

What is Oil-Canning?

At its technical core, oil-canning is a form of elastic buckling. When a thin metal panel is subjected to residual or applied stress that exceeds its ability to remain flat, it deflects out of plane — bowing, rippling, or pillowing across its surface. The critical word here is elastic: unlike plastic deformation, the panel has not yielded. The metal has not been permanently bent or damaged. If the stresses are released — say, by removing a fastener or allowing the panel to cool — the surface returns to its original flat condition. No permanent damage has occurred.

This elasticity is precisely why oil-canning is so counterintuitive to clients unfamiliar with metal behavior. A surface that appears wavy in one lighting condition can look perfectly flat minutes later as the sun moves or the temperature changes. The same panel photographed at noon and at 4:00 p.m. can look like two entirely different products.

Visually, oil-canning presents as waviness, pillowing, or a corrugated ripple effect across the broad, flat areas of a panel surface — typically the zones between seams, ribs, or fastener lines. It is heavily dependent on the angle and quality of light. Low-angle sunlight, raking artificial light during night-time inspection, and oblique camera angles are the conditions under which oil-canning is most visible. Under diffuse overhead lighting or on overcast days, the same panels may appear entirely smooth.

Oil-canning is documented across a wide spectrum of metal products and industries, including:

- Standing seam metal roofing systems
- Architectural wall panels and rainscreen cladding
- Appliance enclosures and cabinet skins
- Automotive body outer panels and hood skins
- HVAC equipment housing and ductwork
- Industrial control enclosures and switchgear panels
- Precision sheet-metal components for electronics and defense

Wherever thin, flat metal is used over a broad, unsupported area, the conditions for oil-canning exist. The question is not whether the risk is present, but whether it can be managed to an acceptable level

Root Causes

Oil-canning is rarely the product of a single failure. It is most accurately understood as a cumulative stress phenomenon — the result of multiple contributing factors, each of which

adds to the total stress state of the panel until the panel's resistance to buckling is overcome. Identifying and managing these factors, individually and in combination, is the foundation of any effective mitigation strategy.

Coil and Material Stress

Long before a flat sheet is cut, formed, or installed, it already carries residual internal stress — locked in during the steelmaking and rolling process at the mill. As hot-rolled or cold-rolled coil is produced, internal stresses are introduced by the rolling process itself and are further altered by annealing (controlled heating and cooling used to adjust temper and ductility). These stresses are not uniformly distributed across the width of the coil.

When a wide master coil is slit into narrower strip coils — as is standard practice in coil service centers — the slitting operation releases edge stresses asymmetrically, creating what the industry terms "wavy edge" or "full center" coil conditions. A wavy-edge coil has excess material at its edges relative to its center; a full-center coil has excess material at the center. Either condition means the flat sheet is not truly flat before a single forming operation has been performed. These pre-existing stress patterns are extremely difficult to eliminate downstream in the fabrication process, making material selection and coil sourcing the first and most important line of defense.

Material temper is equally significant. Softer, fully annealed material — which is more ductile and easier to form — is substantially more susceptible to oil-canning than harder tempers. For aluminum, T4 and T6 tempers demonstrate better resistance to oil-canning than O-temper (annealed) material. For steel, full-hard or half-hard tempers outperform dead-soft material in flat-panel applications. The tradeoff is that harder material is more challenging to form without cracking, requiring careful engineering to balance formability against flatness performance.

Forming & Fabrication

Every forming operation — roll forming, press braking, stamping — introduces new bending stresses into the material. In roll formed panels, these stresses are concentrated at the bends and features that define the panel profile: seam edges, ribs, and hem folds. The flat zones between these features experience no direct bending but must absorb whatever stress imbalances remain from the forming process. Long, unbroken flat spans between features offer no inherent out-of-plane stiffness, making them vulnerable to any stress gradient that exceeds the panel's buckling threshold.

Process variability compounds the problem. Variations in roll former speed, minor roll misalignment, tooling wear over a production run, and inconsistencies in incoming coil

width or thickness all alter the stress distribution in the finished panel. A set of panels produced at the start of a tooling life may exhibit less oil-canning than panels produced from the same tooling months later as rolls wear and alignment drifts.

For fabricated and welded assemblies, the challenge intensifies. Welding introduces intense, localized heat that causes thermal expansion followed by rapid contraction as the weld cools. Uneven heat input, poor weld sequencing, and inadequate fixturing can produce significant residual stress — which concentrates in exactly the flat panel zones most vulnerable to buckling.

Substrate and Installation Conditions

Metal panels do not exist in isolation — they are attached to structures, and they faithfully telegraph whatever imperfections exist in those structures. If a purlin is slightly out of plane, if a framing rail has a slight bow, or if a substrate is nominally within standard construction tolerances but not perfectly flat, the panel fastened to it is forced to conform to that irregular surface. The energy required to force the panel into conformance becomes stored stress — stress that the panel then expresses as oil-canning in the unsupported zones between fasteners.

Camber in structural steel members (beams and joists are routinely fabricated with intentional or unintentional upward bow), differential settlement of foundations, and thermal movement of the supporting structure after installation can all cause or worsen oil-canning over the lifetime of a building — sometimes producing conditions that were not present at initial installation.

Fastening and Attachment

The method by which panels are attached to the structure is among the most controllable installation-side variables — and among the most frequently mismanaged. Overdriven fasteners are one of the most common causes of oil-canning in installed systems. Each over-torqued screw creates a point of forced deflection, pulling or pushing the panel face out of plane at that point. The flat areas between fasteners must then absorb that concentrated stress, and if the span is wide enough or the stress high enough, the result is visible buckling.

Fixed clip systems that do not allow panel movement — whether by design or due to improper installation of floating clips — effectively clamp the panel at multiple points simultaneously, creating a constrained stress state. Fastener spacing that is too wide increases the unsupported span between attachment points, lowering the panel's effective buckling threshold and increasing the likelihood of visible waviness.

Thermal Cycling

All metals expand when heated and contract when cooled. For installed metal panels, this is not an abstract engineering principle — it is a daily physical reality. A dark steel panel on a south-facing building facade in a temperate climate can experience surface temperature swings of 50–60°F (28–33°C) between early morning and peak afternoon exposure. That thermal movement must go somewhere. If the panel is restrained by fasteners, clips, or adjacent panels from moving freely, the thermal expansion generates compressive force within the panel face. When that compressive force exceeds the panel's buckling resistance, oil-canning appears.

Critically, because thermal cycling is daily and continuous, oil-canning driven by this mechanism will appear and disappear predictably — more visible when panels are at maximum temperature and the thermal compressive force is greatest, less visible in the morning before peaking solar loading. This is one of the clearest diagnostic indicators that thermal movement is the primary driver.

Why it Matters

Because oil-canning is categorically a cosmetic defect — it does not compromise structural integrity, weather resistance, thermal performance, or any measurable panel specification — it is tempting to dismiss its commercial significance. That dismissal is a mistake. The real-world cost of oil-canning to suppliers, fabricators, contractors, and building owners is substantial and multidimensional.

Client Rejection and Contractual Disputes: Despite the ASTM standard's clear language, clients who observe oil-canning on an installed system frequently demand remediation — panel replacement, rework, or financial compensation. When the project specifications did not define acceptable oil-canning limits in advance (which is most cases), there was no objective contractual reference point. Disputes default to subjective visual judgment, and subjective visual judgment in low-angle light almost always favors the client. Litigation in this space is not uncommon, and legal costs frequently exceed the cost of the original installation error.

Rework and Remediation Costs: Physical remediation of oil-canning after installation is expensive, disruptive, and technically uncertain. Grinding or planishing flat areas introduces additional stress. Panel replacement requires careful removal to avoid damaging adjacent panels, procurement of replacement material (which may or may not match the original run's cosmetic character), and full reinstallation. On large commercial projects, remediation costs can reach hundreds of thousands of dollars — for a defect that has no functional impact whatsoever.

Inspection Failures and Schedule Impact: Oil-canning discovered late in a production run or at final installation inspection triggers re-inspection cycles, delays project completion, and creates cascading schedule impacts on downstream trades. In fast-track construction programs, a cosmetic hold point can generate liquidated damages exposure that far exceeds the underlying cost of the defect itself.

Supply Chain Reputation: Suppliers and fabricators associated with oil-canning complaints — even when the root cause lies in substrate preparation or installation practice — absorb reputational consequences. Specification preference in commercial construction is heavily relationship- and reputation-driven. A single high-profile oil-canning dispute on a visible project can remove a supplier from consideration for future work by the affected architect or general contractor.

Photography Problem: In the current era of ubiquitous smartphone cameras and social media, a single well-timed photograph of a wavering metal facade — taken in raking late-afternoon sunlight — can travel far beyond the original project. Images shared among professional networks, posted to contractor review forums, or included in dispute documentation create a persistent, searchable record that outlasts the project itself. The visual nature of oil-canning makes it uniquely vulnerable to this dynamic.

Mitigation

There is no single intervention that eliminates oil-canning. It is a phenomenon driven by the fundamental physics of thin metal under stress, and those physics cannot be fully designed away. What can be achieved — through disciplined application of overlapping measures across design, material selection, fabrication, and installation — is a dramatic reduction in the frequency, severity, and visibility of oil-canning, and a dramatic reduction in the commercial risk it creates.

Design for Stiffness

The most cost-effective intervention in the oil-canning problem is design — applied before a single dollar of tooling or material is committed. Panel geometry is the primary lever. A flat panel spanning a wide, unsupported distance is geometrically predisposed to buckle under relatively modest stress. Breaking up that flat expanse fundamentally changes the mechanical behavior of the panel.

Practical design interventions include:

- **Ribs, beads, and striations:** Even shallow embossed lines across the panel face provide significant out-of-plane stiffness, raising the buckling threshold substantially.

- **Crowning:** Intentionally forming a slight crown (as little as 1–2 mm across a wide panel) places the panel surface in tension rather than compression, making it far more resistant to buckling. This is the same principle used in automotive body panel design. Crowning is also achieved through the use of a closed cell foam backer rod placed under the center of the panel.
- **Span limitation:** Minimizing the unsupported flat area relative to panel thickness is one of the most direct ways to reduce oil-canning risk. Shortening the span between ribs or seams is more effective than increasing gauge alone.
- **Heavier gauge specification:** Where panel width demands it, specifying 24-gauge rather than 26-gauge steel — or 0.040-inch rather than 0.032-inch aluminum — meaningfully increases the panel's resistance to buckling, though at added material cost.

Material Selection

Material decisions made at the specification stage have a lasting impact on oil-canning performance throughout the product's life. Key considerations include:

- **Tighter flatness tolerances:** Standard mill flatness tolerances permit a degree of waviness that is acceptable for structural applications but problematic for exposed architectural panels. Specifying tighter flatness tolerances — or sourcing material that meets them — reduces the baseline stress burden before fabrication begins.
- **Tension-leveled coil:** Tension leveling is a coil processing operation in which the strip is passed through a series of small-diameter rolls under controlled tension, yielding and re-yielding the material to relieve residual stress and produce a genuinely flat starting surface. For applications where cosmetic flatness is critical, tension-leveled material represents the most significant upstream intervention available.
- **Temper selection:** Harder tempers offer better resistance to oil-canning. Consult with the material supplier to identify the hardest temper compatible with the required forming operations.
- **Low-gloss or matte coatings:** While this intervention does not change the underlying geometry, matte or textured coatings scatter reflected light and render surface waviness substantially less visible to the naked eye. On projects where oil-canning risk is elevated, coating selection can be a practical and cost-effective way to reduce visual impact without changing the structural approach.

Substrate Preparation and Installation

The best-fabricated panel will exhibit oil-canning if it is installed onto an imperfect substrate or fastened incorrectly. Installation-side controls include:

- Substrate flatness verification: Before panels arrive on site, verify substrate flatness to the specified tolerance — typically ¼ inch over 20 feet for commercial roofing and cladding applications. Identify and correct irregularities through shimming, packing, or framing adjustment before panel installation begins.
- Check for structural camber: Inspect beams, joists, and purlins for camber that will telegraph into the cladding system. If camber is present, determine whether it can be accepted within panel tolerances or must be corrected.
- Floating fastener systems: Specify and install floating clip or slotted-hole fastener systems that allow panels to move freely in response to thermal cycling without building up compressive stress. Verify that installers understand the distinction between fixed and floating clips and are using them correctly.
- Fastener torque discipline: Over-driven fasteners are a primary installation-side cause of oil-canning. Define and enforce a specific installation torque or "hand-tight plus turns" protocol. Conduct spot-checks during installation to verify compliance.
- Panel handling: Transport and handle panels fully supported across their length. Allowing long panels to hang unsupported, or to be carried on edge without adequate support, can introduce permanent kinks or temporary stress states that affect installation performance.

Conclusion

Oil-canning is not a new problem. It has been a feature of thin-gauge metal panel production and installation since the industry began, and it is formally recognized as an inherent material characteristic by the governing ASTM standard. But it is becoming a more commercially significant problem — driven by architectural design trends that favor larger flat-panel facades, wider panel profiles, and open building envelopes that showcase broad, uninterrupted metal surfaces under demanding lighting conditions.

The solution is not a single corrective action. It is a discipline — applied consistently and collaboratively across specifications, material sourcing, fabrication process control, and installation practice — combined with honest, proactive communication with clients about what to expect from metal panels in service. No panel, from any supplier, is immune to oil canning under all conditions. The goal is to understand the physics, manage the contributing factors, establish clear expectations, and deliver a product whose real-world appearance the client has seen, reviewed, and accepted before a single fastener is driven.

Suppliers and fabricators who invest in that discipline — who design for stiffness, source tension-leveled material, maintain rigorous fabrication controls, and engage their clients in honest pre-project conversations about what thin metal panels look like in raking afternoon sunlight — will differentiate themselves in an increasingly competitive market. They will

spend less on rework, less on dispute resolution, and less on damaged relationships. And they will build a reputation that is worth more than any individual project.

Oil-Canning cannot be fully eliminated. But it can be understood, managed, communicated, and controlled to a level that protects the project, the client relationship, and the supplier's reputation — and that is a standard every organization in this industry should be working toward.