systems in multifamily buildings in New York City. This building has been offered by the owner to participate in the project.

The audit conducted at this site focused on inspecting the general condition of the heating system including steam distribution piping, boiler controls, burner operating efficiency and domestic hot water generating system. In addition, an inventory of hot water fixtures, washing machines, and dish washers were made so that the building's base line hot water and heating energy use could be estimated.

The building's historic fuel use for three years was collected to compute the building's base energy use (corrected for heating degree days). From these data we can compute the energy intensity of the building based on heating degree days. This number will be used as a benchmark to compare changes in fuel use after implementing the recommended measures in this report and after installing the TRVs.

As a result of our walk-through survey, the following low cost and no cost measures to reduce building energy use are recommended for operation and maintenance procedures.

1. Tune Boiler

Our combustion efficiency test indicates that the burner is needs tuning and that the boiler fire side surfaces should be cleaned. We measured a combustion efficiency of 76% below the burners optimal operating efficiency. In addition, we measured a smoke number of one (1) which indicates incomplete combustion. The smoke number and high stack temperature are signs that the boiler needs cleaning. We estimate that the cost for tuning and cleaning should not cost more than $300.

2. Replace Leaking Radiator Vents

Several apartments had air vents on the radiators that were leaking or painted closed. The radiator vent releases air at a fixed rate from the radiator as steam enters. This vent is essential for correctly controlling steam flow into the radiator. Vents that leak waste steam and cause other problems in the boiler by increasing the amount of boiler make- up water. We estimate that 10 to 20 radiators will require new vents. We recommend that the building superintendent inspect all radiators and replace inoperative vents with Hoffman #40 or equivalent. We estimate, using in-house labor, that the vent replacements should not cost more than $200.

3. Replace Leaking Steam Main Vents

An inspection of the steam mains indicated that 3 to 4 steam main vents leaked. The steam main vent quickly releases air from the steam main for equal distribution of steam. We recommend that the building superintendent inspect all vents on the steam mains and replace the inoperative vents with Gorton #1 or equivalent. Replacement of these vents should not cost more than $250.

4. Insulate Steam Piping Where Insulation Has Deteriorated.

There are lengths of steam piping in the building that need to be insulated because the insulation has deteriorated, most likely from water leaks. We recommend that the superintendent insulate this piping. Most of the piping is from 2 to 3 inches in diameter requiring a 1-inch thick fiberglass pipe insulation. The steam pipe insulation should not cost more than $150, using in-house labor.

5. Insulate Domestic Hot Water Piping

The domestic hot water piping in the boiler room and basement was not insulated. We recommend that the superintendent insulate this piping with 1-inch thick fiberglass pipe insulation and cover it with a plastic jacket. Domestic hot water pipe insulation, using in-house labor, should not cost more than $100.

1. ARCHITECTURAL

1710 West 4th Street, Brooklyn, New York has 23 apartments with a conditioned floor area of approximately 15,820 square feet. The building is a four-story walk-up structure comprised of six apartments on floors 2, 3 and 4; and five apartments on the first floor. The front door faces east.

A typical floor contains two apartments comprised of three rooms and a kitchen, and 4 apartments comprised of two rooms and a kitchen. Each room is heated by a single cast iron radiator and in general, the bathrooms and kitchens are heated by risers.

The building is typical masonry construction comprised of face brick, common brick with an interior finish of plaster or gypsum board. We estimate the wall composite has a R-value of 4.3 or a U-value of 0.23.

The windows throughout the building are double pane units installed about 8 years ago. They are, in general, in good condition and we estimate their R-value 1.7 or a U-value of 0.60.

The roof is a built-up membrane on a flat deck over an air space which is from 12 to 24 inches high. There are no leaks and the roof appears to be in good condition. There is, however, no roof insulation. We estimate the roof composite has a R-value of 3.25 or a U-value of 0.31.

2. OCCUPANCY

There are approximately 36 residents in the this building, or 1.5 people per apartment.

3. BOILER

The building is heated by a single low pressure steam steel boiler, a model FST 40 unit rated at 40 boiler hp manufactured by Federal. Low pressure steam is distributed throughout the building in a one-pipe gravity return system.

The boiler is in good mechanical condition. The steady state efficiency test indicates the boiler needs a tuning, including cleaning of the fire side surfaces.

The burner is an Iron Fireman dual fuel unit, model C12O/GO/SMC2.5, which is a fully modulating burner. The input rating for natural gas is 1820 MBH and oil is 15 gph. The unit appears to be mechanically sound. However, as indicated, the unit needs tuning.

These combustion efficiency test results indicates the boiler is in need of a tuning:

CO_2:	7.0%
O_2:	10.0%
Stack Temperature	480°F
Room Temperature:	70°F
Net Stack Temperature:	410°F
Smoke Number:	1
Burner on-cycle Draft :	-0.10 inches wg
Combustion Efficiency :	76%

This burner can achieve an efficiency from 82 to 84% by tuning.

4. CONTROLS

The boiler is controlled by a combination of pressure controllers and a Heat-Timer. The pressure controls include a Honeywell manual reset controller set at 12 psig. The boiler operating pressuretrol is set at 5 psig with a 2 psig differential.

The Heat-Timer is a model EPC equipped with a condensate sensing bulb. The unit is set to provide heat at the day setting of 56°F. from 6am to 10pm. The night setting is at 45°F. The heat adjustment setting is at "B" .

The controls appear to be in good operating condition and the settings are appropriate.

5. DISTRIBUTION SYSTEM:

a. Radiators

Low pressure steam is distributed through a one-pipe gravity return system. In general the steam distribution system is in good condition. The radiators are cast iron tubular style with a total equivalent direct radiation (EDR) of 1,500 square feet.
The condition of the radiators was generally good. Several radiators had leaking vents and tenants said that there was water hammer.

b. Piping

The steam distribution piping in the basement appears to be in fair condition. We recommend replacing the leaking steam main vents.

In general, the steam pipe insulation appears to be in fair condition. However we did notice areas where the pipe insulation has deteriorated. This piping should be re-insulated.

Domestic hot water piping is not insulated in the boiler room and much of the basement. Likewise this piping needs to be insulated.

6. DOMESTIC HOT WATER

The boiler normally fires on oil during the winter. During the summer it runs on natural gas and provides hot water to the adjacent building. This will provide useful information on the efficiency of generating domestic hot water (DHW) with an immersion coil. We estimate that the DHW load is about half the boiler's capacity, and therefore, combining both building's DHW loads equal the boiler's capacity.

DHW is generated by the heating boiler in an immersion coil. A Holby mixing valve tempers the domestic hot water temperature. We measured a DHW temperature of between 120 to 130°F. This is adequate and the system appears to be in good condition.

7. INVENTORY OF FUEL CONSUMING EQUIPMENT:

There is no central laundry facility at this site. An inventory was taken of the washing machines and dishwashers so that their contribution to the building's hot water consumption can be determined. We found one washing machine and no dishwashers.

8. BUILDING HEAT LOSS CALCULATION

A building heat loss calculation established the buildings' theoretical heat loss characteristics; it was compared to actual energy consumed and the amount of radiation installed.

Based on the U-values computed for each of the main architectural components, we can compute the building's theoretical heat loss from the following simple equation: $UA(T_i-T_o)$, where U is the composite heat conduction value of the building component; A is the component surface area; and T_i and T_o represent the building's indoor and outdoor temperatures respectively. Additional heat losses attributed to infiltration are based on 0.5 air changes per hour.

Based on the previous data the computed heat loss for the building is approximately 326,500 Btuh. This is equivalent to 1,360 square feet of equivalent direct radiation (EDR). The installed EDR is approximately 1,490 square feet. This is a close approximation to the theoretical building load.

9. FUEL ANALYSIS

The building consumed an average of 15,585 gallons of #2 fuel oil in 1988, 1989 and 1990, averaging 0.15 gallons of #2 oil per degree day per apartment.

BUILDING ENERGY AUDIT

at

1722 West Fourth Street
Brooklyn, New York 11223

Sponsored by

NEW YORK STATE ENERGY RESEARCH AND DEVELOPMENT AUTHORITY

In Connection With The

THERMOSTATIC RADIATOR VALVE RESEARCH PROJECT

Performed By

EME Group

135 Fifth Avenue
New York, New York 10010

February 26, 1991

I . SUMMARY OF FINDINGS

This building energy audit is part of a four-year research project sponsored by the New York State Energy Research And Development Authority (NYSERDA) to demonstrate the cost-effectiveness of installing thermostatic radiator valves (TRVs) on one-pipe steam systems in multifamily buildings in New York City. This building has been offered by the owner to participate in the project.

The audit conducted at this site focused on inspecting the general condition of the heating system including steam distribution piping, boiler controls, burner operating efficiency and domestic hot water generating system. In addition, an inventory of hot water fixtures, washing machines, and dish washers were made so that the building's base line hot water and heating energy use could be estimated.

The building's historic fuel use for three years was collected to compute the building's base energy use (corrected for heating degree days). From these data we can compute the energy intensity of the building based on heating degree days. This number will be used as a benchmark to compare changes in fuel use after implementing the recommended measures in this report and after installing the TRVs.

As a result of our walk-through survey, the following low cost and no cost measures to reduce building energy use are recommended for operation and maintenance procedures.

1. Tune Boiler

Our combustion-efficiency test indicates that the burner needs tuning and that the boiler fire side surfaces should be cleaned. We measured a combustion efficiency of 79%, slightly below the burners optimal operating efficiency. We estimate that the cost for the tuning should not exceed $250.

2. Replace Leaking Radiator Vents

Several apartments had air vents on the radiators which were leaking or painted closed. The radiator vent releases air at a fixed rate from the radiator as steam enters. This vent is essential for correctly controlling steam flow into the radiator. Vents which leak waste steam and cause other problems in the boiler by increasing the amount of boiler make-up water. We estimate that from 10 to 20 radiators will require new vents. We recommend that the building superintendent inspect all of the radiators and replace inoperative vents with Hoffman #40 or equivalent. We estimate, using in-house labor, that the vent replacements should not cost more than $160.

3. Replace Leaking Steam Main Vents

Similar to 1710 West 4th Street, an inspection of the steam mains indicated that some vents were leaking. The steam main vent quickly releases air from the steam main so that equal distribution of steam is accomplished. We recommend that the building superintendent inspect all the vents on the steam mains and replace the inoperative vents with Gorton #1 or equivalent. Replacement of these vents should not cost more than $250.

4. Insulate Steam Piping Where Insulation Has Deteriorated.
There are lengths of steam piping in the building that need to be insulated because the insulation has deteriorated, most likely from water leaks. We recommend that the superintendent insulate this piping. Most of the piping is from 2 to 3 inches in diameter, requiring a 1-inch thick fiberglass pipe insulation. The steam pipe insulation should not cost more than $250, using in-house labor.

5. Insulate Domestic Hot Water Piping

The domestic hot water piping in the boiler room and basement was not insulated. We recommend that the superintendent insulate this piping with 1-inch thick fiberglass pipe insulation and cover it with a plastic jacket. Domestic hot water pipe insulation, using in-house labor, should not cost more than $100.

1. ARCHITECTURAL

1722 West 4th Street, Brooklyn, New York is adjacent and identical to 1710 West 4th Street and has 23 apartments with a conditioned floor area of approximately 15,820 square feet. The building is a four-story walk-up structure comprised of six apartments on floors 2, 3 and 4 and five apartments on the first floor. The front door faces east.

A typical floor contains two apartments comprised of three rooms and a kitchen, and 4 apartments comprised of two rooms and a kitchen. Each room is heated by a single cast iron radiator and in general, the bathrooms and kitchens are heated by risers.

The building is typical masonry construction comprised of face brick, common brick with an interior finish of plaster or gypsum board. We estimate the wall composite has a R-value of 4.3 or a U-value of 0.23.

The windows throughout the building are double pane units installed about eight years ago. They are, in general, in good condition and we estimate their R-value 1.7 or a U-value of 0.60.

The roof is a built-up membrane on a flat deck over an air space which we estimate to be from 12 to 24 inches high. There are no leaks and the roof appears to be in good condition. There is, however, no roof insulation. We estimate the roof composite has a R-value of 3.25 or a U-value of 0.31.

2. OCCUPANCY

There are 70 residents in the this building, or 3 people per apartment.

3. BOILER

The building is heated by a single low pressure steam cast iron packaged boiler manufactured by Weil McLain. It is a series 84 model rated at 43.6 boiler hp. Low pressure steam is distributed throughout the building in a one-pipe gravity return system.

The boiler is in good mechanical condition. The steady state efficiency test indicates a tuning is necessary.

The burner, model PR 863, is an integral part of the packaged boiler. This is a single position firing burner with an input rating of 11 to 15.5 gph. The unit appears to be mechanically sound. However, as indicated, the unit needs a tuning. Following are the results of the combustion efficiency test:

CO2:	9.5%
02:	8.0%
Stack Temperature:	550°F
Room Temperature:	70°F
Net Stack Temperature:	480°F
Smoke Number:	1
Burner on-cycle Draft:	-0.04 inches wg
Combustion Efficiency:	79%

This burner can achieve an efficiency between 82 and 84% by tuning.

4. CONTROLS

The boiler is controlled by a combination of pressure controllers and a Heat-Timer. The pressure controls include a Honeywell manual reset controller set at 10 psig. The boiler operating pressuretrol is set at 4 psig with a 2 psig differential.

The Heat-Timer is a model E, an outdated model that does not use the advanced Heat-Timer capability of establishing heat circulation through the condensate sensor. The unit is set to provide heat at the day setting of 55°F from 6am to 10pm. The night setting is at 45°F. The heat adjustment setting is at "B".

All of the controls appear to be in good operating condition and the settings are appropriate.

5. DISTRIBUTION SYSTEM

a. Radiators

Low pressure steam is distributed through a one-pipe gravity return system. In general the steam distribution system is in good condition. The radiators are cast iron tubular style with a total equivalent direct radiation (EDR) of 1,519 square feet.

The condition of the radiators was generally good. Several radiators had leaking vents. There were no indications from the tenants of water hammer.

b. Piping

The steam distribution piping in the basement appears to be in fair condition. We do recommend replacing the leaking steam main vents.

In general, the steam pipe insulation appears to be in fair condition. However we did notice areas where the pipe insulation has deteriorated. This piping should be re-insulated.

Domestic hot water piping is not insulated in the boiler room and much of the basement. Likewise this piping needs to be insulated.

6. DOMESTIC HOT WATER

The boiler in 1710 provides hot water during the nonheating months and is generated by the boiler in 1722 using three immersion coils during the heating season. Each coil is rated at 70 to 90 gph. A Holby mixing valve tempers the domestic hot water temperature. We measured a DHW temperature of between 120 to 130°F. This is adequate and the system appears to be in good condition.

7. INVENTORY OF FUEL CONSUMING EQUIPMENT

There is no central laundry facility at this site. An inventory was taken of the washing machines and dishwashers to measure their hot water consumption. We counted seven washing machines and no dishwashers.

8. BUILDING HEAT LOSS CALCULATION

A building heat loss calculation established the building's theoretical heat loss characteristics; it was compared to actual energy consumed and the amount of radiation installed.

Based on the U-values computed for each of the main architectural components, we can compute the building's theoretical heat loss using the equation: $UA(T_i - T_o)$, where U is the composite heat conduction value of the building component; A is the component surface area; and T_i and T_o represent the building's indoor and outdoor temperatures respectively. Additional heat losses attributed infiltration are based on 0.5 air changes per hour.

Based on the above data the computed heat loss for the building is approximately 349,950 Btuh. This is equivalent to 1,458 square feet of equivalent direct radiation (EDR). The installed EDR which we measured was approximately 1,520 square feet. This is a close approximation to the theoretical building load.

9. FUEL ANALYSIS

The building consumed an average of 17,745 gallons of #2 fuel oil in 1988, 1989 and 1990, an average of 0.17 gallons #2 fuel per degree day per apartment.

BUILDING ENERGY AUDIT

at

347 East 173rd Street
Bronx, New York 10457

Managed By

Ann-Gur Realty
825 E. 233rd Street
Bronx, New York 10466

Building Owner: Irving Yasgur

Sponsored by

NEW YORK STATE ENERGY RESEARCH AND DEVELOPMENT AUTHORITY

In Connection With The

THERMOSTATIC RADIATOR VALVE RESEARCH PROJECT

Performed By

EME GROUP

135 Fifth Avenue
New York, New York 10010

September 11, 1991

I . SUMMARY OF FINDINGS

This building energy audit is part of a four-year research project sponsored by the New York State Energy Research And Development Authority (NYSERDA) to demonstrate the cost-effectiveness of installing thermostatic radiator valves (TRVs) on one-pipe steam systems in multifamily buildings in New York City. This is a replacement building for 336 E. 90th St., New York, NY, one of the original buildings.

The audit conducted at this site focused on inspecting the general condition of the heating system including steam distribution piping, boiler controls, burner operating efficiency and domestic hot water generating system. In addition, an inventory of hot water fixtures, washing machines, and dish washers were made so that the building's base line hot water and heating energy use could be estimated.

The building's historic fuel use for three years was collected to compute the building's base energy use (corrected for heating degree days). From these data we can compute the energy intensity of the building based on heating degree days. This number will be used as a benchmark to compare changes in fuel use after implementing the recommended measures in this report and after installing the TRVs.

The heating system in this building is in good condition. The boiler test indicated a need for tuning and cleaning, however, according to the owner, it is tuned and cleaned at the beginning of the heating season.

As a result of our walk-through survey, the following low cost and no cost operation and maintenance procedures are recommended to provide for a more efficient heating system.

1. Tune and Clean Boiler

Our combustion efficiency test indicates that the burner needs tuning. We measured a combustion efficiency of about 78% which is below the burner's optimal operating efficiency.

2. Replace Leaking Radiator Vents

Several apartments had leaking shut-off valves and air vents. The air vent is designed to release air at a fixed rate as steam enters the radiator. Vents that leak waste steam and cause other problems in the boiler by increasing the amount of boiler make up water. We estimate that 5 to 10 radiator air vents need replacement.

We recommend that the building superintendent inspect all radiators and replace inoperative vents with Hoffman #40 or equivalent. A steam leak in apartment #11 needs to be repaired. We estimate, using in-house labor, that the vent replacements should not cost more than $50.

3. Insulate Steam Piping In Basement

We found that approximately the following pipe lengths require insulation:

- o 4 inch diameter pipe - 40 feet
- o 3 inch diameter pipe - 12 feet
- o 2 inch diameter pipe - 20 feet

We recommend that the superintendent insulate the piping with 1-inch thick fiberglass pipe insulation. Steam pipe insulation should not cost more than $200, using in-house labor.

1. ARCHITECTURAL

347 East 173rd Street, Bronx, New York is a five-story walk-up multifamily building with a small commercial space on the ground floor. There is a total of 20 apartments with a conditioned floor area of approximately 14,100 square feet. The front door faces south.

There are generally three types of apartment layouts per floor, consisting of one 1-bedroom, two 2-bedroom and one 3-bedroom units. Bedrooms and living rooms are heated by cast iron radiators, and the bathrooms and kitchens are heated by risers.

The building is typical masonry construction comprised of face brick; common brick with an interior finish of plaster or gypsum board. We estimate the wall composite has an R-value of 4.3 or a U-value of 0.23.

The windows are metal frame double pane units which were installed a few years ago. The windows are in fair condition and we estimate their R-value at 1.7 or a U-value of 0.60.

The roof is a built-up membrane on a flat deck over an air space which we estimate to be from 12 to 24 inches high. There are no leaks and the roof appears to be in good condition. There is no roof insulation and we estimate the roof composite has an R-value of 3.25 or a U-value of 0.31.

2. OCCUPANCY

There are a total of 84 residents; 60% represent children. This averages 4.2 people per apartment.

3. BOILER

The building is heated by a single low pressure steam steel boiler, a model FST 50 rated at 50 boiler hp, manufactured by Federal. Low pressure steam is distributed throughout the building in a one-pipe gravity return system.

The boiler appears to be in fair operating condition. The steady state combustion efficiency test, however, indicates that the boiler needs a tuning and cleaning.

The burner is an Industrial Combustion (IC) Hev-E-Oil model AM4DH No.4 fuel oil unit with an input rating of 3 gph to 17 gph. The burner is capable of full modulation or low-high firing. The unit appears to be mechanically sound.
Following are the results of the combustion efficiency test:

CO_2:	5 %
Stack Temperature:	350°F
Room Temperature:	70°F
Net Stack Temperature:	270°F
Smoke Number:	0
Burner on-cycle Draft:	-0.20 inches wg
Combustion Efficiency:	75%

This boiler should provide a steady state efficiency of between 80 and 82%; we recommend tuning the burner.

4. CONTROLS

The boiler is controlled by a combination of pressure controllers and a Heat-Timer model E. The pressure controls include a Honeywell manual reset controller set at 15 psig. The boiler operating pressuretrol is set at 2.5 psig with a 1/2 psig differential. Heat establishment is determined by a third pressuretrol set at 1 psig.

All of the controls appear to be in fair operating condition. The settings, however, are difficult to read.

5. DISTRIBUTION SYSTEM

a. Radiators

Low pressure steam is distributed through a one-pipe gravity return system. The steam distribution system is generally in good condition. The radiators are conventional cast iron columnar type.

b. Piping

The steam distribution piping in the basement appears to be in good condition. As noted in the summary, lengths of steam piping need to be insulated.

6. DOMESTIC HOT WATER

Hot water is generated by the heating boiler through an immersion coil. A Holby mixing valve tempers the domestic hot water temperature. We measured a DHW temperature of 120°F which is appropriate. We did not notice any low-flow or reduced flow shower heads or flow restrictors.

7. INVENTORY OF FUEL CONSUMING EQUIPMENT

There is no central laundry facility at this site. We estimate, based on the number of apartments to which we gained access, that there are 12 washing machines, and no dishwashers.

8. BUILDING HEAT LOSS CALCULATION

A building heat loss calculation established the building's theoretical heat loss characteristics; it was compared to actual energy consumed and the amount of radiation installed.

Based on the U-values computed for each of the main architectural components, we can compute the building's theoretical heat loss using the equation: $UA(T_i-T_o)$, where U is the composite heat conduction value of the building component; A is the component surface area; and T_i and T_o represent the building's indoor and outdoor temperatures respectively. Additional heat losses attributed to infiltration is based on 0.5 air changes per hour.

Based on the previous data the computed heat loss for the building is approximately 420,182 Btuh. This is equivalent to 1,750 square feet of equivalent direct radiation (EDR). The installed EDR measured was approximately 1,485 square feet. This is a close approximation to the theoretical building heat loss.

9. FUEL ANALYSIS

The building consumed an average of 61,040 gallons of No.4 fuel oil in the last three years. In No.2 fuel oil equivalents, this averages 0.22 gallons No.2 fuel oil per degree day per apartment which is above average (0.18) compared to the Building Energy Use Tracking System (BEUTS) developed by the New York City, H.P.D. Energy Conservation Division.

BUILDING ENERGY AUDIT

at

256 Pacific Street
Brooklyn, New York 11201

Managed By

Philip Goodman
364 West 18th Street
New York, New York 10011

Sponsored by

NEW YORK STATE ENERGY RESEARCH AND DEVELOPMENT AUTHORITY

In Connection With The

THERMOSTATIC RADIATOR VALVE RESEARCH PROJECT

Performed By

THE EME GROUP

135 Fifth Avenue
New York, New York 10010

March 7, 1991

I . SUMMARY OF FINDINGS

This building energy audit is part of a four-year research project sponsored by the New York State Energy Research And Development Authority (NYSERDA) to demonstrate the cost-effectiveness of installing thermostatic radiator valves (TRVs) on one-pipe steam systems in multifamily buildings in New York City. This building has been offered by the owner to participate in the project.

The audit conducted at this site focused on inspecting the general condition of the heating system including steam distribution piping, boiler controls, burner operating efficiency and domestic hot water generating system. In addition, an inventory of hot water fixtures, washing machines, and dish washers were made so that the building's base line hot water and heating energy use could be estimated.

The building's historic fuel use for two years was collected to compute the building's base energy use (corrected for heating degree days). From these data we can compute the energy intensity of the building based on heating degree days. This number will be used as a benchmark to compare changes in fuel use after implementing the recommended measures in this report and after installing the TRVs.

The heating system in this building is in good condition; however, several operating and maintenance procedures need to be implemented.

1. Tune and Clean Boiler

Our combustion efficiency test indicates that the burner needs tuning. We measured a combustion efficiency of about 70% which is below the burner's optimal operating efficiency. In addition, we measured a smoke number of four which indicates incomplete combustion. The smoke number and high stack temperature (850°F. net) are signs the boiler needs cleaning. We estimate that the cost for tuning and cleaning should not exceed $350.

2. Replace Leaking Radiator Vents

Several apartments had leaking shut-off valves and air vents. The air vent releases air at a fixed rate as steam enters the radiator. Vents that leak waste steam and cause other problems in the boiler by increasing the amount of boiler make up water. We estimate that at least 7 radiators will require new vents.

We recommend that the building superintendent inspect all radiators and replace inoperative vents with Hoffman #40 or equivalent. Also a steam leak in apartment #11 needs to be repaired. We estimate, using in-house labor, that the vent replacements should not cost more than $100.

3. Insulate Steam Piping In Basement

None of the steam piping in the basement is insulated. We recommend that the superintendent insulate the piping with 1-inch thick fiberglass pipe insulation. Steam pipe insulation should not cost more than $250, using in-house labor.

4. Insulate Domestic Hot Water Piping

None of the domestic hot water piping in the boiler room and basement is insulated. We recommend that the superintendent insulate this piping with 1-inch thick fiberglass pipe insulation and cover it with a plastic jacket. Domestic hot water pipe insulation, using in-house labor, should not cost more than $200.

5. Reduce Domestic Hot Water Temperature

The domestic hot water temperature ranged from 130°F to 170°F in the apartments. The high temperature indicates of a faulty mixing valve that failed in the fully open position. We recommend the superintendent first adjust the valve's setting to provide a more moderate domestic hot water temperature. If that does not result of a reduced temperature, it is most likely that the mixing valve will need to be replaced, which we estimate will cost from $300 to $500.

6. Weatherstrip Doors

We recommend that the front entrance, vestibule and bulkhead doors be weatherstripped by the building superintendent. We estimate this will cost about $5 per door.

1. ARCHITECTURAL

256 Pacific Street, Brooklyn, New York is similar in construction and layout to 260 Pacific Street. There are a total of 25 apartments with a conditioned floor area of approximately 16,930 square feet. The building is a five-story walk-up structure comprised of 5 apartments per floor. The front door faces north.

There are generally two types of apartment layouts per floor; four of which are 2- bedroom units, the fifth a 1-bedroom unit. Bedrooms and living rooms are heated by cast iron radiators and the bathrooms and kitchens are heated by risers.

The building is typical masonry construction made of face brick, common brick with an interior finish of plaster or gypsum board. We estimate the wall composite has an R-value of 4.3 or a U-value of 0.23.

The windows primarily are metal frame double pane units which were installed a few years ago. The windows are in fair condition and we estimate their R-value at 1.7 or a U-value of 0.60.

The roof is a built-up membrane on a flat deck over an air space estimated to be between 12 and 24 inches high. There are no leaks and the roof appears to be in good condition. There is no roof insulation; we estimate the roof composite has an R-value of 3.25 or a U-value of 0.31.

2. OCCUPANCY

There are 80 residents, half of which are children. This averages 3.2 people per apartment.

3. BOILER

The building is heated by a single low pressure steam steel boiler, a model MP 40 unit rated 40 boiler hp, manufactured by Rockmills. Low pressure steam is distributed throughout the building in a one-pipe gravity return system.

The boiler, installed in 1986, is in good operating condition. The steady state combustion efficiency test, however, indicates that the boiler needs tuning and cleaning.

The burner is a Carlin 701 CRD two position firing unit with input rating from 6 to 13.2 gph. The unit appears to be mechanically sound.

Following are the results of the combustion efficiency test:

CO_2:	12 %
Stack Temperature:	920°F
Room Temperature:	70°F
Net Stack Temperature:	850°F
Smoke Number:	4
Burner on-cycle Draft:	-0.20 inches wg
Combustion Efficiency:	70%

This boiler should provide a steady state efficiency of between 82 and 84%.

4. CONTROLS

The boiler is controlled by a combination of pressure controllers and a Heat-Timer model E. The pressure controls include a Honeywell manual reset controller set at 10 psig. The boiler operating pressuretrol is set at 5 psig with a 2-1/2 psig differential. The heat establishment pressure is set at 2.5 with a 2.0 psig differential.

The Heat-Timer is set at 55°F from 6am to 10pm. The night setting is at 40°F. The heat adjustment setting is at "B" .

All of the controls appear to be in good operating condition and the settings are appropriate.

5. DISTRIBUTION SYSTEM

a. Radiators

Low pressure steam is distributed through a one-pipe gravity return system. In general the steam distribution system is in good condition. The radiators are conventional cast iron tubular type.

Seven radiators need new shut-off valves and air vents. Since we did not gain access to all apartments, we estimate there may be additional vents that require replacement. There were no indications from the tenants of water hammer.

b. Piping

The steam distribution piping in the basement appears to be in good condition. We recommend insulating the bare piping. Domestic hot water piping also requires insulation.

6. DOMESTIC HOT WATER

Hot water is generated by the heating boiler through an immersion coil. A Holby mixing valve tempers the domestic hot water temperature. We measured a DHW temperature from 130 to 170°F. This is excessive and needs to be investigated.

We did not notice any low flow or reduced flow shower heads or flow restrictors.

7. INVENTORY OF FUEL CONSUMING EQUIPMENT

There is no central laundry facility at this site. We counted 12 washing machines; there were no dishwashers in the apartments.

8. BUILDING HEAT LOSS CALCULATION

A building heat loss calculation established the building's theoretical heat loss characteristics; it was compared to actual energy consumed and the amount of radiation installed.

Based on the U-values computed for each of the main architectural components, we can compute the building's theoretical heat loss from the equation: $UA(T_i-T_o)$, where U is the composite heat conduction value of the building component; A is the component surface area; and T_i and T_o represent the building's indoor and outdoor temperatures respectively. Additional heat losses attributed to infiltration is based on 0.5 air changes per hour.

Based on the above data the computed heat loss for the building is approximately 386,400 Btuh. This is equivalent to 1,610 square feet of equivalent direct radiation (EDR). The installed EDR measured was approximately 1,443 square feet. The 11.5% difference between the theoretical building heat loss and the existing radiation is, we believe, due to the removal of radiators from the kitchens.

9. FUEL ANALYSIS

The building consumed an average of 17,923 gallons of #2 fuel oil in 1989 and 1990. This averages 0.16 gallons #2 fuel per degree day per apartment which is slightly below average compared to the Building Energy Use Tracking System (BEUTS) developed by the New York City, H.P.D. Energy Conservation Division.

BUILDING ENERGY AUDIT

at

260 Pacific Street
Brooklyn, New York 11201

Managed By

Philip Goodman
364 West 18th Street
New York, New York 10011

Sponsored by

NEW YORK STATE ENERGY RESEARCH AND DEVELOPMENT AUTHORITY

In Connection With The

THERMOSTATIC RADIATOR VALVE RESEARCH PROJECT

Performed By

THE EME GROUP

135 Fifth Avenue
New York, New York 10010

March 7, 1991

I . SUMMARY OF FINDINGS

This building energy audit is part of a four-year research project sponsored by the New York State Energy Research And Development Authority (NYSERDA) to demonstrate the cost-effectiveness of installing thermostatic radiator valves (TRVs) on one-pipe steam systems in multifamily buildings in New York City. This building has been offered by the owner to participate in the project.

The audit conducted at this site focused on inspecting the general condition of the heating system including steam distribution piping, boiler controls, burner operating efficiency and domestic hot water generating system. In addition, an inventory of hot water fixtures, washing machines, and dish washers were made so that the building's base line hot water and heating energy use could be estimated.

The building's historic fuel use for two years was collected to compute the building's base energy use (corrected for heating degree days). From these data we can compute the energy intensity of the building based on heating degree days. This number will be used as a benchmark to compare changes in fuel use after implementing the recommended measures in this report and after installing the TRVs.

The heating system in this building is in good condition; however, a number of operation and maintenance procedures are required to provide for a more efficient heating system.

1. Tune and Clean Boiler

Our combustion efficiency test indicates that the burner needs tuning. We measured a combustion efficiency of about 76% which is below the burner's optimal operating efficiency. In addition, we measured a smoke number of one, which, although not excessive, indicates incomplete combustion. The smoke number and high stack temperature (800°F net) are signs that the boiler needs cleaning. We estimate the cost for the tuning and cleaning should not exceed $350.

2. Replace Leaking Radiator Vents

We noticed two apartments had leaking shut-off valves and air vents. The air vent releases air at a fixed rate as steam enters the radiator. Vents that leak waste steam and cause other problems in the boiler by increasing the amount of boiler make up water.

We recommend that the building superintendent inspect all radiators and replace inoperative vents with Hoffman #40 or equivalent. A steam leak in apartment #11 needs to be repaired. We estimate, using in-house labor, that the vent replacements should not cost more than $50.

3. Repitch Radiators

A number of radiators inspected were not properly pitched, causing water hammer from the condensate in the radiator.

Gravity return one-pipe steam systems require that all horizontal pipe runs and radiators be pitched back toward the supply pipe at a minimum of 1/4 inch per foot. The superintendent should inspect the radiators and make repairs.

4. Insulate Steam Piping In Basement

None of the steam piping in the basement is insulated. We recommend that the superintendent insulate the piping with 1-inch thick fiberglass pipe insulation. Steam pipe insulation should not cost more than $250, using in-house labor.

5. Insulate Domestic Hot Water Piping

None of the domestic hot water piping in the boiler room and basement is insulated. We recommend that the superintendent insulate this piping with 1-inch thick fiberglass pipe insulation and cover the insulation with a plastic jacket. Domestic hot water pipe insulation, using in-house labor, should not cost more than $200.

6. Weatherstrip Doors

We recommend that the front entrance, vestibule and bulkhead doors be weatherstripped by the building superintendent. We estimate this will cost about $5 per door.

7. Repair Water Leaks

There is a large water leak from the sewage pipe located above the boiler. The leaking water will eventually damage the boiler insulation and may corrode the boiler surface. In addition there is a hot water leak in apartment #10.

1. <u>ARCHITECTURAL</u>

260 Pacific Street, Brooklyn, New York is similar in construction and layout to 256 Pacific Street; however, its eastward facing wall is exposed. This results in a somewhat larger heat load on the building.

The floor layout, average size and type of the apartment is identical to 256 Pacific Street.

The building is typical masonry construction made of face brick; common brick with an interior finish of plaster or gypsum board. We estimate the wall composite has an R-value of 4.3 or a U-value of 0.23.

The windows primarily are metal frame double pane units installed a few years ago. The windows are in fair condition and we estimate their R-value at 1.7 or a U-value of 0.60.

The roof is a built-up membrane on a flat deck over an air space which we estimate to be from 12 to 24 inches high. There are no leaks and the roof appears to be in good condition. There is no roof insulation and we estimate the roof composite has an R-value of 3.25 or a U-value of 0.31.

2. <u>OCCUPANCY</u>

Similarly to 256 Pacific Street there are approximately 80 residents, a third of which are children. This averages 3.2 people per apartment. This is based on having access to 19 of the 25 apartments in the building.

3. BOILER

The building is heated by a single low pressure steam steel boiler, a model MP 40 unit rated for 40 boiler hp, manufactured by Rockmills. Low pressure steam is distributed throughout the building in a one-pipe gravity return system.

The boiler was installed in 1986 and in general is in good operating condition. The steady state combustion efficiency test, however, indicates the boiler needs tuning and cleaning.

The burner is a Carlin 701 CRD two position firing unit with input rating from 6 to 13.2 gph. The unit appears to be mechanically sound.

Following are the results of the combustion efficiency test:

CO_2:	13 %
Stack Temperature:	800°F
Room Temperature:	70°F
Net Stack Temperature:	730°F
Smoke Number:	1
Burner on-cycle Draft:	-0.15 inches wg
Combustion Efficiency:	76%

This boiler should provide a steady state efficiency of between 82 and 84%.

4. CONTROLS

The boiler is controlled by a combination of pressure controllers and a Heat-Timer model E. The pressure controls include a Honeywell manual reset controller set at 10 psig. The boiler operating pressuretrol is set at 5 psig with a 1 psig differential. The heat establishment pressure is set at 2.5 with a 1.0 psig differential.

The Heat-Timer is set at 55°F from 6am to 10pm. The night setting is at 35°F. The heat adjustment setting is at "C" .

All of the controls appear to be in good operating condition and the settings are appropriate.

5. DISTRIBUTION SYSTEM

a. Radiators

Low pressure steam is distributed through a one-pipe gravity return system. The steam distribution system is generally in good condition. The radiators are conventional cast iron tubular type.

We identified two radiators which require new shut-off valves and air vents. Since we did not gain access into all of the apartments, we estimate there may be additional vents that require replacement. There were no indications from the tenants of water hammer.

b. Piping

The steam distribution piping in the basement appears to be in good condition. We recommend insulating the bare piping. The domestic hot water piping also requires insulation.

6. DOMESTIC HOT WATER

Hot water is generated by the heating boiler through an immersion coil. A Holby mixing valve tempers the domestic hot water temperature. We measured a DHW temperature of between 130 to 140°F. This should be reduced to between 125 to 130°F at the faucet. We did not notice any low flow or reduced flow shower heads or flow restrictors.

7. INVENTORY OF FUEL CONSUMING EQUIPMENT

There is no central laundry facility at this site. We counted 13 washing machines; there were no dishwashers in the apartments.

8. BUILDING HEAT LOSS CALCULATION

A building heat loss calculation established the building's theoretical heat loss characteristics; it was compared to actual energy consumed and the amount of radiation installed.

Based on the U-values computed for each of the main architectural components, we can compute the building's theoretical heat loss from the equation: $UA(T_i-T_o)$, where U is the composite heat conduction value of the building component; A is the component surface area; and T_i and T_o represent the building's design indoor and outdoor temperatures respectively. Additional heat losses attributed to infiltration is based on 0.5 air changes per hour.

Based on the above data the computed heat loss for the building is approximately 431,100 Btuh. This is equivalent to 1,796 square feet of equivalent direct radiation (EDR). The installed EDR measured was approximately 1,859 square feet. This closely approximates the theoretical building heat loss.

9. FUEL ANALYSIS

The building consumed an average of 18,083 gallons of #2 fuel oil in 1989 and 1990. This averages 0.16 gallons #2 fuel per degree day per apartment which is slightly below average compared to the Building Energy Use Tracking System (BEUTS) developed by the New York City, H.P.D. Energy Conservation Division.

BUILDING ENERGY AUDIT

at

3044 Wallace Avenue
Bronx, New York 10467

Managed By

Ann-Gur Realty
825 E. 233rd Street
Bronx, New York 10466

Building Owner: Irving Yasgur

Sponsored by

NEW YORK STATE ENERGY RESEARCH AND DEVELOPMENT AUTHORITY

In Connection With The

THERMOSTATIC RADIATOR VALVE RESEARCH PROJECT

Performed By

EME GROUP

135 Fifth Avenue
New York, New York 10010

September 11, 1991

I . SUMMARY OF FINDINGS

This building energy audit is part of a four-year research project sponsored by the New York State Energy Research And Development Authority (NYSERDA) to demonstrate the cost-effectiveness of installing thermostatic radiator valves (TRVs) on one-pipe steam systems in multifamily buildings in New York City. This building has been offered by the owner to participate in the project.

The audit conducted at this site focused on inspecting the general condition of the heating system including steam distribution piping, boiler controls, burner operating efficiency and domestic hot water generating system. In addition, an inventory of hot water fixtures, washing machines, and dish washers were made so that the building's base line hot water and heating energy use could be estimated.

The building's historic fuel use for two years was collected to compute the building's base energy use (corrected for heating degree days). From these data we can compute the energy intensity of the building based on heating degree days. This number will be used as a benchmark to compare changes in fuel use after implementing the recommended measures in this report and after installing the TRVs.

The heating system in this building is in good condition. The boiler is tuned and cleaned annually and all of the pipe insulation is in fair condition. A few air vents on the radiators need replacement.

1. Replace Leaking Radiator Vents

The air vents on radiators in the following apartments need to be replaced: 3E bedroom; 4B bedroom; apartment 5B kitchen riser; and apartment 5A, kitchen riser.

The air vent is designed to release air at a fixed rate as steam enters the radiator. Vents that leak waste steam and cause other problems in the boiler by increasing the amount of boiler make up water.

We recommend that the building superintendent inspect all of the radiators and replace the inoperative vents with Hoffman #40 or equivalent. Using in-house labor, each vent replacements should not cost more than $10.

2. Reduce Hot Water Temperature

We measured an average hot water temperature of 135°F. This is excessive and contributes to unnecessarily high building energy use. We recommend a faucet hot water temperature from 120 to 125°F. Lowering of the hot water temperature is accomplished by adjusting the Holby mixing valve.

1. ARCHITECTURAL

3044 Wallace Avenue, Bronx, New York is a five-story walk-up multifamily building comprising 26 apartments. It is bell-shaped with all four walls generally exposed.

There are generally two types of apartment layouts per floor, consisting of a two-bedroom (A line) and the remaining one-bedroom units. Bedrooms and living rooms are heated by cast iron tubular radiators and the bathrooms and kitchens are heated by risers.

The building is typical masonry construction made of face brick; common brick with an interior finish of plaster or gypsum board. We estimate the wall composite has an R-value of 4.3 or a U-value of 0.23.

The windows are metal frame double pane units installed a few years ago. The windows are in fair condition, and we estimate their R-value at 1.7 or a U-value of 0.60.

The roof is a built-up membrane on a flat deck over an air space from 12 to 24 inches high. There are no leaks and the roof appears to be in good condition. There is no roof insulation; we estimate the roof composite has an R-value of 3.25 or a U-value of 0.31.

2. OCCUPANCY

We estimate from our survey a total of 68 residents, almost half of which are children. This averages 2.8 people per apartment.

3. BOILER

The building is heated by a single low pressure steam steel boiler manufactured by Rockmills. It is a model MP 50 unit which is rated 50 boiler hp. Low pressure steam is distributed throughout the building in a one-pipe gravity return system.

The boiler was installed in 1982 and is in good operating condition. The steady state combustion efficiency test, however, indicates that the boiler needs tuning.

The burner is a Unipower model A52GO35A-X6 dual fuel unit currently firing natural gas. It is a fixed fire burner rated at 1330 MBH, equivalent to approximately 13 CCf per hour. The unit is in good condition.

Following are the results of the combustion efficiency test:

CO_2:	9%
Stack Temperature:	375°F
Room Temperature:	75°F
Net Stack Temperature:	300°F
Burner on-cycle Draft:	-0.03 inches wg
Combustion Efficiency:	83%

4. CONTROLS

The boiler is controlled by a combination of pressure controllers and a Heat-Timer model ETP. The pressure controls include a Honeywell manual reset controller set at 10 psig. The boiler operating pressuretrol is set at 4 psig with a 1-1/2 psig differential. Heat establishment is determined by an in-line aquastat.

All of the controls appear to be in good operating condition and the settings are appropriate.

5. DISTRIBUTION SYSTEM

a. Radiators

Low pressure steam is distributed through a one-pipe gravity return system. In general the steam distribution system is in good condition. The radiators are conventional cast iron tubular type.

b. Piping

The steam distribution piping in the basement appears to be in good condition. We did not identify any appreciable lengths of piping that requires insulation.

6. DOMESTIC HOT WATER

Hot water is generated by the heating boiler through an immersion coil. A Holby mixing valve tempers the domestic hot water temperature. We did not find any low flow or reduced flow shower heads or flow restrictors.

7. INVENTORY OF FUEL CONSUMING EQUIPMENT

There is no central laundry facility at this site. We estimate, based on the number of apartments which we gained access, that there are a total of 14 washing machines, there were no dishwashers in the apartments.

8. BUILDING HEAT LOSS CALCULATION

A building heat loss calculation established the building's theoretical heat loss characteristics; it was compared to actual energy consumed and the amount of radiation installed.

Based on the U-values computed for each of the main architectural components, we can compute the building's theoretical heat loss from the equation: $UA(T_i-T_o)$, where U is the composite heat conduction value of the building component; A is the component surface area; and T_i and T_o represent the building's design indoor and outdoor temperatures respectively. Additional heat losses attributed to infiltration is based on 0.5 air changes per hour.

Based on the above data the computed heat loss for the building is approximately 452,336 Btuh. This is equivalent to 1,884 square feet of equivalent direct radiation (EDR). The installed EDR measured was approximately 2,092 square feet. This is a close approximation to the theoretical building heat loss.

9. FUEL ANALYSIS

The building consumed an average of 57,238 therms of natural gas in 1989 and 1990. In No.2 fuel oil equivalents, this averages 0.18 gallons No.2 per degree day per apartment. This is average consumption compared to the Building Energy Use Tracking System (BEUTS) developed by the New York City, H.P.D. Energy Conservation Division.