

Montana Tech Natural Resources Building



Heat Pump Addition

Phase I – Design Guide for Second Phase

Design Scope

Overview

The design project is intended to produce the addition of a complete and working heat pump system to the existing Natural Resources Building at Montana Tech University. The heat pump system will provide both heating and cooling, but will not simultaneously heat and cool. The heat sink for the new heat pump is to be the Orphan Boy Mine. The mine is flooded with water at a constant 78°F. The project is to include a closed loop in the mine shaft. A feasibility study has been performed on the project and equipment sizes have been determined. This input to the final design is in no way meant to limit the ingenuity of the design effort. The final design is the responsibility of the final design team; however the given sizes may be used without duplicating the work accomplished in the feasibility study. A schematic of the proposed system is included in this package.

Mechanical Room Design

The heat pump and associated equipment is to be installed inside the mine entrance. A space is to be found near the shaft to accommodate the new equipment. All equipment is to be suitable for the environment, but the mine entrance is much like a basement room and the difficulties of utilizing this space are considered to be less than the cost of a new above-ground building. All lighting and required ventilation are a part of this design. Existing supply and return piping is to be utilized between the mine and building.

Heat Sink Piping

The feasibility study has determined a requirement for 15 parallel 1" HDPE coils of 700 ft each to transfer the required amount of heat in the shaft. An extra 2 coils are desired to allow for safety factor and pipe blockage, 17 total loops. The coils and pipe header system will be designed to lower into the existing pipe shaft.

Heat Pump

The heat pump shall be a water-to-water type at a nominal 60 tons. It shall be set up to operate with the heat sink loop as described above. The shaft water is a constant 78°F. The heat pump shall provide a minimum 52 tons of cooling with a leaving temperature of 45°F and a 10°F delta-T. The heat pump shall provide

a minimum of 800,000BTUh heating with a leaving temperature of 140°F and a 20°F delta-T. The heat pump shall be capable of operating at a leaving temperature of 60°F cooling.

Connection to Existing System

The existing building heat is supplied by a steam converter on the first floor. The steam converter is designed to raise 310 GPM from 140°F to 180°F. It is being operated at a leaving temperature of 140°F. The heating water pump has a VSD that varies the flow of the system.

The proposed design will intercept the return piping to the steam converter and divert a portion of the heating water to the heat pump. The heat pump will add as much heat as possible and return the water to the same line before the steam converter. The heat pump is in series with the converter. The steam converter will then add the heat required to raise the mixed return and preheated water temperature to the current supply temperature setting.

The existing building cooling is supplied by an air-cooled chiller just outside the building. The existing chiller is 169 tons, designed to cool 385 GPM from 53°F to 41°F. It is being operated at leaving temperatures between 45 to 65°F. The chilled water pump has a VSD that varies the chiller flow.

The proposed design is to intercept the chilled water return piping to the chiller and divert a portion of the chilled water to the heat pump. The heat pump will chill the water and return it to the same line before the chilled water pump. The heat pump and chiller are in series. The existing chiller will then chill the mixed return and pre-chilled water to the required supply water set point.

There is a set of 6" supply and return pipes that have been installed from the building to the mine site. These pipes extend to the building and up to the building attic. The existing return piping, both chilled and heating, may be intercepted in the attic. However, it is essential that the box heat on each floor be included in the water being sent to the heat pumps and this may force the new connection to be made in the first floor mechanical room. The chilled water only supplied the attic units and may be intercepted in the attic or the piping could be extended underground outside the building to the far end chiller yard.

The existing water treatment equipment may have to be supplemented to cover the new pipe and equipment and a new system will be needed for the heat sink system.

Freeze Protection

All of the calculations made during the design phase have been made with pure water and no freeze protection. Where freeze protection is required, the capacity and pumping calculations must be adjusted.

Control Sequence

Pumps - The existing systems all have primary and standby pumps that are alternated by a schedule in the control system. Each new pump shall have a standby and be alternated in the same manner.

Heat Pump Control – The heat pump mode will be controlled by outside temperature. The heat pump will provide cooling when the outside temperature is equal to or above 65°F (adjustable) and heating when the outside temperature is below 60°F (adjustable). The heat pump will have a minimum of 4 hours down time between the cooling and heating modes of operation.

Heating Mode - When the heat pump is in heating mode and there is a call for heating, the valves will modulate open to divert heating water to the heat pump loop. When the valves are proved open, the heat pump loop pump will start. When positive flow is determined, the heat pump will start. The heat pump will produce 140°F (adjustable) water and return it to the primary heating loop. The existing heating system shall operate as designed to supply the building with the required heating water.

Cooling Mode - When the heat pump is in cooling mode and there is a call for cooling, the valves will modulate open to divert cooling water to the heat pump loop. When the valves are proved open, the heat pump loop pump will start. When positive flow is determined, the heat pump will start. The heat pump will produce 45°F (adjustable) water and return it to the primary cooling loop before the existing pump. The existing chiller system shall operate as designed to supply the building with the required chilled water.

Heat Sink - The heat sink loop pump will start with the cooling/heating loop pumps. The final design will include complete instrumentation and trending as

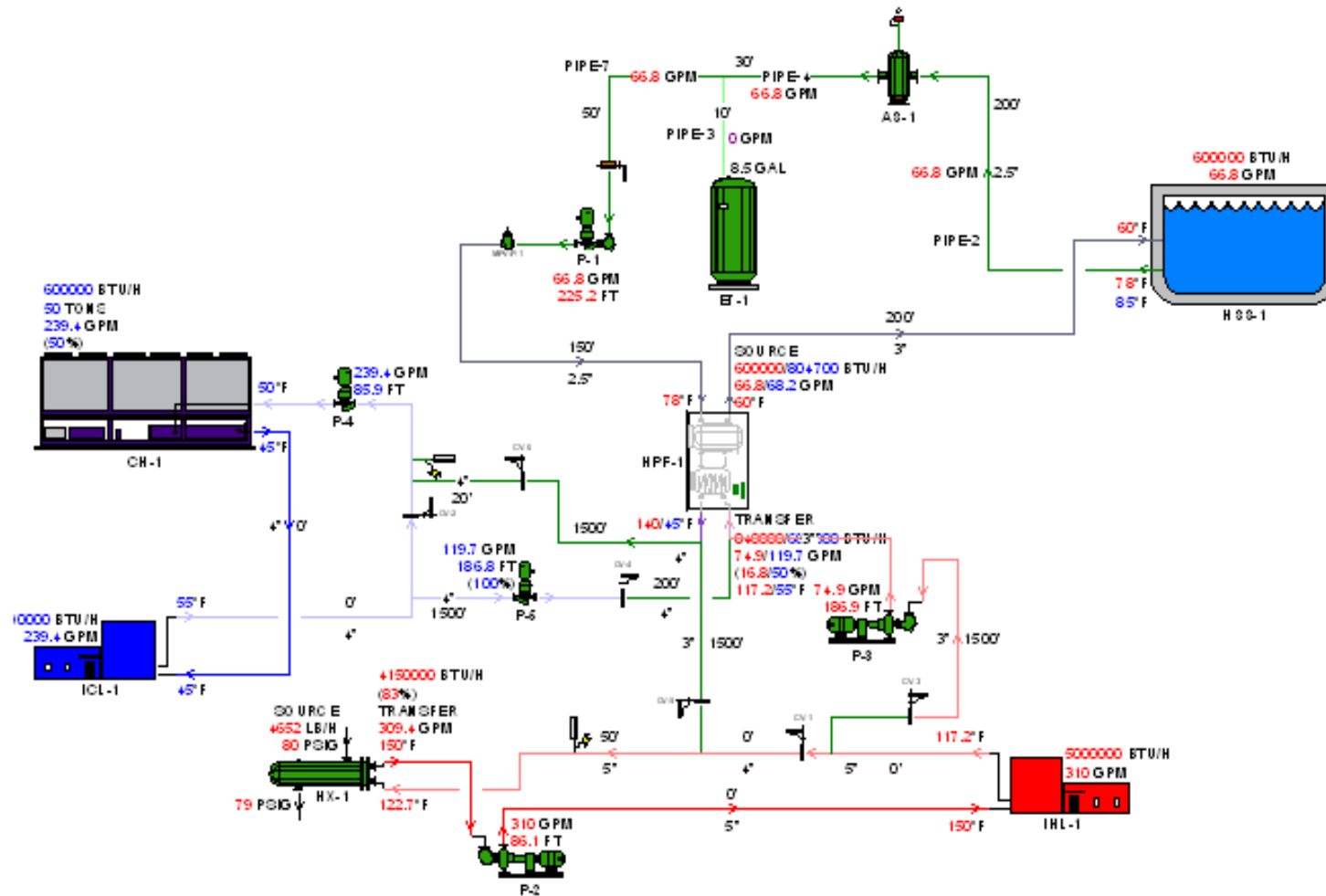
an extension of the existing control system. This will include sensing the heat sink water temperatures to document the heat sink operation.

System Start-up

The final design will include test and balancing of the entire water-side system except that the AHUs and heating coils in the boxes need not be rebalanced.

Electrical System

Provide the design for a complete operating electrical system to support the heat pump installation. This includes providing power from the existing transmission transformer near the building to the mine site. Power shall be provided to the heat pump, pumps, and miscellaneous mechanical equipment. Lighting and miscellaneous power shall also be provided at the mine site.



Unit Summary Report

Butte,

Year 2008 Quarter 1

Date: 14-Nov-10

MT Heat Pump

Prepared By:
 Mack Wallace
 Wisewatt LLC

Division Description	Total
Division 22 Plumbing	\$214,935.89
Division 23 Heating, Ventilating, and Air-Conditioning (HVAC)	\$181,598.07
Division 26 Electrical	\$89,404.90
Division 33 Utilities	\$116,346.00
Subtotal	\$602,284.86
General Contractor's Markup on Subs	5.00% \$28,047.06
Subtotal	\$630,331.92
General Conditions	10.00% \$63,033.19
Subtotal	\$693,365.11
General Contractor's Overhead and Profit	15.00% \$104,004.77
Grand Total	\$797,369.88

Unit Detail Report

Butte,

Year 2008 Quarter 1

Date: 14-Nov-10

MT Heat Pump

Prepared By:
 Mack Wallace
 Wisewatt LLC

LineNumber		Description	Quantity	Unit	Total Incl. O&P	Ext. Total Incl. O&P
Division 22 Plumbing						
220719104528	S	Insulation, pipe fitting (price copper tube one size less than I.P.S.),cellularglass, all service jacket, sealant, 0 water vapor transmission, working temperature (-450 Deg.F to +900 Deg.F), 2" wall, 4" iron pipe size, includes fabric and mastic	50.00	Ea.	\$29.40	\$1,470.00
220719104528	A	Engineering Fees, mechanical (plumbing & HVAC), maximum	1.00	Contract	\$2.97	\$148.50
220719107420	S	Insulation, pipe covering (price copper tube one size less than I.P.S.), fiberglass with all service jacket, 2" wall, 4" iron pipe size	1,500.00	L.F.	\$10.28	\$15,420.00
220719107420	A	Engineering Fees, mechanical (plumbing & HVAC), maximum	1.00	Contract	\$1.04	\$1,560.00
221113442090	S	Pipe, steel, black, welded, 3" diameter, schedule 40, Spec. A-53, includes yoke & roll hanger assembly, sized for covering, 10' OC	1,000.00	L.F.	\$32.05	\$32,050.00
221113442090	A	Engineering Fees, mechanical (plumbing & HVAC), maximum	1.00	Contract	\$3.24	\$3,240.00
221113442110	S	Pipe, steel, black, welded, 4" diameter, schedule 40, Spec. A-53, includes yoke & roll hanger assembly, sized for covering, 10' OC	3,500.00	L.F.	\$39.51	\$138,285.00
221113442110	A	Engineering Fees, mechanical (plumbing & HVAC), maximum	1.00	Contract	\$3.99	\$13,965.00
221113487412	S	Pipe, fittings and valves, suction diffuser, steel, grooved end inlet x flanged outlet, grooved joint, 4" x 4", add 1 coupling (material only) per joint for installed price, includes joint coupling labor, excludes joint coupling material	3.00	Ea.	\$790.95	\$2,372.85
221113487412	A	Engineering Fees, mechanical (plumbing & HVAC), maximum	1.00	Contract	\$79.89	\$239.67
221123104080	S	Pump, general utility, centrifugal, end suction, horizontal base mounted, vertical split case, rated @ 100' head, single stage, 500 GPM, 20 H.P., 4" discharge, includes drip proof motor	1.00	Ea.	\$5,617.50	\$5,617.50
221123104080	A	Engineering Fees, mechanical (plumbing & HVAC), maximum	1.00	Contract	\$567.37	\$567.37
Division 22 Subtotal						\$214,935.89
Division 23 Heating, Ventilating, and Air-Conditioning (HVAC)						
230523300580	S	Valves, iron body, butterfly, lug type, pneumatic operator, 4"	7.00	Ea.	\$397.88	\$2,785.16
230523300580	A	Engineering Fees, mechanical (plumbing & HVAC), maximum	1.00	Contract	\$40.19	\$281.33
230593200200	S	Balancing, water, chiller, (Subcontractor's quote including material & labor)	1.00	Ea.	\$425.43	\$425.43

LineNumber		Description	Quantity	Unit	Total Incl. O&P	Ext. Total Incl. O&P
230593201000	S	Balancing, water, pumps, (Subcontractor's quote including material & labor)	3.00	Ea.	\$220.22	\$660.66
230913601000	S	Water level control, electric water feeder	2.00	Ea.	\$294.29	\$588.58
230913601000	A	Engineering Fees, mechanical (plumbing & HVAC), maximum	1.00	Contract	\$29.72	\$59.44
230923100172	S	Control Components/DDC Systems, subcontractor's quote incl. material & labor, analog inputs, sensors (avg. 50' run in 1/2" EMT), water temperature (see Div. 15120 for well tap add)	10.00	Ea.	\$551.20	\$5,512.00
230923103229	S	Control Components/DDC Systems, subcontractor's quote incl. material & labor, D.D.C controller (avg. 50' run in conduit), mechanical room, 32 point controller, incl. 120V/1 phase power supply	20.00	Ea.	\$4,593.37	\$91,867.40
232120100120	S	Air control, air separator, 4" diameter, includes strainer	1.00	Ea.	\$2,213.52	\$2,213.52
232120100120	A	Engineering Fees, mechanical (plumbing & HVAC), maximum	1.00	Contract	\$223.57	\$223.57
232120462120	S	Expansion tanks, steel, liquid expansion, painted, 100 gallon capacity, ASME	1.00	Ea.	\$1,155.91	\$1,155.91
232120462120	A	Engineering Fees, mechanical (plumbing & HVAC), maximum	1.00	Contract	\$116.75	\$116.75
232120540330	S	Flow check control, cast iron body, flanged inlet, threaded outlet, 4" size	3.00	Ea.	\$715.75	\$2,147.25
232120540330	A	Engineering Fees, mechanical (plumbing & HVAC), maximum	1.00	Contract	\$72.29	\$216.87
232120761060	S	Strainer, Y type, bronze body, flanged, 150 lb., 4" pipe size, flanged	3.00	Ea.	\$1,574.57	\$4,723.71
232120761060	A	Engineering Fees, mechanical (plumbing & HVAC), maximum	1.00	Contract	\$159.03	\$477.09
232123135610	S	Pump, circulating, cast iron, base mounted, coupling guard, bronze impeller, flanged joints, 20 H.P., to 1350 GPM, 6" size	1.00	Ea.	\$6,741.58	\$6,741.58
232123135610	A	Engineering Fees, mechanical (plumbing & HVAC), maximum	1.00	Contract	\$680.90	\$680.90
232123135620	S	Pump, circulating, cast iron, base mounted, coupling guard, bronze impeller, flanged joints, 25 H.P., to 1550 GPM, 6" size	1.00	Ea.	\$6,889.03	\$6,889.03
232123135620	A	Engineering Fees, mechanical (plumbing & HVAC), maximum	1.00	Contract	\$695.79	\$695.79
236426100210	S	Water chiller, screw liquid chiller, packaged unit, water cooled, 80 ton, includes standard controls, excludes water tower	1.00	Ea.	\$53,136.10	\$53,136.10
Division 23 Subtotal						\$181,598.07
Division 26 Electrical						
260505100120	S	Conduit, rigid galvanized steel, 1-1/4" to 2" diameter, electrical demolition, remove conduit to 15' high, incl fittings & hangers	1,000.00	L.F.	\$1.96	\$1,960.00
260505100120	A	Engineering Fees, mechanical (plumbing & HVAC), maximum	1.00	Contract	\$0.20	\$200.00
260513160100	S	Medium-cable single cable, copper, XLP shielding, 5 kV, #2, in conduit, excl splicing & terminations	36.00	C.L.F.	\$475.43	\$17,115.48

LineNumber		Description	Quantity	Unit	Total Incl. O&P	Ext. Total Incl. O&P
260513160100	A	Engineering Fees, mechanical (plumbing & HVAC), maximum	1.00	Contract	\$48.02	\$1,728.72
260519550400	S	Non-metallic sheathed cable, copper with ground wire, 600 V, 3 conductor, #10, (Romex)	20.00	C.L.F.	\$339.82	\$6,796.40
260519550400	A	Engineering Fees, mechanical (plumbing & HVAC), maximum	1.00	Contract	\$34.32	\$686.40
262213100900	S	Transformer, dry-type, single phase 240/480 V primary 120/240 V secondary, 7.5 kVA	1.00	Ea.	\$1,311.84	\$1,311.84
262213100900	A	Engineering Fees, mechanical (plumbing & HVAC), maximum	1.00	Contract	\$132.50	\$132.50
262213104700	S	Transformer, dry-type, 3 phase 480 V primary 120/208 V secondary, 500 kVA	1.00	Ea.	\$22,557.86	\$22,557.86
262213104700	A	Engineering Fees, mechanical (plumbing & HVAC), maximum	1.00	Contract	\$2,278.34	\$2,278.34
262413102700	S	Switchboards, fused switch, 4 wire, 277/480 V, 800 amp, incl CT compartment, excl CT's or PT's	1.00	Ea.	\$12,755.60	\$12,755.60
262413102700	A	Engineering Fees, mechanical (plumbing & HVAC), maximum	1.00	Contract	\$1,288.32	\$1,288.32
262416300300	S	Panelboards, 1 phase 3 wire, main lugs, 120/240 V, 100 amp, 20 circuits, NQOD, incl 20 A 1 pole plug-in breakers	2.00	Ea.	\$1,360.37	\$2,720.74
262416300300	A	Engineering Fees, mechanical (plumbing & HVAC), maximum	1.00	Contract	\$137.40	\$274.80
262416301300	S	Panelboards, 3 phase 4 wire, main lugs, 277/480 V, 100 amp, 20 circuits, NEHB, incl 20 A 1 pole plug-in breakers	1.00	Ea.	\$2,319.91	\$2,319.91
262416301300	A	Engineering Fees, mechanical (plumbing & HVAC), maximum	1.00	Contract	\$234.31	\$234.31
262419300200	S	Motor control center, starters, class 1, type B, comb. MCP, FVNR, with control XFMR, size 2, 25 HP, 18" high, incl starters & structures	3.00	Ea.	\$2,114.66	\$6,343.98
262419300200	A	Engineering Fees, mechanical (plumbing & HVAC), maximum	1.00	Contract	\$213.58	\$640.74
262419300350	S	Motor control center, starters, class 1, type B, comb. MCP, FVNR, with control XFMR, size 4, 75 HP, 24" high, incl starters & structures	1.00	Ea.	\$4,455.21	\$4,455.21
262419300350	A	Engineering Fees, mechanical (plumbing & HVAC), maximum	1.00	Contract	\$449.98	\$449.98
262419300900	S	Motor control center, combination of starters, up to 72" high	1.00	Ea.	\$2,864.46	\$2,864.46
262419300900	A	Engineering Fees, mechanical (plumbing & HVAC), maximum	1.00	Contract	\$289.31	\$289.31
Division 26 Subtotal						\$89,404.90
Division 33 Utilities						
335113101040	S	Natural Gas Piping, polyethylene, coils natural gas distribution, 60 PSI, 1-1/4" diameter, @ 100', coupling, SDR 11, excludes excavation or backfill	13,000.00	L.F.	\$4.77	\$62,010.00
335113101040	A	Engineering Fees, mechanical (plumbing & HVAC), maximum	1.00	Contract	\$0.48	\$6,240.00
337119151070	S	Electrical Underground Ducts and Manholes, PVC, with coupling, 4" diameter, schedule 40, installed by direct burial in slab or duct bank	3,600.00	L.F.	\$12.13	\$43,668.00
337119151070	A	Engineering Fees, mechanical (plumbing & HVAC), maximum	1.00	Contract	\$1.23	\$4,428.00
Division 33 Subtotal						\$116,346.00

LineNumber		Description	Quantity	Unit	Total Incl. O&P	Ext. Total Incl. O&P
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