RAYTHEON
MANUFACTURING COMPANY

RADIO RECEIVING TUBE DIVISION
CHAPEL STREET · NEWTON · 58 · MASS.

Tube Design Circular No. 7

CORRELATION OF WEIGHT & DIAMETER FOR VARIOUS GRID WINDING WIRES - by

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CORRELATION OF WEIGHT & DIAMETER FOR VARIOUS GRID WINDING WIRES

From: G. Freedman

Foreward:

This report is issued to give nominal center values for commonly used grid winding wires. Due to differences in density figures between vendors the Material Purchasing Specification (MP) values may not be in exact agreement. MP values for additional sizes of wires will be specified by interpolation or calculation from existing MP values.

Weight limits on a plus and minus 3.0% basis are also given. While this is the limit desired by the vendors, the Raytheon purchase limits are determined by requirements of tube characteristics and weight limits are specified by analogy with other grid wires.

The amount of the premium charge--if any--for closer tolerances will depend on the grid material.

(A.C.R.)

Tables of all the grid winding wires used at Raytheon have been prepared and are enclosed. These are:

1. Molybdenum
2. Tungsten
3. Molybdenum Alloy A (Kemet)
4. Hastelloy HB (Kemet)
5. Gridnic E (Driver-Harris)
6. Gridnic T (Driver-Harris)
7. #93 Alloy (RCA)
8. #213M Alloy (Cohn)

These tables were developed by several hundred experimental determinations of weight and size for the different wires. The statistical averages of this data and 95% of the deviations from these averages were found to be satisfied by the following equation:

$$\text{Wt.(mg/200 mm)} = (K \pm 3\% \text{ of } K)(\text{diam})^2$$

-K being a constant different for each alloy.

The K values are as follows:

1. Molybdenum	1.020	5. Gridnic E	.905
2. Tungsten	1.96	6. Gridnic T	.885
3. Molybdenum Alloy A	.910	7. #93 Alloy	.952
4. Hastelloy HB	.948	8. #213M Alloy	.920

For sizes not given in the tables, use the above constants and formula.

The +3% deviation allowed in the upper & lower wt. limits as well within the deviation allowed the vendors in our MPs. All wt.-size values available in the literature fall within the listed ranges for the particular sizes & alloys.

Molybdenum

Wt. (mg/200 mm) = $1.010\ (\text{diam})^2$ to $1.050\ (\text{diam})^2$

Diameter	Lower Limit mgs/200 mm	Upper Limit mgs/200 mm	Diameter	Lower Limit mgs/200 mm	Upper Limit mgs/200 mm
.0010	1.01	1.05	.0048	23.30	24.22
.0011	1.22	1.27	.0050	25.24	26.22
.0012	1.45	1.51	.0052	27.30	28.41
.0013	1.71	1.77	.0054	29.43	30.62
.0014	1.98	2.03	.0055	30.575	31.80
.0015	2.28	2.36	.0056	31.72	32.98
.0016	2.58	2.69	.0058	34.00	35.35
.0017	2.92	3.04	.006	36.39	37.80
.0018	3.28	3.40	.0063	40.30	41.70
.0019	3.64	3.78	.0065	42.70	44.30
.0020	4.04	4.21	.0068	46.70	48.60
.0022	4.88	5.07	.0070	49.50	51.50
.0024	5.82	6.05	.0073	53.80	55.90
.0025	6.32	6.57	.0075	56.80	59.90
.0026	6.82	7.07	.0078	61.4	63.80
.0028	7.92	8.23	.0080	64.7	67.2
.0030	9.09	9.45	.0083	69.6	72.4
.0032	10.35	10.78	.0085	72.9	75.8
.0033	10.99	11.43	.0088	78.2	31.4
.0034	11.68	12.12	.0090	81.8	85.1
.0035	12.38	12.88	.0093	87.4	90.8
.0036	13.08	13.60	.0095	91.2	94.8
.0038	14.59	15.17	.0098	97.0	100.8
.0040	16.17	16.80	.0100	101.0	105.0
.0043	18.69	19.43			
.00445	19.845	20.795			
.0045	20.23	21.25			
.0047	22.31	23.20			

Tungsten

Wt. (mg/200 mm) = 1.90 to 2.02 $(\text{diam})^2$

Diameter	Lower Limit mgs/200 mm	Upper Limit mgs/200 mm	Diameter	Lower Limit mgs/200 mm	Upper Limit mgs/200 mm
.0010	1.90	2.02	.0050	47.5	50.5
.0011	2.30	2.44	.0052	51.3	54.5
.0012	2.74	2.91	.0054	55.5	59.0
.0013	3.21	3.42	.0056	59.7	63.5
.0014	3.72	3.96	.0058	64.0	68.0
.0015	4.27	4.54	.006	68.4	72.7
.0016	4.86	5.16	.0063	75.5	80.2
.0017	5.48	5.84	.0065	80.2	85.0
.0018	6.15	6.54	.0068	87.7	93.1
.0019	6.86	7.30	.0070	93.2	99.0
.0020	7.60	8.08	.0073	101.3	107.5
.0022	9.20	9.78	.0075	107.0	113.
.0024	10.95	11.62	.0078	115.5	123.
.0025	11.9	12.6	.0080	124.	129.
.0026	12.9	13.7	.0083	131.	139.
.0028	14.9	15.8	.0085	137.	146.
.0030	17.1	18.2	.0088	147.	156.
.0032	19.5	20.7	.0090	154.	164.
.0033	20.7	22.0	.0093	164.	174.
.0034	21.9	23.4	.0095	172.	183.
.0035	23.3	24.8	.0098	181.	192.
.0036	24.6	26.2	.0100	190.	202.
.0038	27.4	29.2			
.0040	30.4	32.3			
.0043	35.1	37.4			
.0045	38.5	40.8			
.0047	42.0	44.7			
.0048	43.7	46.5			

Molybdenum Alloy A (Kemet)

$$\text{Wt. (mg/200 mm)} = \begin{matrix}.883 \\ \text{to} \\ .937\end{matrix} \ (\text{diam})^2$$

Diameter	Lower Limit mgs/200 mm	Upper Limit mgs/200 mm	Diameter	Lower Limit mgs/200 mm	Upper Limit mgs/200 mm
.0010	.883	.937	.0047	19.6	20.7
.0011	1.068	1.132	.0048	20.4	21.7
.0012	1.27	1.35	.0050	22.5	23.4
.0013	1.49	1.58	.0052	24.00	25.4
.0014	1.73	1.84	.0054	25.8	27.4
.0015	1.99	2.12	.0056	27.8	29.4
.0016	2.26	2.40	.0058	29.7	31.6
.0017	2.55	2.71	.006	31.8	33.7
.0018	2.86	3.04	.0063	35.1	37.2
.0019	3.19	3.39	.0065	37.2	39.5
.0020	3.53	3.75	.0068	40.7	43.2
.0022	4.31	4.54	.0070	43.2	45.9
.0024	5.08	5.42	.0073	47.2	50.0
.0025	5.52	5.86	.0075	49.6	52.6
.0026	5.96	6.35	.0078	53.7	56.9
.0028	6.92	7.35	.0080	56.5	59.9
.0030	7.95	8.43	.0083	60.8	64.6
.0032	9.05	9.60	.0085	63.7	67.6
.0033	9.60	10.02	.0088	68.5	72.6
.0034	10.02	10.82	.0090	71.5	76.0
.0035	10.80	11.49	.0093	76.4	81.1
.0036	11.42	12.20	.0095	79.8	84.6
.0038	12.70	13.52	.0098	86.5	91.9
.0040	14.12	15.00	.0100	88.3	93.7
.0043	16.35	17.30			
.0045	18.8	19.0			

Hastelloy HB (Kemet)

Wt. (mg/200 mm) = .920 to .976 $(\text{diam})^2$

Diameter	Lower Limit mgs/200 mm	Upper Limit mgs/200 mm	Diameter	Lower Limit mgs/200 mm	Upper Limit mgs/200 mm
.0010	.920	.976	.0047	20.15	21.6
.0011	1.11	1.18	.0048	21.2	22.42
.0012	1.325	1.41	.0050	23.0	24.6
.0013	1.55	1.65	.0052	24.9	26.4
.0014	1.80	1.91	.0054	26.8	28.5
.0015	2.07	2.19	.0056	28.7	30.6
.0016	2.36	2.49	.0058	31.0	32.8
.0017	2.66	2.82	.006	33.2	34.8
.0018	2.98	3.16	.0063	36.5	38.4
.0019	3.32	3.42	.0065	38.8	40.7
.0020	3.68	3.90	.0068	42.4	44.5
.0022	4.45	4.72	.0070	45.2	47.3
.0024	5.20	5.62	.0073	49.2	51.5
.0025	5.74	6.10	.0075	51.7	54.2
.0026	6.22	6.60	.0078	56.0	58.7
.0028	7.21	7.65	.0080	58.8	61.8
.0030	8.27	8.78	.0083	63.4	66.5
.0032	9.45	10.00	.0085	66.4	69.7
.0033	10.00	10.62	.0088	71.2	74.7
.0034	10.62	11.25	.0090	74.5	78.3
.0035	11.25	11.95	.0093	79.5	83.5
.0036	11.9	12.65	.0095	83.1	87.2
.0038	13.3	14.1	.0098	87.3	91.8
.0040	14.6	15.6	.0100	92.0	97.6
.0043	17.02	18.05			
.0045	18.65	20.00			

Gridnic E (Driver-Harris)

Wt. (mg/200 mm) = .878 to .932 $(\text{diam})^2$

Diameter	Lower Limit mgs/200 mm	Upper Limit mgs/200 mm	Diameter	Lower Limit mgs/200 mm	Upper Limit mgs/200 mm
.0010	.878	.932	.0050	22.0	23.15
.0011	1.056	1.13	.0052	23.8	25.4
.0012	1.26	1.34	.0054	25.6	27.2
.0013	1.48	1.57	.0056	27.6	29.2
.0014	1.72	1.83	.0058	29.5	31.3
.0015	1.97	2.09	.006	31.7	33.6
.0016	2.24	2.38	.0063	34.9	36.9
.0017	2.54	2.69	.0065	37.0	39.2
.0018	2.84	3.02	.0068	40.5	43.0
.0019	3.08	3.36	.0070	43.2	45.6
.0020	3.52	3.73	.0073	46.8	49.6
.0022	4.25	4.51	.0075	49.4	52.3
.0024	5.05	5.36	.0078	53.4	56.6
.0025	5.48	5.82	.0080	56.3	59.6
.0026	5.93	6.30	.0083	60.5	64.0
.0028	6.88	7.30	.0085	63.4	67.2
.0030	7.90	8.38	.0088	67.9	72.0
.0032	9.00	9.55	.0090	71.2	75.4
.0033	9.56	10.15	.0095	79.3	84.1
.0034	10.15	10.78	.0098	86.2	91.2
.0035	10.75	11.40	.0100	87.8	93.2
.0036	11.36	12.05			
.0038	12.7	13.48			
.0040	14.05	14.90			
.0043	16.2	17.2			
.0045	17.8	18.8			
.0047	19.4	20.6			
.0048	20.4	21.6			

Gridnic T (Driver-Harris)

Wt. (mg/200 mm) = .858 to .912 $(\text{diam})^2$

Diameter	Lower Limit mgs/200 mm	Upper Limit mgs/200 mm	Diameter	Lower Limit mgs/200 mm	Upper Limit mgs/200 mm
.0010	.858	.912	.0050	21.4	22.8
.0011	1.038	1.012	.0052	23.2	24.6
.0012	1.235	1.311	.0054	25.1	26.6
.0013	1.45	1.52	.0056	27.0	28.6
.0014	1.67	1.79	.0058	28.9	30.7
.0015	1.93	2.05	.006	30.7	33.8
.0016	2.20	2.33	.0063	34.1	36.1
.0017	2.48	2.64	.0065	36.2	48.4
.0018	2.78	2.94	.0068	39.4	42.0
.0019	3.01	3.20	.0070	42.0	44.6
.0020	3.43	3.64	.0073	45.7	48.6
.0022	4.15	4.42	.0075	48.2	51.2
.0024	4.94	5.25	.0078	52.2	55.3
.0025	5.36	5.70	.0080	55.0	58.3
.0026	5.71	6.16	.0083	59.2	61.3
.0028	6.73	7.14	.0085	61.8	65.7
.0030	7.73	8.20	.0088	66.3	70.5
.0032	8.80	9.35	.0090	69.5	73.9
.0033	9.35	9.91	.0095	77.5	82.3
.0034	9.93	10.51	.0098	84.1	38.2
.0035	10.51	11.12	.0100	85.8	91.2
.0036	11.11	11.8			
.0038	12.4	13.15			
.0040	13.7	14.6			
.0043	15.9	16.9			
.0045	17.4	18.4			
.0047	19.0	20.1			
.0048	19.7	21.5			

#93 Alloy (RCA)

$$\text{Wt. (mg/200 mm)} = \begin{matrix}.924 \\ \text{to} \\ .980\end{matrix} (\text{diam})^2$$

Diameter	Lower Limit mgs/200 mm	Upper Limit mgs/200 mm	Diameter	Lower Limit mgs/200 mm	Upper Limit mgs/200 mm
.0010	.924	.980	.0050	23.1	24.5
.0011	1.12	1.19	.0052	25.0	26.5
.0012	1.33	1.40	.0054	27.0	28.6
.0013	1.56	1.66	.0056	29.0	30.8
.0014	1.81	1.95	.0058	31.0	33.0
.0015	2.08	2.20	.006	33.3	35.3
.0016	2.27	2.51	.0063	36.7	38.9
.0017	2.67	2.83	.0065	38.6	41.3
.0018	2.99	3.18	.0068	42.5	45.2
.0019	3.34	3.55	.0070	45.5	49.1
.0020	3.70	3.92	.0073	49.3	52.2
.0022	4.48	4.75	.0075	51.8	55.1
.0024	5.33	5.65	.0078	56.2	59.6
.0025	5.78	6.13	.0080	59.2	62.7
.0026	6.25	6.63	.0083	63.6	67.5
.0028	7.25	7.68	.0085	66.6	70.7
.0030	8.32	8.82	.0088	71.6	76.0
.0032	9.44	10.05	.0090	74.4	79.5
.0033	10.09	10.7	.0093	79.9	84.8
.0034	10.68	11.3	.0095	83.5	88.5
.0035	11.3	12.00	.0098	87.8	93.1
.0036	11.95	12.7	.0100	92.4	98.0
.0038	13.32	14.1			
.0040	14.8	15.6			
.0043	17.1	18.3			
.0045	18.95	20.1			
.0047	20.4	21.6			
.0048	21.2	22.5			

#213M Alloy (Cohn)

Wt. (mg/200 mm) = .893 to .947 $(\text{diam})^2$

Diameter	Lower Limit mgs/200 mm	Upper Limit mgs/200 mm	Diameter	Lower Limit mgs/200 mm	Upper Limit mgs/200 mm
.0010	.893	.947	.0050	22.3	23.7
.0011	1.081	1.14	.0052	24.1	25.6
.0012	1.29	1.36	.0054	26.1	27.6
.0013	1.51	1.60	.0056	28.0	29.7
.0014	1.75	1.85	.0058	30.0	31.8
.0015	2.01	2.13	.006	32.2	34.1
.0016	2.27	2.42	.0063	35.5	37.6
.0017	2.58	2.73	.0065	37.8	40.0
.0018	2.90	3.06	.0068	41.2	43.7
.0019	3.22	3.41	.0070	43.8	46.4
.0020	3.57	3.79	.0073	47.7	50.5
.0022	4.32	4.57	.0075	50.2	53.2
.0024	5.15	5.45	.0078	54.3	57.5
.0025	5.58	5.91	.0080	57.1	60.6
.0026	6.04	6.40	.0083	61.4	65.2
.0028	7.00	7.42	.0085	64.5	67.3
.0030	8.03	8.52	.0088	69.1	73.3
.0032	9.15	9.80	.0090	72.4	76.7
.0033	9.74	10.30	.0093	77.2	81.8
.0034	10.30	10.95	.0095	80.5	85.5
.0035	10.90	11.6	.0098	80.5	85.5
.0036	11.55	12.3	.0100	89.3	94.7
.0038	12.9	13.7			
.0040	14.3	15.1			
.0043	16.5	17.5			
.0045	18.3	19.2			
.0047	19.7	20.9			
.0048	20.5	21.8			