Installation Guide 14 min read Updated June 2026

Refractory Anchor Design Guide: V-Anchor vs Y-Anchor, Spacing, and Alloy Selection

Anchor type selection, spacing calculations for floors, walls, and roofs, alloy selection by temperature zone, and the five installation errors that cause anchor-zone cracking.

A **refractory anchor** is a metallic fastener welded to the furnace shell that mechanically locks a castable lining in place and controls crack spacing during thermal cycling. Without anchors, castable linings in overhead, vertical, and high-vibration positions cannot resist the combination of dead weight, thermal expansion forces, and mechanical shock that occurs during normal furnace operation. The anchor serves three functions: (1) primary mechanical support — holding the lining against the shell when the castable cannot support its own weight; (2) crack control — dividing the lining into discrete panels that crack predictably along anchor lines rather than catastrophically across the full lining; and (3) thermal stress relief — allowing differential thermal expansion between the metal shell and the ceramic lining without delamination. Anchor design is defined by four variables: type (V, Y, stud, or hex mesh), spacing, embedment depth, and alloy selection. Each variable must match the lining thickness, operating temperature, position (floor/wall/roof), and thermal cycling frequency. This guide provides the engineering basis for each variable and the common failure modes that result from incorrect selection.

The Zibo refractory cluster supplies castable linings across cement, steel, glass, and petrochemical furnace applications. In all these sectors anchor design is a source of premature lining failure — field data from relining campaigns consistently shows that 30—40% of early castable failures originate at or near anchor zones, caused by incorrect anchor type, over-spacing, wrong alloy, or missing expansion provision at the anchor tip.

Anchor Types: V, Y, Stud, and Hex Mesh

V-Anchor (Standard for Most Applications)

The V-anchor (inverted V or hairpin shape) is the most common anchor type for castable linings 100—250 mm thick. It provides three-dimensional mechanical interlock with the castable: the two legs resist pull-out in the axis perpendicular to the shell, and the V shape resists lateral movement parallel to the shell. Standard wire diameter is 6—8 mm for linings up to 150 mm thick, 8—10 mm for 150—250 mm. The V-anchor is suitable for walls, floors, and roofs in the standard temperature and lining thickness range.

Y-Anchor (Improved Roof Performance)

The Y-anchor adds a third leg to the V, creating a triangular support geometry. The additional leg significantly increases resistance to lateral displacement, which is the dominant failure mode in overhead (roof) castable linings where vibration and thermal shock tend to cause the lining to walk sideways relative to the anchor array before falling. Y-anchors are standard for roof linings >150 mm thick and any overhead application subject to mechanical vibration (vibrating conveyors above, adjacent hammer mills, etc.). The additional material cost vs V-anchor is typically 40—60% — justified by the consequence of roof lining failure.

Stud Anchor (Thin Linings, Overlay Applications)

Stud anchors (threaded or headed studs welded perpendicular to the shell) are used for thin wear linings (30—80 mm) applied over existing shell surfaces or as abrasion-resistant overlays in chutes, hoppers, and cyclones. They provide pull-out resistance without the lateral interlock of V/Y anchors, which limits their application to flat surfaces where gravity loads are perpendicular to the shell.

Hex Mesh / Metallic Mesh Overlay

Hexagonal metal mesh (typically 304 or 310 stainless, 1.5—2.5 mm wire, 50—75 mm cell) is used as an anchor system for thin spray-applied or trowelled linings (15—40 mm) in boiler tubes, cyclones, and ductwork. The mesh is spot-welded to the substrate and the refractory is applied through the mesh openings. Not suitable as a primary anchor system for linings >50 mm — mesh stiffness prevents thermal expansion of the metal, causing spalling.

Anchor Type	Lining Thickness	Best Position	Temperature Limit	Notes
V-Anchor (6 mm wire)	80—150 mm	Wall, floor	Hot face per alloy	Standard choice for most applications
V-Anchor (8—10 mm wire)	150—250 mm	Wall, floor, roof	Hot face per alloy	Heavier wire for thick linings
Y-Anchor	150—300 mm	Roof, overhead	Hot face per alloy	Required for overhead >150 mm; recommended for vibrating environments
Stud Anchor	30—80 mm	Flat wall, floor overlay	Per alloy	No lateral interlock; limit to gravity-perpendicular loads
Hex Mesh	15—40 mm	Curved surfaces, ductwork	1,000℃ max	Not for primary structural linings; risk of stiffness-induced spalling above 50 mm

Spacing Calculations

Anchor spacing determines the unsupported castable span between anchor points. The maximum allowable span is governed by the tensile strength of the castable at elevated temperature (typically 1—3 MPa at service temperature) and the dead weight of the lining. Practical spacing rules derived from field performance:

Position	Lining Thickness	V-Anchor Spacing (c/c)	Y-Anchor Spacing (c/c)
Floor / Hearth	100—200 mm	200—250 mm	Not required
Vertical Wall	100—200 mm	200—250 mm	Not required
Vertical Wall	>200 mm	150—200 mm	200—250 mm
Inclined (>45° from vertical)	100—200 mm	150—200 mm	200—250 mm
Roof / Overhead	100—150 mm	150 mm max	150—200 mm
Roof / Overhead	>150 mm	Not recommended	150 mm max

Critical rule: Spacing wider than 250 mm in any orientation leaves unsupported zones that crack along the mid-span between anchors within 3—6 thermal cycles. This is the single most common anchor-related failure mode in field surveys — contractors reduce anchor count to cut cost and the lining panels crack predictably at mid-span.

Embedment Depth

The anchor must be embedded to at least 60% of the lining thickness to develop full mechanical interlock. For a 150 mm lining, minimum embedment is 90 mm (the tip of the V should be at 90 mm from the hot face). The remaining 10—40% of lining thickness above the anchor tip is the hot-face working layer. If the anchor tip extends to within 20 mm of the hot face, it will be exposed to service temperature and must be selected for full hot-face temperature, not cold-face temperature. If the anchor is too short (embedment <50%), the castable above the anchor tip is unsupported and will spall progressively from the hot face down.

Alloy Selection by Temperature Zone

The anchor operates across a temperature gradient from cold-face temperature (typically 150—350℃) at the shell weld to hot-face temperature at the anchor tip. The alloy must be selected for the maximum temperature at the tip, not the average. For a 150 mm lining with 50 mm hot-face castable above the anchor tip, the tip temperature is approximately 65—75% of the hot-face temperature. For a kiln with 1,400℃ hot face, the anchor tip may reach 900—1,050℃ — above the service limit of 304 stainless (800℃) but within the range of 310S (1,050℃).

Alloy	Composition	Max Service Temp (continuous)	Typical Application
Carbon steel (mild)	Fe, <0.3% C	400℃	Cold-face zones only; never hot-face contact
304 / 304L SS	18Cr / 8Ni	800℃	Wall and floor linings with hot-face temp <1,100℃

Alloy	Composition	Max Service Temp (continuous)	Typical Application
310S SS	25Cr / 20Ni	1,050℃	Standard high-temperature anchor; cement kiln, glass furnace walls
330 Alloy / RA 330	35Ni / 18Cr / 1.25Si	1,150℃	Severe cycling; EAF roofs; carburising environments
253 MA	21Cr / 11Ni / 0.17N / Ce	1,150℃	Oxidising high-temp; good scaling resistance
Alloy 600 (Inconel)	76Ni / 15Cr / 8Fe	1,200℃	Extreme temperature, reducing or cycling atmosphere
Cast HH (Fe-25Cr-12Ni)	25Cr / 12Ni, cast	1,100℃	High-load roof anchors; cast shape allows complex geometry
Cast HK (Fe-26Cr-20Ni)	26Cr / 20Ni, cast	1,150℃	Highest-temperature cast anchor; radiant tube supports, reformer tube anchors

Do not use 304 SS above 850℃ hot-face temperature. At temperatures above 800℃, 304 stainless undergoes sensitisation (chromium carbide precipitation at grain boundaries) which dramatically reduces corrosion and oxidation resistance. The anchor corrodes from the inside out and fails without visible surface degradation. 310S is the minimum specification for any anchor in contact with castable in zones above 1,100℃ hot-face service.

Expansion Provision: The Anchor Tip Rule

The most common cause of anchor-zone cracking in new linings during first heat-up is the absence of expansion provision at the anchor tip. Steel anchors have a coefficient of thermal expansion (CTE) of 12—18 $\times 10^{-6}$/℃ depending on alloy, compared to castable CTE of 6—9 $\times 10^{-6}$/℃. For a 90 mm embedded anchor heating from 20℃ to 900℃ (tip temperature), the differential expansion is:

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Delta L (steel)    = 90 mm x 15e-6/C x 880 C = 1.19 mm
Delta L (castable) = 90 mm x 7.5e-6/C x 880 C = 0.59 mm
Differential       = 0.60 mm over 90 mm embedment

Without expansion provision: the anchor tip expands 0.60 mm
more than the surrounding castable, cracking it radially.
With 2 mm ceramic fibre tip wrap: expansion absorbed by fibre
compression before castable is stressed.
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Practical tip provision methods:

- **Ceramic fibre tape wrap:** Wrap 2—3 mm of 1260℃-grade ceramic fibre tape around the anchor tip before casting. The fibre compresses during heat-up, absorbing differential expansion. This is the industry standard method — adds <2 minutes per anchor during installation.
- **Wax dip:** Dip the anchor tip in melted wax to create a 1—2 mm wax layer. The wax burns out during initial heat-up before the lining reaches service temperature, leaving a gap that accommodates expansion. Less reliable than fibre tape for tips in the 80—100 mm embedment range because the gap may be insufficient at full operating temperature.

Five Installation Errors That Cause Anchor-Zone Failure

01 **No tip expansion provision.** Anchor tip cracks the castable radially during first heat-up. Symptom: star-shaped cracks centred on each anchor tip after first firing. Fix: ceramic fibre tape wrap before casting — cannot be retrofitted after casting.
02 **Over-spacing to reduce anchor count.** Mid-span cracking between anchors within 3—6 cycles. Symptom: straight cracks parallel to anchor rows at mid-span. Particularly common in roof linings where contractors reduce Y-anchor count from design. Non-repairable without full relining of the affected panels.
03 **Wrong alloy for tip temperature.** Anchor oxidises and loses cross-section at the tip, reducing pull-out strength. Symptom: localised castable patches dropping out from roof without cracking — the anchor tip failed in tension, releasing the panel. Inspect with core drill on adjacent panels; corroded anchor cross-section visible at tip depth.
04 **Insufficient embedment depth (<50% of lining thickness).** Hot-face working layer above the anchor tip is unsupported. Spalls progressively from hot face down to anchor tip level. Symptom: uniform thin-layer spalling leaving rough surface at constant depth — the depth equals the under-embedded tip position.
05 **Poor weld quality at anchor root.** Incomplete fusion or undercut at weld toe allows the anchor to pull out under castable dead weight. Symptom: complete panel drop-out from overhead lining with clean anchor root (weld failed, not castable). Require fillet weld minimum throat equal to anchor wire diameter; 100% visual inspection + dye-penetrant on roof anchors.

Anchor Design for Your Furnace?

Share your lining thickness, position, operating temperature, and castable grade. We provide anchor type, spacing, and alloy specification within 6 hours.

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Weld Specification for Anchor-to-Shell Joints

Anchor-to-shell welding is a specialised procedure that is frequently executed with the wrong filler metal. The weld must be specified separately from structural welds on the same shell. Key requirements:

- **Filler metal:** Match the anchor alloy, not the shell material. A 310S anchor welded to a carbon steel shell requires E310 filler, not E308 or E309. Using mismatched filler creates a diluted weld zone with lower high-temperature strength than either base material.

- **Weld geometry:** Full circumferential fillet weld around both legs at the shell surface. Minimum throat = anchor wire diameter. Partial welds (one side only) create bending loads at the weld during thermal cycling that quickly propagate fatigue cracks.
- **Pre-heat:** Carbon steel shell above 25 mm thickness requires pre-heat (75—120℃) before welding high-alloy anchors to prevent hydrogen cracking in the HAZ.
- **Inspection:** Visual + dye-penetrant (PT) on all roof and overhead anchor welds before casting. The weld is inaccessible after the lining is poured.

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Lining thickness, position, temperature — we return anchor type, spacing, and alloy in 6 hours.

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What is the correct spacing for V-anchors in a castable lining?

Standard V–anchor spacing for horizontal castable linings (floors, hearths) is 150—200 mm centre–to–centre. For vertical walls the spacing increases to 200—250 mm. For overhead (roof) applications use 150 mm maximum spacing because the full lining weight is supported by the anchors in tension. Spacing wider than 250 mm in any orientation leaves unsupported castable zones that will crack along the mid–span between anchors.

What alloy should I use for refractory anchors above 1,000℃?

Above 1,000℃ tip temperature, use 310S stainless steel (25Cr/20Ni) as the minimum specification. 310S retains adequate strength to 1,050℃. For tip temperatures 1,050—1,200℃, use 330 alloy (35Ni/18Cr) or RA 253MA. Above 1,200℃ tip temperature, specify Alloy 600 (Inconel) or cast alloy anchors in HH or HK grade. Carbon steel anchors are limited to cold–face zones below 400℃.

Should refractory anchors be coated before casting?

No paint or primer on the anchor body — anchors must be bare metal for mechanical bond with the castable. The tip only should be wrapped with 2—3 mm of ceramic fibre tape before casting to create a compressible zone that allows the anchor to thermally expand without cracking the surrounding castable during first heat-up. Without this tip treatment, star-shaped cracks appear at every anchor location after first firing.

Why do refractory anchors fail at the weld rather than in the body?

Weld-zone failure is caused by: (1) incorrect filler metal — the weld must match the anchor alloy, not the shell material; (2) undercut at the weld toe, which reduces the effective throat and creates a stress concentration; (3) hydrogen cracking in the HAZ of the shell plate from preheat mismatch. Specify the anchor–to–shell weld procedure separately from structural welds. Require dye–penetrant inspection on all roof and overhead anchor welds before casting, since the weld is inaccessible after the lining is poured.

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Al_2O_3 80—90%, abrasion resistant, service temp to 1,650℃. For anchored roof and wall linings in EAF and ladle applications.

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Insulating Castable

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