



The Measure of the Glass

- To the optimist, the glass is half full.
- To the pessimist, the glass is half empty.
- To the engineer, the glass is twice as big as it needed to be.

Geometric Dimensioning & Tolerancing for Quality

**A Presentation by
Kishwaukee College's
Mark Schwendau**

© 2005

How did **GD&T** happen?

- On April 21, 1864, a man named William Sellers gave a speech, "On a Uniform System of Screw Threads," to Philadelphia engineers and machinists gathered in the lecture hall of the Franklin Institute.
- In the early 1900's, the first drafting standards came out to improve quality of parts from drawings.
- **In the 1940's GD&T was born as an international drafting standard to facilitate design of the P-51 Mustang between North American Aviation and Briton's Rolls Royce Merlin. It was top secret.**
- In 1946 the International Standards Organization (ISO-TC10) was formed in the interest of worldwide drawing communication.
- In 1966, the United Standard was published, now **ANSI/ASME - Y14.5M-1994 or ISO-1002.**

Why are drawing standards so important?

- Engineering drawings are legal documents that form part of a contract so they must be formal and precise.
- When drawings are created wrong, or misunderstood, the cost of resultant errors increases exponentially with more scrap parts.
- The data of drawings created today will become the foundation for our future tomorrow.
- Drawings prepared to symbol-based standards facilitate International understanding.

What is GD&T in General?

- It is an international graphic language consisting of standardized symbols, rules, definitions, and conventions (universal syntax).
- It is used to describe the size, form, orientation, profile and location of part features.
- It is based on a design philosophy called “functional dimensioning” based on functional relationships.
- It uses datums and datum systems to define dimensional requirements with respect to part interfaces for manufacture/inspection/assembly.
- It provides information that can be used to control tooling and assembly interfaces as well as develop a record of quality history.

What is GD&T based on?

GD&T is founded in functional dimensioning, or functional design, also called, Design for Assembly/Manufacturing (DFA/DFM) It requires us to ask questions such as:

How does the part come into place and into use during any one or all of the following three situations?

- Production
- Inspection
- Assembly

What are the Benefits of GD&T?

- **Illustrates functional design relationships**
- **Reduces scrap and rework**
- **Provides a standard international language**
- **Reduces drawing changes**
- **Increases production rates**
- **Insures part interchangeability**
- **Provides inspection verification consistency**
- **Allows multiple source procurement**
- **Facilitates functional gauging**
- **Makes maximum use of available parts**

GD&T more specifically...

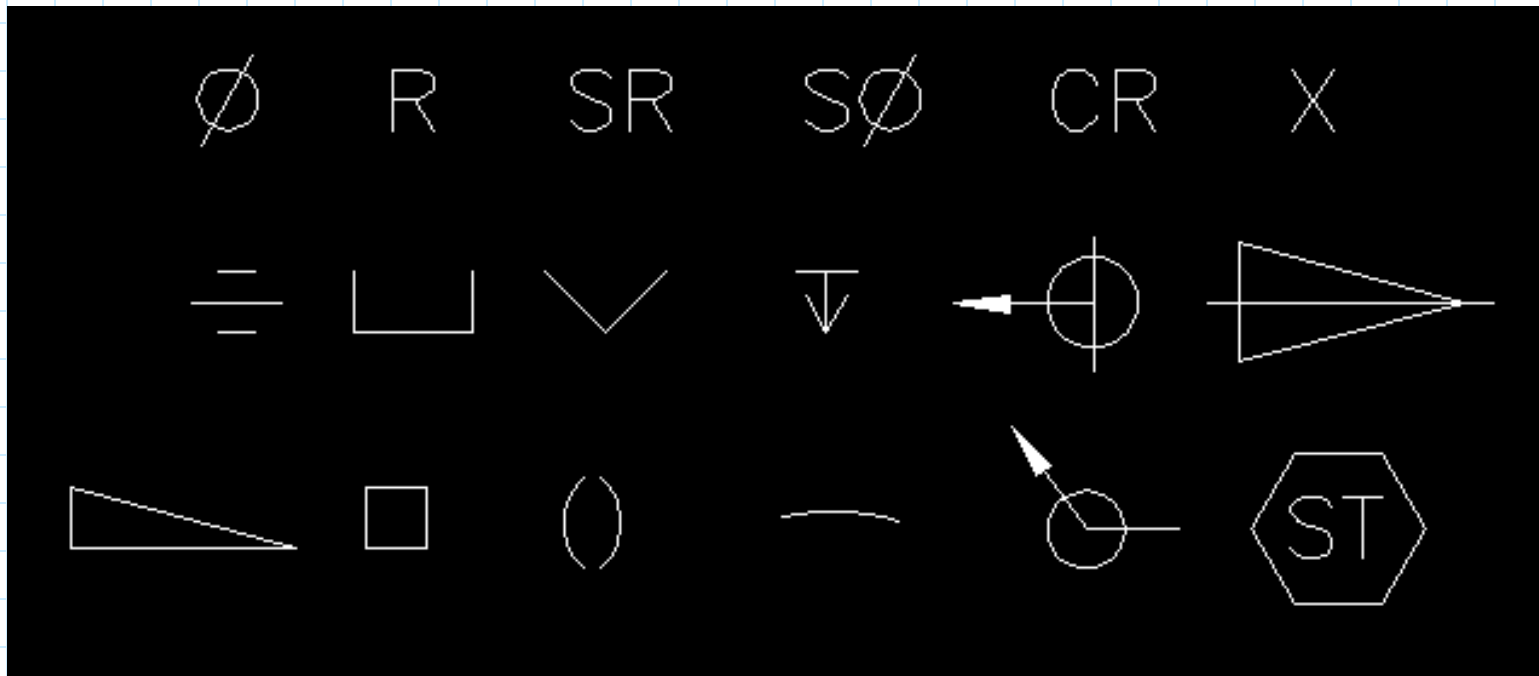
- **eliminates tolerance stack-up as each dimension is from a datum rather than the last dimension.**
- **can actually offer “bonus tolerance” in some situations when a feature tolerance offers extra tolerance to a location tolerance.**
- **offers a round location tolerance zone that is 54% larger than the square one of conventional toerlancing.**

Who Benefits from GD&T?

- Those who build mating parts to close tolerances for requiring interchangeability in assembly.
- Those in mass production where blindly selected parts are essential. JIT manufacturing requires parts that absolutely must fit at assembly. Lack of JIC parts requires zero defect for JIT.
- Those in R&D rapid prototyping as the best way to define variation allowed between part features and getting things right the first time.
- Those who are responsible implementing and documenting a quality process.















What is the “D” of GD&T?

The “D” stands for the dimensioning component and is accompanied by its own set of symbols.



What is the “T” of GD&T?

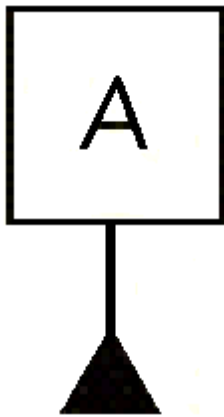
The “T” stands for the tolerancing component and is accompanied by its own set of symbols.

GD&T TOLERANCE SYMBOLS				
FORM	PROFILE	ORIENTATION	RUNOUT	POSITION
				
STRAIGHTNESS	LINE PROFILE	PARALLELISM	CIRCULAR RUNOUT	TRUE POSITION
				
FLATNESS	SURFACE PROFILE	ANGULARITY	TOTAL RUNOUT	SYMMETRY
				
CIRCULARITY		PERPENDICULARITY		CONCENTRICITY
				
CYLINDRICITY				

What kind of “D” is in GD&T?

There are two basic methods of dimensioning:

- Point-to-Point or Chain Fashion
- Baseline or Datum



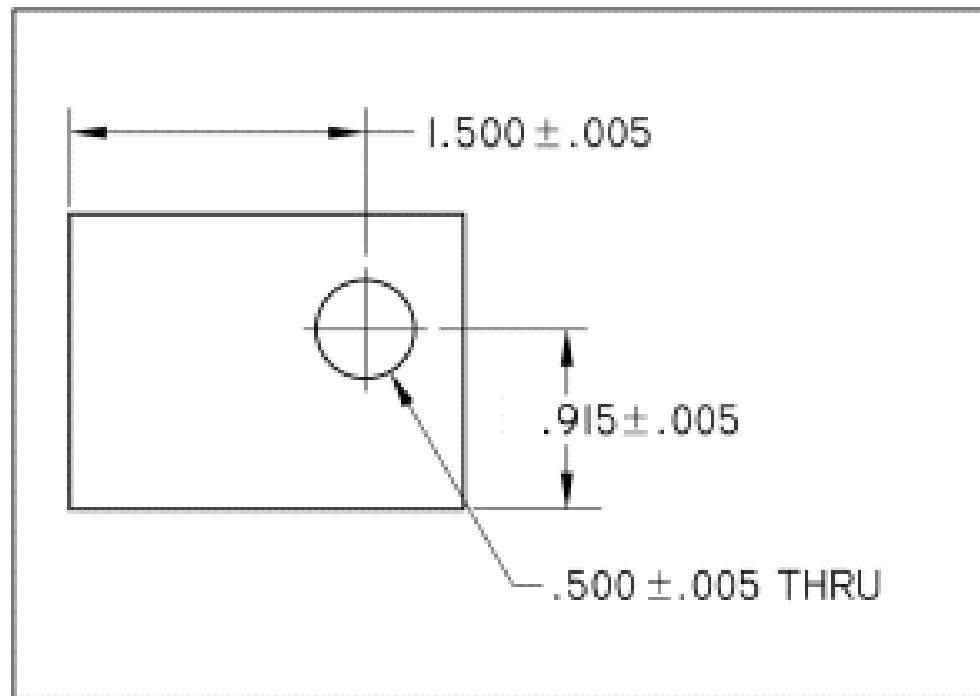
GD&T makes use of Datums

Many Programs Use GD&T!

- **J.I.T. Manufacturing**
- **Functional Drafting**
- **Six Sigma**
- **AQL**
- **ISO 9000-1-2-3-4**
- **TQM**
- **SPC**
- **Evaluation by Mechatronics**
- **Collaborative Design**

How is GD&T Different?

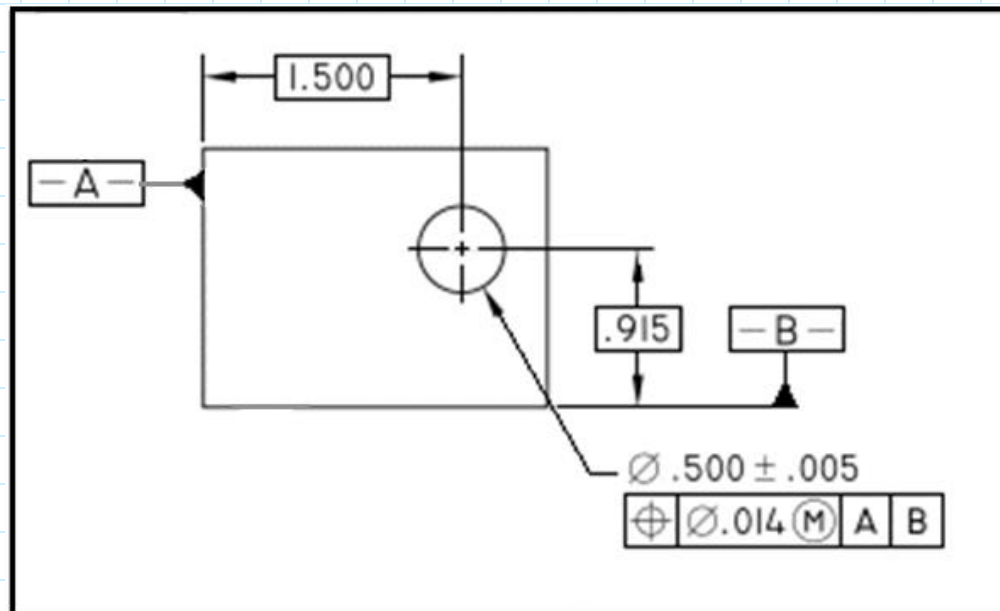
Conventional linear dimensioning and tolerancing is done like this.



Conventional Linear Method

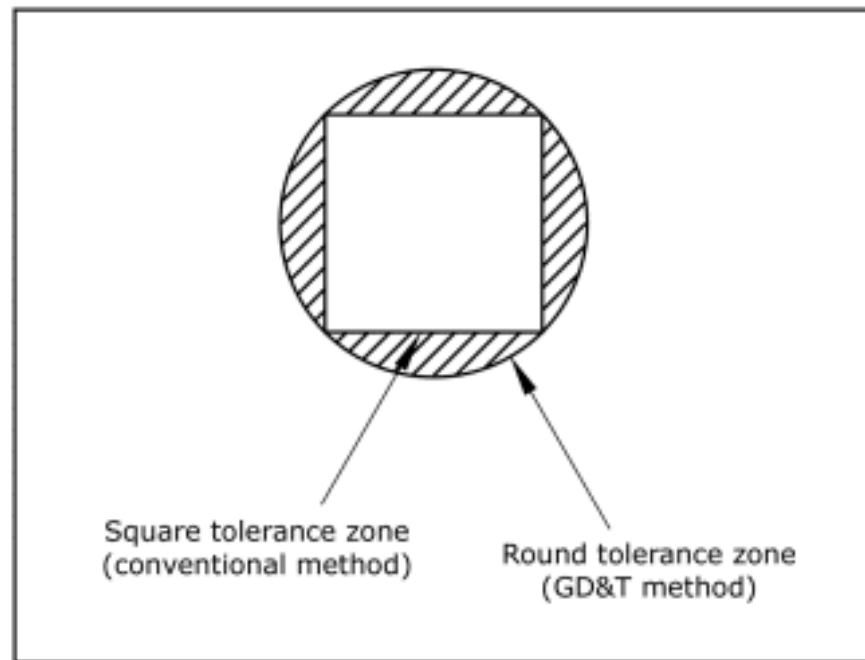
GD&T relates location and size...

Geometric dimensioning and tolerancing is done like this.



and in so doing picks up tolerance space!

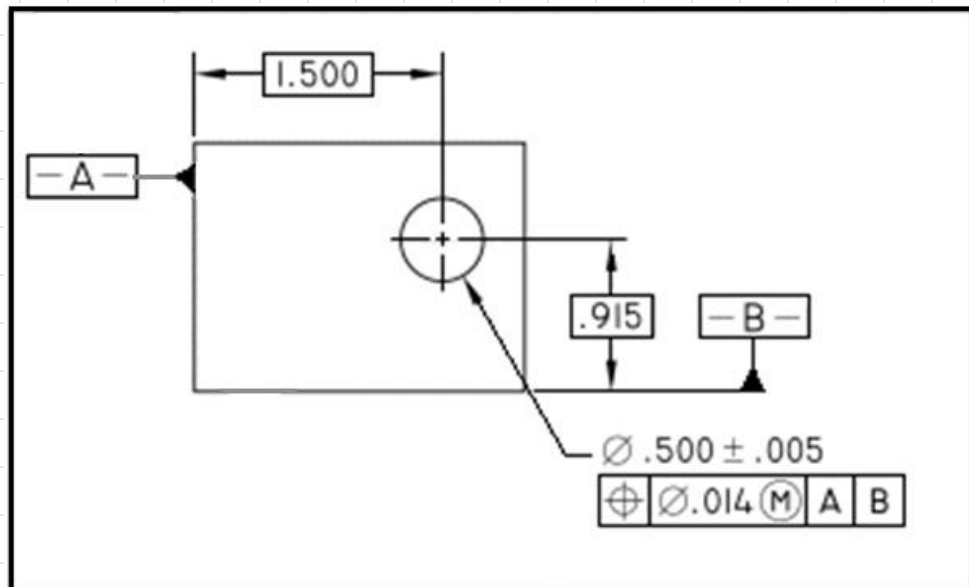
**GD&T offers a tolerance zone 54% larger than
conventional dimensioning and tolerancing.**



GD&T Offers Logical Math!

As the feature of size (hole) gets larger, the location tolerance feature (hole center axis) gets smaller.

	Size	Location
MMC	.495	.014
	.496	.013
	.497	.012
	.498	.011
	.499	.010
	.500	.009
	.501	.008
	.502	.007
	.503	.006
LMC	.504	.005



GD&T Rules

GD&T is governed by specific rules.

- 1. Where only a tolerance of size is specified, the limits of an individual feature prescribe the extent to which variations in its form, as well as in its size, are allowed. (perfect form at MMC rule)**
- 2. RFS applies with respect to the individual tolerance, datum reference, or both, where no modifying symbol is specified. (RFS assumed rule)**
- 3. Holds that a primary datum have three points of contact, secondary two and tertiary one. (3-2-1 rule)**

GD&T and Quality Inspection

- machine vision methods, architectures and applications
- lighting methods and systems for inspection
- surface inspection methods
- special optical systems for inspection and measurement
- infrared methods for dimensional measurements
- 3-D machine vision methods and applications
- 3-D data manipulation
- micro-scale measurement methods
- structured lighting methods and applications
- phase shifting methods applied to inspection of non-optical parts

GD&T Certification Test

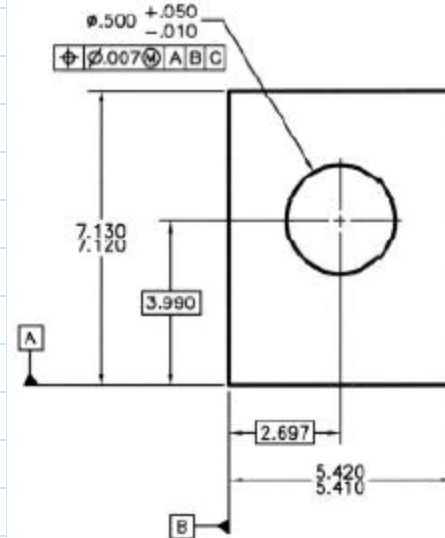
GD&T offers a certification test to verify credentialing.

How many points of contact are required for a tertiary datum ?

- A. 1
- B. 2
- B. 3
- D. None

Sample Questions

What is the MMC of the hole in the illustration below?



- A. .007
- B. .057
- C. .490
- D. .500
- E. .550

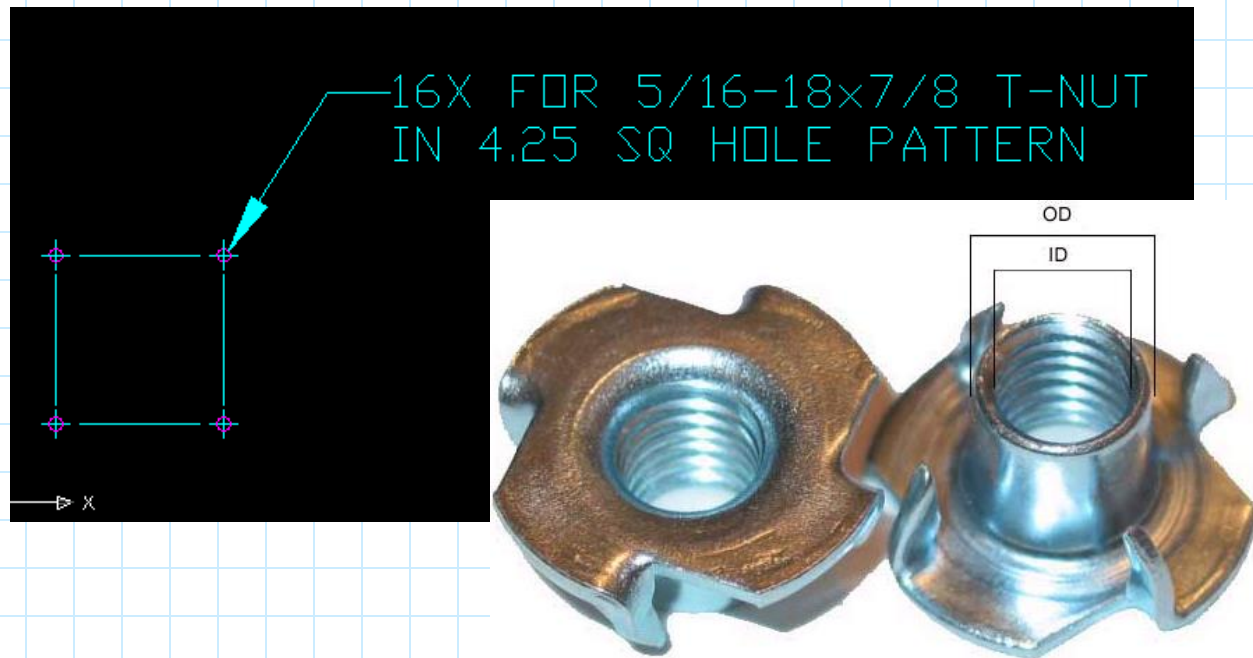
GD&T Tabletop Case



GD&T Tabletop Case

A furniture manufacturing job called for a tabletop to be made from Medium Density Fiber (MDF) board (also called particle or flake board). MDF is classified by weight at 40-50 PCF density designated M1 thru M3. Fiber board is composed of 82% wood fiber, 9% gluing amino resins, 1% paraffin (if wax coated) and 8% water.

The tabletop called for a 4.25" square pattern of holes with t-nut inserts to be installed through the top before a Formica laminate was glued over the top.

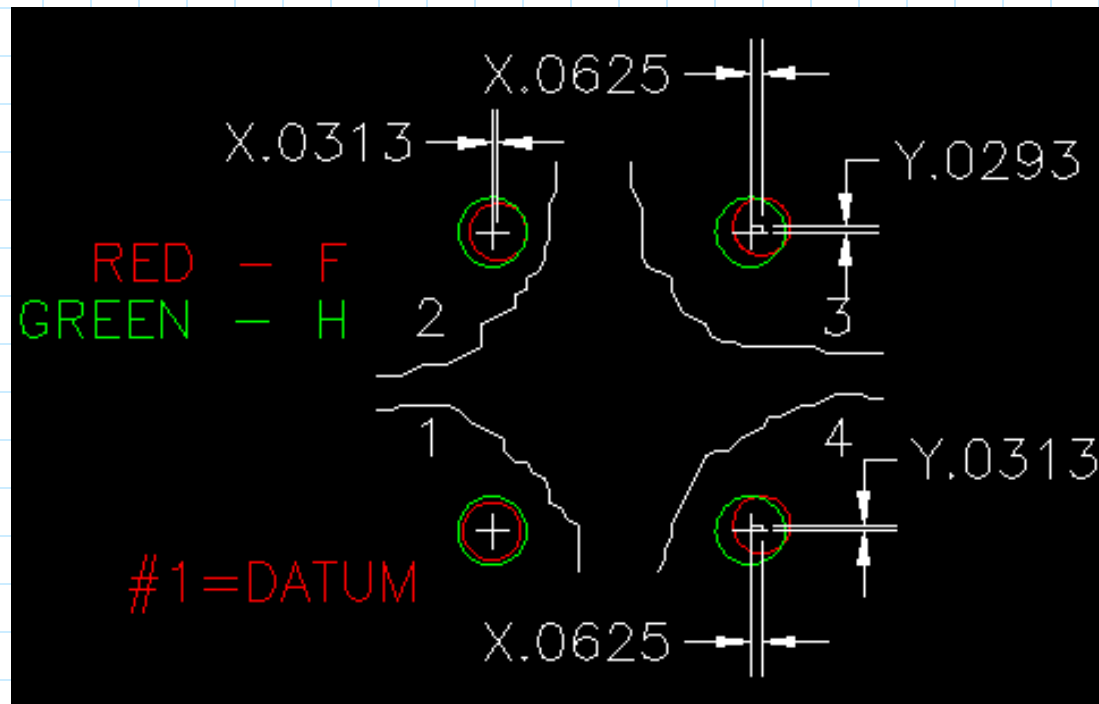


The bottom of the tabletop was to mate with a table leg with a metal plate 1/8" thick having four countersunk holes to receive four flathead screws.

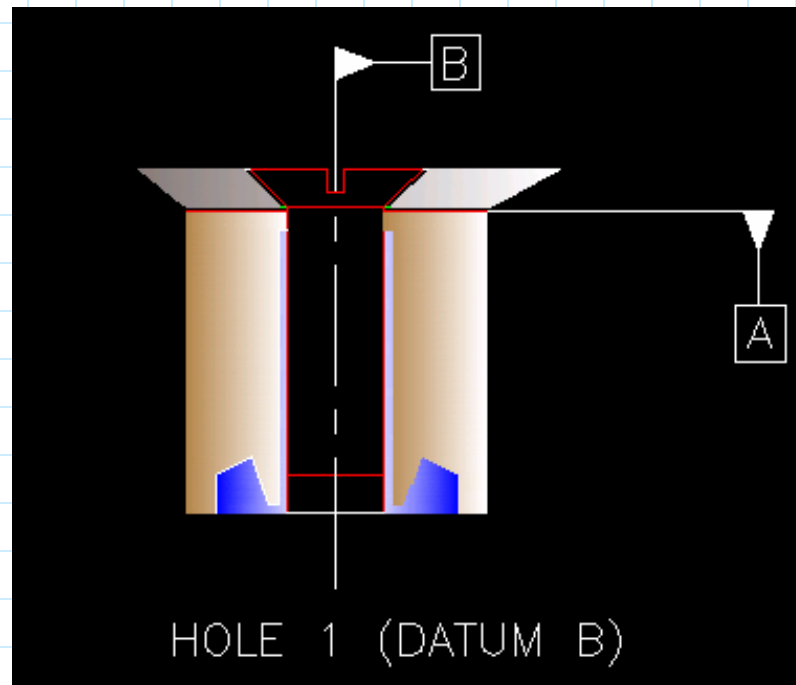
Previous steel and stainless steel models of this tabletop (using studs and nuts) always went together flawlessly. The prototype models of the fiber board models also went together without a problem. Then, later...

Tabletops were arriving from the warehouse to various sites around the country and customers were not able to assemble them. The t-nut pattern in the fiber board tabletop did not align with the hole pattern on the metal table leg. Orders were returned for inspection and a corrective action quality report was required.

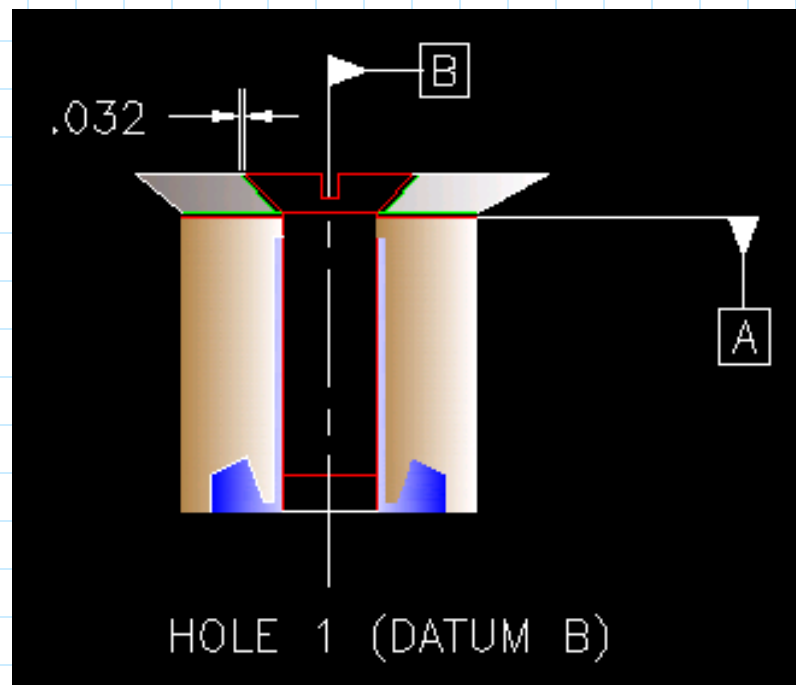
When the tops came back to the plant, it was maddening to find that none of the tops were wrong consistently. They were wrong and wrong differently.



The first step was to comparatively inspect the assembled models on the showroom floor with the returns. From these working and non-working models, a range of working tolerance was determined. The function of the part was studied and datums were established.



The second step was to contrast Actual Local Size (ALS), the value of any individual distance at any cross section of a FOS against the Actual Mating Envelope (AME) a similar perfect feature counterpart.



$$(H - F) / 2 = T$$

$$.375 - .312 / 2 = .032$$

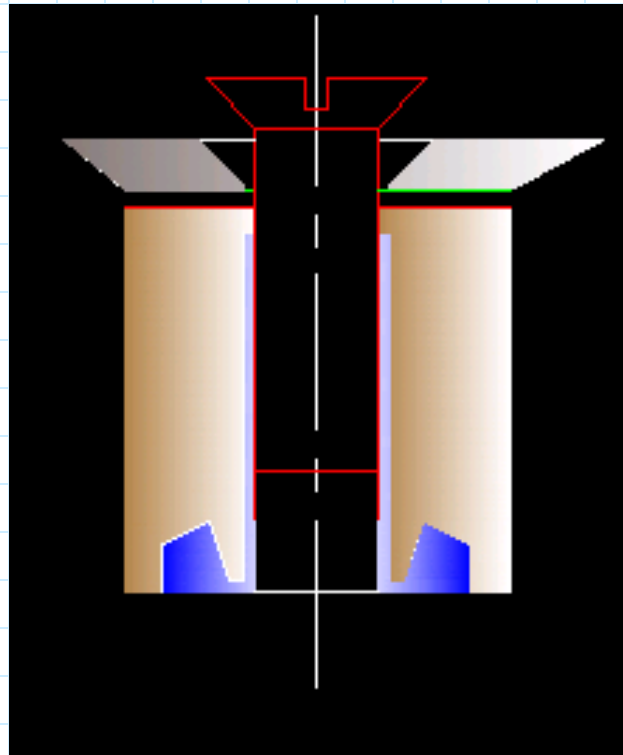
.312-18NC-2B class allowance is .001

Legend: H = hole diameter

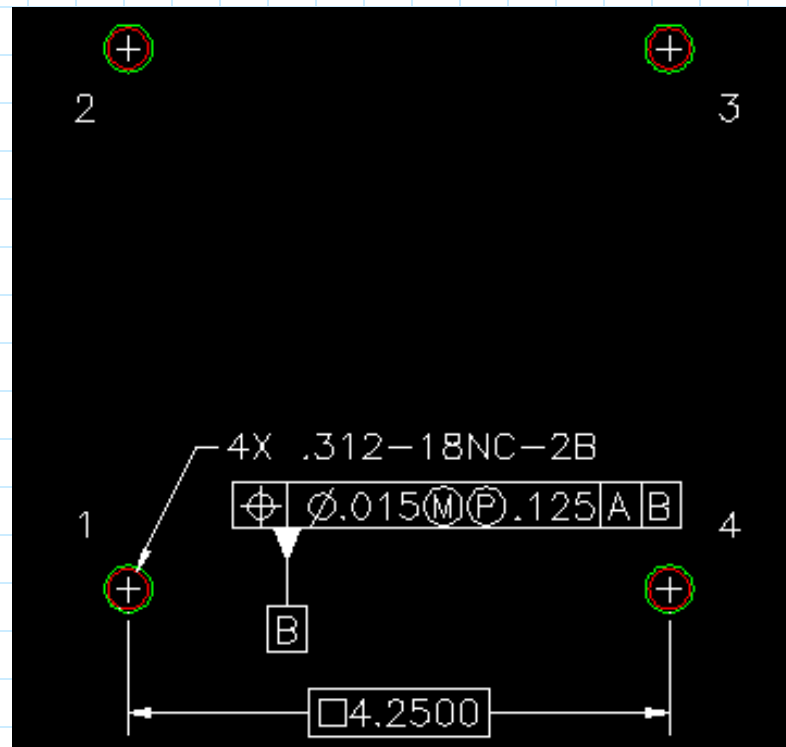
F = fixed fastener diameter

T = tolerance

Because this application involves a threaded fastener mating both a threaded and non-threaded part, a projected tolerance zone is required.



After this was done, a GD&T drawing was prepared using the existing traditional toleranced drawing and data from inspection.



Some people mistakenly believe since threaded fasteners center themselves in the threaded hole, MMC is not applicable. MMC is needed on threaded features to facilitate hard gauging. While MMC may offer a small amount of bonus in threads, it will depend on the class of fit of a particular size thread. MMC allows the use of hard gauging to verify position tolerance, even when a projected tolerance zone is applied.



At this point, does anyone in our group want to take a stab at what was going on in the failure of function in our tabletop assembly?

After sharing the data offered by the GD&T research with the manufacturer of the fiber board desktops, they noted that their supplier of fiber board makes various grades of Medium Grade fiber board M1 through M3. The heavier grades are packed denser, heavier, and contain more resin and less water.

The 8% moisture in the tops were actually the source of the distortion while in warehouse storage in northern Illinois!

In this case GD&T was a tremendous aid in both identifying and communicating a very abstract problem. The solution was to go from a cheaper and lighter M1, 40PCF fiber board to a more expensive M3, 45 PCF medium density fiber board.

In this instance GD&T was used to communicate a complex and intermittent problem with engineers and CNC professionals to help them better isolate the source of the problem.

The Incredible Shrinking Hole Case!



Thinking in terms of GD&T, how could a LMC hole become a MMC hole?



How can a hole shrink?

A Corrective Action Report (CAR) was requested to determine why workers on an assembly line for road salt spreaders were suddenly and unexplainably having a difficult, if not impossible, time assembling the bearing blocks of an auger in the trough ends of a salt spreader. The product compared to the drawing determined the hole was out of tolerance to the auger bearing race to go through it.



At this point, does anyone in our group want to take a stab at what was going on in the failure of function in our salt spreader assembly?



GD&T Shrinking Hole Case

The CAR determined a new hire in the paint department was spraying too heavy a coat of paint. The tolerance of the hole was changed from the design drawing for the worse. The corrective action was to insert plastic plugs in the holes before painting so paint coverage would no longer be an issue.



GD&T Shrinking Hole Case

GD&T helped resolved this case in thinking in terms of Least Material Condition (LMC) doing the seemingly impossible and going towards (and past) Most Material Condition (MMC).

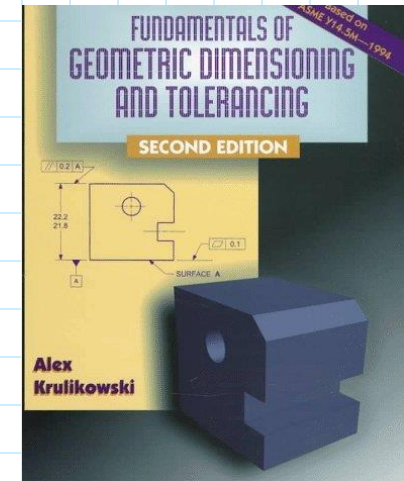
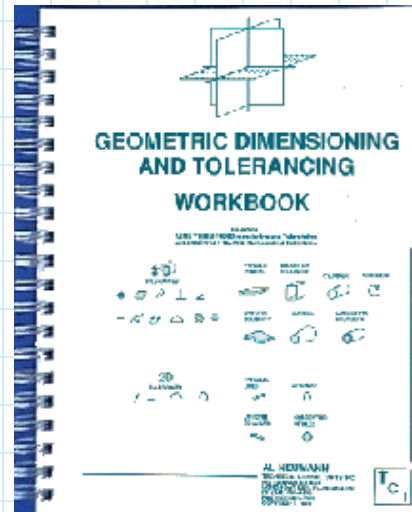
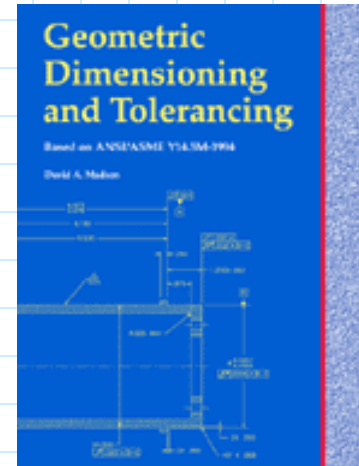
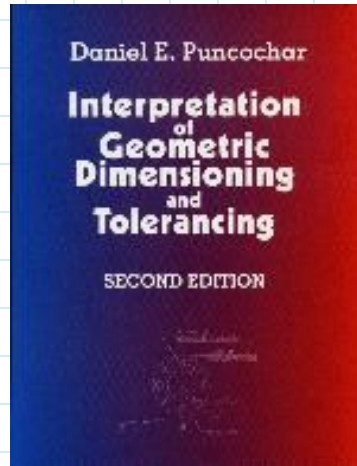
GD&T Internet Resources

- <http://www.asme.org>
- <http://www.efunda.com>
- <http://www.engineersedge.com>
- <http://www.eng-tips.com>
- <http://www.iigdt.com>
- <http://www.nicet.org>
- <http://www.nist.gov>
- <http://www.sae.org>
- <http://www.sme.org>
- <http://www.tec-ease.com>
- <http://www.tenlinks.com>
- <http://www.QualityCoach.net>

GD&T Resources

- **American Society of Mechanical Engineers (ASME)**
22 Law Drive
Fairfield, NJ 07007-2900
800-THE-ASME
- **Eastern Michigan University Center for Quality (CFQ)**
2000 Huron River Drive, Suite 101
Ypsilanti, MI 48197
800-932-8689
- **National Tooling and Machining Association (NTMA)**
9300 Livingston Road
Fort Washington, MD 20744-4998
800-248-6862

GD&T Text Resources



Advanced GD&T Resources



**Advanced Dimensional Management Press
16004 SW Tualatin-Sherwood Road #163
Sherwood, Oregon, 97140-8521
503- 625-2480**

Levels of Understanding the Language of GD&T

- **Listening – workshops, classes and seminars**
- **Speaking – questioning and answering**
- **Reading – print reading**
- **Writing – preparing drawings from directions**
- **Culture – knowing how to prepare drawings**

How can we get started in GD&T?

- Do a pre and post evaluation before and after implementation of GD&T
- Immediately make use of geometric dimensioning symbols
- Establish how a part comes into place and establish datums.
- Establish how mating parts function and establish appropriate tolerancing symbols

GD&T Local Expert Resource

**Geometric Dimensioning for the
Real World**

**Dr. Don Shepherd
Shepherd Industries
3930 Old State Road
Kirkland, IL 60146
815-393-3035**

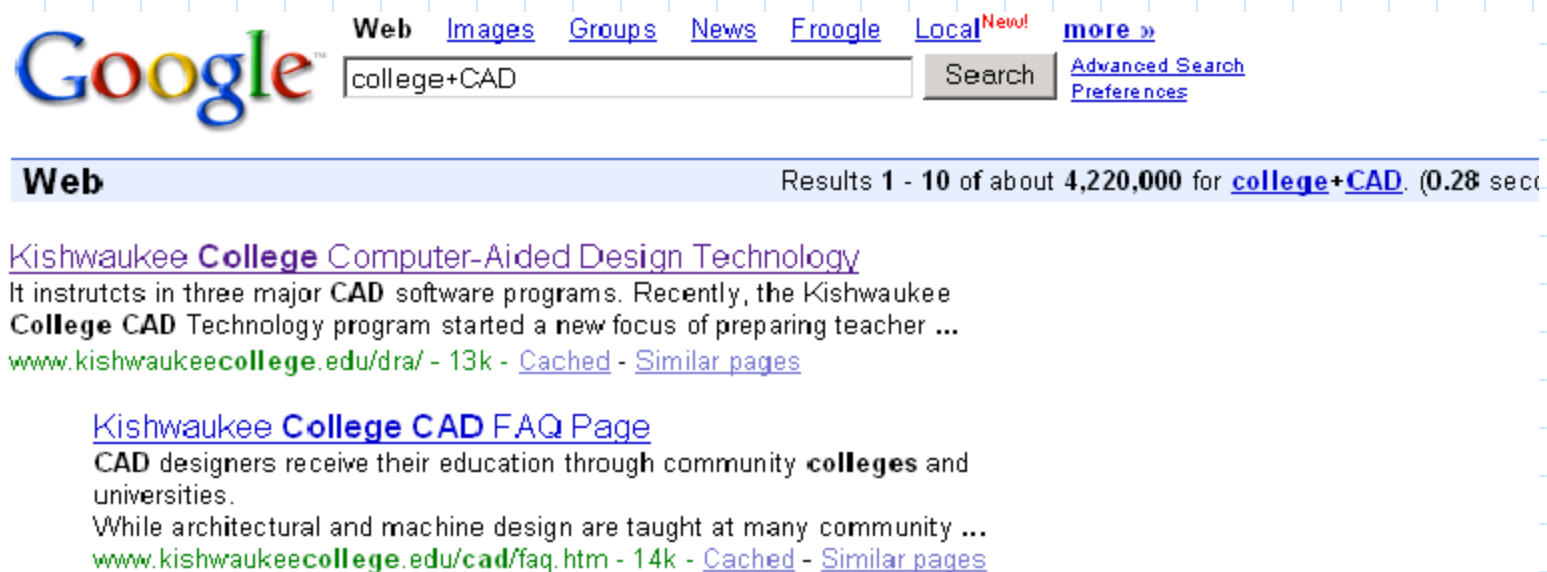


info@gdtfortherealworld.com

The End



Visit Us on the Web Too!



The screenshot shows a Google search interface with the search term 'college+CAD' entered. The search results are displayed under the 'Web' tab, showing two results from Kishwaukee College. The first result is titled 'Kishwaukee College Computer-Aided Design Technology' and describes the college's CAD programs. The second result is titled 'Kishwaukee College CAD FAQ Page' and provides information about CAD education at the college.

Google Web Images Groups News Froogle Local ^{New!} more »
college+CAD Search Advanced Search Preferences

Web Results 1 - 10 of about 4,220,000 for [college+CAD](#). (0.28 sec)

[Kishwaukee College Computer-Aided Design Technology](#)
It instructs in three major CAD software programs. Recently, the Kishwaukee College CAD Technology program started a new focus of preparing teacher ...
www.kishwaukeecollege.edu/dra/ - 13k - [Cached](#) - [Similar pages](#)

[Kishwaukee College CAD FAQ Page](#)
CAD designers receive their education through community colleges and universities.
While architectural and machine design are taught at many community ...
www.kishwaukeecollege.edu/cad/faq.htm - 14k - [Cached](#) - [Similar pages](#)

Top ranked and oldest college CAD website on the web!