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Effective Training Inc., Westland MI, 800.886.0909 **Volume 02: Issue 4**

Known as the "Doctor of Dimensioning," Alex Krulikowski is a noted educator, author, and expert on Geometric Dimensioning and Tolerancing (GD&T). He has more than 30 years of industrial experience putting GD&T to practical use on the shop floor.

Alex has taught GD&T to tens of thousands through his workshops and seminars, and to countless others through his books, self-study courses, videos, and computer-based training programs.

Web Highlights

Enterprise Metrology Closes the Loop with MCAD
Steve Logee discusses Enterprise Metrology (EM), which "promises to make dimensional data and the programs that collect and analyze them readily accessible and consistent throughout manufacturing processes."

ETImail *is a regular online publication devoted to Geometric Dimensioning & Tolerancing. Each edition features a host of GD&T resources and links, as well as dimensioning tips by noted GD&T author and ETI founder, Alex Krulikowski. We also invite you to visit our website, etinews.com. To view past issues of ETImail, see the archives.*

ETImail is now available in PDF format. To read the PDF file, you will need Adobe Acrobat Reader.

In This Issue

Here are this issue's highlights. Click on any link to jump directly to a feature:

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Alex Answers The Top 10 GD&T Questions, Part 2

Alex Krulikowski

ETI was founded by Alex Krulikowski in 1985. This issue celebrates over 20 years of providing GD&T products and services with answers to five more of the ten most commonly asked GD&T questions. Volume 2, Issue 3, featured the first five.

In 1985, I began a small start up company that provided training and consulting in a little-known discipline called geometric dimensioning and tolerancing. One year later, I developed a GD&T self-study course. Twenty years later, Effective Training Inc. has evolved into a corporation that provides GD&T training, products and services to organizations across the globe.

I've been asked quite a few questions about GD&T usage and details throughout the past 20 years. In this issue, I'll reveal 5 more of the top 10 questions about GD&T, with their answers. I hope you find them helpful.

Top 10 GD&T Questions, part 2:

1. Regarding the primary datum specified in the feature control frame when using true position for holes on a part that has holes bored into it from more than one side, so it has holes on surfaces other than those that are called out as datum -A- as shown in Figure 1.

Read part 1 of an article called, *Measure Right for All Your Needs* in the October 2005 issue of Desktop Engineering.

To read the article, click here.

GD&T Data in the 3-D World

Part 2 of Logee's article (November 2005 issue of DE) discusses an add-on software module for MCAD systems that makes use of the system's GD&T capabilities in allowing design engineers to select the features to inspect and the methods for inspecting them.

To read the article, click here.

Part 2 of *Measure Right for All Your Needs* was published in the November 2005 issue of Desktop Engineering.

www.deskeng.com

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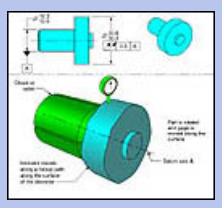
New at ETI

The GD&T Trainer Personal Version brings affordable GD&T training to your home.

GD&T Trainer Now in a Personal Version

Designed for use by one person on a stand-alone PC, the Personal Version of our GD&T Trainer is ideal for anyone who wants convenient, affordable GD&T training at home.



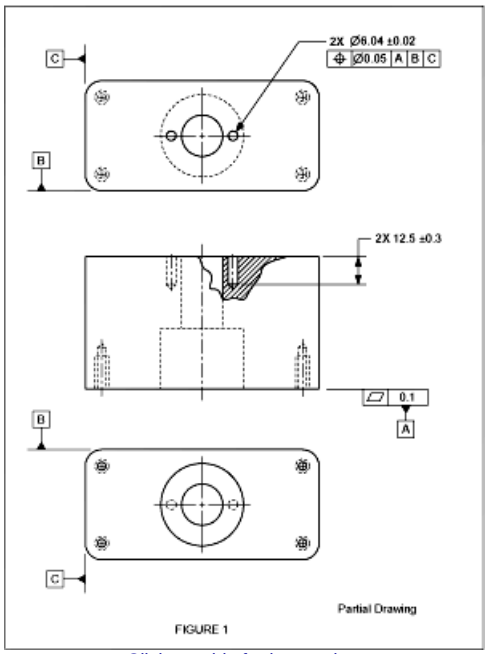


FIGURE 1

Click graphic for larger view

I've always been under the impression that the primary datum called out in the feature control frame should be the one on which the holes lie — or at least a datum that is parallel to that surface. I've just learned that some of my colleagues have always been defaulting to A, B, C as their datums, regardless of which surface the holes are placed on, thus, "always" making datum A their primary datum. Which of these practices is correct?

The ASME Y14.5M-1994 Standard has a description on page 47, section 3.4.3, including Fig. 3-21, that still leaves something to the imagination (in my humble opinion). Please point out a page that gives a better answer to my question, if one should exist. If not, your interpretation will suffice.

Read Alex's Answer

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2. How is a datum referenced in multiple locations? In other words, if the same datum symbol is located in more than one location, do the additional symbols have to be designated as “REF?”

Read Alex's Answer

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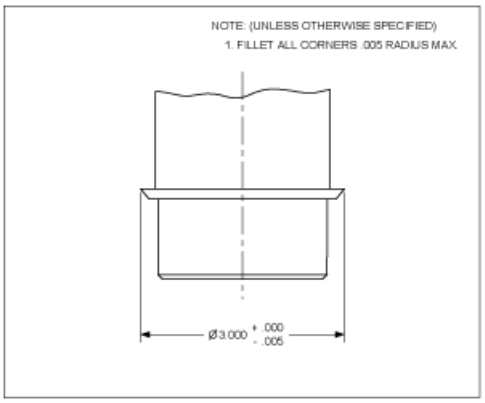
3. I can't seem to find an answer in your *Fundamentals of GD&T* textbook for the correct interpretation of a feature that has a "knife edge point," with a tolerance, and a general note call-out for an edge break up to max.005.

In the drawing below, what is the correct interpretation of measuring the 3.000 +.000/-.005 dia., with a variable edge break of .0001 to .005 Max?



Click graphic for larger view

Some people say "Rule # 1" applies. I don't agree. I was always under the impression that the feature dimension (in this case, with a knife edge) should be taken from the theoretical point of intersection, and reduced from that point by the amount of "edge break" that was put on this knife edge (i.e. T.S.C. "To Sharp Corner"). Hence, the part could be still considered good, if the part was "mic'ed" lower than 2.995 and if the edge break didn't exceed .005 Radius Max.

Please tell me where I can find the correct answer to this question in printed literature.

Read Alex's Answer

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4. We all know how easy it is to reference the center of a circular hole as a datum, but what is the correct way of referencing the center of a hexagonal feature as a datum?

I did consider referencing the 6 flats of the hex feature with a surface profile tolerance and calling this out as the datum, but you wouldn't do this for a circular hole, so why do it for a hexagonal hole?

I also considered inscribing a phantom circle into the hexagon and proceeding as you would for a circle.

I look forward to your comments.

Read Alex's Answer

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5. When does a radius turn into a diameter? If a radius passes 180 degrees of arc, is it considered a feature of size?

Read Alex's Answer

Answer to Question 1

Unfortunately, the application of GD&T is much more complex than the interpretation. Controversy often occurs because each person is using a different dimensioning approach (i.e. functional dimensioning vs. dimensioning for manufacturing or inspection, etc.).

Your application is not covered in Y14.5. The figures in the standard do not help much in the application of GD&T because they are incomplete by intention and are made only to show a point explained in the text.

Your impression "…that the primary datum callout in the feature control frame should always be the one on which the holes lie…" is often true. When functionally dimensioning a part, it is very common to use the part surface that the hole enters into as the primary datum feature reference in the position control that locates the hole. This is typical whenever the surface has a mating part, and the part that assembles into the hole also assembles into the adjoining part hole. By using the surface as the primary datum feature, the orientation of the hole to the surface is also being controlled (in addition to the location), which supports the function of assembly. An example of this dimensioning method is shown in Figure 2.

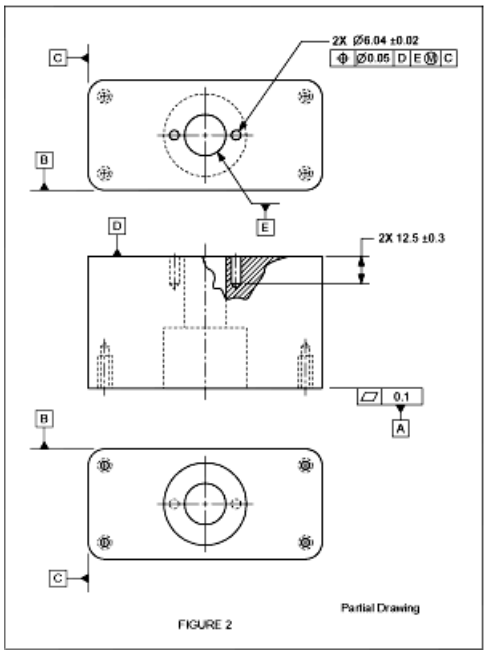

FIGURE 2

Click graphic for larger view

This dimensioning situation is so common that I have created a rule of thumb for it:

Alex's GD&T Rule of Thumb

When using a position tolerance to locate a hole, the part surface that the hole enters into is usually specified as the primary datum feature reference.

Using a different surface for the primary datum feature is not necessarily illegal, but often does not represent the functional requirements of the hole. I find that the dimensioning shown in Figure 1 is often a result of using the manufacturing approach for applying GD&T.

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Answer to Question 2

No. The Y14.5 standard states in paragraph 3.3.2, "Where the same datum feature symbol is used to identify the same feature in other locations of a drawing, it need not be identified as reference."

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Answer to Question 3

You pose some interesting questions. The knife edge application you are working with is not covered in the ASME Y14.5 Standards or in any textbooks that I am aware of. I can provide some opinions on your application. One could argue that the drawing is unclear and subject to more than one interpretation.

First, I will address the issue whether or not the 3.000 diameter is a feature of size. Whether a knife edge diameter is or is not a feature of size is not specifically covered in the standard. Some committee members would argue both sides of this issue. However, I believe that this diameter should be considered a feature of size. It is a circular element with opposed points, meaning that the diameter (3.000) of

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The GD&T Trainer Professional Edition—a virtual classroom at your desktop

GD&T Training Made Easy

The GD&T Trainer Professional Edition (Y14.5M-1994) contains 28 student-focused lessons covering the fundamentals of GD&T. Instant lesson feedback and quizzes reinforce the material.

Highlights include a GD&T glossary, tolerancing application and inspection examples, audio narration, full-color technical animations, 3-D solid part examples, and a certification exam.
To read more about it, Click here
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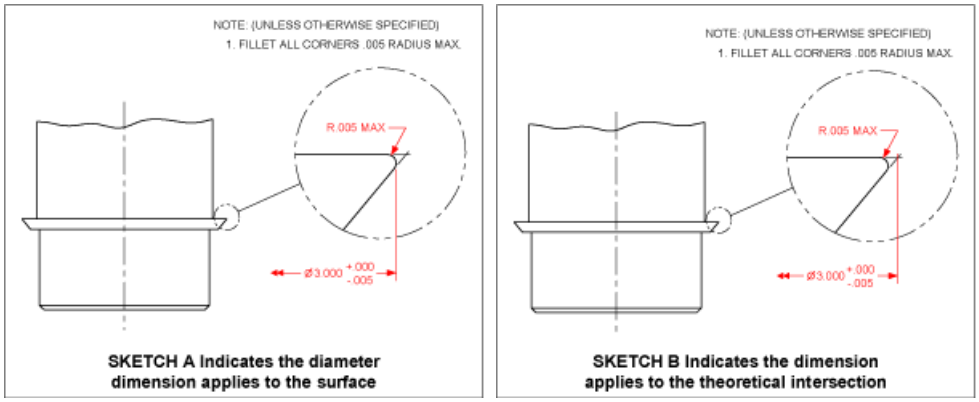
GD&T advanced concepts taught by the experts. . .

Advanced Concepts of GD&T Textbook

The textbook stresses the application of GD&T in industry and takes an

the edge formed by these two surfaces must be a **perfect** circle when produced at MMC. This does not have a major impact on your question about the interpretation of the 3.000 diameter.

Next, I will give an opinion on the size dimension and how it is impacted by the general radius note. There are no references about how to dimension a knife edge or interpret the affect of the general radius note in the Y14.5 Standard. Considering the way the diameter dimension is specified, I would interpret it as applying to the actual surface of the diameter (circular element) and not to a theoretical intersection of the surfaces that create a diameter. Interpreting the 3.000 diameter as a dimension to the circular element created by the radius of 0 to .005, the measurements come from the surface of the diameter. The limits of size state that the circular feature can be no greater than 3.000 and no less than 2.995. The drawing could have been more specific in this area; I would suggest a separate view like the one shown in sketch A to make the requirement clear.



Click graphics for larger views

If the drawing intended the diameter to apply to the intersection point of the two surfaces, it should have been dimensioned as shown in sketch B.

The note: FILLET ALL CORNERS .005 MAX creates an allowance for deviating from a sharp corner to a very small radius; however, that does not change the size requirement of the diameter.

On drawings that use general notes for radii, the method to interpret the effect of the general radii note on dimensions is a fairly common problem.

Keep in mind, this is an opinion. I cannot cite a reference in a standard to support this position. I am using my knowledge of standards, deductive reasoning, and my experience in interpreting drawings to formulate my position.

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Answer to Question 4

Great question!

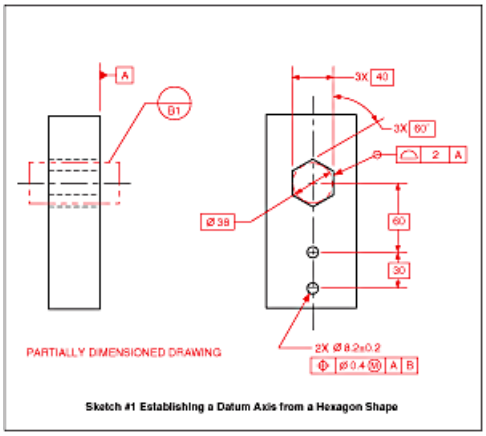
A lot of engineers struggle with this problem. There is no information in the Y14.5 standard about how to establish a datum axis from a hexagon-shaped feature. The problem is further complicated because a hex-shaped feature is not a feature of size. A hexagon could be thought of as three planar features of size, but that gets very complicated to specify as three datum features and to reference them in feature control frames.

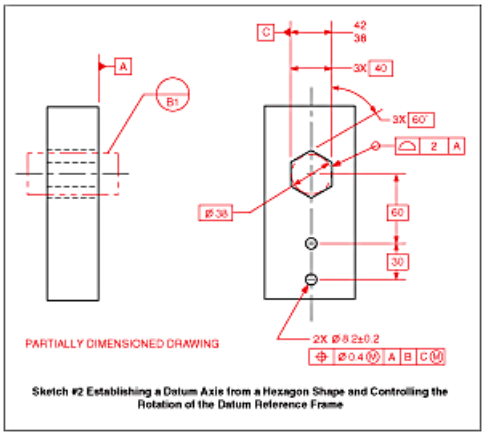
Your thoughts about ". . . inscribing a phantom circle into the hexagon and proceeding as you would for a circle. . . " are along the right path. I would change the phantom circle to a phantom cylinder and specify it as a datum target as shown in sketch #1. The target would represent the datum feature simulator, and the datum would be the axis of the datum feature simulator. This method, although not specifically shown in the standard, clearly communicates the design intent and does not violate any concepts from the standard.

If the diameter of the phantom cylinder is defined with a basic dimension, the datum feature

simulator would be fixed in size (similar to an MMC application of a feature of size datum feature). If the diameter of the phantom cylinder is shown tangent to the hex, with no dimension shown for size, the datum feature simulator would be variable in size (similar to an RFS application for a feature of size datum feature).

There are several ways to control the rotation of the datum reference frame established from the datum axis. One way is to use one set of the flats of the hexagon as another datum feature to orient the datum reference frame. This is shown in sketch #2.





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I am confident that this method would clearly communicate the design intent. However, if you asked several GD&T pundits, they may have other ways of establishing a datum axis from a hex shape. Variation in the application of GD&T is the natural result when the standard doesn't cover a dimensioning topic.

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Answer to Question 5

This is a common concern of many people I talk with. The ASME standards are not explicit about when a radius or diameter becomes a feature of size. This causes confusion about how to correctly specify GD&T and datum features on drawings.

One of the main purposes of a feature of size is to be able to establish an axis (or centerplane) from the surfaces or elements of the feature of size. In some cases, the axis is used to analyze the location of the feature of size. In other cases, the feature of size is used to establish a datum axis for measurement.

In my opinion, one can make a case for a radius or a diameter to be a feature of size under the right conditions.

Your thought about passing 180 degrees of arc is on the right track. When dealing with cylindrical type features, they can be considered a feature of size if they contain opposed elements. The requirement of opposed elements comes from the definition of feature of size in Y14.5. If a radius or a cylinder (full or partial) contains opposed elements, it may be considered a feature of size.

Keep in mind that a radius with 180 degrees of arc may be considered a feature of size — at least theoretically — by the definition in Y14.5, but it would not be a useful feature of size. It would only have one set of opposed elements. It could not be used to establish an axis repeatably from the radius.

From a practical standpoint, a radius would have to contain more that 180 degrees of arc to be a usable feature of size. How much more? There is no rule given in the standard, I can only say that the more degrees an arc contains, the more repeatably an axis can be established. In other words, the more degrees, the more useful the feature of size. Each application is different, and there is no single value that can be given for the number of degrees of arc; however, in many applications, a radius of 270 degrees would be sufficient to establish a repeatable axis. Would 269 or 268 degrees of arc work? Sure. Would 181 degrees of arc work? Theoretically, yes; from a practical standpoint, probably not.

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The "ultimate" GD&T reference tool is only available thru ETI

Economical Tool You Can't Afford To Miss
Carry this pocket-sized reference with you on the job and have a resource to all your GD&T questions at your fingertips. Order one for each member of your team!

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ETI offers convenient, customized, onsite workshops in a variety of GD&T-related topics.

ETI Offers On-Site Training
Effective Training brings hands-on GD&T instruction right to your location. Workshops can be customized to include your drawings and parts.

ASME Y14.41 - 2003
Blueprint Reading
GD&T Fundamentals
Fundamentals Overview

There you have it...the last five of the top ten most frequently asked questions that I've received in 20 years as a GD&T instructor and consultant. As always, I welcome your questions or comments.

***ETI's 20th Anniversary:** In 2005, Effective Training Incorporated (ETI) celebrated their twentieth anniversary as a training and consulting corporation based in Westland, Michigan. The company was founded in August 1985 in the home of local design engineer, Alex Krulikowski, and now provides geometric dimensioning and tolerancing (GD&T) products and training to organizations across the globe. Read more about it.*

We welcome your feedback. Send comments about this article to ETImailbag. Your opinions will be posted in the next issue.

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Standards in the News

ETImail's Standards in the News *takes a look at real-life issues involving standards. This month: the need for product traceability.*

Excerpt from the Manufacturing Center website

Manufacturing Success With Product Traceability
Given the demands of a regulated manufacturing environment, a driving need for better quality control, and a relentless desire to increase customer satisfaction, traceability systems look to play an increasing role in manufacturing processes.

For many manufacturers, recent federal regulations on product and part traceability have placed new demands on their production process. Compliance with the TREAD Act, RoHS, and SPEC 2000 has caused concern and sent companies scrambling to meet these industry and governmental requirements. Industry guidelines have been in place for years. SPEC 2000, for instance, includes standards and specifications for traceability technologies such as bar coding, 2-D data matrix symbologies, and RFID (radio frequency identification). Indeed, during the last 30 years, product traceability has seen widespread deployment across many different industries, including automotive, medical, aerospace, and military.

Eliminate Recalls
The TREAD Act represents the government's answer to traceability deficiencies in the automotive industry. This law was signed into effect on November 1, 2000. It represents the most significant expansion of the U.S. Vehicle Safety Act in 25 years. Specifically, the TREAD Act requires manufacturers of motor vehicles and motor vehicle equipment to report information on parts derived from both foreign and domestic sources. This information must assist in the identification of any defects related to motor vehicle safety. In parallel to this regulatory structure is the overarching desire for quality control by manufacturers. Traceability technology provides companies with a tool that proactively addresses product deficiencies. Through the implementation of traceability systems, the companies can minimize the cost of product recalls.

GD&T Advanced Concepts
Tolerance Stacks
ASME-ISO Comparison
Statistical Tolerance Stacks

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ETI's Discussion Board: Talk about GD&T issues with other peers and professionals.

ETI'S Discussion Board
ETI's website has an interactive forum that's easy to access and may give you a broader knowledge of GD&T-related topics.

To visit the board, click here.

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Quality Quote

Perfection is not attainable, but if we chase perfection, we can catch excellence.

— Vince Lombardi

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ETI Staff

President

Full story

*Excerpt is from the article, "**Manufacturing Success With Product Traceability**," by Robin Barbero, VP sales and marketing at PTG Industries, from Tooling & Production, April 2006. Troy Lee, sales manager PTG Industries, assisted in compiling the article. See the T&P archives at manufacturingcenter.com.*

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Alex's Tech Tip

From teaching ideas to new GD&T training products and on-the-job resources, the ETImail Tech Tip will keep you informed about new technology and training trends. This issue's Tech Tip: web-based training options have improved.

ONLINE TRAINING BECOMES MORE PREVALENT AND MORE AFFORDABLE
Since the onset of web-based training about 10 years ago, it has become a more common choice among those seeking a convenient, accessible training alternative. In order to offer our customers more options, we created the ETI Online Learning Center over three years ago. Our first course covered the GM Addendum. Since that time, we've tweaked our offerings, added more options, and priced it to be more affordable. Take a look at some of the new features and content:

- **Training begins any time**
  Students no longer need to wait to begin training on a certain course date. Once registration is complete, log on and start learning.
- **More training content**
  We've added a complete GD&T fundamentals course that includes animated explanations of concepts, 3-D solid parts, and audio narration of lesson/quiz content.
- **Improved course options**
  Users may now choose from several options. Select the complete 28-lesson course, or choose a single module covering a particular topic for a quick refresher course. There's also an in-house certification test available for use by organizations.
- **Priced more affordably**
  More students means less overhead. Because our online training has become so popular, we've been able to pass the savings on to our clients. One student can now take our complete course for under $300. *(Only $147 during our special online training sale - offer ends December 31, 2006.)*
- **Training availability for organizations**
  Our learning management system now offers the option of company-wide online training.

Fundamentals of Geometric Dimensioning & Tolerancing Online Course
The 28-lesson, fully interactive course explains the terms, symbols, modifiers, rules, and basic

concepts of geometric tolerancing as prescribed in ASME Y14.5M-1994. ETI's online training provides instant feedback, and it's accessible from your desktop any time of the day or night.

This self-paced course features audio narration, instant lesson feedback, and quizzes that reinforce the material. Lessons contain geometric control application and inspection examples and 3-D solid part images. Other course highlights include user-friendly navigation, detailed full-color graphics, technical animations, and a full glossary of GD&T terms. Over 100 tolerancing insights from GD&T expert and ETI president Alex Krulikowski are also included. View lesson content.

Course Learning Tools
—Interactive lesson content
—Easy-to-read lesson/quiz screens
—Multiple question formats
—Detailed drawings & graphics illustrate concepts
—Instant lesson feedback explains why answer is wrong

Special Learning Technology
—Animations demonstrating concepts
—3D solid parts for better visualization
—Geometric control inspection animations
—Audio narration of lesson/quiz content

Special Learning Aids
—GD&T glossary of over 150 terms & concepts
—100+ Author's Comments by Alex Krulikowski
—Content referenced with Ultimate Pocket Guide
—Geometric control application examples

Fundamentals of GD&T Web-Based Training
Complete Course

Regular price $294, sale price only $147

Register Now

Due to popular demand, the WBT sale has been extended until December 31, 2006. For more information about web-based training options for organizations, call 800-886-0909 or email wbt@etinews.com.

If you know about a new tech tool or an innovative idea that would aid our readers, please write us: ETImailbag.

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ETI News

ETI continues to add new GD&T products and services and provide you with more GD&T training options. Keep an eye on this section to read about our latest news. This issue: ETI video training on DVD is now available.

Fundamentals of GD&T Video Training DVD Sets

GD&T video training for professionals

View video sample

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Read more about it

The Fundamentals of GD&T DVD Series is a convenient, comprehensive video training program that teaches the fundamentals of geometric dimensioning from your DVD player. Train yourself or your employees anywhere you can play DVDs:

- On your portable DVD player

- Using your DVD player and TV
- Using the DVD-ROM drive on your PC or laptop

The video training series is taught by ETI president, Alex Krulikowski, an internationally known GD&T expert. Alex has a degree in industrial vocational education, over 30 years of industry experience, and was a manager of dimensional engineering at GM. He explains GD&T basics in a clearly understood fashion, using a series of goals and objectives, with the help of 3-D part models to help demonstrate concepts.

Fundamentals of GD&T video training is available in three convenient options:

- Fundamentals of GD&T Full Course - 8 DVD Set
- GD&T Fundamentals Overview - 4 DVD Set
- GD&T Fundamentals Individual DVD Learning Module

ORDER NOW

Order your Complete Fundamentals of GD&T Video Training 8-DVD Set today.

Call 800-886-0909 or click here for more information.

GD&T Trainer Professional Edition LAN Upgrade to be Released Soon

Latest software release for LAN, corporate, and site license purchasers includes a new skills survey, an overview course, and the Digital Design Dictionary.

Version 3.4 of the GD&T Trainer Professional Edition software will be available in the fourth quarter of 2006. The upgrade brings important new features to the interactive, computer-based geometric dimensioning and tolerancing course.

In addition to the Fundamentals of GD&T class and seminar options, users can now also choose a 10-lesson GD&T overview course. The short course can be used as a quick training overview for those whose jobs call for a basic understanding of GD&T principles, as a refresher course for those already familiar with the topic, and as an on-the-job resource. The new 50-question GD&T skills survey allows users to assess their skill level before choosing which course option is right for them.

The latest upgrade contains all the features of the previous training program, including instant lesson feedback, technical animations that demonstrate concepts, audio narration, and over 100 author's comments that give tolerancing insights from course developer and ETI president, Alex Krulikowski. However, the GD&T glossary that allowed users to access terms and definitions within the lessons has been upgraded to the new, more comprehensive Digital Design Dictionary.

The Digital Design Dictionary (available separately for $49) defines over 200 technical terms used on engineering drawings. It includes drawing conventions; geometric dimensioning and tolerancing (GD&T); solid model tolerancing; gages and fixtures; casting and forgings; and more. The terms are cross-referenced to the paragraphs in various ASME standards.

The upgrade will be available in the fourth quarter of 2006, and it is only available for LAN, Corporate, and Site License purchases of the GD&T Trainer Professional Edition. Clients who currently own a Trainer LAN, Corporate or Site License will receive the upgrade if they have a current maintenance contract. This upgrade is not available for the GD&T Trainer Single-User, Multi-User, and Personal Versions.

Read more about the GD&T Trainer Professional Edition.

Read more about the Digital Design Dictionary.

For more information about the GD&T Trainer Professional Edition upgrade, call 800-886-0909.

ETImail Feedback

ETI would like your opinion...

What products or training would you like to see added to our line-up? Take a short 5-question survey to let us know what you think.

Click here to take survey

ETI would like to hear from you. If you have an opinion about any ETImail article or feature, please write to our ETImailbag.

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We would appreciate it if you'd keep us in mind when you need GD&T training, consulting, or products. Feel free to contact us by email or by phone at 734-728-0909 or 800-886-0909.

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