ANALYSIS FOR:

CITY OF BLOOMFIELD WATER PLANT

POWER ANAYSIS

Issued To:

City of Bloomfield
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Submitted by:

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GENERAL INFORMATION FOR SITE #1 AND SITE #2

Data was gathered at both sites using a Fluke Data Logger, Model 435-II (Serial Number 31933102; Firmware Revision V05.04). All measurements were based on a Wye Mode with Nominal Voltage set at 480V, Nominal Current set at 300 Amps, Nominal Frequency set at 60Hz. Recording Intervals was set at 0h 10m 0s 0msec. All data was downloaded to Power Log Software version 5.4 with Fluke 430-II DLL Version 1.2.0.13.

SITE #1 RECORDINGS (FILTER BUILDING, BACK BUILDING)

Recordings were taken at the Water Plant Filter Building Area on February 15, 2018 at 1:59PM and remained in service until February 22, 2018 1:59PM. Recordings were taken for Voltage (L-N (per Phase); N-G), Amperage, and other pertinent aspects of analysis.

Data Analysis is listed below.

VOLTAGE ANALYZED

- Vrms Ph-N (A Phase)
    - Maximum Value Ascertained – 287.76V Ph-N (497.82 calculated)
        - Upper Extremes were Time Stamped:
            - 2/17/18 9:30am – Value of 287.76
            - 2/17/18 9:49am – Value of 287.68
            - 2/17/18 9:29am – Value of 287.68
            - 2/18/18 12:59am – Value of 287.58
            - 2/21/18 3:49am – Value of 287.54
    - Minimum Value Ascertained – 281.76V Ph-N (487.44 calculated)
        - Lower Extremes were Time Stamped:
            - 2/21/18 5:59pm – Value of 281.76
            - 2/15/18 5:49pm – Value of 281.8
            - 2/18/18 6:49pm – Value of 281.9
            - 2/18/18 5:59pm – Value of 282.02
            - 2/15/18 6:39pm – Value of 282.1
    - *Average Value Ascertained – 285.154 Ph-N (493.32 calculated)*
- Vrms Ph-N (B Phase)
    - Maximum Value Ascertained – 288.86V Ph-N (499.73 calculated)

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        - Upper Extremes were Time Stamped:
            - 2/17/18 5:59am – Value of 288.86
            - 2/17/18 9:39am – Value of 288.84
            - 2/17/18 9:29am – Value of 288.76
            - 2/16/18 12:39am – Value of 288.6
            - 2/17/18 11:09am – Value of 288.58
    - Minimum Value Ascertained – 283V Ph-N (489.59 calculated)
        - Lower Extremes were Time Stamped:
            - 2/21/18 5:59pm – Value of 283
            - 2/18/18 7:19pm – Value of 283.04
            - 2/18/18 7:29pm – Value of 283.16
            - 2/18/18 6:49pm – Value of 283.16
            - 2/18/18 7:39pm – Value of 283.22
    - *Average Value Ascertained – 286.245 Ph-N (495.20 calculated)*
- Vrms Ph-N (C Phase)
    - Maximum Value Ascertained – 288.04V Ph-N (498.31 calculated)
        - Upper Extremes were Time Stamped:
            - 2/17/18 9:49am – Value of 288.04
            - 2/17/18 9:39am – Value of 288.04
            - 2/21/18 3:49am – Value of 288.02
            - 2/17/18 9:29am – Value of 288.02
            - 2/21/18 3:39am – Value of 287.86
    - Minimum Value Ascertained – 282.22V Ph-N (488.24 calculated)
        - Lower Extremes were Time Stamped:
            - 2/21/18 5:59pm – Value of 282.22
            - 2/18/18 5:59pm – Value of 282.4
            - 2/15/18 5:49pm – Value of 282.46
            - 2/18/18 7:19pm – Value of 282.5
            - 2/18/18 7:29pm – Value of 282.62
    - *Average Value Ascertained – 285.562 Ph-N (494.02 calculated)*
- Vrms N-G
    - Maximum Value Ascertained – 0.02V Ph-N
    - Minimum Value Ascertained – 0.02V Ph-N
    - Average Value Ascertained – 0.02V Ph-N

Based on the average Voltage values documented above (Phase to N), the Phase A to B percentage variance is <1% (0.38%); A to C percentage variance is <1% (0.14%); B to C parentage variance is <1% (0.24%).

Neglectable Unbalance on Voltage between phases recorded. The voltage levels data illustrates a higher than normal voltage range. These values can be presented to the local utility for acceptable ranges and verification of voltages.

Phase to Ground is within acceptable parameters.

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AMPERAGE ANALYZED

- Arms (A Phase)
  - Maximum Value Ascertained – 197 Amps
    - Upper Extremes were Time Stamped:
      - 2/21/18 9:19pm – Value of 197
      - 2/21/18 1:19pm – Value of 193
      - 2/15/18 11:49pm – Value of 191
      - 2/19/18 7:19pm – Value of 188
      - 2/28/18 4:49pm – Value of 188
  - Minimum Value Ascertained – 23 Amps
  - *Average Value Ascertained – 109.42 Amps*
- Arms (B Phase)
  - Maximum Value Ascertained – 170 Amps
    - Upper Extremes were Time Stamped:
      - 2/19/18 11:29pm – Value of 170
      - 2/21/18 8:19pm – Value of 163
      - 2/18/18 10:19pm – Value of 162
      - 2/20/18 8:29pm – Value of 160
      - 2/16/18 9:09pm – Value of 160
  - Minimum Value Ascertained – 20 Amps
  - *Average Value Ascertained – 94.7192 Amps*
- Arms (C Phase)
  - Maximum Value Ascertained – 172 Amps
    - Upper Extremes were Time Stamped:
      - 2/21/18 8:19pm – Value of 172
      - 2/21/18 1:19pm – Value of 163
      - 2/21/18 12:39pm – Value of 163
      - 2/18/18 4:49pm – Value of 163
      - 2/15/18 11:49pm – Value of 163
  - Minimum Value Ascertained – 18 Amps
  - *Average Value Ascertained – 92.3889 Amps*

Based on the data collected above, the average of all 3 phases is 98.8427 Amps based on a Phase to Neutral Analysis. A to B Arms percent variance is 14.4%; A to C Arms is 16.8784%; B to C is 2.49%.

The A Phase current to B and C phase currents show a possible unbalanced current three phase system (10.7%). This can be caused by several items, but does not necessarily indicate an immediate problem. An Unbalanced current system can be caused by:

- Three Phase Equipment with unbalance in its winding, such as a “tired” motor.

- A large single-phase Load on Phase A (Load unbalanced at Lighting Panel or another source).
- Continuous switching of three-phase loads. Motors, generators, etc.
- Unequal impedances in the incoming distribution system (this will have to be verified by the Utility).

Suggested that the Water Plant personnel keep a log of occurrences that may indicate the unbalance needs to be addressed such as:

- Motors needing re-built earlier than normal maintenance would suggest.
- Excessive heat at Motors.
- Multiple Phase Faults on VFDs

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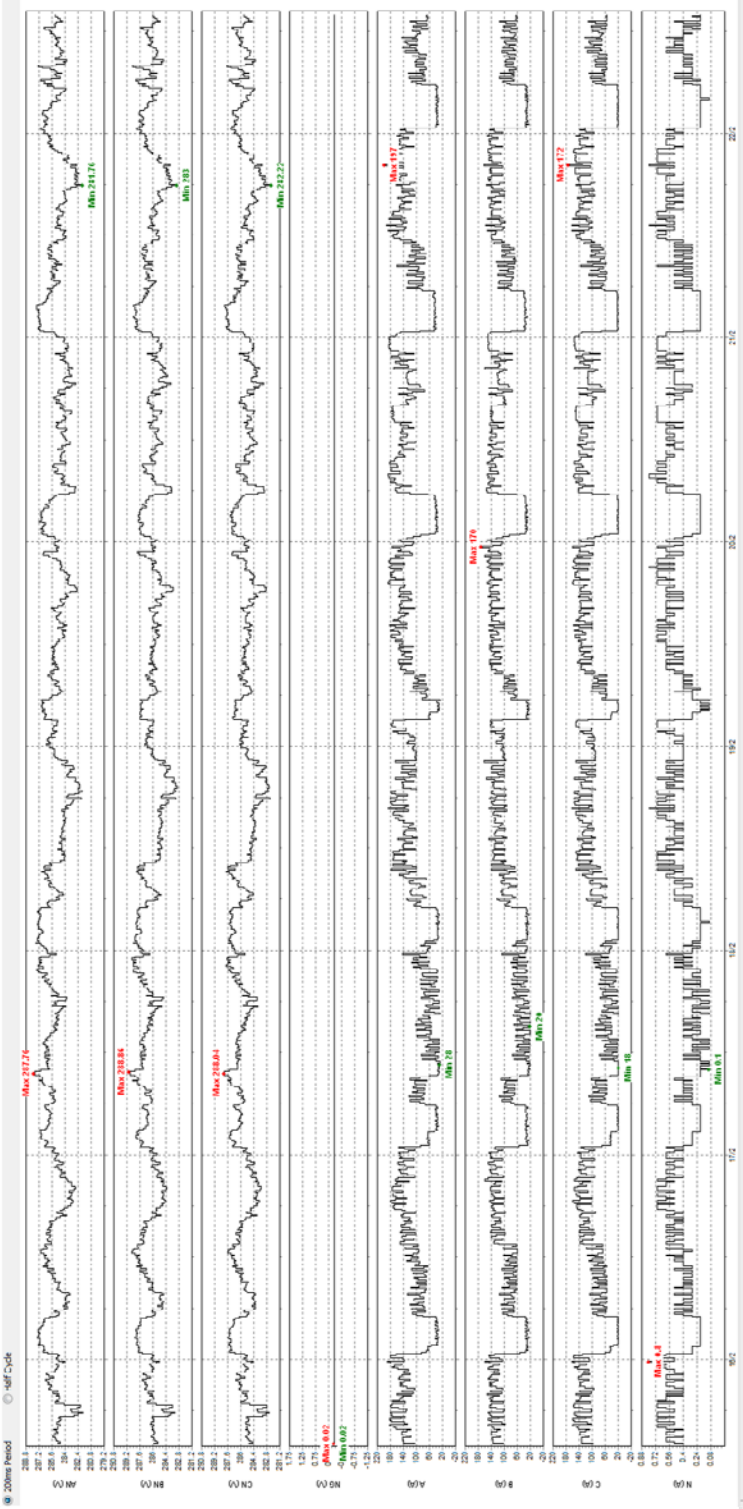
System Vrms and Arms graphical representation:



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FREQUENCY ANALYZED

- Frequency (10s)
  - Maximum Value Ascertained – 60.067Hz
  - Minimum Value Ascertained – 59.879Hz
  - *Average Value Ascertained – 59.9976Hz*

Frequency is within acceptable parameters.

HORMONICS ANALYZED

- Harmonics (Based on Voltage)
  - Total Harmonic Distortion THD
    - Maximum Value
      - Phase A – 2.57%
      - Phase B – 2.87%
      - Phase C – 2.66%
    - Average Value
      - Phase A – 1.64%
      - Phase B – 1.97%
      - Phase C – 1.81%
  - Average H3 (3rd Harmonic)
    - Phase A – 0.283%
    - Phase B – 0.461%
    - Phase C – 0.303%
  - Average H5 (5th Harmonic)
    - Phase A – 0.819%
    - Phase B – 0.933%
    - Phase C – 0.908%
  - Average H7 (7th Harmonic)
    - Phase A – 0.351%
    - Phase B – 0.479%
    - Phase C – 0.401%
  - Average H9 (9th Harmonic)
    - Phase A – 0.072%
    - Phase B – 0.051%
    - Phase C – 0.068%
  - Average H11 (11th Harmonic)
    - Phase A – 0.114%
    - Phase B – 0.109%
    - Phase C – 0.106%

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Harmonic Values are within an acceptable range for a power system in the individual Harmonic ranges. All Harmonics, including the Total Harmonic Distortion Range should be a close to zero as possible.

Verification of grounding and bonding, especially in VFD applications, can assist in lowing the harmonic values.

SITE #2 RECORDINGS (MAIN BUILDING)

Recordings were taken at the Water Plant Main Building Area (first disconnect switch) on March 7, 2018 at 6:59PM and remained in service until March 9, 2018 6:59PM. Recordings were taken for Voltage (L-N (per Phase); N-G), Amperage, and other pertinent aspects of analysis.

Data Analysis is listed below.

VOLTAGE ANALYZED

- Vrms Ph-N (A Phase)
    - Maximum Value Ascertained – 290.86V Ph-N (503.19 calculated)
        - Upper Extremes were Time Stamped:
            - 3/9/18 1:09am – Value of 290.86
            - 3/9/18 1:19am – Value of 290.58
            - 3/9/18 1:49am – Value of 290.52
            - 3/9/18 12:59am – Value of 290.48
            - 3/8/18 2:59am – Value of 290.42
    - Minimum Value Ascertained – 284.42V Ph-N (492.04 calculated)
        - Lower Extremes were Time Stamped:
            - 3/8/18 6:49pm – Value of 284.42
            - 3/8/18 6:59pm – Value of 284.54
            - 3/7/18 8:09pm – Value of 284.74
            - 3/8/18 6:39pm – Value of 285.12
            - 3/9/18 5:49pm – Value of 285.14
    - *Average Value Ascertained – 288.05 Ph-N (498.33 calculated)*
- Vrms Ph-N (B Phase)
    - Maximum Value Ascertained – 293.02V Ph-N (506.92 calculated)

        - Upper Extremes were Time Stamped:
            - 3/9/18 1:09am – Value of 293.02
            - 3/9/18 10:29am – Value of 292.98
            - 3/9/18 1:59am – Value of 292.94
            - 3/9/18 8:59am – Value of 292.88
            - 3/9/18 12:49am – Value of 292.88
    - Minimum Value Ascertained – 286.92V Ph-N (496.37 calculated)
        - Lower Extremes were Time Stamped:
            - 3/8/18 6:49pm – Value of 286.92
            - 3/8/18 6:59pm – Value of 286.96
            - 3/7/18 8:09pm – Value of 287.54
            - 3/8/18 6:39pm – Value of 287.7
            - 3/7/18 7:59pm – Value of 287.7
    - *Average Value Ascertained – 290.446 Ph-N (502.47 calculated)*
- Vrms Ph-N (C Phase)
    - Maximum Value Ascertained – 287.18V Ph-N (496.82 calculated)
        - Upper Extremes were Time Stamped:
            - 3/9/18 12:49am – Value of 287.18
            - 3/9/18 1:09am – Value of 287.06
            - 3/9/18 2:29am – Value of 286.92
            - 3/9/18 1:19am – Value of 286.9
            - 3/9/18 1:59am – Value of 286.86
    - Minimum Value Ascertained – 281.12V Ph-N (486.34 calculated)
        - Lower Extremes were Time Stamped:
            - 3/8/18 6:49pm – Value of 281.12
            - 3/8/18 6:59pm – Value of 281.18
            - 3/7/18 8:09pm – Value of 281.74
            - 3/7/18 9:09pm – Value of 282.06
            - 3/7/18 7:59pm – Value of 282.1
    - *Average Value Ascertained – 284.609 Ph-N (492.37 calculated)*
- Vrms N-G
    - Maximum Value Ascertained – 0.18V Ph-N
    - Minimum Value Ascertained – 0.12V Ph-N
    - Average Value Ascertained – 0.14V Ph-N

Based on the average Voltage values documented above (Phase to N), the Phase A to B percentage variance is <1% (0.83%); A to C percentage variance is <2% (1.2%); B to C percentage variance is around 2% (2.03%). The total % Voltage Unbalance is 1.074%.

Neglectable Unbalance on Voltage between phases recorded. The voltage levels data illustrates a higher than normal voltage range. These values can be presented to the local utility for acceptable ranges and verification of voltages.

Phase to Ground is within acceptable parameters.

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AMPERAGE ANALYZED

- Arms (A Phase)
  - Maximum Value Ascertained – 81 Amps
    - Upper Extremes were Time Stamped:
      - 3/8/18 11:19pm – Value of 81
      - 3/8/18 8:09pm – Value of 78
      - 3/9/18 12:09pm – Value of 77
      - 3/8/18 11:29pm – Value of 77
      - 3/7/18 9:39pm – Value of 74
  - Minimum Value Ascertained – 9 Amps
  - *Average Value Ascertained – 41.3993 Amps*
- Arms (B Phase)
  - Maximum Value Ascertained – 65 Amps
    - Upper Extremes were Time Stamped:
      - 3/7/18 9:39pm – Value of 65
      - 3/8/18 11:29pm – Value of 64
      - 3/8/18 8:09pm – Value of 64
      - 3/8/18 7:59pm – Value of 64
      - 3/8/18 11:19pm – Value of 63
  - Minimum Value Ascertained – 2 Amps
  - *Average Value Ascertained – 32.0903 Amps*
- Arms (C Phase)
  - Maximum Value Ascertained – 77 Amps
    - Upper Extremes were Time Stamped:
      - 3/8/18 11:19pm – Value of 77
      - 3/8/18 8:09pm – Value of 74
      - 3/9/18 6:59pm – Value of 71
      - 3/9/18 12:09pm – Value of 71
      - 3/8/18 11:49pm – Value of 70
  - Minimum Value Ascertained – 8 Amps
  - *Average Value Ascertained – 38.5104 Amps*

Based on the data collected above, the average of all 3 phases is 37.33 Amps based on a Phase to Neutral Analysis. A to B Arms percent variance is 25.33%; A to C Arms is 7.23%; B to C is 18.19%.

The B Phase Current to A and C Phase Currents show a possible unbalanced current three phase system (14.03%). This can be caused by several items, but does not necessarily indicate an immediate problem. An Unbalanced current system can be caused by:

- Three Phase Equipment with unbalance in its winding, such as a “tired” motor.

- A large single-phase Load on Phase A (Load unbalanced at Lighting Panel or another source).
- Continuous switching of three-phase loads. Motors, generators, etc.
- Unequal impedances in the incoming distribution system (this will have to be verified by the Utility).

Suggested that the Water Plant keep a log of occurrences that may indicate the unbalance needs to be addressed such as:

- Motors needing re-built earlier than normal maintenance would suggest.
- Excessive heat at Motors.
- Multiple Phase Faults on VFDs

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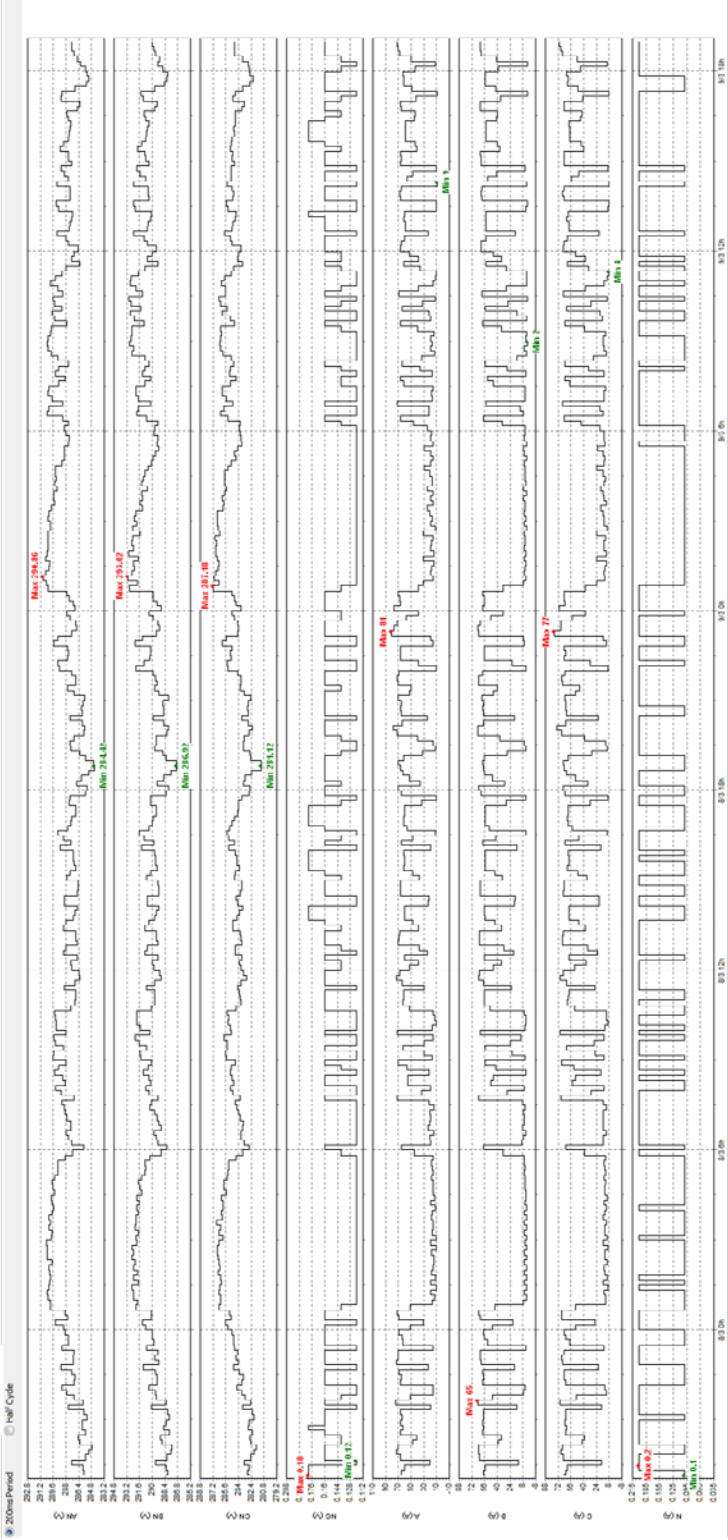
System Vrms and Arms graphical representation:



FREQUENCY ANALYZED

- Frequency (10s)
  - Maximum Value Ascertained – 60.062Hz
  - Minimum Value Ascertained – 59.931Hz
  - *Average Value Ascertained – 59.9986Hz*

Frequency is within acceptable parameters.

HORMONICS ANALYZED

- Harmonics (Based on Voltage)
  - Total Harmonic Distortion THD
    - Maximum Value
      - Phase A – 8.33%
      - Phase B – 8.18%
      - Phase C – 8.26%
    - Average Value
      - Phase A – 6.84%
      - Phase B – 6.75%
      - Phase C – 6.83%
  - Average H3 (3rd Harmonic)
    - Phase A – 3.756%
    - Phase B – 3.767%
    - Phase C – 3.748%
  - Average H5 (5th Harmonic)
    - Phase A – 1.098%
    - Phase B – 0.948%
    - Phase C – 0.986%
  - Average H7 (7th Harmonic)
    - Phase A – 0.658%
    - Phase B – 0.699%
    - Phase C – 0.595%
  - Average H9 (9th Harmonic)
    - Phase A – 0.449%
    - Phase B – 0.442%
    - Phase C – 0.408%
  - Average H11 (11th Harmonic)
    - Phase A – 0.311%
    - Phase B – 0.305%
    - Phase C – 0.198%

In general, Harmonics should be limited to 3 to 5% distortion. The THD exceeds both distortion limits while the 3rd Harmonic also exceeds the limited 3%. Recommended to verify all grounding and bonding between motors, VFDs and other related equipment.

In the event that grounding and bonding does not correct the harmonics shown above, other solutions can be explored based on equipment within the plant.

Harmonic Distortions can adversary effect motors, cables, low signal circuit boards, etc. The effects are similar to that of an unbalanced current three phase system.

Harmonic Values above the 3rd harmonic are within acceptable range for a power system in the individual Harmonic ranges. All Harmonics, including the Total Harmonic Distortion Range should be a close to zero as possible.

CONCLUSION

Based on the Average Amperages ascertained (Filter Building – 98.84, Main Building – 37.33), the Total Average Amps needed is 136.17.

In the sizing of a generator, the peak measured load is compiled and averaged.

- Filter Building
    - Maximum Phase A – 197 Amps
    - Maximum Phase B – 170 Amps
    - Maximum Phase C – 172 Amps
- Main Building
    - Maximum Phase A – 81 Amps
    - Maximum Phase B – 65 Amps
    - Maximum Phase C – 77 Amps

Average Peak Filter Building Amperage – 179.67A; Average Peak Main Building Amperage – 74.33. Adding these together 254.00 Amps.

Typical Oversize of 10 to 20%. 10% additional – 279.4 Amps

(Amps * Volts (460vac) * 1.73) / 1000 = 222.349 kW.

Estimated 225kW to 250kW Generator for Plant Wide protection. For future expansion, a 300kW generator may be considered.