PROFILE SERVICES

Oakbank, MB
Canada

(204) 619-3636
jdsykes@profileservices.ca
www.profileservices.ca

7 December 2015

Industrial Mythology

The Cost of GD&T

Originally Released on Tec-Ease.ca
6 June 2010

Notice:

Inspection protocols proposed within this document are individual approaches that offer low risk of accepting out-of-specification parts; other acceptable approaches may exist which are not discussed herein.

It remains the responsibility of the client(s) to verify any conversions, calculations, datums or controls that may be provided by Tec-Ease, Inc. and its representatives.

Unless Otherwise Stated:

- All dimensions are in millimeters [mm].
- Simplified geometries have been used to illustrate key concepts.
- Drawings and graphics may have been left incomplete by intent to illustrate key concepts.
- Geometric Dimensioning & Tolerancing in accordance with ASME Y14.5M-1994.

Revision Level	Release Date	Change Details	By
0	8 December 2015	Release to ProfileServices.ca	J.Sykes

The fact is, GD&T ***will*** cost you more than traditional plus or minus tolerancing. It's a FACT, just ask anyone. Anyone who has been involved in GD&T can tell you tales of woe where implementing GD&T has added cost and no value. How can you argue with that? EVERYONE knows it's true.

Okay, maybe it's more ***industrial myth*** than fact, but every great myth has a tinge of truth in it. If you're interested, I'm going to tell you a portion of my story.

A Long Time Ago …

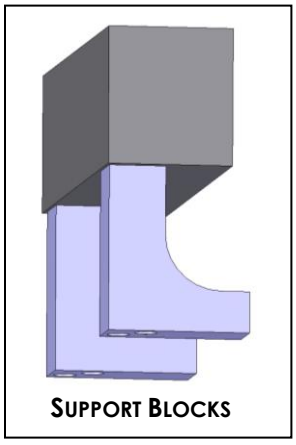
Late 1990s, three of us were assigned to attend a GD&T training session with an eye to deciding whether it would help our business unit. We attended, tried to figure out what was going on, and rejected the idea of GD&T. We had a fairly stable process with acceptable scrap, and decent communication between design, manufacturing and service. I really didn't understand GD&T itself from that session, so making such radical changes would arguably be costly. This backed up our unit management's thoughts, so the idea died.

A couple years later, I was asked to look into GD&T again; same instructor with the same answers, and I didn't grasp anything more than I did the first time. I reported the issues that I had with the training materials being a "house blend" of ISO & ASME GD&T, with a dash of business-unit standards and some other miscellaneous content sprinkled in, and topped off with the inability to get clear, source-supportable answers. I thought that the idea had died on the vine again, but several months later I was formally tasked with implementing GD&T into our business unit; that quickly grew to leading an engineering team through a GD&T implementation in two business units on three global campuses.

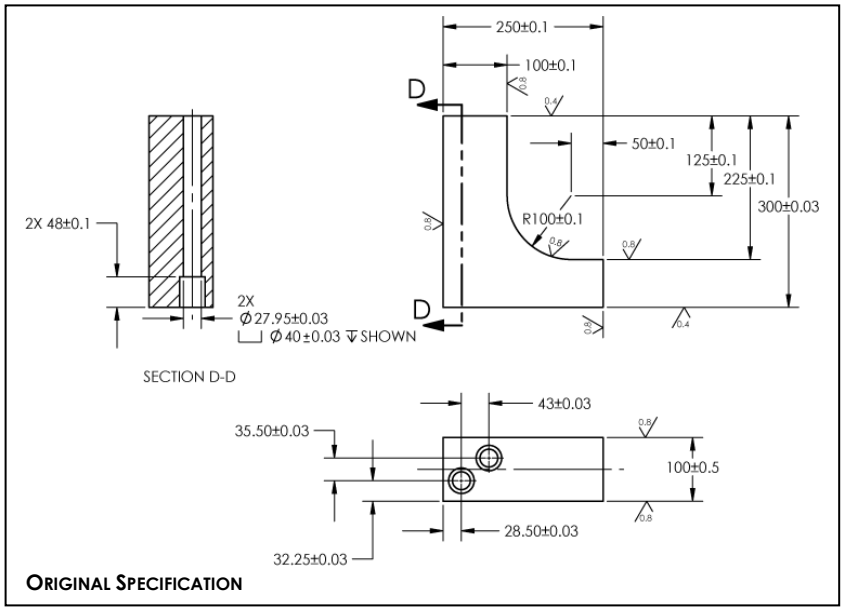
We brought in Tec-Ease Inc. as a training source and our core group of design and manufacturing engineers started to develop a baseline understanding of GD&T. Then Tec-Ease walked us through several product review sessions to help us grasp the reality of our designs, which sometimes differed substantially from our company-line perceptions.

Inevitably, the project faced some scope creep. Cost reduction, design revisions (accumulated over three years), design standardization across these business units, field service-based design revisions, and a few other fun little surprises were added to the pile. Our team had been meeting for about six to eight months, improving our GD&T skills, working on analyzing & converting some components and completely revamping designs in some cases, when I got the word … we had four months to overhaul four core product lines. The consequences to my team, if we failed, were made clear to me alone. We faced opposition from purchasing, manufacturing, inspection, even engineering and business management. There's fodder for many other stories in there, but for now I'll focus on the cost implications in a GD&T environment.

Our company had a reputation for putting out ***the*** premium product in our market segment. Our competitors' products didn't run or produce as well, nor look as good as our products. Our reputation commanded a premium that we had maintained for decades, but now offshore competition from developing nations of the Pacific Rim was eating into our primary customer base; cost minimization was an absolute requirement for survival. Our mandated goal was a minimum 15% cost reduction on all components, so we started looking at cost vs complexity for a number of components; we needed the low-hanging apples. One item jumped out at us right away, a support block shaped like a foot. Our original spec had size tolerances of +/- 0.1mm (+/- .003") pretty much everywhere and surface finishes of 0.4 to 0.8um. Each of those pieces cost 375_{USD} on average, so we were targeting a cost of 318_{USD}.



SUPPORT BLOCKS



ORIGINAL SPECIFICATION

By this point, the buyers were vocally involved and demanded that we not touch this part because they had already beaten their suppliers down to the point where they were barely making $5 profit per piece, so adding GD&T could only raise the price.

Fortunately, I wasn't working for the purchasing group. We asked where they got the idea that we would drive the price up, and their responses indicated the conventional wisdom; ***GD&T meant that tolerances were really tight and that you have to inspect all features controlled with GD&T***. We had suppliers making these parts in Canada, the USA and Europe, with some suppliers claiming expertise in GD&T while others reportedly had no knowledge of it at all. Sounded like a fair test to our team.

Rethinking Part Requirements …

We started back at the beginning; what was the required functionality of this support?

- Provide a stand-off from the bottom of the affixed plate to protect fittings projecting from the plate from damage,
- Used in pairs on each plate to help stabilize an individual or assembly of plates in storage or handling,
- Not overhang the back surface of the plate,
- Acceptable aesthetics for a professional appearance,
- Minimize project-based customization of support blocks.

To achieve that functionality,

- Top and bottom surfaces of each support block must be parallel,
- Overall heights of individually interchangeable support blocks must have minimal variance,
- Two M24 fasteners will be used to secure each support block to a plate,
- Adopt a standard "toe" length,
- Determine maximum acceptable surface aesthetics limits.

First step in applying GD&T: *Establish Datums*.

- The assembly would rest on the floor, making contact on the sole of the support block; the sole would be the primary datum feature.
- Preventing overhang at the back meant that the relationship from the back of the block was important; the back face would be the secondary datum feature.
- The location of the two c'bored mounting holes relative to each other wasn't terribly important, but to prevent cracking they couldn't get too close to the edges of the support block; the center plane of the width of the block would be the tertiary datum.

Second step in applying GD&T: *Control Datum Features*.

- The bottom of the block, as primary datum feature, needed a moderate degree of flatness to ensure stability; a flatness of 0.5mm was selected.
- To improve stability of the center of gravity, perpendicularity on the back face of 1.5mm with respect to the primary datum was established; a perpendicularity of 1.5mm would also ensure that the heel did not overhang the back of the plate.
- The actual width of the block was not critical, however centering of the mounting with respect to the actual width of the block was important; the width-surfaces used to define the datum center plane were controlled by a general surface profile of 10mm with respect to the datum reference frame.

Third step in applying GD&T: *Locate All Features Back To The Datums*.

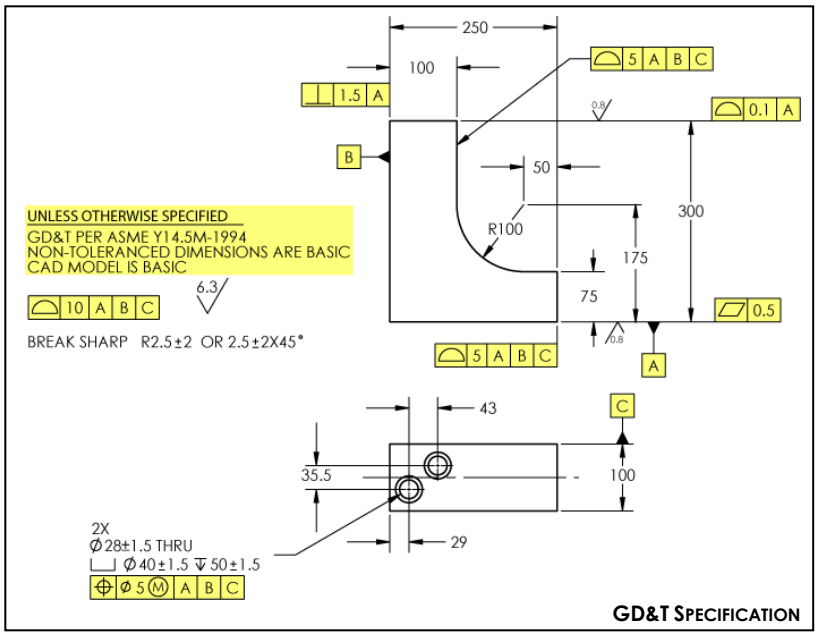
- A general surface profile control of 10mm with respect to the datum reference frame provided a starting point. This ensured that all features were toleranced for location, orientation, form, and size in some cases.
- To make sure the blocks were all the same height, a surface profile of 0.1mm with respect to the primary datum was applied; this would

also restrict the parallelism to 0.1mm with respect to the primary datum.

- The two c'bored mounting holes were increased in size to increase manufacturing tolerance without sacrificing fastener integrity. The position tolerances could then be increased as well, to Ø5 at MMC to further increase the manufacturing tolerance without sacrificing functionality.

Along with a BREAK SHARP specification, the control of size, location, orientation and form of all features was complete, at least based on mechanical function. The issue of aesthetics, however, could force us to add refinement controls for orientation and form to some surfaces to improve the "look" of the product. That was expected to be the show-stopper, so we left it for last. We presented the old & new drawings to the management team, who quickly passed it up to the President for a decision. We explained to him that we were targeting a 15% cost reduction on this simple part by means of opening tolerances, and that opening aesthetic requirements could significantly increase the savings. We had samples ready to show him "how bad" it could be based on the new specs, and he encouraged us to loosen the surface finish requirements further, even suggesting just flame-cutting the ankle of the workpieces for greater savings. Our management team wouldn't let it go that far, but they did permit a significant increase in surface finish for that area.

Supplier Quotes …
We finalized the spec and issued it for tender to the regular suppliers of this part, but we also had other vendors give us quotes. We had quotes as high as €475 (~700_{USD}$), 420_{USD}$ from the States, and 385_{USD}$ from Canada. A



GD&T SPECIFICATION

couple vendors submitted quotes between the original price of 375_{USD}$, and the targeted price of $318 $_{USD}$. One vendor, Mike, came in with a price around $185 $_{CDN}$ (~$120 $_{USD}$).

So we had an engineered article with a 375_{USD}$ original supplier cost… the design simplified a bit and GD&T added with a targeted reduction to 318_{USD}$ … quotes as high as €475 (~700_{USD}$), 420_{USD}$ from the States, and 385_{USD}$ from Canada. A couple vendors had submitted quotes between the original and the targeted prices, and Mike had come in with a price around $185 $_{CDN}$ (~$120 $_{USD}$).

With a quote better than 60% below the target and more than 80% below the highest quote, I knew that something was wrong there. Mike was an approved vendor for other parts, and I had dealt with him frequently in the past. His shop was a good three hour drive from our plant, and he kept two to six people busy most of the time with our work. I called him up and explained that his quote was significantly lower than expected, then asked if he understood the GD&T specification.

Fortunately, Mike's a patient fellow and took the time to remind me of a training session that he'd attended earlier.

After the history lesson Mike went on, quite accurately, to explain to me what the geometric tolerances meant. He recognized that these were very coarse tolerances and very open surface quality expectations; he even asked me if the drawing tolerances and surface requirements were correct because they were out of character for us. I won't let a vendor lose money in this way, so I told

GD&T Intro Session for Suppliers
At that supplier intro session, I'd brought in a dozen or so of our unit's vendors for an "Intro to GD&T" session. We covered the highlights of GD&T, provided a bit more depth on position, surface profile, and runout controls, then showed sample drawings. I went on to explain the business unit's plans for the implementation of GD&T and what these vendors should expect. There was time for some Q&A, and one vendor asked me what would happen if he decided not to implement GD&T … before I could answer, another vendor at the opposite end of the room simply said "I don't know what parts he's making for you, but I'll take the business." Another vendor summarized it nicely when he said, "I guess we all know the answer to that one now, don't we?" I never had to answer the question.
I remember that Mike had paid attention and took notes in that session, but didn't ask many questions. They left with a few GD&T "cheat sheets" and more than a little uncertainty.

him that we couldn't accept his quote if it wasn't profitable for him; I still thought he'd made some fundamental error on his estimate, so he laid it out for me. Having his shop in the middle of nowhere meant that his taxes were low and his people worked for next to nothing and considered themselves fairly paid. In our estimation, the material couldn't even be bought for his quote, but his next response surprised me. Mike recognized that we had opened the thickness spec up to allow a range of metric or inch plate sizes to be used as stock, and he had taken it one step further; he had a reliable source of cut-off plate materials that met our specifications. Mike assured me that he would be making a decent profit on each piece, and then he dropped the bomb … he had a refurbished machine on order already that would be delivered in 6 months and then he'd be able to drop the price by another $20. That was almost 75% off of our current cost.

My team assembled the managers and buyers for a conference call to discuss the quotes and particularly Mike's tender. We called on several of the suppliers to explain why their costs had risen so significantly. It took some digging and "persuasion", but the template answer was that they added 50 to 200% to the cost as soon as they saw GD&T because they assumed it would have to be manufactured to their tightest abilities, with 100% inspection. They hadn't even been looking at the specification details of the parts they had already been making with the old drawings. They were making everything as tight as they possibly could regardless of the spec, so their ignorance of tolerancing, much less GD&T, was actually costing them profit as they were over-manufacturing parts.

As a result, the buyers cut new purchase orders. The same old suppliers would now supply the parts for $318 USD, achieving our 15% cost reduction. That Mike's honesty and business savvy could have resulted in a 75% reduction in costs was less important than maintaining a status quo.

Management Support …

A year later, the initial deadline having passed successfully into history, I was working away on updating and improving the rushed GD&T applications from that first deadline. The drawings weren't clean, my team had been disbanded, and I was still developing my GD&T skills. I was supporting the rollout to the shop and contractors and resolving longstanding and new service issues by migrating component drawings to

GD&T and inspecting to meaningful controls. I was in the middle of presenting a GD&T Overview session for project and business managers when our operations manager, an engineer, interrupted the session. He applauded my efforts to fix what was wrong and lead our operation forward, kicking and screaming. He noted for all present that the move to GD&T was mandated as a strategic goal by the VP of Engineering while those in management positions within our operation only worried about tactical gains for their group in the current period, never mind the next quarter or years down the line. Then he got up & left.

Those experiences were related and inevitable in an environment paying lip service to the merits of GD&T. My team's efforts would never result in anything of substantial benefit because at the end of the day all that mattered was what your own group did today, whereas GD&T is a long-term enterprise-wide strategy. By that first deadline, I had been directed by engineering management not to be involved in the manufacturing rollout of GD&T except when asked for assistance on specific issues; I was an engineering resource, and the shop, inspection and suppliers were to be responsible for themselves. Of course I was already heavily involved in those areas, and found myself invited to a lot of meetings with support requests; I had integrated the shop's participation into our initial engineering rollout, so those team leaders recognized the impact and benefits to their groups. Still, the management team didn't support those efforts.

That brings me to the heart of the issue with any technology implementation, and particularly from my experiences with GD&T; every affected member of an enterprise must be personally invested in the success of that technology or it will fail to attain its true value, the value that the implementation decision was based on. Without full and passionate advocacy and support throughout the system, failure is imminent. In that failure is carried the wasted resources already invested and future prospects lost. That's why the common perception of any new technology, Lean, Six-Sigma, GD&T … is that it will cost you. When a technology implementation doesn't go full-out, the full value is never attained and it becomes part of the industrial mythology. Despite the reality of what GD&T could do to communicate our actual design requirements, reduce waste and improve efficiency, systemic blinders resulted in GD&T costing us more.

It's not all gloom and doom because not all companies follow the lip-service philosophy. I work with some companies now that have used GD&T to effectively document their tribal knowledge, to improve their product functionality and quality, and to attain manufacturing efficiencies that were once distant goals. Those companies regularly provide refresher training in GD&T and other technologies to ensure that their people get the greatest opportunity to improve themselves and their work. Many of them assist or compel their suppliers toward greater capabilities. Some call in technical coaches like me to walk them thru their designs and fabrication processes. One engineering manager told me that initially it was a struggle to get funding for training anybody in GD&T; now it's written into their job requirements and even senior management must pass GD&T tests. By carrying it through their entire process, GD&T had provided significant net value. Maybe GD&T ***doesn't*** have to be a wasted cost? It's your choice and your commitment.

Author Biography:

Jim Sykes P.Eng., GDTP-S, had twelve years of engineering design experience in the mold and packaging industry before attaining his Geometric Dimensioning and Tolerancing Professional – Senior Level certification and starting Profile Services, an Engineering Support Services provider. Two years later, Jim started teaching and coaching for Tec-Ease Inc. Jim has helped companies in defense, aerospace, automation, medical devices and other industries throughout North America, Eastern and Western Europe, and into Africa. Jim has worked with standards-development organizations for most of the last twenty years, and holds several patents.

Contact Details:

Jim Sykes, P.Eng, GDTP-S jdsykes@profileservices.ca

001-204-619-3636 (Canada)