



Geometric Dimensioning & Tolerancing Casting Quality Tip Series

Simple GD&T Improvements: An Opportunity when Revising Casting Drawings

Background

Geometric Dimensioning & Tolerancing (GD&T) (ASME Y14.5 – 2018) was developed in the United Kingdom in the early 1940s. It originated from the realization that actual parts are three-dimensional and the prior (and still existing) Coordinate Tolerancing System is two-dimensional.

GD&T folklore claims that the idea of 3D tolerancing sprang forth from the shop floor where mating parts with fixed or loose fasteners typically required the use of hand-held electric drills to open up one among several holes to get a final fastener to fit. That is the consequence of what the GD&T standard calls the “virtual condition” of a hole. In simple terms, all the holes between mating parts are not as perfectly straight with uniform diameter as the old 2D drawings showed. Those imperfections in axis and diameter caused one last hole to need to be widened in order to get all the fasteners to fit.

Problem

Because the Defense Logistics Agency (DLA) procures castings for legacy weapon systems designed as many as fifty years ago, suppliers who originally made the castings are often out of business, the tooling they used has been lost, and the red-lined drawings they relied upon are gone. That means that new suppliers must attempt to make old castings without the benefit of the manufacturing engineering knowledge and resources to do so. Not surprisingly, new suppliers have a difficult time achieving first article approvals when they make legacy castings. Most often, the reason is dimensional inaccuracies: ***68% of first article disapprovals of legacy castings are dimensional non-conformances.*** That means it takes longer and costs more for DLA to procure legacy castings.

Solution

GD&T is a system for defining and communicating engineering tolerances and geometrical requirements. A 3D approach to tolerancing is at the forefront of this system. As 2D drawings are being updated for other reasons, simple GD&T improvements can be made which will help new suppliers achieve first article approvals.

Discussion

Typical reasons for a casting drawing change include, but are not limited to:

- Revision letter change
- Material change or additional material option
- Minor dimensional change from an assembly issue with mating parts
- A missing or incomplete dimension discovered during mold cavity tooling construction
- Conversion from hand-drawn to .dwg file output from a new solid model

- Alternate manufacturing process option, such as “machined-from-wrought stock” instead of a casting. (Occasionally allowed to simplify procurements of aged, low volume replacement part castings)

Specifically, when primary datums are undefined or incomplete:

- If adding or modifying datums, make sure that the primary datums A, B, & C are *as-cast* surfaces from which other as-cast and upgraded net shape surfaces begin.
- Remove any critical or significant tolerances from the drawing title block default tolerances section. Those default tolerances are often tighter than necessary. Instead, tolerance those features individually and thoughtfully as specific surfaces. If the surface doesn’t have a specific function, let the tolerance be wider.
- Optionally, remove surface finish requirements from tight tolerance features... when surface finish is specified on a tight machined tolerance, but the surface finish is not functional or cosmetic, just put the required tolerance on the feature. *A worthy soundbite for a foundational benefit of GD&T: “It is a contract for inspection, not a recipe for manufacture.”* As an example, for low volume, legacy defense castings, the investment casting process, combined with additive manufacturing technologies, can be the most cost-effective mold cavity-making process for faster, approvable, net shape castings. Investment castings commonly replace machined surfaces with as-cast, net-shape surfaces.

Conclusion

While learning GD&T can seem like a daunting task, implementing a few key principles can make a big difference. This GD&T Casting Quality Tip series will explore simple, yet effective ways to implement GD&T concepts. This series includes case studies on clarifying datum targets, defining the position of a feature and profile of a surface, and eliminating machining notation by defining tolerances and surface texture.