VUULCAN REFRACTORIES · TECHNICAL CENTER · L4A TECHNICAL BRIEF | Standards & Quality

How to Read a Refractory COA: What Every Number Means and What to Watch For

Vuulcan Refractories Technical Team | Updated January 2024 | 14 min read

Complete guide to interpreting Certificate of Analysis documents, identifying quality red flags, and verifying supplier claims. Covers Al_2O_3, CaO, Fe_2O_3, bulk density, CCS, MOR, PLC, and common falsification patterns — based on analysis of 500+ COA documents from China, India, and Europe.

Contents

- What a COA Must Contain
- Section 1: Chemical Composition — Al_2O_3, CaO, Fe_2O_3, Alkali
- Section 2: Physical Properties — Bulk Density, CCS, MOR, PLC
- Red Flag Patterns & Falsification Indicators
- COA Acceptance / Rejection Decision Tree
- Quick Reference: Acceptable Tolerances by Property

A refractory Certificate of Analysis (COA) is a quality assurance document that reports chemical composition, physical properties, and test results for a specific production batch of castable or shaped brick. Only 35% of refractory buyers systematically review COA data; the remaining 65% rely solely on supplier assurances — creating quality risk of 15–40% performance shortfall when specification deviations go undetected.

What a Properly Formatted COA Must Contain

A complete COA includes five sections:

- **Product identification** — grade, batch number, production date, quantity
- **Chemical composition** — by XRF or wet chemical analysis (% by weight)
- **Physical properties** — bulk density, CCS, MOR, PLC with test conditions
- **Test standards** — ASTM, GB, ISO reference numbers
- **Authorized signature** — laboratory name, test date, QC manager sign-off

```
EXAMPLE COA HEADER — Low Cement Castable AL-70
═══════════════════════════════════════════════
```

```
Product Name:   Low Cement Castable, Grade AL-70
Product Code:   VRF-LCC-70
Batch Number:   20240315-A
Production Date: March 15, 2024
Quantity:       25,000 kg (1000 bags × 25 kg)

CHEMICAL COMPOSITION (% by weight)
Parameter            Specification     Actual    Status
Al₂O₃                70.0 ± 1.5        70.5      ✓
SiO₂                 —                 26.8      —
Fe₂O₃                ≤ 1.5             1.2       ✓
CaO                  ≤ 2.5             1.8       ✓
Alkali (Na₂O+K₂O)    ≤ 0.8             0.5       ✓

PHYSICAL PROPERTIES
Bulk Density (g/cm³, 110°C×24h)      2.50±0.10     2.58    ✓
CCS (MPa, 110°C×24h)                 ≥ 55          62      ✓
CCS (MPa, 1000°C×3h)                 ≥ 65          75      ✓
MOR (MPa, 1000°C)                    ≥ 10          12.5    ✓
PLC (%, 1000°C×3h)                   ± 0.5         -0.3    ✓
```

Section 1: Chemical Composition

Al_2O_3 — Primary Performance Indicator

Alumina content determines refractoriness, slag resistance, and thermal stability. Higher Al_2O_3 = higher service temperature capability.

Al_2O_3 Range	Classification	Typical Application
45–50%	Semi-silica / fireclay	Low-temp backup linings, <1200°C
55–65%	Standard high-alumina	General industrial furnaces
65–75%	High-performance LCC	Cement kilns, steel ladles
75–85%	Premium LCC / ULCC	Alkali environments, EAF
85–95%	Corundum / ULCC	Extreme conditions, petrochemical

Red Flag: Al_2O_3 deviating >1.5% from specification. A 2% reduction (e.g., 68% actual vs 70% specified) reduces RUL (refractoriness under load) by ~30–40°C — critical failure risk in marginal temperature applications. Batch-to-batch variance >2.5% indicates poor raw material control.

CaO — Critical for LCC/ULCC Classification

CaO indicates cement level in castable. Low CaO is essential for alkali resistance, slag resistance, and high hot strength.

CaO Content	Classification	Performance Level
8–15%	Conventional castable	Baseline
2.0–2.5%	LCC (Low Cement)	Good — alkali & slag resistance
1.0–2.0%	True LCC	High — cement kiln transition zone rated
<1.0%	ULCC (Ultra-Low Cement)	Highest — EAF, severe slag environments

Red Flag: "LCC" with CaO >2.5% — not true LCC, performs as conventional castable. "ULCC" with CaO 1.5–2.0% — actually LCC. CaO not reported at all — assume conventional castable, reject. In cement kiln transition zones: CaO 2.8% vs 1.5% shows 40–60% shorter campaign life.

Fe_2O_3 — Impurity Control

Iron oxide acts as flux (lowers melting point) and causes discoloration. Acceptable levels:

- High-grade: ≤1.0% | Standard: 1.0–1.5% | Economy: 1.5–2.5%
- Fe_2O_3 >2.0% reduces RUL by 20–30°C and increases thermal expansion coefficient

Alkali Content (Na_2O + K_2O)

Alkali oxides are fluxes that lower melting point and reduce high-temperature strength. Specification: ≤0.8% for high-performance grade, ≤1.2% for standard grade.

Note: Alkali content not reported in COA for cement kiln or glass furnace applications — request this data explicitly before acceptance. It is the single most predictive parameter for transition zone campaign life.

Section 2: Physical Properties

Bulk Density (g/cm³)

Condition	Likely Cause	Impact
Density 5–10% low (brick)	Under-firing	Strength −20–30%, service life −25–40%
Density 3–6% low (castable)	Excess water in test sample	Field performance may be acceptable if installed correctly

Density >5% high	Different raw materials or mis-labeled grade	Investigate before acceptance

Acceptable tolerance: ±0.05 g/cm³ for brick (±2%); ±0.10 g/cm³ for castable (±4%).

Cold Crushing Strength (CCS)

Tested at two conditions:

- **CCS @ 110°C × 24h** — Green strength after curing. Indicates cement hydration quality (castable) or firing quality (brick).
- **CCS @ 1000°C × 3h** — Hot strength. Indicates high-temperature structural integrity.

> **Red Flag:** CCS @ 1000°C significantly higher than CCS @ 110°C — reverse strength development, indicates poor hydraulic bond. Large drop >30% from 110°C to 1000°C — ceramic bond not forming, raw material quality issue.

Modulus of Rupture (MOR)

MOR measures flexural strength — critical for thermal shock resistance. MOR at high temperature (1200–1400°C) is the most meaningful parameter for in-service performance.

- Acceptable: MOR @ 1400°C ≥6 MPa for LCC in cement kiln service
- Red flag: MOR <4 MPa @ 1400°C — inadequate thermal shock resistance

Permanent Linear Change (PLC)

PLC measures dimensional stability after firing. Critical for joint integrity and lining tightness.

PLC Value	Interpretation	Risk
0 to −0.5%	Slight shrinkage — normal	Low
−0.5 to −1.5%	Excessive shrinkage	Joint opening, gas bypass
0 to +0.5%	Slight expansion — normal	Low
>+1.0%	Excessive expansion	Lining buckling, spalling

Red Flag Patterns & Falsification Indicators

Pattern	Likely Explanation	Action

All values exactly at specification minimum	COA copied from specification sheet, not actual test	Request re-test with third-party lab witness
CCS values identical across batches (0 variance)	Fabricated data	Reject; demand witnessed test
Al_2O_3 + SiO_2 + other oxides ≠ ~100%	Selective reporting / rounding to hide impurities	Request full oxide balance
No batch number or production date	Generic / recycled COA	Do not accept; batch traceability required
SiO_2 and alkali not reported	Hiding low-quality raw materials	Mandatory for cement kiln applications
Lab name not verifiable	In-house "lab" with no accreditation	Require CNAS/CMA-accredited lab report

COA Acceptance / Rejection Decision Tree

1. **Product ID complete?** (batch no., date, quantity) → No: Reject immediately
2. **Al_2O_3 within ±1.5% of spec?** → No: Reject unless deviation favorable + application reviewed
3. **CaO within spec for claimed grade?** (LCC ≤2.5%, ULCC ≤1.0%) → No: Reject as mis-labeled
4. **CCS @ 110°C and 1000°C both ≥ spec?** → No: Investigate raw material or firing issue
5. **PLC within ±0.5%?** → No: Dimensional instability risk, consult application engineer
6. **Lab signature + test date present?** → No: Do not accept without certification
7. **All above pass** → Accept with batch record retention ≥5 years

Quick Reference: Acceptable Tolerances by Property

Property	Tolerance	Critical Threshold (Reject)
Al_2O_3	±1.5% of nominal	>2% below spec
CaO (LCC)	≤2.5%	>2.5% = not true LCC
CaO (ULCC)	≤1.0%	>1.5% = not ULCC
Fe_2O_3	≤1.5% standard	>2.5%
Na_2O+K_2O	≤0.8% high-perf	>1.2%

Bulk Density (brick)	±0.05 g/cm³	>5% below spec
Bulk Density (castable)	±0.10 g/cm³	>6% below spec
CCS @ 110°C	±10% of spec	>15% below spec
CCS @ 1000°C	±10% of spec	>15% below spec
MOR @ 1400°C (LCC)	≥6 MPa	<4 MPa
PLC	±0.5%	>±1.5%

vuulcanrefractories.com/technical-center/how-to-read-refractory-coa/ | Vuulcan Refractories Technical Team |