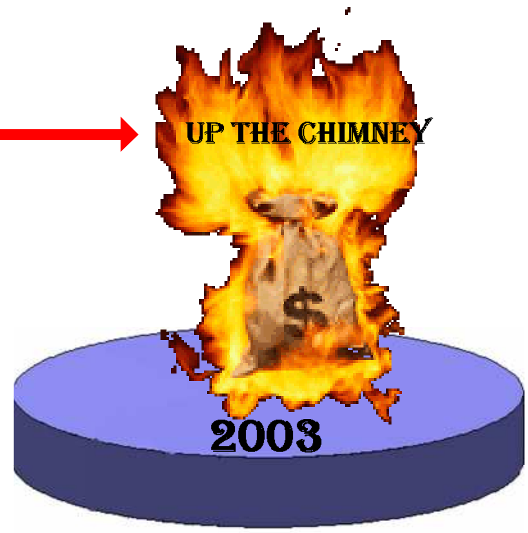
RURAL ALASKA ENERGY MANAGEMENT EFFICIENCY RECOMMENDATION FOR OIL FIRED BOILERS

Author: Jerry Nicholson - 2003

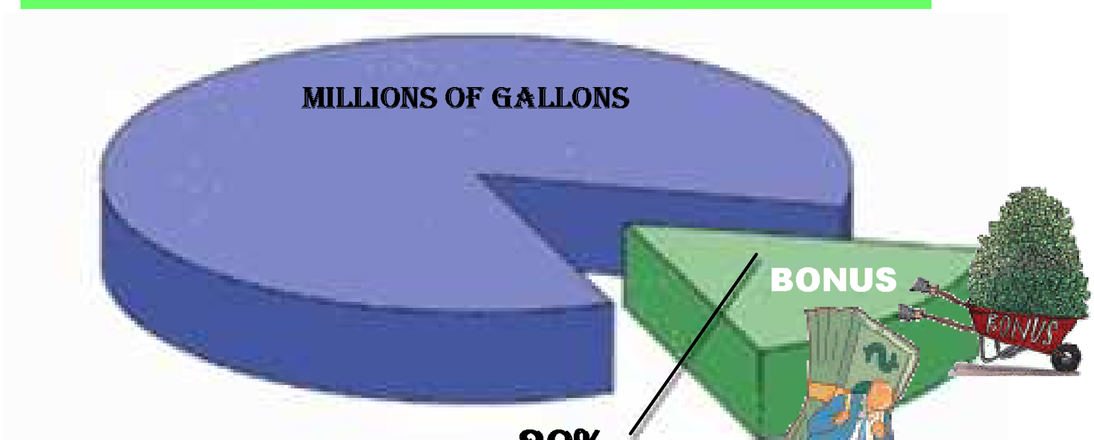
CLINICS
SCHOOL DISTRICTS
WATER TREATMENT PLANTS
INDIAN HOUSING APT COMPLEX'S
CITY & MULTI-PURPOSE BUILDINGS



CURRENT CONDITIONS

ENERGY MANAGEMENT FOR BOILERS

HEATING OIL USAGE & POTENTIAL COST SAVINGS



20%
MINIMUM REDUCTION
ONE YEAR PAYBACK

HEATING OIL IN RURAL ALASKA

DOCUMENTATION OF ACTUAL PROOF OF 20% TO 40% SAVING OF HEATING OIL IN RURAL ALASKA

NUSHAGAK CONSULTANTS
225 EAST FIREWEED LANE
ANCHORAGE, ALASKA 99503
907 277 1864

INTRODUCTION – COMPANY OVERVIEW

Jerry Nicholson, the founder and owner of Nushagak Consultants has provided commercial construction services to rural (bush) Alaska public and private sectors for more than 30 years.

A lifetime Alaska Native raised in rural Alaska, Mr. Nicholson has been an active participant in the design and installation (**Design-Build**) of many rural Alaska new construction and renovation modernization projects. With this extensive project experience, he also has completed many **Bid Contract** projects.

In construction business travels Mr. Nicholson feels at home when visiting villages due to an unique understanding of rural Alaska cultural lifestyles. This insight is derived in part from living and ancestry dating back to the 1800's in rural Alaska.

Captain Jerry Nicholson commercial fished Bristol Bay from 1959 to 1982

Mr. Nicholson leads Nushagak Consultants with the following qualifications:

- PROFICIENT IN ENERGY AND PREVENTATIVE MAINTENANCE MANAGEMENT FOR BUILDING FACILITIES
- JOURNEYMEN ELECTRICIAN AND PLUMBER
- JOURNEYMEN FINISH AND ROUGH CARPENTER
- ALASKA STATE MECHANICAL ADMINISTRATOR (Master Plumbing & Heating License)
  - Trade Categories licensed in:
    - Unlimited Commercial and Industrial Plumbing
    - Unlimited Commercial Ventilation – Sheet metal – Temperature Controls
    - Commercial Heating, Cooling and Temperature Controls
    - Residential Plumbing and Hydronic Heating
    - Residential Heating – Cooling - Ventilation
- EQUIVALENT MASTER DEGREE IN CONSTRUCTION BUSINESS ADMINISTRATION

In the following photos of qualifications of completed projects, Mr. Nicholson has trained many rural Alaska Natives enabling some to move forward into better positions or obtain a journeymen license.

The pictorial also delineates Mr. Nicholson's professionalism and understanding of rural Alaska building techniques and he has earned a reputation for comprehensive, thorough and conscientious workmanship. Clients value his rural knowledge, business persona, individualized and efficient service.

FY 2003

RURAL ALASKA ENERGY MANAGEMENT
EFFICIENCY RECOMMENDATION
FOR OIL FIRED BURNERS

prepared for

State of Alaska

Design Engineers

Alaska Energy Authorities

Facility Owners and Managers

prepared by

Jerry Nicholson, M.A.

Nushagak Consultants

225 East Fireweed

Anchorage, Alaska 99503

jerrynicholson@alaska.net

907 277 1864

Questions? Feel free to e-mail or call Jerry

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RURAL ALASKA ENERGY MANAGEMENT EFFICIENCY RECOMMEDATION FOR OIL FIRE BOILERS

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"ENERGY MANAGEMENT PAYBACK"

1. INTRODUCTION

Throughout rural Alaska oil fired boilers operate year around at their highest set point temperature (180-200 degree's). When it is 70 degrees outside air temperature, the boilers continue to burn oil just to maintain boiler high set point temperature (even if there is no heat loss from the facility being served). In the winter, because of storage in above ground outside oil tanks, cold oil temperature has such a drastic effect on oil fired heating equipment; it shows this often by the blackened chimney (on the roof) caused by soot from a malfunctioning oil burner. The author of this report has observed "wasted fuel oil conditions" in rural Alaska.

The purpose for this report is to recommend to designing engineers, owners/managers the importance of installation of appurtenances on oil fired equipment that minimizes wasted fuel oil and cold oil temperature conditions. The result is significant; e.g., *substantial fuel oil savings is to be realized from oil burners that are used for boilers and furnaces in rural Alaska (15% to 30% plus of fuel costs). An improvement bonus is that electricity is saved and oil fired equipment will last longer with lower maintenance and man-hour expense.*

Since 1965, the author has designed, installed and maintained oil fired heating systems in western and northern areas of Alaska. Currently he continues to hold a State of Alaska Mechanical Administrator's license whose qualifications also include the following: Building Heat Loss to calculate heating load requirements for low pressure hydronic boilers and heat emissions units (baseboard,etc); Oil fired burners and oil pumps; Single/two pipe oil systems; Monoflow, direct return, reverse return, and loop hydronic circuits, primary/secondary controls, heating circulator pump GPM flow requirements, heating pipe sizing and pressure drops, relative water velocities, pumping heads/static pressure, Heating system curves, and control valve CV ratings; Mechanical drafting and layout; Automatic temperature controls and electrical wiring.

The author's knowledge and experience has been derived in part from relationship with the following: Bell & Gossett, ITT Industries, Johnson Controls Incorporated, Controls Systems International, Alaska Professional Engineers, Master heating mechanics and Anchorage Community College. Since 1990 he designed and installed automatic energy saving controls for oil fired boilers in rural Alaska with 22% to 40% in fuel oil savings.

As a member of the heating discipline profession, the author has become aware of important additions to oil fired heating systems that improves performance and saves fuel oil for consumers. The additions are described in the following paragraphs.

1.1 THE INSTALLATION OF A PREHEAT OIL DAY TANK FOR COLD OIL (Below 32F)

Oil burner nozzles characteristics are factory-checked with No.2 fuel oil, 34 to 36 SSU fixed flow properties (viscosity) at 100F. The fuel oil industry reports that fuel oil supplied for oil burners has a viscosity which scarcely alters for temperature changes above 32F. Combustion will therefore not alter significantly as long as oil temperature is held above 32F. Certain problems can occur on oil fired equipment where the oil tank may be exposed to temperatures lower than 32F. An above ground outdoor fuel oil tank for example can easily become quite cold so that the oil thickens enough to change the atomizing pattern of the nozzle. As the temperature of No. 2 fuel decreases the viscosity increases.

A change such as this (oil thickens), will result partly in oil droplets becoming bigger thus making the oil burner flame longer and more "sluggish" in burning. It also increases nozzle output resulting in smokier burner operation, the end result of which is soot caked in the combustion chamber and flue, (e.g. Blackened chimney described in Introduction). *Tests have shown that a soot layer just 0.03 inch thick reduces heat transfer by 9.5% and a 0.18 inch layer by 69%! As a result, more heating fuel oil is burned.*[1]

The significant correction to this problem is the addition of a preheat device and/or placement of an inside oil day tank to preheat the "cold" oil. This can maintain consistent viscosity of the fuel to within acceptable range, improve atomization and reduce nozzle fuel flow rate, (see appendix *"Nozzle Knowledge"* showing viscosity).

[1] Improving Energy Efficiency - Natural Resources Canada - Office of Energy Efficiency

1.2 THE INSTALLATION OF AN ENERGY MANAGEMENT AUTOMATIC CONTROLLER

Many boiler plants have simple outdoor reset controls; some only have conventional manual controls which essentially tell the boiler that the supply temperature of the boiler water or glycol is hot or cold. More sophisticated Direct Digital Controls (DDC) provide much more precise control and *save significant amounts of money*. The DDC have logic to anticipate what the water temperature of the boiler supply water should be according to outside air temperature and computation of trends to meet building heating loads. This makes for a more accurate and constant supply hot water temperature without large boiler temperature swings that is typical of conventional manual controls that waste energy and fuel oil. Direct Digital Controls are also part of the strategy of preventing boilers from rapid cycling, like starting and stopping your car repeatedly, this wastes money. The benefits in the use of DDC automatic boiler controls are: *"Less fluctuation of indoor temperature; Reduced expansion noises; Reduced possibility of thermal shock; Nearly constant water circulation and; Reduced fuel usage"*.[2]

Through observation of facilities in rural Alaska, the author noticed oil-fired boilers operating on simple outdoor reset and conventional manual temperature controls. The manual temperature controls were set at 180 to 200 degrees year around. In "*Energy Management for Boilers*", (a supplement to this report), the author describes further the results of the large of amount of fuel wasted when conventional manual temperature controls are set high year around. On page two of the supplement, pictures delineate building heat loss and the amount of BTU's needed to heat a building based on different outside air temperatures.

In summary, when the boiler set point temperature is automatically set back to burn only enough fuel to maintain building heat loss; *fuel oil is saved*. As an example, when its 70 degrees outside air temperature, the automatic boiler controller will shut the boiler down, when the outside air temperature is 30F degrees the boiler controller will automatically set the boiler water or glycol supply temperature to 150 degrees. This results in the boiler burner running less with less fuel oil consumption and electricity is saved. Therefore, the big and necessary correction to wasting fuel oil in rural Alaska and *saving significant dollars* is the addition of an automatic boiler controller that works in conjunction with the existing conventional manual controls.

1.3 CONCLUSION

Because of today's oil heating prices in rural Alaska, there is huge fuel oil savings in heating by the addition of a preheat oil day tank and an automatic temperature boiler controller. Payback for installing automatic controls on a boiler and a preheat day tank has a one to two year payback on the initial capital investment. The payback would be certain, but it varies depending upon building circumstances surrounding the installation. In *"Energy Audits Have Proven Paybacks"* report, the author performed an energy audit for Markair Airlines in 1992, and in an actual automatic boiler control installation saved Markair 40% of fuel costs; exactly what the average projected savings should be according to the audit. In 2001, an automatic control installation resulted in a one year payback for the Bethel Moravian Church in Bethel, Alaska.

[2] PM Engineer Magazine John Siegenthaler, P.E. February 27, 2001 Outdoor Reset Control

2. ENERGY MANAGEMENT FOR BOILERS (Automatic Controls)

Before getting into technical details about how automatic boiler control works, it's important to explain how your boiler, home or commercial building and the Outside Air Temperature (OAT) should work in harmony with each other. If all components are working together you will have 18% to 30% "savings or more; that's Energy Management!" Here is how it works:

If your house or commercial building has a lot of air leaks (windows, doors, heavy traffic, etc.), not insulated properly, the boiler will run excessively. Boilers that run 365 days of the year, with a constant set point temperature of 190F to 200F waste a tremendous amount of fuel. Especially, on days when the Outside Air Temperature (OAT) is warm, building heat demand and heat loss is low.

Boilers three years or older that have not been cleaned causes a percentage of fuel oil used to go right up the stack with no effect in providing BTU's needed to heat the water or glycol. Secondly, many older oil burners are not energy efficient since they run at 60% efficiency. New burners are now available that have 85% efficiency or more.

Another important factor of old boilers, minerals in water over a period of time will cake on the inside water jacket of the boilers. This causes longer burner on cycle because the caking prevents the water/glycol to heat properly. Recommended is using rain water to help prevent this from happening.

Mentioned are BTU's (British thermal unit). BTU's is how we measure the quantity of energy. Examples are: if you burn one (1) gallon of # 2 fuel oil in your boiler per hour, 140,000 Btu's is generated. Building heat loss is also measured in BTU's.

Figure "A" (below) and pictures following (diagram 2.1) are four interesting and separate scenarios in boiler set point temperature by Outside Air Temperature (OAT) change. The home selected is a 1200 sq ft and is built off of the ground on pilings. The under floor has a plywood soffit. 90 feet of baseboard is needed to meet building heating demand. Heat loss calculations are based on these Coefficients of Transmission ("R"& "U" factors):

- ✓ R-24 WALLS: 2x6 wood studs; T1-11 siding; 6" R-19 insulation; vapor barrier; 1/2" sheetrock
- ✓ R-38 CEILING: 12" insulation; vapor barrier; 1/2" sheetrock
- ✓ R-22 FLOOR: 1-1/8" plywood; TGI's; carpet; 6" insulation; 1/4" plywood soffit
- ✓ U-2.07 DOORS & WINDOWS: 2 ea insulated metal doors; 6ea 3x4 wood frame double pane windows (U-2.07).

The baseboard radiation chosen for this scenario is 3/4" residential manufactured by Weil-Mclain. With 65F entering air the radiation has an output of 630 Btu's per linear foot at 190F average degree water temperature. As the building heat loss demand lowers, the radiation has lower output to meet demand.

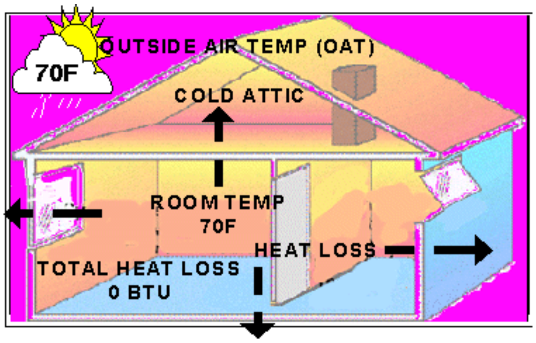
DO NOT USE THE TOTAL HEAT LOSS BTU's FOR THIS HOUSE TO CALCULATE YOUR BOILER. Other factors are added to these calculations. The total heat loss shown is for building demand only.

FIGURE A: BOILERS WITH AUTOMATIC CONTROL

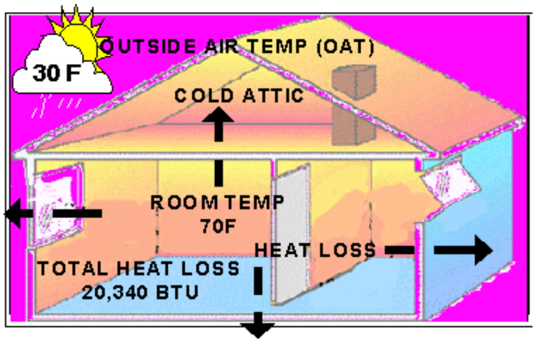
OAT	HEAT LOSS	BASEBOARD BTU OUTPUT	BOILER TEMP
+70 F	ZERO	ZERO	ZERO
+30 F	20,028 BTU	31,500 BTU	150 F
-10 F	41,112 BTU	45,900 BTU	170 F
-25 F	49,018 BTU	51,300 BTU	200 F

2.1 DIAGRAM EXAMPLES

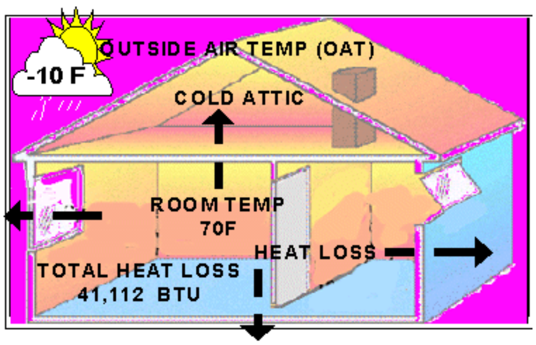
Heat Loss & Boiler Set Point Temperature



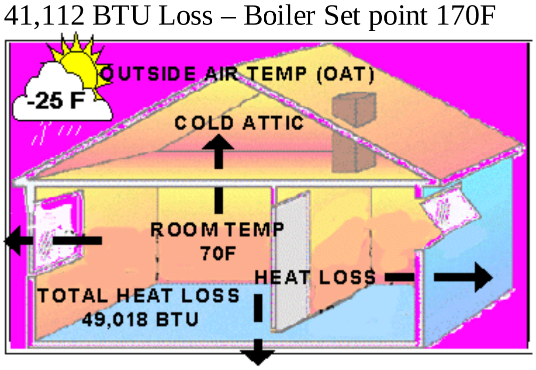
Plus +70 F above Zero
0 Heat losses – BOILER OFF



Plus +30 F above Zero
20, 840 BTU Loss – Boiler Min set: 140F



Minus -10 F below Zero
41,112 BTU Loss – Boiler Set point 170F



Minus - 25 F below Zero
48,018 BTU Loss – Boiler set point 200F

Boilers that are manually (conventional controller) set at 190F/200F with the Outside Air Temperature (OAT) above 65F are using excessive amount of fuel oil, needlessly. Over an extended warm spell, this amounts to wasted expense and energy.

When the OAT reaches 30F, -10F etc., boilers need to supply only enough BTU to meet house heating demand. Let's discuss this a little further:

If the OAT is 30F and the house heating demand only needs 20,000 BTU to maintain 70 degrees F house temperature, the boiler only needs to supply enough heat to meet that demand. In the diagram (+30), the house needs 20,340 BTU, the 90 feet of baseboard has an output of 31,500 BTU. The boiler can supply that output at 150 degree set point temperature.

In rural Alaska there are two typical installations to wire Thermostats to the boiler:

1. Zone controls are wired directly to end switches to control the circulator to make the boiler independent. The Honeywell controller is jumpered at the TT to provide a 10 to 20 degree differential from boiler set point temperature. In other words: If the boiler is set to shut down at 190 degrees the on cycle would be at 180F or 170F
2. Thermostats are wire to zone valves than directly to the boiler controller. In this case when thermostats are not calling for heat, the controller goes to its low setting of 140 degrees. As long as the T-stat is on, the boiler will continue to operate to its high point set point temperature. This in most cases is 200 degrees.

In both cases, if the boiler is set to shut down at 200 degrees F and the building heat demand only calls for 150 degree water to meet the demand, it makes sense to heat the boiler to 150 degrees than to 200 degrees. *Shorter run times save oil and electricity*. Remember water heats faster than glycol.

The house shown is assumed that domestic hot water is provided by another source. Otherwise at 70 degree Outside Air Temperature (OAT) with domestic hot water supplied by the boiler, automatic set point temperature would be 140 degrees to maintain domestic water temperature.

On the next page, Markair saved 40% in fuel oil costs in 1991 and the Bethel Moravian Church 18% plus in FY 2000.

2.2 BETHEL MORAVIAN CHURCH – BETHEL, ALASKA

In FY 2000 an automatic temperature controller was installed for the boilers for the Bethel Moravian Church, a 10,000 sq ft building. They had a fuel oil savings of 18% from February 2000 to 2001. This was based on fuel oil used in the same period in 1999 to 2000. In reality, the savings are much higher because in 1999 there was no air handling units installed in 1999. The air handlers were installed in the month of February 2000. This added an extra heating load to the boilers, which was not present in 1999.

Further, the Moravian Church is a brand new building. The building walls and ceiling were sprayed with 6" of urethane creating a high R-value and tightness (air leaks). Also the main seating area of the church is protected by heated offices that are on the perimeter of the building.

2.3 MARKAIR TERMINAL AND CARGO FACILITY - KING SALMON, ALASKA

Markair's 22,000 sq ft airline terminal achieved 40% in fuel oil savings, after an Automatic Temperature Controller was installed for the boilers in 1991. The reason for the large amount of savings was:

- ❖ Night set back was installed on all of the thermostats
- ❖ In the entry's, thermostats were automatically turned off at a designated time and turned back on at 6am.
- ❖ Cargo doors were monitored, after 20 minutes opening, an alarm notified personnel to shut the doors.

2.4 FREQUENTLY ASKED QUESTIONS

<u>What type of facilities can automatic controllers be installed in</u>?

Automatic Controllers can be installed in:

- ♦ Residential Homes - Apartment and Commercial Buildings
- ♦ Village Water and Sewer projects or existing

Comment: In travels throughout the state of Alaska in villages, various water treatment plants were visited that houses the boilers that preheat the water for the circulating water system. In observations, boilers were set at 190 degrees all the time, even in the summer. This is an excellent tool for cities and villages that have to preheat their water. It saves a tremendous amount of money.

<u>Is it affordable</u>?

CERTAINLY, the cost of new technology has really come down in the last seven (7) years (compare the price of computers back in 1995 to now). Your capital investment starts paying you back right away. Depending upon your application, you should receive a payback in one (1) year or less. Savings and CD accounts don't have that type of payback.

<u>What about electrical brownouts and spikes?</u>

The author has been involved in the installation of these types of automatic controls for the last twelve (12) years in Alaska (Bethel, Barrow, Deadhorse, Kodiak, Chevak, Aleknagik and Pilot Station). Never in the last twelve years has he seen a controller destroyed from electrical spikes or brown outs. Technology is not like the old days.

2.4 FREQUENTLY ASKED QUESTIONS (continue)

What about the existing conventional manual controls on boilers?

In the installation of an automatic DDC controller, existing controls on the boilers are not removed. In other words: If the automatic controller is shut off, the existing conventional boiler controls supplied by the boiler manufacturer will take over. The manual secondary high limit controller is always in control to shut down if the boiler goes above the high limit setting.

Does the automatic controller need adjustment all the time?

Absolutely not!! Once the controller is programmed upon installation, nothing more needs to be done. The controller is a stand alone system.

Cold weather versus Warm weather?

Naturally, money is not saved if it is 25 below from October to February all the time. However, at 10pm if it's 25 below and at 3am it warms to 30 degrees above zero, automatic control saves money.

An exceptionally warm winter like 2000-2001 brings the most savings. The big savings is in the spring, summer and fall.

What else can be done to save on heating oil?

1. Do not use 100% FDA approved glycol in the boiler. Mix to meet weather conditions

2. Inspect the boiler to see if it is clean, look into the burner chamber with a flashlight. If there is carbon build up on sections of the boiler, it needs cleaning. Look at the boiler maintenance manual for instructions

3. As mention earlier, cold oil during cold winter months becomes thick, is hard to burn and causes the burner nozzle not to spray correctly. If you are on a two pipe system you will notice ice or frost on the oil lines and filter in the building, this is caused by extreme cold oil. The author never installs a two pipe system in cold regions except on an inside preheat day tank for commercial applications. For residential, a one pipe system with a large filter canister inside for preheat and a tiger loop system for bleeding the air is recommended.

4. If the boiler is over fifteen years old and the sections (inner water jacket) and (outer flue jacket) have not been cleaned in all those years, it should be replaced.

5. Set back thermostats to 68F at night.

3. ENERGY AUDITS HAVE PROVEN PAYBACKS

In 1992, the author performed energy analysis and cost saving audits for heating oil and electrical usage on selected commercial buildings in Barrow, Deadhorse, Fairbanks, King Salmon and Kodiak. The following is an excerpt from the executive summary completed for Markair Incorporated in 1992:

The cost savings are conservative due to limited historical information on some subject buildings (The numbers for King Salmon are more accurate because direct digital controls installed by NMI in 1990 monitored actual fuel consumption by computer).

The buildings audited by are typical and similar in nature to other public & private buildings in bush Alaska. These audits, based on combined historical and estimated data show energy costs have run: $3.50 sq. ft.

Studies by government / private agencies, Rural Cap, North Slope Borough, and F.R.E. Roen indicate similar commercial buildings should have an energy cost of approximately: $2.15 per sq. ft to $3.75 per sq. ft (depending on location) with an average of approximately $2.60 per sq. ft.

A wide variety of savings can be realized by the installation of process management, automatic temperature and Direct Digital Controls (DDC). Rural Cap, North Slope Borough and energy conservation firms indicate expected savings in electrical usage of 10% to 28% (average 16%), and on heating 14% to 56% (average of 34%). (Note: These studies were done with conventional mechanical controls installed, and additional savings should be expected by installing DDC).

Assuming an average split of energy costs of 43% for heating oil and 57% for electrical (Rural Cap studies); the buildings audited should expect an average of 24% energy saving (see Markair Historic data chart). Using some limited historical information on a few selected buildings shows the energy cost split to be slightly different than Rural Cap estimates. This is to be expected however, due to changes in fuel costs, etc., since the 1988 studies by Rural Cap.

When applied to these specific buildings audited, the average cost becomes more meaningful:

- Fairbanks --------- 25% or $40,500 per year
- Deadhorse -------- 28% or $21,600 per year
- King Salmon ----- 22% or $13,800 per year
- Kodiak ------------ 22% or $ 9,900 per year
- Barrow ------------ 28% or $14,300 per year

Total Estimated Electrical and Heating Oil Savings per Year ---------- $100,100.00

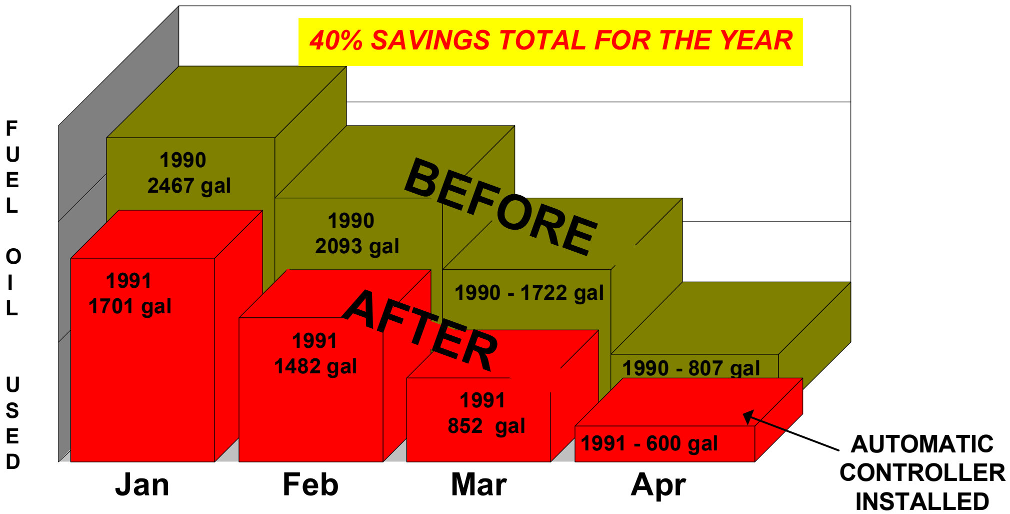
These numbers are estimates based on data gathered by statewide organizations and supplemented with the available historical data the subject buildings owner could supply. However, the actual installation of Direct Digital Control (DDC) in King Salmon (1991) has reduced fuel consumption by 35% over the first four (4) months of operation with 40% achieved over a one year period....exactly what the average projected savings should be according to these studies.

These projected savings indicated a PAYBACK PERIOD of two to three years, depending on location, with an expected average of 2.5 years. The North Slope Borough studies show an expected return of two years or less, while Rural Cap indicates two or three years.

2003 UPDATED NOTICE

The survey discussed above was done in 1992, it shows that payback has been reduced to a year payback depending upon circumstances. In the year 2001, the Bethel Moravian Church in Bethel, Alaska realized a one year payback.

ENERGY MANAGEMENT PAYBACK IS A FACT



ACTUAL FUEL OIL CONSUMPTION for 1990 &1991
KING SALMON ALASKA

950,000 BTU Oil fired hydronic boilers with direct digital control installed by Jerry Nicholson in MarkAir's 22,000 sq ft Building in King Salmon Alaska

ENERGY MANAGEMENT

1991

THE PAYBACK

DIRECT DIGITAL CONTROL WAS INSTALLED BY NMI IN LATE 1990 TO MONITOR & CONTROL THE BOILERS, CIRCULATORS, BASEBOARD RADIATION, CABINET/HORIZONTAL UNIT HEATERS & AIRHANDLER. THE RESULT OVER A FOUR MONTH PERIOD OF DOCUMENTATION IN 1991 , WAS A 35% SAVINGS IN FUEL OIL.

THE YEAR 1991; 40% IN FUEL SAVINGS WAS ACHIEVED.

THE BOILERS FUEL CONSUMPTION WAS MONITORED VIA COMPUTER FOR ACTUAL USAGE AS WELL AS MANUALLY CHECKING THE GALLONS USED. THE AVERAGE OUTSIDE AIR TEMPERATURE FOR BOTH YEARS, 1990 & 1991, WAS THE SAME FOR THE MONTHS MONITORED.

PROJECT ENGINEER: jerry nicholson	DRAWN BY: jn	DATE: 1-4-94	APPROVED: jn

KING SALMON COMMERCIAL BLDG
ENERGY CONSERVATION

Nushagak Consultants
225 East Fireweed Lane
Anchorage, Alaska 99503
907 277 1864 Fax 277 1835

SYSTEM
BEFORE & AFTER DDC
DIRECT DIGITAL CONTROL (DDC)
OIL GRAPH CHART DELINEATING
FUEL OIL SAVINGS

KING SALMON, ALASKA

Building Controls Specialists

file:com_bro, Broc-6

DRAWING

***** MARKAIR, INC *****

ELECTRIC AND HEATING OIL ANALYSIS

ACTUAL COSTS (FY 1990 PERIOD ENDING MAY 1, 1991) AND PROJECTED SAVINGS

NOTE #		BLG SQ FT	ACTUAL OIL/GAS COST	COST SQ FT	ACTUAL ELECTRIC COST	COST SQ FT	ACTUAL ELECTRIC/ OIL COST	TOTAL COST SQ FT	(7) PROJECTED SAVINGS 24% AV	PERCENT
(1)	**FAI**									
	HANGER	32,000	$43,100	$1.35	$52,600	$1.64	$95,700	$2.99	$23,100	24%
	CARGO	8,000	11,800	1.48	9,300	1.16	21,100	2.64	5,500	26%
(2)	WEAVER	14,500	22,800	1.57	25,700	1.77	48,500	3.34	11,900	25%
	SUBT/AVERA	54,500	$77,700	$1.43	$87,600	$1.61	$165,300	3.03	$40,500	25%
(4)	**SCC**									
	TERMINAL	18,000	40,800	2.27	20,700	1.15	61,500	3.42	17,200	28%
	CARGO	6,400	10,500	1.64	5,000	0.78	15,500	2.42	4,400	28%
	SUBT/AVERA	24,400	$51,300	2.10	25,700	1.05	77,000	3.16	21,600	28%
(3)	**AKN**	15,000	20,200	1.35	43,400	2.89	63,600	4.24	13,800	22%
(3) (5)	**ADQ**									
	TERMINAL	13,500	15,000	1.11	29,800	2.21	44,800	3.32	9,900	22%
(6)	**BRW**	12,000	17,400	1.45	33,600	2.80	51,000	4.25	14,300	28%
	TOTAL	119,400	$181,600	$1.52	$220,100	$1.84	$401,700	$3.36	$100,100	25%

NOTES:

(1) Heating oil price based on $1.00 gal.
(2) W.B.J. projected cost based on current half usage.
(3) Fuel oil prices based on $1.50 gal.
(4) Projected natural gas costs based on expected 30% savings due to NMI's gas conversion, actual in first 3 months is 60%.
(5) Fiqures prior to terminal expansion.
(6) Barrow information not available - numbers are based on available info in area
(7) Based on Alaska state expected savings w/ partial monitoring of: (1) 34% oil
(2) 16% electric
Above equats to 24% average
(8) (3) ***SCC*** Before gas conversion

	BLG SQ FT	ACTUAL OIL/GAS COST	COST SQ FT	ACTUAL ELECTRIC COST	COST SQ FT	ACTUAL ELECTRIC/ OIL COST	TOTAL COST SQ FT	PROJECTED SAVINGS	PERCENT
Terminal	18,000	58,300	3.24	20,700	1.15	79,000	4.39	23,100	29%
Cargo	6,400	14,100	2.21	5,000	0.78	19,100	2.98	5,600	31%
Total	24,400	$72,400	$2.97	$25,700	$1.05	$98,100	$4.02	$28,700	29%

file/mk-ea

Data collected by the combined efforts of Markair and NMI

NOZZLE KNOWLEDGE

An Excerpt from: A Total Look at Oil Burner Nozzles
A Reference Guide for Burner Service Technicians
“Effects of Viscosity On Nozzle Performance”

One of the most important factors affecting nozzle performance is viscosity... technically defined as a measure of resistance to flow within a liquid. More commonly, viscosity is thought of in terms of “thickness.” For example a gallon of gasoline can be poured through the spout of a can much faster than a gallon of tar. That’s because the tar has a much higher viscosity than gasoline … or greater resistance to flow. Strangely enough, the opposite is true to nozzle applications. As we will see in a minute, with an increase in viscosity, nozzle flow rate also increases.

Temperature is the main factor in changing oil viscosities. It works something like a scale (Fig. 1). As the temperature goes down, the viscosity goes up. Take No. 2 fuel oil for example: at a temperature of 100oF, it has a viscosity of 35 SSU (Seconds Saybolt Universal). But when the temperature drops to 20^{o}F, the viscosity increases to 65 SSU.

An outside [or basement] storage tank may contain cold oil … and cold oil can cause problems. Here’s what happens: the thick oil passes into the nozzle, through the slots, and into the swirl chamber. Since it is more viscous, the rotational velocity is slowed down. This causes a thickening of the walls in the cone of oil as it emerges from the orifice, so the nozzle actually delivers more fuel and larger droplets (see Figures 2 and 3). And as a result, the flame front moves away from the burner head. In severe cases, atomization may be so poor that the fuel cannot be ignited. Or if it is ignited, it often produces a long, narrow and noisy fire that burns off the back wall of the combustion burner

Temperature F	100	80	30	20
Viscosity (SSU)	35	37	52	65

Figure 1: How temperature affects viscosity

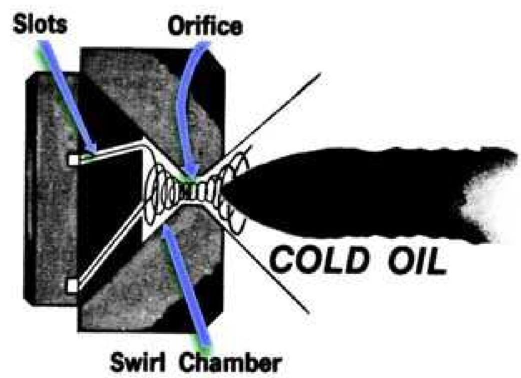
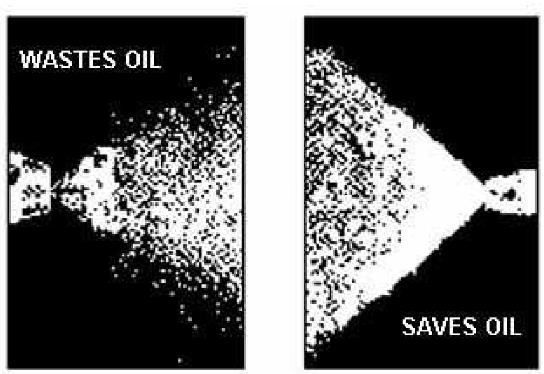


Figure 2: Cold Oil

Fire results in more smoke



Cleaner Fire Results in less smoke

Figure 3: High Viscosity Spray versus Low Viscosity Spray