

```
In[*]:= d = Transpose[Import[NotebookDirectory[] <> "MagnetWire10-50.txt", "CSV"]]
```

```
Out[*]:= {{0.0651, 0.058, 0.0517, 0.0462, 0.0412, 0.0367, 0.0329, 0.0293, 0.0261,
0.0234, 0.0209, 0.0186, 0.0166, 0.0149, 0.0133, 0.0119, 0.0106, 0.0094,
0.0085, 0.0075, 0.0067, 0.0059, 0.0053, 0.0048, 0.0042, 0.0037, 0.0033, 0.003,
0.0026, 0.0023, 0.0021, 0.00189, 0.00171, 0.00145, 0.00129, 0.00117, 0.00105},
{0.0659, 0.0587, 0.0524, 0.0469, 0.0418, 0.0373, 0.0335, 0.0298, 0.0266,
0.0239, 0.0213, 0.019, 0.017, 0.0153, 0.0137, 0.0123, 0.0109, 0.0097, 0.0088,
0.0078, 0.007, 0.0062, 0.0056, 0.005, 0.0045, 0.004, 0.0035, 0.0032, 0.0028,
0.0025, 0.0023, 0.00205, 0.00173, 0.00158, 0.0014, 0.00124, 0.00113},
{0.0666, 0.0594, 0.0531, 0.0475, 0.0424, 0.0379, 0.034, 0.0303, 0.027,
0.0243, 0.0217, 0.0194, 0.0173, 0.0156, 0.014, 0.0126, 0.0112, 0.01, 0.009,
0.0081, 0.0072, 0.0065, 0.0058, 0.0052, 0.0047, 0.0042, 0.0037, 0.0033,
0.003, 0.0027, 0.0024, 0.0022, 0.002, 0.0017, 0.0015, 0.0013, 0.0012},
{79.94, 100.4, 126.8, 159.4, 201.1, 253.2, 318.4, 400.6, 507.1, 633.7, 804.5, 1010,
1279, 1600, 2028, 2513, 3208, 4052, 4995, 6337, 8055, 10250, 12800, 15750, 20020, 26240,
33330, 40800, 50940, 66140, 80060, 103500, 130000, 163400, 204900, 259700, 324700},
{0.0667, 0.0595, 0.0532, 0.0476, 0.0425, 0.038, 0.0341, 0.0304, 0.0271, 0.0244,
0.0218, 0.0195, 0.0174, 0.0157, 0.0141, 0.0127, 0.0112, 0.01, 0.009, 0.008,
0.0071, 0.0064, 0.0057, 0.0051, 0.0046, 0.004, 0.0035, 0.0032, 0.0029,
0.0025, 0.0023, 0.00209, 0.00181, 0.00165, 0.00139, 0.00127, 0.00115},
{0.0675, 0.0603, 0.0539, 0.0482, 0.0431, 0.0386, 0.0346, 0.031, 0.0276, 0.0249,
0.0223, 0.0199, 0.0178, 0.0161, 0.0144, 0.013, 0.0117, 0.0104, 0.0094,
0.0084, 0.0075, 0.0067, 0.006, 0.0055, 0.0049, 0.0043, 0.0038, 0.0035, 0.0031,
0.0027, 0.0025, 0.00225, 0.00196, 0.00178, 0.00155, 0.00139, 0.00128},
{0.0682, 0.061, 0.0545, 0.0488, 0.0437, 0.0391, 0.0351, 0.0315, 0.0281, 0.0253,
0.0227, 0.0203, 0.0182, 0.0165, 0.0147, 0.0133, 0.0121, 0.0108, 0.0097,
0.0087, 0.0078, 0.007, 0.0063, 0.0057, 0.0051, 0.0045, 0.0041, 0.0037,
0.0033, 0.0029, 0.0026, 0.0024, 0.0021, 0.0019, 0.0017, 0.0015, 0.0014},
{79.18, 99.7, 125.6, 157.7, 199.2, 250.6, 314.5, 395.3, 502.5, 625, 790.5, 992.1, 1254,
1571, 1987, 2463, 3136, 3948, 4873, 6161, 7837, 9891, 12380, 15290, 19360, 25270,
31940, 39340, 49600, 63170, 76160, 99110, 123800, 154600, 196900, 247500, 307700},
{0.0683, 0.0611, 0.0546, 0.0489, 0.0438, 0.0392, 0.0352, 0.0316, 0.0282, 0.0254,
0.0228, 0.0204, 0.0183, 0.0166, 0.0148, 0.0134, 0.0119, 0.0106, 0.0096,
0.0085, 0.0076, 0.0068, 0.0061, 0.0055, 0.0049, 0.0043, 0.0038, 0.0035,
0.0031, 0.0027, 0.0025, 0.00219, 0.00201, 0.00185, 0.00159, 0.00147, 0.00125},
{0.0691, 0.0618, 0.0553, 0.0496, 0.0444, 0.0398, 0.0358, 0.0321, 0.0287, 0.0259,
0.0232, 0.0208, 0.0187, 0.017, 0.0152, 0.0138, 0.0123, 0.011, 0.0099, 0.0089,
0.008, 0.0072, 0.0064, 0.0058, 0.0052, 0.0046, 0.0041, 0.0038, 0.0034,
0.0029, 0.0027, 0.00245, 0.00221, 0.00198, 0.00175, 0.00159, 0.00143},
{0.0698, 0.0625, 0.056, 0.0502, 0.045, 0.0404, 0.0363, 0.0326, 0.0292, 0.0263,
0.0236, 0.0212, 0.0191, 0.0173, 0.0155, 0.0141, 0.0126, 0.0114, 0.0102,
0.0092, 0.0083, 0.0075, 0.0067, 0.0061, 0.0055, 0.0049, 0.0044, 0.004,
0.0036, 0.0032, 0.0029, 0.0027, 0.0024, 0.0021, 0.0019, 0.0017, 0.0016},
{78.42, 99, 124.4, 156, 197.3, 248, 310.6, 390, 497.9, 616.3, 776.5, 974.2, 1229,
1542, 1946, 2413, 3064, 3844, 4751, 5985, 7619, 9532, 11960, 14830, 18700, 24300,
30550, 37880, 48260, 60200, 72260, 94720, 117600, 145800, 188900, 235300, 290700},
```

```
{0.0699, 0.0626, 0.0561, 0.0503, 0.0451, 0.0405, 0.0364, 0.0327, 0.0293, 0.0264,
 0.0237, 0.0213, 0.0192, 0.0174, 0.0156, 0.0142, 0.0125, 0.0112, 0.0101,
 0.009, 0.0081, 0.0072, 0.0065, 0.0058, 0.0052, 0.0046, 0.0041, 0.0037, 0.0033,
 0.0029, 0.0027, 0.00239, 0.00221, 0.00205, 0.00169, 0.00157, 0.00135},
{0.0707, 0.0633, 0.0568, 0.051, 0.0458, 0.0412, 0.0371, 0.0333, 0.03, 0.0271,
 0.0244, 0.022, 0.0198, 0.018, 0.0162, 0.0147, 0.0132, 0.0119, 0.0107,
 0.0096, 0.0086, 0.0077, 0.007, 0.0063, 0.0056, 0.005, 0.0045, 0.0041,
 0.0036, 0.0033, 0.003, 0.0026, 0.00241, 0.00218, 0.0019, 0.00174, 0.00158},
{0.0714, 0.064, 0.0574, 0.0516, 0.0464, 0.0418, 0.0377, 0.034, 0.0306, 0.0277,
 0.025, 0.0226, 0.0204, 0.0185, 0.0167, 0.0151, 0.0138, 0.0125, 0.0112,
 0.0101, 0.0091, 0.0082, 0.0074, 0.0067, 0.006, 0.0054, 0.0049, 0.0044,
 0.0039, 0.0036, 0.0032, 0.0029, 0.0026, 0.0023, 0.0021, 0.0019, 0.0018},
{77.66, 98.3, 123.2, 154.3, 195.4, 245.4, 306.7, 384.7, 493.3, 607.6, 762.5, 956.3,
 1204, 1513, 1905, 2363, 2992, 3740, 4629, 5809, 7401, 9173, 11540, 14370, 18040, 23330,
 29160, 36420, 46920, 57230, 68360, 90330, 111400, 137000, 180900, 223100, 273700},
{14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32,
 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50}}
```

In[]:= **g = d[[17]]**

```
Out[ ]:= {14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31,
 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50}
```

In[]:= **b1 = d[[2]]**

```
Out[ ]:= {0.0659, 0.0587, 0.0524, 0.0469, 0.0418, 0.0373, 0.0335, 0.0298,
 0.0266, 0.0239, 0.0213, 0.019, 0.017, 0.0153, 0.0137, 0.0123, 0.0109, 0.0097,
 0.0088, 0.0078, 0.007, 0.0062, 0.0056, 0.005, 0.0045, 0.004, 0.0035, 0.0032,
 0.0028, 0.0025, 0.0023, 0.00205, 0.00173, 0.00158, 0.0014, 0.00124, 0.00113}
```

In[]:= **b2 = d[[6]]**

```
Out[ ]:= {0.0675, 0.0603, 0.0539, 0.0482, 0.0431, 0.0386, 0.0346, 0.031, 0.0276,
 0.0249, 0.0223, 0.0199, 0.0178, 0.0161, 0.0144, 0.013, 0.0117, 0.0104,
 0.0094, 0.0084, 0.0075, 0.0067, 0.006, 0.0055, 0.0049, 0.0043, 0.0038, 0.0035,
 0.0031, 0.0027, 0.0025, 0.00225, 0.00196, 0.00178, 0.00155, 0.00139, 0.00128}
```

In[]:= **b3 = d[[10]]**

```
Out[ ]:= {0.0691, 0.0618, 0.0553, 0.0496, 0.0444, 0.0398, 0.0358, 0.0321, 0.0287,
 0.0259, 0.0232, 0.0208, 0.0187, 0.017, 0.0152, 0.0138, 0.0123, 0.011, 0.0099,
 0.0089, 0.008, 0.0072, 0.0064, 0.0058, 0.0052, 0.0046, 0.0041, 0.0038,
 0.0034, 0.0029, 0.0027, 0.00245, 0.00221, 0.00198, 0.00175, 0.00159, 0.00143}
```

In[]:= **b4 = d[[14]]**

```
Out[ ]:= {0.0707, 0.0633, 0.0568, 0.051, 0.0458, 0.0412, 0.0371, 0.0333,
 0.03, 0.0271, 0.0244, 0.022, 0.0198, 0.018, 0.0162, 0.0147, 0.0132, 0.0119,
 0.0107, 0.0096, 0.0086, 0.0077, 0.007, 0.0063, 0.0056, 0.005, 0.0045, 0.0041,
 0.0036, 0.0033, 0.003, 0.0026, 0.00241, 0.00218, 0.0019, 0.00174, 0.00158}
```

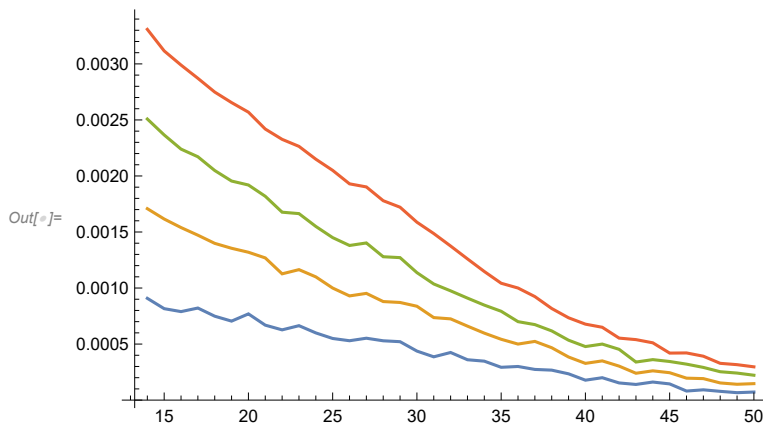
```
In[ ]:= b0 = N[(1 / 200) * 92^((36 - n) / 39) /. n -> g]
```

```
Out[ ]:= {0.0640837, 0.0570682, 0.0508207, 0.0452571, 0.0403027, 0.0358905, 0.0319615, 0.0284625,
0.0253466, 0.0225718, 0.0201008, 0.0179002, 0.0159406, 0.0141955, 0.0126415, 0.0112576,
0.0100252, 0.00892766, 0.00795031, 0.00707996, 0.00630488, 0.00561466, 0.005,
0.00445263, 0.00396518, 0.0035311, 0.00314453, 0.00280029, 0.00249373, 0.00222073,
0.00197761, 0.00176112, 0.00156832, 0.00139663, 0.00124373, 0.00110758, 0.000986326}
```

```
In[ ]:= t1 = (b1 - b0) / 2;
t2 = (b2 - b0) / 2;
t3 = (b3 - b0) / 2;
t4 = (b4 - b0) / 2;
```

```
In[ ]:= d1 = Transpose[{g, t1}];
d2 = Transpose[{g, t2}];
d3 = Transpose[{g, t3}];
d4 = Transpose[{g, t4}];
```

```
In[ ]:= ListPlot[{d1, d2, d3, d4}, Joined -> True]
```



```
In[ ]:= ans1 = FindFit[d1, c1 + c2 awg + c3 awg^2 + c4 awg^3, {c1, c2, c3, c4}, awg];
ans2 = FindFit[d2, c1 + c2 awg + c3 awg^2 + c4 awg^3, {c1, c2, c3, c4}, awg];
ans3 = FindFit[d3, c1 + c2 awg + c3 awg^2 + c4 awg^3, {c1, c2, c3, c4}, awg];
ans4 = FindFit[d4, c1 + c2 awg + c3 awg^2 + c4 awg^3, {c1, c2, c3, c4}, awg];
```

```
In[ ]:= ans1
```

```
Out[ ]:= {c1 -> 0.00111558, c2 -> -9.84613 * 10^-6, c3 -> -7.02367 * 10^-7, c4 -> 9.54867 * 10^-9}
```

```
In[ ]:= FindFit[d2, c1 + c2 awg - c3^2 awg^2 + c4 awg^3, {c1, c2, c3, c4}, awg]
```

```
Out[ ]:= {c1 -> 0.00256418, c2 -> -0.0000653664, c3 -> 7.54385 * 10^-10, c4 -> 6.64498 * 10^-9}
```

```
In[ ]:= c = 0.0254 * 10^6
```

```
Out[ ]:= 25400.
```

```
In[ ]:= cc = DiagonalMatrix[{1, c}]
```

```
Out[ ]:= {{1., 0.}, {0., 25400.}}
```

`In[]:= {c * c1, c * c2, c * Sqrt[c3], c * c4^(1 / 3)} /. ans1`

`Out[]:= {28.3357, -0.250092, 0. + 21.2871 i, 53.8867}`

`In[]:= {c * c1, c * c2, c * Sqrt[c3], c * c4^(1 / 3)} /. ans2`

`Out[]:= {65.7318, -1.72539, 7.40065, 45.5547}`

`In[]:= {c * c1, c * c2, c * Sqrt[c3], c * c4^(1 / 3)} /. ans3`

`Out[]:= {96.5489, -2.46276, 0. + 10.0374 i, 60.1336}`

`In[]:= {c * c1, c * c2, c * Sqrt[c3], c * c4^(1 / 3)} /. ans4`

`Out[]:= {112.267, -1.58965, 0. + 37.5287 i, 83.6449}`

`In[]:= f1 = c1 + c2 awg + c3 awg^2 + c4 awg^3 /. ans1;`

`f2 = c1 + c2 awg + c3 awg^2 + c4 awg^3 /. ans2;`

`f3 = c1 + c2 awg + c3 awg^2 + c4 awg^3 /. ans3;`

`f4 = c1 + c2 awg + c3 awg^2 + c4 awg^3 /. ans4;`

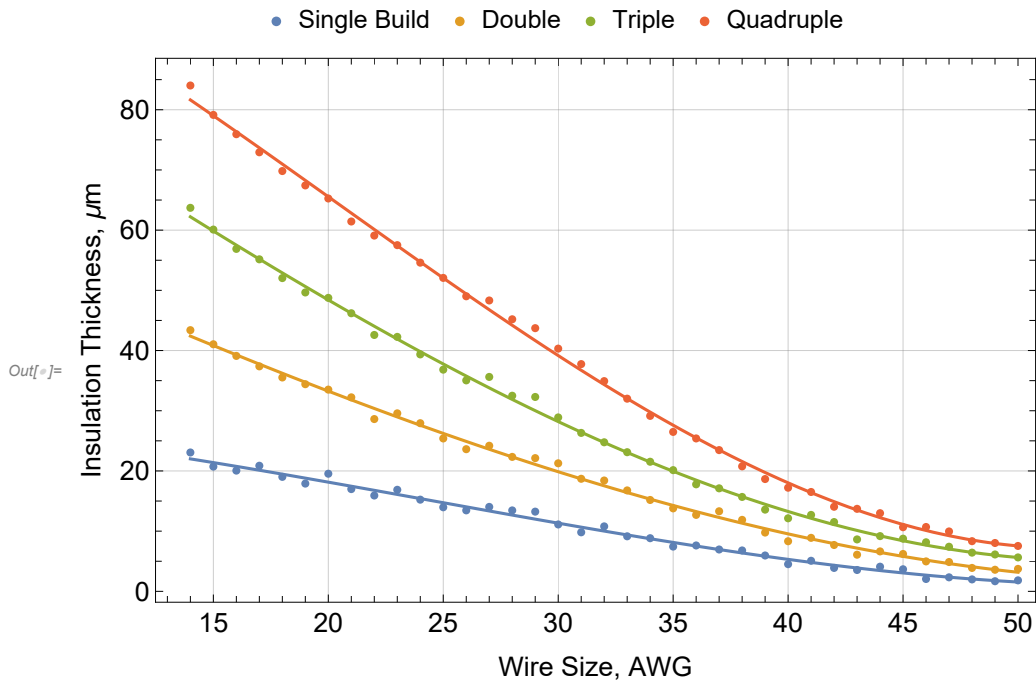
`In[]:= F = {f1, f2, f3, f4}`

`Out[]:= {0.00111558 - 9.84613 × 10-6 awg - 7.02367 × 10-7 awg2 + 9.54867 × 10-9 awg3,
0.00258787 - 0.0000679289 awg + 8.48931 × 10-8 awg2 + 5.76899 × 10-9 awg3,
0.00380114 - 0.0000969591 awg - 1.56163 × 10-7 awg2 + 1.32693 × 10-8 awg3,
0.00441995 - 0.0000625847 awg - 2.18303 × 10-6 awg2 + 3.57123 × 10-8 awg3}`

```

In[ ]:= Show[ListPlot[{d1.cc, d2.cc, d3.cc, d4.cc},
  PlotLegends → Placed[{"Single Build", "Double", "Triple", "Quadruple"}, Above]],
  Plot[{c f1, c f2, c f3, c f4}, {awg, First[g], Last[g]}], ImageSize → 500, Frame → True,
  GridLines → Automatic, BaseStyle → {FontFamily → "Arial", FontSize → 14},
  FrameLabel → {"Wire Size, AWG", "Insulation Thickness,  $\mu\text{m}$ "}]

```



```

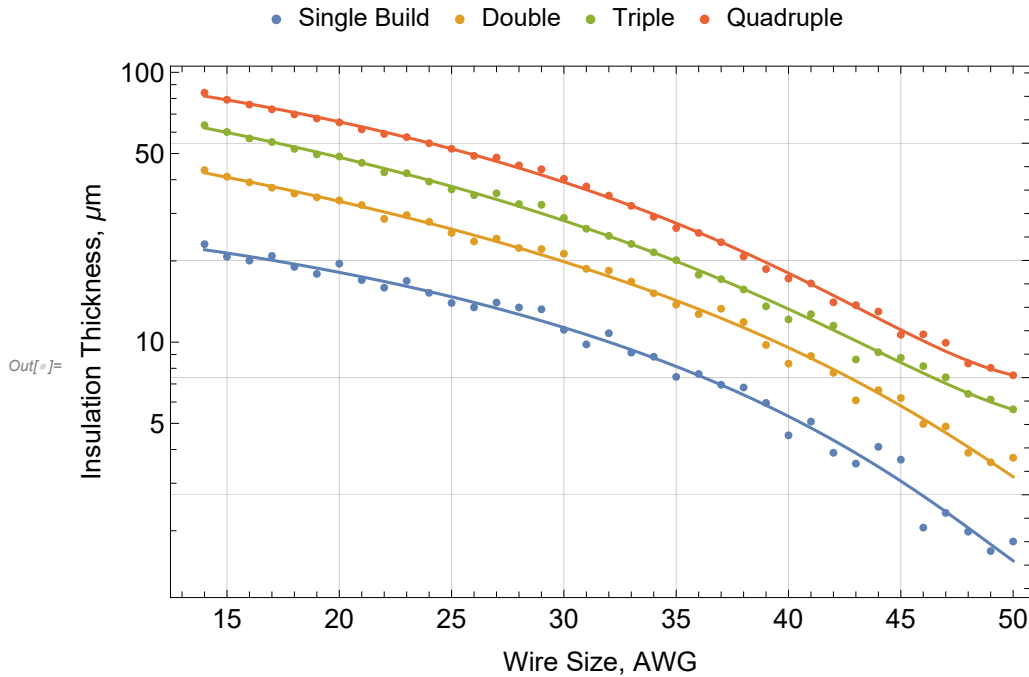
In[ ]:=

```

```

In[ ]:= Show[ListLogPlot[{d1.cc, d2.cc, d3.cc, d4.cc},
  PlotLegends → Placed[{"Single Build", "Double", "Triple", "Quadruple"}, Above]],
  LogPlot[{c f1, c f2, c f3, c f4}, {awg, First[g], Last[g]}], ImageSize → 500,
  Frame → True, GridLines → Automatic, BaseStyle → {FontFamily → "Arial", FontSize → 14},
  FrameLabel → {"Wire Size, AWG", "Insulation Thickness, μm"}]

```



```

In[ ]:= Rw[awg_] := (1 / 200) * 92 ^ ((36 - awg) / 39) / 2

```

```

In[ ]:= myKi = 0.26;
myKc = 398;

```

```

In[ ]:= myDelta[awg_, build_] :=
  {0.0011155776255229505` - 9.846126890068907` * ^-6 awg -
    7.023669053819485` * ^-7 awg^2 + 9.54866513096241` * ^-9 awg^3, 0.0025878668342363205` -
    0.00006792892126543374` awg + 8.489306918453663` * ^-8 awg^2 + 5.768986428683123` * ^-9 awg^3,
    0.003801136295648189` - 0.0000969590898853849` awg - 1.5616297682509383` * ^-7 awg^2 +
    1.3269342226252801` * ^-8 awg^3, 0.004419945042475516` - 0.00006258466872690876` awg -
    2.183029090378475` * ^-6 awg^2 + 3.571230197571358` * ^-8 awg^3} [[build]]

```

```

In[ ]:= myDelta[14, 1]

```

```

Out[ ]:= 0.000866269

```

```

In[ ]:= myDelta[14, 4]

```

```

Out[ ]:= 0.00321388

```

```

In[ ]:= myKw[kc_, ki_, awg_, build_] := Module[{R, d},
  R = Rw[awg];
  d = myDelta[awg, build];
  ki (2 kc R^2 + (2 R d + d^2) (kc + ki)) / (2 ki R^2 + (2 R d + d^2) (kc + ki))
]

```

```

In[ ]:= myKw[myKc, myKi, 40, 3]

```

```

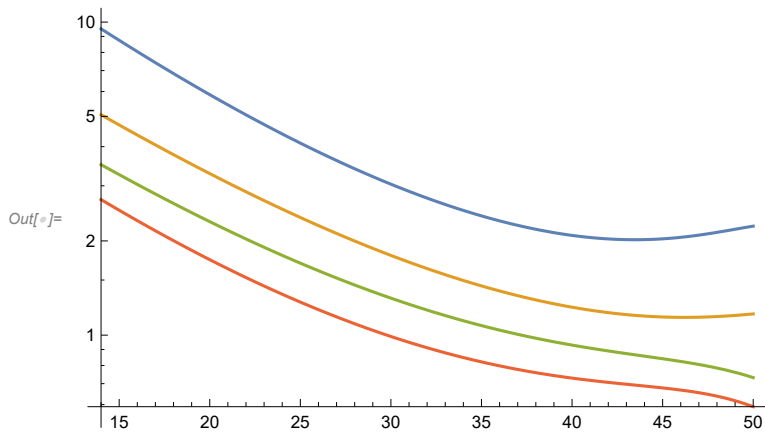
Out[ ]:= 0.929403

```

```

In[ ]:= LogPlot[{myKw[myKc, myKi, awg, 1], myKw[myKc, myKi, awg, 2], myKw[myKc, myKi, awg, 3],
  myKw[myKc, myKi, awg, 4]}, {awg, First[g], Last[g]}, PlotRange -> All]

```



```

In[ ]:= k1 = Table[{awg, myKw[myKc, myKi, awg, 1]}, {awg, First[g], Last[g]}];
k2 = Table[{awg, myKw[myKc, myKi, awg, 2]}, {awg, First[g], Last[g]}];
k3 = Table[{awg, myKw[myKc, myKi, awg, 3]}, {awg, First[g], Last[g]}];
k4 = Table[{awg, myKw[myKc, myKi, awg, 4]}, {awg, First[g], Last[g]}];

```

```

In[ ]:= ListLogPlot[{k1, k2, k3, k4}, PlotRange -> All, ImageSize -> 500, Frame -> True,
  GridLines -> Automatic, BaseStyle -> {FontFamily -> "Arial", FontSize -> 14},
  FrameLabel -> {"Wire Size, AWG", "Bulk Conductivity, W/(m*K)"},
  PlotLegends -> Placed[{"Single Build", "Double", "Triple", "Quadruple"}, Above]]

```

