Fixed vs. Floating Fastener Formulas: Hole Tolerance Calculations

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Key Takeaways

086 - Engineered Component — GB□T 78 □ ISO 4027 (Series 025) — GB□T 78 □ ISO 4027

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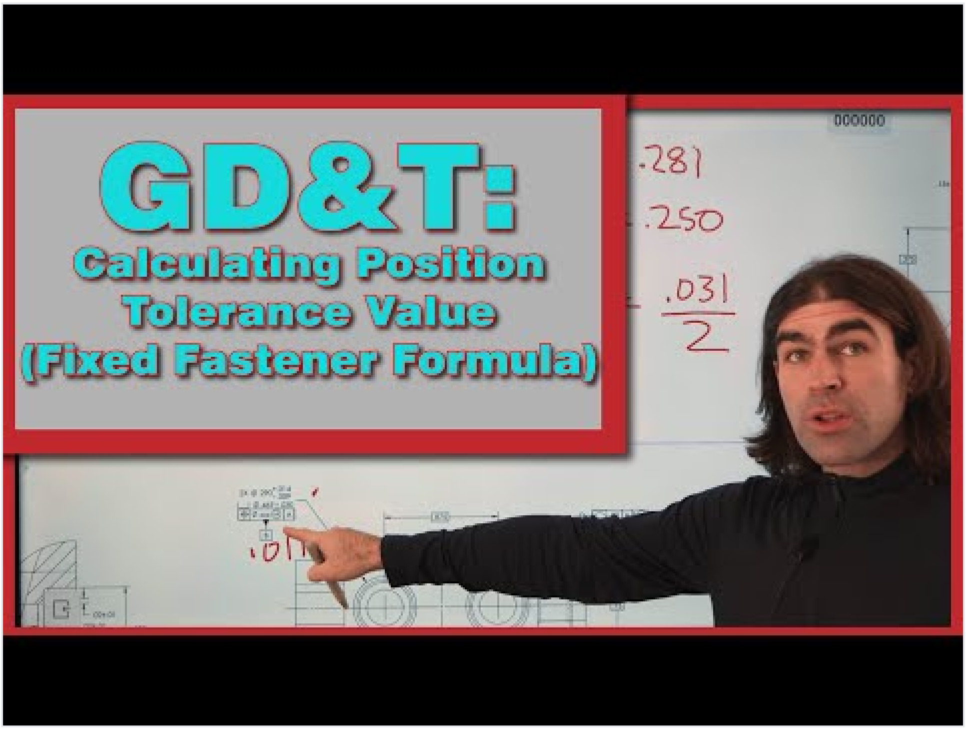
- The floating fastener formula H = F + T applies when both mating parts have clearance holes, allowing the part with the smaller position tolerance to use more of the available clearance.
- The fixed fastener formula t1 + t2 = H – F is used when one part has a threaded hole or captive fastener, requiring tighter coordination of tolerances.
- Always calculate hole sizes at maximum material condition (MMC) to prevent interference, and consider the effect of projected tolerance zones for threaded inserts.
- Double fixed fastener conditions demand extra care because all compliance is eliminated; avoiding this scenario or using tighter tolerances is crucial.
- Use standard clearance hole sizes from ISO 273 or similar references to simplify design and ensure manufacturability.

Have you ever specified hole sizes for a bolted assembly only to have parts that bind or rattle because the tolerances didn’t add up? If you’ve faced rework costs or design headaches from misaligned fasteners, understanding the fixed and floating fastener formulas is the solution. This article breaks down the two fundamental assembly conditions, their formulas, and when to apply each one.



► Watch video: https://www.youtube.com/watch?v=XJY0GgilDis

Calculating Position Tolerance Values With Fixed Fastener Formula— by R. Dean Odell on YouTube... with so that's it for this video quick talk about calculating tolerances for position with the fixed fastener formula enjoyed the videou00a0...

The Floating Fastener Condition: Both Parts Have Clearance Holes

103 - Clamping Handle Screw (Short) — DIN 6336 GN 313 (Series 042) — DIN 6336 GN 313

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In a floating fastener assembly, the bolt or screw passes through clearance holes in both mating parts, and the fastener is not rigidly fixed to either component. Think of two plates clamped together with a nut and bolt—each part can shift slightly during alignment. This freedom allows the total positional tolerance to be shared equally or proportionally between the two holes.

The classic floating fastener formula states that the maximum allowable positional tolerance is the difference between the minimum hole diameter and the maximum fastener diameter. Expressed simply: **T = H – F**, where T is the combined positional tolerance, H is the hole size at maximum material condition (MMC), and F is the fastener's MMC size. To find the required hole size, you rearrange: **H = F + T**. When each part gets its own tolerance, the formula expands to $\mathbf{H = F + T_1 + T_2}$, where T_1 and T_2 are the positional tolerances for Part 1 and Part 2. Even when hole sizes differ, you can allocate the total tolerance budget accordingly, but the core relationship holds—more total tolerance means a larger required hole.

This simplicity is why designers often prefer floating fasteners where possible. The assembly is forgiving: as long as the combined hole tolerances stay within the calculated limit, the fastener drops in without interference.

The Fixed Fastener Condition: One Threaded Hole, One Clearance Hole

In a fixed fastener assembly, one part contains a threaded hole (or a fixed stud), while the mating part has a clearance hole. The fastener is essentially locked in position on the threaded side, eliminating the ability to shift during assembly. All positional variation now comes from the location of the threaded hole and the clearance hole. This makes the fixed fastener condition more demanding.

The fixed fastener formula is $\mathbf{t_1 + t_2 = H - F}$ (or $\mathbf{H = F + t_1 + t_2}$), where t_1 is the positional tolerance of the threaded hole, t_2 is the positional tolerance of the clearance hole, H is the clearance hole size at MMC, and F is the fastener's maximum diameter. Here, the total positional tolerance must fit within the clearance minus the fastener size. Because the threaded hole's location is harder to control precisely (machining limitations, tap wander), you often need to allocate a larger share of the tolerance to t_1, leaving less for the clearance hole—or increase the clearance hole size to compensate.

Compared to floating assemblies, fixed fasteners demand tighter coordination between the two parts. Overlooking this can lead to bolts that won't start or bind in the hole. The formula helps engineers balance part manufacturability with assembly function.

Choosing Which Formula to Use in Your Design

Selecting between the fixed and floating fastener formulas depends on your assembly's structure. If both parts can accommodate through-holes, the floating fastener method usually yields looser tolerances and easier manufacturing. When one side must be threaded—for space constraints, blind mounting, or to eliminate a nut—the fixed fastener formula governs. Some designs involve a mix: a double fixed fastener scenario, where both parts have threaded inserts, demands special care because all compliance is lost.

Recognizing the condition early in the design avoids downstream surprises. Apply the floating fastener equation when you have two clearance holes, and the fixed variant when a threaded feature constrains one side. By plugging your fastener size and desired hole tolerances into these formulas, you can check for fit before cutting metal. The payoff is fewer fit problems, shorter assembly times, and reduced rework costs.

Applying the Formulas: Real-World Examples and Edge Cases

An engine mounting bracket that bolts to a cast transmission housing illustrates where the fixed fastener formula delivers immediate value. The bracket typically uses clearance holes, while the housing has tapped threads. If a 10 mm bolt passes through a 10.5 mm minimum clearance hole, the combined tolerance budget is 0.5 mm. Splitting that evenly gives each part a 0.25 mm position tolerance at MMC. That may be achievable with standard drilling, but if the part requires a tighter tolerance due to functional requirements, the designer must shift the budget accordingly—perhaps giving the bracket 0.15 mm and the housing 0.35 mm.

For assemblies with two clearance holes, the floating fastener condition offers more flexibility. Imagine a cover plate attaching to a base, both with through-holes, using an M8 bolt and nut. With an 8.5 mm minimum hole and an 8 mm maximum bolt, the total position tolerance pool is 0.5 mm. Since the formula is H = F + T, where T is the sum of both part tolerances, each part could be assigned up to 0.25 mm tolerance—or one part could use 0.1 mm and the other 0.4 mm, as long as the total doesn't exceed 0.5 mm. This flexibility often means the less critical part can have a looser, cheaper tolerance.

Edge cases arise when positional tolerances are not equal. If one part requires near-perfect positioning for electrical contacts or sealing, the design might allocate most of the slack to the other part. However, the geometric bonus tolerance concept (when holes are larger than MMC) can salvage an impractical split. For instance, if a clearance hole in the bracket is drilled at 10.6 mm instead of 10.5 mm, the extra 0.1 mm increases the total available tolerance, effectively granting a bonus on top of the initial calculation. This is where consulting a Clearance Hole Sizes — ISO 273 reference helps—choosing the next larger standard hole may relax tolerances without sacrificing fit.

Double fixed fastener assemblies, where both parts have threaded inserts, are a special pain point. Each screw threads into its own fixed nut, leaving no room for drift. In such cases, the tolerance calculation becomes a zero-sum game: any positional error reduces available clearance, and the parts may misalign even if the individual tolerances are met. The best engineering fix is to avoid double fixed conditions where possible, or use slotted holes or floating nuts to introduce compliance.

Finally, remember that thermal expansion and vibration can change engagement conditions. A fixed fastener that assembles perfectly at room temperature might bind when the housing expands. Incorporating a small additional clearance beyond the formula’s minimum helps absorb these real-world effects without complicating the tolerance stack.

Aspect	Floating Fastener	Fixed Fastener	Key Formula
Definition	Both parts have clearance holes; fastener floats.	One part has a threaded hole or captive fastener.	–
Typical Use	Bolted joints with through-holes and separate nuts.	Blind assemblies, tapped housings, stud-mounted parts.	–
Tolerance Calculation	Position tolerances can be unequal; total slack is shared.	Total position tolerance sum equals hole minus fastener diameter.	Floating: H = F + T Fixed: H = F + t1 + t2
MMC Dependency	Holes and fastener evaluated at MMC; bonus tolerance when hole size increases.	Threads treated as fixed at MMC; projected tolerance often needed.	–
Common Pitfall	Assuming both parts get equal tolerance without checking function.	Forgetting to add projected tolerance zone for threaded hole.	–
Reference	ASME Y14.5, ISO 273 clearance holes	ASME Y14.5, ISO 273 clearance holes	–

Ensuring Assembly Success: Next Steps

Calculating hole tolerances with the floating and fixed fastener formulas is a foundational skill for any designer or manufacturing engineer. The real power lies in using these formulas early, during concept design, to confirm that chosen fastener sizes and hole diameters can realistically accommodate manufacturing variation. A spreadsheet or simple tolerance calculator makes quick work of the equations; the harder part is determining which condition applies to each joint in your assembly.

After the numbers are in, the next step is to communicate the results clearly on your engineering drawings through GD&T symbols. Placing a position tolerance on each hole with the proper material condition modifier (MMC or LMC) locks in the intended fit. For threaded holes, consider using a projected tolerance zone to account for the fastener’s extension above the surface, which prevents interference when the screw engages at an angle.

Review your assembly with a tolerance stack-up analysis, especially for multi-fastener joints where hole pattern location errors compound. If the stack shows a potential interference, revisit hole sizes or adjust tolerances before prototyping. This preemptive check eliminates trial-and-error on the shop floor, where rework costs are orders of magnitude higher than computer screen adjustments.

By embedding these tolerance formulas into your design checklist, you shift from reactive problem-solving to proactive precision engineering. A few minutes of calculation saves hours of assembly time and ensures that every bolt slides home without a fight.

Frequently Asked Questions

What is the difference between fixed and floating fastener conditions?
In a floating fastener condition, both mating parts have clearance holes and the bolt passes through, allowing a nut to secure the joint from the opposite side. In a fixed fastener condition, one part has a threaded hole or a captive fastener, so the screw's location is effectively locked from one end. This distinction controls which tolerance formula to use and typically makes the fixed condition less forgiving.

How is the floating fastener formula applied in practice?
The formula is H = F + T, where H is the minimum clearance hole diameter, F is the maximum fastener diameter, and T is the sum of the position tolerances for both holes at MMC. Designers first select a fastener, then determine the required tolerances based on manufacturing capabilities; the formula then yields the necessary hole size to guarantee assembly.

Why does the fixed fastener formula usually require tighter positional tolerances?
Because the threaded side offers no free play—the screw must maintain its fixed position—the entire compliance must come from the clearance hole side. This forces the sum of the two part tolerances to be smaller than the difference between hole and fastener diameters, leaving less room for positional error compared to the floating scenario.

Can a design use a combination of fixed and floating fasteners?
Yes, many assemblies mix both types. For example, a housing may use fixed fasteners for tapped holes in one area and floating fasteners elsewhere where through-bolts with nuts are feasible. The designer must analyze each interface individually using the appropriate formula to avoid interference.

How do you verify assembly fit after applying fastener tolerance formulas?
After calculating hole sizes and tolerances, perform a worst-case tolerance stack-up analysis, often using a spreadsheet or GD&T software, to confirm that parts will assemble under all extreme combinations. For critical joints, consider a statistical tolerance analysis (RSS) to predict assembly acceptance rates in production.

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