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# PROPERTIES OF PIEZOELECTRIC MATERIALS

by

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The purpose of this monograph is to provide a source of data on a wide variety of piezoelectric materials which will be useful to those conducting research in this area as well as to the engineer designing ultrasonic transducers, filters, and other piezoelectric devices.

The references are keyed to the data by the number heading each column of data. In some cases, the reference reports additional data not included in this monograph. The reader is therefore urged to consult the references before embarking upon a research program.

The numerical data are given in the rationalized MKS system in accordance with the IRE Standards on Piezoelectricity, as are the symbols employed. Table I defines the symbols employed and gives their MKS unit. Since a large amount of literature still uses the CGS system, Table II presents the factors to convert CGS units to MKS units. On the data pages, the digits in the data columns are to be multiplied by the power of ten in the column immediately to the right of the symbol to obtain the value in the MKS system.

The compounds are arranged alphabetically by chemical name. The pure compounds are followed by the binary alloys, followed by ternary compounds, etc. The multiple component compounds are arranged alphabetically by main constituent, secondary constituent, etc., and by decreasing amount of main constituent.

## REFERENCE TEXTS

The following books and articles will provide a foundation of the theory of piezoelectricity and its many applications:

"A Textbook on Crystal Physics", W. A. Wooster, Cambridge University Press, 1938.

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"Ultrasonic Physics", Richardson, Elsevier, New York, 1952.

**TABLE I**
**Definition of Symbols**

| Symbol | Quantity | MKS Units* |
|---|---|---|
| c | Elastic Stiffness | $N/m^2$ |
| d | Piezoelectric Strain Constant (Coefficient) | C/N or m/V |
| D | Electric Displacement | $C/m^2$ |
| e | Piezoelectric Stress Constant (Moduli) | $C/m^2$ |
| E | Electric Field Strength | V/m |
| g | Piezoelectric Strain Constant | $m^2/C$ |
| h | Piezoelectric Stress Constant | N/C or V/m |
| k | Coupling Coefficient | |
| K | Dielectric Constant | N/C or V/M |
| P | Dielectric Polarization | $C/m^2$ |
| Q | Mechanical Q | |
| $s^{E**}$ | Elastic Compliance (E = constant) | $m^2/N$ |
| S | Strain | |
| T | Stress (Tensile Positive) | $n/m^2$ |
| u | Elastic Displacement | m |
| Y | Young's Modulus | $N/m^2$ |
| $\beta^T$ | Dielectric Impermeability (T = constant) | m/F |
| $\epsilon^T$ | Permittivity (T = constant) | F/m |
| $\eta^S$ | Dielectric Susceptibility (S = constant) | |
| $\theta$ | Absolute Temperature | $^oK$ |
| $\rho$ | Density | $kg/m^3$ |
| $\chi^T$ | Reciprocal Susceptibility (T = constant) | |

* N = newton, m = meter, V = volt, C = coulomb, F = farad, $^oK$ = degrees kelvin, kg = kilogram

** Superscript denotes quantity which is held constant.

**TABLE II**
**Conversion Factors from CGS to Rationalized MKS Units**

| Symbol | Factor | |
|---|---|---|
| c, T, Y | $10^{-1}$ | $N/m^2$ per dyne/$cm^2$ |
| d | $\frac{1}{3} \times 10^{-4}$ | C/N per statcoulomb/dyne |
| D | $\frac{1}{12\pi \times 10^5}$ | $C/m^2$ per statcoulomb/$cm^2$ |
| e, P | $\frac{1}{3} \times 10^{-5}$ | $C/m^2$ per statcoulomb/$cm^2$ |
| E | $3 \times 10^4$ | V/m per statvolt/cm |
| g | $3 \times 10^5$ | $m^2/C$ per dyne/statcoulomb |
| h | $3 \times 10^4$ | N/C per dyne/statcoulomb |
| s | 10 | $m^2/N$ per $cm^2$/dyne |
| $\epsilon$ | $\frac{1}{36\pi \times 10^9}$ | F/m per statfarad/cm |
| $\eta$ | $4\pi$ | (numeric) |
| $\rho$ | $10^3$ | $kg/m^3$ per gram/$cm^3$ |

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**MATERIAL:** Barium Titanate (Pure)

| Property \ Reference | | 2 | 10 | 13 | 16 | 17 | 18 | 23 |
|---|---|---|---|---|---|---|---|---|
| $T_C$ | - - | | | 108 | | 130 | 115 | 115 |
| K | - - | | | 2300 | | 1620 | 1700 | 1700 |
| Y | $\times 10^{10}$ | 11 | | | | | 11 | 11 |
| $\rho$ | $\times 10^{3}$ | 5.7 | | | | | | 5.8 |
| $c_{33}^{D}$ | $\times 10^{10}$ | | 18.9 | | | | | |
| $d_{15}$ | $\times 10^{-12}$ | | 270 | | 392 | | | |
| $d_{31}$ | $\times 10^{-12}$ | -78 | -79 | -97 | -34.5 | -50 | -78 | -78 |
| $d_{33}$ | $\times 10^{-12}$ | | 191 | | 85.6 | | 190 | 190 |
| $\epsilon_{33}^{T}$ | $\times \epsilon_o$ | | 1900 | | 168 | | | |
| $g_{31}$ | $\times 10^{-3}$ | -5.2 | -4.7 | | -23 | | | |
| $g_{33}$ | $\times 10^{-3}$ | | 11.4 | | 57.5 | | | 13.0 |
| $k_{15}$ | - - | | | | 0.57 | | | |
| $k_{31}$ | - - | 0.214 | | | 0.315 | | 0.22 | 0.22 |
| $k_{33}$ | - - | | | | 0.56 | | 0.52 | 0.52 |
| $k_r$ | - - | | | 0.37 | 0.37 | 0.20 | | 0.37 |
| $s_{11}^{E}$ | $\times 10^{-12}$ | | 8.55 | | 8.05 | | | |
| $s_{12}^{E}$ | $\times 10^{-12}$ | | -2.61 | | -2.35 | | | |
| $s_{13}^{E}$ | $\times 10^{-12}$ | | -2.85 | | -5.24 | | | |
| $s_{33}^{E}$ | $\times 10^{-12}$ | | 8.93 | | 15.7 | | | |
| $s_{44}^{E}$ | $\times 10^{-12}$ | | 23.3 | | 18.4 | | | |
| Q | - - | | | | | | 400 | 400 |

**MATERIAL:** Barium Titanate (Pure) Con't

| Property | | Reference 38 | 42 | 12 | 19 | | | |
|---|---|---|---|---|---|---|---|---|
| $T_C$ | - - | | 120 | | | | | |
| K | - - | 1700 | 1900 | | | | | |
| Y | $\times 10^{10}$ | | | | | | | |
| $\rho$ | $\times 10^{3}$ | 5.7 | 5.72 | | | | | |
| $c_{33}^{D}$ | $\times 10^{10}$ | 17.6 | | | | | | |
| $d_{15}$ | $\times 10^{-12}$ | | | | | | | |
| $d_{31}$ | $\times 10^{-12}$ | -78 | | -56 | -33 | | | |
| $d_{33}$ | $\times 10^{-12}$ | 190 | | 130 to 160 | | | | |
| $\epsilon_{33}^{T}$ | $\times \epsilon_o$ | | | | | | | |
| $g_{31}$ | $\times 10^{-3}$ | | | | | | | |
| $g_{33}$ | $\times 10^{-3}$ | | | 10.7 | | | | |
| $k_{15}$ | - - | | | 0.41 | | | | |
| $k_{31}$ | - - | 0.21 | 0.21 | 0.17 | | | | |
| $k_{33}$ | - - | 0.50 | 0.49 | 0.45 | | | | |
| $k_r$ | - - | 0.36 | 0.35 | | | | | |
| $s_{11}^{E}$ | $\times 10^{-12}$ | 9.99 | | | 8.0 | | | |
| $s_{12}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{13}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{33}^{E}$ | $\times 10^{-12}$ | 9.52 | | | | | | |
| $s_{44}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| Q | - - | 400 | | | | | | |

**MATERIAL:** Cadmium Sulphide (Annealed in Sulphur Vapor)

| Property \ Reference | | 33 | 32 | | | | | |
|---|---|---|---|---|---|---|---|---|
| $T_C$ | - - | | | | | | | |
| K | - - | 9.0 | | | | | | |
| Y | $\times 10^{10}$ | | | | | | | |
| $\rho$ | $\times 10^{3}$ | | | | | | | |
| $c_{33}^{D}$ | $\times 10^{10}$ | | | | | | | |
| $d_{15}$ | $\times 10^{-12}$ | -14.35 | | | | | | |
| $d_{31}$ | $\times 10^{-12}$ | -3.67 | -1.53 | | | | | |
| $d_{33}$ | $\times 10^{-12}$ | 10.65 | 2.56 | | | | | |
| $\epsilon_{33}^{T}$ | $\times \epsilon_o$ | | | | | | | |
| $g_{31}$ | $\times 10^{-3}$ | | | | | | | |
| $g_{33}$ | $\times 10^{-3}$ | | | | | | | |
| $k_{15}$ | - - | | | | | | | |
| $k_{31}$ | - - | | | | | | | |
| $k_{33}$ | - - | | | | | | | |
| $k_r$ | - - | | | | | | | |
| $s_{11}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{12}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{13}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{33}^{E}$ | $\times 10^{-12}$ | 16 | | | | | | |
| $s_{44}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| Q | - - | | | | | | | |

**MATERIAL:** Ceramic A - (Brush Electronics)

| Property | | Reference 11 | 12 | | | | | |
|---|---|---|---|---|---|---|---|---|
| $T_C$ | - - | | | | | | | |
| K | - - | | | | | | | |
| Y | $\times 10^{10}$ | | 11.0 | | | | | |
| $\rho$ | $\times 10^{3}$ | 5.77 | | | | | | |
| $c_{33}^{D}$ | $\times 10^{10}$ | | | | | | | |
| $d_{15}$ | $\times 10^{-12}$ | | | | | | | |
| $d_{31}$ | $\times 10^{-12}$ | | -78 | | | | | |
| $d_{33}$ | $\times 10^{-12}$ | | 190 | | | | | |
| $\epsilon_{33}^{T}$ | $\times \epsilon_o$ | | 1720 | | | | | |
| $g_{31}$ | $\times 10^{-3}$ | | | | | | | |
| $g_{33}$ | $\times 10^{-3}$ | | | | | | | |
| $k_{15}$ | - - | | 0.49 | | | | | |
| $k_{31}$ | - - | | 0.214 | | | | | |
| $k_{33}$ | - - | | 0.52 | | | | | |
| $k_r$ | - - | | | | | | | |
| $s_{11}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{12}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{13}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{33}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{44}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| Q | - - | | | | | | | |

| MATERIAL: Ceramic B (Brush Electronics) (A Barium - Calcium Titanate) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Property \ Reference | | 37 | | | | | | |
| $T_C$ | - - | 115 | | | | | | |
| K | - - | 1200 | | | | | | |
| Y | $\times 10^{10}$ | | | | | | | |
| $\rho$ | $\times 10^{3}$ | 5.5 | | | | | | |
| $c_{33}^{D}$ | $\times 10^{10}$ | | | | | | | |
| $d_{15}$ | $\times 10^{-12}$ | | | | | | | |
| $d_{31}$ | $\times 10^{-12}$ | -58 | | | | | | |
| $d_{33}$ | $\times 10^{-12}$ | 150 | | | | | | |
| $\epsilon_{33}^{T}$ | $\times \epsilon_o$ | | | | | | | |
| $g_{31}$ | $\times 10^{-3}$ | | | | | | | |
| $g_{33}$ | $\times 10^{-3}$ | | | | | | | |
| $k_{15}$ | - - | | | | | | | |
| $k_{31}$ | - - | 0.190 | | | | | | |
| $k_{33}$ | - - | 0.490 | | | | | | |
| $k_r$ | - - | 0.325 | | | | | | |
| $s_{11}^{E}$ | $\times 10^{-12}$ | 8.62 | | | | | | |
| $s_{12}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{13}^{E}$ | $\times 10^{-12}$ | 9.0 | | | | | | |
| $s_{33}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{44}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| Q | - - | 400 | | | | | | |

**MATERIAL:** Lead Niobate

| Property \ Reference | | 18 | 23 | 34 | | | | |
|---|---|---|---|---|---|---|---|---|
| $T_C$ | - - | 570 | 490 | 565 | | | | |
| K | - - | 225 | 225 | 165 | | | | |
| Y | $\times 10^{10}$ | 3.5 | 3.5 | | | | | |
| $\rho$ | $\times 10^{3}$ | | 5.9 | 5.5 | | | | |
| $c_{33}^{D}$ | $\times 10^{10}$ | | | | | | | |
| $d_{15}$ | $\times 10^{-12}$ | | | | | | | |
| $d_{31}$ | $\times 10^{-12}$ | -11 | -11 | | | | | |
| $d_{33}$ | $\times 10^{-12}$ | 80 | 80 | | | | | |
| $\epsilon_{33}^{T}$ | $\times \epsilon_o$ | | | | | | | |
| $g_{31}$ | $\times 10^{-3}$ | | | | | | | |
| $g_{33}$ | $\times 10^{-3}$ | | 40 | | | | | |
| $k_{15}$ | - - | | | | | | | |
| $k_{31}$ | - - | 0.045 | 0.045 | | | | | |
| $k_{33}$ | - - | 0.42 | 0.42 | 0.30 | | | | |
| $k_r$ | - - | 0.07 | 0.07 | | | | | |
| $s_{11}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{12}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{13}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{33}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{44}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| Q | - - | 11 | | 5 | | | | |

| MATERIAL: Triglycine Sulphate (Pure) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Property \ Reference | | 39 | 21 | 36 | 45 | | | |
| $T_C$ | - - | 47 | | | | | | |
| Q | - - | | | | | | | |
| K | - - | | | | | | | |
| Y | $\times 10^{10}$ | | | | | | | |
| $\rho$ | $\times 10^{3}$ | | | | | | | |
| $d_{23}$ | $\times 10^{-12}$ | 65 | 84 | 14 | | | | |
| $d_{21}$ | $\times 10^{-12}$ | | 22.7 | 5 | 30 | | | |
| $d_{22}$ | $\times 10^{-12}$ | | 22 | 9.3 | | | | |
| $d_{25}$ | $\times 10^{-12}$ | | | 2 | | | | |
| | | | | | | | | |
| $k_{21}$ | - - | | 0.18 | | | | | |
| $k_{22}$ | - - | | 0.18 | | | | | |
| $k_{23}$ | - - | | 0.44 | | | | | |
| | | | | | | | | |
| $s_{11}^E$ | $\times 10^{-12}$ | | | 35.1 | 34 | | | |
| $s_{12}^E$ | $\times 10^{-12}$ | | | -10.1 | | | | |
| $s_{13}^E$ | $\times 10^{-12}$ | | | -53.8 | | | | |
| $s_{33}^E$ | $\times 10^{-12}$ | 82 | | 86.0 | 87 | | | |
| $s_{44}^E$ | $\times 10^{-12}$ | | | 95.7 | | | | |
| $s_{66}^E$ | $\times 10^{-12}$ | | | 164.9 | | | | |

**MATERIAL:** Zinc Oxide (Pure with Lithium Dopant)

| Property \ Reference | | 33 | | | | | | |
|---|---|---|---|---|---|---|---|---|
| $T_C$ | - - | | | | | | | |
| K | - - | 8.2 | | | | | | |
| Y | $x10^{10}$ | | | | | | | |
| $\rho$ | $x10^{3}$ | | | | | | | |
| $c_{33}^{D}$ | $x10^{10}$ | | | | | | | |
| $d_{15}$ | $x10^{-12}$ | -13.3 | | | | | | |
| $d_{31}$ | $x10^{-12}$ | -4.67 | | | | | | |
| $d_{33}$ | $x10^{-12}$ | 12.0 | | | | | | |
| $\epsilon_{33}^{T}$ | $x\epsilon_o$ | | | | | | | |
| $g_{31}$ | $x10^{-3}$ | | | | | | | |
| $g_{33}$ | $x10^{-3}$ | | | | | | | |
| $k_{15}$ | - - | | | | | | | |
| $k_{31}$ | - - | | | | | | | |
| $k_{33}$ | - - | | | | | | | |
| $k_r$ | - - | | | | | | | |
| $s_{11}^{E}$ | $x10^{-12}$ | | | | | | | |
| $s_{12}^{E}$ | $x10^{-12}$ | | | | | | | |
| $s_{13}^{E}$ | $x10^{-12}$ | | | | | | | |
| $s_{33}^{E}$ | $x10^{-12}$ | | | | | | | |
| $s_{44}^{E}$ | $x10^{-12}$ | | | | | | | |
| Q | - - | | | | | | | |

**MATERIAL:** Barium Titanate (95%) Barium Zirconate (5%)

| Property \ Reference | | 42 | | | | | | |
|---|---|---|---|---|---|---|---|---|
| $T_C$ | - - | 105 | | | | | | |
| K | - - | | | | | | | |
| Y | $\times 10^{10}$ | | | | | | | |
| $\rho$ | $\times 10^{3}$ | 5.44 | | | | | | |
| $c_{33}^D$ | $\times 10^{10}$ | | | | | | | |
| $d_{15}$ | $\times 10^{-12}$ | | | | | | | |
| $d_{31}$ | $\times 10^{-12}$ | -60 | | | | | | |
| $d_{33}$ | $\times 10^{-12}$ | 150 | | | | | | |
| $\epsilon_{33}^T$ | $\times \epsilon_o$ | 1400 | | | | | | |
| $g_{31}$ | $\times 10^{-3}$ | -4.8 | | | | | | |
| $g_{33}$ | $\times 10^{-3}$ | 12.1 | | | | | | |
| $k_{15}$ | - - | 0.15 | | | | | | |
| $k_{31}$ | - - | 0.40 | | | | | | |
| $k_{33}$ | - - | 0.28 | | | | | | |
| $k_r$ | - - | | | | | | | |
| $s_{11}^E$ | $\times 10^{-12}$ | 11 | | | | | | |
| $s_{12}^E$ | $\times 10^{-12}$ | | | | | | | |
| $s_{13}^E$ | $\times 10^{-12}$ | | | | | | | |
| $s_{33}^E$ | $\times 10^{-12}$ | | | | | | | |
| $s_{44}^E$ | $\times 10^{-12}$ | | | | | | | |
| Q | - - | 200 | | | | | | |

**MATERIAL:** Barium Niobate (60%) Lead Niobate (40%)

| Property | | Reference 34 | 33 | | | | | |
|---|---|---|---|---|---|---|---|---|
| $T_C$ | - - | 300 | 300 | | | | | |
| K | - - | 750 | 800 | | | | | |
| Y | $\times 10^{10}$ | | | | | | | |
| $\rho$ | $\times 10^{3}$ | 5.6 | 5.6 | | | | | |
| $c_{33}^{D}$ | $\times 10^{10}$ | | | | | | | |
| $d_{15}$ | $\times 10^{-12}$ | | | | | | | |
| $d_{31}$ | $\times 10^{-12}$ | | -25 | | | | | |
| $d_{33}$ | $\times 10^{-12}$ | | | | | | | |
| $\epsilon_{33}^{T}$ | $\times \epsilon_o$ | | | | | | | |
| $g_{31}$ | $\times 10^{-3}$ | | | | | | | |
| $g_{33}$ | $\times 10^{-3}$ | | | | | | | |
| $k_{15}$ | - - | | | | | | | |
| $k_{31}$ | - - | | | | | | | |
| $k_{33}$ | - - | | | | | | | |
| $k_r$ | - - | 0.16 | 0.16 | | | | | |
| $s_{11}^{E}$ | $\times 10^{-12}$ | | 10.3 | | | | | |
| $s_{12}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{13}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{33}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{44}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| Q | - - | | | | | | | |

**MATERIAL:** Barium Niobate (50%) Lead Niobate (50%)

| Property \ Reference | | 17 | 34 | 40 | | | | |
|---|---|---|---|---|---|---|---|---|
| $T_C$ | - - | 315 | 260 | 260 | | | | |
| K | - - | 1205 | 1530 | 1550 | | | | |
| Y | $\times 10^{10}$ | | | | | | | |
| $\rho$ | $\times 10^{3}$ | | 5.6 | 5.6 | | | | |
| $c_{33}^{D}$ | $\times 10^{10}$ | | | | | | | |
| $d_{15}$ | $\times 10^{-12}$ | | | | | | | |
| $d_{31}$ | $\times 10^{-12}$ | -36.6 | | -58 | | | | |
| $d_{33}$ | $\times 10^{-12}$ | | | | | | | |
| $\epsilon_{33}^{T}$ | $\times \epsilon_o$ | | | | | | | |
| $g_{31}$ | $\times 10^{-3}$ | | | | | | | |
| $g_{33}$ | $\times 10^{-3}$ | | | | | | | |
| $k_{15}$ | - - | | | | | | | |
| $k_{31}$ | - - | | | | | | | |
| $k_{33}$ | - - | | | | | | | |
| $k_r$ | - - | 0.16 | 0.25 | 0.25 | | | | |
| $s_{11}^{E}$ | $\times 10^{-12}$ | | | 10.1 | | | | |
| $s_{12}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{13}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{33}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{44}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| Q | - - | | | | | | | |

**MATERIAL:** Barium Titanate (97%) Calcium Titanate (3%)

| Property \ Reference | | 12 | | | | | | |
|---|---|---|---|---|---|---|---|---|
| $T_C$ | - - | | | | | | | |
| K | - - | | | | | | | |
| Y | $\times 10^{10}$ | 12.2 | | | | | | |
| $\rho$ | $\times 10^{3}$ | | | | | | | |
| $c_{33}^{D}$ | $\times 10^{10}$ | | | | | | | |
| $d_{15}$ | $\times 10^{-12}$ | | | | | | | |
| $d_{31}$ | $\times 10^{-12}$ | -53 | | | | | | |
| $d_{33}$ | $\times 10^{-12}$ | 135 | | | | | | |
| $\epsilon_{33}^{T}$ | $\times \epsilon_o$ | 1390 | | | | | | |
| $g_{31}$ | $\times 10^{-3}$ | | | | | | | |
| $g_{33}$ | $\times 10^{-3}$ | | | | | | | |
| $k_{15}$ | - - | 0.39 | | | | | | |
| $k_{31}$ | - - | 0.17 | | | | | | |
| $k_{33}$ | - - | 0.43 | | | | | | |
| $k_r$ | - - | | | | | | | |
| $s_{11}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{12}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{13}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{33}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{44}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| Q | - - | | | | | | | |

**MATERIAL:** Barium Titanate (95%) Calcium Titanate (5%)

| Property \ Reference | | 2 | 13 | 15 | 24 | | | |
|---|---|---|---|---|---|---|---|---|
| $T_C$ | - - | | 115 | 118 | 115 | | | |
| K | - - | 1190 | 1160 | 1320 | | | | |
| Y | $\times 10^{10}$ | 11.6 | | 12.4 | | | | |
| $\rho$ | $\times 10^{3}$ | 5.5 | | 5.74 | 5.5 | | | |
| $c_{33}^{D}$ | $\times 10^{10}$ | | | | 15.8 | | | |
| $d_{15}$ | $\times 10^{-12}$ | | | | 257 | | | |
| $d_{31}$ | $\times 10^{-12}$ | -58 | -53 | -61 | -58 | | | |
| $d_{33}$ | $\times 10^{-12}$ | | | | 150 | | | |
| $\epsilon_{33}^{T}$ | $\times \epsilon_o$ | | | | 1355 | | | |
| $g_{31}$ | $\times 10^{-3}$ | | | -5.2 | -5.5 | | | |
| $g_{33}$ | $\times 10^{-3}$ | | | | | | | |
| $k_{15}$ | - - | | | | 0.495 | | | |
| $k_{31}$ | - - | 0.193 | | | 0.19 | | | |
| $k_{33}$ | - - | | | | 0.49 | | | |
| $k_r$ | - - | | 0.29 | 0.34 | 0.325 | | | |
| $s_{11}^{E}$ | $\times 10^{-12}$ | | | | 8.7 | | | |
| $s_{12}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{13}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{33}^{E}$ | $\times 10^{-12}$ | | | | 9.0 | | | |
| $s_{44}^{E}$ | $\times 10^{-12}$ | | | | 22.7 | | | |
| Q | - - | | | | 500 | | | |

**MATERIAL:** Barium Titanate (96%) Lead Titanate (4%)

| Property \ Reference | | 12 | | | | | | |
|---|---|---|---|---|---|---|---|---|
| $T_C$ | - - | | | | | | | |
| K | - - | | | | | | | |
| Y | $\times 10^{10}$ | 11.4 | | | | | | |
| $\rho$ | $\times 10^{3}$ | | | | | | | |
| $c_{33}^{D}$ | $\times 10^{10}$ | | | | | | | |
| $d_{15}$ | $\times 10^{-12}$ | | | | | | | |
| $d_{31}$ | $\times 10^{-12}$ | -38 | | | | | | |
| $d_{33}$ | $\times 10^{-12}$ | 105 | | | | | | |
| $\epsilon_{33}^{T}$ | $\times \epsilon_o$ | 995 | | | | | | |
| $g_{31}$ | $\times 10^{-3}$ | | | | | | | |
| $g_{33}$ | $\times 10^{-3}$ | | | | | | | |
| $k_{15}$ | - - | 0.34 | | | | | | |
| $k_{31}$ | - - | 0.14 | | | | | | |
| $k_{33}$ | - - | 0.39 | | | | | | |
| $k_r$ | - - | | | | | | | |
| $s_{11}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{12}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{13}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{33}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{44}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| Q | - - | | | | | | | |

**MATERIAL:** Barium Titanate (95%) Lead Titanate (5%)

| Property | | Reference 2 | | | | | | |
|---|---|---|---|---|---|---|---|---|
| $T_C$ | - - | | | | | | | |
| K | - - | 1175 | | | | | | |
| Y | $\times 10^{10}$ | 11.0 | | | | | | |
| $\rho$ | $\times 10^{3}$ | 5.7 | | | | | | |
| $c_{33}^{D}$ | $\times 10^{10}$ | | | | | | | |
| $d_{15}$ | $\times 10^{-12}$ | | | | | | | |
| $d_{31}$ | $\times 10^{-12}$ | -53 | | | | | | |
| $d_{33}$ | $\times 10^{-12}$ | | | | | | | |
| $\epsilon_{33}^{T}$ | $\times \epsilon_o$ | | | | | | | |
| $g_{31}$ | $\times 10^{-3}$ | -5.1 | | | | | | |
| $g_{33}$ | $\times 10^{-3}$ | | | | | | | |
| $k_{15}$ | - - | | | | | | | |
| $k_{31}$ | - - | 0.172 | | | | | | |
| $k_{33}$ | - - | | | | | | | |
| $k_r$ | - - | | | | | | | |
| $s_{11}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{12}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{13}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{33}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{44}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| Q | - - | | | | | | | |

**MATERIAL:** Barium Titanate (90%) Lead Titanate (10%)

| Property \ Reference | | 18 | | | | | | |
|---|---|---|---|---|---|---|---|---|
| $T_C$ | - - | 150 | | | | | | |
| K | - - | 500 | | | | | | |
| Y | $\times 10^{10}$ | 12 | | | | | | |
| $\rho$ | $\times 10^{3}$ | | | | | | | |
| $c_{33}^{D}$ | $\times 10^{10}$ | | | | | | | |
| $d_{15}$ | $\times 10^{-12}$ | | | | | | | |
| $d_{31}$ | $\times 10^{-12}$ | -23 | | | | | | |
| $d_{33}$ | $\times 10^{-12}$ | 70 | | | | | | |
| $\epsilon_{33}^{T}$ | $\times \epsilon_o$ | | | | | | | |
| $g_{31}$ | $\times 10^{-3}$ | | | | | | | |
| $g_{33}$ | $\times 10^{-3}$ | | | | | | | |
| $k_{15}$ | - - | | | | | | | |
| $k_{31}$ | - - | 0.12 | | | | | | |
| $k_{33}$ | - - | 0.36 | | | | | | |
| $k_r$ | - - | 0.20 | | | | | | |
| $s_{11}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{12}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{13}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{33}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{44}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| Q | - - | 800 | | | | | | |

**MATERIAL:** Barium Titanate (88%) Lead Titanate (12%)

| Property \ Reference | | 37 | | | | | | |
|---|---|---|---|---|---|---|---|---|
| $T_C$ | - - | 150 | | | | | | |
| K | - - | 850 | | | | | | |
| Y | $\times 10^{10}$ | | | | | | | |
| $\rho$ | $\times 10^{3}$ | 5.7 | | | | | | |
| $c_{33}^D$ | $\times 10^{10}$ | | | | | | | |
| $d_{15}$ | $\times 10^{-12}$ | | | | | | | |
| $d_{31}$ | $\times 10^{-12}$ | -30 | | | | | | |
| $d_{33}$ | $\times 10^{-12}$ | 90 | | | | | | |
| $\epsilon_{33}^T$ | $\times \epsilon_o$ | | | | | | | |
| $g_{31}$ | $\times 10^{-3}$ | | | | | | | |
| $g_{33}$ | $\times 10^{-3}$ | | | | | | | |
| $k_{15}$ | - - | | | | | | | |
| $k_{31}$ | - - | 0.125 | | | | | | |
| $k_{33}$ | - - | 0.365 | | | | | | |
| $k_r$ | - - | 0.210 | | | | | | |
| $s_{11}^E$ | $\times 10^{-12}$ | 7.82 | | | | | | |
| $s_{12}^E$ | $\times 10^{-12}$ | | | | | | | |
| $s_{13}^E$ | $\times 10^{-12}$ | | | | | | | |
| $s_{33}^E$ | $\times 10^{-12}$ | 8.13 | | | | | | |
| $s_{44}^E$ | $\times 10^{-12}$ | | | | | | | |
| Q | - - | 1200 | | | | | | |

**MATERIAL:** Ceramic A (95%) Calcium Titanate (5%)

| Property \ Reference | | 12 | | | | | | |
|---|---|---|---|---|---|---|---|---|
| $T_C$ | - - | | | | | | | |
| K | - - | | | | | | | |
| Y | $\times 10^{10}$ | 11.6 | | | | | | |
| $\rho$ | $\times 10^{3}$ | | | | | | | |
| $c_{33}^{D}$ | $\times 10^{10}$ | | | | | | | |
| $d_{15}$ | $\times 10^{-12}$ | | | | | | | |
| $d_{31}$ | $\times 10^{-12}$ | -58 | | | | | | |
| $d_{33}$ | $\times 10^{-12}$ | 150 | | | | | | |
| $\epsilon_{33}^{T}$ | $\times \epsilon_o$ | 1185 | | | | | | |
| $g_{31}$ | $\times 10^{-3}$ | | | | | | | |
| $g_{33}$ | $\times 10^{-3}$ | | | | | | | |
| $k_{15}$ | - - | | | | | | | |
| $k_{31}$ | - - | 0.193 | | | | | | |
| $k_{33}$ | - - | 0.50 | | | | | | |
| $k_r$ | - - | | | | | | | |
| $s_{11}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{12}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{13}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{33}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{44}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| Q | - - | | | | | | | |

**MATERIAL:** Lead Hafnate (50%) Lead Titanate (50%)

| Property \ Reference | | 8 | | | | | | |
|---|---|---|---|---|---|---|---|---|
| $T_C$ | - - | 330 | | | | | | |
| K | - - | 672 | | | | | | |
| Y | $\times 10^{10}$ | | | | | | | |
| $\rho$ | $\times 10^{3}$ | 8.4 | | | | | | |
| $c_{33}^{D}$ | $\times 10^{10}$ | | | | | | | |
| $d_{15}$ | $\times 10^{-12}$ | | | | | | | |
| $d_{31}$ | $\times 10^{-12}$ | -54 | | | | | | |
| $d_{33}$ | $\times 10^{-12}$ | | | | | | | |
| $\epsilon_{33}^{T}$ | $\times \epsilon_o$ | | | | | | | |
| $g_{31}$ | $\times 10^{-3}$ | -8.8 | | | | | | |
| $g_{33}$ | $\times 10^{-3}$ | | | | | | | |
| $k_{15}$ | - - | | | | | | | |
| $k_{31}$ | - - | | | | | | | |
| $k_{33}$ | - - | | | | | | | |
| $k_r$ | - - | 0.38 | | | | | | |
| $s_{11}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{12}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{13}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{33}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{44}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| Q | - - | | | | | | | |

MATERIAL: Lead Niobate (80%) Barium Niobate (20%)

| Property | | Reference 34 | 40 | | | | | |
|---|---|---|---|---|---|---|---|---|
| $T_C$ | - - | 430 | 425 | | | | | |
| K | - - | 400 | 400 | | | | | |
| Y | $\times 10^{10}$ | | | | | | | |
| $\rho$ | $\times 10^{3}$ | 5.9 | 5.9 | | | | | |
| $c_{33}^D$ | $\times 10^{10}$ | | | | | | | |
| $d_{15}$ | $\times 10^{-12}$ | | | | | | | |
| $d_{31}$ | $\times 10^{-12}$ | | 25 | | | | | |
| $d_{33}$ | $\times 10^{-12}$ | | | | | | | |
| $\epsilon_{33}^T$ | $\times \epsilon_o$ | | | | | | | |
| $g_{31}$ | $\times 10^{-3}$ | | | | | | | |
| $g_{33}$ | $\times 10^{-3}$ | | | | | | | |
| $k_{15}$ | - - | | | | | | | |
| $k_{31}$ | - - | | | | | | | |
| $k_{33}$ | - - | | | | | | | |
| $k_r$ | - - | 0.20 | 0.20 | | | | | |
| $s_{11}^E$ | $\times 10^{-12}$ | | 12.2 | | | | | |
| $s_{12}^E$ | $\times 10^{-12}$ | | | | | | | |
| $s_{13}^E$ | $\times 10^{-12}$ | | | | | | | |
| $s_{33}^E$ | $\times 10^{-12}$ | | | | | | | |
| $s_{44}^E$ | $\times 10^{-12}$ | | | | | | | |
| Q | - - | 20 | 15 | | | | | |

| MATERIAL: Lead Niobate (70%) Barium Niobate (30%) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Property \ Reference | | 17 | 34 | 40 | 42 | | | |
| $T_C$ | - - | 345 | 340 | 350 | 340 | | | |
| K | - - | 640 | 900 | 640 | | | | |
| Y | $\times 10^{10}$ | | | | | | | |
| $\rho$ | $\times 10^{3}$ | | | 5.9 | 5.9 | | | |
| $c_{33}^{D}$ | $\times 10^{10}$ | | | | | | | |
| $d_{15}$ | $\times 10^{-12}$ | | | | | | | |
| $d_{31}$ | $\times 10^{-12}$ | -36.6 | | -41 | -40 | | | |
| $d_{33}$ | $\times 10^{-12}$ | | | | 100 | | | |
| $\epsilon_{33}^{T}$ | $\times \epsilon_o$ | | | | 900 | | | |
| $g_{31}$ | $\times 10^{-3}$ | | | | -5.0 | | | |
| $g_{33}$ | $\times 10^{-3}$ | | | | 12.5 | | | |
| $k_{15}$ | - - | | | | | | | |
| $k_{31}$ | - - | | | | 0.13 | | | |
| $k_{33}$ | - - | | | | 0.33 | | | |
| $k_r$ | - - | 0.19 | 0.24 | 0.24 | 0.24 | | | |
| $s_{11}^{E}$ | $\times 10^{-12}$ | | | 10.9 | 10.9 | | | |
| $s_{12}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{13}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{33}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{44}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| Q | - - | | 350 | 350 | 350 | | | |

MATERIAL: Lead Niobate (65%) Barium Niobate (35%)

| Property | | Reference 34 | 40 | | | | | |
|---|---|---|---|---|---|---|---|---|
| $T_C$ | - - | 300 | 300 | | | | | |
| K | - - | 1020 | 1250 | | | | | |
| Y | $\times 10^{10}$ | | | | | | | |
| $\rho$ | $\times 10^{3}$ | 5.9 | | | | | | |
| $c_{33}^D$ | $\times 10^{10}$ | | | | | | | |
| $d_{15}$ | $\times 10^{-12}$ | | | | | | | |
| $d_{31}$ | $\times 10^{-12}$ | | -60 | | | | | |
| $d_{33}$ | $\times 10^{-12}$ | | | | | | | |
| $\epsilon_{33}^T$ | $\times \epsilon_o$ | | | | | | | |
| $g_{31}$ | $\times 10^{-3}$ | | | | | | | |
| $g_{33}$ | $\times 10^{-3}$ | | | | | | | |
| $k_{15}$ | - - | | | | | | | |
| $k_{31}$ | - - | | | | | | | |
| $k_{33}$ | - - | | | | | | | |
| $k_r$ | - - | 0.30 | 0.34 | | | | | |
| $s_{11}^E$ | $\times 10^{-12}$ | | | | | | | |
| $s_{12}^E$ | $\times 10^{-12}$ | | | | | | | |
| $s_{13}^E$ | $\times 10^{-12}$ | | | | | | | |
| $s_{33}^E$ | $\times 10^{-12}$ | | | | | | | |
| $s_{44}^E$ | $\times 10^{-12}$ | | | | | | | |
| Q | - - | 400 | 330 | | | | | |

MATERIAL: Lead Niobate (60%) Barium Niobate (40%)

| Property \ Reference | | 17 | 40 | 42 | 34 | | | |
|---|---|---|---|---|---|---|---|---|
| $T_C$ | - - | 290 | 270 | 260 | | | | |
| K | - - | 1190 | 1500 | | 1600 | | | |
| Y | $\times 10^{10}$ | | | | | | | |
| $\rho$ | $\times 10^{3}$ | | 5.9 | 5.9 | 5.9 | | | |
| $\bar{c}_{33}$ | $\times 10^{10}$ | | | | | | | |
| $d_{15}$ | $\times 10^{-12}$ | | | | | | | |
| $d_{31}$ | $\times 10^{-12}$ | -56.6 | | -91 | -90 | | | |
| $d_{33}$ | $\times 10^{-12}$ | | | | 220 | | | |
| $\epsilon_{33}^{T}$ | $\times \epsilon_o$ | | | | 1500 | | | |
| $g_{31}$ | $\times 10^{-3}$ | | | | -6.8 | | | |
| $g_{33}$ | $\times 10^{-3}$ | | | | 16.5 | | | |
| $k_{15}$ | - - | | | | | | | |
| $k_{31}$ | - - | | | | 0.22 | | | |
| $k_{33}$ | - - | | | | 0.55 | | | |
| $k_r$ | - - | 0.27 | 0.38 | 0.38 | 0.38 | | | |
| $s_{11}^{E}$ | $\times 10^{-12}$ | | | 11.5 | 11.5 | | | |
| $s_{12}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{13}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{33}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{44}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| Q | - - | | | | | | | |

MATERIAL: Lead Niobate (55%) Barium Niobate (45%)

| Property \ Reference | | 34 | 40 | | | | | |
|---|---|---|---|---|---|---|---|---|
| $T_C$ | - - | 250 | 250 | | | | | |
| K | - - | 1620 | 1600 | | | | | |
| Y | $x10^{10}$ | | | | | | | |
| $\rho$ | $x10^{3}$ | 5.8 | | | | | | |
| $c_{33}^{D}$ | $x10^{10}$ | | | | | | | |
| $d_{15}$ | $x10^{-12}$ | | | | | | | |
| $d_{31}$ | $x10^{-12}$ | | -74 | | | | | |
| $d_{33}$ | $x10^{-12}$ | | | | | | | |
| $\epsilon_{33}^{T}$ | $x\epsilon_o$ | | | | | | | |
| $g_{31}$ | $x10^{-3}$ | | | | | | | |
| $g_{33}$ | $x10^{-3}$ | | | | | | | |
| $k_{15}$ | - - | | | | | | | |
| $k_{31}$ | - - | | | | | | | |
| $k_{33}$ | - - | | | | | | | |
| $k_r$ | - - | 0.35 | 0.37 | | | | | |
| $s_{11}^{E}$ | $x10^{-12}$ | | | | | | | |
| $s_{12}^{E}$ | $x10^{-12}$ | | | | | | | |
| $s_{13}^{E}$ | $x10^{-12}$ | | | | | | | |
| $s_{33}^{E}$ | $x10^{-12}$ | | | | | | | |
| $s_{44}^{E}$ | $x10^{-12}$ | | | | | | | |
| Q | - - | 230 | 260 | | | | | |

**MATERIAL:** Lead Niobate (90%) Barium Titanate (10%)

| Property \ Reference | | 34 | 40 | | | | | |
|---|---|---|---|---|---|---|---|---|
| $T_C$ | - - | 495 | 500 | | | | | |
| K | - - | 250 | 250 | | | | | |
| Y | $\times 10^{10}$ | | | | | | | |
| $\rho$ | $\times 10^{3}$ | 5.6 | 5.6 | | | | | |
| $c_{33}^D$ | $\times 10^{10}$ | | | | | | | |
| $d_{15}$ | $\times 10^{-12}$ | | | | | | | |
| $d_{31}$ | $\times 10^{-12}$ | | -21 | | | | | |
| $d_{33}$ | $\times 10^{-12}$ | | | | | | | |
| $\epsilon_{33}^T$ | $\times \epsilon_o$ | | | | | | | |
| $g_{31}$ | $\times 10^{-3}$ | | | | | | | |
| $g_{33}$ | $\times 10^{-3}$ | | | | | | | |
| $k_{15}$ | - - | | | | | | | |
| $k_{31}$ | - - | | | | | | | |
| $k_{33}$ | - - | 0.3 | | | | | | |
| $k_r$ | - - | | 0.20 | | | | | |
| $s_{11}^E$ | $\times 10^{-12}$ | | 14.0 | | | | | |
| $s_{12}^E$ | $\times 10^{-12}$ | | | | | | | |
| $s_{13}^E$ | $\times 10^{-12}$ | | | | | | | |
| $s_{33}^E$ | $\times 10^{-12}$ | | | | | | | |
| $s_{44}^E$ | $\times 10^{-12}$ | | | | | | | |
| Q | - - | 8 | 5 | | | | | |

MATERIAL: Lead Niobate (70%) Barium Titanate (30%)

| Property \ Reference | | 34 | | | | | | |
|---|---|---|---|---|---|---|---|---|
| $T_C$ | - - | 285 | | | | | | |
| K | - - | 860 | | | | | | |
| Y | $\times 10^{10}$ | | | | | | | |
| $\rho$ | $\times 10^{3}$ | 5.88 | | | | | | |
| $c_{33}^D$ | $\times 10^{10}$ | | | | | | | |
| $d_{15}$ | $\times 10^{-12}$ | | | | | | | |
| $d_{31}$ | $\times 10^{-12}$ | | | | | | | |
| $d_{33}$ | $\times 10^{-12}$ | | | | | | | |
| $\epsilon_{33}^T$ | $\times \epsilon_o$ | | | | | | | |
| $g_{31}$ | $\times 10^{-3}$ | | | | | | | |
| $g_{33}$ | $\times 10^{-3}$ | | | | | | | |
| $k_{15}$ | - - | | | | | | | |
| $k_{31}$ | - - | | | | | | | |
| $k_{33}$ | - - | | | | | | | |
| $k_r$ | - - | 0.22 | | | | | | |
| $s_{11}^E$ | $\times 10^{-12}$ | | | | | | | |
| $s_{12}^E$ | $\times 10^{-12}$ | | | | | | | |
| $s_{13}^E$ | $\times 10^{-12}$ | | | | | | | |
| $s_{33}^E$ | $\times 10^{-12}$ | | | | | | | |
| $s_{44}^E$ | $\times 10^{-12}$ | | | | | | | |
| Q | - - | 675 | | | | | | |

**MATERIAL:** Lead Niobate (70%) Barium Zirconate (30%)

| Property \ Reference | | 34 | | | | | | |
|---|---|---|---|---|---|---|---|---|
| $T_C$ | - - | 125 | | | | | | |
| K | - - | 1820 | | | | | | |
| Y | $\times 10^{10}$ | | | | | | | |
| $\rho$ | $\times 10^{3}$ | 5.94 | | | | | | |
| $c_{33}^{D}$ | $\times 10^{10}$ | | | | | | | |
| $d_{15}$ | $\times 10^{-12}$ | | | | | | | |
| $d_{31}$ | $\times 10^{-12}$ | | | | | | | |
| $d_{33}$ | $\times 10^{-12}$ | | | | | | | |
| $\epsilon_{33}^{T}$ | $\times \epsilon_o$ | | | | | | | |
| $g_{31}$ | $\times 10^{-3}$ | | | | | | | |
| $g_{33}$ | $\times 10^{-3}$ | | | | | | | |
| $k_{15}$ | - - | | | | | | | |
| $k_{31}$ | - - | | | | | | | |
| $k_{33}$ | - - | | | | | | | |
| $k_r$ | - - | 0.10 | | | | | | |
| $s_{11}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{12}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{13}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{33}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{44}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| Q | - - | 56 | | | | | | |

MATERIAL: Lead Niobate (70%) Cadmium Niobate (30%)

| Property \ Reference | | 34 | 34 | | | | | |
|---|---|---|---|---|---|---|---|---|
| $T_C$ | - - | 485 | 355 | | | | | |
| K | - - | 182 | 320 | | | | | |
| Y | $\times 10^{10}$ | | | | | | | |
| $\rho$ | $\times 10^{3}$ | 5.55 | 5.60 | | | | | |
| $c_{33}^{D}$ | $\times 10^{10}$ | | | | | | | |
| $d_{15}$ | $\times 10^{-12}$ | | | | | | | |
| $d_{31}$ | $\times 10^{-12}$ | | | | | | | |
| $d_{33}$ | $\times 10^{-12}$ | | | | | | | |
| $\epsilon_{33}^{T}$ | $\times \epsilon_o$ | | | | | | | |
| $g_{31}$ | $\times 10^{-3}$ | | | | | | | |
| $g_{33}$ | $\times 10^{-3}$ | | | | | | | |
| $k_{15}$ | - - | | | | | | | |
| $k_{31}$ | - - | | | | | | | |
| $k_{33}$ | - - | | | | | | | |
| $k_r$ | - - | | | | | | | |
| $s_{11}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{12}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{13}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{33}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{44}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| Q | - - | | | | | | | |

**MATERIAL:** Lead Niobate (70%) Niobium Oxide (30%)

| Property \ Reference | | 34 | | | | | | |
|---|---|---|---|---|---|---|---|---|
| $T_C$ | - - | 570 | | | | | | |
| K | - - | 550 | | | | | | |
| Y | $\times 10^{10}$ | | | | | | | |
| $\rho$ | $\times 10^{3}$ | 5.56 | | | | | | |
| $c_{33}^{D}$ | $\times 10^{10}$ | | | | | | | |
| $d_{15}$ | $\times 10^{-12}$ | | | | | | | |
| $d_{31}$ | $\times 10^{-12}$ | | | | | | | |
| $d_{33}$ | $\times 10^{-12}$ | | | | | | | |
| $\epsilon_{33}^{T}$ | $\times \epsilon_o$ | | | | | | | |
| $g_{31}$ | $\times 10^{-3}$ | | | | | | | |
| $g_{33}$ | $\times 10^{-3}$ | | | | | | | |
| $k_{15}$ | - - | | | | | | | |
| $k_{31}$ | - - | | | | | | | |
| $k_{33}$ | - - | | | | | | | |
| $k_r$ | - - | 0.05 | | | | | | |
| $s_{11}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{12}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{13}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{33}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{44}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| Q | - - | 575 | | | | | | |

**MATERIAL:** Lead Niobate (90%) Strontium Niobate (10%)

| Property \ Reference | | 34 | | | | | | |
|---|---|---|---|---|---|---|---|---|
| $T_C$ | - - | 600 | | | | | | |
| K | - - | 212 | | | | | | |
| Y | $\times 10^{10}$ | | | | | | | |
| $\rho$ | $\times 10^{3}$ | 5.60 | | | | | | |
| $c_{33}^D$ | $\times 10^{10}$ | | | | | | | |
| $d_{15}$ | $\times 10^{-12}$ | | | | | | | |
| $d_{31}$ | $\times 10^{-12}$ | | | | | | | |
| $d_{33}$ | $\times 10^{-12}$ | | | | | | | |
| $\epsilon_{33}^T$ | $\times \epsilon_o$ | | | | | | | |
| $g_{31}$ | $\times 10^{-3}$ | | | | | | | |
| $g_{33}$ | $\times 10^{-3}$ | | | | | | | |
| $k_{15}$ | - - | | | | | | | |
| $k_{31}$ | - - | | | | | | | |
| $k_{33}$ | - - | | | | | | | |
| $k_r$ | - - | 0.12 | | | | | | |
| $s_{11}^E$ | $\times 10^{-12}$ | | | | | | | |
| $s_{12}^E$ | $\times 10^{-12}$ | | | | | | | |
| $s_{13}^E$ | $\times 10^{-12}$ | | | | | | | |
| $s_{33}^E$ | $\times 10^{-12}$ | | | | | | | |
| $s_{44}^E$ | $\times 10^{-12}$ | | | | | | | |
| Q | - - | 10 | | | | | | |

**MATERIAL:** Lead Niobate (80%) Strontium Niobate (20%)

| Property | | Reference 17 | | | | | | |
|---|---|---|---|---|---|---|---|---|
| $T_C$ | - - | 450 | | | | | | |
| K | - - | 440 | | | | | | |
| Y | $\times 10^{10}$ | | | | | | | |
| $\rho$ | $\times 10^{3}$ | | | | | | | |
| $c_{33}^{D}$ | $\times 10^{10}$ | | | | | | | |
| $d_{15}$ | $\times 10^{-12}$ | | | | | | | |
| $d_{31}$ | $\times 10^{-12}$ | -43.3 | | | | | | |
| $d_{33}$ | $\times 10^{-12}$ | | | | | | | |
| $\epsilon_{33}$ | $\times \epsilon_o$ | | | | | | | |
| $g_{31}$ | $\times 10^{-3}$ | | | | | | | |
| $g_{33}$ | $\times 10^{-3}$ | | | | | | | |
| $k_{15}$ | - - | | | | | | | |
| $k_{31}$ | - - | | | | | | | |
| $k_{33}$ | - - | | | | | | | |
| $k_r$ | - - | 0.26 | | | | | | |
| $s_{11}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{12}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{13}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{33}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{44}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| Q | - - | | | | | | | |

**MATERIAL:** Lead Niobate (70%) Strontium Niobate (30%)

| Property \ Reference | | 17 | 34 | | | | | |
|---|---|---|---|---|---|---|---|---|
| $T_C$ | - - | 380 | 400 | | | | | |
| K | - - | 502 | 1030 | | | | | |
| Y | $\times 10^{10}$ | | | | | | | |
| $\rho$ | $\times 10^{3}$ | | 5.65 | | | | | |
| $c_{33}^D$ | $\times 10^{10}$ | | | | | | | |
| $d_{15}$ | $\times 10^{-12}$ | | | | | | | |
| $d_{31}$ | $\times 10^{-12}$ | -53.3 | | | | | | |
| $d_{33}$ | $\times 10^{-12}$ | | | | | | | |
| $\epsilon_{33}^T$ | $\times \epsilon_o$ | | | | | | | |
| $g_{31}$ | $\times 10^{-3}$ | | | | | | | |
| $g_{33}$ | $\times 10^{-3}$ | | | | | | | |
| $k_{15}$ | - - | | | | | | | |
| $k_{31}$ | - - | | | | | | | |
| $k_{33}$ | - - | | | | | | | |
| $k_r$ | - - | 0.31 | 0.15 | | | | | |
| $s_{11}^E$ | $\times 10^{-12}$ | | | | | | | |
| $s_{12}^E$ | $\times 10^{-12}$ | | | | | | | |
| $s_{13}^E$ | $\times 10^{-12}$ | | | | | | | |
| $s_{33}^E$ | $\times 10^{-12}$ | | | | | | | |
| $s_{44}^E$ | $\times 10^{-12}$ | | | | | | | |
| Q | - - | | 38 | | | | | |

**MATERIAL:** Lead Niobate (60%) Strontium Niobate (40%)

| Property | | Reference 17 | | | | | | |
|---|---|---|---|---|---|---|---|---|
| $T_C$ | - - | 310 | | | | | | |
| K | - - | 755 | | | | | | |
| Y | $\times 10^{10}$ | | | | | | | |
| $\rho$ | $\times 10^{3}$ | | | | | | | |
| $c_{33}^D$ | $\times 10^{10}$ | | | | | | | |
| $d_{15}$ | $\times 10^{-12}$ | | | | | | | |
| $d_{31}$ | $\times 10^{-12}$ | -53.3 | | | | | | |
| $d_{33}$ | $\times 10^{-12}$ | | | | | | | |
| $\epsilon_{33}^T$ | $\times \epsilon_o$ | | | | | | | |
| $g_{31}$ | $\times 10^{-3}$ | | | | | | | |
| $g_{33}$ | $\times 10^{-3}$ | | | | | | | |
| $k_{15}$ | - - | | | | | | | |
| $k_{31}$ | - - | | | | | | | |
| $k_{33}$ | - - | | | | | | | |
| $k_r$ | - - | 0.26 | | | | | | |
| $s_{11}^E$ | $\times 10^{-12}$ | | | | | | | |
| $s_{12}^E$ | $\times 10^{-12}$ | | | | | | | |
| $s_{13}^E$ | $\times 10^{-12}$ | | | | | | | |
| $s_{33}^E$ | $\times 10^{-12}$ | | | | | | | |
| $s_{44}^E$ | $\times 10^{-12}$ | | | | | | | |
| Q | - - | | | | | | | |

MATERIAL: Lead Niobate (55%) Strontium Niobate (45%)

| Property | | Reference 17 | | | | | | |
|---|---|---|---|---|---|---|---|---|
| $T_C$ | - - | 250 | | | | | | |
| K | - - | 1060 | | | | | | |
| Y | $\times 10^{10}$ | | | | | | | |
| $\rho$ | $\times 10^{3}$ | | | | | | | |
| $c_{33}^D$ | $\times 10^{10}$ | | | | | | | |
| $d_{15}$ | $\times 10^{-12}$ | | | | | | | |
| $d_{31}$ | $\times 10^{-12}$ | -50.0 | | | | | | |
| $d_{33}$ | $\times 10^{-12}$ | | | | | | | |
| $\epsilon_{33}^T$ | $\times \epsilon_o$ | | | | | | | |
| $g_{31}$ | $\times 10^{-3}$ | | | | | | | |
| $g_{33}$ | $\times 10^{-3}$ | | | | | | | |
| $k_{15}$ | - - | | | | | | | |
| $k_{31}$ | - - | | | | | | | |
| $k_{33}$ | - - | | | | | | | |
| $k_r$ | - - | 0.22 | | | | | | |
| $s_{11}^E$ | $\times 10^{-12}$ | | | | | | | |
| $s_{12}^E$ | $\times 10^{-12}$ | | | | | | | |
| $s_{13}^E$ | $\times 10^{-12}$ | | | | | | | |
| $s_{33}^E$ | $\times 10^{-12}$ | | | | | | | |
| $s_{44}^E$ | $\times 10^{-12}$ | | | | | | | |
| Q | - - | | | | | | | |

**MATERIAL:** Lead-Tin Oxide (60%) Lead Titanate (40%)

| Property | | Reference 8 | | | | | | |
|---|---|---|---|---|---|---|---|---|
| $T_C$ | - - | 225 | | | | | | |
| K | - - | 776 | | | | | | |
| Y | $\times 10^{10}$ | | | | | | | |
| $\rho$ | $\times 10^{3}$ | 8.2 | | | | | | |
| $c_{33}^{D}$ | $\times 10^{10}$ | | | | | | | |
| $d_{15}$ | $\times 10^{-12}$ | | | | | | | |
| $d_{31}$ | $\times 10^{-12}$ | -28 | | | | | | |
| $d_{33}$ | $\times 10^{-12}$ | | | | | | | |
| $\epsilon_{33}^{T}$ | $\times \epsilon_o$ | | | | | | | |
| $g_{31}$ | $\times 10^{-3}$ | -5.0 | | | | | | |
| $g_{33}$ | $\times 10^{-3}$ | | | | | | | |
| $k_{15}$ | - - | | | | | | | |
| $k_{31}$ | - - | | | | | | | |
| $k_{33}$ | - - | | | | | | | |
| $k_r$ | - - | 0.20 | | | | | | |
| $s_{11}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{12}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{13}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{33}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{44}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| Q | - - | | | | | | | |

**MATERIAL:** Lead-Tin Oxide (55%) Lead Titanate (45%)

| Property \ Reference | | 8 | | | | | | |
|---|---|---|---|---|---|---|---|---|
| $T_C$ | - - | 235 | | | | | | |
| K | - - | 1260 | | | | | | |
| Y | $\times 10^{10}$ | | | | | | | |
| $\rho$ | $\times 10^{3}$ | 8.0 | | | | | | |
| $c_{33}^{D}$ | $\times 10^{10}$ | | | | | | | |
| $d_{15}$ | $\times 10^{-12}$ | | | | | | | |
| $d_{31}$ | $\times 10^{-12}$ | -46 | | | | | | |
| $d_{33}$ | $\times 10^{-12}$ | | | | | | | |
| $\epsilon_{33}^{T}$ | $\times \epsilon_o$ | | | | | | | |
| $g_{31}$ | $\times 10^{-3}$ | -5.1 | | | | | | |
| $g_{33}$ | $\times 10^{-3}$ | | | | | | | |
| $k_{15}$ | - - | | | | | | | |
| $k_{31}$ | - - | | | | | | | |
| $k_{33}$ | - - | | | | | | | |
| $k_r$ | - - | 0.25 | | | | | | |
| $s_{11}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{12}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{13}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{33}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{44}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| Q | - - | | | | | | | |

**MATERIAL:** Lead Titanate (52%) Lead Zirconate (48%)

| Property \ Reference | | 29 | | | | | | |
|---|---|---|---|---|---|---|---|---|
| $T_C$ | - - | | | | | | | |
| K | - - | | | | | | | |
| Y | $\times 10^{10}$ | | | | | | | |
| $\rho$ | $\times 10^{3}$ | 7.9 | | | | | | |
| $c_{33}^D$ | $\times 10^{10}$ | 14.0 | | | | | | |
| $d_{15}$ | $\times 10^{-12}$ | 166 | | | | | | |
| $d_{31}$ | $\times 10^{-12}$ | -43.0 | | | | | | |
| $d_{33}$ | $\times 10^{-12}$ | 110 | | | | | | |
| $\epsilon_{33}^T$ | $\times \epsilon_o$ | | | | | | | |
| $g_{31}$ | $\times 10^{-3}$ | -7.3 | | | | | | |
| $g_{33}$ | $\times 10^{-3}$ | 18.7 | | | | | | |
| $k_{15}$ | - - | 0.408 | | | | | | |
| $k_{31}$ | - - | 0.170 | | | | | | |
| $k_{33}$ | - - | 0.435 | | | | | | |
| $k_r$ | - - | 0.289 | | | | | | |
| $s_{11}^E$ | $\times 10^{-12}$ | 10.8 | | | | | | |
| $s_{12}^E$ | $\times 10^{-12}$ | -3.35 | | | | | | |
| $s_{13}^E$ | $\times 10^{-12}$ | -3.21 | | | | | | |
| $s_{33}^E$ | $\times 10^{-12}$ | 10.9 | | | | | | |
| $s_{44}^E$ | $\times 10^{-12}$ | 28.3 | | | | | | |
| Q | - - | 1170 | | | | | | |

MATERIAL: Lead Titanate (50%) Lead Zirconate (50%)

| Property \ Reference | | 8 | 29 | | | | | |
|---|---|---|---|---|---|---|---|---|
| $T_C$ | - - | 400 | | | | | | |
| K | - | 641 | | | | | | |
| Y | $\times 10^{10}$ | | | | | | | |
| $\rho$ | $\times 10^{3}$ | 7.1 | 7.55 | | | | | |
| $c_{33}^D$ | $\times 10^{10}$ | | 13.5 | | | | | |
| $d_{15}$ | $\times 10^{-12}$ | | 166 | | | | | |
| $d_{31}$ | $\times 10^{-12}$ | | -43.0 | | | | | |
| $d_{33}$ | $\times 10^{-12}$ | | 110 | | | | | |
| $\epsilon_{33}^T$ | $\times \epsilon_o$ | | | | | | | |
| $g_{31}$ | $\times 10^{-3}$ | | -9.35 | | | | | |
| $g_{33}$ | $\times 10^{-3}$ | | 23.1 | | | | | |
| $k_{15}$ | - - | | 0.504 | | | | | |
| $k_{31}$ | - - | | 0.230 | | | | | |
| $k_{33}$ | - - | | 0.546 | | | | | |
| $k_r$ | - - | | 0.397 | | | | | |
| $s_{11}^E$ | $\times 10^{-12}$ | | 12.4 | | | | | |
| $s_{12}^E$ | $\times 10^{-12}$ | | -3.35 | | | | | |
| $s_{13}^E$ | $\times 10^{-12}$ | | -4.22 | | | | | |
| $s_{33}^E$ | $\times 10^{-12}$ | | 13.3 | | | | | |
| $s_{44}^E$ | $\times 10^{-12}$ | | 32.8 | | | | | |
| Q | - - | | 950 | | | | | |

MATERIAL: PZT-4 (Lead Titanate - Lead Zirconate) (Clevite Corp.)

| Property \ Reference | | 18 | 24 | 37 | 2 | | | |
|---|---|---|---|---|---|---|---|---|
| $T_C$ | - - | 340 | 340 | 328 | | | | |
| K | - - | 1200 | | 1350 | 1200 | | | |
| Y | $\times 10^{10}$ | 8.1 | | | 8.15 | | | |
| $\rho$ | $\times 10^{3}$ | | 7.5 | 7.5 | | | | |
| $c_{33}^{D}$ | $\times 10^{10}$ | | 15. . | | | | | |
| $d_{15}$ | $\times 10^{-12}$ | | 256 | | | | | |
| $d_{31}$ | $\times 10^{-12}$ | -105 | -111 | -117 | -131 | | | |
| $d_{33}$ | $\times 10^{-12}$ | 250 | 450 | 270 | | | | |
| $\epsilon_{33}^{T}$ | $\times \epsilon_o$ | | 1885 | | | | | |
| $g_{31}$ | $\times 10^{-3}$ | | | | | | | |
| $g_{33}$ | $\times 10^{-3}$ | | | | | | | |
| $k_{15}$ | - - | | 0.65 | | | | | |
| $k_{31}$ | - - | 0.29 | ^ 31 | 0.31 | | | | |
| $k_{33}$ | - - | 0.63 | 0.64 | 0.64 | | | | |
| $k_r$ | - - | 0.50 | 0.52 | | | | | |
| $s_{11}^{E}$ | $\times 10^{-12}$ | | 12.3 | 11.8 | | | | |
| $s_{12}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{13}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{33}^{E}$ | $\times 10^{-12}$ | | 14.9 | 14.9 | | | | |
| $s_{44}^{E}$ | $\times 10^{-12}$ | | 38.4 | | | | | |
| Q | - - | 600 | 600 | 500 | | | | |

**MATERIAL:** PZT-5 (Lead Titanate - Lead Zirconate) (Clevite Corp.)

| Property | | Reference '4 | 25 | 37 | | | | |
|---|---|---|---|---|---|---|---|---|
| $T_C$ | - - | 360 | | 365 | | | | |
| K | - - | | 1500 | 1500 | | | | |
| Y | $\times 10^{10}$ | | 6.75 | | | | | |
| $\rho$ | $\times 10^{3}$ | 7.5 | | 7.55 | | | | |
| $c_{33}^{D}$ | $\times 10^{10}$ | 13.5 | | | | | | |
| $d_{15}$ | $\times 10^{-12}$ | 495 | | | | | | |
| $d_{31}$ | $\times 10^{-12}$ | -140 | | -140 | | | | |
| $d_{33}$ | $\times 10^{-12}$ | 320 | | 320 | | | | |
| $\epsilon^{T}$ | $\times \epsilon_o$ | 1690 | | | | | | |
| $g_{31}$ | $\times 10^{-3}$ | | | | | | | |
| $g_{33}$ | $\times 10^{-3}$ | | | | | | | |
| $k_{15}$ | - - | 0.655 | | | | | | |
| $k_{31}$ | - - | 0.32 | | 0.32 | | | | |
| $k_{33}$ | - - | 0.675 | | 0.675 | | | | |
| $k_r$ | - - | 0.54 | | | | | | |
| $s_{11}^{E}$ | $\times 10^{-12}$ | 14.8 | | 14.8 | | | | |
| $s_{12}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{13}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{33}^{E}$ | $\times 10^{-12}$ | 17.1 | | 17.1 | | | | |
| $s_{44}^{E}$ | $\times 10^{-12}$ | 50 | | | | | | |
| Q | - - | 75 | | | | | | |

MATERIAL: Lead Zirconate (53%) Lead Titanate (47%)

| Property \ Reference | | 20 | | | | | | |
|---|---|---|---|---|---|---|---|---|
| $T_C$ | - - | 385 | | | | | | |
| K | - - | 542 | | | | | | |
| Y | $\times 10^{10}$ | | | | | | | |
| $\rho$ | $\times 10^{3}$ | 7.40 | | | | | | |
| $c_{33}^D$ | $\times 10^{10}$ | | | | | | | |
| $d_{15}$ | $\times 10^{-12}$ | | | | | | | |
| $d_{31}$ | $\times 10^{-12}$ | -71 | | | | | | |
| $d_{33}$ | $\times 10^{-12}$ | | | | | | | |
| $\epsilon_{33}^T$ | $\times \epsilon_o$ | | | | | | | |
| $g_{31}$ | $\times 10^{-3}$ | -14.7 | | | | | | |
| $g_{33}$ | $\times 10^{-3}$ | | | | | | | |
| $k_{15}$ | - - | | | | | | | |
| $k_{31}$ | - - | | | | | | | |
| $k_{33}$ | - - | | | | | | | |
| $k_r$ | - - | 0.48 | | | | | | |
| $s_{11}^E$ | $\times 10^{-12}$ | | | | | | | |
| $s_{12}^E$ | $\times 10^{-12}$ | | | | | | | |
| $s_{13}^E$ | $\times 10^{-12}$ | | | | | | | |
| $s_{33}^E$ | $\times 10^{-12}$ | | | | | | | |
| $s_{44}^E$ | $\times 10^{-12}$ | | | | | | | |
| Q | - - | | | | | | | |

MATERIAL: Lead Zirconate (60%) Lead Titanate (40%)

| Property | | Reference 8 | 29 | | | | | |
|---|---|---|---|---|---|---|---|---|
| $T_C$ | - - | 350 | | | | | | |
| K | - - | 524 | | | | | | |
| Y | $\times 10^{10}$ | | | | | | | |
| $\rho$ | $\times 10^{3}$ | 7.3 | 7.60 | | | | | |
| $c_{33}^D$ | $\times 10^{10}$ | | 18.9 | | | | | |
| $d_{15}$ | $\times 10^{-12}$ | | 293 | | | | | |
| $d_{31}$ | $\times 10^{-12}$ | | -44.2 | | | | | |
| $d_{33}$ | $\times 10^{-12}$ | | 117 | | | | | |
| $\epsilon_{33}^T$ | $\times \epsilon_o$ | | | | | | | |
| $g_{31}$ | $\times 10^{-3}$ | | -13.3 | | | | | |
| $g_{33}$ | $\times 10^{-3}$ | | 35.2 | | | | | |
| $k_{15}$ | - - | | 0.625 | | | | | |
| $k_{31}$ | - - | | 0.238 | | | | | |
| $k_{33}$ | - - | | 0.585 | | | | | |
| $k_r$ | - - | | 0.400 | | | | | |
| $s_{11}^E$ | $\times 10^{-12}$ | | 10.4 | | | | | |
| $s_{12}^E$ | $\times 10^{-12}$ | | -2.96 | | | | | |
| $s_{13}^E$ | $\times 10^{-12}$ | | -3.72 | | | | | |
| $s_{33}^E$ | $\times 10^{-12}$ | | 12.05 | | | | | |
| $s_{44}^E$ | $\times 10^{-12}$ | | 36.9 | | | | | |
| Q | - - | | 430 | | | | | |

**MATERIAL:** Lead Zirconate (58%) Lead Titanate (42%)

| Property \ Reference | | 29 | | | | | | |
|---|---|---|---|---|---|---|---|---|
| $T_C$ | - - | | | | | | | |
| K | - - | | | | | | | |
| Y | $\times 10^{10}$ | | | | | | | |
| $\rho$ | $\times 10^{3}$ | 7.64 | | | | | | |
| $c_{33}^{D}$ | $\times 10^{10}$ | 15.8 | | | | | | |
| $d_{15}$ | $\times 10^{-12}$ | 325 | | | | | | |
| $d_{31}$ | $\times 10^{-12}$ | -48.9 | | | | | | |
| $d_{33}$ | $\times 10^{-12}$ | 129 | | | | | | |
| $\epsilon_{33}^{T}$ | $\times \epsilon_o$ | | | | | | | |
| $g_{31}$ | $\times 10^{-3}$ | -13.9 | | | | | | |
| $g_{33}$ | $\times 10^{-3}$ | 36.1 | | | | | | |
| $k_{15}$ | - - | 0.646 | | | | | | |
| $k_{31}$ | - - | 0.254 | | | | | | |
| $k_{33}$ | - - | 0.607 | | | | | | |
| $k_r$ | - - | 0.428 | | | | | | |
| $s_{11}^{E}$ | $\times 10^{-12}$ | 10.5 | | | | | | |
| $s_{12}^{E}$ | $\times 10^{-12}$ | -3.07 | | | | | | |
| $s_{13}^{E}$ | $\times 10^{-12}$ | -4.12 | | | | | | |
| $s_{33}^{E}$ | $\times 10^{-12}$ | 12.8 | | | | | | |
| $s_{44}^{E}$ | $\times 10^{-12}$ | 37.7 | | | | | | |
| Q | - - | 500 | | | | | | |

**MATERIAL:** Lead Zirconate (56%) Lead Titanate (44%)

| Property \ Reference | | 29 | | | | | | |
|---|---|---|---|---|---|---|---|---|
| $T_C$ | - - | | | | | | | |
| K | - - | | | | | | | |
| Y | $\times 10^{10}$ | | | | | | | |
| $\rho$ | $\times 10^{3}$ | 7.59 | | | | | | |
| $c_{33}^D$ | $\times 10^{10}$ | 15.3 | | | | | | |
| $d_{15}$ | $\times 10^{-12}$ | 357 | | | | | | |
| $d_{31}$ | $\times 10^{-12}$ | -54.3 | | | | | | |
| $d_{33}$ | $\times 10^{-12}$ | 142 | | | | | | |
| $\epsilon_{33}^T$ | $\times \epsilon_o$ | | | | | | | |
| $g_{31}$ | $\times 10^{-3}$ | -14.5 | | | | | | |
| $g_{33}$ | $\times 10^{-3}$ | 37.8 | | | | | | |
| $k_{15}$ | - - | 0.657 | | | | | | |
| $k_{31}$ | - - | 0.267 | | | | | | |
| $k_{33}$ | - - | 0.619 | | | | | | |
| $k_r$ | - - | 0.450 | | | | | | |
| $s_{11}^E$ | $\times 10^{-12}$ | 11.0 | | | | | | |
| $s_{12}^E$ | $\times 10^{-12}$ | -3.22 | | | | | | |
| $s_{13}^E$ | $\times 10^{-12}$ | -4.63 | | | | | | |
| $s_{33}^E$ | $\times 10^{-12}$ | 14.0 | | | | | | |
| $s_{44}^E$ | $\times 10^{-12}$ | 39.8 | | | | | | |
| Q | - - | 490 | | | | | | |

**MATERIAL:** Lead Zirconate (55%) Lead Titanate (45%)

| Property | | Reference 4 | 8 | 18 | | | | |
|---|---|---|---|---|---|---|---|---|
| $T_C$ | - - | | 330 | 350 | | | | |
| K | - - | 585 | 606 | 500 | | | | |
| Y | $x10^{10}$ | 7.5 | | 7 5 | | | | |
| $\rho$ | $x10^{3}$ | 7.1 | 7.2 | | | | | |
| $c_{33}^{D}$ | $x10^{10}$ | | | | | | | |
| $d_{15}$ | $x10^{-12}$ | | | | | | | |
| $d_{31}$ | $x10^{-12}$ | -50 | -56 | -56 | | | | |
| $d_{33}$ | $x10^{-12}$ | 130 | | 130 | | | | |
| $\epsilon_{33}^{T}$ | $x\epsilon_o$ | | | | | | | |
| $g_{31}$ | $x10^{-3}$ | -11.0 | -11.7 | | | | | |
| $g_{33}$ | $x10^{-3}$ | 29 | | | | | | |
| $k_{15}$ | - - | | | | | | | |
| $k_{31}$ | - - | 0.22 | | 0.23 | | | | |
| $k_{33}$ | - - | 0.5 to 0.6 | | 0.55 | | | | |
| $k_r$ | - - | 0.37 | 0.36 | 0.39 | | | | |
| $s_{11}^{E}$ | $x10^{-12}$ | | | | | | | |
| $s_{12}^{E}$ | $x10^{-12}$ | | | | | | | |
| $s_{13}^{E}$ | $x10^{-12}$ | | | | | | | |
| $s_{33}^{E}$ | $x10^{-12}$ | | | | | | | |
| $s_{44}^{E}$ | $x10^{-12}$ | | | | | | | |
| Q | - - | | | 300 | | | | |

| MATERIAL: Lead Zirconate (54%) Lead Titanate (46%) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Property \ Reference | | 26 | 29 | | | | | |
| $T_C$ | - - | 390 | | | | | | |
| K | - - | | | | | | | |
| Y | $\times 10^{10}$ | | | | | | | |
| $\rho$ | $\times 10^{3}$ | 7.41 | 7.62 | | | | | |
| $c_{33}^D$ | $\times 10^{10}$ | | 14.8 | | | | | |
| $d_{15}$ | $\times 10^{-12}$ | | 440 | | | | | |
| $d_{31}$ | $\times 10^{-12}$ | -71 | -60.2 | | | | | |
| $d_{33}$ | $\times 10^{-12}$ | | 152 | | | | | |
| $\epsilon_{33}^T$ | $\times \epsilon_o$ | | | | | | | |
| $g_{31}$ | $\times 10^{-3}$ | | -15.1 | | | | | |
| $g_{33}$ | $\times 10^{-3}$ | | 38.1 | | | | | |
| $k_{15}$ | - - | | 0.701 | | | | | |
| $k_{31}$ | - - | | 0.280 | | | | | |
| $k_{33}$ | - - | | 0.626 | | | | | |
| $k_r$ | - - | 0.49 | 0.470 | | | | | |
| $s_{11}^E$ | $\times 10^{-12}$ | | 11.6 | | | | | |
| $s_{12}^E$ | $\times 10^{-12}$ | | -3.33 | | | | | |
| $s_{13}^E$ | $\times 10^{-12}$ | | -4.97 | | | | | |
| $s_{33}^E$ | $\times 10^{-12}$ | | 14.8 | | | | | |
| $s_{44}^E$ | $\times 10^{-12}$ | | 45.0 | | | | | |
| Q | - - | | 680 | | | | | |

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**MATERIAL:** Lead Zirconate (52%) Lead Titanate (48%)

| Property \ Reference | | 29 | 42 | | | | | |
|---|---|---|---|---|---|---|---|---|
| $T_C$ | - - | | 370 | | | | | |
| K | - - | | | | | | | |
| Y | $\times 10^{10}$ | | | | | | | |
| $\rho$ | $\times 10^{3}$ | 7.55 | | | | | | |
| $c_{33}^D$ | $\times 10^{10}$ | 13.4 | | | | | | |
| $d_{15}$ | $\times 10^{-12}$ | 494 | | | | | | |
| $d_{31}$ | $\times 10^{-12}$ | -93.5 | | | | | | |
| $d_{33}$ | $\times 10^{-12}$ | 223 | | | | | | |
| $\epsilon_{33}^T$ | $\times \epsilon_o$ | 730 | 730 | | | | | |
| $g_{31}$ | $\times 10^{-3}$ | -14.5 | | | | | | |
| $g_{33}$ | $\times 10^{-3}$ | 34.5 | | | | | | |
| $k_{15}$ | - - | 0.694 | | | | | | |
| $k_{31}$ | - - | 0.313 | | | | | | |
| $k_{33}$ | - - | 0.670 | | | | | | |
| $k_r$ | - - | 0.529 | | | | | | |
| $s_{11}^E$ | $\times 10^{-12}$ | 13.8 | | | | | | |
| $s_{12}^E$ | $\times 10^{-12}$ | -4.07 | | | | | | |
| $s_{13}^E$ | $\times 10^{-12}$ | -5.80 | | | | | | |
| $s_{33}^E$ | $\times 10^{-12}$ | 17.1 | | | | | | |
| $s_{44}^E$ | $\times 10^{-12}$ | 48.2 | | | | | | |
| Q | - - | 860 | | | | | | |

**MATERIAL:** LZ-4A (Lead Zirconate - Lead Titanate) (Brush Electronics)

| Property | | Reference 38 | 42 | | | | | |
|---|---|---|---|---|---|---|---|---|
| $T_C$ | - - | | 320 | | | | | |
| K | - - | 1200 | | | | | | |
| Y | $\times 10^{10}$ | | | | | | | |
| $\rho$ | $\times 10^{3}$ | 7.6 | | | | | | |
| $c_{33}^D$ | $\times 10^{10}$ | | | | | | | |
| $d_{15}$ | $\times 10^{-12}$ | | | | | | | |
| $d_{31}$ | $\times 10^{-12}$ | -130 | | | | | | |
| $d_{33}$ | $\times 10^{-12}$ | 300 | | | | | | |
| $\epsilon_{33}^T$ | $\times \epsilon_o$ | | 1200 | | | | | |
| $g_{31}$ | $\times 10^{-3}$ | | -12.3 | | | | | |
| $g_{33}$ | $\times 10^{-3}$ | | 28.3 | | | | | |
| $k_{15}$ | - - | | | | | | | |
| $k_{31}$ | - - | 0.30 | | | | | | |
| $k_{33}$ | - - | 0.76 | | | | | | |
| $k_r$ | - - | 0.55 | | | | | | |
| $s_{11}^E$ | $\times 10^{-12}$ | 14.6 | | | | | | |
| $s_{12}^E$ | $\times 10^{-12}$ | | | | | | | |
| $s_{13}^E$ | $\times 10^{-12}$ | | | | | | | |
| $s_{33}^E$ | $\times 10^{-12}$ | 14.8 | | | | | | |
| $s_{44}^E$ | $\times 10^{-12}$ | | | | | | | |
| Q | - - | 500 | | | | | | |

**MATERIAL:** LZ-5A (Lead Zirconate - Lead Titanate)
(Brush Electronics)

| Property | | Reference 38 | 42 | | | | | |
|---|---|---|---|---|---|---|---|---|
| $T_C$ | - - | | 350 | | | | | |
| K | - - | 1500 | | | | | | |
| Y | $\times 10^{10}$ | | | | | | | |
| $\rho$ | $\times 10^{3}$ | 7.5 | | | | | | |
| $c_{33}^{D}$ | $\times 10^{10}$ | 13.5 | | | | | | |
| $d_{15}$ | $\times 10^{-12}$ | | | | | | | |
| $d_{31}$ | $\times 10^{-12}$ | -140 | | | | | | |
| $d_{33}$ | $\times 10^{-12}$ | 320 | | | | | | |
| $\epsilon_{33}^{T}$ | $\times \epsilon_o$ | | 1500 | | | | | |
| $g_{31}$ | $\times 10^{-3}$ | | -10.6 | | | | | |
| $g_{33}$ | $\times 10^{-3}$ | | 24.4 | | | | | |
| $k_{15}$ | - - | | | | | | | |
| $k_{31}$ | - - | 0.32 | 0.32 | | | | | |
| $k_{33}$ | - - | 0.68 | 0.68 | | | | | |
| $k_r$ | - - | 0.54 | 0.54 | | | | | |
| $s_{11}^{E}$ | $\times 10^{-12}$ | 14.7 | 14.8 | | | | | |
| $s_{12}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{13}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{33}^{E}$ | $\times 10^{-12}$ | 16.9 | | | | | | |
| $s_{44}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| Q | - - | 75 | | | | | | |

| MATERIAL: LZ-6 (Lead Zirconate - Lead Titanate) (Brush Electronics) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Property \ Reference | | 38 | | | | | | |
| $T_C$ | - - | | | | | | | |
| K | - - | 1075 | | | | | | |
| Y | $\times 10^{10}$ | | | | | | | |
| $\rho$ | $\times 10^{3}$ | 7.5 | | | | | | |
| $c_{33}^{D}$ | $\times 10^{10}$ | | | | | | | |
| $d_{15}$ | $\times 10^{-12}$ | | | | | | | |
| $d_{31}$ | $\times 10^{-12}$ | -78 | | | | | | |
| $d_{33}$ | $\times 10^{-12}$ | 191 | | | | | | |
| $\epsilon_{33}^{T}$ | $\times \epsilon_o$ | | | | | | | |
| $g_{31}$ | $\times 10^{-3}$ | | | | | | | |
| $g_{33}$ | $\times 10^{-3}$ | | | | | | | |
| $k_{15}$ | - - | | | | | | | |
| $k_{31}$ | - - | 0.229 | | | | | | |
| $k_{33}$ | - - | 0.54 | | | | | | |
| $k_r$ | - - | 0.39 | | | | | | |
| $s_{11}^{E}$ | $\times 10^{-12}$ | 11.5 | | | | | | |
| $s_{12}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{13}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{33}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{44}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| Q | - - | 340 | | | | | | |

**MATERIAL:** Potassium Niobate (50%) Sodium Niobate (50%)

| Property \ Reference | | 23 | | | | | | |
|---|---|---|---|---|---|---|---|---|
| $T_C$ | - - | 410 | | | | | | |
| K | - - | 294 | | | | | | |
| Y | $\times 10^{10}$ | 10.4 | | | | | | |
| $\rho$ | $\times 10^{3}$ | 4.3 | | | | | | |
| $c_{33}^D$ | $\times 10^{10}$ | | | | | | | |
| $d_{15}$ | $\times 10^{-12}$ | | | | | | | |
| $d_{31}$ | $\times 10^{-12}$ | -32 | | | | | | |
| $d_{33}$ | $\times 10^{-12}$ | 80 | | | | | | |
| $\epsilon_{33}^T$ | $\times \epsilon_o$ | | | | | | | |
| $g_{31}$ | $\times 10^{-3}$ | | | | | | | |
| $g_{33}$ | $\times 10^{-3}$ | 32 | | | | | | |
| $k_{15}$ | - - | | | | | | | |
| $k_{31}$ | - - | 0.21 | | | | | | |
| $k_{33}$ | - - | 0.51 | | | | | | |
| $k_r$ | - - | 0.34 | | | | | | |
| $s_{11}^E$ | $\times 10^{-12}$ | | | | | | | |
| $s_{12}^E$ | $\times 10^{-12}$ | | | | | | | |
| $s_{13}^E$ | $\times 10^{-12}$ | | | | | | | |
| $s_{33}^E$ | $\times 10^{-12}$ | | | | | | | |
| $s_{44}^E$ | $\times 10^{-12}$ | | | | | | | |
| Q | - - | 140 | | | | | | |

**MATERIAL:** Sodium Niobate (95%) Cadmium Niobate (5%)

| Property \ Reference | | 40 | | | | | | |
|---|---|---|---|---|---|---|---|---|
| $T_C$ | - - | 375 | | | | | | |
| K | - - | 600 | | | | | | |
| Y | $\times 10^{10}$ | | | | | | | |
| $\rho$ | $\times 10^{3}$ | 4.2 | | | | | | |
| $c_{33}^{D}$ | $\times 10^{10}$ | | | | | | | |
| $d_{15}$ | $\times 10^{-12}$ | | | | | | | |
| $d_{31}$ | $\times 10^{-12}$ | -6 | | | | | | |
| $d_{33}$ | $\times 10^{-12}$ | | | | | | | |
| $\epsilon_{33}^{T}$ | $\times \epsilon_o$ | | | | | | | |
| $g_{31}$ | $\times 10^{-3}$ | | | | | | | |
| $g_{33}$ | $\times 10^{-3}$ | | | | | | | |
| $k_{15}$ | - - | | | | | | | |
| $k_{31}$ | - - | | | | | | | |
| $k_{33}$ | - - | | | | | | | |
| $k_r$ | - - | 0.04 | | | | | | |
| $s_{11}^{E}$ | $\times 10^{-12}$ | 11.9 | | | | | | |
| $s_{12}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{13}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{33}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{44}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| Q | - - | | | | | | | |

**MATERIAL:** Sodium Niobate (90%) Cadmium Niobate (10%)

| Property \ Reference | | 40 | | | | | | |
|---|---|---|---|---|---|---|---|---|
| $T_C$ | - - | 330 | | | | | | |
| K | - - | 950 | | | | | | |
| Y | $\times 10^{10}$ | | | | | | | |
| $\rho$ | $\times 10^{3}$ | 4.3 | | | | | | |
| $c_{33}^{D}$ | $\times 10^{10}$ | | | | | | | |
| $d_{15}$ | $\times 10^{-12}$ | | | | | | | |
| $d_{31}$ | $\times 10^{-12}$ | -22 | | | | | | |
| $d_{33}$ | $\times 10^{-12}$ | | | | | | | |
| $\epsilon_{33}^{T}$ | $\times \epsilon_o$ | | | | | | | |
| $g_{31}$ | $\times 10^{-3}$ | | | | | | | |
| $g_{33}$ | $\times 10^{-3}$ | | | | | | | |
| $k_{15}$ | - - | | | | | | | |
| $k_{31}$ | - - | | | | | | | |
| $k_{33}$ | - - | | | | | | | |
| $k_r$ | - - | 0.11 | | | | | | |
| $s_{11}^{E}$ | $\times 10^{-12}$ | 11.6 | | | | | | |
| $s_{12}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{13}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{33}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{44}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| Q | - - | | | | | | | |

**MATERIAL:** Sodium Niobate (89%) Cadmium Niobate (11%)

| Property \ Reference | | 18 | | | | | | |
|---|---|---|---|---|---|---|---|---|
| $T_C$ | - - | 220 | | | | | | |
| K | - - | 2000 | | | | | | |
| Y | $\times 10^{10}$ | 11 | | | | | | |
| $\rho$ | $\times 10^{3}$ | | | | | | | |
| $c_{33}^{D}$ | $\times 10^{10}$ | | | | | | | |
| $d_{15}$ | $\times 10^{-12}$ | | | | | | | |
| $d_{31}$ | $\times 10^{-12}$ | 70 | | | | | | |
| $d_{33}$ | $\times 10^{-12}$ | 175 | | | | | | |
| $\epsilon_{33}^{T}$ | $\times \epsilon_o$ | | | | | | | |
| $g_{31}$ | $\times 10^{-3}$ | | | | | | | |
| $g_{33}$ | $\times 10^{-3}$ | | | | | | | |
| $k_{15}$ | - - | | | | | | | |
| $k_{31}$ | - - | 0.18 | | | | | | |
| $k_{33}$ | - - | | | | | | | |
| $k_r$ | - - | 0.30 | | | | | | |
| $s_{11}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{12}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{13}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{33}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{44}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| Q | - - | 300 | | | | | | |

| MATERIAL: Sodium Niobate (85%) Cadmium Niobate (15%) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Property \ Reference | | 40 | | | | | | |
| $T_C$ | - - | 285 | | | | | | |
| K | - - | 1350 | | | | | | |
| Y | $\times 10^{10}$ | | | | | | | |
| $\rho$ | $\times 10^{3}$ | 4.3 | | | | | | |
| $c_{33}^D$ | $\times 10^{10}$ | | | | | | | |
| $d_{15}$ | $\times 10^{-12}$ | | | | | | | |
| $d_{31}$ | $\times 10^{-12}$ | -40 | | | | | | |
| $d_{33}$ | $\times 10^{-12}$ | | | | | | | |
| $\epsilon_{33}^T$ | $\times \epsilon_o$ | | | | | | | |
| $g_{31}$ | $\times 10^{-3}$ | | | | | | | |
| $g_{33}$ | $\times 10^{-3}$ | | | | | | | |
| $k_{15}$ | - - | | | | | | | |
| $k_{31}$ | - - | | | | | | | |
| $k_{33}$ | - - | | | | | | | |
| $k_r$ | - - | 0.18 | | | | | | |
| $s_{11}^E$ | $\times 10^{-12}$ | 11.6 | | | | | | |
| $s_{12}^E$ | $\times 10^{-12}$ | | | | | | | |
| $s_{13}^E$ | $\times 10^{-12}$ | | | | | | | |
| $s_{33}^E$ | $\times 10^{-12}$ | | | | | | | |
| $s_{44}^E$ | $\times 10^{-12}$ | | | | | | | |
| Q | - - | | | | | | | |

**MATERIAL:** Sodium Niobate (80%) Cadmium Niobate (20%)

| Property \ Reference | | 40 | 42 | | | | | |
|---|---|---|---|---|---|---|---|---|
| $T_C$ | - - | 240 | 240 | | | | | |
| K | - - | | | | | | | |
| Y | $\times 10^{10}$ | | | | | | | |
| $\rho$ | $\times 10^{3}$ | 4.3 | 4.3 | | | | | |
| $c_{33}^D$ | $\times 10^{10}$ | | | | | | | |
| $d_{15}$ | $\times 10^{-12}$ | | | | | | | |
| $d_{31}$ | $\times 10^{-12}$ | | -80 | | | | | |
| $d_{33}$ | $\times 10^{-12}$ | | 200 | | | | | |
| $\epsilon_{33}^T$ | $\times \epsilon_o$ | | 2000 | | | | | |
| $g_{31}$ | $\times 10^{-3}$ | | -4.5 | | | | | |
| $g_{33}$ | $\times 10^{-3}$ | | 8.5 | | | | | |
| $k_{15}$ | - - | | | | | | | |
| $k_{31}$ | - - | | 0.17 | | | | | |
| $k_{33}$ | - - | | 0.42 | | | | | |
| $k_r$ | - - | | 0.30 | | | | | |
| $s_{11}^E$ | $\times 10^{-12}$ | | 10.5 | | | | | |
| $s_{12}^E$ | $\times 10^{-12}$ | | | | | | | |
| $s_{13}^E$ | $\times 10^{-12}$ | | | | | | | |
| $s_{33}^E$ | $\times 10^{-12}$ | | | | | | | |
| $s_{44}^E$ | $\times 10^{-12}$ | | | | | | | |
| Q | - - | | | | | | | |

**MATERIAL:** Sodium Niobate (75%) Cadmium Niobate (25%)

| Property \ Reference | | 40 | 42 | | | | | |
|---|---|---|---|---|---|---|---|---|
| $T_C$ | - - | 200 | 200 | | | | | |
| K | - - | | | | | | | |
| Y | $\times 10^{10}$ | | | | | | | |
| $\rho$ | $\times 10^{3}$ | 4.4 | 4.4 | | | | | |
| $c_{33}^{D}$ | $\times 10^{10}$ | | | | | | | |
| $d_{15}$ | $\times 10^{-12}$ | | | | | | | |
| $d_{31}$ | $\times 10^{-12}$ | -60 | -60 | | | | | |
| $d_{33}$ | $\times 10^{-12}$ | | 150 | | | | | |
| $\epsilon_{33}^{T}$ | $\times \epsilon_o$ | | 2000 | | | | | |
| $g_{31}$ | $\times 10^{-3}$ | | -3.4 | | | | | |
| $g_{33}$ | $\times 10^{-3}$ | | 8.5 | | | | | |
| $k_{15}$ | - - | | | | | | | |
| $k_{31}$ | - - | | 0.14 | | | | | |
| $k_{33}$ | - - | | 0.35 | | | | | |
| $k_r$ | - - | 0.26 | 0.26 | | | | | |
| $s_{11}^{E}$ | $\times 10^{-12}$ | 9.0 | 9.0 | | | | | |
| $s_{12}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{13}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{33}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{44}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| Q | - - | | | | | | | |

**MATERIAL:** Sodium Niobate (70%) Cadmium Niobate (30%)

| Property \ Reference | | 40 | | | | | | |
|---|---|---|---|---|---|---|---|---|
| $T_C$ | - - | 155 | | | | | | |
| K | - - | 2500 | | | | | | |
| Y | $\times 10^{10}$ | | | | | | | |
| $\rho$ | $\times 10^{3}$ | 4.2 | | | | | | |
| $c_{33}^{D}$ | $\times 10^{10}$ | | | | | | | |
| $d_{15}$ | $\times 10^{-12}$ | | | | | | | |
| $d_{31}$ | $\times 10^{-12}$ | -66 | | | | | | |
| $d_{33}$ | $\times 10^{-12}$ | | | | | | | |
| $\epsilon_{33}^{T}$ | $\times \epsilon_o$ | | | | | | | |
| $g_{31}$ | $\times 10^{-3}$ | | | | | | | |
| $g_{33}$ | $\times 10^{-3}$ | | | | | | | |
| $k_{15}$ | - - | | | | | | | |
| $k_{31}$ | - - | | | | | | | |
| $k_{33}$ | - - | | | | | | | |
| $k_r$ | - - | 0.24 | | | | | | |
| $s_{11}^{E}$ | $\times 10^{-12}$ | 10.1 | | | | | | |
| $s_{12}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{13}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{33}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{44}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| Q | - - | | | | | | | |

| MATERIAL: Barium Titanate (95%) Calcium Titanate (5%) Cobalt Carbonate (0.25%) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Property \ Reference | | 13 | 15 | | | | | |
| $T_C$ | - - | 112 | 111 | | | | | |
| K | - - | 1110 | 1270 | | | | | |
| Y | $\times 10^{10}$ | | 11.6 | | | | | |
| $\rho$ | $\times 10^{3}$ | | 5.61 | | | | | |
| $c_{33}^{D}$ | $\times 10^{10}$ | | | | | | | |
| $d_{15}$ | $\times 10^{-12}$ | | | | | | | |
| $d_{31}$ | $\times 10^{-12}$ | -51 | -60 | | | | | |
| $d_{33}$ | $\times 10^{-12}$ | | | | | | | |
| $\epsilon_{33}^{T}$ | $\times \epsilon_o$ | | | | | | | |
| $g_{31}$ | $\times 10^{-3}$ | | -5.3 | | | | | |
| $g_{33}$ | $\times 10^{-3}$ | | | | | | | |
| $k_{15}$ | - - | | | | | | | |
| $k_{31}$ | - - | | | | | | | |
| $k_{33}$ | - - | | | | | | | |
| $k_r$ | - - | 0.30 | 0.33 | | | | | |
| $s_{11}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{12}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{13}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{33}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{44}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| Q | - - | | | | | | | |

| MATERIAL: Barium Titanate (95%) Calcium Titanate (5%) Cobalt Carbonate (0.5%) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Property \ Reference | | 13 | 15 | | | | | |
| $T_C$ | - - | 108 | 110 | | | | | |
| K | - - | 1200 | 1340 | | | | | |
| Y | $\times 10^{10}$ | | 12.2 | | | | | |
| $\rho$ | $\times 10^{3}$ | | 5.64 | | | | | |
| $c_{33}^{D}$ | $\times 10^{10}$ | | | | | | | |
| $d_{15}$ | $\times 10^{-12}$ | | | | | | | |
| $d_{31}$ | $\times 10^{-12}$ | -50 | -59 | | | | | |
| $d_{33}$ | $\times 10^{-12}$ | | | | | | | |
| $\epsilon_{33}^{T}$ | $\times \epsilon_o$ | | | | | | | |
| $g_{31}$ | $\times 10^{-3}$ | | -5.0 | | | | | |
| $g_{33}$ | $\times 10^{-3}$ | | | | | | | |
| $k_{15}$ | - - | | | | | | | |
| $k_{31}$ | - - | | | | | | | |
| $k_{33}$ | - - | | | | | | | |
| $k_r$ | - - | 0.29 | 0.32 | | | | | |
| $s_{11}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{12}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{13}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{33}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{44}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| Q | - - | | | | | | | |

| MATERIAL: Barium Titanate (95%) Calcium Titanate (5%) Cobalt Carbonate (0.75%) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Property \ Reference | | 13 | 15 | 24 | | | | |
| $T_C$ | - - | 106 | 105 | 105 | | | | |
| K | - - | 1100 | 1420 | | | | | |
| Y | $x10^{10}$ | | 12.4 | | | | | |
| $\rho$ | $x10^{3}$ | | 5.69 | 5.7 | | | | |
| $c_{33}^{D}$ | $x10^{10}$ | | | | | | | |
| $d_{15}$ | $x10^{-12}$ | | | | | | | |
| $d_{31}$ | $x10^{-12}$ | -45 | -59 | -59 | | | | |
| $d_{33}$ | $x10^{-12}$ | | | | | | | |
| $\epsilon_{33}^{T}$ | $x\epsilon_o$ | | | 1605 | | | | |
| $g_{31}$ | $x10^{-3}$ | | -4.7 | | | | | |
| $g_{33}$ | $x10^{-3}$ | | | | | | | |
| $k_{15}$ | - - | | | | | | | |
| $k_{31}$ | - - | | | 0.182 | | | | |
| $k_{33}$ | - - | | | | | | | |
| $k_r$ | - - | 0.27 | 0.31 | 0.31 | | | | |
| $s_{11}^{E}$ | $x10^{-12}$ | | | 8.06 | | | | |
| $s_{12}^{E}$ | $x10^{-12}$ | | | | | | | |
| $s_{13}^{E}$ | $x10^{-12}$ | | | | | | | |
| $s_{33}^{E}$ | $x10^{-12}$ | | | | | | | |
| $s_{44}^{E}$ | $x10^{-12}$ | | | | | | | |
| Q | - - | | | | | | | |

| MATERIAL: Barium Titanate (95%) Calcium Titanate (5%) Cobalt Carbonate (1.0%) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Property \ Reference | | 13 | 15 | | | | | |
| $T_C$ | - - | 105 | 104 | | | | | |
| K | - - | 1160 | | | | | | |
| Y | $x10^{10}$ | | 11.8 | | | | | |
| $\rho$ | $x10^{3}$ | | 5.73 | | | | | |
| $c_{33}^{D}$ | $x10^{10}$ | | | | | | | |
| $d_{15}$ | $x10^{-12}$ | | | | | | | |
| $d_{31}$ | $x10^{-12}$ | -45 | -56 | | | | | |
| $d_{33}$ | $x10^{-12}$ | | | | | | | |
| $\epsilon_{33}^{T}$ | $x\epsilon_o$ | | | | | | | |
| $g_{31}$ | $x10^{-3}$ | | -4.3 | | | | | |
| $g_{33}$ | $x10^{-3}$ | | | | | | | |
| $k_{15}$ | - - | | | | | | | |
| $k_{31}$ | - - | | | | | | | |
| $k_{33}$ | - - | | | | | | | |
| $k_r$ | - - | 0.27 | 0.28 | | | | | |
| $s_{11}^{E}$ | $x10^{-12}$ | | | | | | | |
| $s_{12}^{E}$ | $x10^{-12}$ | | | | | | | |
| $s_{13}^{E}$ | $x10^{-12}$ | | | | | | | |
| $s_{33}^{E}$ | $x10^{-12}$ | | | | | | | |
| $s_{44}^{E}$ | $x10^{-12}$ | | | | | | | |
| Q | - - | | | | | | | |

| MATERIAL: Barium Titanate (95%) Calcium Titanate (5%) Cobalt Carbonate (1.25%) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Property \ Reference | | 15 | | | | | | |
| $T_C$ | - - | 100 | | | | | | |
| K | - - | 1500 | | | | | | |
| Y | $\times 10^{10}$ | 12.9 | | | | | | |
| $\rho$ | $\times 10^{3}$ | 5.70 | | | | | | |
| $c_{33}^{D}$ | $\times 10^{10}$ | | | | | | | |
| $d_{15}$ | $\times 10^{-12}$ | | | | | | | |
| $d_{31}$ | $\times 10^{-12}$ | -56 | | | | | | |
| $d_{33}$ | $\times 10^{-12}$ | | | | | | | |
| $\epsilon_{33}^{T}$ | $\times \epsilon_o$ | | | | | | | |
| $g_{31}$ | $\times 10^{-3}$ | -4.1 | | | | | | |
| $g_{33}$ | $\times 10^{-3}$ | | | | | | | |
| $k_{15}$ | - - | | | | | | | |
| $k_{31}$ | - - | | | | | | | |
| $k_{33}$ | - - | | | | | | | |
| $k_r$ | - - | 0.29 | | | | | | |
| $s_{11}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{12}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{13}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{33}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{44}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| Q | - - | | | | | | | |

**MATERIAL:** Barium Titanate (95%) Calcium Titanate (5%) Cobalt Carbonate (1.5%)

| Property \ Reference | | 15 | | | | | | |
|---|---|---|---|---|---|---|---|---|
| $T_C$ | - - | 100 | | | | | | |
| K | - - | 1500 | | | | | | |
| Y | $\times 10^{10}$ | 11.6 | | | | | | |
| $\rho$ | $\times 10^{3}$ | 5.71 | | | | | | |
| $c_{33}^{D}$ | $\times 10^{10}$ | | | | | | | |
| $d_{15}$ | $\times 10^{-12}$ | | | | | | | |
| $d_{31}$ | $\times 10^{-12}$ | -59 | | | | | | |
| $d_{33}$ | $\times 10^{-12}$ | | | | | | | |
| $\epsilon_{33}^{T}$ | $\times \epsilon_o$ | | | | | | | |
| $g_{31}$ | $\times 10^{-3}$ | -4.4 | | | | | | |
| $g_{33}$ | $\times 10^{-3}$ | | | | | | | |
| $k_{15}$ | - - | | | | | | | |
| $k_{31}$ | - - | | | | | | | |
| $k_{33}$ | - - | | | | | | | |
| $k_r$ | - - | 0.29 | | | | | | |
| $s_{11}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{12}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{13}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{33}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{44}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| Q | - - | | | | | | | |

| MATERIAL: Barium Titanate (90%) Calcium Titanate (6%) Lead Titanate (4%) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Property \ Reference | | 12 | | | | | | |
| $T_C$ | - - | | | | | | | |
| K | - - | | | | | | | |
| Y | $\times 10^{10}$ | 12.4 | | | | | | |
| $\rho$ | $\times 10^{3}$ | | | | | | | |
| $c_{33}^{D}$ | $\times 10^{10}$ | | | | | | | |
| $d_{15}$ | $\times 10^{-12}$ | | | | | | | |
| $d_{31}$ | $\times 10^{-12}$ | -40 | | | | | | |
| $d_{33}$ | $\times 10^{-12}$ | 115 | | | | | | |
| $\epsilon_{33}^{T}$ | $\times \epsilon_o$ | 800 | | | | | | |
| $g_{31}$ | $\times 10^{-3}$ | | | | | | | |
| $g_{33}$ | $\times 10^{-3}$ | | | | | | | |
| $k_{15}$ | - - | 0.43 | | | | | | |
| $k_{31}$ | - - | 0.167 | | | | | | |
| $k_{33}$ | - - | 0.48 | | | | | | |
| $k_r$ | - - | | | | | | | |
| $s_{11}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{12}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{13}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{33}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{44}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| Q | - - | | | | | | | |

**MATERIAL:** Barium Titanate (84%) Calcium Titanate (8%) Lead Titanate (8%)

| Property | | Reference 7 | 12 | | | | | |
|---|---|---|---|---|---|---|---|---|
| $T_C$ | - - | | | | | | | |
| K | - - | | | | | | | |
| Y | $\times 10^{10}$ | | 13.1 | | | | | |
| $\rho$ | $\times 10^{3}$ | | | | | | | |
| $c_{33}^{D}$ | $\times 10^{10}$ | | | | | | | |
| $d_{15}$ | $\times 10^{-12}$ | | | | | | | |
| $d_{31}$ | $\times 10^{-12}$ | -22.2 | -27 | | | | | |
| $d_{33}$ | $\times 10^{-12}$ | | 80 | | | | | |
| $\epsilon_{33}^{T}$ | $\times \epsilon_o$ | 498 | 600 | | | | | |
| $g_{31}$ | $\times 10^{-3}$ | | | | | | | |
| $g_{33}$ | $\times 10^{-3}$ | | | | | | | |
| $k_{15}$ | - - | | 0.35 | | | | | |
| $k_{31}$ | - - | | 0.124 | | | | | |
| $k_{33}$ | - - | | 0.4 | | | | | |
| $k_r$ | - - | 0.208 | | | | | | |
| $s_{11}^{E}$ | $\times 10^{-12}$ | 7.32 | | | | | | |
| $s_{12}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{13}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{33}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{44}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| Q | - - | 1090 | | | | | | |

| MATERIAL: Barium Titanate (80%) Calcium Titanate (12%) Lead Titanate (8%) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Property \ Reference | | 7 | 42 | | | | | |
| $T_C$ | - - | | 160 | | | | | |
| K | - - | | | | | | | |
| Y | $\times 10^{10}$ | | | | | | | |
| $\rho$ | $\times 10^{3}$ | | 5.3 | | | | | |
| $c_{33}^D$ | $\times 10^{10}$ | | | | | | | |
| $d_{15}$ | $\times 10^{-12}$ | | | | | | | |
| $d_{31}$ | $\times 10^{-12}$ | -17.9 | -35 | | | | | |
| $d_{33}$ | $\times 10^{-12}$ | | 90 | | | | | |
| $\epsilon_{33}^T$ | $\times \epsilon_o$ | 417 | 600 | | | | | |
| $g_{31}$ | $\times 10^{-3}$ | | -7.3 | | | | | |
| $g_{33}$ | $\times 10^{-3}$ | | 18 | | | | | |
| $k_{15}$ | - - | | | | | | | |
| $k_{31}$ | - - | | 0.12 | | | | | |
| $k_{33}$ | - - | | 0.30 | | | | | |
| $k_r$ | - - | 0.184 | 0.22 | | | | | |
| $s_{11}^E$ | $\times 10^{-12}$ | 7.522 | 13 | | | | | |
| $s_{12}^E$ | $\times 10^{-12}$ | | | | | | | |
| $s_{13}^E$ | $\times 10^{-12}$ | | | | | | | |
| $s_{33}^E$ | $\times 10^{-12}$ | | | | | | | |
| $s_{44}^E$ | $\times 10^{-12}$ | | | | | | | |
| Q | - - | 1185 | 350 | | | | | |

**MATERIAL:** Barium Titanate (80%) Lead Titanate (12%) Calcium Titanate (8%)

| Property | | Reference 23 | 24 | 12 | | | | |
|---|---|---|---|---|---|---|---|---|
| $T_C$ | - - | 145 | 140 | | | | | |
| K | - - | 500 | | | | | | |
| Y | $\times 10^{10}$ | 11.9 | | 12.8 | | | | |
| $\rho$ | $\times 10^{3}$ | 5.4 | 5.4 | | | | | |
| $c_{33}^{D}$ | $\times 10^{10}$ | | | | | | | |
| $d_{15}$ | $\times 10^{-12}$ | | | | | | | |
| $d_{31}$ | $\times 10^{-12}$ | -31 | | -20 | | | | |
| $d_{33}$ | $\times 10^{-12}$ | 79 | | 60 | | | | |
| $\epsilon_{33}^{T}$ | $\times \epsilon_o$ | | | 400 | | | | |
| $g_{31}$ | $\times 10^{-3}$ | | | | | | | |
| $g_{33}$ | $\times 10^{-3}$ | 18 | | | | | | |
| $k_{15}$ | - - | | | 0.30 | | | | |
| $k_{31}$ | - - | 0.15 | | 0.113 | | | | |
| $k_{33}$ | - - | 0.41 | | 0.34 | | | | |
| $k_r$ | - - | 0.24 | 0.19 | | | | | |
| $s_{11}^{E}$ | $\times 10^{-12}$ | 7.8 | | | | | | |
| $s_{12}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{13}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{33}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{44}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| Q | - - | 600 | 1200 | | | | | |

| MATERIAL: | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Property \ Reference | | | | | | | | |
| $T_C$ | - - | | | | | | | |
| K | - - | | | | | | | |
| Y | $\times 10^{10}$ | | | | | | | |
| $\rho$ | $\times 10^{3}$ | | | | | | | |
| $c_{33}^{D}$ | $\times 10^{10}$ | | | | | | | |
| $d_{15}$ | $\times 10^{-12}$ | | | | | | | |
| $d_{31}$ | $\times 10^{-12}$ | | | | | | | |
| $d_{33}$ | $\times 10^{-12}$ | | | | | | | |
| $\epsilon_{33}^{T}$ | $\times \epsilon_o$ | | | | | | | |
| $g_{31}$ | $\times 10^{-3}$ | | | | | | | |
| $g_{33}$ | $\times 10^{-3}$ | | | | | | | |
| $k_{15}$ | - - | | | | | | | |
| $k_{31}$ | - - | | | | | | | |
| $k_{33}$ | - - | | | | | | | |
| $k_r$ | - - | | | | | | | |
| $s_{11}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{12}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{13}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{33}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{44}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| Q | - - | | | | | | | |

| MATERIAL : | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Property \ Reference | | | | | | | | |
| $T_C$ | - - | | | | | | | |
| K | - - | | | | | | | |
| Y | $\times 10^{10}$ | | | | | | | |
| $\rho$ | $\times 10^{3}$ | | | | | | | |
| $c_{33}^{D}$ | $\times 10^{10}$ | | | | | | | |
| $d_{15}$ | $\times 10^{-12}$ | | | | | | | |
| $d_{31}$ | $\times 10^{-12}$ | | | | | | | |
| $d_{33}$ | $\times 10^{-12}$ | | | | | | | |
| $\epsilon_{33}^{T}$ | $\times \epsilon_o$ | | | | | | | |
| $g_{31}$ | $\times 10^{-3}$ | | | | | | | |
| $g_{33}$ | $\times 10^{-3}$ | | | | | | | |
| $k_{15}$ | - - | | | | | | | |
| $k_{31}$ | - - | | | | | | | |
| $k_{33}$ | - - | | | | | | | |
| $k_r$ | - - | | | | | | | |
| $s_{11}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{12}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{13}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{33}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| $s_{44}^{E}$ | $\times 10^{-12}$ | | | | | | | |
| Q | - - | | | | | | | |

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