

GD&T: THE LANGUAGE THAT CONNECTS ENGINEERING PROFESSIONALS

Helping organizations become fluent in
geometric dimensioning and tolerancing



ASME **L&D** LEARNING & DEVELOPMENT

THIS GUIDE AT A GLANCE

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Organizations need engineers who can communicate and collaborate effectively. A common design language is essential for this.

GD&T uses a symbolic language to indicate how significantly part features can deviate from the measurements listed in the design model. It's used on engineering drawings and within computer-generated models to communicate the level of precision required for a given part.

This language contains everything that communicates a component's functional requirements. This includes all the details involved in fabrication: dimensions, tolerances, definitions, rules, and symbols. These all currently follow **ASME Y14.5-2018**.

But simply knowing what the symbols mean isn't enough.

Engineering professionals need to understand how to implement the language across entire teams, from design to manufacturing.

This guide explores why GD&T is the recommended standard for professionals throughout the end-to-end engineering process. Learn how implementing the method across your organization can boost design accuracy, reduce lead time, and improve the quality of parts. Plus, discover common mistakes, best practices and practical applications of GD&T.

WHY GD&T SHOULD BE THE ENGINEER'S FIRST LANGUAGE

The way engineers design parts can depend entirely on where they train, and who they work with. Tolerances are crucial in the manufacturing process because they determine how well a feature will fit into the final piece, as well as how reliable that final piece will be.

One of the most common problems is form and function overlap, which occurs because organizations aren't willing to let go of using the traditional method. The traditional plus/minus approach to tolerancing is vague and lacks standardization, leaving much of the design process up to misinterpretation. There are **too many disparate approaches to allow for effectively designing** and creating precision parts. Other engineers then end up guessing the designer's intent, and the result looks like a poor quality product that doesn't function properly.

Errors in the manufacturing process can cause significant delays and cost implications. Inconsistencies are extremely difficult to rectify and result in tolerance stack-ups that don't work, parts that don't fit, and customers who aren't happy. But more importantly,

miscoordination between lead designers and engineers about parts design can be a matter of life or death. Many well-known disasters have occurred due to engineering miscalculations.

On top of this, engineering companies are struggling to collaborate effectively while operating virtually. 85% of engineering and manufacturing businesses are currently feeling the strain from lack of skilled workers, making the need for standardization more important still.

GD&T can make up for the shortcomings of traditional tolerancing because it accurately communicates the product design to the manufacturer. This allows designers and engineers to be very specific about what they need.



85%*

of engineering and manufacturing businesses are currently feeling the strain from lack of skilled workers

THE FUNDAMENTALS OF GD&T

Learning a language is about more than simply understanding the letters of the alphabet. And GD&T is no different.

Engineers need to know not only what the symbols mean, but also the fundamental rules of working with them, such as:

- **Understanding** the different types of tolerances
- **Working** with allowance and clearance effectively
- **Using** GD&T properly and with the rest of your team

SYMBOL	GEOMETRIC CHARACTERISTIC	TOLERANCE TYPE	CONTROL SUMMARY
	Flatness	Form (No relation between features)	Controls form (shape) of surfaces and can also control form of an axis or median plane Datum reference is not allowed
	Straightness		
	Cylindricity		
	Circularity (Roundness)		
	Perpendicularity	Orientation (No relation between features)	Controls orientation (tilt) of surfaces, axes, or median planes for size and non-size features Datum reference required
	Parallelism		
	Angularity		
	Position	Location	Locates center points, axes, and median planes for size features Also controls orientation
	Profile of a surface		Locates surfaces Also controls size, form, and orientation of surfaces based on datum reference
	Profile of a line		
	Total runout	Runout	Controls surface coaxiality Also controls form and orientation of surfaces
	Circular runout		
	Concentricity	Location (Derived median points)	Locates derived median points of a feature <i>Not common... Consider using position, runout, or profile</i>
	Symmetry		

GD&T PITFALLS AND BEST PRACTICES

Using the traditional plus/minus approach to tolerancing often leads to errors, which is why applying GD&T is the preferred method. However, using GD&T incorrectly can be just as detrimental to the final design as not using it at all.

While almost every design engineer will have a good understanding of geometric dimensioning and tolerancing, many professionals end up using it incorrectly.

Here are some common pitfalls to consider:

1

Not applying GD&T across the entire organization

There's a common misconception that the responsibility of applying GD&T lies solely with the designers. But in order to determine the manufacturing plan and quality proposal, there's a need for professionals in these disciplines to have a comprehensive understanding of GD&T, too.

2

Using both traditional and GD&T approaches

Some engineers continue applying the traditional methodology to some areas of the designs, and using GD&T for others. Organizations need to fully embrace and consistently use GD&T to see the full benefits.

3

Misunderstanding the power of profile

Profile tolerancing controls the feature's form, size, orientation and sometimes even location. But its importance is often overlooked in favor of other symbols.

4

Measuring flatness and parallelism the same way

A feature's flatness is tested relative to that feature. But parallelism requires a reference from which the parallelism of the feature is determined.

GD&T BEST PRACTICES

Companies that use GD&T over the traditional tolerancing approach can still encounter mistakes and inaccuracies. This may be because they're operating on the assumption that their engineers will be well-versed in GD&T. Or, perhaps because they believe that providing some form of GD&T training will be sufficient to guarantee consistent application.

Luckily, there are two simple steps that companies can follow to avoid this:

1

Provide the right training

Creating an internal implementation strategy is a crucial first step to ensure engineers across any organization are using GD&T correctly. That means investing in organized training programs, so that both new and existing employees are working with the same processes and applications.

2

Assess the GD&T adoption

Once companies commit to training engineering professionals in reading and using GD&T, analysis of the implementation's success must follow. Ensuring that everyone is using GD&T, and that they're using it correctly, is imperative.

These best practices apply to many other engineering and manufacturing concepts. Applying the implementation and adoption practices can open the doors to establishing more robust and standardized approaches across the business.



A DEEP DIVE INTO THE BENEFITS

Eliminating tolerancing errors can help manufacturers save time, money, and resources trying to fix faulty features after the parts have been created.

The use of a standardized GD&T language guarantees that every team is able to communicate clearly with each other—**saving time and increasing efficiency**. The importance of communication in the manufacturing process cannot be overstated. Today's complex part designs require accurate communication across various departments.

With every team using a consistent language, **companies can avoid costly misinterpretations**. Instead, the notes accurately convey clear dimensional objectives and functional specifications, as well as the tolerance zone within which the part will have its desired impact. As a result, **production becomes streamlined**, quality of features is improved and the rate of parts rejection is significantly decreased.

But the most crucial advantage of GD&T is the increased end-to-end flexibility gained by using it. Because GD&T specifies the design intent, it allows designers to provide larger tolerances within complex designs. If a drawing specifies how the position of a feature can vary while still offering full functionality, the greatest tolerance range can be used without impacting the design intent.

Traditional tolerancing can't deliver these benefits. However, **GD&T enables engineers to communicate their designs with as much accuracy as possible**.



HEAR FROM OUR EXPERT

We gave some of our most commonly asked questions to Scott, who has provided us with valuable insight about how GD&T can help engineers through the manufacturing process. Here's everything you need to know.

What's the importance of understanding GD&T symbols and when to use them?

The GD&T symbols and rules are like a toolbox. Some tools in the toolbox you will use very often, others you'll hardly use at all. It is important to know when you need a given tool, and how to use it. For example, the profile and position "tools" are ones that are needed to be used more often than others.

Are there any hidden benefits of applying GD&T?

One of the lesser known benefits of GD&T is that it helps organizations produce stronger datasets. Better data collection leads not only to smarter troubleshooting and problem solving, but also to the ability to leverage 3D modeling as well as 2D prints. The more useful data that can be collected, the easier it is for design engineers to plan for common tolerancing shortfalls.

What's the biggest downfall of traditional tolerancing?

The biggest issue with traditional plus/minus tolerancing is that it's not standardized. So, it's subject to misinterpretations throughout the process—from design to manufacturing—and this leads to complications, miscalculations, and inaccuracies.

Why do you think people aren't using GD&T properly?

Many designers aren't using GD&T properly because they aren't tolerancing for function, and they're thinking about the design too much from a manufacturing perspective. Design engineers are the authors, and communicating properly is crucial. If they do their job well, the other engineers will do their job well.



Scott Neumann

Scott Neumann, a graduate of the University of Florida with a bachelor's degree in Mechanical Engineering, is one of ASME's combo course instructors. As the president of GeoTol, he specializes in geometric tolerancing product definition, tolerance stack-up analysis, measurement data and inspection techniques.

Scott has presented hundreds of geometric tolerancing training programs in engineering, manufacturing, and quality assurance at many major corporations since 2007. Scott has also practiced consulting and mentoring to improve product documentation and inspection methods on a variety of products.

MOVING FROM THEORY TO APPLICATION

For design, manufacturing, and reliability engineers to work together with accuracy, they need to understand each other.

Speaking the same language is step one. Company-wide application of GD&T helps engineers be sure that the part defined on the drawing has the desired form, fit and function, within the largest possible tolerance zone.

But what does that look like in practice?

At ASME, we work with large organizations to refine and expand their understanding and use of GD&T. Here's an example of how we do that.

Case study: how one healthcare manufacturer realigned their teams with GD&T training

The client

A leading organization in the manufacture and maintenance of electromechanical equipment for healthcare providers. Including ICU ventilators, anesthesia, and respiratory equipment.

The ask

After recurring inconsistencies between their central R&D plant in the US and their partner organizations in India and China caused parts to arrive off spec, they asked ASME L&D to help realign their engineering teams. They wanted us to get everyone confidently back on the same page.

The answer

The GD&T combo course. By running the course online, we're able to deliver a consistent learning experience to a class of 20+ engineering professionals around the world, in real time. This allowed them to ask and hear each other's questions, so they could all benefit from the knowledge that was shared.

The result

After the course, we received feedback that we'd successfully established a shared design language and the client is extremely satisfied with the consistency they now see between their three R&D plants. Their drawing review processes are now far more effective in helping them to maintain the high standards that the healthcare industry demands.

“ASME L&D showed tremendous flexibility to make it work for our organization and help us establish a global baseline. Without that, we wouldn’t have achieved our goal.”

Mechanical Engineering
Manager



COURSE OVERVIEW

The ASME Learning & Development combo course is designed to teach GD&T to large groups of engineers.

Our instructors and subject matter experts are practicing engineers, industry professionals, consultants, researchers, and academics who bring real world experience and best practices to our learning environments.

“Learn the skills needed to interpret engineering designs to prevent mistakes during the manufacturing process.”

Here's what you can expect to learn.

ASME combo course overview

Geometric Dimensioning and Tolerancing Fundamentals 1	Geometric Tolerancing Applications and Tolerance Stacks
<p>This section of the course will teach you how to:</p> <ul style="list-style-type: none">• Demonstrate a thorough understanding of the fundamental geometric concepts• Interpret and explain the application of geometric symbols on drawings• Explain how to select the datum reference frames properly• Calculate the position and profile tolerances	<p>This section of the course will teach you how to:</p> <ul style="list-style-type: none">• Employ the proper application of geometric tolerancing on parts and assemblies• Perform linear and axial tolerance stacks• Reallocate tolerances to meet manufacturing capabilities

Course resources, included in the purchase:

- GeoTol Pro 2020 Fundamentals Workbook
- Fundamentals Solutions
- GeoTol Apps & Stacks Workbook
- Apps & Stacks Solutions

 **Find out more about the course**

COURSE OVERVIEW

The content is a mix of straightforward lectures and collaborative exercises, making use of your own design drawings as working examples. This allows us to demonstrate the theory to attendees in a meaningful way – with tangible examples of GD&T in practice.

Taking place over four days, the training schedule is customized to your business needs and can be completed remotely. For example, if there are specific areas within the training that you'd like to focus on, then the content will be geared towards this.

Upon completion, engineers will be fully trained in the fundamentals and applications of GD&T. As a practical course, the information is illustrated through examples of application – allowing attendees to put the learning into action.

Price breakdown

For teams of 10 learners:
\$1,250/learner

For teams of 20 learners:
\$1,200/learner

“Students often bring some of their parts into class so we can create a template together. Which allows me to show them how they would tolerance their part right then and there. This is the kind of hands-on learning experiences that the ASME combo course was designed for.”

Scott Neumann

LET'S TALK ABOUT IT

So, you want to learn and implement the language that keeps engineering running smoothly across industries? Whether you're looking for a refresher course to help realign your teams, or you're after a fully comprehensive training program – we can help.

ASME is the go-to expert in both fundamentals and real-world applications of geometric dimensioning and tolerancing. Our GD&T combo course delivers the foundational language engineers need to ensure consistency throughout the design process. In four days, attendees gain the skills and knowledge they need to avoid costly manufacturing mistakes, provide better quality control and shorten delivery times.

Get in touch today to inquire about ASME's GD&T corporate sessions.

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