City of Muscatine

312 E. Fifth Street
Muscatine, Iowa

Public Safety Building
HVAC Additional Cooling Capacity Study

A&J #201644.00
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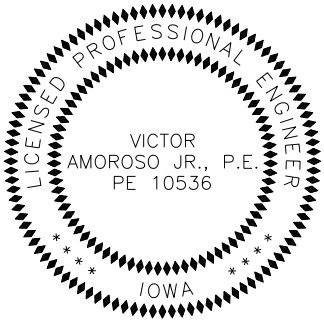
I hereby certify that the portion of this technical submission described below was prepared by me or under my direct supervision and responsible charge. I am a duly Licensed Professional Engineer under the laws of the State of Iowa.



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My license renewal date is December 31, 2017.

Pages or sheets covered by this seal:
Mechanical Portions

Date issued: 9/12/2016

Executive Summary

The existing geothermal field for the City of Muscatine Public Safety Building has a calculated 44.5 tons of cooling capacity. The geothermal field has less calculated heat absorption capacity than the heat rejection from heat pumps in the cooling mode. The heat rejection is listed as 49.1 tons. Due to the building's 24 hour operation year round, the Public Safety Building geothermal field HVAC system cannot take advantage of occupancy schedules to allow the geothermal field to "catch up" and dissipate the heat during off hours when the building cooling load is reduced. This results in geothermal field temperatures slowly rising during peak cooling demand until the loop temperature exceeds the upper limits of the water to water heat pumps operating range. This "high" loop temperature reduces heat pump functionality over a longer period of continuous hot and humid weather.

There is no available real estate nearby the Public Safety Building to expand the geothermal field. The field was initially installed under the parking lot using all available locations for the city geothermal field. Since no more wells can be added, measures should be taken to reduce the cooling load on the geothermal field.

Measures should include the following:

a. Reduce the cooling provided by the existing chilled water cooling coil in the air handling unit. This will reduce the cooling demand on geothermal water to water heat pumps.
b. Reduce the total cooling demand on the heat pumps to reduce the heat rejection to the geothermal loop.
c. Include replacement inverter duty motors and variable frequency drives for the main air handling unit supply and return fans to be handed over to the owner.

I. A&J has explored the following options:
   A. Installing a slipstream air cooled chiller on the return chilled water side to reduce the temperature of the return chilled water to the heat pumps. This option removes cooling demand from the geothermal loop and prevents the geothermal field from overheating.

B. Installing mini-split ductless air conditioning systems in selected areas to replace cooling capacity provided by the air handling unit. This will reduce the load on the geothermal loop and also the air handling unit.
C. Installing a combination of mini-split systems and an air cooled chiller. This is a “hybrid” geothermal/conventional HVAC system.
D. Switching a few water to air heat pumps to the return chilled water from the geothermal loop for heat rejection/absorption.
E. Change piping and controls to use the geothermal loop to generate hot domestic water as the primary source, not the backup source.

II. The following is a listing of the benefits and disadvantages for each option.
A. Installing slipstream air cooled chiller (regardless of capacity)
1. Advantages
a) Installing a slipstream air cooled chiller will take load off of the geothermal field by reducing cooling load on the existing heat pump modules (Multistack units).
b) This option will add a bit of redundancy to the existing heat pump system should the water to water heat pump experience equipment failure that results in reduced heat rejection capacity. The amount of redundancy depends on the cooling capacity of the slipstream chiller installed.
c) A&J estimates that a 20 ton chiller will provide enough redundancy to replace “lost” cooling should one (1) water to water heat pump module fail.
2. Disadvantages
a) The slipstream air cooled chiller still relies on the single air handling unit to deliver the cooling. Loss of a fan motor or fan variable frequency drive will result in total loss of cooling capability provided by the air handling unit.
b) The slipstream air cooled chiller does not reduce the cooling load on the air side of the air handling unit.

B. Installing ductless mini-split air conditioning systems.
    1. Advantages
        a) Mini-split systems can be placed in critical areas such as the sleeping/recreational areas and areas of high cooling demand.
        b) Equipment space required is relatively low compared to a ducted air handling system.
        c) The de-centralized nature of the mini-split systems makes it a good method for adding redundancy as it does not rely on the central air handling unit, ducted system, water to water heat pump, or the geothermal loop heat exchanger to function.
    2. Disadvantages
        a) Due to the compartmentalized nature of the building, the existing air distribution system, and the lack of large open areas, even strategically placed mini-split systems will only reduce the cooling load on the air handling unit by approximately 10-15%. This is not enough cooling load relief, in our opinion to bring the geothermal loop field capacity into equilibrium with the building cooling demand.
        b) The mini-split systems alone will not completely solve the problem of the geothermal field cooling overloading because not enough cooling demand is removed from the geothermal loop.
        c) As a result of these significant shortcomings, A&J is not investigating options involving only mini-split systems any further.

C. Installing a combination of mini-split systems and an air cooled chiller (hybrid system)
    1. Advantages
        a) Mini-split systems add cooling and heating redundancy in case of the centralized air handling unit fails. There is no reliance on the single air handling unit or the heat pump system to provide all of the building heating or cooling.
        b) The mini-split systems add additional capacity in spaces with additional cooling demand.

c) The slipstream air cooled chiller provides additional cooling capacity and is primarily responsible for reducing the cooling demand on the existing heat pumps and the geothermal field.

d) The slipstream air cooled chiller provides redundancy in case of a water to water heat pump module failure. The amount of redundancy depends on the cooling capacity of the slipstream chiller.

2. Disadvantages

a) Neither the air cooled chiller or the mini-split systems will provide sufficient capacity to maintain all building temperature set points should there be a major HVAC malfunction such as an air handling unit fan or a total heat pump failure (affecting all modules). However, it was never the design intent to provide completely redundant cooling capacity.

D. Switching water to air heat pumps to the return chilled water for heat rejection/absorption from the geothermal loop.

1. The existing water to air heat pumps are connected directly to the geothermal loop and rely on the geothermal loop to be within the operating temperature range of the heat pumps in order for them to function. The geothermal field loop temperature has exceeded the operating temperature limit of the heat pumps numerous times causing the heat pumps to shut down.
2. The return chilled water will provide more stable temperatures within the water to air heat pumps operating range. The return water temperature can also be more easily controlled to be within the heat pump operating range.
3. This modification should be made regardless of which option is taken to reduce cooling load on the geothermal loop.

E. Make the geothermal water to water heat pumps the primary supplier of domestic hot water.

III. Estimate probable construction costs. All estimates include the probable cost of replacement fan motors and VFDs as requested by the owner.

A. Installing a 20 ton water cooled slipstream chiller.

1. A&J estimates that the total project cost for installing a 20 ton cooling capacity chiller to be between $41,237 and $68,729. Refer to cost estimate attached for detailed cost breakdown.

B. Installing a 10 ton capacity air cooled chiller with remote heat exchanger, and three (3) 3 ton capacity ductless mini-split system ductless heat pumps (9 tons heat pump cooling capacity).

1. A&J estimates that the total project cost for installing a hybrid system consisting of an air cooled chiller at 10 tons and three (3) mini-split systems at 9 tons to be between $79,930 and $133,216. Refer to cost estimate attached for detailed cost breakdown.

C. Installing a 20 ton capacity water cooled chiller and three (3) 3 ton capacity ductless mini-split systems. This is a hybrid system with a larger chiller that will provide enough redundancy to cover one water to water heat pump module failure.

1. A&J estimates that the total project cost for installing a hybrid system with the 20 ton water cooled chiller would cost between $75,681 and $126,135. Refer to cost estimate attached for detailed cost breakdown.

IV. Recommendations

A. Based on the 24/7 operation of parts of the public safety building and the apparent need for some component redundancy, A&J recommends Option C above.

1. One nominal 20 ton slipstream water cooled chiller.
2. Three 3 ton ductless mini-split heat pumps that are air cooled.

Estimate of Probable Project Cost
Rev. 1

City of Muscatine
Public Safety Building
#201644.00

Option	Low Construction Cost (2)	Mean Construction Cost	High Construction Cost (3)	Low Soft Costs (1)	Mean Soft Costs (1)	High Soft Costs (1)	Low Project Costs	Mean Project Costs	High Project Costs
Option A	$37,488.75	$49,985	$62,481.25	$3,748.88	$4,998.5	$6,248.13	$41,237.63	$54,983.50	$68,729.38
Option B	$72,663.75	$96,885	$121,106.25	$7,266.38	$9,688.5	$12,110.63	$79,930.13	$106,573.50	$133,216.88
Option C	$68,801.25	$91,735	$114,668.75	$6,880.13	$9,173.5	$11,466.88	$75,681.38	$100,908.50	$126,135.63

Option A 20 tons Air Cooled Chiller Only
Option B 10 tons Air Cooled Chiller + 9 tons of Heat Pumps
Option C 20 tons Air Cooled Chiller + 9 tons of Heat Pumps

1. Soft Costs include cost of permit, contractor's insurance, and engineering design fees.
2. Low construction costs is mean construction cost -25% to account for unforseen changes to design (less demolition, reuse equipment, easier way to accompllish goal)
3. High construction cost is mean sconstruction cost +25% to account for unforseen changes to design (more demolition, inflation, difficult working conditions)

Estimate of Probable Mechanical and Electrical Construction Cost				A&J #201644.00
City of Muscatine Public Safety Building				
12-Sep-16				
REV. 1 7-OCT-2016				
Item	**Quantity**	**Unit**	**Unit Price**	**Total**
Option A - Air Cooled Chiller Only				
Mechanical Items				
Trane 20 ton Air Cooled Chiller W/ Remote HX	1	EA	$22,800	$22,800
Air Cooled Chiller Installation	40	HR	$50	$2,000
Crane Lifting	1	LUMP	$1,500	$1,500
Demolish existing glycol feed tank	1	EA	$300	$300
Disconnect existing heat pumps from geothermal loop	1	LUMP	$500	$500
Connect existing heat pumps to chilled water return	1	LUMP	$700	$700
Test and Balancing	1	LUMP	$6,000	$6,000
Sub-Total Mechanical				$33,800
Electrical Items				
Air Cooled Chiller, 208/3/60. Includes disconnect switch at chiller, motor connection, and feeder to chiller from panel in Third Floor Mechanical Room.	1	EACH	$1,800	$1,800
Outdoor Unit -208/3/60. Includes NEMA 3R disconnect switch at heat pump, motor connection, and feeder to heat pump from panel in Third Floor Mechanical Room.	1	EACH	$2,100	$2,100
Disconnect power connection for Glycol Feed Tank	1	EACH	$150	$150
Disconnect power connection for Existing Heat Pump	1	EACH	$150	$150
Reconnect Existing Heat Pump, extend exisitng feeder to new location	1	EACH	$600	$600
New Motors and VFDs - to be turned over to owner				
7.5 HP/208V/3ph inverter duty motor	1	EA	$1,100	$1,100
15 HP/208V/3ph inverter duty motor	1	EA	$1,650	$1,650
15 HP/208V/3ph VFD	1	EA	$4,798	$4,798
7.5 HP/208V/3ph VFD	1	EA	$3,837	$3,837
Sub-Total Electrical				$16,185
Option A Total				$49,985

Option B - Combination 10 ton Air Cooled Chiller w/ Remote Heat Exchanger and Heat Pumps

Mechanical Items				
Item	**Quantity**	**Unit**	**Unit Price**	**Total**
Mitsubishi P Series 3 ton Indoor Ceiling Cassette PLA-A42BA6	3	EA		
Mitsubishi P Series Single Zone 3 ton Outdoor Unit PUZ-A42NHA6	3	EA		
MPLS385812T-100 Refrigerant Line Set	3	EA		
MHK1 Backlit Wireless Remote Controller	3	EA		
Mitsubishi Equipment Package				$23,100
Heat Pump Installation	75	HR	$50	$3,750
Crane Lifting	1	LUMP	$2,000	$2,000
Trane TTA180 Air Cooled Chiller w/ remote heat exchanger (10 ton capacity)	1	EA	$30,250	$30,250
Air Cooled Chiller Installation	30	HR	$50	$1,500
Demolish existing glycol feed tank	1	LUMP	$200	$200
Disconnect existing heat pumps from geothermal loop	1	EA	$500	$500
Connect existing heat pumps to chilled water return	1	LUMP	$700	$700
Test and Balancing	1	LUMP	$4,500	$4,500
Sub-Total Mechanical				$66,500

Electrical Items				
Air Cooled Chiller, 208/3/60. Includes NEMA 3R disconnect switch at chiller, motor connection, and feeder to chiller from panel in Third Floor Mechanical Room.	1	EACH	$2,100	$2,100
Outdoor Unit -208/3/60. Includes NEMA 3R disconnect switch at heat pump, motor connection, and feeder to heat pump from panel in Third Floor Mechanical Room.	3	EACH	$2,100	$6,300
Indoor terminal unit - 208/230, 1 phase, 60 Hz, feed from associated heat pump. Includes motor connection, disconnect switch at unit and feeder to associated heat pump.	6	EACH	$750	$4,500
Disconnect power connection for Glycol Feed Tank	1	EACH	$150	$150
Disconnect power connection for Existing Heat Pump	1	EACH	$150	$150
Reconnect Existing Heat Pump, extend exisitng feeder to new location	1	EACH	$600	$600
Install new circuit breaker panel in Third Floor Mechanical Room for power feeders to new heat pumps. Includes new circuit breaker at electrical service in Basement and panel feeder from Basement to new panel in Third Floor Mechanical Room.	1	EACH	$5,200	$5,200
New Motors and VFDs - to be turned over to owner				
7.5 HP/208V/3ph inverter duty motor	1	EA	$1,100	$1,100
15 HP/208V/3ph inverter duty motor	1	EA	$1,650	$1,650
15 HP/208V/3ph VFD	1	EA	$4,798	$4,798
7.5 HP/208V/3ph VFD	1	EA	$3,837	$3,837
Sub-Total Electrical				$30,385

Option B Total	$96,885

Option C - Combination 20 ton Air Cooled Chiller and Heat Pumps

Mechanical Items				
Item	**Quantity**	**Unit**	**Unit Price**	**Total**
Mitsubishi P Series 3 ton Indoor Ceiling Cassette PLA-A42BA6	3	EA		
Mitsubishi P Series Single Zone 3 ton Outdoor Unit PUZ-A42NHA6	3	EA		
MPLS385812T-100 Refrigerant Line Set	3	EA		
MHK1 Backlit Wireless Remote Controller	3	EA		
Mitsubishi Equipment Package				$23,100
Heat Pump Installation	75	HR	$50	$3,750
Trane 20 ton Air Cooled Chiller W/ Remote HX	1	EA	$22,800	$22,800
Crane Lifting	1	LUMP	$2,000	$2,000
Air Cooled Chiller Installation	40	HR	$50	$2,000
Demolish existing glycol feed tank	1	LUMP	$200	$200
Disconnect existing heat pumps from geothermal loop	1	EA	$500	$500
Connect existing heat pumps to chilled water return	1	LUMP	$700	$700
Test and Balancing	1	LUMP	$4,500	$4,500
Sub-Total Mechanical				$59,550
Electrical Items				
Air Cooled Chiller, 208/3/60. Includes disconnect switch at chiller, motor connection, and feeder to chiller from panel in Third Floor Mechanical Room.	1	EACH	$1,800	$1,800
Outdoor Unit -208/3/60. Includes NEMA 3R disconnect switch at heat pump, motor connection, and feeder to heat pump from panel in Third Floor Mechanical Room.	4	EACH	$2,100	$8,400
Indoor terminal unit - 208/230, 1 phase, 60 Hz, feed from associated heat pump. Includes motor connection, disconnect switch at unit and feeder to associated heat pump.	6	EACH	$750	$4,500
Disconnect power connection for Glycol Feed Tank	1	EACH	$150	$150
Disconnect power connection for Existing Heat Pump	1	EACH	$150	$150
Reconnect Existing Heat Pump, extend exisitng feeder to new location	1	EACH	$600	$600
Install new circuit breaker panel in Third Floor Mechanical Room for power feeders to new heat pumps. Includes new circuit breaker at electrical service in Basement and panel feeder from Basement to new panel in Third Floor Mechanical Room.	1	EACH	$5,200	$5,200
New Motors and VFDs - to be turned over to owner				
7.5 HP/208V/3ph inverter duty motor	1	EA	$1,100	$1,100
15 HP/208V/3ph inverter duty motor	1	EA	$1,650	$1,650
15 HP/208V/3ph VFD	1	EA	$4,798	$4,798
7.5 HP/208V/3ph VFD	1	EA	$3,837	$3,837
Sub-Total Electrical				$32,185
Option C Total				$91,735