

VerdeChrome®

REFRACTORY APPLICATION GUIDE

Chromium Oxide Green & Chrome Corundum

How to specify, formulate and hold campaign life in slag-aggressive furnaces, kilns and ladles

10	0.1–8 µm	≥1880 °C	≤0.03%	2
chromium oxide green grades	D50 range	refractoriness	water-soluble Cr(VI)	chrome corundum grades

A working guide for refractory engineers, buyers and plant EHS teams. It explains what chromium oxide actually does in a matrix, where it is worth the money and where it is not, and how to choose a grade for a specific wear mode instead of a catalogue page.

> **Lining life is decided in the matrix, not in the aggregate.**

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What is in this guide, and who it is for

Seventeen sections: the first eight cover the material, sections 9–13 cover furnaces, and 14–17 are the selection and compliance tools. Read it with your own wear data in hand.

If you buy

Price per kilogram is the wrong number. Page 3 turns a lining into cost per month of campaign, and page 9 lists the six certificate values worth insisting on.

If you formulate

Pages 4–8 give the mechanism, the grade table and the three comparisons you need to defend a substitution. Pages 11–15 give the formulation windows.

If you run the plant

Pages 6 and 19 cover Cr(VI) control, batch traceability and what an audit will ask for. Page 13–15 map the wear mode to the application.

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What this guide does not do

It does not quote your furnace, your slag or your current lining life. Every range here is a starting point drawn from our own production data and from typical industry practice — it has to be validated on your equipment. Where a number is ours we say so; where it is an industry benchmark we mark it as typical.

The two families in one view

Family	Chemistry	What we supply	Numbers that define it
Chromium oxide green	Cr_2O_3, ≥99%	Ten grades, D50 0.1–8 µm; six of them at ≤5 ppm Cr(VI)	Migratory Cr(VI) 300 or 5 ppm; water-soluble salts ≤0.70%
Chrome corundum	α-$(Al,Cr)_2O_3$ solid solution	CC and FCC aggregate, 0–1 to 5–8 mm	Al_2O_3 80–90%, Cr_2O_3 5–17%, refractoriness ≥1880 °C

A lining is bought per month, not per kilogram

The four costs that follow a short lining are rarely in the refractory quotation. They are in the reline schedule, the production report and the scrap bin.

Refractory material is usually 15–30% of the true cost of a lining. The rest is installation labour, crane and scaffold time, cooldown and heat-up energy, lost output during the stop, and the quality losses that follow a cold start. When a lining fails three months early, none of those costs appear in the purchase order — but all of them appear in the annual budget.

Material

15–30% of lining cost. The only line the buyer sees.

Installation

Labour, scaffold, crane, supervision. Paid again every reline, so more relines is more labour, not less.

Lost output

A furnace that is down is not making product. Usually the single largest number in the case — and the one nobody quantifies before choosing a supplier.

Start-up quality

First casts after a cold start carry more scrap, more temperature scatter and more defects. Every extra reline repeats that curve.

The same lining, two campaign lengths

Per three years of operation	6-month campaign	9-month campaign	What it means
Relines	6	4	Two fewer shutdowns
Installation labour and equipment	6×	4×	−33% labour
Production days lost	18	12	6 days of output recovered
Refractory material bought	100%	67%	−33% material
Cold-start scrap events	6	4	Two fewer quality excursions

Illustrative arithmetic: campaigns of 6 and 9 months over 36 months, three days of lost output per reline. Put your own numbers in the same columns and the answer usually moves in one direction.

> **The cheapest refractory is almost never the cheapest lining.**
> Ask for the cost per month of campaign, not the price per kilogram. If a supplier cannot tell you which wear mode their product resists, they cannot tell you how long it will last either.

What to put in the inquiry

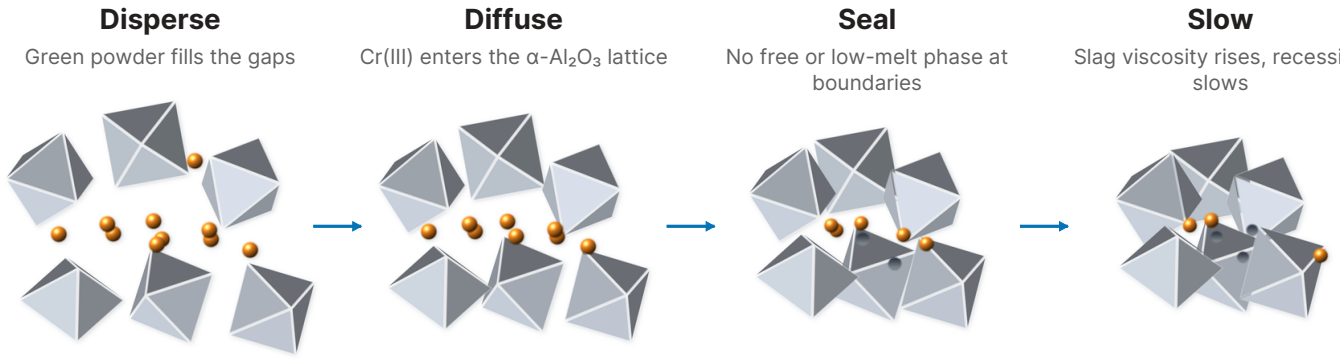
- The campaign length you get today and the one you need — a supplier cannot beat a number they have not seen
- Which zone failed, and whether it wore thin, cracked or spalled: three different problems, three different products
- Slag analysis and tapping temperature — in copper and nickel work this decides more than the refractory brand
- Your installation constraint: brick, castable, gunning, or the time actually available in the stop
- The Cr(VI) declaration your market requires, so it is priced in from the start

FIELD NOTE If your finance team approves on price per tonne, put cost per month of campaign in the same table. It changes the conversation faster than any datasheet.

How chromium oxide green works

Chromium enters the lattice, and the matrix becomes a continuous solid solution

Green powder sits in the particle gaps and makes diffusion possible.
Corrosion resistance depends on solution sealing and matrix density.

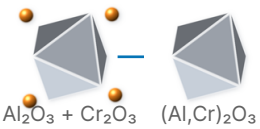


Corrosion resistance depends on sealing and pore removal



Kinetics of the submicron fraction

Shorter diffusion paths, higher local driving force, faster solution and densification



Reaction bonding in a working mix

In-situ solution seals the boundary and builds a bridge

Schematic; results depend on addition level, dispersion, size blend, formulation and firing

Two process targets

Target density at a lower temperature

Judge by density and slag resistance, then verify the energy and cost change from a lower set point.

Better slag resistance at the existing schedule

Hold temperature and soak time; gain more complete sealing from solution and size optimisation.

Process coordination

Addition level, dispersion, size blend, forming, atmosphere and schedule have to match; the degree of solution also depends on firing temperature and soak time.

One exception: the logic reverses with the composition

In an alumina body a little chromium in the corundum lattice helps. In a chromia body such as a high-chrome brick, alumina entering the chromia lattice lowers slag resistance (page 11). Same solid solution, opposite direction, opposite conclusion.

FIELD NOTE Ask for a polished section of a fired trial body. A chromium map across the aggregate boundary tells you in five minutes whether the micropowder entered solution.

Five ways a lining dies — and what Cr_2O_3 does to each

Most lining failures are a mismatch between the material and the dominant wear mode. Before choosing a grade, decide which of these five is actually killing the lining.



Corrosion



Penetration



Spalling



Redox



Abrasion

Wear mode	What is happening	What a Cr_2O_3 matrix does	What you see in service
Chemical corrosion	Slag dissolves Al_2O_3 out of the matrix at the hot face	Lowers Al_2O_3 activity, raises slag viscosity, slows further dissolution	Slower hot-face recession; slag keeps its sharp interface longer
Capillary penetration	Liquid slag is drawn into open porosity and along grain boundaries	Boundaries sealed by solid solution, less open network	Thinner penetration layer, less spalling on cool-down
Thermal spalling	Expansion mismatch between hot face and cold back cracks the body	Solid solution reduces expansion and stresses at the interface	Fewer through-cracks after the first thermal cycles
Redox and vapour attack	FeO, alkali and metal vapours reduce or react with the matrix	Cr_2O_3 is markedly less reactive to FeO than alumina alone	Less blistering, less localised deep pitting
Erosion and abrasion	Hot particles and moving liquid abrade the surface	Harder, denser matrix, but abrasion is not its main strength	Helps, but do not buy Cr_2O_3 for abrasion alone

A chrome-bearing matrix is expensive per kilogram, so spending it on a mode it does not address is the most common way to waste money in this category. A slag-line problem and an abrasion problem can look identical on a worn brick; they need different answers.

How to read a worn lining before you re-specify

- Cut a section through the worn zone and measure the penetration depth, not just the remaining thickness — penetration predicts the next failure.
- Look for a colour change front: a sharp chromium-rich hot face means corrosion control is working; a diffuse front means penetration is the problem.
- Check where the cracks start. Cracks parallel to the hot face are thermal; cracks running into the joint are penetration-driven.

> **Match the grade to the mode, then the mode to the grade.**
> We will help you read the worn lining and pick the mode. It costs one photograph and a section dimension, and it is the step that most often changes the specification.

Three misdiagnoses we see most often

Called corrosion, was penetration

A thin worn face with a deep discoloured zone behind it is penetration. More chromium helps only if it seals the boundary.

Called thermal shock, was dry-out

A castable that cracks on first heat is usually a water and schedule problem, not a material problem.

Called abrasion, was corrosion

A smooth, glassy wear surface with no gouging is chemical. Abrasion leaves directional grooves.

Chromium oxide green: one chemistry, ten grades

Same Cr_2O_3 in every grade; what changes is particle size and Cr(VI) level.

Model	D50 (µm)	Cr_2O_3 ≥%	Migratory Cr(VI) ≤ppm	Water-soluble salts ≤%	Sieve residue 45 µm ≤%	pH	Typical use
General matrix (migratory Cr(VI) ≤300 ppm)							
G-5001	1–2	≥99	≤300	≤0.70	≤0.30	6–8	General matrix
G-5002	2–3	≥99	≤300	≤0.70	≤0.30	6–8	General matrix
G-5003	3–4	≥99	≤300	≤0.70	≤0.30	6–8	General matrix
G-5005	4–8	≥99	≤300	≤0.70	≤0.30	6–8	Coarse matrix
Low Cr(VI) family (migratory Cr(VI) ≤5 ppm)							
G-5699	1–2	≥99	≤5	≤0.70	≤0.30	6–8	Low Cr(VI) type
G-5799	4–8	≥99	≤5	≤0.70	≤0.30	6–8	Larger crystal size
G-5899	3–8	≥99	≤5	≤0.70	≤0.30	6–8	For high-chrome bricks
G-5999	3–4	≥99	≤5	≤0.70	≤0.30	6–8	Bimodal, for castables
Submicron (≥98.5%, for sintering)							
G-5070	0.6–1	≥98.5	≤5	≤0.70	≤0.30	6–8	Submicron
G-5075	0.1–0.6	≥98.5	≤5	≤0.70	≤0.30	6–8	Ultra-fine submicron

Which size does what

0.1–1 µm (G-5070, G-5075) drives sintering and densification: highest surface area, most cold strength per percent, biggest effect on water demand.

1–4 µm (G-5001/5002/5003, G-5699, G-5999) is the workhorse castable matrix; G-5999 is dual-peaked at 3–4 µm to pack between aggregate and fines.

4–8 µm (G-5005, G-5799) lowers water demand and suits pressed brick, where a coarser matrix reduces press cracking.

Which Cr(VI) level to ask for

Two levels exist: ≤300 ppm migratory Cr(VI) and ≤5 ppm on the low-Cr(VI) grades (G-5699, G-5799, G-5899, G-5999, G-5070, G-5075).

Choose the 5 ppm family when the product is audited, exported, in contact with drinking water or food equipment, used in cement, or a Cr(VI) declaration is required.

45 µm sieve residue is the quiet specification: it causes pinholes and spalling in thin sections, and it is the first number to check on an incoming certificate.

> **Order by grade number, not by "chrome green".**
> "Chrome oxide green 99%" can arrive as a pigment milling run, a micronised batch or a coarse grade. The number on the bag is the only way to keep a formulation reproducible.

Why ten grades instead of three

Because a refractory is designed around a packing curve, and a packing curve needs a particular particle size, not a particular brand. Ten grades let a formulator put chromium at 0.3 µm to drive sintering, at 3–4 µm for the dual peak between aggregate and fines, and at 4–8 µm to keep water demand down in a pressed brick. It is the same Cr_2O_3 doing three different jobs in the same body.

Pigment grade vs refractory grade: what the certificate does not tell you

Both are chromium oxide micropowders with the same formula. One is designed to make colour, the other to make a matrix. The difference is in what the supplier optimises.

What the supplier optimises	Pigment grade	Our refractory grade	Why it matters
Primary target	Tint strength and colour under a specific illuminant	Packing density and reaction in the matrix	Colour is irrelevant in a brick
Particle size	Milled for colour, distribution not fixed	D50 declared and held per grade	Reproducible water demand and strength
Sieve residue at 45 µm	Not a selling point	≤0.30%—a limit, not a target	Coarse particles cause pinholes and spalling
Surface chemistry	Often treated or coated	Untreated, pH 6–8	Predictable response to deflocculants
Cr(VI) control	Rarely specified for refractories	300 ppm and 5 ppm families	Audit and EHS exposure
Certificate contents	Colour and pigment tests	Cr_2O_3, salts, residue, Cr(VI), pH	The numbers a refractory formulation needs

None of this makes pigment grade a bad product — it makes it a different product. The problem appears at the mixer, when a pigment-grade lot behaves like a different raw material from the previous delivery and the castable needs more water, flows differently or shrinks more on drying.

Three questions to ask any green supplier

1. **Which of your grades is designed for refractory use, and what is its D50 window?**
   A supplier who cannot answer has not designed for your process, whatever the purity says.
2. **What is your sieve residue limit at 45 µm, and do you test every batch?**
   This is the single best proxy for milling consistency.
3. **Can you supply the same grade with ≤5 ppm Cr(VI), and what does it cost?**
   If the answer is no, your product cannot be exported into an audited market.

> **A pigment certificate tells you the colour. It does not tell you how the powder packs.**
> For a refractory, ask for the refractory specification sheet before the colour card.

What we send with a substitution proposal

- The grade, its D50 window and the three most recent batch certificates
- The Cr(VI) value, and which grade family it came from
- A suggested addition level, with what to change in water and dispersant
- A statement of which wear mode the change addresses, so the trial can be measured

Micropowder, chromite or chrome corundum: three ways to get chromium in

There is more than one chromium source on the market. They differ in what else they bring in with the chromium — and that "what else" is usually what limits the lining.

	Chromite ore (typical)	Chrome corundum (FCC / CC)	Micropowder + corundum
Cr_2O_3 content	40–46%	13–17% (FCC) / 5–8% (CC)	99% in the powder; any level in the body
SiO_2	3–8%	≤0.1% (FCC)	≤0.70% in the powder
FeO / Fe_2O_3	12–20%	≤0.2% (FCC)	≤0.4%
Alkali (Na_2O + K_2O)	Present, variable	≤1.0% (FCC)	≤0.6%
Cr(VI) in service	Higher risk when oxidised	Low	Lowest with the 5 ppm grades
Energy to produce	Mining and sintering	Electric melting, energy-intensive	No second melt for the powder
Dosing flexibility	Fixed mineral analysis	Fixed grain size	Any D50, any percentage

Where chromite still wins

Chromite is cheap per tonne and has a long history in ladle and tundish linings where the duty is moderate. If a lining is failing from abrasion rather than slag, chromite can be the rational choice — and we will say so.

Where green wins

Where the failure is slag chemistry at the hot face, the design freedom matters more than the raw-material price: you can put 5% or 15% chromium into the matrix, at exactly the particle size the packing needs, without importing the ore's silica, iron and alkali at the same time.

Chrome corundum — aluminothermic FCC in particular — sits between the two: a clean, high-chromium aggregate that carries the load, usually combined with green in the matrix. That combination is what pages 11–15 recommend for slag lines.

> **Chromite is cheap per tonne and expensive per month.**
> Compare chromium sources on cost per month of campaign at equal penetration depth — not on price per tonne of Cr_2O_3.

The Cr(VI) difference that never appears in the price

Chromite carries iron and can oxidise during service and cooldown, which in some markets brings a Cr(VI) exposure and disposal obligation with the lining. Green is supplied already in the low-Cr(VI) state, and the low-Cr(VI) family makes that measurable at ≤5 ppm. On a total cost basis that difference is frequently worth more than the price gap between the two raw materials.

How to compare two quotations honestly

- Convert both to cost per kilogram of Cr_2O_3 delivered, then to cost per month of campaign
- Ask for the silica, iron and alkali each material brings with it — they are part of what you are buying
- Ask which wear mode each product is designed for; if the answer is "all of them", it is a price list rather than a recommendation

Consistency at the mixer: the six numbers to insist on

The most expensive raw material is the delivery that behaves differently from the last one. These are the values we control batch to batch — and the failures each one prevents.

What we control	Our limit	What it prevents in your plant
D50 window per grade	Declared, held	Water demand drift between batches; flow-table scatter; strength variation
Sieve residue at 45 µm	≤0.30%	Coarse particles that open pinholes in thin castables and start spalling
Water-soluble salts	≤0.70%	Efflorescence and steam spalling on heat-up; Cr(VI) leaching in service
Migratory Cr(VI)	300 or 5 ppm	Audit findings, EHS exposure, export refusals
pH	6–8	Unexpected response to deflocculant and set retarder
Crystal size (G-5799, G-5899)	Larger, stable	Strength scatter in pressed bricks; inconsistent slag resistance

A simple incoming-goods protocol

1. **Ask for three consecutive COAs before the first order.**
   One certificate proves a batch; three prove a process.
2. **Check sieve residue and water-soluble salts first.**
   They explain most of the surprises that appear later in the mixer.
3. **Keep a retained sample of every delivery.**
   When a lining behaves oddly, the sample is the only way to find out whether the raw material moved.

We issue a certificate with every batch, and we keep the retained sample. If a delivery is questioned, the conversation starts from data rather than from opinion.

> **Consistency is a specification, not a promise.**
> Put the six limits on your purchase specification. A supplier who cannot accept them is telling you something useful.

A purchase specification you can send today

Clause	Value to write	How it is verified
Cr_2O_3 content	≥99% (≥98.5% for submicron)	Supplier certificate, every batch
Particle size	Grade number and its D50 window	Supplier certificate, every batch
Sieve residue, 45 µm	≤0.30%	Supplier certificate plus incoming check
Water-soluble salts	≤0.70%	Supplier certificate
Migratory Cr(VI)	≤5 ppm where the product is audited	Supplier certificate
pH	6–8	Supplier certificate

When a delivery is questioned

- Pull the retained sample before the argument starts
- Run one bench mix against the reference grade at the same water and dispersant
- Compare fired porosity, not only green strength — porosity is the number that predicts service life

Chrome corundum: CC and FCC — two routes, two chromium levels

The first difference is the route: CC is electric-melted at 5–8% Cr_2O_3; FCC is made by an aluminothermic self-propagating reaction at 13–17%. The route sets the chromium level, the impurity spectrum and the cost structure.

CC: melted, chromium is added

Industrial alumina and chromium oxide are melted in an electric arc furnace, then crushed and graded. Chromium is a batch addition, so holding it at 5–8% is the economical choice — every extra point is bought as raw material.

Crystals are well developed and dense; the price is electrical energy.

FCC: aluminothermic, chromium comes from the reacti

Aluminium metal reduces the chromium source, and the reaction supplies its own heat — no sustained external heating. The product is a high-chrome $(Al,Cr)_2O_3$ solid solution, and the chromium level follows the charge up to 13–17%.

Most of the electrical energy disappears, but cost moves to aluminium powder and the chromium source; solidification differs, giving finer grains and higher calcium and alkali.

Route against specification

	CC (electric melt)	FCC (aluminothermic)
Cr_2O_3, %	5–8	13–17
Al_2O_3, %	85–90	80–85
Heat source	Electric arc furnace	Aluminothermic reaction
Where chromium comes from	Added as chromium oxide	Reduced from the chromium source
Impurity signature	Relatively higher Si, Mg	Relatively higher Ca, alkali
Power / cost driver	High; electricity price	Low; aluminium and chromium source
Crystal habit	Coarse, well developed	Finer
Refractoriness, °C	≥1880	≥1880
1100 °C water quench, cycles	≥35	≥35

When to choose FCC

Where slag severity is highest: copper and nickel converters and launders, gasifier reaction zones, waste-incineration slag zones. You are buying maximum chromium in the aggregate.

When to choose CC

Where cycling and cost decide: ladle slag lines, cement kiln transition zones, and general high-alumina bodies that need corrosion resistance without a full high-chrome specification.

> **Ask the route first, then the chromium number.**
> Both are sold as chrome corundum; compare only after route, chromium level and impurity are matched.

A note on thermal expansion

Alumina–chromium solid solutions expand less than alumina alone, and the difference grows with chromium content. That is one reason a chrome-corundum body survives 1100 °C water quenches that crack a conventional high-chrome brick in about fifteen cycles: the strain per cycle is smaller before the material is even tested.

High-chrome brick: structure decides life, chromium is only the start

Two bricks of the same analysis can differ twofold in campaign life. The difference is aggregate type, and whether the matrix has been contaminated with alumina.

Aggregate: fused and sintered are two different structures

Microstructural feature	Fused chromia aggregate	Sintered chromia aggregate
Crystal habit	Coarse crystals, smooth grain surface	20–50 µm grains, clear regular habit
Cracks	Long intragranular cracks from cooling stress	Mostly at grain boundaries, few through-cracks
Pores	Large and irregular	Micron-scale round pores inside grains, fine intergranular pores
Aggregate–matrix bond	Bonded, with a pore band at the grain rim	Bonded, structurally more even
Effect on life	Cracks become entry points for slag and thermal strain	More stable slag and spalling resistance

Making fused chromia denser is a false premise

The long cracks in a fused grain come from cooling stress, not porosity; sintering harder does not close them.

Nor should Cr_2O_3 be pushed to maximum density: it is volatile, and chromium and oxygen diffuse at very different rates. Over-densifying costs thermal shock resistance and machinability.

Hence the practice: a fused base with some sintered material.

Matrix: where the alumina contamination sits

The aggregate sets the start, the matrix decides the end — slag must cross the matrix to reach the bond.

The usual defect is alumina contamination: too much Al_2O_3 in solution lowers the slag resistance of the chromia, and the excess sits in the grain boundaries as aluminium phosphate glass, wrapping the fine crystals. Impurity is low in total but sits exactly on the path the slag takes.

What to check on acceptance

Microstructural issue	Effect on performance	What to verify
Long cracks in fused aggregate	Lower slag and spalling resistance	Aggregate type; polished section
Excess Al_2O_3 in the matrix	Lower slag resistance of the chromia	Matrix Al_2O_3 level and distribution
Aluminium phosphate glass	Lower hot strength and slag resistance	Bond system and firing schedule
Soluble salts; ZrO_2 agglomeration	Efflorescence; scatter in cycling	Salts ≤0.70%; ZrO_2 dispersion

> **Chromium content sets the ceiling; microstructure decides whether you reach it.**
> Ask which aggregate, how much alumina the matrix carries, and what the bond system is.

What goes wrong in a high-chrome brick

- Matrix too coarse: open porosity after firing and a penetration front in the first campaign
- Submicron overdose: press cracking and a water demand the press cannot handle
- Under-fired body: chromium stays as a discrete phase instead of entering solution
- D50 drift between batches: porosity scatter at the same press setting

Chrome-corundum castables, Cr_2O_3 10–25%

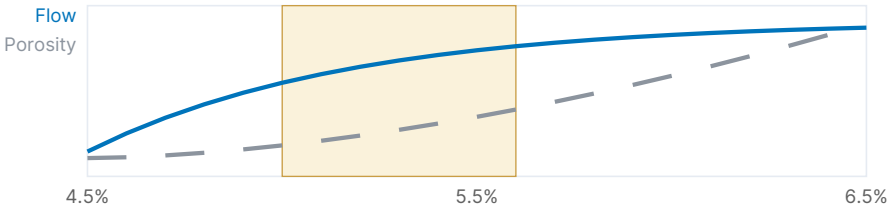
Castables fail for different reasons than bricks: water demand, flow, segregation and dry-out. The green grade has to serve the placement, not only the chemistry.

A castable is a packing problem before it is a chemistry problem. The matrix has to fill the voids between aggregate grains with the least possible water, because every extra litre of water becomes porosity, and porosity becomes the path for slag.

Grade selection by castable duty

Castable duty	Cr_2O_3 level	Green grade	Reasoning
Slag line, copper / nickel	15–25%	G-5999 + G-5070	Dual-peak matrix packs between FCC aggregate; submicron drives sintering
Ladle slag line	10–18%	G-5999	Balanced flow and corrosion; less water-sensitive than submicron-heavy mixes
Waste incineration slag zone	15–25%	G-5999 + G-5070	Maximum corrosion resistance plus cycling tolerance
Glass-contact repair	12–20%	G-5999	Low alkali and low iron matter more than strength here
General high-alumina body	8–15%	G-5003 / G-5005	Cost-balanced; green as a partial replacement, not a redesign

Water and flow



dashed grey: apparent porosity
solid blue: flow
shaded: working window (x axis: water, % of dry mix)

Water buys flow and pays in porosity.
Rule of thumb: hold water within ±0.3 points of the reference mix and recover flow with dispersant.

Dry-out and first heat

Green does not increase the risk of steam spalling by itself, but it does lower permeability in a well-sintered matrix. Hold the dry-out schedule, and do not shorten the 120–350 °C hold because the castable looks dry.

> **In a castable the micropowder has to pay its way twice: chemistry and placement.**
> If the mix needs water to place, the corrosion benefit is already spent on porosity.

Three numbers to watch in a castable trial

- Flow at fixed water — if it drops more than 10% against the reference, the packing changed, not only the chemistry
- Apparent porosity after firing — the number that predicts penetration, not the one that predicts strength
- Penetration depth on the worn part — cut it, measure it, and compare with a reference part from the same zone

Copper and nickel smelting: fayalite slag is the enemy

In copper and nickel furnaces the slag is FeO-rich and silica-saturated. It dissolves alumina aggressively, and it does so at the hot face where you cannot see it.

Fayalite-type slag attacks an alumina matrix by dissolving Al_2O_3 into the melt. The reaction does not need a defect to start; it only needs contact and temperature. That is why a good castable can still lose 30–50 mm a campaign in a converter slag zone: the material is not weak, it is simply soluble.

Where the money goes in a copper furnace

Part	Dominant wear	Recommendation	What to expect
Converter mouth and slag line	Corrosion plus thermal cycling	FCC aggregate + G-5999 / G-5070 matrix	Slower recession; fewer patch campaigns
Anode furnace sidewall	Corrosion, matte penetration	High-chrome brick with G-5899 / G-5799	Sealed boundaries limit matte wicking
Launder and tap hole	Corrosion, erosion by metal stream	FCC + G-5999 castable	Longer interval between relines
Settler slag zone	Corrosion, some abrasion	FCC + G-5070	Penetration front stays shallow

Why the micropowder matters here

In FeO-rich slag, chromium in solution lowers Al_2O_3 activity at the interface and thickens the slag boundary layer. The practical result is a decelerating corrosion rate rather than a linear one — the difference between a lining that thins steadily and one that survives the campaign.

What we would ask before quoting

Slag composition (FeO/SiO_2 ratio, Cr_2O_3, Al_2O_3), tapping temperature, campaign length, and a photo of the worn section. Those four answers move the recommendation more than any catalogue number.

> **In fayalite slag, every point of chromium in solution buys penetration depth.**
> Spend the chromium in the matrix, not on abrasion resistance you do not need.

Matte, slag and metal: three different enemies in one furnace

A copper furnace does not have one wear problem, it has three. Slag dissolves alumina; matte penetrates joints and reacts with silicates; metal erodes and can reduce the oxide at the hot face. They occur at different elevations of the same furnace, which is why a single “high-chrome” specification normally overspends in one zone and underspends in another.

Three rules for a copper furnace lining

- Put the chromium in the matrix, not only in the aggregate — the matrix meets the slag first
- Specify by zone: the mouth, the slag line, the launder and the settler do not fail in the same way
- Measure penetration depth on every worn part; remaining thickness alone tells the wrong story

FIELD NOTE Water cooling below the slag line during a stop is a common cause of early cracking. The material rarely gets the blame.

Glass furnaces: contamination is worse than wear

A glass furnace does not only ask the refractory to survive. It asks it not to change the glass — colour, redox, bubbles or stones.

In glass contact, the failure that costs the most is rarely a worn block. It is a batch of glass that has picked up iron, chromium in the wrong oxidation state, or a stone from a spalled refractory surface. A lining that wears 10% faster is a budget item; a redox upset is a recall.

Zone-by-zone expectations

Zone	Duty	Recommendation	What it protects
Melting sidewall and hot spots	Glass corrosion, upward drilling	FCC aggregate, low-iron chromium oxide matrix	Colour and redox stability
Throat and feeder	High-velocity glass flow, corrosion	FCC + G-5999 castable	Glass quality at the gob
Regenerator and superstructure	Alkali vapour, thermal cycling	CC aggregate, low-alkali matrix	Structural life; less drip
Repair and patching	Short campaigns, thermal shock	G-5003 / G-5005 matrix with CC	Patch life without colour risk

What the chromium oxide must not bring in

Iron, titanium and alkali change glass. We cap Fe_2O_3 and alkali, and both numbers are on the certificate.

On glass contact, the ≤5 ppm Cr(VI) family is the default, not an upgrade.

E-glass fibre tanks

Chromia is used where the alumino-borosilicate melt attacks hardest: sidewall, throat. The value is not only corrosion resistance but the absence of stones and bubbles — on a fibre line those matter more than an extra campaign.

Redox and colour

Dissolved chromium can change oxidation state in the melt and tint the glass. The control is to keep the chromium locked in the solid solution, where the glass cannot reach it — what a well-fired matrix does.

> **In glass, protect the product, not just the lining.**
> If a refractory change risks redox or colour, the cost of the risk is not measured in tonnes of refractory.

A glass-contact checklist

- Iron and titanium on the certificate, not “low” in a datasheet
- Alkali content, because it lowers the softening point at the glass interface
- Redox behaviour of the chromium in the fired body — keep it in the solid solution
- Spalling history: a through-crack releases particles straight into the glass

What we do not recommend in glass contact

- Untested cement or patch mixes in the forehearth — a colour upset costs far more than the repair
- Any grade without an iron and a titanium figure on the certificate
- Reusing a high-chrome brick from another furnace without its service history

Waste incineration, cement and lime: alkali, salts and cycling

Three processes that look unrelated share the same failure pattern: aggressive alkali and salt chemistry, plus repeated thermal cycling that opens the door for it.

Process	Dominant attack	Recommendation	What changes
Waste incineration, slag zone	Molten ash and salt, heavy cycling	FCC + G-5999 / G-5070	Less slag adhesion, slower penetration
Waste incineration, secondary chamber	Alkali vapour, thermal shock	CC + G-5070	Fewer through-cracks after stops
Cement kiln, burning zone	Alkali and sulphate, coating instability	Chrome-corundum with controlled alkali	Stable coating, less spalling
Cement kiln, transition	Thermal cycling, alkali	CC aggregate, G-5005 matrix	Better cycling tolerance
Lime kiln, burning zone	Alkali, abrasion by lime	CC + G-5003 / G-5005	Balanced corrosion and cost

One regulatory difference worth knowing

In cement, chromium in the raw material and in the refractory can contribute to water-soluble Cr(VI) in the finished cement, which is regulated in several markets because of skin sensitisation. For a cement kiln, the Cr(VI) grade is therefore a specification item and not an EHS footnote: ask for the ≤5 ppm family and keep the certificate with the batch record.

In waste incineration

The slag is a mixed salt and oxide melt that wets almost everything. The useful defence is a matrix that slag does not wet easily and that resists penetration after the first layer is consumed.

In cement and lime

The dominant mechanism is often cycling, not melting. A material that survives 35 water quenches will usually outlast a slightly more corrosion-resistant one that cracks after fifteen.

> **Alkali and cycling arrive together. Specify for both.**
> For cement kilns, put the Cr(VI) grade on the drawing, not only in the environmental file.

Why alkali is worse than temperature

Alkali oxides and sulphates do not simply erode a surface. They diffuse into the matrix, lower its local refractoriness and change the expansion of the penetrated layer, so the next thermal cycle cracks a zone that was previously sound. That is why an alkali-loaded lining often fails suddenly after a stop, and why cycling tolerance and alkali resistance have to be specified together.

A stop is a stress test

Most of the damage in an alkali-loaded lining is done during the stop and the restart, not in steady operation. The penetrated layer has a different expansion from the material behind it, so the first cool-down opens it and the first heat-up drives it off. If your lining history shows failures clustered after shutdowns, specify for cycling before you specify for corrosion.

FIELD NOTE A lining that survives one unplanned stop a year is already telling you where the next failure will be.

Three steps to a grade

You do not need to remember ten grades. Answer three questions in order: where does it fail, in what form, and how much chromium.

1 Read the failure → **2 Choose the form** → **3 Set the grade**

Match the worn part to one of five modes

Brick, castable or gunning — by zone shape and stop window

Grade by formulation target, addition by matrix share

Step 1 · Read the worn part

What you see on the worn part	Diagnosis	What follows
Uniform thinning, sharp interface	Chemical corrosion	The common case; chromium oxide micropowder is designed for it
Discoloured band behind the face	Capillary penetration	Densify and seal the matrix first
Cracks and layers parallel to the face	Thermal spalling	Lower expansion and raise cycling tolerance
Deep pits and blistering	Redox and vapour attack	Track the FeO, alkali and vapour source
Directional grooves	Abrasion	Hardness and grading, not chromium

Step 2 · Choose the product form

Large, simple, long-campaign zones want brick. Complex, small or inaccessible zones want castable. Fast repairs want gunning or patching material with a chromium oxide micropowder matrix. New builds and major rebuilds should be divided by zone rather than specified as one system.

Step 3 · Set the grade and the addition

Formulation target	Green grade	Addition (of matrix)	Aggregate
Density and cold strength	G-5070 / G-5075	3–8%	CC
Slag resistance, moderate slag	G-5799 / G-5005	5–12%	CC or FCC
Slag resistance, heavy slag	G-5899 / G-5999	10–15%	FCC
Dual-peak castable matrix	G-5999	5–15%	FCC
Low Cr(VI) requirement	5 ppm version of the above	As above	As above

> **Three answers, one grade.**
> Whichever answer you cannot give is what the trial has to establish — and it is usually not the grade, it is the failure mode that was never settled.

Documents we can issue with a delivery

- Batch certificate: Cr_2O_3, D50, sieve residue, water-soluble salts, Cr(VI) and pH
- Retained-sample reference and storage date
- Grade datasheet with the D50 window and the intended application
- A written trial recommendation, including what to measure and when to read it

Symptom, cause, action

Print this page and put it on the mixing floor. Locate the cause before changing the grade.

Symptom	Most likely cause	Check first	Move towards
Castable flow drops suddenly	Green surface area changed / water uncontrolled / dispersant aged	45 µm residue, D50, dispersant batch	Hold water, restore flow with dispersant
Explosive spalling on heat-up	Free water too high / low permeability / heating too fast	Dry-out curve, residual water, drying time	Extend the 120–350 °C hold
Through-cracks after service	Thermal shock / penetration layer expands differently	Stop records, penetration depth, crack path	Raise cycling tolerance, cut porosity
Sheet spalling at the hot face	Penetration layer expansion mismatch	Thickness and colour of the penetrated band	More solution, less open porosity
Local deep pit	Tramp metal / local erosion / reduction	Pit location and shape, nearby metal flow	Re-specify that zone only
Metal or slag through the joints	Joint too wide / insufficient mortar / allowance	Masonry record, joint width	Fix the masonry and mortar, not the brick
Cr(VI) result out of spec	Pigment-grade mixed in / wrong grade / sample mix-up	Delivery certificate, retained sample, batch	Lock the 5 ppm family, use traceable batches
Strength scatter between batches	D50 drift / press pressure unstable	Batch record, pressure curve	Write D50 window and pressure into the spec
Patch material debonds	Surface not prepared / damp / wrong system	Substrate condition, moisture, grade	Cut back to sound material, same system
Body is friable after teardown	Under-fired / over-addition / alkali too high	Firing curve, addition level, alkali	Review the firing schedule and grade choice

One rule: look at the shape before the data. Shape decides the failure mode; the data only confirms it. Three different shapes — pitted, sheeted, uniformly thinned — can all be described as “relatively fast”, and each needs a different answer.

> **Locate the cause before changing the material.**
> Most conclusions of “the material is not good enough” end up resting on a process parameter. Fill in the four columns first.

FIELD NOTE When the same batch behaves differently on two furnaces, check the masonry and the dry-out before the material.

Questions we are asked

These come from technical meetings. The answers are short because the reasoning is on pages 4–9.

Can we just use pigment-grade chromium oxide?

It will fire into a brick, but the size distribution is not designed for packing and the 45 µm residue is uncontrolled. Water demand will drift between batches. Use a grade with a refractory specification.

Is more chromium oxide micropowder always better?

No. Above roughly 15% in a corundum matrix, the excess can appear as a separate phase when firing is incomplete — and a separate phase is not a solid solution. Water demand and press cracking rise as well.

Do the 5 ppm and 300 ppm families perform the same?

Same chemistry and same size system; the difference is how Cr(VI) is controlled in production. Choose the 5 ppm family where the product is audited or exported.

Is the difference between CC and FCC only the chromium level?

No. CC is electric-melted at 5–8% Cr_2O_3, with coarse crystals and high power demand; FCC comes from an aluminothermic reaction at 13–17%, with finer grains and higher calcium and alkali. Read the route with the chromium number.

What has to be re-verified with a new green supplier?

One bench comparison: water demand, flow, setting time, fired apparent porosity, strength. Five tests, not a purity number.

Does chromium oxide micropowder change working time?

Slightly. Higher surface area shifts setting time with pH, so the retarder has to be re-set.

Can we have slag resistance and thermal shock resistance together?

Yes, but through solution and lower porosity rather than through more chromium. More chromium improves slag resistance; it does not automatically improve cycling.

What documents can you supply?

A batch certificate (Cr_2O_3, D50, residue, soluble salts, Cr(VI), pH), test records traceable to the batch number, and retained samples for re-testing.

Can we get samples and small quantities?

Yes. Samples are for bench work; small quantities are for pilot parts. They answer different questions.

Why does everyone keep mentioning 45 µm residue?

Because it is the direct source of pinholes and spalling, and the easiest item to overlook.

How do we compare with imported material?

The specification language is the same. The difference is that every batch certificate states residue and Cr(VI), and both can be traced and re-tested.

How do we get a sample?

Send the grade and the application; samples are arranged with the quotation. Custom screening needs its own lead time.

> **The more specific the question, the more useful the answer.**
> Send furnace type, zone, slag analysis and current campaign length, and the reply is a grade with a starting formulation — not a datasheet.

What we test, what we issue, and how a trial runs

The last two pages are the ones your quality and EHS colleagues will read. They are short because the answer is a document, not a claim.

Topic	What we do	What you receive
Cr(VI) control	Closed-loop control of Cr(VI) generation in production; two grade families (≤300 ppm and ≤5 ppm migratory)	Cr(VI) value on every batch certificate
Test methods	Chemical and physical testing in line with ISO 4621-1986 practice, plus our own sieve and Cr(VI) checks	Certificates traceable to the batch number
Traceability	Batch retained samples kept for reference	Batch record on request; a sample to re-test
Physical form	Powder; grain sizes 100 mesh, 0–1, 1–3, 3–5, 5–8 mm for corundum	Custom screening on request
Support	Grade selection, formulation review, worn-lining reading	A written recommendation per application

A trial that proves something in three steps

1 Sample and lab mix

We send sample quantities for a bench mix. You test flow, setting, strength and fired porosity against your reference. Typically one to two weeks.

2 Pilot part

Cast or press one part, install it in the wear zone and leave the rest of the lining as it was. The comparison is then internal: same furnace, same slag, same campaign.

3 Read the lining, then scale

Cut the worn pilot part and your reference part side by side. Penetration depth and hot-face recession decide the specification — not the datasheet.

Sources

[1] Chen Xiaoxia, Liang Yonghe. Microstructure analysis of high-Cr_2O_3 bricks. WISCO Technology, 2005, 43(4): 3–6.

[2] Yin Hongji, Geng Keming, Wang Jinxiang. Effect of titanium oxide on the sintering behaviour of chromium oxide materials. Journal of the Chinese Ceramic Society, 2009, 37(12): 1995–1999.

[3] ISO 4621:1986, Chromium oxide pigments — Specifications and methods of test.

[4] Batch test records for every grade (traceable by batch: Cr_2O_3, D50, sieve residue, soluble salts, Cr(VI), pH).

> **Test the pilot part against your own reference, in your own furnace.**
> Any supplier can send a sample. Ask for the one that comes with a recommendation for your slag and your wear mode.

FIELD NOTE A trial that is not measured is a purchase. Decide the two numbers you will compare before the part goes in.

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Lining life is decided in the matrix, not in the aggregate.

So we do two things: powder that puts chromium into the lattice, and aggregate that holds its structure.

Chromium oxide green

Ten grades, D50 0.1–8 µm

Migratory Cr(VI) 300 / 5 ppm

Soluble salts ≤0.70%, residue ≤0.30%

Chrome corundum

CC and FCC, α-$(Al,Cr)_2O_3$ solid solution

Al_2O_3 80–90%, Cr_2O_3 5–17%

Refractoriness ≥1880 °C, ≥35 water quenches

Contact

sales@chromeoxidegreen.com

www.chromeoxidegreen.com

Grade selection, formulation review, worn-lining reading

Three points to take away

- Select by failure mode, not by price list.
- Formulate by particle size and solution, not by purity.
- Accept on six measured values, not on one certificate.

Technical evaluation edition: every range quoted is a starting point, to be verified on customer equipment, and is not a specification guarantee. Industry benchmark values in the comparison tables are labelled as typical.

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