

ECO No. 3 - Install Air Curtains on Freezer Doors

Recommended Action

Turn off infrared heaters and electric heating bands which are installed in the door frames to the freezers. Instead, install air curtains to prevent cold air from escaping from the freezers.

Total Energy Usage Savings	=	2,145,396 kWh/yr (7,321 MMBtu/yr)
Total Yearly Demand Savings	=	1,936 kW-Month/yr
Estimated Energy Usage Cost Savings	=	\$ 108,238/yr
Estimated Yearly Demand Cost Savings	=	\$ 15,962/yr
Estimated Total Cost Savings	=	\$ 124,200/yr
Estimated Implementation Cost	=	\$18,900
Simple Payback	=	two months

Background

Currently, the facility is using infrared heaters, and heating bands in the freezer door frames to prevent the doors from freezing shut. As observed by the audit team, the facility has twelve doors, of which ten door frames have heating units installed. The doors were measured at approximately 8 x 12 feet. The temperature inside the freezer rooms was measured to be between 7°F and 32°F. According to the plant personnel, the power rating for each infrared heater was 8kW; and the power rating for the heating bands was 15 kW. In addition to the electrical energy associated with the heating units, the heat generated by the heating units increases the cooling load of the ammonia refrigeration system. Two ammonia compressors, 250 hp and 500 hp, are used to produce the refrigeration in the freezers. The 250 hp compressor operates 24 hours per day, 7 days per week, for a total of 8,760 hours per year. The 500 hp compressor operates 11 hours per day, 7 days per week, for a total of 4,380 hours per year.

It is recommended that air curtains be installed on the freezer doors and be used instead of the current heating units. Air curtains should be mounted on top of the door frames. Air curtains will not permit the cold air to escape. Thus, they will prevent the doors from freezing shut, reduce the cooling load and also reduce electrical energy associated with the heating units.

Anticipated Savings

The current electrical energy usage, CEU, for the infrared heaters and the heating bands can be calculated as follows:

$$\text{CEU} = \text{kW} \times \text{N} \times \text{LF} \times \text{UF} \times \text{H}$$

where,

kW	=	power rating of infrared heaters and heating bands, 23 kW
N	=	number of infrared heaters and heating bands, 10
LF	=	fraction of rated power at which the heaters operate, 1
UF	=	fraction of operating time that the heaters are on, 0.75
H	=	annual operating hours of the equipment, 8,760 hrs/yr

CEU is thus:

$$\begin{aligned}\text{CEU} &= (23)(10)(0.75)(1)(8,760) \\ \text{CEU} &= 1,511,100 \text{ kWh/yr (5,156 MMBtu/yr)}\end{aligned}$$

The current energy usage cost, CEUC, is thus:

$$\begin{aligned}\text{CEUC} &= \text{CEU} \times (\text{unit cost of electricity, \$/kWh}) \\ \text{CEUC} &= (1,511,100)(0.050451) \\ \text{CEUC} &= \$76,237/\text{yr}\end{aligned}$$

When air curtains are used instead of heating bands and infrared heaters, the energy used by the ammonia refrigeration system to compensate for the heat gain in the refrigerated room can be saved. Since the heating bands are installed in the door frames, some of the energy is dissipated outside of the refrigerated area. It is estimated that as much as 75% of the energy is dissipated in the freezer rooms. Thus, the yearly energy savings, ES, are estimated from the following relationship.

$$\text{ES} = \text{CEU} \times (1 - \text{CLR}) \times \text{UF} \times \text{FR} / \text{COP}$$

where,

CEU	=	electrical energy of the infrared heater and the heating bands, kWh/yr
CLR	=	ratio of compressor's idling power draw to loaded power draw, no units
UF	=	fraction of operating hours that the compressor is in use, 1
FR	=	fraction of the energy dissipated in the freezer room, 0.75

COP = coefficient of performance of ammonia refrigeration, 2 (estimated), no units

Thus, the energy savings for the 250 hp ammonia compressor is estimated as:

ES = (1,511,100)(1)(1)(0.75)/(2)
 ES = 566,663 kWh/yr (1,934 MMBtu/yr)

The energy cost savings, ECS, is calculated as follows:

ECS = ES x (unit cost of electricity, \$/kWh)
 ECS = (1,133,325)(0.050451)
 ECS = \$28,589/yr

Summary of Energy Savings						
Compressor Power (hp)	EFFc	CLR	UF	H (hrs/yr)	ES (kWh/yr)	ECS (\$/yr)
250	0.935	0	1	8,760	566,663	28,589
500	0.925	0.3	0.5	4,380	198,332	10,006
Total:					764,995	38,595

The anticipated energy usage cost, AEUC, which would be a result of the implementation of the air curtains, can be calculated as follows:

AEUC = AEU x (unit cost of electricity, \$/kWh)

where,

AEU = anticipated energy usage of the air curtain, kWh/yr

AEU is calculated as follows:

AEU = L x C x H x UF_{AC} x N

where,

L = power used by an air curtain unit, 2 hp
 C = conversion constant, 0.746 kW/hp
 H = operating hours of the air curtains, 8,760 hrs/yr
 UF_{AC} = fraction of time that the air flows, 1, no units
 N = number of air curtains

thus,

$$\begin{aligned} \text{AEU} &= (2)(0.746)(8,760)(1)(10) \\ \text{AEU} &= 130,699 \text{ kWh/yr} \end{aligned}$$

The anticipated energy usage cost savings, AEUC, is:

$$\begin{aligned} \text{AEUC} &= (130,699)(0.050451) \\ \text{AEUC} &= \$6,594/\text{yr} \end{aligned}$$

The energy usage cost savings, EUCS, can now be calculated:

$$\begin{aligned} \text{EUCS} &= \text{CEUC} + \text{ECS} - \text{AEUC} \\ \text{EUCS} &= (76,237) + (38,595) - (6,594) \\ \text{EUCS} &= \$108,238/\text{yr} \end{aligned}$$

Yearly Demand Savings

The annual yearly demand savings, YDS_1 , realized by replacing the heating units can be estimated as follows:

$$\text{YDS}_1 = \text{kW} \times \text{LF} \times \text{CF} \times \text{M} \times \text{N}$$

where,

$$\begin{aligned} \text{kW} &= \text{power rating of infrared heaters and heating bands, } 23 \text{ kW} \\ \text{LF} &= \text{fraction of rated power at which the infrared heaters operate, } 0.75 \\ \text{CF} &= \text{coincidence factor (estimated fraction of demand savings that will} \\ &\quad \text{affect the peak demand of the month), } 1, \text{ no units} \\ \text{M} &= \text{number of months that demand is charged, } 12, \text{ no units} \\ \text{N} &= \text{number of heating units, } 10 \end{aligned}$$

thus,

$$\begin{aligned} \text{YDS}_1 &= (23)(0.75)(1)(12)(10) \\ \text{YDS}_1 &= 2,070 \text{ kW-month/yr} \end{aligned}$$

The anticipated yearly demand charge, YDC, which would be a result of the implementation of the air curtains, can be calculated as follows:

$$\text{YDC} = \text{kW} \times \text{LF} \times \text{CF} \times \text{M} \times \text{N}$$

where,

- L = power used by the air curtain unit, 2 hp
- C = conversion constant, 0.746 kW/hp
- LF = fraction of rated power at which the air curtains operate, 1
- CF = coincidence factor (estimated fraction of demand savings that will affect the peak demand of the month), 1, no units
- M = number of months that demand is charged, 12, no units
- N = number of air curtain units, 10

thus,

$$\begin{aligned}\text{YDC} &= (2)(0.746)(0.75)(1)(1)(12)(10) \\ \text{YDC} &= 134 \text{ kW-month/yr}\end{aligned}$$

The total yearly demand savings, TYDS, are:

$$\begin{aligned}\text{TYDS} &= \text{YDS}_1 - \text{YDC} \\ \text{TYDS} &= (2,070) - (134) \\ \text{TYDS} &= 1,936 \text{ kW-month/yr}\end{aligned}$$

Thus, the total yearly demand cost savings, YDCS, can be calculated as follows:

$$\begin{aligned}\text{YDCS} &= \text{TYDS} \times (\text{average demand cost, \$/kW-month}) \\ \text{YDCS} &= (1,936)(8.2446) \\ \text{YDCS} &= \$15,962/\text{yr}\end{aligned}$$

Total Cost Savings

The total cost savings, TCS, is simply the sum of the total yearly demand cost savings and the total energy usage cost savings:

$$\begin{aligned}\text{TCS} &= \text{YDCS} + \text{EUCS} \\ \text{TCS} &= (15,962) + (108,238) \\ \text{TCS} &= \$124,200/\text{yr}\end{aligned}$$

Implementation Cost

The savings can be obtained by purchasing and installing ten, high velocity model air curtain units. Upon discussion with a manufacturer of air curtains, these high velocity model air curtain units, with two 1 hp motors per unit, are designed to keep warmer air from entering into the freezer areas. The implementation cost includes the installation of ten air curtain units, control panels, and the necessary wall mounting material. The cost for ten high velocity model air curtains is \$15,750 (\$1,575 per unit). The cost for one control panel which can be supplied for multiple units is \$950. The cost for wall mounting material is approximately \$400. If the installation work is performed by in-house personnel, it is estimated that it would take approximately 60 hours total labor for the entire project at \$30 per man-hour for a total of \$1,800. The cost savings of \$124,200/yr would pay for the implementation cost of \$18,900 in less than two months.

Note: It is advisable to initially install only one of the air curtain units to ensure this replacement meets performance standards.

The cost estimate and information about the air curtain units have been provided by MARS AIR DOOR®.

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