

The Technical Association of Refractories, Japan
Certified Reference Material Series for X-ray Fluorescence Analysis of Refractories
JRRM 321 (High-Alumina Refractory)
Results of Analyses

Unit : mass%

Constituent	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	TiO ₂	MnO	CaO	MgO	Na ₂ O	K ₂ O	P ₂ O ₅	Cr ₂ O ₃	ZrO ₂
Certified value	44.6 ₈	38.9 ₁	3.97 ₁	0.94 ₅	0.06 ₅	0.92 ₀	3.18 ₁	0.46 ₈	2.28 ₀	3.36 ₆	0.99 ₅	0.02 ₈
Laboratories												
L ₁	44.6 ₈	38.4 ₆	4.00 ₁	0.95 ₈	0.06 ₈	0.91 ₃	3.18 ₈	0.47 ₇	2.32 ₄	3.41 ₀	1.00 ₆	0.02 ₁
L ₂	44.8 ₅	38.8 ₄	3.96 ₄	0.92 ₂	0.06 ₅	0.92 ₃	3.15 ₁	0.47 ₁	2.16 ₀	3.35 ₄	0.98 ₈	0.02 ₄
L ₃	44.6 ₀	38.6 ₇	3.93 ₄	0.95 ₃	0.06 ₆	0.92 ₄	3.15 ₄	0.47 ₄	2.23 ₇	3.36 ₇	1.01 ₄	0.02 ₆
L ₄	44.8 ₈	38.8 ₉	3.94 ₀	0.94 ₂	0.06 ₄	0.91 ₇	3.22 ₂	0.47 ₄	2.29 ₅	3.37 ₂	0.99 ₆	0.02 ₂
L ₅	44.8 ₀	39.1 ₀	3.99 ₉	0.94 ₃	0.06 ₂	0.91 ₂	3.11 ₈	0.46 ₃	2.28 ₁	3.28 ₈	0.99 ₁	0.03 ₉
L ₆	44.6 ₂	39.3 ₀	4.01 ₀	0.95 ₄	0.06 ₄	0.94 ₄	3.17 ₅	0.46 ₂	2.28 ₄	3.42 ₉	0.98 ₈	0.03 ₄
L ₇	44.4 ₀	39.3 ₄	3.99 ₇	0.95 ₄	0.06 ₈	0.90 ₁	3.27 ₇	0.46 ₅	2.27 ₈	3.37 ₆	0.99 ₃	0.02 ₇
L ₈	44.6 ₄	38.6 ₅	3.92 ₂	0.93 ₇	0.06 ₆	0.92 ₂	3.16 ₆	0.45 ₉	2.38 ₂	3.33 ₃	0.98 ₄	0.03 ₁
Average \bar{X}	44.68 ₄	38.90 ₆	3.970 ₉	0.945 ₄	0.065 ₄	0.919 ₅	3.181 ₄	0.468 ₁	2.280 ₁	3.366 ₁	0.995 ₀	0.028 ₀
Reproducibility $S_{\bar{x}}$	0.15 ₉	0.31 ₇	0.035 ₃	0.012 ₁	0.002 ₁	0.012 ₇	0.048 ₇	0.006 ₆	0.064 ₄	0.043 ₈	0.010 ₀	0.006 ₄
(within laboratory) $S_{I(T)}$ ^{*1}	0.10 ₆	0.09 ₁	0.017 ₇	0.005 ₇	0.000 ₉	0.013 ₅	0.019 ₁	0.010 ₆	0.027 ₇	0.016 ₂	0.006 ₅	0.002 ₄
Uncertainty C (95%) ^{*2}	0.13 ₀	0.27 ₀	0.03 ₀	0.01 ₀	0.00 ₂	0.01 ₁	0.04 ₁	0.00 ₆	0.05 ₄	0.03 ₇	0.00 ₈	0.00 ₅

(Note) *1 $S_{\bar{x}}$ is intermediate precision without a time condition. *2 The half-width confidence interval C (95%) = $t_{\ell-1, 0.05} \times S_{\bar{x}} / \sqrt{\ell}$ (ℓ = number of laboratories)

- (1) List of laboratories : Krosaki Harima Corporation, Shinagawa Refractories Co, Ltd, TYK Corporation, AGC Ceramics Co, Ltd, TOSHIBA NANOANALYSIS CORPORATION, JFE Techno-Research Corporation, CLEARIZE Co., Ltd, NIPPON STEEL TECHNOLOGY Co., Ltd
- (2) Analytical techniques : Wet chemical analysis method (ISO 21587)
- (3) Analytical values : Each value is the average of two values obtained by two measurements on different days. These analysis values are shown converted into LOI (Loss on ignition) component free values.
- (4) Outlier tests were carried out by Grubbs test. The samples rejected by Grubbs tests were discussed in view of analytical techniques and it was determined whether the outliers should be adopted or not.
- (5) Date of preparation : March, 2019

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JRRM 322 (High-Alumina Refractory)
Results of Analyses

Unit : mass%

Constituent	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	TiO ₂	MnO	CaO	MgO	Na ₂ O	K ₂ O	P ₂ O ₅	Cr ₂ O ₃	ZrO ₂
Certified value	39.8 ₂	49.7 ₄	4.51 ₆	0.57 ₃	0.29 ₀	1.10 ₄	0.60 ₂	1.10 ₄	0.71 ₄	0.64 ₁	0.05 ₆	0.51 ₂
Laboratories L ₁	39.9 ₃	49.3 ₆	4.52 ₉	0.58 ₈	0.29 ₁	1.12 ₈	0.60 ₁	1.12 ₂	0.70 ₆	0.65 ₄	0.05 ₅	0.57 ₁
L ₂	40.2 ₅	49.8 ₂	4.50 ₆	0.56 ₂	0.28 ₈	1.11 ₄	0.60 ₄	1.09 ₄	0.70 ₄	0.63 ₀	0.05 ₅	0.50 ₉
L ₃	39.7 ₁	50.0 ₇	4.45 ₉	0.57 ₄	0.28 ₄	1.09 ₃	0.59 ₆	1.07 ₈	0.70 ₅	0.64 ₇	0.06 ₇	0.48 ₈
L ₄	39.7 ₇	49.7 ₇	4.44 ₅	0.55 ₆	0.28 ₄	1.07 ₈	0.57 ₈	1.11 ₀	0.73 ₈	0.64 ₅	0.04 ₆	0.56 ₅
L ₅	40.1 ₇	49.7 ₉	4.44 ₈	0.56 ₈	0.28 ₆	1.09 ₂	0.60 ₄	1.10 ₅	0.71 ₅	0.61 ₄	0.05 ₄	0.50 ₂
L ₆	39.8 ₉	49.8 ₀	4.64 ₆	0.56 ₂	0.29 ₈	1.08 ₂	0.62 ₂	1.10 ₂	0.70 ₃	0.63 ₅	0.06 ₂	0.51 ₂
L ₇	39.4 ₀	49.7 ₅	4.55 ₇	0.58 ₆	0.29 ₁	1.12 ₀	0.60 ₂	1.11 ₇	0.70 ₇	0.61 ₄	0.06 ₀	0.46 ₄
L ₈	39.4 ₄	49.5 ₄	4.53 ₈	0.59 ₁	0.30 ₀	1.12 ₆	0.61 ₃	1.10 ₅	0.73 ₄	0.68 ₆	0.05 ₂	0.48 ₈
Average \bar{X}	39.82 ₀	49.73 ₈	4.516 ₀	0.573 ₄	0.290 ₂	1.104 ₁	0.602 ₅	1.104 ₁	0.714 ₀	0.640 ₆	0.056 ₄	0.512 ₄
Reproducibility $S_{\bar{x}}$	0.30 ₅	0.20 ₉	0.068 ₀	0.013 ₆	0.006 ₀	0.020 ₂	0.012 ₈	0.013 ₉	0.014 ₂	0.023 ₆	0.006 ₅	0.037 ₇
(within laboratory) $S_{I(T)}$ ^{*1}	0.05 ₅	0.18 ₂	0.025 ₆	0.004 ₀	0.003 ₈	0.013 ₃	0.005 ₈	0.011 ₁	0.009 ₇	0.010 ₉	0.001 ₅	0.010 ₉
Uncertainty C (95%) ^{*2}	0.25 ₀	0.17 ₀	0.05 ₇	0.01 ₁	0.00 ₅	0.01 ₇	0.01 ₁	0.01 ₂	0.01 ₂	0.02 ₀	0.00 ₅	0.03 ₂

(Note) *1 $S_{\bar{x}}$ is intermediate precision without a time condition. *2 The half-width confidence interval C (95%) = $t_{\ell-1, 0.05} \times S_{\bar{x}} / \sqrt{\ell}$ (ℓ = number of laboratories)

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Unit : mass%

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Certified value	31.8 ₉	55.8 ₁	1.70 ₇	0.20 ₂	0.23 ₂	2.07 ₅	2.71 ₈	1.45 ₆	0.19 ₃	2.63 ₂	0.20 ₈	0.65 ₀
Laboratories												
L ₁	31.9 ₃	55.7 ₃	1.70 ₄	0.20 ₈	0.23 ₉	2.08 ₄	2.76 ₉	1.44 ₇	0.21 ₀	2.66 ₂	0.21 ₁	0.65 ₉
L ₂	31.9 ₅	55.9 ₀	1.71 ₃	0.19 ₀	0.22 ₈	2.08 ₆	2.69 ₁	1.44 ₅	0.17 ₃	2.65 ₇	0.21 ₈	0.70 ₀
L ₃	31.8 ₅	55.8 ₉	1.68 ₈	0.20 ₂	0.22 ₈	2.09 ₀	2.69 ₉	1.44 ₄	0.18 ₂	2.62 ₅	0.21 ₄	0.65 ₈
L ₄	31.7 ₃	55.5 ₉	1.70 ₇	0.20 ₂	0.22 ₆	2.10 ₆	2.73 ₀	1.44 ₆	0.20 ₂	2.63 ₂	0.19 ₈	0.58 ₈
L ₅	32.1 ₇	56.0 ₇	1.70 ₄	0.20 ₂	0.22 ₁	2.07 ₈	2.69 ₈	1.42 ₉	0.17 ₄	2.61 ₃	0.19 ₈	0.60 ₈
L ₆	31.9 ₇	56.0 ₁	1.71 ₈	0.19 ₈	0.23 ₄	2.02 ₃	2.73 ₀	1.48 ₀	0.19 ₆	2.54 ₀	0.21 ₃	0.67 ₈
L ₇	31.9 ₂	55.9 ₁	1.71 ₉	0.20 ₀	0.23 ₉	2.04 ₅	2.69 ₉	1.45 ₅	0.19 ₉	2.75 ₈	0.20 ₉	0.68 ₃
L ₈	31.6 ₀	55.3 ₄	1.70 ₁	0.21 ₁	0.24 ₂	2.08 ₈	2.72 ₄	1.50 ₃	0.20 ₈	2.56 ₈	0.20 ₆	0.62 ₂
Average \bar{X}	31.89 ₀	55.80 ₅	1.706 ₈	0.201 ₆	0.232 ₁	2.075 ₀	2.717 ₅	1.456 ₁	0.193 ₀	2.631 ₉	0.208 ₄	0.649 ₅
Reproducibility $S_{\bar{x}}$	0.16 ₉	0.24 ₂	0.010 ₂	0.006 ₁	0.007 ₃	0.027 ₁	0.026 ₁	0.023 ₇	0.014 ₇	0.065 ₇	0.007 ₅	0.039 ₅
(within laboratory) $S_{I(T)}$ ^{*1}	0.08 ₅	0.09 ₄	0.011 ₃	0.004 ₈	0.002 ₈	0.012 ₅	0.028 ₃	0.033 ₈	0.003 ₉	0.023 ₀	0.002 ₀	0.024 ₁
Uncertainty C (95%) ^{*2}	0.14 ₀	0.20 ₀	0.00 ₉	0.00 ₅	0.00 ₆	0.02 ₃	0.02 ₂	0.02 ₀	0.01 ₂	0.05 ₅	0.00 ₆	0.03 ₃

(Note) *1 $S_{\bar{x}}$ is intermediate precision without a time condition. *2 The half-width confidence interval C (95%) = $t_{\ell-1, 0.05} \times S_{\bar{x}} / \sqrt{\ell}$ (ℓ = number of laboratories)

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Certified value	24.9 ₂	62.7 ₀	3.30 ₉	4.98 ₂	0.09 ₈	0.31 ₃	0.97 ₇	0.12 ₃	0.39 ₀	1.55 ₃	0.30 ₂	0.00 ₉
Laboratories												
L ₁	25.1 ₂	62.6 ₃	3.43 ₇	5.05 ₅	0.10 ₃	0.34 ₈	0.97 ₅	0.13 ₆	0.39 ₈	1.59 ₁	0.30 ₆	0.01 ₃
L ₂	25.0 ₈	62.6 ₁	3.28 ₄	4.87 ₄	0.09 ₈	0.30 ₇	0.97 ₀	0.12 ₈	0.38 ₄	1.51 ₄	0.29 ₈	0.00 ₄
L ₃	25.0 ₂	62.7 ₈	3.24 ₆	4.79 ₉	0.09 ₆	0.31 ₃	0.97 ₀	0.11 ₈	0.38 ₂	1.55 ₇	0.30 ₆	0.01 ₈
L ₄	25.0 ₈	62.8 ₅	3.30 ₈	5.06 ₃	0.09 ₄	0.28 ₉	0.97 ₈	0.13 ₈	0.38 ₇	1.56 ₂	0.29 ₅	0.00 ₆
L ₅	25.0 ₈	62.7 ₄	3.26 ₈	5.03 ₅	0.09 ₈	0.31 ₅	0.96 ₄	0.11 ₇	0.39 ₈	1.55 ₀	0.29 ₂	0.01 ₁
L ₆	24.7 ₂	63.1 ₂	3.23 ₈	4.97 ₀	0.09 ₆	0.29 ₀	0.95 ₄	0.12 ₀	0.37 ₆	1.52 ₇	0.30 ₄	0.00 ₇
L ₇	24.4 ₆	62.5 ₂	3.44 ₇	5.07 ₆	0.09 ₉	0.32 ₃	1.01 ₂	0.11 ₆	0.37 ₈	1.58 ₆	0.31 ₄	0.00 ₇
L ₈	24.8 ₂	62.3 ₉	3.24 ₆	4.98 ₃	0.10 ₀	0.31 ₈	0.99 ₃	0.11 ₄	0.41 ₃	1.53 ₄	0.30 ₅	0.00 ₈
Average \bar{X}	24.92 ₂	62.70 ₅	3.309 ₂	4.981 ₉	0.098 ₀	0.312 ₉	0.977 ₀	0.123 ₄	0.389 ₅	1.552 ₆	0.302 ₅	0.009 ₃
Reproducibility $S_{\bar{x}}$	0.23 ₅	0.22 ₄	0.085 ₂	0.099 ₁	0.002 ₇	0.019 ₀	0.018 ₁	0.009 ₆	0.012 ₅	0.027 ₁	0.007 ₀	0.004 ₆
(within laboratory) $S_{I(T)}$ ^{*1}	0.10 ₆	0.11 ₀	0.016 ₆	0.028 ₆	0.002 ₁	0.004 ₈	0.008 ₂	0.002 ₅	0.010 ₈	0.010 ₀	0.004 ₉	0.000 ₆
Uncertainty C (95%) ^{*2}	0.20 ₀	0.19 ₀	0.07 ₁	0.08 ₃	0.00 ₂	0.01 ₆	0.01 ₅	0.00 ₈	0.01 ₀	0.02 ₃	0.00 ₆	0.00 ₄

(Note) *1 $S_{\bar{x}}$ is intermediate precision without a time condition. *2 The half-width confidence interval C (95%) = $t_{\ell-1, 0.05} \times S_{\bar{x}} / \sqrt{\ell}$ (ℓ = number of laboratories)

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Certified value	19.9 ₉	68.9 ₈	2.47 ₀	2.24 ₉	0.01 ₂	0.70 ₀	0.26 ₄	1.69 ₀	3.08 ₆	0.14 ₈	0.03 ₈	0.04 ₅
Laboratories												
L ₁	20.0 ₇	68.6 ₄	2.48 ₉	2.29 ₇	0.01 ₃	0.72 ₂	0.27 ₂	1.70 ₃	3.14 ₆	0.14 ₈	0.03 ₆	0.04 ₀
L ₂	20.2 ₃	68.9 ₁	2.48 ₁	2.21 ₉	0.01 ₂	0.70 ₂	0.25 ₆	1.71 ₂	3.02 ₈	0.14 ₄	0.04 ₀	0.03 ₈
L ₃	20.1 ₈	68.6 ₅	2.44 ₄	2.23 ₀	0.01 ₂	0.70 ₆	0.26 ₅	1.70 ₆	3.07 ₃	0.14 ₆	0.03 ₇	0.04 ₄
L ₄	19.8 ₉	68.7 ₄	2.43 ₉	2.20 ₆	0.01 ₂	0.68 ₅	0.26 ₀	1.68 ₂	3.12 ₅	0.15 ₂	0.03 ₄	0.04 ₆
L ₅	20.1 ₈	69.3 ₃	2.44 ₇	2.25 ₅	0.01 ₂	0.70 ₁	0.26 ₆	1.71 ₃	2.93 ₂	0.14 ₁	0.04 ₁	0.05 ₄
L ₆	19.6 ₇	69.0 ₆	2.49 ₅	2.26 ₀	0.01 ₂	0.70 ₂	0.26 ₂	1.65 ₀	3.13 ₈	0.15 ₄	0.04 ₁	0.04 ₆
L ₇	20.0 ₀	69.1 ₆	2.52 ₁	2.28 ₂	0.01 ₂	0.68 ₁	0.27 ₂	1.65 ₅	2.98 ₄	0.14 ₁	0.03 ₈	0.04 ₅
L ₈	19.6 ₉	69.3 ₆	2.44 ₂	2.24 ₁	0.01 ₂	0.70 ₄	0.25 ₈	1.69 ₆	3.25 ₈	0.15 ₆	0.03 ₈	0.04 ₄
Average \bar{X}	19.98 ₉	68.98 ₁	2.469 ₈	2.248 ₈	0.012 ₁	0.700 ₄	0.263 ₉	1.689 ₆	3.085 ₅	0.147 ₈	0.038 ₁	0.044 ₆
Reproducibility $S_{\bar{x}}$	0.22 ₀	0.29 ₁	0.031 ₀	0.031 ₀	0.000 ₃	0.012 ₇	0.006 ₀	0.025 ₀	0.103 ₆	0.005 ₉	0.002 ₆	0.004 ₇
(within laboratory) $S_{I(T)}$ ^{*1}	0.12 ₂	0.14 ₃	0.013 ₉	0.015 ₉	0.000 ₇	0.009 ₉	0.007 ₆	0.016 ₂	0.022 ₂	0.003 ₆	0.002 ₄	0.003 ₈
Uncertainty C (95%) ^{*2}	0.18 ₀	0.24 ₀	0.02 ₆	0.02 ₆	0.00 ₀	0.01 ₁	0.00 ₅	0.02 ₁	0.08 ₇	0.00 ₅	0.00 ₂	0.00 ₄

(Note) *1 $S_{\bar{x}}$ is intermediate precision without a time condition. *2 The half-width confidence interval C (95%) = $t_{\ell-1, 0.05} \times S_{\bar{x}} / \sqrt{\ell}$ (ℓ = number of laboratories)

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Results of Analyses

Unit : mass%

Constituent	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	TiO ₂	MnO	CaO	MgO	Na ₂ O	K ₂ O	P ₂ O ₅	Cr ₂ O ₃	ZrO ₂
Certified value	15.9 ₂	73.8 ₆	1.88 ₁	2.62 ₉	0.02 ₀	0.49 ₅	0.39 ₃	1.83 ₆	1.69 ₄	0.31 ₁	0.49 ₆	0.30 ₉
Laboratories L ₁	16.0 ₅	73.8 ₅	1.87 ₈	2.60 ₁	0.02 ₁	0.52 ₆	0.38 ₃	1.85 ₀	1.72 ₅	0.30 ₁	0.51 ₂	0.34 ₀
L ₂	16.3 ₁	73.6 ₅	1.88 ₈	2.62 ₀	0.02 ₁	0.49 ₆	0.40 ₄	1.86 ₆	1.74 ₆	0.29 ₃	0.49 ₅	0.28 ₇
L ₃	15.9 ₁	73.9 ₃	1.84 ₀	2.58 ₂	0.01 ₈	0.49 ₈	0.38 ₇	1.84 ₄	1.67 ₀	0.29 ₈	0.50 ₀	0.31 ₈
L ₄	15.8 ₈	73.9 ₄	1.83 ₄	2.56 ₄	0.01 ₈	0.46 ₇	0.37 ₀	1.87 ₂	1.62 ₉	0.33 ₂	0.48 ₂	0.35 ₄
L ₅	16.0 ₅	73.8 ₂	1.82 ₃	2.63 ₈	0.01 ₈	0.48 ₂	0.38 ₉	1.82 ₀	1.67 ₃	0.33 ₆	0.47 ₃	0.28 ₈
L ₆	15.9 ₀	74.0 ₂	1.98 ₀	2.69 ₆	0.02 ₀	0.48 ₆	0.39 ₈	1.78 ₂	1.64 ₁	0.30 ₃	0.50 ₆	0.30 ₁
L ₇	15.7 ₇	73.7 ₉	1.89 ₈	2.63 ₇	0.02 ₀	0.50 ₂	0.40 ₉	1.82 ₀	1.70 ₆	0.30 ₀	0.50 ₀	0.29 ₇
L ₈	15.5 ₂	73.8 ₇	1.91 ₀	2.69 ₂	0.02 ₀	0.50 ₂	0.40 ₅	1.83 ₆	1.75 ₉	0.32 ₄	0.50 ₁	0.29 ₀
Average \bar{X}	15.92 ₄	73.85 ₉	1.881 ₄	2.628 ₈	0.019 ₅	0.494 ₉	0.393 ₁	1.836 ₂	1.693 ₆	0.310 ₉	0.496 ₁	0.309 ₄
Reproducibility $S_{\bar{x}}$	0.22 ₉	0.10 ₉	0.051 ₀	0.047 ₇	0.001 ₂	0.017 ₃	0.013 ₄	0.028 ₉	0.047 ₈	0.016 ₈	0.012 ₅	0.025 ₄
(within laboratory) $S_{I(T)}$ ^{*1}	0.04 ₈	0.15 ₅	0.015 ₀	0.007 ₆	0.001 ₀	0.011 ₅	0.005 ₁	0.016 ₈	0.020 ₁	0.003 ₅	0.008 ₀	0.004 ₆
Uncertainty C (95%) ^{*2}	0.19 ₀	0.09 ₀	0.04 ₃	0.04 ₀	0.00 ₁	0.01 ₄	0.01 ₁	0.02 ₄	0.04 ₀	0.01 ₄	0.01 ₀	0.02 ₁

(Note) *1 $S_{\bar{x}}$ is intermediate precision without a time condition. *2 The half-width confidence interval C (95%) = $t_{\ell-1, 0.05} \times S_{\bar{x}} / \sqrt{\ell}$ (ℓ = number of laboratories)

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- (2) Analytical techniques : Wet chemical analysis method (ISO 21587)
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- (5) Date of preparation : March, 2019

The Technical Association of Refractories, Japan
Certified Reference Material Series for X-ray Fluorescence Analysis of Refractories
JRRM 327 (High-Alumina Refractory)
Results of Analyses

Unit : mass%

Constituent	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	TiO ₂	MnO	CaO	MgO	Na ₂ O	K ₂ O	P ₂ O ₅	Cr ₂ O ₃	ZrO ₂
Certified value	9.977	76.33	3.061	1.453	0.141	0.212	1.483	2.169	2.890	0.555	0.684	0.996
Laboratories												
L ₁	9.901	76.59	3.004	1.467	0.142	0.207	1.497	2.208	2.941	0.562	0.685	1.000
L ₂	10.084	76.29	3.053	1.431	0.146	0.209	1.519	2.232	3.056	0.536	0.687	0.948
L ₃	9.985	75.91	3.090	1.440	0.133	0.221	1.430	2.206	2.869	0.554	0.695	1.000
L ₄	10.062	76.14	3.084	1.460	0.138	0.210	1.544	2.260	2.863	0.552	0.688	1.007
L ₅	9.968	76.62	3.008	1.464	0.140	0.219	1.466	2.035	2.804	0.554	0.670	0.980
L ₆	9.881	76.40	3.140	1.465	0.135	0.202	1.411	2.095	2.790	0.542	0.660	1.043
L ₇	10.282	75.96	3.056	1.442	0.144	0.207	1.487	2.154	2.870	0.570	0.702	1.007
L ₈	9.656	76.76	3.052	1.458	0.148	0.222	1.510	2.160	2.926	0.571	0.688	0.986
Average \bar{X}	9.977 ₄	76.33 ₄	3.060 ₉	1.453 ₄	0.140 ₇	0.212 ₁	1.483 ₀	2.168 ₈	2.889 ₉	0.555 ₁	0.684 ₄	0.996 ₄
Reproducibility $S_{\bar{x}}$	0.181 ₁	0.31 ₄	0.044 ₄	0.013 ₇	0.005 ₂	0.007 ₃	0.045 ₀	0.074 ₅	0.084 ₆	0.012 ₄	0.013 ₆	0.027 ₂
(within laboratory) $S_{I(T)}$ ^{*1}	0.065 ₇	0.12 ₁	0.024 ₁	0.017 ₉	0.003 ₂	0.006 ₇	0.012 ₃	0.017 ₆	0.024 ₂	0.005 ₈	0.003 ₃	0.014 ₅
Uncertainty C (95%) ^{*2}	0.15 ₁	0.26 ₀	0.03 ₇	0.01 ₁	0.00 ₄	0.00 ₆	0.03 ₈	0.06 ₂	0.07 ₁	0.01 ₀	0.01 ₁	0.02 ₃

(Note) *1 $S_{\bar{x}}$ is intermediate precision without a time condition. *2 The half-width confidence interval C (95%) = $t_{\ell-1, 0.05} \times S_{\bar{x}} / \sqrt{\ell}$ (ℓ = number of laboratories)

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JRRM 328 (High-Alumina Refractory)
Results of Analyses

Unit : mass%

Constituent	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	TiO ₂	MnO	CaO	MgO	Na ₂ O	K ₂ O	P ₂ O ₅	Cr ₂ O ₃	ZrO ₂
Certified value	7.05 ₈	85.8 ₆	0.20 ₇	3.36 ₂	0.18 ₇	0.10 ₈	0.05 ₆	0.60 ₅	0.10 ₄	1.97 ₃	0.10 ₃	0.00 ₃
Laboratories												
L ₁	7.09 ₂	85.8 ₀	0.19 ₆	3.35 ₈	0.19 ₁	0.10 ₄	0.05 ₆	0.63 ₂	0.11 ₁	2.03 ₂	0.10 ₂	0.00 ₁
L ₂	7.23 ₂	85.6 ₅	0.20 ₈	3.31 ₂	0.18 ₈	0.11 ₅	0.05 ₄	0.59 ₇	0.09 ₀	1.93 ₈	0.10 ₆	0.00 ₂
L ₃	7.20 ₀	85.8 ₃	0.20 ₇	3.33 ₆	0.18 ₂	0.10 ₆	0.05 ₆	0.58 ₇	0.09 ₈	1.96 ₂	0.10 ₅	0.00 ₄
L ₄	6.90 ₀	85.6 ₀	0.21 ₀	3.30 ₈	0.18 ₂	0.11 ₂	0.05 ₅	0.59 ₄	0.11 ₀	1.98 ₈	0.10 ₁	0.00 ₂
L ₅	7.10 ₁	86.0 ₇	0.20 ₆	3.37 ₄	0.18 ₃	0.10 ₃	0.05 ₆	0.59 ₃	0.10 ₃	1.95 ₃	0.10 ₅	0.00 ₃
L ₆	6.83 ₈	86.1 ₀	0.20 ₈	3.39 ₂	0.19 ₀	0.12 ₀	0.05 ₄	0.61 ₇	0.09 ₆	1.98 ₈	0.10 ₂	0.00 ₄
L ₇	7.15 ₅	85.8 ₀	0.21 ₇	3.45 ₅	0.18 ₉	0.09 ₆	0.05 ₆	0.59 ₇	0.10 ₉	1.95 ₄	0.09 ₉	0.00 ₃
L ₈	6.94 ₉	86.0 ₄	0.20 ₄	3.35 ₉	0.19 ₁	0.11 ₂	0.05 ₈	0.62 ₁	0.11 ₁	1.96 ₆	0.10 ₃	0.00 ₄
Average \bar{X}	7.058 ₄	85.86 ₁	0.207 ₀	3.361 ₈	0.187 ₀	0.108 ₅	0.055 ₆	0.604 ₈	0.103 ₅	1.972 ₆	0.102 ₉	0.002 ₉
Reproducibility $S_{\bar{x}}$	0.145 ₄	0.19 ₂	0.005 ₉	0.047 ₅	0.003 ₉	0.007 ₉	0.001 ₂	0.016 ₄	0.007 ₈	0.029 ₇	0.002 ₃	0.000 ₈
(within laboratory) $S_{I(T)}$ ^{*1}	0.078 ₇	0.15 ₇	0.005 ₁	0.026 ₁	0.001 ₆	0.012 ₄	0.003 ₁	0.012 ₀	0.002 ₉	0.019 ₅	0.002 ₅	0.001 ₃
Uncertainty C (95%) ^{*2}	0.12 ₂	0.16 ₀	0.00 ₅	0.04 ₀	0.00 ₃	0.00 ₇	0.00 ₁	0.01 ₄	0.00 ₇	0.02 ₅	0.00 ₂	0.00 ₁

(Note) *1 $S_{\bar{x}}$ is intermediate precision without a time condition. *2 The half-width confidence interval C (95%) = $t_{\ell-1, 0.05} \times S_{\bar{x}} / \sqrt{\ell}$ (ℓ = number of laboratories)

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Unit : mass%

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Certified value	2.01 ₆	88.5 ₁	1.01 ₅	3.78 ₂	0.03 ₅	1.49 ₀	0.21 ₇	0.86 ₉	1.34 ₀	0.08 ₅	0.37 ₄	0.15 ₃
Laboratories												
L ₁	1.97 ₇	88.5 ₉	1.01 ₅	3.74 ₄	0.03 ₆	1.49 ₃	0.21 ₇	0.89 ₉	1.37 ₈	0.08 ₇	0.37 ₅	0.14 ₈
L ₂	1.97 ₀	88.2 ₉	1.02 ₈	3.78 ₈	0.03 ₅	1.46 ₆	0.22 ₄	0.84 ₇	1.38 ₅	0.08 ₂	0.37 ₂	0.15 ₆
L ₃	2.07 ₆	88.2 ₀	1.00 ₆	3.61 ₄	0.03 ₅	1.46 ₃	0.21 ₄	0.88 ₃	1.34 ₀	0.08 ₄	0.37 ₄	0.15 ₇
L ₄	2.03 ₃	88.2 ₆	1.00 ₈	3.93 ₄	0.03 ₆	1.45 ₉	0.21 ₀	0.89 ₉	1.37 ₀	0.07 ₉	0.38 ₀	0.15 ₆
L ₅	2.03 ₃	88.9 ₃	1.00 ₂	3.79 ₂	0.03 ₄	1.53 ₇	0.22 ₅	0.85 ₂	1.26 ₅	0.08 ₂	0.37 ₂	0.15 ₄
L ₆	1.94 ₉	88.6 ₁	1.01 ₈	3.82 ₆	0.03 ₄	1.48 ₆	0.20 ₆	0.84 ₈	1.31 ₆	0.09 ₁	0.37 ₆	0.15 ₅
L ₇	2.07 ₂	88.4 ₀	1.04 ₄	3.74 ₀	0.03 ₅	1.51 ₅	0.22 ₄	0.84 ₆	1.30 ₀	0.08 ₀	0.37 ₂	0.15 ₁
L ₈	2.01 ₈	88.8 ₃	1.00 ₀	3.81 ₆	0.03 ₇	1.49 ₇	0.21 ₄	0.88 ₀	1.36 ₇	0.09 ₂	0.37 ₄	0.15 ₀
Average \bar{X}	2.016 ₀	88.51 ₄	1.015 ₁	3.781 ₈	0.035 ₃	1.489 ₅	0.216 ₈	0.869 ₂	1.340 ₁	0.084 ₆	0.374 ₄	0.153 ₄
Reproducibility $S_{\bar{x}}$	0.047 ₀	0.27 ₂	0.014 ₈	0.090 ₈	0.001 ₁	0.027 ₄	0.007 ₂	0.023 ₂	0.042 ₆	0.005 ₀	0.002 ₇	0.003 ₃
(within laboratory) $S_{I(T)}$ ^{*1}	0.015 ₂	0.14 ₄	0.005 ₂	0.012 ₉	0.000 ₃	0.008 ₀	0.002 ₉	0.011 ₂	0.015 ₈	0.003 ₈	0.002 ₆	0.002 ₈
Uncertainty C (95%) ^{*2}	0.03 ₉	0.23 ₀	0.01 ₂	0.07 ₆	0.00 ₁	0.02 ₃	0.00 ₆	0.01 ₉	0.03 ₆	0.00 ₄	0.00 ₂	0.00 ₃

(Note) *1 $S_{\bar{x}}$ is intermediate precision without a time condition. *2 The half-width confidence interval C (95%) = $t_{\ell-1, 0.05} \times S_{\bar{x}} / \sqrt{\ell}$ (ℓ = number of laboratories)

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Certified value	0.97 ₆	92.4 ₁	0.03 ₄	1.92 ₃	0.00 ₀	0.04 ₀	1.95 ₁	0.23 ₉	0.99 ₈	0.98 ₀	0.01 ₄	0.00 ₂
Laboratories L ₁	0.97 ₃	92.8 ₁	0.03 ₅	1.92 ₉	0.00 ₁	0.03 ₇	1.95 ₁	0.25 ₂	1.01 ₆	0.99 ₇	0.01 ₅	0.00 ₁
L ₂	0.98 ₄	92.3 ₆	0.03 ₅	1.84 ₈	0.00 ₀	0.05 ₀	1.95 ₈	0.23 ₅	1.00 ₄	0.96 ₄	0.01 ₆	0.00 ₀
L ₃	0.97 ₆	92.3 ₂	0.03 ₂	1.92 ₅	0.00 ₀	0.04 ₁	1.95 ₆	0.23 ₀	0.94 ₅	0.97 ₉	0.01 ₃	0.00 ₀
L ₄	1.00 ₂	92.4 ₄	0.03 ₆	1.90 ₈	0.00 ₀	0.04 ₈	1.96 ₄	0.25 ₉	0.97 ₂	1.02 ₂	0.01 ₄	0.00 ₁
L ₅	0.97 ₈	92.6 ₀	0.03 ₂	1.90 ₅	0.00 ₀	0.04 ₂	1.93 ₁	0.24 ₆	0.94 ₂	0.94 ₄	0.01 ₆	0.00 ₃
L ₆	0.92 ₈	92.8 ₂	0.03 ₈	1.94 ₂	0.00 ₀	0.02 ₆	1.92 ₆	0.23 ₆	0.97 ₉	0.98 ₀	0.01 ₆	0.00 ₃
L ₇	1.00 ₄	92.2 ₀	0.03 ₄	1.99 ₄	0.00 ₀	0.03 ₅	1.96 ₀	0.22 ₂	1.07 ₅	0.96 ₄	0.01 ₀	0.00 ₃
L ₈	0.96 ₄	91.7 ₅	0.03 ₂	1.93 ₆	0.00 ₁	0.04 ₂	1.96 ₅	0.23 ₁	1.05 ₂	0.99 ₀	0.01 ₃	0.00 ₂
Average \bar{X}	0.976 ₁	92.41 ₂	0.034 ₂	1.923 ₄	0.000 ₂	0.040 ₀	1.951 ₄	0.238 ₉	0.998 ₁	0.980 ₀	0.014 ₁	0.001 ₆
Reproducibility $S_{\bar{x}}$	0.023 ₉	0.34 ₉	0.002 ₃	0.041 ₀	0.000 ₃	0.007 ₆	0.014 ₆	0.012 ₂	0.048 ₁	0.023 ₉	0.002 ₁	0.000 ₉
(within laboratory) $S_{I(T)}$ ^{*1}	0.012 ₇	0.15 ₁	0.003 ₁	0.012 ₉	0.000 ₅	0.003 ₂	0.020 ₅	0.006 ₂	0.013 ₈	0.005 ₉	0.000 ₂	0.001 ₀
Uncertainty C (95%) ^{*2}	0.02 ₀	0.29 ₀	0.00 ₂	0.03 ₄	0.00 ₀	0.00 ₆	0.01 ₂	0.01 ₀	0.04 ₀	0.02 ₀	0.00 ₂	0.00 ₁

(Note) *1 $S_{\bar{x}}$ is intermediate precision without a time condition. *2 The half-width confidence interval C (95%) = $t_{\ell-1, 0.05} \times S_{\bar{x}} / \sqrt{\ell}$ (ℓ = number of laboratories)

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Certified value	0.23 ₀	99.0 ₄	0.11 ₄	0.01 ₀	0.00 ₂	0.03 ₅	0.02 ₄	0.28 ₉	0.12 ₂	0.08 ₅	0.00 ₆	0.04 ₁
Laboratories L ₁	0.21 ₆	99.0 ₆	0.11 ₀	0.01 ₀	0.00 ₂	0.03 ₂	0.02 ₅	0.28 ₉	0.13 ₀	0.08 ₄	0.00 ₆	0.03 ₅
L ₂	0.22 ₆	99.0 ₃	0.12 ₂	0.00 ₈	0.00 ₂	0.03 ₉	0.02 ₇	0.28 ₇	0.11 ₀	0.09 ₂	0.00 ₇	0.04 ₈
L ₃	0.21 ₆	99.0 ₄	0.12 ₀	0.01 ₀	0.00 ₁	0.03 ₆	0.02 ₃	0.29 ₄	0.12 ₈	0.08 ₂	0.00 ₆	0.04 ₀
L ₄	0.21 ₈	99.0 ₇	0.09 ₆	0.00 ₉	0.00 ₂	0.03 ₉	0.02 ₆	0.28 ₄	0.11 ₈	0.08 ₈	0.00 ₇	0.04 ₁
L ₅	0.24 ₁	99.0 ₇	0.10 ₉	0.01 ₀	0.00 ₂	0.03 ₄	0.02 ₄	0.28 ₇	0.11 ₄	0.08 ₁	0.00 ₆	0.02 ₇
L ₆	0.23 ₄	99.0 ₁	0.11 ₄	0.01 ₂	0.00 ₁	0.03 ₄	0.02 ₁	0.29 ₄	0.12 ₉	0.09 ₀	0.00 ₆	0.05 ₇
L ₇	0.25 ₀	99.0 ₃	0.12 ₄	0.01 ₁	0.00 ₁	0.03 ₅	0.02 ₆	0.27 ₇	0.11 ₅	0.08 ₂	0.00 ₆	0.04 ₈
L ₈	0.23 ₆	99.0 ₃	0.11 ₈	0.01 ₀	0.00 ₂	0.03 ₄	0.02 ₄	0.29 ₇	0.13 ₀	0.08 ₂	0.00 ₆	0.03 ₄
Average \bar{X}	0.229 ₆	99.04 ₂	0.114 ₁	0.010 ₀	0.001 ₆	0.035 ₄	0.024 ₅	0.288 ₆	0.121 ₈	0.085 ₁	0.006 ₂	0.041 ₂
Reproducibility $S_{\bar{x}}$	0.012 ₆	0.02 ₂	0.009 ₁	0.001 ₁	0.000 ₅	0.002 ₄	0.001 ₉	0.006 ₄	0.008 ₁	0.004 ₂	0.000 ₅	0.009 ₆
(within laboratory) $S_{H(T)}$ ^{*1}	0.005 ₉	0.00 ₉	0.002 ₅	0.000 ₇	0.000 ₅	0.002 ₃	0.001 ₀	0.004 ₀	0.004 ₂	0.004 ₀	0.000 ₀	0.001 ₂
Uncertainty C (95%) ^{*2}	0.01 ₁	0.02 ₀	0.00 ₈	0.00 ₁	0.00 ₀	0.00 ₂	0.00 ₂	0.00 ₅	0.00 ₇	0.00 ₄	0.00 ₀	0.00 ₈

(Note) *1 $S_{\bar{x}}$ is intermediate precision without a time condition. *2 The half-width confidence interval C (95%) = $t_{\ell-1, 0.05} \times S_{\bar{x}} / \sqrt{\ell}$ (ℓ = number of laboratories)

- (1) List of laboratories : Krosaki Harima Corporation, Shinagawa Refractories Co, Ltd, TYK Corporation, AGC Ceramics Co, Ltd, TOSHIBA NANOANALYSIS CORPORATION, JFE Techno-Research Corporation, CLEARIZE Co., Ltd, NIPPON STEEL TECHNOLOGY Co., Ltd
- (2) Analytical techniques : Wet chemical analysis method (ISO 21587)
- (3) Analytical values : Each value is the average of two values obtained by two measurements on different days. These analysis values are shown converted into LOI (Loss on ignition) component free values.
- (4) Outlier tests were carried out by Grubbs test. The samples rejected by Grubbs tests were discussed in view of analytical techniques and it was determined whether the outliers should be adopted or not.
- (5) Date of preparation : March, 2019

The Technical Association of Refractories, Japan
Certified Reference Material Series for X-ray Fluorescence Analysis of Refractories
JRRM 332 (High-Alumina Refractory)
Results of Analyses

Unit : mass%

Constituent	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	TiO ₂	MnO	CaO	MgO	Na ₂ O	K ₂ O	P ₂ O ₅	Cr ₂ O ₃	ZrO ₂
Certified value	0.00 ₃	99.9 ₉	0.00 ₀	0.00 ₀	0.00 ₀	0.00 ₁	0.00 ₁	0.00 ₃	0.00 ₀	0.00 ₃	0.00 ₀	0.00 ₀
Laboratories L ₁	0.00 ₄	99.9 ₉	0.00 ₀	0.00 ₀	0.00 ₀	0.00 ₃	0.00 ₅	0.00 ₀	0.00 ₀	0.00 ₀	0.00 ₀	0.00 ₀
L ₂	0.00 ₀	99.9 ₈	0.00 ₀	0.00 ₀	0.00 ₀	0.00 ₁	0.00 ₄	0.00 ₆	0.00 ₂	0.00 ₄	0.00 ₀	0.00 ₀
L ₃	0.00 ₀	100.0 ₀	0.00 ₀	0.00 ₀	0.00 ₀	0.00 ₀	0.00 ₂	0.00 ₀	0.00 ₀	0.00 ₀	0.00 ₀	0.00 ₀
L ₄	0.00 ₆	99.9 ₈	0.00 ₁	0.00 ₀	0.00 ₀	0.00 ₄	0.00 ₀	0.00 ₆	0.00 ₀	0.00 ₄	0.00 ₀	0.00 ₂
L ₅	0.00 ₈	99.9 ₈	0.00 ₀	0.00 ₀	0.00 ₀	0.00 ₀	0.00 ₀	0.00 ₃	0.00 ₀	0.00 ₂	0.00 ₀	0.00 ₂
L ₆	0.00 ₂	99.9 ₈	0.00 ₀	0.00 ₀	0.00 ₀	0.00 ₀	0.00 ₀	0.00 ₈	0.00 ₁	0.01 ₀	0.00 ₀	0.00 ₀
L ₇	0.00 ₃	99.9 ₉	0.00 ₀	0.00 ₀	0.00 ₀	0.00 ₀	0.00 ₀	0.00 ₂	0.00 ₀	0.00 ₁	0.00 ₀	0.00 ₀
L ₈	0.00 ₃	100.0 ₀	0.00 ₀	0.00 ₀	0.00 ₀	0.00 ₀	0.00 ₀	0.00 ₂	0.00 ₀	0.00 ₀	0.00 ₀	0.00 ₀
Average \bar{X}	0.003 ₂	99.98 ₈	0.000 ₁	0.000 ₀	0.000 ₀	0.001 ₀	0.001 ₄	0.003 ₄	0.000 ₄	0.002 ₆	0.000 ₀	0.000 ₅
Reproducibility $S_{\bar{x}}$	0.002 ₇	0.00 ₈	0.000 ₄	0.000 ₀	0.000 ₀	0.001 ₅	0.001 ₉	0.002 ₉	0.000 ₆	0.003 ₅	0.000 ₂	0.001 ₁
(within laboratory) $S_{I(T)}$ ^{*1}	0.000 ₈	0.00 ₂	0.000 ₀	0.000 ₀	0.000 ₀	0.000 ₄	0.000 ₈	0.000 ₆	0.000 ₄	0.000 ₉	0.000 ₂	0.000 ₂
Uncertainty C (95%) ^{*2}	0.00 ₂	0.01 ₀	0.00 ₀	0.00 ₀	0.00 ₀	0.00 ₁	0.00 ₂	0.00 ₃	0.00 ₁	0.00 ₃	0.00 ₀	0.00 ₁

(Note) *1 $S_{\bar{x}}$ is intermediate precision without a time condition. *2 The half-width confidence interval C (95%) = $t_{\ell-1, 0.05} \times S_{\bar{x}} / \sqrt{\ell}$ (ℓ = number of laboratories)

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