# Design a Class Infusion Project of ASME Geometric Dimensioning and Tolerancing Standard

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## Abstract

This paper describes the development of a short course of Geometric Dimensioning and tolerancing (GD&T) for Mechanical Engineering (ME)/Mechanical Engineering Technology (MET) students in their freshman/sophomore classes. This class-infusion project was assisted and validated by an ASME Standards and Certification Engineer and was jointly sponsored by the ASME Committee on Engineering Education and the ASME Council on Standards and Certification. To assess the performance of the project, an instrument was developed with multiple-choice problems and survey questions for the students. The results of a field test in a sophomore manufacturing class are presented. The module is available at the ASME Dropbox and the developers are seeking other colleges to promote the project and participate in the field test.


## 1. Introduction

After surveying 2500 industry engineering supervisors, early career mechanical engineers and ME Department Heads it was found that 46.9% of industry supervisors state a weakness in understanding of standards among ME/MET graduates and 48.3% of early career engineers state their own weakness of standards understanding[1]. In addition, under the program curriculum section in the self-study report requirements for both the Engineering Accreditation Commission (EAC) and Engineering Technology Accreditation Commission (ETAC), evidence of "incorporates appropriate engineering standards" must be documented[2,3]. To help achieve the goal of providing the knowledge of engineering standards to ME/MET students, ASME assembled a team of standards experts and engineering faculty to collaboratively devise and test an approach to infuse a selection of engineering standards into selected undergraduate course content - strategically spread through each of the typical four years[4].

As GD&T is commonly adopted in the design and manufacturing industries, this paper presents a class infusion project involving this system. Because GD&T uses a symbolic language to improve the communication for designers, manufacturers, and inspectors, a part's function can be fully and concisely described when using the standard correctly[5]. Many companies are migrating their conventional drawings to GD&T drawings so having knowledge of this standard will certainly enhance ME/MET students in their design capability and future career development. Several papers have discussed teaching GD&T in engineering education[6,7,8]. For those colleges which do not offer the standard in their program curriculum, this project becomes even more important.

In order not to disrupt a course's schedule, the authors developed a series of short twenty-five-minute PowerPoint presentations covering the following topics:

a. Traditional dimensions and tolerances.
b. Types of traditional tolerances.
c. An interesting example/problem of stacked tolerance.
d. Inadequateness of traditional dimensions & tolerances.
e. GD&T symbols and GD&T standards.

To be able to present the class infusion in approximately twenty-five minutes, the paper starts with a short introduction of traditional dimensions and tolerances. Also, to raise students' interests in dimensioning and tolerancing, an example of stacked tolerance is introduced. A key design example is then given to explain the limits of only using traditional dimensioning and tolerancing, and the need of ASME GD&T Standards is finally introduced. A field test was performed in a class of introduction to manufacturing processes including a power point presentation, an assessment test, and a students' opinion survey. Results of the test are provided and discussed.

## 2. Traditional Dimensions and Tolerances

The presentations begin with the definition of dimensions (figure 1) followed by examples of traditional size, location, and orientation dimensions (figure 2).

1. What Is a Dimension?

Measurement of an object expressed in appropriate unit

Must be measured at 68˚F (20˚C)

**Figure 1**: Definition of Dimensions

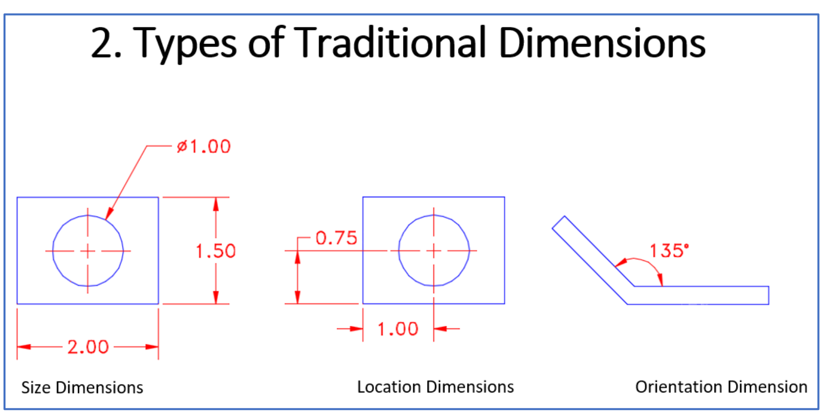

**Figure 2**: Types of Traditional Dimensions

The next topic covered is the definition of a tolerance (figure 3) along with explaining the difference between dimensions and tolerances (figure 4) taken from the fundamental rules of ASME Y14.5 2009[9]. Figure 4 particularly indicates that the tolerance should include both a traditional tolerance and a geometric tolerance and explains that a minor error in dimensioning and tolerancing could lead to a significant financial loss in the final product[10].

3. What Is a Tolerance?

Total amount allowed to vary for a specific Dimension

**Figure 3**: Definition of a Tolerance

4. Dimensions vs. Tolerances

In real world, each dimension shall have a tolerance

Tolerances include traditional tolerances and GD&T

Traditional dimensioning & tolerancing cannot completely describe the real function of each part

A “$1-10” in drawing error could cost a significant money (one million) loss in the final product

ASME Y14.5 GD&T Standard provides a complete guideline for engineering drawing design

**Figure 4**: Dimensions versus Tolerances

**3. Types of Traditional Tolerances**

To be able to further discuss GD&T tolerances, it is important to make students aware of the many types of traditional tolerances[10] available to use when dimensioning ang tolerancing. Figure 5 shows that traditional tolerances include limit tolerance, equal-bilateral tolerance, unilateral tolerance, and unequal-bilateral tolerance. The dimension "1.50" is called the nominal value[10], this is the designation used for the purpose of general identification of a dimension.

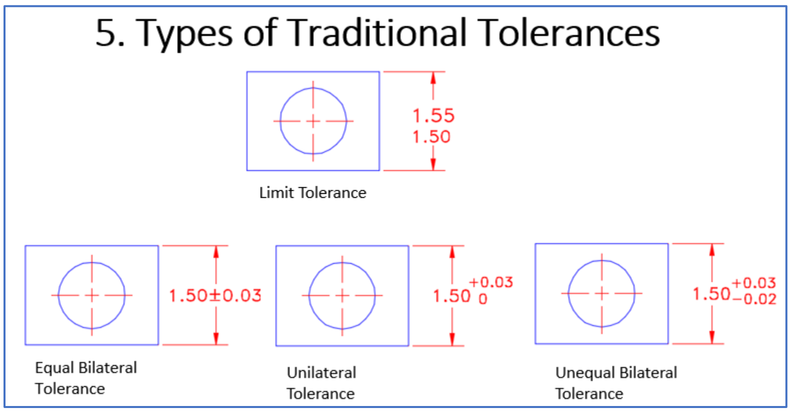


**Figure 5**: Traditional Tolerances

**4. An interesting example/problem of stacked tolerance**

To assist students with learning the proper use of tolerances in an engineering drawing, Figure 6 provides a simple multiple-choice problem for tolerance calculations. Figure 7 presents the solution of the problem. From this example, students will understand why the tolerance will be "stacked" for a dimension which is not specified in a drawing.

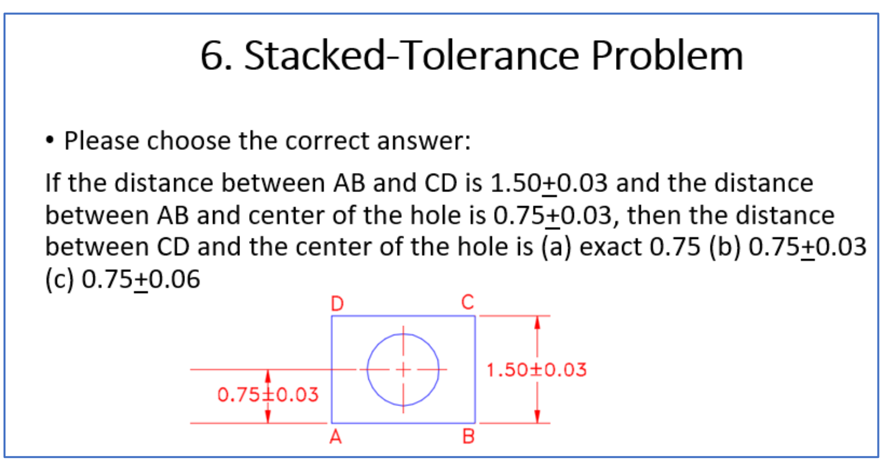


**Figure 6**: Example for a Stacked-Tolerance Calculation

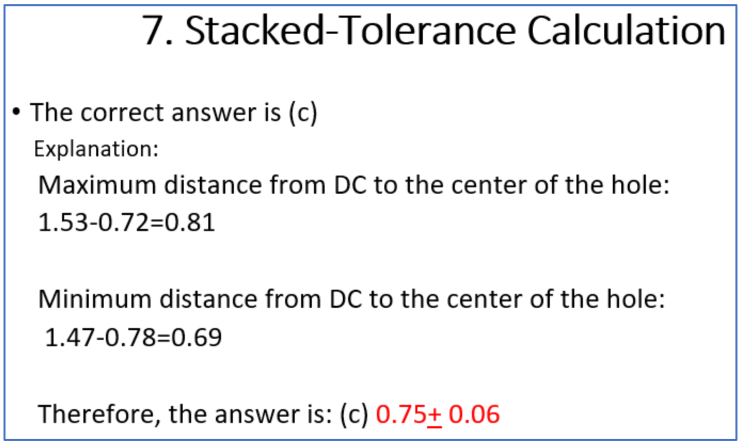


**Figure 7**: Solution of the Problem in Figure 6

**5. Inadequateness of traditional dimensions & tolerances**

To attract students' attention towards the benefits of GD&T, Figure 8 provides an example to demonstrate the inadequateness of traditional dimensioning and tolerancing when applied to an assembly between two concentric holes and a slender and long shaft. The shaft is designed to slide freely through the two holes A and B. In traditional dimensioning and tolerancing, a drawing only provides the sizes and tolerances of the holes and the shaft with the following two critical pieces of information missing:

a. Concentricity of the two holes.
b. Straightness of the shaft.

This example illustrates the need of GD&T knowledge in the design of mechanical assemblies.

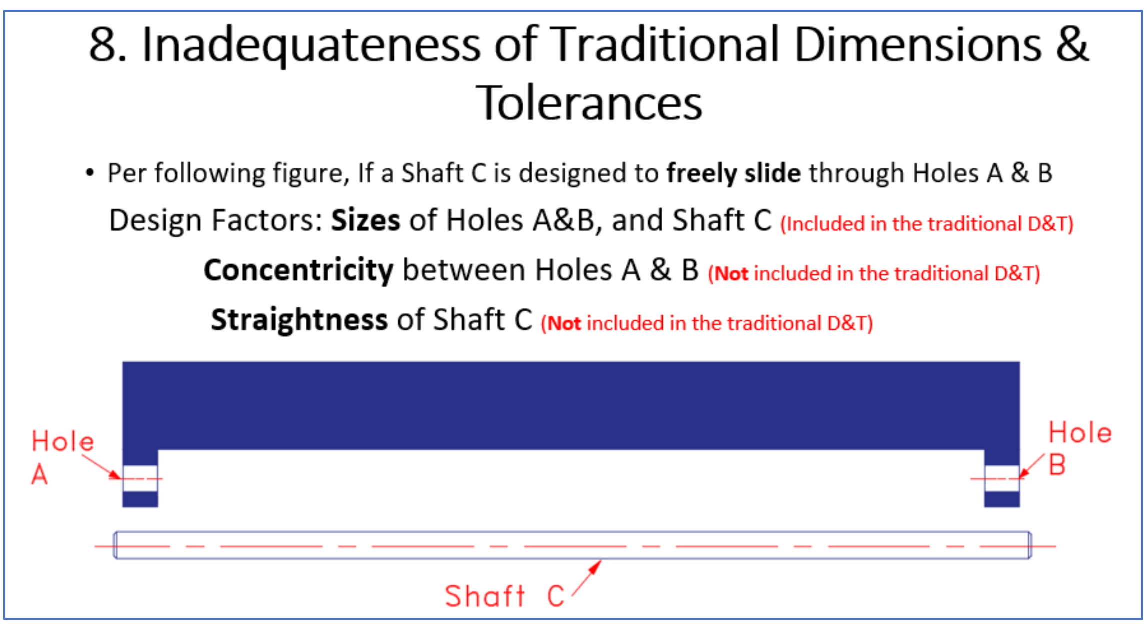

**Figure 8**: Inadequateness of Traditional Dimensioning and Tolerancing

**6. GD&T Symbols and Standard**

Figure 9 defines GD&T and lists all geometric characteristic symbols. A very commonly seen drawing using position tolerance is also provided as a visual aid. Finally, Figure 10 presents the current GD&T standard in the United States: ASME Y 14.5 - 2009

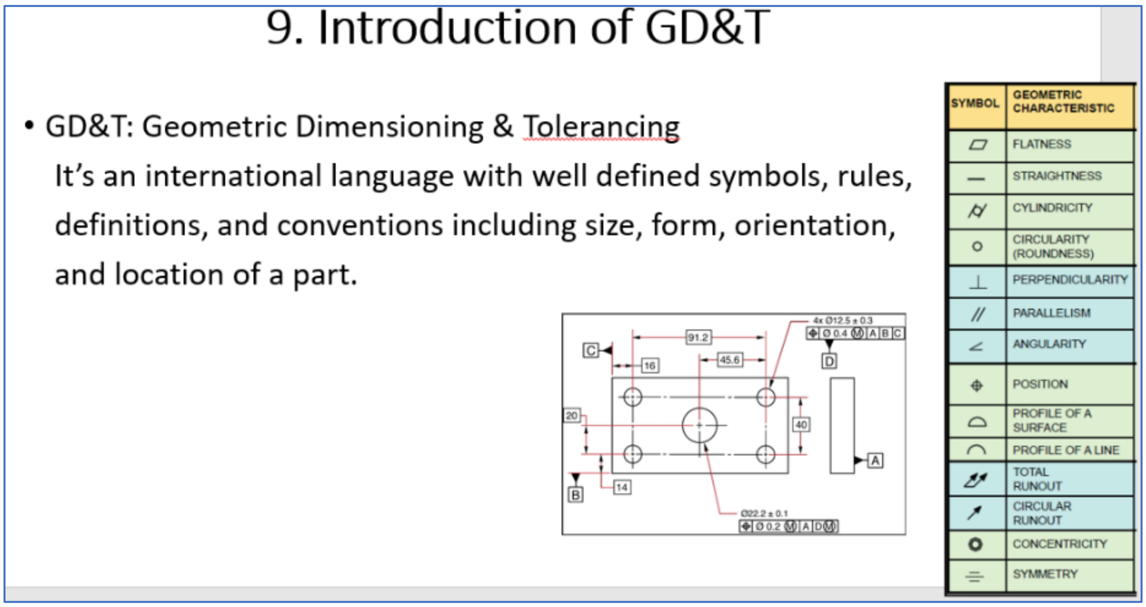


**Figure 9:** GD&T Symbols

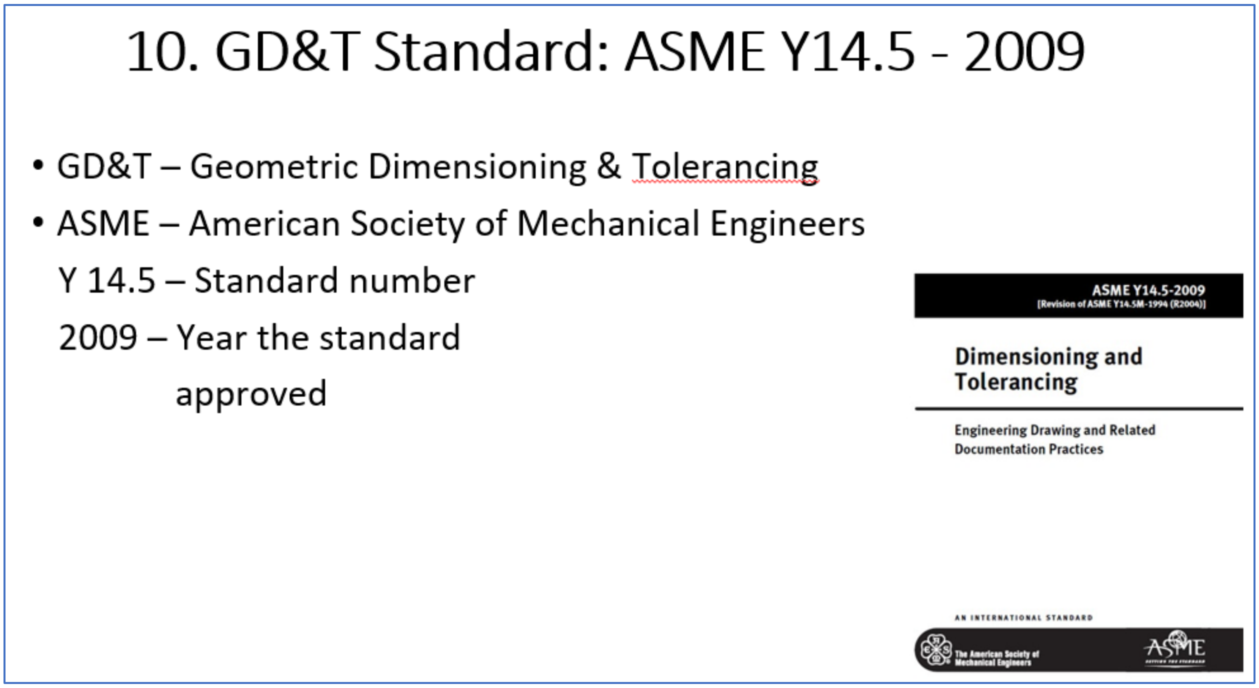


**Figure 10:** ASME Y14.5-2009

**7. Field Test**

To assess the performance of the project, an instrument was developed with multiple-choice problems. In addition, a survey consisting of four questions was conducted among the students: (1) This topic presents a clear description of traditional dimensions and tolerances, (2) Explanation of a stacked tolerance is clear, (3) The reasons of "why GD&T?" is clear, and (4) Definition of GD&T standards is clear. Figure 11 shows the performance-assessment problems.

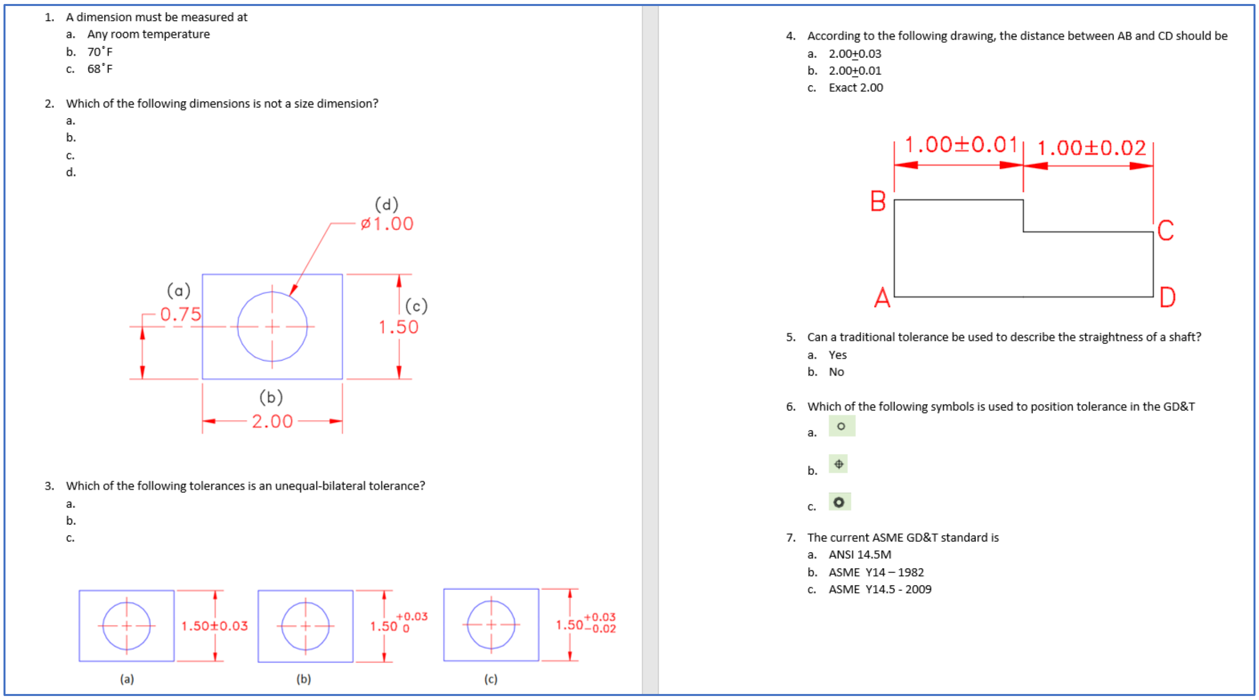


**Figure 11**: Performance-Assessment Problems

The survey and performance-assessment test were given to students in a manufacturing-process course. Figure 12 shows the results of the survey-questions and Figure 13 shows the results of the class review test. Results of the survey are summarized below:

a. 94% students agree or strongly agree that a clear description of traditional dimensions and tolerances is well addressed.
b. 94% students agree or strongly agree that the stacked tolerance is well addressed.
c. 88% students agree or strongly agree that "why GD&T?" is clearly addressed.
d. 100% students agree or strongly agree that definition of GD&T standard is clear.
e. Students received an 84% test average in multiple choice problem assessment.

This module is available at the ASME Dropbox and the developers are seeking other colleges to promote the project and participate the field test.

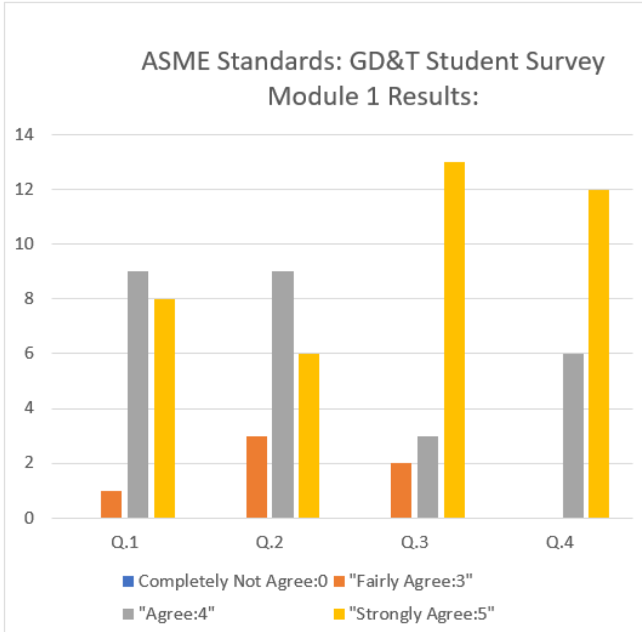


**Figure 12:** Survey-Question Results

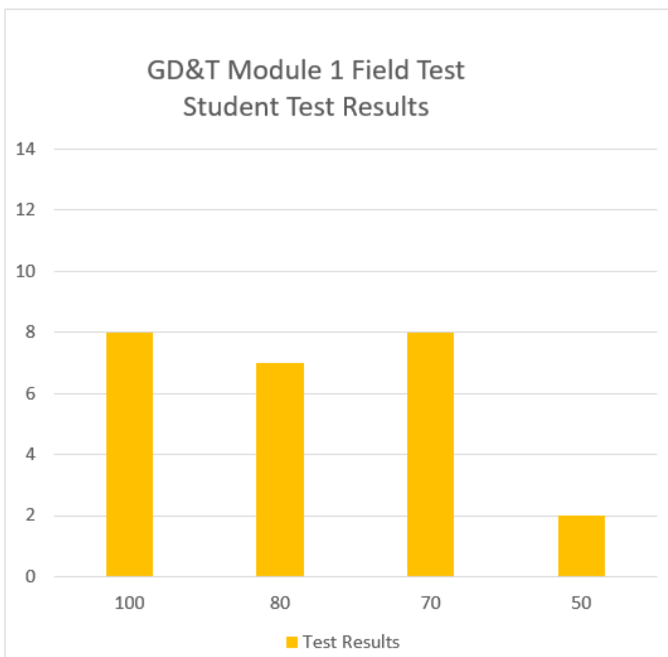


**Figure 13:** Performance-Assessment Results

## 8. Summary

From this field test, students displayed a very positive response in the survey questions and performed well in the assessment test. As observed from Question 3 in the survey, they particularly agree that the reasons of "why GD&T" is clear. This class-infusion project took approximately twenty-five minutes in total and therefore, it will not affect the progress of the original class. This module is available at the ASME Dropbox and the developers are seeking other colleges to promote the project and participate the field test.

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