Study

on

Mechanical Insulation

in

Hospitals and Schools

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Executive Summary

Mechanical insulation is used extensively in commercial buildings. There are approximately 5 million commercial buildings (80 billion square feet[1]) consuming approximately 18 percent of all primary energy used in the United States. Energy usage in commercial buildings varies by size and by building activity. This study focused on quantifying the use of mechanical insulation in two building types: hospitals and schools.

The approach was to contact insulation contractor members of the National Insulation Association (NIA) to obtain insulation specifications and quantity take-offs for recent hospital and school projects. Using this data, insulation energy assessments were then performed to estimate the energy savings due to mechanical insulation.

The results of the study highlight the importance of mechanical insulation in commercial buildings. The quantities of mechanical insulation in schools and hospitals are large. For hospitals, insulated piping (domestic hot water, heating hot water, chilled water, and steam) averages about 13 miles per hospital, while insulated supply ductwork averages over 4 acres per hospital. Schools contain smaller but still significant quantities of mechanical insulation. Insulated piping in schools (domestic hot water, heating hot water, and chilled water) averages about 2 miles per school, while insulated supply ductwork averages about 2 acres per school.

The piping and ductwork in hospitals and schools are generally well insulated. All the buildings analyzed exceed the insulation requirements of ASHRAE Standard 90.1-2007. Four of the five schools exceed the requirements of the recently published ASHRAE Standard 90.1-2010 as well. Only one of the nine hospitals exceed the 2010 requirements, and additional energy savings ranging from 0.1 percent to 2.6 percent could accrue with compliance to ASHRAE Standard 90.1-2010 in the other eight hospitals.

For the schools studied, it is estimated that mechanical insulation saves, on average, 13 kBtu/sf/yr of site energy (about 20 percent of the total usage). For hospitals, the energy savings from mechanical insulation are estimated to average about 149 kBtu/sf/yr (roughly 78 percent of the total site energy usage). These large numbers highlight the importance of mechanical insulation in commercial buildings. In fact, it can be argued that some of the energy distribution systems in commercial buildings could not function without mechanical insulation because distribution losses would become excessive. The importance of properly maintaining the insulation on these distribution systems is evident.

[1] U.S. Department of Energy, *2009 Buildings Energy Data Book*.

Background and Objective

In May 2009, the National Insulation Association (NIA) and the International Association of Heat and Frost Insulators and Allied Workers (International) created an alliance to work together to educate industry on and promote the benefits of mechanical insulation. One of the major initiatives of the alliance is the Mechanical Insulation Education and Awareness Campaign (MIC).

The MIC is being executed under the umbrella of the U.S. Department of Energy's (DOE's) Industrial Technologies Program by Project Performance Corporation (PPC) and NIA, in conjunction with its alliance with the International.

The MIC is a program to increase awareness of the energy efficiency, emission reduction, economic stimulus, and other benefits of mechanical insulation in the industrial and commercial markets. The potential of mechanical insulation to play a significant role as a tool to reduce energy intensity is immense. However, the lack of sufficient data to support energy efficiency potential, combined with a deficient understanding of what mechanical insulation is and how it could be utilized, impedes policy makers and actors in industrial and commercial sectors in making a supportable case for increased use and maintenance of mechanical insulation. While current uncertainties hinder mechanical insulation from playing a larger role in energy efficiency decisions, the MIC was created to meet two key initiatives: 1) educate industry on the benefits of mechanical insulation by providing practical data and case studies and 2) launch a public education and awareness campaign targeting multiple industry segments.

One of the tasks of the MIC focuses on the use of mechanical insulation in the commercial building segment. There are approximately 5 million commercial buildings (80 billion square feet[2]) consuming approximately 18 percent of all primary energy used in the United States. Energy usage in commercial buildings varies by size and by building activity. Recognizing the wide range in building size and function, it was decided to focus on two building types in this initial study: hospitals and schools.

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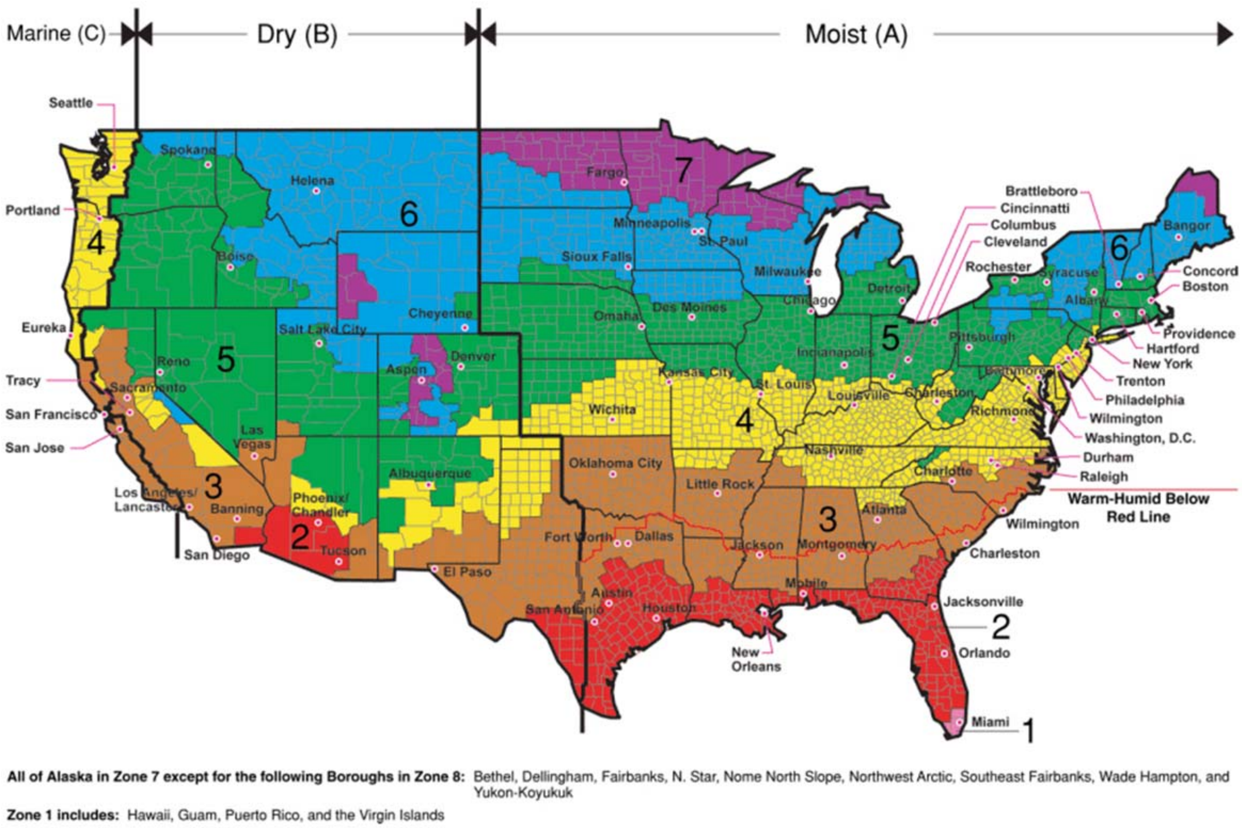
[2] U.S. Department of Energy *2009 Buildings Energy Data Book*.

Approach

The approach selected was to contact NIA insulation contractor members to request insulation specifications and quantity take-offs for recent hospital and school projects. Using this data, insulation energy assessments were then performed to estimate the energy savings due to mechanical insulation. The projects were selected to represent the range of climates reflected in DOE Climate Zones 1-7 (Figure 1).



While the vast majority of mechanical insulation applications in commercial buildings are indoors (not exposed to weather), the climate zone location does impact the type of HVAC equipment utilized and the run times of the equipment. Building locations across the range of climate zones were therefore of interest. The process of obtaining data on suitable projects proved more difficult than anticipated. Many of the projects submitted involved renovations or small additions rather than new construction. For this and a variety of other reasons, the quantities of projects hoped for were not achieved in every climate zone, but the 14 buildings that were selected, 9 hospitals and 5 schools, are thought to be representative of the range of climates in the United States.

Early on in the project, it became evident that the information needed to complete an insulation energy assessment for each project identified would be difficult to obtain. The data from the insulation contractors generally consisted of the insulation specification for the project and a summary take-off identifying the quantities and sizes of mechanical insulation by system. Information about the design and operation of the mechanical systems in the project was not available. For example, while the insulation specification might indicate that all supply-air ductwork shall be insulated with 2 in. of duct wrap, that specification will not indicate whether the supply ducts are for a variable-air-volume (VAV) system, a constant-air-volume (CAV) system with terminal reheat, or a dual-duct system. Another example is that while a take-off may indicate the system involved (e.g., medium-pressure steam), information about the actual operating pressures (and the associated operating temperatures) involved was not available.

Ideally, an insulation energy assessment would involve the gathering of information about the energy systems, the equipment installed, and the operating strategies. In this study, many of the facilities had been designed and bid, but construction was not yet started or not complete. While some information (e.g., floor areas and general information about the project) was sometimes available, the level of detail needed was lacking.

The approach was therefore modified to gain as much information as possible with the data available. A number of assumptions were required, so the DOE Commercial Building Benchmark Models[3] were used as a guide. These publicly available benchmark models provided estimates of the total site energy use intensities (EUI) for hospitals and schools in all climate zones. In addition, the Benchmark Models were used to guide the assignment of equipment efficiencies for the buildings in this study (if not available elsewhere).

A number of additional assumptions were required to develop the energy savings estimates, including the operating temperatures and the ambient conditions of the piping and ductwork, the operating hours of the mechanical systems involved, and the fraction of lost energy associated with the locations.

Scope and Limitations

The projects selected for analysis were chosen from a list of projects submitted by participating insulation contractors. No effort was made to randomize the selection or to ensure that the selections were representative or typical of the projects actually being constructed in each region of the country. Likewise, no effort was made to weight the results to the actual construction activity in each region. Any attempt to extrapolate these results to a nationwide basis should therefore include an analysis of construction activity by region with the appropriate adjustments.

The scope of the study was limited to reviewing the specifications and take-offs provided and, using this information, developing estimates of the energy impact of the mechanical insulation systems in the selected buildings. No effort was made to critique the specifications for adequacy or completeness, or to verify that the insulation take-offs were correct or that the insulation systems were installed as specified.

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[3] http://www1.eere.energy.gov/buildings/commercial_initiative/reference_buildings.html, accessed Sept 2010

As indicated, the energy calculations required many assumptions. While these assumptions are believed to be reasonable for the types of buildings involved, they could not be verified by field visits. The results of this study should be viewed with these limitations in mind.

Results

A total of 14 projects were analyzed as part of this study (5 schools and 9 hospitals). The locations and general characteristics of the buildings are summarized in Table 1.

Table 1. Project Information

Facility	Location	Type	Climate Zone	Gross Floor Area	Notes
Schools					
Elementary School	Sunrise, FL	Primary School	1A	124,000	All Elec, CAV
High School	Humble, TX	High School	2A	435,000	VAV
Middle School	Cleveland, GA	Middle School	4A	125,700	Roof Top Units and Water Loop Heat Pumps
Elementary School	Harvard, IL	Primary School	5A	120,000	VAV
Elementary School	Post Falls, ID	Primary School	5B	44,500	Water Loop Heat Pumps w/DOAS
Hospitals					
Hospital	Hollywood, FL	Hospital	1A	170,000	New Tower
Hospital	Phoenix, AZ	Hospital	2B	685,000	New Tower, CEP
Hospital	Dallas, TX	Hospital	3A	460,000	Expansion
Hospital	Los Angeles, CA	Hospital	3B	460,000	New Building
Medical Center	Merriam, KS	Hospital	4A	240,800	Expansion
Medical Center	Everett, WA	Hospital	4C	680,000	New Tower
Regional Health Center	Lafayette, IN	Hospital	5A	410,000	New Hospital
Hospital	Helena, MT	Hospital	6B	130,000	Addition
Hospital	Anchorage, AK	Hospital	7	85,800	New Tower

While most of these hospital projects were additions or expansions of existing hospital facilities, the nature of the projects allowed them to be treated as stand-alone facilities for analysis purposes.

The results of this study indicate that a significant quantity of mechanical insulation is being utilized in hospitals and schools. Table 2 summarizes the quantities of pipe and duct insulation in each of the 14 facilities analyzed.

Table 2. Insulation Quantities

Facility	Location	Gross Floor Area	Domestic Hot Water Piping		Heating Hot Water Piping		Steam Piping		Chilled Water Piping		Insulated Supply Ductwork		Insulated Return Ductwork	
			LF	ft/ft^2	LF	ft/ft^2	LF	ft/ft^2	LF	ft/ft^2	SF	ft^2/ft^2	SF	ft^2/ft^2
Schools														
Elementary School	Sunrise, FL	124,000	1,194	0.01					1,027	0.01	39,552	0.32	26,412	0.21
High School	Humble, TX	435,000	7,787	0.02	7,179	0.02			4,700	0.01	256,000	0.59	4,400	0.01
Middle School	Cleveland, GA	125,700	3,902	0.03							41,000	0.33	28,000	0.22
Elementary School	Harvard, IL	120,000	3,315	0.03	7,435	0.06			2,260	0.02	53,000	0.44		0.00
Elementary School	Post Falls, ID	44,500	2,856	0.06	4,510	0.10					11,180	0.25	3,481	0.08
Averages for Schools		169,840	3,811	0.022	6,375	0.032			2,662	0.012	80,146	0.472	15,573	0.085
Hospitals														
Hospital	Hollywood, FL	170,000	18,201	0.11	13,425	0.08	6,270	0.04	5,968	0.04	38,576	0.23	25,717	0.15
Hospital	Phoenix, AZ	685,000	41,934	0.06	51,000	0.07	1,670	0.00	12,642	0.02	410,458	0.60	266,520	0.39
Hospital	Dallas, TX	460,000	19,674	0.04	27,625	0.06	6,016	0.01	4,561	0.01	213,660	0.46	1,894	0.00
Hospital	Los Angeles, CA	460,000	31,920	0.07	39,230	0.09	8,864	0.02	4,951	0.01	298,510	0.65		
Medical Center	Merriam, KS	240,800	9,665	0.04	23,508	0.10	5,128	0.02	5,079	0.02	125,400	0.52	93,300	0.39
Medical Center	Everett, WA	680,000	50,300	0.07	46,000	0.07	6,700	0.01	4,730	0.01	291,335	0.43	865	0.00
Regional Health Center	Lafayette, IN	410,000	33,100	0.08	39,000	0.10	11,459	0.03	7,429	0.02	207,400	0.51	12,800	0.03
Hospital	Helena, MT	130,000	10,550	0.08	14,561	0.11	1,435	0.01	3,618	0.03	60,500	0.47		
Hospital	Anchorage, AK	85,800	14,100	0.16	46,900	0.55	795	0.01	975	0.01	75,000	0.87		
Averages for Hospitals		369,067	25,494	0.069	33,472	0.091	5,371	0.015	5,550	0.015	191,204	0.518	66,849	0.152

Insulation Quantities in Schools

All the school projects included insulation on domestic hot water piping (DHW).The total lengths of DHW piping ranged from 1,200 linear feet to 7,800 linear feet (1 ½ miles). Within each of the facilities, size and thickness of insulation varied as well. All the facilities contained significant percentages of ½ in. and ¾ in. DHW piping with 1 in. thick insulation (typically used for drops and run-outs to fixtures and for recirculation lines). The largest DHW lines in schools were 3 in. insulated with 1 ½-in.-thick insulation. On average, the schools analyzed contained about 0.022 linear feet of DHW piping per square foot of floor space.

Insulation quantities for the HVAC systems, as expected, depended on the HVAC systems used. Piping for hydronic heating systems (HHW) was present in three of the five schools. Hydronic piping is commonly used to supply heating coils in air handling units and terminal boxes and for perimeter heating. The three schools that had HHW piping averaged about 0.032 linear feet per square foot of floor space.

Chilled water piping was identified in three of the five schools and averaged about 0.012 linear feet per square foot of building area. Sizes ranged from 1 in. up to 14 in. Note that two of the schools utilized water loop heat pumps for heating and cooling (no chilled water piping was present).

All the schools had insulated supply-air ductwork (averaging about 0.47 ft^2 of duct surface per ft^2 of floor area). Current energy codes and standards do not require insulation for supply-air ducts in conditioned (or indirectly conditioned) spaces. Condensation control and/or noise control are likely the design objectives for these systems.

Four of the five schools had insulated return-air ductwork as well. Note that energy codes and standards do not typically require insulation on return-air ductwork within the building envelope, but acoustical considerations are important in classrooms.

Insulation Quantities in Hospitals

Mechanical insulation quantities are greater in hospitals than in schools because 1) on average, hospitals are larger than schools and 2) hospitals contain more energy-intensive systems than schools. Additionally, mechanical insulation has a larger energy impact because most hospitals operate 24 hours per day year round.

Insulated domestic hot water piping in hospitals is extensive. Quantities ranged from 9,700 linear ft to over 50,000 linear ft (9.5 miles) . Piping sizes ranged up to 4 in. The hospitals averaged about 0.069 linear feet of DHW piping per ft^2 of floor space.

Hydronic heating water piping was also identified in all the hospitals analyzed. HHW is used extensively in hospitals to supply air handling units, terminal boxes, and perimeter heat loops. The Phoenix Hospital project has 51,000 linear ft of HHW piping (9.7 miles). Sizes range from ½ in. to 18 in. On average, the hospitals contained about 0.091 linear ft of HHW piping per square foot of building area.

All the hospitals contained a significant amount of steam supply and condensate piping. Hospitals use steam for sterilization, humidification, and laundry facilities. Quantities of steam piping ranged from about 800 linear ft to about 11,000 linear ft. Sizes ranged from ½ in. up to 18 in. On average, the hospitals had about 0.015 ft of steam piping per square foot of floor area.

Chilled water piping was present in all hospitals as well and averaged about 0.015 linear ft per square foot of floor area. The Phoenix hospital has roughly 12,600 linear ft (2.4 miles) of chilled water piping. Chilled water piping sizes range up to 20 in. in diameter.

Large quantities of insulated supply-air ductwork were identified in all the hospitals analyzed. Quantities ranged from 39,000 ft^2 to 410,000 ft^2 and averaged about 0.52 ft^2 of supply-air ductwork per square foot of floor area.

Insulated return-air ductwork was present in six of the nine hospitals analyzed and averaged 0.15 ft^2 of duct surface area per square foot of floor area.

Energy Impact of Mechanical Insulation in Schools and Hospitals

Estimates of the energy savings attributable to mechanical insulation are summarized in Table 3. These energy savings are all estimated relative to a baseline case of no insulation (the bare case). The savings are shown in several different ways: absolute site energy savings in billions of Btu/year, savings normalized to the gross floor area of the project (kBtu/sf), and savings normalized to the projected annual Site Energy Usage of the building (in percentages).

Table 3 Energy Savings Due to Mechanical Insulation

Facility	Location	Type	Climate Zone	Gross Floor Area	DOE RefBldg EUI, kBtu/sf/yr	Projected Annual Site Usage, 10^9 Btu/yr	Energy Savings, 10^9 Btu/yr	Energy Savings, kBtu/ft2	% of Site Energy Usage
Schools									
Elementary School	Sunrise, FL	Primary School	1A	124,000	58	7.2	0.28	2.3	4%
High School	Humble, TX	Secondary School	2A	435,000	85	37.0	10.47	24	28%
Middle School	Cleveland, GA	Middle School	4A	125,700	62	7.8	0.48	4	6%
Elementary School	Harvard, IL	Primary School	5A	120,000	66	7.9	1.27	11	16%
Elementary School	Post Falls, ID	Primary School	5B	44,500	59	2.6	1.19	27	45%
Averages for Schools								**13**	**20%**
Hospitals									
Hospital	Hollywood, FL	Hospital	1A	170,000	193	32.8	32.0	188	98%
Hospital	Phoenix, AZ	Hospital	2B	685,000	192	131.5	60.8	89	46%
Hospital	Dallas, TX	Hospital	3A	460,000	197	90.6	55.6	121	61%
Hospital	Los Angeles, CA	Hospital	3B	460,000	183	84.2	85.1	185	101%
Medical Center	Merriam, KS	Hospital	4A	240,800	203	48.9	38.6	160	79%
Medical Center	Everett, WA	Hospital	4C	680,000	188	127.8	84.6	124	66%
Regional Health Center	Lafayette, IN	Hospital	5A	410,000	197	80.8	65.9	161	82%
Hospital	Helena, MT	Hospital	6B	130,000	175	22.8	15.1	116	66%
Hospital	Anchorage, AK	Hospital	7	85,800	195	16.7	16.7	194	100%
Averages for Hospitals								**149**	**78%**

As discussed earlier, most of the projects analyzed were either recently completed or under construction. Actual energy consumption data was not available for most of these buildings. The site energy usage values were therefore projected using the DOE Commercial Building Benchmark Models as a point of comparison.

As indicated in Table 3, the savings due to mechanical insulation vary greatly. The largest savings are for the hospital in Los Angeles (85 billion Btu/yr), while the smallest savings are in the elementary school in Sunrise, Florida (0.28 billion Btu/yr). The ratio of high to low is roughly 300 to 1. Normalized to building area, the savings range from roughly 200 kBtu/sf to 2 kBtu/sf (a ratio of 100 to 1).

The primary reason for the large variation is the difference in building function and systems. Hospitals are typically large facilities with many energy-intensive systems that operate continuously. Schools are generally smaller with fewer energy-intensive systems that operate only five days a week for nine months per year.

To illustrate, Table 4 contrasts the take-off quantities for the Los Angeles hospital with the quantities for the elementary school in Florida.

Table 4. Comparison of Quantities in Two Facilities			
Item	Units	Los Angeles Hospital	Florida Elementary School
Ductwork	SF	298,500	65,680
Domestic Hot Water Piping	LF	31,920	1,194
Chilled Water Piping	LF	4,951	962
High Pressure Steam Supply Piping	LF	300	
Medium Pressure Steam Supply	LF	588	
Low Pressure Steam Supply	LF	5,967	
Steam Condensate Piping	LF	2,014	
Heating Hot Water piping	LF	38,915	

Based on differences in quantities alone, it is obvious that the mechanical insulation systems in the large hospital will result in significantly more energy savings than those in the elementary school. Additionally, most of the systems in the hospital will operate 8,760 hours per year, compared to roughly 2,300 hours per year for the school.

Table 3 also shows that the variation in savings within the two categories of buildings is less but still significant. For the schools, energy savings ranged from 10 billion Btu/yr to 0.28 billion Btu/yr (a range of about 40 to 1). Normalized to floor area, the variation is still roughly 12 to 1 (from 27 to 2.3 kBtu/sf/yr). Again, this variation is explained by the differences in the systems installed. Within the hospital category, the estimated savings due to mechanical insulation ranged from a high of 85 billion Btu/yr to a low of 17 billion Btu/yr . This is a 5 to 1 variation. Normalizing to floor area reduces this variation to about 2 to 1 (194 kBtu/sf/yr to 89 kBtu/sf/yr). The average energy savings for the nine hospitals in this study was 149 kBtu/sf/yr.

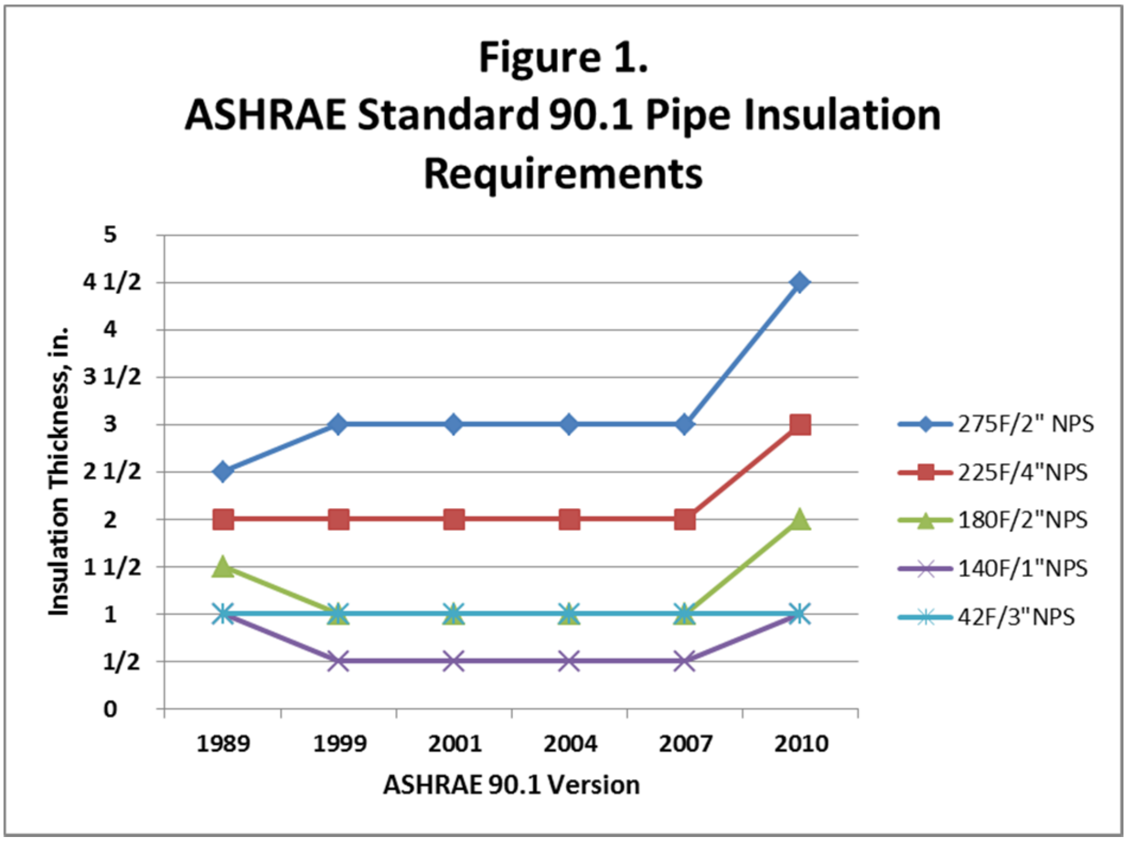
These energy savings are large. Expressed as a percentage of the total projected energy usage of the building, they range from 4 percent to 101 percent.

In reality, that doubling of energy consumption could but would probably not occur because the boiler capacity would be exceeded (boilers would be running flat out trying to replace the heat lost from over 15 miles of uninsulated steam and hot water lines), while at the same time the chiller capacity would be exceeded (trying to satisfy the increased cooling load caused by over 15 miles of uninsulated hot lines). Temperature control in the patient spaces would be lost, and the patients would need to be moved to another hospital because the thermal conditions inside would be unacceptable. The hospital would be shut down until the system could be repaired, so the energy usage would not double.

These results illustrate the critical nature of mechanical insulation for the efficient operation of the energy distribution systems in many commercial buildings. Without insulation, extensive steam, hot water, and chilled water distribution systems would be impractical.

Comparisons to ASHRAE Standard 90.1

An objective of this study was to investigate how the mechanical insulation levels in these buildings compare to levels required by the ASHRAE Standard 90.1. The ASHRAE Standard 90.1-2010, which was recently published, contains more stringent requirements for insulation on above-ambient piping than previous versions. The requirements for cold piping and for ductwork are unchanged from earlier versions of the standard. Figure 1 shows the history of thickness requirements for selected sizes of piping. As illustrated in the figure, the requirements had remained essentially unchanged since the 1989 version of the standard.



The data available in this study provides an opportunity to address two questions of interest: 1) How do the insulation levels being installed in real buildings compare to the levels required by ASHRAE 90.1? and 2) What is the likely impact of the increase in stringency for the above-ambient piping?

Table 5 compares the estimated energy savings for the 14 buildings with the savings that would be expected if the insulation requirements of ASHRAE Standard 90.1 had been strictly followed. Savings were calculated for three cases: 1) using insulation levels as specified for the project (labeled “As Built” in the table), 2) using the insulation thickness requirements in ASHRAE Standard 90.1-2007 (labeled ASHRAE-2007)[4], and 3) using the insulation thickness requirements in ASHRAE Standard 90.1-2010.

As before, the savings are expressed as billions of Btu/yr (relative to the bare case). The last two columns compute the differences between the cases expressed as a percent of the projected annual site energy usage.

Taking the Harvard, Illinois, elementary school as an example, the as-built savings are estimated at 1.27 billion Btu/yr. If the piping and ductwork in the school had been insulated in strict compliance with ASHRAE Standard 90.1-2007, the energy savings would be 1.25 billion Btu/yr. We conclude that, overall, the school building exceeds the requirements of 90.1-2007. If the piping and ductwork had been insulated in strict compliance with ASHRAE 90.1-2010, the estimated savings would be 1.30 billion Btu/yr. The incremental energy savings (As Built→2010) is 0.03 billion Btu/yr, or about 0.6 percent of the projected annual site usage of this school.

Table 5. Comparisons to ASHRAE Standard 90.1

Building Information						Energy Savings				
Facility	Location	Type	Climate Zone	Gross Floor Area	Projected Annual Site Usage, 10^9 Btu/yr	As Built, 10^9 Btu/yr	ASHRAE 2007 Compliant, 10^9 Btu/yr	ASHRAE 2010 Compliant, 10^9 Btu/yr	% Savings ASHRAE (2007→2010)	% Savings ASHRAE (AsBuilt→2010)
Schools										
Elementary School	Sunrise, FL	Primary School	1A	124,000	5.7	0.28	0.20	0.21	0.2%	-1.2%
High School	Humble, TX	Secondary School	2A	435,000	37	10.5	10.0	10.4	1.1%	-0.2%
Middle School	Cleveland, GA	Middle School	4A	125,700	7.8	0.48	0.38	0.39	0.1%	-1.2%
Elementary School	Harvard, IL	Primary School	5A	120,000	7.9	1.27	1.25	1.30	0.6%	0.4%
Elementary School	Post Falls, ID	Primary School	5B	44,500	2.6	1.19	1.13	1.17	1.5%	-0.8%
Averages for Schools									0.7%	-0.6%
Hospitals										
Hospital	Hollywood, FL	Hospital	1A	170,000	33	32.0	30.8	31.9	3.4%	-0.3%
Hospital	Phoenix, AZ	Hospital	2B	685,000	132	60.8	59.1	61.0	1.4%	0.1%
Hospital	Dallas, TX	Hospital	3A	460,000	91	55.6	54.0	55.7	1.9%	0.1%
Hospital	Los Angeles, CA	Hospital	3B	460,000	86	85.1	83.6	86.4	3.2%	1.5%
Medical Center	Merriam, KS	Hospital	4A	240,800	49	38.6	38.0	38.9	2.0%	0.6%
Medical Center	Everett, WA	Hospital	4C	680,000	128	84.6	82.6	84.9	1.8%	0.2%
Regional Health Center	Lafayette, IN	Hospital	5A	410,000	81	65.9	64.6	66.7	2.6%	1.0%
Hospital	Helena, MT	Hospital	6B	130,000	23	15.1	14.8	15.2	2.0%	0.5%
Hospital	Anchorage, AK	Hospital	7	85,800	17	16.7	16.5	17.1	2.3%	2.6%
Averages for Hospitals									2.1%	1.0%

[4] Note that the ASHRAE Standard 90.1-2007 is used as a base for this discussion. Since the requirements for mechanical insulation are unchanged from the 1999 version through 2007, comparisons hold for those earlier versions as well.

Comparing the as-built savings with the ASHRAE standard, we conclude that all 14 of the buildings (100 percent) exceed the 2007 standard. In addition, we note that 4 of the 5 schools (80 percent) exceed the 2010 standard. For the hospitals, only 1 of the 9 facilities (11 percent) exceeds the 2010 Standard. Additional savings ranging from 0.1 percent to 2.6 percent are estimated for the 8 other hospitals if they were compliant with the 2010 standard.

Comparing the two versions of the ASHRAE Standard 90.1, we see that the incremental savings expected for the 2010 version over the 2007 version range from 0.1 percent to 3.4 percent. The average savings are 0.7 percent for these schools and 2.1 percent for these hospitals.

Four of the five schools exceed the requirements of the 2010 standard as well. For hospitals, only one of the nine hospitals exceed the 2010 requirements, and additional energy savings ranging from 0.1 percent to 2.6 percent could accrue if the other eight complied with ASHRAE Standard 90.1-2010.

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