Limited Energy Study
West Point, NY
Contract No. DACA65-93-C-0118

EXECUTIVE SUMMARY
and
FINAL REPORT

19971023 137

DTIC QUALITY INSPECTED 2

Prepared By

Benatec Associates

Prepared By Charles L. Johnson, Jr.

Reviewed By David M. Burkett

13 May 1994

933702/10

DEPARTMENT OF THE ARMY
CONSTRUCTION ENGINEERING RESEARCH LABORATORIES, CORPS OF ENGINEERS
P.O. BOX 9005
CHAMPAIGN, ILLINOIS 61826-9005

REPLY TO
ATTENTION OF: TR-I Library

17 Sep 1997

Based on SOW, these Energy Studies are unclassified/unlimited. Distribution A. Approved for public release.

Marie Wakefield,
Librarian Engineering

INDEX

EXECUTIVE SUMMARY

In the Holleder Sports Complex at West Point Military Academy there exists an indoor ice skating rink. Due to perceived operational inefficiencies, it was anticipated that energy was being wasted. Furthermore, it was noted that during the normal operation of the ice making plant, heat was being rejected from the building. Questions were asked as to the possibility of recapturing this rejected heat and utilizing it to increase the operational efficiency and reduce the energy wasted. This study has in fact justified that certain changes can be made to save energy and increase operational efficiencies.

The existing ice making refrigerant plant was originally installed with a heat reclaiming subsystem to utilize waste heat to provide for the required underslab heating system and to melt waste ice scrapings (snow) from the ice resurfacing process. The underslab heating system is working properly, but there is not enough recovered waste heat left to totally melt the snow from resurfacing. This snow builds up over time and is melted by spraying domestic hot water at 140°F over the snow pile. This process is labor intensive, energy use intensive, and reduces the capacity of the domestic hot water system to satisfy hot water needs in other parts of the building.

Actual compressor run times were obtained from the operator of the ice refrigerant plant and calculations showed that 2,122,100 MBH per year of energy was available for recovery.

The following functions will utilize the above waste energy in the indicated amounts:

Underslab Heating System	789,200 MBH
Snow Melt System	774,700 MBH
"Zamboni" Resurface Water	431,960 MBH
TOTAL WASTE HEAT REUSED	1,995,860 MBH

The above energy will be captured by the installation of two new systems. A desuperheat recovery unit will be installed and directly serve the snow melt system and indirectly heat the required water needed for ice resurfacing. The second system is the actual water heater to heat domestic water for the resurfacing process. The cost for installation is $20,350.

A LCCID Life Cycle Cost Analysis Program was run and the following factors obtained:

Simple Payback	2.38 Years
Savings to Investment Ratio (SIR)	6.89

Any SIR greater than 1.0 is considered a worthwhile investment for adequate return on monies spent.

The differences between the available heat and the reused heat amounts to 126,240 MBH per year. A study was performed to investigate heating adjacent office areas with this additional heat. LCCID analysis indicated a SIR of 0.31 indicating infeasible application.

INTRODUCTION

The ice skating rink at West Point, New York is located in Building 714, Holleder Center. This rink is built for competitive hockey but is also used for recreational skating. The rink is 90 feet by 200 feet or 18,000 square feet. This facility is presently in constant operation from July 1 through March 31 and is closed for the months of April, May, and June.

A direct liquid overfeed (R-22) ice making plant consisting of two 100-horsepower, 68-ton compressors provides the cooling requirements for this plant. The ice making plant was designed so that only one compressor would be required to maintain the rink system after initial ice has been made. A 25-ton heat recovery condensing package was installed as part of the original plant. This recovery package reclaims heat from the hot gas system through a condenser/heat exchanger which transfer energy to a glycol fluid. This glycol fluid is stored in an open tank and is circulated through the condenser/tank system by a dedicated transfer pump. Two building systems, slab heating and snow melting utilize the recovered heat and are directly connected to the storage tank with their dedicated pumping/piping systems. Refer to Appendix D, Page D-2, for existing reclaim system schematics.

Slab Heating System

This system is a system of piping run below the concrete ice rink floor designed to eliminate any freezing in this zone to prevent heaving of the concrete floor. Forty-five degree fahrenheit water is maintained in this system at all times.

Snow Melting System

This system is a piping grid installed in a pit and is used to melt snow that is obtained from the "Zamboni" used for top dressing the ice.

During the months of operation, the refrigeration plant is under automatic operation and loaded for one compressor operation approximately 75 percent of the time. The heat recovery system operates whenever the compressor operates and the first stage of recovered heat is used to maintain the underfloor system. What energy is left over is utilized for snow melting functions. Because of the inefficiencies of the snow melting system, it is reported that approximately 3,000 gallons of 140°F domestic hot water is sprayed on the snow pile each day to assist in the snow melting function. One hundred twenty degree fahrenheit domestic hot water is also utilized by the "Zamboni" to top dress and make new ice.

SCOPE OF WORK

The scope of work for this study is to investigate all feasible alternatives for utilization of the waste heat available from the refrigeration equipment serving the ice skating rink at the Holleder Sports Complex using state of the art technology. The following ECO's shall be evaluated:

a. Heating the water in the ice melt pit to facilitate the melting of ice shavings from the rink.

b. Heating water to 120°F for the "Zamboni" for dressing the ice.

c. Heating offices adjacent to the rink in the Holleder Center.

All ECO's shall be documented using sketches, floor plans, schematics, estimates and calculations to prove validity of all changes considered.

ENERGY CONSERVATION ANALYSIS

Energy, as reclaimed by the existing heat recovery system, has not proven to be effected. As discussed in the INTRODUCTION, the methods by which snow is manually melted at this facility using domestic hot water sprayed directly on the snow is not economical. The inefficiency is due largely to the type of equipment designed to capture the waste heat and the relatively low temperature that it must operate.

Heat recovery condensers of the type used at the Holleder Sports Complex are capable of only obtaining 90°F operating water temperatures. It has been reported that this system normally operates at around 80°F to 85°F. After the portion of the energy recovered is utilized to heat the slab, not enough energy is left to melt the snow with any efficiency.

Newer technology enables a portion of the waste heat to be captured at a higher energy level (125°F) and, thus, be utilized more efficiently. This new equipment is referred to as a "desuperheating" heat recovery unit. More effective use of the recovered energy can be realized if the temperature of this energy is closer to the direct use. The "Zamboni" requires 120°F water for ice top dressing and this condition can be met with this equipment. Also, the snow melting will occur faster at the higher temperature.

It is suggested that new heat recovery systems be installed to maximize the recovery of the available heat. The yearly available heat is as follows:

2,122,100 MBH (Appendix B, Page B-1)

Uses for this recovered heat are as follows:

Underslab Heat	789,200	MBH (*)
Snow Melt System	774,700	MBH (Appendix B, Page B-2)
"Zamboni" Water Heat	431,960	MBH (Appendix B, Page B-3)
TOTAL RECOVERED USE	1,995,860	MBH Per Year

* Underslab heat is calculated at 10 Tons of constant load while ice system is utilized.

The underslab heating system must be retained before any additional heat can be recovered. This analysis suggests that the existing 25-Ton condenser, glycol storage tank, and underslab heating system remain as is, and that the snow melting system be removed from this system. New equipment shall be installed to more efficiently melt this snow and also provide hot water the "Zamboni" for ice top dressing. Refer to Appendix D, Page D-1. The existing 250 gallon hot water heater will be removed to make room for the new 340 gallon recovery water heater needed to heat "Zamboni" water. The "Zamboni" has a 190 gallon storage tank on board. The recovery water heater was sized to accommodate this tank and provide adequate storage for repeated fills during hockey games. Refer to Appendix D, Page D-3. The new heat exchanger is to be installed above the existing heat exchanger leaving room for tube pull. Note, the new "Zamboni" water heater located in the corner of the room where existing heater was removed.

Fuel oil is presently used to heat the domestic water that is used to melt the snow. The calculation in this study used an oil cost of $0.75 per gallon, and a heat content of oil as 138,700 BTU/gallon to obtain the energy cost of $5.41 per million BTU.

Three individual analysis were made and are as follows:

System No. 1

Snow Melt Only - A desuperheater heat recovery unit will be installed and connected to the snow melting system. This system will be a closed piping system and be operated manually and independent of the underslab heating system. Refer to Appendix D, Page D-4. The new desuperheating exchanger will operate in series with the existing recovery exchanger that will be left in place to accomplish underslab heating requirements. Pump shall be energized and run continuously during ice melting periods.

Construction Cost	$ 11,840
Yearly Savings	$ 7,422

System No. 2

Snow Melt and "Zamboni" Top Dress Water - The snow melt system above will be installed as well as a heater to provide 120°F water to the "Zamboni" for ice top dressing. Refer to Appendix D, Page D-4. All equipment shown on this schematic will be installed if this system is installed. Automatic valving will allow 125°F heated water from the desuperheater to first satisfy the needs (120°F) of the storage tank and then proceed to the snow melt pit. When the tank has been satisfied, 125°F heated water will flow directly to the snow melt pit.

Construction Cost	$ 20,350
Yearly Savings	$ 9,549

System No. 3

Adjacent Office Heat - A system to heat adjacent offices with waste heat from the refrigerant plant was investigated. This system comprised an additional storage tank, wall fin radiation, pumps, piping, and controls to provide supplemental heat to six (6) adjacent rooms/areas. System was limited to these areas in that only 19,000 BTU peak heat was available. Due to high initial system costs to heat a small area and the low grade energy (125°F) available causing oversized radiation selection, this reclaim system is not economically feasible.

Construction Cost	$ 17,545
Yearly Savings	$ 337

NON-ENERGY SAVINGS

As previously discussed, the present manner in which snow is melted at this facility is highly wasteful. To get rid of this excess snow that the existing system won't handle, maintenance personnel spray domestic hot water on the snow pile to provide for its melting. Heating of the domestic hot water is considered in the energy calculation part of this study. Two other items of non-energy savings functions can be addressed and are as follows:

1. Manpower to stand and spray the water on the snow.
2. Costs for water and sewage treatment.

Manpower

1 Hour/Day x 275 Days Operation	=	275 Manhours
275 Manhours x $12.00/Hour	=	$3,300/Year Cost

Water Usage

3,000 Gallons is Estimated Daily Use		
3,000 Gallons x 275 Day Operation	=	825,000 Gallons/Year

Domestic Charge for Water of $1.50/1,000 Gallons x 825,000 =	$ 1,240.00
Sewage Charge of $3.00/1,000 Gallons x 825,000 =	2,475.00
	$ 3,715.00

Total non-energy savings for the snow melting process would then be $7,000, which is a considerable savings for the small size of this project.

SUMMARY

Energy is available to be economically reclaimed at the rink ice plant in West Point. This fact, coupled with the highly inefficient, labor intensive manner in which the waste snow is disposed of, provides the reasons to install new energy reclaiming equipment to aid in this snow removal process. The new system to melt the snow is a duplication of an existing system, but is justified because of the energy saved, and more important, the need to remove this "waste snow" from the site.

An added benefit is the new system that will heat water that the "Zamboni" uses to top dress the ice.

Both systems analyzed have a Savings to Investment Ratio (SIR) well in excess of one (1), which makes them economically feasible.

APPENDIX A

COMPRESSOR RUN TIMES

Ice Rink Compressor Run Time (In Hours) JULY 1992		Building 714 Hollander Building
DATE	COMP #1	COMP #2
1	0	0
2	0	0
3	0	0
4	0	0
5	0	0
6	12	13
7	24	24
8	8	24
9	5	17
10	3	21
11	4	22
12	8	23
13	9	22
14	9	23
15	9	23
16	8	23
17	1	21
18	0	21
19	5	22
20	8	22
21	10	21
22	7	22
23	3	23
24	3	19
25	1	18
26	2	21
27	8	22
28	5	22
29	7	22
30	3	22
31	2	20
TOTALS	164	553
717 Run Hours ÷ 744 Available Hours = 96.4% Utilization		

Ice Rink Compressor Run Time (In Hours) AUGUST 1992		Building 714 Hollander Building
DATE	COMP #1	COMP #2
1	3	20
2	5	21
3	5	22
4	8	22
5	5	22
6	1	18
7	0	18
8	0	17
9	0	20
10	0	16
11	0	17
12	0	19
13	0	16
14	0	16
15	0	14
16	0	16
17	0	15
18	0	15
19	0	16
20	0	15
21	0	15
22	0	16
23	0	16
24	0	18
25	0	18
26	0	20
27	0	18
28	0	19
29	0	18
30	0	19
31	0	18
TOTALS	27	550
577 Run Hours ÷ 744 Available Hours = 77.6% Utilization		

Ice Rink Compressor Run Time (In Hours) SEPTEMBER 1992		Building 714 Hollander Building
DATE	COMP #1	COMP #2
1	0	15
2	0	16
3	0	15
4	0	17
5	0	15
6	0	16
7	0	14
8	0	15
9	0	18
10	0	16
11	0	17
12	0	17
13	9	9
14	18	0
15	17	0
16	16	0
17	17	1
18	18	1
19	16	0
20	17	0
21	17	0
22	19	0
23	18	0
24	18	0
25	16	0
26	18	1
27	17	0
28	10	0
29	18	0
30	16	0
TOTALS	295	203
498 Run Hours ÷ 720 Available Hours = 69.2% Utilization		

Ice Rink Compressor Run Time (In Hours) OCTOBER 1992		Building 714 Hollander Building
DATE	COMP #1	COMP #2
1	19	0
2	18	0
3	20	0
4	23	0
5	19	0
6	18	0
7	21	0
8	19	1
9	19	0
10	20	1
11	21	0
12	20	1
13	7	10
14	2	21
15	0	20
16	4	22
17	0	22
18	3	22
19	2	16
20	0	20
21	4	14
22	18	0
23	19	1
24	21	4
25	23	0
26	16	0
27	21	0
28	18	0
29	18	0
30	20	4
31	16	4
TOTALS	449	183
632 Run Hours ÷ 744 Available Hours = 84.9% Utilization		

Ice Rink Compressor Run Time (In Hours) NOVEMBER 1992		Building 714 Hollander Building
DATE	COMP #1	COMP #2
1	14	1
2	7	11
3	1	16
4	0	20
5	0	20
6	0	20
7	0	18
8	0	19
9	1	16
10	0	19
11	0	21
12	1	16
13	4	21
14	5	17
15	0	20
16	0	19
17	13	5
18	17	1
19	20	0
20	18	0
21	19	3
22	21	2
23	21	0
24	9	10
25	0	17
26	0	15
27	0	24
28	0	21
29	0	19
30	0	18
TOTALS	171	409
580 Run Hours ÷ 720 Available Hours = 80.6% Utilization		

Ice Rink Compressor Run Time (In Hours) DECEMBER 1992		Building 714 Hollander Building
DATE	COMP #1	COMP #2
1	8	9
2	18	0
3	18	0
4	19	0
5	17	0
6	19	0
7	17	0
8	6	11
9	0	14
10	0	17
11	0	15
12	0	13
13	0	18
14	1	14
15	9	7
16	14	0
17	18	0
18	17	0
19	18	0
20	20	0
21	15	0
22	7	11
23	0	16
24	0	12
25	0	10
26	0	19
27	0	16
28	0	15
29	10	5
30	17	0
31	15	0
TOTALS	283	222
505 Run Hours ÷ 744 Available Hours = 67.9% Utilization		

Ice Rink Compressor Run Time (In Hours) JANUARY 1993		Building 714 Hollander Building
DATE	COMP #1	COMP #2
1	17	0
2	18	3
3	19	0
4	17	0
5	7	11
6	0	19
7	0	17
8	0	19
9	0	18
10	0	17
11	0	18
12	11	6
13	18	0
14	16	1
15	18	4
16	19	0
17	18	2
18	20	0
19	6	11
20	1	16
21	1	18
22	3	18
23	5	20
24	1	21
25	0	19
26	12	5
27	18	0
28	16	0
29	17	0
30	17	0
31	18	0
TOTALS	313	263
576 Run Hours ÷ 744 Available Hours = 77.4% Utilization		

Ice Rink Compressor Run Time (In Hours) FEBRUARY 1993		Building 714 Hollander Building
DATE	COMP #1	COMP #2
1	16	1
2	5	9
3	0	16
4	0	17
5	0	17
6	1	20
7	0	18
8	0	17
9	11	6
10	19	0
11	19	0
12	18	0
13	18	0
14	20	0
15	20	1
16	6	11
17	0	18
18	0	21
19	4	18
20	3	21
21	0	19
22	1	22
23	13	6
24	21	0
25	20	0
26	19	4
27	21	4
28	21	0
TOTALS	276	266
542 Run Hours ÷ 672 Available Hours = 80.7% Utilization		

Ice Rink Compressor Run Time (In Hours) MARCH 1993		Building 714 Hollander Building
DATE	COMP #1	COMP #2
1	19	1
2	7	12
3	0	19
4	0	19
5	0	19
6	0	20
7	0	21
8	0	18
9	13	7
10	19	0
11	19	0
12	19	0
13	18	0
14	9	0
TOTALS	123	136
259 Run Hours ÷ 336 Available Hours = 77.1% Utilization		

APPENDIX B

AVAILABLE RECOVERY HEAT

933702/10

Available Recovery Heat from Ice Making Process				Building 714
Month	Days	Maximum MBH Available	% Utilized	Recoverable Heat (MBH)
*October	31	303,500	84.9	257,700
November	30	293,800	80.6	236,800
December	31	303,500	67.9	206,100
January	31	303,500	77.4	234,900
February	28	274,200	80.7	221,200
March	31	303,500	77.1	234,000
April	Closed	--	--	--
May	Closed	--	--	--
June	Closed	--	--	--
July	31	303,500	96.4	292,600
August	31	303,500	77.6	235,500
September	30	293,800	69.2	203,300
TOTAL/YEAR	--	2,682,800	--	2,122,100

Assumptions:
One 68-ton compressor runs at 100% capacity.
50% of total heat is recoverable.

* Sample Calculation:

12,000 BTU/Ton-Hr. x 68 Tons	=	816 MBH/Hr.
816 MBH/Hr. x 24 Hrs/Day	=	19,584 MBH/Day
19,584 MBH/Day x 31 Days/Mo.	=	607,104 MBH/Mo.
607,104 MBH/Mo. x 50% Recoverable	=	303,500 MBH/Mo.
303,500 MBH/Mo. x 84.9% Utilized	=	257,700 MBH Recoverable

At this facility, ice is resurfaced using a "Zamboni." This automatic resurfacing machine planes the ice, picks up the snow and lays down a new ice surface using hot water. The machine at this facility has an ice chest of 100 cubic foot capacity. Reports from maintenance personnel indicate that each resurfacing procedure fills the ice chest to one half its capacity or 50 cubic feet of ice. This left over ice/snow is deposited into a "Snow Pit" where it is melted for disposal. The frequency of this resurfacing procedure is as follows:

October 1 through March 31	--	6 Times/Day During Week Days
	--	9 Times/Day During Weekends
April 1 through June 30	--	Rink is closed.
July 1 through August 15 (Hockey Camp)	--	12 Times/Day
August 15 through October 1	--	2 Times/Day

The following table indicates monthly ice load and required energy for disposal:

Ice Disposal From Resurfacing Procedure — Building 714

Month	50 Ft^3 Loads	Lbs. of Ice	MBH's to Melt
October	210	603,750	86,638
November	204	586,500	84,163
December	210	603,750	86,638
January	210	603,750	86,638
February	192	552,000	79,212
March	210	603,750	86,638
April	Closed	--	--
May	Closed	--	--
June	Closed	--	--
July	372	1,069,500	153,473
August	210	603,750	86,638
September	60	172,500	24,754
TOTAL/YEAR	1,878	5,399,250	774,792

NOTE: Ice density is 57.5 Lbs/Ft^3.
143.5 BTU is needed to melt 1 Lb. of ice.

120°F hot water is applied to the ice for the resurfacing function and the amount applied is equal to the amount removed during the planing procedure. The energy to supply this water is shown on the table below:

Ice Resurfacing Water 120°F Needed for Zamboni			Building 714
Month	Lbs. of Water	Gallons of Water	MBH's to Heat Water 40°F to 120°F
October	603,750	72,500	48,300
November	586,500	70,400	46,900
December	603,750	72,500	48,300
January	603,750	72,500	48,300
February	552,000	66,250	44,200
March	603,750	72,500	48,300
April	Closed	--	--
May	Closed	--	--
June	Closed	--	--
July	1,069,500	128,391	85,560
August	603,750	72,500	48,300
September	172,500	20,708	13,800
TOTAL/YEAR	5,399,250	648,249	431,960

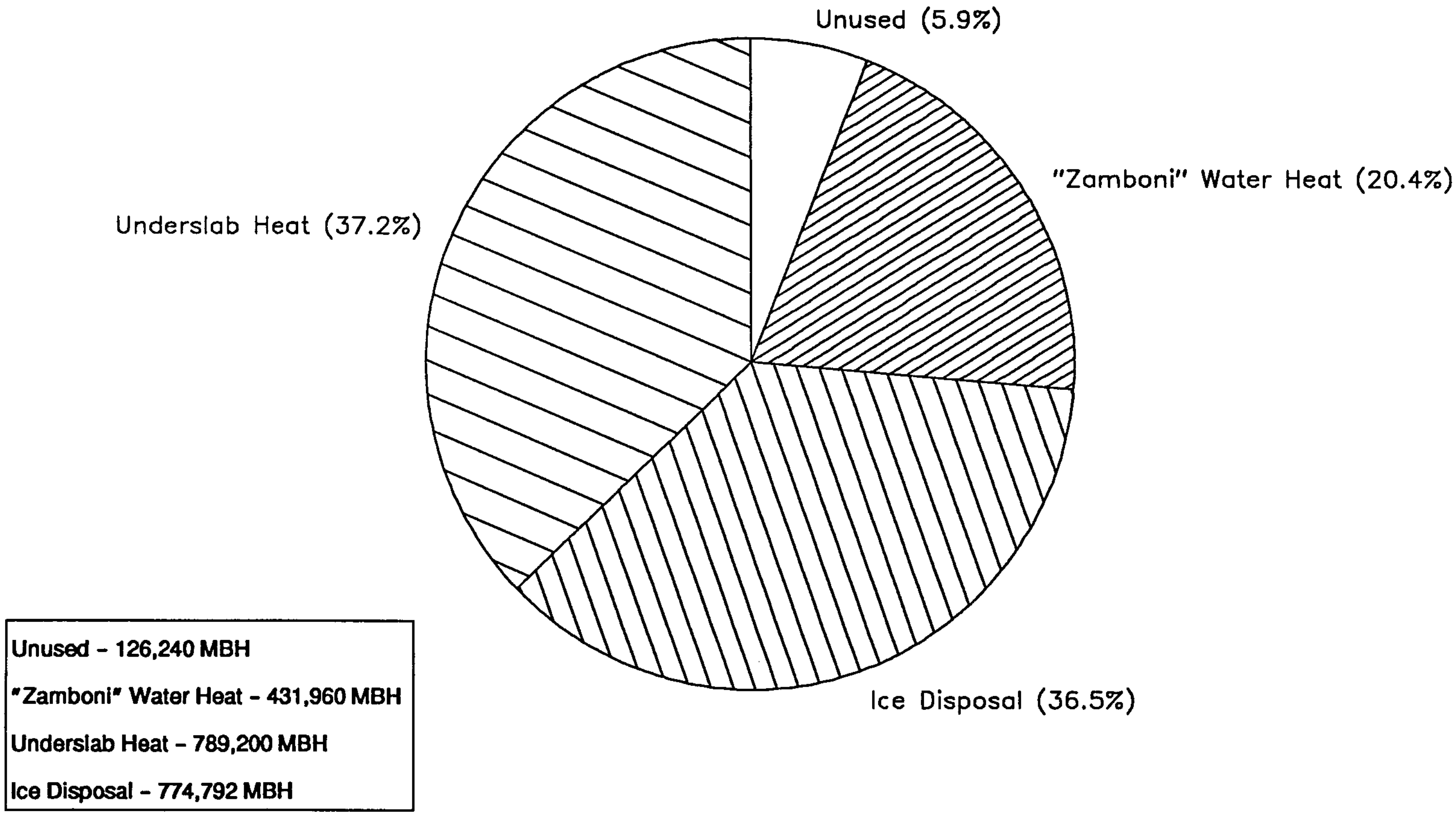
APPENDIX C

RECOVERED HEAT USES

933702/10

Uses for Recovered Heat from Ice Making Process				Building 714
Month	Under Slab Heat MBH	Ice Melt MBH	"Zamboni" Water Heat MBH	Total Per Month MBH
October	89,300	86,600	48,300	224,200
November	86,400	84,200	46,900	217,500
December	89,300	86,600	48,300	224,200
January	89,300	86,600	48,300	224,200
February	80,600	79,200	44,200	204,000
March	89,300	86,600	48,300	224,200
April	Closed	--	--	--
May	Closed	--	--	--
June	Closed	--	--	--
July	89,300	153,500	85,560	328,360
August	89,300	86,600	48,300	224,200
September	86,400	24,800	13,800	125,000
TOTAL/YEAR	789,200	774,700	431,960	1,995,860

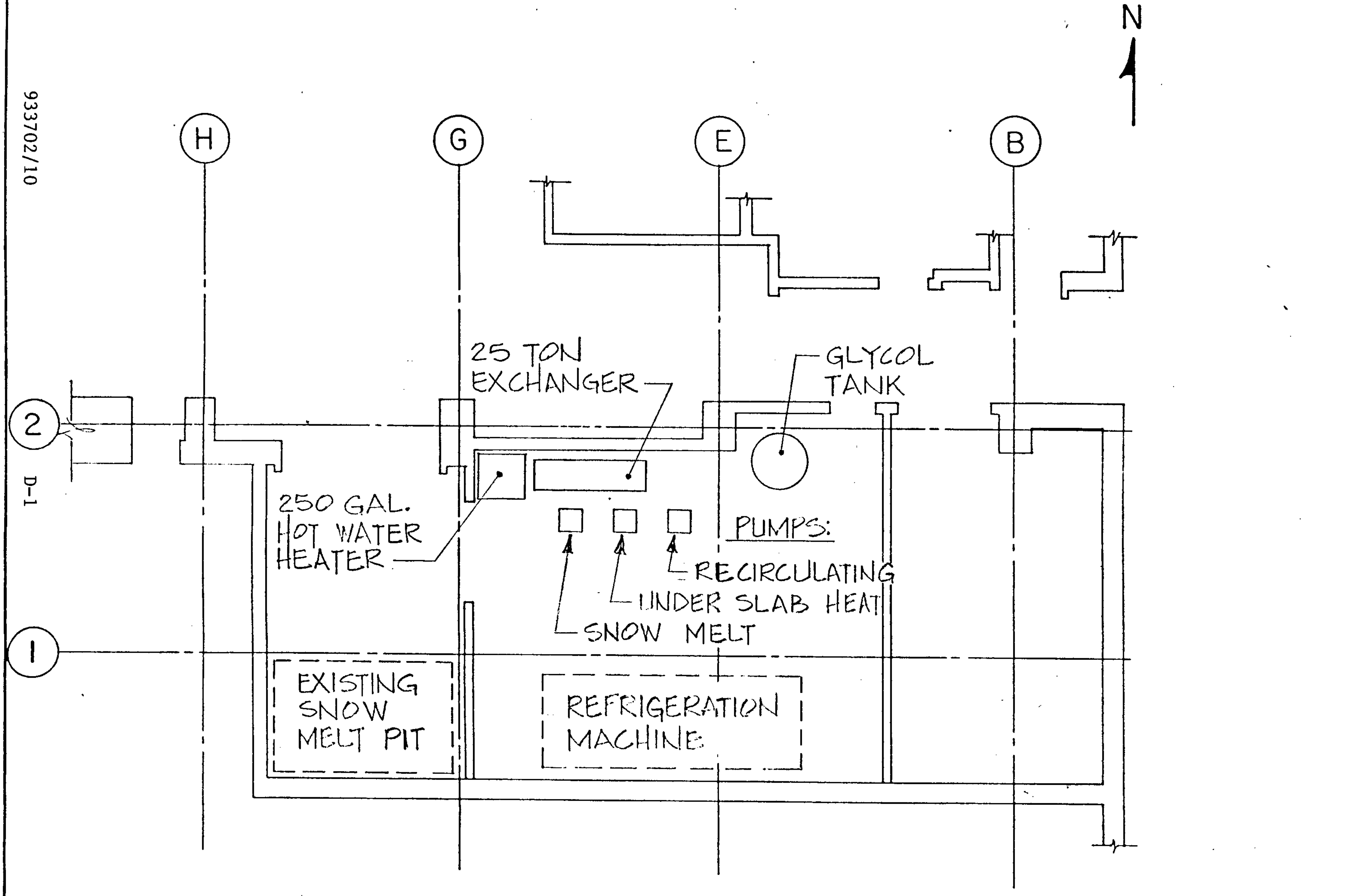
RECOVERED HEAT USES



Above graph reflects the yearly uses of the total heat recovered of 2,122,100 MBH.

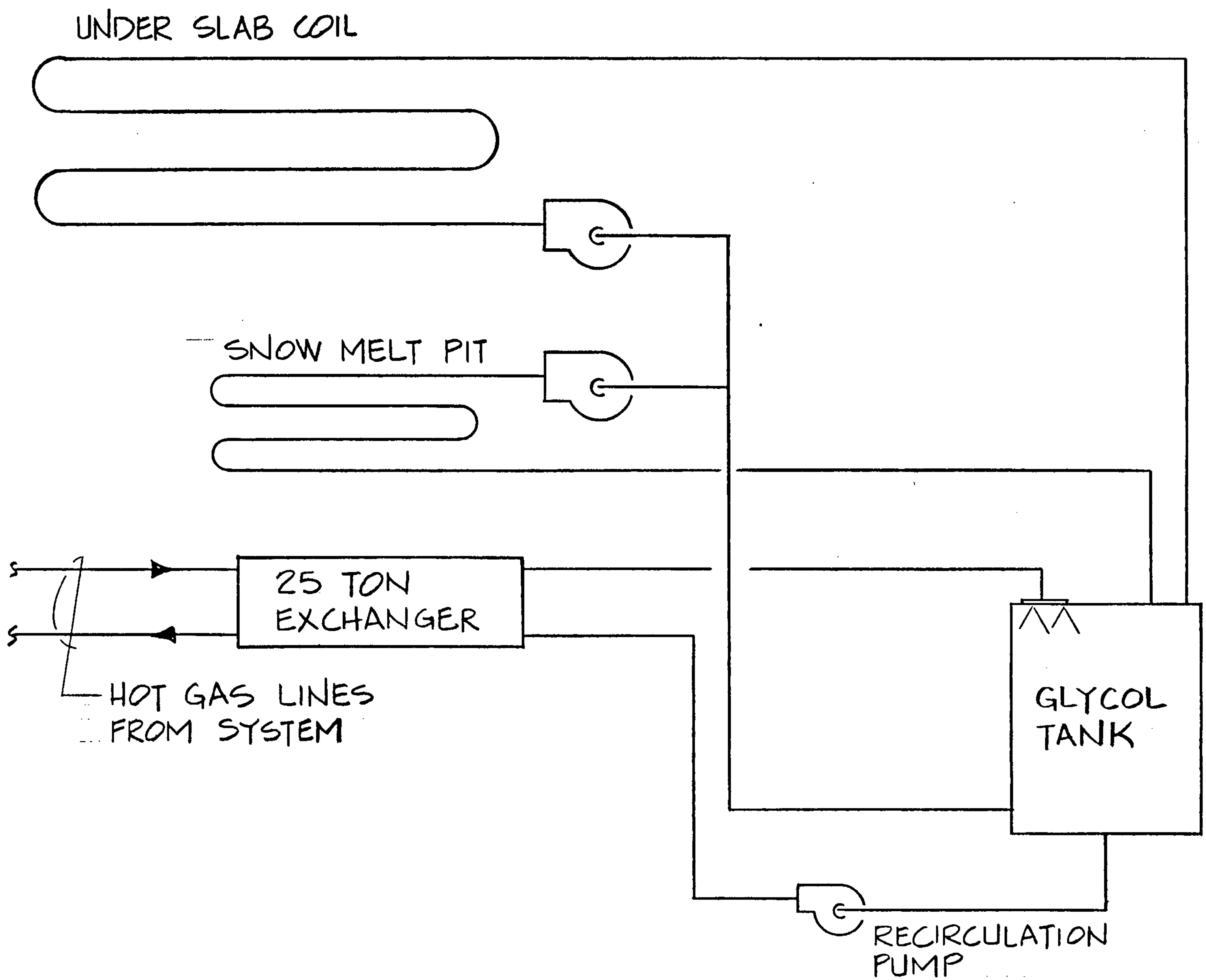
APPENDIX D

DRAWINGS AND SCHEMATICS

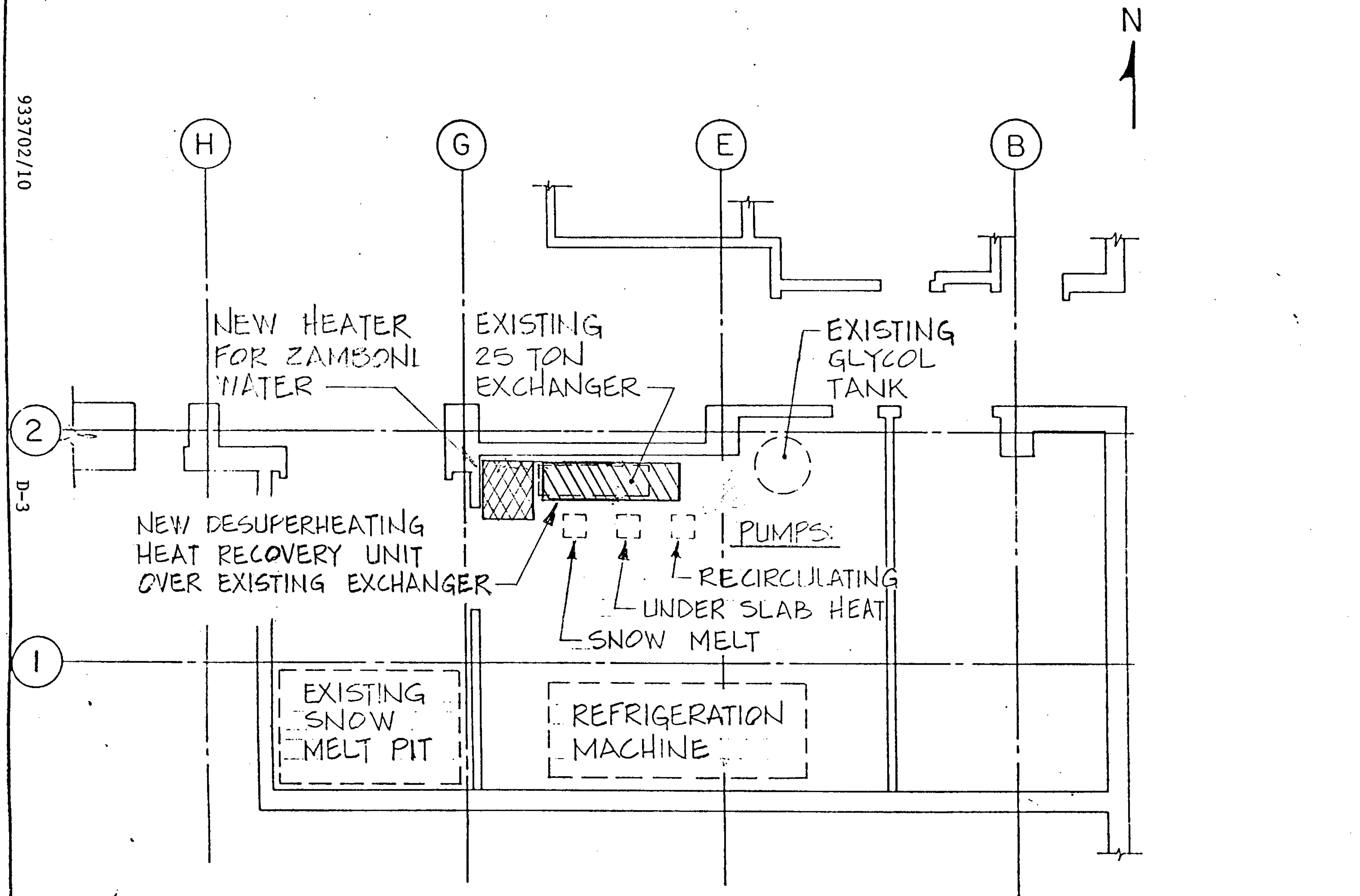


ICE MACHINE EQUIPMENT ROOM – EXISTING EQUIPMENT LOCATIONS

SCALE: 1/8" = 1'-0"

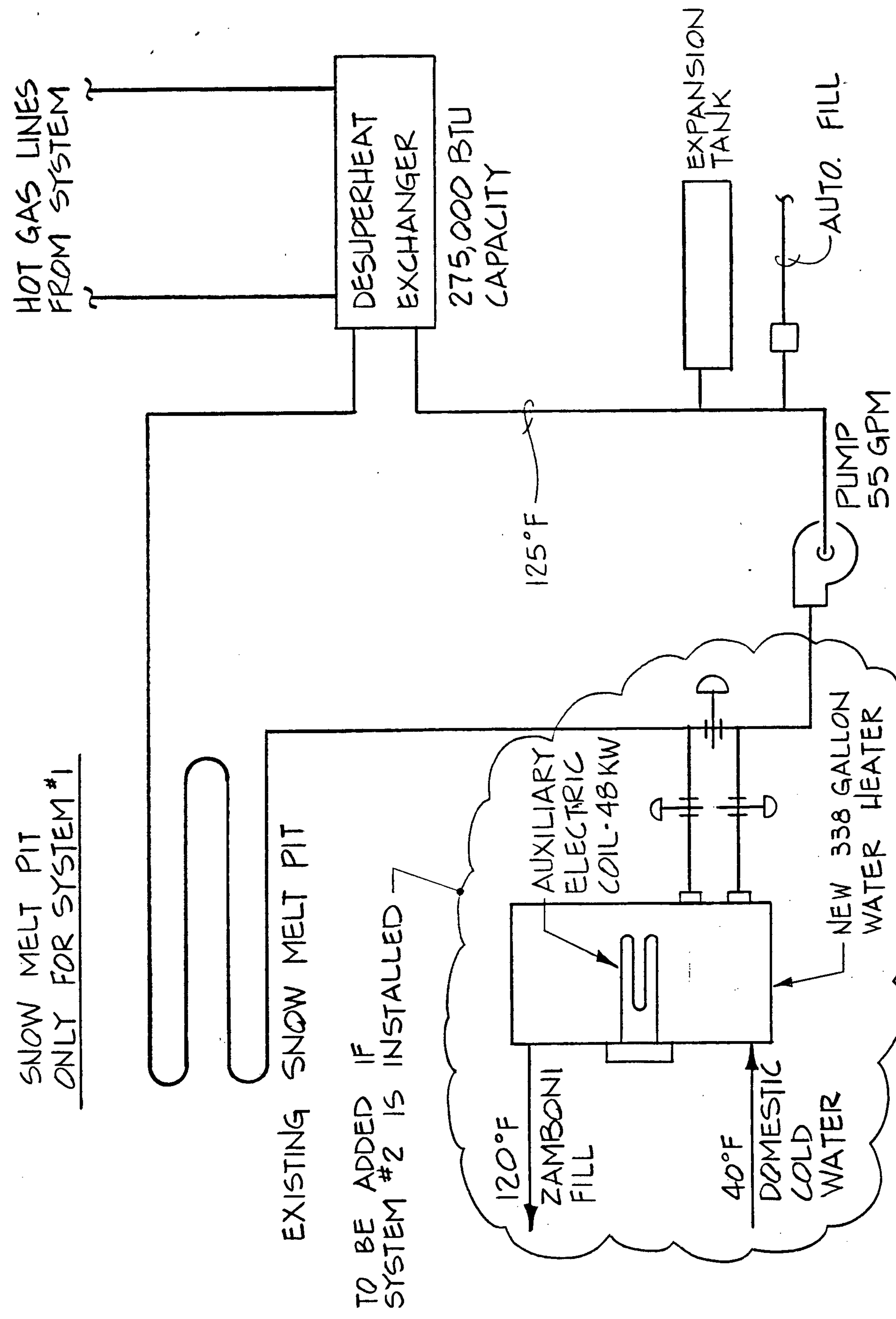


EXISTING RECLAIM PACKAGE SCHEMATIC



ICE MACHINE EQUIPMENT ROOM – NEW EQUIPMENT LOCATIONS

SCALE: 1/8" = 1'-0"



NEW DESUPERHEAT SYSTEM SCHEMATIC

APPENDIX E

LCCID COMPUTER RUNS

933702/10

LIFE CYCLE COST ANALYSIS SUMMARY STUDY: USMA
ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP) LCCID 1.080
INSTALLATION & LOCATION: U.S.M.A.,NY REGION NOS. 2 CENSUS: 1
PROJECT NO. & TITLE: 933702/10 WEST POINT ICE RINK
FISCAL YEAR 1994 DISCRETE PORTION NAME: SNOW MELT
ANALYSIS DATE: 05-12-94 ECONOMIC LIFE 20 YEARS PREPARED BY: D.M. BURKETT

1. INVESTMENT
A. CONSTRUCTION COST $ 11840.
B. SIOH $ 652.
C. DESIGN COST $ 711.
D. TOTAL COST (1A+1B+1C) $ 13203.
E. SALVAGE VALUE OF EXISTING EQUIPMENT $ 0.
F. PUBLIC UTILITY COMPANY REBATE $ 0.
G. TOTAL INVESTMENT (1D - 1E - 1F) $ 13203.

2. ENERGY SAVINGS (+) / COST (-)
DATE OF NISTIR 85-3273-X USED FOR DISCOUNT FACTORS OCT 1993

FUEL	UNIT COST $/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL $ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	$ 23.40	0.	$ 0.	15.41	$ 0.
B. DIST	$ 5.41	688.	$ 3722.	17.35	$ 64578.
C. RESID	$ .00	0.	$ 0.	19.35	$ 0.
D. NAT G	$ .00	0.	$ 0.	18.65	$ 0.
E. COAL	$ .00	0.	$ 0.	17.20	$ 0.
F. LPG	$ .00	0.	$ 0.	15.90	$ 0.
M. DEMAND SAVINGS			$ 0.	14.74	$ 0.
N. TOTAL		688.	$ 3722.		$ 64578.

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-) $ 3700.
(1) DISCOUNT FACTOR (TABLE A) 14.74
(2) DISCOUNTED SAVING/COST (3A X 3A1) $ 54538.

B. NON RECURRING SAVINGS(+) / COSTS(-)

ITEM	SAVINGS(+) COST(-) (1)	YR OC (2)	DISCNT FACTR (3)	DISCOUNTED SAVINGS(+)/ COST(-)(4)
.				
d. TOTAL	$ 0.			0.

C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+)/COST(-)(3A2+3Bd4)$ 54538.

4. FIRST YEAR DOLLAR SAVINGS 2N3+3A+(3Bd1/(YRS ECONOMIC LIFE))$ 7422.

5. SIMPLE PAYBACK PERIOD (1G/4) 1.78 YEARS

6. TOTAL NET DISCOUNTED SAVINGS (2N5+3C) $ 119116.

7. SAVINGS TO INVESTMENT RATIO (SIR)=(6 / 1G)= 9.02
(IF < 1 PROJECT DOES NOT QUALIFY)

8. ADJUSTED INTERNAL RATE OF RETURN (AIRR): 15.09 %

LIFE CYCLE COST ANALYSIS SUMMARY STUDY: USMA
ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP) LCCID 1.080
INSTALLATION & LOCATION: U.S.M.A.,NY REGION NOS. 2 CENSUS: 1
PROJECT NO. & TITLE: 933702/10 WEST POINT ICE RINK
FISCAL YEAR 1994 DISCRETE PORTION NAME: SNOW MELT & HOT WATER
ANALYSIS DATE: 05-12-94 ECONOMIC LIFE 20 YEARS PREPARED BY: D.M. BURKETT

1. INVESTMENT

A. CONSTRUCTION COST	$ 20350.		
B. SIOH	$ 1120.		
C. DESIGN COST	$ 1221.		
D. TOTAL COST (1A+1B+1C)	$ 22691.		
E. SALVAGE VALUE OF EXISTING EQUIPMENT		$ 0.	
F. PUBLIC UTILITY COMPANY REBATE		$ 0.	
G. TOTAL INVESTMENT (1D - 1E - 1F)			$ 22691.

2. ENERGY SAVINGS (+) / COST (-)
DATE OF NISTIR 85-3273-X USED FOR DISCOUNT FACTORS OCT 1993

FUEL	UNIT COST $/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL $ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	$ 23.40	-9.	$ -211.	15.41	$ -3245.
B. DIST	$ 5.41	1120.	$ 6059.	17.35	$ 105127.
C. RESID	$ .00	0.	$ 0.	19.35	$ 0.
D. NAT G	$ .00	0.	$ 0.	18.65	$ 0.
E. COAL	$ .00	0.	$ 0.	17.20	$ 0.
F. LPG	$ .00	0.	$ 0.	15.90	$ 0.
M. DEMAND SAVINGS			$ 0.	14.74	$ 0.
N. TOTAL		1111.	$ 5849.		$ 101882.

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-) $ 3700.
(1) DISCOUNT FACTOR (TABLE A) 14.74
(2) DISCOUNTED SAVING/COST (3A X 3A1) $ 54538.

B. NON RECURRING SAVINGS(+) / COSTS(-)

ITEM	SAVINGS(+) COST(-) (1)	YR OC (2)	DISCNT FACTR (3)	DISCOUNTED SAVINGS(+)/ COST(-)(4)
d. TOTAL	$ 0.			0.

C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+)/COST(-)(3A2+3Bd4)$ 54538.

4. FIRST YEAR DOLLAR SAVINGS 2N3+3A+(3Bd1/(YRS ECONOMIC LIFE))$ 9549.

5. SIMPLE PAYBACK PERIOD (1G/4) 2.38 YEARS

6. TOTAL NET DISCOUNTED SAVINGS (2N5+3C) $ 156420.

7. SAVINGS TO INVESTMENT RATIO (SIR)=(6 / 1G)= 6.89
(IF < 1 PROJECT DOES NOT QUALIFY)

8. ADJUSTED INTERNAL RATE OF RETURN (AIRR): 13.55 %

LIFE CYCLE COST ANALYSIS SUMMARY STUDY: USMA
ENERGY CONSERVATION INVESTMENT PROGRAM (ECIP) LCCID 1.080
INSTALLATION & LOCATION: U.S.M.A.,NY REGION NOS. 2 CENSUS: 1
PROJECT NO. & TITLE: 933702/10 WEST POINT ICE RINK
FISCAL YEAR 1994 DISCRETE PORTION NAME: ADJACENT OFFICE HEAT
ANALYSIS DATE: 05-12-94 ECONOMIC LIFE 20 YEARS PREPARED BY: D.M. BURKETT

1. INVESTMENT

A. CONSTRUCTION COST	$ 17545.		
B. SIOH	$ 965.		
C. DESIGN COST	$ 1053.		
D. TOTAL COST (1A+1B+1C)	$ 19563.		
E. SALVAGE VALUE OF EXISTING EQUIPMENT		$ 0.	
F. PUBLIC UTILITY COMPANY REBATE		$ 0.	
G. TOTAL INVESTMENT (1D - 1E - 1F)			$ 19563.

2. ENERGY SAVINGS (+) / COST (-)
DATE OF NISTIR 85-3273-X USED FOR DISCOUNT FACTORS OCT 1993

FUEL	UNIT COST $/MBTU(1)	SAVINGS MBTU/YR(2)	ANNUAL $ SAVINGS(3)	DISCOUNT FACTOR(4)	DISCOUNTED SAVINGS(5)
A. ELECT	$ 23.40	-5.	$ -117.	15.41	$ -1803.
B. DIST	$ 5.41	84.	$ 454.	17.35	$ 7885.
C. RESID	$ .00	0.	$ 0.	19.35	$ 0.
D. NAT G	$ .00	0.	$ 0.	18.65	$ 0.
E. COAL	$ .00	0.	$ 0.	17.20	$ 0.
F. LPG	$ .00	0.	$ 0.	15.90	$ 0.
M. DEMAND SAVINGS			$ 0.	14.74	$ 0.
N. TOTAL		79.	$ 337.		$ 6082.

3. NON ENERGY SAVINGS(+) / COST(-)

A. ANNUAL RECURRING (+/-) $ 0.
(1) DISCOUNT FACTOR (TABLE A) 14.74
(2) DISCOUNTED SAVING/COST (3A X 3A1) $ 0.

B. NON RECURRING SAVINGS(+) / COSTS(-)

ITEM	SAVINGS(+) COST(-) (1)	YR OC (2)	DISCNT FACTR (3)	DISCOUNTED SAVINGS(+)/ COST(-)(4)
d. TOTAL	$ 0.			0.

C. TOTAL NON ENERGY DISCOUNTED SAVINGS(+)/COST(-)(3A2+3Bd4) $ 0.

4. FIRST YEAR DOLLAR SAVINGS 2N3+3A+(3Bd1/(YRS ECONOMIC LIFE)) $ 337.

5. SIMPLE PAYBACK PERIOD (1G/4) 57.97 YEARS

6. TOTAL NET DISCOUNTED SAVINGS (2N5+3C) $ 6082.

7. SAVINGS TO INVESTMENT RATIO (SIR)=(6 / 1G)= .31
(IF < 1 PROJECT DOES NOT QUALIFY)

8. ADJUSTED INTERNAL RATE OF RETURN (AIRR): -2.75 %

APPENDIX F

COST ESTIMATES

SYSTEM NO. 1 - SNOW MELT ONLY

Estimate for snow melt system was obtained from Rink Systems, dealing with the same personnel who installed the original system. A lump sum price of $11,840 is the turnkey price for the total project for the snow melt system including desuperheater, pump, piping, controls, and installation. See attached quote which should be considered as a good estimate at this stage.

Rink Systems™ INC.

1103 Hershey Street, Albert Lea, Minnesota 56007
507 / 373-9175 1-800-944-7930 Fax: 507 / 377-1060

☆ REFRIGERATION EQUIPMENT ☆ DASHER BOARDS ☆ ACCESSORIES & SUPPLIES ☆ SERVICE

FACSIMILE TRANSMISSION

FAX # 507-377-1060

NUMBER OF PAGES 2

COMPANY West Point FAX # 717-763-7397

ATTN: Chuck Johnson

Pricing for Desuperheater Work

FROM: Harold Lipman DATE: 2-4-94 TIME:

933702/10

RINK SYSTEMS INC.

1103 Hershey Street, Albert Lea, Minnesota 56007
507 / 373-9175 1-800-944-7930 Fax: 507 / 377-1060

☆ REFRIGERATION EQUIPMENT ☆ DASHER BOARDS ☆ ACCESSORIES & SUPPLIES ☆ SERVICE

2/4/94

U.S.M.A. WEST POINT NY.

ATT CHUCK JOHNSON

PRICEING FOR REPAIR WORK AT THE ICE ARENA.

MATERIAL & LABOR________ 8.620.00

EXP TO&FROM WEST POINT__ 3.220.00

TOTAL__________ 11.840.00

THANK YOU

Harold Lyman

CONSTRUCTION COST ESTIMATE	DATE PREPARED 5/1/94	SHEET 1 OF 1

PROJECT: HOLLEDER - HEAT RECLAME

LOCATION: WEST POINT M.A.

ARCHITECT ENGINEER: BENATEC ASSOCIATES

BASIS FOR ESTIMATE
- [ ] CODE A (No design completed)
- [x] CODE B (Preliminary design)
- [ ] CODE C (Final design)
- [ ] OTHER (Specify)

DRAWING NO.: SYSTEM # 2 | ESTIMATOR: JOHNSON | CHECKED BY: Burkett

SUMMARY	QUANTITY NO. UNITS	QUANTITY UNIT MEAS.	LABOR PER UNIT	LABOR TOTAL	MATERIAL PER UNIT	MATERIAL TOTAL	TOTAL COST
WATER HEATER	1	ea	650	650	2240	2240	2890
PIPING	LS		525	525	465	465	990
CONTROL VALVES	3	ea	55	165	150	450	615
CONTROLS	1	ea	450	450	1500	1500	1950
ELECTRICAL	1	ea	390	390	200.	200	590
SUBTOTAL							7035
10% OH							704
SUBTOTAL							7739
10% PROFIT							774
SUBTOTAL							8510
SYSTEM #1							11,840
TOTAL SYSTEM #2						$	20,350

ENG FORM 150
1 AUG 59

(ER 1110-345-730) PREVIOUS EDITION MAY BE USED (TRANSLUCENT)

* U.S. GOVERNMENT PRINTING OFFICE : 1959 O—516148

933702/10

CONSTRUCTION COST ESTIMATE	DATE PREPARED 5-1-94	SHEET 1 OF 1

PROJECT: HOLLEDER - HEAT RECLAME

LOCATION: WEST POINT M.A.

ARCHITECT ENGINEER: BENATEC ASSOCIATES

BASIS FOR ESTIMATE
- ☐ CODE A (No design completed)
- ☒ CODE B (Preliminary design)
- ☐ CODE C (Final design)
- ☐ OTHER (Specify)

DRAWING NO.: SYSTEM #3

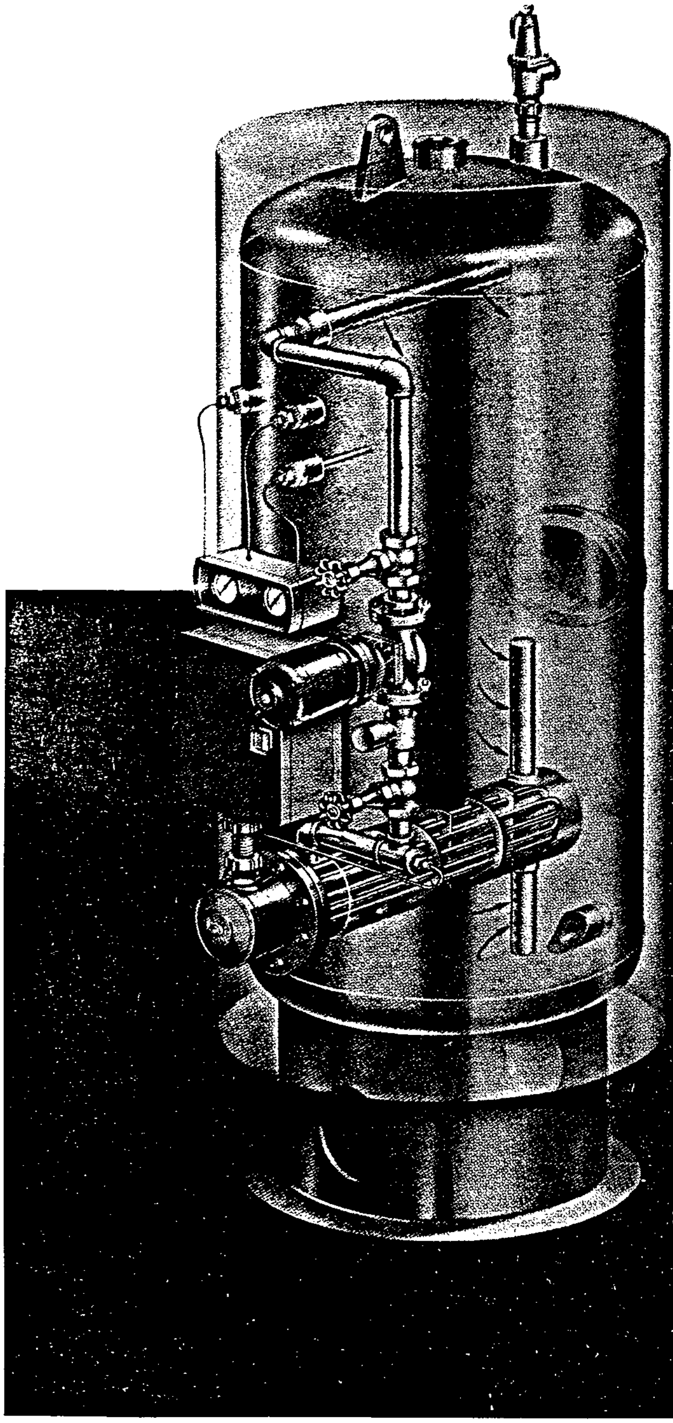
ESTIMATOR: JOHNSON

CHECKED BY: Burkett

SUMMARY	QUANTITY NO. UNITS	QUANTITY UNIT MEAS.	LABOR PER UNIT	LABOR TOTAL	MATERIAL PER UNIT	MATERIAL TOTAL	TOTAL COST
STORAGE TANK				600		1900	2500
RADIATION				550		2250	2800
PUMP				300		1200	1500
PIPING				1850		1350	3200
INSULATION				350		450	800
CONTROLS				400		1800	2200
ELECTRICAL				600		900	1500
SUB TOTAL							14,500
10% OH							1,450
SUB TOTAL							15,950
10% PROFIT							1,595
							17,545

APPENDIX G

CATALOG CUTS



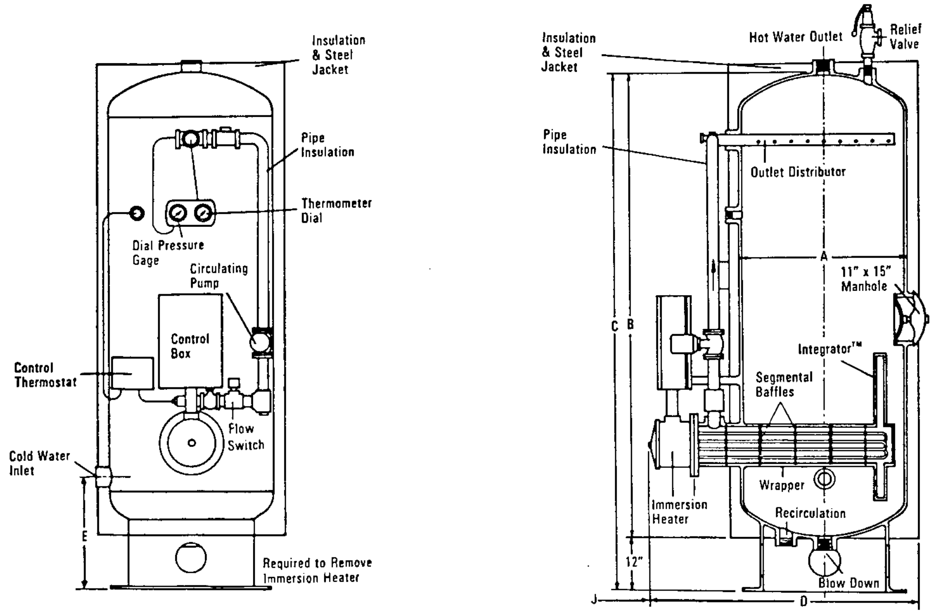
P-KW® Strata-Flo™ 600

Electric Water Heater

PATTERSON-KELLEY CO.
Division of HARSCO Corporation
EAST STROUDSBURG, PENNSYLVANIA 18301

Water heaters • boilers • shell-and-tube-and plate heat exchangers • steam generators • blenders • dryers • corrosion-resistant cements

VERTICAL HEATERS
SIZES AND CAPACITIES



STORAGE SECTIONS*

Roughing-in Dimensions Only

TANK NO.	GALLONS STORAGE	WATER CONNS.	BLOW DOWN (IN.)	DIMENSIONS (IN.)				
				A	B	C	D	E
6-1V	170	2	1½	30	60	72	54	26
6-2V	240	2	1½	30	84	96	54	26
6-3V	284	2	1½	36	72	84	60	27
6-4V	338	2	1½	36	84	96	60	27
6-5V	392	2	1½	36	96	108	60	27
6-6V	460	2½	2	42	84	96	66	28
6-7V	530	2½	2	42	96	108	66	28
6-8V	680	2½	2½	48	96	108	72	29
6-9V	865	2½	2½	48	120	132	72	29
6-9.5V	840	3	2½	54	96	108	78	32
6-10V	1085	3	2½	54	120	132	78	32
6-10.5V	1033	3	2½	60	96	108	84	32
6-11V	1300	3	2½	60	120	132	84	32
6-12V	1980	3	2½	72	120	132	96	35

*Other shell sizes available on request.

How to select a vertical heater

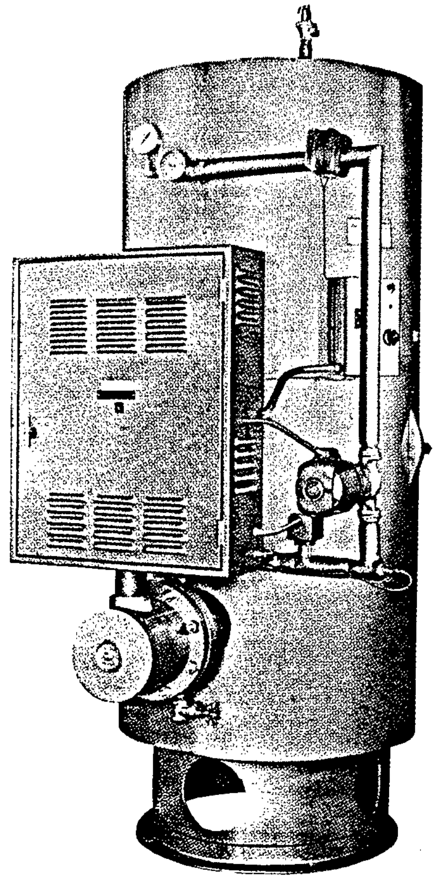
Refer to the ASHRAE Handbook (Systems), Chapter 37, for determining the recovery and storage capacities. If Figures 9-16 are used in the sizing method, multiply the amount of stored water by the factor 1.43 to arrive at the storage capacity.

The unique design of the P-KW 600 electric water heater permits size reductions. Multiply the recovery capacity by .75; then select the recovery section from the table below, based on your supply voltage of 208v, 240v or 480v, and indicate the model number.

Multiply the storage capacity by .70; then select the storage section from the table on page 3 and list the tank number. This complete model number would then be written in the specification.

To estimate other recovery capacities, apply the following formula:

$$\frac{\text{GPH x Temperature Rise (F°)}}{410} = \text{KW}$$



RECOVERY SECTIONS

MODEL 6-48V1

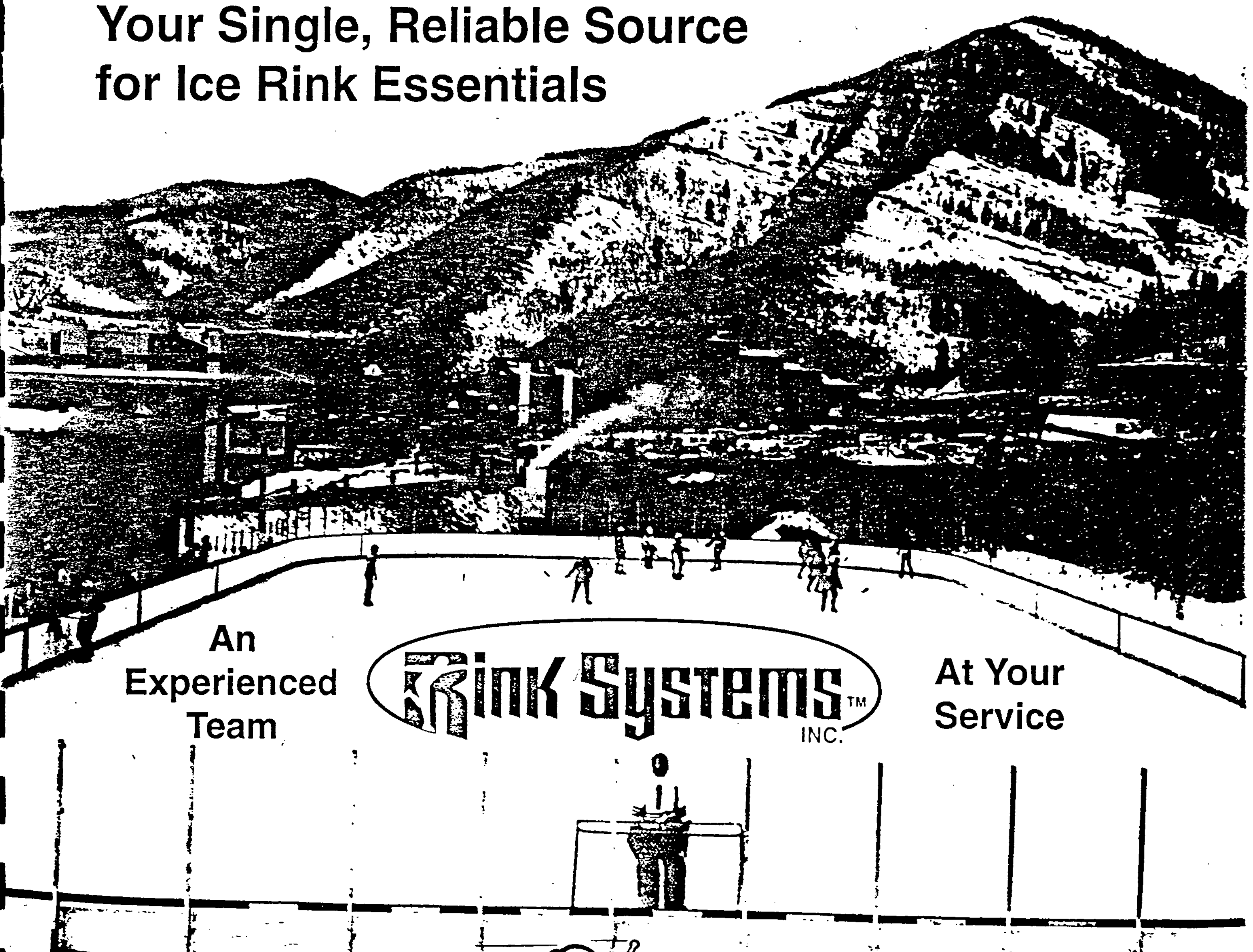
P-KW 600 MODEL NO.	KW INPUT 208V 240V* 480V*	GALLONS PER HOUR*		208 Volts				240 Volts				480 Volts			
		100°F. RISE	140°F. RISE	STEPS	TOTAL LINE AMPS	J (IN.)	MIN. TANK DIA.	STEPS	TOTAL LINE AMPS*	J (IN.)	MIN. TANK DIA.	STEPS	TOTAL LINE AMPS*	J (IN.)	MIN. TANK DIA.
6-20V1	20	82	58	2	56	16½	30	2	49	16½	30	2	25	16½	30
6-24V1	24	98	70	2	67	21	30	2	58	21	30	2	29	21	30
6-30V1	30	123	87	2	84	27½	36	2	73	27½	36	2	37	27½	36
6-36V1	36	147	105	3	100	21	30	2	87	34	42	2	44	34	36
6-40V1	40	164	117	2	111	16½	30	2	97	16½	30	2	49	16½	30
6-48V1	48	196	140	2	134	21	30	2	116	21	30	2	58	21	30
6-60V1	60	246	175	2	167	27½	36	2	145	27½	36	2	73	27½	36
6-72V1	72	295	210	3	200	21	30	2	174	34	42	2	87	34	36
6-80V1	80	328	234	3	222	34	42	4	193	38½	48	4	97	16½	30
6-90V1	90	369	264	3	250	27½	36	—	—	—	—	—	—	—	—
6-96V1	96	393	281	4	267	21	30	4	232	21	30	4	116	21	30
6-108V1	108	443	316	—	—	—	—	—	—	—	—	3	130	34	36
6-120V1	120	492	351	4	334	27½	36	4	289	27½	36	4	145	27½	36
6-144V1	144	590	421	5	400	27½	36	4	347	34	42	4	174	34	42
6-180V1	180	738	527	6	500	27½	36	5	434	34	42	5	217	34	42
6-216V1	216	885	632	8	600	34	42	6	520	34	42	6	260	34	42
6-225V1	225	922	659	8	625	27½	42	—	—	—	—	—	—	—	—
6-240V1	240	980	700	—	—	—	—	—	—	—	—	8	289	47	54
6-300V1	300	1229	878	10	833	27½	42	—	—	—	—	10	361	60	72
6-360V1	360	1470	1050	—	—	—	—	—	—	—	—	10	434	73	72

*For 220V or 440V, multiply by 0.84 — For 230V or 460V, multiply by 0.92

Arena Supplies

Equipment, Parts, Accessories.

Your Single, Reliable Source for Ice Rink Essentials



For FAST SERVICE

Call TOLL-FREE 1-800-944-7930

Phone: 507/373-9175 Fax: 507/377-1060

RINK SYSTEMS, INC. 1103 Hershey Street, Albert Lea, Minnesota 56007

Mpls./St. Paul Sales & Service: 4575 W. 77th St. Suite 102, Edina MN 55435 Phone: 612/830-8227

Rink Systems Inc. Waste Heat Utilization

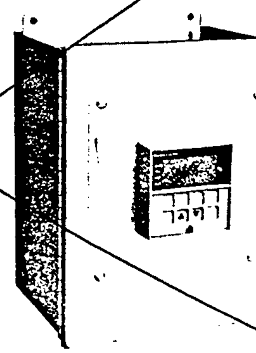
CUT YOUR ARENA'S ENERGY COSTS WITH "FREE" HEAT

In order to make ice, your refrigeration system removes a tremendous amount of heat from your rink floor. With the proper equipment this "free" heat can be retained and used to achieve dramatic energy savings.

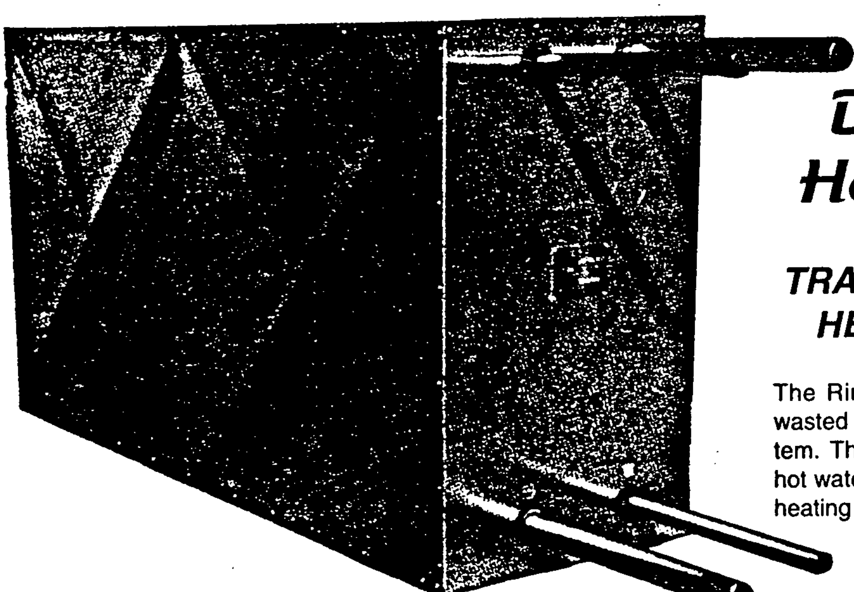
Rink Systems, Inc. has developed heat reclamation systems which make these "free" BTU's available to a variety of applications. Some of these are: heating the snow melting pit, swimming pool, hot water and supplementing the arena and adjoining area's space heating requirements.

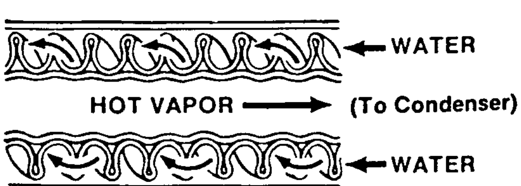
Since every arena's situation is unique, we invite you to call us and describe your installation and your objectives. We will work with you in planning the most effective use of your waste heat. Once we determine the auxiliary heating potential of your Rink Systems refrigeration equipment, we can provide you with a price quotation for an energy-saving Rink Systems waste heat utilization system.

Rink Systems Inc. Ice Temperature Electronic Control



- Highly sensitive to changes in ice floor temperature.
- Durable, dependable solid state electronic design - no mechanical parts.
- More accurate response in regulating the frequency of compressor cycling.
- Programmable digital readout.
- Uses the same floor sensor and cable as the older controls for easy installation.
- Two year warranty.





Rink Systems Inc. Desuperheating Heat Recovery Unit

TRANSFERS WASTE COMPRESSOR HEAT TO YOUR WATER SYSTEM

The Rink Systems Desuperheater transfers the otherwise wasted heat of a refrigeration system to a water heating system. This simple, cost-efficient method will provide domestic hot water, resurfacer water, swimming pool water or other fluid heating needs.

The all-copper coaxial (tube-within-a-tube) heat exchanger is hydrostatically tested to a burst pressure of shipment and carries a 5-year warranty.

Two-part, high-density insulation insures minimum heat loss and quiet operation. A broad selection of capacities and option are available to help meet your specific water heating needs.