TECHNICAL MEMORANDUM

Geothermal System Assessment

Town of Pagosa Springs
Pagosa Springs, Colorado

Prepared For	Pagosa Springs Sanitation General Improvements District
Prepared By	Steve Omer, P.E.
DATE	June 30, 2020
VERSION	1
PROJECT NO.	4092-008-01

PLUMMER

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1 INTRODUCTION

The Town of Pagosa Springs (Town) has been operating a geothermal heat distribution utility since 1981. The system uses a heat exchanger and closed loop distribution system to convey heat to nearby businesses and residences. Since the original installation, only general maintenance and the addition of flow meters has been completed and there has been no expansion of the service area. The existing equipment continues to perform as designed and provide an economical heat source to utility customers.

This technical memorandum (TM) provides a summarized review of the system completed by Plummer on behalf of the Town. The review includes an assessment of existing conditions of the major infrastructure, the existing demands and capacity for system expansion, and potential new ways to expand both the heat distribution utility and the geothermal resource for uses other than heat delivery; each section includes recommended improvements. Manufacturer quotes and capital planning level cost estimates are included in the appendices for each recommended improvement, maintenance item, or major expansion opportunity.

2 EXISTING CONDITIONS

The existing geothermal wells, heat exchanger, and distribution piping network have been in service since 1981. Minimal changes have been to the system since the original development was completed. The original piping at the well heads and within the geothermal building is steel, the distribution piping is Transite, and some of the pipe connections at the heat exchanger building have been replaced with HDPE. The following sections discuss each major component of the system.

2.1 GEOTHERMAL WELLS

The Town owns three geothermal wells, two of which are in active use. They are locally designated as the Rumbaugh Well, Well 3 and Well 5. Production from the Rumbaugh Well is not directly used by the Town but is leased to the Overlook Hot Springs. Well 3 has not been in operation in recent years and Well 5 is currently used to supply geothermal water to the heat exchanger.

Wells 3 and 5 share a single water right that is limited to 450 gallons per minute (gpm); the Town is able to consistently draw the full water right through Well 5, and Well 3 has not been operated in recent years. The Rumbaugh Well has a seasonably variable water right of 150 gpm during the heating season and 35 gpm during the non-heating season; 35 gpm is currently leased to the Overlook Hot Springs on an annual basis. Figure 1 shows the current condition of Well 5; the coating appears to be in good condition with some scale showing due to discharges from the air relief valve (this scale is not harming the coating or impacting the coatings rust preventive ability for the metal piping).

Figure 1. Well 5

2.2 HEAT EXCHANGER AND GEOTHERMAL BUILDING

Water from the geothermal supply well enters the geothermal building and passes through a plate and frame heat exchanger unit that transfers heat into the water in the distribution loop. The distribution loop water is supplied by a connection to the Pagosa Area Water and Sanitation District (PAWSD) potable water supply. Geothermal water leaving the heat exchanger is used by the nearby greenhouse project and then transferred to the Springs Resort for use in their geothermal pool and hot tubs. However, the geothermal water may also be discharged into the San Juan River if the Springs Resort lease should ever terminate. Flow from the well through the heat exchanger is artesian (there is no pump used to convey the geothermal water). The heat distribution system operates as a closed loop and a pump in the geothermal building moves water though the heat exchanger and distribution piping.

The piping and equipment in the geothermal building is in good repair. The temperature sensors were replaced in 2019 and the pipe coating is in good condition overall. Figure 2 (below) shows the heat exchanger and connecting piping. The yellow piping is the hot geothermal water from the well, the red piping is the geothermal water leaving the heat exchanger, orange piping is heated water for distribution,

and green piping is the return from the distribution loop.

The plate and frame heat exchanger is a Tranter Supercharger Model with 326 plates that provide a total exchange surface area of 2650.5 square feet. This unit is relatively small within the Tranter product line, with similar units being able to provide up to 22,000 square feet of surface area. Operators occasionally tighten the heat exchanger plate pack to control leakage. The heat exchanger has a plate pack length tolerance range of 51.64 to 54.88 inches, and the current plate pack measurement is 51.81 inches. As the gaskets reach maximum compression, the torque required to tighten and seal the exchanger begins to rise exponentially.

Figure 2. Heat Exchanger

Table 1 summarizes the results of heat exchanger performance modeling completed by Tranter (Appendix A). Geothermal water enters the exchanger at 140 degrees F; all other temperatures at the exchanger are dependent on system performance and user demands. The Existing Conditions model scenario represents recent system performance, while the Max Distribution scenario shows the maximum performance that could be achieved with the existing system. The Theoretical Condition evaluates performance potentials that could be achieved with additional water rights; this condition is only presented as an example and increasing water rights is not a recommendation of this study.

Table 1. Modeled Heat Exchanger Performance

Description	Geothermal Flow Rate	Distribution Flow Rate	Heat Exchanged (kBtu/day)
Existing Conditions	450	375	131, 077
Max Distribution	450	700	158,908
Theoretical Condition[1]	700	700	225,311

1) This Theoretical Condition would require additional water rights

2.3 DISTRIBUTION SYSTEM

The distribution system delivers heated water to customer taps through two loops of buried pipe and occasional air release and flow control valves. One loop serves customers to the North of Hwy 160 along the Highway and Lewis Street, while the second loop serves customers along Durango, San Juan, and 8th Streets. There are several air release valve vaults to help release accumulated air from the system. At the far end of each loop of the distribution system, there is a flow control valve that provides some restriction where the system transitions from the feed to the return piping. The distribution system consists of approximately 1,480 feet of 6-inch, 14,304 feet of 8-inch, and 2,313 feet of 10-inch piping; there is a total of 18,100 feet or 3.4 miles of pipe in the system. A map of the system is provided in Appendix B.

At the time of original construction, Transite was a preferred piping material due to its relatively low weight and low friction loss. Transite is an asbestos-reinforced concrete material and due to modern regulations on asbestos exposure, it is no longer a desirable material. Potable water systems are actively abandoning Transite piping and there are federal regulations that apply to working with and disposing of Transite.

Limited sections of buried piping, where the distribution pipes enter the geothermal building, have previously been replaced with HDPE piping. HDPE has a maximum service temperature of 140 degrees F in pressurized applications, so further use of this material is not recommended.

The existing distribution pump can convey up to 700 gpm but is typically operated at a flow rate of 375 gpm. Staff have reported increased pipe failures when the system is operated at higher flow rates. The ability to increase flow in the distribution system may be a limitation to system expansion.

Customer connections are made with tapping saddles on the feed piping; many were installed during the original system construction and capped with a galvanized plug. The service piping varies by age of installation and materials, which currently includes galvanized steel, HDPE, and PEX. Staff have not

reported significant issues with customer service connections.

2.4 RECOMMENDED IMPROVEMENTS

The overall geothermal system was constructed of durable materials and needs minimal preventative maintenance except for the distribution piping, which should be considered for replacement (see discussion in 2.4.3 below). However, there is an unused well head near the Town's wells that is heavily deteriorated; while it is not Town property, coordinated repair efforts may be worthwhile. The aging distribution piping represents the largest need for system improvements. The heat exchanger should also be considered for preventive maintenance as the stack length is close to the lower limit of tolerance and further tightening to control leaks will require continually increased force as the gaskets reach maximum compression.

2.4.1 Wells

The Town owned wells and the coatings appear to be in good condition. There is an unused well head adjacent to the Town's Well 5 that has a severely corroded shutoff valve. If this were to completely fail, it would have a negative impact on the geothermal resource and could impact all existing geothermal well owners. Plummer recommends a coordinated repair effort between the Town and well owner to protect the geothermal resource. Considering the poor condition of the existing valve, the repair may require a new valve hot tapped into the well casing below the existing valve. Also, any metal piping or valves that remain exposed should be coated in a 2-part epoxy paint system, such as Tnemec 1095, to prevent future corrosion.

Figure 3. Corroded Well Head

2.4.2 Heat Exchanger

While the heat exchanger continues to perform per its original design; it has never had gasket replacement, and the plate stack is nearing the minimum tolerance. Communications with the heat exchanger manufacturer have identified a recommended maintenance protocol. Due to the age of the unit, and the relatively compressed stack length, Tranter recommends a factory cleaning and inspection of the entire plate stack. Factory representatives are available to disassemble the heat exchanger, service the plates and gaskets, and reassemble the unit. Alternatively, Town staff may do the local work and ship the plates to Tranter for service at their facility. Tranter provided a quote of $35,032 (Appendix C) to perform the maintenance work and included the potential cost of a replacement plate at $148 per plate. The plate replacement cost is simply representative as they cannot predict if, or how many, plates may need replacement due to leaks found during the factory inspection process. Plummer recommends this preventive maintenance be completed to preserve operation of this critical piece of equipment.

2.4.3 Distribution System

Newer piping materials are available that do not contain hazardous asbestos and are designed for hot service temperatures of the geothermal system. Due to the relatively large 8-inch piping, only two manufacturers were identified as capable of supplying replacement pipe; a third manufacturer of high temperature thermoplastic piping was contacted but they do not provide sizes larger than 6-inch. Both materials identified can be installed and tapped in an identical manner to HDPE. Polypropylene and Polyethylene are leading thermoplastic materials for piping, the most common variants are known as PP and HDPE; both are available in special formulations for high temperature usage.

Polypropylene Random Copolymer (PPR) piping is the high temperature version of PP piping and PE-RT (Polyethylene of Raised Temperature) is the HDPE variant that is appropriate for geothermal service. Both can be purchased pre-insulated. Table 2 presents the budgetary cost of each material as bare pipe and with 2-inches of pre-installed insulation.

Table 2. Replacement Piping Material Cost

Description	Uninsulated ($/ft)	Insulated ($/ft)
6” PE-RT	22.5	39
8” PE-RT	38	56
10” PE-RT	64	94
6” PPR	53	88
8” PPR	60	96

The existing distribution system is insulated on the feed piping (going towards geothermal customers) and uninsulated on the return piping. Staff have reported the heat loss keeps the surrounding soil thawed to within a foot of the surface; while earth is a reasonable insulator, this loss is limiting the amount of heat that can be delivered to utility customers. Selection of pre-insulated piping is recommended for both feed and return piping to maximize utilization of the geothermal resource. Table 3 below presents the potential heat savings for insulated piping.

Table 3. Distribution Heat Loss

Description	Heat Loss (Btu/Hr-Ft)
8" Uninsulated PPR	145
8" Insulated PPR	22.7
Potential Heat Conservation	145 – 22.7 = 122.3

1) 400 feet length used correlates to the planned replacement piping in the CDOT McCabe Creek realignment project.

If the information from Table 3 is extrapolated to the whole system, the energy savings could be very significant. It becomes difficult to approximate the actual impact because of varying temperatures and velocities throughout the system. There is approximately 9,000 feet of return piping in the system and if the impact was 75 percent of that calculated above, the total heat savings is estimated to be 19,800 kBtu/day,

Due to asbestos regulations, replacement of Transite piping should not be achieved through a pipe bursting replacement method and requires specialized contractors and landfill facilities for disposal. Slip lining was also investigated as a potential repair mechanism; slip lining projects require access openings at intervals similar to sewer manholes, meaning the existing pipe would be cut at regular intervals further weakening the overall pipe system. Slip lining also has a similar installation cost to open trench pipe installation (without pavement repair costs).

The original distribution piping has been in use for almost 40 years and Transite was intended to have a 50 year service life. Plummer recommends the Transite piping be replaced with high temperature rated thermoplastic piping (PPR or PE-RT) when replacing the distribution piping. Considering the age of the Transite piping, complete distribution piping replacement should be included in capital planning; a Class IV Cost Estimate is included in Appendix D.

Insulated feed and return piping replacements are also recommended for future replacement projects.

The upgrade to all insulated piping could enable the Town to deliver heat to more customers and increase the potential revenue from the utility.

2.4.4 Service Connections and Metering

As discussed above in Section 2.3, there are a variety of materials in use at customer service connections, including galvanized steel, HDPE, and PEX. Plummer recommends standardizing to PEX for future service connections and any required service repairs.

Most existing customers have working meters to record the therms of heat capacity consumed. In recent years, the Town decided to bill customers on past usage averages and not continue with meter readings. This billing method creates potential loss due to changes in customer demand and impacts ability to access financial solvency of the geothermal utility. Plummer recommends meter reading be resumed (if only on a periodic basis) to track usage and develop a data set that could support a future financial assessment of the utility.

3 SYSTEM CAPACITY

A 2007 study found a mid-winter heat transfer rate of 98,300 kBtu/Day, with metered usage of approximately 26,900 kBtu/day. This historical data can be used to compare heat transfer to metered usage indicating that roughly 75 percent of heat transferred is lost in the distribution system and not sold to customers. Some background heat loss is inherent to this type of system and reducing those losses can be achieved by replacement with insulated piping; the total reduction is a function of technology selection and feet of pipe replaced. There were 21 metered customers in 2007, 32 customers in 2013 and leases to 2 hot springs companies, and 3 new customers since that time bringing the total to 35. The heat exchanger is typically operated with the full geothermal flow of 450 gpm, with the distribution loop running at 375 gpm.

3.1 CURRENT GEOTHERMAL DEMANDS

User demands have not been actively metered since 2013. A flat rate based on 8 year averages was adopted and implemented in 2014, and meter readings and meter maintenance have been largely discontinued since that time. A model of current heat exchanger performance shows a rate of 131,100 kBtu/Day. Assuming 75 percent distribution loss, this leads to an approximation of 32,800 kBtu/day delivered to current customers.

3.2 EXISTING GEOTHERMAL CAPACITY

The system is currently operated at the full permittable water right of the geothermal well, so no further expansion is considered for that side of the system. The distribution loop is currently run at less than the maximum capacity of the existing equipment. The pump that controls flow in the loop is able to provide flow up to 700 gpm; however, it is currently operated at 375 gpm. Model results indicate that increasing the flow is calculated to increase the potential heat transfer rate up to 158,900 kBtu/day, as compared to the model estimated 131,100 kBtu/day for operation at 375 gpm; however, geothermal staff report increased pipe breaks when running the pump at higher speeds and expanding capacity by increasing the pump flow rate could lead to the need for significant pipe repair.

Another important consideration is the impact of changes to existing customers. During the 2019/2020 operating season, changes made at the Springs Resort temporarily limited flow through the heat exchanger which caused the distribution loop temperature to drop as low as 110 degrees F (the long term average is 122 degrees F). While no customers complained about service issues, one reported their

exchange system ran longer than usual. Due to this situation, the heat exchanger modeling was completed to review the amount of energy that can be exchanged without the return temperature dropping below 110F.

3.3 REMAINING GEOTHERMAL CAPACITY

The remaining capacity of the existing system is estimated to be the difference between current amount of heat transfer, 131,100 kBtu/day and the maximum rate of 158,900 kBtu/day; the resulting available capacity is estimated to be 27,800 kBtu/day. Based on previous meter readings, the average customer uses 3,150 kBtu/day; if the data excludes the largest consumers and focuses on residential customers, the average reduces to 2,100 kBtu/day. There is potential to add up to 9 new average customers or 13 average residential customers.

If the distribution piping were replaced with insulated materials, the system loss could be significantly reduced while increasing availability of sellable energy. Section 2.4.3 shows a potential heat savings of up to 19,800 kBtu/day. This could allow an additional 6 to 10 customers to be added to the system.

3.4 POTENTIAL FOR CAPACITY EXPANSION

There are several theoretical ways to increase system capacity. These approaches include:

1) increases to flow rate on either the geothermal or distribution loop would increase the amount of heat transferred assuming additional demand is added.
2) adding demand can lead to a higher temperature difference which increases the heat transfer to a limited degree but could have a negative impact on existing customers. The following paragraphs discuss options that have been reviewed.

3.4.1 Geothermal Water Right Increase

An increase to the geothermal water right for Wells 3 and 5 was attempted in 1990 and refused by the Colorado Division of Water Resources; an increase in geothermal flow would provide additional capacity to expand the geothermal utility. The unleased portion of the Rumbaugh well right could also be run to the existing geothermal building.

3.4.2 Closed Loop Geothermal Approach

A review of reinjection well expenses indicates that a closed loop geothermal approach should be

removed from further consideration. Injection wells can cost millions of dollars to construct and the operating expense (reinjection pump electrical cost) can be very significant. Also, this unique approach might have permitting issues with the Division of Water Resources.

3.4.3 Increased Flow Rate

The most viable way to increase capacity of the existing system is by increasing the flow rate within the distribution loop. This would increase the heat transfer potential at the exchanger while maintaining the service level expected by existing customers. This approach may require replacement or repair of the distribution system piping.

4 EXPANSION OPPORTUNITIES

The following sections discuss several options for potential expanded usage of the geothermal system. Options considered include added traditional use for heating and snowmelt, cooling, and electrical power generation.

4.1 SUMMER COOLING OPTION

The Town has the ability (and water rights) to pump water from the river and could potentially run this through the heat exchanger during summer months. The potential to use existing infrastructure to offer cooling to existing geothermal customers was reviewed based on river temperature data collected by the USGS near the Hot Springs Boulevard bridge. During the review period of 1958 through 2013, the average river temperature between June and September was 63.4 degrees F. Thus, the minimal difference between the available source temperature and the desired temperature of most homes and businesses makes summer cooling an impractical use of the system.

4.2 INCREASED TRADITIONAL USAGE

There is remaining capacity for traditional heating and snowmelt usage. Building heat provides a more predictable impact to system loading than snowmelt, and a preference for those types of connections is recommended. Snowmelt related demands can vary greatly with weather and outdoor temperatures; whereas buildings are insulated, and interior heating provides a more predictable load for the geothermal system to support. While the ability to accommodate many new customers is currently limited by the condition of the distribution system, this remains a viable way to expand use of the geothermal utility.

The local High School was considered as a potential addition to the system. They currently have three 3-million Btu/day boilers and can run two of them simultaneously to keep up with typical winter heating demands. The geothermal system is not capable of transferring enough heat to support this load without additional water rights and other significant upgrades.

4.3 POWER GENERATION

There is a potential to generate electrical power with the latent heat in the geothermal water. Novacab has a thermal electric storage system (TESS) that is primarily marketed to help industrial users reduce peak electrical charges by storing energy during low cost periods and releasing it during the peak charge period. This technology could be used to generate electricity that the Town could then sell to the La Plata

Electric Association (LPEA). The manufacturer estimates up to 1,634 MWh could be produced annually. LPEA uses negotiated rates for power generators which could be as low as $0.042/kWh; this rate would lead to a potential annual revenue of $68,600. The revenue estimate is dependent on LPEA accepting the generated electricity and paying the rate of 4.2 cents per kWh; the actual rate may be negotiated higher than the minimum presented in this report. Using this conceptual-level information, a theoretical payback period of 12 years is calculated for the equipment cost of $805,000. Information presented in this section for the Novacab technology is based on a promotional-level proposal from Novacab is included as Appendix E.

The Novacab units would be installed down stream of utility customers during heating season with piping designed to bypass the distribution loop during summer months. Figure B (in Appendix E) presents a flow diagram of the existing system and potential piping connections for the electrical generation equipment. Novacab estimates the temperature drop across their system will be approximately 10 degrees F, so the existing system should be capable of supporting both the existing utility customers and the new load provided the geothermal flow is maintained at 450 gpm. The Novacab controller unit would best be housed inside the existing geothermal building, while the two reactor units are provided in shipping containers that can withstand outdoor installation.

5 CONCLUSIONS

The geothermal resources and heat distribution utility owned by the Town provide a unique and cost-effective source for winter heating and snowmelt for existing customers. The system continues to perform within design intentions after nearly 40 years of seasonal service. With appropriate maintenance, the system can continue to be a reliable utility resource for the local community.

The Town's wells are in good condition; however, it may be worthwhile coordinating repair of abandoned well heads. Maintenance is recommended for the existing heat exchanger, which will restore the plate pack to a factory new condition. Replacing the gaskets and cleaning the plates will enable the heat exchange to continue operation for many years into the future.

The distribution piping is also recommended for planned replacement. The existing Transite piping is approaching the end of the intended service life, and the tendency for pipe breaks is a limiting factor for system expansion. Complete distribution replacement would be an expensive single project but would provide the most economical solution. Pipe replacement should be planned and completed either incrementally or all at once depending on funding capabilities.

Expansion of current uses to include electrical power generation has the potential to provide a dependable revenue source for the Town, while allowing for the continued traditional usage of providing heating and snowmelt to utility customers. If geothermal power generation is developed, it could help provide funding for distribution replacement and other system maintenance needs.

APPENDIX A

Tranter Performance Modeling

HEAT EXCHANGERS HEAT EXCHANGERS

TRANTER
The heat transfer people

Performance Specification

Customer: Plummer
Email:
Cust. Reference: D-52825 New Cond

Model: UXP-400-H-6-UR-326

Date: 5/4/2020
Proposal No.:
Run No.: 1198322
Item No.:
Technician: Malcom Cagle
Units Required: 1

Intended End Use: Heat exchanger to cool Water 24.67 °F using 110 °F Water with pressure drop at or below 2.75 psi on hot side and at or below 2 psi on cold side.

		Hot Side		Cold Side		
Fluid Name		Water		Water		
OPERATING DATA		***Inlet***	***Outlet***	***Inlet***	***Outlet***	
Total Liquid flow	GPM	450.00	450.00	375.00	375.00	GPM
Operating Temperature	°F	140.00	115.33	110.00	139.38	°F
Pressure drop (allowed / calc.)	psi	10.00 / 2.75		10.00 / 2.00		psi
Total Heat Exchanged	Btu/h	5,461,533				
U-Service	Btu/(h·ft²·°F)	939				
Total Heat Transfer Area	ft²	2,650.51				
LMTD	°F	2.20				
FLUID PROPERTIES		***Inlet***	***Outlet***	***Inlet***	***Outlet***	
Density	lb/ft³	61.37	61.78	61.85	61.38	
Specific Heat	Btu/(lb·°F)	1.00	1.00	1.00	1.00	
Thermal Conductivity	Btu/(h·ft·°F)	0.38	0.37	0.37	0.38	
Viscosity (avg.)	cP	0.47	0.58	0.61	0.47	
CONNECTIONS						
Position		M3	S3	S2	M2	
Type		LJSE	LJSE	LJSE	LJSE	
Size		6"	6"	6"	6"	
Rating		ANSI 16.5 150#	ANSI 16.5 150#	ANSI 16.5 150#	ANSI 16.5 150#	
Material		316L SS		316L SS		
CONSTRUCTION						
Pass Arrangement		2(1 + 1)		2		
Channel Arrangement		81H+82H		81H+0H		
Plate Material (Material/Thickness)		316 SS / 0.6 mm				
Gasket Material (Hot/Cold)		NBR		NBR		
No. of Plates		326				
Frame material / Paint / Color		SA-516-70 Carbon Steel / Enamel / RAL 5012 (Royal Blue)				
Tightening Bolts/Nuts/Finish		SA-193-B7 Carbon Steel / 8/2H Tie Nuts / FZB				
Pressure (design / test)	psi(g)	150.00 / 195.00		150.00 / 195.00		
Temperature (min / design)	°F	14.00 / 250.00		14.00 / 250.00		
Weight empty / flooded (per unit)	lbs	7,675 / 10,011				
Pressure vessel code		ASME				

Remarks:

Performance (clean in unit as is) D-52825

The performance guarantee, if applicable, is based on the accuracy of the data presented above, and the customers ability to supply product and operating conditions in conformance with the above.

Tranter, Inc. P.O. Box 2289 Wichita Falls, TX 76306
Phone: (940) 249-9688 Fax: (940) 723-1131 Email: malcom.cagle@tranter.com

HEAT EXCHANGERS HEAT EXCHANGERS

TRANTER
The heat transfer people

Performance Specification

Customer: Plummer
Email:
Cust. Reference: D-52825 New Cond

Model: UXP-400-H-6-UR-326

Date: 5/4/2020
Proposal No.:
Run No.: 1198320
Item No.:
Technician: Malcom Cagle
Units Required: 1

Intended End Use: Heat exchanger to cool Water 29.91 °F using 110 °F Water with pressure drop at or below 2.76 psi on hot side and at or below 6.57 psi on cold side.

		Hot Side		Cold Side		
Fluid Name		Water		Water		
OPERATING DATA		***Inlet***	***Outlet***	***Inlet***	***Outlet***	
Total Liquid flow	GPM	450.00	450.00	700.00	700.00	GPM
Operating Temperature	°F	140.00	110.09	110.00	129.08	°F
Pressure drop (allowed / calc.)	psi	10.00 / 2.76		10.00 / 6.57		psi
Total Heat Exchanged	Btu/h		6,621,154			
U-Service	Btu/(h·ft²·°F)		1,107			
Total Heat Transfer Area	ft²		2,650.51			
LMTD	°F		2.26			
FLUID PROPERTIES		***Inlet***	***Outlet***	***Inlet***	***Outlet***	
Density	lb/ft³	61.37	61.85	61.85	61.56	
Specific Heat	Btu/(lb·°F)	1.00	1.00	1.00	1.00	
Thermal Conductivity	Btu/(h·ft·°F)	0.38	0.37	0.37	0.37	
Viscosity (avg.)	cP	0.47	0.61	0.61	0.51	
CONSTRUCTION						
Pass Arrangement		2(1 + 1)		2		
Channel Arrangement		81H+82H		81H+0H		
Plate Material (Material/Thickness)		316 SS / 0.6 mm				
Gasket Material (Hot/Cold)		NBR		NBR		
No. of Plates		326				
Frame material / Paint / Color		SA-516-70 Carbon Steel / Enamel / RAL 5012 (Royal Blue)				
Tightening Bolts/Nuts/Finish		SA-193-B7 Carbon Steel / 8/2H Tie Nuts / FZB				
Pressure (design / test)	psi(g)	150.00 / 195.00		150.00 / 195.00		
Temperature (min / design)	°F	14.00 / 250.00		14.00 / 250.00		
Weight empty / flooded (per unit)	lbs	7,675 / 10,012				
Pressure vessel code		ASME				

Remarks:

Performance (clean in unit as is) D-52825

The performance guarantee, if applicable, is based on the accuracy of the data presented above, and the customers ability to supply product and operating conditions in conformance with the above.

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HEAT EXCHANGERS HEAT EXCHANGERS

TRANTER
The heat transfer people

Performance Specification

Customer: Plummer
Email:
Cust. Reference: D-52825 New Cond

Model: UXP-400-H-6-UR-326

Date: 4/23/2020
Proposal No.:
Run No.: 1197690
Item No.:
Technician: Malcom Cagle
Units Required: 1

Intended End Use: Heat exchanger to cool Water 27.26 °F using 110 °F Water with pressure drop at or below 6.38 psi on hot side and at or below 6.55 psi on cold side.

		Hot Side		Cold Side		
Fluid Name		Water		Water		
OPERATING DATA		***Inlet***	***Outlet***	***Inlet***	***Outlet***	
Total Liquid flow	GPM	700.00	700.00	700.00	700.00	GPM
Operating Temperature	°F	140.00	112.74	110.00	137.05	°F
Pressure drop (allowed / calc.)	psi	10.00 / 6.38		10.00 / 6.55		psi
Total Heat Exchanged	Btu/h		9,387,959			
U-Service	Btu/(h·ft²·°F)		1,246			
Total Heat Transfer Area	ft²		2,650.51			
LMTD	°F		2.84			
FLUID PROPERTIES		***Inlet***	***Outlet***	***Inlet***	***Outlet***	
Density	lb/ft³	61.37	61.82	61.85	61.42	
Specific Heat	Btu/(lb·°F)	1.00	1.00	1.00	1.00	
Thermal Conductivity	Btu/(h·ft·°F)	0.38	0.37	0.37	0.38	
Viscosity (avg.)	cP	0.47	0.60	0.61	0.48	
CONNECTIONS						
Position		M3	S3	S2	M2	
Type		LJSE	LJSE	LJSE	LJSE	
Size		6"	6"	6"	6"	
Rating		ANSI 16.5 150#	ANSI 16.5 150#	ANSI 16.5 150#	ANSI 16.5 150#	
Material		316L SS		316L SS		
CONSTRUCTION						
Pass Arrangement		2(1 + 1)		2		
Channel Arrangement		81H+82H		81H+0H		
Plate Material (Material/Thickness)		316 SS / 0.6 mm				
Gasket Material (Hot/Cold)		NBR		NBR		
No. of Plates		326				
Frame material / Paint / Color		SA-516-70 Carbon Steel / Enamel / RAL 5012 (Royal Blue)				
Tightening Bolts/Nuts/Finish		SA-193-B7 Carbon Steel / 8/2H Tie Nuts / FZB				
Pressure (design / test)	psi(g)	150.00 / 195.00		150.00 / 195.00		
Temperature (min / design)	°F	14.00 / 250.00		14.00 / 250.00		
Weight empty / flooded (per unit)	lbs	7,675 / 10,012				
Pressure vessel code		ASME				

Remarks:

Performance (clean in unit as is) D-52825

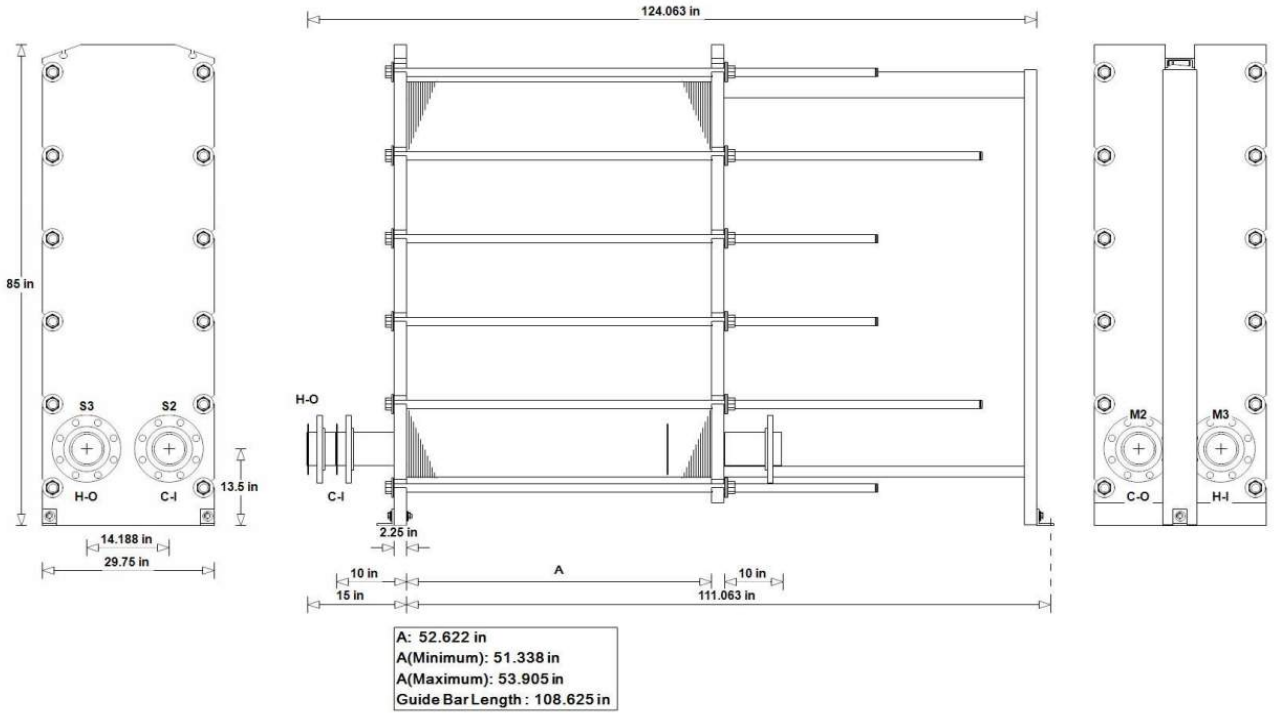
The performance guarantee, if applicable, is based on the accuracy of the data presented above, and the customers ability to supply product and operating conditions in conformance with the above.

Tranter, Inc. P.O. Box 2289 Wichita Falls, TX 76306
Phone: (940) 249-9688 Fax: (940) 723-1131 Email: malcom.cagle@tranter.com

TRANTER
The heat transfer people

SUPER H ER SSEM
UXP-400-H-6-UR-326

Si in m er
1197690



APPENDIX B

Distribution System Map


FIGURE No. A
PAGOSA SPRINGS GEOTHERMAL SYSTEM
EXISTING SYSTEM & CUSTOMER LOCATION MAP
PAGOSA SPRINGS COLORADO
PLUMMER
1485 FLORIDA ROAD, STE C206 | DURANGO, CO 81301
970.247.0724 | TBPE REGISTERED FIRM NUMBER F-13
SCALE: 1" = 400'-0"
0
200'
400'
RUMBAUGH WELL
GEOTHERMAL BUILDING
WELL #5
WELL #3
GEOTHERMAL DISTRIBUTION PIPING
COPYRIGHT 2020, Plummer

APPENDIX C

Tranter Maintenance Quote

Date: 5/13/2020

To:
Town of Pagosa Springs
PO Box 1859
551 Hot Springs Blvd
Pagosa Springs, CO 81147

Your contact is:
Sales Representative: ENERGY WEST
Name: Dennis Greaney
Email: dgreaney@energy-west.com
Phone: 303-921-5989

Quotation No.: 524976 Revision No.: 0

Inquiry Reference: UXP-400, D-52825, P-28740-H, Refurb, FS & PA

Dear Martin Schmidt:

Thank you for your valued inquiry. We are pleased to offer you Tranter Heat Exchanger Products and/or Services as itemized below:

Item	Part #/Model	Description	Unit Price	Qty	Total Price
1	Refurbishment	Clean, dye test and regasket a UXP-400 with 326 plates. (new NBR gaskets included)	$20,892.00	1.00	$20,892.00
2	Field Service	FS techs to remove plates from a UXP-400 with 326 plates and then go back and install plates into a UXP-400 frame once refurbishment is complete.	$14,140.00	1.00	$14,140.00
3	Plate Assembly	Replacement plate assembly for a UXP-400.	$148.00	1.00	$148.00
				Total Price:	**$35,180.00**

Shipping Est.: 2 - 3 Weeks ARO
Payment Terms: Net 30
Currency: US Dollar
Freight: FOB Shipping Point
Quote Expiration: 7/12/2020

The above price is net at the current exchange rate and excludes all Federal, State, or Municipal taxes. Price includes Tranter Standard Packaging. All orders are subject to credit approval and acceptance by Tranter, Inc. The terms of this agreement incorporate and are subject to Tranter, Inc.'s standard terms of sale.

*Estimate is inclusive of all labor, travel, meals, lodging, and expenses for (2) service technician(s), and is based on (2) technician(s) working (2) 10-hour day(s). The rate for any additional hours necessary is $100.00 per tech per regular hour and $150.00 per tech per overtime hour.

Charges are estimated only. Actual charges will apply.

Service estimate is based on the work being complete under standard conditions. If circumstance beyond Tranter's control result in increased time required completing the work, additional charges will apply.

It is expected that all utilities such as water and power be provided by the customer for the purpose of disassembly, re-assembly, testing and any other necessary work required in the repair or installation of the Heat Exchanger. The

MAIN OFFICE & FACTORY
Tranter, Inc.
1900 Old Burk Hwy
Wichita Falls, Texas 76306
Phone: (940) 723-7125
Fax: (940) 723-5131

customer is also responsible for providing necessary equipment (forklift, pallet jack, etc.) to locate all tools and parts within reasonable access to the immediate work area.

The customer is required to have the unit isolated, drained and ready for work to begin upon the arrival of the Tranter, Inc. field service technicians.

It is the customer's responsibility to remove any necessary piping from the heat exchanger.

The customer is also required to supply all manpower and tools involved in any hoisting of frames and or all piping to be removed in the disassembly and re-assembly of the Heat Exchanger. Tranter, Inc. will not be responsible for the removal or installation of the customer's piping or insulation connected to or on the Heat Exchanger.

Tranter, Inc. will provide the tools necessary to disassemble and re-assemble the Heat Exchanger. All freight charges involved in shipping these tools to and from the customer's facility (if required) will be the responsibility of the customer unless the service of the Heat Exchanger is deemed to be warranty.

It is the customer's responsibility to advise Tranter, Inc. of any onsite safety requirements, safety classes, restrictions, site access restrictions or requirements (such as "no beard/mustache" or "steel toe work shoes required"), and or documentation that must be completed before arriving onsite. Failure to do so will result in an invoicing for the serviceman's expenses if he is not allowed access to the site.

A PURCHASE ORDER AND AGREEMENT TO THE FOREGOING IS REQUIRED PRIOR TO A TRANTER, INC. FIELD SERVICE VISIT.

The cost for the cleaning and refurbishing of the plate pack include the following services / materials:

Removal of the old gaskets
Thorough cleaning of the plates
100% dye-penetrant exam of the plates
Application of new gaskets
Plate assemblies marked and stacked in sequential order

All freight to and from the refurbishing facility is to be paid by the customer.

Please contact Tranter West Coast at 559-686-1840 prior to shipping the plate pack to our facility at:

Tranter Inc.
West Coast Service Center
857 E. Levin
Tulare, CA 93274

In accordance with OSHA Right-To-Know regulations and EPA regulations, all returned materials that have been subject to process fluids must include an MSDS sheet of the process fluids. Failure to do so will result in refusal of the shipment.

Pricing and part availability is based on current availability of materials as of today and is subject to change due to prior sale and/or raw material based lead times.

All pricing and materials are strictly subject to material availability and prior sale.

The above quoted prices are valid for 60 days from the date of this quotation and are subject to change without notice thereafter.

We warrant our goods will be free from defects in material or workmanship under normal use and conditions, as defined by our specifications, for (1) year after shipment from our facility for all Aftermarket Parts and Labor.

MAIN OFFICE & FACTORY
Tranter, Inc.
1900 Old Burk Hwy
Wichita Falls, Texas 76306
Phone: (940) 723-7125
Fax: (940) 723-5131

Our standard payment terms are Net 30 Days, subject to credit approval and acceptance by Tranter, Inc. Orders $250,000 (and above) may require milestone payments. Credit cards accepted: MasterCard, Visa, and American Express.

Shipment of quoted goods is FOB Shipping Point; freight collect.

Title transfer passes to the buyer at point of shipment (collect unless otherwise specified).

Should an order result from this quote, please forward a PO to Tranter Inc. c/o Energy West Controls.

Feel free to contact me with any questions or concerns. And as always, we appreciate the opportunity to serve your heat exchanger needs.

Best Regards,

Christine Rails
Parts & Service Specialist
Tranter, Inc.

Jeffrey Simpson
Parts & Service Regional Sales Manager - Northwest
Tranter, Inc.
857 E. Levin Ave.
Tulare, CA 93274 United States
Jeffrey.Simpson@tranter.com
Phone: (559) 686-1840
Mobile:(559) 303-7566
Fax:(559) 686-3964

Tranter's Terms and Conditions of Sale

Limited Warranty and Limitation of Liability

(1) This contract is between merchants for the sale of goods, for commercial use. Seller warrants its goods will be free from defects in material or workmanship under normal use and conditions, as defined by its specifications, (1) year after Seller's shipment for Supermax and Maxchanger, (2) years after Seller's shipment for Platecoil/Econocoil and Superchanger units and (3) years for Superchanger Units used in HVAC application. Buyer's entire remedy and Seller's entire liability under this warranty shall be repair or replacement by Seller, at Seller's factory or any part(s) Seller determines to be defective after inspection at its factory, or, at Seller's election, refund of the price paid for such part(s).

(2) Seller guarantees the product(s) supplied will operate and perform its (their) intended use and function in the application(s) described in the "intended end-use" and with proper maintenance for (1) year after Seller's shipment. This guarantee is based on the accuracy of the data from the customer, and the customer's ability to supply relevant product and operating conditions. Buyer agrees that Seller, at Seller's expense, shall have the opportunity to correct, cure, or remedy any performance deficiency or failure that is reasonable attributable to any defect or deficiency in workmanship, material, or design of the product(s).

(3) Except as provided below, if notified promptly in writing and given full and timely authority, information and assistance, Seller shall defend and hold Buyer harmless in any suit to the extent it claims Seller's goods infringe a United States patent existing when Seller accepted Buyer's order. If the use of such goods in enjoined, Seller may, at its choice and expense, procure for Buyer the right to continue using them, replace them with non-infringing goods, modify them so they become non-infringing, or remove them and refund their purchase price. The foregoing states Seller's entire liability for patent infringement.

(4) The above warranties are made in lieu of all other warranties, express or implied, including but not limited to implied warranties of merchantability, fitness for a particular purpose, or title or non-infringement. There are no other warranties concerning seller's goods or services. No change or addition shall be valid unless in writing signed by an authorized agent of Seller.

(5) In no event shall Seller be liable for any consequential, indirect, special or punitive damages (including but not limited to lost profits or additional expense), even if Seller knows of the possibility of such damages.

(6) The seller's maximum liability shall not exceed 25% of the amount paid by the Buyer for the goods and / or services in dispute.

(7) Buyer shall have no cause of action for breach of this agreement or relating to the goods or services hereunder after two (2) years from Seller's date of shipment or provision of services.

Acceptance and Returns

(8) Seller's acceptance of orders is expressly conditioned on Buyer's consent to these terms and conditions, and any other terms in Seller's quotation. Changes may not be implied from Seller's acts. Any terms of Buyer's order which are inconsistent with these terms shall not be binding on Seller. Unless Buyer objects in writing to specific terms within (21) days from the date of Tranter's issuance of Tranter's Terms and Conditions of Sales, Buyer shall have deemed to have accepted them.

(9) The goods shall be deemed conforming and accepted unless Seller receives written objection within three (3) months of delivery. Any acceptance test shall be at Buyer's expense and must be made when the equipment is new, clean and undamaged, before it has been placed in service, and within three (3) months after delivery. Buyer shall furnish Seller of a report of any such test, at Buyer's expense, detailing the test procedure and disclosing all results.

(10) Returns may be made only with prior Seller approval and by prepaid freight. Credit allowances for merchandise returned or repaired without prior written authorization shall be entirely at Seller's discretion.

Shipping; Risks of Loss; Delay; Changes or Cancellations

(11) All sales (domestic or international shipments) are made EXW Seller's factory, and risk of loss and risks of further handling shall pass to Buyer when Seller makes the goods available to Buyer for shipment. Freight and handling quotations are based on rates then in effect, and are subject to change if the rate changes or Buyer specifies a route. If Buyer chooses to use Tranter's freight service, Buyer forfeits the right to inspect the freight bill issued between the freight carrier and Tranter.

(12) Seller will not be liable for delays in manufacture or shipment due to causes beyond its control, including without limitation delays caused by acts of God, threat of terrorism or war, civil unrest, fire, failures or delays in its usual courses of supply of material or other conditions. If products shortages should occur, Seller reserves the right to allocate its production among its customers on such basis as Seller may determine in its sole discretion.

(13) If Buyer wishes to change or cancel its order, such request must be specified in writing; will not be binding unless expressly accepted in writing by Seller; and will be subject to reasonable charges for costs incurred and work performed before the date Seller accepts it, including but not limited to drawings, material procurement, calculations, manufacturing labor and overhead, inspections and certifications

(14) Tranter, Inc.'s acceptance of this order is predicated on Tranter, Inc.'s understanding that the goods/services provided to buyer/customer by Tranter, Inc. under this order will be used in the United States and that they are not for export. If this is not correct, Tranter, Inc. requests that the buyer/customer advise Tranter, Inc. to ensure that any exportation of the goods/services provided to customer/buyer under this order is in compliance with U.S. export control regulations.

Payment

(15) Each shipment is an independent transaction for which payment is required. Seller reserves the right to vary terms of payment or require payment before manufacturing or shipment if, in Seller's judgment, Buyer's financial conditions so requires. If Buyer requests or causes a delay, payment shall be due on the sooner of the date the goods are ready for shipment or when Seller would have been prepared to ship but for delays Buyer causes or requests.

(16) All present or future taxes or duties applicable to the goods or services or their manufacture, use, or sale shall be added to the purchase price and are the Buyer's sole responsibility. If any taxing authority later determines taxes or duties are due, Seller may bill and collect the same from Buyer without limitation as to time.

(17) Seller may increase the selling price of goods not yet shipped, upon thirty (30) days' advance written notice. Unless Buyer notifies Seller in writing during this period that is does not consent, the increased price shall be paid on all goods shipped after this period. If Buyer does not consent, Seller may terminate this agreement as to portions as yet unperformed.

(18) Payment is in USA currency. Timely payment is of the essence. Except as otherwise agreed by Seller in writing, non-payment of the invoiced amount shall constitute a breach of this agreement thirty (30) days after the date of invoice. Seller retains a purchase money security interest in the goods until paid in full. Notwithstanding anything written or oral to the contrary, under no circumstances will Seller contract for or charge interest on unpaid amounts in excess of the maximum lawful amount, and anything with may be so constructed shall be deemed reformed to provide for no more than the maximum lawful amount.

(19) Payments made with a credit card are subject to a 3% convenience fee.

Governing Law, Venue, and Arbitration

(20) All agreements and proceedings relating to the Seller's goods or services shall be governed under the laws of the State of Texas and the USA, excluding conflicts of laws, provisions or disputes regarding goods or services. Applicability of the UN Convention on International Sale of Goods is disclaimed to the full extent permitted by law.

(21) This Agreement is made and performable in Wichita Falls, Texas. Any action relating directly or indirectly to the Seller's goods or services shall be brought only in the state court located in Wichita Falls, Texas, and the parties agree to such jurisdiction; provided, however, if the goods or services to which the dispute relates were or were intended to be shipped outside the USA, such dispute shall be resolved by binding arbitration in Dallas, Texas under the then-current rules of the American Arbitration Association, and judgment on the award may be entered in any court of competent jurisdiction. The arbitrator(s) shall have not power to award relief prohibited under this Agreement. Reasonable discovery shall be permitted according to the Federal Rules of Civil Procedure.

Additional Terms Applicable to Buyer- Supplied, Designed,- or –Specified Goods.

(22) Seller warrants that its goods will be manufactured according to such designs, specifications or instructions as Buyer may make in writing, but SELLER MAKES NO OTHER WARRANTY WITH RESPECT TO EQUIPMENT MANUFACTURED PURSUANT TO BUYER'S DESIGNS, SPEFICIATIONS, INSTRUCTIONS AND/OR MATERIALS, OR THOSE OF BUYER-DESIGNATED SUPPLIER. BUYER AGREES THAT SELLER ASSUMES NO LIABILITY FOR, AND MAKES NO WARRANTY WITH RESPECT TO, THE PERFORMANCE OF QUALITY, MERCHANTABILITY, FITNESS FOR PARTICULAR PURPOSE, TITLE, OR NON-INFRINGEMENT OF SUCH EQUIPMENT.

(23) Buyer represents and warrants to Seller that any designs, specifications or instructions Buyer provides will be complete, accurate, non-infringing, and fit for the Buyer's purposes. Buyer will hold harmless, indemnify and defend Seller from any costs or expenses, including without limitation reasonable attorney's fees, arising from breach or threatened breach of this warranty or the use of Buyer-supplied or Buyer-designated materials.

APPENDIX D

Distribution Replacement Material and Cost Estimate

HDPE: High-Density Polyethylene

What is HDPE?

High-density polyethylene (HDPE) pipe is an exceptional piping product with a lengthy list of benefits. HDPE has been in use for more than 50 years, building decade after decade of proven performance. It is a ductile, durable, virtually inert thermoplastic that is highly resistant to cyclical fatigue and well suited for a broad range of demanding applications. As the largest HDPE supplier in North America, ISCO Industries can provide piping solutions anywhere in the U.S. and across the globe.

Performance Characteristics

- Temp range of -40°F to 140°F
- Burst strength of 4X the operating pressure
- Hydraulically efficient (C-Factor 150)
- Non-toxic and non-tasting for AWWA/NSF
- Leak Free

Physical Characteristics

- Lightweight
- Flexible
- UV protected (2% Carbon Black)
- Fatigue and surge tolerant
- Corrosion/Abrasion/Chemical resistant (ph1.5 to 14)

PE-RT: Polyethylene of Raised Temperature

What is PE-RT?

Polyethylene of Raised Temperature (PE-RT) pipe is a piping product that can handle temperature and pressure ranges greater then standard HDPE. With a 50 year design life, PE-RT has the same fusion parameters as standard PE4710 pipes and is pressure rated to 180 F with no reduction in design life. This fusible monolithic piping system guarantees zero leakage and is compatible with any other piping system.

Physical Characteristics

- Lightweight
- Flexible
- UV protected (2% Carbon Black)
- Corrosion/Abrasion/Chemical resistant
- Fatigue and surge tolerant
- Impact durability/seismic flexibility
- Leak Free
- CC3 Chlorine Resistance Rating

Performance Characteristics

- Burst strength of 4X the operating pressure
- Hydraulically efficient (C-Factor 150)
- Non-toxic and non-tasting for AWWA/NSF C906 approval
- > 20 times stress crack resistance

PlatinumStripe® 1800 Series PE-RT
Polyethylene Raised Temperature Pipe & Fittings

PlatinumStripe® 1800 PE-RT significantly expands the operation window for polyethylene (PE) pipes with pressure ratings up to 180°F. PlatinumStripe® 1800 PE-RT is intended for high-temperature industrial, mining, oil and gas gathering applications.

Complies with:

- ASTM D3350 Cell Class PE445574C
- ASTM D2837 HDB = 800 psi at 180°F
- ASTM F2619 HDPE Line Pipe
- API 15 LE Polyethylene Line Pipe
- ASTM F714 Polyethylene Pipe
- ASTM D3261 and D2513 (Molded Fittings)
- ASTM F2206 (Fabricated Fittings)

Key Benefits of PlatinumStripe® 1800 PE-RT piping systems:

- Higher permissible operating temperatures compared to standard PE4710 products
- Allows continuous operation at temperatures from -49°F (-45°C) to 180°F (82°C)
- Intermittent operating temperatures up to 203°F (95°C) are possible for some applications
- >20 times PE4710 requirements for stress crack resistance
- Allows use of native backfill material from trench (sandless installation) for shallow, non-traffic applications
- Follows same fusion parameters as standard PE4710 pipes
- Patented stabilizer system for high temperature oxidative environments with ASTM D3350 CC3 rating
- Full range of pipe sizes, pressure capabilities, molded and fabricated fittings

PlatinumStripe® 1800 PE-RT is identified with four platinum color stripes.

PlatinumStripe® 1800 PE-RT Pipe Material Physical Properties		
Property	**Standard**	**Typical Value+**
Material Designation	ASTM F714, ASTM F2619	PE 4710
Cell Classification	ASTM D3350	445574C (black)
Density [4]	ASTM D792	0.950 g/cc (natural)
Melt Index [4]	ASTM D1238	0.1 g/10 min
Flexural Modulus [5]	ASTM D790B	150,000 psi
Tensile Strength [5]	ASTM D638	>3500 psi
SCG (PENT) [7]	ASTM F1473	10,000 hours
HDB at 73°F (23°C) [4] HDB at 180°F (82.2°C)	ASTM D2837	1600 psi 800 psi
Color [C]	D3350	Black
This is not a product specification and does not guarantee or establish specific minimum or maximum values or manufacturing tolerance for material or piping products to be supplied. Values obtained from tests of specimens taken from piping product may vary from these typical values.		

Common Dimension Ratios for PlatiunumStripe™ 1800 PE-RT

IPS		DR7			DR9			DR11			DR17			DR21		
Pipe Size in.	OD, in.	Min. wall, in.	Avg. ID, in.	Wgt. lbs/ft.	Min. wall, in.	Avg. ID, in.	Wgt. lbs/ft.	Min. wall, in.	Avg. ID, in.	Wgt. lbs/ft.	Min. wall, in.	Avg. ID, in.	Wgt. lbs/ft.	Min. wall, in.	Avg. ID, in.	Wgt. lbs/ft.
2	2.375	0.339	1.656	0.90	0.26	1.82	0.77	0.22	1.92	0.64	0.14	2.08	0.43			
3	3.50	0.500	2.440	2.06	0.39	2.68	1.66	0.32	2.83	1.39	0.21	3.06	0.94			
4	4.50	0.643	3.137	3.40	0.50	3.44	2.75	0.41	3.63	2.31	0.27	3.94	1.55	0.21	4.05	1.27
6	6.625	0.946	4.619	7.37	0.74	5.07	5.96	0.60	5.35	5.00	0.39	5.80	3.36	0.32	5.96	2.75
8	8.625	1.232	6.013	12.50	0.96	6.59	10.11	0.78	6.96	8.47	0.51	7.55	5.69	0.41	7.75	4.66
10	10.75	1.536	7.494	19.42	1.19	8.22	15.70	0.98	8.68	13.16	0.63	9.41	8.83	0.51	9.66	7.24
12	12.75	1.821	8.889	27.31	1.42	9.75	22.08	1.16	10.29	18.51	0.75	11.16	12.43	0.61	11.46	10.19
14	14				1.56	10.70	26.63	1.27	11.30	22.32	0.82	12.25	14.98	0.67	12.59	12.28
16	16				1.78	12.23	34.78	1.46	12.92	29.15	0.94	14.01	19.57	0.76	14.38	16.04
18	18				2.00	13.76	44.02	1.64	14.53	36.89	1.06	15.75	24.77	0.86	16.18	20.30
20	20				2.22	15.29	54.34	1.82	16.15	45.54	1.18	17.51	30.58	0.95	17.98	25.07
22	22							2.00	17.76	55.10	1.29	19.26	37.00	1.05	19.78	30.33
24	24							2.18	19.37	65.58	1.41	21.01	44.03	1.14	21.58	36.10
26	26										1.53	22.76	51.67	1.24	23.38	42.36
28	28										1.65	24.51	59.93	1.33	25.17	49.13
30	30										1.77	26.26	68.80	1.43	26.97	56.40
32	32										1.88	28.01	78.28	1.52	28.77	64.17
34	34										2.00	29.76	88.37	1.62	30.57	72.44
36	36										2.12	31.51	99.07	1.71	32.37	81.21
42	42													2.00	37.76	110.54

Pipe weights are calculated in accordance with PPI TR-7. Average inside diameter is calculated using Nominal OD and Minimum wall plus 6% for use in estimating fluid flow. Actual ID will vary. When designing components to fit the pipe ID, refer to pipe dimensions and tolerances in the applicable pipe manufacturing specification. Additional sizes and DR available. Contact Performance Pipe or visit www.performancepipe.com

Design Pressures

Operating Temperatures

Application	Dimensional Ratio	73ºF	100ºF	120ºF	140ºF	160ºF	180ºF
Water, Brine Alcohols, Glycols, and Dry Natural Gas (non 49CFR192 applications)	DR 7	333 psig	280 psig	244 psig	210 psig	187 psig	167 psig
	DR 9	250 psig	210 psig	183 psig	158 psig	141 psig	125 psig
	DR 11	200 psig	168 psig	146 psig	126 psig	112 psig	100 psig
	DR 13.5	160 psig	134 psig	117 psig	101 psig	90 psig	80 psig
	DR 17	125 psig	105 psig	91 psig	79 psig	70 psig	63 psig
	DR 21	100 psig	84 psig	73 psig	63 psig	56 psig	50 psig
2% or Greater Concentrations of Liquid Hydrocarbons or Other Solvating/Permeating Chemicals	DR 7	167 psig	140 psig	122 psig	105 psig	94 psig	84 psig
	DR 9	125 psig	105 psig	92 psig	79 psig	71 psig	63 psig
	DR 11	100 psig	84 psig	73 psig	63 psig	56 psig	50 psig
	DR 13.5	80 psig	67 psig	59 psig	51 psig	45 psig	40 psig
	DR 17	63 psig	53 psig	46 psig	40 psig	35 psig	32 psig
	DR 21	50 psig	42 psig	37 psig	32 psig	28 psig	25 psig

The above pressures are the maximum long-term pressure ratings for the applications shown. Different chemical and environmental use considerations may require use of additional design factors or additional service life considerations.

Geothermal Distribution AC Piping Replacement
Opinion of Probable Construction Costs

Division	Description	Quantity	Units	Cost per Unit ($)	Installation Multiplier	Cost (nearest $100)
1	**GENERAL CONDITIONS**					**15,000**
	Geotechnical Allowance	1	EA	15,000	1.0	15,000
2	**CIVIL / SITEWORK**					**1,953,600**
	As-Built Survey	9100	LF	1	1.0	9,100
	Traffic Control	120	Days	1,500	1.0	180,000
	Pavement Removal, 4-inches thick	2100	SY	8	1.0	16,800
	Pavement Replacement, 4-inches thick	2100	SY	55	1.0	115,500
	6-inch Geothermal Distribution Piping, incl. 4ft - T,B, & C	750	LF	90	1.0	67,500
	8-inch Geothermal Distribution Piping, incl. 4ft - T,B, & C	7155	LF	100	1.0	715,500
	10-inch Geothermal Distribution Piping, incl. 4ft - T,B, & C	4625	LF	110	1.0	508,800
	Directional Drill under Highway	250	LF	400	1.0	100,000
	New Air Relase Valve Stations	3	EA	25,000	1.0	75,000
	10-inch Gate Valves, incl. boxes, etc.	12	EA	5,500	1.0	66,000
	8-inch Gate Valves, incl. boxes, etc.	18	EA	5,000	1.0	90,000
	6-inch Gate Valves, incl. boxes, etc.	2	EA	4,700	1.0	9,400
	Service Reconnection	35	EA	900	1.0	31,500
					SUBTOTAL 1	**1,968,600**
	CONSTRUCTION PRORATES (See Note 1)	10.0%	of Subtotal 1	196,860	1.0	196,900
	CONTRACTOR'S OVERHEAD & PROFIT (See Note 2)	15.0%	of Subtotal 1	295,290	1.0	295,300
					SUBTOTAL 2	**2,460,800**
	CONTINGENCY (See Note 4)	40.0%	of Subtotal 2	984,320	1.0	984,400
					SUBTOTAL 3	**3,445,200**
	ENGINEERING COSTS	15.0%	of Subtotal 3	516,780	1.0	516,800
					TOTAL	**3,962,000**

Notes

1 **Construction Prorates** [a] [b] **10%**

(a) General conditions includes cost associated with permits, licenses, insurance, environmental safe guards, sediment and drainage control, and special construction practices to maintain continued plant operations. Also includes misc construction materials needed for project not included above.

2 **Contractor's Overhead & Profit** [a] **15%**

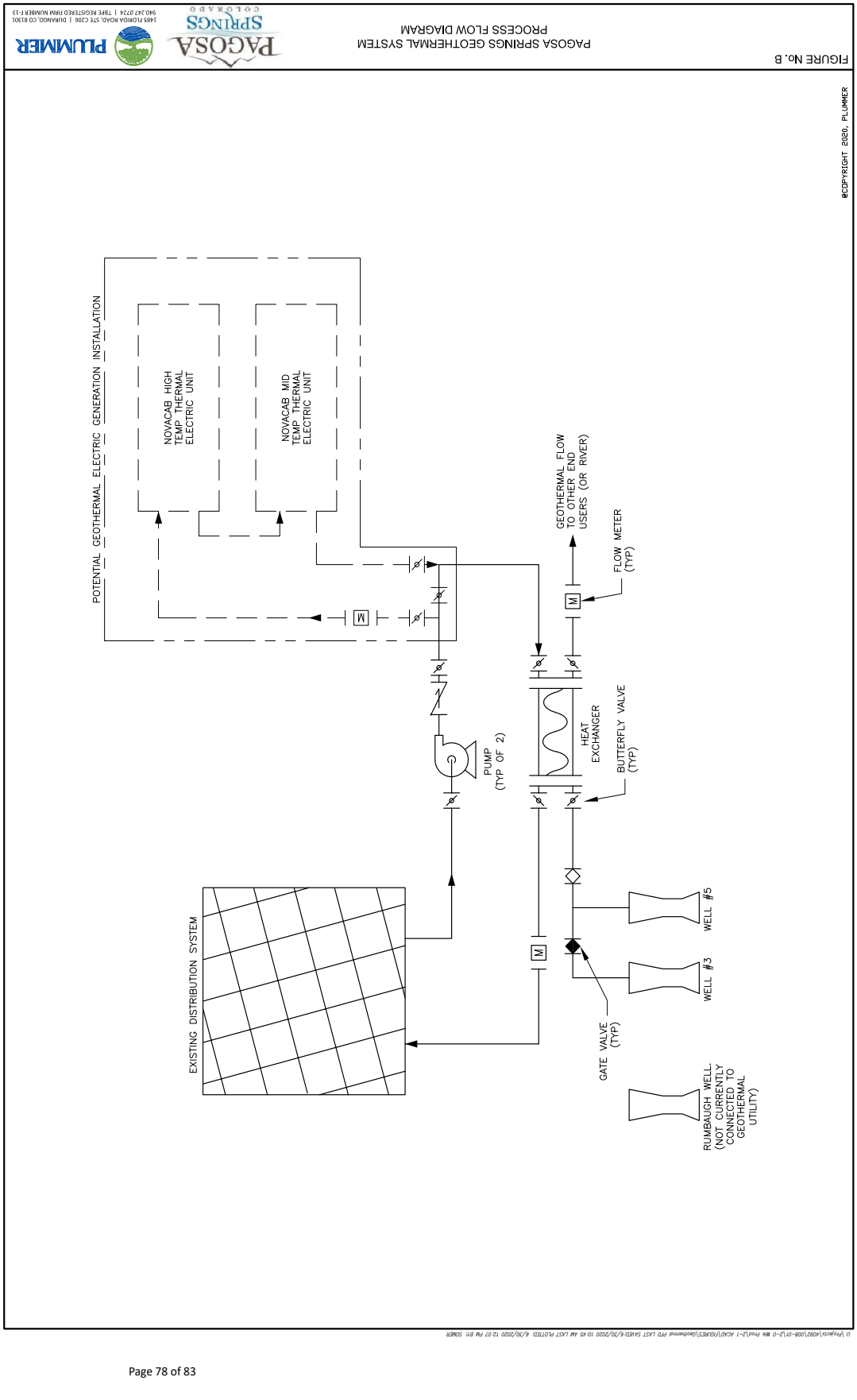
(a) Contractor's overhead and profit include costs for mobilization/demobilization, administration, and contractor/subcontractor overhead costs and profits.

4 **Design Contingency** [a] **40%**

(a) The design continency is added to the subtotal based on the conceptual nature of information developed for this evaluation.

APPENDIX E

Novacab Equipment Estimate


PAGOSA SPRINGS GEOTHERMAL SYSTEM
PROCESS FLOW DIAGRAM
FIGURE No. B
PAGOSA SPRINGS COLORADO
PLUMMER
1485 FLORIDA ROAD, STE C206 | DURANGO, CO 81301
970.247.0724 | TBPE REGISTERED FIRM NUMBER F-13
©COPYRIGHT 2020, PLUMMER
POTENTIAL GEOTHERMAL ELECTRIC GENERATION INSTALLATION
NOVACAB HIGH TEMP THERMAL ELECTRIC UNIT
NOVACAB MID TEMP THERMAL ELECTRIC UNIT
GEOTHERMAL FLOW TO OTHER END USERS (OR RIVER)
FLOW METER (TYP)
PUMP (TYP OF 2)
HEAT EXCHANGER
BUTTERFLY VALVE (TYP)
EXISTING DISTRIBUTION SYSTEM
WELL #5
WELL #3
GATE VALVE (TYP)
RUMBAUGH WELL (NOT CURRENTLY CONNECTED TO GEOTHERMAL UTILITY)


SMART PHASES INC.
Multi-sources TESS/Geothermal
for the Pagosa Spring project
Geothermal with TESS Project
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Novacab
DRAFT (For Discussions) May 2020
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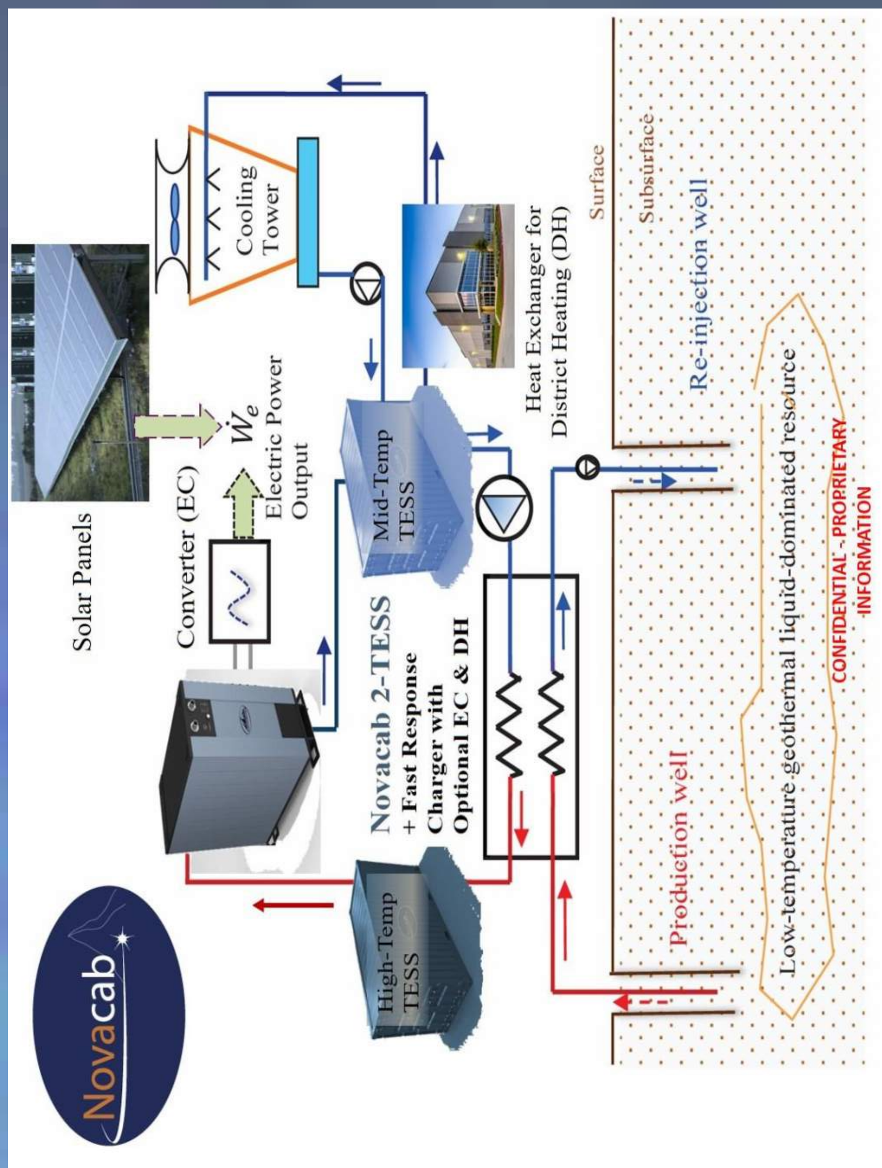
A 250 kW Peak / 2-TESS system

- 2-TESS Approach
  - At the Pagosa Spring site, the remaining geothermal power output, without the aid of the TESS, cannot easily be exploited to match the (micro)grid demand and is seriously restricted by grid connection/stability issues introduced by the intermittent low-grad (temperature) nature of waste heat sources.
  - The 2 – TESS with Fast Response Converter coupled with the "remaining" waste heat curtail insufficient use of this heat, resulting in a substantial reduction in energy rejection and increase in generated revenues (optional tie-in with Solar is possible but not required).
- The Novacab integrated system aims:
  - 1st to use the cheap and wasted thermal power to achieve the heat demand of nearby users or District Heating (DH)/Snow Melting and,
  - 2nd to convert a substantial portion of the stored energy back to the grid or to compensate parasitic loads (with the converter), therefore improving the utilization of waste (geothermal) energy.

The 250 kW Smart Phases TESS system

- Heat recovery:
  - From 110 F water in Winter
  - From 143 F water in Summer
- Estimated Cost of equipment
  - Double TESS + Converter + Controller system (Solar PV optional)
  - $805,000 (before grants, taxes, installation, PV, etc.)
- Potential production
  - 250 kW in the Summer (up to 962 MWh/season)
  - 180 kW in the Winter (up to 672 MWh/season)
  - For a potential of [redacted] MWh/year
    - or $179,800 (@$0.11/kWh)
- Potential Payback of 4.5 years for the equipment



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The Novacab "SmartPhases" Converter
Novacab
A smart controller optimizing the dual Temperature TESS units
To maximize the thermal response/storage with:
The light blue mid-temperature TESS unit
And the High-temperature dark blue TESS unit
1. To supply and turn on the charge mode
2. To evaluate if the output will match the smartgrid demand
3. The excess power will be use to supply the fast response charger
4. To divide the geothermal power into 2 parts: the heat demand of DH
5. Full-time continuous management of the source (Solar+Geothermal)
6. To store extra energy in the 2 temp. TESS units
TESS Converter -- Power Controller
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