White Paper

Improving Communication of Design Intent

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[This white paper is an introduction to the subject of improving communication of design intent. It is meant as a brief summary of the topic. Further research on the subject is highly recommended.

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Improving Print Clarity to More Accurately Communicate Design Intent

For years contract manufacturers (CMs) and their original equipment manufacturer (OEM) partners have struggled to communicate design intent. This article will explore how to improve that process by examining prints and how to actually remove information that distracts from the engineers' design intent. Eliminating design intent miscommunication will help avoid project delays, confusion and added costs.

This article will address:
1. What are the critical features and what distracting extras can be eliminated?
2. How are the critical features clarified, toleranced and inspected?
3. What is the impact of poorly documented prints?
4. In an example the article will show how the use of precision GD&T can show a reduction from many measured features down to one measured result.

Founded in Minneapolis, MN in 1964, Lowell Inc. is a precision machining contract manufacturer and a leader in the development of sophisticated implantable medical devices. At Lowell, they are taking the lead in an innovative approach to Geometric Design and Tolerancing (GD&T) and looking at it not only as a communication tool, but also as a business strategy. Their commitment to technology, equipment and GD&T are some of its key elements. This article will explore the road Lowell has taken and how any manufacturer can use this strategy to clarify design intent, streamline the manufacturing and inspection process, shorten time to market, and yes – even reduce cost.

Prior to the broad application of computer aided design/computer aided manufacture (CAD/CAM) software in the late 1980s, design engineers would sit at a drafting table and laboriously fully dimension prints with +/- tolerancing. Changes were made with a mechanical pencil and a pile of eraser crumbs. That all changed with the advent of mainstream CAD software and solid modeling. Today – if it were possible to manufacture the "perfect" mathematical part – it would look exactly like the solid model. So what can companies today do to approach the perfect part? That is where the ASME Y14.5 Dimensioning and Tolerancing and Y14.41 Digital Product Definition Data Practices Standards come in. They provide the common language of GD&T and method to communicate it.

Historically, many engineers would go by the old saying that "more is better" when dimensioning a drawing. If one callout for parallelism wasn't sufficient, then surely three or four was better. This led to drawings becoming cluttered with multiple datums and tolerance schemes. As parts got smaller and more complex, this phenomenon got increasingly worse.

And the true meaning of the drawing – design intent – was lost in a mish-mash of overly-complicated tolerancing schemes. This created problems not only in design, but throughout the entire product development process. Those schemes needed to be designed, manufactured and inspected, and the lack of clarity caused and repeated problems and delays at each step.

The following is an example of a +/- tolerancing scheme run amok. The print below shows a theoretical ring with complex features, in this case a series of small arc radii, and development of a tolerancing scheme.

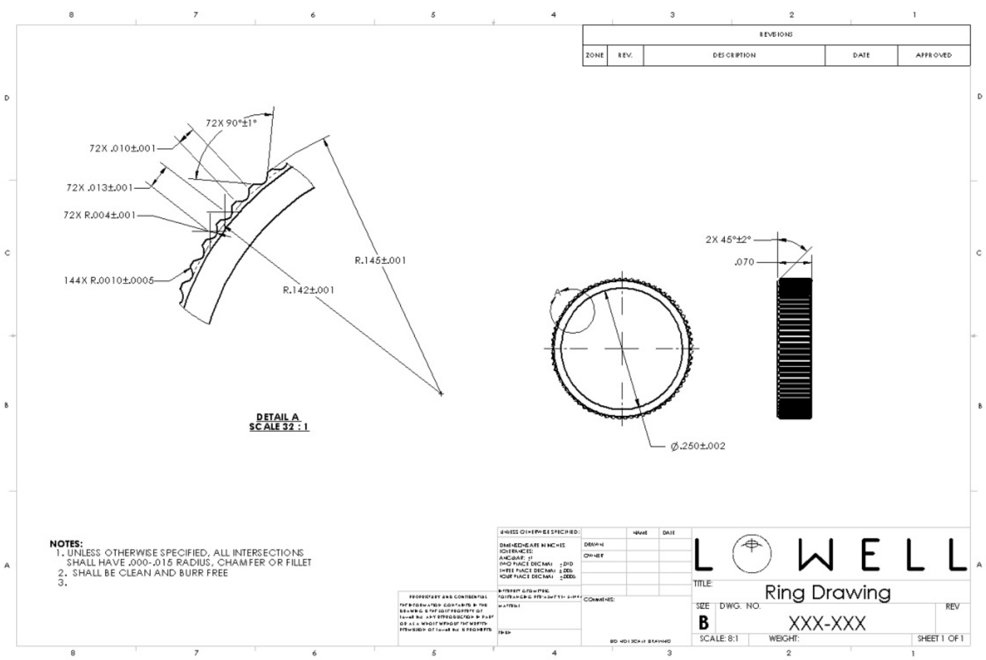

Figure 1. 2D Orthographic Based Drawing (+/- Drawing)

Most everyone has seen parts dimensioned in this way – and clearly more is not better. If you were to inspect each of these dimensions, you'd be looking at hundreds of features that are called out, including 74 angles, 222 radii, 74 peak-to-peak, 74 angles, 74 points on the minor radius and 74 arcs of the outside radius. Anyone who has attempted to measure a small radius with any certainty based on three measured points knows the likelihood of introducing error. In excess of 100%. Missing or over-dimensioning only creates confusion and opportunity for error. These errors are then repeated at every stage of development. It is compounded when a contract manufacturer (CM) is brought into the picture. A lot of inside knowledge is required to "fudge" this part through the inspection process. When a CM is involved, unless that inside knowledge is passed down, design intent is lost. This is where the precise language of GD&T, in conjunction with the 3D solid model, can help.

This is the different approach that Lowell is spearheading. We use precision GD&T to not only dimension the part, but to describe it's functionality as well. It all starts with the solid model. CAD/CAM software enables Lowell to design the mathematically-perfect part and depict it in the 3D solid model. Perfect models always represent the mid geometry of the defined tolerance zone. The example in Figure 2 is the 3D solid model for our theoretical ring shown in Figure 1. The model contains nominal geometry of the mathematical perfect part. Querying digital elements provide the dimensions, relationships, and attributes necessary to manufacture the part. The model is only one component of the product definition data set used in parallel with the drawing graphic sheet and external documentation.

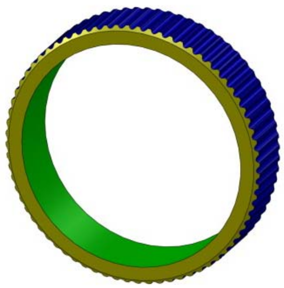

Figure 2. 3D Solid Model

Lowell then takes the 3D solid model and uses it as the baseline for creating the drawing. The key is that the print reflects the model in describing the conformance criteria of the part – not just dimensioning features. Lowell starts by only including information that relays the engineers' design intent. In the drawing, only GD&T reference frames, datums and engineering specifications are shown. In Figure 3 it is clearly conveyed that the central holes' axis, not the outer diameter axis, is how the outer profile is defined, measured and analyzed. When executed correctly, this results in a more robust drawing containing less clutter than the traditional +/- drawing with more usable information.

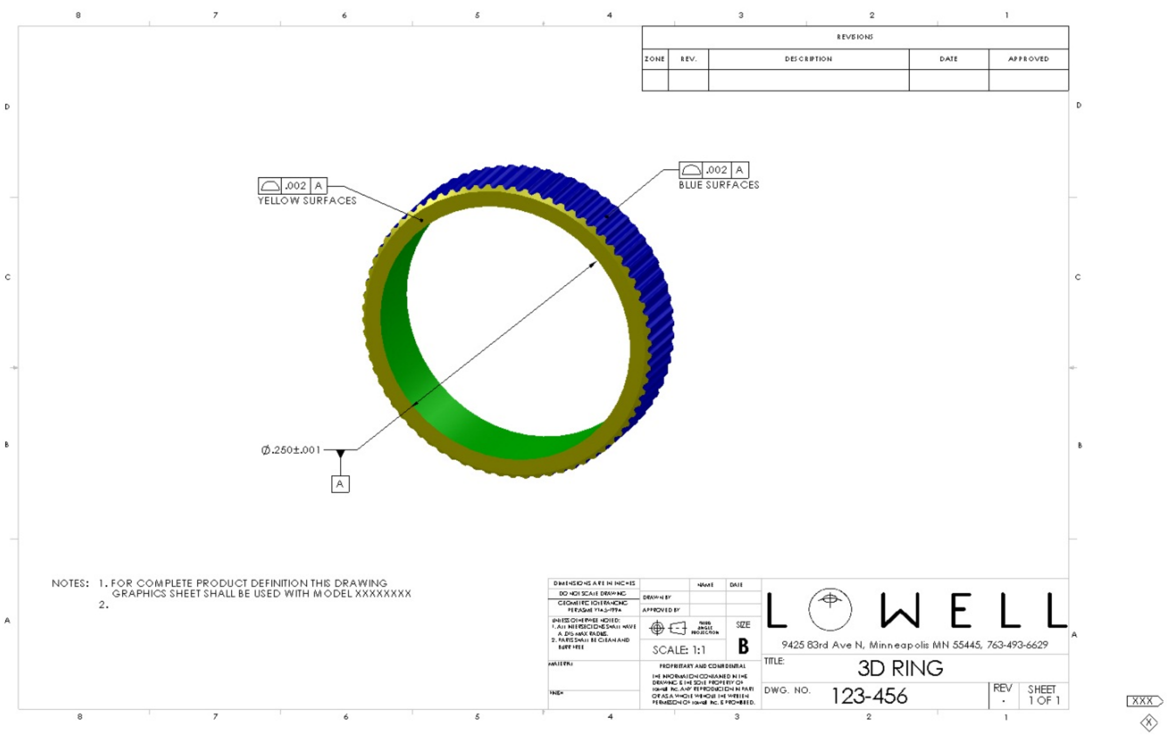

Figure 3. 3D Model-Based Drawing

The 3D solid model used in tandem with 3D model-based drawings eliminates many questions. It assures you that everything is done properly at every step. Figure 4 depicts the product development process at Lowell. As a CM, they work exclusively with their customers' designs. Lowell's Development Engineers work closely with their customers to eliminate design ambiguity.

Once the design is settled they use the design model to build their manufacturing and inspection programs. In Computer-Aided Manufacturing (CAM), the model is the basis for their machining programs. In Computer-Aided Inspection (CAI), the same model is used to program their advanced CMM/PMM inspection protocols. Inspection data is then analyzed and catalogued with SmartProfile™ and pc•demis software. This inspection data is critical for set up, in-process and final inspection. With this approach, only one 3D solid model is used to generate design, manufacturing and inspection data. All this information in turn is stored within the design history file for a clean record of all life cycle activity. The benefits of speaking in the common language of GD&T flow along each step of the process – clear depiction of design intent yields fewer project delays. (For more information on this process please refer to Lowell's article on Profile Tolerancing in the August 2009 issue of MD+DI.)

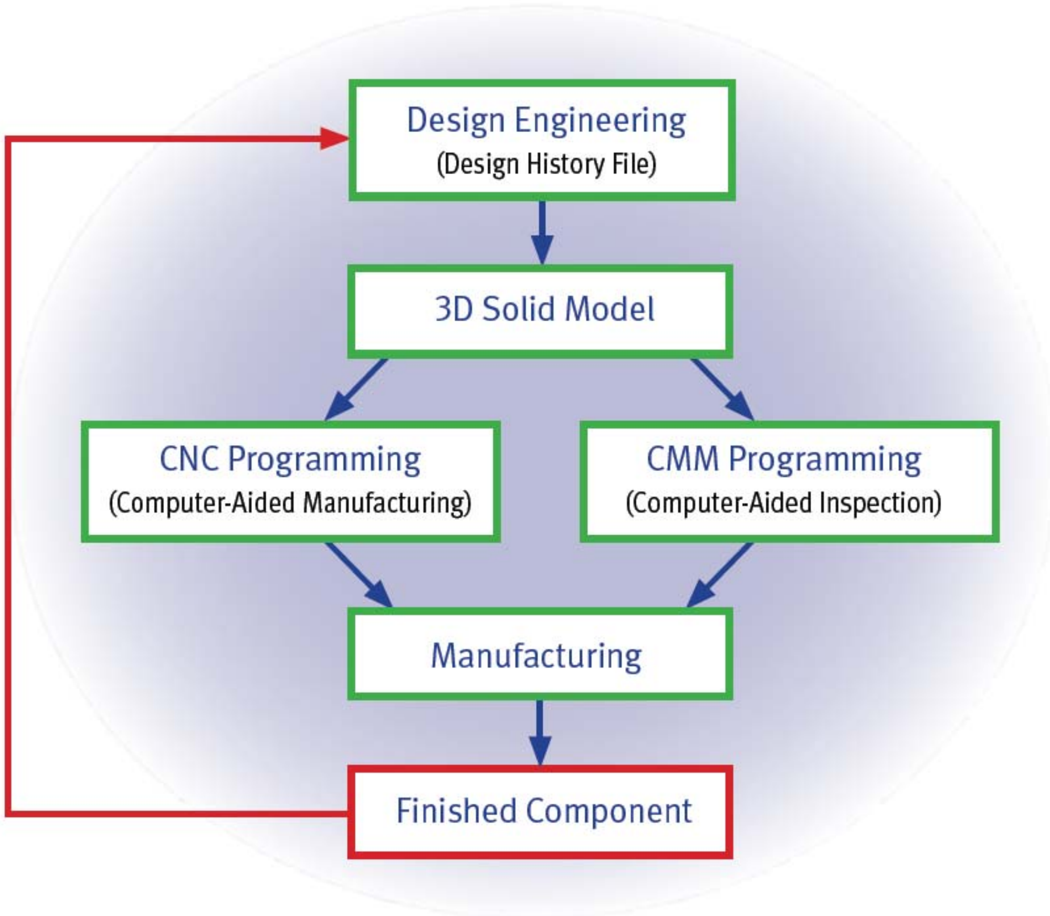

Figure 4. Product Development Cycle Information Flow

Conclusion

The long term gains for companies that adopt GD&T and 3D model-based drawings are many. But one of the clearest is that the true design intent is conferred and it survives changes in personnel, manufacturing and inspection equipment. Inside knowledge is put aside and the language of GD&T is used for continuous product improvements, line extensions and accessory development. In addition, there is absolute clarity when working with contract manufacturers who may not have been along from the beginning in the development cycle. The solid model, when used in conjunction with 3D model-based drawings and GD&T, will clarify design intent, shorten lead times, reduce errors, and ultimately reduce costs.

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A Partnership in Communicating Design Intent

A commitment to communicating design intent is a true partnership between a medical device manufacturer and their supplier. Here are some tips on how you can be sure your suppliers clearly understand your design intent:

- Do they have advanced training in GD&T from an organization such as IIGDT? Do any of their engineers have certifications from ASME?
- Are they routinely using the solid model as the basis for their understanding of design intent? Will they work with you to point out areas where that intent is unclear?
- How comfortable are they with 3D model-based drawings and the use of Profile Tolerancing?
- Have they invested in the high-end physical metrology equipment, such as a Leitz precision measuring machine (PMM), needed to measure complex geometries with small deviations, some less than 0.001 mm?
- Have they acquired profile analysis software, such as SmartProfile, needed to analyze the complex surface profiles simultaneously?

Only by partnering with a supplier that understands, invests in and is committed to clear communication of design intent through GD&T can you experience its full benefits – designers and suppliers speaking in a common language that communicates design intent free of ambiguity.

Greg Berrevoets is a New Product Development Engineer for Lowell, Inc. in Minneapolis, MN. Greg has 20 years experience in the Medical Device industry and spent over 15 years at Pioneer Surgical as a Senior Project Engineer. He is a certified GD&T Professional through ASME and Six Sigma Black Belt. Greg is also an avid outdoorsman and fisherman. After working hours he can be found on one of Minnesota's over 10,000 lakes.
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