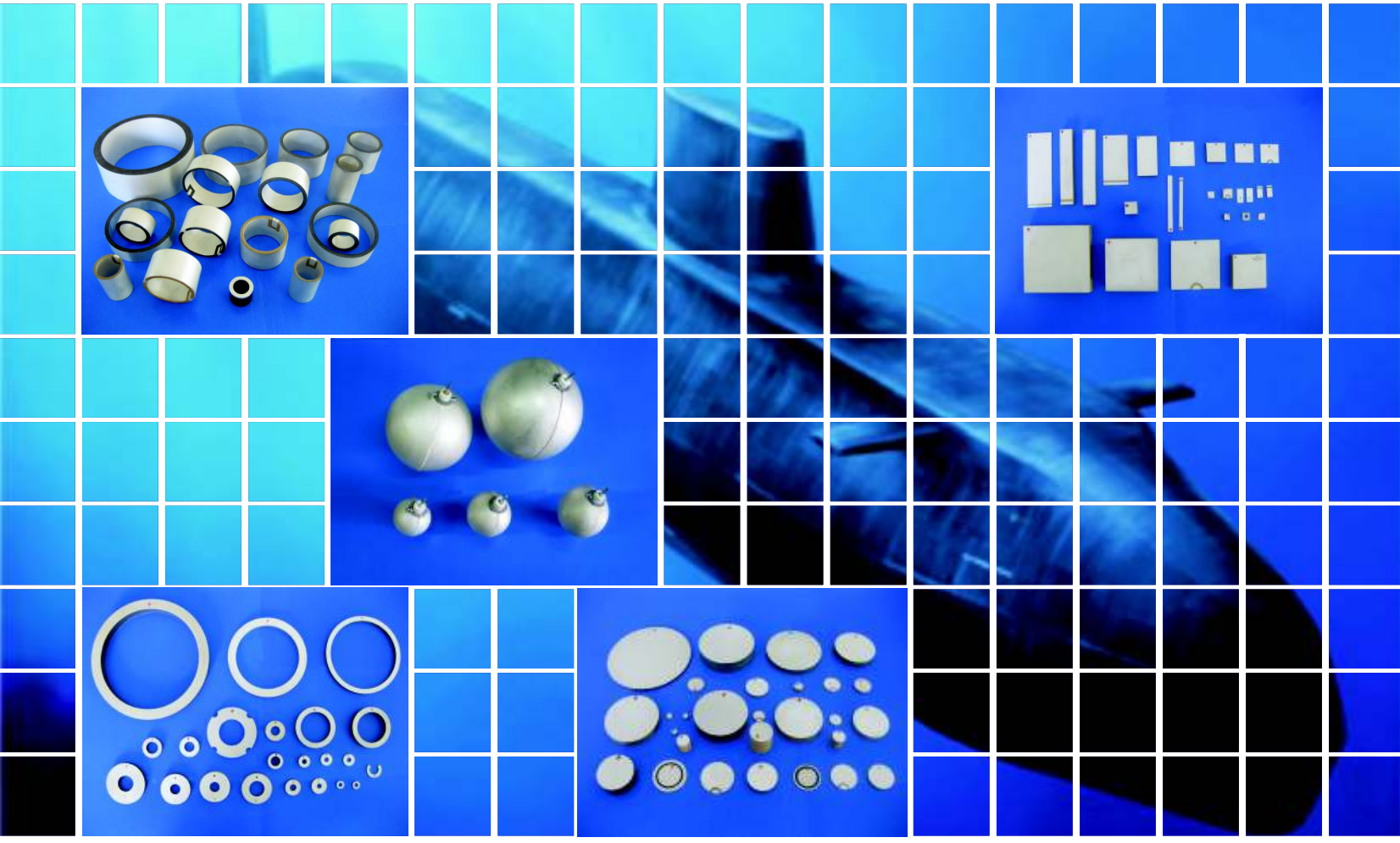
SPARKLER PIEZOCERAMICS



Lead Zirconate Titanate & Lead Titanate based Piezoelectric elements & devices

SPARKLER PIEZOCERAMICS

This bulletin provides salient properties of six grades of Sparkler Piezoceramics, based on Lead Zirconate Titanate and Lead Titanate materials. Materials based on Lead Zirconate Titanate are designated as SP-4, SP-8, SP-5A, SP-5J and SP-5H corresponding to US DOD Navy Type I, III, II, V & VI respectively. The Lead Titanate based material is designated as SP-2.

HIGH POWER FERRO-ELECTRICALLY HARD MATERIALS:

These grades of materials can withstand high level of electrical excitation and mechanical stresses. These are admirably suited for high voltage or high power generators and transducers.

SP-4 (Type I)*: SP-4 is well suited for all high powered transducers for ultrasonic cleaning and deep water hydrophones, liquid atomization and other high power acoustic radiation applications. It is a modified version of Lead Zirconate Titanate material capable of producing large mechanical drive amplitudes while maintaining low dielectric and mechanical losses.

SP-8 (Type III)*: SP-8 is designed for high surface loading power transducers for plastic welding and material processing. It has an excellent mechanical quality factor, reasonably good coupling co-efficient and low dielectric loss factor which provides ultimate power handling capability.

HIGH SENSITIVITY FERRO-ELECTRICALLY SOFT MATERIALS:

These class of materials feature high piezoelectric sensitivity and permittivity. These find extensive use in a variety of sensors, pick ups, low-power motor type transducers, receivers and low power generators. Inherently, these grades are unsuited for high drive conditions and are susceptible to self heating beyond their operating temperature and are not recommended to be used for such applications.

SP-5A (Type II)* : This grade has high dielectric constant with high piezoelectric sensitivity. It is ideally suited for low power applications, pressure sensors, accelerometers, receivers, flow meters, NDT systems, medical equipments and host of other devices. This grade has excellent time stability and high electrical sensitivity at high temperatures.

SP-5J (Type V)*: This grade is especially suited for armament impact fuzes and naval hydrophones and other applications requiring combination of high energy and high voltage.

SP-5H (Type VI)*: It is modified Lead Zirconate Titanate material having extremely high dielectric constant, high coupling co-efficient and high “d” constant. It has been used in a wide range of applications starting from fuzes, ink jet printers, actuators, translators, etc.

LEAD TITANATE BASED MATERIAL:

SP-2 GRADE: It is a modified Lead Titanate piezoelectric composition designed to yield a high electromechanical to planar coupling factor ratio (k_t/k_p). Therefore, the ultrasonic waveform from SP-2 can be very clear and free of cross mode interferences. SP-2 provides a valuable material for NDT and medical use transducers, accelerometers, hydrophones, etc.

***US DOD STD 1376 (SH) Ceramic Types I to VI**

PIEZOELECTRIC PROPERTIES :

DATA	Lead Zirconate Titanate					Lead Titanate
	SP-4	SP-8	SP-5A	SP-5J	SP-5H	SP-2
Piezoelectric Coupling Co-efficient:						
k_p	0.60	0.50	0.61	0.63	0.63	0.01
k_{33}	0.68	0.63	0.70	0.71	0.73	0.52
Piezoelectric Charge Constants (x 10^{-12} C/N)						
d_{33}	320	215	450	550	650	68
d_{31}	-122	-97	-195	-220	-285	-3
Piezoelectric Voltage Constants (x10^{-3} Vm/N)						
g_{33}	27	24	26	22	20	39
g_{31}	-11	-11	-11	-9	-9	-1.7
Relative Dielectric Constant, K^T_3 (Low Signal,@1kHz)	1325	1000	1750	2450	3250	195
Dissipation Factor, tan δ (low field)	0.004	0.004	0.020	0.020	0.020	0.010
Density, ρ (kg/m^3)	7600	7600	7700	7500	7500	6900
Curie Temperature, T_c (^oC)	325	330	340	260	190	200
Mechanical Quality Factor, Q_m	500	1000	75	70	65	-
Figure of Merit d_h x g_h (x 10^{-15})	150	110	65	150	67	2400
Elastic Constants, short circuit (x 10^{-12} m^2/N)						
s^E_{11}	12	12	16	14	15	-
s^E_{33}	18	13	21	19	21	-
Frequency Constants (Hz-m or kHz-mm)						
N_p (planar mode disk)	2200	2270	1950	2000	1950	-
N_t (thickness mode disk)	1905	2030	1800	1950	2000	2200
N_c (circumferential mode cylinder)	990	1060	860	870	860	-
N_{31} (length mode cylinder)	1580	1700	1330	1295	1386	-
N_{sp} (radial mode sphere)	1675	1810	1480	1430	1520	-
Ageing Rate , % change per time decade						
K^T_3	-2.5	-4.6	-0.8	-2.0	-2.2	-0.3
k_p	-1.6	-2.0	-0.6	-1.5	-0.9	-
N_p	+1.0	+0.8	+0.2	+0.3	+0.2	+0.2
Electrical Field Dependence						
Max Positive Field (V/mm)	700	800	600	450	400	-
Max Negative Field (V/mm)	350	400	300	225	200	-
Max AC field, rms @ 25 deg C (V/mm)	350	400	80	80	80	80
Resistivity, @ 25 deg C (Ohm-cm)	>10^{12}	10^{10}	>10^{13}	>10^{12}		

All data shown represent nominal characteristics measured 24 hrs after poling, at 25 deg C +/- 2; and are provided for design information only. Standard tolerances may vary within +/- 20% of these values.

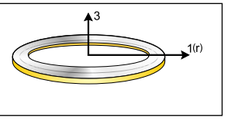
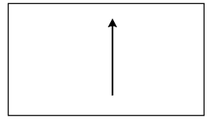
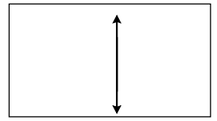
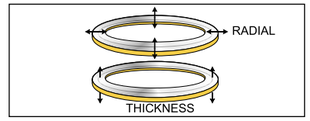
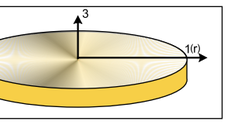
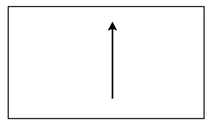
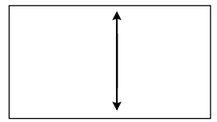
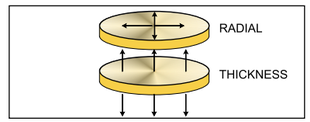
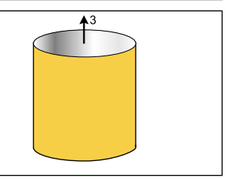
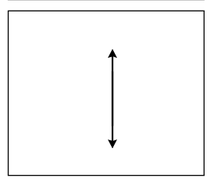
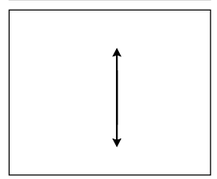
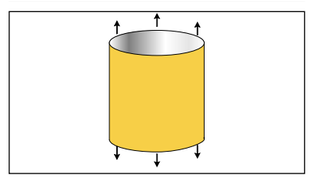
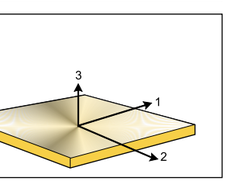
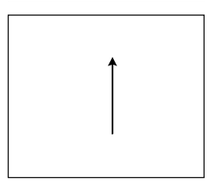
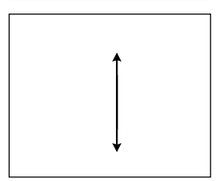
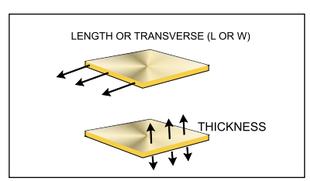
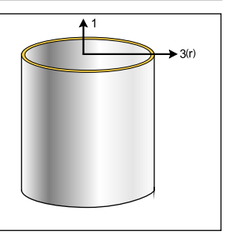
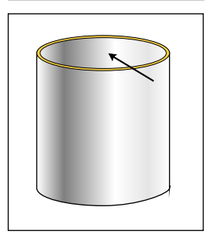
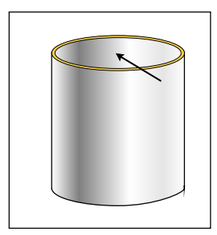
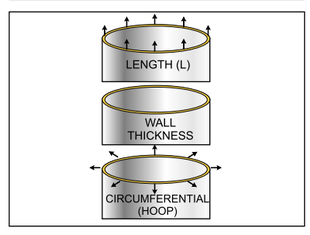
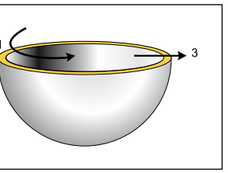
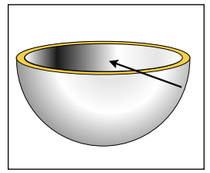
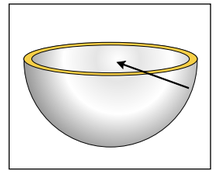
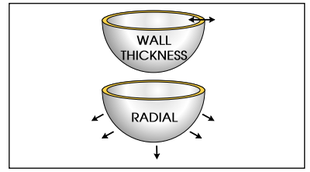
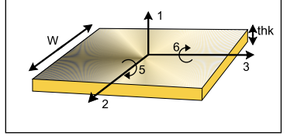
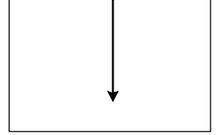
MATERIAL CROSS REFERENCE CHART

SPARKLER MATERIAL GRADES					
	SP-4	**SP-8**	**SP-5A**	**SP-5J**	**SP-5H**
US DOD MIL STD 1376 (SH)	Navy Type I	Navy Type III	Navy Type II	Navy Type V	Navy Type VI

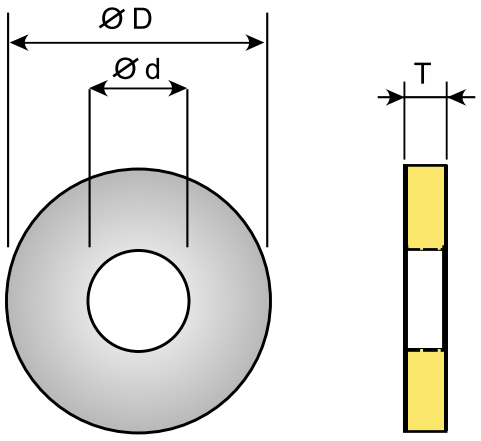
** US DOD MIL STD 1376 (SH)*

MODES OF VIBRATION, DISPLACEMENT & VOLTAGE

MODES OF VIBRATION, DISPLACEMENT & VOLTAGE

SHAPE	AXES	POLARISATION DIRECTION	APPLIED FIELD VOLTAGE OUTPUT	MODE OF VIBRATION DISPLACEMENT APPLIED STRESS	FREQUENCY	CAPACITANCE	DISPLACEMENT (STATIC)	VOLTAGE (STATIC)
RING					$f_r = \frac{N_P}{(OD\text{-}ID)}$ $f_r = \frac{N_t}{thk}$	$C = \frac{K^T_{33}\varepsilon_0\pi(OD^2 - ID^2)}{4.thk}$	$\triangle r = \frac{2.d_{33}.V.(OD - ID)}{thk}$ $\triangle thk = d_{33}.V$	$V = \frac{g_{31}.f_r}{2.\pi(OD - ID)}$ $V = \frac{4.g_{33}.F_3.thk}{\pi.(OD^2 - ID^2)}$
THIN DISK					$f_r = \frac{N_P}{OD}$ $f_r = \frac{N_t}{thk}$	$C = \frac{K^T_{33}\varepsilon_0.\pi.r^2}{thk}$	$\triangle r = \frac{2.d_{33}.V.r}{thk}$ $\triangle thk = d_{33}.V$	$V = \frac{g_{31}.f_r}{2.\pi.r}$ $V = \frac{g_{33}.F_3.thk}{\pi.r^2}$
ROD					$f_r = \frac{N_3}{L}$	$C = \frac{K^T_{33}.\varepsilon_0.\pi.r^2}{L}$	$\triangle thk = d_{33}.V$	$V = \frac{g_{33}.F_3.L}{\pi.r^2}$
PLATE					$f_r = \frac{N_l}{L \text{ or } W}$ $f_r = \frac{N_t}{thk}$	$C = \frac{K^T_{33}.\varepsilon_0.\pi.L.W}{thk}$	$\triangle W = \frac{d_{31}.V.W}{thk}$ $\triangle L = \frac{d_{31}.V.W}{thk}$ $\triangle thk = d_{33}.V$	$V = \frac{g_{31}.F_l}{W}$ $V = \frac{g_{31}.F_2}{L}$ $V = \frac{g_{33}.F_3.thk}{L.W}$
TUBE					$f_r = \frac{N_1}{L}$ $f_r = \frac{2.N_t}{(OD\text{-}ID)}$ $f_r = \frac{2.N_C}{(OD+ID)}$	$C = \frac{2\pi.K^T_{33}.\varepsilon_0.L}{\ln\left(\frac{OD}{ID}\right)}$	$\triangle L = \frac{2.d_{31}.V.L}{(OD - ID)}$ $\triangle L = \frac{d_{31}.d_m}{thk}.V$ where $d_m = (OD + ID)/2$	$V = \frac{g_{31}.F_1}{\pi.d_m}$ $V = \frac{g_{31}.OD.P}{2}$ where P = Pressure
HEMISPHERE					$f_r = \frac{2.N_1}{(OD\text{-}ID)}$ $f_r = \frac{2.N_{SP}}{(OD+ID)}$	$C = \frac{K^T_{33}\varepsilon_0\pi(OD + ID^2)}{4.(OD - ID)}$	$\triangle thk = d_{33}.V$ $\triangle r = \frac{2.d_{31}.V.r}{thk}$	n/a n/a
SHEAR PLATES					$f_a = \frac{N_5}{thk}$	$C = \frac{K^T_{33}.\varepsilon_0.L.W}{thk}$	$\triangle thk = d_{15}.V$	$V = \frac{d_{15}.F_{15}}{W}$

RINGS



RINGS SILVER ELECTRODED
POSITIVE POLARITY INDICATED

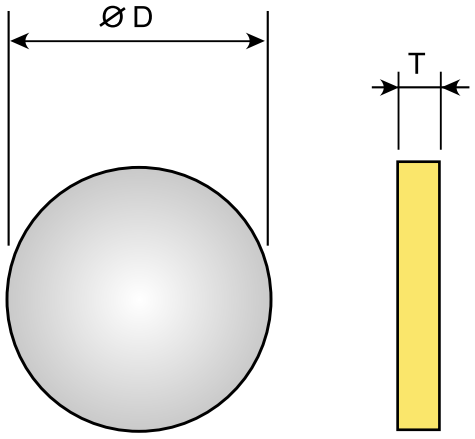
Rings		
D (mm)	***d (mm)***	***T (mm)***
150.00	125.00	15.00
100.00	80.00	6.00
	88.00	6.00
70.00	20.00	6.00
55.00	25.40	7.80
50.80	38.00	8.00
	28.00	6.00
	19.10	6.35
	15.00	5.00
50.00	38.00	8.00
	20.00	5.15,6.00
42.00	12.80	12.70
40.00	20.00	6.00
	14.00	6.00
38.10	25.40	6.35
	19.10	6.35
	12.70	6.35
38.00	15.00	6.00
35.00	15.00	6.00
	10.00	3.00
30.00	20.00	6.00
	15.00	5.00
25.40	12.70	3.00
25.00	16.00	4.00
	15.00	5.00
	12.00	3.00
	11.60	5.00
	10.00	2.65, 4.00

Rings		
D (mm)	***d (mm)***	***T (mm)***
22.50	5.00	4.00
	4.00	0.50
20.00	12.00	2.00
	8.00	3.00,4.50,6.00
	6.00	3.00
	3.00	3.00
18.60	3.00	0.50
17.60	3.00	0.50
17.20	10.00	3.00
15.20	3.00	0.50
15.00	11.00	1.00
	10.00	3.00,12.50
	6.35	4.00
	6.00	3.00,5.00
	10.00	3.00
14.00	6.50	4.00
12.00	6.00	6.00
	4.50	1.50
10.00	5.00	2.00
	4.00	2.00
9.85	7.30	4.00
8.00	3.50	2.00
7.00	3.00	2.00
6.00	4.00	2.00
	2.00	2.00

Standard Tolerances:

Outer Diameter, D : ± 2.5% or 0.2, whichever is more
Inner Diameter, d : ±1.5% or 0.1 , whichever is more
Thickness, T : ± 0.05mm
Flatness and Planoparallelism : Within 0.015mm
Frequency : Upto 2 MHz - ± 7%; Above 2 MHz - ± 10%

DISCS



DISCS SILVER ELECTRODED
POSITIVE POLARITY INDICATED

DISKS	
(mm)	T (mm)
100.00	5.00
78.00	3.00
70.00	1.00 to 8.00
53.80	1.65
50.80	1.00 to 12.00
44.50	0.5 to 8.00
40.00	0.5 to 8.00
38.10	0.50 to 8.00
35.00	0.50 to 8.00
31.80	0.50 to 8.00
30.50	0.50 to 8.00
30.00	0.50 to 8.00
27.50	0.30 to 10.00
25.00	0.30 to 10.00
24.00	0.30 to 10.00
22.00	0.30 to 10.00

DISKS	
D (mm)	T (mm)
21.00	0.30 to 10.00
20.00	0.30 to 10.00
19.00	0.30 to 10.00
18.00	0.30 to 10.00
15.00	0.30 to 10.00
12.50	0.30 to 10.00
12.00	0.30 to 10.00
11.00	0.30 to 10.00
10.00	0.30 to 10.00
9.50	0.30 to 10.00
8.00	0.30 to 10.00
7.25	0.30 to 10.00
6.35	0.30 to 10.00
5.00	0.30 to 10.00
4.00	0.30 to 10.00
3.00	0.30 to 10.00

Standard Tolerances:

Outer Diameter,D : ± 2.5% or 0.2, whichever is more

Thickness, T : ± 0.05mm ***Flatness and Planoparallelism*** : Within 0.015

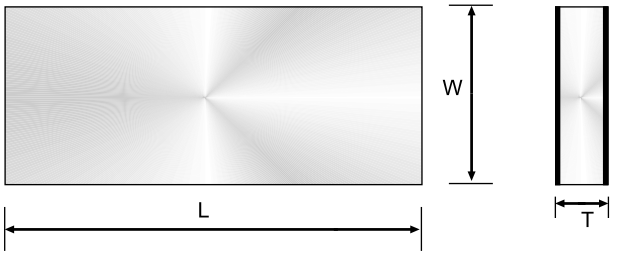
Frequency : Upto 2 MHz - ± 7%; Above 2 MHz - ± 10%

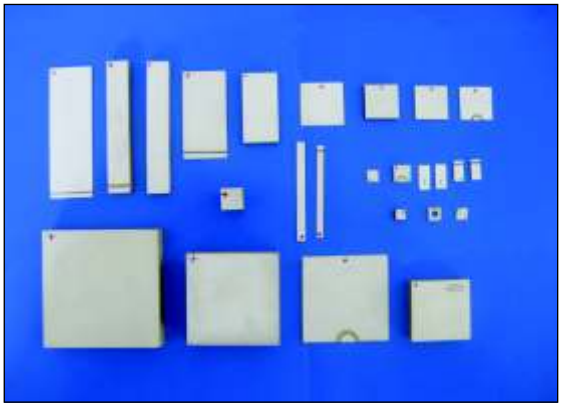
Material Grades :

SP-4, SP-8, SP-5A, SP-5J, SP-5H

Other sizes on request

RECTANGULAR / SQUARE PLATES





RECTANGULAR / SQUARE PLATES	
L x W (mm)	**T (mm)**
76.2 x 25.4	0.50 to 12.00
76.2 x 12.7	0.50 to 12.00
70 x 30	0.50 to 5.00
65 x 65	14.00
56 x 5	0.40 to 5.00
52 x 4	0.40 to 5.00
50.8 x 25.4	0.50 to 12.00
50 x 50	1.00 to 14.00
50 x 20	0.50 to 12.00
40 x 20	0.50 to 10.00
35 x 35	0.50 to 10.00
34 x 34	0.50 to 10.00
30 x 30	0.40 to 10.00
30 x 8	0.40 to 10.00
25 x 25	0.40 to 10.00
25 x 8	0.40 to 10.00
22 x 20	0.40 to 10.00
21 x 15	0.40 to 10.00
20.5 x 8	0.40 to 5.00

RECTANGULAR / SQUARE PLATES	
L & W (mm)	**T (mm)**
20 x 20	0.30 to 10.00
18 x 13	0.30 to 10.00
17 x 13	0.30 to 10.00
15 x 15	0.30 to 10.00
15 x 10	0.30 to 10.00
15 x 7	0.30 to 10.00
15 x 9	0.30 to 10.00
14.5 x 7	0.30 to 5.00
12 x 5.5	0.30 to 6.00
12 x 9	0.30 to 6.00
12 x 6	0.30 to 6.00
10 x 10	0.30 to 10.00
10 x 8	0.30 to 10.00
8 x 8	0.30 to 8.00
7 x 3	0.30 to 6.00
6 x 6	0.30 to 6.00
5.5 x 5.5	0.30 to 5.00
3 x 3	0.30 to 3.00

Standard Tolerances:

L & W : ± 2.5% or 0.5, whichever is more

Thickness, T : ± 0.05mm ***Flatness and Planoparallelism*** : Within 0.015 mm

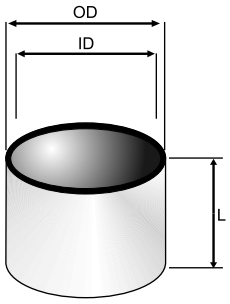
Frequency : Upto 2 MHz - ± 7%; Above 2 MHz - ± 10%

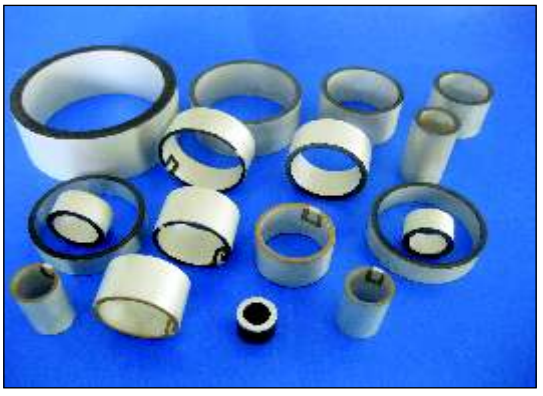
Material Grades :

SP-4, SP-8, SP-5A, SP-5J, SP-5H

Other sizes on request

CYLINDERS / TUBES





OD (mm)	ID (mm)	L (mm)
150	140	50
83.7	71	31.7
66	60	12,20,25,37,50
58	52	24
52	46	12
45.2	38.6	30
45	39	12,25,37
44	38	24,32
44	40	16
43	34	24
42	38	15,16
40	38	15
40	35	32
38	32	13,18
33	28	20
33	27	12,25,30,37
32.5	27.3	28
31.8	25	19
30	24	12.5
29	25	37

OD (mm)	ID (mm)	L (mm)
28	25	37
26	20	12,25,37
25	19	19
24	20	15
22	16	12,25,37
20	17	4,9
20	14	14
18.5	15.5	27
18	14	12,25,37
16	12	12,25,37
13	11	6.5
13	11.4	13
12.95	11.38	25.4
11	9	6.5
6.35	5.2	12

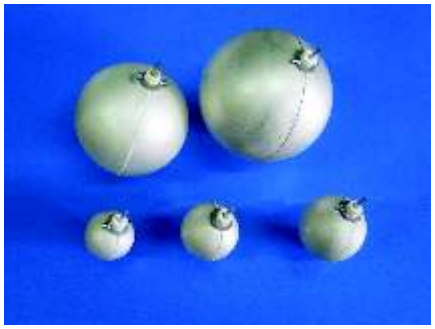
Cylindrical surfaces, silver electroded.
Polarity Marked.
Inside Cylindrical surface +ve polarity.
Tolerances (fully machined)
OD : ± 0.2 / 0.1mm **ID** : ± 0.2 / 0.1mm
Length : ± 0.1 mm

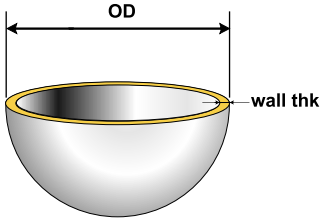
Material Grades : SP-4, SP-8, SP-5A, SP-5J, SP-5H **Other sizes on request**

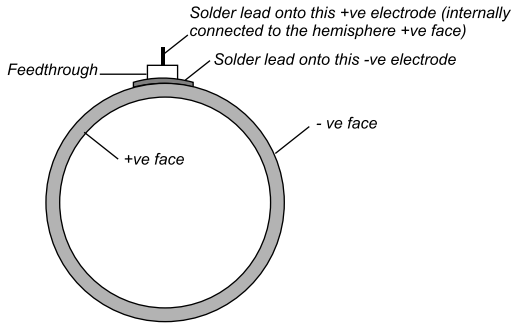
STANDARD FREQUENCY DISCS

Dia (mm)	Thickness frequency (MHz)									Standard Tolerances
	10	8.0	6.0	5.0	4.0	2.5	2.0	1.0	0.5	
5	✓	✓	✓	✓	✓	✓	✓	✓	✓	Frequency : Up to 2 MHz- ±7% Above 2 MHz- ±10% Diameter, D: +2.5% Flatness & plano-parallelism: Within 0.015mm Other Sizes on request
8	✓	✓	✓	✓	✓	✓	✓	✓	✓	
10	✓	✓	✓	✓	✓	✓	✓	✓	✓	
15	✓	✓	✓	✓	✓	✓	✓	✓	✓	
20	✓	✓	✓	✓	✓	✓	✓	✓	✓	
24	—	✓	✓	✓	✓	✓	✓	✓	✓	
25	—	✓	✓	✓	✓	✓	✓	✓	✓	
30	—	✓	✓	✓	✓	✓	✓	✓	✓	
38.1	—	✓	✓	✓	✓	✓	✓	✓	✓	
40	—	✓	✓	✓	✓	✓	✓	✓	✓	
50.8	—	✓	✓	✓	✓	✓	✓	✓	✓	

HEMISPHERES / SPHERES







OD (mm)	Wall thk (mm)
70	3
60	3
35	3
30	3
25.4	1.5
22	2.2
15	1.5

Construction of Spheres :

Sphere constructed out of two hemispheres , with feedthrough attached as shown above.

Tolerances

OD : ± 2.5% or +/- 0.2mm whichever is more

Wall thk : ±0.1

Material Grades

SP-4, SP-8, SP-5A, SP-5J, SP-5H

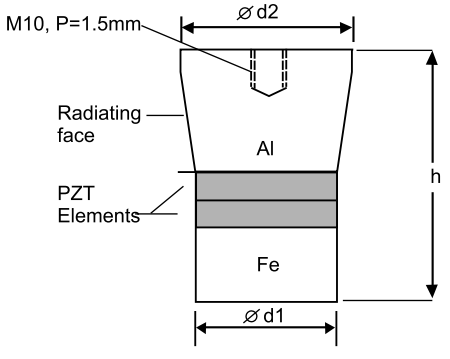
Other sizes on request

ELECTRODES :

All elements are electroded with fired – on adherent silver of solderable quality and positive polarity is marked on each piece. Special electrode patterns like wrap-around electrodes can be made available on request. For shear mode elements, electroless nickel electrodes will be provided. Electrical contacts may be made by soldering, bonding or clamping. For soldering, the electrode surfaces may be mildly abraded, the preferred solder composition is: 62% tin, 36% lead, 2% silver. Soldering iron may be 20W rating and soldering time should be kept as short as possible to avoid depoling.

SANDWICH TRANSDUCERS FOR ULTRASONIC CLEANERS

Langevin transducers, constructed from a pair of SP-4 rings, feature compactness, high electro-acoustic conversion efficiency, low heat generation, large amplitude, durability and stability in use



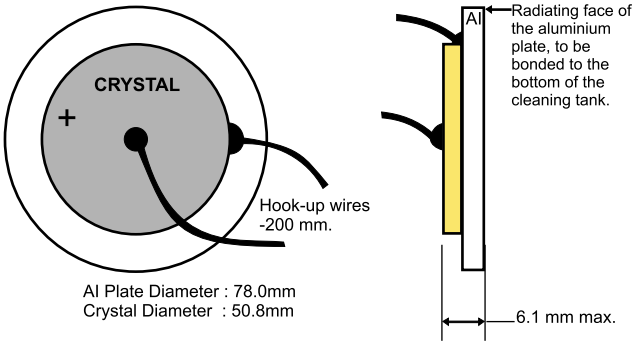
CONICAL RADIATING FACE

Part No.	∅ d1 (mm)	∅ d2 (mm)	h (mm)	Frequency (kHz)	Impedance (Ω) – max.	Δf / f_r	Mass (gm)	Cap (pF)	IR (MΩ)	Power max (W)
S 25.38.1	40	50	79	25 ±0.5	30	0.09	535	3700	10000	70/50
S 37.38.1	40	50	48	37±1.0	30	0.09	335	3700	10000	70/50

The transducers are further classified into 5 frequency bands A/B/C/D/E. A protective varnish is also provided. The transducer can be screwed on to the SS stud (M10, pitch=1.5mm)welded to the bottom of the cleaning tank. The transducers can also be bonded to the tank bottom

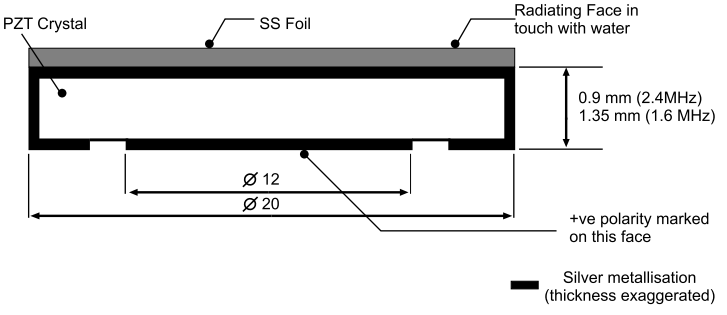
RADIAL MODE 40 kHz TRANSDUCERS

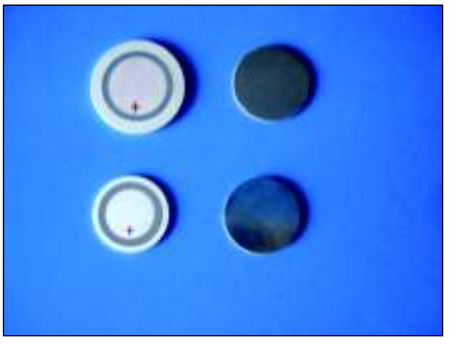
It is a 40 kHz, ready to use transducer, handling 30 Watts input power on continuous basis. With an epoxy resin, the aluminum face of the transducer can be bonded to the bottom of the cleaning tank.
It schematic sketch and typical characteristics are listed below:



Capacitance, low signal, 1 kHz	6200 pF, nominal
tan δ , 1 kHz	0.007 max., 0.004 typical
Radial resonant frequency	44.0 - 46.0 kHz
Impedance	25 Ω max.
Power handling	30 watts
$\triangle f/f_r$	0.06 min.

ELEMENTS FOR NEBULISERS

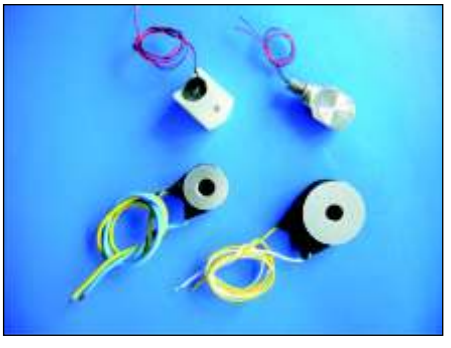


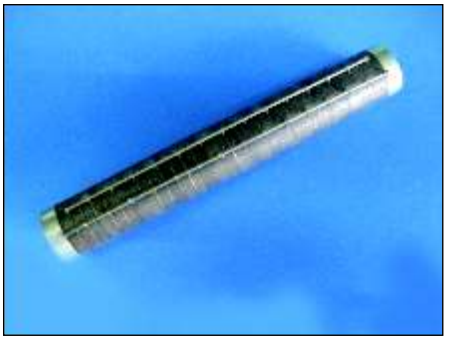


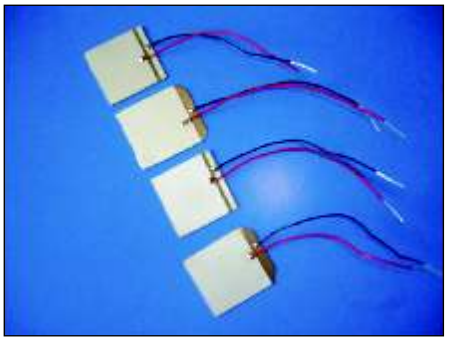
Frequency :1.65 MHz;2.4 MHz
Frequency Tolerance :+/-5%

Material : SP-4 (PZT4) or SP-8 (PZT8)
SS foil approx. 0.05mm thick bonded to the radiating face.

OTHER PRODUCTS / DEVICES:







Sparkler also manufactures customs transducers and probes, piezoelectric stack assemblies, Tonpilz transducers, bimorphs elements, stacked piezoelectric translator (high voltage), dynamic force rating transducers and probes as per customer's design / specification. Details available on request.

QUALITY POLICY

Sparkler's five grades of piezoelectric materials based on PZT meet the specifications of US DOD MIL STD 1376. The company has in place a quality system, which assures the consistent quality of the end product. Sparkler carries out 100% inspection of all the end product to the agreed specifications. Also, the company can manufacture products to the customer specifications. Sparkler Quality Management Systems are Certified to IS0 9001:2008 standards

SPARKLER CERAMICS PVT. LTD.

J-508, MIDC, Bhosari, Pune - 411 026. INDIA
Tel.: +91-20-30692878, 27130275
Fax: +91-20-27130955
Email: piezo@sparklerceramics.com
Web: www.sparklerceramics.com

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