Fermi National Accelerator Laboratory

TM-1505

Fermilab D-0 Experimental Facility Energy Conservation Report and Mechanical Systems Design Optimization and Cost Analysis Study

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FERMILAB D-0 EXPERIMENTAL FACILITY

ENERGY CONSERVATION REPORT
AND
MECHANICAL SYSTEMS DESIGN OPTIMIZATION AND COST ANALYSIS STUDY

31 OCTOBER,1987

S.F.KRSTULOVICH

FERMILAB CONSTRUCTION ENGINEERING SERVICES

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31 OCTOBER, 1987
ANALYST: S.F.KRSTULOVICH

FERMILAB CONSTRUCTION ENGINEERING SERVICES

ENERGY CONSERVATION REPORT

Analysis Data Summary

SCOPE: This report is developed as part of the Fermilab D-0 Experimental Facility Project Title II Design Documentation Update under the provisions of D.O.E. Document 6430.1, Chapter XIII-21, Section 14, paragraph a. As such, it concentrates primarily on HVAC mechanical systems design optimization and cost analysis.

a. Identification of Methods used for Building Energy Consumption Analysis: Carrier Corporation Model E20-II software run on an IBM PS/2 computer has been used to generate all loads, weather calculations, system simulations, life cycle costs, and payback data. This program has been used in conjunction with published data from:

   1. ASHRAE Fundamentals - Chapter 24: Weather data and design considerations

   2. Fermilab On-Site Records of lake and cooling pond performance

   3. Air Force Manual 88-29: Facility design and planning engineering weather data

   4. Richardson Engineering Services Corporation: Construction Costs Data

b. Methodology of Analysis: Life cycle cost analysis employs the unified present worth approach. Significant figures used in this exercise are 20 years reflecting minimum useful system life and 7.0% discount factor based upon projected outlooks from Chase, Data Resource Institute, Mellon and Evans. Project construction costs are paid off as a lump sum in the first year without amortization. The electrical energy escalation costs, used in consideration of the same projected outlooks used for the discount factor, seem rather conservative in the light of Illinois Edison's particular problems with over-built nuclear facilities coming on line.

   Payback analysis is based on the simple payback method with a maximum two (2) year return on investment period targeted.

   Building energy analysis is based on the bin method with temperature/humidity projections made by algorithm from the ASHRAE design weather data. System performance is executed in an integrated dynamic fashion from selected points of rating.

To analyze a complex structure, like this facility, the total building was divided into three (3) Subconstructions based upon the entirely different design conditions and systems employed in each of these zones. In essence, each of these subconstructions is analyzed as a separate building except insofar as they affect one another at their thermodynamic boundaries. The three (3) basic subconstructions are as follows:

Subcon 1/3: Describes the Collision and Assembly Halls

Subcon 2/3: Describes the Movable Counting House, Detector Platform and Side Bay Areas, together with the Deionized Chilled Water Systems

Subcon 3/3: Describes the Low Conductivity Cooling Water Systems

Applicable alternative mechanical systems were selected for each of the Subconstructions and were then combined as total building combined systems into several possible arrangements. These were then compared to each other, including the designed combined systems arrangement and FY1975 combined systems arrangement, to evaluate their merits.

For Subconstruction 1/3 (the Collision and Assembly Halls), three (3) alternative HVAC systems were evaluated, including a typical FY1975 design. The systems were:

1. Reciprocating chillers with lake water cooling, chilled water free cooling heat exchanger, pump cycling, high bay heat circulating fans, lake water filtration, integrated DDC controls, high efficiency motors, central station air handling units with nested fan inlet vanes and integrated enthalpy economizer. This represents our as designed system.

2. Centrifugal chillers with all other energy features incorporated in the systems arrangement above. This represents Alternate System No. 1.

3. Reciprocating chillers with pond water cooling and none of the energy features incorporated in the systems arrangements above. This represents Alternate System No. 2, our FY1975 basic system design.

For Subconstruction 2/3 (the Movable Counting House, Detector Platform and Side Bay Areas, together with the Deionized Chilled Water Systems), three (3) alternative HVAC systems were evaluated including a typical FY1975 design. The systems were:

1. Reciprocating chillers with lake water cooling, central station air handling units, chilled water computer room air conditioning units, water cooled electronics racks and these energy features: chilled water free cooling heat exchanger, pump cycling, lake water filtration, integrated DDC controls, high efficiency motors, integrated enthalpy economizer and supply air cooling temperature reset. This represents our as designed system.

2. Centrifugal chillers with lake water cooling, central station air handling units, chilled water computer room air conditioning units, water cooled electronics racks and all of the energy features incorporated in the systems arrangement above. This represents Alternate System No. 1.

3. Reciprocating chillers with pond water cooling, central station air handling units, chilled water computer room air conditioning units, water cooled electronics racks and none of the energy features incorporated in the systems arrangement above. This represents Alternate System No. 2, our FY1975 basic system design.

For Subconstruction 3/3 (the Low Conductivity Cooling Water Systems), two (2) alternative HVAC systems were evaluated, including a typical FY1975 design. The systems were:

1. Hydronic free cooling heat exchanger with these energy features: lake water cooling, lake water filtration, high efficiency motors and automatic lake water pump staging. This represents the 3/3 configuration for both our as designed system and the Alternate System No. 1.

2. Hydronic free cooling heat exchanger with pond water cooling and none of the energy features incorporated in the systems arrangement above. This represents Alternative System No. 2, our FY1975 basic system design.

All of these alternative HVAC systems for each Subconstruction area were then combined to yield three (3) total building combined systems arrangements for comparison. These arrangements are as follows:

1. The as designed arrangement (consisting of the first alternative from each Subconstruction), which is a reciprocating chiller system with lake water cooling and full building energy conservation features.

2. Alternate Arrangement No. 1 (consisting of the second alternative from Subconstructions 1/3 and 2/3 combined with the first alternative from Subconstruction 3/3), which is a centrifugal chiller system with lake water cooling and full building energy conservation features.

3. Alternate Arrangement No. 2 - our base case FY1975 design (consisting of the third alternative from Subconstructions 1/3 and 2/3 combined with the second alternative from Subconstruction 3/3), which is a reciprocating chiller system with pond water cooling and none of the energy conservation features of the arrangements above.

The systems arrangements used in this analysis as our FY1975 base case are actually typical of designs used as late as the early 1980s and, therefore, are probably more favorable than an actual 1975 design would be. This, however, only acts to make the calculated savings advantage of the designed systems more conservative. The advantage to using these arrangements as our base case is that we can use actual experience in the operation of such facilities for a more realistic comparison to the designed systems arrangement. This experience factor is especially valuable to analysis accuracy since it is impossible to find a generic example typical of such specialized nuclear research facilities from the 1970s, with complex building pressurization profiles, massive detector load cycling, and so forth.

In adapting simulation profiles to standard software format options, several modeling approximation techniques were employed. Fermilab lake water for cooling is seen from historical data to be sensitive to weather conditions, and is therefore modeled after open cooling towers rather than stable groundwater sources. The Main Ring cooling ponds are also weather sensitive according to historical data, but maintain higher temperatures than lake water due to Main Ring cooling loads, and are therefore modeled after closed circuit cooling towers. The low conductivity water systems (Subconstruction 3/3) were modeled as a one square foot perimeter area with no exterior surface boundaries, no load other than the LCW cooling wattages, and as having "cooling only" requirements. Due to software constraints, the LCW system equipment is fictionally configured as a constant volume central air handler with virtually no air side static pressure drop, coupled to a free cooling heat exchanger and pumping system. This effectively eliminates fictional fan energy from the equation and permits us to simulate all of the other system features. The effect of nested air handling unit inlet vanes is modeled through a corresponding adjustment in fan static pressure requirements. The staging of pumps is likewise modeled by an adjustment in pump head requirements corresponding to the facility load cycling profiles. Both integrated DDC building pressurization control and DDC calculated outside air intake control are modeled by an adjustment to the average outside air volume corresponding to historical operating data from a similar facility on site. Lake water filtration and high efficiency motors are both modeled by a corresponding adjustment in fan, pump and chiller efficiency. Finally, high bay area ceiling heat circulation fans are modeled by an adjustment to the area heating set point corresponding to lowered temperature averages due to decreased area stratification.

A major question in the design of the D-0 facility mechanical; systems was the selection of reciprocating versus centrifugal chillers. Apart from the danger of driving the centrifugal units into a surge condition during periods of abnormally high lake water temperatures and the need for higher condenser water flows to lower LWT, it was decided to favor the centrifugal over reciprocating units in this analysis so as to place beyond question any benefits of reciprocating units. To this end, it was assumed that the construction costs of both types of units would be the same, even though the centrifugal units would actually cost about $20,000 more than the reciprocating type.

c. Description of the Major Energy Conservation Features Selected: The design building HVAC systems arrangement constitutes a central reciprocating chiller plant with filtered lake water cooling, computerized Direct Digital Controls (DDC) and full building energy conservation features. Due to the strict process requirements of this facility, advances in energy conservation are primarily focused on refinement of necessary system types rather than in a comparison of optional system varieties.

The selection of reciprocating versus centrifugal chillers is borne out in the analysis by the fact that although centrifugal units have a higher rated efficiency at full load than reciprocating units, the wide swings in load cycling coupled with prolonged periods of chilled water free cooling put our chillers at modest to very low load during most of the year. At this point the curves for reciprocating chillers outperform the centrifugals significantly, such that there is actually an overall annual energy savings for the reciprocating units. Another feature along these lines is that the centrifugal units would require higher condenser water flows at times to prevent surging, and this in turn shows up as increased energy costs for pumping over the reciprocating units selection. The reciprocating chillers are of the high efficiency, multi-staged type with dual circuited condensers for increased efficiency at part load, and are augmented by an integrated hydronic economizer free cooling heat exchanger using lake water to permit full or partial chiller shut-down for several months out of the year. Chiller efficiency as well as low conductivity and chilled water free cooling heat exchanger approach is improved by use of lake water high efficiency filtration which reduces both heat transfer fouling factors as well as heat exchanger maintenance costs.

The use of lake water over Main Ring cooling pond water is also a significant energy saving factor. First of all, the lower temperatures and annual ice-pack of this large body of water, which is not presently being used for any other cooling purposes, permits chillers to operate at greater efficiencies and allows for longer periods of free cooling at lower temperatures than would be obtainable from the Main Ring cooling ponds. Secondly, however, by not using the Main Ring cooling ponds, we keep them from increasing in temperature which would adversely affect the efficiency of the major Main Ring

cooling systems. The energy cost avoidance in this case would be considerable, but is not credited in this analysis for the sake of simplicity. Along these same lines, reduced LCW cooling water temperatures obtainable in summer using lake water will increase equipment efficiencies at the D-0 facility, which is also not credited in this analysis for the sake of simplicity. The operation of lake water pumps is also automatically staged by computer through a reading of supply and return water temperatures to match cooling water load requirements and thus allow for lake water pumping costs energy savings. The incremental nature of load staging at this facility favored the use of simple, low-cost pump staging techniques over variable speed designs in life cycle cost analysis.

Both fan and pump performance in every case is enhanced through the use of high efficiency motors, which contribute significantly to energy savings in the light of the 24 hour operation of these units at the D-0 site. All fans, pumps and air handling units at this site are of the high quality, industrial grade type, selected specifically for high efficiency performance. Air handling units are equipped with nested inlet vanes to increase fan efficiency, in addition to integrated enthalpy economizer systems for free air-side cooling capacity.

The Assembly Hall High Bay Area is equipped with ceiling mounted heat circulating fans to reduce air temperature stratification and thus conserve energy by reducing required indoor air temperature at the roof level to maintain temperature setpoint at the floor. This in turn reduces building heat transmission losses by reducing the average effective temperature difference across building surfaces exposed to the outdoors.

Air handling systems in the Side Bay areas are designed to further conserve energy by computerized supply air temperature reset which looks at all zone temperatures and recalculates optimum AHU supply air temperatures so as to delay turn-on of any individual zone heating coil for as long as possible before temperature in any other zone rises above the comfort tolerance level. These savings are not credited in this analysis for the sake of simplicity. Along these same lines, dehumidification reheat in the Assembly and Collision Halls is reset in a similar manner by computer to minimize heating coil turn-on, which is also not credited in this analysis for the sake of simplicity.

System performance is further enhanced by the use of dynamic control through a Direct Digital Control system employing proportional-integral-derivative response coupled to pulse width modulation for permanent calibration - high accuracy tracking. This technology also allows for sophisticated strategy through its boolean operatives. The system is of a fully modular and distributed processing architecture which is expandable by adding to each subsystem as required. The DDC controls system consists of stand-alone intelligent local field processors for all building systems

connected to one another and to a local front end computer to create a local area network. The system is modular both in design of software as well as hardware and shall allow for change of function and operation in the field without programming changes or changes to hardware. Control strategies and setpoints may be changed on line by Fermilab personnel to the end that integral energy management features (such as demand limiting) may be brought on line as historical data is generated. Energy conservation through high accuracy control tuning which eliminates the constant setpoint over-shooting associated with conventional control systems is also not credited in this analysis for the sake of simplicity.

Two significant energy conservation features deriving directly from the use of DDC computerized controls at the D-0 facility serve to reduce excessive intake of outdoor air by HVAC systems. The first feature constantly calculates and resets outdoor air intake dampers to maintain exact minimum percentage of outdoor air based on mathematical comparison of outdoor air, return air and mixed air temperatures. This eliminates excessive outdoor air intake during cold weather due to increased outdoor air density, which is typical of conventional control systems designed to merely maintain preset minimum outdoor air damper position.

The second feature allows the central control computer to simultaneously look at the many building pressurization zones, with their varying degrees of positive, negative and neutral relationships to outdoors and to orchestrate the total building HVAC system, so as to preclude individual control systems from fighting each other and gulping or exhausting excessive outdoor air while maintaining fine pressure control. Our experience with conventional controls in similar applications proves that this is impossible without DDC, and results in periods of uncontrollable cycling with subsequent energy waste beyond the conservative factors employed in this analysis.

d. Evaluation of Solar Applications: The overwhelming balance of excess heat in this structure precludes the use of either active or passive solar energy applications.

e. Discussion of Evaluation of Non-Renewable Energy Supply Alternatives: Due to the electrically intensive nature of this facility, coupled with the abundance of waste heat, the use of natural gas (the only other viable non-renewable energy supply on site) is precluded over electricity.

In engineering the overall integrated mechanical systems configuration, consideration has been made to assure minimal utilization of non-renewable resources in the form of electrical energy with respect to D.O.E. Document 4330.3.

f. Estimates of Total HVAC Energy Input to the Building: The Fermilab D-0 Experimental Facility is characterized by exceptionally intense cooling loads. Overall building design load intensity is calculated at 100 square feet per ton.

Building Annual Energy Input for Designed HVAC Systems:

KWH Per Year: 1,182,331
Annual DOE Resource Impact Factor: 4,035,910 MBH
Annual BTU/Gross Square Foot/Year: 95,638

g. 45% Energy Use Reduction Goal Data:

1. The following information represents the estimated total HVAC energy use of a representative building of the appropriate category in FY1975:

   Building Annual Energy Input for FY1975 HVAC Systems:

   KWH Per Year: 2,128,445
   Annual DOE Resource Impact Factor: 7,264,383 MBH
   Annual BTU/Gross Square Foot/Year: 172,142

2. The following is the estimated percentage of energy use reduction for the designed HVAC systems as opposed to typical FY1975 HVAC Systems:

   Building Present Scope: 45% Reduction

   As described within the text, this goal is realized on the basis of conservative analysis, with several energy conservation features not being credited for the sake of analysis simplicity.

3. Due to the atypical requirements, loads, and design of this building, the method of simulating by computer the performance of typical FY1975 HVAC systems in the as-designed structure has been used to estimate the baseline HVAC energy use of a representative building of the appropriate category in FY1975.

4. The estimated additional HVAC systems construction cost to achieve the 45% percent of energy use reduction over the typical FY1975 systems is as follows:

   Building Present Scope: $77,500 additional costs (10%)

   Most of the additional costs derive from extension of cooling water lines to the Main Ring lake in lieu of the Main Ring cooling ponds, but are not fully credited in energy cost avoidance to operation of the Main Ring systems as discussed above. Furthermore, these additional costs **do not** take into account actual construction cost **savings** from using the designed DDC control systems in lieu of conventional controls. Actual

comparison of controls costs for D-0 with those for similar facilities on site suggest savings of as much as $50,000, which would reduce actual additional costs to about $27,500 (4%). In view of the complexity of calculating exact control cost differences however, it was decided to ignore such savings for the sake of simplicity in this analysis.

5. The estimated energy cost savings over the minimal 20-year projected HVAC systems life including additional HVAC systems construction cost, first year energy cost savings, and present worth energy source factors are as follows:

   Building Present Scope: $969,807 cost savings

h. Outline of Metering Provisions: Due to the nature of DDC control systems and the need for metering data acquisition to execute the energy conservation strategies, virtually all major energy flows are intrinsically monitored, summarized, and printed at the local front end computer printer. This information will also be useful in generating site weather data, evaluating lake cooling water performance data (especially as it is related to weather), give Fermilab personnel data to evaluate alterations to initial energy management strategies and confirm HVAC systems performance in relation to estimated projections. Among the items metered are:

   1. All lake cooling water flows.

   2. All energy BTU's wasted from building through both cooling water and exhaust air.

   3. All hours of free cooling for individual systems.

   4. All compressor run time hours for chillers.

   5. All heater stages run time hours.

   6. All general equipment status data.

j. Comparison of Design HVAC System, Alternate Centrifugal Chiller System, and FY1975 Base Case System: Results of these comparisons are summarized on the three (3) Systems Summary Sheets attached hereafter.

TOTAL BUILDING SYSTEMS COMBINED PERFORMANCE SUMMARY

DESIGNED CONFIGURATION

RECIPROCATING CHILLERS - FULL BUILDING ENERGY FEATURES

Statistic	Present Scope	Report Page Number Statistic References
HVAC Systems Parameters		
Area:	42,200 SF	(IV-2)+(V-2)+(VI-2)
Tons:	420	(IV-4)+(V-4)+(VI-4)
SF/Ton:	100	
Annual Operating Cost:	$ 59,125	(IV-11)+(V-11)+(VI-9)
Annual Op. Cost/SF:	$ 1.40	
Annual Maintenance Cost:	$ 12,000	(VII-2)
Construction Cost:	$ 752,900	(VII-2)
20 Yr. Cumulative Cost:	$ 2,340,147	(VII-4)
HVAC Energy		
KWH/Yr.	1,182,331	(IV-11)+(V-11)+(VI-9)
DOE RUF MBH:	13,717,127	(IV-11)+(V-11)+(VI-9)
DOE RIF MBH:	4,035,910	(IV-11)+(V-11)+(VI-9)
BTU/SF/Yr.	95,638	
Energy Reduction from 1975:	45%	
Non-HVAC Energy		
KWH/Yr.	7,686,513	(IV-11)+(V-11)+(VI-9)
DOE RUF MBH:	89,163,546	(IV-11)+(V-11)+(VI-9)
DOE RIF MBH:	26,234,068	(IV-11)+(V-11)+(VI-9)
BTU/SF/Yr.	621,660	
Total Building Energy		
KWH/Yr.	8,805,179	(IV-11)+(V-11)+(VI-9)
DOE RUF MBH:	102,880,672	(IV-11)+(V-11)+(VI-9)
DOE RIF MBH:	30,269,977	(IV-11)+(V-11)+(VI-9)
BTU/SF/Yr.	717,298	

TOTAL BUILDING SYSTEMS COMBINED PERFORMANCE SUMMARY

ALTERNATE NO. 1 CONFIGURATION

CENTRIFUGAL CHILLERS - FULL BUILDING ENERGY FEATURES

Statistic	Present Scope	Report Page Number Statistic References
HVAC Systems Parameters		
Area:	42,200 SF	(IV-2)+(V-2)+(VI-2)
Tons:	420	(IV-4)+(V-4)+VI-4)
SF/Ton:	100	
Annual Operating Cost:	$ 65,087	(IV-27)+(V-25)+(VI-9)
Annual Op. Cost/SF:	$ 1.54	
Annual Maintenance Cost:	$ 12,000	(VII-6)
Construction Cost:	$ 752,900	(VII-6)
% of Design Constr. Cost:	100%	
Constr. Cost Difference:	$ 0.0	(VII-6)-(VII-2)
Annual Op. Cost Diff.:	$ 5,962	((IV-27)+(V-25)+(VI-9))-((IV-11)+(V-11)+(VI-9))
Design System Payback:	0.0 years	(VII-17)
20 Yr. Cumulative Cost:	$2,431,364	(VII-8)
Cumulative Cost Diff.:	$ 91,217	(VII-14)
HVAC Energy		
KWH/Yr.	1,261,817	(IV-27)+(V-25)+(VI-9)
DOE RUF MBH:	14,639,178	(IV-27)+(V-25)+(VI-9)
DOE RIF MBH:	4,307,200	(IV-27)+(V-25)+(VI-9)
BTU/SF/Yr.	102,066	
Energy Increase from Design:	107%	
Energy Reduction from 1975:	41%	
Non-HVAC Energy		
KWH/Yr.	7,686,513	(IV-27)+(V-25)+(VI-9)
DOE RUF MBH:	89,163,546	(IV-27)+(V-25)+(VI-9)
DOE RIF MBH:	26,234,068	(IV-27)+(V-25)+(VI-9)
BTU/SF/Yr.	621,660	
Total Building Energy		
KWH/Yr.	8,948,330	(IV-27)+(V-25)+(VI-9)
DOE RUF MBH:	103,802,724	(IV-27)+(V-25)+(VI-9)
DOE RIF MBH:	30,541,268	(IV-27)+(V-25)+(VI-9)
BTU/SF/Yr.	723,727	

TOTAL BUILDING SYSTEMS COMBINED PERFORMANCE SUMMARY

ALTERNATE NO. 2 FY1975 CONFIGURATION

RECIPROCATING CHILLERS - BASIC BUILDING DESIGN

Statistic	Present Scope	Report Page Number Statistic References
HVAC Systems Parameters		
Area:	42,200	(IV-2)+(V-2)+(VI-2)
Tons:	420	(IV-4)+(V-4)+(VI-4)
SF/Ton:	100	
Annual Operating Cost:	$ 106,423	(IV-43)+(V-39)+(VI-18)
Annual Op. Cost/SF:	$ 2.52	
Annual Maintenance Cost:	$ 10,000	(VII-10)
Construction Cost:	$ 675,400	(VII-10)
% of Design Constr. Cost:	90%	
Constr. Cost Difference:	-$ 77,500	(VII-10)-(VII-2)
Annual Op. Cost Diff.:	$ 47,298	((IV-43)+(V-39)+VI-18))-((IV-11)+(V-11)+(VI-9))
Design System Payback:	1.7 years	(VIII-18)
20 Yr. Cumulative Cost:	$3,309,954	(VII-12)
Cumulative Cost Diff.:	$ 969,807	(VII-15)
HVAC Energy		
KWH/Yr.	2,128,445	(IV-43)+(V-39)+(VI-18)
DOE RUF MBH:	24,689,962	(IV-43)+(V-39)+(VI-18)
DOE RIF MBH:	7,264,383	(IV-43)+(V-39)+(VI-18)
BTU/SF/Yr.	172,142	
Energy Increase from Design:	180%	
Non-HVAC Energy		
KWH/Yr.	7,686,513	(IV-43)+(V-39)+(VI-18)
DOE RUF MBH:	89,163,546	(IV-43)+(V-39)+(VI-18)
DOE RIF MBH:	26,234,068	(IV-43)+(V-39)+(VI-18)
BTU/SF/Yr.	621,660	
Total Building Energy		
KWH/Yr.	9,814,958	(IV-43)+(V-39)+(VI-18)
DOE RUF MBH:	113,853,508	(IV-43)+(V-39)+(VI-18)
DOE RIF MBH:	33,498,451	(IV-43)+(V-39)+(VI-18)
BTU/SF/Yr.	793,802	

APPENDICES

At the authors' request, the Appendices to TM-1505 are being distributed upon request only.

If you would like a copy of same, please contact the Publications Office at MS #107 or Ext. 3278.

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Appendices

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FERMILAB CONSTRUCTION ENGINEERING SERVICES

II.

FERMILAB D-0 EXPERIMENTAL FACILITY

SITE WEATHER DATA AND DESIGN PROFILES

31 OCTOBER, 1987
ANALYST: S.F.KRSTULOVICH

FERMILAB CONSTRUCTION ENGINEERING SERVICES

WEATHER SUMMARY

Site Name : AURORA,IL FERMI, User Defined Date : 11-03-87

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TABLE 1. SITE DESIGN WEATHER DATA

Latitude	= 42 deg.	Elevation	= 744 Feet
Summer design dry bulb	= 93 F	Winter design dry bulb	= -6 F
Summer design wet bulb	= 76 F	Daily range	= 20 F

****

TABLE 2. PEAK SOLAR GAINS (Btu/(hr-sqft))

Month	N	NE	E	SE	S	SW	W	NW	H
January	5.6	13.2	107.4	173.8	189.1	173.8	107.4	13.2	107.6
July	17.1	144.7	189.6	148.8	88.4	148.8	189.6	144.7	264.5

Carrier peak solar data used.
Values corrected for altitude (744 ft), design dewpoint (69.3 F)
% Available Sunshine : Average data: Summer = 73 % ; Winter = 35 %

****

TABLE 3. OCCUPANCY SCHEDULE DATA

	Sun	Mon	Tue	Wed	Thu	Fri	Sat
Begin	OFF	7 A	7 A	7 A	7 A	7 A	9 A
End	OFF	6 P	6 P	6 P	6 P	6 P	2 P

Average occupancy : 10.0 hrs/day; 6.0 days/week
Number of summer shutdown days = 0

****

TABLE 4. TEMPERATURE BIN DATA

Bin Dry Bulb (F)	Bin Wet Bulb (F)	Bin Specific Humidity (lb/lb)	Bin Hours (hr/yr) Total Hours	Occupied Hours	Unoccupied Hours
93	76.0	0.0153	0.0	0.0	0.0
90	71.8	0.0124	40.4	25.8	14.6
85	69.0	0.0114	95.7	59.4	36.3
80	66.3	0.0106	244.6	145.3	99.3
75	63.6	0.0099	453.0	237.7	215.3
70	60.9	0.0093	628.2	270.6	357.6
65	58.2	0.0087	727.8	264.5	463.3
60	55.4	0.0083	755.4	255.0	500.4
55	52.7	0.0079	726.7	244.7	482.0
50	50.0	0.0076	679.7	232.1	447.6
45	45.0	0.0063	652.2	229.5	422.7
40	40.0	0.0052	651.3	237.6	413.7
35	35.0	0.0043	655.5	238.5	417.0
30	30.0	0.0035	635.6	218.2	417.4
25	25.0	0.0028	569.7	174.5	395.2
20	20.0	0.0022	459.3	122.4	336.9
15	15.0	0.0017	330.9	78.1	252.8
10	10.0	0.0013	211.8	46.1	165.7
5	5.0	0.0010	121.4	25.1	96.3
0	0.0	0.0008	63.6	12.7	50.9
-5	-5.0	0.0006	31.5	6.2	25.3
-6	-6.0	0.0006	25.7	4.6	21.1
-6	-6.0	0.0006	0.0	0.0	0.0

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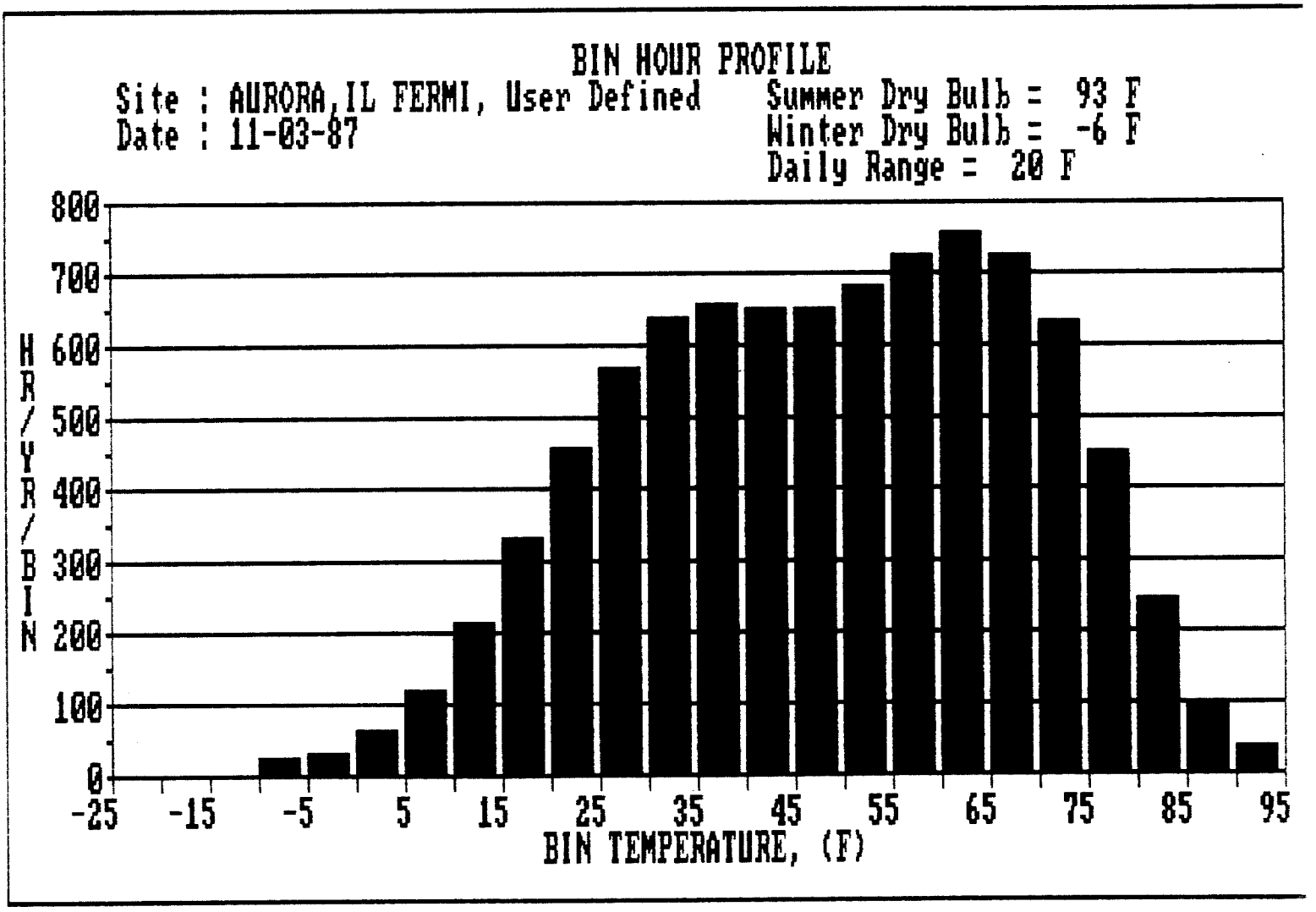

BIN HOUR PROFILE
Site : AURORA,IL FERMI, User Defined
Date : 11-03-87
Summer Dry Bulb = 93 F
Winter Dry Bulb = -6 F
Daily Range = 20 F
HR/YR/BIN
800
700
600
500
400
300
200
100
0
-25
-15
-5
5
15
25
35
45
55
65
75
85
95
BIN TEMPERATURE, (F)

III.

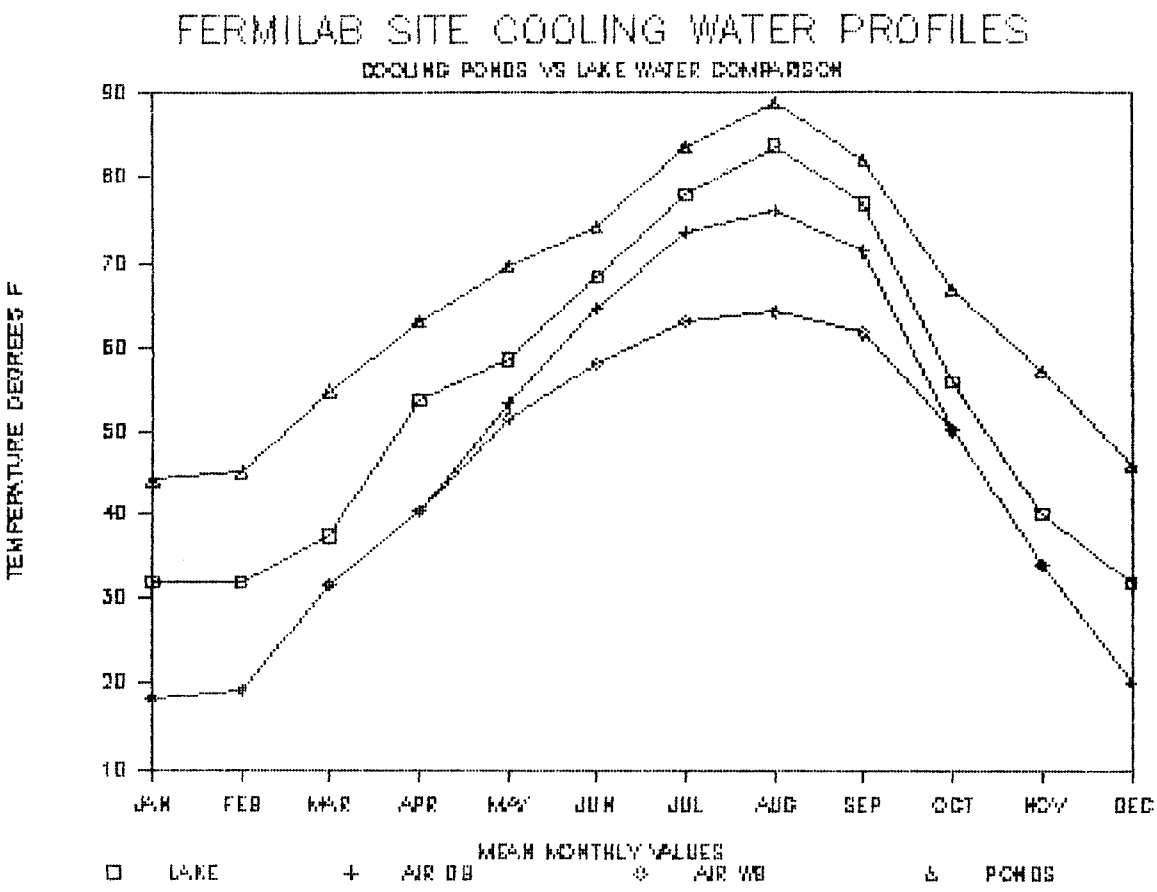
FERMILAB D-0 EXPERIMENTAL FACILITY

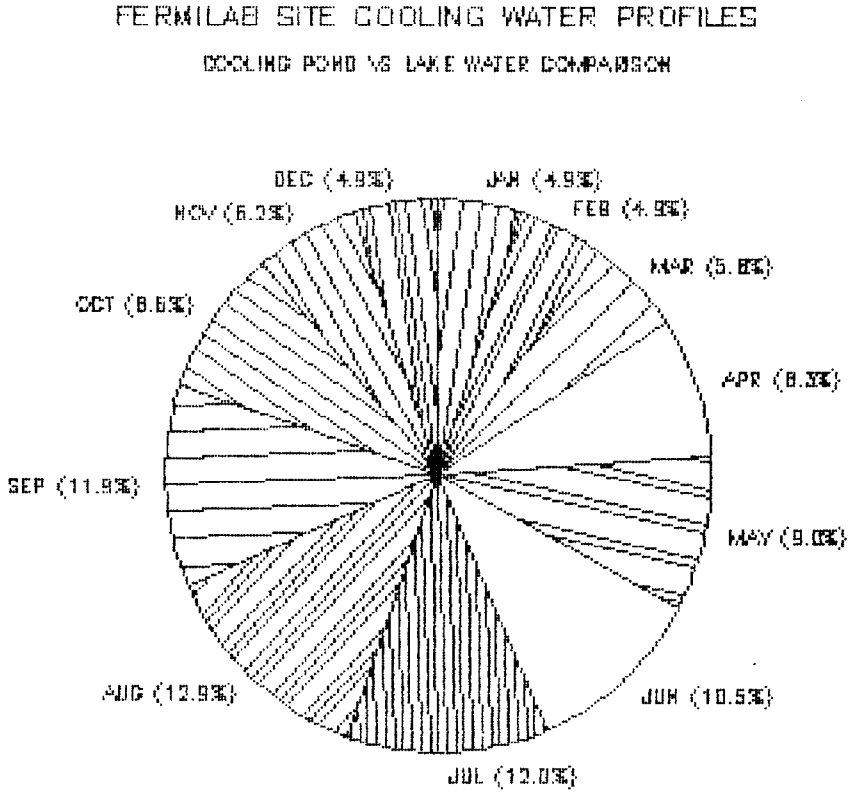
SITE MAIN RING LAKE COOLING DATA

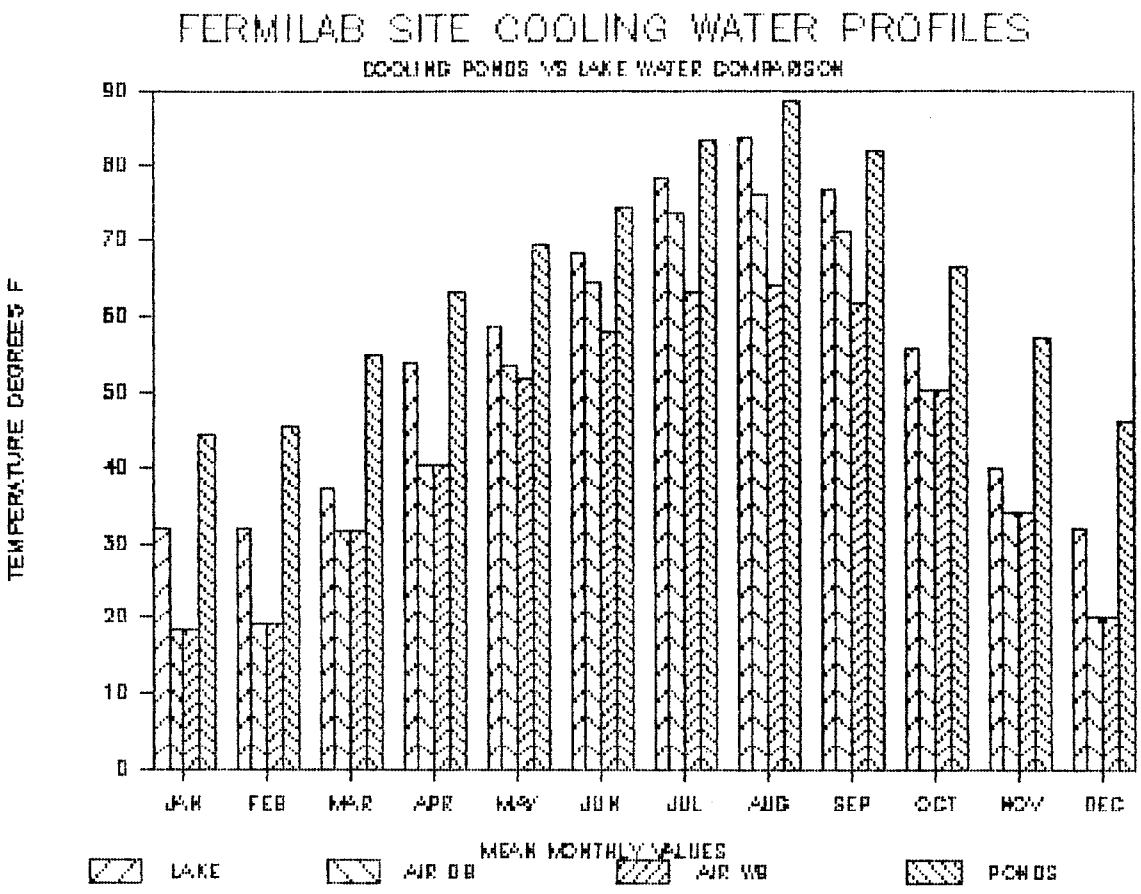
31 OCTOBER, 1987

ANALYST: S.F.KRSTULOVICH

FERMILAB CONSTRUCTION ENGINEERING SERVICES


FERMILAB SITE COOLING WATER PROFILES
COOLING PONDS VS LAKE WATER COMPARISON
TEMPERATURE DEGREES F
90
80
70
60
50
40
30
20
10
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
MEAN MONTHLY VALUES
LAKE
AIR DB
AIR WB
PONDS


FERMILAB SITE COOLING WATER PROFILES
COOLING POND VS LAKE WATER COMPARISON
DEC (4.9%)
JAN (4.9%)
NOV (5.3%)
FEB (4.9%)
MAR (5.8%)
OCT (8.6%)
APR (8.3%)
SEP (11.9%)
MAY (9.0%)
AUG (12.9%)
JUN (10.5%)
JUL (12.0%)


FERMILAB SITE COOLING WATER PROFILES
COOLING PONDS VS LAKE WATER COMPARISON
TEMPERATURE DEGREES F
90
80
70
60
50
40
30
20
10
0
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
MEAN MONTHLY VALUES
LAKE
AIR DB
AIR WB
PONDS

FERMILAB ANNUAL SITE SURFACE WATER PROFILES

MEAN MONTH VALUES OF SIGNIFICANT INDICATORS

	JAN	FEB	MAR	APR	MAY
LAKE WATER TEMP	32.0	32.0	37.4	53.8	58.6
OA AIR TEMP DB	18.3	19.2	31.6	40.4	53.3
OA AIR TEMP WB	18.3	19.2	31.6	40.4	51.7
POND WATER TEMP	44.3	45.2	54.8	63.1	69.5

JUN	JUL	AUG	SEP	OCT	NOV	DEC
68.3	78.1	83.7	76.9	55.9	40.1	32.0
64.7	73.6	76.2	71.3	50.3	34.2	20.1
58.1	63.1	64.2	61.7	50.2	34.2	20.1
74.3	83.5	88.9	82.1	66.7	57.2	46.1

IV.

FERMILAB D-O EXPERIMENTAL FACILITY

SUBCONSTRUCTION 1/3 - COLLISION AND ASSEMBLY HALLS
SYSTEMS ANALYSIS

31 OCTOBER, 1987
ANALYST: S.F.KRSTULOVICH

FERMILAB CONSTRUCTION ENGINEERING SERVICES

IV-a.

FERMILAB D-O EXPERIMENTAL FACILITY

SUBCONSTRUCTION 1/3 - COLLISION AND ASSEMBLY HALLS
BUILDING SECTOR PHYSICAL PARAMETERS AND DESCRIPTION

31 OCTOBER, 1987

ANALYST: S.F.KRSTULOVICH

FERMILAB CONSTRUCTION ENGINEERING SERVICES

COMPLEX BUILDING INPUT SUMMARY

Building Name : D-0 SUBCONSTRUCT 1/3 Date : 11-16-87
Site : AURORA,IL FERMI, User Defined 60117862.0

****

1. ROOM CONDITIONS AND FLOOR AREAS

Thermostat settings : Cooling = 78 F; Heating = 68 F; Setback = 0 F
Warm-up factor = 0 %; Room design relative humidity = 60 %
Floor Areas: Perimeter = 24,400 Sqft; Interior = 0 Sqft
Cooling provided during unoccupied period.

---

2. WALLS, ROOF, GLASS, SKYLIGHTS:

Exposure	Area (Sqft)	U-Factor BTU/(hr-sqft-F)	Glass Area (Sqft)	Glass U-Factor BTU/(hr-sqft-F)
North Wall	1,300	0.150	100	1.130
Northeast Wall	0	0.150	0	1.130
East Wall	3,100	0.150	0	1.130
Southeast Wall	0	0.150	0	1.130
South Wall	6,600	0.150	0	1.130
Southwest Wall	0	0.150	0	1.130
West Wall	2,800	0.150	0	1.130
Northwest Wall	0	0.150	0	1.130
Perimeter Roof	14,900	0.130	0	0.550
Interior Roof	0	0.130	0	0.550

WALLS: Color = Dark; Wt. = Medium; ROOF: Color = Medium; Wt. = Medium
BUILDING WT. = Medium; VERTICAL GLASS : Single Glazed
Shade Factors : Glass = 1.000 ; Skylights = 0.000
Internal shades are not used. ; A ceiling plenum is not used.

---

3. LIGHTS:

Perimeter : 3.000 Watts/Sqft = 73,200 Watts Total
Interior : 0.000 Watts/Sqft = 0 Watts Total
Diversity Factors : Occupied = 100 %; Unoccupied = 100 %
Perimeter Lights : Ballast , exposed
Interior Lights : Ballast , recessed

---

4. MISCELLANEOUS ELECTRICAL LOADS:

Perimeter : Occupied = 2.459 Watts/Sqft = 60,000 Watts Total
Unoccupied = 0.820 Watts/Sqft = 20,000 Watts Total
Interior : Occupied = 0.000 Watts/Sqft = 0 Watts Total
Unoccupied = 0.000 Watts/Sqft = 0 Watts Total

---

5. PEOPLE LOADS

Total Occupancy = 2,440 sqft/person = 10 people total
Activity Level: 4. Medium work
Sensible = 295.0 BTU/hr/person; Latent = 455.0 BTU/hr/person
Diversity Factors : Occupied = 70 %; Unoccupied = 20 %

---

6. MISCELLANEOUS INTERNAL LOADS:

Sensible : Occupied = 0 BTU/hr; Unoccupied = 0 BTU/hr
Latent : Occupied = 0 BTU/hr; Unoccupied = 0 BTU/hr

---

7. WALLS ADJACENT TO NON-CONDITIONED REGIONS:

Wall Areas : Perimeter = 21,500 Sqft; Interior = 0 Sqft
Wall U-Factor = 0.320 BTU/(hr-sqft-F)
Adjacent region heating temperature = 60 F
Adjacent region cooling temperature = 60 F

---

8. INFILTRATION DATA:

Air Flow Rates: Occupied = 200 cfm; Unoccupied = 100 cfm

IV-b.

FERMILAB D-O EXPERIMENTAL FACILITY

SUBCONSTRUCTION 1/3 - COLLISION AND ASSEMBLY HALLS
BUILDING LOAD CALCULATIONS

31 OCTOBER, 1987
ANALYST: S.F.KRSTULOVICH

FERMILAB CONSTRUCTION ENGINEERING SERVICES

LOAD PROFILE SUMMARY

Building Name : D-O SUBCONSTRUCT 1/3 (Complex) Date : 11-16-87

Site Name : AURORA,IL FERMI, User Defined 60117862.0

****

TABLE 1. OCCUPIED PERIOD (Load does not include vent. load, fan heat)

Bin Temp (F)	Bin Hours (hr/yr)	<-------Perimeter Zone-------> Sensible (tons)	Latent (tons)	Plenum (tons)	Zone (F)	<---------Interior Zone-----> Sensible (tons)	Latent (tons)	Plenum (tons)	Zone (F)
93	0.0	42.29	0.61	0.00	78	0.00	0.00	0.00	--
90	25.8	39.53	0.27	0.00	78	0.00	0.00	0.00	--
85	59.4	37.68	0.19	0.00	78	0.00	0.00	0.00	--
80	145.3	35.84	0.12	0.00	78	0.00	0.00	0.00	--
75	237.7	34.00	0.06	0.00	78	0.00	0.00	0.00	--
70	270.6	32.15	0.01	0.00	78	0.00	0.00	0.00	--
65	264.5	30.31	-0.03	0.00	78	0.00	0.00	0.00	--
60	255.0	28.47	-0.07	0.00	78	0.00	0.00	0.00	--
55	244.7	26.63	-0.09	0.00	78	0.00	0.00	0.00	--
50	232.1	24.78	-0.12	0.00	78	0.00	0.00	0.00	--
45	229.5	22.94	-0.22	0.00	78	0.00	0.00	0.00	--
40	237.6	21.10	-0.31	0.00	78	0.00	0.00	0.00	--
35	238.5	19.26	-0.39	0.00	78	0.00	0.00	0.00	--
30	218.2	17.41	-0.45	0.00	78	0.00	0.00	0.00	--
25	174.5	15.57	-0.51	0.00	78	0.00	0.00	0.00	--
20	122.4	13.73	-0.56	0.00	78	0.00	0.00	0.00	--
15	78.1	11.89	-0.60	0.00	78	0.00	0.00	0.00	--
10	46.1	10.04	-0.63	0.00	78	0.00	0.00	0.00	--
5	25.1	8.20	-0.65	0.00	78	0.00	0.00	0.00	--
0	12.7	6.36	-0.67	0.00	78	0.00	0.00	0.00	--
-5	6.2	4.52	-0.68	0.00	78	0.00	0.00	0.00	--
-6	4.6	4.15	-0.69	0.00	78	0.00	0.00	0.00	--

TABLE 2. UNOCCUPIED PERIOD (Load does not include vent. load, fan heat)

90	14.6	27.92	0.08	0.00	78	0.00	0.00	0.00	--
85	36.3	26.12	0.04	0.00	78	0.00	0.00	0.00	--
80	99.3	24.32	0.00	0.00	78	0.00	0.00	0.00	--
75	215.3	22.53	-0.03	0.00	78	0.00	0.00	0.00	--
70	357.6	20.73	-0.05	0.00	78	0.00	0.00	0.00	--
65	463.3	18.93	-0.07	0.00	78	0.00	0.00	0.00	--
60	500.4	17.14	-0.09	0.00	78	0.00	0.00	0.00	--
55	482.0	15.34	-0.10	0.00	78	0.00	0.00	0.00	--
50	447.6	13.54	-0.12	0.00	78	0.00	0.00	0.00	--
45	422.7	11.74	-0.17	0.00	78	0.00	0.00	0.00	--
40	413.7	9.95	-0.21	0.00	78	0.00	0.00	0.00	--
35	417.0	8.15	-0.25	0.00	78	0.00	0.00	0.00	--
30	417.4	6.35	-0.28	0.00	78	0.00	0.00	0.00	--
25	395.2	4.56	-0.31	0.00	78	0.00	0.00	0.00	--
20	336.9	2.76	-0.34	0.00	78	0.00	0.00	0.00	--
15	252.8	0.96	-0.35	0.00	78	0.00	0.00	0.00	--
10	165.7	0.00	0.00	0.00	--	0.00	0.00	0.00	--
5	96.3	0.00	0.00	0.00	--	0.00	0.00	0.00	--
0	50.9	0.00	0.00	0.00	--	0.00	0.00	0.00	--
-5	25.3	0.00	0.00	0.00	--	0.00	0.00	0.00	--
-6	21.1	0.00	0.00	0.00	--	0.00	0.00	0.00	--
-6	0.0	-30.67	-0.33	0.00	68	0.00	0.00	0.00	--

SOLAR GAIN SUMMARY

Building Name : D-0 SUBCONSTRUCT 1/3 (Complex) Date : 11-16-87

Site Name : AURORA,IL FERMI, User Defined 60117862.0

****

TABLE 1. SOLAR GAINS BY EXPOSURE

Bin Temp (F)	Solar Gains by Exposure (BTU/(hr-sqft)) North	NE	East	SE	South	SW	West	NW	Perim Horiz	Inter Horiz
93	13.0	30.4	47.4	53.6	50.4	74.4	56.9	27.5	0.0	0.0
90	9.2	21.5	33.6	38.1	35.9	52.9	40.4	19.5	0.0	0.0
85	8.8	20.4	32.0	36.3	34.4	50.5	38.6	18.5	0.0	0.0
80	8.3	19.3	30.3	34.6	32.9	48.1	36.7	17.5	0.0	0.0
75	7.8	18.2	28.7	32.9	31.4	45.8	34.9	16.5	0.0	0.0
70	7.4	17.1	27.1	31.2	29.9	43.4	33.0	15.5	0.0	0.0
65	6.9	16.0	25.4	29.4	28.4	41.0	31.2	14.5	0.0	0.0
60	6.5	14.9	23.8	27.7	27.0	38.6	29.3	13.5	0.0	0.0
55	6.0	13.8	22.2	26.0	25.5	36.3	27.5	12.6	0.0	0.0
50	5.5	12.6	20.5	24.2	24.0	33.9	25.6	11.6	0.0	0.0
45	5.1	11.5	18.9	22.5	22.5	31.5	23.8	10.6	0.0	0.0
40	4.6	10.4	17.3	20.8	21.0	29.1	21.9	9.6	0.0	0.0
35	4.1	9.3	15.6	19.0	19.5	26.8	20.1	8.6	0.0	0.0
30	3.7	8.2	14.0	17.3	18.0	24.4	18.2	7.6	0.0	0.0
25	3.2	7.1	12.4	15.6	16.5	22.0	16.4	6.6	0.0	0.0
20	2.8	6.0	10.7	13.9	15.0	19.6	14.5	5.6	0.0	0.0
15	2.3	4.9	9.1	12.1	13.5	17.3	12.7	4.7	0.0	0.0
10	1.8	3.8	7.5	10.4	12.0	14.9	10.8	3.7	0.0	0.0
5	1.4	2.7	5.8	8.7	10.6	12.5	9.0	2.7	0.0	0.0
0	0.9	1.6	4.2	6.9	9.1	10.1	7.1	1.7	0.0	0.0
-5	0.4	0.5	2.6	5.2	7.6	7.8	5.3	0.7	0.0	0.0
-6	0.3	0.2	2.3	4.9	7.3	7.3	4.9	0.5	0.0	0.0
-6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

ETD SUMMARY

Building Name : D-O SUBCONSTRUCT 1/3 (Complex) Date : 11-16-87

Site Name : AURORA,IL FERMI, User Defined 60117862.0

****

TABLE 1. OCCUPIED PERIOD

Bin Temp (F)	Equivalent Temperature Differences (F) By Exposure North	NE	East	SE	South	SW	West	NW	Perim Roof	Inter Roof
93	8.0	11.4	13.8	23.5	29.8	27.0	20.7	10.3	30.4	-----
90	5.4	7.8	9.5	16.4	20.8	18.9	14.4	7.0	21.7	-----
85	1.0	3.3	4.9	11.5	15.7	13.9	9.6	2.5	16.4	-----
80	-3.4	-1.3	0.3	6.6	10.5	8.9	4.7	-2.0	11.1	-----
75	-7.8	-5.8	-4.3	1.7	5.4	3.9	-0.1	-6.5	5.8	-----
70	-12.2	-10.3	-8.9	-3.2	0.2	-1.1	-4.9	-10.9	0.5	-----
65	-16.6	-14.8	-13.5	-8.1	-4.9	-6.1	-9.8	-15.4	-4.9	-----
60	-21.0	-19.3	-18.1	-13.0	-10.1	-11.1	-14.6	-19.9	-10.2	-----
55	-25.4	-23.8	-22.7	-17.9	-15.2	-16.1	-19.4	-24.4	-15.5	-----
50	-29.8	-28.4	-27.3	-22.8	-20.4	-21.1	-24.2	-28.8	-20.8	-----
45	-34.2	-32.9	-31.9	-27.7	-25.5	-26.1	-29.1	-33.3	-26.1	-----
40	-38.6	-37.4	-36.5	-32.5	-30.7	-31.1	-33.9	-37.8	-31.4	-----
35	-43.0	-41.9	-41.1	-37.4	-35.8	-36.1	-38.7	-42.3	-36.7	-----
30	-47.4	-46.4	-45.7	-42.3	-41.0	-41.1	-43.6	-46.7	-42.0	-----
25	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
20	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
15	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
10	-54.9	-54.5	-54.1	-51.9	-51.6	-51.1	-52.9	-54.6	-53.2	-----
5	-59.3	-59.0	-58.7	-56.8	-56.7	-56.1	-57.7	-59.1	-58.6	-----
0	-63.7	-63.5	-63.3	-61.7	-61.9	-61.1	-62.5	-63.6	-63.9	-----
-5	-68.1	-68.1	-67.9	-66.6	-67.0	-66.1	-67.3	-68.1	-69.2	-----
-6	-69.0	-69.0	-68.8	-67.5	-68.0	-67.1	-68.3	-69.0	-70.2	-----

TABLE 2. UNOCCUPIED PERIOD

90	5.4	7.8	9.5	16.4	20.8	18.9	14.4	7.0	21.7	-----
85	1.0	3.3	4.9	11.5	15.7	13.9	9.6	2.5	16.4	-----
80	-3.4	-1.3	0.3	6.6	10.5	8.9	4.7	-2.0	11.1	-----
75	-7.8	-5.8	-4.3	1.7	5.4	3.9	-0.1	-6.5	5.8	-----
70	-12.2	-10.3	-8.9	-3.2	0.2	-1.1	-4.9	-10.9	0.5	-----
65	-16.6	-14.8	-13.5	-8.1	-4.9	-6.1	-9.8	-15.4	-4.9	-----
60	-21.0	-19.3	-18.1	-13.0	-10.1	-11.1	-14.6	-19.9	-10.2	-----
55	-25.4	-23.8	-22.7	-17.9	-15.2	-16.1	-19.4	-24.4	-15.5	-----
50	-29.8	-28.4	-27.3	-22.8	-20.4	-21.1	-24.2	-28.8	-20.8	-----
45	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
40	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
35	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
30	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
25	-41.8	-41.0	-40.3	-37.2	-36.1	-36.1	-38.4	-41.2	-37.3	-----
20	-46.2	-45.5	-44.9	-42.1	-41.3	-41.1	-43.2	-45.7	-42.6	-----
15	-50.5	-50.0	-49.5	-47.0	-46.4	-46.1	-48.0	-50.2	-47.9	-----
10	-54.9	-54.5	-54.1	-51.9	-51.6	-51.1	-52.9	-54.6	-53.2	-----
5	-59.3	-59.0	-58.7	-56.8	-56.7	-56.1	-57.7	-59.1	-58.6	-----
0	-63.7	-63.5	-63.3	-61.7	-61.9	-61.1	-62.5	-63.6	-63.9	-----
-5	-68.1	-68.1	-67.9	-66.6	-67.0	-66.1	-67.3	-68.1	-69.2	-----
-6	-69.0	-69.0	-68.8	-67.5	-68.0	-67.1	-68.3	-69.0	-70.2	-----
-6	-74.0	-74.0	-74.0	-74.0	-74.0	-74.0	-74.0	-74.0	-74.0	-----

IV-c.

FERMILAB D-O EXPERIMENTAL FACILITY

SUBCONSTRUCTION 1/3 - COLLISION AND ASSEMBLY HALLS
SYSTEM COMPARISON PERFORMANCE SIMULATIONS

31 OCTOBER, 1987
ANALYST: S.F.KRSTULOVICH

FERMILAB CONSTRUCTION ENGINEERING SERVICES

IV-c.-1.

FERMILAB D-O EXPERIMENTAL FACILITY

SUBCONSTRUCTION 1/3 - COLLISION AND ASSEMBLY HALLS
OPERATIONAL PERFORMANCE SIMULATION

DESIGN BASIS SYSTEM
RECIPROCATING CHILLERS AND CENTRAL STATION AHU'S
WITH THESE ENERGY FEATURES:
LAKE COOLING WATER, LAKE WATER FILTERS, HYDRONIC FREE COOLING HEAT EXCHANGER,
HIGH EFFICIENCY MOTORS, INTEGRATED BUILDING PRESSURIZATION CONTROLS,
AUTOMATIC LAKE WATER PUMP STAGING, CEILING HEAT CIRCULATION FANS,
NESTED AHU FAN INLET VANES, INTEGRATED ENTHALPY ECONOMIZER

31 OCTOBER, 1987
ANALYST: S.F.KRSTULOVICH

FERMILAB CONSTRUCTION ENGINEERING SERVICES

SYSTEM INPUT SUMMARY

Job Name : D-O SUBCON 1/3 DESIGN SYS Page 1
Building Name : D-O SUBCONSTRUCT 1/3 (Complex) Date : 11-16-87
Site : AURORA,IL FERMI, User Defined 60117862.0
Scope of Analysis : Cooling and Heating Systems

****

A. AIR HANDLING SYSTEMS

>1. PERIMETER TERMINAL TYPE : CONSTANT VOLUME

Supply fan type : Backward inclined or airfoil with inlet vanes
Supply fan total static pressure = 3.00 in. wg.
Return fan type : Controlled pitch axial
Return fan total static pressure = 1.75 in. wg.
Design supply air= 42000 cfm @ 67 F; Vent. air= 3000 cfm
Are cooling terminals used for heating ? <Y>
Economizer type : Integrated, enthalpy controlled
Is a ventilation reclaim device used ? <N>
Are ventilation air dampers closed for unoccupied periods ? <N>

****

B. HEATING PLANTS

> 1 . PERIMETER PLANT : ELECTRICAL RESISTANCE

Is hydronic heating used ? <N>

****

****

C. COOLING PLANTS

>1. PERIMETER PLANT : RECIPROCATING WATER COOLED
Capacity @ 85 F entering water = 75.0 tons
KW/Ton @ 85 F entering water = 0.85 kw/ton
Is hydronic cooling used ? <Y>
Is chilled water reset used ? <N>
Is hot gas bypass used ? <N>
Is condenser performance altitude adjusted ? <Y>
Is there one compressor per condenser circuit ? <Y>
Are compressors cycled ? <Y>
Heat sink type : Open cooling tower
Minimum entering water temperature = 32 F
Is a hydronic economizer used ? <Y> ; Economizer efficiency = 80 %

****

D. PUMPING SYSTEMS

System	PERIMETER dT, F	PERIMETER dP, ft wg	dT, F	dP, ft wg
Chilled water	10.00	100.00	0.00	0.00
Hot water	0.00	0.00	0.00	0.00
Condenser water	15.00	50.00	0.00	0.00
Ground water	0.00	0.00	0.00	0.00

****

E. NON-HVAC SYSTEMS

>1. NON-HVAC ELECTRICAL ENERGY USE
Lighting kw: Occupied = 73.2 kw; Unoccupied = 73.2 kw
Misc. kw : Occupied = 60.0 kw; Unoccupied = 20.0 kw
Other kw : Occupied = 0.0 kw; Unoccupied = 0.0 kw

>2. DHW SYSTEM (Not utilized in this system)

****

F. FUEL COSTS

>1. ELECTRICAL ENERGY USE	Period Occupied ($/kwh)	Period Unoccupied ($/kwh)
Compressor	0.050	0.050
Resistance	0.050	0.050
Inductive	0.050	0.050

>2. OTHER FUELS	Unit Cost
Natural Gas	n/a $/therm
Fuel Oil	n/a $/U.S.gal
Propane	n/a $/lb
Remote Heating	n/a $/MBTU
Remote Cooling	n/a $/MBTU

TOTAL BUILDING ENERGY SUMMARY

Job Name : D-0 SUBCON 1/3 DESIGN SYS — Period : All
Building Name : D-0 SUBCONSTRUCT 1/3 (Complex) — Zone : Block
Site : AURORA,IL FERMI, User Defined — Serial Number:
Date : 11-16-87 — 60117862.0

****

HVAC ENERGY Component	Annual Cost ($/yr)	Energy or Fuel Units Consumed	DOE RUF (1000 BTU)	DOE RIF (1000 BTU)
Electric (Occ)	7855	157091 kwh/yr	1822255	536152
Electric (Unocc)	13612	272247 kwh/yr	3158060	929178
Natural Gas	0	0 therms/yr	0	0
Fuel Oil	0	0 U.S. gal/yr	0	0
Propane	0	0 lb/yr	0	0
Remote Heating	0	0 MBTU/yr	0	0
Remote Cooling	0	0 MBTU/yr	0	0
HVAC Total	21467		4980316	1465329
NON-HVAC ENERGY				
Electric (Occ)	20836	416730 kwh/yr	4834063	1422298
Electric (Unocc)	26242	524846 kwh/yr	6088219	1791301
Non-HVAC Total	47079		10922282	3213599
Grand Total	68546		15902597	4678928
Total/Sq.Ft.	2.81		651.75	191.76

HVAC Summary:

HVAC Total Cost	=	0.88 $/Sq.Ft./yr
	=	31.32 % of Total Cost
Total HVAC Electrical Energy	=	17.60 kwh/Sq.Ft./yr
	=	31.32 % of Total Electrical Energy
Non-Electrical HVAC Energy	=	-0.00 % of Total Energy

Key:

1 kwh	= 11600 BTU RUF; 3412 BTU RIF
1 therm nat gas	= 100000 BTU RUF and RIF
1 U.S. gal oil	= 138700 BTU RUF and RIF
1 Imp. gal oil	= 168000 BTU RUF and RIF
1 lb propane	= 21680 BTU RUF and RIF
RUF	= Resource utilization factor (Source value)
RIF	= Resource impact factor (Point of use value)
MBH	= 1000 BTU/hr
MBTU	= Million BTU

ANNUAL OPERATING COSTS

Job Name : D-0 SUBCON 1/3 DESIGN SYS Page 1
Building Name : D-0 SUBCONSTRUCT 1/3 (Complex) Date : 11-16-87
Site : AURORA,IL FERMI, User Defined 60117862.0
Scope of Analysis : Cooling and Heating Systems

****

A. AIR HANDLING SYSTEMS (ANNUAL FAN OPERATING COST = $20,043)

>1. PERIMETER TERMINAL TYPE : CONSTANT VOLUME

Supply fan type : Backward inclined or airfoil with inlet vanes
Supply fan total static pressure = 3.00 in. wg.
Return fan type : Controlled pitch axial
Return fan total static pressure = 1.75 in. wg.
Design supply air= 42000 cfm @ 67 F; Vent. air= 3000 cfm
Are cooling terminals used for heating ? <Y>
Economizer type : Integrated, enthalpy controlled
Is a ventilation reclaim device used ? <N>
Are ventilation air dampers closed for unoccupied periods ? <N>

****

B. HEATING PLANTS (ANNUAL HEATING PLANT OPERATING COST = $498)

> 1 . PERIMETER PLANT : ELECTRICAL RESISTANCE

Is hydronic heating used ? <N>

****

****

C. COOLING PLANTS (ANNUAL COOLING PLANT OPERATING COST = $580)

>1. PERIMETER PLANT : RECIPROCATING WATER COOLED
Capacity @ 85 F entering water = 75.0 tons
KW/Ton @ 85 F entering water = 0.85 kw/ton
Is hydronic cooling used ? <Y>
Is chilled water reset used ? <N>
Is hot gas bypass used ? <N>
Is condenser performance altitude adjusted ? <Y>
Is there one compressor per condenser circuit ? <Y>
Are compressors cycled ? <Y>
Heat sink type : Open cooling tower
Minimum entering water temperature = 32 F
Is a hydronic economizer used ? <Y> ; Economizer efficiency = 80 %

****

D. PUMPING SYSTEMS (ANNUAL PUMP OPERATING COST = $346)

System	PERIMETER dT, F	PERIMETER dP, ft wg	dT, F	dP, ft wg
Chilled water	10.00	100.00	0.00	0.00
Hot water	0.00	0.00	0.00	0.00
Condenser water	15.00	50.00	0.00	0.00
Ground water	0.00	0.00	0.00	0.00

****

E. NON-HVAC SYSTEMS (ANNUAL NON-HVAC OPERATING COST = $47,079)

>1. NON-HVAC ELECTRICAL ENERGY USE
Lighting kw: Occupied = 73.2 kw; Unoccupied = 73.2 kw
Misc. kw : Occupied = 60.0 kw; Unoccupied = 20.0 kw
Other kw : Occupied = 0.0 kw; Unoccupied = 0.0 kw

>2. DHW SYSTEM (Not utilized in this system)

****

F. FUEL COSTS (GRAND TOTAL ANNUAL OPERATING COST = $68,546)

>1. ELECTRICAL ENERGY USE	Period Occupied ($/kwh)	Period Unoccupied ($/kwh)
Compressor	0.050	0.050
Resistance	0.050	0.050
Inductive	0.050	0.050

>2. OTHER FUELS	Unit Cost
Natural Gas	n/a $/therm
Fuel Oil	n/a $/U.S.gal
Propane	n/a $/lb
Remote Heating	n/a $/MBTU
Remote Cooling	n/a $/MBTU

COOLING PLANT COSTS

Job Name : D-0 SUBCON 1/3 DESIGN SYS
Building Name : D-0 SUBCONSTRUCT 1/3 (Complex)
Site Name : AURORA,IL FERMI, User Defined

Date : 11-16-87
Serial Number:
60117862.0

Bin Temp (F)	Bin Hours hr/yr	Perimeter Cooling Plant Coil Load MBH	Input KW	Cost $/yr	No Interior Zone Exists
			OCCUPIED PERIOD		
90	25.8	666.2	41.9	54.0	
85	59.4	627.6	33.0	97.9	
80	145.3	589.0	24.2	176.1	
75	237.7	371.1	8.9	105.4	
70	270.6	118.0	1.1	14.8	
65	264.5	0.0	0.0	0.0	
60	255.0	0.0	0.0	0.0	
55	244.7	0.0	0.0	0.0	
50	232.1	0.0	0.0	0.0	
45	229.5	0.0	0.0	0.0	
40	237.6	0.0	0.0	0.0	
35	238.5	0.0	0.0	0.0	
30	218.2	0.0	0.0	0.0	
25	174.5	0.0	0.0	0.0	
20	122.4	0.0	0.0	0.0	
15	78.1	0.0	0.0	0.0	
10	46.1	0.0	0.0	0.0	
5	25.1	0.0	0.0	0.0	
0	12.7	0.0	0.0	0.0	
-5	6.2	0.0	0.0	0.0	
-6	4.6	0.0	0.0	0.0	
Total Costs				$448.2	
			UNOCCUPIED PERIOD		
90	14.6	526.9	30.0	21.9	
85	36.3	488.8	21.0	38.1	
80	99.3	450.8	12.1	60.2	
75	215.3	233.5	1.1	11.8	
70	357.6	0.0	0.0	0.0	
65	463.3	0.0	0.0	0.0	
60	500.4	0.0	0.0	0.0	
55	482.0	0.0	0.0	0.0	
50	447.6	0.0	0.0	0.0	
45	422.7	0.0	0.0	0.0	
40	413.7	0.0	0.0	0.0	
35	417.0	0.0	0.0	0.0	
30	417.4	0.0	0.0	0.0	
25	395.2	0.0	0.0	0.0	
20	336.9	0.0	0.0	0.0	
15	252.8	0.0	0.0	0.0	
10	165.7	0.0	0.0	0.0	
5	96.3	0.0	0.0	0.0	
0	50.9	0.0	0.0	0.0	
-5	25.3	0.0	0.0	0.0	
-6	21.1	0.0	0.0	0.0	
Total Costs				$132.0	

PERIMETER HEATING PLANT COSTS

Job Name : D-O SUBCON 1/3 DESIGN SYS — Date : 11-16-87
Building Name : D-O SUBCONSTRUCT 1/3 (Complex) — Serial Number:
Site Name : AURORA,IL FERMI, User Defined — 60117862.0

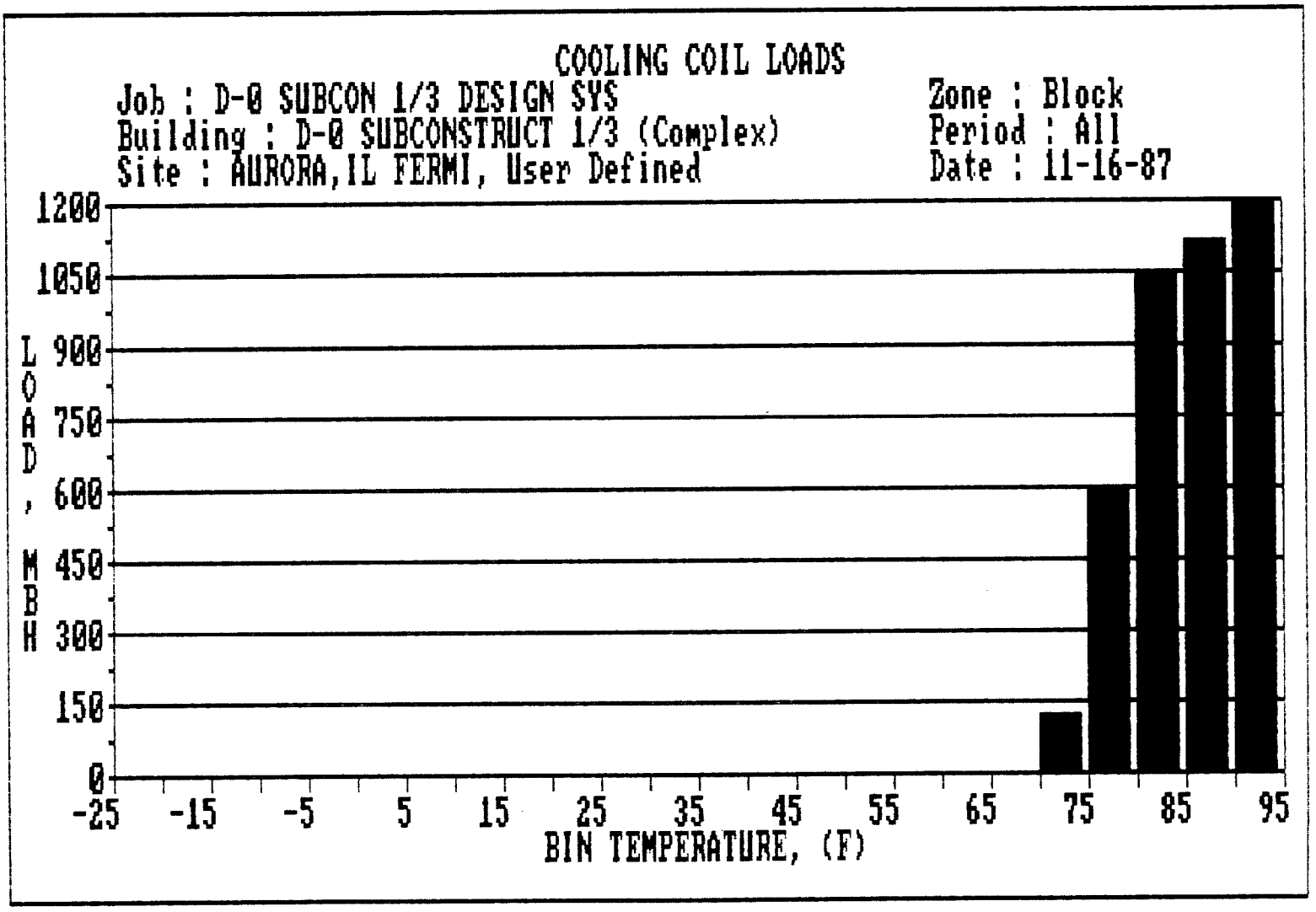
Bin Temp (F)	Bin Hours hr/yr	Coil Load MBH	Primary Plant Output MBH	Primary Plant Input KW	Primary Plant Cost $/yr	No Auxiliary Plant Used
			OCCUPIED PERIOD			
90	25.8	0.0	0.0	0.0	0.0	
85	59.4	0.0	0.0	0.0	0.0	
80	145.3	0.0	0.0	0.0	0.0	
75	237.7	0.0	0.0	0.0	0.0	
70	270.6	0.0	0.0	0.0	0.0	
65	264.5	0.0	0.0	0.0	0.0	
60	255.0	0.0	0.0	0.0	0.0	
55	244.7	0.0	0.0	0.0	0.0	
50	232.1	0.0	0.0	0.0	0.0	
45	229.5	0.0	0.0	0.0	0.0	
40	237.6	0.0	0.0	0.0	0.0	
35	238.5	0.0	0.0	0.0	0.0	
30	218.2	0.0	0.0	0.0	0.0	
25	174.5	0.0	0.0	0.0	0.0	
20	122.4	0.0	0.0	0.0	0.0	
15	78.1	0.0	0.0	0.0	0.0	
10	46.1	0.0	0.0	0.0	0.0	
5	25.1	0.0	0.0	0.0	0.0	
0	12.7	28.8	28.8	8.4	5.4	
-5	6.2	67.4	67.4	19.8	6.1	
-6	4.6	75.1	75.1	22.0	5.1	
Total Costs					$16.5	
			UNOCCUPIED PERIOD			
90	14.6	0.0	0.0	0.0	0.0	
85	36.3	0.0	0.0	0.0	0.0	
80	99.3	0.0	0.0	0.0	0.0	
75	215.3	0.0	0.0	0.0	0.0	
70	357.6	0.0	0.0	0.0	0.0	
65	463.3	0.0	0.0	0.0	0.0	
60	500.4	0.0	0.0	0.0	0.0	
55	482.0	0.0	0.0	0.0	0.0	
50	447.6	0.0	0.0	0.0	0.0	
45	422.7	0.0	0.0	0.0	0.0	
40	413.7	0.0	0.0	0.0	0.0	
35	417.0	0.0	0.0	0.0	0.0	
30	417.4	0.0	0.0	0.0	0.0	
25	395.2	0.0	0.0	0.0	0.0	
20	336.9	6.0	6.0	1.8	29.5	
15	252.8	44.0	44.0	12.9	163.1	
10	165.7	39.1	39.1	11.5	94.9	
5	96.3	55.6	55.6	16.3	78.4	
0	50.9	72.1	72.1	21.1	53.8	
-5	25.3	88.6	88.6	26.0	32.8	
-6	21.1	91.9	91.9	26.9	28.4	
Total Costs					$481.0	

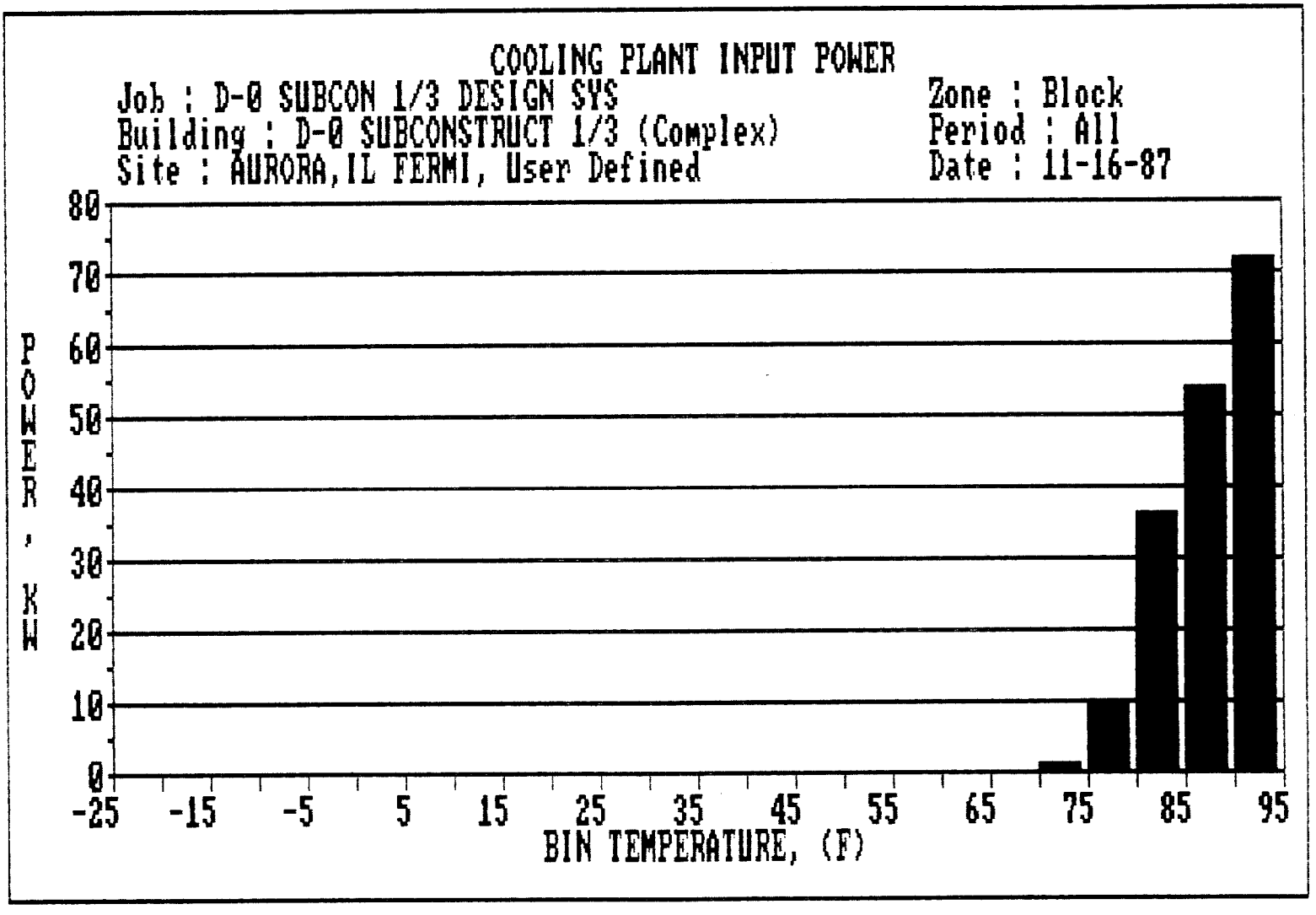
FAN AND PUMP COSTS

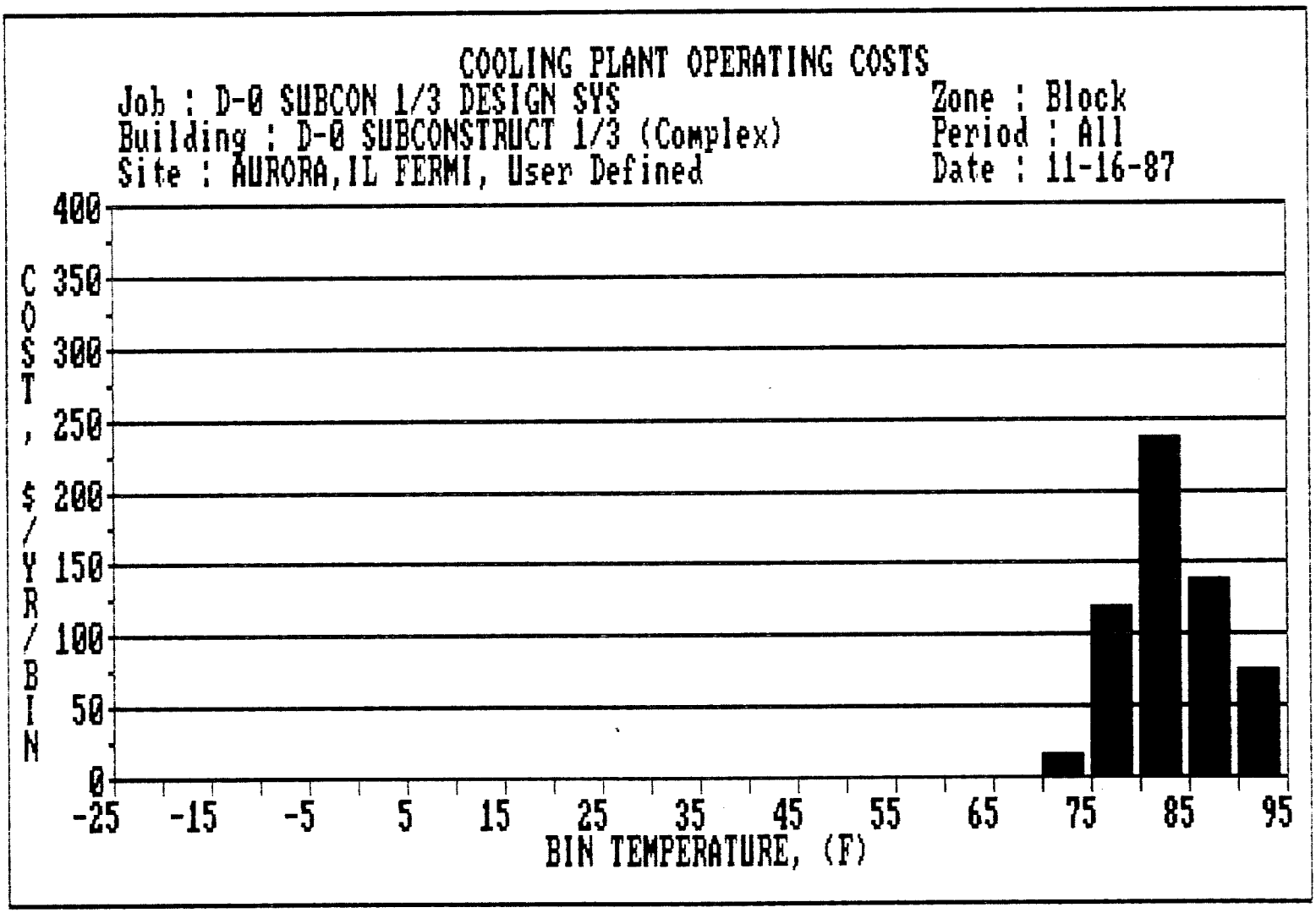
Job Name : D-O SUBCON 1/3 DESIGN SYS
Building Name : D-O SUBCONSTRUCT 1/3 (Complex)
Site Name : AURORA,IL FERMI, User Defined

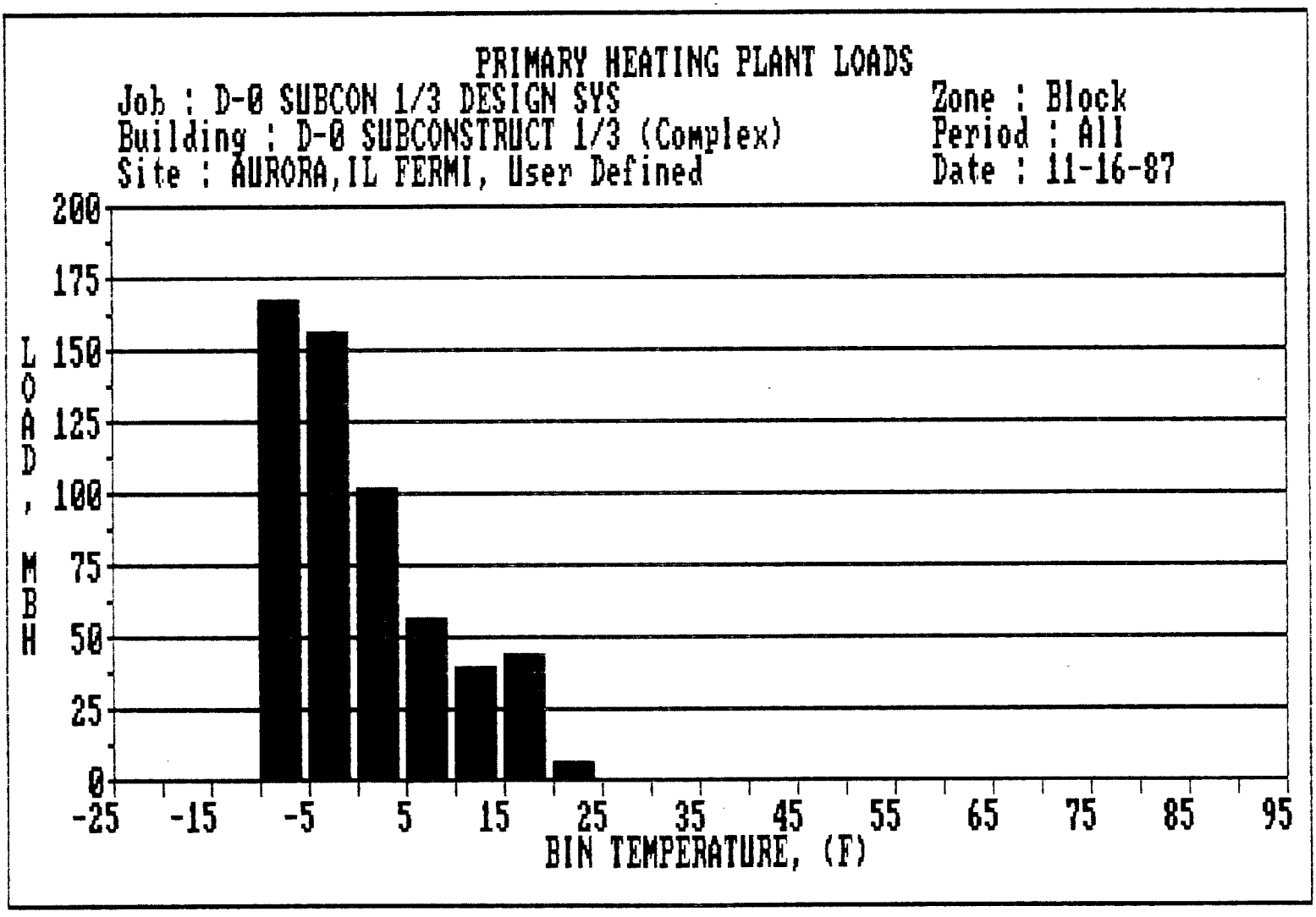
Date : 11-16-87
Serial Number:
60117862.0

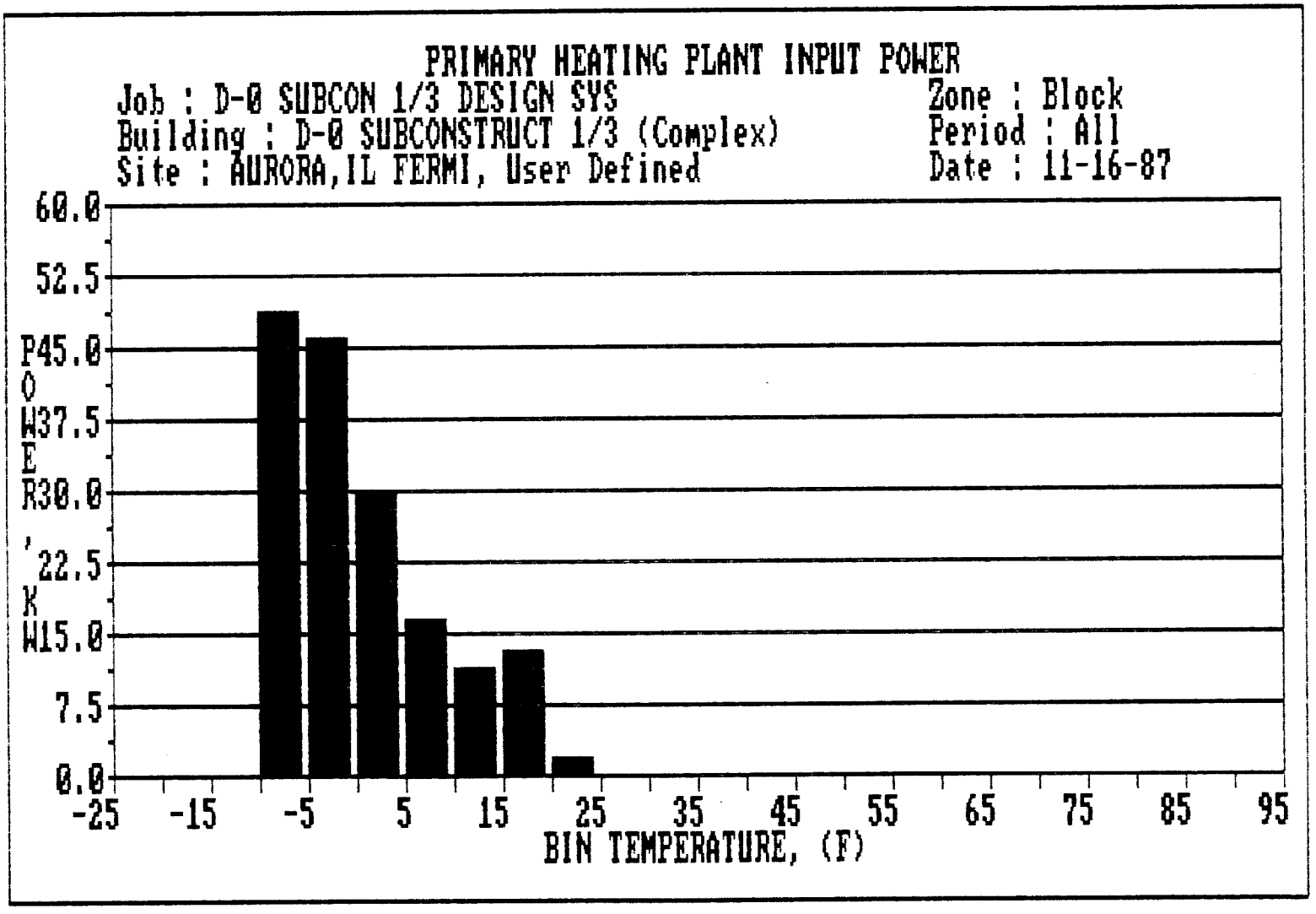
Bin Temp (F)	Bin Hours hr/yr	Perimeter Fans Input KW	Perimeter Fans Cost $/yr	No Interior Zone	All Pumps Input KW	All Pumps Cost $/yr
			OCCUPIED PERIOD			
90	25.8	45.8	59.0		6.3	8.1
85	59.4	45.8	135.9		6.3	18.6
80	145.3	45.8	332.5		6.3	45.5
75	237.7	45.8	543.9		6.3	74.5
70	270.6	45.8	619.1		6.3	84.8
65	264.5	45.8	605.2		0.0	0.0
60	255.0	45.8	583.4		0.0	0.0
55	244.7	45.8	559.9		0.0	0.0
50	232.1	45.8	531.1		0.0	0.0
45	229.5	45.8	525.1		0.0	0.0
40	237.6	45.8	543.6		0.0	0.0
35	238.5	45.8	545.7		0.0	0.0
30	218.2	45.8	499.2		0.0	0.0
25	174.5	45.8	399.3		0.0	0.0
20	122.4	45.8	280.1		0.0	0.0
15	78.1	45.8	178.7		0.0	0.0
10	46.1	45.8	105.5		0.0	0.0
5	25.1	45.8	57.4		0.0	0.0
0	12.7	45.8	29.1		0.0	0.0
-5	6.2	45.8	14.2		0.0	0.0
-6	4.6	45.8	10.5		0.0	0.0
Total Costs			$7158.3			$231.4
			UNOCCUPIED PERIOD			
90	14.6	45.8	33.4		6.3	4.6
85	36.3	45.8	83.1		6.3	11.4
80	99.3	45.8	227.2		6.3	31.1
75	215.3	45.8	492.6		6.3	67.4
70	357.6	45.8	818.2		0.0	0.0
65	463.3	45.8	1060.0		0.0	0.0
60	500.4	45.8	1144.9		0.0	0.0
55	482.0	45.8	1102.8		0.0	0.0
50	447.6	45.8	1024.1		0.0	0.0
45	422.7	45.8	967.2		0.0	0.0
40	413.7	45.8	946.6		0.0	0.0
35	417.0	45.8	954.1		0.0	0.0
30	417.4	45.8	955.0		0.0	0.0
25	395.2	45.8	904.2		0.0	0.0
20	336.9	45.8	770.8		0.0	0.0
15	252.8	45.8	578.4		0.0	0.0
10	165.7	45.8	379.1		0.0	0.0
5	96.3	45.8	220.3		0.0	0.0
0	50.9	45.8	116.5		0.0	0.0
-5	25.3	45.8	57.9		0.0	0.0
-6	21.1	45.8	48.3		0.0	0.0
Total Costs			$12884.8			$114.5

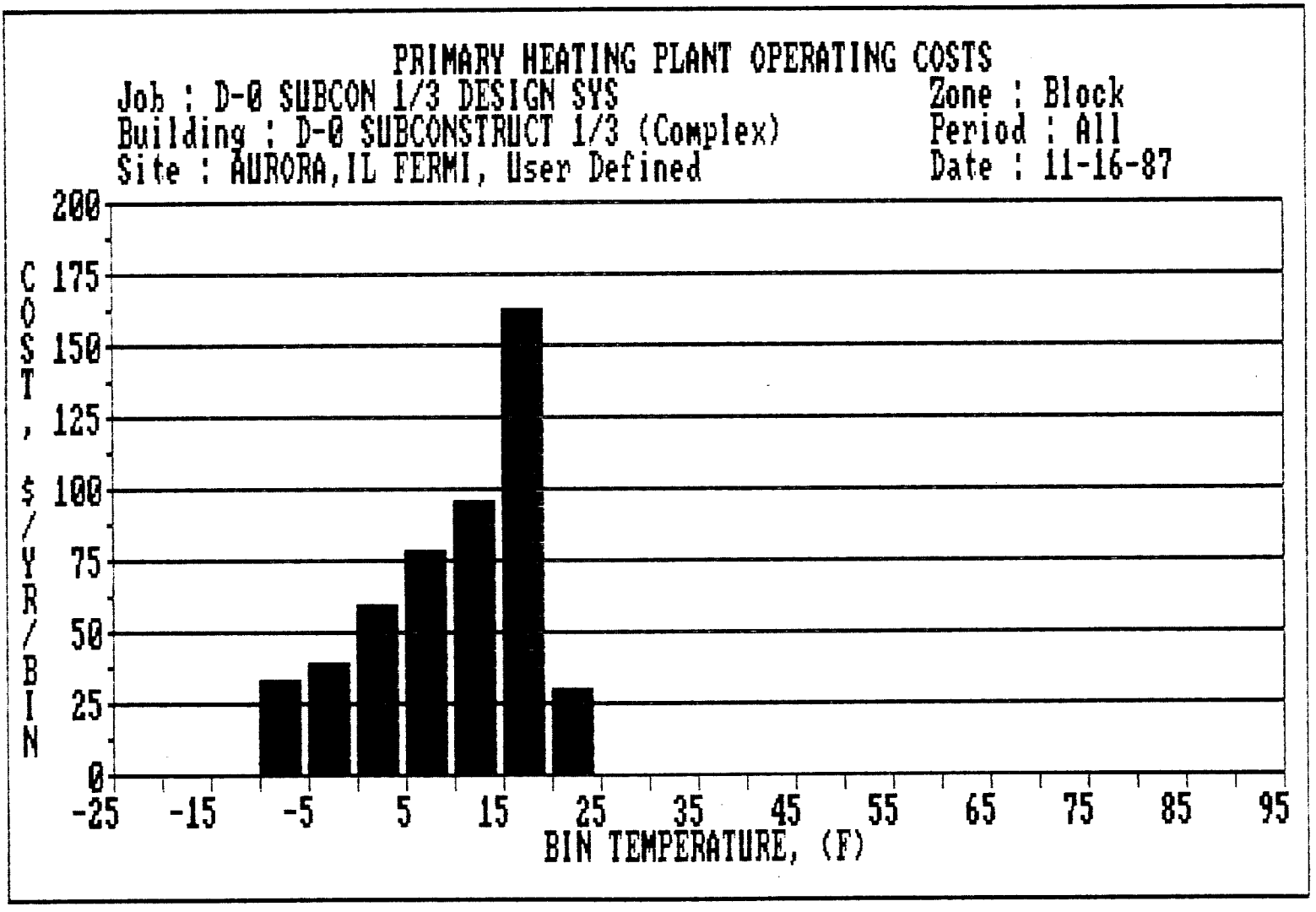

COOLING COIL LOADS
Job : D-0 SUBCON 1/3 DESIGN SYS
Building : D-0 SUBCONSTRUCT 1/3 (Complex)
Site : AURORA,IL FERMI, User Defined
Zone : Block
Period : All
Date : 11-16-87
LOAD, MBH
1200
1050
900
750
600
450
300
150
0
-25
-15
-5
5
15
25
35
45
55
65
75
85
95
BIN TEMPERATURE, (F)

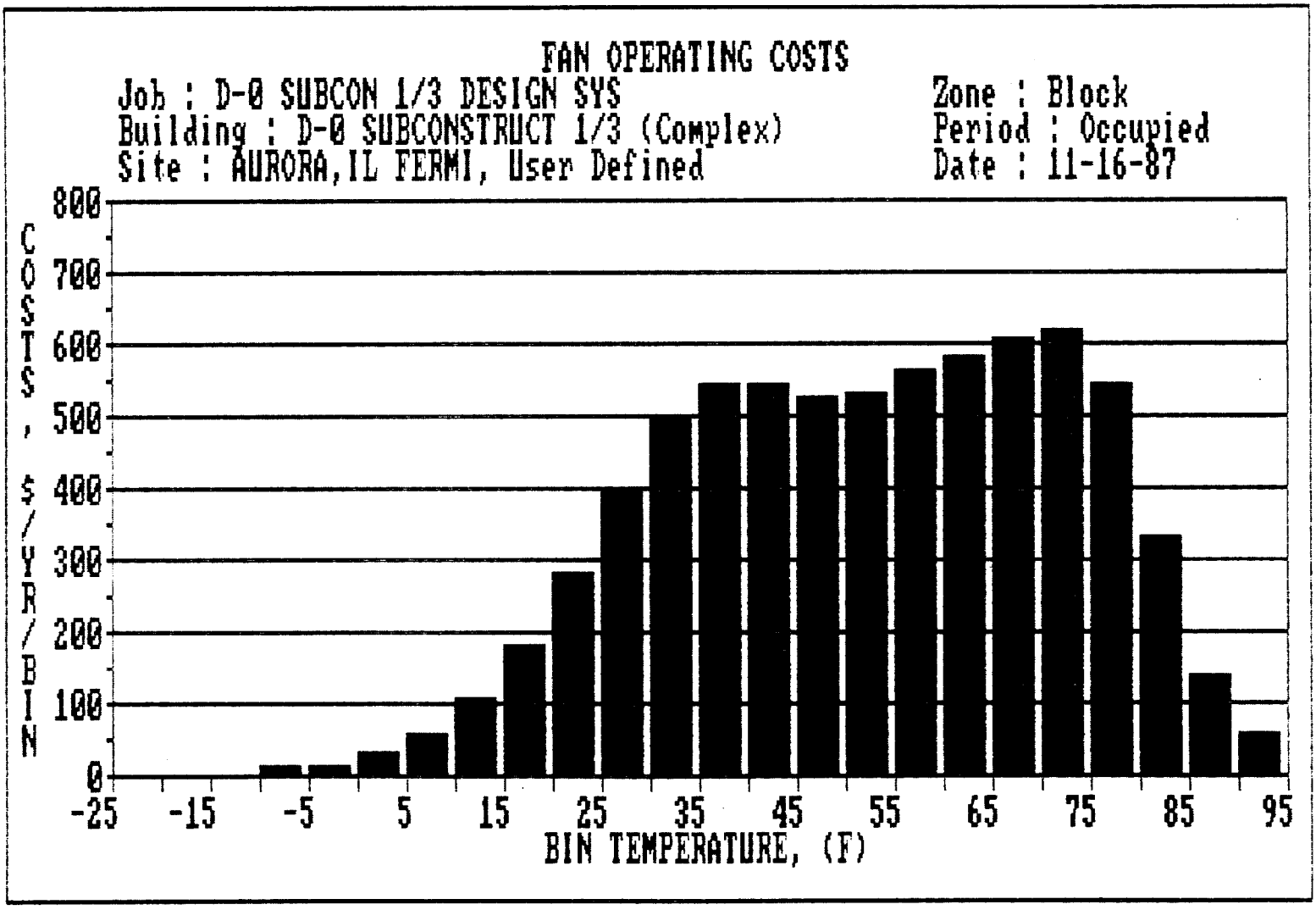

COOLING PLANT INPUT POWER
Job : D-0 SUBCON 1/3 DESIGN SYS
Building : D-0 SUBCONSTRUCT 1/3 (Complex)
Site : AURORA,IL FERMI, User Defined
Zone : Block
Period : All
Date : 11-16-87
POWER, KW
80
70
60
50
40
30
20
10
0
-25
-15
-5
5
15
25
35
45
55
65
75
85
95
BIN TEMPERATURE, (F)


COOLING PLANT OPERATING COSTS
Job : D-0 SUBCON 1/3 DESIGN SYS
Building : D-0 SUBCONSTRUCT 1/3 (Complex)
Site : AURORA,IL FERMI, User Defined
Zone : Block
Period : All
Date : 11-16-87
COST, $/YR/BIN
400
350
300
250
200
150
100
50
0
-25
-15
-5
5
15
25
35
45
55
65
75
85
95
BIN TEMPERATURE, (F)


PRIMARY HEATING PLANT LOADS
Job : D-0 SUBCON 1/3 DESIGN SYS
Building : D-0 SUBCONSTRUCT 1/3 (Complex)
Site : AURORA,IL FERMI, User Defined
Zone : Block
Period : All
Date : 11-16-87
LOAD, MBH
200
175
150
125
100
75
50
25
0
-25
-15
-5
5
15
25
35
45
55
65
75
85
95
BIN TEMPERATURE, (F)


PRIMARY HEATING PLANT INPUT POWER
Job : D-0 SUBCON 1/3 DESIGN SYS
Building : D-0 SUBCONSTRUCT 1/3 (Complex)
Site : AURORA,IL FERMI, User Defined
Zone : Block
Period : All
Date : 11-16-87
60.0
52.5
P45.0
O
W37.5
E
R30.0
,
22.5
K
W15.0
7.5
0.0
-25
-15
-5
5
15
25
35
45
55
65
75
85
95
BIN TEMPERATURE, (F)


PRIMARY HEATING PLANT OPERATING COSTS
Job : D-0 SUBCON 1/3 DESIGN SYS
Building : D-0 SUBCONSTRUCT 1/3 (Complex)
Site : AURORA,IL FERMI, User Defined
Zone : Block
Period : All
Date : 11-16-87
COST, $/YR/BIN
200
175
150
125
100
75
50
25
0
-25
-15
-5
5
15
25
35
45
55
65
75
85
95
BIN TEMPERATURE, (F)


FAN OPERATING COSTS
Job : D-0 SUBCON 1/3 DESIGN SYS
Building : D-0 SUBCONSTRUCT 1/3 (Complex)
Site : AURORA,IL FERMI, User Defined
Zone : Block
Period : Occupied
Date : 11-16-87
COSTS, $/YR/BIN
800
700
600
500
400
300
200
100
0
-25
-15
-5
5
15
25
35
45
55
65
75
85
95
BIN TEMPERATURE, (F)

IV-c.2.

FERMILAB D-O EXPERIMENTAL FACILITY

SUBCONSTRUCTION 1/3 - COLLISION AND ASSEMBLY HALLS
OPERATIONAL PERFORMANCE SIMULATION

ALTERNATE COMPARISON SYSTEM NUMBER 1
CENTRIFUGAL CHILLERS AND CENTRAL STATION AHU'S
WITH THESE ENERGY FEATURES:
LAKE COOLING WATER, LAKE WATER FILTERS, HYDRONIC FREE COOLING HEAT EXCHANGER,
HIGH EFFICIENCY MOTORS, INTEGRATED BUILDING PRESSURIZATION CONTROLS,
AUTOMATIC LAKE WATER PUMP STAGING, CEILING HEAT CIRCULATION FANS,
NESTED AHU FAN INLET VANES, INTEGRATED ENTHALPY ECONOMIZER

31 OCTOBER, 1987
ANALYST: S.F.KRSTULOVICH

FERMILAB CONSTRUCTION ENGINEERING SERVICES

SYSTEM INPUT SUMMARY

Job Name : D-O SUBCON 1/3 ALT 1 SYS Page 1
Building Name : D-O SUBCONSTRUCT 1/3 (Complex) Date : 11-16-87
Site : AURORA,IL FERMI, User Defined 60117862.0
Scope of Analysis : Cooling and Heating Systems

****

A. AIR HANDLING SYSTEMS

>1. PERIMETER TERMINAL TYPE : CONSTANT VOLUME

Supply fan type : Backward inclined or airfoil with inlet vanes
Supply fan total static pressure = 3.00 in. wg.
Return fan type : Controlled pitch axial
Return fan total static pressure = 1.75 in. wg.
Design supply air= 42000 cfm @ 67 F; Vent. air= 3000 cfm
Are cooling terminals used for heating ? <Y>
Economizer type : Integrated, enthalpy controlled
Is a ventilation reclaim device used ? <N>
Are ventilation air dampers closed for unoccupied periods ? <N>

****

B. HEATING PLANTS

> 1 . PERIMETER PLANT : ELECTRICAL RESISTANCE

Is hydronic heating used ? <N>

****

****

C. COOLING PLANTS

>1. PERIMETER PLANT : CENTRIFUGAL WATER COOLED CHILLER
Capacity @ 85 F entering water = 75.0 tons
KW/Ton @ 85 F entering water = 0.78 kw/ton
Is hydronic cooling used ? <Y>
Is chilled water reset used ? <N>
Is condenser performance altitude adjusted ? <Y>
Heat sink type : Open cooling tower
Minimum entering water temperature = 32 F
Is a hydronic economizer used ? <Y> ; Economizer efficiency = 80 %
Number of sequenced chillers = 2

****

D. PUMPING SYSTEMS

	PERIMETER			
System	dT, F	dP, ft wg	dT, F	dP, ft wg
Chilled water	10.00	100.00	0.00	0.00
Hot water	0.00	0.00	0.00	0.00
Condenser water	10.00	50.00	0.00	0.00
Ground water	0.00	0.00	0.00	0.00

****

E. NON-HVAC SYSTEMS

>1. NON-HVAC ELECTRICAL ENERGY USE
Lighting kw: Occupied = 73.2 kw; Unoccupied = 73.2 kw
Misc. kw : Occupied = 60.0 kw; Unoccupied = 20.0 kw
Other kw : Occupied = 0.0 kw; Unoccupied = 0.0 kw

>2. DHW SYSTEM (Not utilized in this system)

****

F. FUEL COSTS

>1. ELECTRICAL ENERGY USE	Period Occupied ($/kwh)	Unoccupied ($/kwh)
Compressor	0.050	0.050
Resistance	0.050	0.050
Inductive	0.050	0.050

>2. OTHER FUELS	Unit Cost
Natural Gas	n/a $/therm
Fuel Oil	n/a $/U.S.gal
Propane	n/a $/lb
Remote Heating	n/a $/MBTU
Remote Cooling	n/a $/MBTU

TOTAL BUILDING ENERGY SUMMARY

Job Name : D-0 SUBCON 1/3 ALT 1 SYS
Building Name : D-0 SUBCONSTRUCT 1/3 (Complex)
Site : AURORA,IL FERMI, User Defined
Date : 11-16-87

Period : All
Zone : Block
Serial Number:
60117862.0

****

HVAC ENERGY Component	Annual Cost ($/yr)	Energy or Fuel Units Consumed	DOE RUF (1000 BTU)	DOE RIF (1000 BTU)
Electric (Occ)	7894	157872 kwh/yr	1831320	538819
Electric (Unocc)	13624	272475 kwh/yr	3160711	929958
Natural Gas	0	0 therms/yr	0	0
Fuel Oil	0	0 U.S. gal/yr	0	0
Propane	0	0 lb/yr	0	0
Remote Heating	0	0 MBTU/yr	0	0
Remote Cooling	0	0 MBTU/yr	0	0
HVAC Total	21517		4992031	1468776
NON-HVAC ENERGY				
Electric (Occ)	20836	416730 kwh/yr	4834063	1422298
Electric (Unocc)	26242	524846 kwh/yr	6088219	1791301
Non-HVAC Total	47079		10922282	3213599
Grand Total	68596		15914313	4682375
Total/Sq.Ft.	2.81		652.23	191.90

HVAC Summary:

HVAC Total Cost	=	0.88 $/Sq.Ft./yr
	=	31.37 % of Total Cost
Total HVAC Electrical Energy	=	17.64 kwh/Sq.Ft./yr
	=	31.37 % of Total Electrical Energy
Non-Electrical HVAC Energy	=	0.00 % of Total Energy

Key:

1 kwh	= 11600 BTU RUF; 3412 BTU RIF
1 therm nat gas	= 100000 BTU RUF and RIF
1 U.S. gal oil	= 138700 BTU RUF and RIF
1 Imp. gal oil	= 168000 BTU RUF and RIF
1 lb propane	= 21680 BTU RUF and RIF
RUF	= Resource utilization factor (Source value)
RIF	= Resource impact factor (Point of use value)
MBH	= 1000 BTU/hr
MBTU	= Million BTU

ANNUAL OPERATING COSTS

Job Name : D-0 SUBCON 1/3 ALT 1 SYS
Building Name : D-0 SUBCONSTRUCT 1/3 (Complex) Date : 11-16-87
Site : AURORA,IL FERMI, User Defined 60117862.0
Scope of Analysis : Cooling and Heating Systems

****

A. AIR HANDLING SYSTEMS (ANNUAL FAN OPERATING COST = $20,043)

>1. PERIMETER TERMINAL TYPE : CONSTANT VOLUME
Supply fan type : Backward inclined or airfoil with inlet vanes
Supply fan total static pressure = 3.00 in. wg.
Return fan type : Controlled pitch axial
Return fan total static pressure = 1.75 in. wg.
Design supply air= 42000 cfm @ 67 F; Vent. air= 3000 cfm
Are cooling terminals used for heating ? <Y>
Economizer type : Integrated, enthalpy controlled
Is a ventilation reclaim device used ? <N>
Are ventilation air dampers closed for unoccupied periods ? <N>

****

B. HEATING PLANTS (ANNUAL HEATING PLANT OPERATING COST = $498)

> 1 . PERIMETER PLANT : ELECTRICAL RESISTANCE
Is hydronic heating used ? <N>

****

****

C. COOLING PLANTS (ANNUAL COOLING PLANT OPERATING COST = $583)

>1. PERIMETER PLANT : CENTRIFUGAL WATER COOLED CHILLER
Capacity @ 85 F entering water = 75.0 tons
KW/Ton @ 85 F entering water = 0.78 kw/ton
Is hydronic cooling used ? <Y>
Is chilled water reset used ? <N>
Is condenser performance altitude adjusted ? <Y>
Heat sink type : Open cooling tower
Minimum entering water temperature = 32 F
Is a hydronic economizer used ? <Y> ; Economizer efficiency = 80 %
Number of sequenced chillers = 2

****

D. PUMPING SYSTEMS (ANNUAL PUMP OPERATING COST = $394)

System	PERIMETER dT, F	PERIMETER dP, ft wg	dT, F	dP, ft wg
Chilled water	10.00	100.00	0.00	0.00
Hot water	0.00	0.00	0.00	0.00
Condenser water	10.00	50.00	0.00	0.00
Ground water	0.00	0.00	0.00	0.00

****

E. NON-HVAC SYSTEMS (ANNUAL NON-HVAC OPERATING COST = $47,079)

>1. NON-HVAC ELECTRICAL ENERGY USE
Lighting kw: Occupied = 73.2 kw; Unoccupied = 73.2 kw
Misc. kw : Occupied = 60.0 kw; Unoccupied = 20.0 kw
Other kw : Occupied = 0.0 kw; Unoccupied = 0.0 kw

>2. DHW SYSTEM (Not utilized in this system)

****

F. FUEL COSTS (GRAND TOTAL ANNUAL OPERATING COST = $68,596)

>1. ELECTRICAL ENERGY USE	Period Occupied ($/kwh)	Period Unoccupied ($/kwh)
Compressor	0.050	0.050
Resistance	0.050	0.050
Inductive	0.050	0.050

>2. OTHER FUELS	Unit Cost
Natural Gas	n/a $/therm
Fuel Oil	n/a $/U.S.gal
Propane	n/a $/lb
Remote Heating	n/a $/MBTU
Remote Cooling	n/a $/MBTU

COOLING PLANT COSTS

Job Name : D-O SUBCON 1/3 ALT 1 SYS
Building Name : D-O SUBCONSTRUCT 1/3 (Complex)
Site Name : AURORA,IL FERMI, User Defined

Date : 11-16-87
Serial Number:
60117862.0

Bin Temp (F)	Bin Hours hr/yr	Perimeter Cooling Plant Coil Load MBH	Input KW	Cost $/yr	No Interior Zone Exists
			OCCUPIED PERIOD		
90	25.8	666.2	40.2	51.8	
85	59.4	627.6	34.9	103.7	
80	145.3	589.0	22.2	161.2	
75	237.7	371.1	10.4	123.7	
70	270.6	118.0	1.1	14.6	
65	264.5	0.0	0.0	0.0	
60	255.0	0.0	0.0	0.0	
55	244.7	0.0	0.0	0.0	
50	232.1	0.0	0.0	0.0	
45	229.5	0.0	0.0	0.0	
40	237.6	0.0	0.0	0.0	
35	238.5	0.0	0.0	0.0	
30	218.2	0.0	0.0	0.0	
25	174.5	0.0	0.0	0.0	
20	122.4	0.0	0.0	0.0	
15	78.1	0.0	0.0	0.0	
10	46.1	0.0	0.0	0.0	
5	25.1	0.0	0.0	0.0	
0	12.7	0.0	0.0	0.0	
-5	6.2	0.0	0.0	0.0	
-6	4.6	0.0	0.0	0.0	
Total Costs				$455.1	
			UNOCCUPIED PERIOD		
90	14.6	526.9	27.7	20.2	
85	36.3	488.8	18.9	34.2	
80	99.3	450.6	12.4	61.4	
75	215.3	233.5	1.1	11.6	
70	357.6	0.0	0.0	0.0	
65	463.3	0.0	0.0	0.0	
60	500.4	0.0	0.0	0.0	
55	482.0	0.0	0.0	0.0	
50	447.6	0.0	0.0	0.0	
45	422.7	0.0	0.0	0.0	
40	413.7	0.0	0.0	0.0	
35	417.0	0.0	0.0	0.0	
30	417.4	0.0	0.0	0.0	
25	395.2	0.0	0.0	0.0	
20	336.9	0.0	0.0	0.0	
15	252.8	0.0	0.0	0.0	
10	165.7	0.0	0.0	0.0	
5	96.3	0.0	0.0	0.0	
0	50.9	0.0	0.0	0.0	
-5	25.3	0.0	0.0	0.0	
-6	21.1	0.0	0.0	0.0	
Total Costs				$127.5	

PERIMETER HEATING PLANT COSTS

Job Name : D-0 SUBCON 1/3 ALT 1 SYS — Date : 11-16-87

Building Name : D-0 SUBCONSTRUCT 1/3 (Complex) — Serial Number:

Site Name : AURORA,IL FERMI, User Defined — 60117862.0

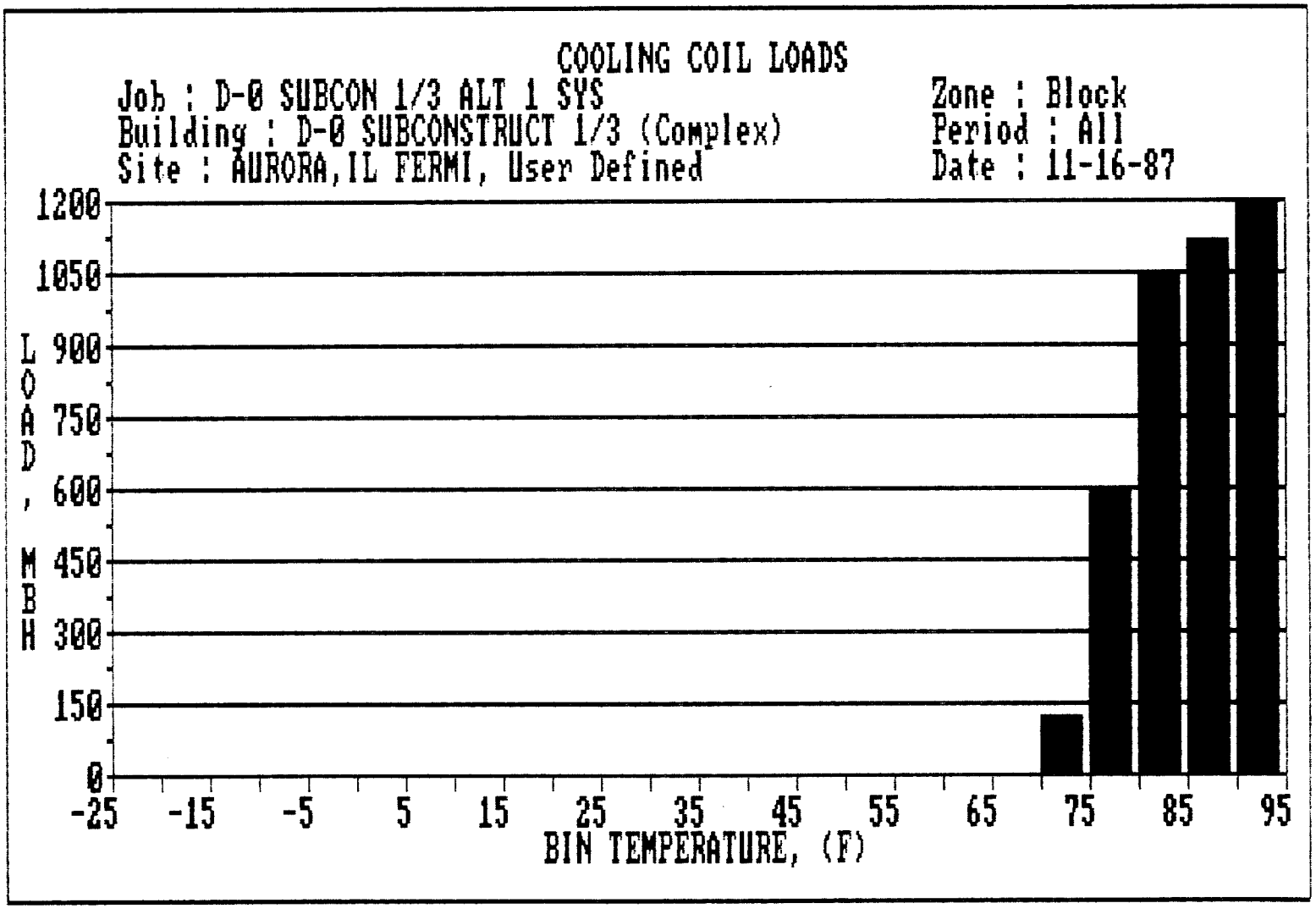
Bin Temp (F)	Bin Hours hr/yr	Coil Load MBH	Primary Plant Output MBH	Primary Plant Input KW	Primary Plant Cost $/yr	No Auxiliary Plant Used
			OCCUPIED PERIOD			
90	25.8	0.0	0.0	0.0	0.0	
85	59.4	0.0	0.0	0.0	0.0	
80	145.3	0.0	0.0	0.0	0.0	
75	237.7	0.0	0.0	0.0	0.0	
70	270.6	0.0	0.0	0.0	0.0	
65	264.5	0.0	0.0	0.0	0.0	
60	255.0	0.0	0.0	0.0	0.0	
55	244.7	0.0	0.0	0.0	0.0	
50	232.1	0.0	0.0	0.0	0.0	
45	229.5	0.0	0.0	0.0	0.0	
40	237.6	0.0	0.0	0.0	0.0	
35	238.5	0.0	0.0	0.0	0.0	
30	218.2	0.0	0.0	0.0	0.0	
25	174.5	0.0	0.0	0.0	0.0	
20	122.4	0.0	0.0	0.0	0.0	
15	78.1	0.0	0.0	0.0	0.0	
10	46.1	0.0	0.0	0.0	0.0	
5	25.1	0.0	0.0	0.0	0.0	
0	12.7	28.8	28.8	8.4	5.4	
-5	6.2	67.4	67.4	19.8	6.1	
-6	4.6	75.1	75.1	22.0	5.1	
Total Costs					$16.5	
			UNOCCUPIED PERIOD			
90	14.6	0.0	0.0	0.0	0.0	
85	36.3	0.0	0.0	0.0	0.0	
80	99.3	0.0	0.0	0.0	0.0	
75	215.3	0.0	0.0	0.0	0.0	
70	357.6	0.0	0.0	0.0	0.0	
65	463.3	0.0	0.0	0.0	0.0	
60	500.4	0.0	0.0	0.0	0.0	
55	482.0	0.0	0.0	0.0	0.0	
50	447.6	0.0	0.0	0.0	0.0	
45	422.7	0.0	0.0	0.0	0.0	
40	413.7	0.0	0.0	0.0	0.0	
35	417.0	0.0	0.0	0.0	0.0	
30	417.4	0.0	0.0	0.0	0.0	
25	395.2	0.0	0.0	0.0	0.0	
20	336.9	6.0	6.0	1.8	29.5	
15	252.8	44.0	44.0	12.9	163.1	
10	165.7	39.1	39.1	11.5	94.9	
5	96.3	55.6	55.6	16.3	78.4	
0	50.9	72.1	72.1	21.1	53.8	
-5	25.3	88.6	88.6	26.0	32.8	
-6	21.1	91.9	91.9	26.9	28.4	
Total Costs					$481.0	

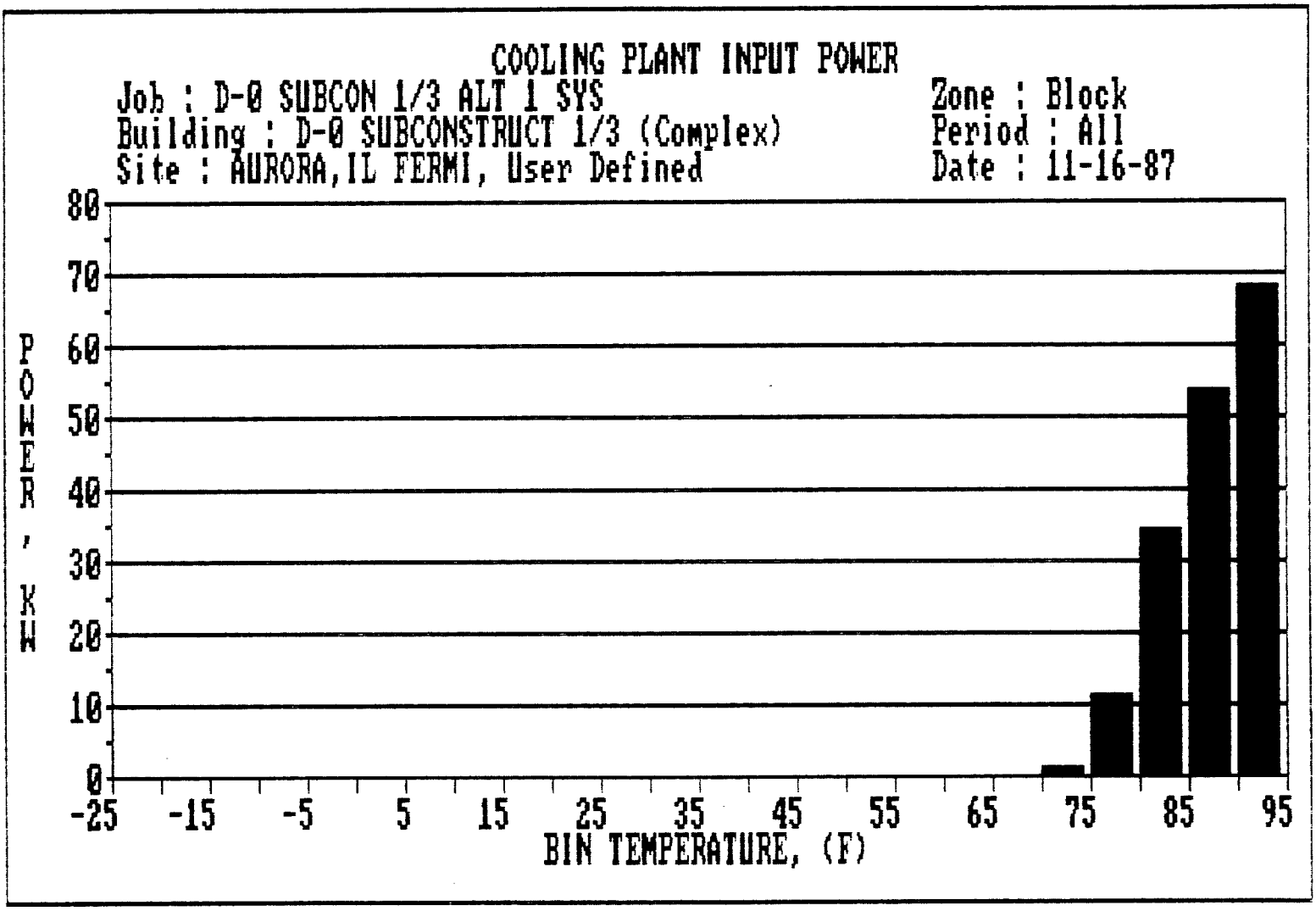
FAN AND PUMP COSTS

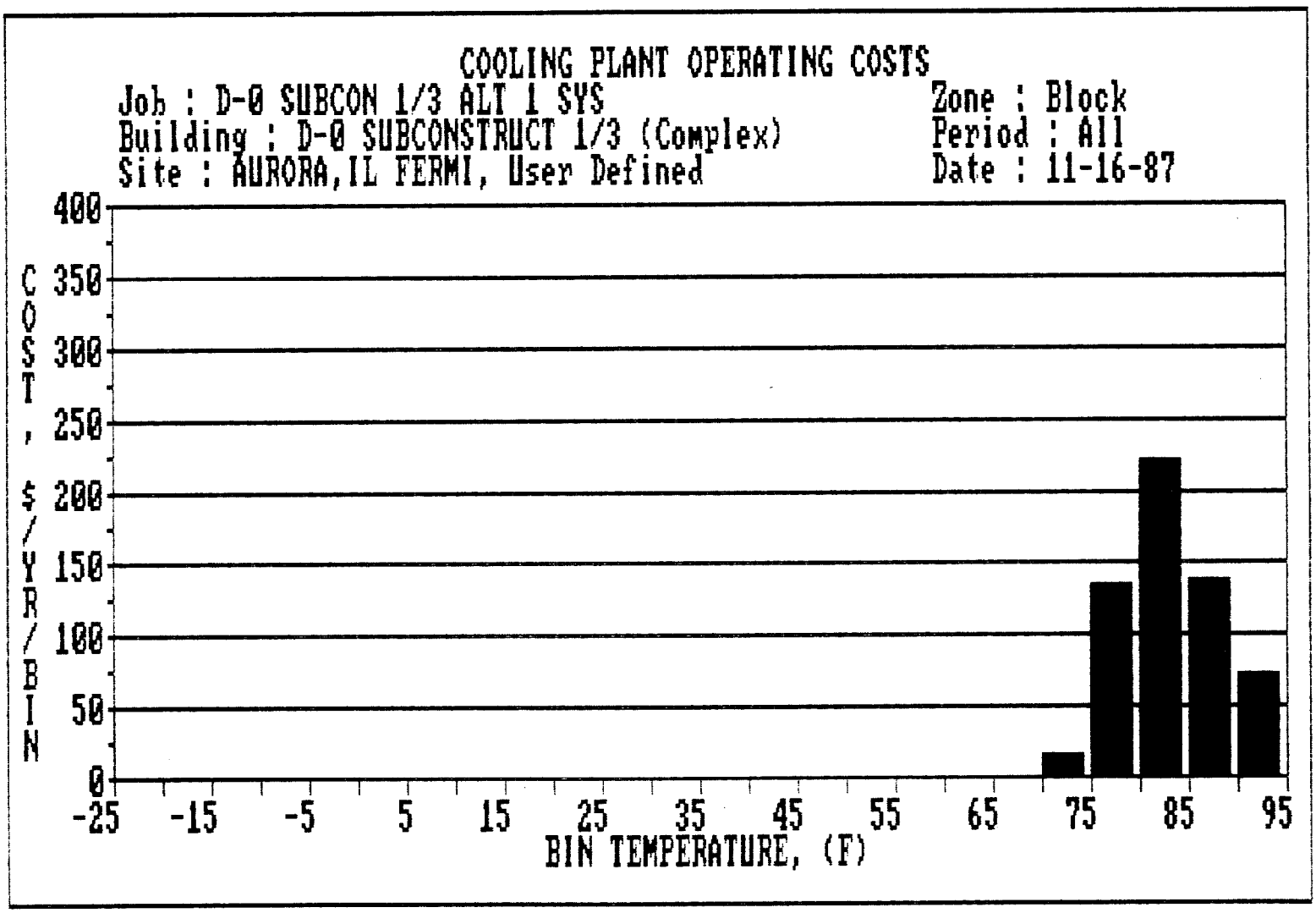
Job Name : D-0 SUBCON 1/3 ALT 1 SYS
Building Name : D-0 SUBCONSTRUCT 1/3 (Complex)
Site Name : AURORA,IL FERMI, User Defined

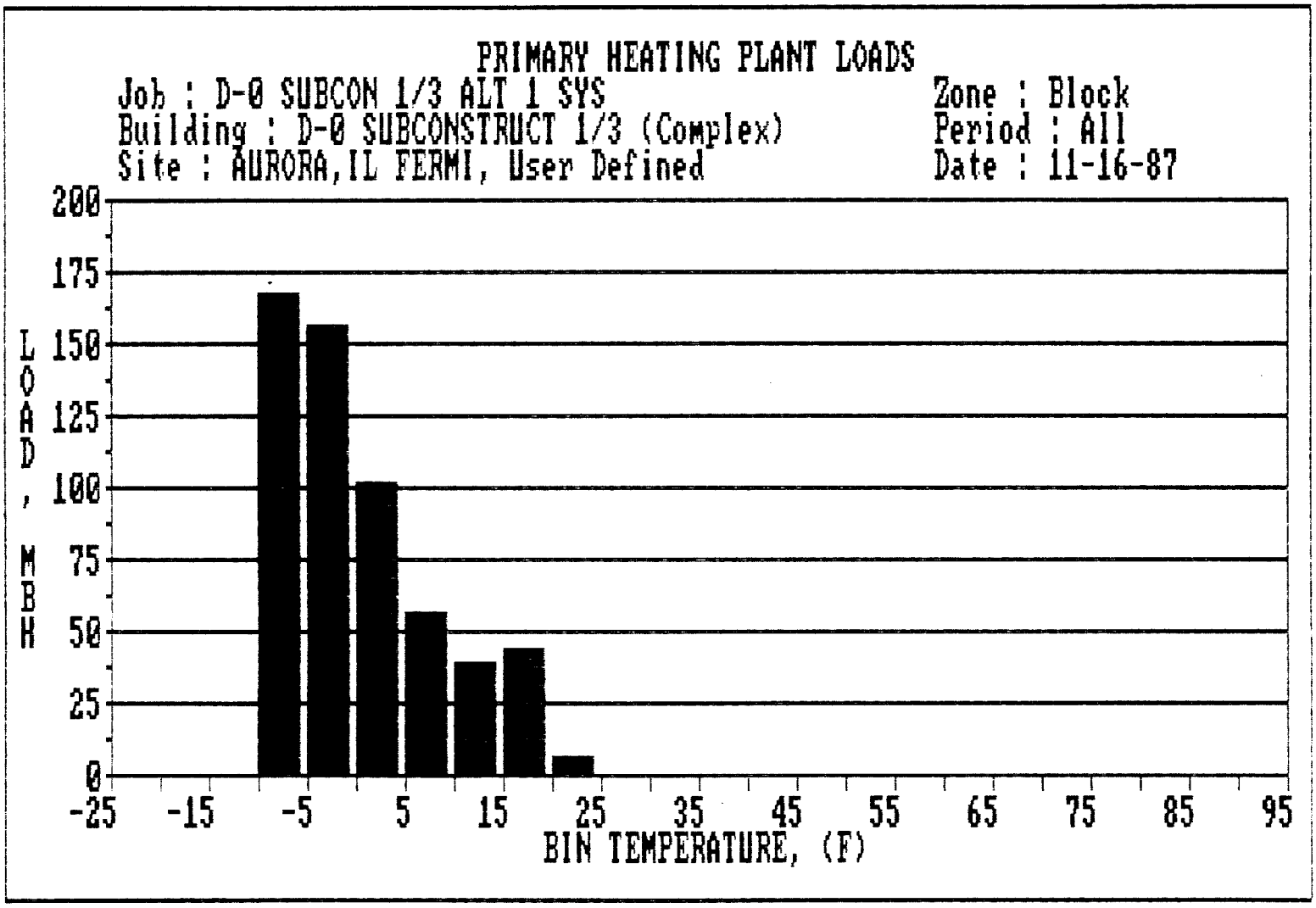
Date : 11-16-87
Serial Number:
60117862.0

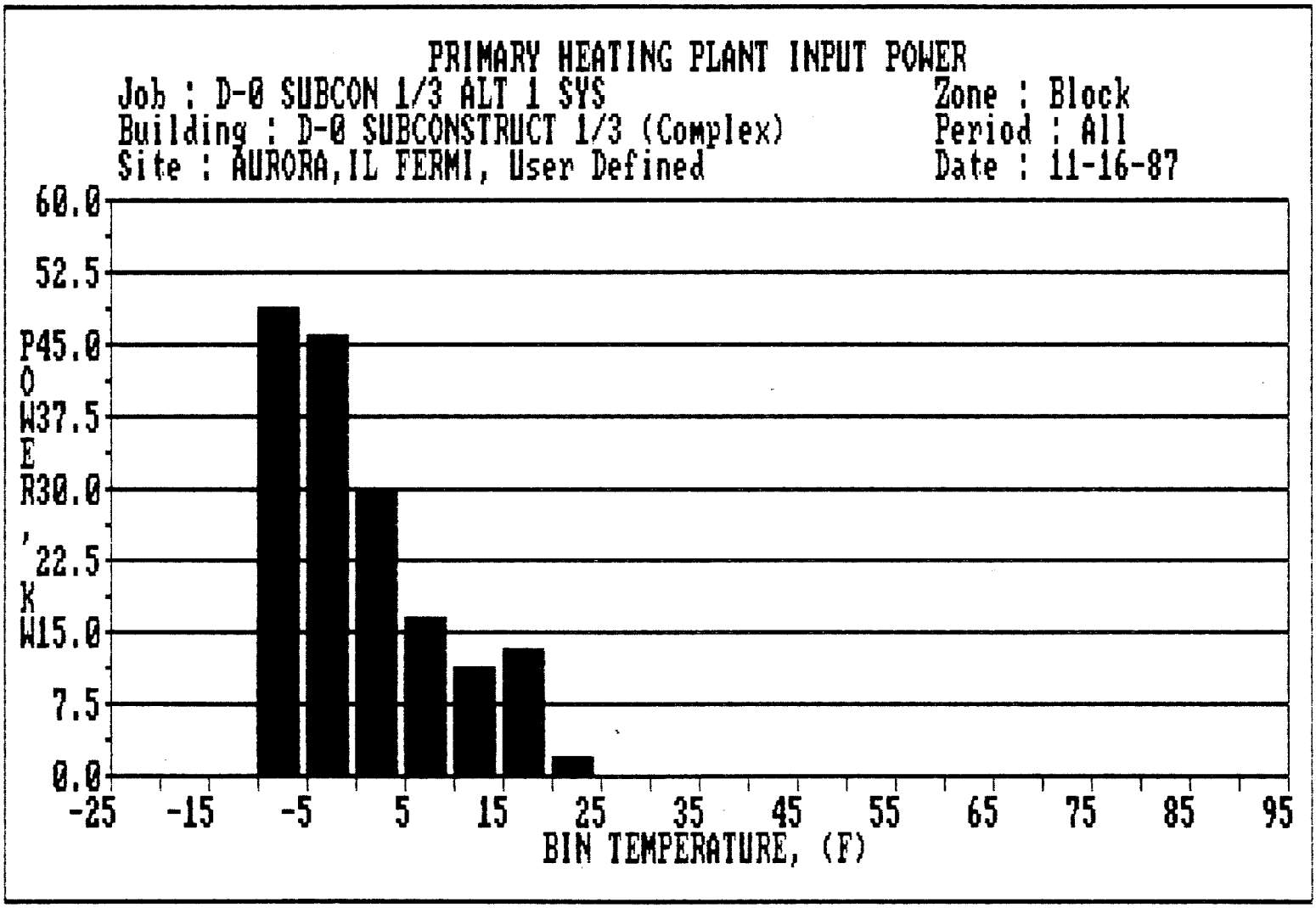
Bin Temp (F)	Bin Hours hr/yr	Perimeter Input KW	Fans Cost $/yr	No Interior Zone	All Pumps Input KW	All Pumps Cost $/yr
			OCCUPIED PERIOD			
90	25.8	45.8	59.0		7.1	9.2
85	59.4	45.8	135.9		7.1	21.2
80	145.3	45.8	332.5		7.1	51.9
75	237.7	45.8	543.9		7.1	84.8
70	270.6	45.8	619.1		7.1	96.6
65	264.5	45.8	605.2		0.0	0.0
60	255.0	45.8	583.4		0.0	0.0
55	244.7	45.8	559.9		0.0	0.0
50	232.1	45.8	531.1		0.0	0.0
45	229.5	45.8	525.1		0.0	0.0
40	237.6	45.8	543.6		0.0	0.0
35	238.5	45.8	545.7		0.0	0.0
30	218.2	45.8	499.2		0.0	0.0
25	174.5	45.8	399.3		0.0	0.0
20	122.4	45.8	280.1		0.0	0.0
15	78.1	45.8	178.7		0.0	0.0
10	46.1	45.8	105.5		0.0	0.0
5	25.1	45.8	57.4		0.0	0.0
0	12.7	45.8	29.1		0.0	0.0
-5	6.2	45.8	14.2		0.0	0.0
-6	4.6	45.8	10.5		0.0	0.0
Total Costs			$7158.3			$263.7
			UNOCCUPIED PERIOD			
90	14.6	45.8	33.4		7.1	5.2
85	36.3	45.8	83.1		7.1	13.0
80	99.3	45.8	227.2		7.1	35.4
75	215.3	45.8	492.6		7.1	76.8
70	357.6	45.8	818.2		0.0	0.0
65	463.3	45.8	1060.0		0.0	0.0
60	500.4	45.8	1144.9		0.0	0.0
55	482.0	45.8	1102.8		0.0	0.0
50	447.6	45.8	1024.1		0.0	0.0
45	422.7	45.8	967.2		0.0	0.0
40	413.7	45.8	946.6		0.0	0.0
35	417.0	45.8	954.1		0.0	0.0
30	417.4	45.8	955.0		0.0	0.0
25	395.2	45.8	904.2		0.0	0.0
20	336.9	45.8	770.8		0.0	0.0
15	252.8	45.8	578.4		0.0	0.0
10	165.7	45.8	379.1		0.0	0.0
5	96.3	45.8	220.3		0.0	0.0
0	50.9	45.8	116.5		0.0	0.0
-5	25.3	45.8	57.9		0.0	0.0
-6	21.1	45.8	48.3		0.0	0.0
Total Costs			$12884.8			$130.4

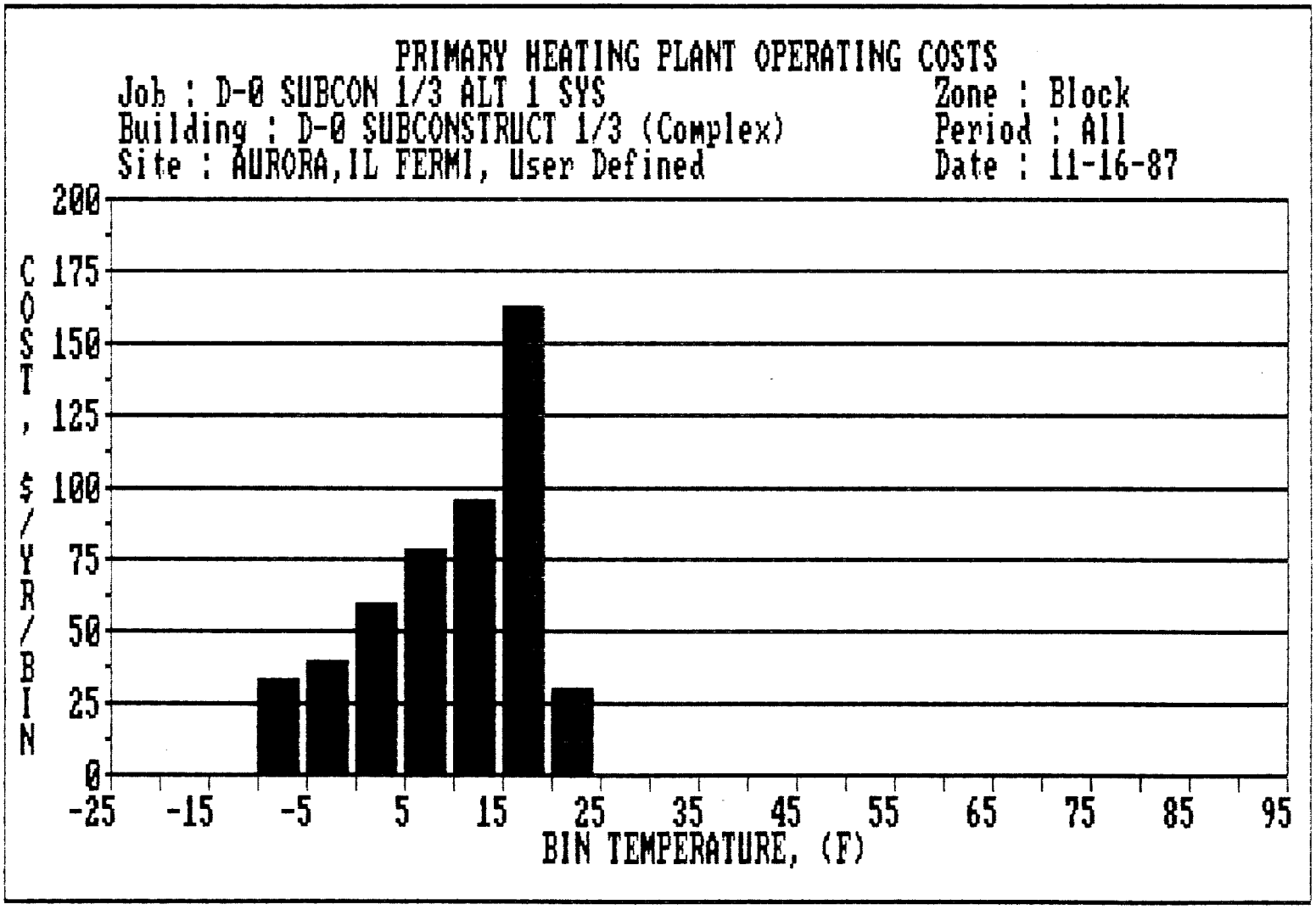

COOLING COIL LOADS
Job : D-0 SUBCON 1/3 ALT 1 SYS
Building : D-0 SUBCONSTRUCT 1/3 (Complex)
Site : AURORA,IL FERMI, User Defined
Zone : Block
Period : All
Date : 11-16-87
LOAD, MBH
1200
1050
900
750
600
450
300
150
0
-25
-15
-5
5
15
25
35
45
55
65
75
85
95
BIN TEMPERATURE, (F)

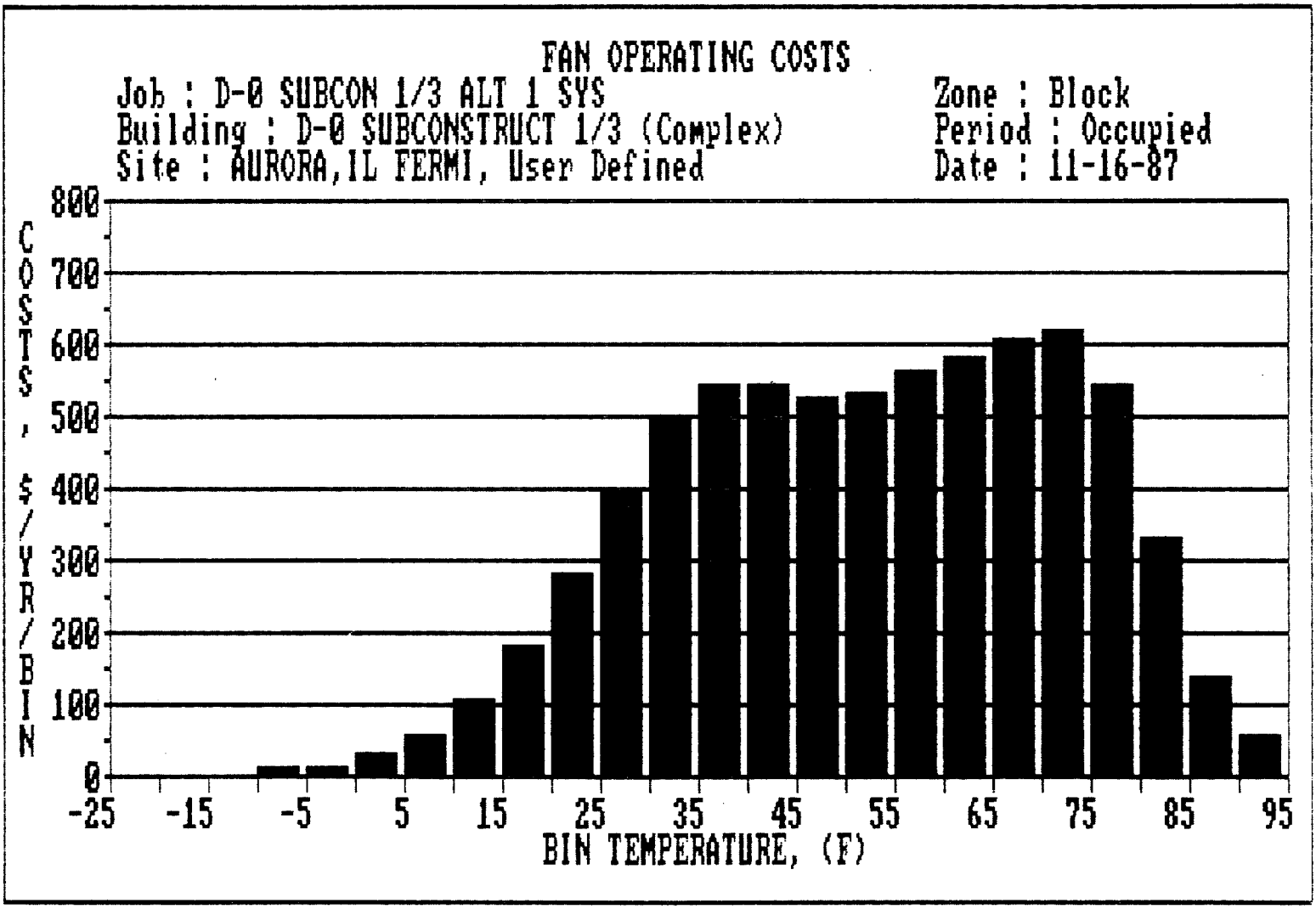

COOLING PLANT INPUT POWER
Job : D-0 SUBCON 1/3 ALT 1 SYS
Building : D-0 SUBCONSTRUCT 1/3 (Complex)
Site : AURORA,IL FERMI, User Defined
Zone : Block
Period : All
Date : 11-16-87
POWER, KW
80
70
60
50
40
30
20
10
0
-25
-15
-5
5
15
25
35
45
55
65
75
85
95
BIN TEMPERATURE, (F)


COOLING PLANT OPERATING COSTS
Job : D-0 SUBCON 1/3 ALT 1 SYS
Building : D-0 SUBCONSTRUCT 1/3 (Complex)
Site : AURORA,IL FERMI, User Defined
Zone : Block
Period : All
Date : 11-16-87
COST, $/YR/BIN
400
350
300
250
200
150
100
50
0
-25
-15
-5
5
15
25
35
45
55
65
75
85
95
BIN TEMPERATURE, (F)


PRIMARY HEATING PLANT LOADS
Job : D-0 SUBCON 1/3 ALT 1 SYS
Building : D-0 SUBCONSTRUCT 1/3 (Complex)
Site : AURORA,IL FERMI, User Defined
Zone : Block
Period : All
Date : 11-16-87
LOAD, MBH
200
175
150
125
100
75
50
25
0
-25
-15
-5
5
15
25
35
45
55
65
75
85
95
BIN TEMPERATURE, (F)


PRIMARY HEATING PLANT INPUT POWER
Job : D-0 SUBCON 1/3 ALT 1 SYS
Building : D-0 SUBCONSTRUCT 1/3 (Complex)
Site : AURORA,IL FERMI, User Defined
Zone : Block
Period : All
Date : 11-16-87
60.0
52.5
45.0
37.5
30.0
22.5
15.0
7.5
0.0
POWER, KW
-25
-15
-5
5
15
25
35
45
55
65
75
85
95
BIN TEMPERATURE, (F)


PRIMARY HEATING PLANT OPERATING COSTS
Job : D-0 SUBCON 1/3 ALT 1 SYS
Building : D-0 SUBCONSTRUCT 1/3 (Complex)
Site : AURORA,IL FERMI, User Defined
Zone : Block
Period : All
Date : 11-16-87
COST, $/YR/BIN
200
175
150
125
100
75
50
25
0
-25
-15
-5
5
15
25
35
45
55
65
75
85
95
BIN TEMPERATURE, (F)


FAN OPERATING COSTS
Job : D-0 SUBCON 1/3 ALT 1 SYS
Building : D-0 SUBCONSTRUCT 1/3 (Complex)
Site : AURORA,IL FERMI, User Defined
Zone : Block
Period : Occupied
Date : 11-16-87
COSTS, $/YR/BIN
800
700
600
500
400
300
200
100
0
-25
-15
-5
5
15
25
35
45
55
65
75
85
95
BIN TEMPERATURE, (F)

IV-c.3.

FERMILAB D-O EXPERIMENTAL FACILITY

SUBCONSTRUCTION 1/3 - COLLISION AND ASSEMBLY HALLS
OPERATIONAL PERFORMANCE SIMULATION

ALTERNATE COMPARISON SYSTEM NUMBER 2
TYPICAL FY1975 DESIGN - BASIC SYSTEM
RECIPROCATING CHILLERS AND CENTRAL STATION AHU'S
WITHOUT ENERGY FEATURES - POND WATER COOLING

31 OCTOBER, 1987
ANALYST: S.F.KRSTULOVICH

FERMILAB CONSTRUCTION ENGINEERING SERVICES

SYSTEM INPUT SUMMARY

Job Name : D-O SUBCON 1/3 FY1975 SYS Page 1
Building Name : D-O SUBCONSTRUCT 1/3 (Complex) Date : 11-25-87
Site : AURORA,IL FERMI, User Defined 60117862.0
Scope of Analysis : Cooling and Heating Systems

****

A. AIR HANDLING SYSTEMS

>1. PERIMETER TERMINAL TYPE : CONSTANT VOLUME

Supply fan type : Backward inclined or airfoil
Supply fan total static pressure = 4.00 in. wg.
Return fan type : Forward curved
Return fan total static pressure = 2.00 in. wg.
Design supply air= 42000 cfm @ 67 F; Vent. air= 6000 cfm
Are cooling terminals used for heating ? <Y>
An economizer is not used.
Is a ventilation reclaim device used ? <N>
Are ventilation air dampers closed for unoccupied periods ? <N>

****

B. HEATING PLANTS

> 1 . PERIMETER PLANT : ELECTRICAL RESISTANCE

Is hydronic heating used ? <N>

****

****

C. COOLING PLANTS

>1. PERIMETER PLANT : RECIPROCATING WATER COOLED
Capacity @ 85 F entering water = 75.0 tons
KW/Ton @ 85 F entering water = 1.00 kw/ton
Is hydronic cooling used ? <Y>
Is chilled water reset used ? <N>
Is hot gas bypass used ? <N>
Is condenser performance altitude adjusted ? <N>
Is there one compressor per condenser circuit ? <Y>
Are compressors cycled ? <N>
Heat sink type : Closed circuit cooling tower
Minimum entering water temperature = 40 F
Is a hydronic economizer used ? <N>

****

D. PUMPING SYSTEMS

System	PERIMETER dT, F	PERIMETER dP, ft wg	dT, F	dP, ft wg
Chilled water	10.00	120.00	0.00	0.00
Hot water	0.00	0.00	0.00	0.00
Condenser water	10.00	120.00	0.00	0.00
Ground water	0.00	0.00	0.00	0.00

****

E. NON-HVAC SYSTEMS

>1. NON-HVAC ELECTRICAL ENERGY USE
Lighting kw: Occupied = 73.2 kw; Unoccupied = 73.2 kw
Misc. kw : Occupied = 60.0 kw; Unoccupied = 20.0 kw
Other kw : Occupied = 0.0 kw; Unoccupied = 0.0 kw
>2. DHW SYSTEM (Not utilized in this system)

****

F. FUEL COSTS

>1. ELECTRICAL ENERGY USE	Period Occupied ($/kwh)	Period Unoccupied ($/kwh)
Compressor	0.050	0.050
Resistance	0.050	0.050
Inductive	0.050	0.050

>2. OTHER FUELS	Unit Cost
Natural Gas	n/a $/therm
Fuel Oil	n/a $/U.S.gal
Propane	n/a $/lb
Remote Heating	n/a $/MBTU
Remote Cooling	n/a $/MBTU

TOTAL BUILDING ENERGY SUMMARY

Job Name : D-0 SUBCON 1/3 FY1975 SYS — Period : All
Building Name : D-0 SUBCONSTRUCT 1/3 (Complex) — Zone : Block
Site : AURORA,IL FERMI, User Defined — Serial Number:
Date : 11-25-87 — 60117862.0

****

HVAC ENERGY Component	Annual Cost ($/yr)	Energy or Fuel Units Consumed	DOE RUF (1000 BTU)	DOE RIF (1000 BTU)
Electric (Occ)	13711	274215 kwh/yr	3180893	935895
Electric (Unocc)	24572	491443 kwh/yr	5700733	1677293
Natural Gas	0	0 therms/yr	0	0
Fuel Oil	0	0 U.S. gal/yr	0	0
Propane	0	0 lb/yr	0	0
Remote Heating	0	0 MBTU/yr	0	0
Remote Cooling	0	0 MBTU/yr	0	0
HVAC Total	38283		8881626	2613189
NON-HVAC ENERGY				
Electric (Occ)	20836	416730 kwh/yr	4834063	1422298
Electric (Unocc)	26242	524846 kwh/yr	6088219	1791301
Non-HVAC Total	47079		10922282	3213599
Grand Total	85362		19803907	5826788
Total/Sq.Ft.	3.50		811.64	238.80

HVAC Summary:

HVAC Total Cost	=	1.57 $/Sq.Ft./yr
	=	44.85 % of Total Cost
Total HVAC Electrical Energy	=	31.38 kwh/Sq.Ft./yr
	=	44.85 % of Total Electrical Energy
Non-Electrical HVAC Energy	=	0.00 % of Total Energy

Key:

1 kwh	= 11600 BTU RUF; 3412 BTU RIF
1 therm nat gas	= 100000 BTU RUF and RIF
1 U.S. gal oil	= 138700 BTU RUF and RIF
1 Imp. gal oil	= 168000 BTU RUF and RIF
1 lb propane	= 21680 BTU RUF and RIF
RUF	= Resource utilization factor (Source value)
RIF	= Resource impact factor (Point of use value)
MBH	= 1000 BTU/hr
MBTU	= Million BTU

ANNUAL OPERATING COSTS

Job Name : D-O SUBCON 1/3 FY1975 SYS Page 1
Building Name : D-O SUBCONSTRUCT 1/3 (Complex) Date : 11-25-87
Site : AURORA,IL FERMI, User Defined 60117862.0
Scope of Analysis : Cooling and Heating Systems

****

A. AIR HANDLING SYSTEMS (ANNUAL FAN OPERATING COST = $23,943)

>1. PERIMETER TERMINAL TYPE : CONSTANT VOLUME

Supply fan type : Backward inclined or airfoil
Supply fan total static pressure = 4.00 in. wg.
Return fan type : Forward curved
Return fan total static pressure = 2.00 in. wg.
Design supply air= 42000 cfm @ 67 F; Vent. air= 6000 cfm
Are cooling terminals used for heating ? <Y>
An economizer is not used.
Is a ventilation reclaim device used ? <N>
Are ventilation air dampers closed for unoccupied periods ? <N>

****

B. HEATING PLANTS (ANNUAL HEATING PLANT OPERATING COST = $5,014)

> 1 . PERIMETER PLANT : ELECTRICAL RESISTANCE

Is hydronic heating used ? <N>

****

****

C. COOLING PLANTS (ANNUAL COOLING PLANT OPERATING COST = $5,508)

>1. PERIMETER PLANT : RECIPROCATING WATER COOLED
Capacity @ 85 F entering water = 75.0 tons
KW/Ton @ 85 F entering water = 1.00 kw/ton
Is hydronic cooling used ? <Y>
Is chilled water reset used ? <N>
Is hot gas bypass used ? <N>
Is condenser performance altitude adjusted ? <N>
Is there one compressor per condenser circuit ? <Y>
Are compressors cycled ? <N>
Heat sink type : Closed circuit cooling tower
Minimum entering water temperature = 40 F
Is a hydronic economizer used ? <N>

****

D. PUMPING SYSTEMS (ANNUAL PUMP OPERATING COST = $3,618)

System	PERIMETER dT, F	PERIMETER dP, ft wg	dT, F	dP, ft wg
Chilled water	10.00	120.00	0.00	0.00
Hot water	0.00	0.00	0.00	0.00
Condenser water	10.00	120.00	0.00	0.00
Ground water	0.00	0.00	0.00	0.00

****

E. NON-HVAC SYSTEMS (ANNUAL NON-HVAC OPERATING COST = $47,079)

>1. NON-HVAC ELECTRICAL ENERGY USE
Lighting kw: Occupied = 73.2 kw; Unoccupied = 73.2 kw
Misc. kw : Occupied = 60.0 kw; Unoccupied = 20.0 kw
Other kw : Occupied = 0.0 kw; Unoccupied = 0.0 kw

>2. DHW SYSTEM (Not utilized in this system)

****

F. FUEL COSTS (GRAND TOTAL ANNUAL OPERATING COST = $95,362)

>1. ELECTRICAL ENERGY USE	Period Occupied ($/kwh)	Period Unoccupied ($/kwh)
Compressor	0.050	0.050
Resistance	0.050	0.050
Inductive	0.050	0.050

>2. OTHER FUELS	Unit Cost
Natural Gas	n/a $/therm
Fuel Oil	n/a $/U.S.gal
Propane	n/a $/lb
Remote Heating	n/a $/MBTU
Remote Cooling	n/a $/MBTU

COOLING PLANT COSTS

Job Name : D-0 SUBCON 1/3 FY1975 SYS — Date : 11-25-87
Building Name : D-0 SUBCONSTRUCT 1/3 (Complex) — Serial Number:
Site Name : AURORA,IL FERMI, User Defined — 60117862.0

Din Temp (F)	Din Hours hr/yr	Perimeter Coil Load MBH	Cooling Plant Input KW	Cost $/yr	No Interior Zone Exists
			OCCUPIED PERIOD		
90	25.8	731.2	60.6	78.2	
85	59.4	676.1	53.6	159.0	
80	145.3	621.0	46.9	340.9	
75	237.7	565.9	40.7	483.9	
70	270.6	510.7	34.9	472.6	
65	264.5	455.6	29.6	390.9	
60	255.0	400.5	24.6	313.6	
55	244.7	345.4	20.0	244.8	
50	232.1	290.3	15.3	177.4	
45	229.5	235.2	11.2	128.5	
40	237.6	180.1	7.7	91.9	
35	238.5	125.0	4.9	58.2	
30	218.2	69.8	2.9	31.4	
25	174.5	14.7	1.1	9.2	
20	122.4	0.0	0.0	0.0	
15	78.1	0.0	0.0	0.0	
10	46.1	0.0	0.0	0.0	
5	25.1	0.0	0.0	0.0	
0	12.7	0.0	0.0	0.0	
-5	6.2	0.0	0.0	0.0	
-6	4.6	0.0	0.0	0.0	
Total Costs				$2960.6	
			UNOCCUPIED PERIOD		
90	14.6	591.9	48.2	35.2	
85	36.3	537.3	41.7	75.8	
80	99.3	482.8	35.7	177.2	
75	215.3	428.2	30.1	323.7	
70	357.6	373.6	24.9	444.7	
65	463.3	319.1	20.1	465.6	
60	500.4	264.5	15.8	394.1	
55	482.0	209.9	11.8	284.5	
50	447.6	155.4	8.0	178.7	
45	422.7	100.8	4.8	101.6	
40	413.7	46.3	2.3	46.6	
35	417.0	0.0	0.0	0.0	
30	417.4	0.0	0.0	0.0	
25	395.2	0.0	0.0	0.0	
20	336.9	0.0	0.0	0.0	
15	252.8	0.0	0.0	0.0	
10	165.7	0.0	0.0	0.0	
5	96.3	0.0	0.0	0.0	
0	50.9	0.0	0.0	0.0	
-5	25.3	0.0	0.0	0.0	
-6	21.1	0.0	0.0	0.0	
Total Costs				$2527.8	

PERIMETER HEATING PLANT COSTS

Job Name : D-0 SUBCON 1/3 FY1975 SYS — Date : 11-25-87

Building Name : D-0 SUBCONSTRUCT 1/3 (Complex) — Serial Number:

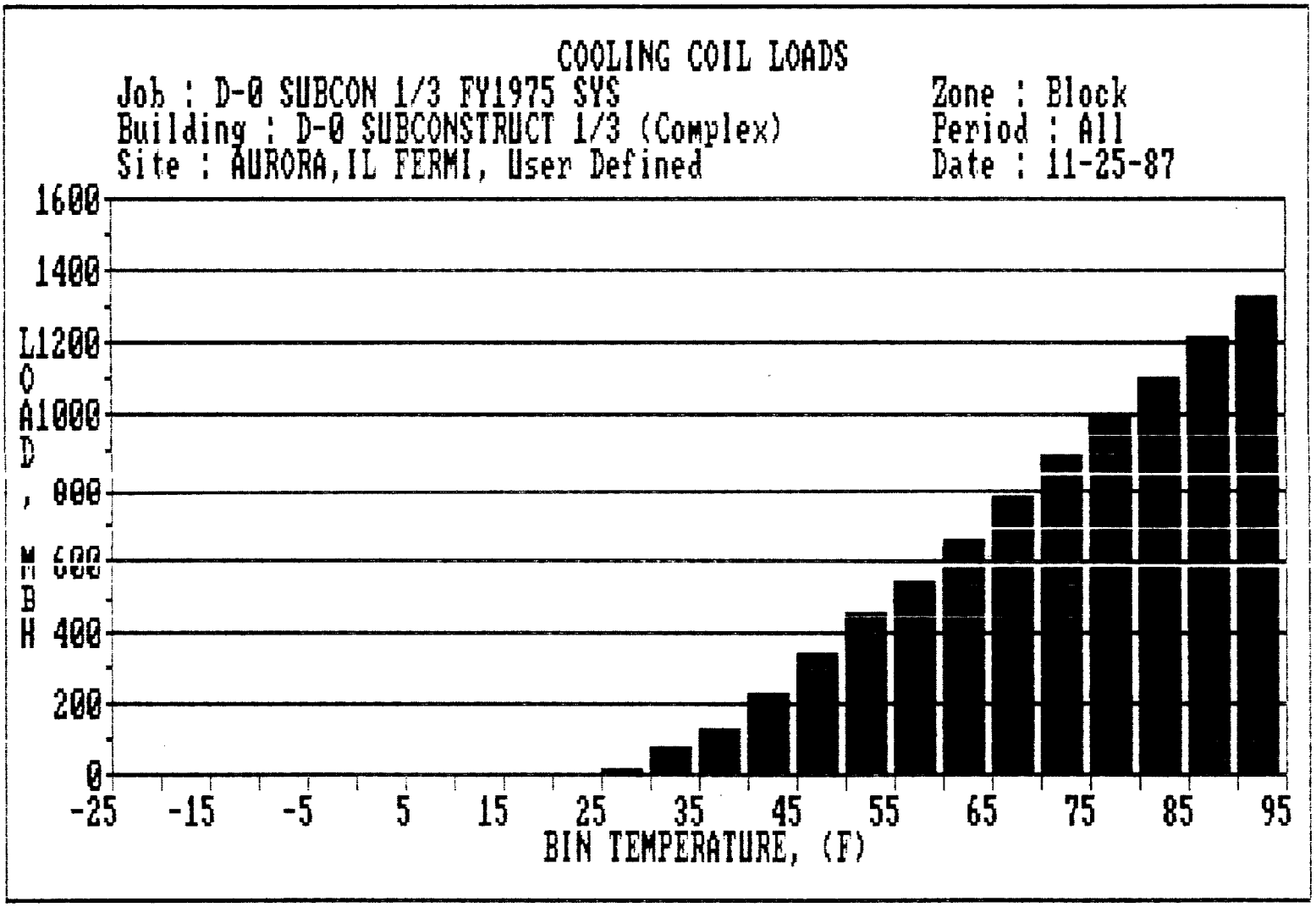
Site Name : AURORA,IL FERMI, User Defined — 60117662.0

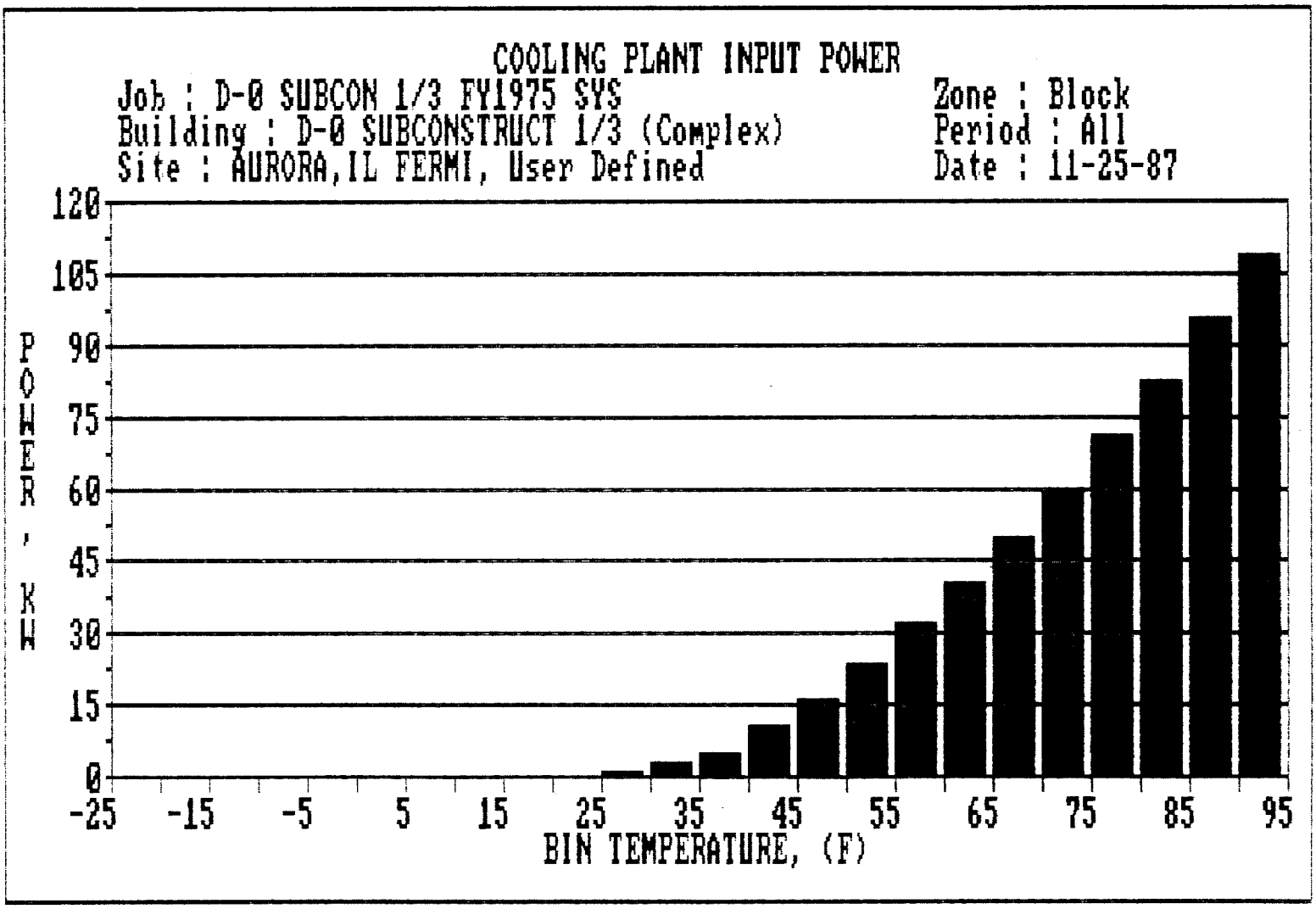
Bin Temp (F)	Bin Hours hr/yr	Coil Load MBH	Primary Plant Output MBH	Primary Plant Input KW	Primary Plant Cost $/yr	No Auxiliary Plant Used
			OCCUPIED PERIOD			
90	25.8	0.0	0.0	0.0	0.0	
85	59.4	0.0	0.0	0.0	0.0	
80	145.3	0.0	0.0	0.0	0.0	
75	237.7	0.0	0.0	0.0	0.0	
70	270.6	0.0	0.0	0.0	0.0	
65	264.5	0.0	0.0	0.0	0.0	
60	255.0	0.0	0.0	0.0	0.0	
55	244.7	0.0	0.0	0.0	0.0	
50	232.1	0.0	0.0	0.0	0.0	
45	229.5	0.0	0.0	0.0	0.0	
40	237.6	0.0	0.0	0.0	0.0	
35	238.5	0.0	0.0	0.0	0.0	
30	218.2	0.0	0.0	0.0	0.0	
25	174.5	0.0	0.0	0.0	0.0	
20	122.4	40.4	40.4	11.8	72.4	
15	78.1	95.5	95.5	28.0	109.3	
10	46.1	150.6	150.6	44.1	101.7	
5	25.1	205.7	205.7	60.3	75.6	
0	12.7	260.8	260.8	76.4	48.5	
-5	6.2	315.9	315.9	92.6	28.7	
-6	4.6	327.0	327.0	95.8	22.0	
Total Costs					$458.3	
			UNOCCUPIED PERIOD			
90	14.6	0.0	0.0	0.0	0.0	
85	36.3	0.0	0.0	0.0	0.0	
80	99.3	0.0	0.0	0.0	0.0	
75	215.3	0.0	0.0	0.0	0.0	
70	357.6	0.0	0.0	0.0	0.0	
65	463.3	0.0	0.0	0.0	0.0	
60	500.4	0.0	0.0	0.0	0.0	
55	482.0	0.0	0.0	0.0	0.0	
50	447.6	0.0	0.0	0.0	0.0	
45	422.7	0.0	0.0	0.0	0.0	
40	413.7	0.0	0.0	0.0	0.0	
35	417.0	8.3	8.3	2.4	50.7	
30	417.4	62.9	62.9	18.4	384.4	
25	395.2	117.4	117.4	34.4	679.9	
20	336.9	172.0	172.0	50.4	848.9	
15	252.8	226.6	226.6	66.4	839.0	
10	165.7	281.1	281.1	82.4	682.4	
5	96.3	335.7	335.7	98.4	473.6	
0	50.9	390.2	390.2	114.3	291.0	
-5	25.3	444.8	444.8	130.3	164.9	
-6	21.1	455.7	455.7	133.5	140.9	
Total Costs					$4555.6	

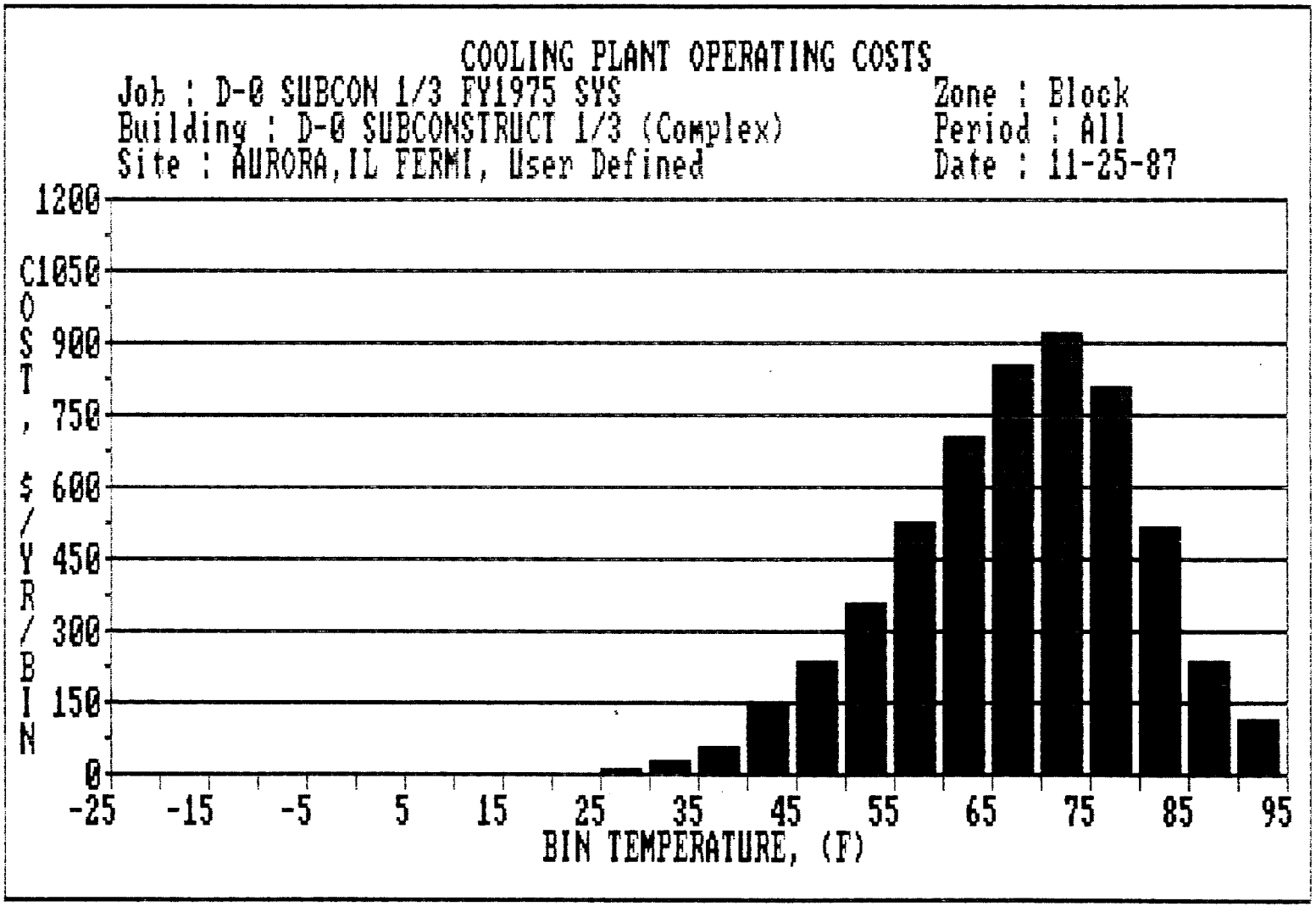
FAN AND PUMP COSTS

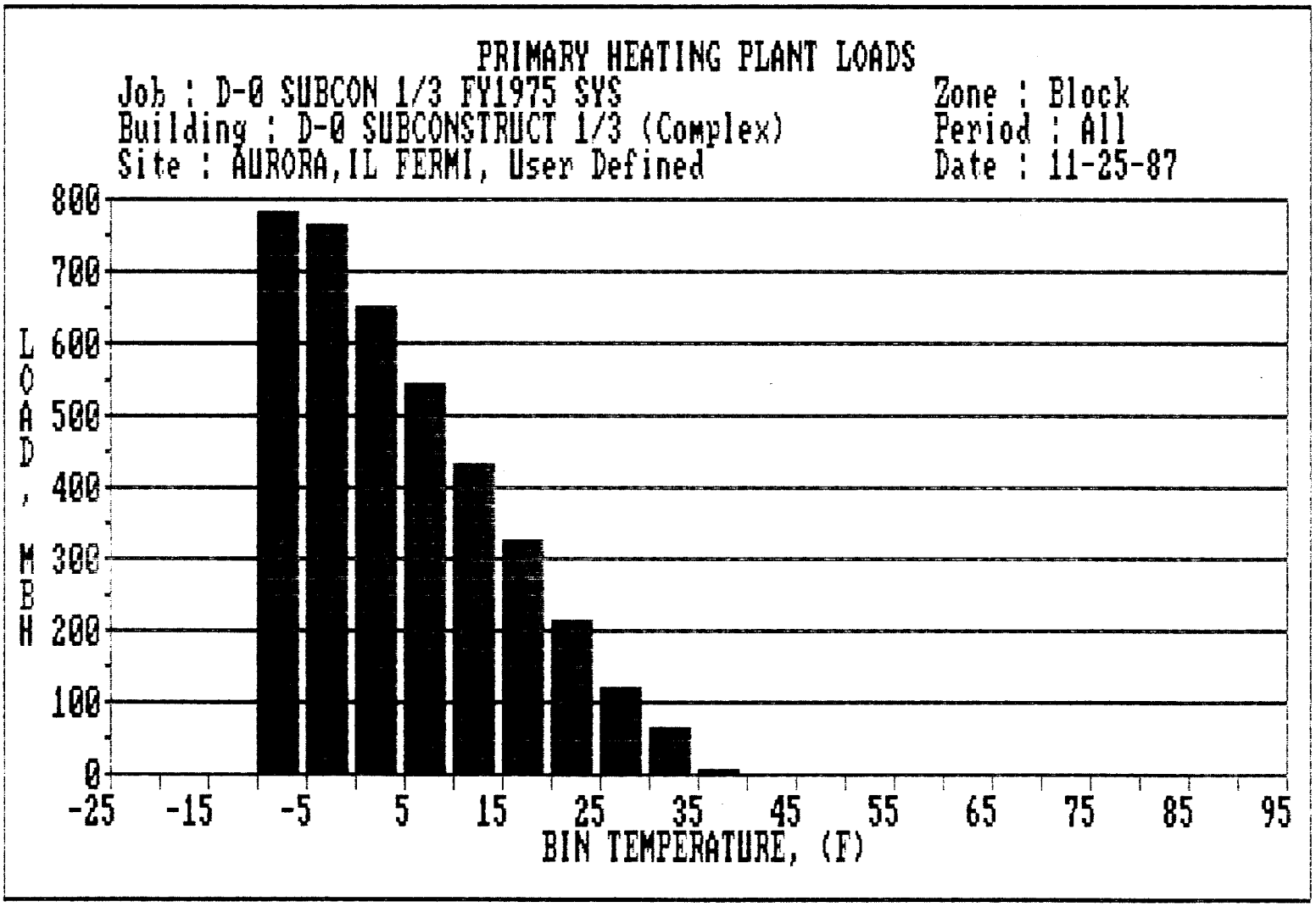
Job Name : D-O SUBCON 1/3 FY1975 SYS — Date : 11-25-87
Building Name : D-O SUBCONSTRUCT 1/3 (Complex) — Serial Number:
Site Name : AURORA,IL FERMI, User Defined — e0117642.0

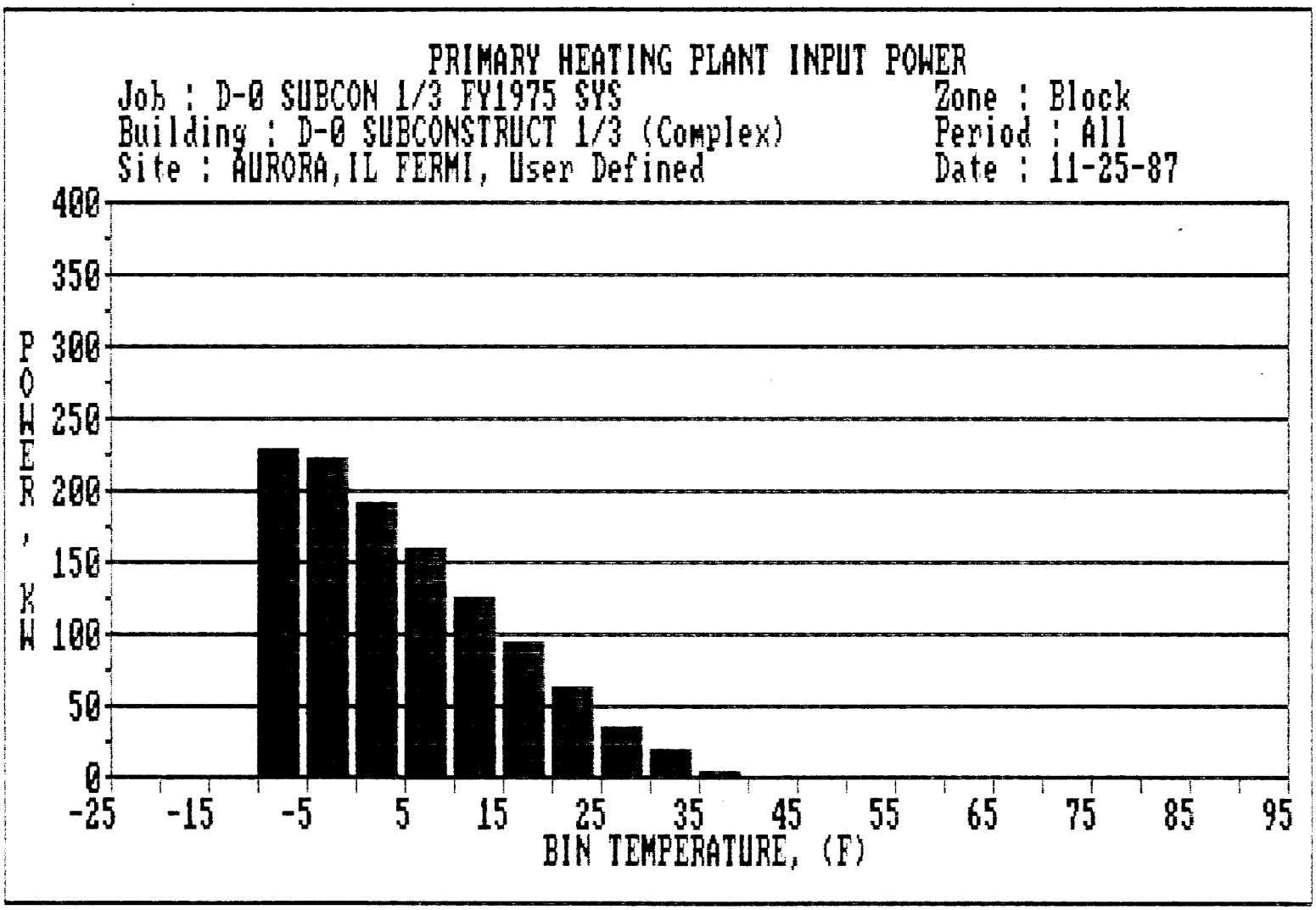
Bin Temp (F)	Bin Hours hr/yr	Perimeter Fans Input KW	Perimeter Fans Cost $/yr	No Interior Zone	All Pumps Input KW	All Pumps Cost $/yr
			OCCUPIED PERIOD			
90	25.8	54.7	70.5		12.1	15.7
85	59.4	54.7	162.4		12.1	36.1
80	145.3	54.7	397.1		12.1	88.2
75	237.7	54.7	649.7		12.1	144.4
70	270.6	54.7	739.6		12.1	164.3
65	264.5	54.7	722.9		12.1	160.6
60	255.0	54.7	697.0		12.1	154.9
55	244.7	54.7	668.8		12.1	148.6
50	232.1	54.7	634.4		12.1	141.0
45	229.5	54.7	627.3		12.1	139.4
40	237.6	54.7	649.4		12.1	144.3
35	238.5	54.7	651.9		12.1	144.8
30	218.2	54.7	596.4		12.1	132.5
25	174.5	54.7	476.9		12.1	106.0
20	122.4	54.7	334.5		0.0	0.0
15	78.1	54.7	213.5		0.0	0.0
10	46.1	54.7	126.0		0.0	0.0
5	25.1	54.7	68.6		0.0	0.0
0	12.7	54.7	34.7		0.0	0.0
-5	6.2	54.7	16.9		0.0	0.0
-6	4.6	54.7	12.6		0.0	0.0
Total Costs			$8551.1			$1720.8
			UNOCCUPIED PERIOD			
90	14.6	54.7	39.9		12.1	8.9
85	36.3	54.7	99.2		12.1	22.0
80	99.3	54.7	271.4		12.1	60.3
75	213.3	54.7	586.5		12.1	130.6
70	357.6	54.7	977.4		12.1	217.2
65	463.3	54.7	1266.3		12.1	281.4
60	500.4	54.7	1367.7		12.1	303.9
55	482.0	54.7	1317.4		12.1	292.7
50	447.6	54.7	1223.4		12.1	271.8
45	422.7	54.7	1155.3		12.1	256.7
40	413.7	54.7	1130.7		12.1	251.2
35	417.0	54.7	1139.7		0.0	0.0
30	417.4	54.7	1140.8		0.0	0.0
25	395.2	54.7	1080.2		0.0	0.0
20	336.9	54.7	920.8		0.0	0.0
15	252.8	54.7	691.0		0.0	0.0
10	165.7	54.7	452.9		0.0	0.0
5	96.3	54.7	263.2		0.0	0.0
0	50.9	54.7	139.1		0.0	0.0
-5	25.3	54.7	69.2		0.0	0.0
-6	21.1	54.7	57.7		0.0	0.0
Total Costs			$15391.8			$2096.9

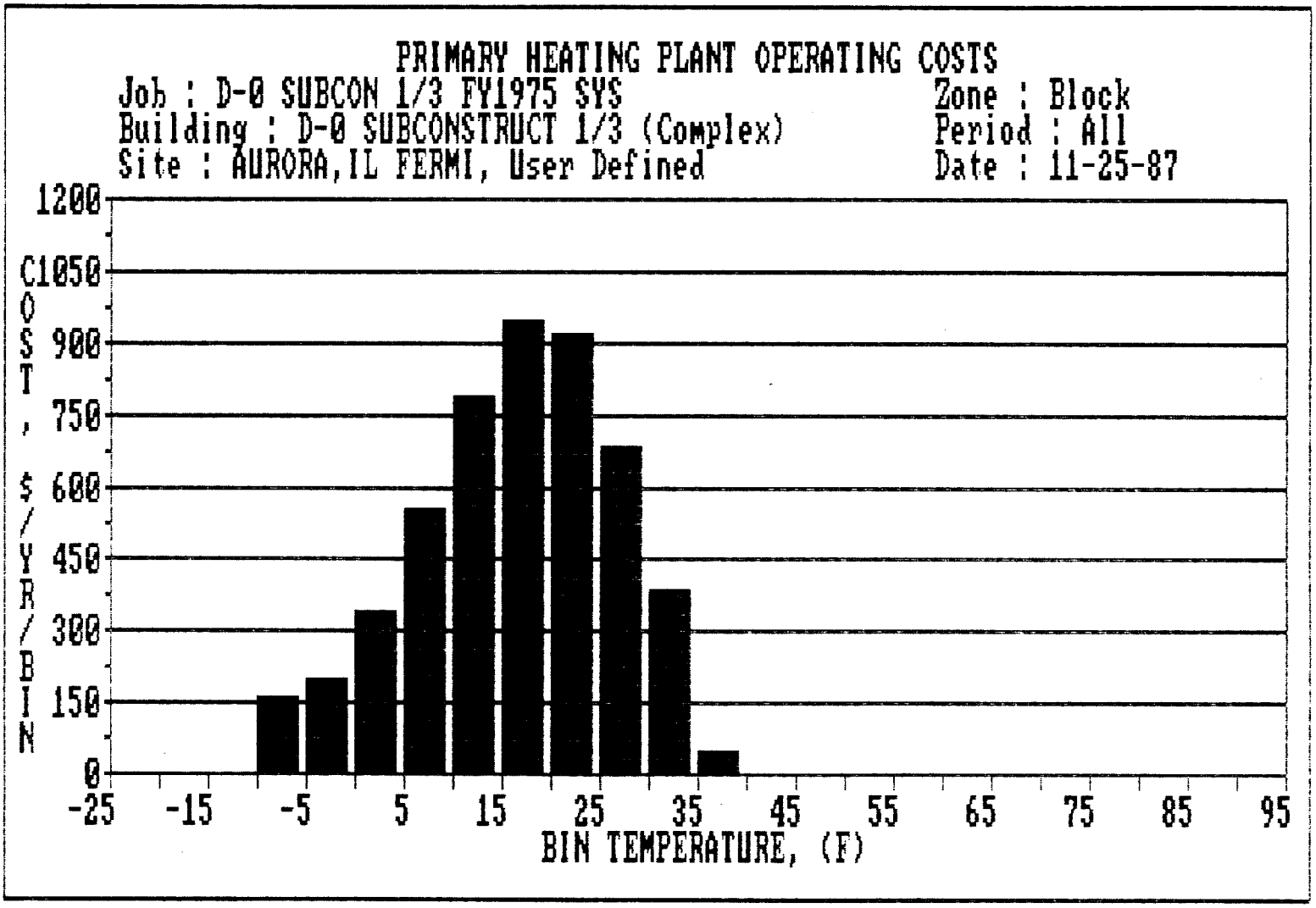

COOLING COIL LOADS
Job : D-0 SUBCON 1/3 FY1975 SYS
Building : D-0 SUBCONSTRUCT 1/3 (Complex)
Site : AURORA,IL FERMI, User Defined
Zone : Block
Period : All
Date : 11-25-87
1600
1400
1200
1000
800
600
400
200
0
LOAD, MBH
-25
-15
-5
5
15
25
35
45
55
65
75
85
95
BIN TEMPERATURE, (F)

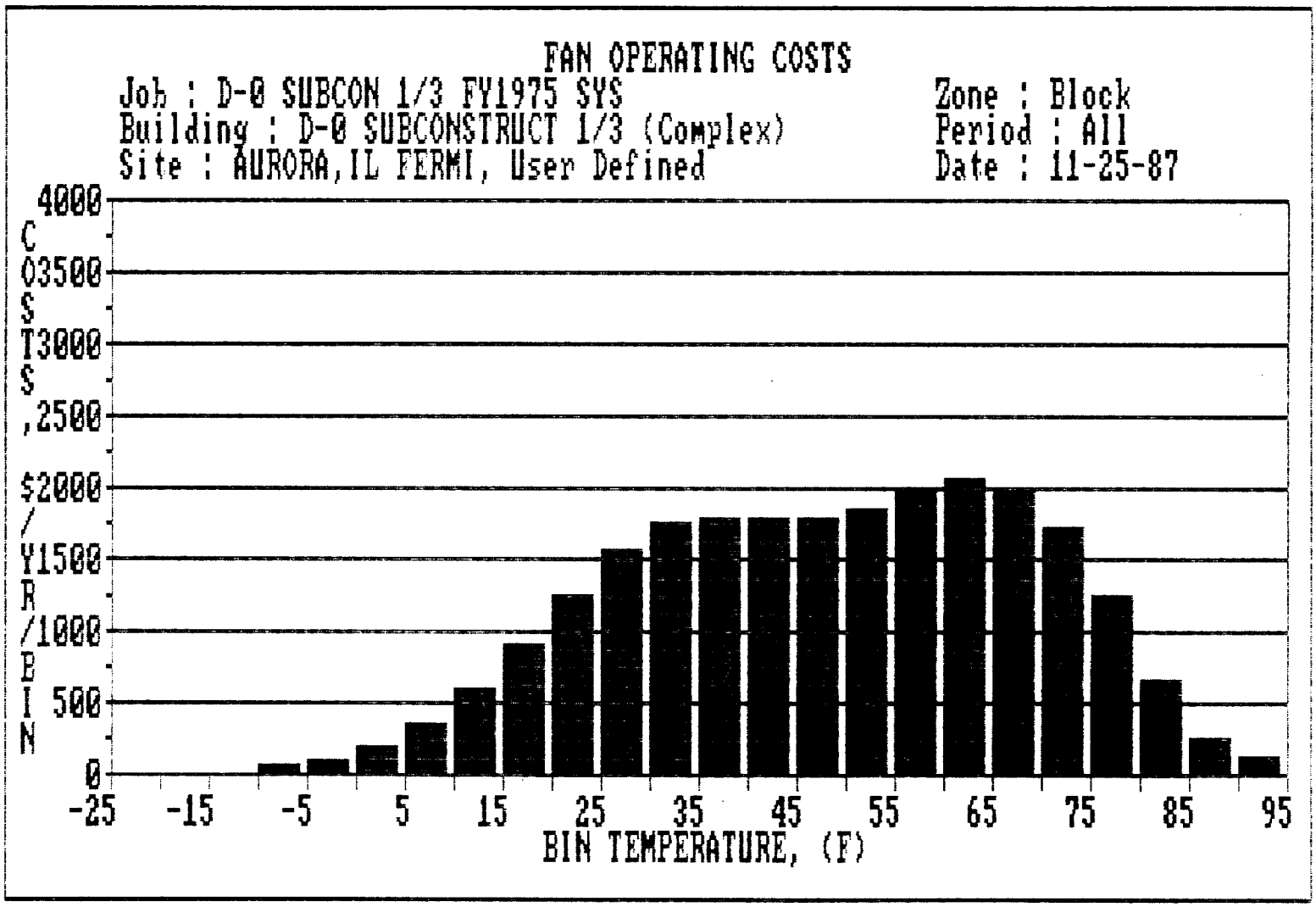

COOLING PLANT INPUT POWER
Job : D-0 SUBCON 1/3 FY1975 SYS
Building : D-0 SUBCONSTRUCT 1/3 (Complex)
Site : AURORA,IL FERMI, User Defined
Zone : Block
Period : All
Date : 11-25-87
POWER, KW
120
105
90
75
60
45
30
15
0
-25
-15
-5
5
15
25
35
45
55
65
75
85
95
BIN TEMPERATURE, (F)


COOLING PLANT OPERATING COSTS
Job : D-0 SUBCON 1/3 FY1975 SYS
Building : D-0 SUBCONSTRUCT 1/3 (Complex)
Site : AURORA,IL FERMI, User Defined
Zone : Block
Period : All
Date : 11-25-87
COST, $/YR/BIN
1200
1050
900
750
600
450
300
150
0
-25
-15
-5
5
15
25
35
45
55
65
75
85
95
BIN TEMPERATURE, (F)


PRIMARY HEATING PLANT LOADS
Job : D-0 SUBCON 1/3 FY1975 SYS
Building : D-0 SUBCONSTRUCT 1/3 (Complex)
Site : AURORA,IL FERMI, User Defined
Zone : Block
Period : All
Date : 11-25-87
LOAD, MBH
800
700
600
500
400
300
200
100
0
-25
-15
-5
5
15
25
35
45
55
65
75
85
95
BIN TEMPERATURE, (F)


PRIMARY HEATING PLANT INPUT POWER
Job : D-0 SUBCON 1/3 FY1975 SYS
Building : D-0 SUBCONSTRUCT 1/3 (Complex)
Site : AURORA,IL FERMI, User Defined
Zone : Block
Period : All
Date : 11-25-87
POWER, KW
400
350
300
250
200
150
100
50
0
-25
-15
-5
5
15
25
35
45
55
65
75
85
95
BIN TEMPERATURE, (F)


PRIMARY HEATING PLANT OPERATING COSTS
Job : D-0 SUBCON 1/3 FY1975 SYS
Building : D-0 SUBCONSTRUCT 1/3 (Complex)
Site : AURORA,IL FERMI, User Defined
Zone : Block
Period : All
Date : 11-25-87
COST, $/YR/BIN
1200
1050
900
750
600
450
300
150
0
-25
-15
-5
5
15
25
35
45
55
65
75
85
95
BIN TEMPERATURE, (F)


FAN OPERATING COSTS
Job : D-0 SUBCON 1/3 FY1975 SYS
Building : D-0 SUBCONSTRUCT 1/3 (Complex)
Site : AURORA,IL FERMI, User Defined
Zone : Block
Period : All
Date : 11-25-87
COSTS/YR/1000 BIN
4000
3500
3000
2500
2000
1500
1000
500
0
-25
-15
-5
5
15
25
35
45
55
65
75
85
95
BIN TEMPERATURE, (F)

V.

FERMILAB D-0 EXPERIMENTAL FACILITY

SUBCONSTRUCTION 2/3 - MCH, PLATFORM & SIDEBAY AREAS WITH DCHW SYSTEMS
SYSTEMS ANALYSIS

31 OCTOBER, 1987
ANALYST: S.F.KRSTULOVICH

FERMILAB CONSTRUCTION ENGINEERING SERVICES

V-a.

FERMILAB D-O EXPERIMENTAL FACILITY

SUBCONSTRUCTION 2/3 - MCH, PLATFORM & SIDEBAY AREAS WITH DCHW SYSTEMS
BUILDING SECTOR PHYSICAL PARAMETERS AND DESCRIPTION

31 OCTOBER, 1987

ANALYST: S.F.KRSTULOVICH

FERMILAB CONSTRUCTION ENGINEERING SERVICES

COMPLEX BUILDING INPUT SUMMARY

Building Name : D-0 SUBCONSTRUCT 2/3 Date : 11-16-87
Site : AURORA,IL FERMI, User Defined 60117862.0

****

1. ROOM CONDITIONS AND FLOOR AREAS

Thermostat settings : Cooling = 78 F; Heating = 68 F; Setback = 0 F
Warm-up factor = 0 %; Room design relative humidity = 50 %
Floor Areas: Perimeter = 16,500 Sqft; Interior = 1,300 Sqft
Cooling provided during unoccupied period.

---

2. WALLS, ROOF, GLASS, SKYLIGHTS:

Exposure	Area (Sqft)	U-Factor BTU/(hr-sqft-F)	Glass Area (Sqft)	Glass U-Factor BTU/(hr-sqft-F)
North Wall	5,300	0.150	0	1.130
Northeast Wall	0	0.150	0	1.130
East Wall	600	0.150	0	1.130
Southeast Wall	0	0.150	0	1.130
South Wall	0	0.150	0	1.130
Southwest Wall	0	0.150	0	1.130
West Wall	600	0.150	0	1.130
Northwest Wall	0	0.150	0	1.130
Perimeter Roof	4,400	0.130	0	0.550
Interior Roof	0	0.130	0	0.550

WALLS: Color = Dark; Wt. = Medium; ROOF: Color = Medium; Wt. = Medium
BUILDING WT. = Medium; VERTICAL GLASS : Single Glazed
Shade Factors : Glass = 1.000 ; Skylights = 0.000
Internal shades are not used. ; A ceiling plenum is not used.

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3. LIGHTS:

Perimeter : 3.000 Watts/Sqft = 49,500 Watts Total
Interior : 3.000 Watts/Sqft = 3,900 Watts Total
Diversity Factors : Occupied = 100 %; Unoccupied = 90 %
Perimeter Lights : Ballast , recessed
Interior Lights : Ballast , exposed

---

4. MISCELLANEOUS ELECTRICAL LOADS:

Perimeter : Occupied = 12.727 Watts/Sqft = 210,000 Watts Total
Unoccupied = 4.242 Watts/Sqft = 70,000 Watts Total
Interior : Occupied = %346.154 Watts/Sqft = 450,000 Watts Total
Unoccupied = %115.385 Watts/Sqft = 150,000 Watts Total

---

5. PEOPLE LOADS

Total Occupancy = 593 sqft/person = 30 people total
Activity Level: 2. Office or retail
Sensible = 245.0 BTU/hr/person; Latent = 205.0 BTU/hr/person
Diversity Factors : Occupied = 70 %; Unoccupied = 20 %

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6. MISCELLANEOUS INTERNAL LOADS:

Sensible : Occupied = 0 BTU/hr; Unoccupied = 0 BTU/hr
Latent : Occupied = 0 BTU/hr; Unoccupied = 0 BTU/hr

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7. WALLS ADJACENT TO NON-CONDITIONED REGIONS:

Wall Areas : Perimeter = 7,900 Sqft; Interior = 0 Sqft
Wall U-Factor = 0.320 BTU/(hr-sqft-F)
Adjacent region heating temperature = 60 F
Adjacent region cooling temperature = 60 F

---

8. INFILTRATION DATA:

Air Flow Rates: Occupied = 50 cfm; Unoccupied = 0 cfm

V-b.

FERMILAB D-O EXPERIMENTAL FACILITY

SUBCONSTRUCTION 2/3 - MCH, PLATFORM & SIDEBAY AREAS WITH DCHW SYSTEMS
BUILDING LOAD CALCULATIONS

31 OCTOBER, 1987
ANALYST: S.F.KRSTULOVICH

FERMILAB CONSTRUCTION ENGINEERING SERVICES

LOAD PROFILE SUMMARY

Building Name : D-0 SUBCONSTRUCT 2/3 (Complex) Date : 11-16-87

Site Name : AURORA,IL FERMI, User Defined 60117862.0

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TABLE 1. OCCUPIED PERIOD (Load does not include vent. load, fan heat)

Bin Temp (F)	Bin Hours (hr/yr)	<-------Perimeter Zone-------> Sensible (tons)	Latent (tons)	Plenum (tons)	Zone (F)	<---------Interior Zone-----> Sensible (tons)	Latent (tons)	Plenum (tons)	Zone (F)
93	0.0	76.41	0.58	0.00	78	129.42	0.04	0.00	78
90	25.8	75.55	0.37	0.00	78	129.41	0.03	0.00	78
85	59.4	74.92	0.36	0.00	78	129.41	0.03	0.00	78
80	145.3	74.28	0.34	0.00	78	129.41	0.03	0.00	78
75	237.7	73.64	0.32	0.00	78	129.41	0.03	0.00	78
70	270.6	73.00	0.31	0.00	78	129.41	0.03	0.00	78
65	264.5	72.37	0.30	0.00	78	129.41	0.03	0.00	78
60	255.0	71.73	0.29	0.00	78	129.41	0.03	0.00	78
55	244.7	71.09	0.28	0.00	78	129.41	0.03	0.00	78
50	232.1	70.45	0.28	0.00	78	129.41	0.03	0.00	78
45	229.5	69.81	0.25	0.00	78	129.41	0.03	0.00	78
40	237.6	69.18	0.23	0.00	78	129.41	0.03	0.00	78
35	238.5	68.54	0.21	0.00	78	129.41	0.03	0.00	78
30	218.2	67.90	0.19	0.00	78	129.41	0.03	0.00	78
25	174.5	67.26	0.18	0.00	78	129.41	0.03	0.00	78
20	122.4	66.63	0.17	0.00	78	129.41	0.03	0.00	78
15	78.1	65.99	0.16	0.00	78	129.41	0.03	0.00	78
10	46.1	65.35	0.15	0.00	78	129.41	0.03	0.00	78
5	25.1	64.71	0.15	0.00	78	129.41	0.03	0.00	78
0	12.7	64.08	0.14	0.00	78	129.41	0.03	0.00	78
-5	6.2	63.44	0.14	0.00	78	129.41	0.03	0.00	78
-6	4.6	63.31	0.14	0.00	78	129.41	0.03	0.00	78

TABLE 2. UNOCCUPIED PERIOD (Load does not include vent. load, fan heat)

90	14.6	33.64	0.10	0.00	78	43.92	0.01	0.00	78
85	36.3	33.02	0.10	0.00	78	43.92	0.01	0.00	78
80	99.3	32.41	0.10	0.00	78	43.92	0.01	0.00	78
75	215.3	31.79	0.10	0.00	78	43.92	0.01	0.00	78
70	357.6	31.18	0.10	0.00	78	43.92	0.01	0.00	78
65	463.3	30.56	0.10	0.00	78	43.92	0.01	0.00	78
60	500.4	29.95	0.10	0.00	78	43.92	0.01	0.00	78
55	482.0	29.33	0.10	0.00	78	43.92	0.01	0.00	78
50	447.6	28.72	0.10	0.00	78	43.92	0.01	0.00	78
45	422.7	28.10	0.10	0.00	78	43.92	0.01	0.00	78
40	413.7	27.49	0.10	0.00	78	43.92	0.01	0.00	78
35	417.0	26.87	0.10	0.00	78	43.92	0.01	0.00	78
30	417.4	26.26	0.10	0.00	78	43.92	0.01	0.00	78
25	395.2	25.64	0.10	0.00	78	43.92	0.01	0.00	78
20	336.9	25.03	0.10	0.00	78	43.92	0.01	0.00	78
15	252.8	24.41	0.10	0.00	78	43.92	0.01	0.00	78
10	165.7	23.80	0.10	0.00	78	43.92	0.01	0.00	78
5	96.3	23.19	0.10	0.00	78	43.92	0.01	0.00	78
0	50.9	22.57	0.10	0.00	78	43.92	0.01	0.00	78
-5	25.3	21.96	0.10	0.00	78	43.92	0.01	0.00	78
-6	21.1	21.83	0.10	0.00	78	43.92	0.01	0.00	78
-6	0.0	-11.23	0.00	0.00	68	0.00	0.00	0.00	68

SOLAR GAIN SUMMARY

Building Name : D-0 SUBCONSTRUCT 2/3 (Complex) Date : 11-16-87

Site Name : AURORA,IL FERMI, User Defined 60117862.0

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TABLE 1. SOLAR GAINS BY EXPOSURE

Bin Temp (F)	Solar Gains by Exposure (BTU/(hr-sqft)) North	NE	East	SE	South	SW	West	NW	Perim Horiz	Inter Horiz
93	13.0	30.4	47.4	53.6	50.4	74.4	56.9	27.5	0.0	0.0
90	9.2	21.5	33.6	38.1	35.9	52.9	40.4	19.5	0.0	0.0
85	8.8	20.4	32.0	36.3	34.4	50.5	38.6	18.5	0.0	0.0
80	8.3	19.3	30.3	34.6	32.9	48.1	36.7	17.5	0.0	0.0
75	7.8	18.2	28.7	32.9	31.4	45.8	34.9	16.5	0.0	0.0
70	7.4	17.1	27.1	31.2	29.9	43.4	33.0	15.5	0.0	0.0
65	6.9	16.0	25.4	29.4	28.4	41.0	31.2	14.5	0.0	0.0
60	6.5	14.9	23.8	27.7	27.0	38.6	29.3	13.5	0.0	0.0
55	6.0	13.8	22.2	26.0	25.5	36.3	27.5	12.6	0.0	0.0
50	5.5	12.6	20.5	24.2	24.0	33.9	25.6	11.6	0.0	0.0
45	5.1	11.5	18.9	22.5	22.5	31.5	23.8	10.6	0.0	0.0
40	4.6	10.4	17.3	20.8	21.0	29.1	21.9	9.6	0.0	0.0
35	4.1	9.3	15.6	19.0	19.5	26.8	20.1	8.6	0.0	0.0
30	3.7	8.2	14.0	17.3	18.0	24.4	18.2	7.6	0.0	0.0
25	3.2	7.1	12.4	15.6	16.5	22.0	16.4	6.6	0.0	0.0
20	2.8	6.0	10.7	13.9	15.0	19.6	14.5	5.6	0.0	0.0
15	2.3	4.9	9.1	12.1	13.5	17.3	12.7	4.7	0.0	0.0
10	1.8	3.8	7.5	10.4	12.0	14.9	10.8	3.7	0.0	0.0
5	1.4	2.7	5.8	8.7	10.6	12.5	9.0	2.7	0.0	0.0
0	0.9	1.6	4.2	6.9	9.1	10.1	7.1	1.7	0.0	0.0
-5	0.4	0.5	2.6	5.2	7.6	7.8	5.3	0.7	0.0	0.0
-6	0.3	0.2	2.3	4.9	7.3	7.3	4.9	0.5	0.0	0.0
-6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

ETD SUMMARY

Building Name : D-0 SUBCONSTRUCT 2/3 (Complex) Date : 11-16-87

Site Name : AURORA,IL FERMI, User Defined 60117862.0

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TABLE 1. OCCUPIED PERIOD

Bin Temp (F)	Equivalent Temperature Differences (F) By Exposure North	NE	East	SE	South	SW	West	NW	Perim Roof	Inter Roof
93	8.0	11.4	13.8	23.5	29.8	27.0	20.7	10.3	30.4	30.4
90	5.4	7.8	9.5	16.4	20.8	18.9	14.4	7.0	21.7	21.7
85	1.0	3.3	4.9	11.5	15.7	13.9	9.6	2.5	16.4	16.4
80	-3.4	-1.3	0.3	6.6	10.5	8.9	4.7	-2.0	11.1	11.1
75	-7.8	-5.8	-4.3	1.7	5.4	3.9	-0.1	-6.5	5.8	5.8
70	-12.2	-10.3	-8.9	-3.2	0.2	-1.1	-4.9	-10.9	0.5	0.5
65	-16.6	-14.8	-13.5	-8.1	-4.9	-6.1	-9.8	-15.4	-4.9	-4.9
60	-21.0	-19.3	-18.1	-13.0	-10.1	-11.1	-14.6	-19.9	-10.2	-10.2
55	-25.4	-23.8	-22.7	-17.9	-15.2	-16.1	-19.4	-24.4	-15.5	-15.5
50	-29.8	-28.4	-27.3	-22.8	-20.4	-21.1	-24.2	-28.8	-20.8	-20.8
45	-34.2	-32.9	-31.9	-27.7	-25.5	-26.1	-29.1	-33.3	-26.1	-26.1
40	-38.6	-37.4	-36.5	-32.5	-30.7	-31.1	-33.9	-37.8	-31.4	-31.4
35	-43.0	-41.9	-41.1	-37.4	-35.8	-36.1	-38.7	-42.3	-36.7	-36.7
30	-47.4	-46.4	-45.7	-42.3	-41.0	-41.1	-43.6	-46.7	-42.0	-42.0
25	-51.8	-51.0	-50.3	-47.2	-46.1	-46.1	-48.4	-51.2	-47.3	-47.3
20	-56.2	-55.5	-54.9	-52.1	-51.3	-51.1	-53.2	-55.7	-52.6	-52.6
15	-60.5	-60.0	-59.5	-57.0	-56.4	-56.1	-58.0	-60.2	-57.9	-57.9
10	-64.9	-64.5	-64.1	-61.9	-61.6	-61.1	-62.9	-64.6	-63.2	-63.2
5	-69.3	-69.0	-68.7	-66.8	-66.7	-66.1	-67.7	-69.1	-68.6	-68.6
0	-73.7	-73.5	-73.3	-71.7	-71.9	-71.1	-72.5	-73.6	-73.9	-73.9
-5	-78.1	-78.1	-77.9	-76.6	-77.0	-76.1	-77.3	-78.1	-79.2	-79.2
-6	-79.0	-79.0	-78.8	-77.5	-78.0	-77.1	-78.3	-79.0	-80.2	-80.2

TABLE 2. UNOCCUPIED PERIOD

90	5.4	7.8	9.5	16.4	20.8	18.9	14.4	7.0	21.7	21.7
85	1.0	3.3	4.9	11.5	15.7	13.9	9.6	2.5	16.4	16.4
80	-3.4	-1.3	0.3	6.6	10.5	8.9	4.7	-2.0	11.1	11.1
75	-7.8	-5.8	-4.3	1.7	5.4	3.9	-0.1	-6.5	5.8	5.8
70	-12.2	-10.3	-8.9	-3.2	0.2	-1.1	-4.9	-10.9	0.5	0.5
65	-16.6	-14.8	-13.5	-8.1	-4.9	-6.1	-9.8	-15.4	-4.9	-4.9
60	-21.0	-19.3	-18.1	-13.0	-10.1	-11.1	-14.6	-19.9	-10.2	-10.2
55	-25.4	-23.8	-22.7	-17.9	-15.2	-16.1	-19.4	-24.4	-15.5	-15.5
50	-29.8	-28.4	-27.3	-22.8	-20.4	-21.1	-24.2	-28.8	-20.8	-20.8
45	-34.2	-32.9	-31.9	-27.7	-25.5	-26.1	-29.1	-33.3	-26.1	-26.1
40	-38.6	-37.4	-36.5	-32.5	-30.7	-31.1	-33.9	-37.8	-31.4	-31.4
35	-43.0	-41.9	-41.1	-37.4	-35.8	-36.1	-38.7	-42.3	-36.7	-36.7
30	-47.4	-46.4	-45.7	-42.3	-41.0	-41.1	-43.6	-46.7	-42.0	-42.0
25	-51.8	-51.0	-50.3	-47.2	-46.1	-46.1	-48.4	-51.2	-47.3	-47.3
20	-56.2	-55.5	-54.9	-52.1	-51.3	-51.1	-53.2	-55.7	-52.6	-52.6
15	-60.5	-60.0	-59.5	-57.0	-56.4	-56.1	-58.0	-60.2	-57.9	-57.9
10	-64.9	-64.5	-64.1	-61.9	-61.6	-61.1	-62.9	-64.6	-63.2	-63.2
5	-69.3	-69.0	-68.7	-66.8	-66.7	-66.1	-67.7	-69.1	-68.6	-68.6
0	-73.7	-73.5	-73.3	-71.7	-71.9	-71.1	-72.5	-73.6	-73.9	-73.9
-5	-78.1	-78.1	-77.9	-76.6	-77.0	-76.1	-77.3	-78.1	-79.2	-79.2
-6	-79.0	-79.0	-78.8	-77.5	-78.0	-77.1	-78.3	-79.0	-80.2	-80.2
-6	-74.0	-74.0	-74.0	-74.0	-74.0	-74.0	-74.0	-74.0	-74.0	-74.0

V-c.

FERMILAB D-0 EXPERIMENTAL FACILITY

SUBCONSTRUCTION 2/3 - MCH. PLATFORM & SIDEBAY AREAS WITH DCHW SYSTEMS
SYSTEM COMPARISON PERFORMANCE SIMULATIONS

31 OCTOBER, 1987
ANALYST: S.F.KRSTULOVICH

FERMILAB CONSTRUCTION ENGINEERING SERVICES

V-c.-1.

FERMILAB D-0 EXPERIMENTAL FACILITY

SUBCONSTRUCTION 2/3 - MCH, PLATFORM & SIDEBAY AREAS WITH DCHW SYSTEMS
OPERATIONAL PERFORMANCE SIMULATION

DESIGN BASIS SYSTEM
RECIPROCATING CHILLERS, CENTRAL STATION AHU'S, COMPUTER ROOM CHW AC UNITS
AND WATER COOLED ELECTRONIC RACKS
WITH THESE ENERGY FEATURES:
LAKE COOLING WATER, LAKE WATER FILTERS, HYDRONIC FREE COOLING HEAT EXCHANGER,
HIGH EFFICIENCY MOTORS, INTEGRATED BUILDING PRESSURIZATION CONTROLS,
AUTOMATIC LAKE WATER PUMP STAGING, INTEGRATED ENTHALPY ECONOMIZER,
SUPPLY AIR COOLING TEMPERATURE RESET

31 OCTOBER, 1987
ANALYST: S.F.KRSTULOVICH

FERMILAB CONSTRUCTION ENGINEERING SERVICES

SYSTEM INPUT SUMMARY

Job Name : D-0 SUBCON 2/3 DESIGN SYS Page 1
Building Name : D-0 SUBCONSTRUCT 2/3 (Complex) Date : 11-16-87
Site : AURORA,IL FERMI, User Defined 60117862.0
Scope of Analysis : Cooling and Heating Systems

****

A. AIR HANDLING SYSTEMS

Are perimeter and interior zone on same supply fan ? <N>

>1. PERIMETER TERMINAL TYPE : CONSTANT VOLUME

Supply fan type : Forward curved
Supply fan total static pressure = 2.00 in. wg.
Return fan type : Controlled pitch axial
Return fan total static pressure = 1.00 in. wg.
Design supply air= 36000 cfm @ 55 F; Vent. air= 600 cfm
Are cooling terminals used for heating ? <Y>
Economizer type : Integrated, enthalpy controlled
Is a ventilation reclaim device used ? <N>
Are ventilation air dampers closed for unoccupied periods ? <N>

>2. INTERIOR TERMINAL TYPE : CONSTANT VOLUME

Supply fan type : Forward curved
Supply fan total static pressure = 0.01 in. wg.
A return fan is not used.
Design supply air= 61384 cfm @ 55 F; Vent. air= 0 cfm
An economizer is not used.
Is a ventilation reclaim device used ? <N>
Are ventilation air dampers closed for unoccupied periods ? <N>

****

B. HEATING PLANTS

Does one primary heating plant serve perimeter and interior ? <Y>

> 1 . BLOCK PLANT : ELECTRICAL RESISTANCE

Is hydronic heating used ? <N>

****

****

C. COOLING PLANTS

Does one plant serve perimeter and interior ? <Y>

>1. BLOCK PLANT : RECIPROCATING WATER COOLED
Capacity @ 85 F entering water = 230.0 tons
KW/Ton @ 85 F entering water = 0.85 kw/ton
Is hydronic cooling used ? <Y>
Is chilled water reset used ? <N>
Is hot gas bypass used ? <N>
Is condenser performance altitude adjusted ? <Y>
Is there one compressor per condenser circuit ? <Y>
Are compressors cycled ? <Y>
Heat sink type : Open cooling tower
Minimum entering water temperature = 32 F
Is a hydronic economizer used ? <Y> ; Economizer efficiency = 80 %

****

D. PUMPING SYSTEMS

System	PERIMETER dT, F	PERIMETER dP, ft wg	INTERIOR dT, F	INTERIOR dP, ft wg
Chilled water	10.00	100.00	0.00	0.00
Hot water	0.00	0.00	0.00	0.00
Condenser water	15.00	50.00	0.00	0.00
Ground water	0.00	0.00	0.00	0.00

****

E. NON-HVAC SYSTEMS

>1. NON-HVAC ELECTRICAL ENERGY USE
Lighting kw: Occupied = 53.4 kw; Unoccupied = 48.1 kw
Misc. kw : Occupied = 660.0 kw; Unoccupied = 220.0 kw
Other kw : Occupied = 0.0 kw; Unoccupied = 0.0 kw

>2. DHW SYSTEM (Not utilized in this system)

****

F. FUEL COSTS

>1. ELECTRICAL ENERGY USE	Period Occupied ($/kwh)	Period Unoccupied ($/kwh)
Compressor	0.050	0.050
Resistance	0.050	0.050
Inductive	0.050	0.050

>2. OTHER FUELS	Unit Cost
Natural Gas	n/a $/therm
Fuel Oil	n/a $/U.S.gal
Propane	n/a $/lb
Remote Heating	n/a $/MBTU
Remote Cooling	n/a $/MBTU

TOTAL BUILDING ENERGY SUMMARY

Job Name : D-0 SUBCON 2/3 DESIGN SYS
Building Name : D-0 SUBCONSTRUCT 2/3 (Complex)
Site : AURORA,IL FERMI, User Defined
Date : 11-16-87

Period : All
Zone : Block
Serial Number:
60117862.0

****

HVAC ENERGY Component	Annual Cost ($/yr)	Energy or Fuel Units Consumed	DOE RUF (1000 BTU)	DOE RIF (1000 BTU)
Electric (Occ)	19356	387115 kwh/yr	4490540	1321225
Electric (Unocc)	14943	298853 kwh/yr	3466692	1019985
Natural Gas	0	0 therms/yr	0	0
Fuel Oil	0	0 U.S. gal/yr	0	0
Propane	0	0 lb/yr	0	0
Remote Heating	0	0 MBTU/yr	0	0
Remote Cooling	0	0 MBTU/yr	0	0
HVAC Total	34298		7957232	2341210
NON-HVAC ENERGY				
Electric (Occ)	111597	2231944 kwh/yr	25890545	7617623
Electric (Unocc)	75478	1509553 kwh/yr	17510814	5152104
Non-HVAC Total	187075		43401359	12769728
Grand Total	221373		51358591	15110937
Total/Sq.Ft.	12.44		2885.31	848.93

HVAC Summary:

HVAC Total Cost	=	1.93 $/Sq.Ft./yr
	=	15.49 % of Total Cost
Total HVAC Electrical Energy	=	38.54 kwh/Sq.Ft./yr
	=	15.49 % of Total Electrical Energy
Non-Electrical HVAC Energy	=	0.00 % of Total Energy

Key:

1 kwh	= 11600 BTU RUF; 3412 BTU RIF
1 therm nat gas	= 100000 BTU RUF and RIF
1 U.S. gal oil	= 138700 BTU RUF and RIF
1 Imp. gal oil	= 168000 BTU RUF and RIF
1 lb propane	= 21680 BTU RUF and RIF
RUF	= Resource utilization factor (Source value)
RIF	= Resource impact factor (Point of use value)
MBH	= 1000 BTU/hr
MBTU	= Million BTU

ANNUAL OPERATING COSTS

Job Name : D-0 SUBCON 2/3 DESIGN SYS Page 1
Building Name : D-0 SUBCONSTRUCT 2/3 (Complex) Date : 11-16-87
Site : AURORA,IL FERMI, User Defined 60117862.0
Scope of Analysis : Cooling and Heating Systems

****

A. AIR HANDLING SYSTEMS (ANNUAL FAN OPERATING COST = $10,320)

Are perimeter and interior zone on same supply fan ? <N>

>1. PERIMETER TERMINAL TYPE : CONSTANT VOLUME

Supply fan type : Forward curved
Supply fan total static pressure = 2.00 in. wg.
Return fan type : Controlled pitch axial
Return fan total static pressure = 1.00 in. wg.
Design supply air= 36000 cfm @ 55 F; Vent. air= 600 cfm
Are cooling terminals used for heating ? <Y>
Economizer type : Integrated, enthalpy controlled
Is a ventilation reclaim device used ? <N>
Are ventilation air dampers closed for unoccupied periods ? <N>

>2. INTERIOR TERMINAL TYPE : CONSTANT VOLUME

Supply fan type : Forward curved
Supply fan total static pressure = 0.01 in. wg.
A return fan is not used.
Design supply air= 61384 cfm @ 55 F; Vent. air= 0 cfm
An economizer is not used.
Is a ventilation reclaim device used ? <N>
Are ventilation air dampers closed for unoccupied periods ? <N>

****

B. HEATING PLANTS (ANNUAL HEATING PLANT OPERATING COST = $0)

Does one primary heating plant serve perimeter and interior ? <Y>

> 1 . BLOCK PLANT : ELECTRICAL RESISTANCE

Is hydronic heating used ? <N>

****

ANNUAL OPERATING COSTS

Job Name : D-0 SUBCON 2/3 DESIGN SYS — Page 2
Building Name : D-0 SUBCONSTRUCT 2/3 (Complex) — Date : 11-16-87
Site : AURORA,IL FERMI, User Defined — 60117862.0
Scope of Analysis : Cooling and Heating Systems

****

C. COOLING PLANTS (ANNUAL COOLING PLANT OPERATING COST = $15,564)

Does one plant serve perimeter and interior ? <Y>

>1. BLOCK PLANT : RECIPROCATING WATER COOLED
Capacity @ 85 F entering water = 230.0 tons
KW/Ton @ 85 F entering water = 0.85 kw/ton
Is hydronic cooling used ? <Y>
Is chilled water reset used ? <N>
Is hot gas bypass used ? <N>
Is condenser performance altitude adjusted ? <Y>
Is there one compressor per condenser circuit ? <Y>
Are compressors cycled ? <Y>
Heat sink type : Open cooling tower
Minimum entering water temperature = 32 F
Is a hydronic economizer used ? <Y> ; Economizer efficiency = 80 %

****

D. PUMPING SYSTEMS (ANNUAL PUMP OPERATING COST = $8,415)

System	PERIMETER dT, F	PERIMETER dP, ft wg	INTERIOR dT, F	INTERIOR dP, ft wg
Chilled water	10.00	100.00	0.00	0.00
Hot water	0.00	0.00	0.00	0.00
Condenser water	15.00	50.00	0.00	0.00
Ground water	0.00	0.00	0.00	0.00

****

E. NON-HVAC SYSTEMS (ANNUAL NON-HVAC OPERATING COST = $187,075)

>1. NON-HVAC ELECTRICAL ENERGY USE
Lighting kw: Occupied = 53.4 kw; Unoccupied = 49.1 kw
Misc. kw : Occupied = 660.0 kw; Unoccupied = 220.0 kw
Other kw : Occupied = 0.0 kw; Unoccupied = 0.0 kw

>2. DHW SYSTEM (Not utilized in this system)

****

F. FUEL COSTS (GRAND TOTAL ANNUAL OPERATING COST = $221,373)

>1. ELECTRICAL ENERGY USE	Period Occupied ($/kwh)	Period Unoccupied ($/kwh)
Compressor	0.050	0.050
Resistance	0.050	0.050
Inductive	0.050	0.050

>2. OTHER FUELS	Unit Cost
Natural Gas	n/a $/therm
Fuel Oil	n/a $/U.S.gal
Propane	n/a $/lb
Remote Heating	n/a $/MBTU
Remote Cooling	n/a $/MBTU

COOLING PLANT COSTS

Job Name : D-0 SUBCON 2/3 DESIGN SYS — Date : 11-16-87
Building Name : D-0 SUBCONSTRUCT 2/3 (Complex) — Serial Number:
Site Name : AURORA,IL FERMI, User Defined — 60117862.0

Bin Temp (F)	Bin Hours hr/yr	Block Cooling Plant Coil Load MBH	Input KW	Cost $/yr
			OCCUPIED PERIOD	
90	25.8	2563.8	168.8	217.7
85	59.4	2549.7	160.3	476.0
80	145.3	2535.9	150.0	1090.0
75	237.7	2522.4	140.4	1668.4
70	270.6	2244.9	127.6	1726.5
65	264.5	1960.5	107.3	1419.0
60	255.0	1754.9	92.2	1175.9
55	244.7	1553.6	78.1	955.8
50	232.1	1553.6	72.6	842.5
45	229.5	1553.6	65.7	753.6
40	237.6	1553.6	56.2	667.7
35	238.5	1553.6	47.8	570.2
30	218.2	1553.6	40.3	440.0
25	174.5	1553.6	33.7	294.0
20	122.4	1553.6	27.9	170.5
15	78.1	1553.6	23.0	89.6
10	46.1	1553.6	22.8	52.6
5	25.1	1553.6	22.7	28.4
0	12.7	1553.6	22.5	14.3
-5	6.2	1553.6	22.4	6.9
-6	4.6	1553.6	22.3	5.1
Total Costs				$12664.8
			UNOCCUPIED PERIOD	
90	14.6	1018.6	63.3	46.2
85	36.3	1007.9	55.3	100.3
80	99.3	1048.9	48.8	242.5
75	215.3	843.5	37.7	406.1
70	357.6	638.1	27.2	487.2
65	463.3	527.5	19.4	448.7
60	500.4	527.5	14.3	356.8
55	482.0	527.5	9.5	229.3
50	447.6	527.5	3.4	75.2
45	422.7	527.5	3.4	71.0
40	413.7	527.5	3.4	69.5
35	417.0	527.5	3.4	70.1
30	417.4	527.5	3.4	70.2
25	395.2	527.5	3.4	66.4
20	336.9	527.5	3.4	56.6
15	252.8	527.5	3.4	42.5
10	165.7	527.5	3.4	27.9
5	96.3	527.5	3.4	16.2
0	50.9	527.5	3.4	8.6
-5	25.3	527.5	3.4	4.3
-6	21.1	527.5	3.4	3.5
Total Costs				$2899.0

BLOCK HEATING PLANT COSTS

Job Name : D-O SUBCON 2/3 DESIGN SYS — Date : 11-16-87

Building Name : D-O SUBCONSTRUCT 2/3 (Complex) — Serial Number:

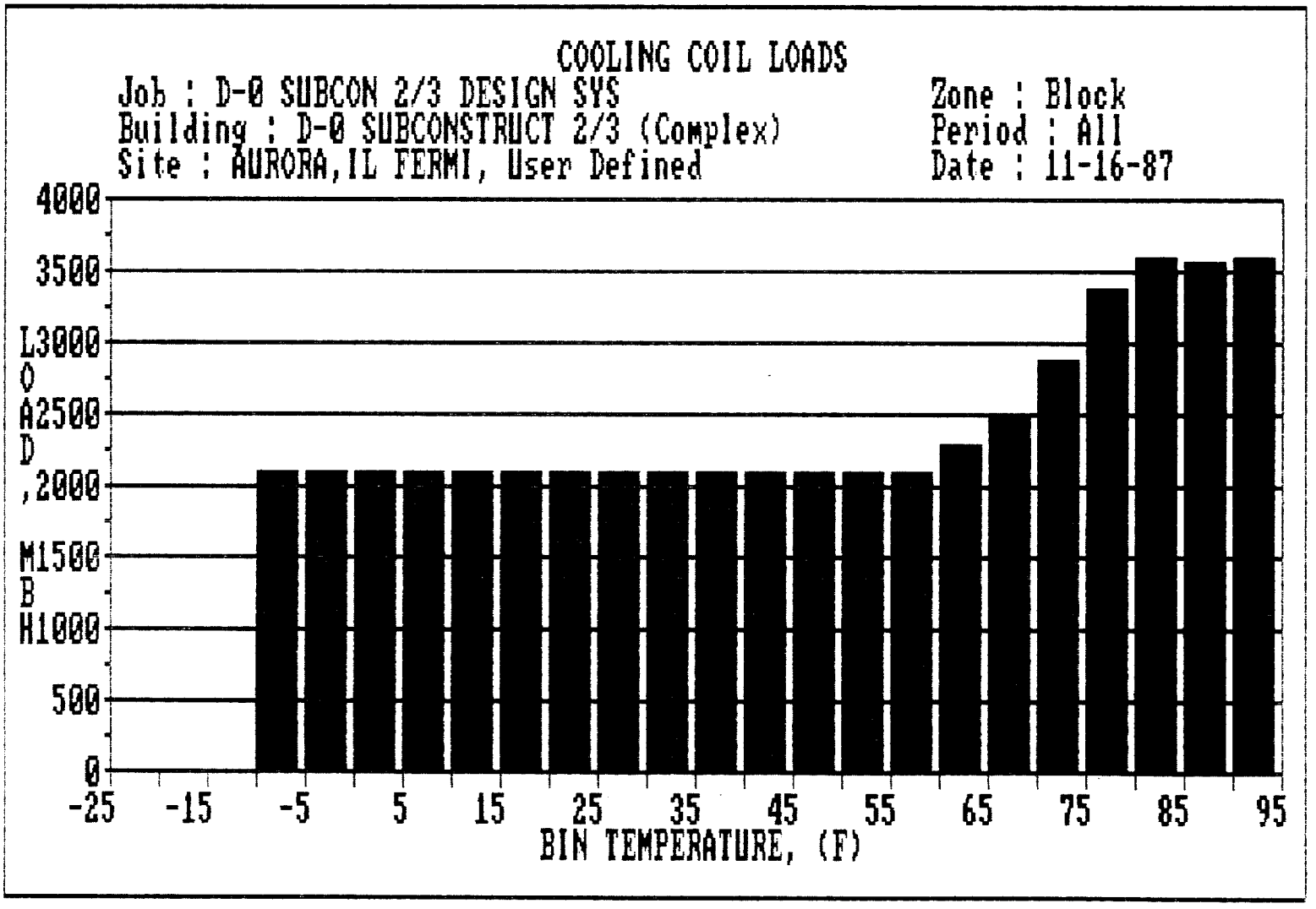
Site Name : AURORA,IL FERMI, User Defined — 60117862.0

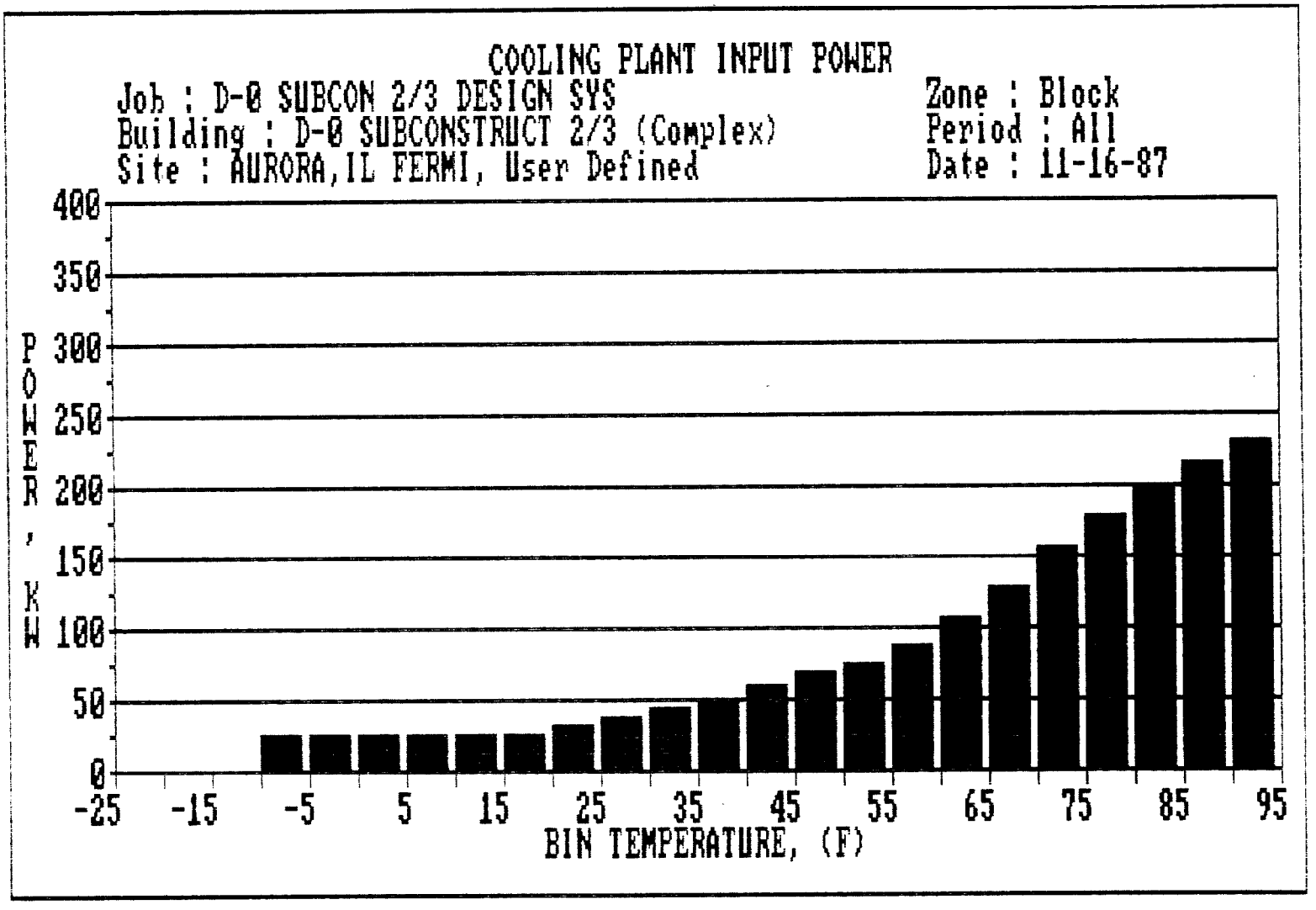
Bin Temp (F)	Bin Hours hr/yr	Coil Load MBH	Primary Plant Output MBH	Primary Plant Input KW	Primary Plant Cost $/yr	No Auxiliary Plant Used
			OCCUPIED PERIOD			
90	25.8	0.0	0.0	0.0	0.0	
85	59.4	0.0	0.0	0.0	0.0	
80	145.3	0.0	0.0	0.0	0.0	
75	237.7	0.0	0.0	0.0	0.0	
70	270.6	0.0	0.0	0.0	0.0	
65	264.5	0.0	0.0	0.0	0.0	
60	255.0	0.0	0.0	0.0	0.0	
55	244.7	0.0	0.0	0.0	0.0	
50	232.1	0.0	0.0	0.0	0.0	
45	229.5	0.0	0.0	0.0	0.0	
40	237.6	0.0	0.0	0.0	0.0	
35	238.5	0.0	0.0	0.0	0.0	
30	218.2	0.0	0.0	0.0	0.0	
25	174.5	0.0	0.0	0.0	0.0	
20	122.4	0.0	0.0	0.0	0.0	
15	76.1	0.0	0.0	0.0	0.0	
10	46.1	0.0	0.0	0.0	0.0	
5	25.1	0.0	0.0	0.0	0.0	
0	12.7	0.0	0.0	0.0	0.0	
-5	6.2	0.0	0.0	0.0	0.0	
-6	4.6	0.0	0.0	0.0	0.0	
Total Costs					$0.0	
			UNOCCUPIED PERIOD			
90	14.6	0.0	0.0	0.0	0.0	
85	36.3	0.0	0.0	0.0	0.0	
80	99.3	0.0	0.0	0.0	0.0	
75	215.3	0.0	0.0	0.0	0.0	
70	357.6	0.0	0.0	0.0	0.0	
65	463.3	0.0	0.0	0.0	0.0	
60	500.4	0.0	0.0	0.0	0.0	
55	482.0	0.0	0.0	0.0	0.0	
50	447.6	0.0	0.0	0.0	0.0	
45	422.7	0.0	0.0	0.0	0.0	
40	413.7	0.0	0.0	0.0	0.0	
35	417.0	0.0	0.0	0.0	0.0	
30	417.4	0.0	0.0	0.0	0.0	
25	395.2	0.0	0.0	0.0	0.0	
20	336.9	0.0	0.0	0.0	0.0	
15	252.8	0.0	0.0	0.0	0.0	
10	165.7	0.0	0.0	0.0	0.0	
5	96.3	0.0	0.0	0.0	0.0	
0	50.9	0.0	0.0	0.0	0.0	
-5	25.3	0.0	0.0	0.0	0.0	
-6	21.1	0.0	0.0	0.0	0.0	
Total Costs					$0.0	

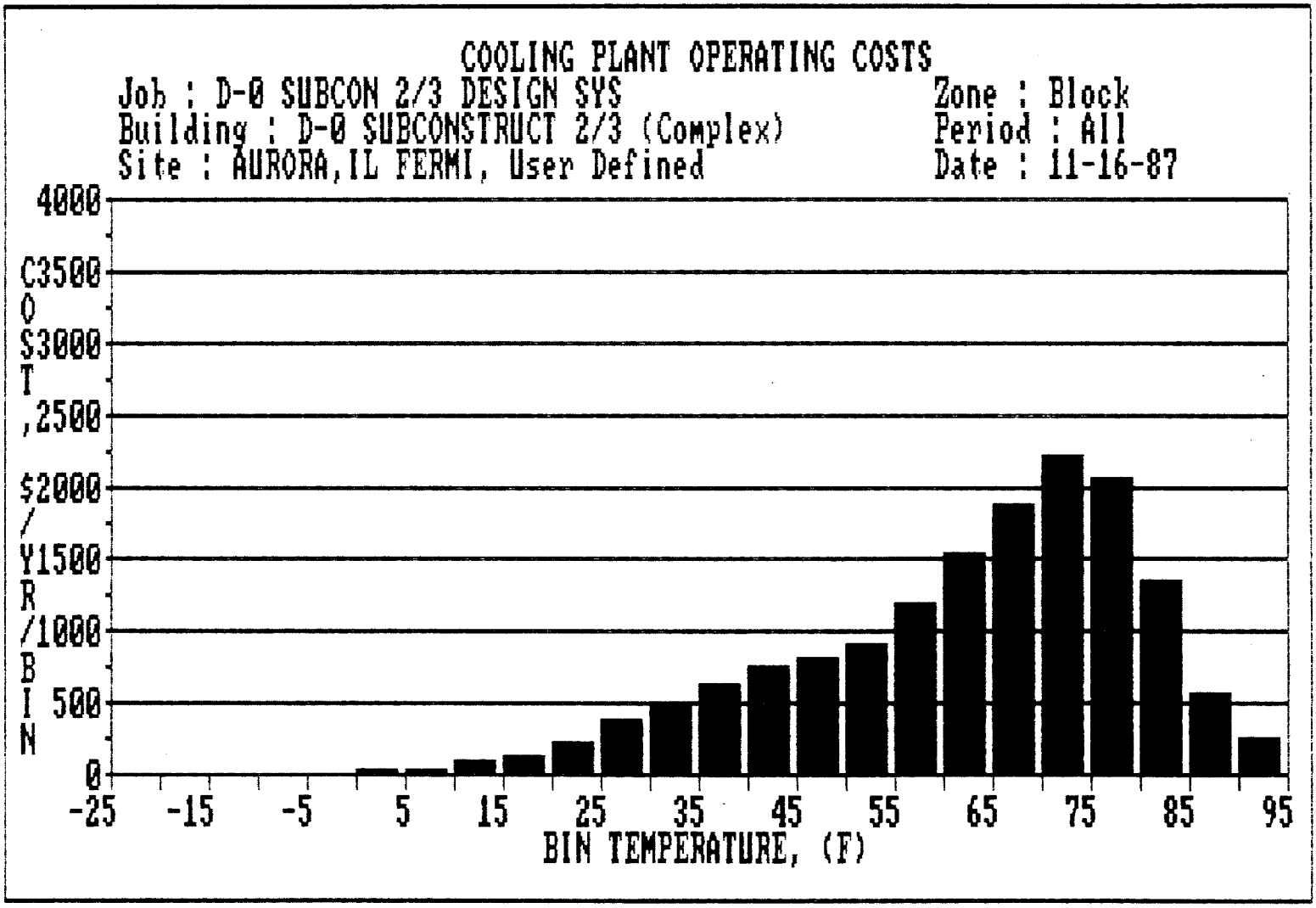
FAN AND PUMP COSTS

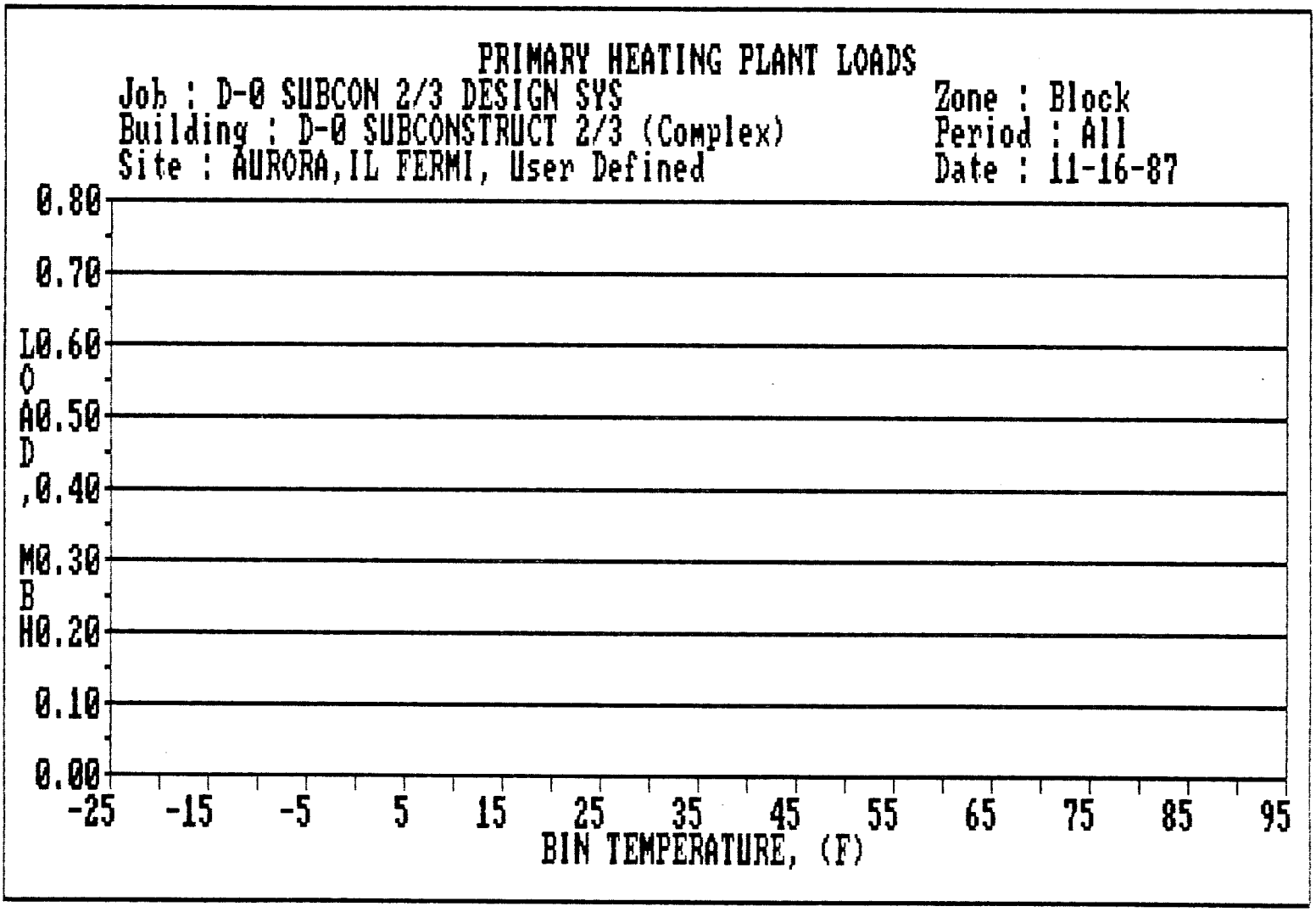
Job Name : D-O SUBCON 2/3 DESIGN SYS — Date : 11-16-87
Building Name : D-O SUBCONSTRUCT 2/3 (Complex) — Serial Number:
Site Name : AURORA,IL FERMI, User Defined — 60117862.0

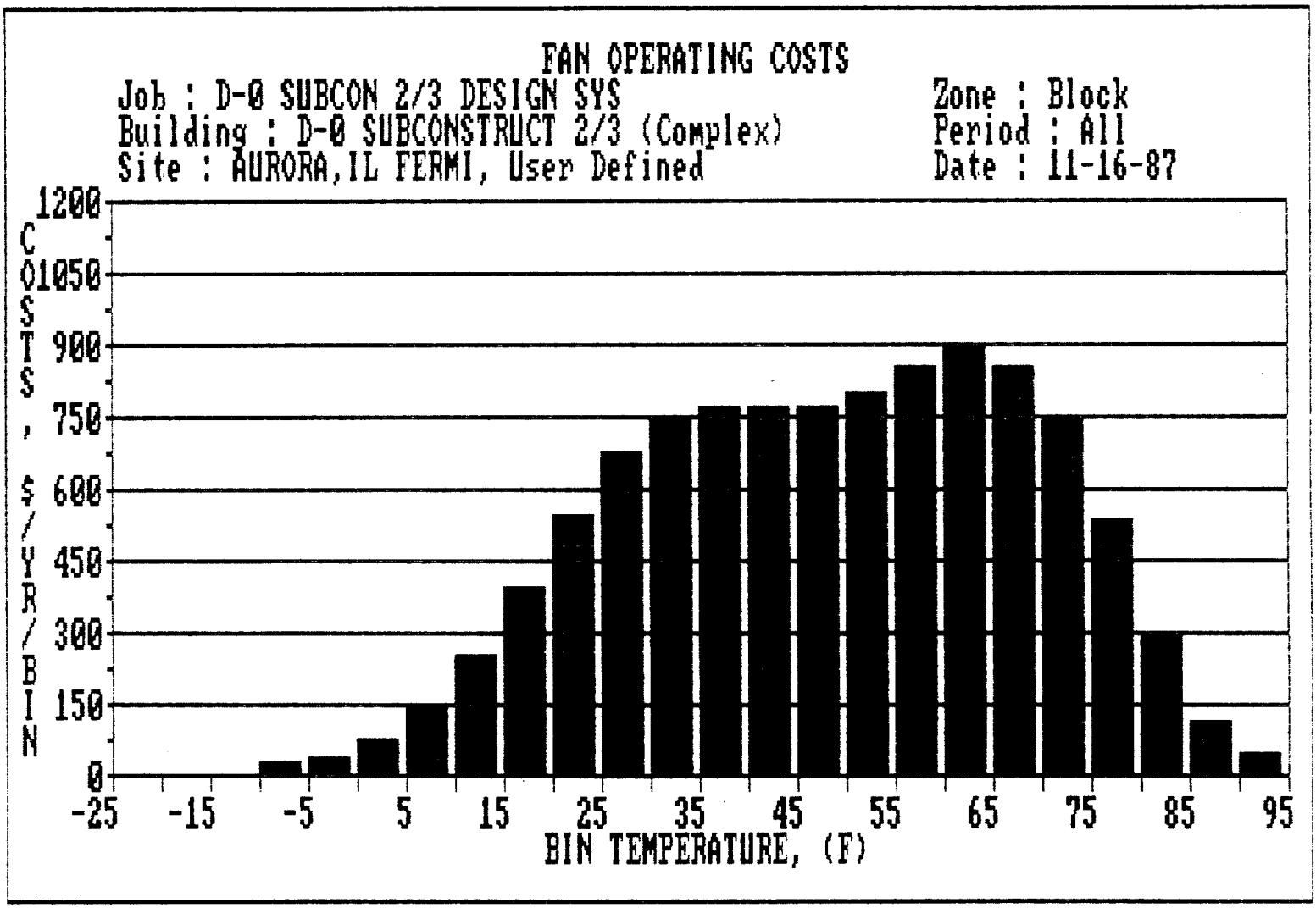
Bin Temp (F)	Bin Hours hr/yr	Perimeter Fans Input KW	Perimeter Fans Cost $/yr	Interior Fans Input KW	Interior Fans Cost $/yr	All Pumps Input KW	All Pumps Cost $/yr
OCCUPIED PERIOD							
90	25.8	23.4	30.2	0.1	0.2	19.2	24.8
85	59.4	23.4	69.6	0.1	0.4	19.2	57.1
80	145.3	23.4	170.2	0.1	1.0	19.2	139.6
75	237.7	23.4	278.4	0.1	1.6	19.2	228.3
70	270.6	23.4	317.0	0.1	1.8	19.2	259.9
65	264.5	23.4	309.8	0.1	1.8	19.2	254.1
60	255.0	23.4	298.7	0.1	1.7	19.2	245.0
55	244.7	23.4	286.6	0.1	1.6	19.2	235.1
50	232.1	23.4	271.9	0.1	1.5	19.2	223.0
45	229.5	23.4	268.8	0.1	1.5	19.2	220.5
40	237.6	23.4	278.3	0.1	1.6	19.2	228.2
35	238.5	23.4	279.4	0.1	1.6	19.2	229.1
30	218.2	23.4	255.6	0.1	1.5	19.2	209.6
25	174.5	23.4	204.4	0.1	1.2	19.2	167.6
20	122.4	23.4	143.4	0.1	0.8	19.2	117.6
15	78.1	23.4	91.5	0.1	0.5	19.2	75.0
10	46.1	23.4	54.0	0.1	0.3	19.2	44.3
5	25.1	23.4	29.4	0.1	0.2	19.2	24.1
0	12.7	23.4	14.9	0.1	0.1	19.2	12.2
-5	6.2	23.4	7.3	0.1	0.0	19.2	6.0
-6	4.6	23.4	5.4	0.1	0.0	19.2	4.4
Total Costs			$3664.8		$20.8		$3005.4
UNOCCUPIED PERIOD							
90	14.6	23.4	17.1	0.1	0.1	19.2	14.0
85	36.3	23.4	42.5	0.1	0.2	19.2	34.9
80	99.3	23.4	116.3	0.1	0.7	19.2	95.4
75	215.3	23.4	252.2	0.1	1.4	19.2	206.8
70	357.6	23.4	418.9	0.1	2.4	19.2	343.5
65	463.3	23.4	542.7	0.1	3.1	19.2	445.1
60	500.4	23.4	586.2	0.1	3.3	19.2	480.7
55	482.0	23.4	564.6	0.1	3.2	19.2	463.0
50	447.6	23.4	524.3	0.1	3.0	19.2	430.0
45	422.7	23.4	495.1	0.1	2.8	19.2	406.1
40	413.7	23.4	484.6	0.1	2.8	19.2	397.4
35	417.0	23.4	488.5	0.1	2.8	19.2	400.6
30	417.4	23.4	488.9	0.1	2.8	19.2	401.0
25	395.2	23.4	462.9	0.1	2.6	19.2	379.6
20	336.9	23.4	394.6	0.1	2.2	19.2	323.6
15	252.8	23.4	296.1	0.1	1.7	19.2	242.8
10	165.7	23.4	194.1	0.1	1.1	19.2	159.2
5	96.3	23.4	112.8	0.1	0.6	19.2	92.5
0	50.9	23.4	59.6	0.1	0.3	19.2	48.9
-5	25.3	23.4	29.6	0.1	0.2	19.2	24.3
-6	21.1	23.4	24.7	0.1	0.1	19.2	20.3
Total Costs			$6596.5		$37.5		$5409.6


COOLING COIL LOADS
Job : D-0 SUBCON 2/3 DESIGN SYS
Building : D-0 SUBCONSTRUCT 2/3 (Complex)
Site : AURORA,IL FERMI, User Defined
Zone : Block
Period : All
Date : 11-16-87
4000
3500
L3000
O
A2500
D
,2000
M1500
B
H1000
500
0
-25
-15
-5
5
15
25
35
45
55
65
75
85
95
BIN TEMPERATURE, (F)


COOLING PLANT INPUT POWER
Job : D-0 SUBCON 2/3 DESIGN SYS
Building : D-0 SUBCONSTRUCT 2/3 (Complex)
Site : AURORA,IL FERMI, User Defined
Zone : Block
Period : All
Date : 11-16-87
POWER, KW
400
350
300
250
200
150
100
50
0
-25
-15
-5
5
15
25
35
45
55
65
75
85
95
BIN TEMPERATURE, (F)


COOLING PLANT OPERATING COSTS
Job : D-0 SUBCON 2/3 DESIGN SYS
Building : D-0 SUBCONSTRUCT 2/3 (Complex)
Site : AURORA,IL FERMI, User Defined
Zone : Block
Period : All
Date : 11-16-87
4000
C3500
O
$3000
T
,2500
$2000
/
Y1500
R
/1000
B
I 500
N
0
-25
-15
-5
5
15
25
35
45
55
65
75
85
95
BIN TEMPERATURE, (F)


PRIMARY HEATING PLANT LOADS
Job : D-0 SUBCON 2/3 DESIGN SYS
Building : D-0 SUBCONSTRUCT 2/3 (Complex)
Site : AURORA,IL FERMI, User Defined
Zone : Block
Period : All
Date : 11-16-87
0.80
0.70
L0.60
O
A0.50
D
,0.40
M0.30
B
H0.20
0.10
0.00
-25 -15 -5 5 15 25 35 45 55 65 75 85 95
BIN TEMPERATURE, (F)


FAN OPERATING COSTS
Job : D-0 SUBCON 2/3 DESIGN SYS
Building : D-0 SUBCONSTRUCT 2/3 (Complex)
Site : AURORA,IL FERMI, User Defined
Zone : Block
Period : All
Date : 11-16-87
COSTS, $/YR/BIN
1200
1050
900
750
600
450
300
150
0
-25
-15
-5
5
15
25
35
45
55
65
75
85
95
BIN TEMPERATURE, (F)

V-c.-2.

FERMILAB D-0 EXPERIMENTAL FACILITY

SUBCONSTRUCTION 2/3 - MCH, PLATFORM & SIDEBAY AREAS WITH DCHW SYSTEMS
OPERATIONAL PERFORMANCE SIMULATION

ALTERNATE COMPARISON SYSTEM NUMBER 1
CENTRIFUGAL CHILLERS, CENTRAL STATION AHU'S, COMPUTER ROOM CHW AC UNITS
AND WATER COOLED ELECTRONIC RACKS
WITH THESE ENERGY FEATURES:
LAKE COOLING WATER, LAKE WATER FILTERS, HYDRONIC FREE COOLING HEAT EXCHANGER,
HIGH EFFICIENCY MOTORS, INTEGRATED BUILDING PRESSURIZATION CONTROLS,
AUTOMATIC LAKE WATER PUMP STAGING, INTEGRATED ENTHALPY ECONOMIZER,
SUPPLY AIR COOLING TEMPERATURE RESET

31 OCTOBER, 1997
ANALYST: S.F.KRSTULOVICH

FERMILAB CONSTRUCTION ENGINEERING SERVICES

SYSTEM INPUT SUMMARY

Job Name : D-0 SUBCON 2/3 ALT 1 SYS
Building Name : D-0 SUBCONSTRUCT 2/3 (Complex) Date : 11-16-87
Site : AURORA,IL FERMI, User Defined 60117862.0
Scope of Analysis : Cooling and Heating Systems

****

A. AIR HANDLING SYSTEMS

Are perimeter and interior zone on same supply fan ? <N>

>1. PERIMETER TERMINAL TYPE : CONSTANT VOLUME

Supply fan type : Forward curved
Supply fan total static pressure = 2.00 in. wg.
Return fan type : Controlled pitch axial
Return fan total static pressure = 1.00 in. wg.
Design supply air= 36000 cfm @ 55 F; Vent. air= 600 cfm
Are cooling terminals used for heating ? <Y>
Economizer type : Integrated, enthalpy controlled
Is a ventilation reclaim device used ? <N>
Are ventilation air dampers closed for unoccupied periods ? <N>

>2. INTERIOR TERMINAL TYPE : CONSTANT VOLUME

Supply fan type : Forward curved
Supply fan total static pressure = 0.01 in. wg.
A return fan is not used.
Design supply air= 61384 cfm @ 55 F; Vent. air= 0 cfm
An economizer is not used.
Is a ventilation reclaim device used ? <N>
Are ventilation air dampers closed for unoccupied periods ? <N>

****

B. HEATING PLANTS

Does one primary heating plant serve perimeter and interior ? <Y>

> 1 . BLOCK PLANT : ELECTRICAL RESISTANCE

Is hydronic heating used ? <N>

****

SYSTEM INPUT SUMMARY

Job Name : D-0 SUBCON 2/3 ALT 1 SYS — Page 2
Building Name : D-0 SUBCONSTRUCT 2/3 (Complex) — Date : 11-16-87
Site : AURORA,IL FERMI, User Defined — 60117862.0
Scope of Analysis : Cooling and Heating Systems

****

C. COOLING PLANTS

Does one plant serve perimeter and interior ? <Y>

>1. BLOCK PLANT : CENTRIFUGAL WATER COOLED CHILLER
Capacity @ 85 F entering water = 230.0 tons
KW/Ton @ 85 F entering water = 0.78 kw/ton
Is hydronic cooling used ? <Y>
Is chilled water reset used ? <N>
Is condenser performance altitude adjusted ? <Y>
Heat sink type : Open cooling tower
Minimum entering water temperature = 32 F
Is a hydronic economizer used ? <Y> ; Economizer efficiency = 80 %
Number of sequenced chillers = 2

****

D. PUMPING SYSTEMS

System	PERIMETER dT, F	PERIMETER dP, ft wg	INTERIOR dT, F	INTERIOR dP, ft wg
Chilled water	10.00	100.00	0.00	0.00
Hot water	0.00	0.00	0.00	0.00
Condenser water	10.00	50.00	0.00	0.00
Ground water	0.00	0.00	0.00	0.00

****

E. NON-HVAC SYSTEMS

>1. NON-HVAC ELECTRICAL ENERGY USE
Lighting kw: Occupied = 53.4 kw; Unoccupied = 48.1 kw
Misc. kw : Occupied = 660.0 kw; Unoccupied = 220.0 kw
Other kw : Occupied = 0.0 kw; Unoccupied = 0.0 kw

>2. DHW SYSTEM (Not utilized in this system)

****

F. FUEL COSTS

>1. ELECTRICAL ENERGY USE	Period Occupied ($/kwh)	Period Unoccupied ($/kwh)
Compressor	0.050	0.050
Resistance	0.050	0.050
Inductive	0.050	0.050

>2. OTHER FUELS	Unit Cost
Natural Gas	n/a $/therm
Fuel Oil	n/a $/U.S.gal
Propane	n/a $/lb
Remote Heating	n/a $/MBTU
Remote Cooling	n/a $/MBTU

TOTAL BUILDING ENERGY SUMMARY

Job Name : D-0 SUBCON 2/3 ALT 1 SYS
Building Name : D-0 SUBCONSTRUCT 2/3 (Complex)
Site : AURORA,IL FERMI, User Defined
Date : 11-16-87

Period : All
Zone : Block
Serial Number:
60117862.0

****

HVAC ENERGY Component	Annual Cost ($/yr)	Energy or Fuel Units Consumed	DOE RUF (1000 BTU)	DOE RIF (1000 BTU)
Electric (Occ)	21736	434726 kwh/yr	5042826	1483721
Electric (Unocc)	16486	329719 kwh/yr	3824742	1125331
Natural Gas	0	0 therms/yr	0	0
Fuel Oil	0	0 U.S. gal/yr	0	0
Propane	0	0 lb/yr	0	0
Remote Heating	0	0 MBTU/yr	0	0
Remote Cooling	0	0 MBTU/yr	0	0
HVAC Total	38222		8867568	2609053
NON-HVAC ENERGY				
Electric (Occ)	111597	2231944 kwh/yr	25890545	7617623
Electric (Unocc)	75478	1509553 kwh/yr	17510814	5152104
Non-HVAC Total	187075		43401359	12769728
Grand Total	225297		52268928	15378780
Total/Sq.Ft.	12.66		2936.46	863.98

HVAC Summary:

HVAC Total Cost	=	2.15 $/Sq.Ft./yr
	=	16.97 % of Total Cost
Total HVAC Electrical Energy	=	42.95 kwh/Sq.Ft./yr
	=	16.97 % of Total Electrical Energy
Non-Electrical HVAC Energy	=	0.00 % of Total Energy

Key:

1 kwh	= 11600 BTU RUF; 3412 BTU RIF
1 therm nat gas	= 100000 BTU RUF and RIF
1 U.S. gal oil	= 138700 BTU RUF and RIF
1 Imp. gal oil	= 168000 BTU RUF and RIF
1 lb propane	= 21680 BTU RUF and RIF
RUF	= Resource utilization factor (Source value)
RIF	= Resource impact factor (Point of use value)
MBH	= 1000 BTU/hr
MBTU	= Million BTU

ANNUAL OPERATING COSTS

Job Name : D-0 SUBCON 2/3 ALT 1 SYS Page 1
Building Name : D-0 SUBCONSTRUCT 2/3 (Complex) Date : 11-16-87
Site : AURORA,IL FERMI, User Defined 60117862.0
Scope of Analysis : Cooling and Heating Systems

****

A. AIR HANDLING SYSTEMS (ANNUAL FAN OPERATING COST = $10,320)

Are perimeter and interior zone on same supply fan ? <N>

>1. PERIMETER TERMINAL TYPE : CONSTANT VOLUME

Supply fan type : Forward curved
Supply fan total static pressure = 2.00 in. wg.
Return fan type : Controlled pitch axial
Return fan total static pressure = 1.00 in. wg.
Design supply air= 36000 cfm @ 55 F; Vent. air= 600 cfm
Are cooling terminals used for heating ? <Y>
Economizer type : Integrated, enthalpy controlled
Is a ventilation reclaim device used ? <N>
Are ventilation air dampers closed for unoccupied periods ? <N>

>2. INTERIOR TERMINAL TYPE : CONSTANT VOLUME

Supply fan type : Forward curved
Supply fan total static pressure = 0.01 in. wg.
A return fan is not used.
Design supply air= 61384 cfm @ 55 F; Vent. air= 0 cfm
An economizer is not used.
Is a ventilation reclaim device used ? <N>
Are ventilation air dampers closed for unoccupied periods ? <N>

****

B. HEATING PLANTS (ANNUAL HEATING PLANT OPERATING COST = $0)

Does one primary heating plant serve perimeter and interior ? <Y>

> 1 . BLOCK PLANT : ELECTRICAL RESISTANCE

Is hydronic heating used ? <N>

****

****

C. COOLING PLANTS (ANNUAL COOLING PLANT OPERATING COST = $18,315)

Does one plant serve perimeter and interior ? <Y>

>1. BLOCK PLANT : CENTRIFUGAL WATER COOLED CHILLER
Capacity @ 85 F entering water = 230.0 tons
KW/Ton @ 85 F entering water = 0.78 kw/ton
Is hydronic cooling used ? <Y>
Is chilled water reset used ? <N>
Is condenser performance altitude adjusted ? <Y>
Heat sink type : Open cooling tower
Minimum entering water temperature = 32 F
Is a hydronic economizer used ? <Y> ; Economizer efficiency = 80 %
Number of sequenced chillers = 2

****

D. PUMPING SYSTEMS (ANNUAL PUMP OPERATING COST = $9,587)

System	PERIMETER dT, F	PERIMETER dP, ft wg	INTERIOR dT, F	INTERIOR dP, ft wg
Chilled water	10.00	100.00	0.00	0.00
Hot water	0.00	0.00	0.00	0.00
Condenser water	10.00	50.00	0.00	0.00
Ground water	0.00	0.00	0.00	0.00

****

E. NON-HVAC SYSTEMS (ANNUAL NON-HVAC OPERATING COST = $187,075)

>1. NON-HVAC ELECTRICAL ENERGY USE
Lighting kw: Occupied = 53.4 kw; Unoccupied = 48.1 kw
Misc. kw : Occupied = 660.0 kw; Unoccupied = 220.0 kw
Other kw : Occupied = 0.0 kw; Unoccupied = 0.0 kw

>2. DHW SYSTEM (Not utilized in this system)

****

F. FUEL COSTS (GRAND TOTAL ANNUAL OPERATING COST = $225,297)

>1. ELECTRICAL ENERGY USE	Period Occupied ($/kwh)	Period Unoccupied ($/kwh)
Compressor	0.050	0.050
Resistance	0.050	0.050
Inductive	0.050	0.050

>2. OTHER FUELS	Unit Cost
Natural Gas	n/a $/therm
Fuel Oil	n/a $/U.S.gal
Propane	n/a $/lb
Remote Heating	n/a $/MBTU
Remote Cooling	n/a $/MBTU

COOLING PLANT COSTS

Job Name : D-O SUBCON 2/3 ALT 1 SYS — Date : 11-16-87
Building Name : D-O SUBCONSTRUCT 2/3 (Complex) — Serial Number:
Site Name : AURORA,IL FERMI, User Defined — 6011786Z.0

Bin Temp (F)	Bin Hours hr/yr	Block Cooling Plant Coil Load MBH	Input kW	Cost $/yr
			OCCUPIED PERIOD	
90	25.8	2563.8	159.2	205.3
85	59.4	2549.7	153.0	454.3
80	145.3	2535.9	144.8	1052.1
75	237.7	2522.4	137.4	1632.8
70	270.6	2244.9	127.6	1726.0
65	264.5	1960.5	112.0	1480.9
60	255.0	1754.9	102.2	1303.4
55	244.7	1553.6	94.3	1153.8
50	232.1	1553.6	92.1	1069.3
45	229.5	1553.6	89.8	1030.7
40	237.6	1553.6	86.0	1021.8
35	238.5	1553.6	64.0	762.9
30	218.2	1553.6	57.6	628.6
25	174.5	1553.6	52.0	453.9
20	122.4	1553.6	47.1	288.1
15	78.1	1553.6	42.7	166.6
10	46.1	1553.6	41.6	95.9
5	25.1	1553.6	41.4	51.9
0	12.7	1553.6	41.1	26.1
-5	6.2	1553.6	40.9	12.7
-6	4.6	1553.6	40.8	9.4
Total Costs				$14626.6
			UNOCCUPIED PERIOD	
90	14.6	1018.6	56.4	41.2
85	36.3	1007.9	50.6	91.9
80	99.3	1048.9	46.2	229.3
75	215.3	843.5	38.6	415.3
70	357.6	638.1	31.9	570.5
65	463.3	527.5	27.2	631.2
60	500.4	527.5	24.4	610.2
55	482.0	527.5	21.8	526.2
50	447.6	527.5	3.3	74.0
45	422.7	527.5	3.3	69.9
40	413.7	527.5	3.3	68.4
35	417.0	527.5	3.3	69.0
30	417.4	527.5	3.3	69.0
25	395.2	527.5	3.3	65.4
20	336.9	527.5	3.3	55.7
15	252.8	527.5	3.3	41.8
10	165.7	527.5	3.3	27.4
5	96.3	527.5	3.3	15.9
0	50.9	527.5	3.3	8.4
-5	25.3	527.5	3.3	4.2
-6	21.1	527.5	3.3	3.5
Total Costs				$3688.6

BLOCK HEATING PLANT COSTS

Job Name : D-0 SUBCON 2/3 ALT 1 SYS — Date : 11-16-87

Building Name : D-0 SUBCONSTRUCT 2/3 (Complex) — Serial Number:

Site Name : AURORA,IL FERMI, User Defined — 60117862.0

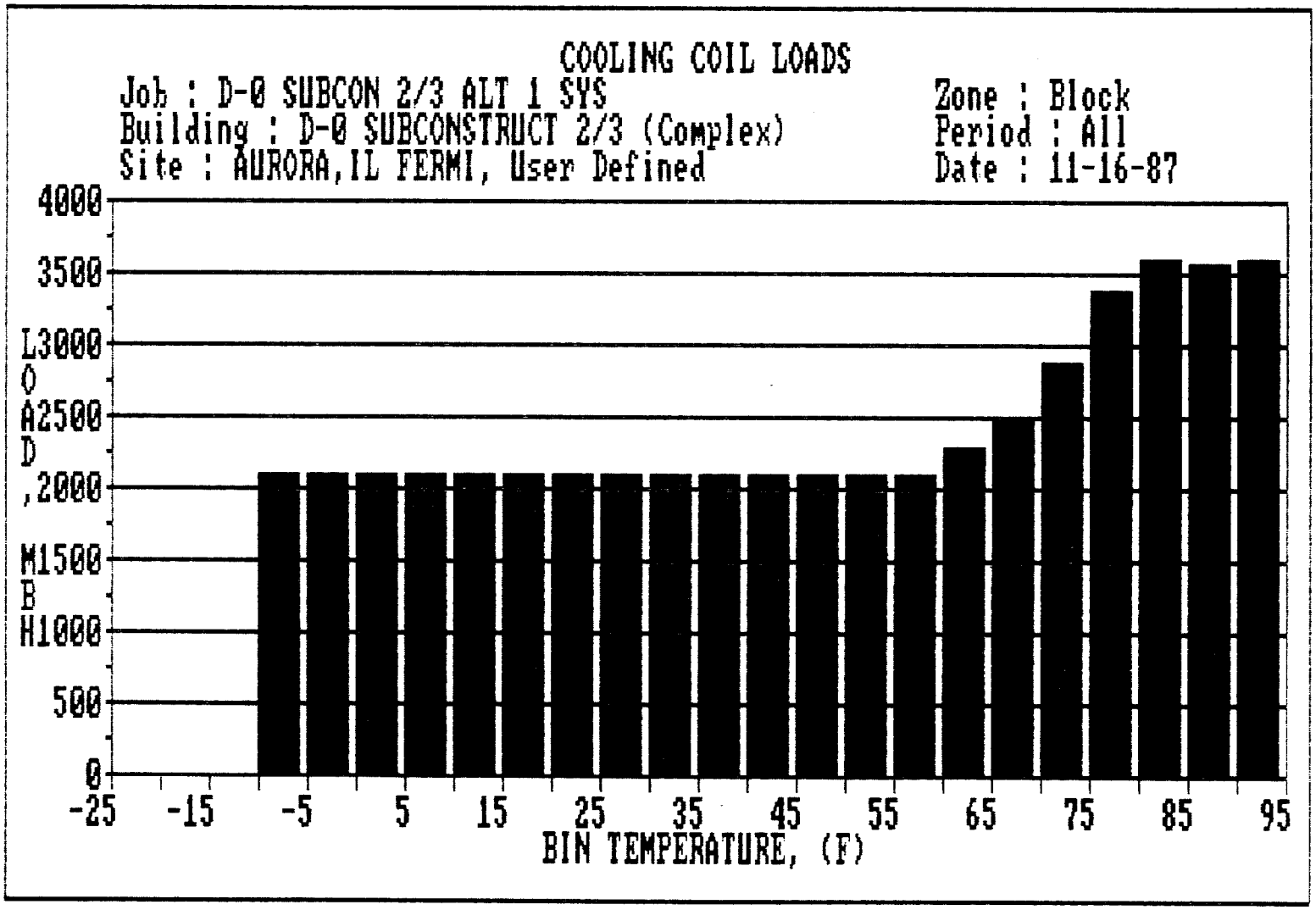
Bin Temp (F)	Bin Hours hr/yr	Coil Load MBH	Primary Plant Output MBH	Primary Plant Input KW	Primary Plant Cost $/yr	No Auxiliary Plant Used
			OCCUPIED PERIOD			
90	25.8	0.0	0.0	0.0	0.0	
85	59.4	0.0	0.0	0.0	0.0	
80	145.3	0.0	0.0	0.0	0.0	
75	237.7	0.0	0.0	0.0	0.0	
70	270.6	0.0	0.0	0.0	0.0	
65	264.5	0.0	0.0	0.0	0.0	
60	255.0	0.0	0.0	0.0	0.0	
55	244.7	0.0	0.0	0.0	0.0	
50	232.1	0.0	0.0	0.0	0.0	
45	229.5	0.0	0.0	0.0	0.0	
40	237.6	0.0	0.0	0.0	0.0	
35	238.5	0.0	0.0	0.0	0.0	
30	218.2	0.0	0.0	0.0	0.0	
25	174.5	0.0	0.0	0.0	0.0	
20	122.4	0.0	0.0	0.0	0.0	
15	78.1	0.0	0.0	0.0	0.0	
10	46.1	0.0	0.0	0.0	0.0	
5	25.1	0.0	0.0	0.0	0.0	
0	12.7	0.0	0.0	0.0	0.0	
-5	6.2	0.0	0.0	0.0	0.0	
-6	4.6	0.0	0.0	0.0	0.0	
Total Costs					$0.0	
			UNOCCUPIED PERIOD			
90	14.6	0.0	0.0	0.0	0.0	
85	36.3	0.0	0.0	0.0	0.0	
80	99.3	0.0	0.0	0.0	0.0	
75	215.3	0.0	0.0	0.0	0.0	
70	357.6	0.0	0.0	0.0	0.0	
65	463.3	0.0	0.0	0.0	0.0	
60	500.4	0.0	0.0	0.0	0.0	
55	482.0	0.0	0.0	0.0	0.0	
50	447.6	0.0	0.0	0.0	0.0	
45	422.7	0.0	0.0	0.0	0.0	
40	413.7	0.0	0.0	0.0	0.0	
35	417.0	0.0	0.0	0.0	0.0	
30	417.4	0.0	0.0	0.0	0.0	
25	395.2	0.0	0.0	0.0	0.0	
20	336.9	0.0	0.0	0.0	0.0	
15	252.8	0.0	0.0	0.0	0.0	
10	165.7	0.0	0.0	0.0	0.0	
5	96.3	0.0	0.0	0.0	0.0	
0	50.9	0.0	0.0	0.0	0.0	
-5	25.3	0.0	0.0	0.0	0.0	
-6	21.1	0.0	0.0	0.0	0.0	
Total Costs					$0.0	

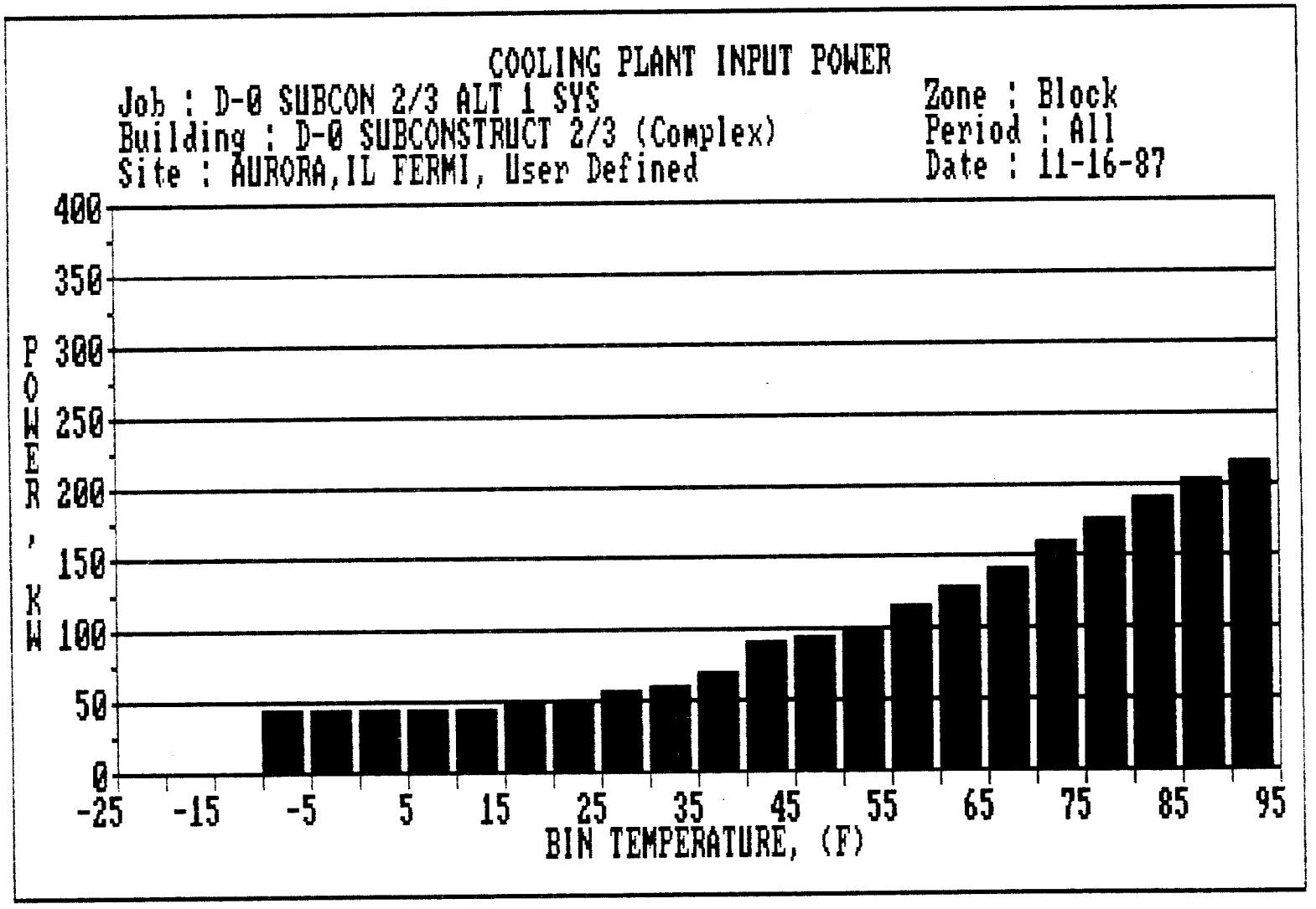
FAN AND PUMP COSTS

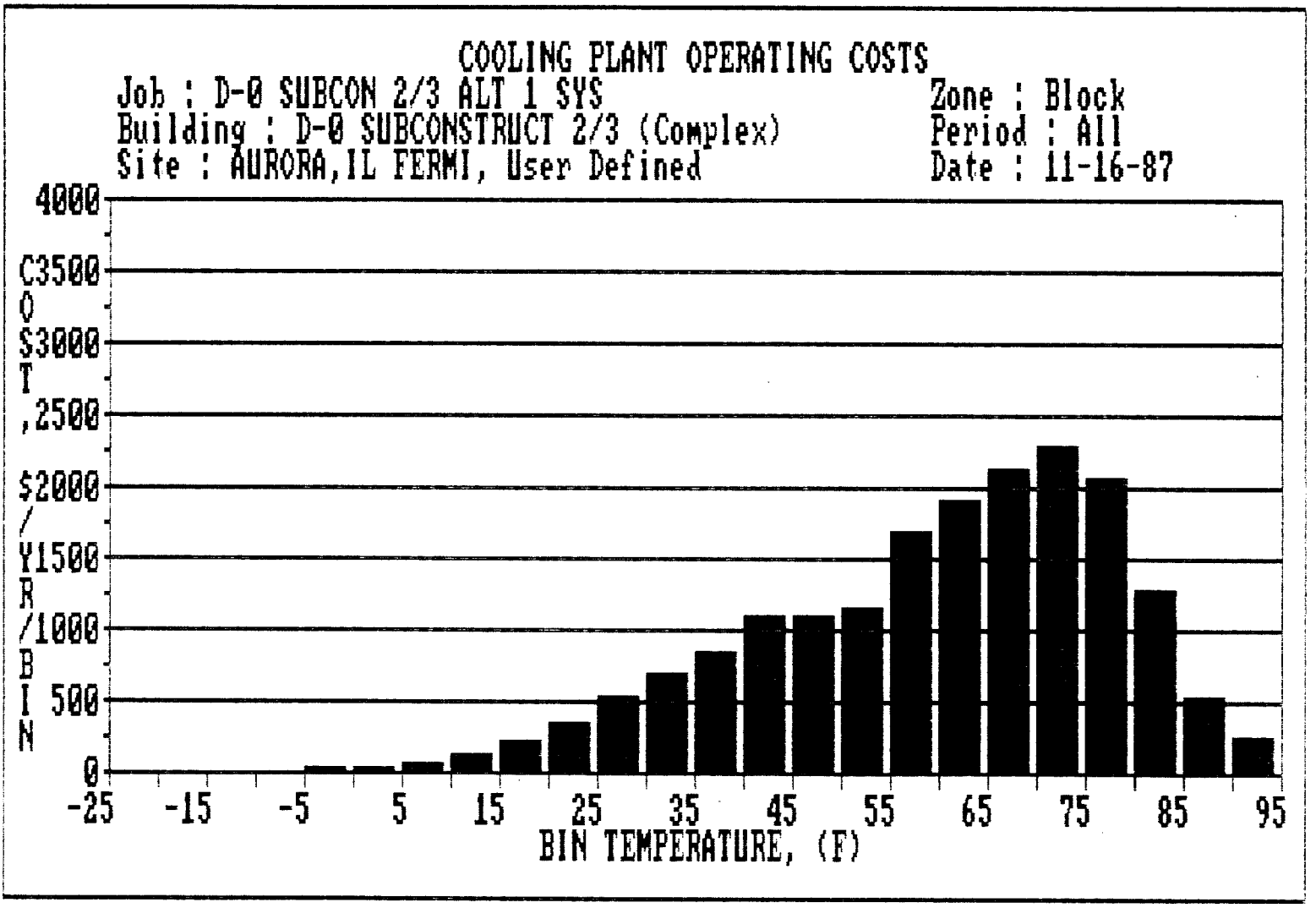
Job Name : D-O SUBCON 2/3 ALT 1 SYS
Building Name : D-O SUBCONSTRUCT 2/3 (Complex)
Site Name : AURORA,IL FERMI, User Defined

Date : 11-16-87
Serial Number:
60117862.0

Bin Temp (F)	Bin Hours hr/yr	Perimeter Fans Input KW	Perimeter Fans Cost $/yr	Interior Fans Input KW	Interior Fans Cost $/yr	All Pumps Input KW	All Pumps Cost $/yr
				OCCUPIED PERIOD			
90	25.8	23.4	30.2	0.1	0.2	21.9	28.2
85	59.4	23.4	69.6	0.1	0.4	21.9	65.0
80	145.3	23.4	170.2	0.1	1.0	21.9	159.0
75	237.7	23.4	278.4	0.1	1.6	21.9	260.2
70	270.6	23.4	317.0	0.1	1.8	21.9	296.2
65	264.5	23.4	309.8	0.1	1.8	21.9	289.5
60	255.0	23.4	298.7	0.1	1.7	21.9	279.1
55	244.7	23.4	286.6	0.1	1.6	21.9	267.8
50	232.1	23.4	271.9	0.1	1.5	21.9	254.0
45	229.5	23.4	268.8	0.1	1.5	21.9	251.2
40	237.6	23.4	278.3	0.1	1.6	21.9	260.0
35	238.5	23.4	279.4	0.1	1.6	21.9	261.0
30	218.2	23.4	255.6	0.1	1.5	21.9	238.8
25	174.5	23.4	204.4	0.1	1.2	21.9	191.0
20	122.4	23.4	143.4	0.1	0.8	21.9	134.0
15	78.1	23.4	91.5	0.1	0.5	21.9	85.5
10	46.1	23.4	54.0	0.1	0.3	21.9	50.5
5	25.1	23.4	29.4	0.1	0.2	21.9	27.5
0	12.7	23.4	14.9	0.1	0.1	21.9	13.9
-5	6.2	23.4	7.3	0.1	0.0	21.9	6.8
-6	4.6	23.4	5.4	0.1	0.0	21.9	5.0
Total Costs			$3664.8		$20.8		$3424.1
				UNOCCUPIED PERIOD			
90	14.6	23.4	17.1	0.1	0.1	21.9	16.0
85	36.3	23.4	42.5	0.1	0.2	21.9	39.7
80	99.3	23.4	116.3	0.1	0.7	21.9	108.7
75	215.3	23.4	252.2	0.1	1.4	21.9	235.6
70	357.6	23.4	418.9	0.1	2.4	21.9	391.4
65	463.3	23.4	542.7	0.1	3.1	21.9	507.1
60	500.4	23.4	586.2	0.1	3.3	21.9	547.7
55	482.0	23.4	564.6	0.1	3.2	21.9	527.5
50	447.6	23.4	524.3	0.1	3.0	21.9	489.9
45	422.7	23.4	495.1	0.1	2.8	21.9	462.6
40	413.7	23.4	484.6	0.1	2.8	21.9	452.8
35	417.0	23.4	488.5	0.1	2.8	21.9	456.4
30	417.4	23.4	488.9	0.1	2.8	21.9	456.8
25	395.2	23.4	462.9	0.1	2.6	21.9	432.5
20	336.9	23.4	394.6	0.1	2.2	21.9	368.7
15	252.8	23.4	296.1	0.1	1.7	21.9	276.7
10	165.7	23.4	194.1	0.1	1.1	21.9	181.4
5	96.3	23.4	112.8	0.1	0.6	21.9	105.4
0	50.9	23.4	59.6	0.1	0.3	21.9	55.7
-5	25.3	23.4	29.6	0.1	0.2	21.9	27.7
-6	21.1	23.4	24.7	0.1	0.1	21.9	23.1
Total Costs			$6596.5		$37.5		$6163.3


COOLING COIL LOADS
Job : D-0 SUBCON 2/3 ALT 1 SYS
Building : D-0 SUBCONSTRUCT 2/3 (Complex)
Site : AURORA,IL FERMI, User Defined
Zone : Block
Period : All
Date : 11-16-87
4000
3500
L3000
O
A2500
D
,2000
M1500
B
H1000
500
0
-25
-15
-5
5
15
25
35
45
55
65
75
85
95
BIN TEMPERATURE, (F)


COOLING PLANT INPUT POWER
Job : D-0 SUBCON 2/3 ALT 1 SYS
Building : D-0 SUBCONSTRUCT 2/3 (Complex)
Site : AURORA,IL FERMI, User Defined
Zone : Block
Period : All
Date : 11-16-87
POWER, KW
400
350
300
250
200
150
100
50
0
-25
-15
-5
5
15
25
35
45
55
65
75
85
95
BIN TEMPERATURE, (F)


COOLING PLANT OPERATING COSTS
Job : D-0 SUBCON 2/3 ALT 1 SYS
Building : D-0 SUBCONSTRUCT 2/3 (Complex)
Site : AURORA,IL FERMI, User Defined
Zone : Block
Period : All
Date : 11-16-87
4000
C3500
O
$3000
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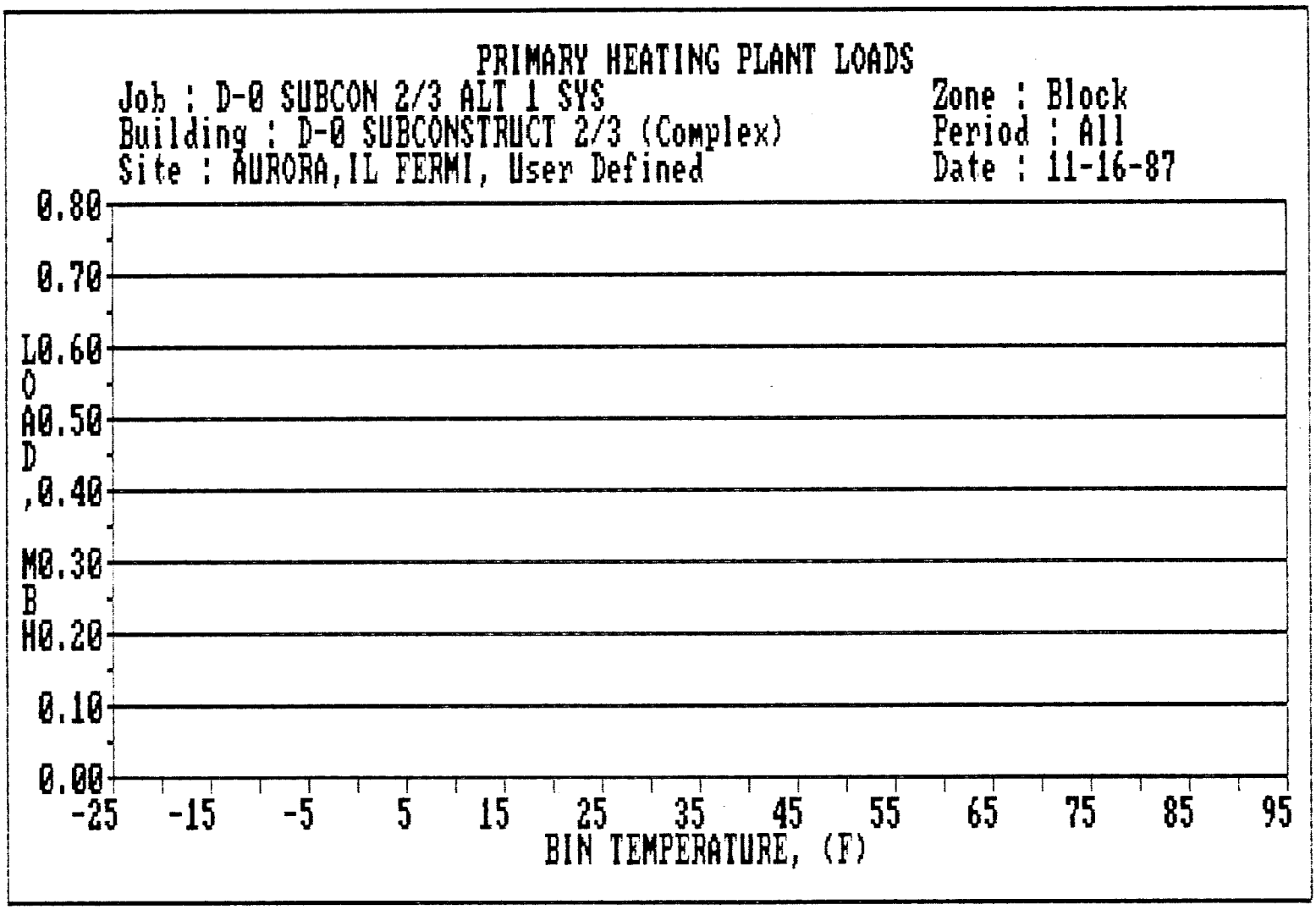
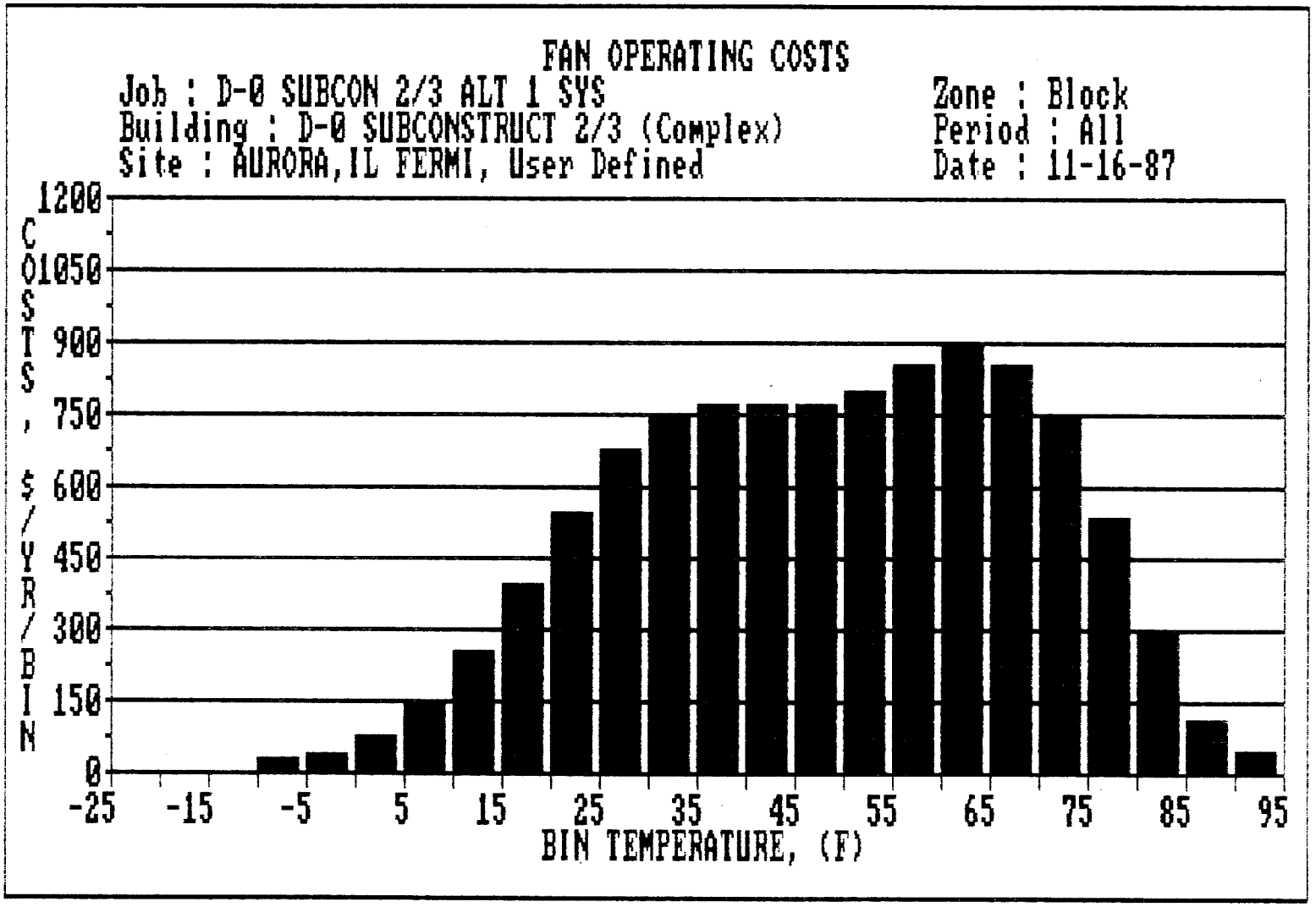
BIN TEMPERATURE, (F)


PRIMARY HEATING PLANT LOADS
Job : D-0 SUBCON 2/3 ALT 1 SYS
Building : D-0 SUBCONSTRUCT 2/3 (Complex)
Site : AURORA,IL FERMI, User Defined
Zone : Block
Period : All
Date : 11-16-87
0.80
0.70
L0.60
O
A0.50
D
,0.40
M0.30
B
H0.20
0.10
0.00
-25 -15 -5 5 15 25 35 45 55 65 75 85 95
BIN TEMPERATURE, (F)


FAN OPERATING COSTS
Job : D-0 SUBCON 2/3 ALT 1 SYS
Building : D-0 SUBCONSTRUCT 2/3 (Complex)
Site : AURORA,IL FERMI, User Defined
Zone : Block
Period : All
Date : 11-16-87
COSTS, $/YR/BIN
1200
1050
900
750
600
450
300
150
0
-25
-15
-5
5
15
25
35
45
55
65
75
85
95
BIN TEMPERATURE, (F)

V-c.-3.

FERMILAB D-0 EXPERIMENTAL FACILITY

SUBCONSTRUCTION 2/3 - MCH, PLATFORM & SIDEBAY AREAS WITH DCHW SYSTEMS
OPERATIONAL PERFORMANCE SIMULATION

ALTERNATE COMPARISON SYSTEM NUMBER 2
TYPICAL FY1975 DESIGN - BASIC SYSTEM
RECIPROCATING CHILLERS, CENTRAL STATION AHU'S, COMPUTER ROOM CHW AC UNITS
AND WATER COOLED ELECTRONIC RACKS
WITHOUT ENERGY FEATURES - POND WATER COOLING

31 OCTOBER, 1987
ANALYST: S.F.KRSTULOVICH

FERMILAB CONSTRUCTION ENGINEERING SERVICES

SYSTEM INPUT SUMMARY

Job Name : D-0 SUBCON 2/3 FY1975 SYS
Building Name : D-0 SUBCONSTRUCT 2/3 (Complex) Date : 11-16-87
Site : AURORA,IL FERMI, User Defined 60117862.0
Scope of Analysis : Cooling and Heating Systems

****

A. AIR HANDLING SYSTEMS

Are perimeter and interior zone on same supply fan ? <N>

>1. PERIMETER TERMINAL TYPE : CONSTANT VOLUME

Supply fan type : Forward curved
Supply fan total static pressure = 2.50 in. wg.
Return fan type : Controlled pitch axial
Return fan total static pressure = 1.25 in. wg.
Design supply air= 36000 cfm @ 55 F; Vent. air= 600 cfm
Are cooling terminals used for heating ? <Y>
An economizer is not used.
Is a ventilation reclaim device used ? <N>
Are ventilation air dampers closed for unoccupied periods ? <N>

>2. INTERIOR TERMINAL TYPE : CONSTANT VOLUME

Supply fan type : Forward curved
Supply fan total static pressure = 0.01 in. wg.
A return fan is not used.
Design supply air= 61384 cfm @ 55 F; Vent. air= 0 cfm
An economizer is not used.
Is a ventilation reclaim device used ? <N>
Are ventilation air dampers closed for unoccupied periods ? <N>

****

B. HEATING PLANTS

Does one primary heating plant serve perimeter and interior ? <Y>

> 1 . BLOCK PLANT : ELECTRICAL RESISTANCE

Is hydronic heating used ? <N>

****

****

C. COOLING PLANTS

Does one plant serve perimeter and interior ? <Y>

>1. BLOCK PLANT : RECIPROCATING WATER COOLED
Capacity @ 85 F entering water = 230.0 tons
KW/Ton @ 85 F entering water = 1.00 kw/ton
Is hydronic cooling used ? <Y>
Is chilled water reset used ? <N>
Is hot gas bypass used ? <N>
Is condenser performance altitude adjusted ? <N>
Is there one compressor per condenser circuit ? <Y>
Are compressors cycled ? <N>
Heat sink type : Closed circuit cooling tower
Minimum entering water temperature = 40 F
Is a hydronic economizer used ? <N>

****

D. PUMPING SYSTEMS

System	PERIMETER dT, F	PERIMETER dP, ft wg	INTERIOR dT, F	INTERIOR dP, ft wg
Chilled water	10.00	120.00	0.00	0.00
Hot water	0.00	0.00	0.00	0.00
Condenser water	15.00	120.00	0.00	0.00
Ground water	0.00	0.00	0.00	0.00

****

E. NON-HVAC SYSTEMS

>1. NON-HVAC ELECTRICAL ENERGY USE
Lighting kw: Occupied = 53.4 kw; Unoccupied = 48.1 kw
Misc. kw : Occupied = 660.0 kw; Unoccupied = 220.0 kw
Other kw : Occupied = 0.0 kw; Unoccupied = 0.0 kw

>2. DHW SYSTEM (Not utilized in this system)

****

F. FUEL COSTS

>1. ELECTRICAL ENERGY USE	Period Occupied ($/kwh)	Period Unoccupied ($/kwh)
Compressor	0.050	0.050
Resistance	0.050	0.050
Inductive	0.050	0.050

>2. OTHER FUELS	Unit Cost
Natural Gas	n/a $/therm
Fuel Oil	n/a $/U.S.gal
Propane	n/a $/lb
Remote Heating	n/a $/MBTU
Remote Cooling	n/a $/MBTU

TOTAL BUILDING ENERGY SUMMARY

Job Name : D-0 SUBCON 2/3 FY1975 SYS
Building Name : D-0 SUBCONSTRUCT 2/3 (Complex)
Site : AURORA,IL FERMI, User Defined
Date : 11-16-87

Period : All
Zone : Block
Serial Number:
60117862.0

****

HVAC ENERGY Component	Annual Cost ($/yr)	Energy or Fuel Units Consumed	DOE RUF (1000 BTU)	DOE RIF (1000 BTU)
Electric (Occ)	32727	654531 kwh/yr	7592563	2233915
Electric (Unocc)	30065	601302 kwh/yr	6975101	2052243
Natural Gas	0	0 therms/yr	0	0
Fuel Oil	0	0 U.S. gal/yr	0	0
Propane	0	0 lb/yr	0	0
Remote Heating	0	0 MBTU/yr	0	0
Remote Cooling	0	0 MBTU/yr	0	0
HVAC Total	62792		14567664	4286158
NON-HVAC ENERGY				
Electric (Occ)	111597	2231944 kwh/yr	25890545	7617623
Electric (Unocc)	75478	1509553 kwh/yr	17510814	5152104
Non-HVAC Total	187075		43401359	12769728
Grand Total	249866		57969024	17055886
Total/Sq.Ft.	14.04		3256.69	958.20

HVAC Summary:

HVAC Total Cost	=	3.53 $/Sq.Ft./yr
	=	25.13 % of Total Cost
Total HVAC Electrical Energy	=	70.55 kwh/Sq.Ft./yr
	=	25.13 % of Total Electrical Energy
Non-Electrical HVAC Energy	=	0.00 % of Total Energy

Key:

1 kwh	= 11600 BTU RUF; 3412 BTU RIF
1 therm nat gas	= 100000 BTU RUF and RIF
1 U.S. gal oil	= 138700 BTU RUF and RIF
1 Imp. gal oil	= 168000 BTU RUF and RIF
1 lb propane	= 21680 BTU RUF and RIF
RUF	= Resource utilization factor (Source value)
RIF	= Resource impact factor (Point of use value)
MBH	= 1000 BTU/hr
MBTU	= Million BTU

ANNUAL OPERATING COSTS

Job Name : D-O SUBCON 2/3 FY1975 SYS Page 1
Building Name : D-O SUBCONSTRUCT 2/3 (Complex) Date : 11-16-87
Site : AURORA,IL FERMI, User Defined 60117862.0
Scope of Analysis : Cooling and Heating Systems

****

A. AIR HANDLING SYSTEMS (ANNUAL FAN OPERATING COST = $12,885)

Are perimeter and interior zone on same supply fan ? <N>

>1. PERIMETER TERMINAL TYPE : CONSTANT VOLUME

Supply fan type : Forward curved
Supply fan total static pressure = 2.50 in. wg.
Return fan type : Controlled pitch axial
Return fan total static pressure = 1.25 in. wg.
Design supply air= 36000 cfm @ 55 F; Vent. air= 600 cfm
Are cooling terminals used for heating ? <Y>
An economizer is not used.
Is a ventilation reclaim device used ? <N>
Are ventilation air dampers closed for unoccupied periods ? <N>

>2. INTERIOR TERMINAL TYPE : CONSTANT VOLUME

Supply fan type : Forward curved
Supply fan total static pressure = 0.01 in. wg.
A return fan is not used.
Design supply air= 61384 cfm @ 55 F; Vent. air= 0 cfm
An economizer is not used.
Is a ventilation reclaim device used ? <N>
Are ventilation air dampers closed for unoccupied periods ? <N>

****

B. HEATING PLANTS (ANNUAL HEATING PLANT OPERATING COST = $0)

Does one primary heating plant serve perimeter and interior ? <Y>

> 1 . BLOCK PLANT : ELECTRICAL RESISTANCE

Is hydronic heating used ? <N>

****

****

C. COOLING PLANTS (ANNUAL COOLING PLANT OPERATING COST = $36,650)

Does one plant serve perimeter and interior ? <Y>

>1. BLOCK PLANT : RECIPROCATING WATER COOLED
Capacity @ 85 F entering water = 230.0 tons
KW/Ton @ 85 F entering water = 1.00 kw/ton
Is hydronic cooling used ? <Y>
Is chilled water reset used ? <N>
Is hot gas bypass used ? <N>
Is condenser performance altitude adjusted ? <N>
Is there one compressor per condenser circuit ? <Y>
Are compressors cycled ? <N>
Heat sink type : Closed circuit cooling tower
Minimum entering water temperature = 40 F
Is a hydronic economizer used ? <N>

****

D. PUMPING SYSTEMS (ANNUAL PUMP OPERATING COST = $13,257)

System	PERIMETER dT, F	PERIMETER dP, ft wg	INTERIOR dT, F	INTERIOR dP, ft wg
Chilled water	10.00	120.00	0.00	0.00
Hot water	0.00	0.00	0.00	0.00
Condenser water	15.00	120.00	0.00	0.00
Ground water	0.00	0.00	0.00	0.00

****

E. NON-HVAC SYSTEMS (ANNUAL NON-HVAC OPERATING COST = $187,075)

>1. NON-HVAC ELECTRICAL ENERGY USE
Lighting kw: Occupied = 53.4 kw; Unoccupied = 48.1 kw
Misc. kw : Occupied = 660.0 kw; Unoccupied = 220.0 kw
Other kw : Occupied = 0.0 kw; Unoccupied = 0.0 kw

>2. DHW SYSTEM (Not utilized in this system)

****

F. FUEL COSTS (GRAND TOTAL ANNUAL OPERATING COST = $249,866)

>1. ELECTRICAL ENERGY USE	Period Occupied ($/kwh)	Period Unoccupied ($/kwh)
Compressor	0.050	0.050
Resistance	0.050	0.050
Inductive	0.050	0.050

>2. OTHER FUELS	Unit Cost
Natural Gas	n/a $/therm
Fuel Oil	n/a $/U.S.gal
Propane	n/a $/lb
Remote Heating	n/a $/MBTU
Remote Cooling	n/a $/MBTU

COOLING PLANT COSTS

Job Name : D-0 SUBCON 2/3 FY1975 SYS — Date : 11-16-87

Building Name : D-0 SUBCONSTRUCT 2/3 (Complex) — Serial Number:

Site Name : AURORA,IL FERMI, User Defined — 60117862.0

Bin Temp (F)	Bin Hours hr/yr	Block Cooling Plant Coil Load MBH	Input KW	Cost $/yr
			OCCUPIED PERIOD	
90	25.8	2584.0	216.8	279.7
85	59.4	2569.9	207.7	616.8
80	145.3	2556.1	198.9	1444.8
75	237.7	2542.6	190.5	2263.7
70	270.6	2529.5	182.5	2468.9
65	264.5	2516.7	174.9	2313.0
60	255.0	2504.2	167.7	2138.5
55	244.7	2491.9	160.8	1966.9
50	232.1	2480.0	150.1	1741.4
45	229.5	2469.0	140.2	1608.3
40	237.6	2458.1	130.9	1555.2
35	238.5	2447.1	122.2	1456.9
30	218.2	2436.2	114.1	1244.3
25	174.5	2425.2	106.4	928.6
20	122.4	2414.3	99.3	607.5
15	78.1	2403.3	92.5	361.3
10	46.1	2392.4	86.2	198.6
5	25.1	2381.4	80.6	101.2
0	12.7	2370.4	80.3	51.0
-5	6.2	2359.5	79.9	24.8
-6	4.6	2357.3	79.8	18.4
Total Costs				$23390.0
			UNOCCUPIED PERIOD	
90	14.6	1038.4	81.8	59.7
85	36.3	1027.8	77.5	140.7
80	99.3	1017.1	73.4	364.4
75	215.3	1006.4	69.4	747.6
70	357.6	995.7	65.7	1174.2
65	463.3	985.1	62.1	1438.2
60	500.4	974.4	58.7	1468.3
55	482.0	963.7	55.4	1334.7
50	447.6	953.0	50.5	1129.5
45	422.7	942.3	45.9	969.9
40	413.7	931.7	41.6	861.0
35	417.0	921.0	37.6	784.3
30	417.4	910.3	33.9	707.3
25	395.2	899.6	31.5	623.1
20	336.9	889.0	31.2	525.3
15	252.8	878.3	30.8	389.7
10	165.7	867.6	30.5	252.5
5	96.3	856.9	30.1	145.0
0	50.9	846.2	29.8	75.8
-5	25.3	835.6	29.4	37.2
-6	21.1	833.4	29.3	31.0
Total Costs				$13259.5

BLOCK HEATING PLANT COSTS

Job Name : D-0 SUBCON 2/3 FY1975 SYS — Date : 11-16-87
Building Name : D-0 SUBCONSTRUCT 2/3 (Complex) — Serial Number:
Site Name : AURORA,IL FERMI, User Defined — 60117862.0

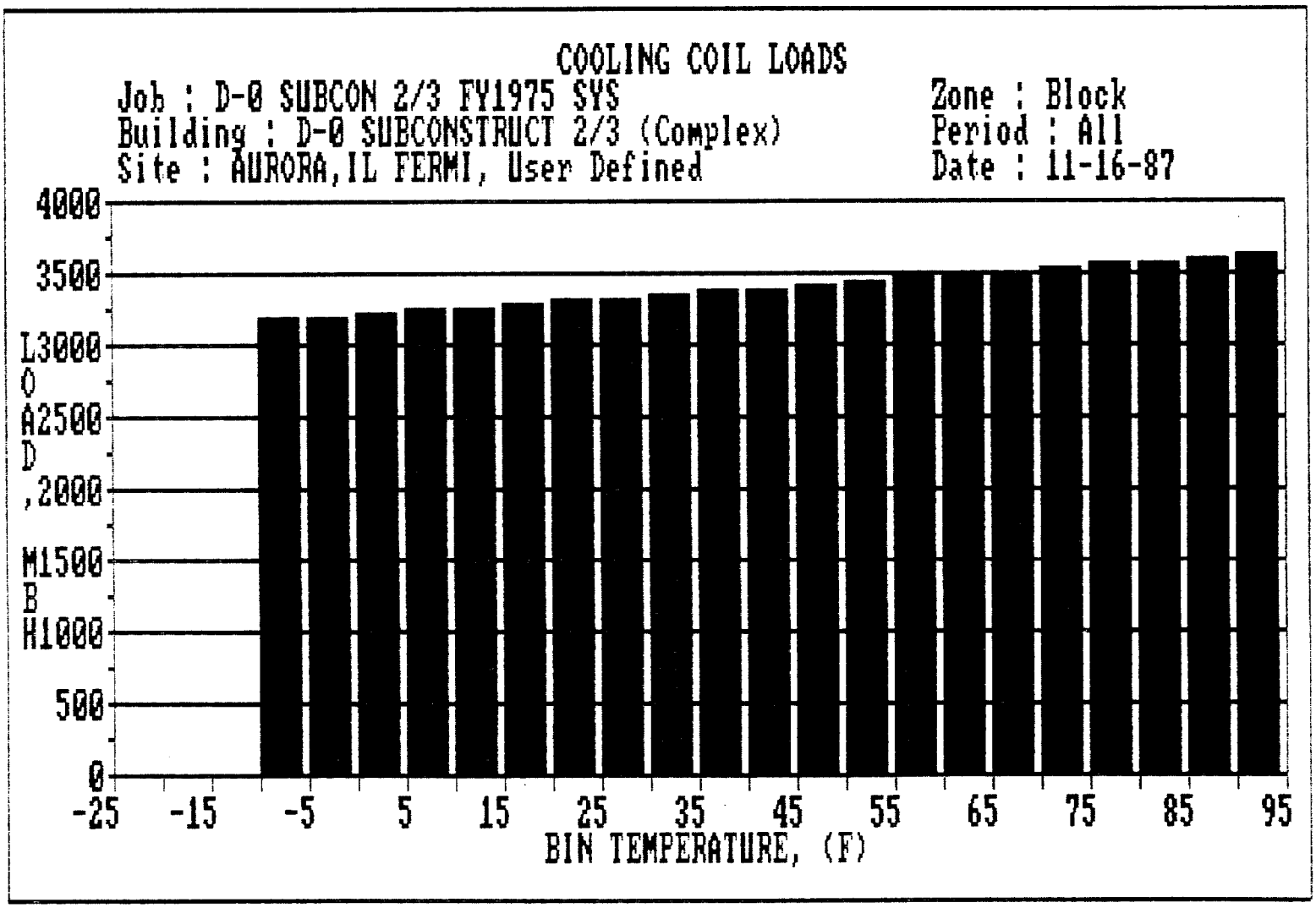
Bin Temp (F)	Bin Hours hr/yr	Coil Load MBH	Primary Plant Output MBH	Input KW	Cost $/yr	No Auxiliary Plant Used
			OCCUPIED PERIOD			
90	25.8	0.0	0.0	0.0	0.0	
85	59.4	0.0	0.0	0.0	0.0	
80	145.3	0.0	0.0	0.0	0.0	
75	237.7	0.0	0.0	0.0	0.0	
70	270.6	0.0	0.0	0.0	0.0	
65	264.5	0.0	0.0	0.0	0.0	
60	255.0	0.0	0.0	0.0	0.0	
55	244.7	0.0	0.0	0.0	0.0	
50	232.1	0.0	0.0	0.0	0.0	
45	229.5	0.0	0.0	0.0	0.0	
40	237.6	0.0	0.0	0.0	0.0	
35	238.5	0.0	0.0	0.0	0.0	
30	218.2	0.0	0.0	0.0	0.0	
25	174.5	0.0	0.0	0.0	0.0	
20	122.4	0.0	0.0	0.0	0.0	
15	78.1	0.0	0.0	0.0	0.0	
10	46.1	0.0	0.0	0.0	0.0	
5	25.1	0.0	0.0	0.0	0.0	
0	12.7	0.0	0.0	0.0	0.0	
-5	6.2	0.0	0.0	0.0	0.0	
-6	4.6	0.0	0.0	0.0	0.0	
Total Costs					$0.0	
			UNOCCUPIED PERIOD			
90	14.6	0.0	0.0	0.0	0.0	
85	36.3	0.0	0.0	0.0	0.0	
80	99.3	0.0	0.0	0.0	0.0	
75	215.3	0.0	0.0	0.0	0.0	
70	357.6	0.0	0.0	0.0	0.0	
65	463.3	0.0	0.0	0.0	0.0	
60	500.4	0.0	0.0	0.0	0.0	
55	482.0	0.0	0.0	0.0	0.0	
50	447.6	0.0	0.0	0.0	0.0	
45	422.7	0.0	0.0	0.0	0.0	
40	413.7	0.0	0.0	0.0	0.0	
35	417.0	0.0	0.0	0.0	0.0	
30	417.4	0.0	0.0	0.0	0.0	
25	395.2	0.0	0.0	0.0	0.0	
20	336.9	0.0	0.0	0.0	0.0	
15	252.8	0.0	0.0	0.0	0.0	
10	165.7	0.0	0.0	0.0	0.0	
5	96.3	0.0	0.0	0.0	0.0	
0	50.9	0.0	0.0	0.0	0.0	
-5	25.3	0.0	0.0	0.0	0.0	
-6	21.1	0.0	0.0	0.0	0.0	
Total Costs					$0.0	

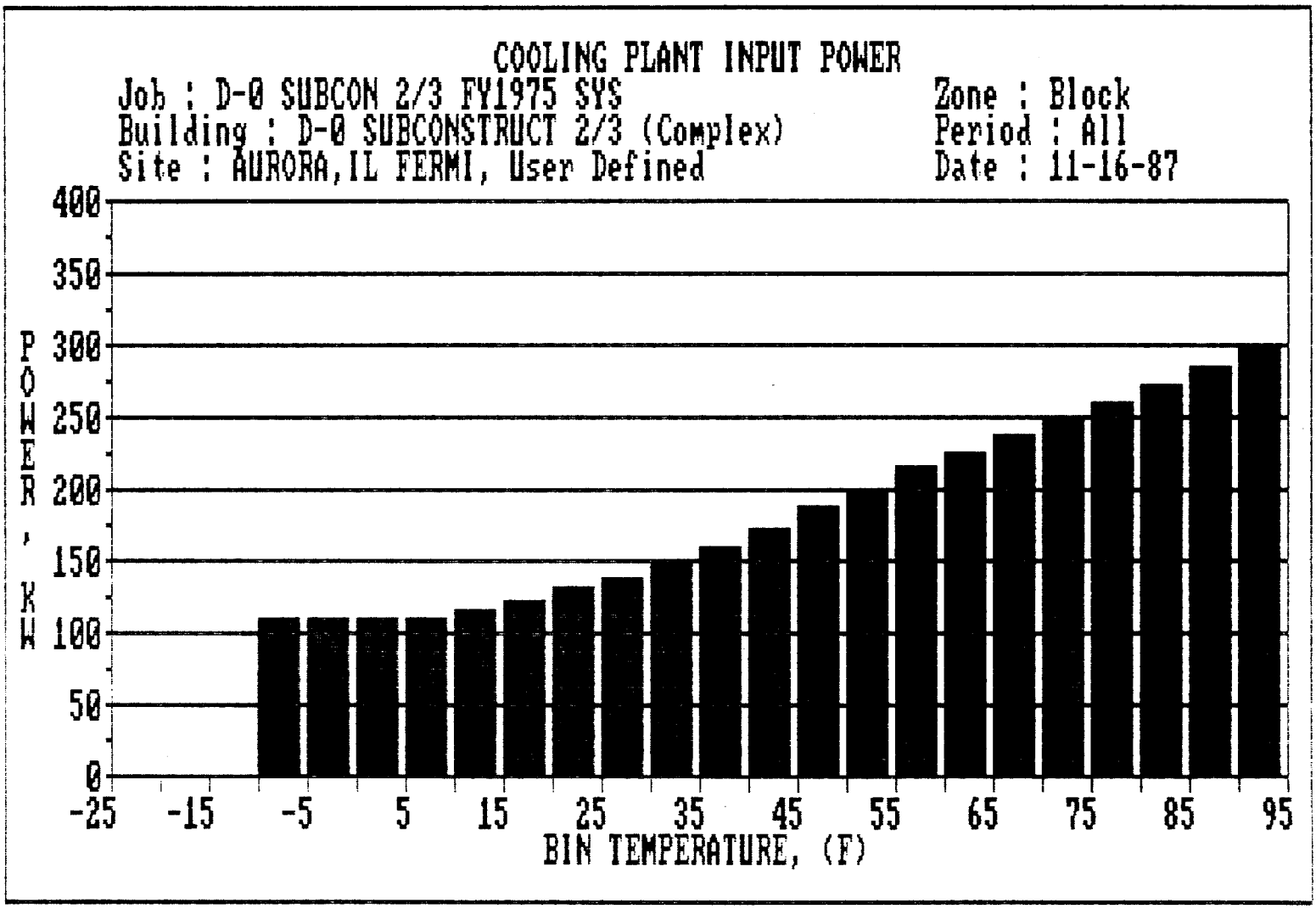
FAN AND PUMP COSTS

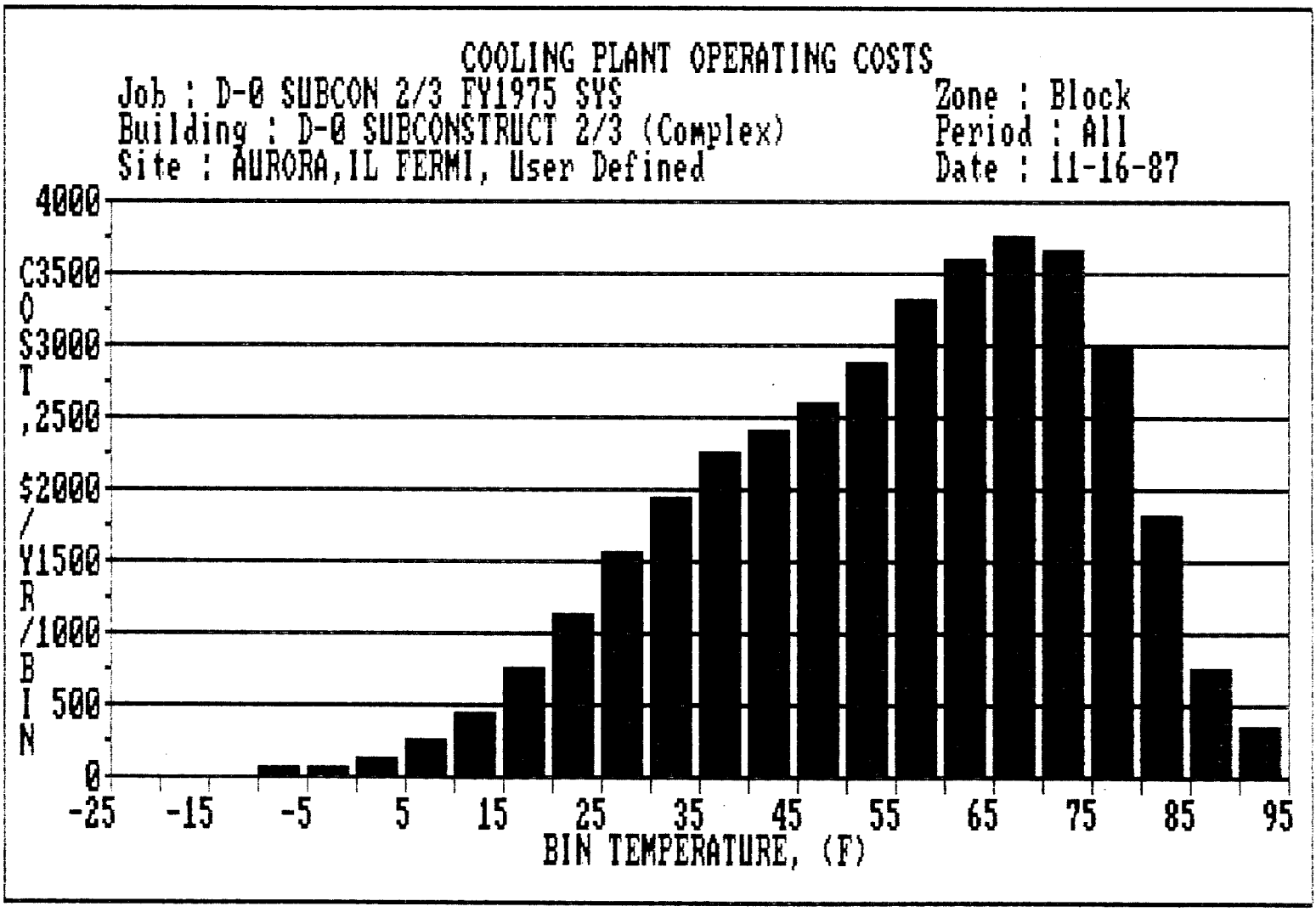
Job Name : D-0 SUBCON 2/3 FY1975 SYS
Building Name : D-0 SUBCONSTRUCT 2/3 (Complex)
Site Name : AURORA,IL FERMI, User Defined

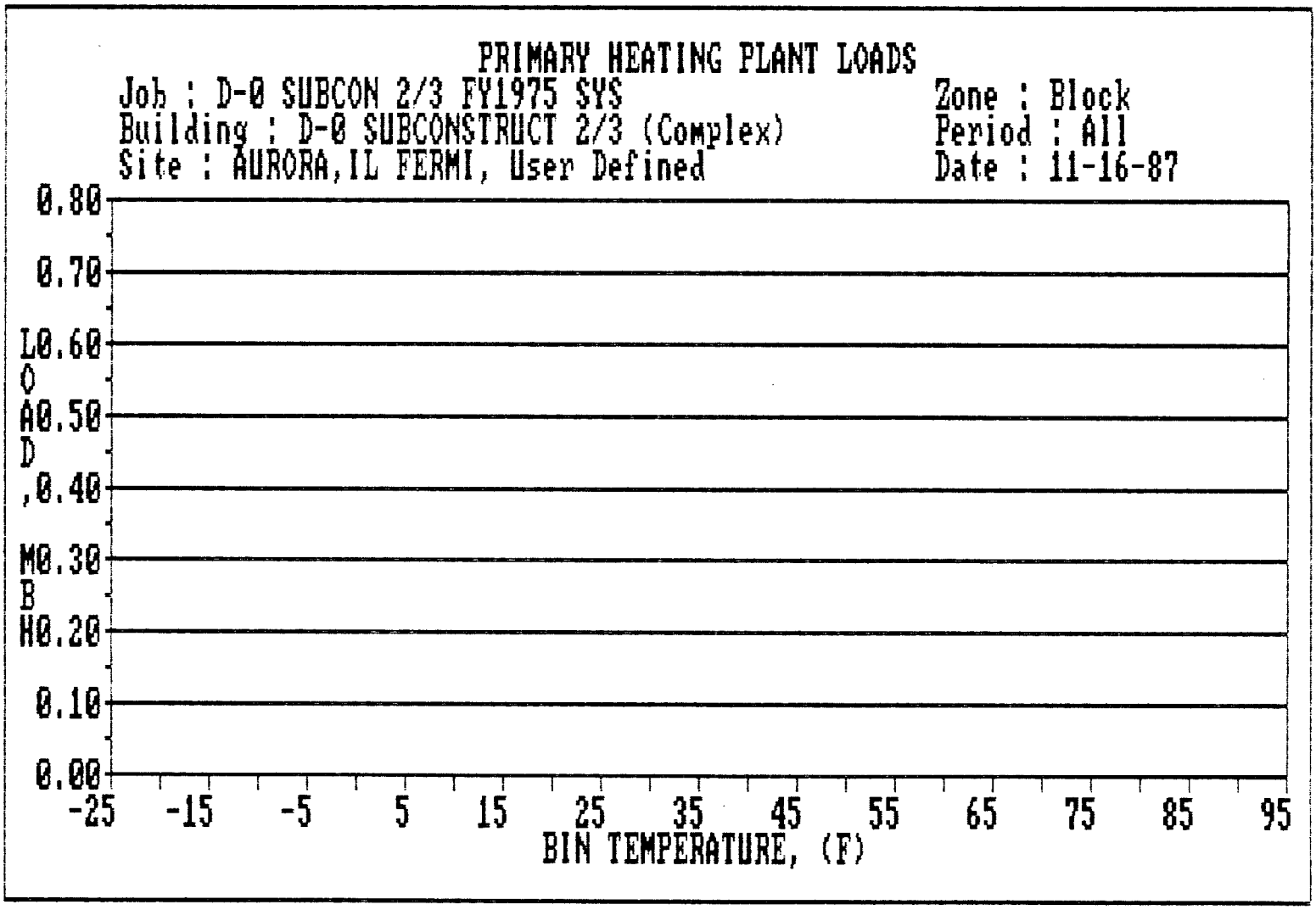
Date : 11-16-87
Serial Number:
60117862.0

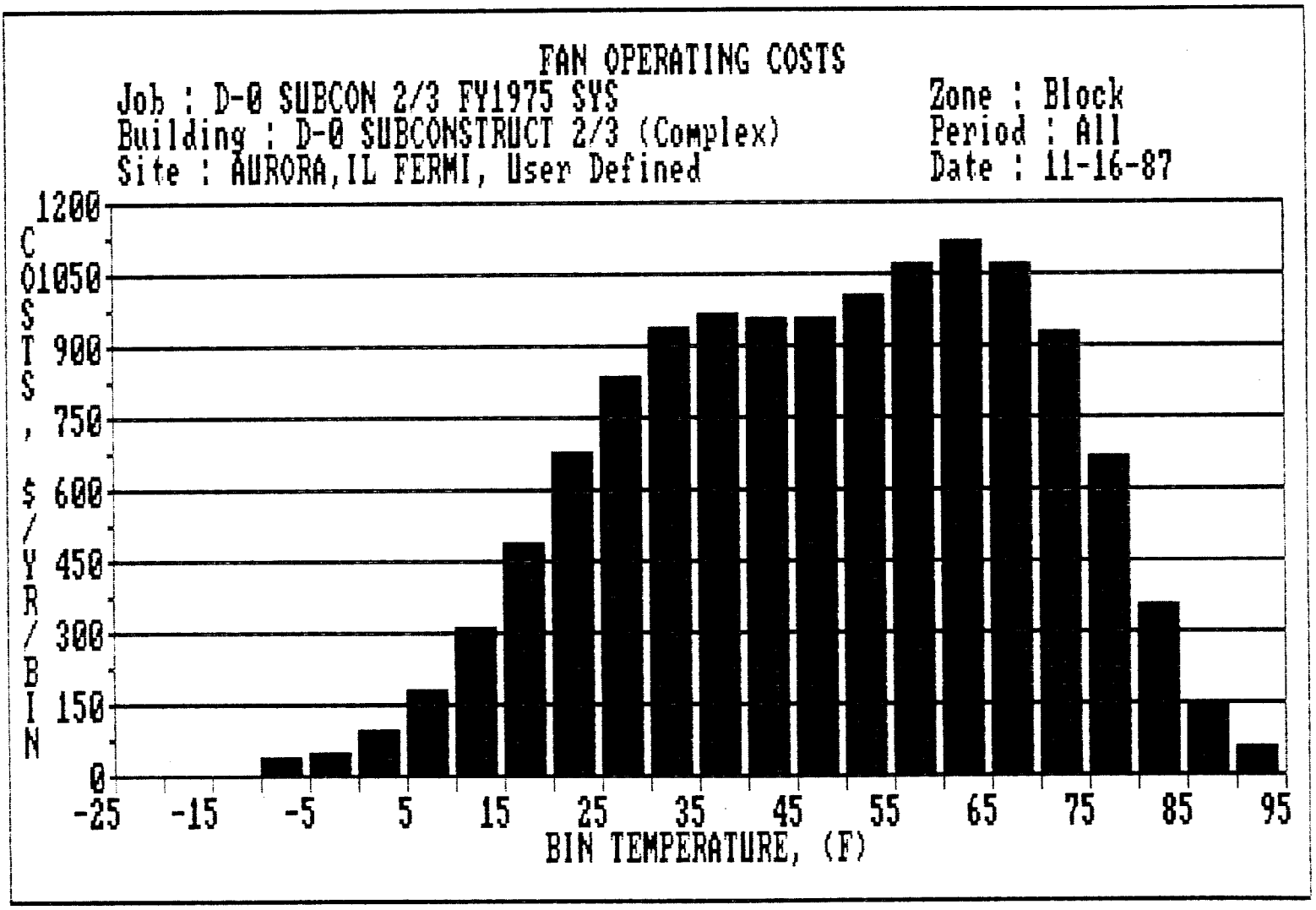
Bin Temp (F)	Bin Hours hr/yr	Perimeter Fans Input KW	Perimeter Fans Cost $/yr	Interior Fans Input KW	Interior Fans Cost $/yr	All Pumps Input KW	All Pumps Cost $/yr
OCCUPIED PERIOD							
90	25.8	29.3	37.8	0.1	0.2	30.3	39.0
85	59.4	29.3	87.0	0.1	0.4	30.3	89.9
80	145.3	29.3	212.8	0.1	1.0	30.3	219.9
75	237.7	29.3	348.0	0.1	1.6	30.3	359.7
70	270.6	29.3	396.2	0.1	1.8	30.3	409.5
65	264.5	29.3	387.3	0.1	1.8	30.3	400.3
60	255.0	29.3	373.4	0.1	1.7	30.3	385.9
55	244.7	29.3	358.3	0.1	1.6	30.3	370.3
50	232.1	29.3	339.8	0.1	1.5	30.3	351.3
45	229.5	29.3	336.0	0.1	1.5	30.3	347.3
40	237.6	29.3	347.9	0.1	1.6	30.3	359.6
35	238.5	29.3	349.2	0.1	1.6	30.3	360.9
30	218.2	29.3	319.5	0.1	1.5	30.3	330.2
25	174.5	29.3	255.5	0.1	1.2	30.3	264.1
20	122.4	29.3	179.2	0.1	0.8	30.3	185.2
15	78.1	29.3	114.4	0.1	0.5	30.3	118.2
10	46.1	29.3	67.5	0.1	0.3	30.3	69.8
5	25.1	29.3	36.8	0.1	0.2	30.3	38.0
0	12.7	29.3	18.6	0.1	0.1	30.3	19.2
-5	6.2	29.3	9.1	0.1	0.0	30.3	9.4
-6	4.6	29.3	6.7	0.1	0.0	30.3	7.0
Total Costs			$4581.0		$20.8		$4734.8
UNOCCUPIED PERIOD							
90	14.6	29.3	21.4	0.1	0.1	30.3	22.1
85	36.3	29.3	53.2	0.1	0.2	30.3	54.9
80	99.3	29.3	145.4	0.1	0.7	30.3	150.3
75	215.3	29.3	315.2	0.1	1.4	30.3	325.8
70	357.6	29.3	523.6	0.1	2.4	30.3	541.2
65	463.3	29.3	678.4	0.1	3.1	30.3	701.1
60	500.4	29.3	732.7	0.1	3.3	30.3	757.3
55	482.0	29.3	705.8	0.1	3.2	30.3	729.4
50	447.6	29.3	655.4	0.1	3.0	30.3	677.4
45	422.7	29.3	618.9	0.1	2.8	30.3	639.7
40	413.7	29.3	605.7	0.1	2.8	30.3	626.1
35	417.0	29.3	610.6	0.1	2.8	30.3	631.1
30	417.4	29.3	611.2	0.1	2.8	30.3	631.7
25	395.2	29.3	578.7	0.1	2.6	30.3	598.1
20	336.9	29.3	493.3	0.1	2.2	30.3	509.9
15	252.8	29.3	370.2	0.1	1.7	30.3	382.6
10	165.7	29.3	242.6	0.1	1.1	30.3	250.8
5	96.3	29.3	141.0	0.1	0.6	30.3	145.7
0	50.9	29.3	74.5	0.1	0.3	30.3	77.0
-5	25.3	29.3	37.0	0.1	0.2	30.3	38.3
-6	21.1	29.3	30.9	0.1	0.1	30.3	31.9
Total Costs			$8245.6		$37.5		$8522.4


COOLING COIL LOADS
Job : D-0 SUBCON 2/3 FY1975 SYS
Building : D-0 SUBCONSTRUCT 2/3 (Complex)
Site : AURORA,IL FERMI, User Defined
Zone : Block
Period : All
Date : 11-16-87
4000
3500
L3000
O
A2500
D
,2000
M1500
B
H1000
500
0
-25
-15
-5
5
15
25
35
45
55
65
75
85
95
BIN TEMPERATURE, (F)


COOLING PLANT INPUT POWER
Job : D-0 SUBCON 2/3 FY1975 SYS
Building : D-0 SUBCONSTRUCT 2/3 (Complex)
Site : AURORA,IL FERMI, User Defined
Zone : Block
Period : All
Date : 11-16-87
POWER, KW
400
350
300
250
200
150
100
50
0
-25
-15
-5
5
15
25
35
45
55
65
75
85
95
BIN TEMPERATURE, (F)


COOLING PLANT OPERATING COSTS
Job : D-0 SUBCON 2/3 FY1975 SYS
Building : D-0 SUBCONSTRUCT 2/3 (Complex)
Site : AURORA,IL FERMI, User Defined
Zone : Block
Period : All
Date : 11-16-87
4000
C3500
O
$3000
T
,2500
$2000
/
Y1500
R
/1000
B
I 500
N
0
-25
-15
-5
5
15
25
35
45
55
65
75
85
95
BIN TEMPERATURE, (F)


PRIMARY HEATING PLANT LOADS
Job : D-0 SUBCON 2/3 FY1975 SYS
Building : D-0 SUBCONSTRUCT 2/3 (Complex)
Site : AURORA,IL FERMI, User Defined
Zone : Block
Period : All
Date : 11-16-87
0.80
0.70
L0.60
O
A0.50
D
,0.40
M0.30
B
H0.20
0.10
0.00
-25 -15 -5 5 15 25 35 45 55 65 75 85 95
BIN TEMPERATURE, (F)


FAN OPERATING COSTS
Job : D-0 SUBCON 2/3 FY1975 SYS
Building : D-0 SUBCONSTRUCT 2/3 (Complex)
Site : AURORA,IL FERMI, User Defined
Zone : Block
Period : All
Date : 11-16-87
COSTS, $/YR/BIN
1200
1050
900
750
600
450
300
150
0
-25
-15
-5
5
15
25
35
45
55
65
75
85
95
BIN TEMPERATURE, (F)

VI-a.

FERMILAB D-O EXPERIMENTAL FACILITY

SUBCONSTRUCTION 3/3 - LCW COOLING SYSTEMS
BUILDING SECTOR PHYSICAL PARAMETERS AND DESCRIPTION

31 OCTOBER, 1987
ANALYST: S.F.KRSTULOVICH

FERMILAB CONSTRUCTION ENGINEERING SERVICES

COMPLEX BUILDING INPUT SUMMARY

Building Name : D-0 SUBCONSTRUCT 3/3 Date : 11-16-87
Site : AURORA,IL FERMI, User Defined 60117862.0

****

1. ROOM CONDITIONS AND FLOOR AREAS

Thermostat settings : Cooling = 92 F; Heating = 91 F; Setback = 0 F
Warm-up factor = 0 %; Room design relative humidity = 50 %
Floor Areas: Perimeter = 1 Sqft; Interior = 0 Sqft
Cooling provided during unoccupied period.

---

2. WALLS, ROOF, GLASS, SKYLIGHTS:

Exposure	Area (Sqft)	U-Factor BTU/(hr-sqft-F)	Glass Area (Sqft)	Glass U-Factor BTU/(hr-sqft-F)
North Wall	0	0.150	0	1.130
Northeast Wall	0	0.150	0	1.130
East Wall	0	0.150	0	1.130
Southeast Wall	0	0.150	0	1.130
South Wall	0	0.150	0	1.130
Southwest Wall	0	0.150	0	1.130
West Wall	0	0.150	0	1.130
Northwest Wall	0	0.150	0	1.130
Perimeter Roof	0	0.130	0	0.550
Interior Roof	0	0.130	0	0.550

WALLS: Color = Dark; Wt. = Medium; ROOF: Color = Medium; Wt. = Medium
BUILDING WT. = Medium; VERTICAL GLASS : Single Glazed
Shade Factors : Glass = 1.000 ; Skylights = 0.000
Internal shades are not used. ; A ceiling plenum is not used.

---

3. LIGHTS:

Perimeter : 0.000 Watts/Sqft = 0 Watts Total
Interior : 0.000 Watts/Sqft = 0 Watts Total
Diversity Factors : Occupied = 0 %; Unoccupied = 0 %
Perimeter Lights : Ballast , exposed
Interior Lights : Ballast , recessed

---

4. MISCELLANEOUS ELECTRICAL LOADS:

Perimeter : Occupied = %600000.000 Watts/Sqft = 600,000 Watts Tota
l
Unoccupied = %200000.000 Watts/Sqft = 200,000 Watts Tota
l
Interior : Occupied = 0.000 Watts/Sqft = 0 Watts Total
Unoccupied = 0.000 Watts/Sqft = 0 Watts Total

---

5. PEOPLE LOADS

Total Occupancy = 0 sqft/person = 0 people total
Activity Level: 6. User defined activity level
Sensible = 0.0 BTU/hr/person; Latent = 0.0 BTU/hr/person
Diversity Factors : Occupied = 0 %; Unoccupied = 0 %

---

6. MISCELLANEOUS INTERNAL LOADS:

Sensible : Occupied = 0 BTU/hr; Unoccupied = 0 BTU/hr
Latent : Occupied = 0 BTU/hr; Unoccupied = 0 BTU/hr

---

7. WALLS ADJACENT TO NON-CONDITIONED REGIONS:

Wall Areas : Perimeter = 0 Sqft; Interior = 0 Sqft
Wall U-Factor = 0.000 BTU/(hr-sqft-F)
Adjacent region is not heated
Adjacent region is not cooled

---

8. INFILTRATION DATA:

Air Flow Rates: Occupied = 0 cfm; Unoccupied = 0 cfm

VI-b.

FERMILAB D-0 EXPERIMENTAL FACILITY

SUBCONSTRUCTION 3/3 - LCW COOLING SYSTEMS
BUILDING LOAD CALCULATIONS

31 OCTOBER, 1987
ANALYST: S.F.KRSTULOVICH

FERMILAB CONSTRUCTION ENGINEERING SERVICES

LOAD PROFILE SUMMARY

Building Name : D-0 SUBCONSTRUCT 3/3 (Complex) Date : 11-16-87

Site Name : AURORA,IL FERMI, User Defined 60117862.0

****

TABLE 1. OCCUPIED PERIOD (Load does not include vent. load, fan heat)

Bin Temp (F)	Bin Hours (hr/yr)	<-------Perimeter Zone------> Sensible (tons)	Latent (tons)	Plenum (tons)	Zone (F)	<--------Interior Zone-----> Sensible (tons)	Latent (tons)	Plenum (tons)	Zone (F)
93	0.0	170.65	0.00	0.00	92	0.00	0.00	0.00	--
90	25.8	170.65	0.00	0.00	92	0.00	0.00	0.00	--
85	59.4	170.65	0.00	0.00	92	0.00	0.00	0.00	--
80	145.3	170.65	0.00	0.00	92	0.00	0.00	0.00	--
75	237.7	170.65	0.00	0.00	92	0.00	0.00	0.00	--
70	270.6	170.65	0.00	0.00	92	0.00	0.00	0.00	--
65	264.5	170.65	0.00	0.00	92	0.00	0.00	0.00	--
60	255.0	170.65	0.00	0.00	92	0.00	0.00	0.00	--
55	244.7	170.65	0.00	0.00	92	0.00	0.00	0.00	--
50	232.1	170.65	0.00	0.00	92	0.00	0.00	0.00	--
45	229.5	170.65	0.00	0.00	92	0.00	0.00	0.00	--
40	237.6	170.65	0.00	0.00	92	0.00	0.00	0.00	--
35	238.5	170.65	0.00	0.00	92	0.00	0.00	0.00	--
30	218.2	170.65	0.00	0.00	92	0.00	0.00	0.00	--
25	174.5	170.65	0.00	0.00	92	0.00	0.00	0.00	--
20	122.4	170.65	0.00	0.00	92	0.00	0.00	0.00	--
15	78.1	170.65	0.00	0.00	92	0.00	0.00	0.00	--
10	46.1	170.65	0.00	0.00	92	0.00	0.00	0.00	--
5	25.1	170.65	0.00	0.00	92	0.00	0.00	0.00	--
0	12.7	170.65	0.00	0.00	92	0.00	0.00	0.00	--
-5	6.2	170.65	0.00	0.00	92	0.00	0.00	0.00	--
-6	4.6	170.65	0.00	0.00	92	0.00	0.00	0.00	--

TABLE 2. UNOCCUPIED PERIOD (Load does not include vent. load, fan heat)

90	14.6	56.88	0.00	0.00	92	0.00	0.00	0.00	--
85	36.3	56.88	0.00	0.00	92	0.00	0.00	0.00	--
80	99.3	56.88	0.00	0.00	92	0.00	0.00	0.00	--
75	215.3	56.88	0.00	0.00	92	0.00	0.00	0.00	--
70	357.6	56.88	0.00	0.00	92	0.00	0.00	0.00	--
65	463.3	56.88	0.00	0.00	92	0.00	0.00	0.00	--
60	500.4	56.88	0.00	0.00	92	0.00	0.00	0.00	--
55	482.0	56.88	0.00	0.00	92	0.00	0.00	0.00	--
50	447.6	56.88	0.00	0.00	92	0.00	0.00	0.00	--
45	422.7	56.88	0.00	0.00	92	0.00	0.00	0.00	--
40	413.7	56.88	0.00	0.00	92	0.00	0.00	0.00	--
35	417.0	56.88	0.00	0.00	92	0.00	0.00	0.00	--
30	417.4	56.88	0.00	0.00	92	0.00	0.00	0.00	--
25	395.2	56.88	0.00	0.00	92	0.00	0.00	0.00	--
20	336.9	56.88	0.00	0.00	92	0.00	0.00	0.00	--
15	252.8	56.88	0.00	0.00	92	0.00	0.00	0.00	--
10	165.7	56.88	0.00	0.00	92	0.00	0.00	0.00	--
5	96.3	56.88	0.00	0.00	92	0.00	0.00	0.00	--
0	50.9	56.88	0.00	0.00	92	0.00	0.00	0.00	--
-5	25.3	56.88	0.00	0.00	92	0.00	0.00	0.00	--
-6	21.1	56.88	0.00	0.00	92	0.00	0.00	0.00	--
-6	0.0	0.00	0.00	0.00	91	0.00	0.00	0.00	--

VI-c.

FERMILAB D-O EXPERIMENTAL FACILITY

SUBCONSTRUCTION 3/3 - LCW COOLING SYSTEMS
SYSTEM COMPARISON PERFORMANCE SIMULATIONS

31 OCTOBER, 1987
ANALYST: S.F.KRSTULOVICH

FERMILAB CONSTRUCTION ENGINEERING SERVICES

VI-c.-1.

FERMILAB D-O EXPERIMENTAL FACILITY

SUBCONSTRUCTION 3/3 - LCW COOLING SYSTEMS
OPERATIONAL PERFORMANCE SIMULATION

DESIGN BASIS SYSTEM
HYDRONIC FREE COOLING HEAT EXCHANGER
WITH THESE ENERGY FEATURES:
LAKE COOLING WATER, LAKE WATER FILTERS, HIGH EFFICIENCY MOTORS,
AUTOMATIC LAKE WATER PUMP STAGING

31 OCTOBER, 1987
ANALYST: S.F.KRSTULOVICH

FERMILAB CONSTRUCTION ENGINEERING SERVICES

SYSTEM INPUT SUMMARY

Job Name : D-0 SUBCON 3/3 DESIGN SYS Page 1
Building Name : D-0 SUBCONSTRUCT 3/3 (Complex) Date : 11-16-87
Site : AURORA,IL FERMI, User Defined 60117862.0
Scope of Analysis : Cooling Systems Only

****

A. AIR HANDLING SYSTEMS

>1. PERIMETER TERMINAL TYPE : CONSTANT VOLUME

Supply fan type : Forward curved

Supply fan total static pressure = 0.01 in. wg.

A return fan is not used.

Design supply air= 50315 cfm @ 55 F; Vent. air= 0 cfm

Are cooling terminals used for heating ? <Y>

An economizer is not used.

Is a ventilation reclaim device used ? <N>

Are ventilation air dampers closed for unoccupied periods ? <N>

****

B. HEATING PLANTS

> 1 . PERIMETER PLANT : ELECTRICAL RESISTANCE

Is hydronic heating used ? <N>

****

****

C. COOLING PLANTS

>1. PERIMETER PLANT : REMOTE SOURCE COOLING
Is hydronic cooling used ? <Y>
Is chilled water reset used ? <N>

****

D. PUMPING SYSTEMS

System	PERIMETER dT, F	PERIMETER dP, ft wg	dT, F	dP, ft wg
Chilled water	20.00	150.00	0.00	0.00
Hot water	0.00	0.00	0.00	0.00
Condenser water	0.00	0.00	0.00	0.00
Ground water	0.00	0.00	0.00	0.00

****

E. NON-HVAC SYSTEMS

>1. NON-HVAC ELECTRICAL ENERGY USE

Lighting kw: Occupied = 0.0 kw; Unoccupied = 0.0 kw
Misc. kw : Occupied = 600.0 kw; Unoccupied = 200.0 kw
Other kw : Occupied = 0.0 kw; Unoccupied = 0.0 kw

>2. DHW SYSTEM (Not utilized in this system)

****

F. FUEL COSTS

>1. ELECTRICAL ENERGY USE	Period Occupied ($/kwh)	Period Unoccupied ($/kwh)
Compressor	0.050	0.050
Resistance	0.050	0.050
Inductive	0.050	0.050

>2. OTHER FUELS	Unit Cost
Natural Gas	n/a $/therm
Fuel Oil	n/a $/U.S.gal
Propane	n/a $/lb
Remote Heating	n/a $/MBTU
Remote Cooling	0.000 $/MBTU

TOTAL BUILDING ENERGY SUMMARY

Job Name : D-0 SUBCON 3/3 DESIGN SYS — Period : All
Building Name : D-0 SUBCONSTRUCT 3/3 (Complex) — Zone : Block
Site : AURORA,IL FERMI, User Defined — Serial Number:
Date : 11-16-87 — 60117862.0

****

HVAC ENERGY Component	Annual Cost ($/yr)	Energy or Fuel Units Consumed	DOE RUF (1000 BTU)	DOE RIF (1000 BTU)
Electric (Occ)	1200	24002 kwh/yr	278424	81919
Electric (Unocc)	2160	43203 kwh/yr	501155	147452
Natural Gas	0	0 therms/yr	0	0
Fuel Oil	0	0 U.S. gal/yr	0	0
Propane	0	0 lb/yr	0	0
Remote Heating	0	0 MBTU/yr	0	0
Remote Cooling	0	0 MBTU/yr	0	0
HVAC Total	3360		779579	229371
NON-HVAC ENERGY				
Electric (Occ)	93858	1877160 kwh/yr	21775057	6406747
Electric (Unocc)	56314	1126280 kwh/yr	13064848	3843994
Non-HVAC Total	150172		34839905	10250741
Grand Total	153532		35619484	10480112
Total/Sq.Ft.	%153532.26		%35619484.10	%10480111.99

HVAC Summary:

HVAC Total Cost = 3360.25 $/Sq.Ft./yr
= 2.19 % of Total Cost
Total HVAC Electrical Energy = %67205.08 kwh/Sq.Ft./yr
= 2.19 % of Total Electrical Energy
Non-Electrical HVAC Energy = 0.00 % of Total Energy

Key:

1 kwh = 11600 BTU RUF; 3412 BTU RIF
1 therm nat gas = 100000 BTU RUF and RIF
1 U.S. gal oil = 138700 BTU RUF and RIF
1 Imp. gal oil = 168000 BTU RUF and RIF
1 lb propane = 21680 BTU RUF and RIF
RUF = Resource utilization factor (Source value)
RIF = Resource impact factor (Point of use value)
MBH = 1000 BTU/hr
MBTU = Million BTU

ANNUAL OPERATING COSTS

Job Name : D-0 SUBCON 3/3 DESIGN SYS Page 1
Building Name : D-0 SUBCONSTRUCT 3/3 (Complex) Date : 11-16-87
Site : AURORA,IL FERMI, User Defined 60117862.0
Scope of Analysis : Cooling Systems Only

****

A. AIR HANDLING SYSTEMS (ANNUAL FAN OPERATING COST = $48)

>1. PERIMETER TERMINAL TYPE : CONSTANT VOLUME

Supply fan type : Forward curved

Supply fan total static pressure = 0.01 in. wg.

A return fan is not used.

Design supply air= 50315 cfm @ 55 F; Vent. air= 0 cfm

Are cooling terminals used for heating ? <Y>

An economizer is not used.

Is a ventilation reclaim device used ? <N>

Are ventilation air dampers closed for unoccupied periods ? <N>

****

B. HEATING PLANTS (ANNUAL HEATING PLANT OPERATING COST = $0)

> 1 . PERIMETER PLANT : ELECTRICAL RESISTANCE

Is hydronic heating used ? <N>

****

****

C. COOLING PLANTS (ANNUAL COOLING PLANT OPERATING COST = $0)

>1. PERIMETER PLANT : REMOTE SOURCE COOLING
Is hydronic cooling used ? <Y>
Is chilled water reset used ? <N>

****

D. PUMPING SYSTEMS (ANNUAL PUMP OPERATING COST = $3,312)

System	PERIMETER dT, F	PERIMETER dP, ft wg	dT, F	dP, ft wg
Chilled water	20.00	150.00	0.00	0.00
Hot water	0.00	0.00	0.00	0.00
Condenser water	0.00	0.00	0.00	0.00
Ground water	0.00	0.00	0.00	0.00

****

E. NON-HVAC SYSTEMS (ANNUAL NON-HVAC OPERATING COST = $150,172)

>1. NON-HVAC ELECTRICAL ENERGY USE

Lighting kw: Occupied = 0.0 kw; Unoccupied = 0.0 kw
Misc. kw : Occupied = 600.0 kw; Unoccupied = 200.0 kw
Other kw : Occupied = 0.0 kw; Unoccupied = 0.0 kw

>2. DHW SYSTEM (Not utilized in this system)

****

F. FUEL COSTS (GRAND TOTAL ANNUAL OPERATING COST = $153,532)

>1. ELECTRICAL ENERGY USE	Period Occupied ($/kwh)	Period Unoccupied ($/kwh)
Compressor	0.050	0.050
Resistance	0.050	0.050
Inductive	0.050	0.050

>2. OTHER FUELS	Unit Cost
Natural Gas	n/a $/therm
Fuel Oil	n/a $/U.S.gal
Propane	n/a $/lb
Remote Heating	n/a $/MBTU
Remote Cooling	0.000 $/MBTU

COOLING PLANT COSTS

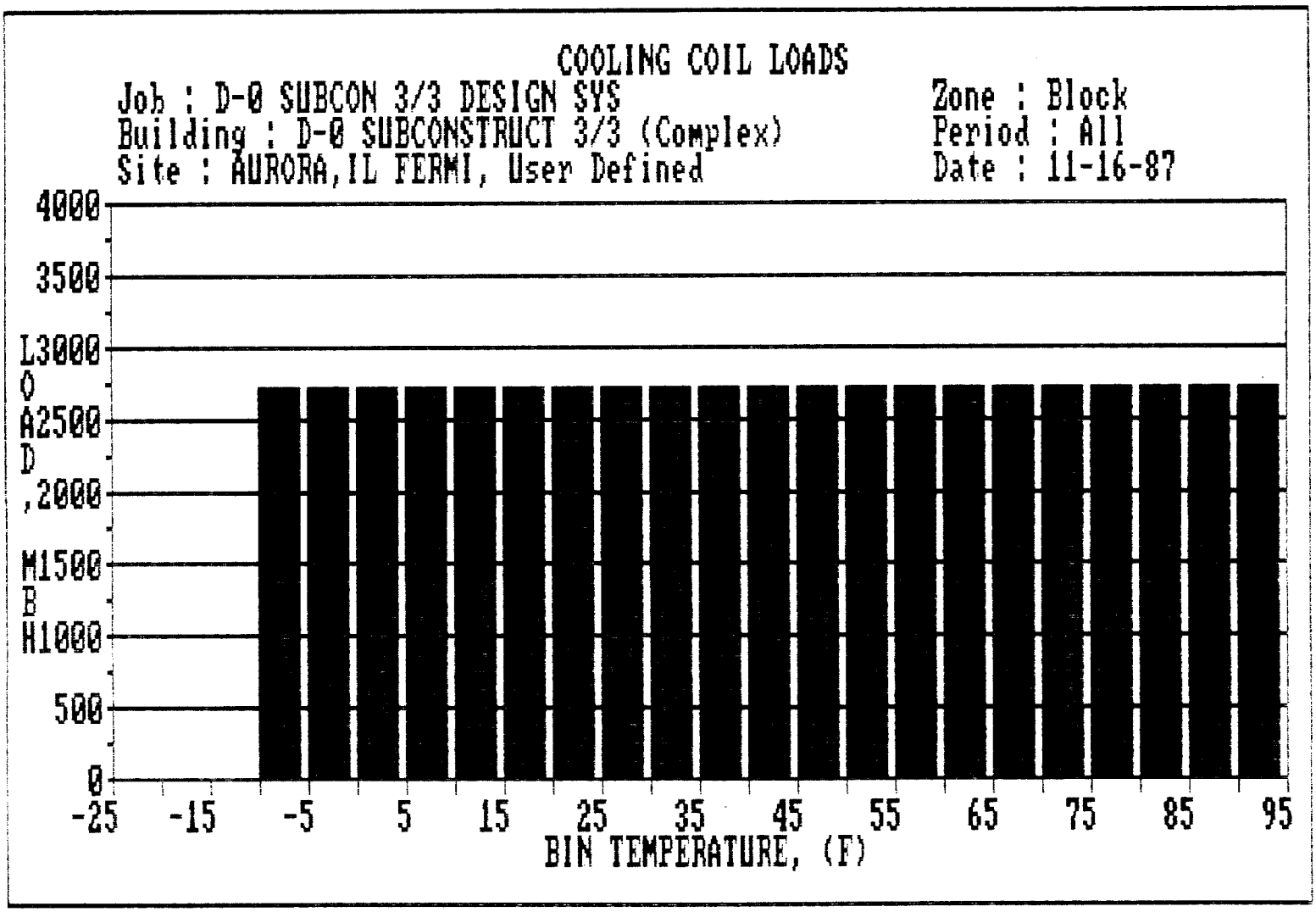
Job Name : D-O SUBCON 3/3 DESIGN SYS — Date : 11-16-87
Building Name : D-O SUBCONSTRUCT 3/3 (Complex) — Serial Number:
Site Name : AURORA,IL FERMI, User Defined — 60117862.0

Bin Temp (F)	Bin Hours hr/yr	Perimeter Cooling Plant Coil Load MBH	Input MBH	Cost $/yr	No Interior Zone Exists
				OCCUPIED PERIOD	
90	25.8	2048.2	2048.2	0.0	
85	59.4	2048.2	2048.2	0.0	
80	145.3	2048.2	2048.2	0.0	
75	237.7	2048.2	2048.2	0.0	
70	270.6	2048.2	2048.2	0.0	
65	264.5	2048.2	2048.2	0.0	
60	255.0	2048.2	2048.2	0.0	
55	244.7	2048.2	2048.2	0.0	
50	232.1	2048.2	2048.2	0.0	
45	229.5	2048.2	2048.2	0.0	
40	237.6	2048.2	2048.2	0.0	
35	238.5	2048.2	2048.2	0.0	
30	218.2	2048.2	2048.2	0.0	
25	174.5	2048.2	2048.2	0.0	
20	122.4	2048.2	2048.2	0.0	
15	78.1	2048.2	2048.2	0.0	
10	46.1	2048.2	2048.2	0.0	
5	25.1	2048.2	2048.2	0.0	
0	12.7	2048.2	2048.2	0.0	
-5	6.2	2048.2	2048.2	0.0	
-6	4.6	2048.2	2048.2	0.0	
Total Costs				$0.0	
				UNOCCUPIED PERIOD	
90	14.6	683.0	683.0	0.0	
85	36.3	683.0	683.0	0.0	
80	99.3	683.0	683.0	0.0	
75	215.3	683.0	683.0	0.0	
70	357.6	683.0	683.0	0.0	
65	463.3	683.0	683.0	0.0	
60	500.4	683.0	683.0	0.0	
55	482.0	683.0	683.0	0.0	
50	447.6	683.0	683.0	0.0	
45	422.7	683.0	683.0	0.0	
40	413.7	683.0	683.0	0.0	
35	417.0	683.0	683.0	0.0	
30	417.4	683.0	683.0	0.0	
25	395.2	683.0	683.0	0.0	
20	336.9	683.0	683.0	0.0	
15	252.8	683.0	683.0	0.0	
10	165.7	683.0	683.0	0.0	
5	96.3	683.0	683.0	0.0	
0	50.9	683.0	683.0	0.0	
-5	25.3	683.0	683.0	0.0	
-6	21.1	683.0	683.0	0.0	
Total Costs				$0.0	

FAN AND PUMP COSTS

Job Name : D-0 SUBCON 3/3 DESIGN SYS — Date : 11-16-87
Building Name : D-0 SUBCONSTRUCT 3/3 (Complex) — Serial Number:
Site Name : AURORA,IL FERMI, User Defined — 60117862.0

Bin Temp (F)	Bin Hours hr/yr	Perimeter Input KW	Perimeter Fans Cost $/yr	No Interior Zone	All Pumps Input KW	All Pumps Cost $/yr
			OCCUPIED PERIOD			
90	25.8	0.1	0.1		7.6	9.8
85	59.4	0.1	0.3		7.6	22.5
80	145.3	0.1	0.8		7.6	54.9
75	237.7	0.1	1.3		7.6	89.9
70	270.6	0.1	1.5		7.6	102.3
65	264.5	0.1	1.4		7.6	100.0
60	255.0	0.1	1.4		7.6	96.4
55	244.7	0.1	1.3		7.6	92.5
50	232.1	0.1	1.3		7.6	87.8
45	229.5	0.1	1.3		7.6	86.8
40	237.6	0.1	1.3		7.6	89.8
35	238.5	0.1	1.3		7.6	90.2
30	218.2	0.1	1.2		7.6	82.5
25	174.5	0.1	1.0		7.6	66.0
20	122.4	0.1	0.7		7.6	46.3
15	78.1	0.1	0.4		7.6	29.5
10	46.1	0.1	0.3		7.6	17.4
5	25.1	0.1	0.1		7.6	9.5
0	12.7	0.1	0.1		7.6	4.8
-5	6.2	0.1	0.0		7.6	2.3
-6	4.6	0.1	0.0		7.6	1.7
Total Costs			$17.1			$1183.0
			UNOCCUPIED PERIOD			
90	14.6	0.1	0.1		7.6	5.5
85	36.3	0.1	0.2		7.6	13.7
80	99.3	0.1	0.5		7.6	37.5
75	215.3	0.1	1.2		7.6	81.4
70	357.6	0.1	2.0		7.6	135.2
65	463.3	0.1	2.5		7.6	175.2
60	500.4	0.1	2.7		7.6	189.2
55	482.0	0.1	2.6		7.6	182.3
50	447.6	0.1	2.4		7.6	169.3
45	422.7	0.1	2.3		7.6	159.8
40	413.7	0.1	2.3		7.6	156.4
35	417.0	0.1	2.3		7.6	157.7
30	417.4	0.1	2.3		7.6	157.8
25	395.2	0.1	2.2		7.6	149.4
20	336.9	0.1	1.8		7.6	127.4
15	252.8	0.1	1.4		7.6	95.6
10	165.7	0.1	0.9		7.6	62.7
5	96.3	0.1	0.5		7.6	36.4
0	50.9	0.1	0.3		7.6	19.2
-5	25.3	0.1	0.1		7.6	9.6
-6	21.1	0.1	0.1		7.6	8.0
Total Costs			$30.7			$2129.4


COOLING COIL LOADS
Job : D-0 SUBCON 3/3 DESIGN SYS
Building : D-0 SUBCONSTRUCT 3/3 (Complex)
Site : AURORA,IL FERMI, User Defined
Zone : Block
Period : All
Date : 11-16-87
4000
3500
L3000
O
A2500
D
,2000
M1500
B
H1000
500
0
-25
-15
-5
5
15
25
35
45
55
65
75
85
95
BIN TEMPERATURE, (F)

VI-c.2.

FERMILAB D-0 EXPERIMENTAL FACILITY

SUBCONSTRUCTION 3/3 - LCW COOLING SYSTEMS
OPERATIONAL PERFORMANCE SIMULATION

ALTERNATE COMPARISON SYSTEM
TYPICAL FY1975 DESIGN - BASIC SYSTEM
HYDRONIC FREE COOLING HEAT EXCHANGER
WITHOUT ENERGY FEATURES - POND WATER COOLING

31 OCTOBER, 1987
ANALYST: S.F.KRSTULOVICH

FERMILAB CONSTRUCTION ENGINEERING SERVICES

SYSTEM INPUT SUMMARY

Job Name : D-O SUBCON 3/3 FY1975 SYS — Page 1
Building Name : D-O SUBCONSTRUCT 3/3 (Complex) — Date : 11-16-87
Site : AURORA,IL FERMI, User Defined — 60117862.0
Scope of Analysis : Cooling Systems Only

****

A. AIR HANDLING SYSTEMS

>1. PERIMETER TERMINAL TYPE : CONSTANT VOLUME

Supply fan type : Forward curved

Supply fan total static pressure = 0.01 in. wg.

A return fan is not used.

Design supply air= 50315 cfm @ 55 F; Vent. air= 0 cfm

Are cooling terminals used for heating ? <Y>

An economizer is not used.

Is a ventilation reclaim device used ? <N>

Are ventilation air dampers closed for unoccupied periods ? <N>

****

B. HEATING PLANTS

> 1 . PERIMETER PLANT : ELECTRICAL RESISTANCE

Is hydronic heating used ? <N>

****

****

C. COOLING PLANTS

>1. PERIMETER PLANT : REMOTE SOURCE COOLING
Is hydronic cooling used ? <Y>
Is chilled water reset used ? <N>

****

D. PUMPING SYSTEMS

System	PERIMETER dT, F	PERIMETER dP, ft wg	dT, F	dP, ft wg
Chilled water	20.00	240.00	0.00	0.00
Hot water	0.00	0.00	0.00	0.00
Condenser water	0.00	0.00	0.00	0.00
Ground water	0.00	0.00	0.00	0.00

****

E. NON-HVAC SYSTEMS

>1. NON-HVAC ELECTRICAL ENERGY USE

Lighting kw:	Occupied =	0.0 kw;	Unoccupied =	0.0 kw
Misc. kw :	Occupied =	600.0 kw;	Unoccupied =	200.0 kw
Other kw :	Occupied =	0.0 kw;	Unoccupied =	0.0 kw

>2. DHW SYSTEM (Not utilized in this system)

****

F. FUEL COSTS

>1. ELECTRICAL ENERGY USE	Period Occupied ($/kwh)	Period Unoccupied ($/kwh)
Compressor	0.050	0.050
Resistance	0.050	0.050
Inductive	0.050	0.050

>2. OTHER FUELS	Unit Cost
Natural Gas	n/a $/therm
Fuel Oil	n/a $/U.S.gal
Propane	n/a $/lb
Remote Heating	n/a $/MBTU
Remote Cooling	0.000 $/MBTU

TOTAL BUILDING ENERGY SUMMARY

Job Name : D-O SUBCON 3/3 FY1975 SYS — Period : All
Building Name : D-O SUBCONSTRUCT 3/3 (Complex) — Zone : Block
Site : AURORA,IL FERMI, User Defined — Serial Number:
Date : 11-16-87 — 60117862.0

****

HVAC ENERGY Component	Annual Cost ($/yr)	Energy or Fuel Units Consumed	DOE RUF (1000 BTU)	DOE RIF (1000 BTU)
Electric (Occ)	1910	38198 kwh/yr	443101	130371
Electric (Unocc)	3438	68756 kwh/yr	797571	234665
Natural Gas	0	0 therms/yr	0	0
Fuel Oil	0	0 U.S. gal/yr	0	0
Propane	0	0 lb/yr	0	0
Remote Heating	0	0 MBTU/yr	0	0
Remote Cooling	0	0 MBTU/yr	0	0
HVAC Total	5348		1240672	365036
NON-HVAC ENERGY				
Electric (Occ)	93858	1877160 kwh/yr	21775057	6406747
Electric (Unocc)	56314	1126280 kwh/yr	13064848	3843994
Non-HVAC Total	150172		34839905	10250741
Grand Total	155520		36080577	10615777
Total/Sq.Ft.	%155519.73		%36080577.04	%10615776.66

HVAC Summary:

HVAC Total Cost = 5347.72 $/Sq.Ft./yr
= 3.44 % of Total Cost

Total HVAC Electrical Energy = %106954.47 kwh/Sq.Ft./yr
= 3.44 % of Total Electrical Energy

Non-Electrical HVAC Energy = 0.00 % of Total Energy

Key:

1 kwh = 11600 BTU RUF; 3412 BTU RIF
1 therm nat gas = 100000 BTU RUF and RIF
1 U.S. gal oil = 138700 BTU RUF and RIF
1 Imp. gal oil = 168000 BTU RUF and RIF
1 lb propane = 21680 BTU RUF and RIF
RUF = Resource utilization factor (Source value)
RIF = Resource impact factor (Point of use value)
MBH = 1000 BTU/hr
MBTU = Million BTU

ANNUAL OPERATING COSTS

Job Name : D-0 SUBCON 3/3 FY1975 SYS Page 1
Building Name : D-0 SUBCONSTRUCT 3/3 (Complex) Date : 11-16-87
Site : AURORA,IL FERMI, User Defined 60117862.0
Scope of Analysis : Cooling Systems Only

****

A. AIR HANDLING SYSTEMS (ANNUAL FAN OPERATING COST = $48)

>1. PERIMETER TERMINAL TYPE : CONSTANT VOLUME

Supply fan type : Forward curved

Supply fan total static pressure = 0.01 in. wg.

A return fan is not used.

Design supply air= 50315 cfm @ 55 F; Vent. air= 0 cfm

Are cooling terminals used for heating ? <Y>

An economizer is not used.

Is a ventilation reclaim device used ? <N>

Are ventilation air dampers closed for unoccupied periods ? <N>

****

B. HEATING PLANTS (ANNUAL HEATING PLANT OPERATING COST = $0)

> 1 . PERIMETER PLANT : ELECTRICAL RESISTANCE

Is hydronic heating used ? <N>

****

****

C. COOLING PLANTS (ANNUAL COOLING PLANT OPERATING COST = $0)

>1. PERIMETER PLANT : REMOTE SOURCE COOLING
Is hydronic cooling used ? <Y>
Is chilled water reset used ? <N>

****

D. PUMPING SYSTEMS (ANNUAL PUMP OPERATING COST = $5,300)

System	PERIMETER dT, F	PERIMETER dP, ft wg	dT, F	dP, ft wg
Chilled water	20.00	240.00	0.00	0.00
Hot water	0.00	0.00	0.00	0.00
Condenser water	0.00	0.00	0.00	0.00
Ground water	0.00	0.00	0.00	0.00

****

E. NON-HVAC SYSTEMS (ANNUAL NON-HVAC OPERATING COST = $150,172)

>1. NON-HVAC ELECTRICAL ENERGY USE

Lighting kw: Occupied = 0.0 kw; Unoccupied = 0.0 kw
Misc. kw : Occupied = 600.0 kw; Unoccupied = 200.0 kw
Other kw : Occupied = 0.0 kw; Unoccupied = 0.0 kw

>2. DHW SYSTEM (Not utilized in this system)

****

F. FUEL COSTS (GRAND TOTAL ANNUAL OPERATING COST = $155,520)

>1. ELECTRICAL ENERGY USE	Period Occupied ($/kwh)	Period Unoccupied ($/kwh)
Compressor	0.050	0.050
Resistance	0.050	0.050
Inductive	0.050	0.050

>2. OTHER FUELS	Unit Cost
Natural Gas	n/a $/therm
Fuel Oil	n/a $/U.S.gal
Propane	n/a $/lb
Remote Heating	n/a $/MBTU
Remote Cooling	0.000 $/MBTU

COOLING PLANT COSTS

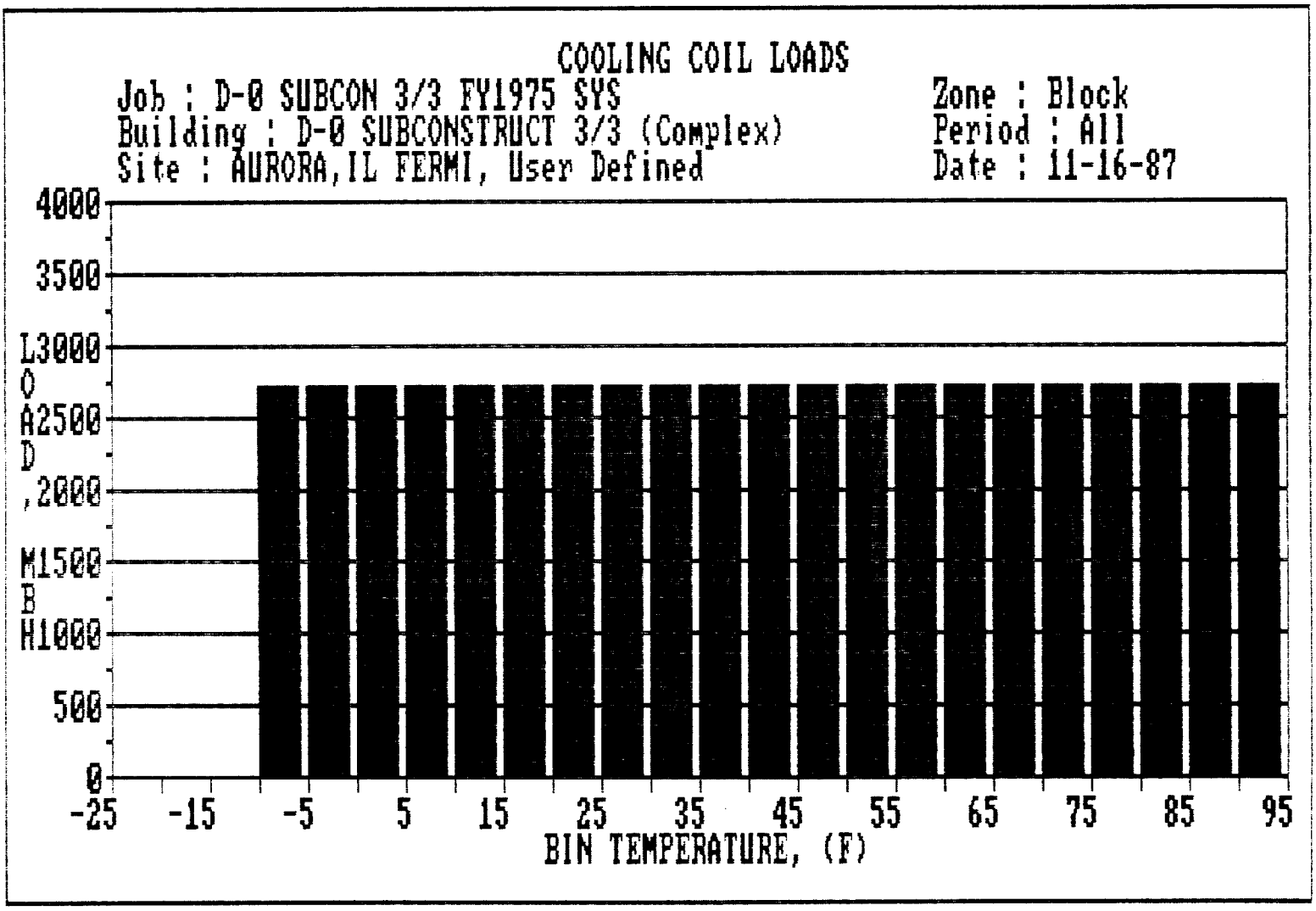
Job Name : D-0 SUBCON 3/3 FY1975 SYS ~ Date : 11-16-87
Building Name : D-0 SUBCONSTRUCT 3/3 (Complex) Serial Number:
Site Name : AURORA,IL FERMI, User Defined 60117862.0

Bin Temp (F)	Bin Hours hr/yr	Perimeter Cooling Plant Coil Load MBH	Input MBH	Cost $/yr	No Interior Zone Exists
			OCCUPIED PERIOD		
90	25.8	2048.2	2048.2	0.0	
85	59.4	2048.2	2048.2	0.0	
80	145.3	2048.2	2048.2	0.0	
75	237.7	2048.2	2048.2	0.0	
70	270.6	2048.2	2048.2	0.0	
65	264.5	2048.2	2048.2	0.0	
60	255.0	2048.2	2048.2	0.0	
55	244.7	2048.2	2048.2	0.0	
50	232.1	2048.2	2048.2	0.0	
45	229.5	2048.2	2048.2	0.0	
40	237.6	2048.2	2048.2	0.0	
35	238.5	2048.2	2048.2	0.0	
30	218.2	2048.2	2048.2	0.0	
25	174.5	2048.2	2048.2	0.0	
20	122.4	2048.2	2048.2	0.0	
15	78.1	2048.2	2048.2	0.0	
10	46.1	2048.2	2048.2	0.0	
5	25.1	2048.2	2048.2	0.0	
0	12.7	2048.2	2048.2	0.0	
-5	6.2	2048.2	2048.2	0.0	
-6	4.6	2048.2	2048.2	0.0	
Total Costs				$0.0	
			UNOCCUPIED PERIOD		
90	14.6	683.0	683.0	0.0	
85	36.3	683.0	683.0	0.0	
80	99.3	683.0	683.0	0.0	
75	215.3	683.0	683.0	0.0	
70	357.6	683.0	683.0	0.0	
65	463.3	683.0	683.0	0.0	
60	500.4	683.0	683.0	0.0	
55	482.0	683.0	683.0	0.0	
50	447.6	683.0	683.0	0.0	
45	422.7	683.0	683.0	0.0	
40	413.7	683.0	683.0	0.0	
35	417.0	683.0	683.0	0.0	
30	417.4	683.0	683.0	0.0	
25	395.2	683.0	683.0	0.0	
20	336.9	683.0	683.0	0.0	
15	252.8	683.0	683.0	0.0	
10	165.7	683.0	683.0	0.0	
5	96.3	683.0	683.0	0.0	
0	50.9	683.0	683.0	0.0	
-5	25.3	683.0	683.0	0.0	
-6	21.1	683.0	683.0	0.0	
Total Costs				$0.0	

FAN AND PUMP COSTS

Job Name : D-0 SUBCON 3/3 FY1975 SYS — Date : 11-16-87
Building Name : D-0 SUBCONSTRUCT 3/3 (Complex) — Serial Number:
Site Name : AURORA,IL FERMI, User Defined — 601178e2.0

Bin Temp (F)	Bin Hours hr/yr	Perimeter Fans Input KW	Perimeter Fans Cost $/yr	No Interior Zone	All Pumps Input KW	All Pumps Cost $/yr
			OCCUPIED PERIOD			
90	25.8	0.1	0.1		12.1	15.6
85	59.4	0.1	0.3		12.1	35.9
80	145.3	0.1	0.8		12.1	87.9
75	237.7	0.1	1.3		12.1	143.8
70	270.6	0.1	1.5		12.1	163.7
65	264.5	0.1	1.4		12.1	160.0
60	255.0	0.1	1.4		12.1	154.3
55	244.7	0.1	1.3		12.1	148.0
50	232.1	0.1	1.3		12.1	140.4
45	229.5	0.1	1.3		12.1	138.9
40	237.6	0.1	1.3		12.1	143.8
35	238.5	0.1	1.3		12.1	144.3
30	218.2	0.1	1.2		12.1	132.0
25	174.5	0.1	1.0		12.1	105.6
20	122.4	0.1	0.7		12.1	74.1
15	78.1	0.1	0.4		12.1	47.3
10	46.1	0.1	0.3		12.1	27.9
5	25.1	0.1	0.1		12.1	15.2
0	12.7	0.1	0.1		12.1	7.7
-5	6.2	0.1	0.0		12.1	3.8
-6	4.6	0.1	0.0		12.1	2.8
Total Costs			$17.1			$1892.8
			UNOCCUPIED PERIOD			
90	14.6	0.1	0.1		12.1	8.8
85	36.3	0.1	0.2		12.1	22.0
80	99.3	0.1	0.5		12.1	60.1
75	215.3	0.1	1.2		12.1	130.3
70	357.6	0.1	2.0		12.1	216.4
65	463.3	0.1	2.5		12.1	280.3
60	500.4	0.1	2.7		12.1	302.7
55	482.0	0.1	2.6		12.1	291.6
50	447.6	0.1	2.4		12.1	270.8
45	422.7	0.1	2.3		12.1	255.7
40	413.7	0.1	2.3		12.1	250.3
35	417.0	0.1	2.3		12.1	252.3
30	417.4	0.1	2.3		12.1	252.5
25	395.2	0.1	2.2		12.1	239.1
20	336.9	0.1	1.8		12.1	203.8
15	252.8	0.1	1.4		12.1	152.9
10	165.7	0.1	0.9		12.1	100.3
5	96.3	0.1	0.5		12.1	58.3
0	50.9	0.1	0.3		12.1	30.8
-5	25.3	0.1	0.1		12.1	15.3
-6	21.1	0.1	0.1		12.1	12.8
Total Costs			$30.7			$3407.1


COOLING COIL LOADS
Job : D-0 SUBCON 3/3 FY1975 SYS
Building : D-0 SUBCONSTRUCT 3/3 (Complex)
Site : AURORA,IL FERMI, User Defined
Zone : Block
Period : All
Date : 11-16-87
4000
3500
L3000
O
A2500
D
,2000
M1500
B
H1000
500
0
-25
-15
-5
5
15
25
35
45
55
65
75
85
95
BIN TEMPERATURE, (F)

VII.

FERMILAB D-O EXPERIMENTAL FACILITY

SYSTEMS LIFE CYCLE COST ANALYSIS
AND
PAYBACK CALCULATIONS

31 OCTOBER, 1987
ANALYST: S.F.KRSTULOVICH

FERMILAB CONSTRUCTION ENGINEERING SERVICES

VII-a.

FERMILAB D-0 EXPERIMENTAL FACILITY

LIFE CYCLE COST ANALYSIS
FOR
DESIGN BASIS SYSTEM
RECIPROCATING CHILLERS WITH ENERGY FEATURES

31 OCTOBER, 1987
ANALYST: S.F.KRSTULOVICH

FERMILAB CONSTRUCTION ENGINEERING SERVICES

PROJECT NAME : FERMILAB D-O EXPERIMENTAL FACILITY
ANALYST : S.F.KRSTULOVICH
COMMENTS : DESIGN BASIS SYSTEM

ESTIMATE YEAR : 1987
COMMISSION YEAR : 1988
LAST STUDY YEAR : 2008

**** NON-FINANCED CASH DEBITS/CREDITS ****
YEAR AMOUNT
1987 752900.00

**** FINANCE INSTRUMENTS ****
NOTE 1 PRINCIPAL (1987 EST.) = $ 0.00
(0 EST.) = $ 0.00
INSTRUMENT = NONE

NOTE 2 PRINCIPAL (1987 EST.) = $ 0.00
(0 EST.) = $ 0.00
INSTRUMENT = NONE

**** FUEL COSTS ****
1987 EST. OF FUEL 1 = $ 59125.00 (ELEC.)
2 = $ 0.00
3 = $ 0.00

**** MAINTENANCE COST ****
1987 EST. OF MAINT. = $ 12000.00

**** DISCOUNT/INTEREST/ESCALATION RATES ****

		FINANCE %		ESCALATION %			
YEAR	% DISC.	LOAN1	LOAN2	FUEL1	FUEL2	FUEL3	MAIN.
1987	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1988	7.90	0.00	0.00	6.40	0.00	0.00	7.00
1989	7.90	0.00	0.00	8.80	0.00	0.00	7.00
1990	7.90	0.00	0.00	8.80	0.00	0.00	7.00
1991	7.90	0.00	0.00	8.80	0.00	0.00	7.00
1992	7.90	0.00	0.00	8.80	0.00	0.00	7.00
1993	7.90	0.00	0.00	8.80	0.00	0.00	7.00
1994	7.90	0.00	0.00	8.80	0.00	0.00	7.00
1995	7.90	0.00	0.00	8.80	0.00	0.00	7.00
1996	7.90	0.00	0.00	8.80	0.00	0.00	7.00
1997	7.90	0.00	0.00	8.80	0.00	0.00	7.00
1998	7.90	0.00	0.00	8.80	0.00	0.00	7.00
1999	7.90	0.00	0.00	8.80	0.00	0.00	7.00
2000	7.90	0.00	0.00	8.80	0.00	0.00	7.00
2001	7.90	0.00	0.00	8.80	0.00	0.00	7.00
2002	7.90	0.00	0.00	8.80	0.00	0.00	7.00
2003	7.90	0.00	0.00	8.80	0.00	0.00	7.00
2004	7.90	0.00	0.00	8.80	0.00	0.00	7.00
2005	7.90	0.00	0.00	8.80	0.00	0.00	7.00
2006	7.90	0.00	0.00	8.80	0.00	0.00	7.00
2007	7.90	0.00	0.00	8.80	0.00	0.00	7.00
2008	7.90	0.00	0.00	8.80	0.00	0.00	7.00

**** UNIFIED PRESENT WORTH LIFE CYCLE COST ****

PROJECT NAME : FERMILAB D-O EXPERIMENTAL FACILITY
ANALYST NAME : S.F.KRSTULOVICH
COMMENTS : DESIGN BASIS SYSTEM

YEAR		1987	1988	1989	1990	1991
CASH	$	752900.00	0.00	0.00	0.00	0.00
MORT.1	$	0.00	0.00	0.00	0.00	0.00
MORT.2	$	0.00	0.00	0.00	0.00	0.00
FUEL 1	$	0.00	59398.98	59894.43	60394.02	60897.77
FUEL 2	$	0.00	0.00	0.00	0.00	0.00
FUEL 3	$	0.00	0.00	0.00	0.00	0.00
MAINT.	$	0.00	11899.91	11800.65	11702.22	11604.61
YEAR'S	$	752900.00	71298.88	71695.09	72096.23	72502.38
CUM.	$	752900.00	824198.88	895893.94	967990.19	1040492.56

YEAR		1992	1993	1994	1995	1996
CASH	$	0.00	0.00	0.00	0.00	0.00
MORT.1	$	0.00	0.00	0.00	0.00	0.00
MORT.2	$	0.00	0.00	0.00	0.00	0.00
FUEL 1	$	61405.73	61917.92	62434.38	62955.15	63480.27
FUEL 2	$	0.00	0.00	0.00	0.00	0.00
FUEL 3	$	0.00	0.00	0.00	0.00	0.00
MAINT.	$	11507.82	11411.83	11316.65	11222.25	11128.65
YEAR'S	$	72913.54	73329.75	73751.02	74177.41	74608.91
CUM.	$	1113406.12	1186735.88	1260486.88	1334664.25	1409273.12

YEAR		1997	1998	1999	2000	2001
CASH	$	0.00	0.00	0.00	0.00	0.00
MORT.1	$	0.00	0.00	0.00	0.00	0.00
MORT.2	$	0.00	0.00	0.00	0.00	0.00
FUEL 1	$	64009.76	64543.67	65082.04	65624.89	66172.27
FUEL 2	$	0.00	0.00	0.00	0.00	0.00
FUEL 3	$	0.00	0.00	0.00	0.00	0.00
MAINT.	$	11035.82	10943.77	10852.49	10761.97	10672.20
YEAR'S	$	75045.58	75487.44	75934.52	76386.86	76844.47
CUM.	$	1484318.75	1559806.25	1635740.75	1712127.62	1788972.12

YEAR		2002	2003	2004	2005	2006
CASH	$	0.00	0.00	0.00	0.00	0.00
MORT.1	$	0.00	0.00	0.00	0.00	0.00
MORT.2	$	0.00	0.00	0.00	0.00	0.00
FUEL 1	$	66724.22	67280.77	67841.96	68407.84	68978.43
FUEL 2	$	0.00	0.00	0.00	0.00	0.00
FUEL 3	$	0.00	0.00	0.00	0.00	0.00
MAINT.	$	10583.19	10494.91	10407.37	10320.56	10234.48
YEAR'S	$	77307.41	77775.68	78249.33	78728.40	79212.91
CUM.	$	1866279.50	1944055.12	2022304.50	2101033.00	2180246.00

YEAR		2007	2008	2009	2010	2011
CASH	$	0.00	0.00	0.00	0.00	0.00
MORT.1	$	0.00	0.00	0.00	0.00	0.00
MORT.2	$	0.00	0.00	0.00	0.00	0.00
FUEL 1	$	69553.79	70133.94	0.00	0.00	0.00
FUEL 2	$	0.00	0.00	0.00	0.00	0.00
FUEL 3	$	0.00	0.00	0.00	0.00	0.00
MAINT.	$	10149.11	10064.46	0.00	0.00	0.00
YEAR'S	$	79702.90	80198.39	0.00	0.00	0.00
CUM.	$	2259949.00	2340147.50	2340147.50	2340147.50	2340147.50

VII-b.

FERMILAB D-O EXPERIMENTAL FACILITY

LIFE CYCLE COST ANALYSIS
FOR
ALTERNATE COMPARISON SYSTEM NUMBER 1
CENTRIFUGAL CHILLERS WITH ENERGY FEATURES

31 OCTOBER, 1987
ANALYST: S.F.KRSTULOVICH

FERMILAB CONSTRUCTION ENGINEERING SERVICES

PROJECT NAME : FERMILAB D-0 EXPERIMENTAL FACILITY
ANALYST : S.F.KRSTULOVICH
COMMENTS : ALTERNATE SYSTEM NO. 1

ESTIMATE YEAR : 1987
COMMISSION YEAR : 1988
LAST STUDY YEAR : 2008

**** NON-FINANCED CASH DEBITS/CREDITS ****

YEAR	AMOUNT
1987	752900.00

**** FINANCE INSTRUMENTS ****

NOTE 1 PRINCIPAL (1987 EST.) = $ 0.00
(0 EST.) = $ 0.00
INSTRUMENT = NONE

NOTE 2 PRINCIPAL (1987 EST.) = $ 0.00
(0 EST.) = $ 0.00
INSTRUMENT = NONE

**** FUEL COSTS ****
1987 EST. OF FUEL 1 = $ 63099.00 (ELEC.)
2 = $ 0.00
3 = $ 0.00

**** MAINTENANCE COST ****
1987 EST. OF MAINT. = $ 12000.00

**** DISCOUNT/INTEREST/ESCALATION RATES ****

		FINANCE %		ESCALATION %			
YEAR	% DISC.	LOAN1	LOAN2	FUEL1	FUEL2	FUEL3	MAIN.
1987	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1988	7.90	0.00	0.00	8.40	0.00	0.00	7.00
1989	7.90	0.00	0.00	8.80	0.00	0.00	7.00
1990	7.90	0.00	0.00	8.80	0.00	0.00	7.00
1991	7.90	0.00	0.00	8.80	0.00	0.00	7.00
1992	7.90	0.00	0.00	8.80	0.00	0.00	7.00
1993	7.90	0.00	0.00	8.80	0.00	0.00	7.00
1994	7.90	0.00	0.00	8.80	0.00	0.00	7.00
1995	7.90	0.00	0.00	8.80	0.00	0.00	7.00
1996	7.90	0.00	0.00	8.80	0.00	0.00	7.00
1997	7.90	0.00	0.00	8.80	0.00	0.00	7.00
1998	7.90	0.00	0.00	8.80	0.00	0.00	7.00
1999	7.90	0.00	0.00	8.80	0.00	0.00	7.00
2000	7.90	0.00	0.00	8.80	0.00	0.00	7.00
2001	7.90	0.00	0.00	8.80	0.00	0.00	7.00
2002	7.90	0.00	0.00	8.80	0.00	0.00	7.00
2003	7.90	0.00	0.00	8.80	0.00	0.00	7.00
2004	7.90	0.00	0.00	8.80	0.00	0.00	7.00
2005	7.90	0.00	0.00	8.80	0.00	0.00	7.00
2006	7.90	0.00	0.00	8.80	0.00	0.00	7.00
2007	7.90	0.00	0.00	8.80	0.00	0.00	7.00
2008	7.90	0.00	0.00	8.80	0.00	0.00	7.00

**** UNIFIED PRESENT WORTH LIFE CYCLE COST ****

PROJECT NAME : FERMILAB D-0 EXPERIMENTAL FACILITY
ANALYST NAME : S.F.KRSTULOVICH
COMMENTS : ALTERNATE SYSTEM NO. 1

YEAR		1987	1988	1989	1990	1991
CASH	$	752900.00	0.00	0.00	0.00	0.00
MORT.1	$	0.00	0.00	0.00	0.00	0.00
MORT.2	$	0.00	0.00	0.00	0.00	0.00
FUEL 1	$	0.00	63391.39	63920.15	64453.31	64990.92
FUEL 2	$	0.00	0.00	0.00	0.00	0.00
FUEL 3	$	0.00	0.00	0.00	0.00	0.00
MAINT.	$	0.00	11899.91	11800.65	11702.22	11604.61
YEAR'S	$	752900.00	75291.30	75720.80	76155.52	76595.53
CUM.	$	752900.00	828191.31	903912.12	980067.62	1056663.12

YEAR		1992	1993	1994	1995	1996
CASH	$	0.00	0.00	0.00	0.00	0.00
MORT.1	$	0.00	0.00	0.00	0.00	0.00
MORT.2	$	0.00	0.00	0.00	0.00	0.00
FUEL 1	$	65533.02	66079.63	66630.81	67186.59	67747.00
FUEL 2	$	0.00	0.00	0.00	0.00	0.00
FUEL 3	$	0.00	0.00	0.00	0.00	0.00
MAINT.	$	11507.82	11411.83	11316.65	11222.25	11128.65
YEAR'S	$	77040.84	77491.46	77947.46	78408.84	78875.64
CUM.	$	1133704.00	1211195.50	1289143.00	1367551.88	1446427.50

YEAR		1997	1998	1999	2000	2001
CASH	$	0.00	0.00	0.00	0.00	0.00
MORT.1	$	0.00	0.00	0.00	0.00	0.00
MORT.2	$	0.00	0.00	0.00	0.00	0.00
FUEL 1	$	68312.08	68881.88	69456.43	70035.77	70619.94
FUEL 2	$	0.00	0.00	0.00	0.00	0.00
FUEL 3	$	0.00	0.00	0.00	0.00	0.00
MAINT.	$	11035.82	10943.77	10852.49	10761.97	10672.20
YEAR'S	$	79347.90	79825.64	80308.91	80797.73	81292.14
CUM.	$	1525775.38	1605601.00	1685909.88	1766707.62	1847999.75

YEAR		2002	2003	2004	2005	2006
CASH	$	0.00	0.00	0.00	0.00	0.00
MORT.1	$	0.00	0.00	0.00	0.00	0.00
MORT.2	$	0.00	0.00	0.00	0.00	0.00
FUEL 1	$	71208.99	71802.95	72401.87	73005.77	73614.72
FUEL 2	$	0.00	0.00	0.00	0.00	0.00
FUEL 3	$	0.00	0.00	0.00	0.00	0.00
MAINT.	$	10583.19	10494.91	10407.37	10320.56	10234.48
YEAR'S	$	81792.17	82297.87	82809.23	83326.34	83849.20
CUM.	$	1929791.88	2012089.75	2094899.00	2178225.20	2262074.50

YEAR		2007	2008	2009	2010	2011
CASH	$	0.00	0.00	0.00	0.00	0.00
MORT.1	$	0.00	0.00	0.00	0.00	0.00
MORT.2	$	0.00	0.00	0.00	0.00	0.00
FUEL 1	$	74228.74	74847.89	0.00	0.00	0.00
FUEL 2	$	0.00	0.00	0.00	0.00	0.00
FUEL 3	$	0.00	0.00	0.00	0.00	0.00
MAINT.	$	10149.11	10064.46	0.00	0.00	0.00
YEAR'S	$	84377.86	84912.35	0.00	0.00	0.00
CUM.	$	2346452.20	2431364.50	2431364.50	2431364.50	2431364.50

FERMILAB D-O EXPERIMENTAL FACILITY

LIFE CYCLE COST ANALYSIS
FOR
ALTERNATE COMPARISON SYSTEM NUMBER 2
TYPICAL FY1975 DESIGN - BASIC SYSTEM
RECIPROCATING CHILLERS WITHOUT ENERGY FEATURES

31 OCTOBER, 1987
ANALYST: S.F.KRSTULOVICH

FERMILAB CONSTRUCTION ENGINEERING SERVICES

PPROJECT NAME : FERMILAB D-O EXPERIMENTAL FACILITY
ANALYST : S.F.KRSTULOVICH
COMMENTS : ALT. SYSTEM NO. 2 - FY1975 BASIC

ESTIMATE YEAR : 1987
COMMISSION YEAR : 1988
LAST STUDY YEAR : 2008

**** NON-FINANCED CASH DEBITS/CREDITS ****
YEAR AMOUNT
1987 675400.00

**** FINANCE INSTRUMENTS ****
NOTE 1 PRINCIPAL (1987 EST.) = $ 0.00
(0 EST.) = $ 0.00
INSTRUMENT = NONE

NOTE 2 PRINCIPAL (1987 EST.) = $ 0.00
(0 EST.) = $ 0.00
INSTRUMENT = NONE

**** FUEL COSTS ****
1987 EST. OF FUEL 1 = $ 106423.00 (ELEC.)
2 = $ 0.00
3 = $ 0.00

**** MAINTENANCE COST ****
1987 EST. OF MAINT. = $ 10000.00

**** DISCOUNT/INTEREST/ESCALATION RATES ****

		FINANCE %		ESCALATION %			
YEAR	% DISC.	LOAN1	LOAN2	FUEL1	FUEL2	FUEL3	MAIN.
1987	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1988	7.90	0.00	0.00	8.40	0.00	0.00	7.00
1989	7.90	0.00	0.00	8.80	0.00	0.00	7.00
1990	7.90	0.00	0.00	8.80	0.00	0.00	7.00
1991	7.90	0.00	0.00	8.80	0.00	0.00	7.00
1992	7.90	0.00	0.00	8.80	0.00	0.00	7.00
1993	7.90	0.00	0.00	8.80	0.00	0.00	7.00
1994	7.90	0.00	0.00	8.80	0.00	0.00	7.00
1995	7.90	0.00	0.00	8.80	0.00	0.00	7.00
1996	7.90	0.00	0.00	8.80	0.00	0.00	7.00
1997	7.90	0.00	0.00	8.80	0.00	0.00	7.00
1998	7.90	0.00	0.00	8.80	0.00	0.00	7.00
1999	7.90	0.00	0.00	8.80	0.00	0.00	7.00
2000	7.90	0.00	0.00	8.80	0.00	0.00	7.00
2001	7.90	0.00	0.00	8.80	0.00	0.00	7.00
2002	7.90	0.00	0.00	8.80	0.00	0.00	7.00
2003	7.90	0.00	0.00	8.80	0.00	0.00	7.00
2004	7.90	0.00	0.00	8.80	0.00	0.00	7.00
2005	7.90	0.00	0.00	8.80	0.00	0.00	7.00
2006	7.90	0.00	0.00	8.80	0.00	0.00	7.00
2007	7.90	0.00	0.00	8.80	0.00	0.00	7.00
2008	7.90	0.00	0.00	8.80	0.00	0.00	7.00

**** UNIFIED PRESENT WORTH LIFE CYCLE COST ****

PROJECT NAME : FERMILAB D-O EXPERIMENTAL FACILITY
ANALYST NAME : S.F.KRSTULOVICH
COMMENTS : ALT. SYSTEM NO. 2 - FY1975 BASIC

YEAR		1987	1988	1989	1990	1991
CASH	$	675400.00	0.00	0.00	0.00	0.00
MORT.1	$	0.00	0.00	0.00	0.00	0.00
MORT.2	$	0.00	0.00	0.00	0.00	0.00
FUEL 1	$	0.00	106916.16	107807.95	108707.19	109613.93
FUEL 2	$	0.00	0.00	0.00	0.00	0.00
FUEL 3	$	0.00	0.00	0.00	0.00	0.00
MAINT.	$	0.00	9916.59	9833.88	9751.85	9670.51
YEAR'S	$	675400.00	116832.74	117641.83	118459.04	119284.45
CUM.	$	675400.00	792232.75	909874.56	1028333.62	1147618.12

YEAR		1992	1993	1994	1995	1996
CASH	$	0.00	0.00	0.00	0.00	0.00
MORT.1	$	0.00	0.00	0.00	0.00	0.00
MORT.2	$	0.00	0.00	0.00	0.00	0.00
FUEL 1	$	110528.23	111450.15	112379.77	113317.14	114262.34
FUEL 2	$	0.00	0.00	0.00	0.00	0.00
FUEL 3	$	0.00	0.00	0.00	0.00	0.00
MAINT.	$	9589.85	9509.86	9430.54	9351.88	9273.88
YEAR'S	$	120118.07	120960.02	121810.32	122669.02	123536.21
CUM.	$	1267736.25	1388696.25	1510506.62	1633175.62	1756711.88

YEAR		1997	1998	1999	2000	2001
CASH	$	0.00	0.00	0.00	0.00	0.00
MORT.1	$	0.00	0.00	0.00	0.00	0.00
MORT.2	$	0.00	0.00	0.00	0.00	0.00
FUEL 1	$	115215.41	116176.42	117145.45	118122.58	119107.85
FUEL 2	$	0.00	0.00	0.00	0.00	0.00
FUEL 3	$	0.00	0.00	0.00	0.00	0.00
MAINT.	$	9196.52	9119.81	9043.74	8968.31	8893.50
YEAR'S	$	124411.92	125296.23	126189.20	127090.89	128001.36
CUM.	$	1881123.75	2006420.00	2132609.20	2259700.20	2387701.50

YEAR		2002	2003	2004	2005	2006
CASH	$	0.00	0.00	0.00	0.00	0.00
MORT.1	$	0.00	0.00	0.00	0.00	0.00
MORT.2	$	0.00	0.00	0.00	0.00	0.00
FUEL 1	$	120101.34	121103.11	122113.24	123131.80	124158.84
FUEL 2	$	0.00	0.00	0.00	0.00	0.00
FUEL 3	$	0.00	0.00	0.00	0.00	0.00
MAINT.	$	8819.32	8745.76	8672.81	8600.47	8528.74
YEAR'S	$	128920.66	129848.87	130786.06	131732.27	132687.58
CUM.	$	2516622.20	2646471.00	2777257.00	2908989.20	3041676.80

YEAR		2007	2008	2009	2010	2011
CASH	$	0.00	0.00	0.00	0.00	0.00
MORT.1	$	0.00	0.00	0.00	0.00	0.00
MORT.2	$	0.00	0.00	0.00	0.00	0.00
FUEL 1	$	125194.46	126238.72	0.00	0.00	0.00
FUEL 2	$	0.00	0.00	0.00	0.00	0.00
FUEL 3	$	0.00	0.00	0.00	0.00	0.00
MAINT.	$	8457.60	8387.05	0.00	0.00	0.00
YEAR'S	$	133652.05	134625.78	0.00	0.00	0.00
CUM.	$	3175328.80	3309954.50	3309954.50	3309954.50	3309954.50

FERMILAB D-0 EXPERIMENTAL FACILITY

LIFE CYCLE COST ANALYSIS
UNIFIED PRESENT WORTH COMPARISONS
FOR
ALL SYSTEMS

31 OCTOBER, 1987
ANALYST: S.F.KRSTULOVICH

FERMILAB CONSTRUCTION ENGINEERING SERVICES

**** UPW LIFE CYCLE COST COMPARISON ****

FILE NO. : LCC1.DAT
PROJECT : FERMILAB D-0 EXPERIMENTAL FACILITY
ANALYST : S.F.KRSTULOVICH
COMMENTS : DESIGN BASIS SYSTEM

FILE NO. : LCC2.DAT
PROJECT : FERMILAB D-0 EXPERIMENTAL FACILITY
ANALYST : S.F.KRSTULOVICH
COMMENTS : ALTERNATE SYSTEM NO. 1

YEAR	(A) FILE 1 $	(B) FILE 2 $	(A-B) YR'S $	(A-B) CUM. $
1987	752900.00	752900.00	0.00	0.00
1988	71298.88	75291.30	-3992.41	-3992.41
1989	71695.09	75720.80	-4025.70	-8018.12
1990	72096.23	76155.52	-4059.30	-12077.41
1991	72502.38	76595.53	-4093.15	-16170.56
1992	72913.54	77040.84	-4127.30	-20297.87
1993	73329.75	77491.46	-4161.71	-24459.58
1994	73751.02	77947.46	-4196.44	-28656.02
1995	74177.41	78408.84	-4231.44	-32887.45
1996	74608.91	78875.64	-4266.73	-37154.19
1997	75045.58	79347.90	-4302.32	-41456.51
1998	75487.44	79825.64	-4338.20	-45794.71
1999	75934.52	80308.91	-4374.38	-50169.09
2000	76386.86	80797.73	-4410.87	-54579.96
2001	76844.47	81292.14	-4447.67	-59027.63
2002	77307.41	81792.17	-4484.77	-63512.39
2003	77775.68	82297.87	-4522.19	-68034.57
2004	78249.33	82809.23	-4559.90	-72594.47
2005	78728.40	83326.34	-4597.95	-77192.41
2006	79212.91	83849.20	-4636.30	-81828.72
2007	79702.90	84377.86	-4674.96	-86503.68
2008	80198.39	84912.35	-4713.96	-91217.64

*** APPARENT BREAK-EVEN YEAR = 1988 ***

**** UPW LIFE CYCLE COST COMPARISON ****

FILE NO. : LCC1.DAT
PROJECT : FERMILAB D-0 EXPERIMENTAL FACILITY
ANALYST : S.F.KRSTULOVICH
COMMENTS : DESIGN BASIS SYSTEM

FILE NO. : LCC3.DAT
PROJECT : FERMILAB D-0 EXPERIMENTAL FACILITY
ANALYST : S.F.KRSTULOVICH
COMMENTS : ALT. SYSTEM NO. 2 - FY1975 BASIC

YEAR	(A) FILE 1 $	(B) FILE 2 $	(A-B) YR'S $	(A-B) CUM. $
1987	752900.00	675400.00	77500.00	77500.00
1988	71298.88	116832.70	-45533.82	31966.18
1989	71695.09	117641.80	-45946.70	-13980.52
1990	72096.23	118459.00	-46362.77	-60343.31
1991	72502.38	119284.40	-46782.02	-107125.32
1992	72913.54	120118.10	-47204.56	-154329.88
1993	73329.75	120960.00	-47630.25	-201960.13
1994	73751.02	121810.30	-48059.27	-250019.41
1995	74177.41	122669.00	-48491.59	-298511.00
1996	74608.91	123536.20	-48927.30	-347438.28
1997	75045.58	124411.90	-49366.32	-396804.62
1998	75487.44	125296.20	-49808.77	-446613.38
1999	75934.52	126189.20	-50254.68	-496868.03
2000	76386.86	127090.90	-50704.04	-547572.06
2001	76844.47	128001.40	-51156.93	-598729.00
2002	77307.41	128920.70	-51613.30	-650342.25
2003	77775.68	129848.90	-52073.22	-702415.44
2004	78249.33	130786.10	-52536.77	-754952.25
2005	78728.40	131732.30	-53003.90	-807956.19
2006	79212.91	132687.59	-53474.69	-861430.88
2007	79702.90	133652.00	-53949.10	-915380.00
2008	80198.39	134625.80	-54427.41	-969807.38

*** APPARENT BREAK-EVEN YEAR = 1989 ***

FERMILAB D-O EXPERIMENTAL FACILITY

SIMPLE PAYBACK CALCULATIONS
FOR
ALL SYSTEMS

31 OCTOBER, 1987
ANALYST: S.F.KRSTULOVICH

FERMILAB CONSTRUCTION ENGINEERING SERVICES

FERMILAB D-0 EXPERIMENTAL FACILITY
SIMPLE PAYBACK

INPUT VALUES	DESIGNED SYSTEM	ALT SYSTEM NO. 1
INITIAL TOTAL COST	$ 752,900	$ 752,900
ANNUAL OPERATING COST	$ 59,125	$ 63,099
ANNUAL MAINTENANCE COST	$ 12,000	$ 12,000
SALVAGE VALUE AT YEAR 20	$ 0	$ 0

	DESIGNED SYSTEM EXPENSES		ALT SYSTEM NO. 1 EXPENSES	
YEAR	ANNUAL	CUMULATIVE	ANNUAL	CUMULATIVE
INITIAL	$ 752,900	$ 752,900	$ 752,900	$ 752,900
**********	**********	**********	**********	**********
1	$ 71,125	$ 824,025	$ 75,099	$ 827,999
2	$ 71,125	$ 895,150	$ 75,099	$ 903,098
3	$ 71,125	$ 966,275	$ 75,099	$ 978,197
4	$ 71,125	$1,037,400	$ 75,099	$1,053,296
5	$ 71,125	$1,108,525	$ 75,099	$1,128,395
6	$ 71,125	$1,179,650	$ 75,099	$1,203,494
7	$ 71,125	$1,250,775	$ 75,099	$1,278,593
8	$ 71,125	$1,321,900	$ 75,099	$1,353,692
9	$ 71,125	$1,393,025	$ 75,099	$1,428,791
10	$ 71,125	$1,464,150	$ 75,099	$1,503,890
11	$ 71,125	$1,535,275	$ 75,099	$1,578,989
12	$ 71,125	$1,606,400	$ 75,099	$1,654,088
13	$ 71,125	$1,677,525	$ 75,099	$1,729,187
14	$ 71,125	$1,748,650	$ 75,099	$1,804,286
15	$ 71,125	$1,819,775	$ 75,099	$1,879,385
16	$ 71,125	$1,890,900	$ 75,099	$1,954,484
17	$ 71,125	$1,962,025	$ 75,099	$2,029,583
18	$ 71,125	$2,033,150	$ 75,099	$2,104,682
19	$ 71,125	$2,104,275	$ 75,099	$2,179,781
20	$ 71,125	$2,175,400	$ 75,099	$2,254,880
SALVAGE	($ 0)	$2,175,400	($ 0)	$2,254,880

PAYBACK FOR DESIGNED SYSTEM OCCURS AFTER 0.0 YEARS ($ 752,900)

TOTAL COST OF DESIGNED SYSTEM FOR 20 YEARS IS $2,175,400
TOTAL COST OF ALT SYSTEM NO. 1 FOR 20 YEARS IS $2,254,880

NO NAME ENTERED
SIMPLE PAYBACK

INPUT VALUES	DESIGNED SYSTEM	FY1975 ALT NO. 2
INITIAL TOTAL COST	$ 752,900	$ 675,400
ANNUAL OPERATING COST	$ 59,125	$ 106,423
ANNUAL MAINTENANCE COST	$ 12,000	$ 10,000
SALVAGE VALUE AT YEAR 20	$ 0	$ 0

	DESIGNED SYSTEM EXPENSES		FY1975 ALT NO. 2 EXPENSES	
YEAR	ANNUAL	CUMULATIVE	ANNUAL	CUMULATIVE
INITIAL	$ 752,900	$ 752,900	$ 675,400	$ 675,400
1	$ 71,125	$ 824,025	$ 116,423	$ 791,823
**********	**********	**********	**********	**********
2	$ 71,125	$ 895,150	$ 116,423	$ 908,246
3	$ 71,125	$ 966,275	$ 116,423	$1,024,669
4	$ 71,125	$1,037,400	$ 116,423	$1,141,092
5	$ 71,125	$1,108,525	$ 116,423	$1,257,515
6	$ 71,125	$1,179,650	$ 116,423	$1,373,938
7	$ 71,125	$1,250,775	$ 116,423	$1,490,361
8	$ 71,125	$1,321,900	$ 116,423	$1,606,784
9	$ 71,125	$1,393,025	$ 116,423	$1,723,207
10	$ 71,125	$1,464,150	$ 116,423	$1,839,630
11	$ 71,125	$1,535,275	$ 116,423	$1,956,053
12	$ 71,125	$1,606,400	$ 116,423	$2,072,476
13	$ 71,125	$1,677,525	$ 116,423	$2,188,899
14	$ 71,125	$1,748,650	$ 116,423	$2,305,322
15	$ 71,125	$1,819,775	$ 116,423	$2,421,745
16	$ 71,125	$1,890,900	$ 116,423	$2,538,168
17	$ 71,125	$1,962,025	$ 116,423	$2,654,591
18	$ 71,125	$2,033,150	$ 116,423	$2,771,014
19	$ 71,125	$2,104,275	$ 116,423	$2,887,437
20	$ 71,125	$2,175,400	$ 116,423	$3,003,860
SALVAGE	($ 0)	$2,175,400	($ 0)	$3,003,860

PAYBACK FOR DESIGNED SYSTEM OCCURS AFTER 1.7 YEARS ($ 874,587)

TOTAL COST OF DESIGNED SYSTEM FOR 20 YEARS IS $2,175,400
TOTAL COST OF FY1975 ALT NO. 2 FOR 20 YEARS IS $3,003,860