Iran-Transfo

ITS-MG01-01

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NBR Materials

Used in oil filled transformers

Technical Terms of Delivery

ITS

IRAN TRANSFO STANDARD
Research & Development Department

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Number of Pages: 25

FOREWORD

The Iran Transfo Standard (ITS) is a group of documents for standardization of Iran-Transfo Company requirements. Their preparation is entrusted to technical committees; any committee interested in the subject dealt with may participate in this preparatory work.

Preparation of this standard has been incepted in R&D Department and discussed in Chemical committee. We thank our colleagues particularly the gents Nazari and Nemati for special support of this revision. Eventually, by approve of following members issued.

✓ Abatizadeh	✓ Ghasemloo	✓ Nemati
✓ Bagheri	✓ Kaviani (Amir)	✓ Najafi
✓ Bakhtiari	✓ Mohammadi (Elmira)	✓ Nazari
✓ Checklu	✓ Mohammadi (mohsen)	✓ Rahmati

All users should ensure that they have the latest edition of this publication.

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Research and Development Department

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1 Scope

These technical terms of delivery apply to materials, made of acrylonitrile butadiene rubber (NBR), such as: sheets, gaskets, rings, O-rings; bands, cords and other formable parts used in oil filled transformers, as sealing or electrical insulation purpose.

2 Technical Requirements

2.1 Basic Requirements

The finished products have to be dark gray to black, free from any superficial faults such as tear marks. The structure should be uniform and free from shrink holes. It is not allowed to show any distortions and formation of burrs. Its dimensions have to be within the prescribed tolerance limits. The NBR products should be suitable for use in hot 100°C mineral oil with characteristics acc. to IEC 60296 2003-11 or IRAN TRANSFO STANDARD ITS-MO01-01 2005-01 and have to resist against Ozone and the atmospheric agents (Type A), or electrical resistance (Type B) upon request in order stage.

2.2 Mechanical Characteristics

The mechanical characteristics of rubber for gaskets are shown in following table:

Density range:	1.30 ± 0.15 g/cm³
Hardness:	70 ± 5 Shore A
Tensile strength:	> 10 N/mm² (M Pa)
Elongation at break:	> 250%

2.3 Temperature Resistance

−30°C to +100°C

2.4 Electrical Characteristics (for Type B)

Electrical Characteristics according to: BS 2751

Min. electric strength:	5kV (per 2.5 mm)
Min. surface resistivity:	5×10^{9} Ω
Min. volume resistivity:	2×10^{9} Ω.cm

2.5 Hot Air Ageing

After 3 days in oven at 100°C, the variations of the Shore hardness have not to be higher than 10 and the decreases of the tensile strength not over 20% of the original values, and no fissures or cracks have to appear.
The tests have to be carried out acc. to ISO 188 Standard

2.6 Compression Set

Compression set is determined according to ISO 815 by constant deformation of the specimen. In derogation of DIN the original specimen is pressed between two even metal plates until there is a reduction of the original thickness as follows:

Panels, cloths and bands:	30%
Round and oval cords, o-rings seals:	35%
Squire cords:	30%
Gaskets with semi-circular diameter:	30%

After compression at above mentioned values of the original thickness and stay in oil at 100°C for 3 days hours, the set has not to be higher than 50%, referred to the clause 4.4.

The tests have to be carried out in accordance with ISO 815.

2.7 Low Temperature Stability

Test in deformated condition conducted as referred to in 2.6 but in air at -30°C. At the end of the period tension is released from the specimen which is stored at the respective sub-zero temperature followed by the determination of the compression set. The value must not exceed 50%.
The specimen is inspected visually at room temperature. There must be no fractures or cracks.
Shore A hardness determined must not exceed the initial value upon delivery.

2.8 Ageing in Oil (Behaviour in Transformer Oil)

The behaviour evaluation of NBR material in transformer oil occurs by checking the hardness, weight and volume of NBR material after storing in transformer oil against the initial value of delivery condition. After 3 days immersion of 10 g specimen in 200 ml oil at 100°C, an increase in the volume (0 to +15%) and weight not higher than (0 to +10%) and change of Shore hardness is not allowed out of (-8 to 0) deviation.
The tests for the volume and weight have to be carried out in accordance with ISO 1817.

2.9 Ozone Resistance (for Type A)

Resistance of NBR rubber to ozone cracking under static strain: 50 pphm, 40°C, 72h, 20% elongation, grade 3 according to DIN 53509 part 1.

2.10 Effect on Transformer Oil

After 3 days immersion of specimen in 100°C hot transformers oil, the following properties must not deviate more than below specified values referred to the initial condition.

- Colour according to oil colour scale book: ≤ 1 colour grade
- Saponification number according to DIN 51559: ≤ 0.5 mg KOH/g mineral oil
- Dielectric loss factor at 90°C: $< 50 \times 10^{-3}$
- Purity: oil turbidity and sludge exudation is not allowed.
- No variation in the sulphur content is allowed.

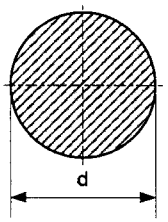
3 Dimensions and Designation

3.1 Round Cords

A Round NBR Cord with d = 10 mm and Ozone resistance designated as:

ITS-MG01-01 – NBR– Round Cord– 10 – Type A

Table 1

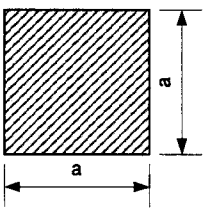
	D	length weight kg/100 m ≈
	3 ± 0.25	0.9
	4 ± 0.25	1.6
	5 ± 0.35	2.6
	6 ± 0.35	3.7
	8 ± 0.4	6.5
	10 ± 0.4	10
	12 ± 0.4	15
	16 ± 0.5	26
	20 ± 0.7	41

3.2 Square Cords

A Square NBR Cord with a = 6 mm and Ozone resistance designated as:

ITS-MG01-01 – NBR– Square Cord– 6 – Type A

Table 2

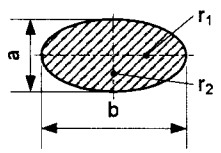
	A	length weight kg/100 m ≈
	4 ± 0.4	2.1
	5 ± 0.5	3.2
	6 ± 0.5	4.7
	8 ± 0.7	8.3
	10 ± 0.7	13
	12 ± 0.8	19
	16 ± 0.8	33
	20 ± 1	52
	25 ± 1	81
	32 ± 1.3	133
	40 ± 1.3	208

3.3 Oval Cords

An Oval NBR Cord with a × b = 11×14 and Ozone resistance designated as:

ITS-MG01-01 – NBR – Oval Cord –11×14 – Type A

Table 3

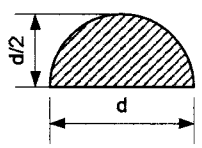
	a	b	r_1	r_2	length weight kg/100 m ≈
	8.5 ±0.7	11 ±0.8	3.8 ±0.4	7.3 ±0.7	10
	11 ±0.8	14 ±0.8	4.9 ±0.5	9 ±0.7	16
	14 ±0.8	18 ±1	6.4 ±0.7	12 ±0.8	26

3.4 Half Round Cords

A Half Round NBR Cord with d = 28 mm and Ozone resistance designated as:

ITS-MG01-01– NBR– Half Round Cord – 28 – Type A

Table 4

	D	length weight kg/100 m ≈
	28 ± 1.3	40

3.5 Sheets

A NBR Sheet with 3 mm thickness, 1000 mm width and 2000 mm length or with Electrical characteristic designated as:

ITS-MG01-01– NBR– sheet – 3×1000×2000 – Type B

Table 5

Thickness	1	2	3	4	5	6	8	10	12	16	20
Tolerance	±0.25						±0.3		±0.4		±0.5
Sheet Sizes Width × Length	1000×1000; 1000×2000 and 1200×2000										
Tolerance	±0.8%										
Basis Weight kg/m² ≈	1.30	2.60	3.90	5.20	6.50	7.80	10.40	13.00	15.60	20.80	26.00

3.6 Rolls

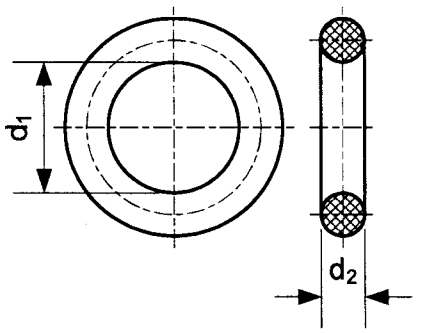
A NBR Roll with 2 mm thickness and 1000 mm width and with Electrical characteristic designated as:

ITS-MG01-01– NBR– Roll – 2 × 1000 – Type B

Table 6

Thickness	1	2	3	4	5	6	8	10
Tolerance	±0.25						±0.3	
Roll width	1000,1200							
Tolerance	±0.8%							

3.7 O–Rings with Round Cross Section



A NBR O–Ring with Round Cross Section and d_1 = 30, d_2 = 5 and Ozone resistance designated as:

ITS-MG01-01– NBR– O-Ring – RCS – 30×5 – Type A

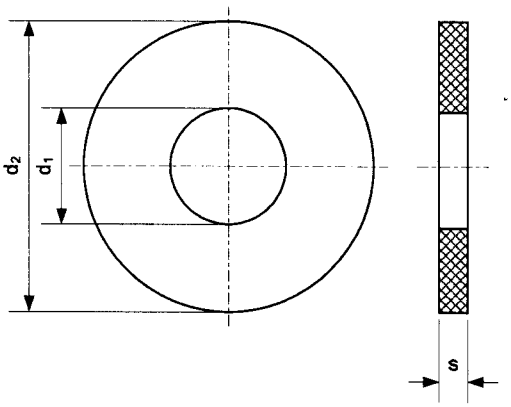
Table 7

d_1	Weight in kg/1000 pieces at diameter d_2																	
	1.50 ±0.07	1.80 ±0.08	2.00 ±0.08	2.50 ±0.09	3.00 ±0.09	3.15 ±0.10	3.20 ±0.10	3.50 ±0.10	3.55 ±0.10	4.00 ±0.11	4.50 ±0.12	5.00 ±0.13	5.50 ±0.13	6.00 ±0.14	7.00 ±0.15	8.00 ±0.17	8.40 ±0.18	10.0 ±0.22
8.76 ±0.17		0.110																
14 ±0.19				0.331														
15 ±0.20		0.175										1.604						
16 ±0.20	0.126																	
17 ±0.21										1.078								
18 ±0.21	0.141					0.673												
19 ±0.21		0.216													4.087			
20 ±0.22	0.155								0.952									
25 ±0.25			0.346			0.896												
26 ±0.26										1.540								
27 ±0.27												2.566						
30 ±0.29										1.745				4.157				12.83
33 ±0.32			0.449															
36 ±0.34											2.631							
42 ±0.40										2.361								16.68
43 ±0.40			0.577															
44 ±0.41										2.463								
45 ±0.42										2.515	3.215							
47 ±0.44										2.617								
50 ±0.46			0.667		1.530													
55 ±0.50			0.731									4.811						
63 ±0.56										3.439								
65 ±0.58												5.613						
69 ±0.61									2.933			5.943						
72 ±0.63												6.175						
75 ±0.67												6.656						

d_1	Weight in kg/1000 pieces at diameter d_2																	
	1.50 ±0.07	1.80 ±0.08	2.00 ±0.08	2.50 ±0.09	3.00 ±0.09	3.15 ±0.10	3.20 ±0.10	3.50 ±0.10	3.55 ±0.10	4.00 ±0.11	4.50 ±0.12	5.00 ±0.13	5.50 ±0.13	6.00 ±0.14	7.00 ±0.15	8.00 ±0.17	8.40 ±0.18	10.0 ±0.22
85 ±0.73									3.580			7.217						
90 ±0.77														11.09				
98 ±0.83																		34.64
100 ±0.84														12.24				
110 ±0.92														13.40		24.22		
114 ±0.94														13.86				
118 ±0.97										6.261								
125 ±1.03																27.30		43.30
126 ±1.04											8.477							
130 ±1.07																28.33		
134 ±1.09										7.082								
137 ±1.10										7.236								
140 ±1.13																30.38		
155 ±1.24																33.46		52.93
156 ±1.24												12.91						
160 ±1.27																34.49		
170 ±1.34																36.54		
175 ±1.38																37.57		
180 ±1.41																38.59		60.94
183 ±1.43																		61.91
184 ±1.43																39.42		
190 ±1.48																40.65		
195 ±1.51														23.21				65.76
200 ±1.55																42.70		
212 ±1.63																45.16		
220 ±1.69																46.81		
227 ±1.73																		76.02
235 ±1.79																49.88		78.59
240 ±1.81																50.91		
245 ±1.85																		81.79
250 ±1.88															40.39			
265 ±1.98																56.04		
270 ±2.00																57.07		
280 ±2.08																		93.02
290 ±2.14																61.18		
313 ±2.29																		103.6
320 ±2.34																		105.9
333 ±2.42																		110.0
339 ±2.46																	78.63	
340 ±2.46																71.44		
348 ±2.48																		113.2
350 ±2.52																73.49		

d_1	Weight in kg/1000 pieces at diameter d_2																	
	1.50 ±0.07	1.80 ±0.08	2.00 ±0.08	2.50 ±0.09	3.00 ±0.09	3.15 ±0.10	3.20 ±0.10	3.50 ±0.10	3.55 ±0.10	4.00 ±0.11	4.50 ±0.12	5.00 ±0.13	5.50 ±0.13	6.00 ±0.14	7.00 ±0.15	8.00 ±0.17	8.40 ±0.18	10.0 ±0.22
375 ±2.68																78.63		
380 ±2.71																		125.1
394 ±2.80																82.53		
410 ±2.90																85.81		
440 ±3.09																		144.3
450 ±3.15																		147.6
470 ±3.27																		154.0
496 ±3.42																		162.3
510 ±3.50																		166.8
610 ±4.10																		198.9
623 ±4.17																		203.0
633 ±4.24																		206.3
636 ±4.26																207.2		
703 ±4.68																		228.7
843 ±5.61																		273.6
1000 ±6.66																		324.0

3.8 Round Flat Gaskets without Flange Holes with Central Hole



A Round Flat NBR Gasket without Flange Holes with Central Hole, with inner diameter d_1 = 21 mm, outer diameter d_2 = 32 mm and thickness s = 6 mm and Ozone resistance designated as:

ITS-MG01-01– NBR – Round Flat Gasket – CH – 21×32×6 – Type A

Table 8

Dimension			Weight in	Dimension			Weight in
d_1	d_2	s	kg/1000 pieces	D_1	d_2	s	kg/1000 pieces
5.5	10	2	0.014	57	67	2	0.253
6	20	7	0.310	59	69	3	0.392
6.4	18	2	0.069	63	100	4	2.463
8	20	2	0.082	65	84	4	1.379
10	18	6	0.137	66	80	5	1.043
10	20	3	0.073	70	92	4	1.456
11	18	2	0.041	70	99	4	2.002
13	40	4	0.585	70	136	4	7.998
14	30	2	0.144	72	87	4	0.974
14	30	4	0.288	72	87	6	1.461
14	45	6	1.120	75	104	4	2.528
16	28	6	0.323	76	108	4	2.405
22	29	1	0.036	80	100	6	2.205
22	33	4	0.247	90	120	4	2.573
22	34	6	0.412	90	120	6	3.859
22	43	4	0.557	90	125	5	4.580
28	36	2	0.105	90	142	2	2.464
28	50	4	0.701	95	160	4	6.769
30	44	4	0.504	106	124	4	1.691
32	60	4	1.052	110	160	6	8.270
34	40	4	0.216	112	170	6	11.95
34	50	2	0.327	117	133	4	1.634
35	70	2	0.750	125	155	6	5.146
36	80	4	2.085	128	142	5	1.930
38	55	4	0.646	135	180	6	8.684
38	90	2	1.359	135	180	10	14.47
38	90	4	2.718	178	203	4	4.638

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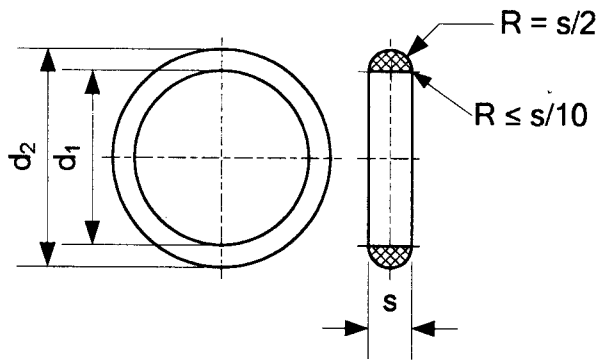
Dimension			Weight in	Dimension			Weight in
d_1	d_2	s	kg/1000 pieces	D_1	d_2	s	kg/1000 pieces
39	51	4	0.441	180	200	6	4.656
40	60	2	0.408	185	235	6	12.86
43	58	4	0.619	190	230	4	6.861
45	65	4	0.898	195	235	6	10.54
45	65	6	1.348	205	255	6	14.09
45	77	4	1.594	205	255	10	23.48
49	92	2	1.238	240	290	6	16.23
50	60	2	0.225	290	330	4	10.13
50	87	4	2.070	290	330	6	15.19
50	100	2	1.532	400	460	6	31.61
50	100	4	3.063	405	445	6	20.83
56	85	4	1.670	455	520	6	38.82

3.9 Sealing Rings with Half Round Cross Section



A NBR Sealing Ring with Half Round Cross Section with d_1=30, d_2=45 and s=16 and Ozone resistance designated as:

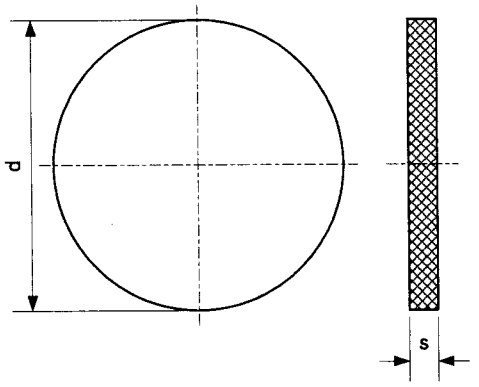
ITS-MG01-01– NBR – Sealing Ring – HRCS – 30×45×16 –Type A

Table 9

Dimension			Weight in kg/pieces
d_1	d_2	s	
12	22	11.0	0.0032
12	30	18.0	0.0102
20	32	13.0	0.0069
20	38	18.0	0.0143
30	45	16.0	0.0151
30	54	24.0	0.0371
36	60	24.0	0.0427
42	59	18.0	0.0258
42	66	24.0	0.0482
48	65	18.0	0.0289
48	72	24.0	0.0538
64	90	25.5	0.0780
70	91	20.5	0.0530
72	98	26.0	0.0900
90	116	25.5	0.1051
125 (-1.40)	153	28.0	0.1721
275 (-2.75)	303	28.0	0.3607
336 (-3.60)	364	28.0	0.4374

Deviations for Dimensions without specified tolerances:
DIN ISO 3302–1–E2 or M3, according to manufacturing type

3.10 Round Flat Gaskets without Hole



A Round Flat NBR Gasket without Hole with diameter d =14 mm and thickness s = 3 mm and Ozone resistance designated as:

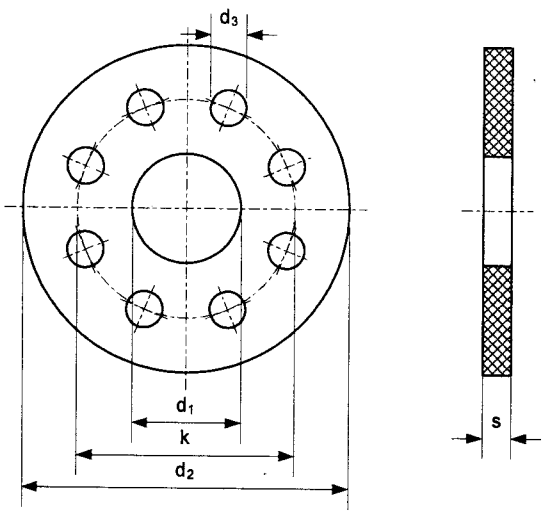
ITS-MG01-01– NBR – Round Flat Gasket – WH – 14×3 – Type A

Table 10

Dimensions		Weight in kg/pieces
d	S	
14	3	0.072
24	2	0.118
26	3	0.247
31	2	0.196
39	2	0.311
45	2	0.414
57	2	0.664

Tolerances: DIN ISO 3302 – 1 – E2

3.11 Round Flat Gaskets with Flange Holes and Central Hole



A Round Flat NBR Gasket with Flange Holes and Central Hole with inner diameter d_1=90 mm, outer diameter d_2=140 mm and thickness s=6 mm and Ozone resistance designated as:

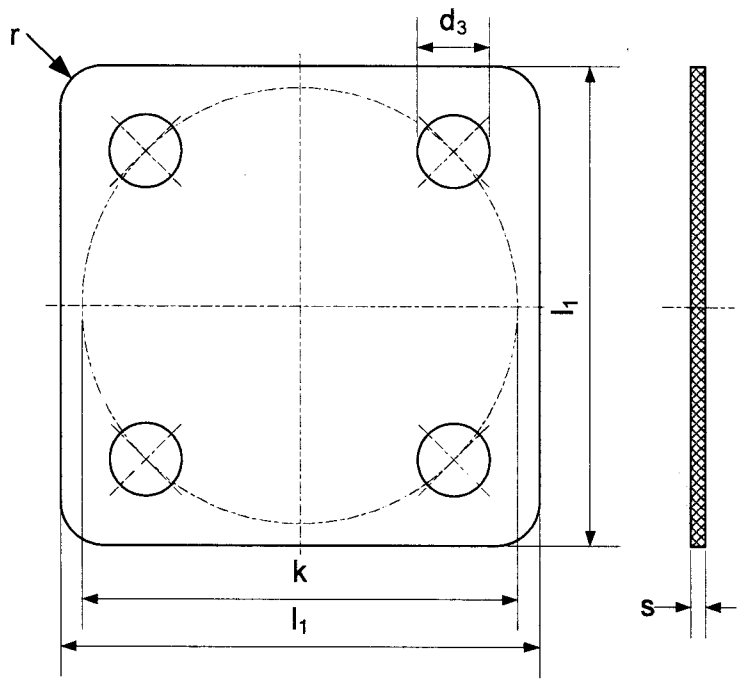
ITS-MG01-01– NBR – Round Flat Gasket – FHCH – 90×140×6 – Type A

Table 11

Dimensions						Weight in kg/piece
d_1	d_2	d_3	K	s	N	
25	80	12	55	4	4	0.0212
25	80	14	55	6	4	0.0305
35	115	15	85	6	4	0.0679
78	126	13	102	4	4	0.0372
90	140	13	120	6	6	0.0640
100	170	15	140	6	6	0.1073
110	170	13	145	6	8	0.0942
130	225	15	185	6	6	0.1981
145	225	18	185	6	6	0.1692
160	240	18	200	6	6	0.1839
195	290	15	250	6	8	0.2708
205	290	14	250	6	8	0.2478
210	290	18	250	6	8	0.2288
240	335	15	290	6	12	0.3172
245	335	23	290	6	12	0.2800
300	400	19	350	6	12	0.4014
300	500	19	400	6	12	0.9528
310	360	9	335	4	12	0.1323
320	410	23	370	6	16	0.3491
325	425	19	362	6	6	0.4460
340	430	19	385	6	12	0.3971
350	450	23	400	6	12	0.4503
370	460	15	420	6	16	0.4340
380	480	15	430	6	20	0.4968

Dimensions						Weight in kg/piece
d_1	d_2	d_3	K	s	N	
386	500	23	460	6	24	0.5375
400	480	18	445	6	8	0.4150
400	500	23	450	6	12	0.5116
400	530	23	480	6	12	0.74
416	556	23	506	6	16	0.7802
420	520	23	480	6	16	0.5224
430	540	18	495	6	16	0.6203
440	540	15	490	6	20	0.5703
440	580	23	530	6	16	0.88
450	550	23	500	6	12	0.5728
450	565	18	535	6	16	0.683
450	570	15	500	6	16	0.7262
450	590	23	540	6	20	0.8247
470	590	23	530	6	12	0.7395
485	600	23	565	6	16	0.7110
500	600	23	550	6	16	0.6205
500	620	23	580	6	16	0.7699
500	640	23	590	6	20	0.9105
510	590	14	560	6	16	0.5183
510	640	23	600	6	24	0.8345
540	650	23	600	6	18	0.7416
540	690	18	640	6	16	1.1000
550	690	23	640	6	20	0.9962
550	710	23	660	6	20	1.1678
570	700	23	635	6	12	0.9716
580	680	18	645	6	24	0.7207
580	700	23	650	6	24	0.8597
600	740	23	680	6	24	1.0680
600	760	23	700	6	20	1.2658
645	715	18	680	6	24	0.5320
650	800	23	750	6	24	1.2511
654	740	18	710	6	24	0.6833
700	840	23	790	6	24	1.2395
800	940	23	890	6	28	1.3968
900	1040	23	990	6	32	1.5539
900	1120	23	1020	6	24	2.6447
950	1080	23	1025	6	40	1.4772

3.12 Square Flat Gaskets without Central Hole with 4 Holes for Flange Bolted Joint



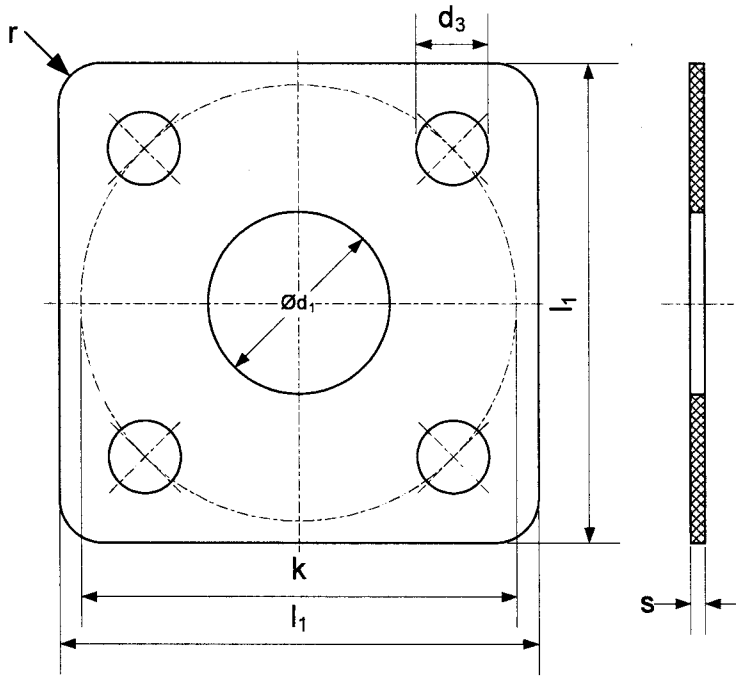
A Square Flat NBR Gasket without Central Hole with 4 holes for a flange bolted Joint with side length l_1= 89 mm, with diameter d_3 = 16 mm and thickness s = 4 mm and Ozone resistance designated as:

ITS-MG01-01– NBR – Square Flat Gasket – WCH – 89×16×4 – Type A

Table 12

Dimensions					Weight in kg/piece
l_1	d_3	K	r	s	
89	16	79	≤5	4	0.037
118	19	121	≤5	4	0.067

3.13 Square Flat Gaskets with Central Hole and 4 Holes for Flange Bolted Joint



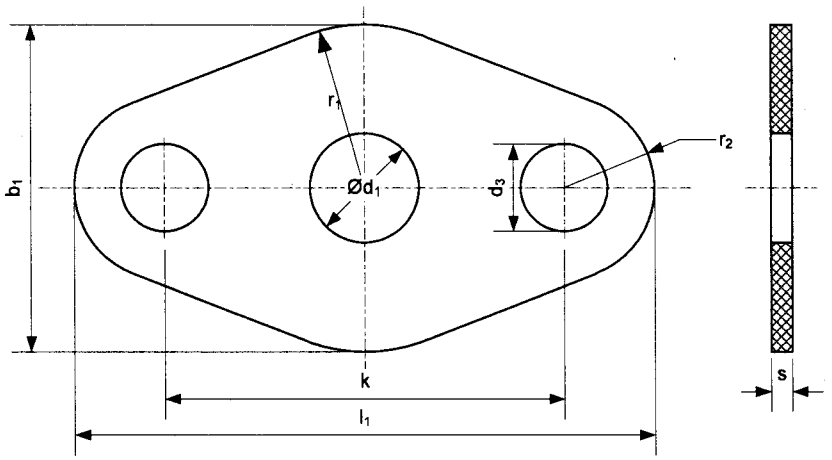
A Square Flat NBR Gasket with Central Hole with inner diameter d_1 = 50 mm and 4 hoes for a flange bolted joint, side length l_1 = 90 mm and thickness s = 4 mm and Ozone resistance designated as:

ITS-MG01-01 – NBR – Square Gasket – CH – 50×90×4 – Type A

Table 13

Dimensions						Weight in kg/piece
d_1	l_1	d_3	K	r	s	
30	90	14	85	13.5	4	0.0344
36	50	7	56	5	2	0.0033
50	90	14	90	13	4	0.0279
50	102	14	98	17	4	0.0396
60	80	10	90	8	4	0.0164
62	100	14	110	6	4	0.0327
105	125	12	141	12.5	4	0.0331

3.14 Oval Flat Gaskets with Central Hole and 2 Holes for Flange Bolted Joint



An Oval Flat NBR Gasket with Central Hole with inner diameter d_1 = 15 and 2 holes for flange bolted joint, length l_1 = 80 and thickness s = 4 mm and Ozone resistance designated as:

ITS-MG01-01 – NBR – Oval Gasket – CH – 15×80×4 – Type A

Table 14

Dimensions								Weight in kg/piece
d_1	l_1	b_1	d_3	k	r_1	r_2	s	
15	80	45	12	55	22.5	12.5	4	0.0185

3.15 Bands

A NBR Band with 10 mm nominal thickness and 30 mm and Ozone resistance width designated as:

ITS-MG01-01– NBR – Band – 10×30 – Type A

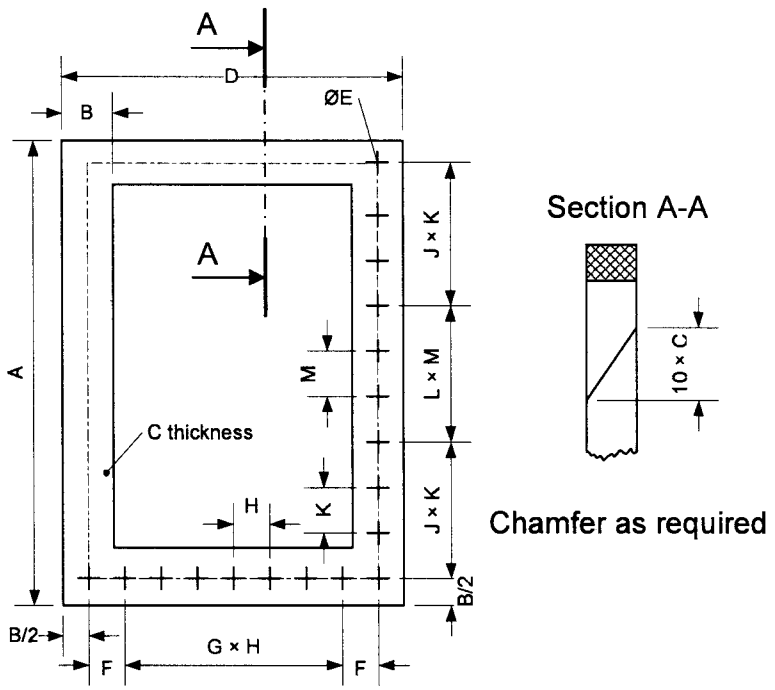
Table 15

Thickness		Width		Weight in kg/100 m
Nominal size	Tolerance	Nominal size	Tolerance	
4	±0.25	15	±0.4	7.8
4	±0.25	28	±0.6	14.6
10	±0.3	30	±0.6	39.0
25	±1	60	±1	195
25	±1	100	±1	325

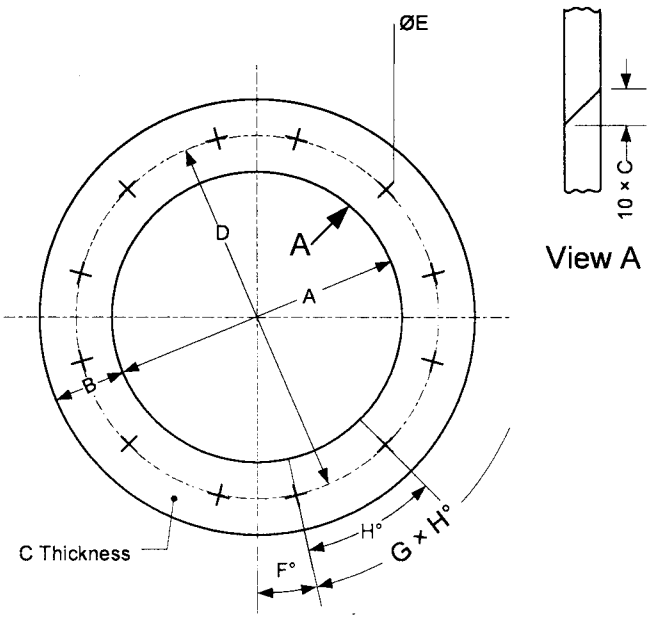
3.16 Gaskets for Manhole and Cable Box of Transformers

The values of parameters in the following figures should be specified by designer in the drawing of respective transformer design:

a) Rectangular



b) Round



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4 CHECKS

4.1 Thickness

The thickness check has to be carried out on at least 5 points spaced 100 mm among them, with a micrometer giving a pressure of 200 ± 20 g/cm².
The final value will be the arithmetical mean of different measurements.

4.2 Elongation at Break and Tensile Strength

Determination of elongation at break and Tensile strength is carried out acc. to DIN 53504.

It is determined on an initial length of 50 mm, by matching the specimen in the breaking zone and by measuring the distance between two reference points previously marked.

4.3 Density and Hardness

The density is specified acc. to ISO 1183 method A.

Hardness: It has to be checked with a Shore A hardness tester, on specimens having plain parallel faces and with a thickness not less than 6 mm. If the thickness does not reach the minimum required value, more specimens have to be laid upon till the required thickness is reached.

Hardness is determined according to DIN 53505 using shore A hardness testers.

4.4 Permanent Deformation (Compression Set test)

The check of the permanent deformation is carried out by pressing a rubber specimen according to ISO 815 that has been described in clause 2.6.

Immediately after the clamping, the plates are put in oil at 100°C for the check of deformation for 3 days.

As soon as the plates are taken out of the oven, they have to be rapidly opened and the specimen has to rest for about 30 min (preventing a too rapid cool) before carrying out the measurement.
If So = initial thickness of the specimen (mm)
Sf = final thickness of the specimen (mm)
Sc = thickness of the compressed specimen (mm)
Then the permanent percentage of deformation D, referred to the initial dimension is given by:

$$D = \frac{So - Sf}{So - Sc} \cdot 100$$

4.5 Ageing in Oil

The specimens are put in a container filled with transformer oil, taking care that they do not get in touch between themselves or against the container walls.

After taking specimens from Oven the following checks should be done:

4.5.1 Volume Variation

If the dimensions of the specimen do not allow an easy determination of the volume variation, the hydrostatic scale has to be used.
In this case, if:

P1: weight of the specimen in air before the test
P2: weight of the specimen in distilled water before the test
P3: weight of the specimen in air after the test
P4: weight of the specimen in distilled water after the test

Then:

$$V\% = \frac{(P3-P4)-(P1-P2)}{P1-P2} \cdot 100$$

4.5.2 Weight variation

Weigh each test piece to the nearest milligram at the standard laboratory temperature before and after immersion. Calculate the percentage change in mass Δm_{100} as follows:

$\Delta m_{100} = [(m_i - m_o)/ m_o] \times 100$

where

m_o is the initial mass of the test piece;

m_i is the mass of the test piece after immersion.

Report the result as the median value for the three test pieces.

4.5.3 Shore A Hardness Variation

Variation of the shore A hardness should be checked according to DIN 53505.

4.6 Oil Contamination (Effect on Transformer Oil)

A specimen is put for 3 days in a container filled with 100°C hot transformer oil having a volume 20 times the specimen weight. After taking specimens from Oven the following checks should be done:

4.6.1 Changing of Colour

Colour changing should be checked according to oil colour scale book.

4.6.2 Purity

Oil turbidity and sludge exudation should be checked visually.

4.6.3 Dielectric loss factor

Dielectric loss factor should be checked according to IEC 60247.

4.7 Corrosive Sulphur

When tested according to clause 2.8 a fine copper strip (0.1 to 0.5 mm × 6 mm × 25 mm) is added to the transformer oil. After storing it with the specimen there shall be classified as corrosive or non-corrosive in accordance with following table (according to ISO 5662). For comparison, a blank copper strip should be put in the oil in other vessel without rubber.

Description of strip	Classification of oil
Orange , red , lavender, multicoloured with lavender blue and/ or silver overlaid on claret red, silvery, brassy or gold, magenta overcast on claret on brassy strip, multi- coloured with red and green showing (peacock) but no grey	Non-corrosive
Transparent black, dark grey or dark brown, graphite or lustreless black, any degree of flaking	Corrosive

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4.8 Ozone resistance (for Type A)

Ozone resistance of NBR materials shall be checked according to DIN 53509 part 1, procedure A for Type A

4.9 Electrical characteristics (for Type B)

Electrical characteristics tests method shall be performed according to BS 903 as:

Min. electric strength: part C4

Min. surface resistivity: part C1

Min. volume resistivity: part C2

5 Certificate of conformity

5.1 Acceptance Tests

The supplier has to send, with the material, the acceptance tests certificate, according to the materials quality control plan.

5.2 Type Tests

With the first supply, the supplier has to certify the technical characteristics of the product as required by this technical specification.

6 Delivery, Packing and Labelling

The NBR material should be delivered in standard packing as:

- NBR bands in rolls with diameter of 300 to 800 mm
- NBR cords in rings with diameter of 300 to 800 mm

6.1 Packing

The packages must be protected against heat, dust, direct sunlight, chemical and mechanical damages

6.2 Storage

Storage areas should be cool, dry, dust reduced and protected against direct sunlight.

6.3 Labelling

- Each package should be labelled with following data:
- Manufacturing name also factory mark
- Order No.
- Date of product
- Quantity
- Gross and net weight

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7 Normative References

The following standard is valid:

BS 903 (2003)

Physical testing of rubber

BS 2751 (2001)

General purpose acrylonitrile-butadiene rubber compounds. Specification

DIN 53509-1 (1990)

Determination of resistance of rubber to ozone cracking under static strain

DIN 53509-2 (1994)

Resistance of rubber to ozone cracking

Reference methods for determining ozone concentration in laboratory test chambers

ISO 5662 (1997)

Testing of insulating oils; detection of corrosive sulfur; copper strip test

DIN 51559-1 (2009)

Testing of mineral oils - Determination of the saponification number - Part 1: Saponification numbers above 2, colorindicator titration

DIN 51559-2 (2009)

Testing of mineral oils - Determination of saponification number - Part 2: Colour-indicator titration, insulating oils

DIN 53504 (1994)

Determination of tensile stress/strain properties of rubber

DIN 53505 (2000)

Shore A and Shore D hardness testing of rubber

ISO 815-1 (2008)

Rubber, vulcanized or thermoplastic -- Determination of compression set -- Part 1: At ambient or elevated temperatures

IEC 60296 (2003)

Fluids for electrotechnical applications - Unused mineral insulating oils for transformers and switchgear

ISO 188 Edition 4.0 (2007)

Rubber, vulcanized or thermoplastic -- Accelerated ageing and heat resistance tests

ISO 1817 Edition 4.0 (2005)

Rubber, vulcanized -- Determination of the effect of liquids

ISO 1183-1 Edition 1.0 (2004)

Plastics -- Methods for determining the density of non-cellular plastics -- Part 1: Immersion method, liquid pyknometer method and titration method