U. S. Department of Commerce
Peter G. Peterson
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National Bureau of Standards
Certificate of Analysis
Standard Reference Material 718
Polycrystalline Alumina Elasticity Standard

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This Standard Reference Material consists of polycrystalline alumina bars cut from a single block of material prepared by isostatically cold pressing and then sintering alumina powder containing 0.1 percent magnesium oxide. It is intended for the calibration of apparatus used in the measurement of resonance frequencies from which elastic moduli are calculated. Each bar has been individually measured and calibrated, and all surfaces were machined flat and parallel.

The bar accompanying this certificate is number   This number is marked on the box containing this bar, which can also be identified by careful weighing and comparison with the mass given in Table 1. The certified values given are for frequency and dynamic elastic moduli at 25 °C in vacuum. The corrections for use in air are −0.99 Hz for flexural resonance frequency and −2.25 Hz for torsional resonance frequency; i.e., the resonance frequencies are lower in air than in vacuum.

The accuracy (probable error) of the Shear modulus is 0.2 percent and for the Young's modulus it is 0.4 percent. Because the actual values were measured in air the uncertainties associated with this measurement are given in air. These are ±0.03 Hz for flexural resonance and ±0.08 Hz for torsional resonance.

Measurements of flexural resonance and torsional resonance at 25 °C and the calculation of elastic moduli were made by R. W. Dickson and J. B. Wachtman, Jr., of the Inorganic Materials Division of the Institute for Materials Research.

Measurements of the temperature dependence of resonance frequency were made by R. W. Dickson at the Institute for Materials Research and by E. Schreiber at the Lamont Geological Observatory of Columbia University, and Queens College, City University of New York.

The materials were prepared under the direction of P. J. Jorgensen of Stanford Research Institute, Palo Alto, California.

The technical and support aspects involved in the preparation, certification, and issuance of this Standard Reference Material were coordinated through the Office of Standard Reference Materials by T. W. Mears.

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J. Paul Cali, Chief
Office of Standard Reference Materials

(over)

TABLE 1. *Properties of alumina standard reference bars for frequency and dynamic elastic moduli at 25 °C in vacuum* [a]

Bar Number	Mass	Length	Width	Thickness	Density	Flexural Frequency	Torsional Frequency	Young's Modulus	Shear Modulus	Poisson's Ratio
	Grams	*cm*	*cm*	*cm*	*g/cm³*	*Hz*	*Hz*	$10^{11} N/m^2$	$10^{11} N/m^2$	
A1	20.5174	12.7003	1.271	0.3222	3.944	2037.56	11249.5	3.900	1.581	0.233
A2	20.4679	12.7002	1.271	.3223	3.934	2032.37	11224.3	3.869	1.569	.232
A6	20.4364	12.7000	1.271	.3223	3.928	2027.82	11203.5	3.846	1.561	.232
A7	20.4388	12.7001	1.271	.3223	3.929	2027.46	11200.4	3.844	1.560	.232
A8	20.4458	12.7003	1.271	.3226	3.926	2027.57	11201.8	3.835	1.557	.231
A9	20.4686	12.7003	1.271	.3228	3.929	2030.70	11216.1	3.847	1.562	.232
A10	20.4708	12.7005	1.271	.3225	3.932	2031.64	11220.8	3.860	1.566	.232
A11	20.4972	12.7006	1.271	.3226	3.936	2035.43	11237.8	3.876	1.572	.233
A12	20.5017	12.7008	1.271	.3222	3.941	2037.12	11247.6	3.898	1.580	.233
A13	20.5579	12.7011	1.271	.3223	3.951	2043.29	11279.6	3.928	1.592	.233
B1	20.4863	12.6998	1.271	0.3224	3.937	2030.55	11216.5	3.863	2.568	0.232
B2	20.4270	12.6998	1.271	.3223	3.926	2027.62	11200.6	3.844	1.560	.232
B6	20.2490	12.6995	1.271	.3221	3.894	2002.33	11071.3	3.720	1.513	.230
B7	20.2543	12.6995	1.271	.3225	3.891	2000.70	11062.4	3.702	1.506	.229
B8	20.2694	12.6996	1.271	.3226	3.893	2003.93	11079.0	3.714	1.510	.229
B9	20.2847	12.6996	1.271	.3227	3.895	2005.27	11085.2	3.719	1.513	.230
B10	20.3098	12.6998	1.271	.3226	3.900	2009.27	11107.4	3.741	1.521	.230
B11	20.3535	12.7002	1.271	.3221	3.914	2015.61	11141.7	3.790	1.540	.230
B12	20.4553	12.7005	1.271	.3223	3.931	2029.48	11213.0	3.856	1.566	.231
B13	20.5947	12.7016	1.271	.3226	3.955	2046.57	11298.6	3.937	1.596	.233
C1	20.5713	12.7008	1.271	0.3227	3.949	2044.29	11289.1	3.919	1.590	0.233
C2	20.4124	12.6998	1.271	.3227	3.920	2022.39	11177.9	3.808	1.548	.230
C3	20.2913	12.6996	1.271	.3220	3.905	2008.83	11109.9	3.759	1.529	.230
C4	20.2657	12.6995	1.271	.3224	3.895	2003.08	11079.2	3.717	1.512	.229
C5	20.2505	12.6996	1.271	.3225	3.891	2000.34	11065.0	3.701	1.506	.229
C6	20.2209	12.6996	1.271	.3221	3.890	1998.10	11054.9	3.700	1.506	.229
C7	20.2274	12.6995	1.271	.3221	3.891	1998.73	11058.1	3.705	1.508	.229
C8	20.2634	12.6997	1.271	.3227	3.891	2002.42	11075.3	3.705	1.508	.229
C12	20.4375	12.7005	1.271	.3221	3.932	2026.81	11202.1	3.851	1.564	.231
C13	20.5306	12.6999	1.271	.3227	3.942	2038.65	11258.3	3.892	1.579	.232
D1	20.5638	12.7006	1.271	0.3226	3.950	2043.27	11281.4	3.919	1.589	0.233
D2	20.5251	12.7003	1.271	.3227	3.942	2038.87	11260.4	3.892	1.579	.232
D3	20.5001	12.7004	1.271	.3228	3.935	2035.35	11243.1	3.869	1.570	.232
D4	20.4892	12.7003	1.271	.3226	3.935	2033.30	11234.1	3.866	1.570	.232
D5	20.4838	12.7002	1.271	.3224	3.937	2033.87	11237.6	3.876	1.573	.232
D6	20.4787	12.7004	1.271	.3225	3.935	2031.77	11227.5	3.863	1.569	.231
D7	20.4863	12.7004	1.271	.3227	3.934	2033.46	11234.8	3.863	1.568	.232
D8	20.4796	12.7006	1.271	.3226	3.934	2033.59	11236.1	3.867	1.570	.231
D12	20.5332	12.7013	1.271	.3226	3.942	2039.18	11259.8	3.896	1.580	.233
D13	20.5710	12.7007	1.271	.3227	3.948	2045.14	11290.3	3.923	1.591	.233

[a] For use in air subtract 0.99 Hz from flexural resonance frequency and 2.25 Hz from torsional resonance frequency.

Estimated accuracy is given in terms of standard deviation based on repeated measurements for length, width, and thickness. For other quantities the estimated uncertainty is based on estimates of the accuracy of the instruments involved, the equations used, the correction factors, and the specimen homogeneity as described in the text. The estimated standard deviations are: mass ±0.0001 gm, length ±0.0002 cm, width ±0.0001 cm, thickness ±0.0003 cm, density ±0.004 gm/cm³. The estimated uncertainties are: flexural frequency in vacuum ±0.06 Hz, torsional frequency in vacuum ±0.18 Hz, Young's modulus ±0.016 × 10^{11} N/m², shear modulus ±0.003 × 10^{11} N/m², and Poisson's ratio ±0.005. The values of resonance frequency in air, obtainable as described above, are more accurate than the vacuum values because they were directly determined. The corresponding estimated uncertainties are ±0.03 Hz for the flexural resonance frequency and ±0.08 Hz for the torsional resonance frequency in air at one atmosphere pressure.

Details of the procedure used to measure resonance frequencies at 25 °C and of the calculation of Young's modulus and the Shear modulus have been given by Dickson and Wachtman [1]. The procedure for measuring the resonance frequencies at a temperature above 25 °C and for calculating Young's modulus and the Shear modulus at this temperature have been given by Dickson and Schreiber [2]. The ratio of a given resonance frequency at elevated temperature to its value at 25 °C has the same value for all bars; the corresponding ratios for the two elastic moduli are also the same for all bars. These ratios, together with the thermal expansion used for their calculation are listed in the following table.

Temperature	ΔL/L in units of 10^{-4}	Flexure Ratio $(f/f_{25})^2$	Young's Modulus (Y/Y_{25})	Torsion Ratio $(f/f_{25})^2$	Shear Modulus Ratio (G/G_{25})
25	0.00	1.00000	1.00000	1.00000	1.00000
100	4.63	0.99202	0.99156	0.99133	0.99087
200	11.57	0.98104	0.97991	0.97923	0.97810
300	19.34	0.96965	0.96779	0.96675	0.96489
400	27.36	0.95782	0.95521	0.95391	0.95131
500	35.80	0.94571	0.94234	0.94072	0.93736
600	44.47	0.93337	0.92924	0.92719	0.92308
700	53.29	0.92039	0.91601	0.91350	0.90866
800	62.24	0.90829	0.90267	0.89979	0.89422
900	71.19	0.89548	0.88915	0.88628	0.88002
1000	80.19	0.88258	0.87556	0.87325	0.86630

1. Dickson, R. W., and Wachtman, Jr., J. B., An Alumina Standard Reference Material for Resonance Frequency and Dynamic Elastic Moduli Measurement I. For Use at 25 °C, J. Res. Nat. Bur. Stand. (U.S.) 75A (Phys. and Chem.), No. 3, 155, (May–June 1971).
2. Dickson, R. W., and Schreiber, E., An Alumina Standard Reference Material for Resonance Frequency and Dynamic Elastic Moduli Measurement II. For Use from 25 to 1000 °C (in preparation).