DELTA EL NILE FOR INDUSTRY · EST. 1996

Closure Incoming Inspection Manual

Every cap & closure defect a buyer may observe on receipt — symptom, likely cause, first action, diagnosis, fix and prevention.

Generated **2026-06-27** from Delta's live defect database · 38 defects · Delta El Nile for Industry

Use this manual at incoming inspection of Delta El Nile caps and closures, before running them on your capping line. Each defect lists the symptom, likely causes, first action, diagnosis, fix and prevention. Generated from the same defect database as the on-site defect advisor.

Quick reference — all defects

GEOMETRIC — DIMENSIONS OUT OF SPEC

- Closure height outside tolerance
- OD (outer diameter) outside tolerance
- Closure weight outside tolerance

MATERIAL — IV, CRYSTALLINITY, BRITTLENESS, MOISTURE

- Brittleness (closures crack under normal torque)
- Stress cracking in hot-climate storage (Egypt / GCC water market)
- Splay / silver streaks (surface moisture marks)
- Visible weld line (knit line at flow-front meeting)

PACKAGING & TRANSIT

- Storage temperature excursion (warehouse / container / retail above spec)
- Carton contamination (dust, fiber, transit residue)

IMD_MANUFACTURING

- Contamination (specks, fibers, foreign material)
- Deformation (out-of-round, warped, ovality)
- Color drift (shade outside approved swatch)
- Surface defects (scratches, flow lines, weld lines, scuff)
- Thread incompletion (short shot, malformed threads)
- Tamper-evidence band defect (broken / missing bridges, incomplete)
- Sealing surface defect (scratches, sink marks on seal land)
- Pinhole / micro-perforation (thin spots, dome holes)

CAPPER_MACHINE

- Cocked / tilted closure application
- Cross-threading on application
- Over-torque (stripped threads, cracked closures, hot-climate stress cracking)
- Insufficient application torque (loose caps, leakers)
- Tamper-evidence band breaks during application
- Chuck damage marks (scuffs / dents on closure OD)
- Missing cap (capper pick-and-place miss)
- Cap applied upside-down / wrong orientation
- Application angle deviation (chuck approach > 2° tilt)
- CO2 retention failure / pressure leakers (cross-component)
- Chuck size mismatch (wrong chuck for cap SKU)
- Chuck liner worn or missing (rubber/PU inner sleeve)
- Chuck grip force out of specification (too low or too high)
- Capper spindle bearing wear (chuck wobble during rotation)
- Multi-head capper: head-to-head torque variation (>15%)
- Pneumatic supply pressure drop (capper air below spec)
- Magnetic clutch calibration drift (single or multi-head)
- Bottle starwheel centering drift (bottle off-axis under chuck)
- Chuck thermal distortion (heat-induced fitment drift)
- Capper lubrication failure (spindle / chuck mechanism dry)
- Removal torque variation (high between-bottle SD on opening)

Geometric — dimensions out of spec 3

MAJOR Closure height outside tolerance

Total closure height measured top-of-dome to bottom-of-TE-band is outside ±0.15 mm of nominal. Symptoms downstream: capper application depth needs adjustment shift-to-shift; some closures sit proud of bottle finish (visually obvious).

LIKELY CAUSES

- Mold height shimming drift at Delta
- Cooling time variation between IM cycles
- Wrong SKU shipped (carton mislabeled)
- Mixed-cavity tool with one cavity drifted

FIRST ACTION

Measure 30 closures with height gage / digital depth gage. Calculate mean and range.

DIAGNOSE

- Height gage measurement on 30 closures from random carton positions
- Calculate mean, range; compare to SKU spec
- Check carton label vs ordered SKU
- Sort by visible cavity number if molded into TE — identify drifted cavity

FIX

- Step 1: If mean off by >0.15mm, contact Delta with measurements + lot #
- Step 2: Adjust capper application depth as interim measure (within ±0.1mm range)
- Step 3: Replacement lot from validated cavities if drift is confirmed

PREVENT

- Incoming height check on 30 pieces per pallet
- Maintain calibrated digital depth gage

Sources: SKU spec sheet — height tolerance · ISO 22411 (caps and closures)

MAJOR

OD (outer diameter) outside tolerance

Closure OD outside SKU-spec ±0.10 mm. Symptoms: capper chuck slips on undersized closures (insufficient grip → torque slip); oversized closures get chuck damage (chuck force concentrated on a smaller contact band).

LIKELY CAUSES

- Mold cavity OD drift (wear)
- Cooling shrinkage variation
- Wrong SKU shipped

FIRST ACTION

Measure OD with calipers at 0° and 90° on 30 closures. Mean and range.

DIAGNOSE

- OD measurement at 2 axes per closure (rules out ovality misread)
- Compare to SKU nominal
- Check capper chuck wear (worn chuck reads as undersized closure)

FIX

- Step 1: Confirm OD measurement protocol (2 axes)
- Step 2: If consistently off-nominal → Delta issue, request CAPA
- Step 3: Verify capper chuck wear; replace if heat-checked

PREVENT

- OD sampling at incoming QC
- Capper chuck periodic inspection

Sources: ISO 22411 · SKU spec sheet

MAJOR

Closure weight outside tolerance

Average closure weight outside SKU spec ±0.10g. Indicates short shot, flash, or wrong SKU. Light closures often correlate with thin walls (leak risk); heavy closures with flash (rough TE band).

LIKELY CAUSES

- Mold shot weight programming drift at Delta
- Different MB density (color drift correlation)
- Wrong SKU shipped

FIRST ACTION

Weigh 30 closures on 0.01g scale. Mean, range vs SKU spec.

DIAGNOSE

- 30-piece weight sample
- Compare to SKU nominal
- Correlate with visual defects

FIX

- Step 1: If off-spec, Delta CAPA
- Step 2: Replacement lot

PREVENT

- Weight QC per pallet
- Calibrated scale annually

Sources: SKU spec sheet

Material — IV, crystallinity, brittleness, moisture

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CRITICAL

Brittleness (closures crack under normal torque)

Closures crack, split, or shatter when capper applies normal torque (12-22 in-lbs depending on SKU). Often shows as a circumferential split through the TE band region or a radial split through the dome. Strong indicator of over-dried or recycled-content resin imbalance. DISTINCT FROM hot-climate stress cracking: brittleness shows up immediately AT capping (crack rate visible on the line); hot-climate cracking shows up DAYS or WEEKS later in storage/transit — see stress_cracking_hot_climate.

LIKELY CAUSES

- Resin over-drying at Delta (excessive degradation reduces molecular weight, embrittles)
- rPET blend ratio exceeded validated specification without notification
- Closure stored at low humidity for too long (moisture absorption builds toughness)
- Resin batch contamination with off-spec recycle stream

FIRST ACTION

STOP capping. Test 10 closures: apply rated torque (per SKU) on a known-good preform. Count cracks/splits. If >1 in 10 cracks, Delta-side defect. If cracks appear only later (days to weeks post-capping) → not brittleness, see stress_cracking_hot_climate.

DIAGNOSE

- Manual torque test: torque-wrench-controlled application on 10 closures
- Visual after: any radial or circumferential split = embrittlement
- Cross-reference Delta CoA (Certificate of Analysis) for the lot — IV and rPET % listed
- If rPET % > validated specification → contact Delta procurement

FIX

- Step 1: Quarantine lot; contact Delta with crack rate + CoA
- Step 2: Delta reviews drying parameters + rPET blend ratio for the lot
- Step 3: Replacement lot from a validated-spec run

PREVENT

- CoA review at incoming — confirm rPET % matches purchase order
- Sample torque test (3-5 closures) at start of each new lot on the capper

Sources: ASTM D256 (impact) · Petcore rPET QA Guidelines 2020

CRITICAL

Stress cracking in hot-climate storage (Egypt / GCC water market)

Closures pass all QC checks at the capping line, then crack, split, or fail in storage / transit / at retail — typically 3-30 days after capping. Failure pattern: radial or circumferential splits through the dome, splits through TE band region, or sometimes through the side wall. CRITICAL ISSUE for water bottle programs in Egypt, GCC (Saudi Arabia, UAE, Kuwait, Qatar, Oman, Bahrain), North Africa, and other hot-climate markets where storage temperatures regularly exceed 45°C in summer (sea containers can hit 60-70°C; outdoor warehouses without AC frequently 50-55°C). ROOT CAUSE is a combination of two factors: (1) the capper applies torque above optimal — operators commonly over-torque "just to be safe" for water bottles (no CO_2 pressure to worry about, so they assume tighter is better), leaving high residual hoop stress in the closure plastic; (2) elevated storage temperature accelerates the molecular relaxation of stressed polymer chains, causing slow-growing micro-cracks (environmental stress cracking / ESC) that eventually fail catastrophically. The two factors COMBINE — neither alone causes the failure, but together they reliably do. This is the single most common closure failure mode in hot-climate water markets.

LIKELY CAUSES

- [CAPPER — primary] Application torque set above optimal: operator over-torque on water lines (no CSD pressure → operator assumes tighter is better). Standard 29/25 water torque is 10-18 in-lbs; field failures cluster when bottlers run at 18-22 in-lbs
- [STORAGE — primary] Sustained storage temperature above 45°C: outdoor warehouses in summer Egypt/GCC, sea containers in transit, retail shelves in direct sun
- [STORAGE — secondary] Thermal cycling: day-night 25-55°C swings in containers create fatigue loading on residual-stressed plastic
- [MATERIAL] HDPE grade with insufficient ESCR (Environmental Stress Crack Resistance) for hot-climate application — typically MI > 1.5 g/10min is too easy-flow; closures need bimodal HDPE with MI < 1.0 for stress-prone applications

FIRST ACTION

STOP shipping to hot-climate markets pending diagnosis. Sample 30 bottles from the failed lot AND 30 from the last known-good lot. Document: (1) application torque setpoint and measured break torque at capping; (2) storage temperature log if available (data logger sticker); (3) time-to-failure (days from capping to crack); (4) crack pattern photographs. The COMBINATION of (1) torque above mid-window AND (2) temp above 45°C AND (3) failure 3-30 days post-capping confirms ESC root cause.

DIAGNOSE

- == STEP 1: confirm the failure mode ==
- Visual inspection of failed closures under magnification — ESC failures show characteristic slow-crack-growth striations on the fracture surface (vs brittle failures which show clean break)
- Compare crack pattern to brittleness reference (immediate at capping) — ESC cracks are typically delayed and may show whitening at the crack tip from molecular orientation
- == STEP 2: quantify the torque stress ==

FIX

- == IMMEDIATE (current shipping lot) ==
- Step 1: Quarantine the lot until investigation complete. Do not ship to hot-climate markets
- Step 2: Contact Delta with full diagnostic package (torque measurements, temp logs, crack photos, CoA)
- Step 3: Delta engineering reviews resin grade + recommends mitigation: (a) replacement lot from lower-MFI run for hot-climate market, (b) accelerated-aging validation, (c) revised packaging spec

PREVENT

- CAPPER SOP: hot-climate water SKUs run at MID-window torque, never upper bound — engineering signoff required for any deviation
- STORAGE SOP: temperature logging mandatory for any shipment to a market with summer average above 40°C
- MATERIAL SOP: closure resin spec for hot-climate SKUs must include MFI < 1.0 g/10min, validated ESCR rating, supplier CoA on every lot

Sources: ASTM D1693 (Environmental Stress Cracking of Polyethylene) · ISO 22088 (Plastics — Environmental stress cracking) · Bevcap Hot-Climate Application Guide §4 · Petcore Europe Closure Material Selection Guide 2023 · Plastics Europe HDPE for Packaging Closures — ESCR considerations · Delta Hot-Climate Water Market Reference (Egypt / GCC) — v232.76

MINOR

Splay / silver streaks (surface moisture marks)

Silver streaks or marks radiating from the gate point. Indicates resin moisture at IM. Cosmetic in most applications; can correlate with weakness if severe.

LIKELY CAUSES

- Resin drying time too short at Delta
- Hopper humidity (Delta plant during summer)

FIRST ACTION

Visual sampling: count silver-streak occurrences in 30-piece sample.

DIAGNOSE

- Visual inspection
- Compare to acceptable-defects swatch

FIX

- Notify Delta if >5% of sample affected

PREVENT

- Acceptance criteria in QA spec

Sources: SPI Cosmetic Standards §B

MINOR **Visible weld line (knit line at flow-front meeting)**

Visible vertical or angular line on outer surface where polymer flow fronts met in the mold. Cosmetic on opaque closures; visible on clear. Slightly weaker mechanically along weld line.

LIKELY CAUSES

- Insufficient melt temperature at Delta
- Flow rate too low (slow injection)
- Mold venting partially blocked

FIRST ACTION

Visual sampling under angled light.

DIAGNOSE

- Count visible weld lines on 30 closures

FIX

- If >10% affected, Delta IM parameter review

PREVENT

- Weld line tolerance in QA spec

Sources: SPI Cosmetic Standards §B

Packaging & transit

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CRITICAL **Storage temperature excursion (warehouse / container / retail above spec)**

Closures arrive at distribution or retail showing premature failure (cracking, deformation, color change, residual stress whitening) due to storage or transit at temperatures above the closure material specification. Egypt / GCC summer specifics: open warehouses 45-55°C, sea containers in port 60-70°C, retail shelves in direct sun 55-65°C surface temperature on the closure. Black-colored closures absorb significantly more solar heat — surface temps can exceed 75°C even in 45°C ambient. Closures that are completely fine at moderate temperatures can fail dramatically when subjected to sustained heat. Common scenarios: (a) container parked in Jeddah / Dubai / Cairo port for 2 weeks awaiting customs, (b) regional distribution from a warehouse without AC, (c) retail product sitting in window display.

LIKELY CAUSES

- Container / warehouse no AC, summer ambient > 45°C
- Sea container in port for extended period — interior 60-70°C
- Black or dark-colored closures in direct sun absorbing extra heat
- Warehouse rotation slow — product dwelling for months in heat

FIRST ACTION

Verify the failure correlation with temperature exposure: install temperature loggers in 5 cartons traveling the affected route, OR request retail-side temperature logs. Document max temperature, cumulative hours above 45°C, and thermal cycling amplitude. Cross-reference with closure failure rate by retail location.

DIAGNOSE

- Temperature logger deployment in cartons going to affected market
- Document: max temp, hours above 35°C / 45°C / 55°C, day-night cycle amplitude
- Field survey at distributor / retailer: walk-through with infrared thermometer at peak afternoon (1-3pm)
- Surface temperature on the bottles + closures (black-cap surfaces will read significantly higher than ambient)

FIX

- Step 1: Quarantine affected lots; do not ship more to the high-temp distribution chain until corrective action verified
- Step 2: For current product in market: rotate to cooler retail locations; accelerate sell-through to reduce dwell time
- Step 3: Specify climate-controlled (< 35°C) warehousing in the contract with the distributor
- Step 4: For sea container shipping: insulated container OR reefer; night loading; routing optimization to reduce port dwell

PREVENT

- Temperature spec in customer contract: maximum 35°C average, peaks not to exceed 45°C for more than 4h/day
- Quarterly temperature audit at major distribution warehouses
- Container temperature logging mandatory for shipments to hot-climate markets

Sources: ASTM F1980 (Accelerated Aging of Sterile Barrier Systems) — temperature reference · GCC Water Industry Storage Standards · Egyptian Drinking Water Industry Association — Storage Guidelines · Bevcap Hot-Climate Application Guide §5

MAJOR **Carton contamination (dust, fiber, transit residue)**

Carton contents visibly contaminated with dust, fiber, or transit residue. Most often: carton liner shed; rarely outside contamination.

LIKELY CAUSES

- Carton liner abraded during transport
- Carton damaged in transit (puncture)
- Warehouse contamination at bottler

FIRST ACTION

Inspect 10 cartons from the shipment. If contamination is present on contents, photograph and contact Delta with photos + freight info.

DIAGNOSE

- Visual inspection of carton interior
- Closure outer surface inspection from top of stack
- Carton condition (puncture? wet?)

FIX

- Step 1: Quarantine contaminated cartons
- Step 2: Delta reviews packing process if recurring
- Step 3: Freight forwarder claim if transit damage

PREVENT

- Double-bag closures in cartons (Delta standard)
- Warehouse environment control at bottler
- Inspection upon delivery

Sources: Delta Packing Spec · SPI Closure Storage Guidelines

imd_manufacturing

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CRITICAL **Contamination (specks, fibers, foreign material)**

Dark specks, fibers, or foreign material visible on or in the closure body. STATION 01 (top view) IMD catches this; rare escapes may show as black flecks in clear or light-color closures, or as gray streaks in white. Food-contact applications: ANY visible contamination is a hard reject.

LIKELY CAUSES

- Resin contamination at Delta hopper (rare; resin is sieved)
- Mold release agent contamination at parting line
- Carton liner fiber shed during transport (rare; closure cartons are double-bagged)
- Air-blown contamination during de-molding (extremely rare on Delta's line)

FIRST ACTION

STOP capping line. Quarantine affected lot. Photograph 5 contaminated samples on white background with carton lot number visible.

DIAGNOSE

- Inspect 30 closures from the same carton under bright LED lamp
- Count contaminated units; calculate ppm rate
- Cross-reference carton lot number with Delta IMD reject log (Delta can pull the lot-specific reject rate)
- If >100 ppm, escalate to Delta QA — IMD parameters may need recalibration on the mold/cavity that produced this lot

FIX

- Step 1: Quarantine the full lot pending Delta investigation
- Step 2: Delta investigation: pull mold cavity ID from lot code, inspect cavity surface
- Step 3: Delta provides replacement lot + reject lot CAPA (corrective action) documentation
- Step 4: Update incoming QC: add to the inspection checklist for the next 5 lots

PREVENT

- Storage: keep cartons closed in clean dry conditions until use
- Capping room: positive air pressure, HEPA filtration where applicable
- Sampling: 30-piece visual inspection per pallet lot before transferring to capper hopper

Sources: SPI Closures Best Practice §3.2 · Petcore Closure QA Guidelines 2020

CRITICAL

Deformation (out-of-round, warped, ovality)

Closure is not circular — OD measured at two perpendicular axes differs by >0.15 mm. STATION 01 + STATION 04 (top view, tamper band) IMD catches this. Symptoms downstream: cocked application, intermittent torque drop on the capping line, partial seal engagement.

LIKELY CAUSES

- Cooling time too short at Delta IM line (ejected before full crystallization)
- Mold cooling channel partial blockage (one half cools slower)
- Storage stacking pressure (warpage in lower cartons under load)
- Hot storage (>40°C ambient exposure)

FIRST ACTION

Measure OD at two axes with vernier calipers on 30 closures. Flag any with >0.15 mm difference.

DIAGNOSE

- Sample 30 closures from middle and bottom of carton
- Measure OD at 0° and 90° on each
- Record max ovality value; compare to SKU spec sheet tolerance
- Check storage history (carton stacked >5 high? exposed to heat?)

FIX

- Step 1: Quarantine cartons from bottom of pallet (stacking-induced warpage)
- Step 2: Sort cartons by lot date; warped lots return to Delta for credit
- Step 3: Adjust storage: max 4 cartons high; pallet stretchwrap; temperature-controlled

PREVENT

- Storage discipline: max 4 cartons high per pallet, ambient ≤30°C
- FIFO: oldest cartons first; closures stored >6 months at ambient may warp
- Incoming QC: measure ovality on 10 random closures per pallet

Sources: SPI Closures Best Practice §4.1 · PMMI Capping Line efficiency 2021 §6.3

MAJOR

Color drift (shade outside approved swatch)

Closure color visually differs from the approved color standard. STATION 03 (outer surface) IMD includes colorimeter; ΔE >2.0 vs reference flagged. Symptoms: brand owner rejects shipment; consumer-noticeable color mismatch on shelf.

LIKELY CAUSES

- Masterbatch lot variation at Delta (different MB supplier batch)
- Color concentration drift (let-down ratio drifted on IM line)
- UV exposure during transit (yellowing in clear / white closures)
- Brand owner updated reference standard without notifying procurement

FIRST ACTION

Compare 10 closures side-by-side with the approved color standard under D65 daylight illuminant. Take ΔE measurement with handheld spectrophotometer if available.

DIAGNOSE

- Lay 10 closures from current lot next to approved master color chip
- Inspect under D65 (~6500K) lighting — NOT under fluorescent or tungsten
- If spectrophotometer available, measure ΔE; record values
- Check approved Pantone reference + current MB lot info on Delta CoA

FIX

- Step 1: If ΔE >2.0, contact Delta QA with lot # + color measurements
- Step 2: Delta cross-references with internal IMD colorimeter readings for that lot
- Step 3: Replacement lot dispatched if drift is confirmed Delta-side
- Step 4: If drift is brand-owner side (reference updated), Delta requests new reference for future runs

PREVENT

- Maintain approved color master chips in dark storage; replace every 12 months
- D65 light source at incoming QC station
- Confirm Pantone/RAL reference annually with brand owner

Sources: ISO 11664-4 (CIE colorimetry) · Delta IMD spec — STATION 03 colorimeter

MAJOR

Surface defects (scratches, flow lines, weld lines, scuff)

Visible scratches, scuff marks, flow lines, or weld-line strakes on the closure outer surface. STATION 03 (outer surface) IMD catches >0.5mm scratches and 80%+ of weld-line defects. Cosmetic on water/CSD; potentially functional on press-on closures (scratches on sealing land can leak).

LIKELY CAUSES

- Mold surface wear at Delta (cavity polish degraded)
- Carton-to-carton abrasion during transport
- Conveyor scuff on the bottler's sorting line
- Excessive cooling — flow lines from incomplete polymer flow on a thin closure

FIRST ACTION

Inspect 30 closures under bright angled light. Count visible defects ≥1mm. Calculate defect rate.

DIAGNOSE

- Use angled LED inspection lamp (~30° to surface)
- Examine top, side, and tamper-band areas separately
- Photograph 5 worst examples with rule for scale
- Note WHICH surface (top / outer / inner / TE band) — informs root cause

FIX

- Step 1: If >5% of sample has visible defects, contact Delta with photos
- Step 2: Delta inspects production cavity for polish wear; tooling refurbishment if needed
- Step 3: Replacement lot from a different cavity
- Step 4: Check capper sorting line for abrasive contact (rubber rails worn?)

PREVENT

- Soft conveyor materials (UHMWPE rails, not bare metal)
- Avoid double-handling: hopper → chute → capper, no manual transfers
- Incoming QC: visual sampling under angled light

Sources: SPI Closures Best Practice §3.4 · PMMI Capping Line efficiency 2021 §4.2

CRITICAL

Thread incompletion (short shot, malformed threads)

Internal thread profile incomplete — missing thread starts, irregular pitch, or partial fill. STATION 02 (inner thread) IMD catches this; rare escapes cause cross-threading or non-engagement on the capping line. Critical on PCO 1881 (3-thread design); even one incomplete thread can fail the torque test.

LIKELY CAUSES

- Short shot at Delta IM line (insufficient melt volume for full cavity fill)
- Cooling time insufficient for thread crystallization (threads shrink unevenly)
- Mold thread profile worn at one cavity in a multi-cavity tool
- Resin moisture too high (steam interrupts thread fill)

FIRST ACTION

STOP capping. Test 30 closures by hand-screwing onto a known-good preform — note any that bind, cross-thread, or fail to engage.

DIAGNOSE

- Visual: inspect inner thread profile under magnifying lamp; look for missing thread starts
- Functional: hand-thread 30 closures onto known-good preforms; count failures
- Profile gage: insert calibrated thread gage if available; full engagement should be smooth
- Cross-reference with carton/lot code — IMD reject log should show low thread-reject rate; if escapes are happening, the lot was likely run during a cavity-specific issue

FIX

- Step 1: Quarantine the lot; contact Delta with photos + hand-screw failure rate
- Step 2: Delta cavity inspection on the source mold cavity (each closure has cavity ID molded into TE band — Delta can identify the specific cavity)
- Step 3: Replacement lot from validated cavities; Delta CAPA documents the cavity refurb

PREVENT

- Functional hand-thread test on 30 closures from each pallet at incoming QC
- Annual capper torque calibration — masks intermittent thread issues if torque is set too high

Sources: PCO 1881 ISBT Standard · SPI Closures Best Practice §5.1

CRITICAL

Tamper-evidence band defect (broken / missing bridges, incomplete)

Tamper-evidence (TE) band has broken bridges, missing bridges, or incomplete formation. STATION 04 IMD catches this directly. Critical because: (1) TE that pre-breaks during application = bottle ships looking already opened, retailer rejects shelf; (2) TE that won't break on opening = consumer can't open bottle.

LIKELY CAUSES

- Mold parting-line wear (TE bridge geometry off-spec)
- Cooling time insufficient (TE crystallization incomplete; brittle bridges)
- Ejector pressure too high (TE shears off during de-molding)
- Capper applies too much vertical force on TE during seating

FIRST ACTION

Inspect 30 closures: count those with TE band damage. Apply 5 closures to known-good preforms BY HAND (not capper) — note if TE breaks during simple hand-tightening (should not).

DIAGNOSE

- Visual: TE band should have intact bridges (typically 12-16 per closure for PCO 1881)
- Count visible broken bridges per closure on 30-piece sample
- Hand-application test: apply by hand, check if TE breaks prematurely
- Cross-reference with capper line torque + downforce settings (if defect appears only after capper, root cause is capper-side)

FIX

- Step 1: If broken bridges on >2% of sample BEFORE capping → Delta-side issue, quarantine + contact Delta
- Step 2: If TE breaks only AFTER capping → capper-side, reduce capper application downforce
- Step 3: Adjust capper: torque setpoint should be SKU-rated (PCO 1881: 14-22 in-lbs nominal)

PREVENT

- Capper torque calibration quarterly
- Apply 5 closures by hand at start of each shift — TE should remain intact
- Incoming QC: visual TE bridge inspection

Sources: ISBT PCO 1881 v3.0 · Bevcap TE Application Standards · Delta IMD STATION 04

CRITICAL

Sealing surface defect (scratches, sink marks on seal land)

The horizontal sealing surface (where closure meets bottle neck top) has scratches, sink marks, or pits. STATION 05 (sealing surface) IMD catches this. Causes leakers in service — even microscopic defects (~0.05mm depth) can leak under CSD pressure. CROSS-COMPONENT NOTE: Sealing-surface leakers can originate from EITHER side of the seal interface — the closure liner/seal-land defect, OR the preform top sealing surface (see seal_land_damage in the preform defect tree). Diagnose by switching to a different closure lot OR a different preform lot to isolate.

LIKELY CAUSES

- Mold cavity seal-land surface polish worn (closure-side)
- Sink marks from excessive cooling (thicker section pulls inward)
- Damage from capper chuck (chuck face contacts seal land during application)
- Storage damage (closures dragged against rough surfaces during transit)

FIRST ACTION

Inspect 30 closures with bright angled light specifically on the sealing surface (inverted view). Mark any with visible scratches/marks. Functional test: cap onto pressure-tested bottles and leak-test. CROSS-COMPONENT: also invert 30 preforms and inspect the bottle finish top sealing surface — preform-side damage produces identical leaker symptoms.

DIAGNOSE

- Invert closures and inspect seal land under angled light
- Photograph 5 worst examples
- For CSD: apply to pressurized bottle, submerge, check for bubbles
- For water: 10 closures on water bottles, store inverted 24h, check for leaks

FIX

- Step 1: Functional leak test confirms severity
- Step 2: If >1% leak rate AND closure-side root cause confirmed, quarantine lot, contact Delta with leak-test data
- Step 3: Delta cavity inspection (seal land polish) — refurb if needed
- Step 4: Inspect capper chuck — does it contact seal land? Should not for CSD closures (chuck grips OD only)

PREVENT

- Functional leak test on sample from every incoming lot
- Capper chuck design: must grip closure OD; never contact seal land
- Monitor IMD STATION 05 reject rate via Delta's quality reporting

Sources: ISBT Test Methods §401-A (CSD leak) · Bevcap Sealing Standards · Delta Preform Tree (seal_land_damage)

CRITICAL **Pinhole / micro-perforation (thin spots, dome holes)**

Microscopic perforations through the closure body — usually in the dome (top center) for screw caps, or in thin-wall sections of press-on closures. STATION 06 (pinhole detection — backlit imaging) IMD catches this directly. Causes leakers and unattractive product.

LIKELY CAUSES

- Cooling channel partial blockage at Delta IM line (one cavity runs hotter, thin spots form)
- Mold surface burn-mark causing local thinning
- Resin air entrainment (bubbles burst at surface during de-molding)
- Resin too dry / brittle, forms micro-cracks during ejection

FIRST ACTION

STOP capping. Backlight inspection: place 30 closures over bright LED, look for any light transmission through dome/body. Leak-test 30 on pressurized bottles.

DIAGNOSE

- LED backlight inspection: visible light through closure = pinhole
- Apply to 30 bottles, pressurize to SKU rating, submerge 60s — bubbles = leak
- Cross-reference Delta IMD STATION 06 reject log
- Note: dome pinholes most common on press-on (37mm) closures — thinner geometry

FIX

- Step 1: Quarantine the lot; report to Delta with photos + leak rate
- Step 2: Delta identifies the cavity (cavity ID molded in TE band) and inspects
- Step 3: Mold cooling channel cleaning; replacement lot from different cavities

PREVENT

- Backlight inspection routine for press-on (37mm) closures every lot
- Functional leak test every lot
- Monitor Delta's STATION 06 reject log via shared quality dashboard (if subscribed)

Sources: Bevcap Pinhole Standards · Delta IMD STATION 06 spec · SPI Closures §3.6

capper_machine

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CRITICAL **Cocked / tilted closure application**

Closure sits tilted on bottle finish — not perpendicular to bottle centerline. Causes seal failure (leakers) and rejects on shelf appearance. Visible immediately on cap-press machine output conveyor. Distinct from "application angle deviation" (which is about the angle the chuck approaches the bottle): cocked = closure tilted relative to finish AFTER seating; angle deviation = chuck-to-bottle alignment problem DURING application.

LIKELY CAUSES

- Capper chuck misalignment (single-head: one head off; multi-head: rotating turret drift)
- Closure starwheel timing off — closure picked at wrong rotational position
- Bottle finish ovality (preform-side defect — cross-component check)
- Capper application speed too high for current SKU geometry

FIRST ACTION

STOP line. Inspect 10 consecutive output closures. Identify which capper head (if multi-head) produces cocked output. Hand-rotate caps to verify they engage when applied straight. CROSS-COMPONENT: inspect the bottle finish on 5 cocked-cap bottles for ovality or seal-land damage before assuming the capper is at fault.

DIAGNOSE

- Single-head: align chuck to bottle centerline using bottle finish gage
- Multi-head: log defect rate per head over 100 bottles; isolate problem head
- Hand-application test: 5 closures applied by hand. If hand-applied closures seat correctly → capper is the issue
- Check starwheel timing: closure should be released directly above bottle finish

FIX

- Step 1: Chuck alignment — service per OEM manual
- Step 2: Starwheel timing reset
- Step 3: Reduce capper speed by 10% as interim measure
- Step 4: Mechanical inspection: chuck spindle bearings, drive shaft alignment

PREVENT

- Capper chuck alignment weekly check
- Multi-head: per-head defect logging
- Incoming preform QC: ovality + sealing-land inspection on every lot

Sources: PMMI/OMAC Capping Line efficiency 2021 §3.1 · Capper OEM manuals · Delta Preform Tree (seal_land_damage)

CRITICAL **Cross-threading on application**

Closure threads engage at wrong angle, ride over bottle threads instead of meshing. Result: cap appears tightened but threads are damaged; bottle leaks; consumer can't easily open. Distinct from cocked application — cross-threading can occur with straight chuck if rotation starts too early.

LIKELY CAUSES

- Capper rotation engages BEFORE downforce seats closure
- Closure dropped onto bottle finish from too high (bounces, misaligns)
- Capper speed too high for SKU thread profile (PCO 1881 3-start vs PCO 1810 2-start)
- Worn capper magnetic clutch (slips inconsistently)

FIRST ACTION

STOP capping. Remove 5 caps applied just before stop — inspect threads for ride-over damage. If damaged, set capper to single-cycle mode and observe one application sequence in slow motion.

DIAGNOSE

- Inspect bottle threads after cap removal: ride-over leaves visible thread chamfer wear
- Observe application sequence: downforce should fully seat closure on finish BEFORE rotation begins
- Check torque ramp: should be 0 → setpoint over 1-2 spindle revolutions
- Verify SKU-specific application program (PCO 1881: 2.0 spindle revs typical; PCO 1810: 2.5)

FIX

- Step 1: Adjust capper timing — downforce engages first, rotation follows after closure is seated
- Step 2: Reduce capper speed by 15%
- Step 3: Inspect magnetic clutch; service per OEM
- Step 4: Verify SKU-specific application program loaded (not generic)

PREVENT

- SKU-specific application programs (do not use generic settings for new SKU)
- Magnetic clutch calibration semi-annually
- Speed validation when changing SKU

Sources: PCO 1881 ISBT Application Guide · PMMI OMAC Capping §3.2

CRITICAL **Over-torque (stripped threads, cracked closures, hot-climate stress cracking)**

Application torque exceeds SKU rating. IMMEDIATE symptoms (visible at the line): closure cracks circumferentially, TE band breaks prematurely (during application, not opening), bottle finish threads strip, consumer struggles to open. DELAYED symptoms (visible 3-30 days later): closure stress-cracks in storage, especially in hot-climate markets where high residual hoop stress + elevated temperature combine to cause environmental stress cracking (ESC). For water bottle programs in Egypt / GCC / North Africa, the delayed failure mode is the MORE COMMON consequence of over-torque — see stress_cracking_hot_climate for full diagnosis.

LIKELY CAUSES

- Capper torque calibration drift (last calibration > 6 months ago)
- Wrong SKU loaded into capper (e.g. PCO 1881 torque setting applied to a 32/15 closure)
- Magnetic clutch torque setpoint set too high
- Pneumatic torque control low air pressure or stuck regulator

FIRST ACTION

STOP line. Measure applied torque with calibrated torque wrench on 10 closures (apply, then unscrew with torque wrench reading break torque). If torque > SKU max → adjust capper setpoint. FOR HOT-CLIMATE MARKETS: target the MID-window, not the upper bound (29/25 water: 12-14 in-lbs target, not 16-18; PCO 1881 water: 16-18 in-lbs target, not 22).

DIAGNOSE

- Calibrated torque wrench break-torque measurement on 10 applied closures
- Compare reading to SKU torque window: PCO 1881 = 14-22 in-lbs; PCO 1810 = 16-26 in-lbs; 32/15 dairy = 8-14 in-lbs; 29/25 water = 10-18 in-lbs
- Check capper torque setpoint vs SKU sheet
- If correct setpoint but high torque → magnetic clutch slipping high → service clutch

FIX

- Step 1: Reset capper torque to SKU-specified value (mid-window for hot-climate markets)
- Step 2: Calibrate torque wrench (NIST traceable)
- Step 3: Run 20-bottle validation: measure break torque after capping, all within SKU window
- Step 4: If clutch drifting, replace per OEM service interval

PREVENT

- Quarterly torque calibration (mandatory)
- SKU-specific application program — never reuse settings between SKUs
- Break-torque QC sampling: 5 bottles per shift

Sources: ISBT PCO 1881 Application Standards · Bevcap Torque Guide · PMMI/OMAC §3.3 · Bevcap Hot-Climate Application Guide §4

CRITICAL

Insufficient application torque (loose caps, leakers)

Application torque below SKU minimum. Symptoms: caps unscrew under shipping vibration, bottles leak in warehouse, consumer pre-opening risk. For CSD: CO_2 retention loss > 17% over shelf life. Often confused with closure quality issue — but if cap quality is good and torque is low, capper is the problem. CROSS-COMPONENT NOTE: insufficient torque AND low preform neck wall thickness produce identical symptoms (loose-feeling caps, CO_2 loss) — diagnose by measuring both torque AND preform wall thickness before assuming the capper is at fault.

LIKELY CAUSES

- Capper torque setpoint too low (operator override, or program error)
- Magnetic clutch slipping too early (worn out)
- Pneumatic torque control insufficient air pressure
- Operator reduced torque to "prevent breakage" when real issue was over-torque (corrected wrong way)

FIRST ACTION

Measure break-torque on 10 applied closures. If consistently < SKU min, increase setpoint. Re-verify by re-measuring 10. CROSS-COMPONENT: if torque is in-spec but caps still feel loose, measure preform neck wall thickness (see neck_wall_thickness_undersize in preform tree).

DIAGNOSE

- Break-torque on 10 closures
- Compare to SKU min (PCO 1881: 14 in-lbs minimum)
- Verify capper program SKU code
- Check air pressure (90 PSI typical at capper)

FIX

- Step 1: Increase torque to SKU min + 4 in-lbs (mid-window)
- Step 2: Re-validate with 10-bottle break-torque
- Step 3: If clutch worn, service before next shift
- Step 4: If torque is correct but CO_2 retention still fails → run cross-component diagnosis (see co2_retention_failure entry)

PREVENT

- Per-shift torque QC sampling
- Capper air pressure monitoring
- Lockout on torque setpoint changes — operator override requires supervisor key

Sources: ISBT PCO 1881 · Bevcap Torque Guide · Delta Cross-Component Diagnostic

CRITICAL

Tamper-evidence band breaks during application

TE band breaks while the capper is applying the closure — not after, as intended. Bottle ships looking pre-opened; retailer rejects shelf. Distinct from TE band manufacturing defect (which would have been caught by IMD STATION 04).

LIKELY CAUSES

- Capper downforce too high — bridges shear under axial load
- Application speed too high — bridges shear from torsional shock
- Bottle finish protrusion ridge wear (finish flange that retains TE post-application is worn — TE has nothing to engage)
- TE engagement diameter mismatch (closure designed for different finish family)

FIRST ACTION

Inspect 30 freshly-capped bottles for TE band damage. If >2% have broken TE BUT incoming closure samples are intact → capper is the cause.

DIAGNOSE

- Visual: count broken TE on 30 capped bottles
- Hand-application of 5 closures (same lot) → TE should remain intact
- If hand caps intact + machine caps broken → capper is the issue
- Measure capper downforce; compare to OEM spec (PCO 1881: 80-120 N axial load typical)

FIX

- Step 1: Reduce capper downforce by 20%; re-validate
- Step 2: Reduce application speed by 10%
- Step 3: If bottle finish flange worn (preform-side) → root cause is preform; contact Delta
- Step 4: Verify SKU compatibility: closure designed for the specific neck finish

PREVENT

- Capper downforce calibration with the closure SKU
- Routine bottle-finish flange inspection (preform incoming QC)
- SKU compatibility lock — capper program rejects mismatched SKU

Sources: ISBT TE Standards · Bevcap Application Guide §4

MINOR

Chuck damage marks (scuffs / dents on closure OD)

Scuff marks or dents on closure OD where chuck grips. Cosmetic but visible on shelf. If chuck wear is severe, marks may compromise the closure outer surface coating (custom colors / metallic).

LIKELY CAUSES

- Chuck face worn rough (originally polished or rubber-lined)
- Chuck gripping force too high
- Chuck face material incompatible with closure finish (metal chuck on lacquered closure)

FIRST ACTION

Inspect 10 just-capped closures; if scuff marks visible, examine chuck face for wear.

DIAGNOSE

- Visual chuck face inspection
- Replace polish with rubber lining if applicable
- Reduce gripping force on pneumatic capper

FIX

- Step 1: Chuck face refurbishment / replacement
- Step 2: Gripping force calibration
- Step 3: For lacquered/metallic closures: use rubber-lined chucks only

PREVENT

- Chuck face inspection monthly
- Replace chuck face inserts per OEM interval

Sources: PMMI Capping efficiency §4.4

MAJOR

Missing cap (capper pick-and-place miss)

Bottle exits capper line without a cap. Detected by downstream missing-cap sensor (if installed) or visual inspection. If sensor not present, leakers in warehouse.

LIKELY CAUSES

- Closure feeder jam (closures not arriving at capper chute)
- Pick-and-place gripper worn (drops closure)
- Closure hopper empty (operator missed alarm)
- Closure orientation wrong in feed bowl (cap falls upside-down before chuck pickup)

FIRST ACTION

Verify hopper level; check feeder for jams. Confirm missing-cap sensor is enabled and rejecting properly.

DIAGNOSE

- Hopper level inspection
- Feeder bowl jam check
- Sensor calibration verification
- Capper gripper test (cycle 10 times empty)

FIX

- Step 1: Clear feeder jam
- Step 2: Refill hopper
- Step 3: Replace worn gripper if applicable
- Step 4: Validate missing-cap sensor by deliberately running 5 bottles uncapped

PREVENT

- Hopper low-level alarm
- Missing-cap reject sensor calibration weekly
- Feeder bowl preventive maintenance

Sources: PMMI Capping efficiency §2

CRITICAL

Cap applied upside-down / wrong orientation

Capper applies closure inverted (TE band up, dome down). Cannot seal bottle. Caught immediately by visual but problematic if missed.

LIKELY CAUSES

- Closure feed orientation bowl mis-set
- Feeder bowl track damaged — closures tumble
- Wrong feed bowl for the SKU (PCO 1881 closure in a 32/15 feed bowl)

FIRST ACTION

STOP line. Inspect feeder bowl. Verify SKU-correct bowl is in use. Manually invert 5 closures into bowl — verify feed system rejects them.

DIAGNOSE

- Feed bowl SKU compatibility check
- Bowl track inspection
- Orientation sensor calibration

FIX

- Step 1: Correct feed bowl
- Step 2: Bowl track repair if damaged
- Step 3: Calibrate orientation sensor

PREVENT

- Feed bowl labeled with SKU at changeover
- Orientation sensor mandatory on capper

Sources: PMMI Capping efficiency §2.1

CRITICAL Application angle deviation (chuck approach > 2° tilt)

Capper chuck approaches the bottle finish at >2° tilt from vertical during application. Result: the closure liner contacts one side of the sealing land first; the opposite side gets less compression; CO_2 escapes through the under-compressed sector. Distinct from "cocked": the FINAL visible cap position may look straight, but the dynamic application angle during torque was off, leaving an uneven seal. Single most common cause of CSD CO_2-loss leakers that pass visual QC at filling but fail in storage 7-14 days later.

LIKELY CAUSES

- Capper turret tilt out of vertical (mechanical drift in capper frame)
- Capper chuck spindle bearings worn (chuck wobbles during rotation)
- Bottle conveyor not level into the capper (bottles arrive tilted)
- Capper installed on uneven floor / vibration-affected mount

FIRST ACTION

Measure capper chuck vertical alignment with a digital angle gage (laser angle gage preferred). Maximum 2° from vertical at the moment of application contact. CROSS-COMPONENT: also measure preform neck vertical orientation on the bottle conveyor.

DIAGNOSE

- Digital angle gage on capper chuck face — measure tilt at contact position
- Multi-head capper: measure each head separately; log defect rate per head
- Inspect chuck spindle for wobble during rotation (visual at slow speed)
- Measure bottle conveyor entry level (bubble level on conveyor surface)

FIX

- Step 1: Capper turret tilt adjustment per OEM manual
- Step 2: Replace worn chuck spindle bearings
- Step 3: Re-level conveyor + capper mount
- Step 4: Tighten chuck mounting bolts to torque spec

PREVENT

- Quarterly capper chuck angle calibration (digital angle gage record)
- Annual chuck spindle bearing replacement (preventive)
- Capper foundation isolation (rubber mounts) on multi-line facilities

Sources: Bevcap Application Angle Standards §5.2 · PMMI/OMAC Capping §3.4 · ISBT CO2 Retention Test Method · Delta Cross-Component Diagnostic Note

CRITICAL CO_2 retention failure / pressure leakers (cross-component)

CSD bottles lose CO_2 over storage at a rate exceeding 17% over the validated shelf life (industry standard). Bottles arrive at retail "flat" or with low fizz. May or may not show visible leakers — the loss can be slow + diffuse through a partially-compromised seal. Diagnosis is CROSS-COMPONENT: the root cause can be on the closure side (sealing surface, brittleness, thread defect), capper side (torque, angle, downforce), OR preform side (sealing land damage, neck wall thickness undersize, ovality). The diagnosis flow below isolates which component is responsible.

LIKELY CAUSES

- [CLOSURE-SIDE] Sealing surface defect (IMD STATION 05 escape; scratch on seal land)
- [CLOSURE-SIDE] Pinhole / micro-perforation (IMD STATION 06 escape)
- [CLOSURE-SIDE] Brittleness from over-drying or rPET imbalance (micro-cracks during application)
- [CAPPER-SIDE] Insufficient application torque

FIRST ACTION

STOP shipping the affected lot. Quarantine pending diagnosis. Run a 24h CO_2 retention test on 30 bottles from the suspect lot vs 30 bottles from a known-good lot. If retention loss is confirmed, proceed with cross-component diagnosis below.

DIAGNOSE

- == STEP 1 — Quantify the failure ==
- 24h, 7d, 14d CO_2 retention measurements on 30 bottles. Target: <1.0 vol loss at 14d for CSD
- Removal-torque drop test: measure break torque at 0h, 24h, 7d. Drop >40% indicates seal compromise
- == STEP 2 — Isolate the component ==

FIX

- Step 1: Quarantine the affected lot — do not ship until root cause is identified and corrected
- Step 2: Once isolated (Step 2 above), apply the specific remediation for that component:
- Step 2a: Closure-side → contact Delta with photos + CO_2 retention data; Delta investigates IMD escape on the source mold cavity; replacement lot from validated cavities
- Step 2b: Capper-side → adjust angle / torque / chuck; revalidate with 30-bottle CO_2 test

PREVENT

- Cross-component CO_2 retention QC sample monthly: 30 bottles, 24h + 7d test
- Maintain validated SKU-specific application torque + angle parameters per capper head
- Incoming preform QC: sealing-surface visual + wall-thickness check on every CSD lot

Sources: ISBT CSD Test Methods §401-A (CO2 retention) · Bevcap Cross-Component Diagnostic Flow · Petcore CSD Shelf-Life Reference 2021 · PMMI/OMAC Capping Line efficiency 2021 · Delta v232.73 Cross-Component Diagnosis Manual

CRITICAL Chuck size mismatch (wrong chuck for cap SKU)

Capper chuck inner diameter (ID) does not match the closure outer diameter (OD) within tolerance — typically chuck ID should be 0.2–0.4 mm smaller than cap OD for a proper interference grip. Mismatched chuck (often from incomplete SKU changeover) causes immediate symptoms: chuck slips on cap during torque application (under-torque); OR chuck over-grips and deforms cap (ovality, scuff marks). Distinct from chuck wear: this is a fitment issue from the start.

LIKELY CAUSES

- SKU changeover incomplete — operator did not swap chuck set
- Wrong chuck installed during preventive maintenance
- Chuck-size lookup table at the line is outdated
- Closure OD changed slightly between supplier lots without chuck recalibration

FIRST ACTION

STOP line. Measure chuck ID with bore gage. Measure closure OD on 5 fresh caps. Compare to SKU spec table. Interference fit should be 0.2-0.4 mm (chuck ID < cap OD).

DIAGNOSE

- Measure chuck ID with calibrated bore gage at 0° and 90°
- Measure 5 closure OD with calibrated calipers at 2 axes
- Compute interference: cap OD − chuck ID. Target 0.2-0.4 mm
- If interference > 0.4 mm → chuck too tight, will deform caps

FIX

- Step 1: Install correct chuck set for the SKU per chuck-lookup table
- Step 2: Re-validate with 20-bottle torque test + visual inspection
- Step 3: Update SKU changeover checklist to require chuck-swap confirmation
- Step 4: Lock chuck cabinet — only supervisor can swap during shift

PREVENT

- SKU changeover checklist must include chuck-swap signoff
- Color-coded chuck sets per SKU family (PCO 1881 = blue, 29/25 = green, etc.)
- Quarterly chuck ID measurement + log

Sources: Capper OEM Chuck Fitment Guide · PMMI/OMAC Capping §3.5 · Delta Closure SKU Spec

MAJOR Chuck liner worn or missing (rubber/PU inner sleeve)

The replaceable rubber, polyurethane, or silicone liner inside the chuck (which grips the cap OD via friction without scratching) is worn, hardened, glazed, or missing entirely — exposing the metal chuck face directly to the cap. Symptoms: scuff marks on cap OD, slipping during torque application (variable break torque), accelerated chuck face wear. Distinct from chuck-size mismatch: the chuck is the right SIZE but the grip surface is degraded.

LIKELY CAUSES

- Liner has exceeded service life (typically 100,000-500,000 cycles)
- Liner hardened from heat exposure (continuous-run operation)
- Liner glazed by residue buildup (sugar, syrup, sanitizer)
- Liner damaged or torn out during a jam, never replaced

FIRST ACTION

Remove chuck from spindle. Inspect liner visually + tactile (should feel rubbery, not hard or glassy). If worn/hard → replace liner. If liner missing → install correct part.

DIAGNOSE

- Remove + invert chuck; inspect liner under good light
- Tactile test: liner should compress slightly under finger pressure
- Hardness check (if Shore durometer available): typically 60-80 Shore A
- Look for shiny glazed patches → indicates residue contamination

FIX

- Step 1: Replace chuck liner with OEM part
- Step 2: Clean chuck face before installing new liner
- Step 3: Run 20-bottle break-torque validation post-replacement
- Step 4: Log liner replacement in capper maintenance log + cycle counter

PREVENT

- Cycle-count-based liner replacement schedule (per OEM)
- Capper cleaning protocol: remove sugar/sanitizer residue at shift end
- Spare liner stock onsite (at least 2 sets per capper head)

Sources: Capper OEM Maintenance Manual · PMMI/OMAC Capping efficiency §4.4

CRITICAL Chuck grip force out of specification (too low or too high)

Chuck closing/gripping force on the cap is outside the OEM spec window. Symptoms: LOW grip → chuck slips before torque setpoint, intermittent under-torque, "loose feeling" caps; HIGH grip → cap deformation visible as ovality (out-of-round) on the closure OD, scuff marks. Both modes cause CO_2 retention loss in CSD. Different from chuck-size mismatch: chuck is the right size, but the actuator force is wrong.

LIKELY CAUSES

- Pneumatic chuck: regulator drift, low air supply, leaking actuator
- Mechanical chuck: spring fatigue (replaceable spring worn)
- Cam-driven chuck: cam profile worn
- Operator manual adjustment outside spec

FIRST ACTION

Measure chuck grip force at the OEM-specified test position with a force gauge. Compare to OEM nominal (typically 100-200 N for PCO 1881 chucks). Re-adjust regulator/spring/cam to nominal.

DIAGNOSE

- Force gauge measurement at chuck face during simulated grip
- Compare to OEM spec window
- Pneumatic chuck: check air pressure at chuck inlet (typically 4-6 bar / 60-90 PSI)
- Check for air leaks (soap test at fittings during pressurization)

FIX

- Step 1: Pneumatic — adjust regulator or replace leaking actuator
- Step 2: Mechanical — replace fatigued spring
- Step 3: Re-validate with 20-bottle torque test
- Step 4: Document the corrective action in capper maintenance log

PREVENT

- Weekly grip-force calibration at shift start
- Air supply pressure monitor + alarm at the capper
- Annual chuck actuator service per OEM interval

Sources: Capper OEM Service Manual · Bevcap Application Manual §3.2

CRITICAL Capper spindle bearing wear (chuck wobble during rotation)

The bearings supporting the chuck spindle have worn — visible runout (wobble) during chuck rotation at speed. Causes: application angle deviation (chuck wobbles toward bottle off-axis), torque variation across cycles (spindle resistance changes through rotation), and accelerated chuck face wear. Diagnosed by dial-indicator runout measurement on the spindle nose. Strong cross-component link to application_angle_deviation and CO_2 retention failures.

LIKELY CAUSES

- Bearing service interval exceeded (typically 8,000-15,000 operating hours)
- Contamination ingress (sugar residue + moisture)
- Side-load events (chuck strike during jam)
- Inadequate lubrication

FIRST ACTION

Stop capper. Mount dial indicator on stationary frame. Rotate spindle by hand. Measure radial runout at chuck mounting flange. Acceptable: < 0.05 mm TIR (total indicated runout).

DIAGNOSE

- Dial indicator at chuck flange — measure radial runout during hand rotation
- Also measure axial endplay (push/pull on spindle)
- Listen for grinding/squeaking during chuck rotation at speed
- Cross-check application angle (see application_angle_deviation): spindle wear is a common upstream cause

FIX

- Step 1: Replace spindle bearings per OEM (typically pre-loaded angular-contact bearings)
- Step 2: Re-lubricate per OEM spec
- Step 3: Re-measure runout post-service (< 0.05 mm TIR)
- Step 4: Re-validate with angle + torque tests

PREVENT

- Quarterly runout measurement + log
- Annual bearing service for high-volume lines
- Capper cover seals intact (prevent contamination ingress)

Sources: Capper OEM Spindle Service Manual · PMMI/OMAC Capping §4.5

CRITICAL Multi-head capper: head-to-head torque variation (>15%)

On a multi-head rotary capper (typically 6, 12, 18, or 24 heads), measured break torque varies by more than 15% between heads at the same setpoint. Symptoms: intermittent leakers correlated with specific head positions on the conveyor, "every Nth bottle" leaker patterns. Visible only with per-head torque logging. Often misdiagnosed as random closure defects when the root cause is a single drifting head.

LIKELY CAUSES

- One or more magnetic clutches calibrated to different setpoints
- Worn clutch on one head only
- One spindle bearing failed (see spindle_bearing_wear)
- Worn chuck liner on one head only

FIRST ACTION

Run 30 bottles. Number each bottle 1-N by head position (use marker on bottle bottom). Measure break torque per bottle, plot per head. Identify outlier head(s).

DIAGNOSE

- Per-head torque logging over 100+ bottles
- Identify head(s) outside ±10% of mean
- For each outlier head: inspect chuck liner, measure grip force, measure spindle runout
- Test on a known-good closure lot to rule out closure variation

FIX

- Step 1: Identify outlier head(s) by per-head logging
- Step 2: Service or recalibrate the specific head(s)
- Step 3: Re-run 100-bottle per-head test to confirm <10% spread
- Step 4: Document per-head torque profile baseline for future reference

PREVENT

- Per-head torque logging quarterly (or after any service event)
- Synchronized clutch calibration at scheduled intervals
- Capper PLC software with per-head data logging enabled

Sources: PMMI/OMAC Capping efficiency §3.6 · Capper OEM Multi-head Service Manual

CRITICAL Pneumatic supply pressure drop (capper air below spec)

Compressed air supply to the capper drops below OEM spec (typically 90 PSI / 6.2 bar). Effects depend on what the air drives: chuck grip force drops (slipping), pneumatic torque control output drops (under-torque), starwheel actuators slow (timing drift causing cocked application). Often hidden because the gauge at the compressor reads normal but a leak / restriction downstream drops pressure at the capper.

LIKELY CAUSES

- Plant air compressor overload (multiple lines running)
- Air line leak between compressor and capper
- Dryer or filter element clogged
- Hose collapsed or kinked

FIRST ACTION

Install pressure gauge at the capper air inlet (downstream of all hoses/filters). Read pressure during a 30-bottle production run, especially during high-demand cycles. Pressure should not drop below OEM spec.

DIAGNOSE

- Pressure gauge at capper inlet during production
- Note pressure dips correlated with capper cycle events
- Inspect air filter / dryer (clogged element = restriction)
- Soap-test all fittings between compressor and capper for leaks

FIX

- Step 1: Fix the specific cause (leak, clog, regulator, compressor capacity)
- Step 2: Re-validate pressure stability during full production run
- Step 3: Re-validate torque with 20-bottle break-torque test
- Step 4: Document the root cause + corrective action

PREVENT

- Continuous pressure monitoring + alarm at capper inlet
- Air system PM: filters every 3 months, dryer annual
- Air audit annually: leak survey, compressor capacity vs demand

Sources: Capper OEM Air Supply Spec · PMMI/OMAC Capping §2.4

CRITICAL

Magnetic clutch calibration drift (single or multi-head)

The magnetic torque-limiting clutch on a capper head drifts from its calibrated setpoint over time, causing applied torque to silently move outside the SKU window. Bottlers often discover this only when a customer complaint of leakers triggers a torque audit. The clutch may slip too early (under-torque) or too late (over-torque), and the setpoint dial reading no longer matches actual delivered torque.

LIKELY CAUSES

- Magnet weakening (rare; over 5-10 years of use)
- Mechanical wear in clutch coupling
- Setpoint dial slippage or vibration drift
- Recent maintenance event without recalibration

FIRST ACTION

Calibrate the clutch with a NIST-traceable reference torque wrench at SKU setpoint. If measured torque differs from dial reading by >5%, the clutch needs full service or replacement.

DIAGNOSE

- Reference torque wrench measurement at the clutch output shaft
- Compare to dial setpoint at 3 points (low, mid, high of SKU window)
- Check coupling for wear / play
- Inspect for any mechanical interference in the magnet stack

FIX

- Step 1: Recalibrate clutch using reference torque wrench
- Step 2: If recalibration cannot bring delivered torque within ±5% of dial → replace clutch
- Step 3: Re-validate with 20-bottle break-torque test
- Step 4: Document calibration with traceable readings + date stamp

PREVENT

- Quarterly clutch calibration (mandatory) — NIST-traceable
- Lockout on dial — operator override requires supervisor key
- Clutch replacement on age-based schedule (per OEM, typically 7-10 years)

Sources: Capper OEM Clutch Service Manual · Bevcap Torque Calibration Standards

CRITICAL

Bottle starwheel centering drift (bottle off-axis under chuck)

The bottle starwheel that positions the bottle directly under each capper chuck has drifted from center, so the bottle finish is offset from the chuck axis at application time. Result: chuck contacts the cap off-center → cocked application, cross-threading, scuff marks, and uneven torque. Distinct from chuck alignment (chuck-side): this is the BOTTLE-side centering. Both can produce identical symptoms.

LIKELY CAUSES

- Starwheel mounting bolts loose (vibration drift)
- Starwheel pocket geometry worn from cycling
- Bottle guide rails worn
- Conveyor speed mismatch with capper rotation

FIRST ACTION

STOP line. With chuck at the application position, manually rotate starwheel to align next bottle. Measure offset between bottle finish center and chuck center with a gage pin or laser. Acceptable: < 0.5 mm.

DIAGNOSE

- Measure bottle-to-chuck center offset at every head position
- Inspect starwheel pocket for wear pattern
- Check starwheel mounting bolts for torque
- Measure conveyor speed vs capper speed (should match exactly)

FIX

- Step 1: Tighten starwheel mounting
- Step 2: Replace worn starwheel pockets (OEM service kit)
- Step 3: Synchronize conveyor + capper speed
- Step 4: Replace worn bottle guide rails (UHMWPE preferred)

PREVENT

- Monthly starwheel inspection (pocket wear, mounting torque)
- Annual starwheel replacement on high-volume lines
- Conveyor speed lock to capper (mechanical or PLC-synchronized)

Sources: Capper OEM Starwheel Service Manual · PMMI/OMAC Capping §2.2

MAJOR

Chuck thermal distortion (heat-induced fitment drift)

On continuous high-volume runs (12-24h shifts at high speed), the chuck heats from friction with the cap and from spindle bearings. Thermal expansion changes chuck ID by 0.02-0.08 mm — enough to shift fitment from optimal grip to slipping or over-gripping. Symptom: torque consistency degrades over the shift; first hour readings differ from last hour readings on the same SKU + setpoint.

LIKELY CAUSES

- Continuous high-speed operation without cooldown
- Capper enclosure ventilation insufficient
- Ambient plant temperature elevated (summer / no AC)
- Chuck material thermal coefficient incompatible with the application (rare)

FIRST ACTION

Measure chuck temperature with infrared thermometer at shift start, mid-shift, and end of shift. If delta > 30°C, thermal effect is significant. Compare torque QC readings at same intervals.

DIAGNOSE

- IR temperature on chuck at shift start, +4h, +8h, +12h
- Plot temperature vs measured break torque on QC samples
- Check capper ventilation: fans operational, air gaps clear
- Check ambient plant temperature trend

FIX

- Step 1: Add cooldown breaks during continuous runs (15 min per 4h)
- Step 2: Improve capper enclosure ventilation
- Step 3: If ambient is the cause → improve plant HVAC
- Step 4: Use lower-thermal-expansion chuck material for problem SKUs

PREVENT

- Capper enclosure ventilation review per OEM
- Plant ambient temperature monitoring
- Continuous-run cooldown protocol

Sources: Capper OEM Operational Guidelines · PMMI/OMAC Capping §4.7

MAJOR

Capper lubrication failure (spindle / chuck mechanism dry)

Auto-lube or grease-fitting lubrication of spindle, chuck-actuator linkage, or rotary union has failed — running components dry. Symptoms: noise (grinding, squealing), increased torque variation, accelerated wear, heat (see chuck_thermal_distortion), eventually bearing seizure. Often caught early by routine inspection; if missed, escalates to spindle bearing failure within weeks.

LIKELY CAUSES

- Auto-lube reservoir empty (operator missed refill)
- Lube line clogged or pinched
- Wrong lubricant (food-grade required; non-food may degrade)
- PM interval missed during high-volume push

FIRST ACTION

Check auto-lube reservoir level. Inspect lube lines for kinks/damage. Listen for capper noise during operation (grinding/squealing). Check capper noise vs baseline.

DIAGNOSE

- Auto-lube reservoir visual check
- Verify lube lines flow at the discharge points
- Capper noise audit (use vibration meter if available)
- Inspect bearing seal areas for dry/dusty appearance vs proper lube film

FIX

- Step 1: Refill auto-lube reservoir (food-grade)
- Step 2: Clear / replace blocked lube lines
- Step 3: Replace auto-lube pump if failed
- Step 4: Manually grease all fittings to restore lube film

PREVENT

- Auto-lube reservoir checked at every shift start
- PM schedule: lube system inspection monthly
- Spare lube + lubricant cartridges onsite

Sources: Capper OEM Lubrication Schedule · PMMI/OMAC Capping §4.6

CRITICAL **Removal torque variation (high between-bottle SD on opening)**

Removal torque measured across multiple bottles from the same shift varies more than ±25% from the mean (standard deviation > 15% of mean). Consumer-facing impact: some bottles open with normal force, others are extremely tight (elderly/disabled accessibility issue), and a small percentage may be loose (pre-opened appearance, leaker risk). DISTINCT from removal torque DROP test (which measures decay of a SINGLE bottle's torque over 24h/7d/30d storage) — this entry is about between-bottle inconsistency at the same point in time. The single most common cause of customer complaints about "hard to open" bottles AND a leading indicator of underlying capper condition issues.

LIKELY CAUSES

- [CAPPER] Application torque variation between heads (see head_to_head_variation)
- [CAPPER] Magnetic clutch calibration drift between heads (see clutch_calibration_drift)
- [CAPPER] Chuck liner wear inconsistent between heads (see chuck_liner_worn)
- [CAPPER] Spindle bearing wear on individual heads (see spindle_bearing_wear)

FIRST ACTION

STOP if customer complaints triggered investigation. Measure removal torque on 30 bottles from the suspect lot — number by capper head if possible. Calculate mean, SD, range. Acceptable: SD < 15% of mean, range within ±30% of mean.

DIAGNOSE

- Sample 30 bottles, measure break torque with calibrated torque wrench (NIST-traceable)
- Calculate mean, standard deviation, min, max, range
- == ISOLATE the source ==
- Step 1: If multi-head capper, log each bottle by head number → identify outlier head(s) → see head_to_head_variation

FIX

- Step 1: Quarantine the lot showing high variation until investigation complete
- Step 2: For capper-side root cause: recalibrate clutch(es), service worn chucks/spindles, re-validate per-head torque
- Step 3: For closure-side: identify affected cavities via cavity ID, contact Delta with cavity-mapped variation data + sample closures, request cavity-specific CAPA
- Step 4: For preform-side: identify affected preform cavities via body marking, contact Delta similarly

PREVENT

- Weekly removal-torque QC sample: 30 bottles, SD must be < 15% of mean
- Per-head torque calibration log (monthly NIST-traceable)
- Capper cleaning protocol every shift on sugar-syrup lines

Sources: ISBT Removal Torque Standards · Bevcap Removal Torque QC Guide §3 · PMMI/OMAC Capping Line Quality §3.7 · Universal Design Guidelines for Closure Accessibility (Arthritis Foundation) · Delta v232.75 Removal Torque Variation Reference

Appendix — Incoming QC Checklist

Minimum sampling at goods-in, against the Delta spec sheet for the ordered SKU. Reject and quarantine any lot outside tolerance and contact Delta with data + lot number under the quality guarantee.

CHECK	SAMPLE	ACCEPT
CARTON		
Carton seal + label matches ordered SKU	Every carton	Seals intact; SKU + lot match PO
Carton damage / moisture	Every carton	No visible damage
DIMENSIONAL		
Bore / thread diameter (caliper / gauge)	20 / lot	Per finish spec
Closure height & wall	20 / lot	Within tolerance
Ovality / out-of-round	20 / lot	Within spec
FUNCTION		
Application & removal torque	10 / lot	Within target band
Tamper-band bridges / slit integrity	10 / lot	Intact; breaks cleanly
Liner / seal presence & seating	10 / lot	Correct & fully seated
VISUAL		
Colour vs reference; flash / shorts	5 / lot	No visible difference / defect