Designation: F290 – 94 (Reapproved 2015)

Standard Specification for Round Wire for Winding Electron Tube Grid Laterals[1]

This standard is issued under the fixed designation F290; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This specification covers round wire up to 0.006 in. (0.15 mm) in diameter for use as electron tube grid lateral winding wire.

1.2 Five classes of wire are covered based on their tensile properties (see 5.2 and 5.3).

1.3 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

E39 Methods for Chemical Analysis of Nickel (Withdrawn 1995)[3]

E107 Test Methods for Chemical Analysis of Electronic Nickel (Withdrawn 2003)[3]

E129 Test Method for Spectrographic Analysis of Thermionic Nickel Alloys by the Powder Techniques (Withdrawn 1999)[3]

F16 Test Methods for Measuring Diameter or Thickness of Wire and Ribbon for Electronic Devices and Lamps

F205 Test Method for Measuring Diameter of Fine Wire by Weighing

F288 Specification for Tungsten Wire for Electron Devices and Lamps

F289 Specification for Molybdenum Wire and Rod for Electronic Applications

3. Terminology

3.1 *Description of Terms:*

3.1.1 The following description of terms shall apply to the requirements specified in Table 1:

3.1.1.1 *breaking strength*—The stress at which the specimen breaks.

3.1.1.2 *elongation*—The maximum percent of stretch in a specimen of 10-in. (250-mm) gage length.

3.1.1.3 *tensile strength*—The ultimate strength of the material expressed either as grams per milligram per 200 mm length of wire or pounds per square inch.

3.1.1.4 *ultimate strength*—The maximum stress developed in a specimen.

3.1.1.5 *work load*—The difference between the yield load and the ultimate load.

3.1.1.6 *yield strength*—The stress developed at 1 percent elongation when testing a specimen of 10-in. (250-mm) gage length.

4. Chemical Composition

4.1 The wire shall conform to the requirements as to chemical composition as prescribed in Table 2.

5. Tensile Properties

5.1 The wire shall conform to the requirements as to tensile strength, yield strength, working range, and elongation properties as prescribed in Table 1 for the class of wire designated.

5.2 The class designations for the nickel-titanium-magnesium alloy UNS N03300; the nickel-manganese alloy UNS N02211; molybdenum wire, and the nickel-molybdenum-iron alloy UNS N10001; are based on their tensile properties as follows:

5.2.1 *Class I*—The wire shall conform to elongation properties as specified in ranges in Table 1.

5.2.2 *Class II*—The wire shall conform to the following tensile properties:

5.2.2.1 Yield strength with a spread of approximately ± 15 %, as shown in grams-force, minimum and maximum, in Table 2,

5.2.2.2 Working range, as specified in Table 1, and

[1] This specification is under the jurisdiction of ASTM Committee F01 on Electronicsand is the direct responsibility of Subcommittee F01.03 on Metallic Materials, Wire Bonding, and Flip Chip.

Current edition approved July 1, 2015. Published October 2015. Originally approved in 1954 as B290 – 54 T; redesignated F290 in 1955. Last previous edition approved in 2010 as F290 – 94 (2010). DOI: 10.1520/F0290-94R15.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] The last approved version of this historical standard is referenced on www.astm.org.

TABLE 1 Tensile Properties for Nickel-Titanium-Magnesium Alloy (UNS N03300), Nickel-Manganese Alloy (UNS N02211), Molybdenum Wire, and Nickel-Molybdenum-Iron Alloy (UNS N10001) Wire

CLASS I

NOTE 1—Wire supplied as Class I shall conform to the following elongation values as specified by range:

Material	Range	Wire Diameter, in. (mm)	Elongation, %
Nickel-titanium-magnesium alloy (UNS N03300) and nickel-manganese alloy (UNS N02211)	1	All	8 to 16
	2	All	14 to 22
	3	0.003 (0.08) and under	20 and over
	4	Above 0.003 (0.08)	22 and over
Molybdenum	1	All	8 to 16
	2	All	14 to 22
Nickel-molybdenum-iron alloy (UNS N10001)	1	0.001 (0.025)	8 to 18
	2	0.0015 (0.038)	18 to 32
	3	0.002 (0.050) and above	25 and over

CLASS II

NOTE 1—Wire supplied as Class II shall conform to the following requirements as to yield strength (± 15 percent), working range, and elongation:

Material	Wire Diameter		Yield Strength				Working Load, min, gf	Elongation, min, %
	in.	(mm)	Approximate Center Stress psi	(Mpa)	Load min, gf	Load max, gf		
Nickel-titanium-magnesium alloy (UNS N03300)	0.0015	(0.038)	74 000	(510)	51	67	17	8
	0.0016	(0.041)	74 000	(510)	56	76	17	8
	0.0017	(0.043)	70 500	(486)	62	84	17	8
	0.0018	(0.046)	70 500	(486)	69	93	20	8
	0.0019	(0.048)	70 500	(486)	76	104	20	10
	0.0020	(0.051)	70 000	(483)	85	115	35	10
	0.0025	(0.064)	68 500	(472)	130	175	60	10
	0.0027	(0.069)	64 500	(445)	145	190	75	10
	0.0030	(0.076)	63 500	(438)	175	235	90	15
	0.0033	(0.084)	63 000	(434)	210	280	115	15
	0.0035	(0.089)	63 000	(434)	235	315	135	20
	0.0040	(0.102)	61 500	(424)	300	400	190	20
	0.0045	(0.114)	60 000	(414)	370	500	250	20
	0.0050	(0.127)	60 000	(414)	450	610	330	20
	0.0055	(0.140)	60 000	(414)	550	745	400	20
	0.0060	(0.152)	60 000	(414)	655	885	475	20
Nickel-manganese alloy (UNS N02211)	0.0020	(0.051)	59 600	(411)	70	100	30	14
	0.0025	(0.064)	58 400	(403)	110	150	50	14
	0.0027	(0.067)	56 800	(392)	125	170	60	14
	0.0030	(0.076)	56 600	(390)	150	210	80	18
	0.0033	(0.084)	50 400	(347)	175	245	105	18
	0.0035	(0.089)	50 400	(347)	200	270	120	18
	0.004	(0.102)	51 000	(352)	250	340	170	22
	0.0045	(0.114)	47 000	(324)	295	395	230	22
	0.005	(0.127)	46 000	(317)	350	470	305	22
	0.006	(0.152)	43 000	(296)	465	635	490	22
Molybdenum	0.0008	(0.020)	120 000	(827)	24	34	1	8
	0.0010	(0.025)	120 000	(827)	35	50	4	8
	0.0012	(0.030)	118 500	(817)	50	70	6	8
	0.0013	(0.033)	118 500	(817)	60	80	8	8
	0.00133	(0.034)	118 500	(817)	65	85	8	8
	0.00150	(0.038)	113 500	(782)	77	105	10	12
	0.0017	(0.043)	113 500	(782)	95	135	15	12
	0.0020	(0.051)	105 000	(724)	127	173	25	12
	0.0025	(0.064)	101 000	(696)	191	259	40	15
	0.0030	(0.076)	96 000	(662)	262	354	65	17
	0.0033	(0.084)	96 000	(662)	317	429	80	17
	0.0035	(0.089)	96 000	(662)	356	482	90	17
	0.0040	(0.102)	96 000	(662)	466	630	115	17
	0.0045	(0.114)	96 000	(662)	589	797	145	17
	0.0050	(0.127)	96 000	(662)	728	984	180	17
	0.0055	(0.140)	96 000	(662)	880	1190	220	17
	0.0060	(0.152)	96 000	(662)	1047	1417	260	17
Nickel-molybdenum-iron alloy (UNS N10001)	0.0016	(0.041)	92 000	(634)	70	95	40	10
	0.0020	(0.051)	85 000	(586)	102	138	65	10
	0.0025	(0.064)	85 000	(586)	160	215	110	10
	0.0030	(0.076)	80 000	(552)	219	297	165	15
	0.0033	(0.084)	80 000	(552)	272	368	205	15
	0.0035	(0.089)	80 000	(552)	287	389	240	15

TABLE 1 *Continued*

CLASS II

NOTE 1—Wire supplied as Class II shall conform to the following requirements as to yield strength (± 15 percent), working range, and elongation:

Material	Wire Diameter		Yield Strength				Working Load, min, gf	Elongation, min, %
	in.	(mm)	Approximate Center Stress psi	(Mpa)	Load min, gf	Load max, gf		
	0.0040	(0.102)	80 000	(552)	371	503	320	20
	0.0050	(0.127)	80 000	(552)	606	820	485	20

Class III

NOTE 1—Wire supplied as Class III shall conform to the following requirements as to yield strength (±10 %), working range, and elongation:

Material	Wire Diameter		Yield Strength				Working Load, min, gf	Elongation, min, %
	in.	(mm)	Approximate Center Stress psi	(Mpa)	Load min, gf	Load max, gf		
Nickel-titanium-magnesium alloy (UNS N03300)	0.0015	(0.038)	74 000	(510)	53	65	20	10
	0.0016	(0.041)	74 000	(510)	59	73	25	10
	0.0017	(0.043)	70 500	(486)	66	80	30	12
	0.0018	(0.046)	70 500	(486)	72	89	35	12
	0.0019	(0.048)	70 500	(486)	81	99	35	12
	0.0020	(0.051)	70 000	(483)	90	110	45	15
	0.0025	(0.064)	68 500	(472)	135	165	75	15
	0.0027	(0.069)	64 500	(445)	150	185	90	15

Class III

NOTE 1—Wire supplied as Class III shall conform to the following requirements as to yield strength (±10 %), working range, and elongation:

Material	Wire Diameter		Yield Strength				Working Load, min, gf	Elongation, min, %
	in.	(mm)	Approximate Center Stress psi	(Mpa)	Load min, gf	Load max, gf		
Nickel-titanium-magnesium alloy (UNS N03300)	0.0030	(0.076)	63 500	(438)	185	225	120	15
	0.0033	(0.084)	63 000	(434)	220	270	145	15
	0.0035	(0.089)	63 000	(434)	250	305	170	20
	0.0040	(0.102)	61 500	(424)	315	385	230	20
	0.0045	(0.114)	60 000	(414)	390	480	310	20
	0.0050	(0.127)	60 000	(414)	475	585	400	20
	0.0055	(0.140)	60 000	(414)	580	710	485	20
	0.0060	(0.152)	60 000	(414)	690	850	575	20
Nickel-manganese alloy (UNS N02211)	0.0020	(0.051)	59 600	(411)	75	95	40	14
	0.0025	(0.064)	58 400	(403)	115	145	65	14
	0.0027	(0.069)	56 800	(392)	130	165	80	14
	0.0030	(0.076)	56 600	(390)	160	200	100	18
	0.0033	(0.084)	50 400	(347)	190	235	125	18
	0.0035	(0.090)	50 400	(347)	210	260	145	18
	0.0040	(0.102)	51 500	(355)	265	325	200	22
	0.0045	(0.114)	47 500	(328)	310	380	265	22
	0.0050	(0.127)	46 000	(317)	370	450	355	22
	0.006	(0.152)	54 000	(372)	495	605	560	22
Molybdenum	0.0008	(0.020)	120 000	(827)	25	33	1	8
	0.0010	(0.025)	120 000	(827)	40	50	4	8
	0.0012	(0.030)	118 500	(817)	55	65	6	8
	0.0013	(0.033)	118 500	(817)	65	75	8	8
	0.00133	(0.034)	118 500	(817)	70	80	8	8
	0.0015	(0.038)	113 500	(782)	82	100	10	12
	0.0017	(0.043)	113 500	(782)	105	129	15	12
	0.0020	(0.051)	96 000	(662)	135	165	25	15
	0.0025	(0.064)	96 000	(662)	202	248	40	15
	0.0030	(0.076)	96 000	(662)	277	339	65	17
	0.0033	(0.084)	96 000	(662)	336	410	80	17
	0.0035	(0.089)	96 000	(662)	377	461	90	17
	0.0040	(0.102)	96 000	(662)	493	603	115	17
	0.0045	(0.114)	96 000	(662)	624	762	145	17
	0.0050	(0.127)	96 000	(662)	770	942	180	17
	0.0055	(0.140)	96 000	(662)	932	1139	220	17
	0.0060	(0.152)	96 000	(662)	1109	1355	260	17
Nickel-molybdenum-iron alloy (UNS N10001)	0.0016	(0.041)	92 000	(634)	76	92	45	15
	0.0020	(0.051)	85 000	(586)	109	133	75	15
	0.0025	(0.064)	85 000	(586)	167	205	125	15
	0.0030	(0.076)	80 000	(552)	232	284	185	20
	0.0033	(0.084)	80 000	(552)	289	353	230	20
	0.0035	(0.089)	80 000	(552)	305	373	270	20

TABLE 1 *Continued*

Class III

NOTE 1—Wire supplied as Class III shall conform to the following requirements as to yield strength (±10 %), working range, and elongation:

Material	Wire Diameter		Yield Strength				Working Load, min, gf	Elongation, min, %
	in.	(mm)	Approximate Center Stress psi	(Mpa)	Load min, gf	Load max, gf		
	0.0040	(0.102)	80 000	(552)	394	482	360	20
	0.0050	(0.127)	80 000	(552)	642	784	540	20

5.2.2.3 Elongation as specified in Table 1.

5.2.3 *Class III*—The wire shall conform to the following tensile properties:

5.2.3.1 Yield strength with a spread of approximately ±10 %, as shown in grams-force, minimum and maximum, in Table 1.

5.2.3.2 A larger working range as specified in Table 1, and

5.2.3.3 Elongation as specified in Table 1.

5.3 The class designations for tungsten wire are as follows:

5.3.1 *Classes IV and V*—Tungsten wire UNS R07005 shall conform to the tensile properties for both classes as prescribed in Table 3.

6. Dimensions and Permissible Variations

6.1 The wire shall not vary from the specified diameter as determined by weight, by more than the amounts prescribed in Table 4. Center weights of various types of wire are given in Table 5.

6.2 In the case of finished plated wires, the percentage of plating shall be calculated on the basis of the bare wire weight. In specifying rod plated and drawn plated wire, the plating weight will be based on finished wire weight. Orders shall specify the manner of plating.

7. Surface

7.1 *Bare Wire*—The surface of the wire shall be bright, and free from cracks, slivers, fissures, lubricants, or other detrimental defects as determined at a magnification of 10×.

7.2 *Plated Wire*—The bare wire shall conform to the requirements specified in 7.1; the plating shall be free from bubbles, flakes, blisters, porosity, and plating salts, and shall not show peeled containing when tested in accordance with 9.2.

8. Chemical Analysis

8.1 Chemical analysis of the material shall be made in accordance with the methods described in the following paragraphs (8.1.1 to 8.1.3):

8.1.1 *Nickel Alloy Wire (UNS N03300; UNS N02211; UNS N10001)*—The chemical analysis shall be made in accordance with either or both Test Methods E39 and Test Methods E107. The material may alternatively be analyzed in accordance with Test Method E129.

8.1.2 *Molybdenum Wire*—The molybdenum content shall be determined gravimetrically or by a combination of analyses for impurities by spectrochemical and chemical methods.

8.1.3 *Tungsten Wire (UNS R07005)*—The tungsten content shall be determined gravimetrically or by a combination of analyses for impurities by spectrochemical and chemical methods.

9. Test Methods

9.1 *Tensile Properties*—Determine the yield strength, working range, breaking strength, and elongation by using a constant rate of traverse tester calibrated in terms of constant rate of traverse. Rate of traverse should be approximately 1 in. (25 mm)/min with a gage length of 10 in. (250 mm).

TABLE 2 Chemical Composition

Element, percent	Nickel-Titanium-Magnesium Alloy (UNS N03300)		Nickel-Manganese Alloy (UNS N02211)		Molybdenum	Tungsten (UNS R07005)	Nickel-Molybdenum-Iron Alloy (UNS N10001)	
	Limit	Nominal	Limit	Nominal	Limit	Limit	Limit	Nominal
Nickel	97.0 min	98.5	93.7 min	95.2	...	...	remainder	66.5
Carbon	0.4 max	0.25	0.20 max	0.10	...	...	0.12 max	0.05
Copper	0.25 max	0.03	0.25 max	0.05	...	...	...	...
Iron	0.60 max	0.10	0.75 max	0.15	...	...	6.00 max	5.00
Magnesium	0.20 min	0.35	...	...	...	...	...	...
	0.50 max	...	...	...	...	...	...	...
Manganese	0.50 max	0.20	4.25 min	4.5	...	...	1.00 max	0.45
			5.25 max	...	...	...	...	...
Molybdenum	...	...	...	...	99.9 min	...	33.00 max	27.50
Silicon	0.35 max	0.15	0.15 max	0.05	...	...	1.00 max	0.45
Sulfur	0.01 max	0.005	0.015 max	...	...	...	0.030 max	0.012
Titanium	0.20 min	0.40	...	...	...	...	...	...
	0.60 max	...	...	...	...	...	...	...
Tungsten	...	...	...	...	...	99.95 min	...	...
Vanadium	...	...	...	...	...	...	0.60 min	0.25
Phosphorus	...	...	...	...	...	...	0.040 max	...
Chromium	...	...	...	...	...	...	1.00 max	...
Cobalt	...	...	...	...	...	...	2.50 max	...

TABLE 3 Tensile Properties for Tungsten Wire

	Wire Diameter, in. (mm)	Approximate Center Tensile Strength, psi (MPa)	Tensile Strength, g/mg·200 mm length of wire	
			min	max
Class IV	under 0.0005 (0.013)	straightened	65	...
Class V	under 0.0005 (0.013)	unstraightened	90	...
Class IV	0.0005 to 0.002 (0.013 to 0.05)	384 600 (2650)	65	75
Class V	0.0005 to 0.002 (0.013 to 0.05)	439 000 (3025)	75	85

TABLE 4 Permissible Variations in Dimensions

Material	Diameter, in. (mm)	Permissible Variation	Out of Roundness, max
Ductile wire (Classes I, II, III)	Up to 0.006 (0.15)	±4 % from center weight [A]	5 % of diameter
Tungsten wire (Classes IV, V)	Up to 0.002 (0.05)	±3 % from center weight [A]	5 % of diameter

[A] Centerweights of various types of wire are listed in[5] .

TABLE 5 Center Weights[A,B]

Wire Diameter		Center Weight, mg/200 mm				
in.	(mm)	Nickel-Titanium-Magnesium Alloy (UNS N03300)	Nickel-Manganese Alloy (UNS N02211)	Molybdenum	Tungsten (UNS R07005)	Nickel-Molybdenum-Iron Alloy (UNS N10001)
0.0010	(0.025)	0.89	0.89	1.03	1.94	0.95
0.0015	(0.038)	2.00	1.99	2.31	4.37	2.14
0.0016	(0.041)	2.28	2.27	2.63	4.97	2.43
0.0020	(0.051)	3.56	3.54	4.11	7.77	3.80
0.0025	(0.064)	5.56	5.54	6.43	12.14	5.94
0.0030	(0.076)	8.00	7.97	9.25	17.49	8.56
0.0033	(0.084)	9.68	9.65	11.19	21.16	10.36
0.0035	(0.089)	10.89	10.85	12.59	23.80	11.65
0.0040	(0.102)	14.22	14.18	16.45	31.09	15.22
0.0045	(0.114)	18.00	17.94	20.82	39.35	19.26
0.0050	(0.127)	22.23	22.15	25.70	48.58	23.78
0.0055	(0.140)	26.89	26.80	30.10	58.78	28.77
0.0060	(0.152)	32.00	31.90	37.01	69.95	34.24

[A] Center weight = constant × (diameter) ^{2}, where the constant is for a specific alloy and diameter is in mils.
[B] Densities and constants for the various alloys are as follows:

Alloy	UNS No.	Density gm/cm ^{3}	"C" Constant
Nickel-titanium-magnesium-alloy	UNS N03300	8.77	0.889
Nickel-manganese alloy	UNS N02211	8.74	0.886
Molybdenum		10.14	1.028
Tungsten	UNS R07005	19.17	1.943
Nickel-molybdenum-iron alloy (HB)	UNS N10001	9.38	0.951

9.2 *Plate Adherence*—Draw the wire over a 0.10-in. (2.5-mm) radius knife edge, holding the wire against the edge with the thumb. Pull the wire at a 45° angle to the plane of the blade. In addition, draw the wire through a razor slit in a 0.25-in. (6-mm) thick leather pad with the wire riding on the bottom of the slit with approximately 30° angle of approach and a 30° angle of departure. Note the approach side of the leather belt and wire for flaking or peeling of plating.

9.3 *Weight Tolerance*—Determine size and uniformity in accordance with Test Method F205.

9.4 *Diameter Tolerance*—If specified, measure diameter tolerance by equipment calibrated as described in Test Methods F16.

9.5 *Ductility*—Determine the ductility of tungsten and molybdenum in accordance with Specification F288 and Specification F289.

9.6 *Straightness*—Specify straightened wire by the radius of curvature or camber of a given length of wire. The degree of curvature and the length of wire to be used shall be as agreed upon by the purchaser and the seller.

10. Spooling

10.1 The wire shall be spooled in such a manner that it can be unwound under reasonable tension without binding or otherwise becoming distorted. For testing purposes, samples shall be removed from the spool under a tension equivalent to approximately 50 % of its own yield point.

10.2 Each spool shall contain one continuous length of wire. The minimum length per spool shall be 500 m, for sizes up to 0.004 in. (0.10 mm) in diameter; above 0.004 in. (0.10 mm) in diameter the minimum length per spool shall be 200 m.

11. Rejection

11.1 Any spool not conforming to the specified requirements may be rejected. If 15 percent or more of the spools inany shipment do not conform to the specified requirements, the entire shipment may be rejected.

12. Packaging

12.1 The packaging shall be adequate to protect the spools and wire from contamination and physical injury during shipment.

12.2 No dusty or linty materials shall be used for padding.

12.3 The inside of the container shall be free of dust and lint.

13. Marking

13.1 Each spool shall be plainly marked with the following information:

13.1.1 Name of material and class designation (the specific range or the exact elongation must be indicated for Class I),

13.1.2 Diameter of wire in inches (or millimeters) or weight in milligrams per 200 mm, length of wire or both,

13.1.3 Date of manufacture or lot number, or both,

13.1.4 Length in meters, and

13.1.5 Name of manufacturer.

14. Keywords

14.1 electron tube grids; molybdenum wire; small diameter wire; UNS N02211; UNS N03300; UNS N10001; UNS R07005