



METRIC AEROSPACE STANDARD	MA4035™	REV. A
	Issued 1988-06 Reaffirmed 2012-12 Revised 2021-12 Superseding MA4035	
(R) Rings, Retaining - Spiral Wound, Uniform Section Corrosion Resistant, Procurement Specification for, Metric		

RATIONALE

Delete MIL-STD-105, revise sampling requirements and acceptance testing based on zero defectives, add formula for calculating minimum interference fit, update references, extensive editorial updates.

1. SCOPE

1.1 Scope

This specification covers the procurement requirements for corrosion resistant steel retaining rings of the spiral wound type with uniform rectangular cross-sections.

1.2 Classification

Retaining rings shall be of the types and classes shown in Table 1:

Table 1 - Classification

Type	Class	Description
I – External Ring	1	Medium Duty
	2	Heavy Duty
II – Internal Ring	1	Medium Duty
	2	Heavy Duty

1.3 Application

Intended for use on aerospace propulsion systems for retaining parts on shafts and in housing bores where extended temperature use is not greater than 200 °C.

1.4 Dimensions and Tolerances

Dimensions and tolerances in this specification are in millimeters unless otherwise specified.

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2. REFERENCES

2.1 Applicable Documents

The following publications form a part of this document to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order. In the event of conflict between the text of this document and references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

2.1.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

AMS2248 Chemical Check Analysis Limits, Corrosion and Heat-Resistant Steels and Alloys, Maraging and Other Highly-Alloyed Steels, and Iron Alloys

MA4016 Ring, Retaining - External, Spiral Wound, Heavy & Medium Duty Cres, Metric

MA4017 Ring, Retaining - Internal, Spiral Wound, Heavy & Medium Duty Cres, Metric

2.1.2 ASTM Publications

Available from ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959, Tel: 610-832-9585, www.astm.org.

ASTM E8/E8M Tension Testing of Metallic Materials

ASTM E18 Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials

ASTM E353 Chemical Analysis of Stainless, Heat-Resisting, Maraging, and Other Similar Chromium-Nickel-Iron Alloys

ASTM E1417/E1417M Standard Practice for Liquid Penetrant Testing

2.1.3 ASME Publications

Available from ASME, P.O. Box 2900, 22 Law Drive, Fairfield, NJ 07007-2900, Tel: 800-843-2763 (U.S./Canada), 001-800-843-2763 (Mexico), 973-882-1170 (outside North America), www.asme.org.

ASME B46.1 Surface Texture (Surface Roughness, Waviness and Lay)

2.1.4 U.S. Government Publications

Copies of these documents are available online at <http://quicksearch.dla.mil>.

Military Standard:

MIL-STD-2073-1 Standard Practice for Military Packaging

2.2 Definitions

DEFECTIVE: A unit of product which contains one or more defects.

PRODUCTION INSPECTION LOT: Shall be all finished parts of the same part number, made from a single heat of alloy, heat treated at the same time to the same specified condition, produced as one continuous run, and submitted for vendor's inspection at the same time.

2.3 Unit Symbols

%	percent (1% = 1/100)
°C	degree Celsius
mm	millimeter
MPa	megapascals
HR15N	hardness, Rockwell, 15N scale
HR30N	hardness, Rockwell, 30N scale
HRA	hardness, Rockwell, A scale
HRC	hardness, Rockwell, C scale

3. TECHNICAL REQUIREMENTS

3.1 Material Composition

Shall conform to the percentages by weight shown in Table 2, determined by wet chemical methods in accordance with ASTM E353, by spectrographic methods, or by other analytical methods

Table 2 - Material composition

Element	Min	Max
Carbon	---	0.15
Manganese	---	2.00
Silicon	---	1.00
Phosphorus	---	0.040
Sulfur	---	0.030
Chromium	17.00	19.00
Nickel	7.00	10.00
Molybdenum	---	0.75
Copper	---	0.75

3.1.1 Check Analysis

Material composition variations shall meet the requirements of AMS2248.

3.2 Design

Finished (completely manufactured) parts shall conform to the following requirements:

3.2.1 Design and Dimensions

Unless otherwise specified on the part drawing, retaining rings furnished under this specification shall conform to the design, shape, dimensions and other requirements specified on the applicable MA part standard as in 2.1.1. Dimensions shall conform after all processing.

3.2.2 Surface Texture

Surface texture of finished parts shall conform to the requirements as specified on the part drawing, determined in accordance with ASME B46.1.

3.2.3 Crimp

Retaining rings requiring crimping (see Figure 1) shall meet the following requirements:

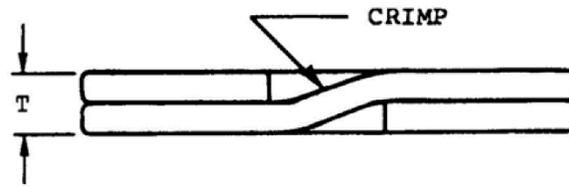


Figure 1 - Crimped retaining ring

3.2.3.1 Crimp Height

The height of the crimp (see Figure 2) shall be equal to the actual thickness of the ring within the tolerances specified in Table 3.

Table 3 - Crimp height tolerance

Ring Thickness T, mm	Crimp Height Tol, mm
up thru 1.12	+0.05, -0.10
1.13 thru 1.69	+0.08, -0.13
1.70 and up	+0.13, -0.18

3.2.3.2 Crimp Length, Angle, and Radius

The crimp length, angle, and radius (see Figure 2) shall conform to the dimensions and tolerances specified in Table 4.

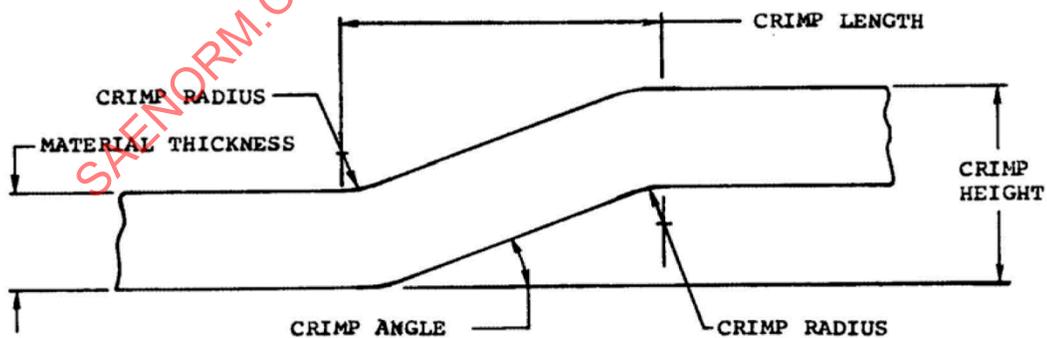


Figure 2 - Crimp

Table 4 - Crimp dimensions

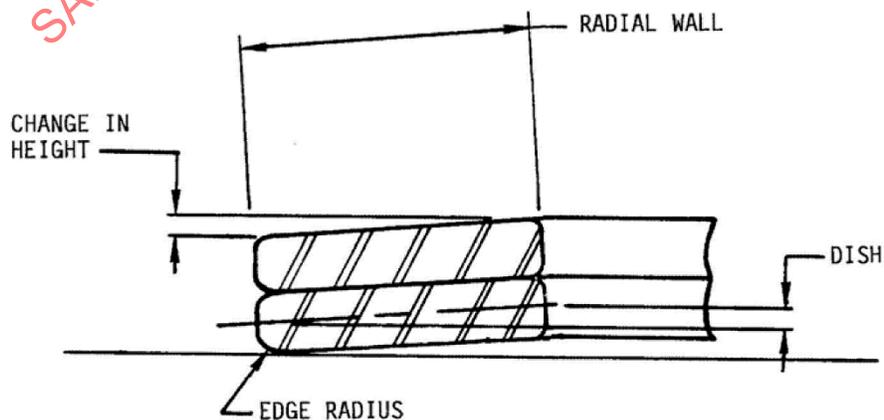
Material Thickness mm	Material Width, mm /Figure 6/	Crimp Angle Max	Crimp Length Max, mm	Crimp Radius Min, mm
up thru 0.53	up thru 6.35	20 degrees	2.5	0.4
0.54 thru 0.79	up thru 6.35	20 degrees	3.5	0.4
0.80 and over	up thru 6.35	20 degrees	5.0	0.4
All Thicknesses	greater than 6.35	20 degrees	6.5	0.8

3.2.4 Dish and Parallelism

The dish shall be considered the height difference in the ring cross section axis of symmetry between the outside diameter (OD) and the inside diameter (ID) as shown in Figure 3. Retaining ring manufacture shall be such as to minimize the amount of the dish. In addition, the radial walls of the retaining rings shall be parallel to each other such that the retaining ring thickness at all locations is within the thickness tolerances specified on the part drawing (see Figure 4). The combined effect of dish and parallelism variation shall be such that the change in retaining ring height in the free state, as shown in Figure 3, shall not exceed the values specified in Table 5.

Table 5 - Allowable change in height

Radial Wall mm	Max Allowable Change in Height
Up thru 1.11	0.025
1.12 thru 1.77	0.050
1.78 thru 2.53	0.075
2.54 thru 3.29	0.10
3.30 thru 4.05	0.13
4.06 thru 4.94	0.15
4.95 thru 5.71	0.18
5.72 thru 6.59	0.20
6.60 thru 7.48	0.23
7.49 thru 8.63	0.25
8.64 thru 10.02	0.28
10.03 thru 12.05	0.30
12.06 thru 16.49	0.33
16.50 thru 25.40	0.36

**Figure 3 - Dish and parallelism**

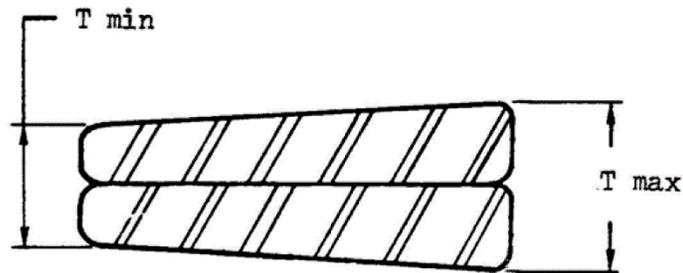


Figure 4 - Parallelism

3.2.5 Misalignment

Each coil of the retaining ring, in the free state, shall lie in line with each other within a maximum misalignment specified in Table 6 (see Figure 5).

Table 6 - Coil misalignment

Nom. Bore or Shaft Size, mm	Coil Misalignment Max, mm
up thru 25	0.25
26 thru 50	0.50
51 thru 150	1.15
151 thru 280	1.75



Figure 5 - Misalignment

3.2.6 Radial Deformation

The maximum deformation from a circular shape shall not exceed the values specified in Table 7 (see Figure 6).

Table 7 - Radial deformation

Nom. Bore or Shaft Size mm	Radial Deformation Max, mm
up thru 50	0.25
51 and up	0.50

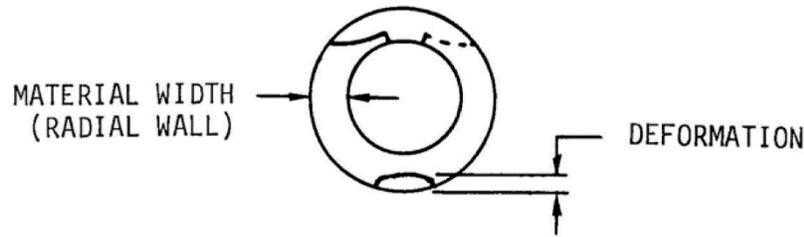


Figure 6 - Radial deformation

3.2.7 Distortion

Distortion due to notching shall be no greater than one-half the total tolerance of the ring thickness. See Figure 7.

3.2.7.1 Kinking

Axial kinking shall not exceed the total thickness tolerance, and shall not cause the ring to exceed the maximum specified thickness. See Figure 7.

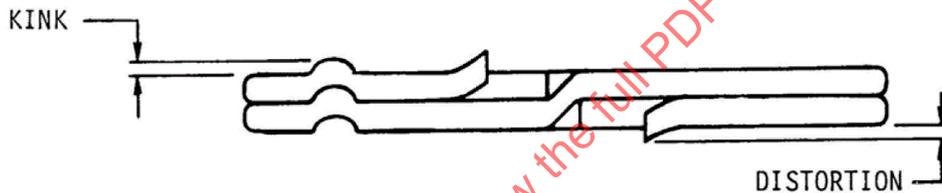


Figure 7 - Distortion

3.2.8 Removal Provision

All rings shall be notched to facilitate their removal from the groove. Dimensioning of the notch shall be in accordance with the part drawing.

3.2.9 Edges

The edges of the ring material shall be rounded except at the ends and at the removal notches. The edge radius (see Figure 3) shall be as specified on the part drawing. All edges, including those at the retaining ring ends and at the removal notches, shall be free from burrs, slivers, dents, nicks, cracks, and other irregularities.

3.3 Fabrication

3.3.1 Rings shall be wound as a spiral of two or more turns from strip of uniform cross section and rounded edges, cold worked sufficiently to meet the requirements of 3.4 on the finished rings.

3.3.2 Passivation

Unless otherwise specified on the part drawing, finished rings shall be passivated by immersion in one of the following solutions at the temperature and for the time shown, rinsing, and drying:

- a. 20 to 50% by volume of nitric acid at 21 to 32 °C for 30 to 40 minutes.
- b. 20 to 25% by volume of nitric acid plus 2 to 3% by weight of sodium dichromate operated at 21 to 32 °C for 30 to 40 minutes, at 49 to 54 °C for 20 to 30 minutes, or at 63 to 68 °C for 10 to 15 minutes.

3.4 Properties

3.4.1 Hardness

Shall be used as a reference to approximate tensile strength, and shall in accordance with Table 8, or equivalent, determined in accordance with ASTM E18:

Table 8 - Hardness

Min. Material Thickness T min/2, mm /Figure 4/	Hardness
0.20 to 0.41, incl	83.0-86.0 HR15N
Over 0.41 to 0.58, incl	64.0-69.5 HR30N
Over 0.58 to 1.22, incl	72.0-74.9 HRA
Over 1.22 to 1.50, incl	39.8-48.5 HRC
Over 1.50 to 1.88, incl	38.0-47.0 HRC
Over 1.88 to 2.26, incl	36.5-45.0 HRC
Over 2.26	34.5-44.0 HRC

3.4.2 Tensile Strength

Rings rectangular section wire shall have minimum tensile strength in accordance with Table 9 and determined in accordance with ASTM E8/E8M:

Table 9 - Tensile Strength

Min Material Thickness T min/2 mm /Figure 4/	Tensile Strength MPa
0.20 to 0.41, incl	1450-1720
Over 0.41 to 0.58, incl	1450-1720
Over 0.58 to 1.22, incl	1380-1590
Over 1.22 to 1.50, incl	1270-1620
Over 1.50 to 1.88, incl	1210-1550
Over 1.88 to 2.26, incl	1140-1450
Over 2.26	1100-1380

3.4.3 Rings shall not be rejected on the basis of hardness if the tensile strength properties specified in 3.4.2 are met.

3.4.4 Performance

All retaining rings shall be capable of undergoing the test of 4.5.2.1 without showing indications of cracks, excessive permanent set or distortion, or other conditions detrimental to use of the rings. Distortion or permanent set shall not be to the extent where the diametral interference between the ring diameter and the groove diameter, under the stack-up of tolerances for minimum fit, is equal to or greater than 0.003 times the groove diameter as specified in Tables 13 and 14.

$$F = \varnothing A - \varnothing C \geq 0.003\varnothing C \quad (\text{Eq. 1})$$

where:

F = minimum interference fit between ring and groove after performance test

$\varnothing A$ = maximum ID, external ring as measured after performance test

$\varnothing A$ = minimum OD, internal ring as measured after performance test

$\varnothing C$ = minimum groove diameter, external ring

$\varnothing C$ = maximum groove diameter, internal ring

3.5 Quality

Parts shall be uniform in quality and condition, clean, sound, smooth, and free from burrs and foreign materials and from imperfections detrimental to their performance.

3.5.1 Fluorescent Penetrant Inspection

Parts shall be fluorescent penetrant inspected in accordance with ASTM E1417/E1417M. There shall be no evidence of cracks, seams, laminations, blanking tears, or laps.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for Inspection

The vendor of parts shall supply all samples for vendor's test and shall be responsible for performing all required tests. Purchaser reserves the right to sample and to perform any confirmatory testing deemed necessary to ensure that the parts conform to the requirements of this specification.

4.2 Responsibility for Compliance

The manufacturer's system for parts production shall be based on preventing product defects rather than detecting the defects at final inspection and then corrective action to be invoked. An effective manufacturing in-process control system shall be established, subject to approval of the purchaser, and used during the production process.

4.3 Product Acceptance Tests

The purpose of production acceptance tests is to check, as simply as possible, using a method which is inexpensive and representative of the part usage, with the uncertainty inherently in random sampling, that the parts comprising a production inspection lot satisfy the requirements of this specification.

4.3.1 Test to determine conformance to all technical requirements of this specification are classified as acceptance tests and shall be performed on each production inspection lot. A summary of acceptance tests is specified in Table 10.

Table 10 - Summary of Acceptance Tests

Characteristic	Rqmt Para	Sample Size	Test Method
Nondestructive Tests			
Design & Dimensions	3.2	4.4.2	Conventional measuring methods and 4.5.1.1
Fluorescent Penetrant Inspection	3.5.1	4.4.2	Per ASTM E1417/E1417M and 4.5.1.2
Quality	3.5	4.4.2	Visual
Packaging and Identification	5.1	None	Visual
Destructive Tests			
Material Composition	3.1	4.4.1	Per material specification
Hardness	3.4.1	4.4.3	ASTM E18 and 4.5.2.2
Tensile Strength	3.4.2	4.4.3	ASTM E8/E8M and 4.5.2.3
Performance	3.4.4	4.4.3	4.5.2.1

4.4 Acceptance Tests Sampling

- 4.4.1 Material: One sample of wire, from which retaining rings were made, from each heat of alloy.
- 4.4.2 Nondestructive Tests - Visual and Dimensional: A random sample shall be selected from each production inspection lot. The size of the sample shall be as specified in Table 11.
- 4.4.3 Destructive Tests: A random sample of parts shall be selected from each production inspection lot. The size of the sample shall be as specified in Table 12.
- 4.4.4 Acceptance Quality: Of random samples examined or tested, acceptance quality shall be based on zero non-conformances.

4.5 Inspection

4.5.1 Nondestructive Tests

- 4.5.1.1 Visual and Dimensional Examination: Sample retaining rings selected in accordance with 4.4.2 shall be visually and dimensionally examined to verify compliance with the requirements of the part drawing and this specification. The rings shall be accepted or rejected in accordance with 4.4.4.
- 4.5.1.2 Nondestructive Inspection: Parts shall be Fluorescent Penetrant Inspected in accordance with ASTM E1417/E1417M and shall meet the requirements in 3.5.1.

- 4.5.2 Destructive Tests: Sample retaining rings selected in accordance with 4.4.3 shall be tested as specified in 4.5.2.1, 4.5.2.2, and 4.5.2.3 and shall be accepted or rejected in accordance with 4.4.4.

- 4.5.2.1 Performance Tests: Prior to the hardness test of 4.5.2.2, the sample retaining rings selected in accordance with 4.4.3 shall be subjected to the tests of 4.5.2.1.1 and 4.5.2.1.2 as applicable.

4.5.2.1.1 Type I, Classes 1 and 2

Type I, Classes 1 and 2: External retaining rings shall be expanded over and removed from a groove having a nominal shaft diameter and groove dimensions as specified in Table 13 (see Figure 1 and Table 4) for the applicable retaining ring size. After repeating this test five times, the rings shall be visually and dimensionally inspected for conformance to the requirements of 3.4.4.

4.5.2.1.2 Type II, Classes 1 and 2

Type II, Classes 1 and 2: Internal retaining rings shall be compressed into and removed from a groove having a nominal bore diameter and groove dimensions as specified in Table 14 (see Figure 2 and Table 4) for the applicable retaining ring size. After repeating this test five times, the rings shall be visually and dimensionally inspected for conformance to the requirements of 3.4.4.

Table 11 - Sampling data
Nondestructive Tests
Visual and Dimensional Characteristics

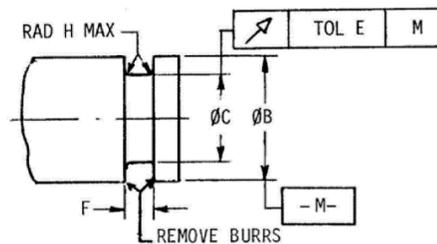
Production Inspection Lot		Sample Size
2 to	8	2
9 to	15	3
16 to	25	5
26 to	50	8
51 to	90	13
91 to	150	20
151 to	280	32
281 to	500	50
501 to	1200	80
1201 to	3200	125
3201 to	10000	200
10001 to	35000	315
35001 to	150000	500
150001 to	500000	800
500001 and over		1250

Table 12 - Sampling Data
Destructive Tests
Material, Properties, and Performance Characteristics

Production Inspection Lot		Sample Size
2 to	5	2
16 to	50	3
51 to	150	5
151 to	500	8
501 to	3200	13
3201 to	35000	20
35001 to	500000	32
500001 and over		50

Table 13 - Groove dimensions, external retaining ring (millimeters)

Groove Runout Tolerance	
E mm	ØB mm
0.10	12 thru 28
0.15	29 thru 55
0.20	56 thru 80
0.25	82 thru 150
0.30	155 thru 280



Nom Shaft ØB	ØC	F	H	Nom Shaft ØB	ØC	F	H
12	11.23-11.35	0.70-0.78	0.13	65	62.66- 62.96	1.42-1.52	0.25
13	12.18-12.30	1.00-1.08	0.13	66	63.64- 63.94	1.42-1.52	0.25
14	13.13-13.25	1.00-1.08	0.13	67	64.56- 64.86	1.42-1.52	0.25
15	14.03-14.15	1.00-1.08	0.13	68	65.56- 65.86	1.42-1.52	0.25
16	14.95-15.10	1.00-1.08	0.13	69	66.56- 66.86	1.42-1.52	0.25
17	15.95-16.10	1.00-1.08	0.13	70	67.56- 67.86	1.42-1.52	0.25
18	16.85-17.00	1.20-1.28	0.13	71	68.56- 68.86	1.42-1.52	0.25
19	17.80-17.95	1.20-1.28	0.13	72	69.50- 69.80	1.42-1.52	0.25
20	18.70-18.85	1.20-1.28	0.13	75	72.46- 72.76	1.42-1.52	0.25
21	19.65-19.80	1.20-1.28	0.25	78	75.40- 75.70	1.73-1.86	0.25
22	20.55-20.70	1.20-1.28	0.25	80	77.36- 77.66	1.73-1.86	0.25
23	21.50-21.65	1.20-1.28	0.25	82	79.30- 79.60	1.73-1.86	0.25
24	22.45-22.60	1.20-1.28	0.25	85	82.20- 82.50	1.73-1.86	0.25
25	23.35-23.50	1.20-1.28	0.25	88	85.16- 85.46	1.73-1.86	0.25
26	24.35-24.50	1.20-1.28	0.25	90	87.06- 87.36	1.73-1.86	0.25
27	25.25-25.45	1.40-1.50	0.25	95	92.00- 92.30	1.73-1.86	0.25
28	26.20-26.40	1.40-1.50	0.25	100	96.86- 97.16	1.73-1.86	0.25
29	27.17-27.37	1.40-1.50	0.25	105	101.70-102.00	1.73-1.86	0.25
30	28.15-28.35	1.40-1.50	0.25	110	106.54-106.84	1.73-1.86	0.25
31	29.07-29.27	1.40-1.50	0.25	115	111.40-111.70	1.73-1.86	0.25
32	30.00-30.20	1.40-1.50	0.25	120	116.30-116.60	2.00-2.13	0.25
34	31.80-32.00	1.40-1.50	0.25	125	121.30-121.60	2.00-2.13	0.25
35	32.70-32.90	1.40-1.50	0.25	130	126.20-126.50	2.00-2.13	0.25
36	33.65-33.85	1.40-1.50	0.25	135	131.10-131.45	2.00-2.13	0.25
37	34.52-34.82	1.40-1.50	0.25	140	136.08-136.43	2.00-2.13	0.25
38	35.50-35.80	1.40-1.50	0.25	145	141.00-141.35	2.00-2.13	0.25
40	37.40-37.70	1.75-1.85	0.25	150	146.00-146.35	2.00-2.13	0.25
42	39.30-39.60	1.75-1.85	0.25	155	150.40-150.80	2.40-2.55	0.25
45	42.10-42.40	1.75-1.85	0.25	160	155.40-155.80	2.40-2.55	0.25
46	43.00-43.30	1.75-1.85	0.25	165	160.40-160.80	2.40-2.55	0.25
47	44.16-44.46	1.75-1.85	0.25	170	165.20-165.60	2.40-2.55	0.25
48	44.90-45.20	1.75-1.85	0.25	175	170.20-170.60	2.40-2.55	0.25
50	46.90-47.20	1.75-1.85	0.25	180	175.00-175.40	2.40-2.55	0.25
52	50.00-50.30	1.42-1.52	0.25	185	180.00-180.40	2.40-2.55	0.25
53	51.00-51.30	1.42-1.52	0.25	190	185.00-185.40	2.40-2.55	0.25
54	52.00-52.30	1.42-1.52	0.25	195	189.80-190.20	2.40-2.55	0.25
55	53.00-53.30	1.42-1.52	0.25	200	194.80-195.20	2.40-2.55	0.25
56	54.00-54.30	1.42-1.52	0.25	210	204.40-204.80	2.40-2.55	0.25
58	55.86-56.16	1.42-1.52	0.25	220	214.20-214.60	2.40-2.55	0.25
59	56.86-57.16	1.42-1.52	0.25	230	224.20-224.60	2.40-2.55	0.25
60	57.86-58.16	1.42-1.52	0.25	240	234.00-234.40	2.40-2.55	0.25
61	58.76-59.06	1.42-1.52	0.25	250	243.60-244.00	2.40-2.55	0.25
62	59.76-60.06	1.42-1.52	0.25	260	253.40-253.80	2.40-2.55	0.25
63	60.76-61.06	1.42-1.52	0.25	270	263.20-263.60	2.40-2.55	0.25
64	61.76-62.06	1.42-1.52	0.25	280	273.00-273.40	2.40-2.55	0.25