



TECHNICAL
DOCUMENTATION
CONSULTANTS
OF ARIZONA, INC.

COURSE SUMMARY

APPLICATION AND INTERPRETATION OF GEOMETRIC DIMENSIONING AND TOLERANCING

TECHNICAL DOCUMENTATION
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**Application and Interpretation of
Geometric Dimensioning and Tolerancing**

Course Summary

ACME Widget Company

June 4-8, 2000

Instructor: Michael Sandford

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Course Overview

Technical Documentation Consultants of Arizona, Inc., (TDC), conducted a comprehensive five-day Geometric Dimensioning and Tolerancing (GD&T) training program for 20 employees at ACME Widget Company. GD&T is a discipline developed to communicate engineering configuration from the designer to the manufacturer through mechanical drawings. This training program is an ideal way to promote a common understanding between engineering staff, quality assurance, and production personnel. It offers complete and concise interpretation to the production team members.

Our training program is unique in that it focuses on all disciplines of the product team. Attendees learn GD&T from the perspective of engineers, drafters, manufacturers and quality control. As more people properly use and understand GD&T, quality will improve and production costs will decline. Students learn that economical production is a team effort between engineering, design, drafting, manufacturing, and quality control.

Our program gives students hands-on experience, requiring them to prepare actual production drawings. These exercises are especially valuable in helping students recognize that production is a team effort. Homework, quizzes and a final exam are assigned. The scores of these exercises are reported within this summary to management as feedback on student performance. Class scores indicate the extent to which students have understood the fundamentals of GD&T principles to the production process. The end result is a group of highly trained personnel that can effectively incorporate GD&T into their daily work assignments.



All TDC of Arizona, Inc. instructors are GDTP certified by ASME in accordance with the qualifications of ASME Y14.5.2 in the Senior Level.

Students learn that economical production is a team effort between engineering, design, drafting, manufacturing, and quality control.

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Class Structure

The class taught at ACME Widget Company consisted of 20 students representing the following areas:

- Project Engineer (2)
- Manufacturing Engineer (1)
- Quality Assurance (1)
- Design Engineer (1)
- Mechanical Engineer (15)

To help students learn and retain GD&T principles, we administer daily quizzes based on class lectures and reading assignments during the morning and afternoon sessions. We also assign homework problems that challenge the student to correct authentic drawings. The instructor grades and returns all exercises as feedback to the students. By the end of the program, students can earn up to 260 points cumulative for the quizzes and homework assignments. This sum is 60% of the point total for the class. Students in this class averaged 256 points (98.5%) on the quizzes and homework assignments.

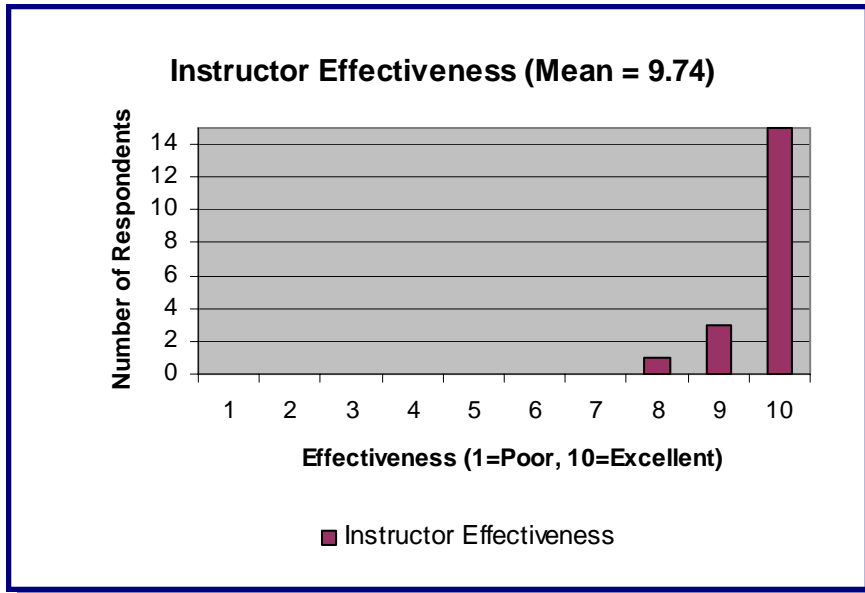
At the end of the class, students ultimately test their GD&T knowledge with a written final examination, representing the remaining 40% of the point total for the class. Scores for the quizzes, homework, and final examination are averaged together for the overall course grade. A 70% minimum is required to pass the course. If a final examination is not returned, the student does not pass the class. The average final examination score for the class was 107.5, out of a possible 117 points (91.9%). The 19 students completing this course averaged a 95.8% overall course score.

Course averages		
Homework/quiz average:	256.0/260	98.5%
Final average:	107.5/117	91.9%
Overall class average:		95.8%

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Students' Evaluation of the Course

On the last day of class, we ask the students to complete and return an evaluation of the course. This evaluation lets the students score the effectiveness of the instructor and course materials and allows them to voice how they feel GD&T can benefit their company. The following summary is generated from the 19 responses received.



How do you feel this course will promote common application and interpretation of Geometric Dimensioning and Tolerancing?

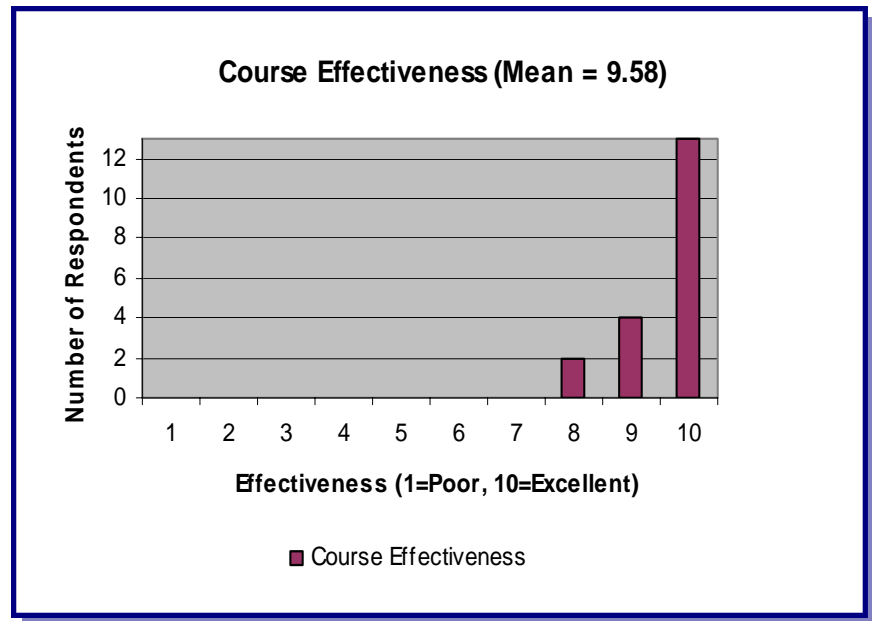
“Yes.” (8 Responses)

“I strongly agree that with this information, I will be able to apply and interpret this knowledge according to ANSI/ASME Y14.5.”

“Absolutely! It is very informative about the GD&T codes.”

“Yes, there are definite inconsistencies in the way the standard is applied and interpreted. These variations cost the company a lot of lost time and scrapped hardware.”

“Perhaps! I think that people will need to use this material frequently to keep abreast of this standard ASME Y14.5.”



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Students' Evaluation of the Course

"Definitely; course is excellent at explaining not just general concepts but also the nuances associated with GD&T."

"Absolutely. This course clarified some incorrect assumptions about how to interpret Y14.5. It will definitely help."

"Yes, the class was much better than reading the standard."

"Absolutely, to complete the circle of knowledge, ACME Widget Company needs to insist that its vendor houses and machine shops take this course!"

"Yes. The more designers, machinists, and inspectors that take it, the better."

"Definitely!!! It is a common language that once learned everyone can use to communicate design intent, manufacturing intent, inspection procedures, etc."

"Yes, gives people a good idea on how to do their job correctly."

"... to complete the circle of knowledge, ACME Widget Company needs to insist that its vendor houses and machine shops take this course!"

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Students' Comments of the Class

“Everyone who deals with mechanical design and fabrication should be required to take this class. Use of GD&T standards adds value, however it is not part of the typical college curriculum. A misconception that I had about GD&T was that it was more restrictive than rectangular coordinates. It can actually be less restrictive, yet at the same time improve part quality and yield* and reduce cost and cycle time. It forces consideration of design decision impacts on fabrication and assembly and leaves less open to interpretation. It's usually a contractual requirement, is becoming an international standard and is increasingly used in the commercial world. Lack of this knowledge is a disadvantage and can be an expensive one.

*An example of increased yield: There can be a 350% increase in the allowable position of a hole when it is dimensioned using GD&T rather than rectangular coordinates, resulting in many more parts passing inspection. This is without degrading part function and even improving part interchangeability.”

“This instructor was excellent—effectively covered a great deal of material in a very short time and was able to give many practical examples due to his experience and background.”

“I feel that this course was very beneficial. I only wish I would have had this course before tackling some design projects. I strongly feel that this class be mandatory for all new hires as well as for experienced people who have no knowledge of GD&T. The introductory class as well as this course should be taken as soon as possible. This class would greatly benefit design engineers, drafters, machinists, and checkers. This would ensure that everyone could work together with a mutual understanding of design intent and drawing interpretations. Also, I feel that having actual parts, gauging tools, etc., helped me visualize and understand the GD&T concepts more clearly.”

“This class has had the biggest impact on my day to day job of any class I've taken at any company.”

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Students' Comments of the Class

"As a member of the Project Engineering Council, I believe this class should be mandatory for skill development for all PE's. The knowledge gained in this class will help me to interpret drawings and verify that the manufactured part meets the requirement of the print and to know what gauging method is correct to use; assist design engineers in creating drawings that will produce a more manufacturable part."

"After I took this course, I felt that I can become a person who has the ability to check drawings. This course is really important for those who are designers. Please teach this course for those people who never have background on GD&T."

"As a recently graduated engineering student, I have never been previously exposed to any tolerancing codes whatsoever. The knowledge contained within this course has been eagerly sought after for a long time and I am glad to have learned the correct way first. I feel this course is very necessary, and all that create or work with engineering drawings should complete it to stay current with code."

"I found the course to be a very good practical application of "14.5" concepts. The hands-on use and demonstration of fixtures was very helpful. The hands-on demonstrations of the various unique measuring and gauging tools gave practical application of real work issues. Great course. Recommend the course be spread over a five week period."

"This course is extremely valuable for anyone who uses, creates or revises designs. Most producibility issues would not exist if all designers and users understood how to apply and interpret GD&T. I find that there are many interpretations made by people that just don't understand."

"Good Job! Hope you keep teaching this course. The instructor was:

- Knowledgeable
- Organized
- Courteous
- Helpful
- Focused"

"Mike Sandford is a very effective and interesting instructor, which is imperative in a class with this much information."

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Students' Comments of the Class

"This was a great class with an immediate effect on my job. I have drawings in work which I can improve as a result of this class."

"I have been looking forward to taking this class since my internship here at ACME Widget Company last summer. Now that I have completed this class, I have a much better understanding of not only reading drawings, but in creating them in such a way that parts can be made quickly and efficiently by any machinist."

"By far, this is the best course I have taken here. The course structure was very well tuned to learning. I will be able to apply a lot from this class to my work."

"Mike had several excellent stories, analogies, and industry examples that reflect his 15+ years experience here. I was pleasantly impressed! I think Mike should increase the cost of the class by \$100 and include a copy of the standard."

"The class is a definite asset. I learned a lot of information as well as how that can be applied. There was a lot of information, but I at least know where I can look if I have questions. The materials supplied are very beneficial. The parts, tools and examples used helped a lot. I will recommend this class to my manager. The instructor was an added bonus. He knew the material, how to apply it and added personal experiences."

"Many cool, interesting, formative visual aides—parts, simple assemblies, inspection equipment—very helpful."

"This class is an eye-opener and the information learned is useful to anyone that creates, uses, or looks at engineering drawings. The class is centered on understanding what GD&T is, which is great as an introduction, but designers would benefit from an application centered class where basic rules of thumb in design are combined with GD&T. In relation to the intermediate class, this class is far better when it comes to learning because it is interactive and the instructor is able to use his experience with real examples to make concepts clearer."

"Really good class. Well worth the time. Very informative."

"This class is an eye-opener and the information learned is useful to anyone that creates, uses, or looks at engineering drawings. "

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Students' Comments of the Class

"The instructor was very effective at presenting the topics of the course in a clear and concise manner. The visual presentations were well laid out and presented in a professional manner. The instructor made a very effective use of visual aides such as parts, gages, and small assemblies to demonstrate the topics of discussion. Overall, the class/course was a great learning tool."

"Were the funding available, I would recommend that this course become much more widespread, at least as common as PRO/E basic training; I realize that there are financial constraints related to offering this course to more personnel, but I believe that the cost will be offset by increased productivity."

"The course was a great overall experience; intense training and lively presentation enabled a high degree of comprehension. Mike worked hard at working each student hard and many practical examples and problems made the topics sink in. It was the most intense training I have received as a working engineer. Prior to taking this course, if I was vacationing in the country of GD&T, I would not have been able to effectively order a hamburger at a restaurant. I could now order a seven-course feast with a fine bottle of Shiraz (the glass at LMC, of course!)."

"Prior to taking this course, if I was vacationing in the country of GD&T, I would not have been able to effectively order a hamburger at a restaurant. I could now order a seven-course feast with a bottle of Shiraz (the glass at LMC, of course!)."

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Closing Remarks



The training programs offered by TDC are based on the ANSI/ASME Y14.5M standard administered and maintained by the American Society of Mechanical Engineers. It is a legal document that establishes a “common language” for use in drawings, technical documents, and databases to convey engineering design intent. Simply, it defines the methods used to communicate all design aspects for the fabrication, inspection, and assembly for virtually any manufactured item.

TDC offers training programs whose quality is unmatched by other training organizations. In our training workshops, ***students learn and have fun in the process!*** Our techniques combine classroom lectures with student involvement, using hundreds of actual parts, tools, and gages that illustrate the fundamental principles of GD&T. TDC also uses quizzes, homework, and a final examination as learning tools. We know this method works because our students tell us through feedback in our Course Summaries, unique to TDC of Arizona.

This Course Summary offers an opportunity to get input from the students who took the workshops. Responses answer questions such as: “Was the material taught in the workshop useful and relevant to the students?” “How can the instructor improve the learning experience?” “Does your company need more training for other key employees?”

A common characteristic of successful companies with motivated, knowledgeable employees is an concerted effort to provide them with timely, on-going training programs. For technical personnel, GD&T training is a vital skill required to convey design intent amongst engineering, manufacturing, quality assurance, and inspection.

We hope this Course Summary is helpful in evaluating your future training needs. If TDC of Arizona can be of assistance in any way, please feel free to contact us.

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We appreciate the opportunity to work with you and look forward to fulfilling your future GD&T training needs!

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Appendix A - Course Attendance Roster

(Student Names)

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Appendix B - Course Outline

Application and Interpretation of Geometric Dimensioning and Tolerancing

Five-Day Workshop

Day 1

Lesson 1 (Morning)

Introduction
History
Advantages of GD&T
Basic dimensions
Maximum material condition
Least material condition
Regardless of feature size

Lesson 2 (Afternoon)

Feature control frames
Material condition modifier rules
Screw thread rule
Envelope rule

Day 2

Lesson 3 (Morning)

Datum definition
Datum placement
Three-plane datum reference frame
Datum targets
Datum selection

Lesson 4 (Afternoon)

Flatness control
Surface straightness control
Axis straightness control
Center plane straightness control
Rate control straightness
Circularity control
Cylindricity control
Conicity control

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Appendix B - Course Outline

Day 3

Lesson 5 (Morning)

Parallelism control
Perpendicularity control
Angularity control
Profile of a line control
Coplanar control

Lesson 6 (Afternoon)

Position tolerance theory
Fastener theory

Day 4

Lesson 7 (Morning)

Projected tolerance zone
Threaded feature material condition modifiers
Inspection of position tolerance
Position tolerance composite feature control frame
Datum of size relationship
Introduction to paper gaging

Lesson 8 (Afternoon)

Position tolerance of coaxial features
Circular runout control
Total runout control
Concentricity control

Day 5

Lesson 9 (Morning)

Position tolerance of non-cylindrical features
Symmetry
Simultaneous requirements
Non-rigid parts
Virtual condition rule

Lesson 10 (Afternoon)

Student teams will complete two drawings for an assembly
Functional gaging will be considered as a means of inspection
Conclusion
Final examination assignment

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Appendix C - Sample Course Evaluation



TDC of Arizona is very proud to offer our clients a unique opportunity to receive feedback from students who complete a GD&T workshop with us. Attached is a sample Course Evaluation form utilized by TDC of Arizona to gather student feedback.

On the last day of a GD&T workshop, students are asked to complete a course evaluation form. It asks the students to rate the content of the workshop and the instructor on a scale from one to ten. Students are also given the opportunity to comment on the course and how it can be improved. Names are optional and students may complete the evaluation forms in complete anonymity. These evaluations are gathered, organized, and reported within this Course Summary document. Students comments are reported *verbatim* within the Course Summary.

These evaluations help us gauge class dynamics, assess student comprehension of the material, and improve our training programs. More importantly, the course summary allows clients to determine whether their hard-earned training dollars were spent wisely!

We take great pride in the fact that TDC of Arizona is the only company providing GD&T training that uses this unique form of evaluation and shares the results with their customers.



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GEOMETRIC DIMENSIONING AND TOLERANCING COURSE EVALUATION

Please take a few minutes to complete the following evaluation form. How has this training program helped you and your company? How could your company become more productive? Your opinions are very important to us. Names are optional. Please leave this form with the instructor before lunch on the final day.

1. How were you introduced to the availability of this course? _____

2. How do you feel this course will promote common application and interpretation of ANSI/ASME Y14.5? _____

3. What other topics would you recommend be covered in this course?

4. How would you rate the overall effectiveness of the instructor? (Circle one)

(Poor)

(Excellent)

1 2 3 4 5 6 7 8 9 10

5. How would you rate the overall effectiveness of this course? (Circle one)

(Poor)

(Excellent)

1 2 3 4 5 6 7 8 9 10

(over)

6. Would you recommend this course to others? Yes _____ No _____

7. Check your job function:

_____ PRODUCT DESIGN

_____ MATERIALS

_____ QUALITY ASSURANCE

_____ INSPECTION

_____ MANUFACTURING

_____ GAGING

_____ MANAGEMENT

_____ OTHER (Please specify) _____

8. Comments: _____

Name (Optional) _____ Date _____