Design calculations for chlorine disinfection:

Defined Units:

Cubic Feet $\text{cf} := 28.31685\text{L}$

Variable definitions:

$Q$ = Average Daily Design Flow, million gallons per day, or mgd
$PF$ = Peaking Factor, unitless
$Q_p$ = Peak Flow, mgd
$\text{HRT}$ = Hydraulic Retention Time, minutes
$\text{Vol}$ = Volume, ft$^3$
$D$ = Depth, ft
$\text{SA}$ = Surface Area, ft$^2$
$\text{Le}$ = Length, ft
$\text{Wi}$ = Width, ft
$\text{AR}$ = Aspect Ratio, L/W, unitless
$L_r$ = Rounded length, ft
$W_r$ = Rounded width, ft
$D_r$ = Rounded depth, ft
$\text{Va}$ = Actual volume, cf
$\text{HRT}_a$ = Actual HRT, min
$T_s$ = slab thickness, ft
$T_w$ = wall thickness, ft
$\text{Slab}$ = volume of slab concrete, ft$^3$
$\text{S\_Wall}$ = volume of sidewall concrete, ft$^3$
$\text{E\_Wall}$ = volume of end wall concrete, ft$^3$
$\text{B\_Wall}$ = volume of baffle wall concrete, ft$^3$
$V_{\text{Conc}}$ = total volume of concrete, ft$^3$
$M_{\text{Conc}}$ = total mass of concrete, kg
$B$ = bar spacing, ft on center
$SG_{\text{c}}$ = specific gravity of concrete
$\text{Rho}_w$ = density of water, 62.4 lb/ft$^3$ or 1,000 kg/m$^3$

$\text{Slab\_Rebar\_long}$ = Longitudinal rebar in slab, ft
$\text{Slab\_Rebar\_horiz}$ = Transverse rebar in slab, ft
$\text{Side\_Wall\_vert\_rebar}$ = Vertical rebar in side walls, ft
$\text{Side\_Wall\_horiz\_rebar}$ = Horizontal rebar in side walls, ft
$\text{End\_Wall\_vert\_rebar}$ = Vertical rebar in end walls, ft
$\text{End\_Wall\_horiz\_rebar}$ = Horizontal rebar in end walls, ft
$\text{Baffle\_Wall\_vert\_rebar}$ = Vertical rebar in baffle walls, ft
$\text{Baffle\_Wall\_horiz\_rebar}$ = Horizontal rebar in baffle walls, ft
$\text{Total\_rebar}$ = Total length of reinf. steel, ft
$\text{Rho\_s}$ = mass per linear foot of steel reinforcing (#4 bars)
$\text{Mass\_rebar}$ = Total mass of reinf. steel, kg
Calculations for the chlorine contact tank, baseline case of 8 mgd average daily flow:

\[
\begin{align*}
Q & := 8 \text{ mgd} \\
PF & := 3 \\
Q_p & := Q \cdot PF = 24 \text{ mgd} \\
Q_p & = 2228.009 \text{ cfm} \\
HRT & := 15 \text{ min} \\
Vol & := HRT \cdot Q_p = 33420.136 \text{ cf} \\
D & := 10 \text{ ft} \\
SA & := \frac{Vol}{D} = 3342.014 \text{ ft}^2 \\
AR & := 10 \\
Wi & := \sqrt{\frac{SA}{AR}} = 18.281 \text{ ft} \\
Le & := Wi \cdot AR = 182.812 \text{ ft} \\
\text{So Length} & = Le = 183 \text{ ft}, \text{ width} Wi = 18.3 \text{ ft}, \text{ and depth} D = 10 \text{ ft}.
\end{align*}
\]

Values were rounded to 180 ft length, 18.5 ft depth, and 10 ft depth.

\[
\begin{align*}
L_r & := 180 \text{ ft} \\
W_r & := 18.5 \text{ ft} \\
D_r & := 10 \text{ ft}
\end{align*}
\]

Wall thicknesses and slab overhang were neglected in some calculations.

\[
\begin{align*}
V_a & := L_r \cdot W_r \cdot D_r = 33300 \text{ cf} \\
HRT_a & := \frac{V_a}{Q_p} = 14.9 \text{ min} \\
\hfill \text{This is acceptable for a 3:1 peak flow HRT}
\end{align*}
\]
Ts := 1.5ft
Tw := 1.0ft
Slab := Wr·3·Lr·Ts = 14985·cf
S_Wall := 2·[Lr·(Dr + 3ft)]·Tw = 4680·cf
E_Wall := [(Wr·3)·(Dr + 3ft)]·2·1ft = 1443·cf
B_Wall := [(Lr − Wr)·(Dr + 3ft)]·2·1ft = 4199·cf
V_Conc := Slab + S_Wall + E_Wall + B_Wall = 25307·cf
SGc := 2.4
Rho_w := 62.43 \frac{lb}{cf}
M_Conc := V_Conc·Rho_w·SGc = 1719931·kg
Slab_Rebar_long := \frac{Lr \cdot (Wr \cdot 3 - 2\text{ft})}{\text{ft}} = 9630\text{ft}

Slab_Rebar_horiz := (Wr \cdot 3) \cdot \frac{(Lr - 2\text{ft})}{\text{ft}} = 9879\text{ft}

Side_Wall_vert_rebar := 2 \cdot \frac{[(Dr + 3\text{ft}) \cdot (Lr - 2\text{ft})]}{\text{ft}} = 4628\text{ft}

Side_Wall_horiz_rebar := 2 \cdot \frac{[(Lr \cdot (Dr + 3\text{ft} - 2\text{ft})]}{\text{ft}} = 3960\text{ft}

End_Wall_vert_rebar := 2 \cdot \frac{[(Wr \cdot 3 - 2\text{ft}) \cdot (Dr + 3\text{ft})]}{\text{ft}} = 1391\text{ft}

End_Wall_horiz_rebar := 2 \cdot \frac{[(Dr + 3\text{ft} - 2\text{ft}) \cdot (Wr \cdot 3)]}{\text{ft}} = 1221\text{ft}

Baffle_Wall_vert_rebar := 2 \cdot \frac{[(Lr - Wr - 2\text{ft}) \cdot (Dr + 3\text{ft})]}{\text{ft}} = 4147\text{ft}

Baffle_Wall_horiz_rebar := 2 \cdot \frac{[(Lr - Wr) \cdot (Dr + 3\text{ft} - 2\text{ft})]}{\text{ft}} = 3553\text{ft}

Note - 3x multiplication factor on Wr reflects that the overall basin width includes 3 passes, each at a channel width of Wr.

Total_rebar := Slab_Rebar_long + Slab_Rebar_horiz + Side_Wall_vert_rebar \ldots = 38409\text{ft}
+ Side_Wall_horiz_rebar + End_Wall_vert_rebar \ldots
+ End_Wall_horiz_rebar + Baffle_Wall_vert_rebar \ldots
+ Baffle_Wall_horiz_rebar

Rho_s := 0.668 \frac{\text{lb}}{\text{ft}}

Mass_rebar := Total_rebar \cdot Rho_s = 11638\text{kg}

Using similar calculations, design criteria can be calculated for other flow rates as follows (values may differ slightly from above):

<table>
<thead>
<tr>
<th>Flow MGD</th>
<th>Lr ft</th>
<th>Wr ft</th>
<th>Dr ft</th>
<th>Va cf</th>
<th>HRTa min</th>
<th>Concrete kg</th>
<th>R. Steel kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>65</td>
<td>7</td>
<td>10</td>
<td>4,550</td>
<td>16.3</td>
<td>393,637</td>
<td>2,822</td>
</tr>
<tr>
<td>2</td>
<td>90</td>
<td>10</td>
<td>10</td>
<td>9,000</td>
<td>16.2</td>
<td>628,704</td>
<td>4,425</td>
</tr>
<tr>
<td>4</td>
<td>130</td>
<td>13</td>
<td>10</td>
<td>16,900</td>
<td>15.2</td>
<td>1,022,307</td>
<td>7,082</td>
</tr>
<tr>
<td>8</td>
<td>180</td>
<td>18.5</td>
<td>10</td>
<td>33,300</td>
<td>14.9</td>
<td>1,720,066</td>
<td>11,638</td>
</tr>
<tr>
<td>12</td>
<td>225</td>
<td>23</td>
<td>10</td>
<td>51,750</td>
<td>15.5</td>
<td>2,459,320</td>
<td>16,397</td>
</tr>
</tbody>
</table>
Design calculations for chlorine chemical requirements:

Defined Units: 

\[ \text{Million Gallon (MG)} = \text{gal} \cdot 10^6 \]

Variable definitions:

- Dose = Target Chlorine dose, mg/L
- \( \text{Cl}_2\text{\_daily} \) = \( \text{Cl}_2\) consumption at baseline flow, lb/day
- \( \text{Cl}_2\text{\_per\_mg} \) = \( \text{Cl}_2\) consumption per unit of flow, lb/mg
- \( \text{Cl}_2\text{\_residual} \) = \( \text{Cl}_2\) residual requiring dechlorination, mg/L
- \( \text{SO}_2\text{\_Cl}_2\text{\_ratio} \) = Amount of SO\(_2\) required to dechlorinate 1 mg \( \text{Cl}_2\), mg/mg
- \( \text{SO}_2\text{\_daily} \) = \( \text{SO}_2\) consumption at baseline flow, lb/day
- \( \text{SO}_2\text{\_per\_mg} \) = \( \text{SO}_2\) consumption per unit of flow, lb/mg

\[
\text{Dose} := 6 \, \text{mg/L}
\]

\[
\text{Cl}_2\text{\_daily} := \text{Dose} \cdot Q = 401 \, \text{lb/day}
\]

\[
\text{Cl}_2\text{\_per\_mg} := \frac{\text{Cl}_2\text{\_daily}}{Q} = 50.072 \, \text{lb/MG}
\]

\[
\text{Cl}_2\text{\_per\_mg} = 22.712 \, \text{kg/MG}
\]

Each day, the amount of chlorine required per MG of flow is indicated above, in kg.

For sulfur dioxide (SO\(_2\)):

\[
\text{Cl}_2\text{\_residual} := 2 \, \text{mg/L}
\]

\[
\text{SO}_2\text{\_Cl}_2\text{\_ratio} := 0.9 \, \frac{\text{mg}}{\text{mg}}
\]

\[
\text{SO}_2\text{\_daily} := \text{Cl}_2\text{\_residual} \cdot \text{SO}_2\text{\_Cl}_2\text{\_ratio} \cdot Q = 120.174 \, \text{lb/day}
\]

\[
\text{SO}_2\text{\_per\_mg} := \frac{\text{SO}_2\text{\_daily}}{Q} = 15.022 \, \text{lb/MG}
\]

\[
\text{SO}_2\text{\_per\_mg} = 6.814 \, \text{kg/MG}
\]

Each day, the amount of SO\(_2\) required per MG of flow is indicated at left, in kg.
Design calculations for sodium hypochlorite disinfection:

For NaOCl disinfection, the concrete basin is assumed to be the same volume and dimensions as for chlorine disinfection. Therefore, those calculations are not repeated here.

Variable definitions:

\[
\begin{align*}
\text{NaOCl\_MW} & := 74.5 \text{ g/mol} \\
\text{NaOCl\_trade} & := 15\% \\
\text{NaOCl\_conc} & := 150000 \text{ mg/L} \\
\text{NaOCl\_flow} & := Q \frac{\text{Dose}}{\text{NaOCl\_conc}} = 13.333 \text{ gal/hr} \\
\text{NaOCl\_active} & := 1.25 \text{ lb/gal} \\
\text{NaOCl\_Mass} & := \text{NaOCl\_flow} \cdot \text{NaOCl\_active} = 181.437 \text{ kg/day}
\end{align*}
\]

This is the flow of 15% solution that is required. The LCI unit process is based on 15% sodium hypochlorite but not including the water. So, the dose must be corrected for the water content.

This could range as high as 1.5 lb/gal, depending on how it is calculated. The user is free to adjust.

Note - Actual flow of liquid will be higher, but it appears that the LCI unit process includes only the chemical and not the water contained in the chemical. So, the mass input should be based on the mass flow rate of chemical only.
Design calculations for sodium sulfite dechlorination:

For dechlorination, a salt of sulfite or bisulfite is assumed. Sodium sulfite is available in the Ecoinvent database. Therefore, that chemical is assumed here. The sulfite ion is assumed to react with HOCl as follows:

\[ \text{SO}_3^{-2} + \text{HOCl} \rightarrow \text{SO}_4^{-2} + \text{Cl}^{-} + \text{H}^{+} \]

The stoichiometric amount of Na$_2$SO$_3$ required is approximately 1.8 mg/L per mg/L of residual chlorine. In practice, 1.6-2.0 may be used, depending on the tolerance for overdosing (and the resulting consumption of DO and production of acid). Here, a dose of 1.6 mg/L per mg/L of residual is used.


Variable definitions:

\[ \text{Na}_2\text{SO}_3\text{ dose} = \text{Ratio of Na}_2\text{SO}_3 \text{ to Cl residual} = 1.6, \text{ unitless} \]
\[ \text{Na}_2\text{SO}_3\text{ Mass} = \text{Mass of Na}_2\text{SO}_3 \text{ added, without water, kg/day} \]

\[ \text{Na}_2\text{SO}_3\text{ dose} := 1.6 \]
\[ \text{Na}_2\text{SO}_3\text{ Mass} := Q \cdot \text{Na}_2\text{SO}_3\text{ dose} \cdot \text{Cl}_2\text{ residual} = 96.907 \cdot \frac{\text{kg}}{\text{day}} \]

Similar calculations can be performed for other design scenarios. Because chemical requirements are proportional to flow, they scale linearly with flow rate. A summary table for the design scenarios included is shown below.

**Summary Table**

<table>
<thead>
<tr>
<th>Flow MGD</th>
<th>Cl2 kg</th>
<th>SO2 kg</th>
<th>NaOCl kg</th>
<th>Na2SO3 kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>23</td>
<td>7</td>
<td>23</td>
<td>12</td>
</tr>
<tr>
<td>2</td>
<td>45</td>
<td>14</td>
<td>45</td>
<td>24</td>
</tr>
<tr>
<td>4</td>
<td>91</td>
<td>27</td>
<td>91</td>
<td>48</td>
</tr>
<tr>
<td>8</td>
<td>182</td>
<td>54</td>
<td>182</td>
<td>97</td>
</tr>
<tr>
<td>12</td>
<td>272</td>
<td>82</td>
<td>273</td>
<td>145</td>
</tr>
</tbody>
</table>
Design calculations for sizing UV channels:

Defined Units:

Cubic Feet \( cf := 28.31685 \cdot L \)

Variable definitions:

- \( Q \) = Average Daily Design Flow, million gallons per day, or mgd
- \( PF \) = Peaking Factor, unitless
- \( Q_p \) = Peak Flow, mgd
- \( HRT \) = Hydraulic Retention Time, minutes
- \( Vol \) = Volume, \( ft^3 \)
- \( D \) = Depth, ft
- \( SA \) = Surface Area, \( ft^2 \)
- \( L_e \) = Length, ft
- \( W_i \) = Width, ft
- \( L_r \) = Rounded length, ft
- \( W_r \) = Rounded width, ft
- \( D_r \) = Rounded depth, ft
- \( T_s \) = slab thickness, ft
- \( T_w \) = wall thickness, ft
- \( S_{lab} \) = volume of slab concrete, \( ft^3 \)
- \( S_{Wall} \) = volume of sidewall concrete, including center wall, \( ft^3 \)
- \( E_{Wall} \) = volume of end wall concrete, \( ft^3 \)
- \( V_{Conc} \) = total volume of concrete, \( ft^3 \)
- \( M_{Conc} \) = total mass of concrete, kg
- \( B \) = bar spacing, ft on center
- \( S_{Gc} \) = specific gravity of concrete
- \( Rho_w \) = density of water, 62.4 lb/\( ft^3 \) or 1,000 kg/m\(^3\)

- \( S_{lab\_Rebar\_long} \) = Longitudinal rebar in slab, ft
- \( S_{lab\_Rebar\_horiz} \) = Transverse rebar in slab, ft
- \( S_{side\_Wall\_vert\_rebar} \) = Vertical rebar in side walls, ft
- \( S_{side\_Wall\_horiz\_rebar} \) = Horizontal rebar in side walls, ft
- \( S_{end\_Wall\_vert\_rebar} \) = Vertical rebar in end walls, ft
- \( S_{end\_Wall\_horiz\_rebar} \) = Horizontal rebar in end walls, ft
- \( S_{Total\_rebar} \) = Total length of reinf. steel, ft
- \( Rho_s \) = mass per linear foot of steel reinforcing (#4 bars)
- \( S_{Mass\_rebar} \) = Total mass of reinf. steel, kg
Calculations for the UV tank assume two channels are needed for UV modules. Each channel is assumed to be 4 feet wide and 5 feet deep plus one foot of freeboard. The length of the channel is assumed to vary slightly to reflect some increase in size associated requiring additional modules to treat the increased flow. However, there is a minimum size required for the equipment to be installed.

\[ Q = 8 \text{ mgd} \]

\[ L_r = 90 \text{ ft} \]
\[ W_r = 4 \text{ ft} \]
\[ D_r = 5 \text{ ft} \]

Wall thicknesses and slab overhang were neglected in some calculations.

\[ T_s = 1.5 \text{ ft} \]
\[ T_w = 1.0 \text{ ft} \]

\[ \text{Slab} = W_r \cdot L_r \cdot T_s = 1080 \text{ cf} \]
\[ S\_\text{Wall} = 3 \cdot [L_r(D_r + 1 \text{ ft})] \cdot T_w = 1620 \text{ cf} \]
\[ E\_\text{Wall} = [(W_r-2)\cdot(D_r + 1 \text{ ft})] \cdot 2 \cdot 1 \text{ ft} = 96 \text{ cf} \]

\[ V\_\text{Conc} = \text{Slab} + S\_\text{Wall} + E\_\text{Wall} = 2796 \text{ cf} \]
\[ \text{SGc} = 2.4 \]
\[ \text{Rho}_w = 62.43 \frac{\text{lb}}{\text{cf}} \]
\[ M\_\text{Conc} = V\_\text{Conc} \cdot \text{Rho}_w \cdot \text{SGc} = 190024 \text{ kg} \]
Slab_Rebar_long := \frac{Lr \cdot (Wr - 2\text{ft})}{\text{ft}} = 540\text{ ft}

Slab_Rebar_horiz := \frac{(Wr \cdot 2)}{\text{ft}} \cdot \frac{(Lr - 2\text{ft})}{\text{ft}} = 704\text{ ft}

Side_Wall_vert_rebar := 3 \cdot \frac{[(Dr + 1\text{ft}) \cdot (Lr - 2\text{ft})]}{\text{ft}} = 1584\text{ ft}

Side_Wall_horiz_rebar := 3 \cdot \frac{[Lr \cdot (Dr + 1\text{ft})]}{\text{ft}} = 1080\text{ ft}

End_Wall_vert_rebar := 2 \cdot \frac{[(Wr \cdot 2) \cdot (Dr + 1\text{ft})]}{\text{ft}} = 96\text{ ft}

End_Wall_horiz_rebar := 2 \cdot \frac{[(Dr + 1\text{ft}) - 2\text{ft}) - (Wr \cdot 2)]}{\text{ft}} = 64\text{ ft}

Note - 3x multiplication factor on Wr reflects that the overall basin width includes 3 passes, each at a channel width of Wr.

Total_rebar := Slab_Rebar_long + Slab_Rebar_horiz + Side_Wall_vert_rebar + Side_Wall_horiz_rebar + End_Wall_vert_rebar + End_Wall_horiz_rebar

\text{Rho}_s := 0.668 \frac{\text{lb}}{\text{ft}}

\text{Mass}_{\text{rebar}} := \text{Total}_{\text{rebar}} \cdot \text{Rho}_s = 1233\text{ kg}

Using similar calculations, design criteria can be calculated for other flow rates as follows (values may differ slightly from above):

<table>
<thead>
<tr>
<th>Flow MGD</th>
<th>Lr ft</th>
<th>Wr ft</th>
<th>Dr ft</th>
<th>Va cf</th>
<th>HRTa min</th>
<th>Concrete kg</th>
<th>R. Steel kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>60</td>
<td>4</td>
<td>5</td>
<td>1,200</td>
<td>n/a</td>
<td>128,867</td>
<td>833</td>
</tr>
<tr>
<td>2</td>
<td>70</td>
<td>4</td>
<td>5</td>
<td>1,400</td>
<td>n/a</td>
<td>149,258</td>
<td>966</td>
</tr>
<tr>
<td>4</td>
<td>80</td>
<td>4</td>
<td>5</td>
<td>1,600</td>
<td>n/a</td>
<td>169,648</td>
<td>1,100</td>
</tr>
<tr>
<td>8</td>
<td>90</td>
<td>4</td>
<td>5</td>
<td>1,800</td>
<td>n/a</td>
<td>190,039</td>
<td>1,233</td>
</tr>
<tr>
<td>12</td>
<td>110</td>
<td>4</td>
<td>5</td>
<td>2,200</td>
<td>n/a</td>
<td>230,819</td>
<td>1,500</td>
</tr>
</tbody>
</table>
Electricity requirements for UV disinfection:

The user is encouraged to seek out information for this parameter. Actual power input consumption will depend on the type of lamp used and the efficiency of converting the power input into effective dose. One laboratory-scale and a few macro-scale (at the plant scale) values are provided here as a starting point. Lee et al. (2012, Int J Life Cycle Assess, 17:565-579) demonstrated a need for 0.052 Wh/L to achieve 99.9% (3-log) removal of total coliform bacteria. A representative from the American Water Works Service Co. in 2008 stated a consumption of 70-100 kWh/MG treated (0.0185-0.0264 Wh/L). A manufacturer's application note (Dabkowski, 2012) states a consumption of between 2.6x10^6 kWh and 3.93x10^6 kWh consumed to treat 48 MGD for 258 days, equating to a requirement of 0.056 to 0.084 Wh/L. For the author, a value of 0.025 Wh/L treated is assumed to be sufficiently conservative (low enough) so as not to bias against the UV disinfection system.

References:

With the selected power requirement of 0.025 Wh/L:

<table>
<thead>
<tr>
<th>Flow MGD</th>
<th>Flow L/day</th>
<th>Elec Wh/d</th>
<th>Elec kWh/day</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3.79E+06</td>
<td>9.46E+04</td>
<td>95</td>
</tr>
<tr>
<td>2</td>
<td>7.57E+06</td>
<td>1.89E+05</td>
<td>189</td>
</tr>
<tr>
<td>4</td>
<td>1.51E+07</td>
<td>3.79E+05</td>
<td>379</td>
</tr>
<tr>
<td>8</td>
<td>3.03E+07</td>
<td>7.57E+05</td>
<td>757</td>
</tr>
<tr>
<td>12</td>
<td>4.54E+07</td>
<td>1.14E+06</td>
<td>1136</td>
</tr>
</tbody>
</table>

Material requirements for UV disinfection system:

Lee et al (2012, see ref above) estimate material requirements for a UV disinfection system treating 1x10^5 m^3/day of wastewater flow

Ref_Flow := 100000 m^3/day

Ref_Flow = 26.417·mgd
### UV System Components, from Lee et al. (2012), Int. J. LCA.

<table>
<thead>
<tr>
<th>System Component</th>
<th>Material</th>
<th>Mass, kg</th>
<th>Equivalent source in Ecoinvent LCI database</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quartz Sleeve</td>
<td>Pure quartz</td>
<td>230</td>
<td>Glass tube, borosilicate {GLO} market for, Alloc Def, U</td>
</tr>
<tr>
<td>Ballast 92</td>
<td>Painted steel</td>
<td>200</td>
<td>Steel, low-alloyed, hot rolled {GLO} market for, Alloc Def, U</td>
</tr>
<tr>
<td>Flood Gate</td>
<td>304 SS</td>
<td>160</td>
<td>Steel, chromium steel 18/8 {GLO} market for, Alloc Def, U</td>
</tr>
<tr>
<td>Lubricant, mL</td>
<td></td>
<td>120</td>
<td></td>
</tr>
<tr>
<td>UV Lamp</td>
<td>UV Glass</td>
<td>100</td>
<td>Glass tube, borosilicate {GLO} market for, Alloc Def, U</td>
</tr>
<tr>
<td>Junction Box</td>
<td>304 SS</td>
<td>86</td>
<td>Steel, chromium steel 18/8 {GLO} market for, Alloc Def, U</td>
</tr>
<tr>
<td>Hoist</td>
<td>400 SS</td>
<td>85</td>
<td>Steel, chromium steel 18/8 {GLO} market for, Alloc Def, U</td>
</tr>
<tr>
<td>Sensor bracketing</td>
<td>304 SS</td>
<td>50</td>
<td>Steel, chromium steel 18/8 {GLO} market for, Alloc Def, U</td>
</tr>
<tr>
<td>Pneumatic cylinder</td>
<td>Coated Al</td>
<td>30</td>
<td>Aluminum, primary, liquid {GLO} market for, Alloc Def, U</td>
</tr>
<tr>
<td>Module Frame</td>
<td>316 SS</td>
<td>24</td>
<td>Steel, chromium steel 18/8 {GLO} market for, Alloc Def, U</td>
</tr>
<tr>
<td>UV module</td>
<td>316 SS</td>
<td>24</td>
<td>Steel, chromium steel 18/8 {GLO} market for, Alloc Def, U</td>
</tr>
<tr>
<td>Washing equipment</td>
<td>316 SS</td>
<td>16</td>
<td>Steel, chromium steel 18/8 {GLO} market for, Alloc Def, U</td>
</tr>
<tr>
<td>Shaft</td>
<td>304 SS</td>
<td>12</td>
<td>Steel, chromium steel 18/8 {GLO} market for, Alloc Def, U</td>
</tr>
<tr>
<td>Bracketing</td>
<td>304 SS</td>
<td>10</td>
<td>Steel, chromium steel 18/8 {GLO} market for, Alloc Def, U</td>
</tr>
<tr>
<td>Bevel Gear</td>
<td>304 SS</td>
<td>8</td>
<td>Steel, chromium steel 18/8 {GLO} market for, Alloc Def, U</td>
</tr>
<tr>
<td>Gearbox</td>
<td>phenobarbital</td>
<td>4</td>
<td>Not included</td>
</tr>
<tr>
<td>Perception part</td>
<td>304 SS</td>
<td>2</td>
<td>Steel, chromium steel 18/8 {GLO} market for, Alloc Def, U</td>
</tr>
<tr>
<td>Other (not incl.)</td>
<td></td>
<td>4</td>
<td>1.2</td>
</tr>
</tbody>
</table>

Total 1162 kg (including 120 mL as a kg)

Actual mass total should be 1042 kg

1037 kg included

314.1 kg
The design reference flow in Lee et al., 2012, was $1 \times 10^5$ m$^3$/day

<table>
<thead>
<tr>
<th>Flow rate</th>
<th>Conversion</th>
</tr>
</thead>
<tbody>
<tr>
<td>$1.00 \times 10^5$ m$^3$/day</td>
<td>26.42 MGD</td>
</tr>
</tbody>
</table>

So, materials above should be scaled accordingly to 8 mgd

For 304 SS, this is equivalent to 18/8 stainless steel (18% chromium, 8% nickel). Econinvent only offers LC data for 18/8 SS. As a result, this is used throughout including where 316 SS was specified by Lee et al., 2012.


<table>
<thead>
<tr>
<th>Material</th>
<th>Mass required, kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glass tube, borosilicate (GLO) market for, Allof Def, U</td>
<td>99.9</td>
</tr>
<tr>
<td>Steel, low alloyed, hot rolled (GLO) market for, Allof Def, U</td>
<td>60.6</td>
</tr>
<tr>
<td>Steel, chromium steel 38/8 (GLO) market for, Allof Def, U</td>
<td>144.5</td>
</tr>
<tr>
<td>Aluminum, primary, liquid (GLO) market for, Allof Def, U</td>
<td>9.1</td>
</tr>
</tbody>
</table>

314.1 kg total. Checks out with above
Summary of chemical and electricity requirements:

<table>
<thead>
<tr>
<th>Flow MGD</th>
<th>Cl2 kg</th>
<th>SO2 kg</th>
<th>Electricity kWh/day</th>
<th>NaOCl kg</th>
<th>Na2SO3 kg</th>
<th>Electricity kWh/day</th>
<th>Electric kWh/day</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>23</td>
<td>7</td>
<td>0</td>
<td>23</td>
<td>12</td>
<td>9</td>
<td>95</td>
</tr>
<tr>
<td>2</td>
<td>45</td>
<td>14</td>
<td>0</td>
<td>45</td>
<td>24</td>
<td>18</td>
<td>189</td>
</tr>
<tr>
<td>4</td>
<td>91</td>
<td>27</td>
<td>0</td>
<td>91</td>
<td>48</td>
<td>36</td>
<td>379</td>
</tr>
<tr>
<td>8</td>
<td>182</td>
<td>54</td>
<td>0</td>
<td>182</td>
<td>97</td>
<td>72</td>
<td>757</td>
</tr>
<tr>
<td>12</td>
<td>272</td>
<td>82</td>
<td>0</td>
<td>273</td>
<td>145</td>
<td>107</td>
<td>1136</td>
</tr>
</tbody>
</table>

Equations for flow-pacing chemicals and electricity:

- Cl2, kg/day = 22.7 * Flow, MGD
- SO2, kg/day = 6.81 * Flow, MGD
- NaOCl, kg/day = 22.7 * Flow, MGD
- Na2SO3, kg/day = 12.1 * Flow, MGD
- Elec (Hypo), kWh/day = 8.95 * Flow, MGD
- Elec (UV), kWh/day = 94.6 * Flow, MGD