ENERGY CALCULATION BOOK

INSULATION • THERMOSTAT SETBACK • WINDOW MODIFICATION
PIPE REPLACEMENT • LAMP REPLACEMENT • VENTILATION CONTROL

STATE OF NEBRASKA

NEBRASKA ENERGY OFFICE, BOX 95085, LINCOLN, NEBRASKA 68509 PHONE (402) 471-2867
NEBRASKA SCHOOL WEATHERIZATION PROGRAM

This booklet is designed to assist school district personnel applying for funding under the School Weatherization Program. It is meant for school buildings under 5,000 square feet in size, or larger schools which have received a waiver of the Technical Assistance requirement. This booklet will help you calculate the energy savings (in btu) and financial savings available by installing clock-type thermostats, insulating, modifying windows, limiting ventilation, replacing incandescent lamps with more efficient light sources, and insulating steam and circulating hot water pipes. This list is not meant to include every energy conservation opportunity available in your school, but is aimed at relatively common and simple projects. We encourage you to examine your building carefully in light of these and other potential energy conservation measures, such as thermostatic radiator valves, modification of air handling system controls, low-leakage air intake and exhaust dampers, and the replacement of inefficient older boilers and furnaces with more efficient models.

We have not included do-it-yourself instructions for these projects due to their variability and complexity, but we encourage you to seek expert assistance--it's usually worth the effort and expense. A professionally prepared Technical Assistance study of your building will identify all energy conservation opportunities and will estimate the cost of implementing them. Such a study will help you set priorities and plan for the future.

Note that one study will serve as the basis for application for funding throughout the life of the program - twice a year through June 1986. Feel free to call the Nebraska Energy Office (402/471-2867) if you have questions about the program, the application process, or this booklet.

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I. THERMOSTAT SETBACK

Heat loss through the building skin is proportional to the difference between the indoor and outdoor temperatures. By lowering the indoor temperature when the building is unoccupied, the temperature difference, and thus the heat loss, is reduced. This can often be performed manually, but sometimes new controls or automatic equipment are required.

A. Determine the percent of your fuel that can be saved by a thermostat setback. The percent saved is:

$$\frac{\text{hours per week set back}}{168} \times 3 \times (\text{day thermostat setting} - \text{unoccupied thermostat setting})$$

The formula will look like this: $\frac{110}{168} \times 3 \times (68-55) = 25\%$ saved

Use your own numbers for hours unoccupied per week and thermostat settings.

B. The first step in determining how much a thermostat setback program can save is to figure out the normal fuel consumption of your building. The most recent 12 months may have been warmer or colder than an average year, so you need to know the average number of heating degree days (HDD - see page 20 of this book) and the number of heating degree days for the 12 months of fuel consumption data you're using. Call your fuel supplier or the Weather Service to find the degree days for the period in question.

The normal fuel use is:

$$\frac{\text{average number of degree days}}{\text{most recent year's degree days}} \times \text{units of fuel used in most recent year}$$

This formula will look like this:

$$\frac{\text{6979 HDD average}}{\text{5896 HDD '82-'83}} \times \text{800 gallons of propane used in 82 - 83} = \text{947 gallons will be used in a normal winter}$$

C. Put it all together. Per cent savings x normal fuel use = fuel savings:

.25 x 947 gallons = 237 gallons saved

D. Figure out the cost savings:

237 gallons x $.65/gallon = $154.05

E. Determine the Energy Savings in btu:. Use the table on page 11:

237 gallons x 95,000 btu/gallon = 225 million btu saved per year

II. ADDING INSULATION

All materials resist the flow of heat, but some resist it much more than others and are used for thermal insulation. Adding insulation to presently uninsulated sections of the building skin is usually more economical than increasing insulation in sections that are already insulated.

A. You need to know the square feet of surface you want to insulate, and the R value, which is the thermal resistance (to the flow of heat) of the structural components and insulation, if any. Find the roof structure on the blueprints or talk to someone who works on the building.

Look up the R values in Table 1B on pages 18 & 19 and add them up. Our example is for a 3,000 square foot flat roof in Atkinson. Count the air space between the underside of the roof and an acoustic tile ceiling as R1, the exterior air film as R.2, and the interior air film as R.7.

exterior air film	.2
built up roof	.33
1/2" rigid insulation	1.4
steel roof deck	0
air space	1.0
1/2" acoustic tile ceiling	1.2
interior air film	.7
Total R Value =	4.83

NOTE The R values used above are underlined in the table.

B. You propose to add 3" of expanded polystyrene. 3" at an R value of 4.17 per inch = 12.5 R value. The new R value = 12.5 + 4.8 = 17.3

C. Now find the average degree days for your area and we can calculate the savings.

The formula looks like this:

$$\text{square feet} \times DD \times 24 \times \left(\frac{1}{\text{old R}} - \frac{1}{\text{new R}}\right) = \text{btu saved per year}$$

Filling in the numbers we developed, it looks like this:

$$3000 \text{ sq. ft.} \times 6825 \text{ DD} \times 24 \times \left(\frac{1}{4.8} - \frac{1}{17.3}\right) = \text{btu saved}$$

The first thing you do is convert $\left(\frac{1}{4.8} - \frac{1}{17.3}\right)$ to a single number.

The first step results in (.208 - 0.58). The next step results in one number-.15. Put this in the formula and compute:

3000 sq. ft. x 6825 DD x 24 x .15 = 73.7 million btu saved per year

D. We're not done yet, but we're close. If you turn the thermostat down during unoccupied hours you reduce the temperature difference from inside to outside, so less heat is lost. So, if you have a setback program, calculate the per cent savings as shown on page 1. Then subtract the savings from 73.7 million btu. Our setback example saved 25%.

.25 x 73.7 million btu = 18.4 million btu saved by the setback

73.7 million btu - 18.4 million btu = 55.3 million btu

E. Your furnace or boiler will actually save more than 55.3 million btu, because of the efficiency of the combustion process (heat is lost up the chimney). To account for this, divide the answer by .70 (70% efficient heating plant):

55.3 : .7 = 79 million btu per year saved.
This is the <u>Energy Savings</u>.

F. The fuel savings equals the energy saved divided by the number of btu in a unit of fuel. If burning oil, it's 140,000 btu per gallon.

79,000,000 btu : 140,000 btu/gallon = 564 gallons of fuel saved

G. Cost Savings = 564 gallons x $1.10/gallon = $620.00 per year

Summary: We raised the R value of 3,000 square feet (4.8) to an R value of 17.3, in Atkinson where the school's thermostat is set back from 68° to 55° for 110 hours per week. Burning oil at $1.10 per gallon and 70% efficiency, we can save 79 million btu per year and $620.00

III. Window Modifications

Glass is a very poor insulator, but is used extensively for psychological, aesthetic, safety and health purposes. Sometimes adding a second layer of glass, or replacing some of the glass with insulated panel or wall is an economical energy savings measure.

New windows and/or storm windows save energy in two ways. Installing storm windows or replacing single glazed windows with double glazed windows increases the R value of the window, and reduces the infiltration of cold air. Therefore, in order to figure out how much you can save, you need to perform two separate calculations. We'll start with the savings by conduction through the glass.

A. Storm Windows

1. Figuring the increase in R value

a. You need the square feet of window being treated (this is the entire area of the opening in the wall) and the degree days for your area.

The R value of single glass is .9.
The R value of double glass is 1.8.

Assuming that the school is near Genoa (6320 DD), and that we want to add storm windows to 350 square feet of windows, the calculation for the yearly energy savings is:

$$\text{square feet} \times DD \times 24 \times \left(\frac{1}{\text{old R}} - \frac{1}{\text{new R}}\right) = \text{btu saved}$$

Filling in the numbers, it looks like this:

$$350 \text{ sq. ft.} \times 6320 \text{ DD} \times 24 \times \left\{\frac{1}{.9} - \frac{1}{1.8}\right\} = \text{btu saved}$$

The first thing you do is convert $\frac{1}{.9} - \frac{1}{1.8}$ to a single number.

The result is (1.11 - .56). The next step results in one number -.55. Put this in the formula and compute:

350 sq. ft. x 6320 DD x 24 x .55 = 29.2 million btu saved per year

b. If you have a thermostat setback program, reduce your savings by a percentage as shown on page 1.

c. Divide the answer above by the furnace efficiency (.7) and you have annual energy savings. We'll assume that no setback is used here, making the savings 29.2 million btu : 7 = 41.7 million btu saved per year.

2. Figuring Infiltration

a. The next step is to calculate the savings from reducing the infiltration of cold air. To do this you need to know the lineal feet of crack. Measure the movable parts of the window. For a 2' wide x 4' double hung (slides up and down) window in which both panes are operable, we have 14 lineal feet of crack (4' on each side, 2' on the top, 2' on the bottom, and 2' in the middle).

Assume that a storm window reduces infiltration by .75 cubic feet of air per minute per lineal foot of crack. Note that we must divide the feet of crack in half. This is because the wind blows in one direction at a time, thereby forcing cold air through half the windows at any given time.

The formula looks like this:

$$\frac{\text{lineal ft.}}{2} \times .75 \text{ cubic feet/minute} \times 1.08 \times DD \times 24 = \text{btu saved per year}$$

Assuming the school in Genoa has 230 feet of crack, the calculation looks like this:

$$\frac{230 \text{ ft.}}{2} \times .75 \text{ cfm} \times 1.08 \times 6{,}320 \text{ DD} \times 24 = 14 \text{ million btu saved per year}$$

b. If necessary, correct for night setback (see page 1).

c. Divide by furnace efficiency:

14 million btu : 7 = 20 million btu saved per year

3. Add it all up:

Conduction savings =	41.7 million btu
Infiltration savings =	20 million btu
Total energy saved =	61.7 million btu

4. Determine the dollar savings. Natural gas is billed in hundred cubic foot units (called a ccf or hcf), each having 100,000 btu, or one thousand cubic foot units (mcf), each of which has one million btu.

$$\frac{61{,}700{,}000 \text{ btu}}{100{,}000 \text{ btu per HCF}} = 617 \text{ HCF saved}$$

617 HCF x $.53 per HCF = $327.00 saved

If you have any questions as to fuel prices or units used, call your supplier.

B. Insulating Panels and New Windows

Sometimes the original glass area is larger than is necessary. In these cases a new window unit incorporating an insulating panel can be installed. This is more costly than adding storm windows, but the savings are greater.

Let's assume that the school near Genoa wants to install new window units with double glazing for half of the 350 square feet and R8 insulating panels for the remaining 175 square feet.

1. First figure the glass savings the way we did it for the storm windows:

$$175 \text{ sq. ft.} \times 6320 \text{ DD} \times 24 \times \left(\frac{1}{.9} - \frac{1}{1.8}\right) = \text{btu saved}$$

$$175 \text{ sq. ft.} \times 6320 \text{ DD} \times 24 \times .55 = 14.6 \text{ million btu saved per year}$$

2. Now calculate the insulated panel savings the same way:

a) $175 \text{ sq. ft.} \times 6320 \text{ DD} \times 24 \times \left(\frac{1}{.9} - \frac{1}{8}\right) = \text{btu per year}$

b) $175 \text{ sq. ft.} \times 6320 \text{ DD} \times 24 \times .99 = 26.3$ million btu saved per year

3. Calculate the infiltration savings. To do this you need to know the infiltration in cubic feet per minute per foot of crack for the existing window and for the new window, and the feet of crack now and after the new windows are installed. Determine the feet of crack by measuring and/or reviewing the plans, blueprints or drawings. For the infiltration rate, assume that:

-the existing window leaks 1.6 cubic feet per minute per foot of crack

-the new window leaks .2 cubic feet per minute per foot of crack

a) Calculate the savings as shown on page 5. In our example, the calculation for the present annual heat loss due to infiltration is:

$$\frac{230 \text{ lineal ft}}{2} \times 1.6 \text{ cfm} \times 1.08 \times 6{,}320 \text{ DD} \times 24 = 41.9 \text{ million btu saved/year}$$

b) calculate the infiltration through the new windows feet of crack the same way (We'll assume the new, smaller windows have 150 lineal feet of crack).

$$\frac{150 \text{ lineal ft}}{2} \times .2 \text{ cfm} \times 1.08 \times 6{,}320 \text{ DD} \times 24 = 2.5 \text{ million btu per year}$$

c) Subtract the new from the old to get the savings:

41.9 million btu - 2.5 million btu = 39.4 million btu saved per year.

4. Add it all up.

Infiltration Savings:	39.4 million btu
Glass Savings:	14.6 million btu
Panel Savings:	26.3 million btu
TOTAL SAVINGS:	80.3 million btu per year

5. Adjust for night setback, if necessary, as shown on page 1.

6. Divide by furnace efficiency of .7 (Skip this step if electric resistance heat is used).
   80.3 million btu / .7 = 114.7 million btu saved

7. Figure the fuel savings. Let's assume that we're using gas heat and are saving 15% by using a night setback.

   a) 114.7 million btu
      x.15 setback correction
      17.2 million btu saved

   b) 114.7 - 17.2 = 97.5 million btu saved

   c) Let's say our gas is billed in HCF, each of which has 100,000 btu. Therefore:

$$\frac{97{,}500{,}000 \text{ btu}}{100{,}000 \text{ btu/HCF}} = 975 \text{ HCF saved per year}$$

And now, last but certainly not least, the dollar savings:

975 HCF saved x $.53 per HCF = $517.00 saved per year

IV. Ventilation Reduction

Ventilation is the intentional introduction of outdoor air into a building to meet health codes, and for moisture and odor control. Exhaust fans pull a cubic foot of fresh, cold air nto the building to replace each cubic foot of heated air they exhaust. Unit ventilators draw return air from the floor and mix it with outside air drawn through the wall. Fans that are running constantly can be turned off when they aren't necessary because the building is unoccupied or the level of activity doesn't justify ventilation. Dampers and vents can be closed during unoccupied hours. Often this can be done manually at no cost, but sometimes time clocks or controls are necessary.

A. To calculate the savings potential of limiting fan operation, you need to know:

- the hours per week the fan can be shut off
- the cubic feet per minute (cfm) that the fan draws. You might find this on the plans, blueprints or specifications for your building or you can find the manufacturer and the model number on the plate on the machine. Then you can call the manufacturer or a distributor for more information.
- the degree days for your area.

1. The first step is to adjust the cfm for the hours the fan will be off. This is "change in" cfm, or cfm.

$$\text{cfm} = \text{cfm} \times \frac{\text{present operating hours/week} - \text{proposed hours/week}}{\text{present operating hours per week}}$$

Let's say we have a 300 cfm fan, now running continuously, which we'll cut back to 50 hours per week, located near Valentine.

$$\text{cfm} = 300 \times \frac{168-50}{168} = 211 \text{ cfm}$$

2. The next step is to put the 211 cfm into the calculation method shown on page 5, "Figuring Infiltration":

The formula is: cfm x DD x 24 x 1.08 = btu saved per year

With our numbers it is:
211 x 7,300 DD x 24 x 1.08 = 39.9 million btu per year

3. Adjust for the thermostat setback if your school sets the temperature down during unoccupied hours. Let's say this school's fuel consumption is reduced 20% through a night setback program:

39.9 million btu x .2 = 7.9 million btu saved by thermostat setback

39.9 million btu - 7.9 million btu = 32 million btu saved by shutting the fan off for 118 hours per week.

4. We'll assume this school is heated by electric resistance heat which is 100% efficient at the point of use.

5. Determine the fuel savings, assuming that a kWh of electricity has 3,413 btu:

$$\frac{31.9 \text{ million btu}}{3,413 \text{ btu per kWh}} = 9,347 \text{ kWh electricity saved per year}$$

6. And now, the dollar savings:

9,347 kWh saved per year x $.06 per kWh = $561.00 saved per year

V. Lighting Modifications

Where incandescent lamps are used, it is often a wise investment to replace them with more efficient light sources, such as fluorescent, metal halide or high pressure sodium lamps. Note that, except for incandescent lamps, all lamps require a ballast. The ballast regulates the flow of current to the lamp, and uses energy. Therefore, a 400 watt high pressure sodium lamp, which might be used in a gym, actually draws 465 watts. A fixture using two-four foot 34 watt fluorescent lamps uses 78 watts. If you have questions, consult an electrician or a wholesale lighting supplier.

A. First, determine the number and wattage of incandescent lamps you want to replace. Let's say it's a gym with 24-500 watt incandescent lamps.

Total existing wattage = 24 fixtures x 500 watts/fixtures = 12,000 watts

B. Next, determine the number and wattage of the replacements fixtures (with assistance from an electrician or lighting supplier). Let's say you decide to use 24 - 175 watt metal halide lamps (210 watts including ballast). Note that, due to the new lamp's higher efficiency, the light level of the new system will equal that of the existing system.

total new wattage = 24 fixtures x 210 watts/fixtures = 5,040 watts

C. Now determine the annual hours of use, including clearing, evening activities, summer school, etc. In this case we'll use 1,600 hours.

D. Subtract the new system wattage from the existing system wattage, divide it by the 1,000 watt hours in a kilowatt hour, multiply times the hours per year, and you have kWh saved per year. Formula:

$$\frac{(\text{Existing system wattage} - \text{new system wattage})}{1,000} \times \text{hours/year} = \text{kWh saved}$$

$$\frac{(12,000 - 5,040)}{1,000} \times 1,600 \text{ hours} = 11,136 \text{ kWh saved per year}$$

E. Convert the kWh saved to btu.
kWh saved x 3,413 btu/kWh = btu/year saved
11,136 kWh x 3,413 btu/kWh = 38 million btu/year saved

F. Again, last but not least, the dollar savings:

kWh saved x $ per kWh = $ saved

<u>Example:</u>
11,136 kWh x $.06/kWh = $668.16 saved per year

VI. Pipe Insulation

If a school building has uninsulated steam and/or circulating hot water pipes, then these should be insulated (particularly if they are long pipe runs through uninsulated spaces). However, two other factors should be considered as well. First, many buildings are heated by constant temperature circulating hot water (often 180°). This type of system should be controlled by an exterior temperature sensor that adjusts the water temperature in response to the outside temperature. This is a very cost-effective retrofit and it's worth getting expert help to investigate it. Second, many buildings use a pump to circulate domestic (shower and kitchen use) hot water throughout the building. This pump should be shut off during unoccupied hours. This can be done manually or by an inexpensive timer.

A. For our example we'll use a school that is steam heated, with the pipes in a crawl space under the building or in tunnels around the perimeter. Note that if the pipes are in the heated space, then the heat lost from them is not wasted. The insulation is most worthwhile if the pipes are in an unheated space, so we recommend that you not waste time and resources unless the pipes are in an unheated area. Back to our example, we'll say the building has 400 feet of bare 2" steam line (low pressure).

   Note: Most steam systems use low pressure steam (approximately 5 pounds per square inch). For these cases, use the 225°F line on the chart.

B. Use the chart on page 14, and follow the instructions. Follow the 2" line across to the "None" line, up to the 225° line and left to 2,300 btu per hour per 10 feet of pipe. We have 40 ten-foot units, so the hourly heat loss is:

   40 x 2,300 btu/hour loss = 92,000 btu/hr loss

C. Let's say we'll add one inch of insulation. Repeat the above process from two inch pipe size over to the 1 inch insulation line, up to the 225° F line, and left to 400 btu per hour per 10 feet of pipe. The loss now is:

   40 x 400 btu/hour loss = 16,000 btu/hr loss

D. Subtract the heat loss of the insulated pipe from the existing heat loss. This is the heat saved.

   92,000 btu/hour loss
   \- 16,000 btu/hour loss
   76,000 btu/hour saved

E. Multiply the above savings times the annual hours of use to get btu saved per year. As our rule of thumb we'll use 4500 hours per year.

76,000 btu/hour x 4,500 hours/year = 342 million btu/year

F. Divide the above by furnace efficiency. Use 70% if you haven't had the heating unit analyzed.

342 million btu - .70 = 489 million btu/year saved

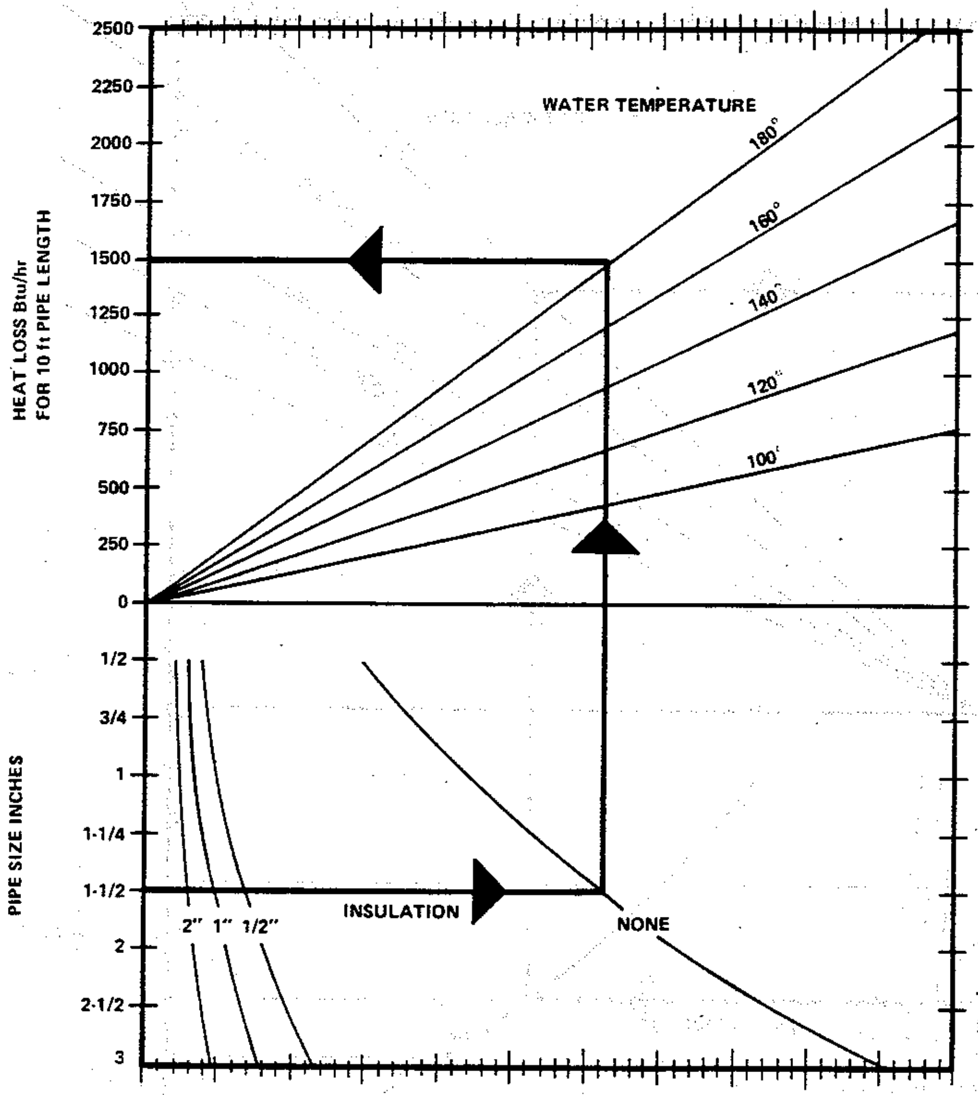
G. Divide the above by the btu in a unit of fuel. Let's say propane is the fuel, at 95,000 btu per gallon.

589 mbtu - 95,000 btu/gallon =
5,147 gallons of propane saved/year

H. Now multiply the gallons saved by the price per gallon and you have it:

5,147 gallons x $.65/gallon = $3,346 saved per year.

Summary: We added one inch of insulation to 400 feet of two inch low pressure steam line in a school with a propane fired boiler. This saved 489 million btus and $3,346 per year.



HEATING-HEAT LOSS FOR VARIOUS PIPE SIZES, INSULATION THICKNESS, AND WATER TEMPERATURES FROM 100°F TO 180°F

Instructions for use of Nomograph

1. Enter the nomograph on the lower vertical line at the pipe size in inches.

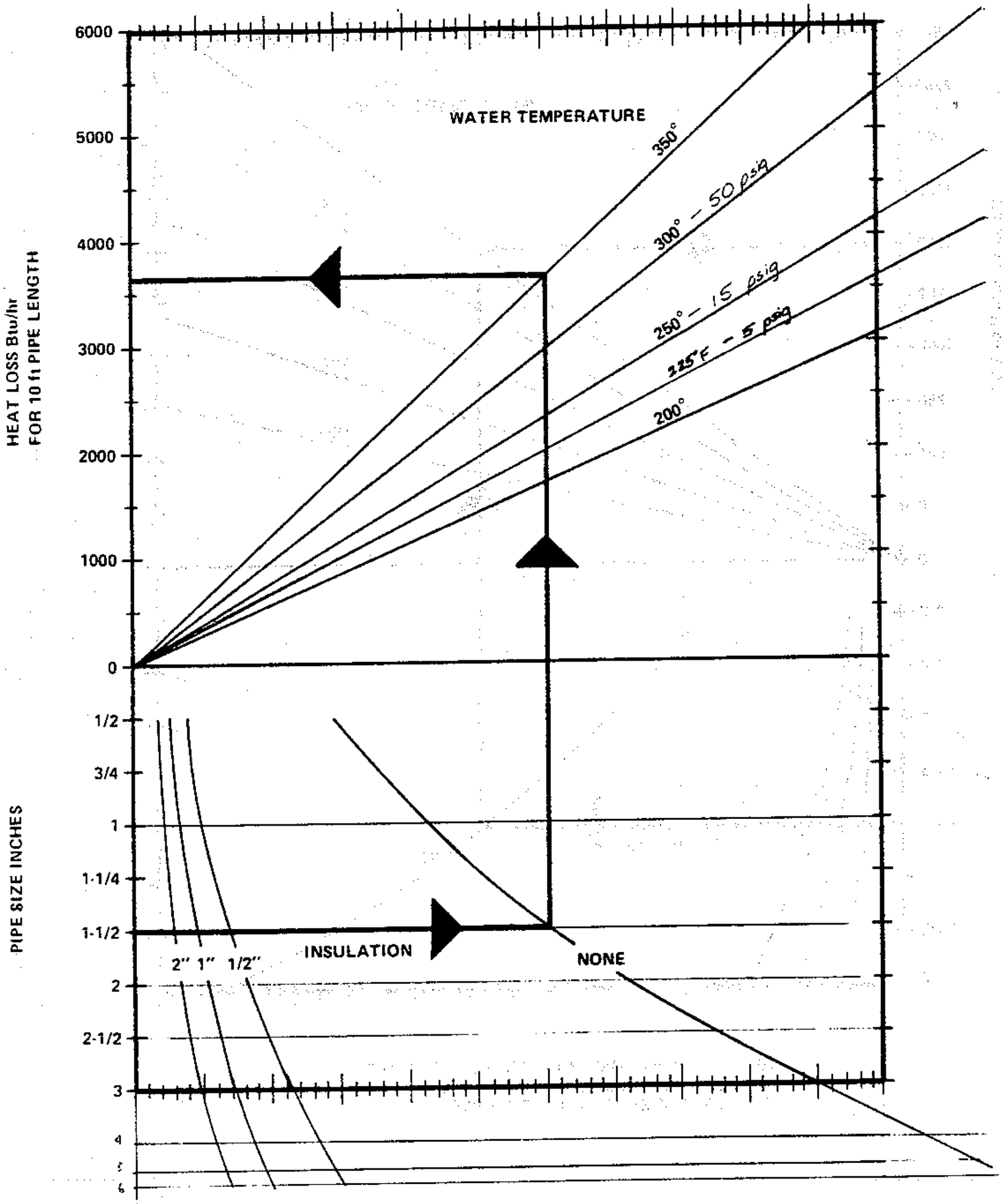
2. Proceed horizontally right to the intersection of the thickness of the insulation.

3. Proceed vertically upward at this intersection to the operating temperature line.

4. Proceed horizontally left to read the heat loss in Btu per hour per 10 foot of pipe length.

5. Multiply this by the pipe length and the number of operating hours per year to determine the annual heat loss.

6. Repeat this procedure for the added thickness of insulation and subtract to determine the annual savings per year by adding insulation.



HEATING-HEAT LOSS FOR VARIOUS PIPE SIZES, INSULATION THICKNESS, AND WATER TEMPERATURES FROM 200°F TO 350°F

Instructions for use of Nomograph

1. Enter the nomograph on the lower vertical line at the pipe size in inches.
2. Proceed horizontally right to the intersection of the thickness of the insulation.
3. Proceed vertically upward at this intersection to the operating temperature line.
4. Proceed horizontally left to read the heat loss in Btu per hour per 10 foot of pipe length.
5. Multiply this by the pipe length and the number of operating hours per year to determine the annual heat loss.
6. Repeat this procedure for the added thickness of insulation and subtract to determine the annual savings per year by adding insulation.

VII. BTU per unit of fuel:

1. Electricity: 3,413 btu per kilowatt hour

2. Natural Gas: 1,000 btu per cubic foot
100,000 btu per HCF or CCF
1,000,000 btu per MCF

3. Fuel Oil: 140,000 btu per gallon

4. Propane: 95,000 btu per gallon

Note that your application must include 12 months of your school's fuel consumption, shown month-by-month. If you have questions about your building's fuel usage and the units used, or don't have accurate records, contact your local utility or fuel supplier.

GLOSSARY

Ballast: an energy consuming device which must be used to start and operate fluorescent and high intensity discharge (HID) lamps (mercury vapor, metal halide, and high pressure sodium lamps).

British Thermal Unit or BTU: a unit of energy (the amount of energy required to raise the temperature of a pound of water one degree Fahrenheit)

Conduction: the movement of heat through a solid material. Heat moves from the interior of a building to the exterior, through the walls, by conduction.

COP (coefficient of performance): the ratio of useful energy output to energy input for a refrigerative device. Analogous to efficiency in combustion devices.

CFM (Cubic Feet Per Minute): the rate of air movement. Exhaust fans are rated in cfm, and the cracks around windows and doors allow so many cfm of cold air to be driven into the building by the wind.

Degree Days: a number which measures the difference between the indoor and outdoor temperatures over an entire heating season. The larger the number, the colder the climate. In Nebraska the number of degree days, based on a 30 year average, ranges from 5,426 in Pawnee City to 7,766 in Harrison.

Efficiency: the ratio of useful energy output to thermal energy input over a designated time (such as heating season), expressed in per cent. A gas furnace may have a 100,000 btu per hour output and a 125,000 per hour input, or an efficiency of 80%. Due to the effect of cycling on and off, the unit's seasonal efficiency might be 60 to 70%.

HCF (or CCF): 100 cubic feet of natural gas, (about 100,000 btu.)

Infiltration: the process by which outside air leaks into a building by natural forces through cracks around windows, doors, etc.

Kilowatt (kW): a unit of power (the rate at which energy is used) equal to one thousand watts.

Kilowatt Hour (kWh): a unit of energy. One kilowatt used for one hour is a kilowatt hour. A hundred watt light burning for 10 hours consumes 1 kWh.

Lineal Foot: a measurement of length, typically the measure of the crack around the windows and doors through which outside air can infiltrate. Rather than a measure of area or of the width of the crack, this is a measure of the length of the crack only.

MCF: 1,000 cubic feet of natural gas (about 1,000,000 btu)

R-Value: resistance to the flow of heat. The higher the R value, the better an insulator the material is.

Thermostat Setback: the lowering of the thermostat setting during unoccupied hours. Lowering the thermostat setting reduces the rate of heat loss from a building.

Ventilation: the intentional change of air by exhausting interior air and replacing it with fresh, outdoor air.

Watt: unit of measurement for electric power.

Table Ib: R-Values for Common Building Materials
(adapted from 1977 ASHRAE Handbook of Fundamentals)

This table may be used in determining insulating values for building components. The R-value of a material depends on its thickness—some values are listed for specific thicknesses; others are listed "per inch" and must be multiplied by the actual thickness of the material to determine the R-value. Manufacturer's measured R-values (using standard tests) may be substituted for the tabulated data where such information is available.

Description	Thickness	R
AIR SPACES (ENCLOSED)		
Ceiling		
Reflective surface	0.5 in.	1.29
	0.75 in.	1.35
	1.5 in.	1.45
	3.5 in.	1.58
Non-reflective surfaces	0.5 in.	0.84
	0.75 in.	0.77
	1.5 in.	0.80
	3.5 in.	0.84
Floor		
Reflective surface	0.5 in.	1.88
	0.75 in.	2.38
	1.5 in.	3.18
	3.5 in.	3.86
Non-reflective surfaces	0.5 in.	0.91
	0.75 in.	1.02
	1.5 in.	1.14
	3.5 in.	1.22
Wall		
Reflective surface	0.5 in.	1.84
	0.75 in.	2.01
	1.5 in.	1.84
	3.5 in.	1.89
Non-reflective surfaces	0.5 in.	0.90
	0.75 in.	0.94
	1.5 in.	0.90
	3.5 in.	0.91
BUILDING BOARD		
Boards, Panels, Subflooring, Sheathing		
Woodboard Panel Products		
Asbestos-cement board	per in.	0.25
Asbestos-cement board	0.125 in.	0.03
Asbestos-cement board	0.25 in.	0.06
Gypsum or plaster board	0.375 in.	0.32
Gypsum or plaster board	0.5 in.	0.45
Gypsum or plaster board	0.625 in.	0.56
Plywood (Douglas Fir)	per in.	1.25
Plywood (Douglas Fir)	0.25 in.	0.31
Plywood (Douglas Fir)	0.375 in.	0.47
Plywood (Douglas Fir)	0.5 in.	0.62
Plywood (Douglas Fir)	0.625 in.	0.77
Plywood or wood panels	0.75 in.	0.93
Vegetable Fiber Board		
Sheathing regular density	0.5 in.	1.32
	0.78125 in.	2.06
Sheathing intermediate density	0.5 in.	1.22
Nail-base sheathing	0.5 in.	1.14
Shingle backer	0.375 in.	0.94
Shingle backer	0.3125 in.	0.78
Sound deadening board	0.5 in.	1.35
Tile and lay-in panels, plain or acoustic	per in.	2.50
	0.5 in.	1.25
	0.75 in.	1.89
Laminated paperboard	per in.	2.00
Homogeneous board from repulped paper	per in.	2.00

Description	Thickness	R
Hardboard		
Medium density	per in.	1.37
High density, service temp. service underlay	per in.	1.22
High density, std. tempered	per in.	1.00
Particleboard		
Low density	per in.	1.85
Medium density	per in.	1.06
High density	per in.	0.85
Underlayment	0.625 in.	0.82
Wood		
Subfloor	0.75 in.	0.94
BUILDING MEMBRANE		
Vapor-permeable felt		0.06
Vapor-seal, 2 layers of mopped 15-lb felt		0.12
Vapor-seal, plastic film		Negl.
FINISH FLOORING MATERIALS		
Carpet and fibrous pad		2.08
Carpet and rubber pad		1.23
Cork tile	0.125 in.	0.28
Terrazzo	1 in.	0.08
Tile-asphalt, linoleum, vinyl, rubber		0.05
Wood, hardwood finish	0.75 in.	0.68
INSULATING MATERIALS		
BLANKET AND BATT		
Mineral fiber, fibrous form processed from rock, slag, or glass		
approx.	2-2.75 in.	7
approx.	3-3.5 in.	11
approx.	5.5-6.5 in.	19
approx.	6-7 in.	22
approx.	8.5 in.	30
BOARD AND SLABS		
Cellular glass	per in.	2.63
Glass fiber, organic bonded	per in.	4.00
Expanded rubber (rigid)	per in.	4.55
Expanded polystyrene extruded		
Cut cell surface	per in.	4.00
Expanded polystyrene extruded		
Smooth skin surface	per in.	5.00
Expanded polystyrene extruded		
Smooth skin surface	per in.	5.26
Expanded polystyrene, molded beads	per in.	3.57
Expanded polyurethane		
(R-11 exp.)	per in.	6.25
Mineral fiber with resin binder	per in.	3.45
Mineral fiberboard, wet felted		
Core or roof insulation	per in.	2.94
Acoustical tile	per in.	2.86
Acoustical tile	per in.	2.70
Mineral fiberboard, wet molded		
Acoustical tile	per in.	2.38
Wood or cane fiberboard		
Acoustical tile	0.5 in.	1.25
Acoustical tile	0.75 in.	1.89

Description		R
Interior finish		
(plank, tile)	per in.	2.86
Wood shredded		
(cemented in preformed slabs)	per in.	1.67
LOOSE FILL		
Cellulosic insulation		
(milled paper or wood pulp)	per in.	3.13-3.70
Sawdust or shavings	per in.	2.22
Wood fiber, softwoods	per in.	3.33
Perlite, expanded	per in.	2.70
Mineral fiber (rock, slag or glass)		
approx.	3.75-5 in.	11
approx.	6.5-8.75 in.	19
approx.	7.5-10 in.	22
approx.	10.25-13.75 in.	30
Vermiculite, exfoliated	per in.	2.13
MASONRY MATERIALS (All Values Per Inch)		
Concretes		
Cement mortar		0.20
Gypsum-fiber concrete 87.5% gypsum, 12.5% wood chips		0.60
Lightweight aggregates		
including expanded shale, clay or slate		0.19
expanded slags		0.28
cinders		0.40
pumice		0.59
vermiculite		0.86
also cellular concretes		1.11
		1.43
Perlite		
expanded		1.08
		1.41
		2.00
Sand and gravel or stone aggregate		
(oven dried)		0.11
Sand and gravel or stone aggregate		
(not dried)		0.08
Stucco		0.20
MASONRY UNITS		
Brick, common	per in.	0.20
Brick, face	per in.	0.11
Clay tile, hollow		
1 cell deep	3 in.	0.80
1 cell deep	4 in.	1.11
2 cells deep	6 in.	1.52
2 cells deep	8 in.	1.85
2 cells deep	10 in.	2.22
3 cells deep	12 in.	2.50
Concrete blocks, three oval core:		
Sand and gravel aggregate	4 in.	0.71
	8 in.	1.11
	12 in.	1.28
Cinder aggregate	3 in.	0.86
	4 in.	1.11
	8 in.	1.72
	12 in.	1.89
Lightweight aggregate	3 in.	1.27
(expanded shale, clay, slate	4 in.	1.50
or slag; pumice)	8 in.	2.00
	12 in.	2.27
Concrete blocks, rectangular core		
Sand and gravel aggregate		
2 core, 8 in. 36 lb.		1.04
Same with filled cores		1.93

Description		R
Lightweight aggregate (expanded shale, clay, slate or slag, pumice):		
3 core, 6 in. 19 lb.		1.65
Same with filled cores		2.99
2 core, 8 in. 24 lb.		2.18
Same with filled cores		5.03
3 core, 12 in. 38 lb.		2.48
Same with filled cores		5.82
Stone, Lime or sand	per in.	0.08
Gypsum partition tile		
3 x 12 x 30 in. solid		1.26
3 x 12 x 30 in. 4-cell		1.35
4 x 12 x 30 in. 3-cell		1.67
PLASTERING MATERIALS		
Cement plaster		
Sand aggregate	per in.	0.20
Sand aggregate	0.375 in.	0.08
Sand aggregate	0.75 in.	0.15
Gypsum plaster		
Lightweight aggregate	0.5 in.	0.32
Lightweight aggregate	0.625 in.	0.39
Lightweight agg. on metal lath	0.75 in.	0.47
Perlite aggregate	per in.	0.67
Sand aggregate	per in.	0.18
Sand aggregate	0.5 in.	0.09
Sand aggregate	0.625 in.	0.11
Sand aggregate on metal lath	0.75 in.	0.13
Vermiculite aggregate	per in.	0.59
ROOFING		
Asbestos-cement shingles		0.21
Asphalt roll roofing		0.15
Asphalt shingles		0.44
Built-up roofing	0.375 in.	0.33
Slate	0.5 in.	0.05
Wood shingles, plain and plastic film faced		0.94
SIDING MATERIALS (ON FLAT SURFACE)		
Shingles		
Asbestos-cement		0.21
Wood, 16 in. 7.5 exposure		0.87
Wood, double, 16-in, 12-in exposure		1.19
Wood, plus insul. backer board	0.3125 in.	1.40
Siding		
Asbestos-cement, 0.25 in., lapped		0.21
Asphalt roll siding		0.15
Asphalt insulating siding (0.5 in. bed)		1.46
Hardboard siding	0.4375 in.	
Wood, drop, 1 x 8		0.79
Wood, bevel, 0.5 x 8 in., lapped		0.81
Wood, bevel, 0.75 x 10 in., lapped		1.05
Wood, plywood, 0.375 in., lapped		0.59
Aluminum or Steel, over sheathing		
Hollow-backed		0.61
Insulating-board back nominal	0.375 in.	1.82
Insulating-board backed nominal 0.375 in., foil backed		2.96
Architectural glass		0.10
WOODS		
Maple, oak, and similar hardwoods	per in.	0.91
Fir, pine, and similar softwoods	per in.	1.25
Fir, pine, and similar softwoods		
	0.75 in.	0.94
	1.5 in.	1.89
	2.5 in.	3.12
	3.5 in.	4.35

Nebraska Heating Degree Day Normals

NOAA - 30 year averages

Station	HDD	Station	HDD
Ainsworth	6726	Hay Springs	7189
Albion	6796	Hebron	6010
Alliance	6946	Holdrege	5926
Alma	5753	Imperial	6122
Arthur	6902	Kearney	6467
Ashland	6197	Kimball	6723
Atkinson	6825	Lexington	6309
Auburn	5636	Lincoln	6218
Beatrice	5819	Lodgepole	6233
Beaver City	5647	Loup City	6541
Benkelman	5766	Madison	6586
Big Springs	6368	Madrid	6179
Blair	6437	McCook	5714
Box Butte	7269	Merriman	6955
Bridgeport	6434	Minden	6002
Broken Bow	6740	Mitchell	6907
Burwell	7042	Mullen	6546
Butte	6886	Norfolk	6981
Cambridge	5893	North Loup	6545
Central City	6197	North Platte	6743
Chadron	7031	Oakdale	6920
Clarkson	6582	Ogallala	6446
Clay Center	5998	Omaha (North)	6601
Columbus	6297	O'Neill	6960
Crete	5922	Osceola	6317
Culbertson	6108	Oshkosh	6501
Curtis	6115	Pawnee City	5426
David City	6261	Purdum	6657
Ewing	6919	Ravenna	6261
Fairbury	5986	Red Cloud	5859
Fairmont	6086	St. Paul	6359
Falls City	5475	Scottsbluff	6774
Fort Robinson	7025	Seward	6063
Franklin	5732	Sidney	6564
Fremont	6117	Stanton	6677
Geneva	6084	Stapleton	6650
Genoa	6320	Syracuse	5961
Gordon	7306	Tecumseh	5890
Gothenburg	6139	Tekamah	6330
Grand Island	6420	Valentine	7300
Halsey	6684	Wakefield	6860
Harrison	7766	Walthill	6843
Hartington	6827	Weeping Water	6056
Hastings	6070	West Point	6602
Hayes Center	6284	York	6082