Sink Marks on Cosmetic Surface Areas of Thick Molded Silicone Features: Compensation Design Protocols

VOLUMETRIC SHRINKAGE PHYSICS & WALL THICKNESS ARCHITECTURE | REEMANE SILICONE

Primary Compliance Standards:	ISO 3302-1 (Dimensional Tolerances), ASME Y14.5 (Flatness Profiling)	**Target Audience:**	Industrial Designers, Mechanical Engineers, DFM Specialists
Manufacturing Framework:	Design for Manufacturability (DFM) / Thermal Volumetric Contraction	**Document ID:**	REEMANE-TECH-WP-325A

1. The Thermodynamics of Volumetric Shrinkage

In the high-end manufacturing of medical wearable enclosures, consumer electronics skins, and premium automotive interface pads, a flawless "A-Surface" (cosmetic exterior) is a mandatory quality baseline. A frequently encountered and visually devastating defect is the "sink mark"—a shallow, localized depression or dimple that ruins the optical flatness of the silicone component. This defect occurs almost exclusively opposite to thick internal features, such as heavy mounting bosses, deep locator pins, or solid impact ribs.

The root cause of a sink mark is not a lack of molding pressure, but rather the fundamental thermodynamics of volumetric shrinkage. Silicone elastomers possess a high Coefficient of Thermal Expansion (CTE). During vulcanization in a hot mold (frequently between one hundred and sixty to two hundred degrees Celsius), the silicone is injected in an expanded state. As the part is ejected and cools to ambient temperature, it undergoes a two to three percent volumetric contraction. In a cross-section with non-uniform thickness, the thin outer skin cures and solidifies instantly against the hot steel mold. However, the thick, heavy internal mass remains semi-liquid and retains heat much longer. As this massive thermal core finally cross-links and cools, it shrinks significantly, generating tremendous internal vacuum forces that physically pull the already-solidified cosmetic outer skin inward, creating the sink mark.

2. The Fallacy of Holding Pressure in LSR

A fatal mistake made by engineers transitioning from rigid thermoplastic injection molding (such as Polycarbonate or ABS) to Liquid Silicone Rubber (LSR) molding is attempting to "pack out" the sink mark. In thermoplastic molding, operators routinely apply massive "pack and hold" hydraulic pressure to force additional molten plastic into the cavity as the thick sections shrink and cool.

Silicone is a thermoset polymer; it cures via an irreversible, heat-activated chemical cross-linking reaction, not a simple thermal phase change. By the time the thick internal mass begins to undergo significant volumetric shrinkage, the microscopic injection gate has completely vulcanized (frozen off). It is physically and mathematically impossible to push more liquid silicone through a solid, cured gate. Therefore, you cannot process your way out of a silicone sink mark. The solution must be purely geometric and architectural.

3. Coring Out and Uniform Wall Architecture

The ultimate defense against volumetric shrinkage and A-Surface dimpling is the absolute eradication of localized thick polymer masses. Reemane Silicone enforces a strict Design for Manufacturability (DFM) protocol dictating uniform nominal wall thickness across the entire component geometry. If a mechanical design strictly requires a tall, thick feature—such as a heavy mounting standoff—the engineer must not design it as a solid block of silicone.

Instead, the feature must be "cored out" from the non-cosmetic underside (the B-Surface). By replacing a solid block of elastomer with a hollow, strategically ribbed shell architecture, the thermal mass of the feature is drastically reduced. This architectural intervention normalizes the cooling rate across the entire cross-section of the part. Because there is no longer a massive, slow-curing core generating disproportionate internal shrinkage forces, the cosmetic A-Surface remains mathematically flat and visually pristine.

4. Transition Radii and Rib-to-Wall Ratios

When executing a cored-out architecture, the internal supporting ribs must be meticulously calculated to prevent them from inducing their own secondary micro-sink marks on the cosmetic face. The golden rule of silicone rib architecture dictates that the thickness of an internal rib at its base must never exceed fifty to sixty percent of the adjacent nominal wall thickness. If the main cosmetic wall is two millimeters thick, the supporting rib intersecting it from below must be no thicker than one point two millimeters.

Furthermore, sharp, ninety-degree right angles at the intersection of the rib and the nominal wall concentrate thermal stress and exacerbate shrinkage pull. Reemane Silicone mandates the integration of generous transition radii (fillets) at all internal rib intersections. These precision radii distribute the volumetric shrinking forces across a significantly wider surface area, entirely preventing the localized pull that causes sink marks and guaranteeing absolute compliance with ASME Y14.5 flatness profiles.

Volumetric Shrinkage Metric	Sub-Optimized Component DFM	Reemane Precision Geometry
Thermal Mass Architecture	**Solid thick blocks (Generates severe core shrinkage).**	**Cored-out architecture (Normalizes thermal contraction).**
Process Intervention Attempt	**Attempting to pack/hold (Fails; gates freeze instantly).**	**Strict geometric wall uniformity enforced at CAD level.**
Internal Rib-to-Wall Ratio	**> 80% thickness (Induces secondary sink marks).**	**Strictly < 60% thickness with precision transition radii.**
A-Surface Optical Flatness	**Visible dimpling, shadowing, and localized depressions.**	**Guaranteed ASME Y14.5 optical flatness compliance.**

Eradicate Cosmetic Defects Before Cutting Steel

Do not rely on ineffective processing tricks to fix fundamental geometric flaws. Partner with Reemane Silicone to deploy expert Design for Manufacturability protocols, precise coring architectures, and calculated rib-to-wall ratios that guarantee perfectly flat cosmetic surfaces.

Submit your 3D CAD models for a comprehensive volumetric shrinkage audit:
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Review our Design for Manufacturability and Precision Tooling capabilities:
www.siliconefactories.com/get-a-quote/