

1249257  
[00655064]

CHPRC CALCULATION COVER SHEET

Selection: 1 Identification

1. Calculation Number SGW-61975	2. Revision 00	3. Title Power Requirements to Raise Temperature of AMTs at 200 W P&T
------------------------------------	-------------------	--

4. Purpose  
To determine the feasibility of supplying the energy required to warm water in the biological treatment plant at 200 West Pump and Treat 10 degrees Celcius.

5. Project/Program/Activity  
200 West Pump and Treat

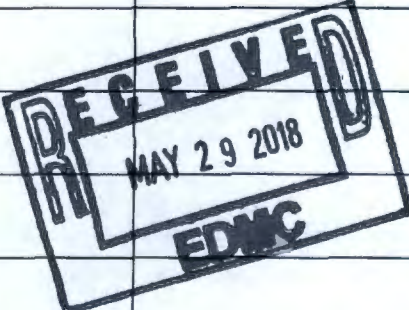
Section 2: Approval

6. Author  Mark Carlson <i>Mark Carlson</i> Print /Signature/Date	3/15/ <sup>2018</sup> <del>2017</del>	7. Checker  <i>Greg Bergquist</i> Print /Signature/Date	3/15/ <sup>2018</sup> <del>2017</del>
--	---------------------------------------	--	---------------------------------------

8. Title Title	Print/Sign	Print/Sign/Date	ADD ROW Date
-------------------	------------	-----------------	-----------------

Section 3: Summary of Revisions

9. Rev. No.	10. Description of Change	11. Affected Pages	12. Author	13. Checker ADD ROW
0 <b>RS</b>	Original per ECR-18-000545	N/A	<i>Mark Carlson</i>	
				<input checked="" type="checkbox"/>
				<input checked="" type="checkbox"/>
				<input checked="" type="checkbox"/>
				<input checked="" type="checkbox"/>
				<input checked="" type="checkbox"/>
				<input checked="" type="checkbox"/>
				<input checked="" type="checkbox"/>



DATE:  
Mar 20, 2018

Approved for Public Release;  
Further Dissemination Unlimited

APPROVED  
By Janis Braden at 3:07 pm, Mar 20, 2018

## Engineering Calculation

### Power Requirements to Raise Temperature of AMTs at 200W P&T

#### 1 Calculation Purpose and Background

The purpose of this calculation is to determine amount of energy required to warm water in the biological treatment plant 10° C. Heating water to improve treatment was one of the recommendations of SGW-60832-00 *Pump and Treat (P&T) Improvement Initiative*. The recommendation is repeated here in italics:

*After engineering design and utility requirements determination, add heating blankets to the existing bioreactor unit and maintain a more consistent and higher unit operating temperature during both winter and summer.*

This calculation serves as the basis of the power requirements for heating water 10° C.

#### 2 Inputs

The following inputs were used in the calculation:

- A flow of 2,500 gallons per minute (gpm) (9,464 liters per minute [lpm])
- A temperature increase of 10° C
- Influent water has a starting temperature that ranged from 17.3° C to 21.6° C and averaged 19.0° C. The average temperature of 19° C was used in this calculation. These data are from March 12, 2017 through March 13, 2018.
- Water has a specific capacity (isochoric or  $C_v$ ) of  $4.16 \frac{kJ}{kg \times T}$  at 18° C (J = Joules, kg = kilograms and T = temperature in degrees Kelvin or degrees Celsius. [From Engineering Toolbox])  
[https://www.engineeringtoolbox.com/specific-heat-capacity-water-d\\_660.html](https://www.engineeringtoolbox.com/specific-heat-capacity-water-d_660.html)
- Density of water at 19° C = 0.998 kg/L (From Engineering Toolbox)  
[https://www.engineeringtoolbox.com/water-temperature-specific-gravity-d\\_1179.html](https://www.engineeringtoolbox.com/water-temperature-specific-gravity-d_1179.html)

#### 3 Assumptions

Line loss was was ignored for this calculation.

Heat exchanger is 90 percent efficient.

A typical month has 30-days.

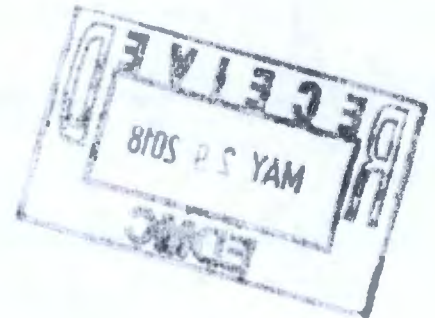
#### 4 Conversions

- 3.78541 L per gallon
- 1,000 mg per gram

#### 5 Calculation

$$\text{Energy Needed to Heat Water} = M \times C_v \times \Delta T$$

Where,



$$M = \text{mass of water} = 9,464 \text{ L} \times 0.998 \text{ kg/L} = 9,445 \text{ kg}$$

$$C_v = 4.16 \frac{\text{kJ}}{\text{kg} \times T}$$

$$\Delta T = 10^\circ\text{C}$$

Volume of water = 9,464 L

$$\text{Energy Needed to Heat Water} = 9,464 \text{ kg} \times 4.16 \frac{\text{kJ}}{\text{kg} T} \times 10^\circ\text{C}$$

$$\text{Energy Needed to Heat Water} = 393,702 \text{ kJ}$$

Next calculate the power needed to heat the water

$$P = E/t$$

Where,

P=power (kW)

E = Energy (kJ)

t= time (sec)

Time = 1 minute = 60-sec

$$P = \frac{393,702 \text{ kJ}}{60 \text{ sec}}$$

$$P = 6,562 \text{ kW}$$

## 6 Results

Given 100 percent efficiency 6,562 kW are needed to heat the water 10°C. Heat exchanger efficiencies are typically 0.85 to 0.95. Assuming an efficiency of 0.9 the power requirement would be increased to 7,291 kW (6,562/0.9=7,291 kW). The monthly consumption of electricity was calculated. Note this calculation assumes no line loss and the real electrical consumption would likely be greater.

$$\text{Monthly Electrical Consumption} = 7,291 \text{ kW} \times \frac{30 \text{ days}}{\text{month}} \times \frac{24 \text{ hours}}{\text{day}} = 5,249,520 \text{ kWh}$$

For comparison, the electrical records for the 200 W Treatment process were reviewed and the average monthly consumption in 2017 was 609,654 kWh. Heating the water requires 8.6 times the power already consumed.

The current electricity rate is \$0.145/kWh. The monthly cost for heating the water was calculated. Note this calculation assumes no line loss and the real cost would likely be greater.

$$\text{Monthly Electrical Cost} = 5,249,520 \text{ kWh} \times \frac{\$0.145}{\text{kWh}} = \$761,180$$

The average monthly electrical cost for the existing process treatment was calculated from the records supplied by MSA to be \$88,400 in 2017.

$$\text{Average Monthly Electricity Cost in 2017} = 609,654 \text{ kWh} \times \frac{\$0.145}{\text{kWh}} = \$88,400$$

## 7 Conclusions

The monthly power requirement would increase from about 610,000 kWh to over 5,000,000 kWh. The monthly power cost would increase from about \$90,000 to over \$800,000. The power required to heat the water is excessive and would require electrical upgrades not considered in this analysis.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
1			Automatic	Manual													
2		Meter	13146161	13146161													
3		Facility	289-T/Bio Process Building														
4		Service (Line)	C8L3, F8X1010														
5		Transformer	C7165P KVA 1500														
6		Data Logger	135														
7		Multiplier	(Manual) 10														
8		Dial Count	(Manual) 6														
9																	
10																	
11	Month/ Year	Pct. Capture	Average (KW)	Monthly Consumption (KW)	Maximum (KW)	Minimum (KW)	Load Factor (%)	Comment	Date/ Time	Energy Reading	Difference	Monthly Consumption (KWH)	Average (KW)	Demand Reading	Demand (KW)	Load Factor (%)	Comment
12																	
13	02/2016	100.0	504.5	351,141	604.1	238.3	83.5%		2/25/2016	383129	36119	361,190	518.3	61.12	611.2	84.8%	
14	03/2016	100.0	421.0	312,791	508.0	227.9	82.9%		3/23/2016	410790	27661	276,610	425.1	51.88	518.8	81.9%	
15	04/2016	100.0	335.9	241,813	445.0	175.0	75.5%		4/23/2016	437245	26455	264,550	357.7	51.4	514.0	89.6%	
16	05/2016	100.0	317.1	235,959	396.7	165.6	79.9%		5/26/2016	462678	25433	254,330	321.5	40.33	403.3	79.7%	
17	06/2016	100.0	264.2	190,241	343.4	138.2	76.9%		6/30/2016	485535	22857	228,570	271.3	40.45	404.5	67.1%	
18	07/2016	90.1	336.3	250,242	428.0	154.1	78.6%		7/25/2016	504882	19347	193,470	321.2	43.73	437.3	73.5%	
19	08/2016	99.6	388.3	288,902	556.6	0.0	69.8%		8/30/2016	538556	33674	336,740	387.9	55.84	558.4	69.5%	
20	09/2016	100.0	429.5	309,241	541.8	263.9	79.3%		9/22/2016	562186	23630	236,300	433.3	54.88	548.8	78.9%	
21	10/2016	100.0	332.9	247,893	418.7	192.2	79.5%		10/25/2016	589558	27372	273,720	345.8	49.59	495.9	69.7%	
22	11/2016	100.0	451.2	325,335	580.7	193.3	77.7%		11/28/2016	625178	35620	356,200	433.8	59.14	591.4	73.4%	
23	12/2016	100.0	471.7	350,911	576.4	378.0	81.8%		12/28/2016	659671	34493	344,930	479.4	58.89	588.9	81.4%	
24	01/2017	100.0	484.3	360,341	582.5	373.3	83.1%		1/28/2017	694975	35304	353,040	477.3	59.16	591.6	80.7%	
25	02/2017	100.0	464.0	311,802	518.8	311.0	89.4%		2/23/2017	724370	29395	293,950	471.0	53.39	533.9	88.2%	
26	03/2017	99.9	383.6	285,030	479.5	287.6	80.0%		3/22/2017	751071	26701	267,010	409.7	51.13	511.3	80.1%	
27	04/2017	100.0	364.6	262,535	535.7	144.0	68.1%		4/26/2017	780182	29111	291,110	346.9	56.95	569.5	60.9%	
28	05/2017	100.0	472.8	351,794	558.7	180.4	84.6%		5/25/2017	812526	32344	323,440	466.8	57.3	573.0	81.5%	
29	06/2017	100.0	479.6	345,315	571.3	72.0	83.9%		6/27/2017	850528	38002	380,020	481.9	57.77	577.7	83.4%	
30	07/2017	100.0	410.7	305,566	531.4	186.5	77.3%		7/26/2017	880043	29515	295,150	420.9	54.05	540.5	77.9%	
31	08/2017	100.0	290.2	215,896	423.7	118.4	68.5%		8/28/2017	903778	23735	237,350	300.8	46.51	465.1	64.7%	
32	09/2017	99.3	384.5	276,867	460.4	237.2	83.5%		9/26/2017	930505	26727	267,270	381.8	47.1	471.0	81.1%	
33	10/2017	100.0	425.2	316,341	529.6	234.9	80.3%		10/26/2017	960108	29603	296,030	413.5	52.41	524.1	78.9%	
34	11/2017	100.0	440.5	317,595	550.6	155.3	80.0%		11/21/2017	987899	27791	277,910	437.6	55.36	553.6	79.0%	
35	12/2017	100.0	493.4	367,113	568.3	359.1	86.8%		12/21/2017	21841	33942	339,420	474.7	54.99	549.9	86.3%	
36	01/2018	100.0	485.4	361,110	563.9	342.0	86.1%		1/26/2018	64690	42849	428,490	499.6	60.72	607.2	82.3%	
37	02/2018	100.0	468.1	314,592	541.4	275.2	86.5%		2/23/2018	95776	31086	310,860	462.3	54.5	545.0	84.8%	

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
1			Automatic	Manual														
2		Meter	13146162	13146162														
3		Facility	289-T/Bio Process Building															
4		Service (Line)	C8L3, F8X1011															
5		Transformer	C7166P KVA 1500															
6		Data Logger	135															
7		Multiplier	(Manual) 10															
8		Dial Count	(Manual) 6															
9																		
10																		
11	Month/ Year	Pct. Capture	Average (KW)	Monthly Consumption (KW)	Maximum (KW)	Minimum (KW)	Load Factor (%)	Comment	Date/ Time	Energy Reading	Difference	Monthly Consumption (KWH)	Average (KW)	Demand Reading	Demand (KW)	Load Factor (%)	Comment	
12																		
13	02/2016	100.0	431.2	300,085	574.6	271.1	75.0%		2/25/2016	170506	30210	302,100	433.6	58.03	580.3	74.7%	EN	
14	03/2016	100.0	456.7	339,357	569.5	235.1	80.2%		3/23/2016	200918	30412	304,120	467.4	59.6	596.0	78.4%	EN	
15	04/2016	100.0	292.7	210,758	424.4	123.5	69.0%		4/23/2016	224676	23758	237,580	321.3	49.24	492.4	65.2%	EN	
16	05/2016	100.0	271.1	201,699	388.4	119.5	69.8%		5/26/2016	247374	22698	226,980	286.9	39.08	390.8	73.4%	EN	
17	06/2016	100.0	262.0	188,622	398.9	123.5	65.7%		6/30/2016	268881	21507	215,070	255.3	40.82	408.2	62.5%	EN	
18	07/2016	90.1	326.5	242,940	438.5	129.2	74.5%		7/25/2016	288859	19978	199,780	331.7	40.56	405.6	81.8%	EN	
19	08/2016	99.6	263.9	196,331	378.7	0.0	69.7%		8/30/2016	311901	23042	230,420	265.4	44.01	440.1	60.3%	EN	
20	09/2016	100.0	313.0	225,349	401.4	203.8	78.0%		9/22/2016	328596	16695	166,950	306.1	37.5	375.0	81.6%	EN	
21	10/2016	100.0	273.7	203,668	377.3	150.8	72.6%		10/25/2016	351430	22834	228,340	288.4	41.07	410.7	70.2%	EN	
22	11/2016	100.0	375.2	270,534	490.3	239.0	76.5%		11/28/2016	380427	28997	289,970	353.1	50.81	506.1	69.8%	EN	
23	12/2016	100.0	564.7	420,126	731.2	362.5	77.2%		12/28/2016	420434	40007	400,070	556.1	73.38	733.8	75.8%	EN	
24	01/2017	100.0	619.5	460,880	734.4	504.7	84.3%		1/28/2017	466006	45572	455,720	616.1	78.88	788.8	78.1%	EN	
25	02/2017	100.0	557.6	374,701	657.0	365.8	84.9%		2/23/2017	501592	35586	355,860	570.2	65.96	659.6	86.4%	EN	
26	03/2017	99.9	451.5	335,492	609.1	269.6	74.1%		3/22/2017	533569	31977	319,770	490.6	61.57	615.7	79.7%	EN	
27	04/2017	100.0	357.4	257,319	488.9	199.1	73.1%		4/26/2017	564054	30485	304,850	363.3	49.52	495.2	73.4%	EN	
28	05/2017	100.0	293.2	218,171	405.4	167.4	72.3%		5/25/2017	585122	21068	210,680	304.1	44.21	442.1	68.8%	EN	
29	06/2017	100.0	273.2	196,695	399.6	42.1	68.4%		6/27/2017	606818	21696	216,960	275.2	40.27	402.7	68.3%	EN	
30	07/2017	100.0	337.0	250,735	416.2	163.6	81.0%		7/26/2017	629616	22798	227,980	325.1	42.41	424.1	76.7%	EN	
31	08/2017	100.0	313.6	233,310	406.8	185.8	77.1%		8/28/2017	654469	24853	248,530	315.0	40.86	408.6	77.1%	EN	
32	09/2017	99.3	411.2	296,070	503.3	290.9	81.7%		9/26/2017	682915	28446	284,460	406.3	51	510.0	79.7%	EN	
33	10/2017	100.0	475.5	353,741	621.9	305.8	76.5%		10/26/2017	715972	33057	330,570	461.7	62.55	625.5	73.8%	EN	
34	11/2017	100.0	548.2	395,232	694.6	290.3	78.9%		11/21/2017	750729	34757	347,570	547.3	70.37	703.7	77.8%	EN	
35	12/2017	100.0	574.9	427,740	652.5	445.0	88.1%		12/21/2017	789849	39120	391,200	547.1	65.97	659.7	82.9%	EN	
36	01/2018	100.0	598.8	445,489	684.0	481.9	87.5%		1/26/2018	841600	51751	517,510	603.4	68.86	688.8	87.6%	EN	
37	02/2018	100.0	595.1	399,906	747.0	377.5	79.7%		2/23/2018	881036	39436	394,360	586.4	75.81	758.1	77.4%	EN	

	A	B	C	D	E
1					
2	Meter	Sum of 13146161 and 13146162			
3	Facility	289-T/Bio Process Building			
4	Service (Line, C8L3, F8X1011				
5	Transformer	C7166P KVA 1500			
6	Data Logger	135			
7	Multiplier	(Manual) 10			
8	Dial Count	(Manual) 6			
9					
10					

11	Month/ Year	Average (KW)	Monthly Consumption (KW)	Monthly Consumption (KWH)	
12					
13	02/2016	935.7	651,226	663,290	EN
14	03/2016	877.7	652148.0	580,730	EN
15	04/2016	628.6	452571.0	502,130	EN
16	05/2016	588.2	437658.0	481,310	EN
17	06/2016	526.2	378863.0	443,640	EN
18	07/2016	662.8	493182.0	393,250	EN
19	08/2016	652.2	485233.0	567,160	EN
20	09/2016	742.5	534590.0	403,250	EN
21	10/2016	606.6	451361.0	502,060	EN
22	11/2016	826.4	595869.0	646,170	EN
23	12/2016	1036.4	771037.0	745,000	EN
24	01/2017	1103.8	821221.0	808,760	EN
25	02/2017	1021.6	686503.0	649,810	EN
26	03/2017	835.1	620522.0	586,780	EN
27	04/2017	722.0	519854.0	595,960	EN
28	05/2017	766.0	569965.0	534,120	EN
29	06/2017	752.8	542010.0	596,980	EN
30	07/2017	747.7	556301.0	523,130	EN
31	08/2017	603.8	449206.0	485,880	EN
32	09/2017	795.7	572937.0	551,730	EN
33	10/2017	900.7	670082.0	626,600	EN
34	11/2017	988.7	712827.0	625,480	EN
35	12/2017	1068.3	794853.0	730,620	EN
36	01/2018	1084.2	806599.0	946,000	EN
37	02/2018	1063.2	714498.0	705,220	EN

**Carlson, Mark A**

---

**From:** Smith, Paul A  
**Sent:** Thursday, March 15, 2018 8:42 AM  
**To:** Bergquist, G G (Greg)  
**Cc:** Carlson, Mark A; Parkhill, Matthew B; Humphrys, Kathryn L (Kay)  
**Subject:** RE: Electrical Rates  
**Attachments:** Meter 12071489 Facility 289-T, 289-TA-Temporary Construction, Well YE-4.xls; Meter 13146162 Facility 289-T-Bio Process Building.xls; Meter 13146161 Facility 289-T-Bio Process Building.xls

Greg,

The current electricity rates are 14.5 cents/kWh. Also, I have attached the meter information for the 289T facility. If you need any more information please let me know.

Thanks,

Paul Smith

**From:** Parkhill, Matthew B  
**Sent:** Tuesday, March 13, 2018 1:11 PM  
**To:** Smith, Paul A <Paul\_A\_Smith@rl.gov>  
**Cc:** Carlson, Mark A <Mark\_A\_Carlson@rl.gov>; Bergquist, G G (Greg) <G\_G\_Greg\_Bergquist@rl.gov>; Humphrys, Kathryn L (Kay) <Kathryn\_L\_Kay\_Humphrys@rl.gov>  
**Subject:** RE: Electrical Rates

Paul,

Please provide Greg the current electricity rates as well as the meter info for the 289T Pump and Treat Facility.

Thanks,



**Matthew Parkhill**  
Electrical Utilities, Distribution Engineer  
o: 509.373.1589 | m: 509.430.1249