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MULTI METRICS, INC.
Machine Part Geometry Management

A bnp EVENT

MULTI METRICS, INC.
Machine Part Geometry Management

The New
ASME Y14.5 2009 Standard

A *Smart*GD&T™ Overview

Quality
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by

Bill Tandler

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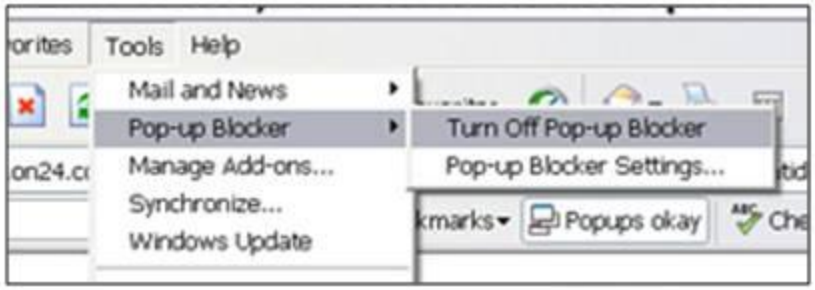

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*Smart*GD&T™

Tutorial Overview

1. "What is GD&T?" - A Reminder
2. New Concepts
3. New Tools Impacting Datums
4. New Tools Impacting Tolerance Zones

What's the purpose of GD&T?

A reminder

Purpose of GD&T

Most people would say . . .

The main purpose of GD&T is to communicate Design intent **unambiguously** to manufacturing and inspection.

Purpose of GD&T

but in fact . . .

The primary purpose of GD&T, is to ensure that **what** we communicate to manufacturing and inspection is **worth** communicating . . . . namely represents functional, assemblable parts.

GD&T

is a tool for reducing **risk** in . . .

1. Design
2. Manufacturing
3. Inspection
4. Assembly

Or, in greater detail . . .

GD&T is a symbolic language for

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1. **researching**

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2. **refining** and

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3. **reduce manufacturing costs** by setting precise, achievable objectives

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the **function** of each feature of a part in Design,
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1. maximize the **fault tolerance** of our designs
2. **guarantee assemblability** and **operation** prior to drawing release
3. **reduce manufacturing costs** by setting precise, achievable objectives
4. turn **inspection** into a **truly scientific process**

GD&T consists of

1. Concepts
2. Tools
3. Rules
4. Processes
5. Best Practices

GD&T consists of

This review of the 2009 Standard addresses these three components

1. Concepts
2. Tools
3. Rules
4. Processes
5. Best Practices

Overview of
ASME Y14.5 2009
Changes

Y14.5 2009 Changes and their Impact

New Concepts

(a partial set)

1. New Names for **Material Condition Modifiers** Ⓢ Ⓜ Ⓛ
2. Loss of the **RFS Modifier** Ⓢ

Y14.5 2009 Changes and their Impact

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New Tools impacting Datums

1. A more complete definition of **Datums**
2. Applicability of the modifiers Ⓢ Ⓜ Ⓛ to Planar Datum Features
3. The new Datum (Feature Simulator) **Translation Modifier**: ►
4. New Degrees of Constraint Modifiers: **[u,v,w,x,y,z]**
5. Expanded Composite Feature Control Frames – **Up to four tiers**.
6. New Datum Reference Frame Axis Labels: **X[A,B,C], Y[…]** etc.

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Y14.5 2009 Changes and their Impact

New Tools impacting Tolerance Zones

(a partial set)

1. Unequally Disposed Profile Modifier: Ⓤ
2. Non-Uniform Modifier: **[NON-UNIFORM]**
3. ALL OVER Modifier: 
4. Continuous Feature Modifier: ⌔CF⌔
5. Independency Modifier: Ⓘ

Y14.5 2009 Changes and their Impact

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Y14.5 2009 Changes and their Impact

Here we go !

Y14.5 2009 Changes and their Impact

New Concepts

(a partial set)

1. New Names for **Material Condition Modifiers** (S) (M) (L)
2. Loss of the **RFS Modifier** (S)

Y14.5 2009 Changes and their Impact

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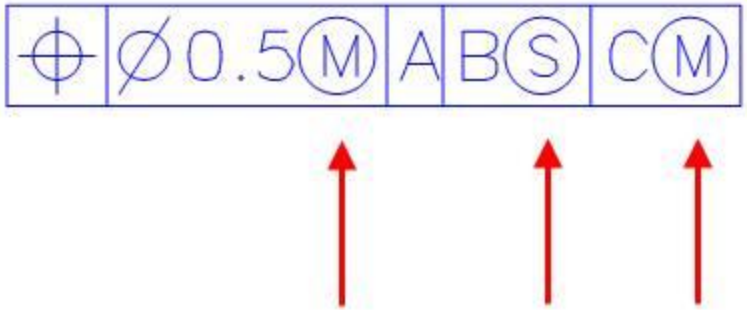
New Names for **Material Condition Modifiers**

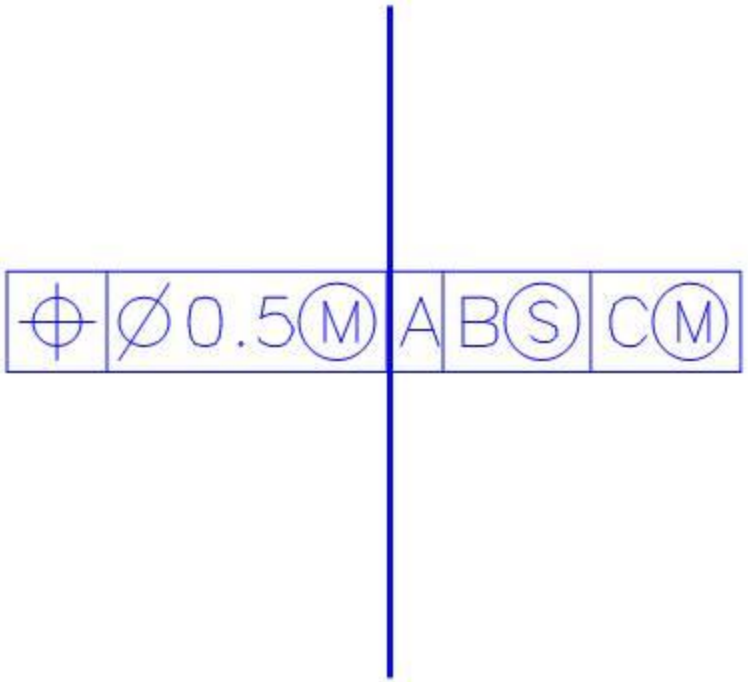


If all these modifiers are called
"**Material Condition**" Modifiers

how can we differentiate between their effects?

New Names for **Material Condition Modifiers**

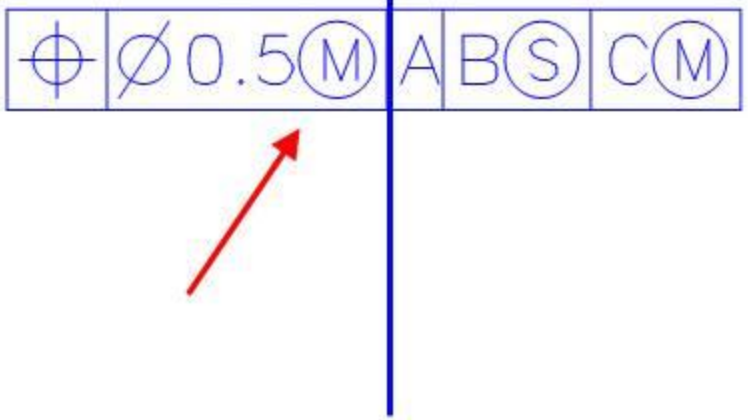
The Great Divide



New Names for **Material Condition Modifiers**

The Great Divide

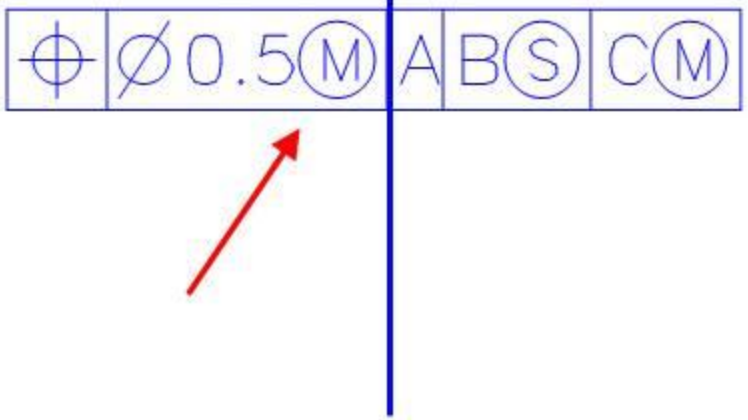
These modifiers impact Tolerance Zone



New Names for **Material Condition Modifiers**

The Great Divide

These modifiers impact Tolerance Zone **Size**



New Names for **Material Condition Modifiers**

The Great Divide

These modifiers impact Tolerance Zone **Size**

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New Names for **Material Condition Modifiers**

The Great Divide

These modifiers impact Tolerance Zone **Size**

These modifiers impact Tolerance Zone **Mobility**

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New 2009 Name

New Names for **Material Condition Modifiers**

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New 2009 Name

"Tolerance Value"
Modifiers

New Names for **Material Condition Modifiers**

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"Tolerance Value"
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New 2009 Name

"Material Boundary"
Modifiers

Y14.5 2009 Changes and their Impact

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(a partial set)

1. New Names for **Material Condition Modifiers** Ⓢ Ⓜ Ⓛ
2. Loss of the **RFS Modifier** Ⓢ

Loss of the **RFS Modifier** Ⓢ

1982

required

Loss of the **RFS Modifier** Ⓢ

1982

required

1994

permitted

Loss of the RFS Modifier Ⓢ

1982

required

1994

permitted

2009

forbidden

Loss of the RFS Modifier Ⓢ

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Not good !

Loss of the **RFS Modifier** Ⓢ

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Why not good ?

Loss of the **RFS Modifier** Ⓢ

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Why not good ?

1. Explicit modifiers inform us directly, and save time when "decoding" Feature Control Frames. **Time is money** !

Loss of the **RFS Modifier** Ⓢ

2009

forbidden

Why not good ?

1. Explicit modifiers inform us directly, and save time when "decoding" Feature Control Frames. **Time is money** !
2. An explicit Ⓢ **confirms** that the designer chose Ⓢ intentionally after considering Ⓜ and Ⓛ, rather than having overlooked the need to make a choice. **Awareness and certainty save money** !

Loss of the **RFS Modifier** Ⓢ

2009

Retaining an explicit Ⓢ is therefore
highly recommended !

Loss of the **RFS Modifier** Ⓢ

2009

Retaining an explicit Ⓢ is therefore **highly recommended** !

You can do so with a corporate document specifying it as a **corporate modification** to the 2009 Standard, or with a **note**, both very common practices in industry.

Y14.5 2009 Changes and their Impact

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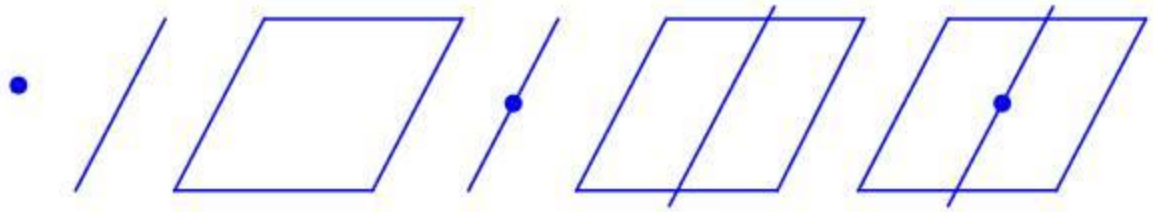
A more complete definition of "**Datums**"

Definition:

Datums are the minimum set of one perfect imaginary reference **point**, and/or **straight line**, and/or **plane**, which together, fully characterize the orientation and location of a **datum feature simulator**.



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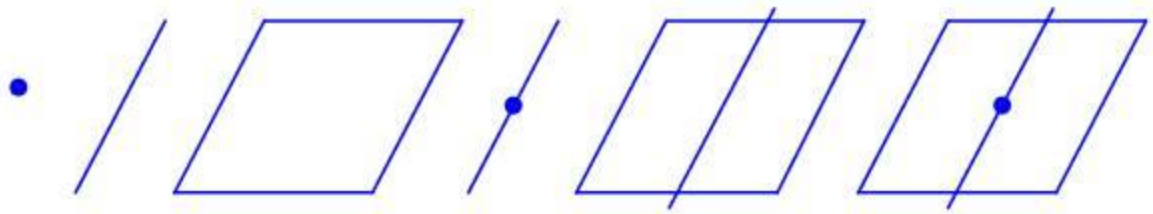
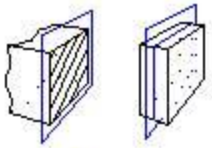
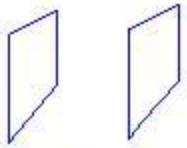
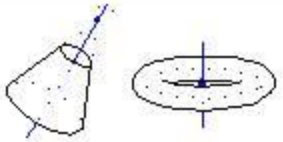
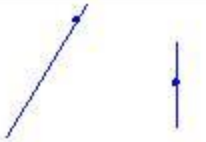
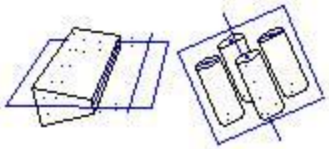
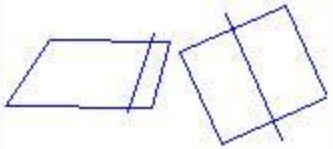


Datums serve to constrain the degrees of freedom of **starter coordinate systems** and turn them into **Datum Reference Frames**.

Datum Feature Simulators & Datums

Datum Feature Simulator	DFS + Datum	Datum	Datum Type	Degrees of Constraint Capability					
				Pitch	Yaw	Roll	Translation		
				Rx	Ry	Rz	Tx	Ty	Tz
Sphere 			Point	—	—	—	√	√	√
Cylinder 			Line	√	√	—	√	√	—
Planar Surface  Slab 			Plane	√	√	—	—	—	√
Cone  Torus 			Point on-Line	√	√	—	√	√	√
Wedge  Cyl. Pattern  Note 1.			Line in-Plane	√	√	√	√	√	—
Compound Curved Surface 			Point on-Line in-Plane	√	√	√	√	√	√

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Applicability of the modifiers Ⓢ Ⓜ Ⓛ to Planar Datum Features

Prior to 2009, the **Material Boundary** modifiers Ⓢ Ⓜ and Ⓛ could not be applied to planar surfaces !

Applicability of the modifiers (S) (M) (L) to Planar Datum Features

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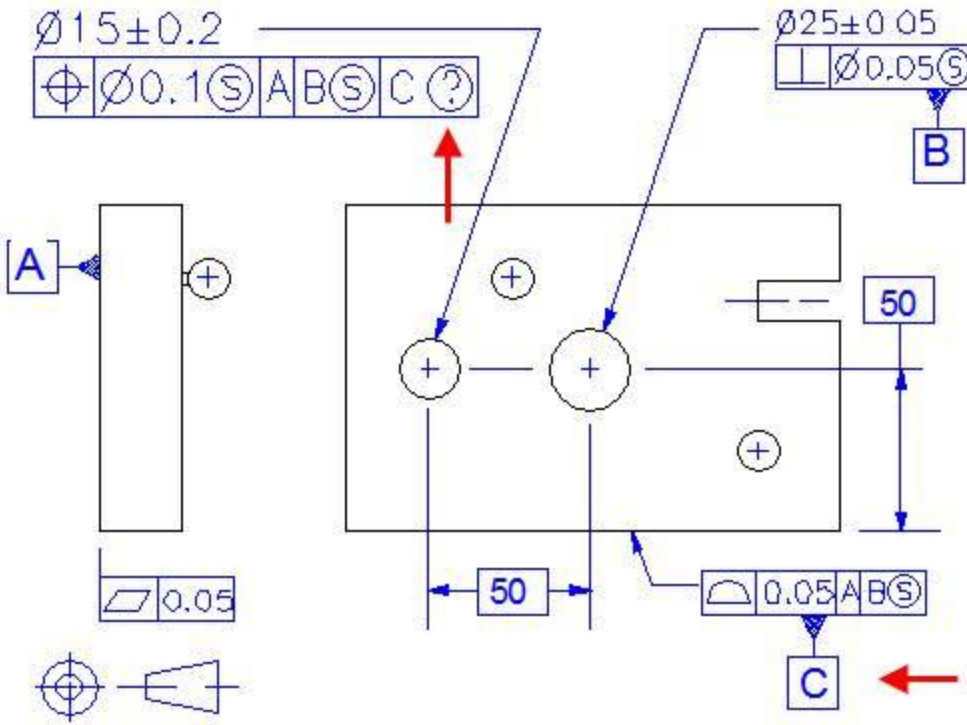

C is a planar surface.

Applicability of the modifiers Ⓢ Ⓜ Ⓛ to Planar Datum Features

The 2009 Standard now makes **Material Boundary** modifiers applicable to planar surfaces, but only those which are "**location constrained**", in other words, to those for which Maximum Material and Least Material boundaries can be defined.

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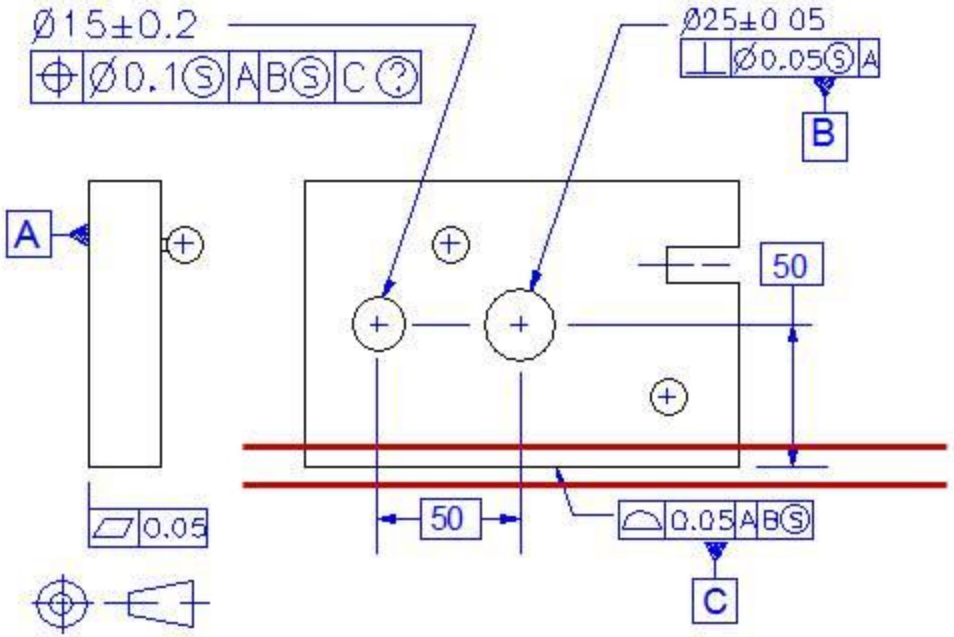

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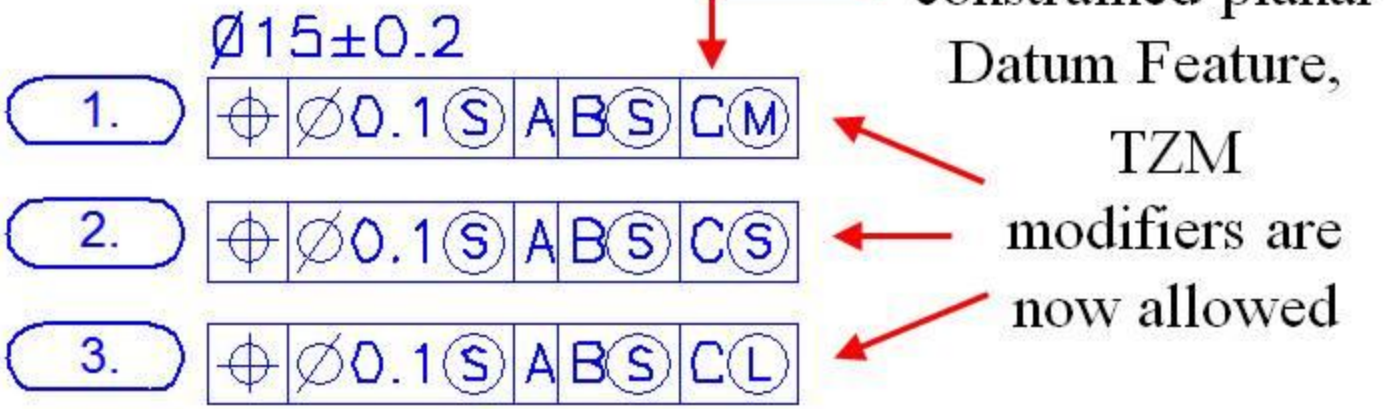
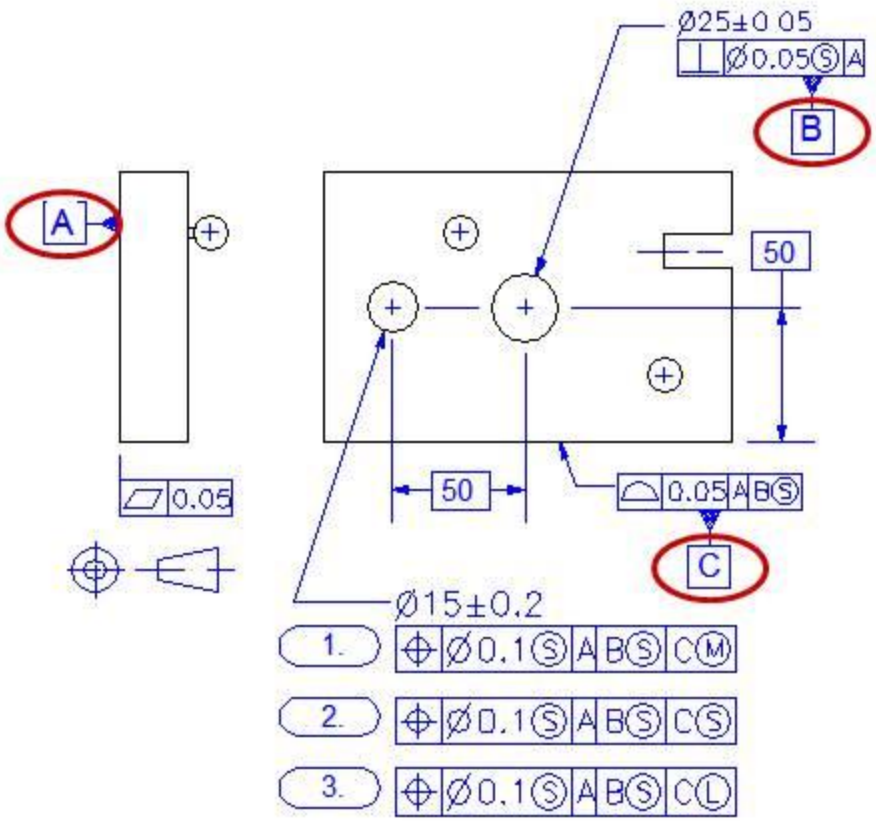


Applicability of the modifiers Ⓢ Ⓜ Ⓛ to Planar Datum Features

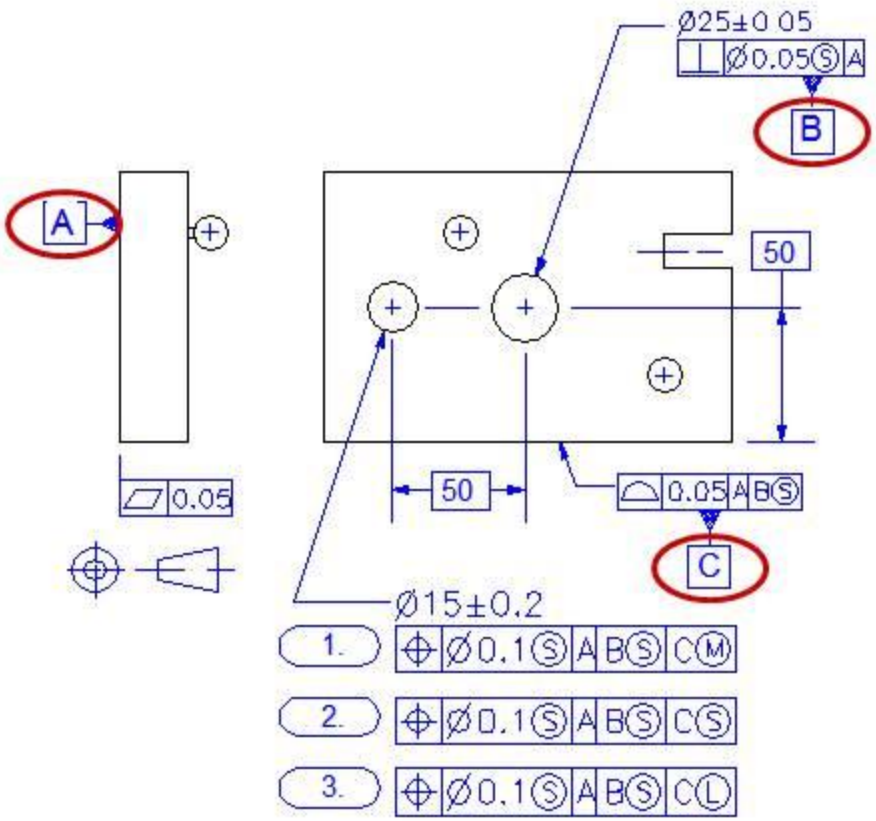
Examples

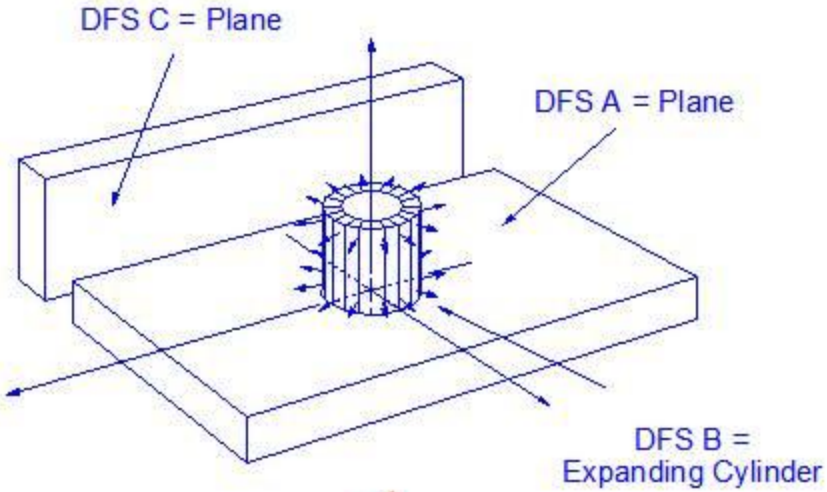
Applicability of the modifiers Ⓢ Ⓜ Ⓛ to Planar Datum Features



Here's the part drawing !

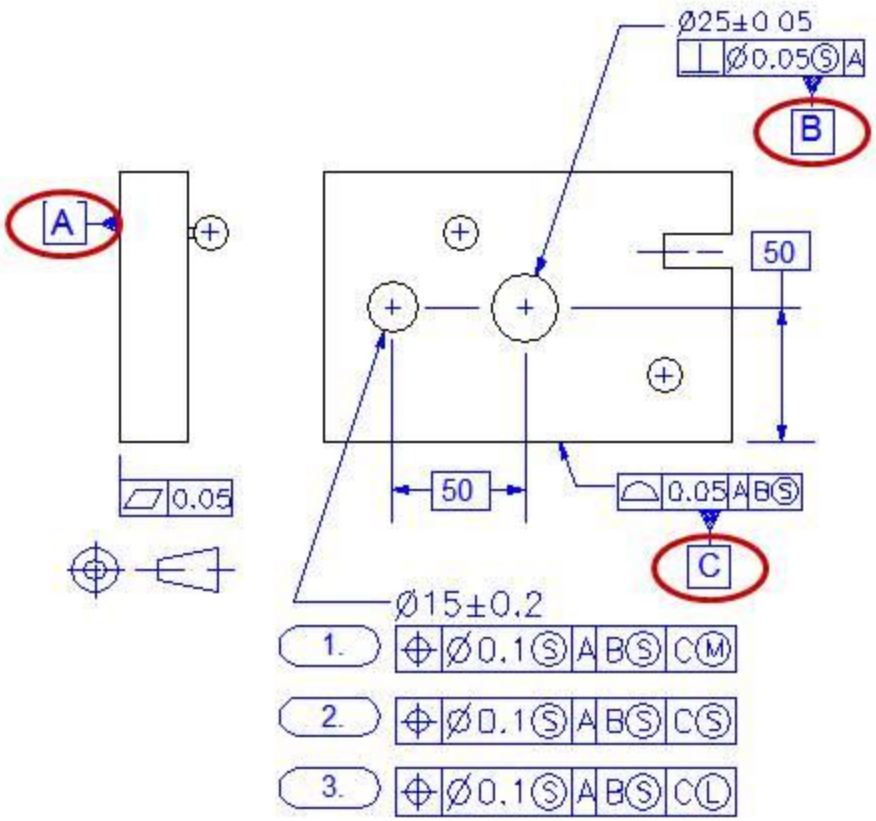
Applicability of the modifiers (S) (M) (L) to Planar Datum Features

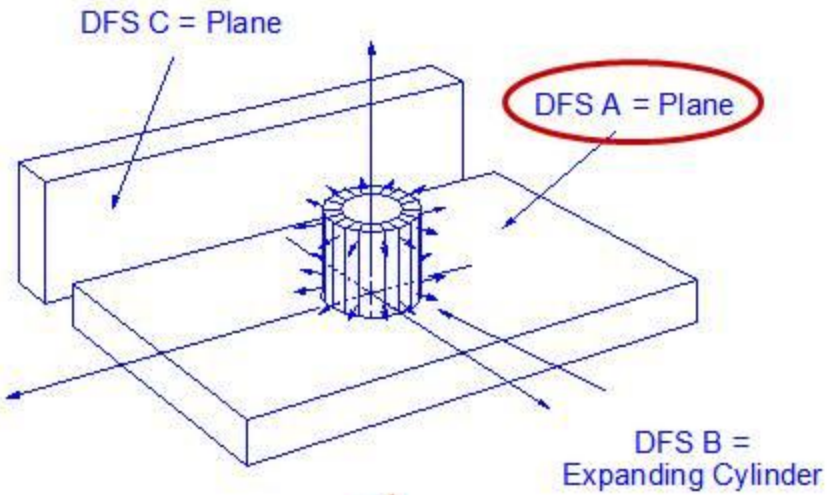




And here are the
Datum Feature Simulators

Applicability of the modifiers S M L to Planar Datum Features





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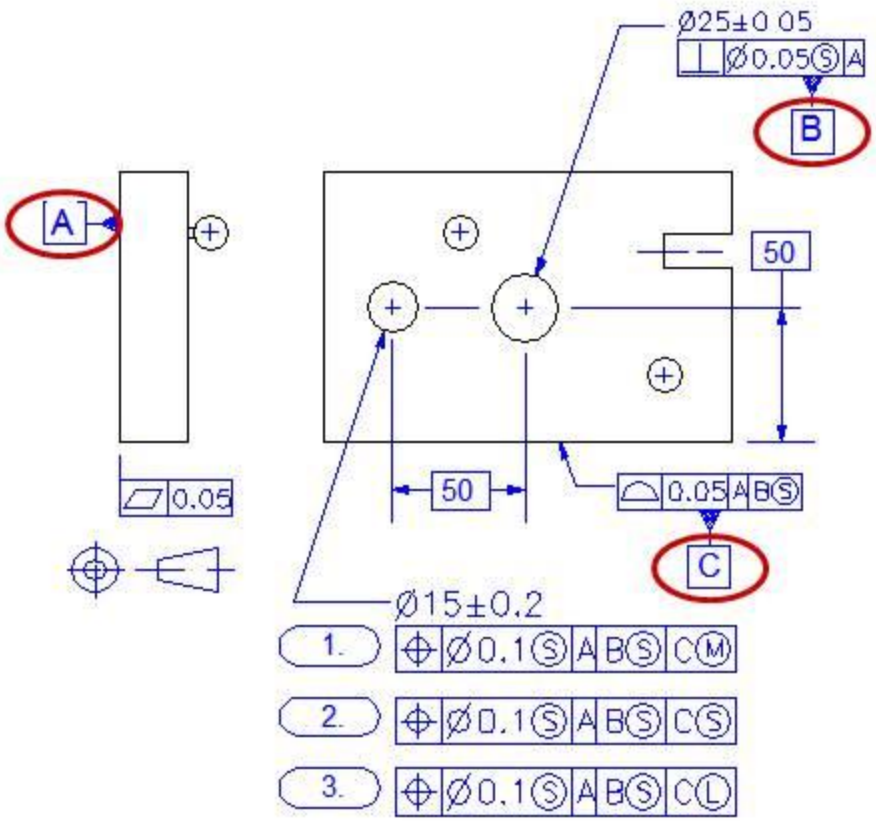

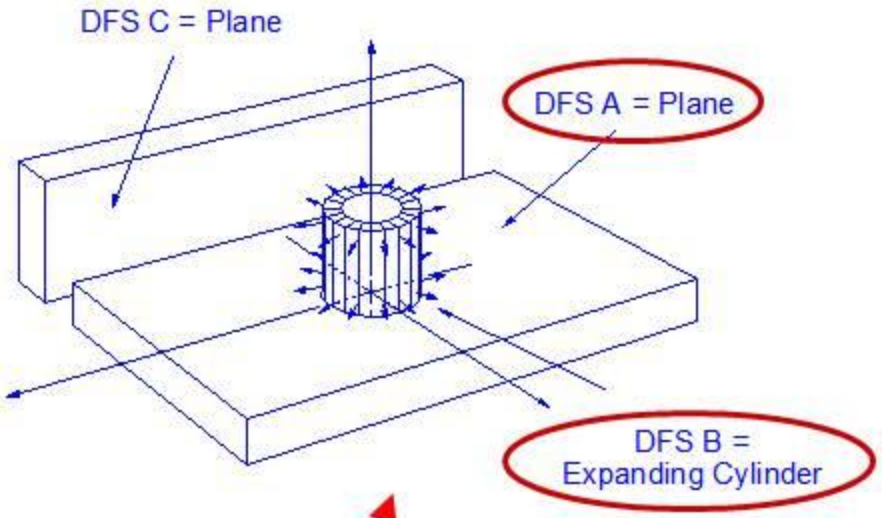

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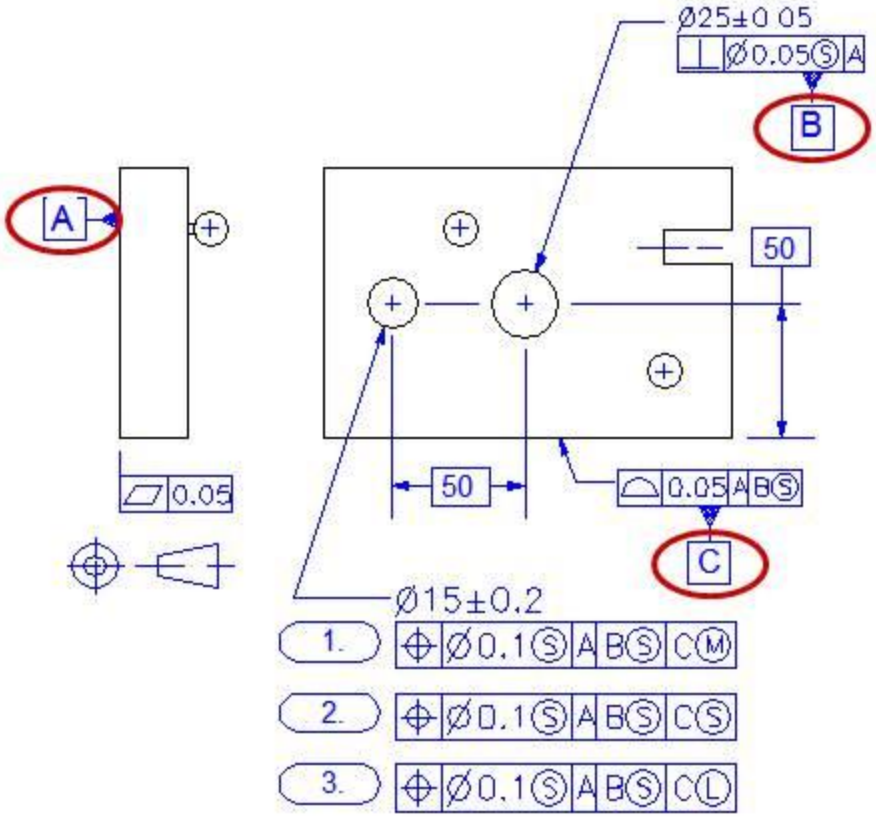
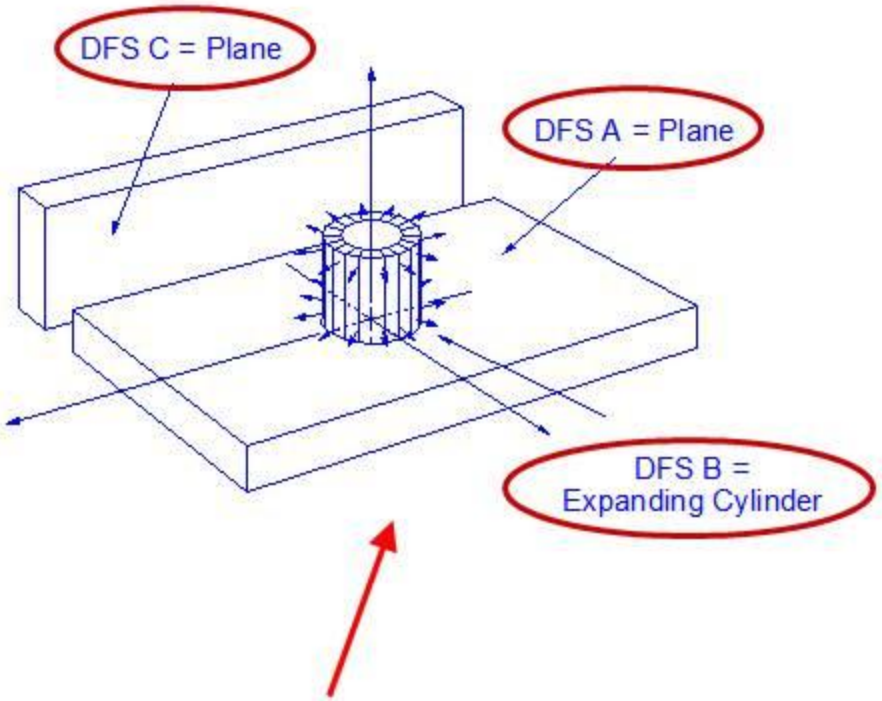
Datum Feature Simulators

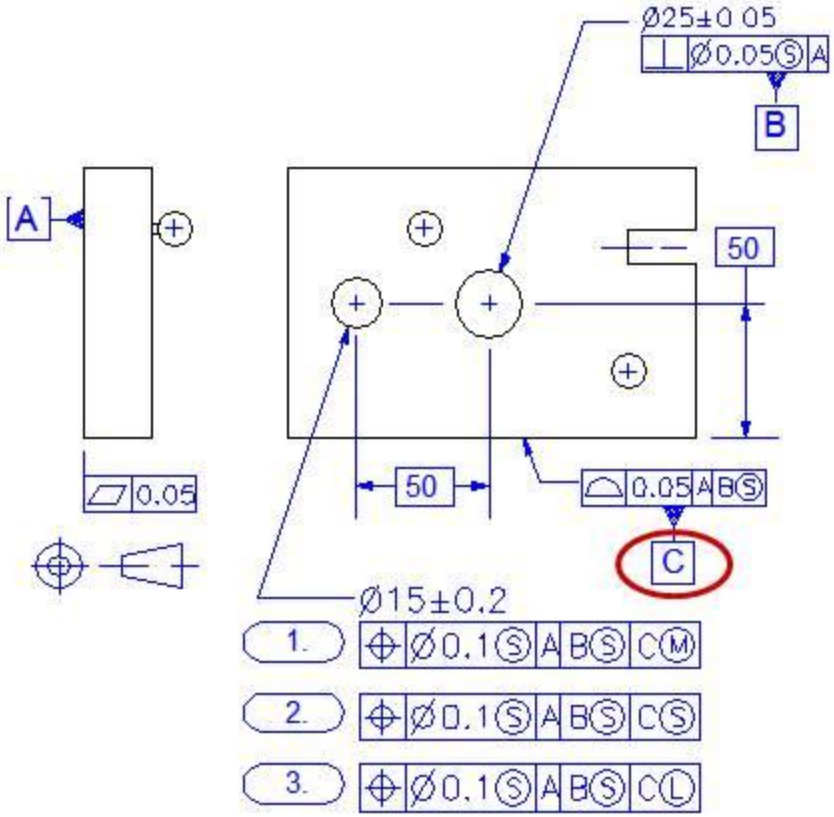
Applicability of the modifiers (S) (M) (L) to Planar Datum Features

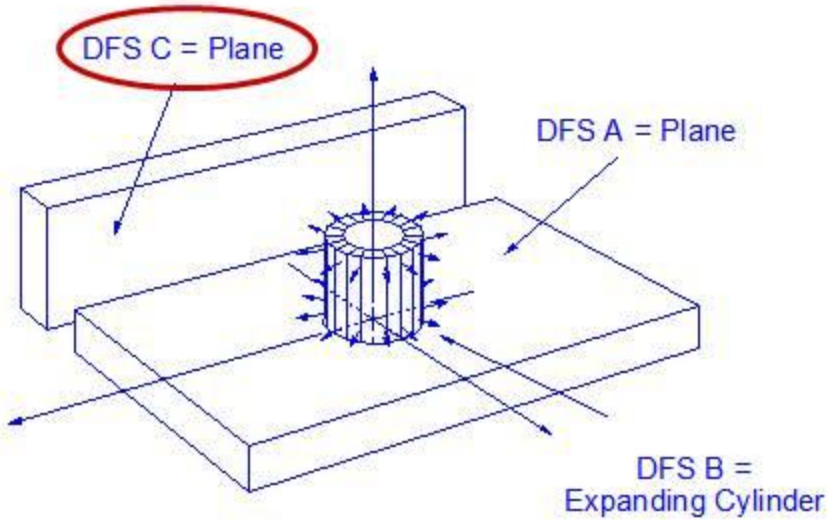




And here are the
Datum Feature Simulators

Applicability of the modifiers Ⓢ Ⓜ Ⓛ to Planar Datum Features

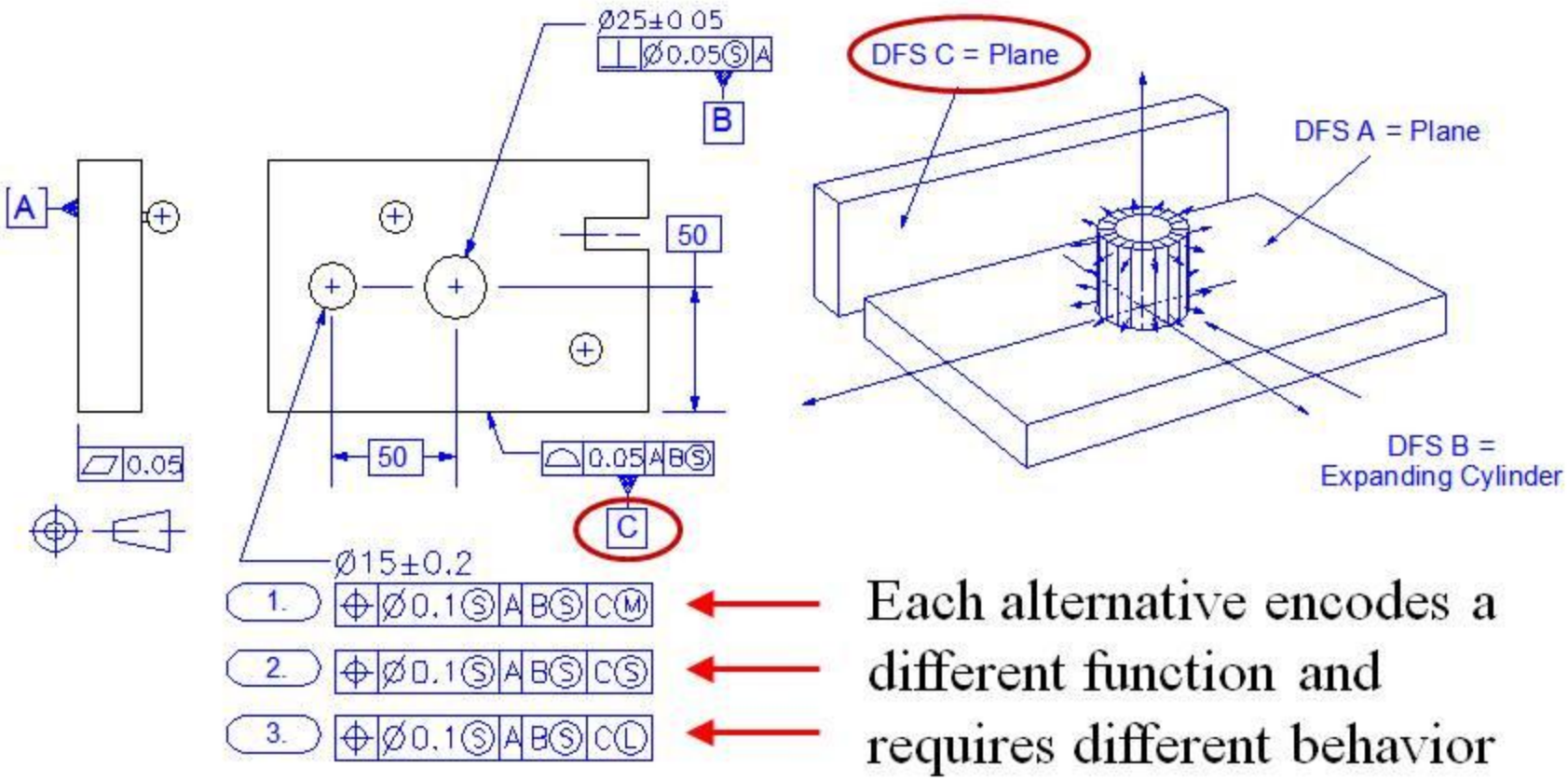




The question is:

How should Simulator C behave?

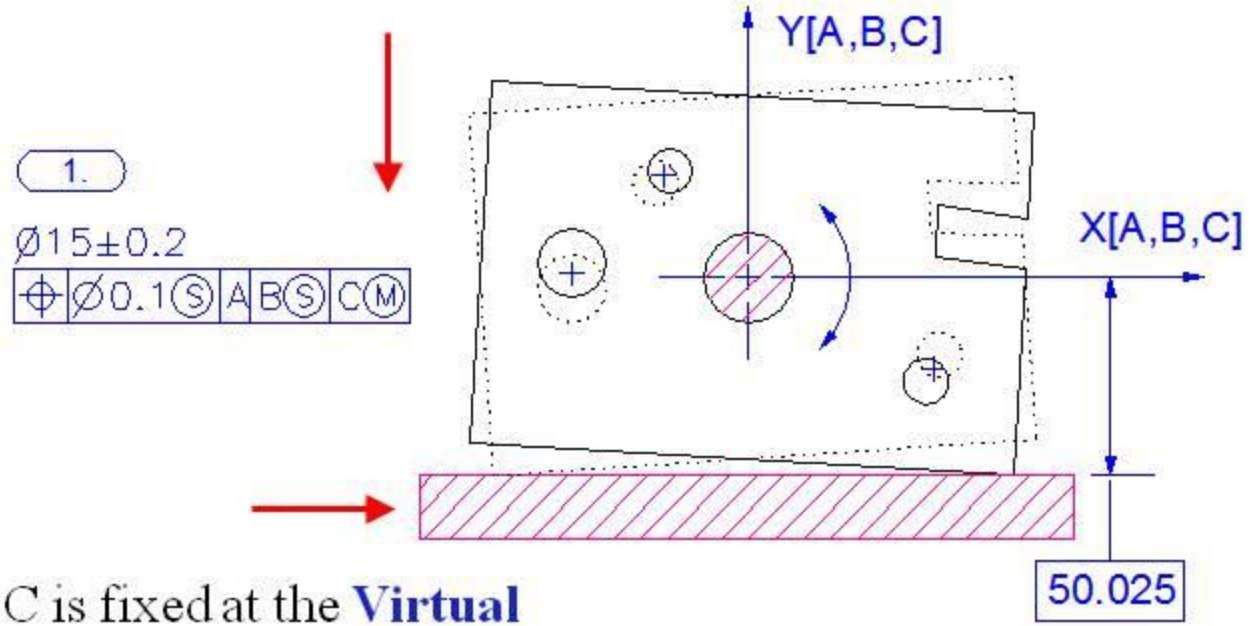
Applicability of the modifiers Ⓢ Ⓜ Ⓛ to Planar Datum Features



Each alternative encodes a different function and requires different behavior

Applicability of the modifiers Ⓢ Ⓜ Ⓛ to Planar Datum Features

If the planar surface is referenced at Ⓜ



Simlator C is fixed at the **Virtual Maximum Material Boundary . . .**

Applicability of the modifiers Ⓢ Ⓜ Ⓛ to Planar Datum Features

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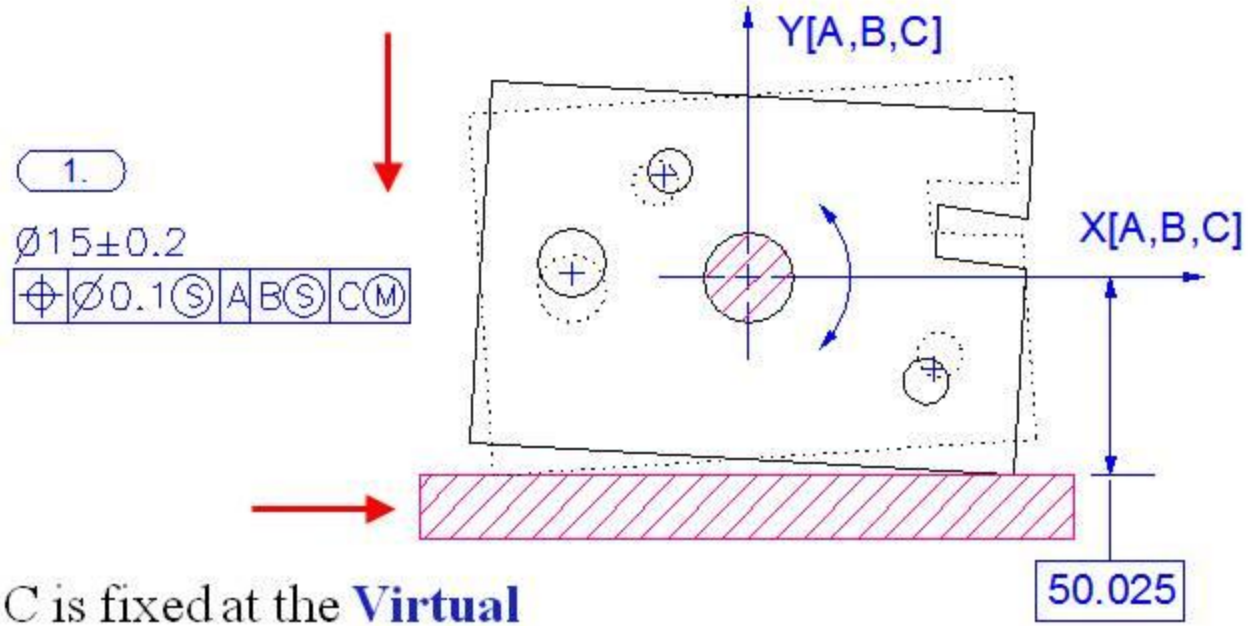

Simlator C is fixed at the **Virtual Maximum Material Boundary . . .**

→ leading to residual **in-space roll mobility**

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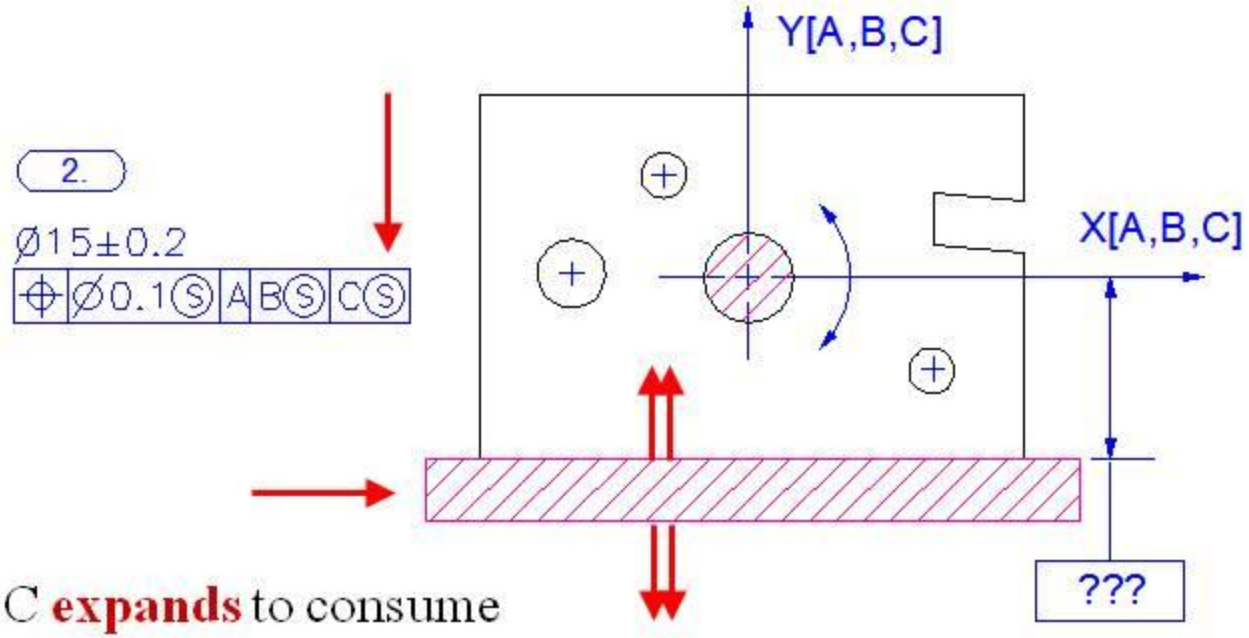

Simlator C **expands** to consume all the space available . . .

Applicability of the modifiers Ⓢ Ⓜ Ⓛ to Planar Datum Features

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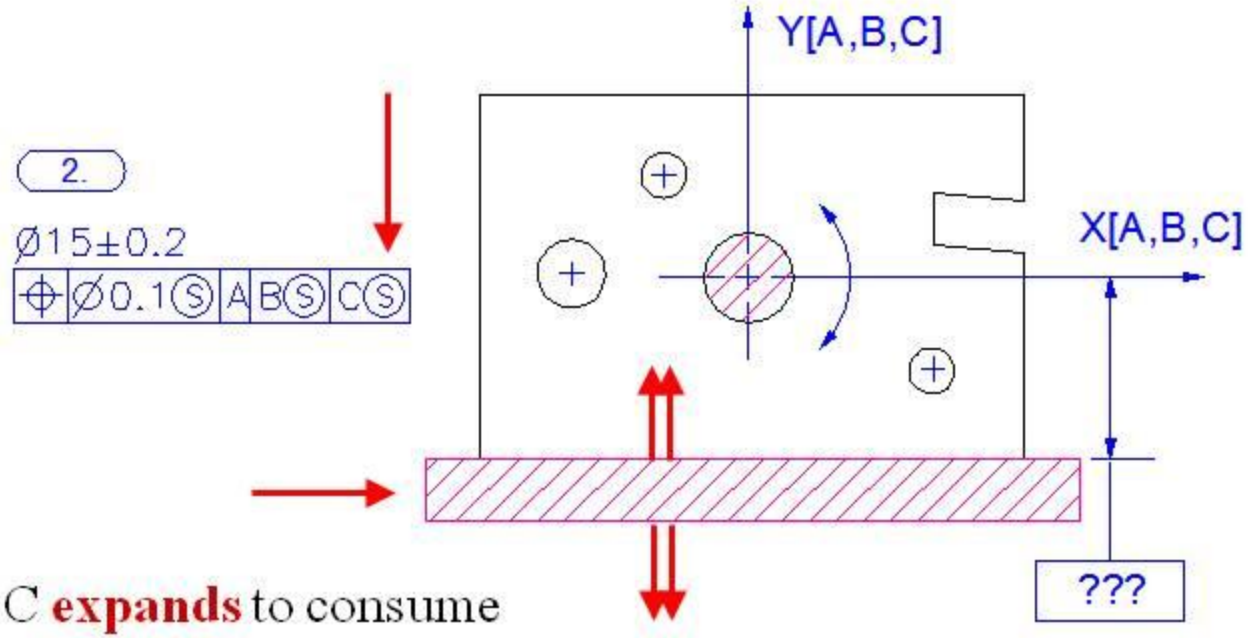
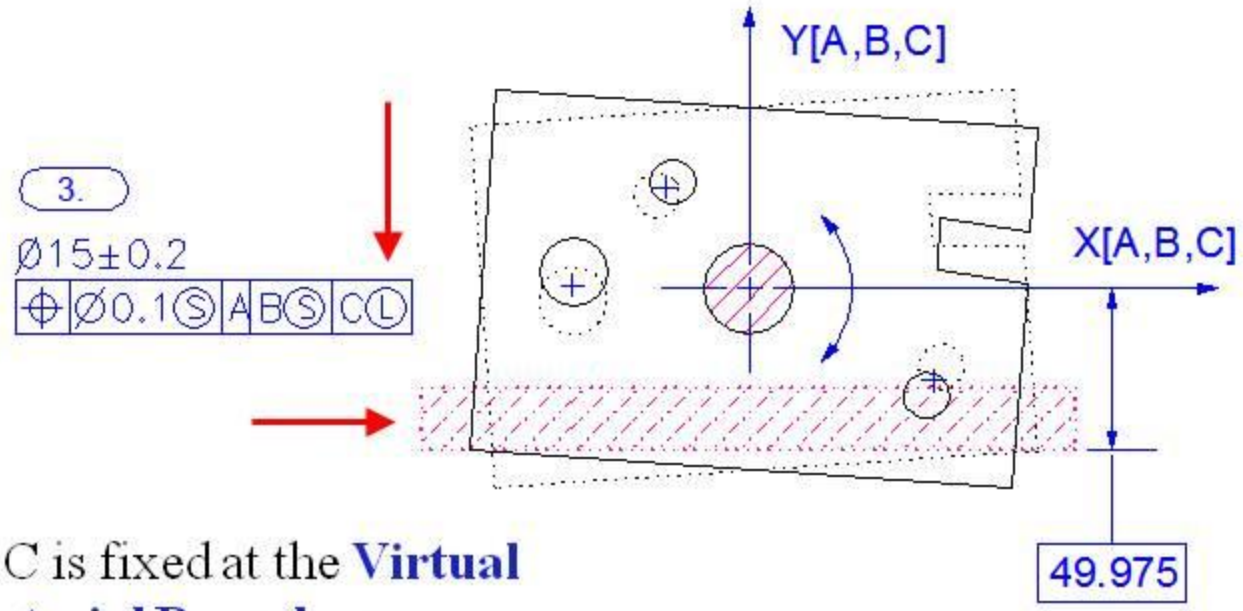


Simlator C **expands** to consume all the space available . . .

→ leading to **in-space roll stability**

Applicability of the modifiers Ⓢ Ⓜ Ⓛ to Planar Datum Features

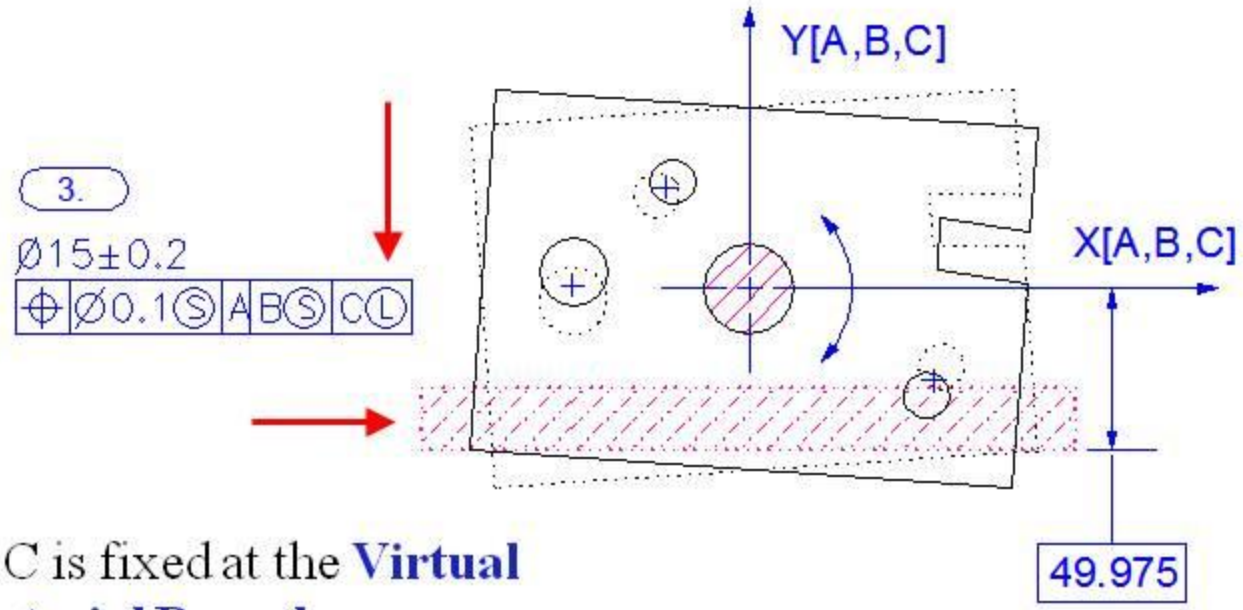
If the planar surface is referenced at Ⓛ



Simlator C is fixed at the **Virtual Least Material Boundary . . .**

Applicability of the modifiers Ⓢ Ⓜ Ⓛ to Planar Datum Features

If the planar surface is referenced at Ⓛ



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Applicability of the modifiers Ⓢ Ⓜ Ⓛ to Planar Datum Features

How useful is this?

Applicability of the modifiers Ⓢ Ⓜ Ⓛ to Planar Datum Features

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Ⓜ encodes potential "**mobility**" (or play) between mating planar features during assembly, and **permits** taking advantage of it.

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Ⓜ encodes potential "**mobility**" (or play) between mating planar features during assembly, and **permits** taking advantage of it.

Ⓢ encodes "**stability**" between mating planar features during assembly, and **forbids** taking advantage of potential "play".

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How useful is this?

Very

Ⓜ encodes potential "**mobility**" (or play) between mating planar features during assembly, and **permits** taking advantage of it.

Ⓢ encodes "**stability**" between mating planar features during assembly, and **forbids** taking advantage of potential "play".

Ⓛ encodes potential "**looseness**" between a planar Datum Feature in its cast versus its machined condition, and **permits** taking advantage of it during material removal.

Y14.5 2009 Changes and their Impact

New Tools impacting Datums

1. A more complete definition of **Datums**
2. Applicability of the modifiers Ⓢ Ⓜ Ⓛ to Planar Datum Features
3. The new Datum (Feature Simulator) **Translation Modifier**: ▶
4. New Degrees of Constraint Modifiers: **[u,v,w,x,y,z]**
5. Expanded Composite Feature Control Frames – **Up to four tiers**.
6. New Datum Reference Frame Axis Labels: **X[A,B,C], Y[…]** etc.

Datum (Feature Simulator) Translation Modifier: ▶

Whereas the **Material Boundary** modifiers Ⓢ Ⓜ and Ⓛ require Datum Feature Simulators to expand, contract or be fixed in size, addition of the **translation modifier** ▷ frees Datum Feature Simulators of size to **also translate** during the DRF establishment process.

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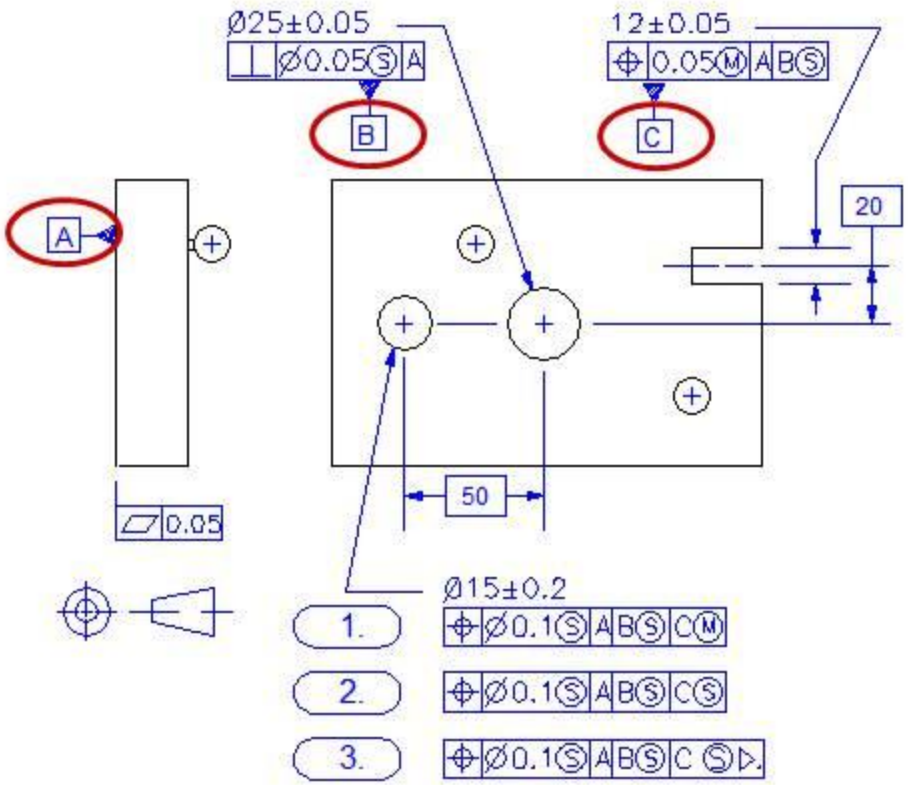
Remember !

The **translation modifier** applies only to "Datum Features of **Size**".

Datum (Feature Simulator) Translation Modifier: ▶

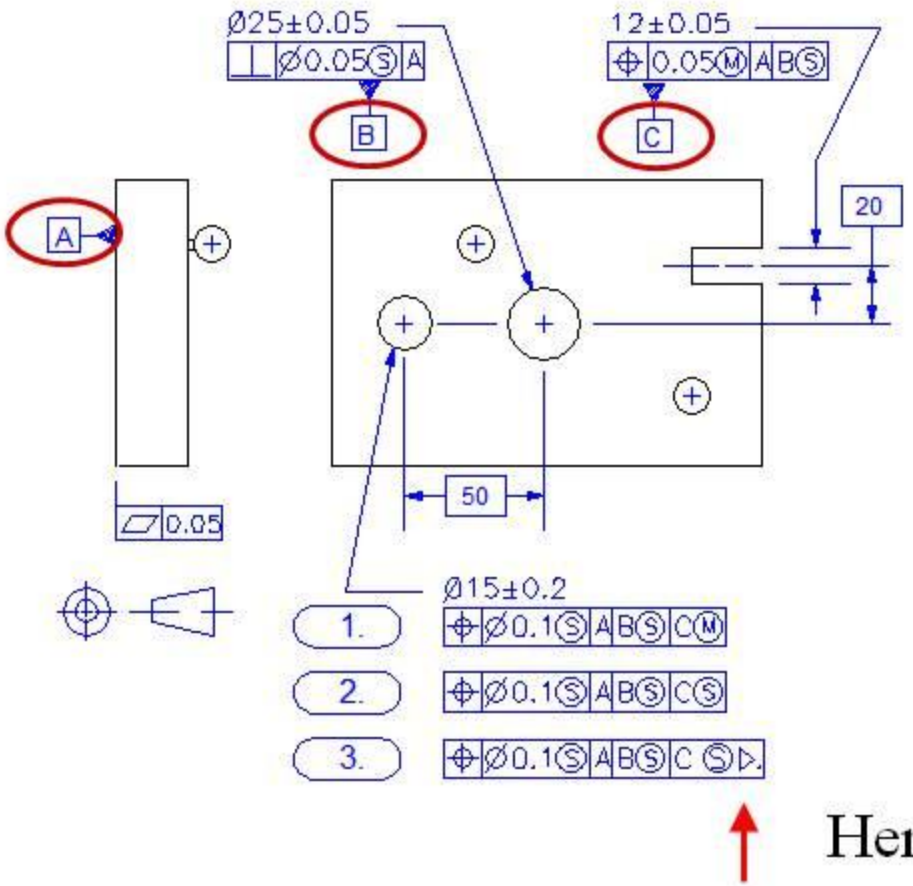
Examples

Datum (Feature Simulator) Translation Modifier: ▶



Here's a part drawing !

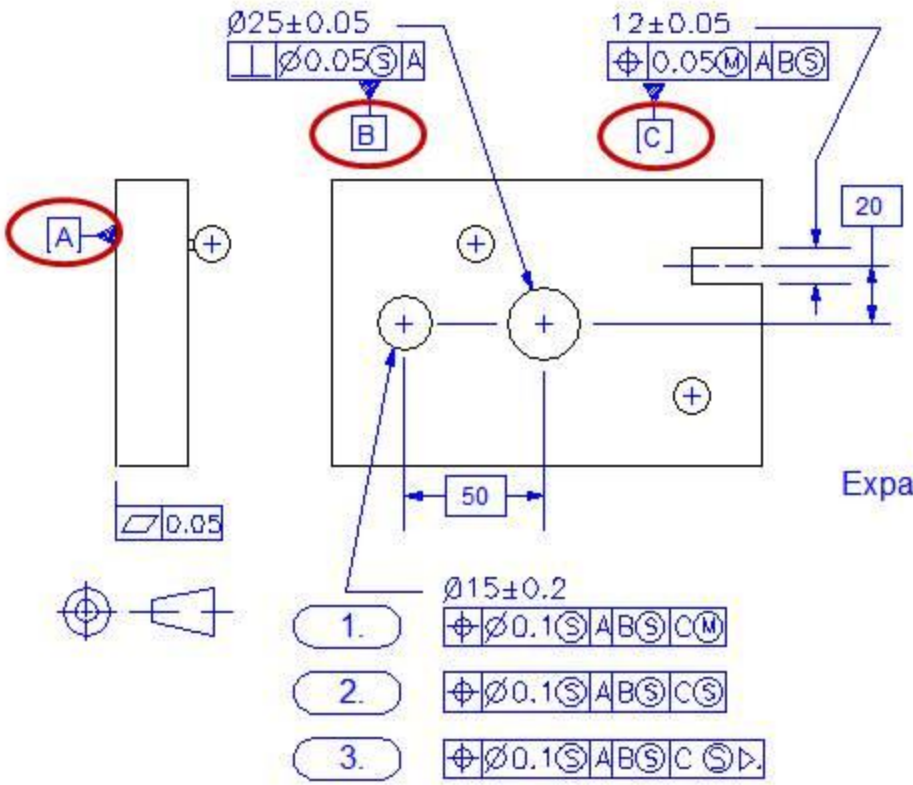
Datum (Feature Simulator) Translation Modifier: ▶

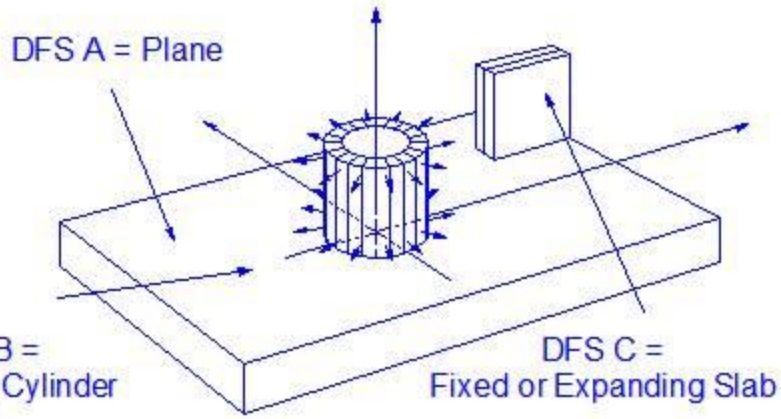


Here's a part drawing !

Here's the Translation modifier.

Datum (Feature Simulator) Translation Modifier: ▶

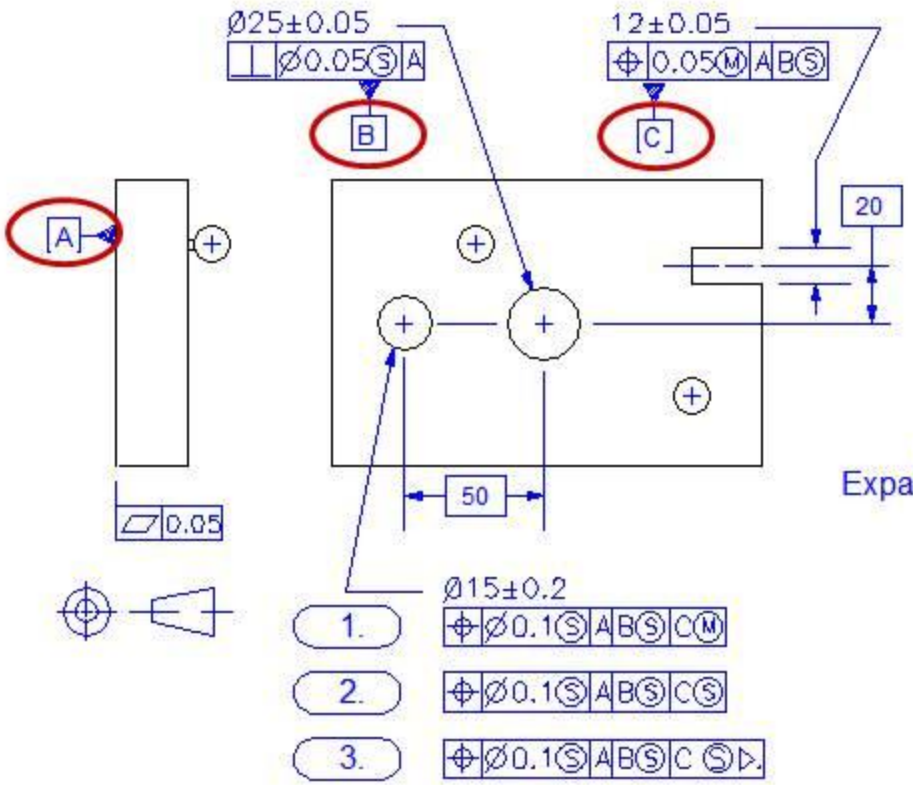


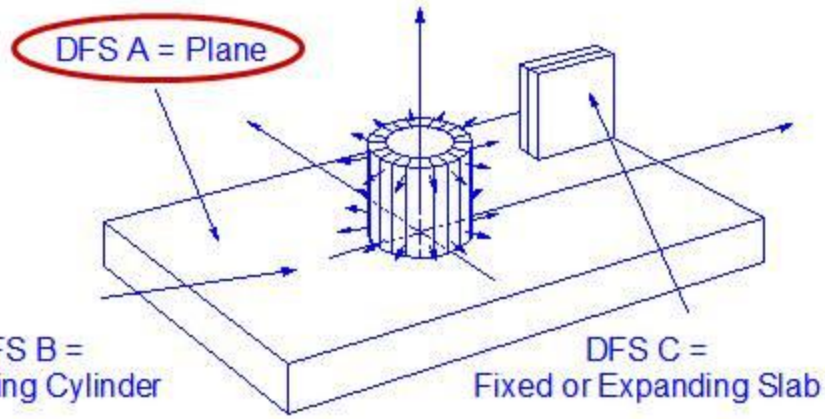


Here are the

Datum Feature Simulators

Datum (Feature Simulator) Translation Modifier: ▶





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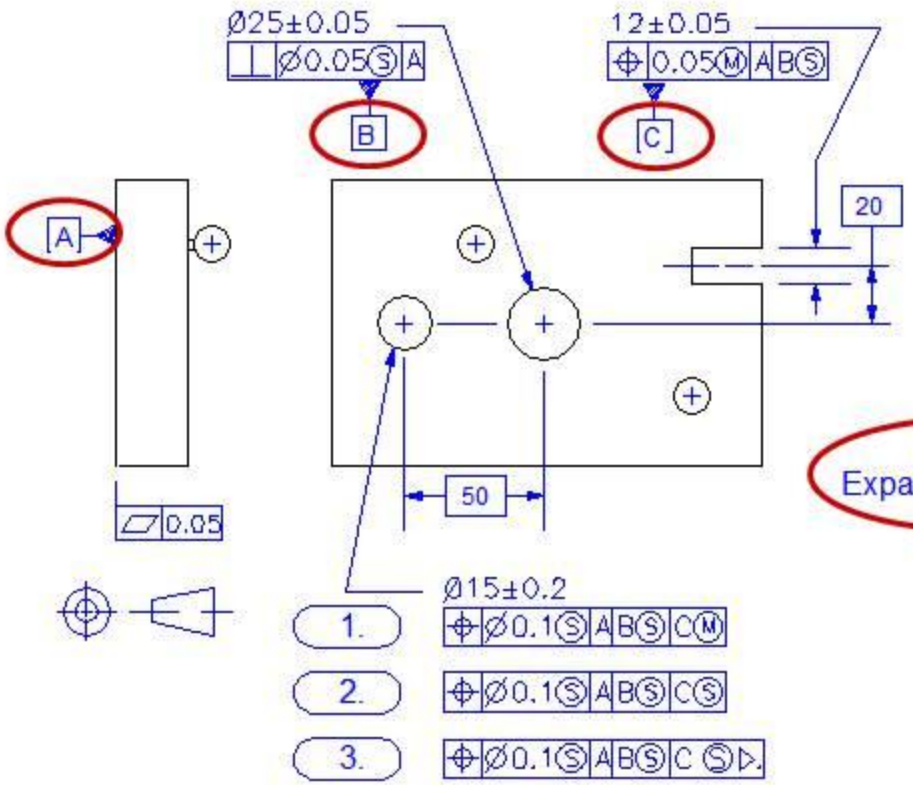

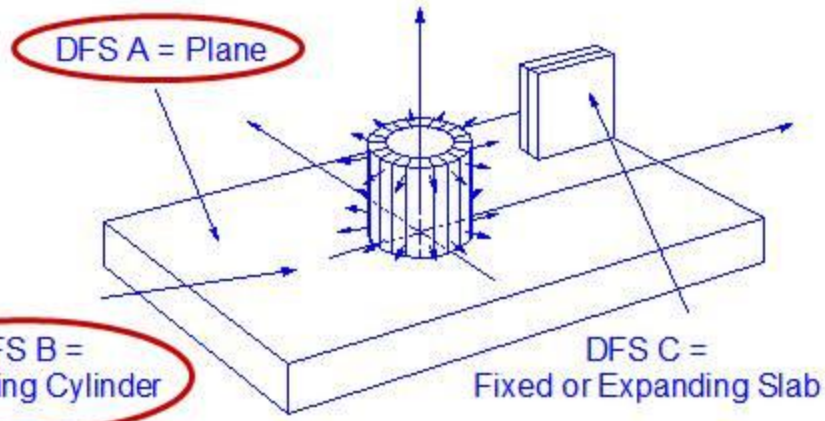

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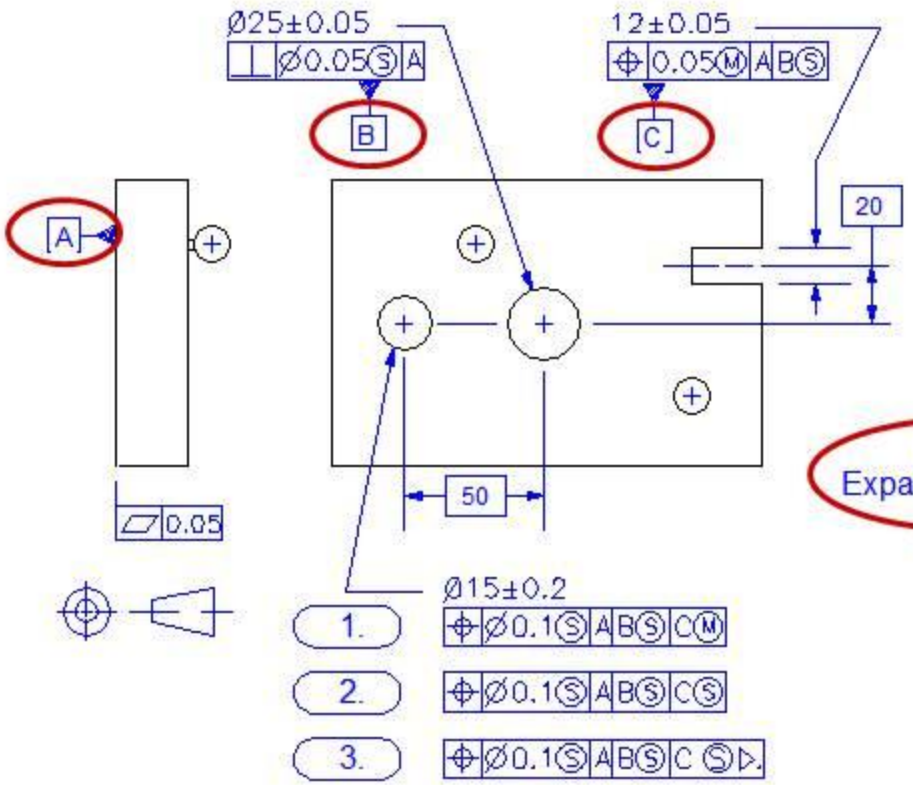

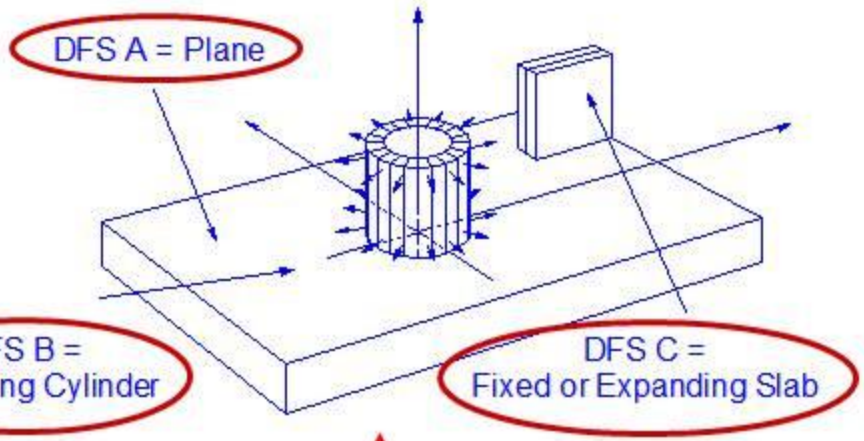

Here are the

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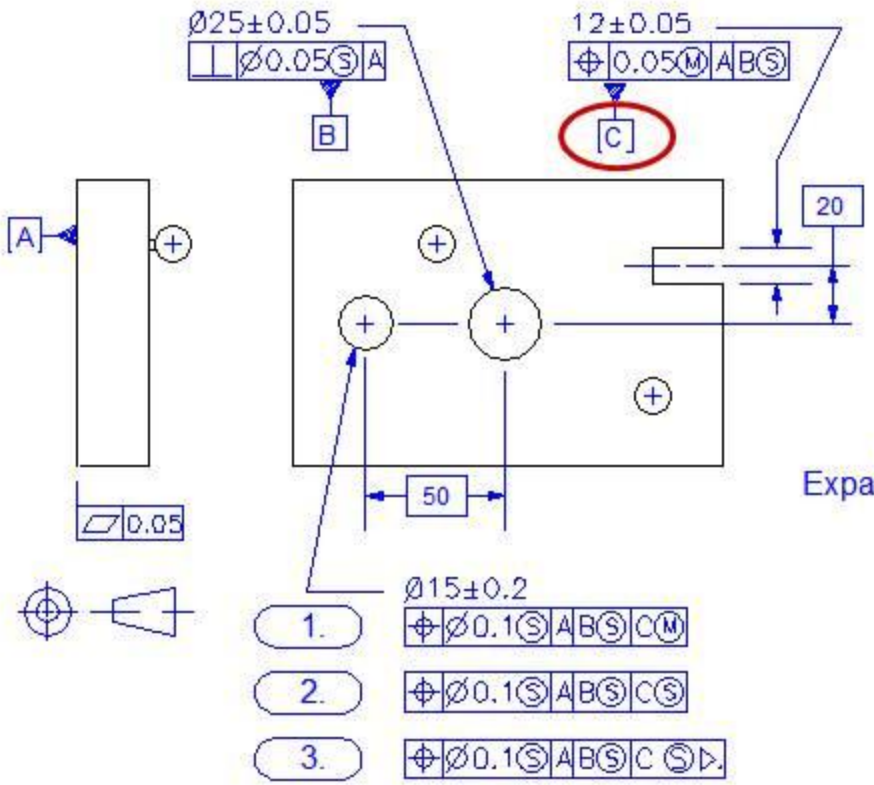
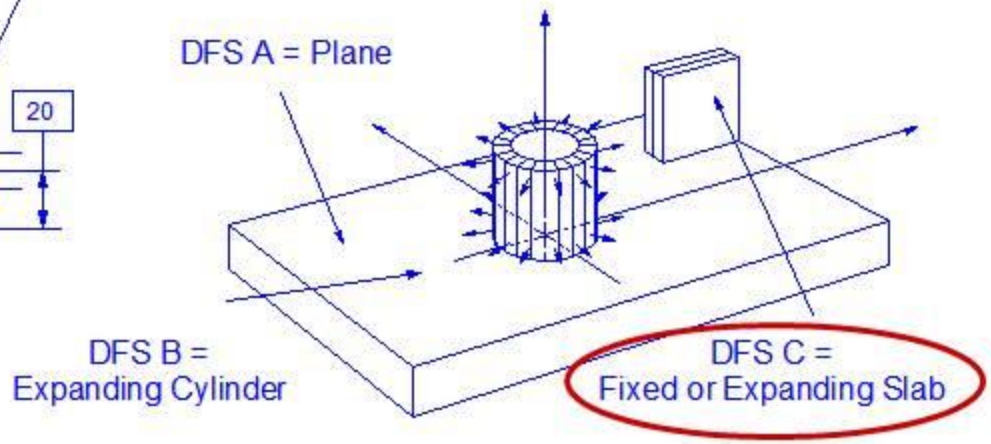


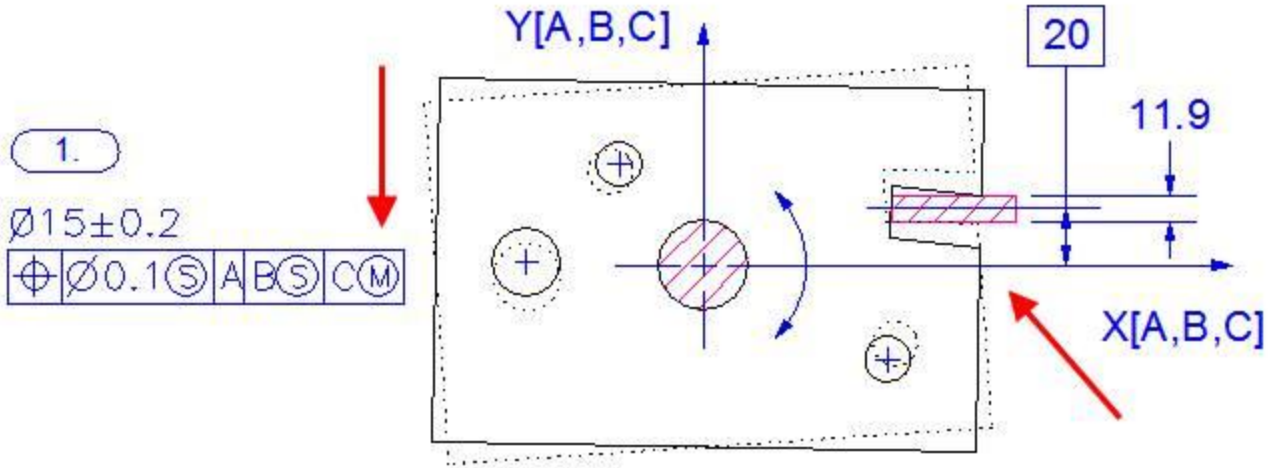


The question is:

How should Simulator C behave?

Datum (Feature Simulator) Translation Modifier: ▶

If the MMB modifier Ⓜ is used **without** ▷



The simulator is **fixed** in **location** and **fixed** in **size**.

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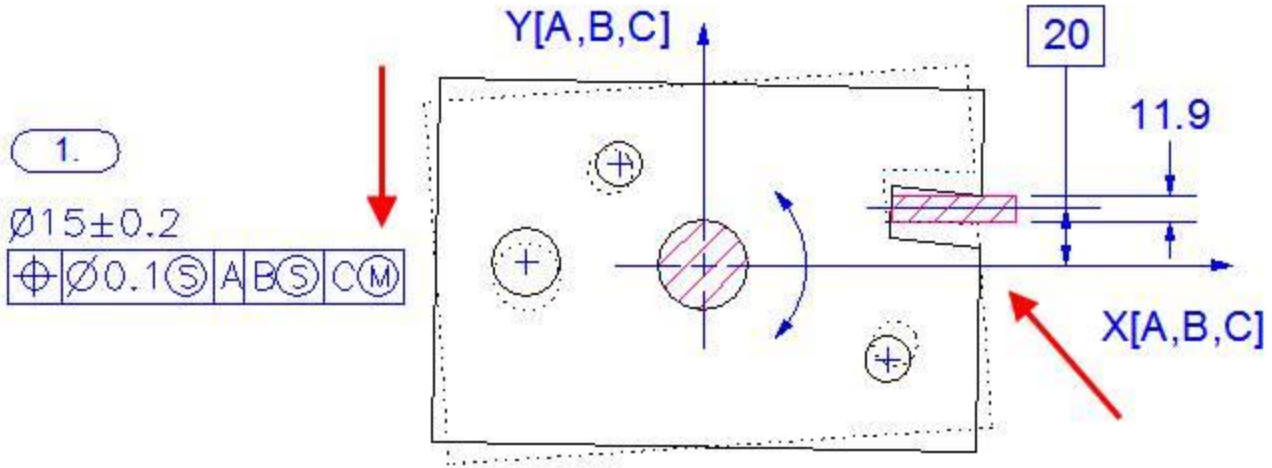
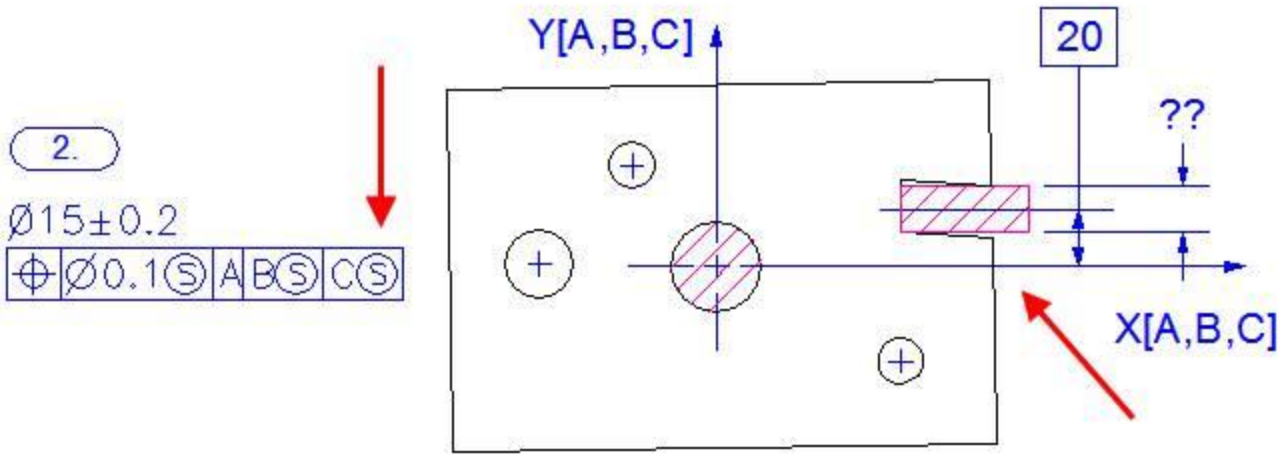


→ leading to residual **in-space roll mobility**
With C serving a "**clocking**" function.

The simulator is **fixed** in **location** and **fixed** in **size**.

Datum (Feature Simulator) Translation Modifier: ▶

If the RMB modifier Ⓢ is used **without** ▷



The simulator is **fixed** in **location** but is **required** to **expand**.

Datum (Feature Simulator) Translation Modifier: ▶

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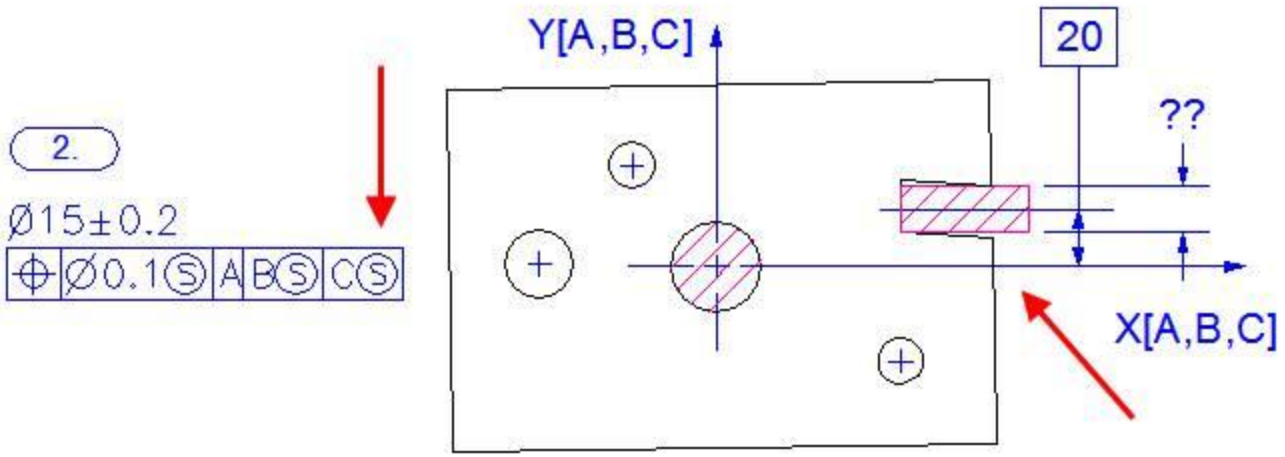

→ leading to residual **in-space roll stability**
With C serving a "**clocking**" function.

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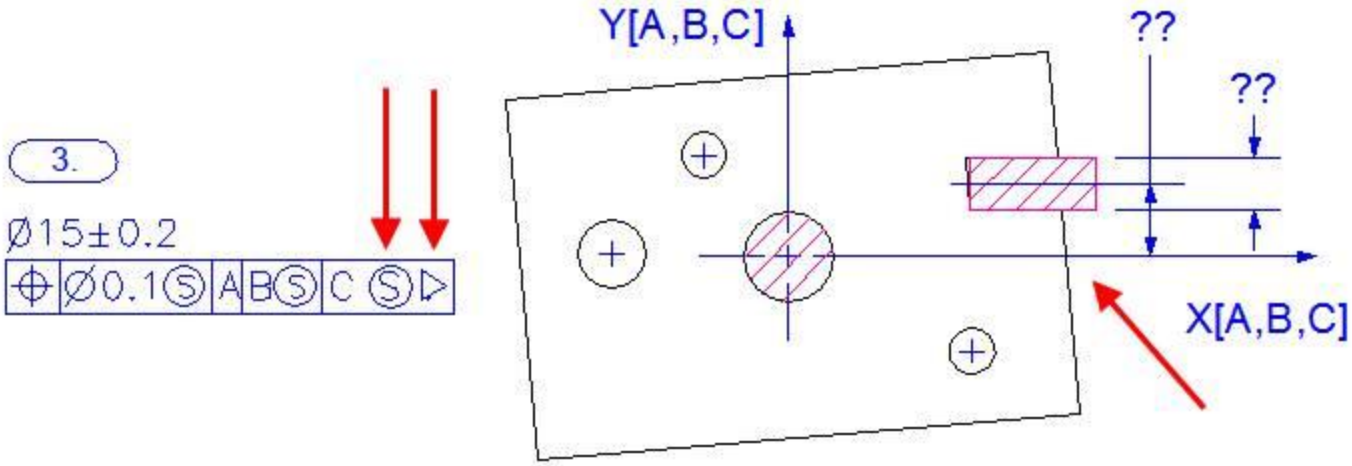
Datum (Feature Simulator) Translation Modifier: ▶

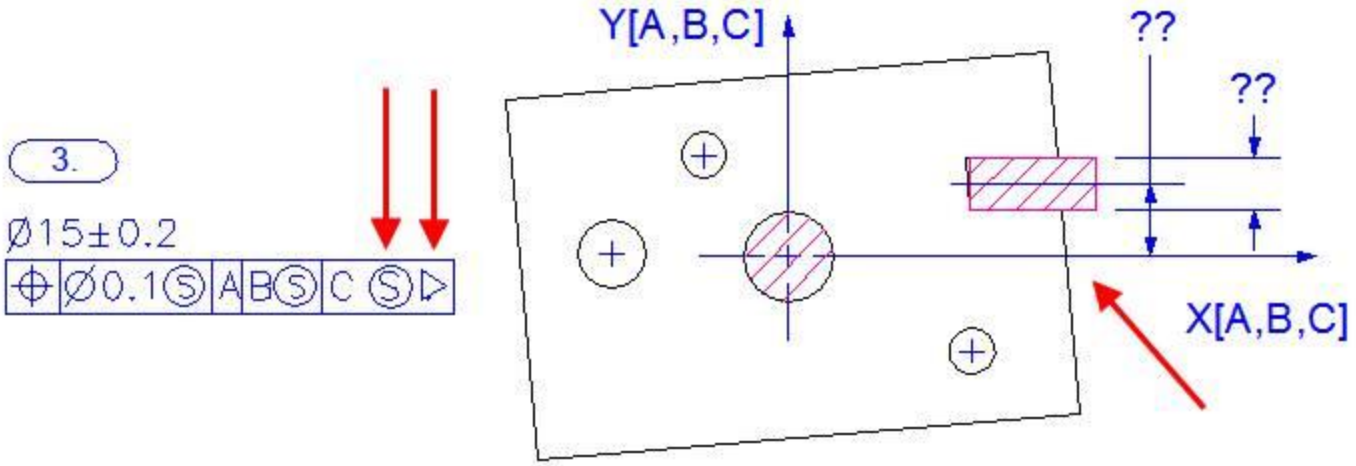
If the RMB modifier Ⓢ is used **with** ▷



The simulator is required to **expand** and **slide**.

Datum (Feature Simulator) Translation Modifier: ▶

If the RMB modifier Ⓢ
is used **with** ▷



→ leading to residual **in-space roll stability**
With C serving an "**aligning**" function.

The simulator is required to **expand** and **slide**.

Datum (Feature Simulator) Translation Modifier: ▶

Impact

encodes the potential "**mobility**" and also the "**clocking**" function.

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encodes the potential "**mobility**" and also the "**clocking**" function.

encodes the "**stability**" and the "**aligning**" function.

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Impact

encodes the potential "**mobility**" and also the "**clocking**" function.

encodes the "**stability**" and the "**aligning**" function.

encodes the potential "**looseness**" and also the "**clocking**" function.

Datum (Feature Simulator) Translation Modifier: ▶

How useful is the **Translation** modifier ?

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How useful is the **Translation** modifier ?

Very

But the number of useful instances
will be small.

Y14.5 2009 Changes and their Impact

New Tools impacting Datums

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2. Applicability of the modifiers Ⓢ Ⓜ Ⓛ to Planar Datum Features
3. The new Datum (Feature Simulator) **Translation Modifier**: ►
4. New Degrees of Constraint Modifiers: **[u,v,w,x,y,z]**
5. Expanded Composite Feature Control Frames – **Up to four tiers**.
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Degrees of Constraint Modifiers: **[u,v,w,x,y,z]**

Let's start with a question:

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What's the purpose of Datum Features ?

Degrees of Constraint Modifiers: **[u,v,w,x,y,z]**

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What's the purpose of Datum Features ?

To constrain
rotational and **translational**
degrees of freedom !

Degrees of Constraint Modifiers: **[u,v,w,x,y,z]**

There are 6 degrees of
rotational and translational freedom:

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There are 6 degrees of rotational and translational freedom:

3 Rotational:	3 Translational:
1. Pitch	1. Tx
2. Yaw	2. Ty
3. Roll	3. Tz

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and a set of **six new tools** for constraining them:

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The **Degrees of Constraint** Modifiers

Degrees of Constraint Modifiers: [u,v,w,x,y,z]

Degrees of Constraint modifiers are placed inside brackets to the right of the **Material Boundary** modifier associated with a Datum Feature label, and serve to specify the degrees of freedom that a particular Datum Feature is **required** and **permitted** to constrain !

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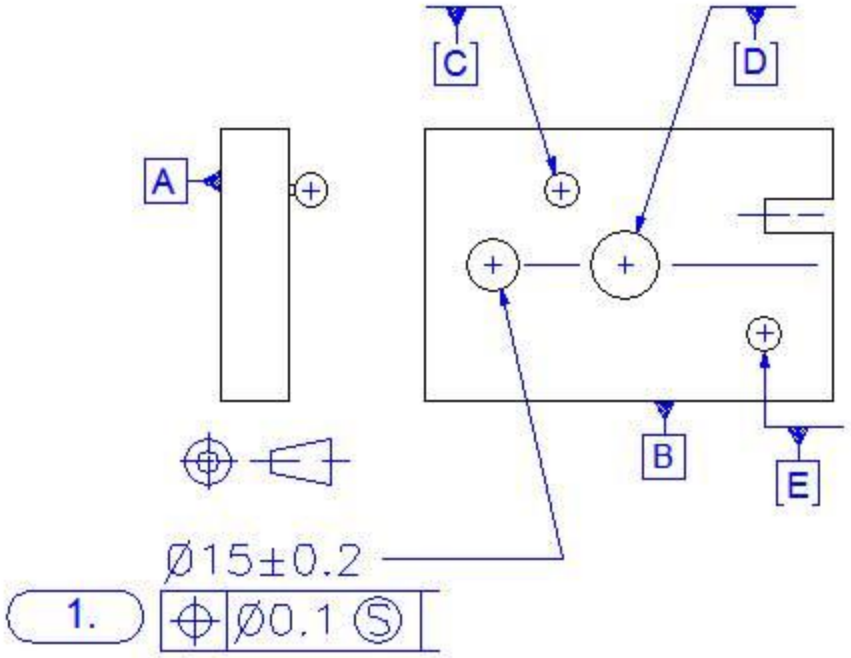
Degrees of Constraint modifiers make the **Can, May, Must** rule explicit !

Degrees of Constraint Modifiers: **[u,v,w,x,y,z]**

Example:



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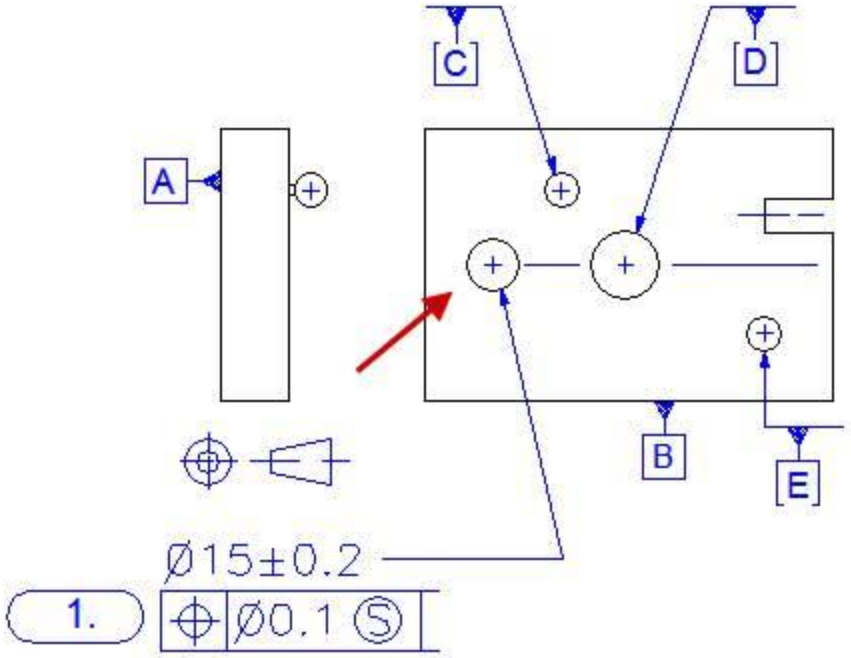

Just for fun, let's try to control the left hand bore relative to a Datum Reference Frame established using . . .

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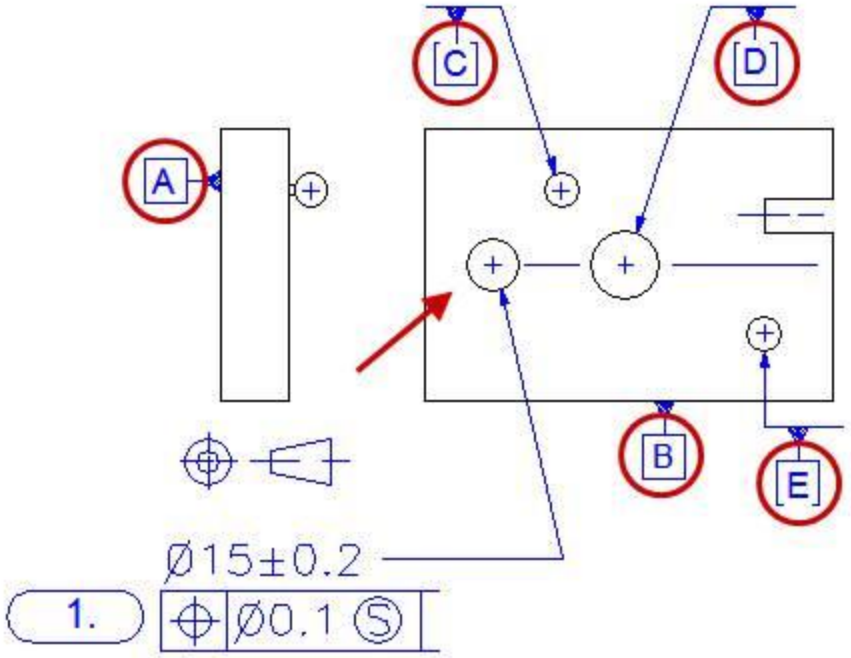

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five Datum Features.

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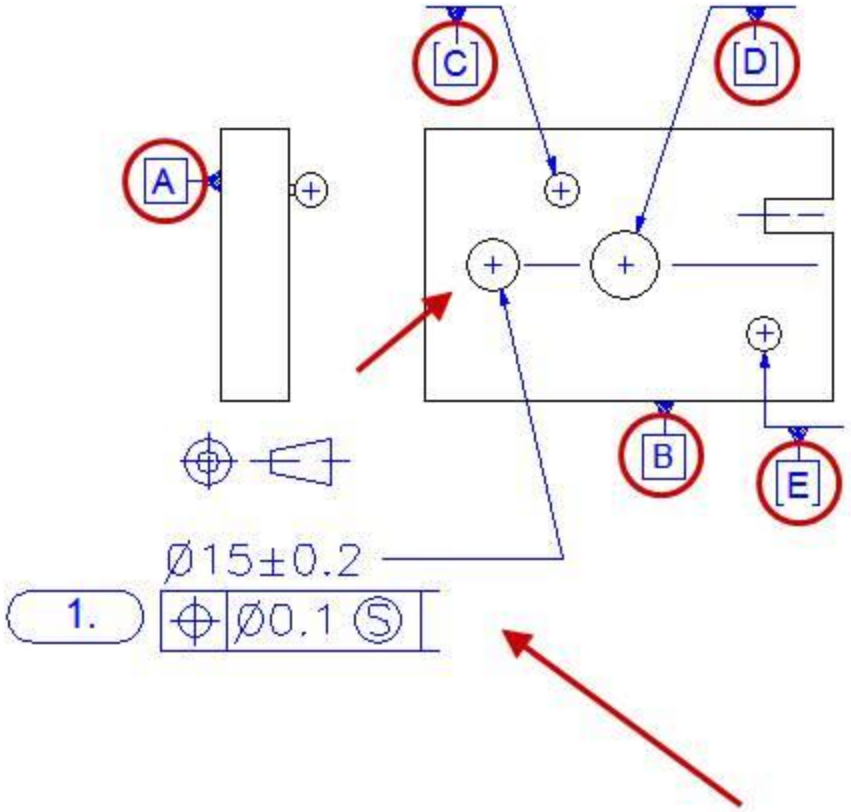

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All we have to do is list them in the Feature Control Frame

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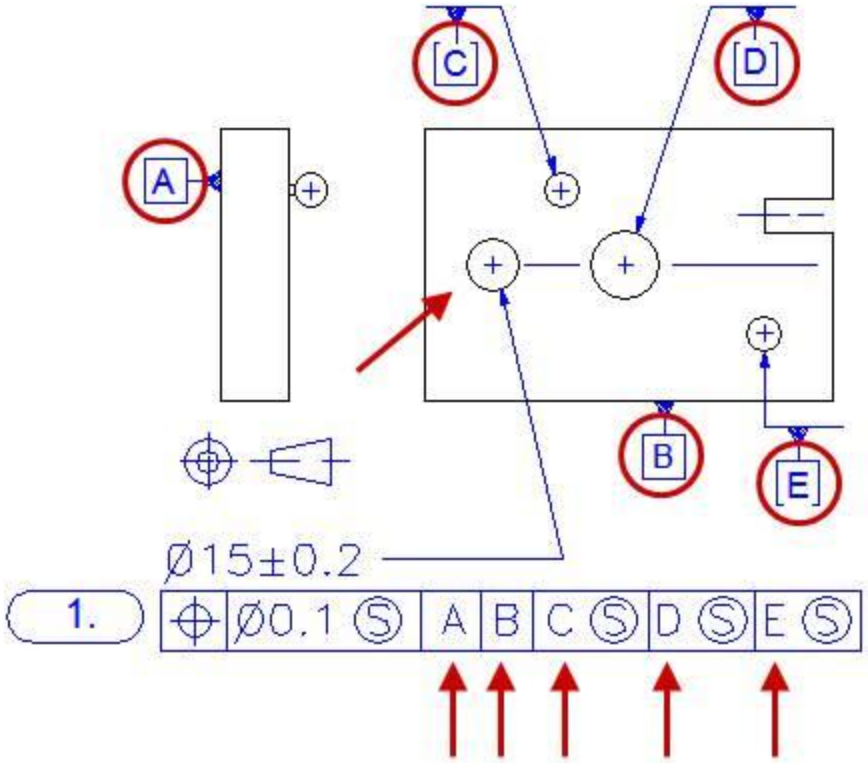

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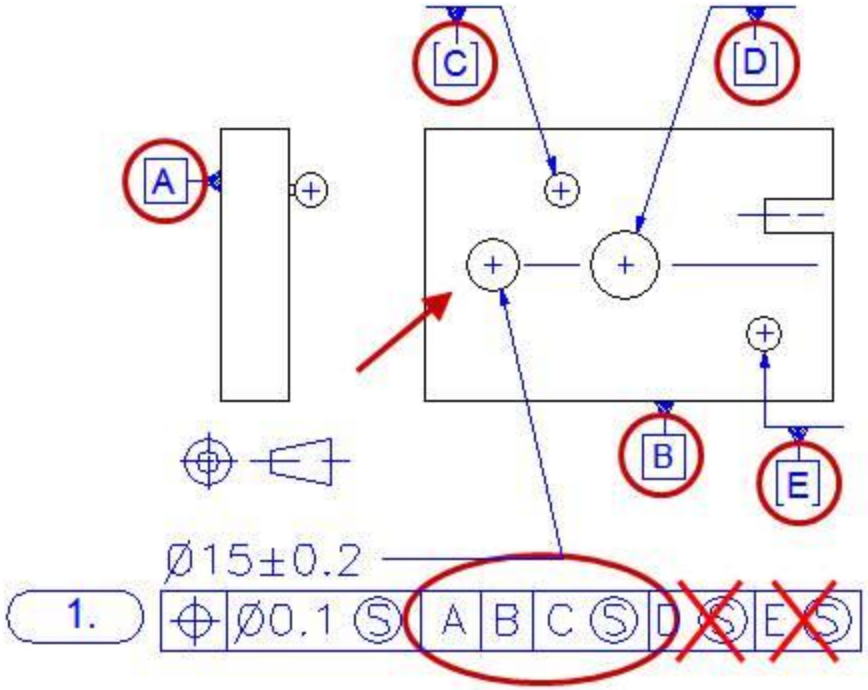
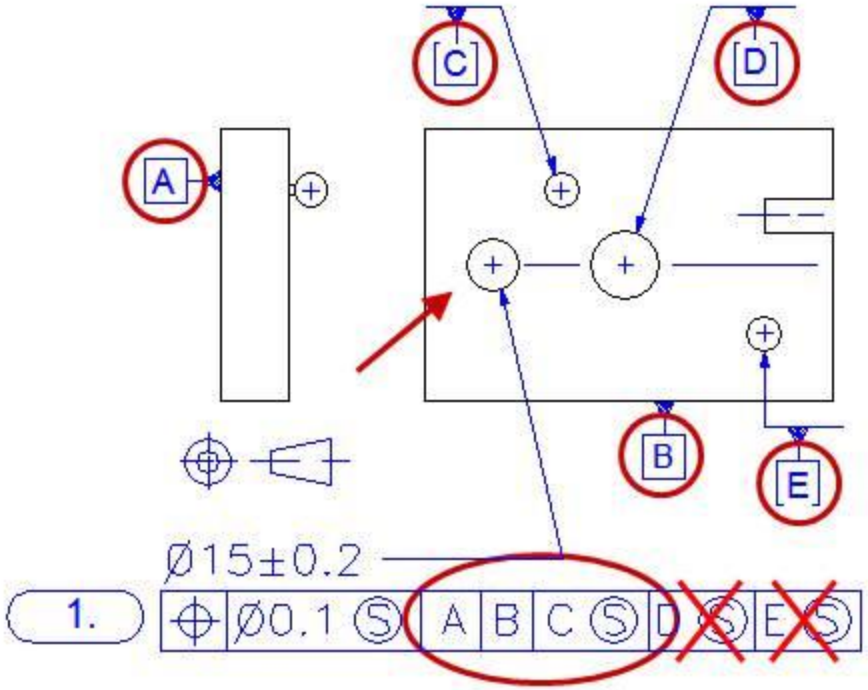


But this doesn't work, because A, B and C already constrain all six degrees of freedom !

Degrees of Constraint Modifiers: **[u,v,w,x,y,z]**

Example:



However, if this is a real, functional objective, which it could be, how can we encode it?

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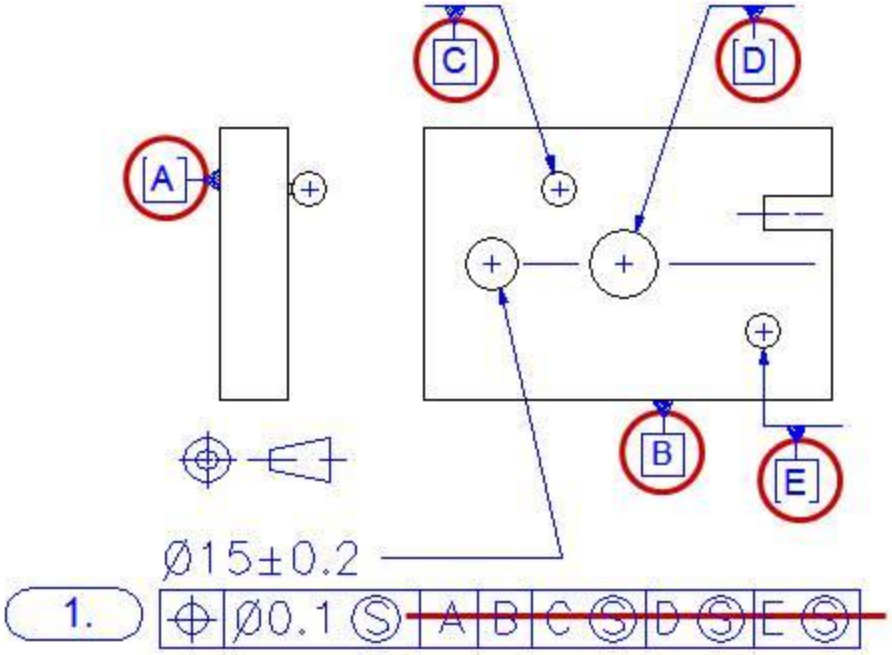
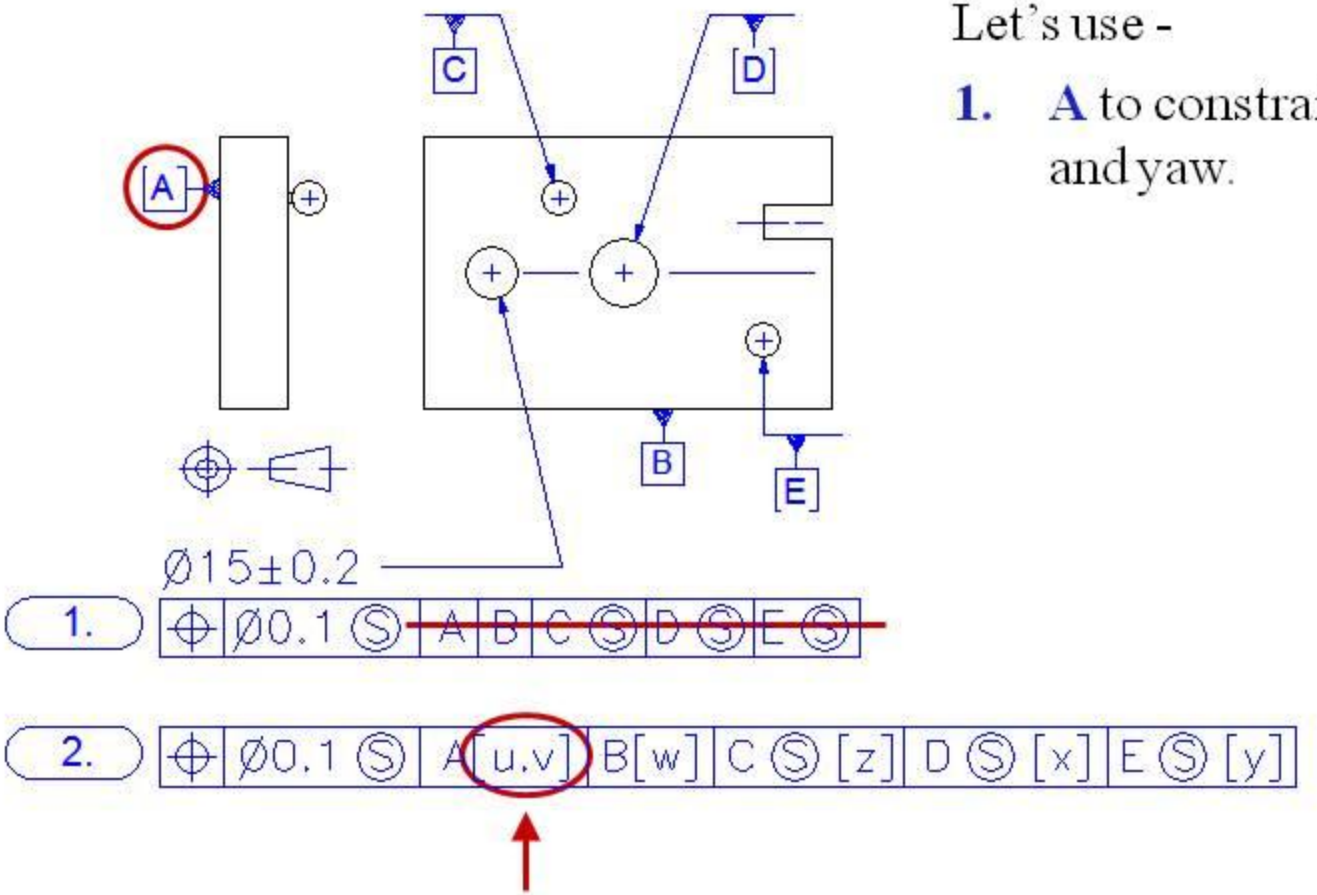


However, if this is a real, functional objective, which it could be, how can we encode it?

Using
Degrees of Constraint
modifiers !

Degrees of Constraint Modifiers: [u,v,w,x,y,z]

Example:

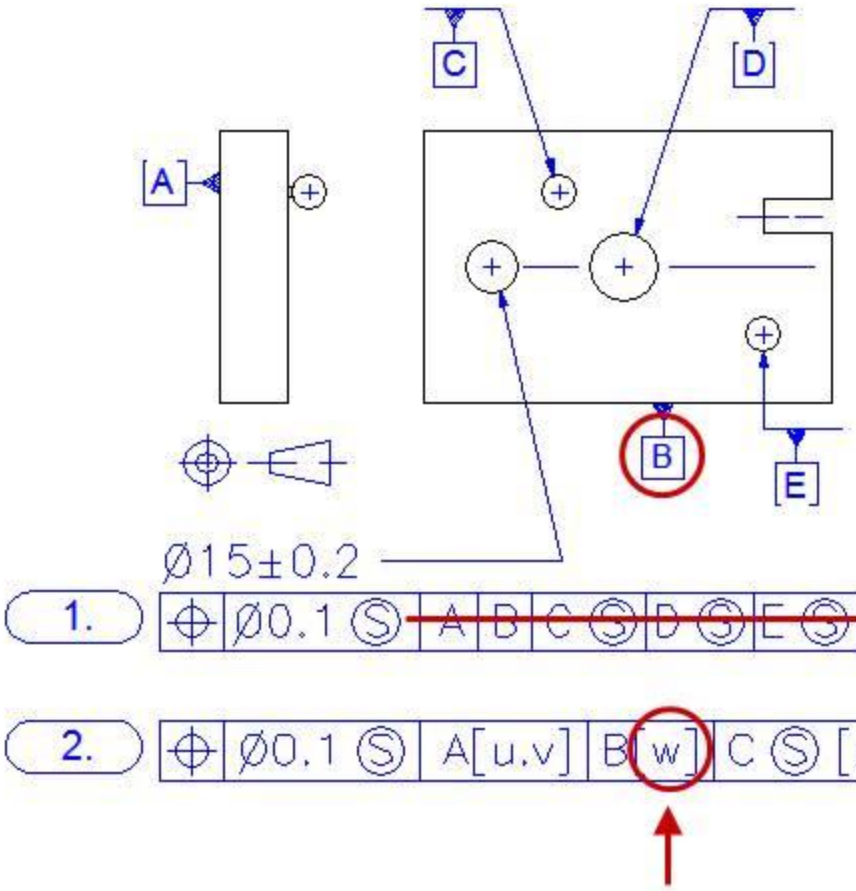


Let's use -

1. **A** to constrain only pitch and yaw.

Degrees of Constraint Modifiers: [u,v,w,x,y,z]

Example:

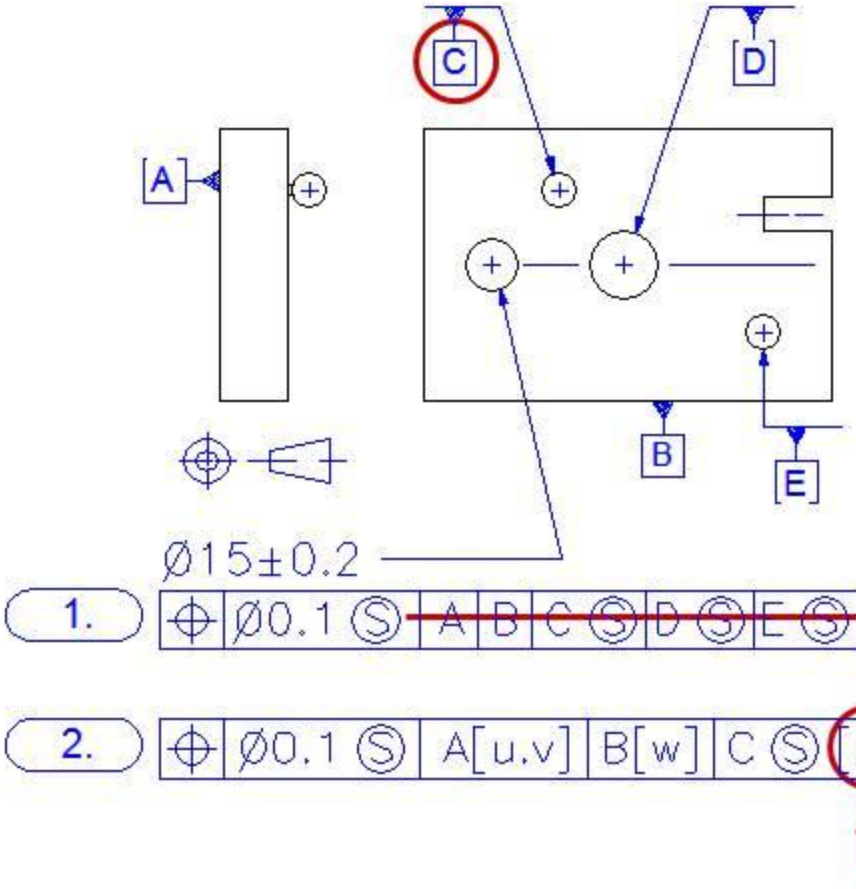


Let's use -

1. **A** to constrain only pitch and yaw.
2. **B** to constrain only roll.

Degrees of Constraint Modifiers: [u,v,w,x,y,z]

Example:

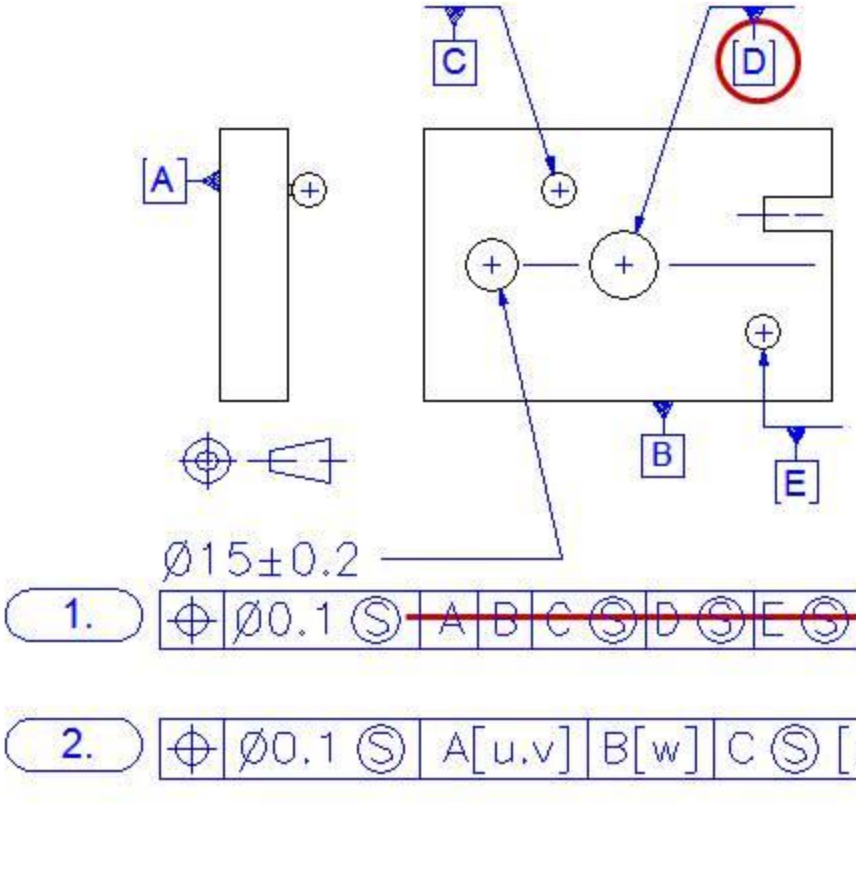


Let's use -

1. **A** to constrain only pitch and yaw.
2. **B** to constrain only roll.
3. **C** to constrain only translation in Z

Degrees of Constraint Modifiers: [u,v,w,x,y,z]

Example:

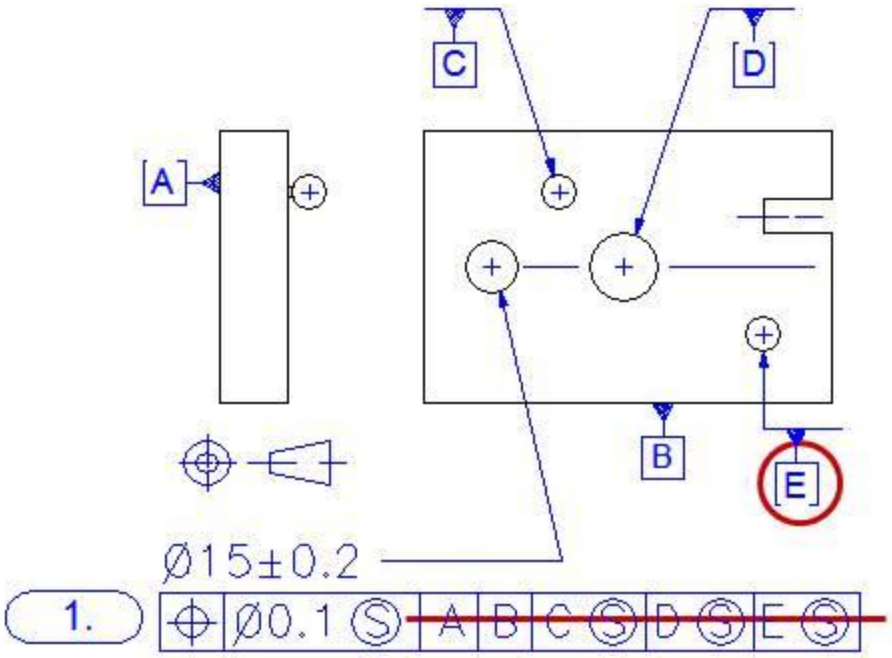


Let's use -

1. **A** to constrain only pitch and yaw.
2. **B** to constrain only roll.
3. **C** to constrain only translation in Z
4. **D** to constrain only translation in X.

Degrees of Constraint Modifiers: [u,v,w,x,y,z]

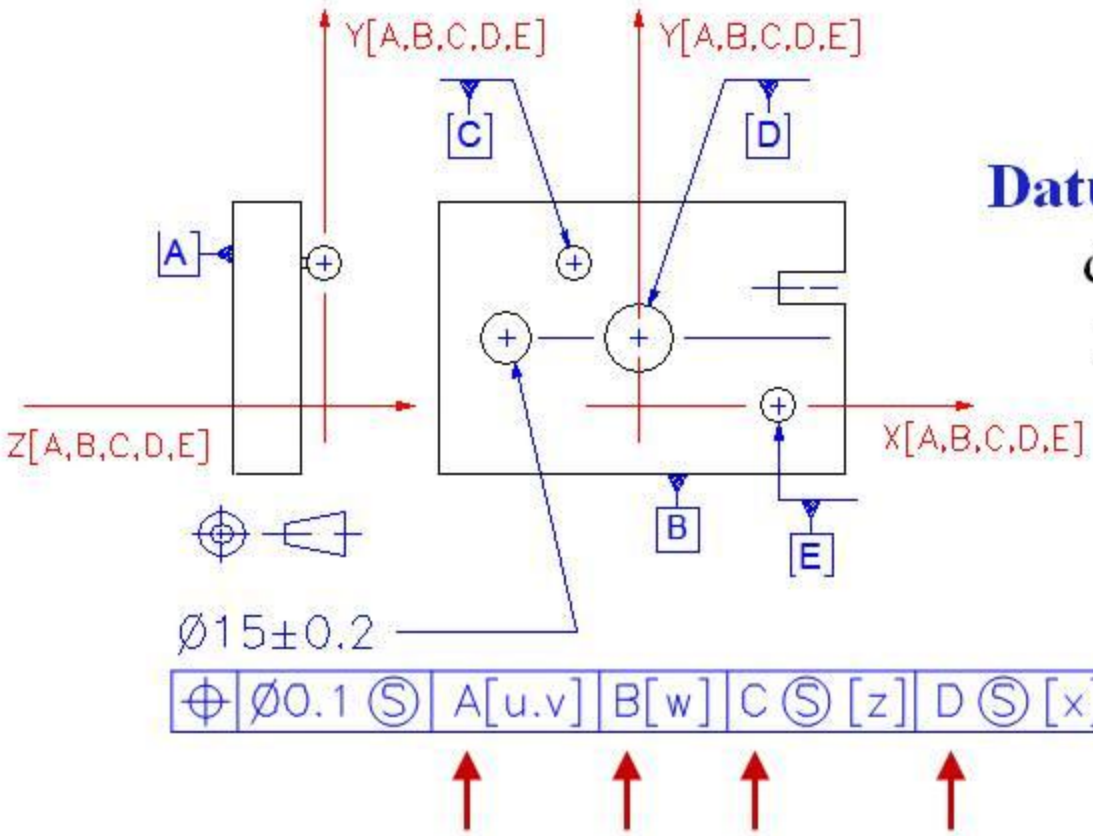
Example:



Let's use -

1. **A** to constrain only pitch and yaw.
2. **B** to constrain only roll.
3. **C** to constrain only translation in Z
4. **D** to constrain only translation in X.
5. **E** to constrain only translation in Y.

Degrees of Constraint Modifiers: **[u,v,w,x,y,z]**



And here it is !
The
Datum Reference Frame
defined by our five
Datum Features !

Degrees of Constraint Modifiers: **[u,v,w,x,y,z]**

Now for a much more

practical

Degrees of Constraint Modifiers

example.

Degrees of Constraint Modifiers: **[u,v,w,x,y,z]**

Now for a much more

practical

Degrees of Constraint Modifiers

example.

But first, the 2009 change in

Composite Feature Control Frames

Y14.5 2009 Changes and their Impact

New Tools impacting Datums

1. A more complete definition of **Datums**
2. Applicability of the modifiers Ⓢ Ⓜ Ⓛ to Planar Datum Features
3. The new Datum (Feature Simulator) **Translation Modifier**: ►
4. New Degrees of Constraint Modifiers: **[u,v,w,x,y,z]**
5. Expanded Composite Feature Control Frames – **Up to four tiers**.
6. New Datum Reference Frame Axis Labels: **X[A,B,C], Y[…]** etc.

Composite Feature Control Frames – **Up to four tiers**

Composite Feature Control Frames

can now have up to

four tiers !!!

Composite Feature Control Frames – **Up to four tiers**

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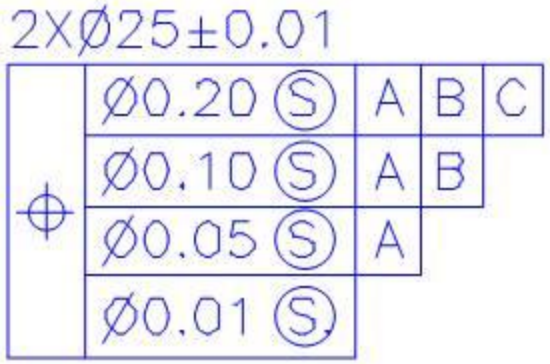
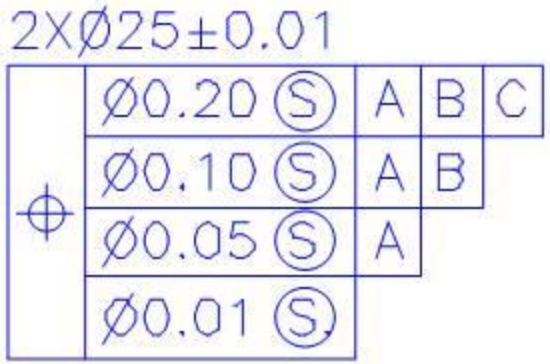


Composite Feature Control Frames – **Up to four tiers**

But, what's so special about

Composite Feature Control Frames ?



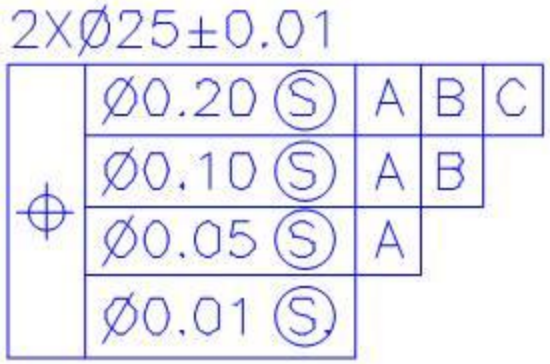
Composite Feature Control Frames – **Up to four tiers**

But, what's so special about

Composite Feature Control Frames ?

They provide special

function encoding power.



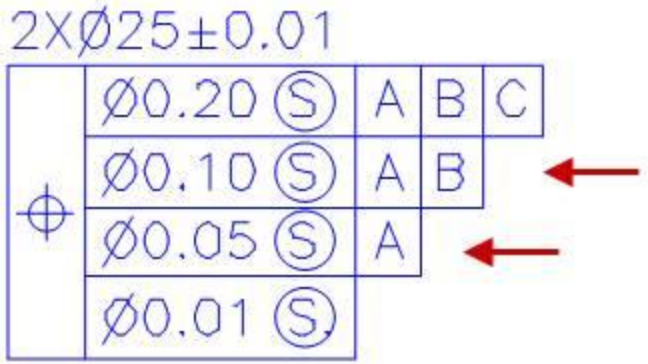
Composite Feature Control Frames – **Up to four tiers**

How?

Composite Feature Control Frames – **Up to four tiers**

How?

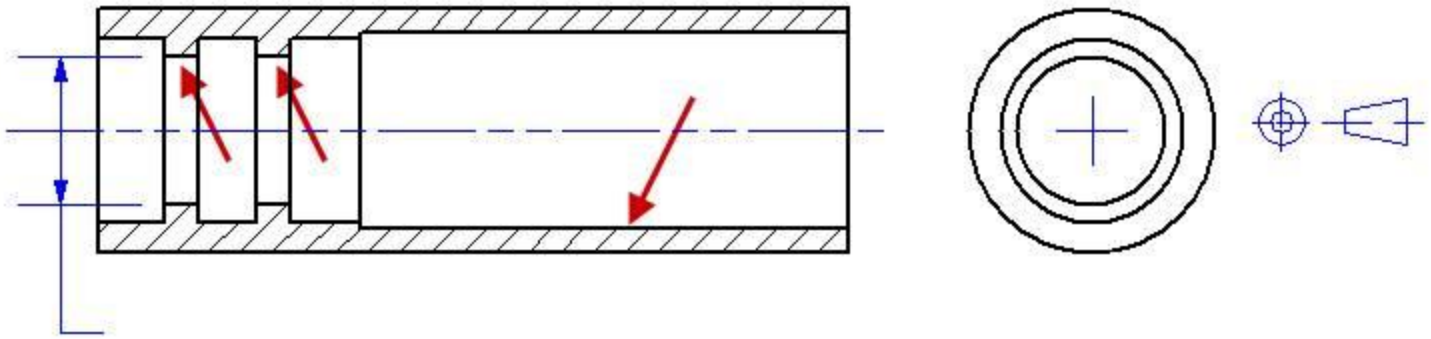
by limiting the Datum Features in the second and all lower tiers to **constraining only rotational** degrees of freedom !



Composite Feature Control Frames – **Up to four tiers**

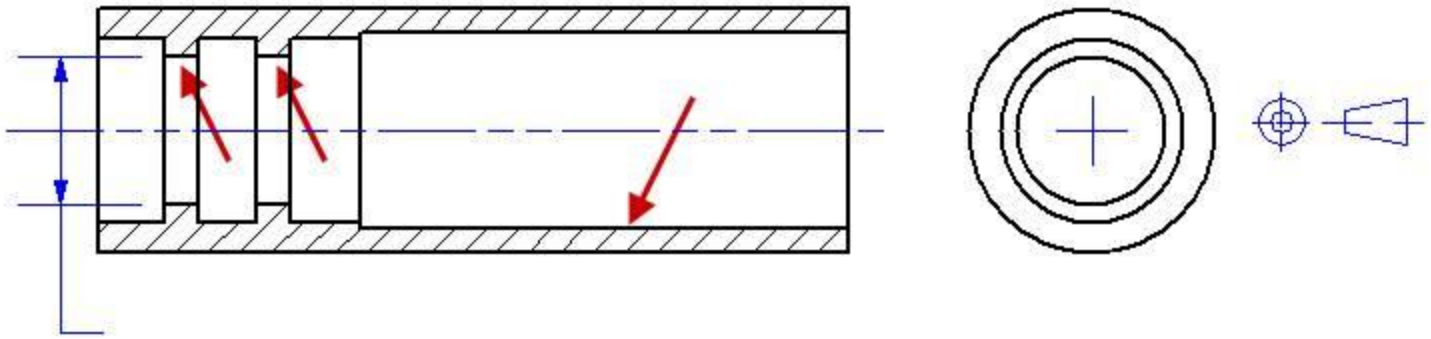
Example

Composite Feature Control Frames – **Up to four tiers**



Focusing on the two small bores on the left and the long bore on the right . . . .

Composite Feature Control Frames – **Up to four tiers**



The functional objectives we want to encode are:

Focusing on the two small bores on the left and the long bore on the right . . . .

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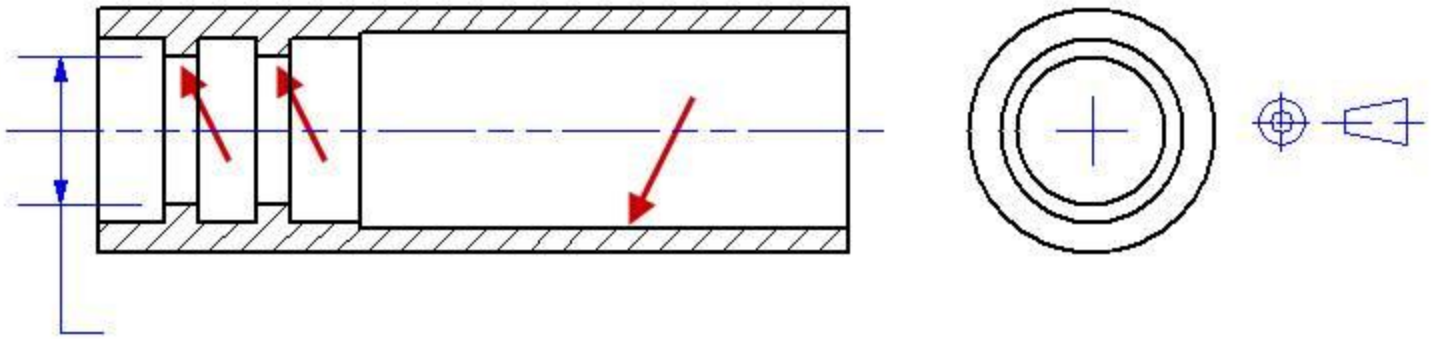
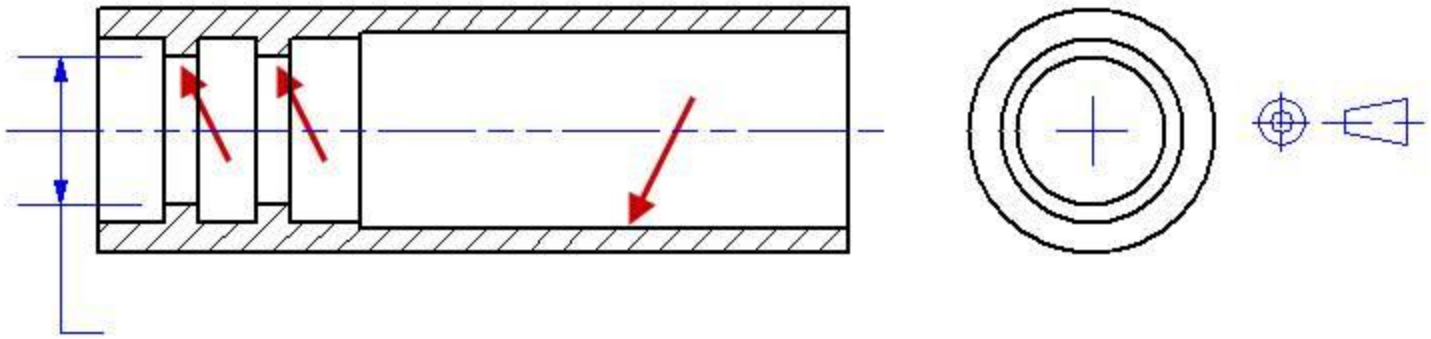


The functional objectives we want to encode are:

1. the **coaxiality** of the two small bores shall be held **reasonably tightly** relative to the long bore (Datum Feature A) on the right.

Composite Feature Control Frames – **Up to four tiers**



The functional objectives we want to encode are:

1. the **coaxiality** of the two small bores shall be held **reasonably tightly** relative to the long bore (Datum Feature A) on the right.
2. the **combined parallelism** of the two small bores shall be held **more tightly** relative to the long bore.

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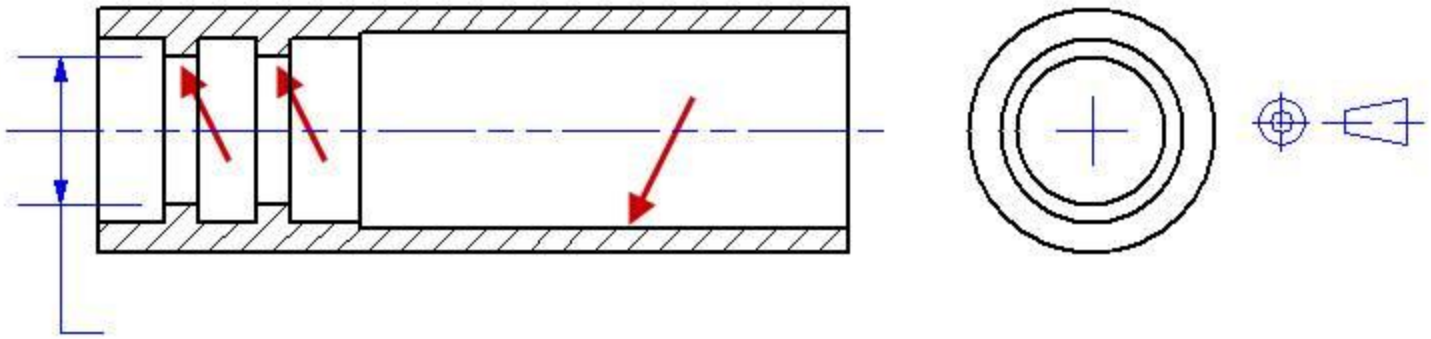

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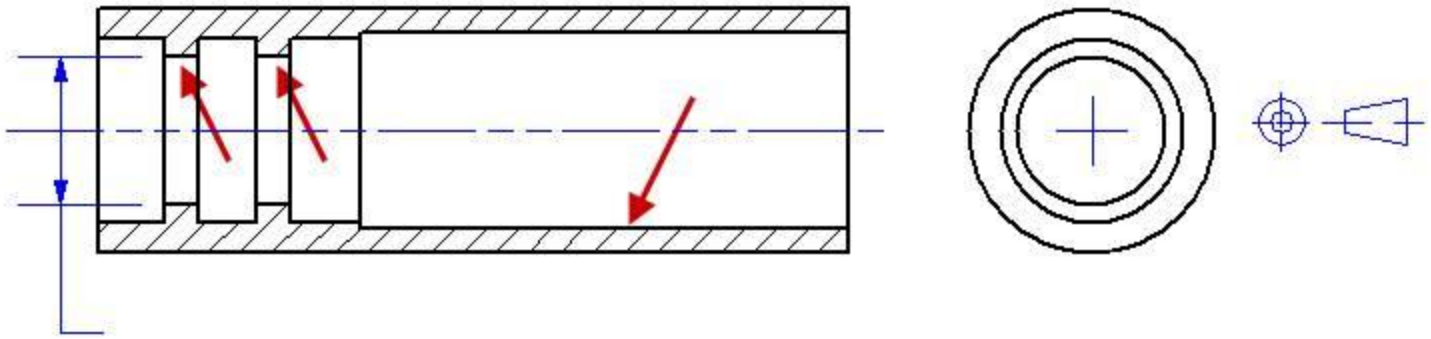
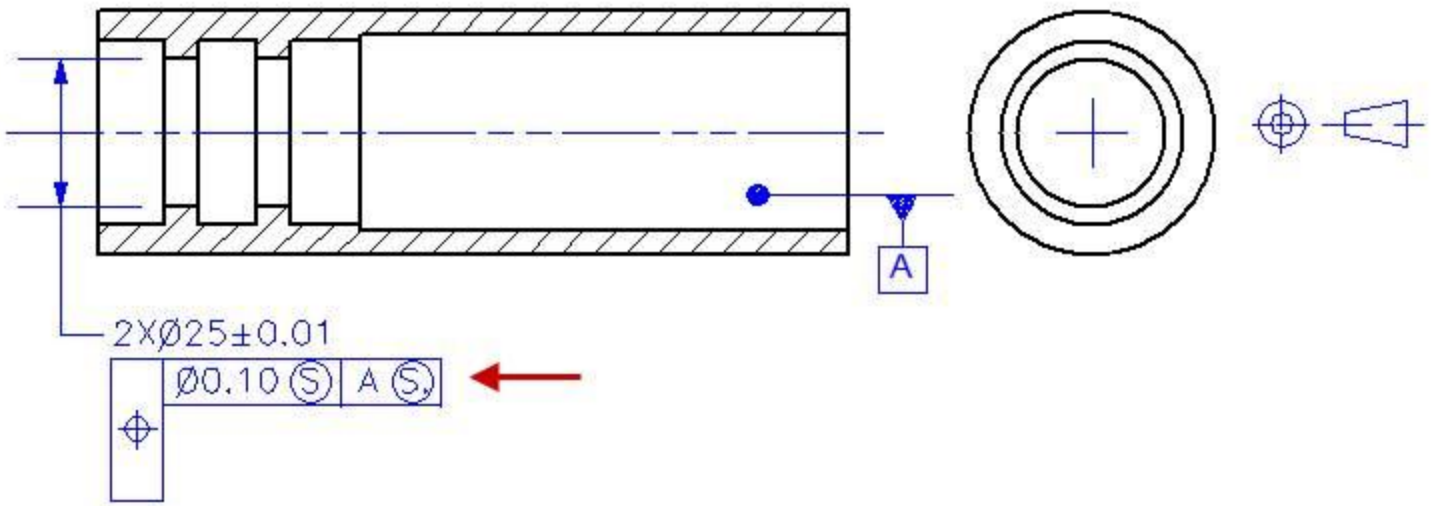
2. the **combined parallelism** of the two small bores shall be held **more tightly** relative to the long bore.
3. the **mutual coaxiality** of the two small bores shall be held **still more tightly**.

Composite Feature Control Frames – **Up to four tiers**



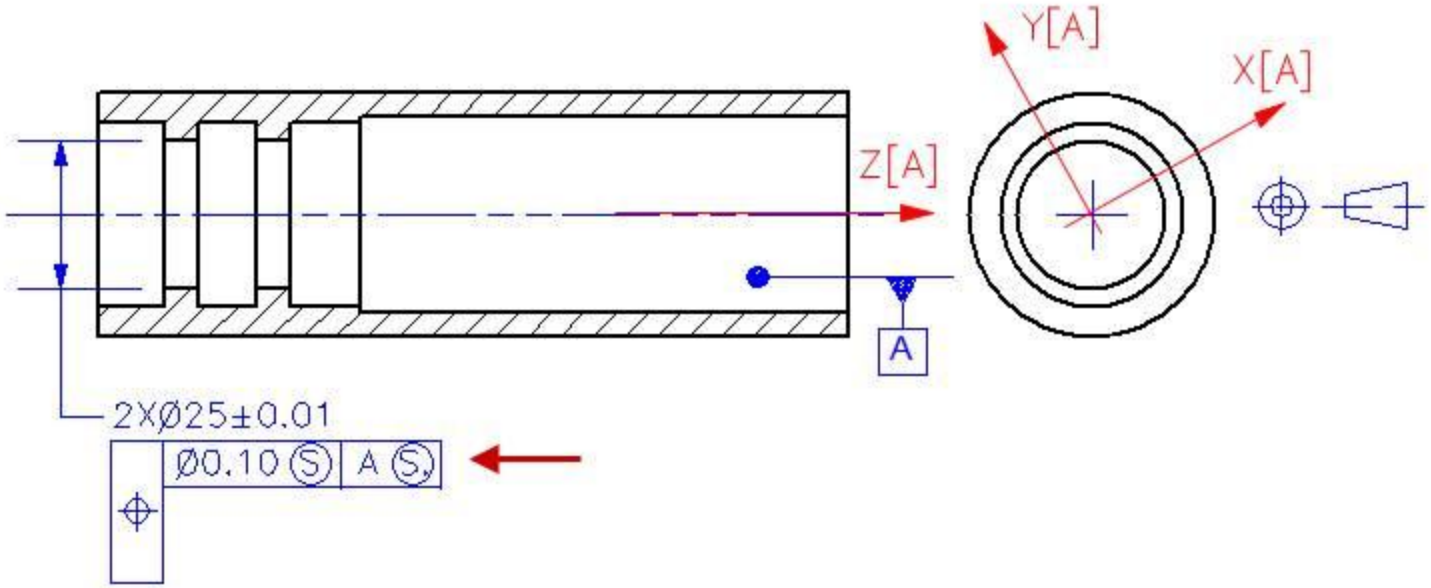
Here's how we can do that using a Composite Feature Control Frame!

Composite Feature Control Frames – **Up to four tiers**



1. Because A in the **first tier** constrains **pitch**, **yaw** and both degrees of **translational freedom**, the first tier imposes global coaxiality relative to A.

Composite Feature Control Frames – **Up to four tiers**



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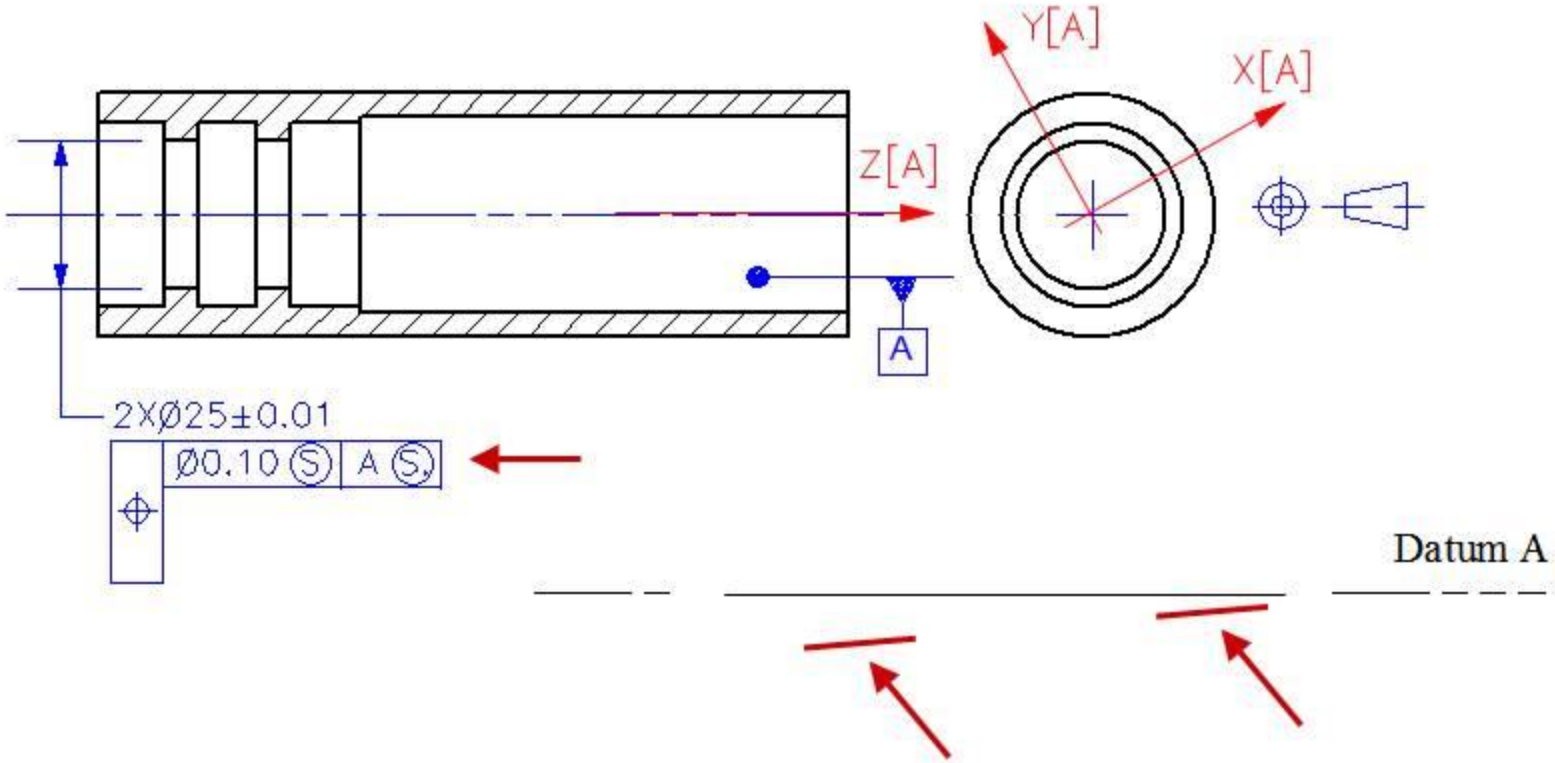

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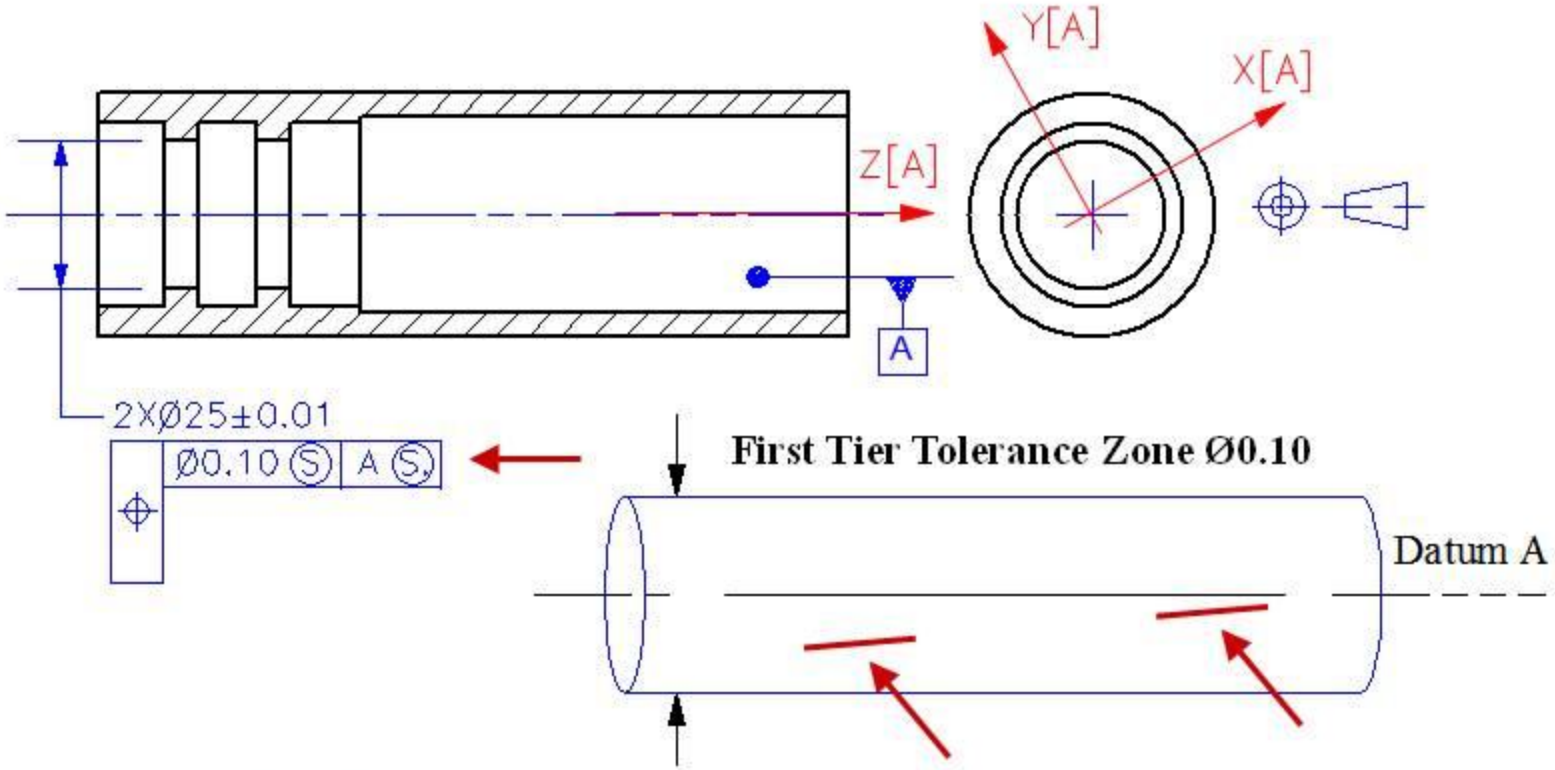
The unfortunately slightly offset, skewed axes of the small bores

Composite Feature Control Frames – **Up to four tiers**



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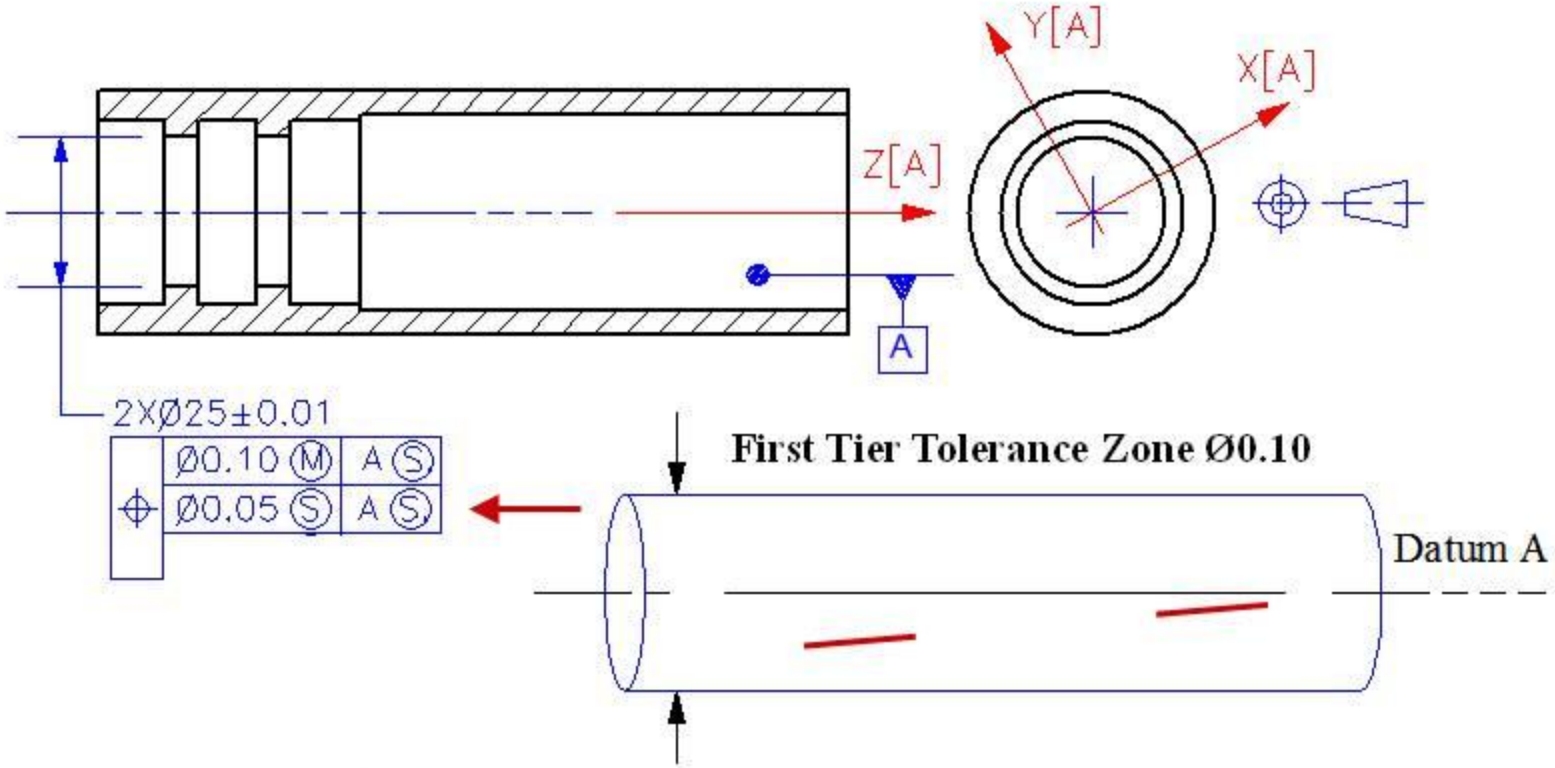
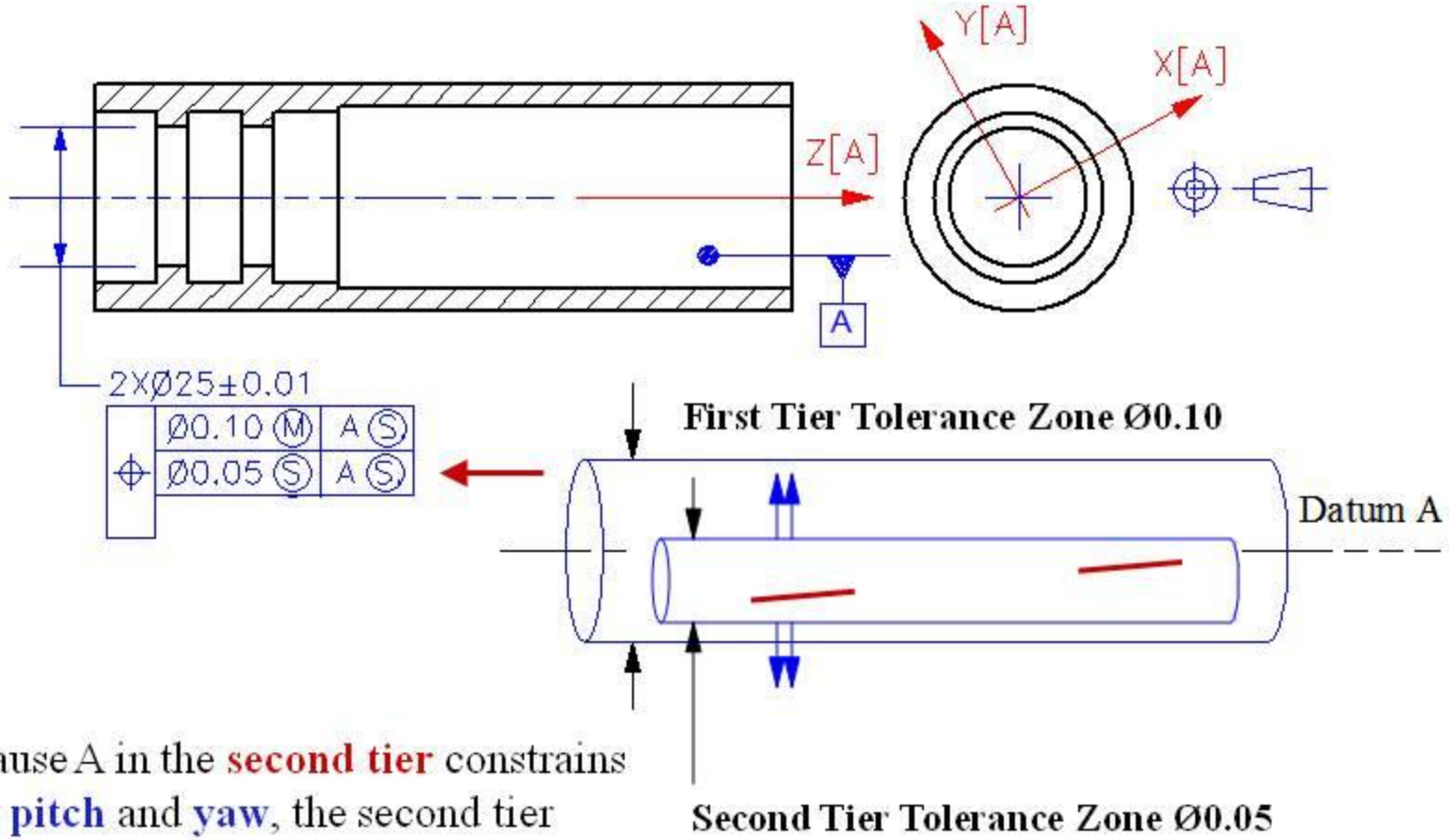


2. Because A in the **second tier** constrains **only pitch** and **yaw**, the second tier imposes refined mutual coaxiality and **refined parallelism** relative to A.

Composite Feature Control Frames – **Up to four tiers**



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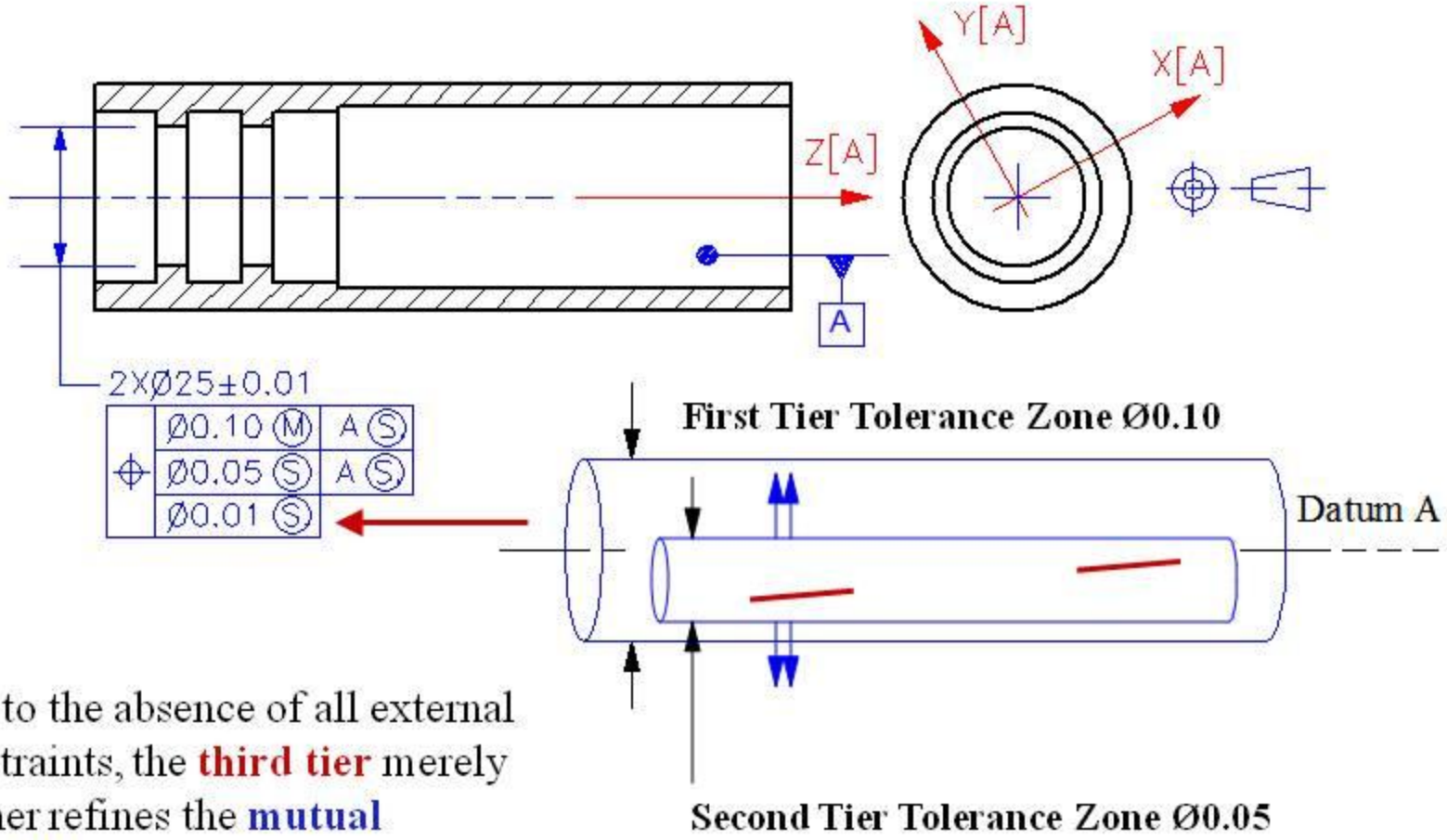
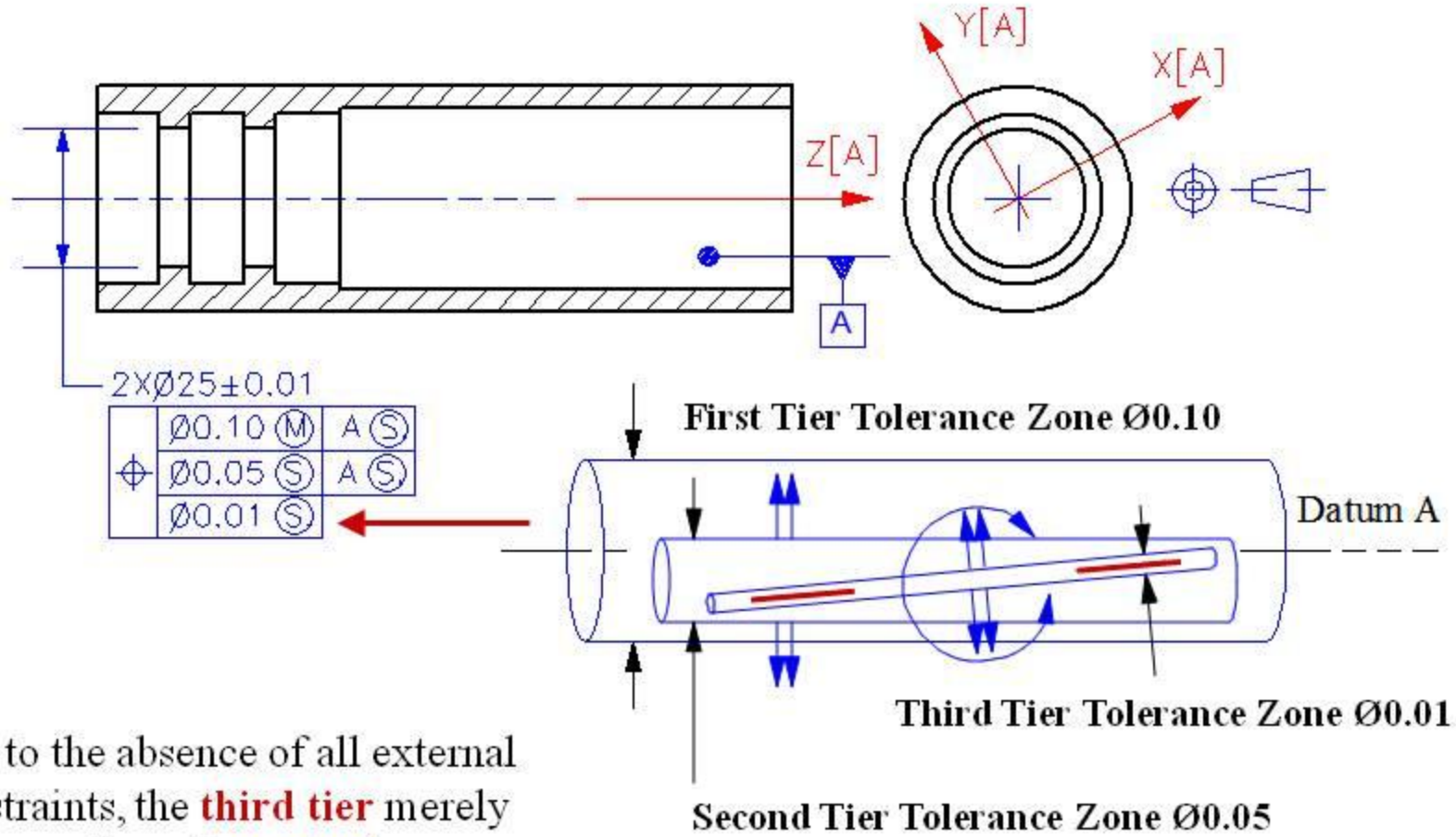


3. Due to the absence of all external constraints, the **third tier** merely further refines the **mutual coaxiality** of the two bores.

Composite Feature Control Frames – **Up to four tiers**



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Composite Feature Control Frames – **Up to four tiers**

This all makes functional sense, but could it be made a little more explicit ?

Composite Feature Control Frames – **Up to four tiers**

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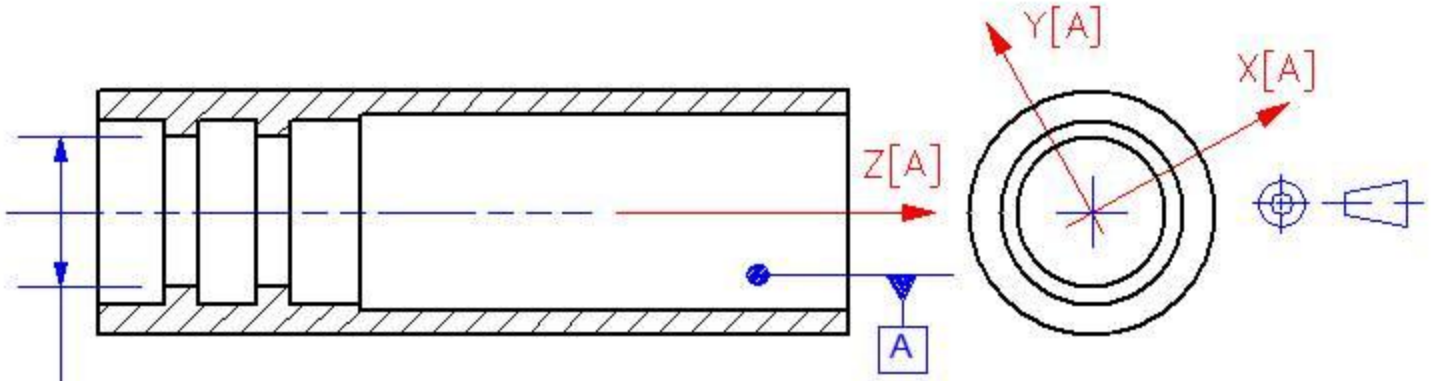
Yes, using

Degrees of Constraint Modifiers !

Composite Feature Control Frames – **Up to four tiers**

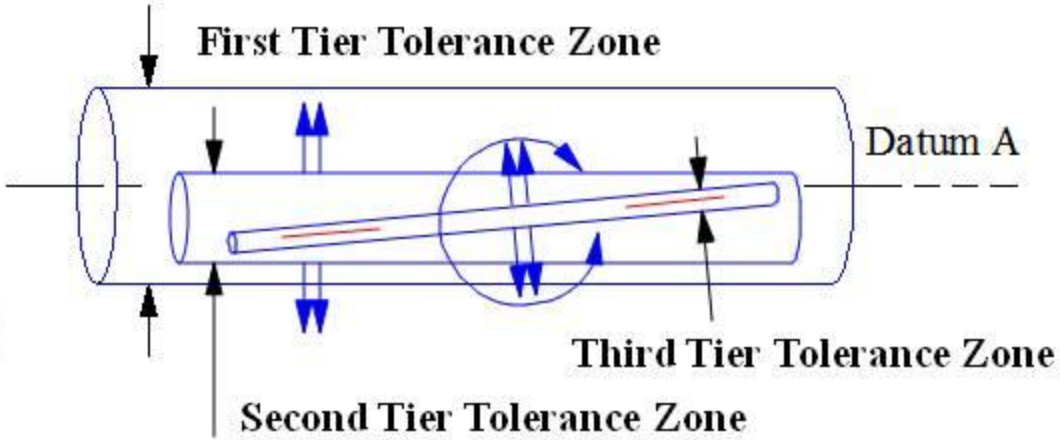


1. 2XØ25±0.01

⌖	Ø0.10 Ⓜ	A Ⓢ
	Ø0.05 Ⓢ	A Ⓢ
	Ø0.01 Ⓢ	

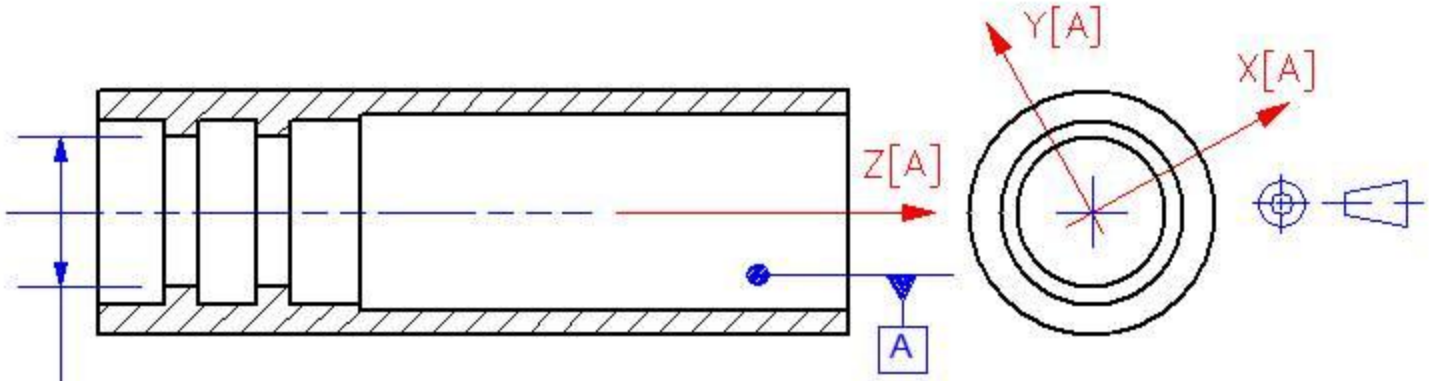
2. 2XØ25±0.01

⌖	Ø0.10 Ⓜ	A Ⓢ	
⌖	Ø0.05 Ⓢ	A Ⓢ	[u,v]
⌖	Ø0.01 Ⓢ		



Degrees of Constraint Modifiers !

Composite Feature Control Frames – **Up to four tiers**



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⌖	Ø0.10 Ⓜ	A Ⓢ	
⌖	Ø0.05 Ⓢ	A Ⓢ	[u,v]
⌖	Ø0.01 Ⓢ		

We no longer need

Composite Feature Control Frames

Degrees of Constraint Modifiers !

Composite Feature Control Frames – **Up to four tiers**

How useful are

Degrees of Constraint Modifiers ?

Composite Feature Control Frames – **Up to four tiers**

How useful are

Degrees of Constraint Modifiers ?

Very !

Composite Feature Control Frames – **Up to four tiers**

How useful are
Degrees of Constraint Modifiers ?

Very !

They eliminate the need for Composite Feature Control Frames and provide even more
function encoding power
than we had before !

Y14.5 2009 Changes and their Impact

New Tools impacting Datums

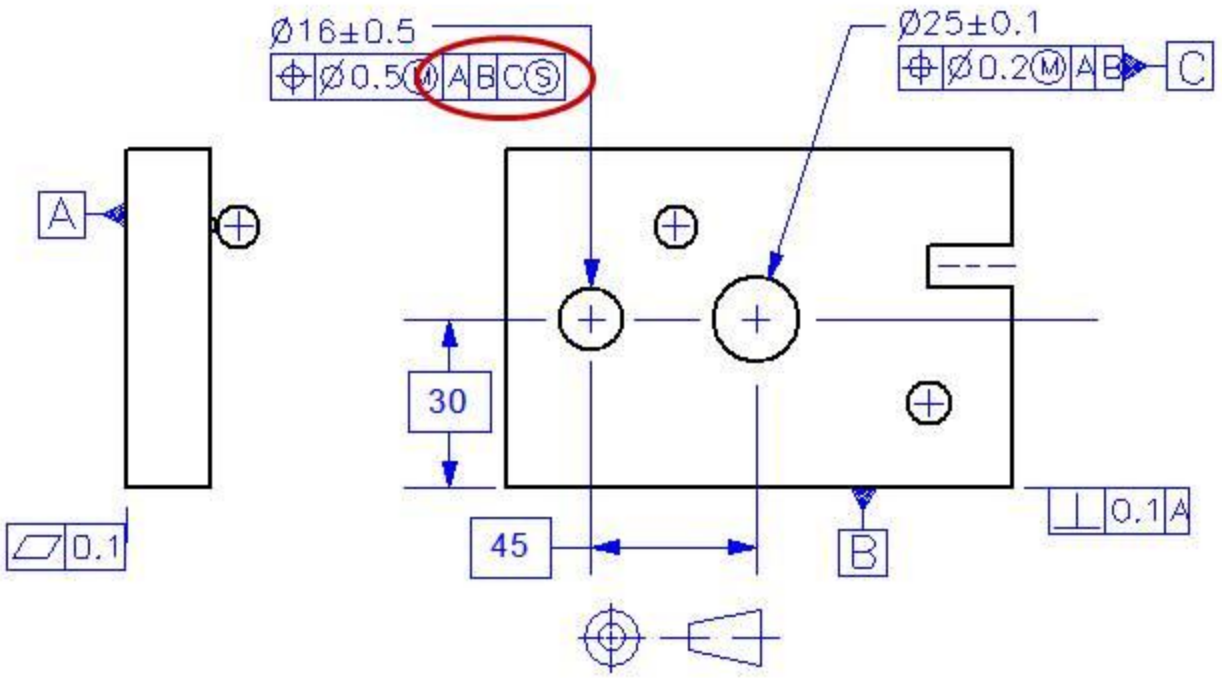
1. A more complete definition of **Datums**
2. Applicability of the modifiers Ⓢ Ⓜ Ⓛ to Planar Datum Features
3. The new Datum (Feature Simulator) **Translation Modifier**: ►
4. New Degrees of Constraint Modifiers: **[u,v,w,x,y,z]**
5. Expanded Composite Feature Control Frames – **Up to four tiers**.
6. New Datum Reference Frame Axis Labels: **X[A,B,C], Y[…]** etc.

Datum Reference Frame Axis Labels: **X[A,B,C], Y[…]** etc.

As we know,

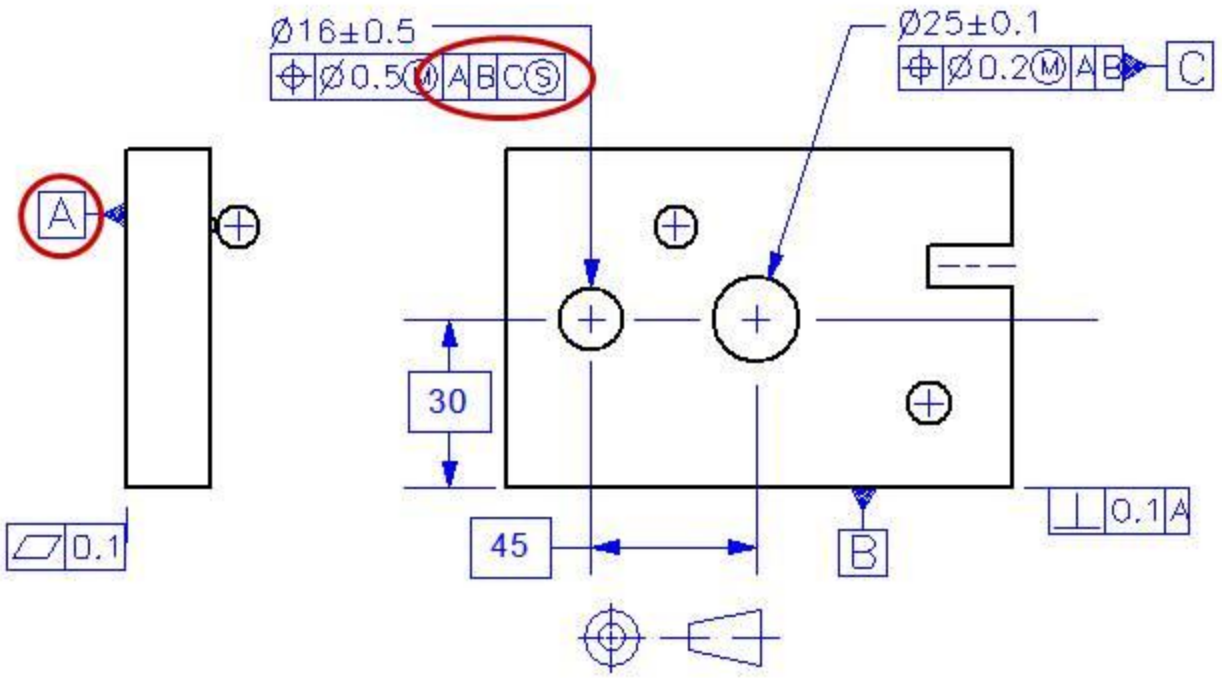
locating the axes of a Datum Reference Frame isn't so easy !

Datum Reference Frame Axis Labels: X[A,B,C], Y[…] etc.



Can you figure out the locations of the X, Y and Z axes of the DRF defined here?

Datum Reference Frame Axis Labels: **X[A,B,C], Y[…]** etc.



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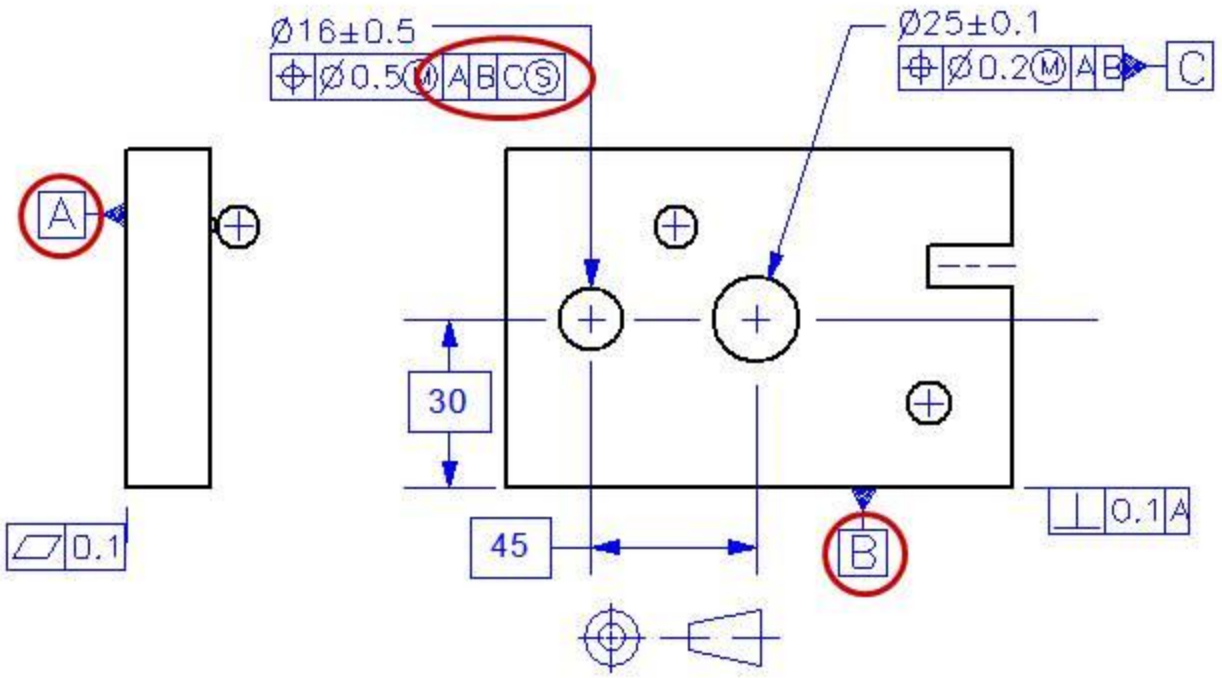

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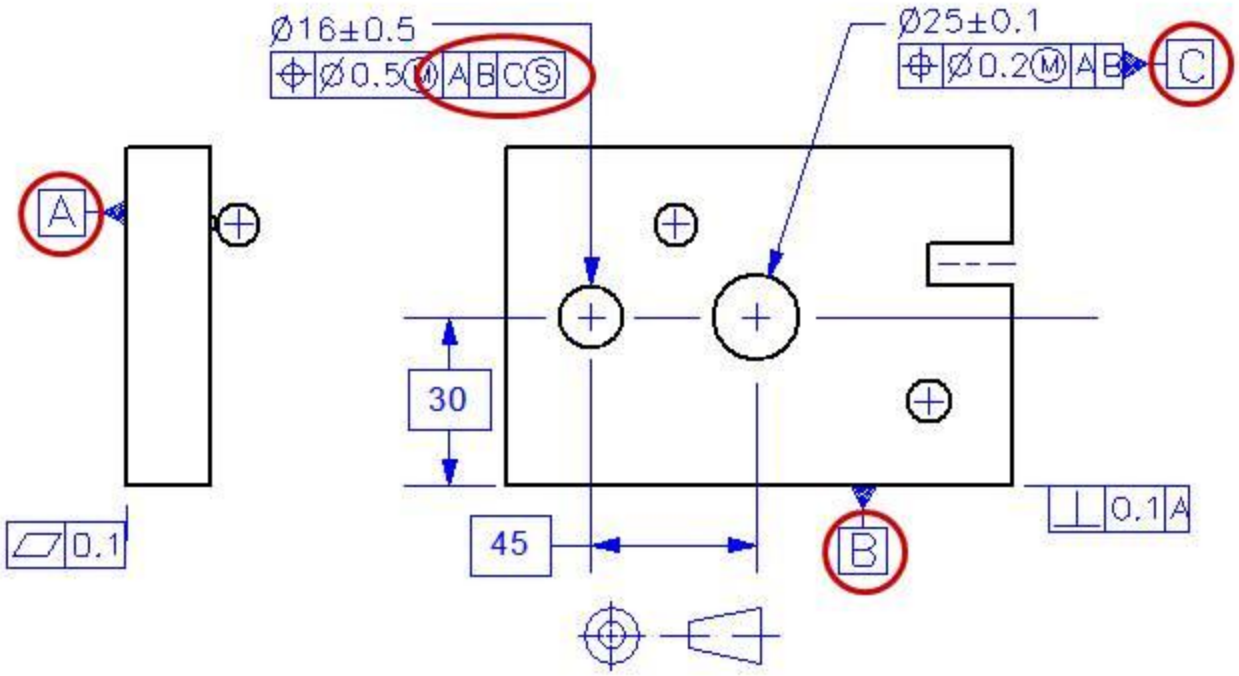

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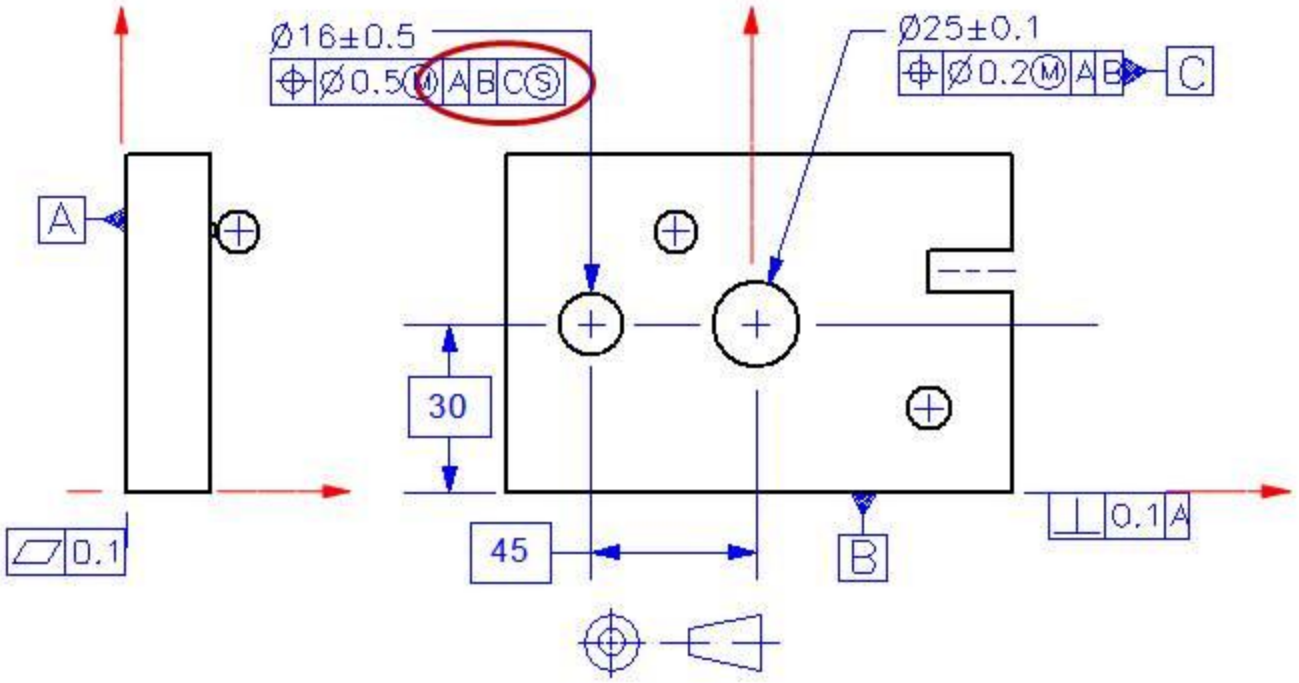
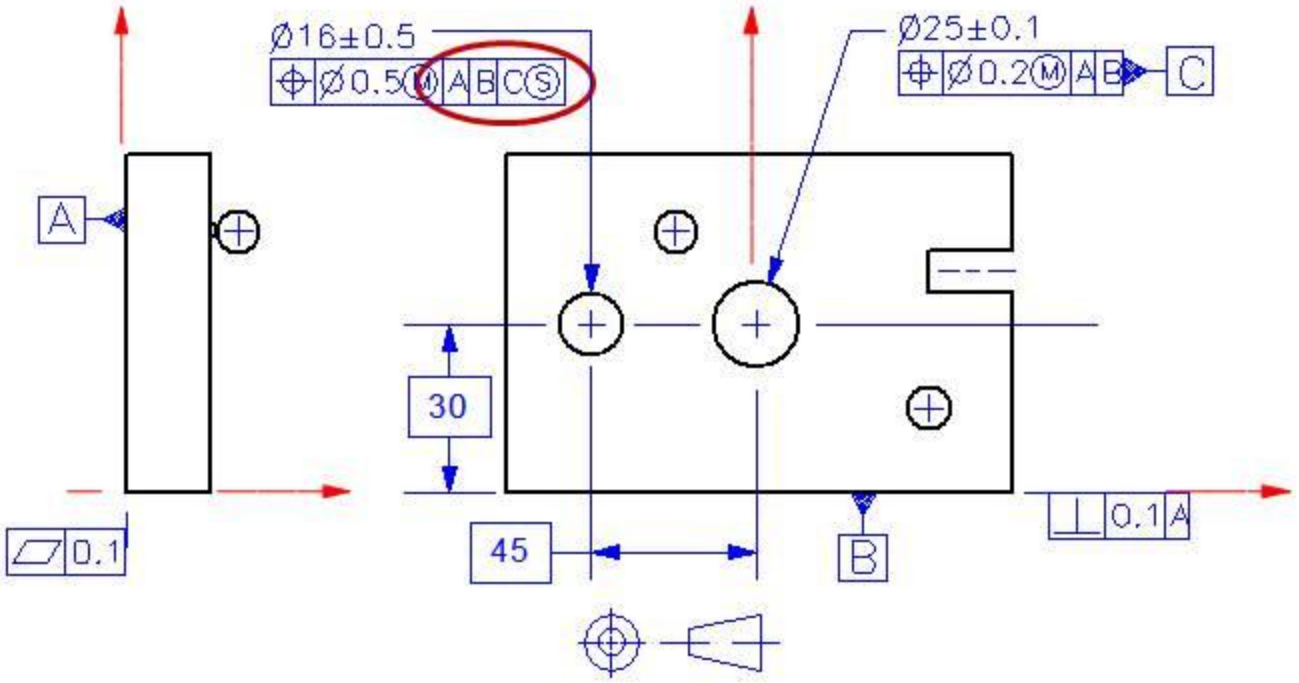


→ Here they are !

Datum Reference Frame Axis Labels: X[A,B,C], Y[…] etc.



→ But which axis is **X**, which is **Y** and which is **Z** ?

Datum Reference Frame Axis Labels: **X[A,B,C], Y[…]** etc.

We now have

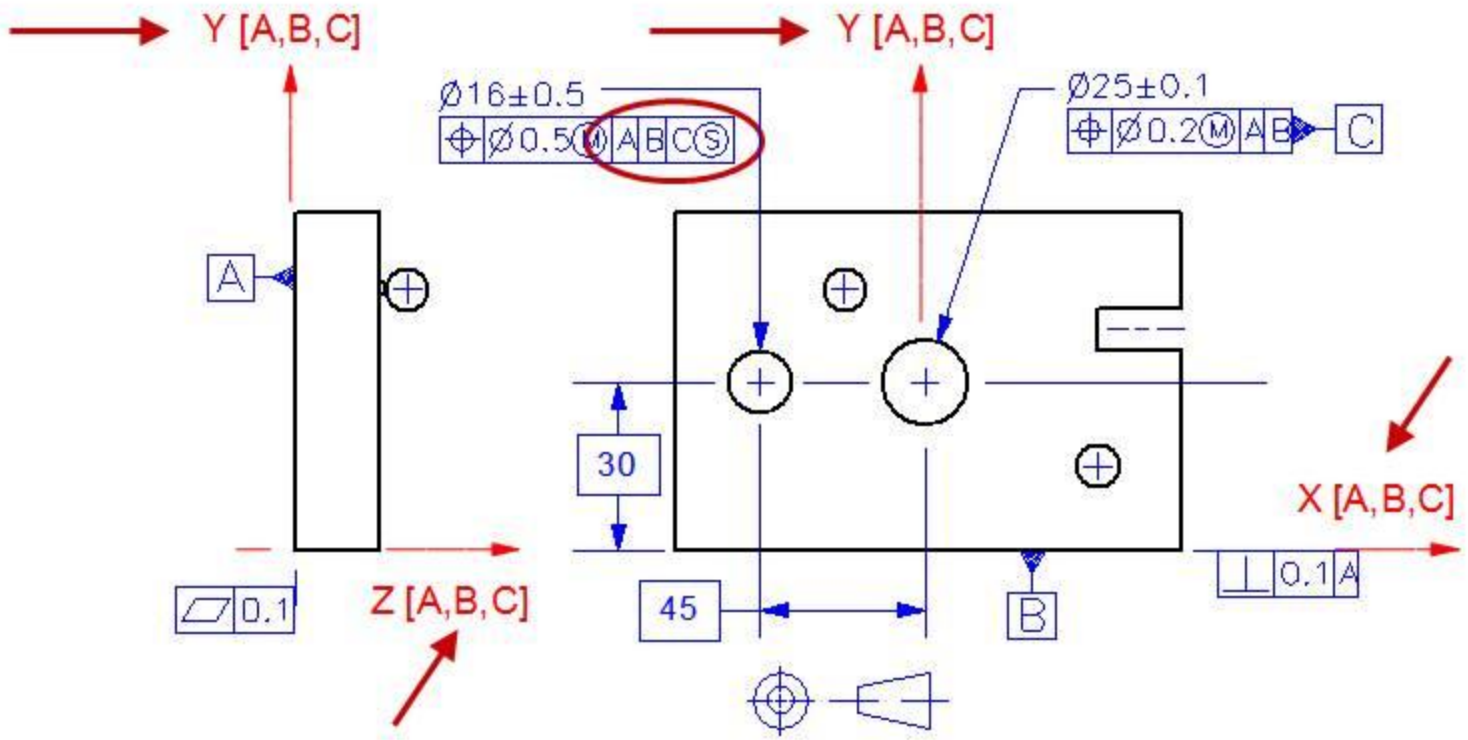
Datum Reference Frame Axis Labels

X[A,B,C]

Y[A,B,C]

Z[A,B,C]

Datum Reference Frame Axis Labels: X[A,B,C], Y[…] etc.



→ Now everyone knows exactly what's going on !

Datum Reference Frame Axis Labels: **X[A,B,C], Y[…]** etc.

How useful are **DRF Axis Labels** ?

Datum Reference Frame Axis Labels: **X[A,B,C], Y[…]** etc.

How useful are
DRF Axis Labels ?

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Benefits

1) DRF axis labels **accelerate the decoding** of Feature Control Frames in the machine shop and in inspection.

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Benefits

1) DRF axis labels **accelerate the decoding** of Feature Control Frames in the machine shop and in inspection.

2) DRF axis labels **standardize** coordinate measuring machine data reporting.

3) DRF axis labels are **required** when using **Degrees of Constraint** modifiers, because the axes are referenced in the code.

Y14.5 2009 Changes and their Impact

New Tools impacting Tolerance Zones

(a partial set)

1. Unequally Disposed Profile Modifier: Ⓤ
2. Non-Uniform Modifier: **[NON-UNIFORM]**
3. ALL OVER Modifier: 
4. Continuous Feature Modifier: ⌔CF⌔
5. Independency Modifier: Ⓘ

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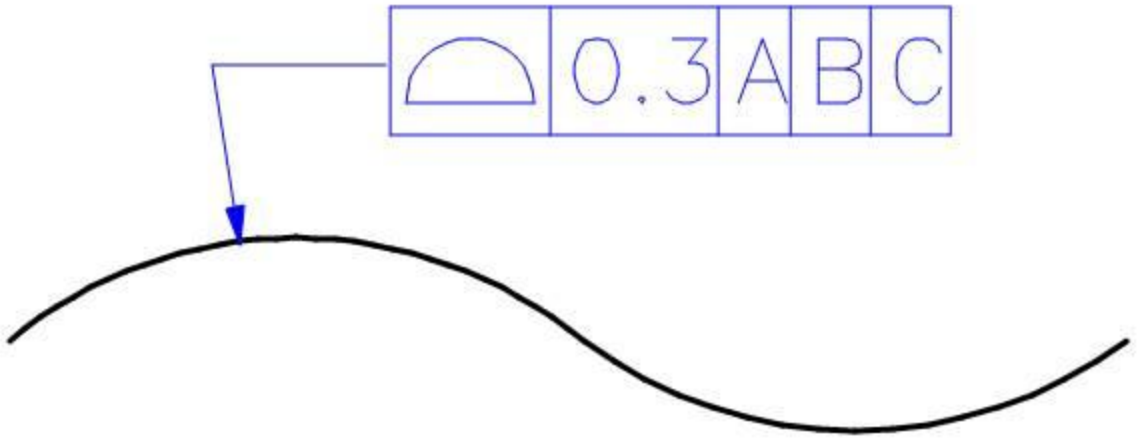
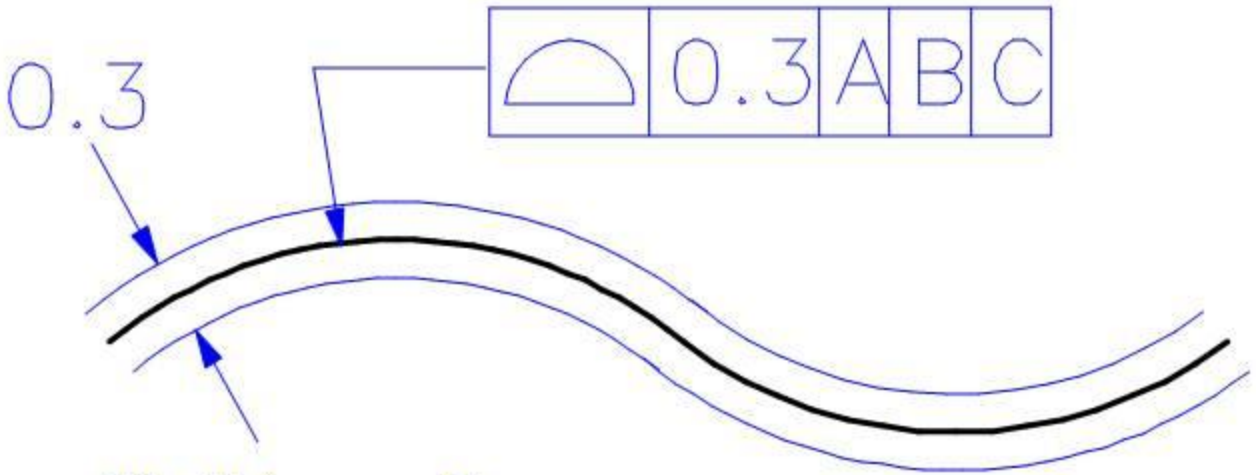
Unequally Disposed Profile Modifier: Ⓤ

The Surface Profile tool specifies **symmetrical** skin-like tolerance zones by **default**.



Unequally Disposed Profile Modifier: Ⓤ

The Surface Profile tool specifies **symmetrical** skin-like tolerance zones by **default**.



The Tolerance Zone

Unequally Disposed Profile Modifier: Ⓤ

The **1994** Standard specifies **unilateral** tolerance zones **graphically**.

Unequally Disposed Profile Modifier: Ⓤ

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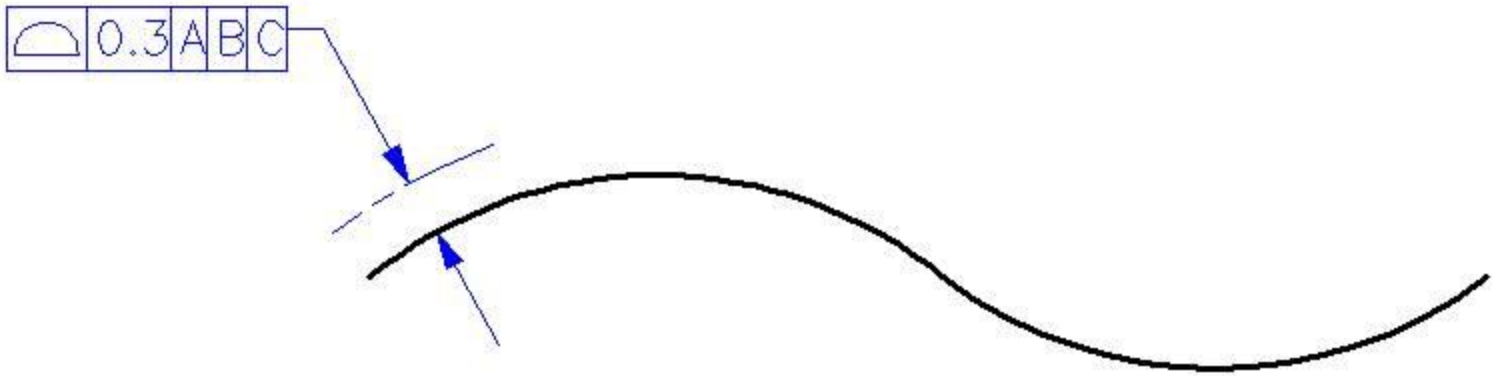
Y14.5M 1994



Unequally Disposed Profile Modifier: Ⓤ

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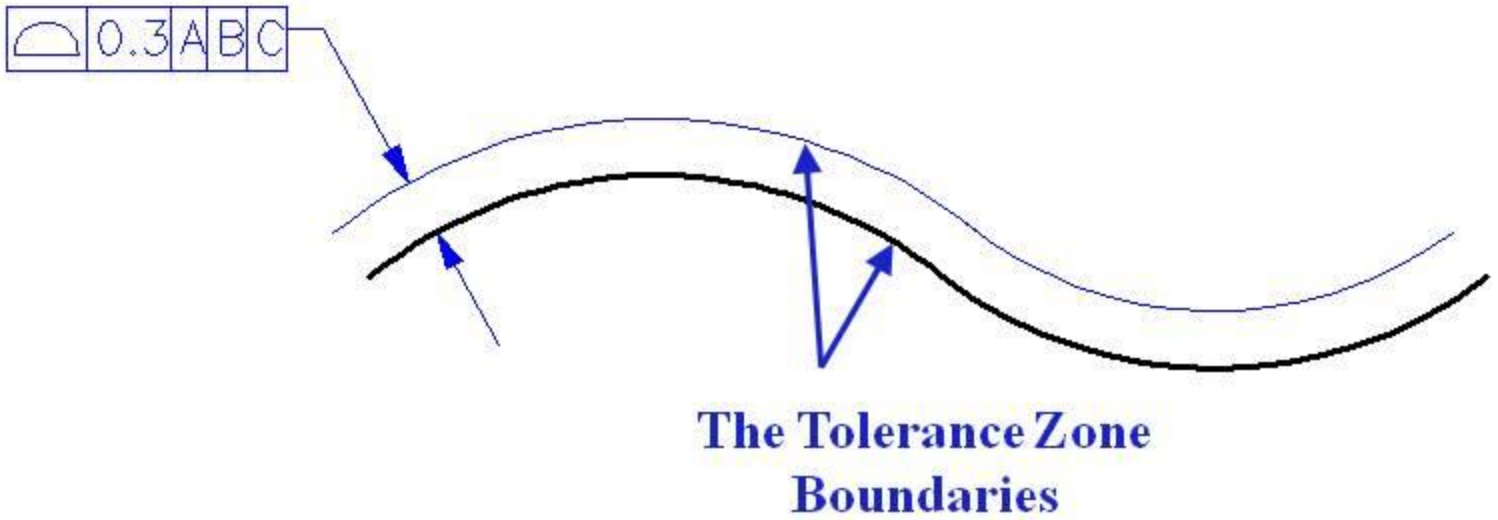
Y14.5M 1994

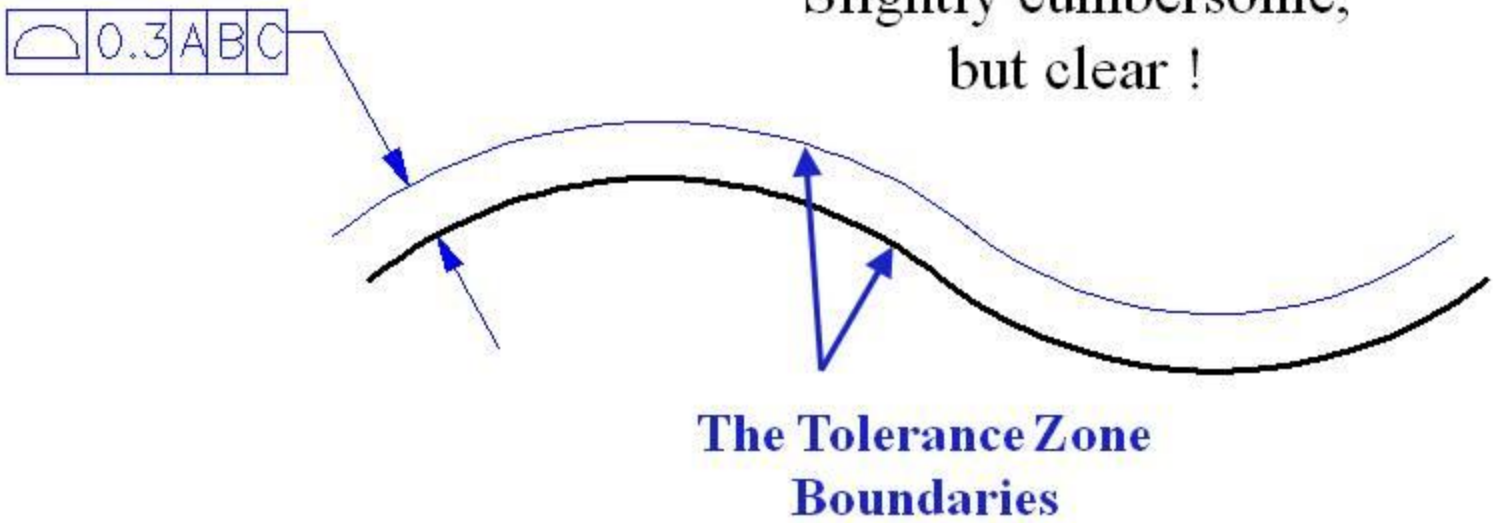


The Tolerance Zone Boundaries

Unequally Disposed Profile Modifier: Ⓤ

The **1994** Standard specifies **unilateral** tolerance zones **graphically**.

Y14.5M 1994



Unequally Disposed Profile Modifier: Ⓤ

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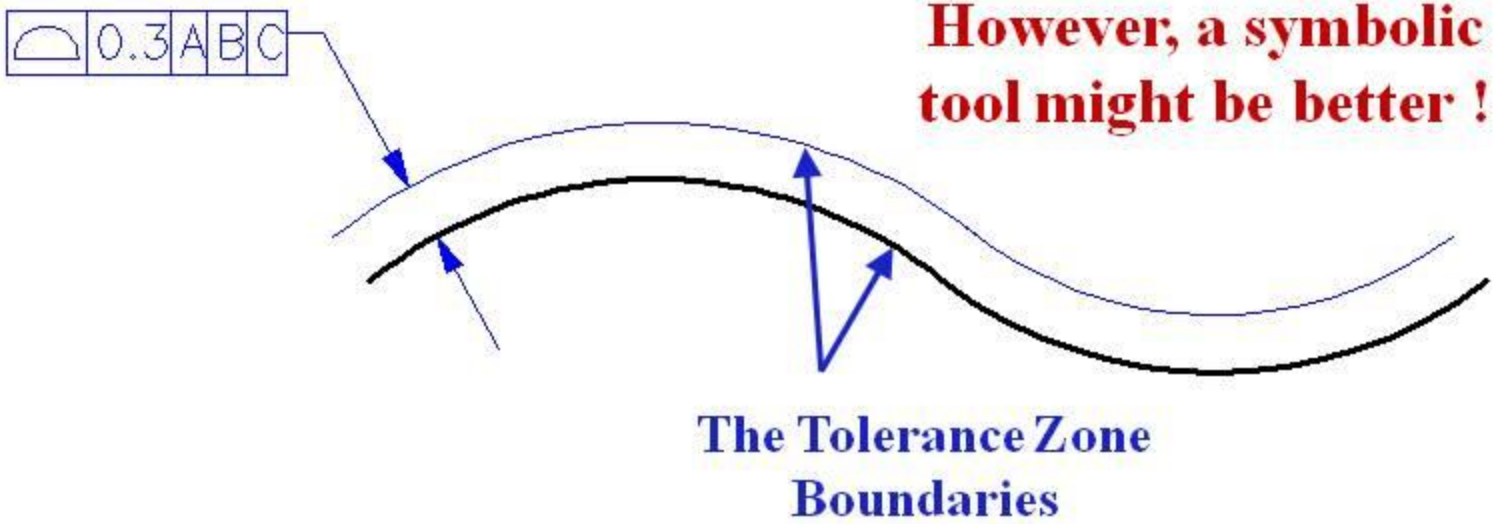
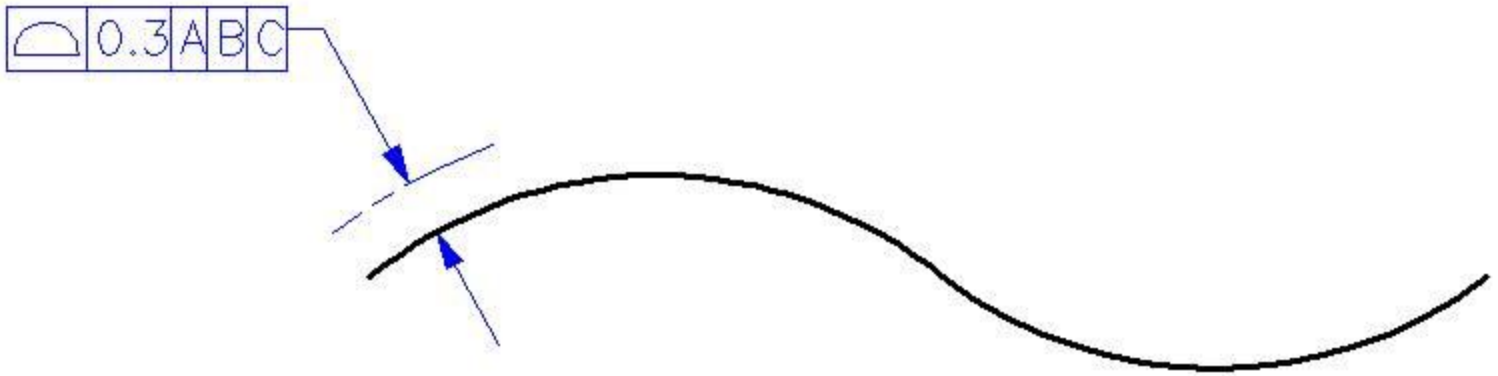
Y14.5M 1994



Unequally Disposed Profile Modifier: Ⓤ

The **2009** Standard specifies **unilateral** tolerance zones **symbolically** using the **unequally disposed** modifier Ⓤ

Y14.5M 1994



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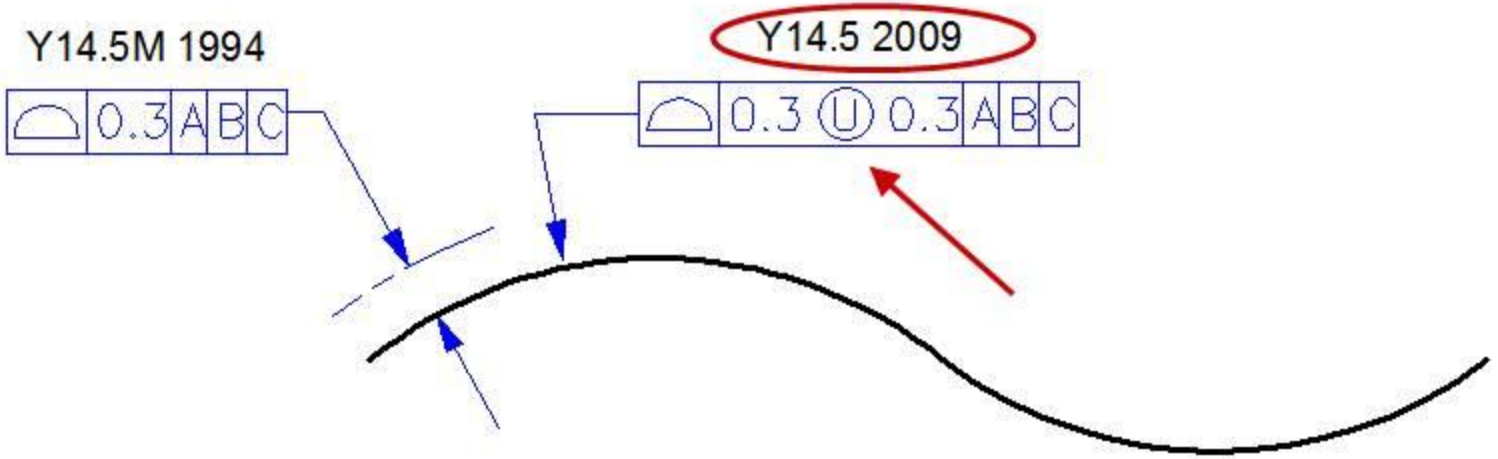

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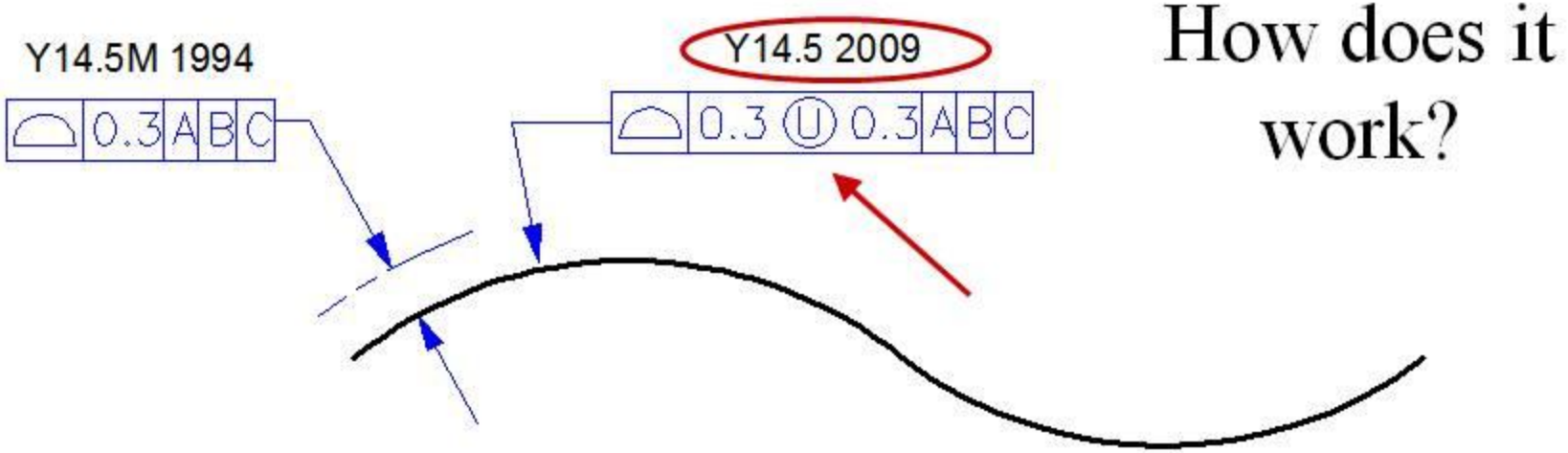
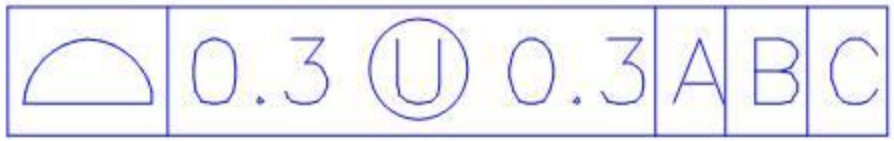


Unequally Disposed Profile Modifier: Ⓤ

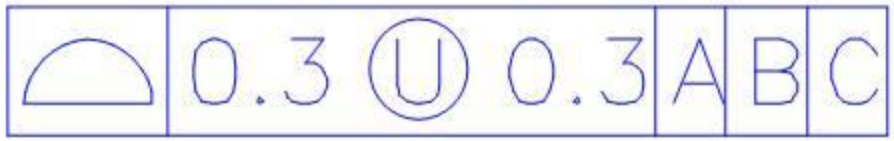
The value in front of the modifier specifies the **total tolerance**, and . . .



Unequally Disposed Profile Modifier: Ⓤ

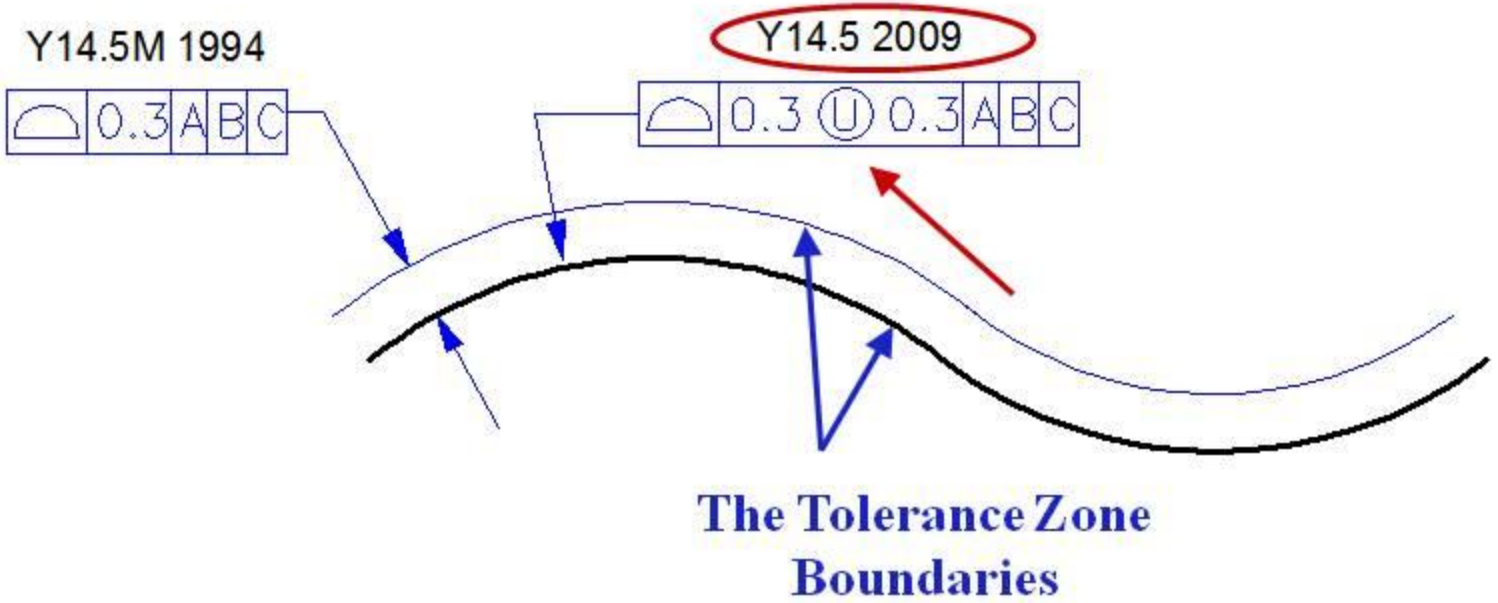
The value in front of the modifier specifies the **total tolerance**, and . . .

. . . the value behind the modifier specifies the **in-space portion** of the tolerance.



Unequally Disposed Profile Modifier: Ⓤ

The **2009** Standard specifies **unilateral** tolerance zones **symbolically** using the **unequally disposed** modifier Ⓤ



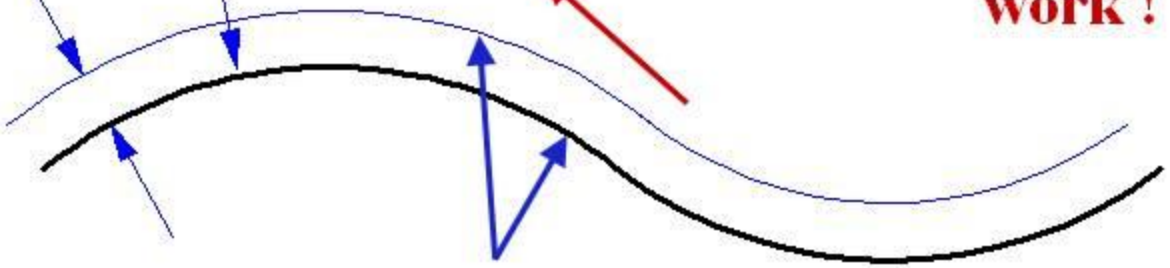
Unequally Disposed Profile Modifier: Ⓤ

The **2009** Standard specifies **unilateral** tolerance zones **symbolically** using the **unequally disposed** modifier Ⓤ

Y14.5M 1994

Y14.5 2009

Once we latch, it seems to work !



The Tolerance Zone Boundaries

Unequally Disposed Profile Modifier: Ⓤ

The **1994** Standard also specifies **unequal bilateral** tolerance zones **graphically**:

Unequally Disposed Profile Modifier: Ⓤ

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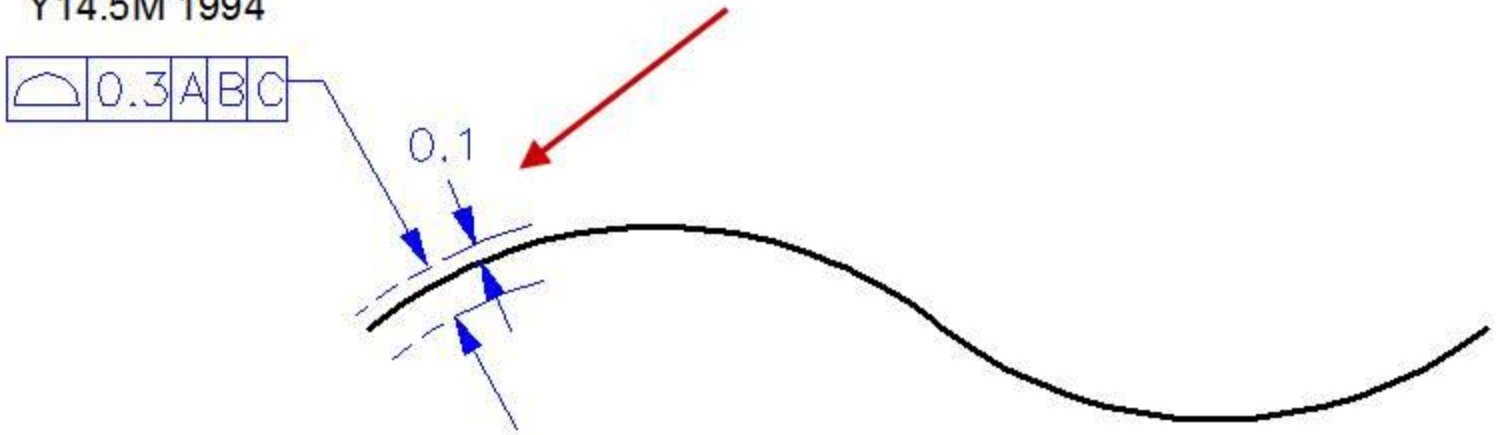
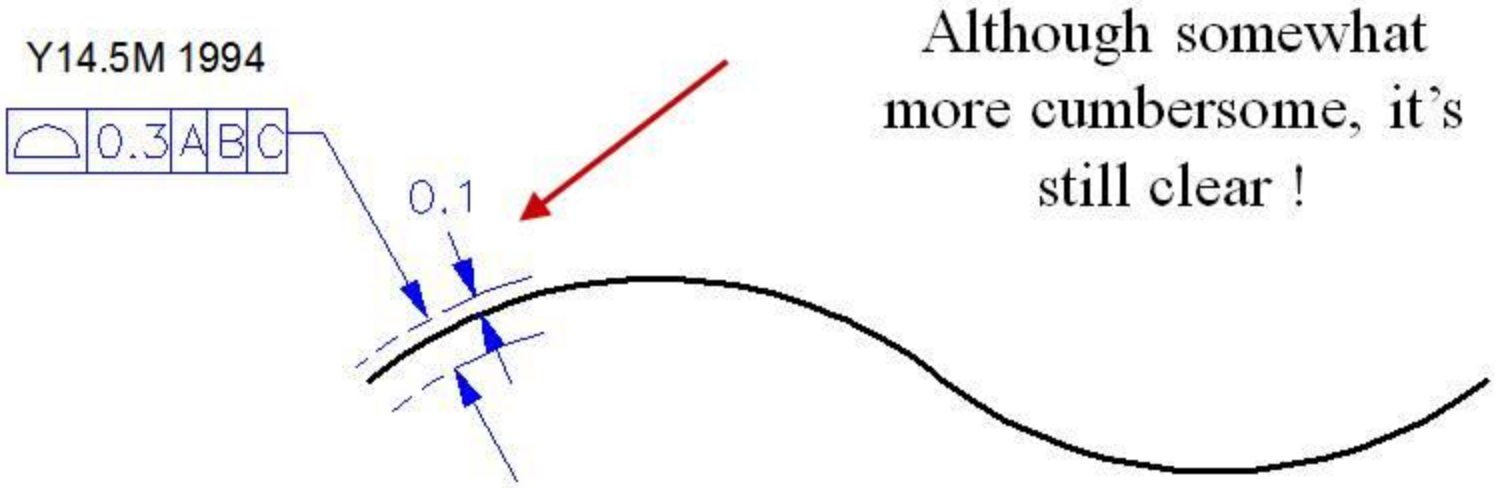
Y14.5M 1994



Unequally Disposed Profile Modifier: Ⓤ

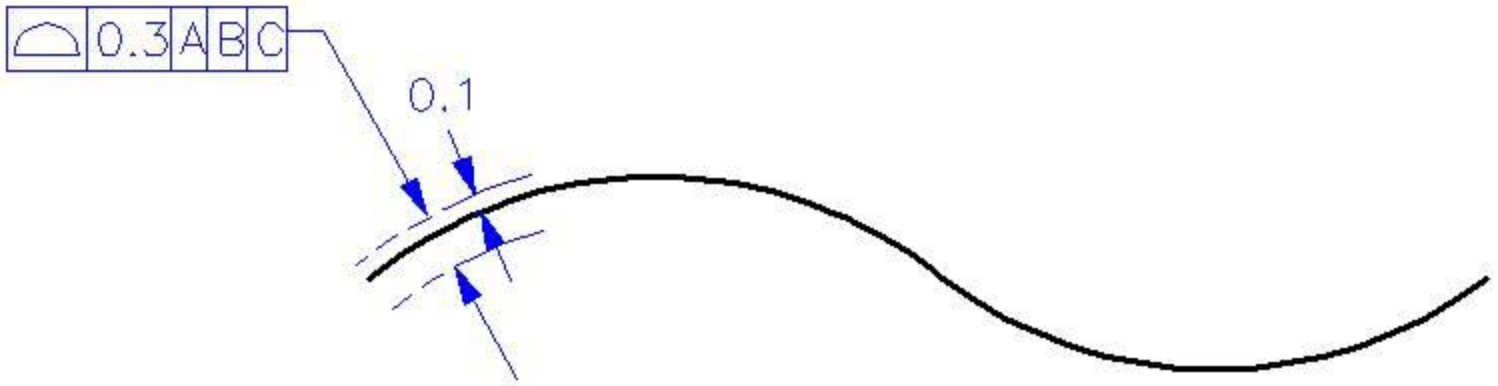
The **1994** Standard also specifies **unequal bilateral** tolerance zones **graphically**:



Unequally Disposed Profile Modifier: Ⓤ

The **2009** Standard also uses the **symbol** Ⓤ to specify **unequal bilateral** tolerance zones

Y14.5M 1994



Unequally Disposed Profile Modifier: Ⓤ

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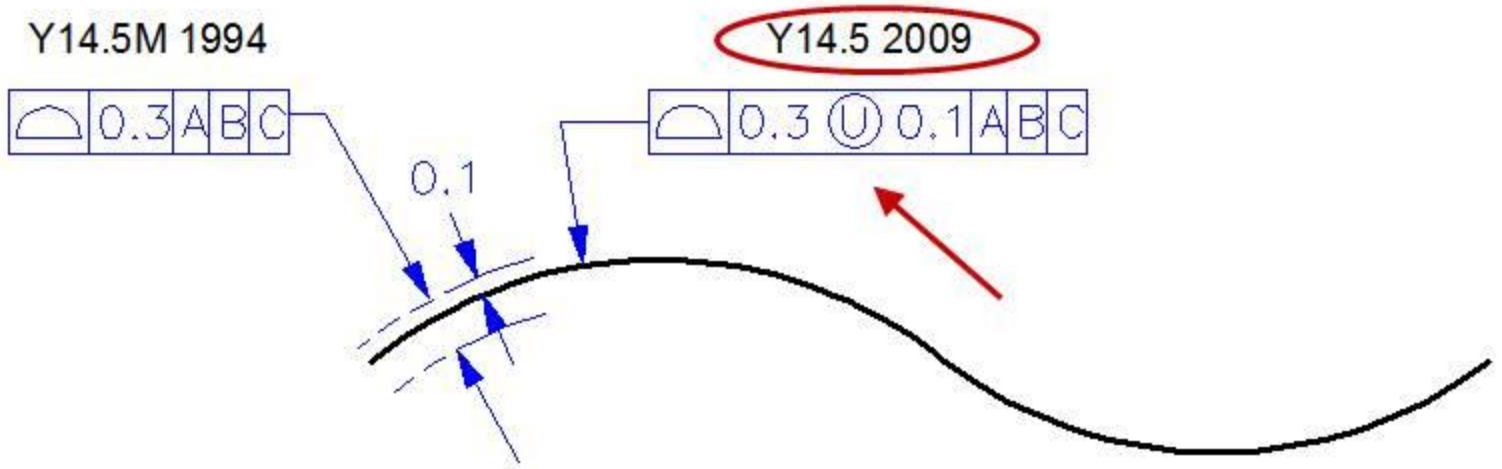
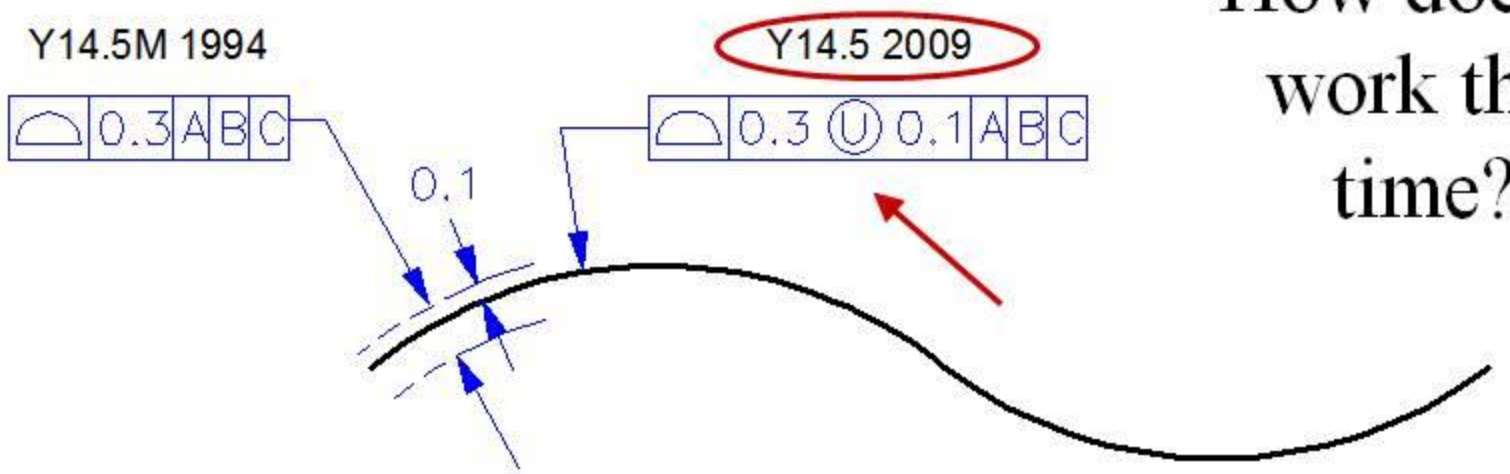


Unequally Disposed Profile Modifier: Ⓤ

The **2009** Standard also uses the **symbol** Ⓤ to specify **unequal bilateral** tolerance zones

How does it work this time?

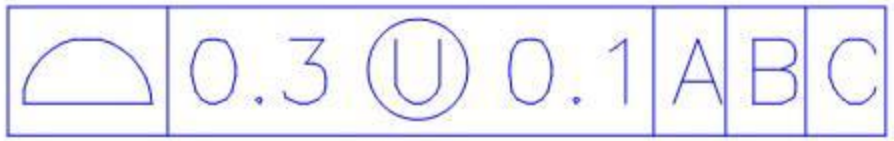


Unequally Disposed Profile Modifier: Ⓤ

Same as before !

Unequally Disposed Profile Modifier: Ⓤ

The value in front of the modifier specifies the **total tolerance**, and . . .



Same as before !

Unequally Disposed Profile Modifier: Ⓤ

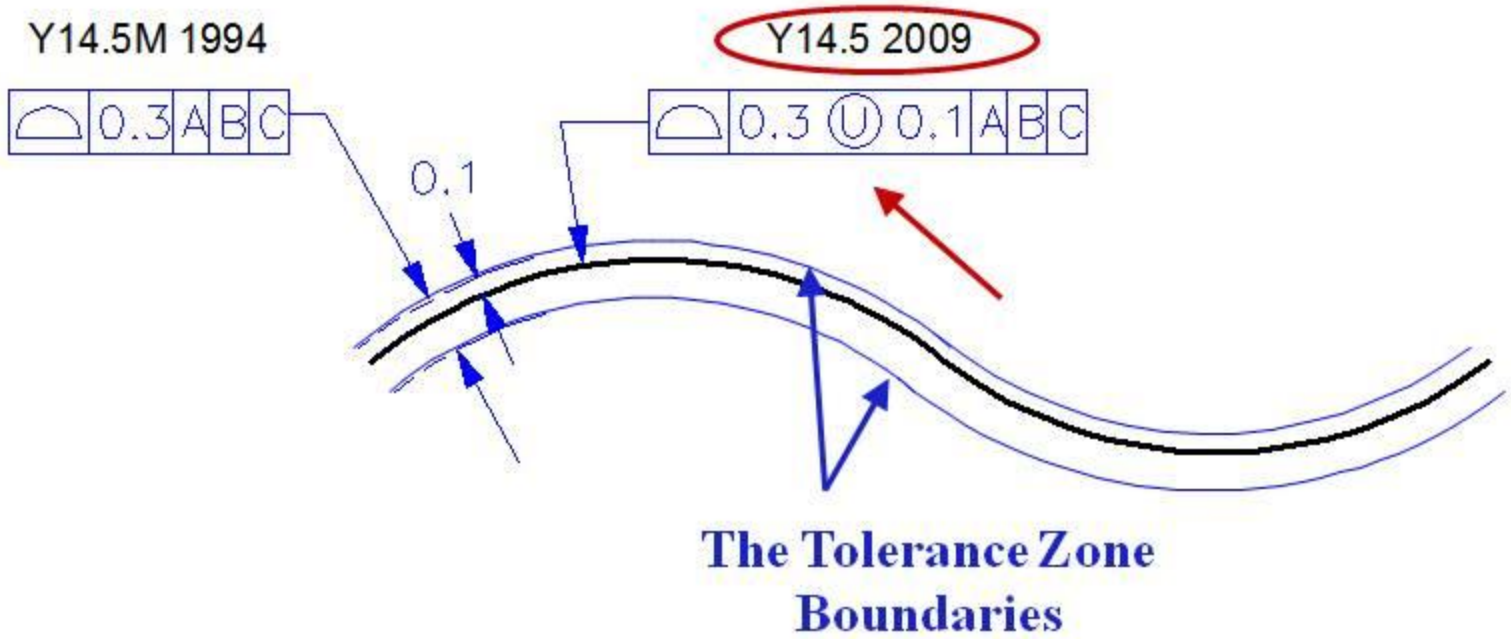
The value in front of the modifier specifies the **total tolerance**, and . . .

. . . the value behind the modifier specifies the **in-space portion** of the tolerance.

Same as before !

Unequally Disposed Profile Modifier: Ⓤ

The **2009** Standard also uses the **symbol** Ⓤ to specify **unequal bilateral** tolerance zones



Unequally Disposed Profile Modifier: Ⓤ

How useful is the **Modifier Ⓤ** ?

Unequally Disposed Profile Modifier: Ⓤ

How useful is the
Modifier Ⓤ ?

Very !

Unequally Disposed Profile Modifier: Ⓤ

How useful is the
Modifier Ⓤ ?

Very !

We have eliminated
dependence on visual cues !

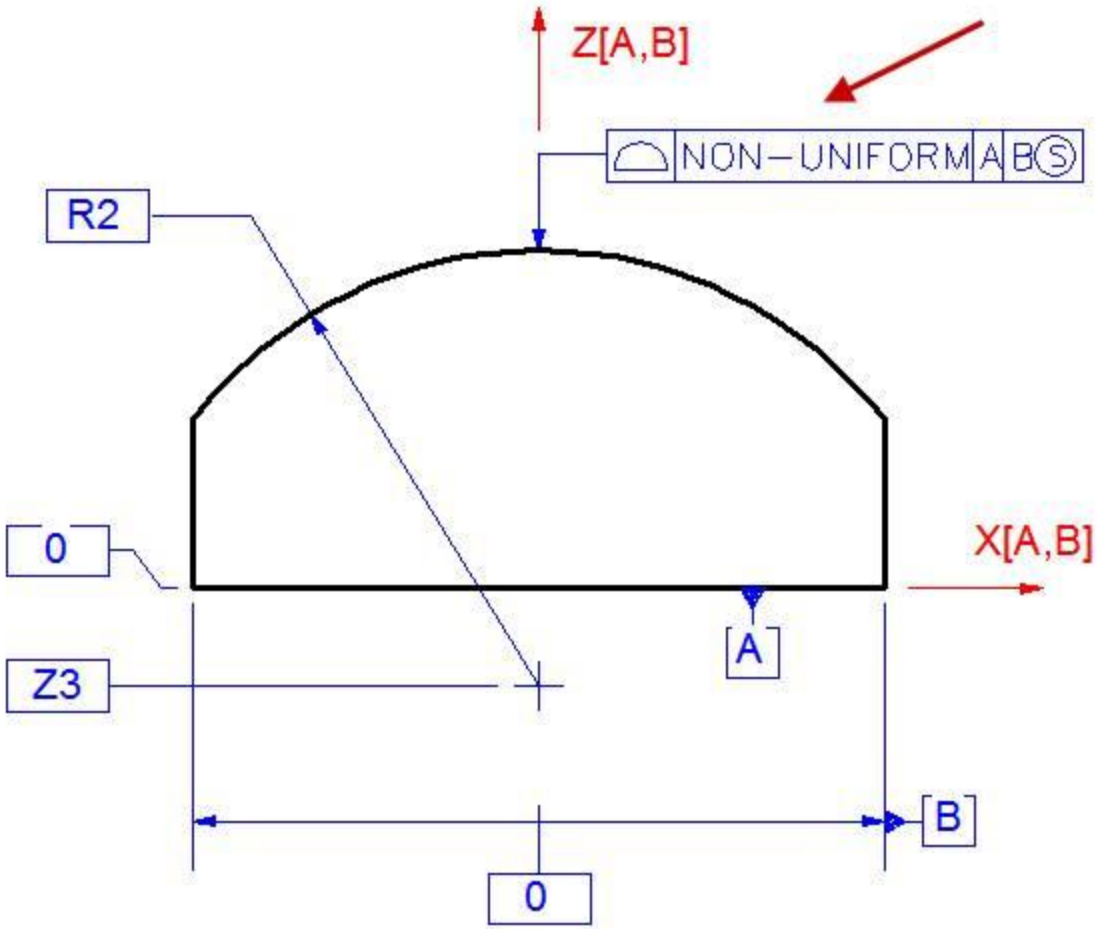
Y14.5 2009 Changes and their Impact

New Tools impacting Tolerance Zones

(a partial set)

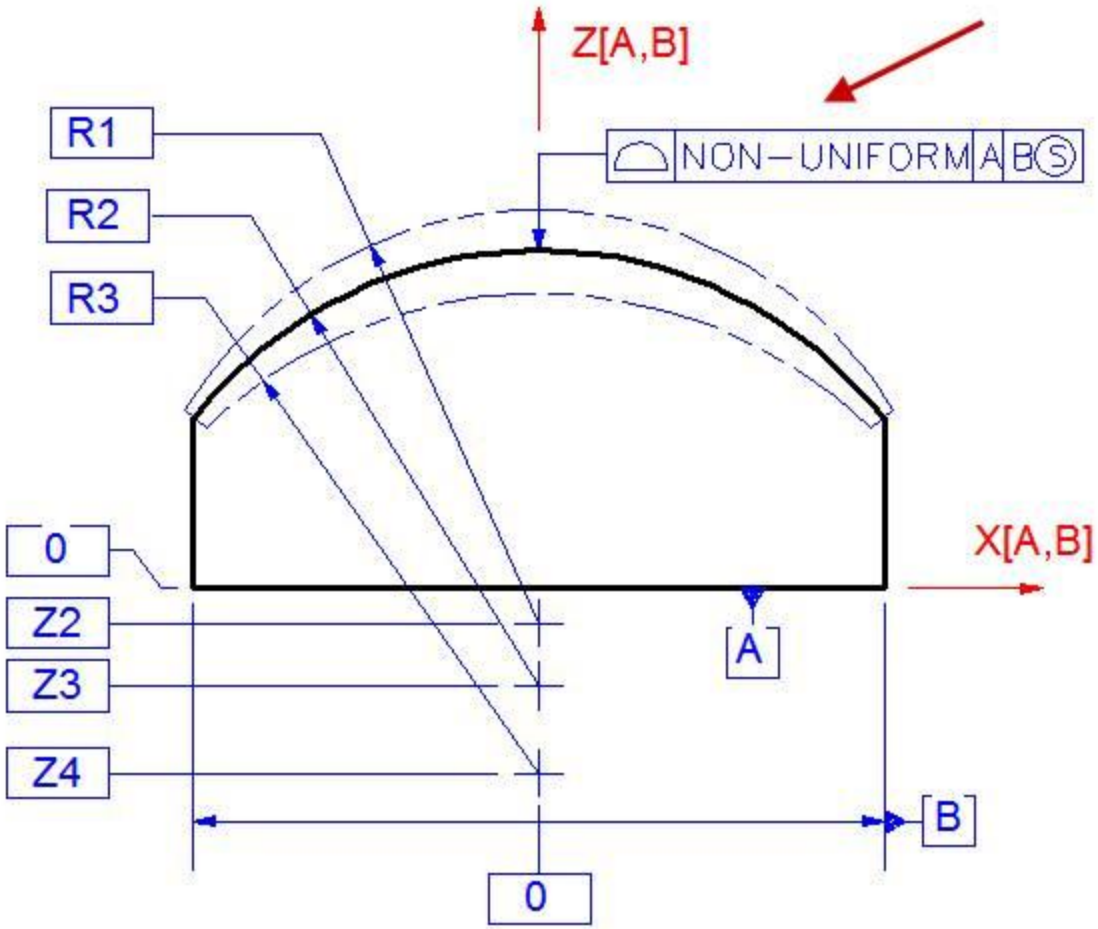
1. Unequally Disposed Profile Modifier: Ⓤ
2. Non-Uniform Modifier: **[NON-UNIFORM]**
3. ALL OVER Modifier: 
4. Continuous Feature Modifier: ⌔CF⌔
5. Independency Modifier: Ⓘ

Non-Uniform Modifier: [NON-UNIFORM]



Where the thickness of a Surface Profile tolerance zone is required to vary . . .

Non-Uniform Modifier: [NON-UNIFORM]



Where the thickness of a Surface Profile tolerance zone is required to vary, its boundaries can be specified graphically in the CAD model or drawing, and the tolerance value specified as [NON-UNIFORM].

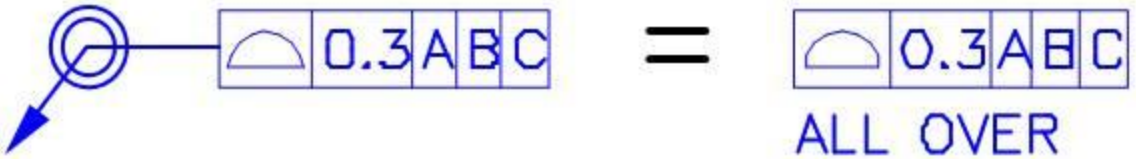
Y14.5 2009 Changes and their Impact

New Tools impacting Tolerance Zones

(a partial set)

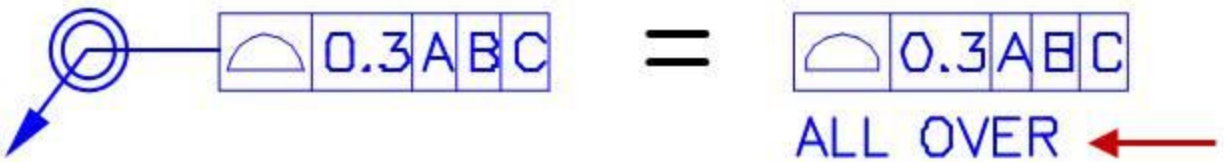
1. Unequally Disposed Profile Modifier: (U)
2. Non-Uniform Modifier: **[NON-UNIFORM]**
3. ALL OVER Modifier: 
4. Continuous Feature Modifier: **CF**
5. Independency Modifier: (I)

ALL OVER Modifier:



The 2009 Standard provides a symbol as a **replacement** for the note **ALL OVER**.

ALL OVER Modifier:



The 2009 Standard provides a symbol as a replacement for the note **ALL OVER**.

But the note **ALL OVER** is still permitted !

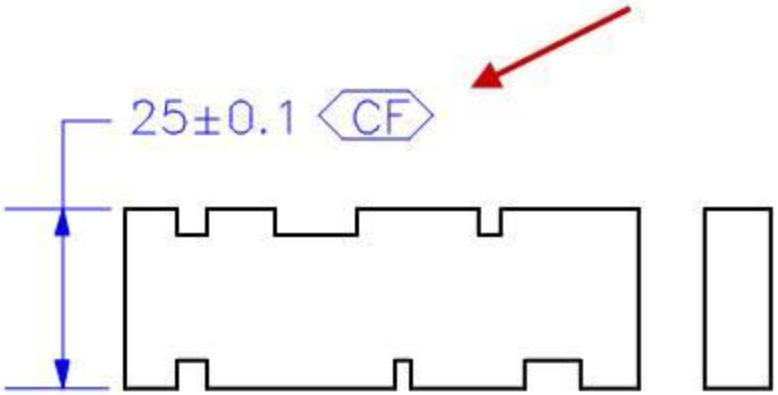
Y14.5 2009 Changes and their Impact

New Tools impacting Tolerance Zones

(a partial set)

1. Unequally Disposed Profile Modifier: (U)
2. Non-Uniform Modifier: **[NON-UNIFORM]**
3. ALL OVER Modifier:
4. Continuous Feature Modifier: CF
5. Independency Modifier: (I)

Continuous Feature Modifier: CF



Apparently applicable only to Features of Size, the "**Continuous Feature**" modifier applies the selected size tool to all the indicated, in-line features of the same size, and imposes the **Envelope Rule** on the entire set as a group.

Y14.5 2009 Changes and their Impact

New Tools impacting Tolerance Zones

(a partial set)

1. Unequally Disposed Profile Modifier: Ⓤ
2. Non-Uniform Modifier: **[NON-UNIFORM]**
3. ALL OVER Modifier: 
4. Continuous Feature Modifier: **CF**
5. Independency Modifier: Ⓘ

The Independency Modifier: Ⓘ

Ⓘ means: **Independent** of the **Envelope Rule**

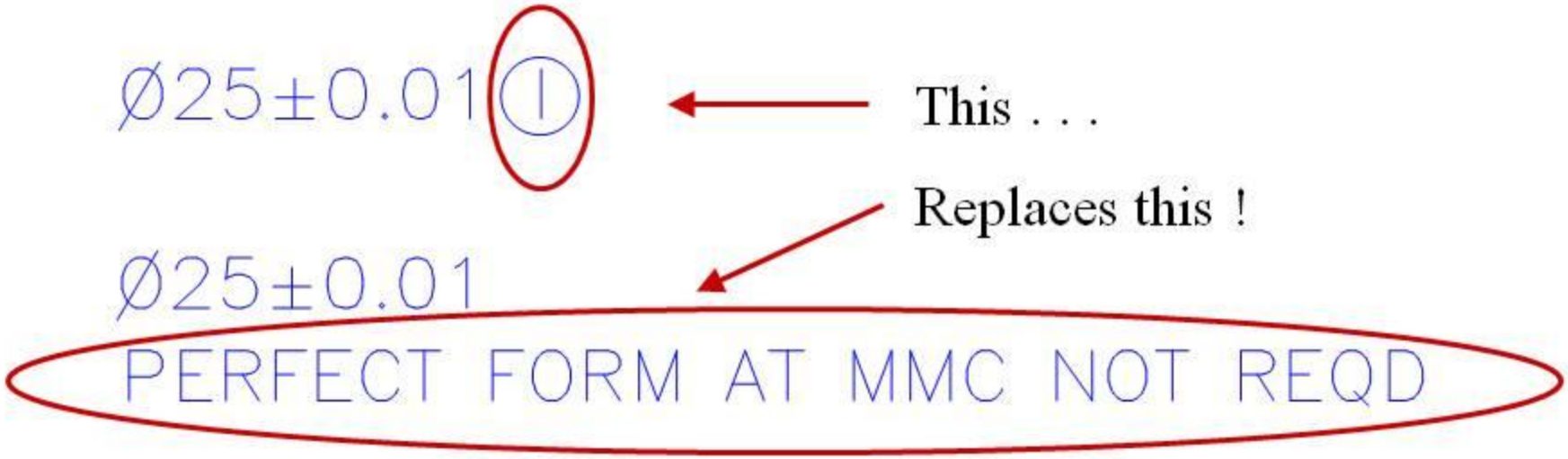
The Independency Modifier: Ⓘ

Ⓘ means: **Independent** of the **Envelope Rule**

This . . .

The Independency Modifier: Ⓘ

Ⓘ means: **Independent** of the **Envelope Rule**

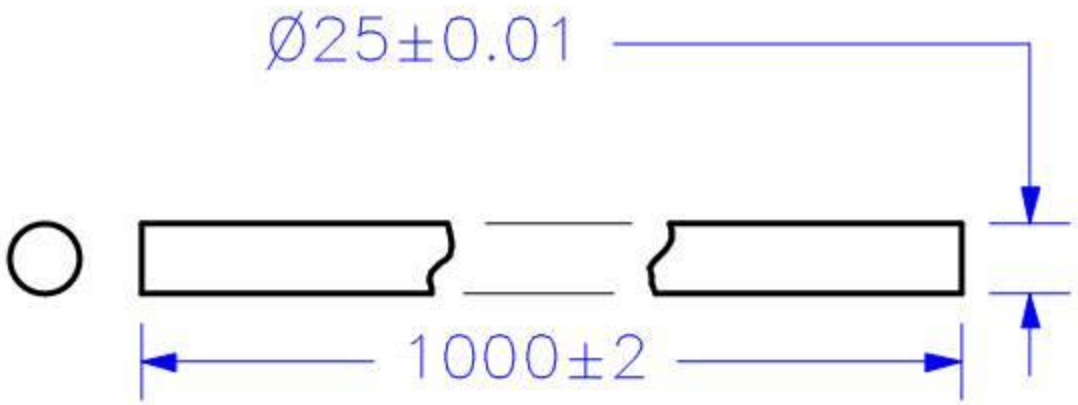


The Independency Modifier: Ⓘ

Example

The Independency Modifier: Ⓘ

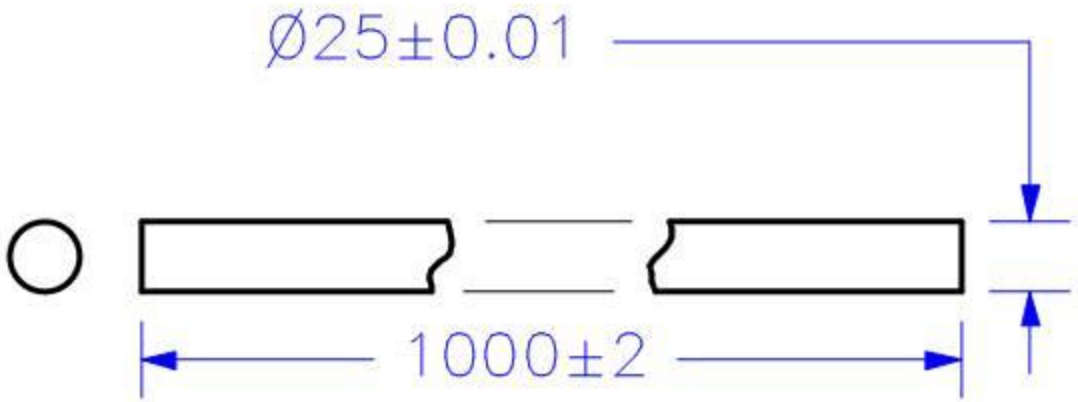
Example



The Independency Modifier: Ⓘ

Example

Is this a functional specification?



The Independency Modifier: Ⓘ

Example

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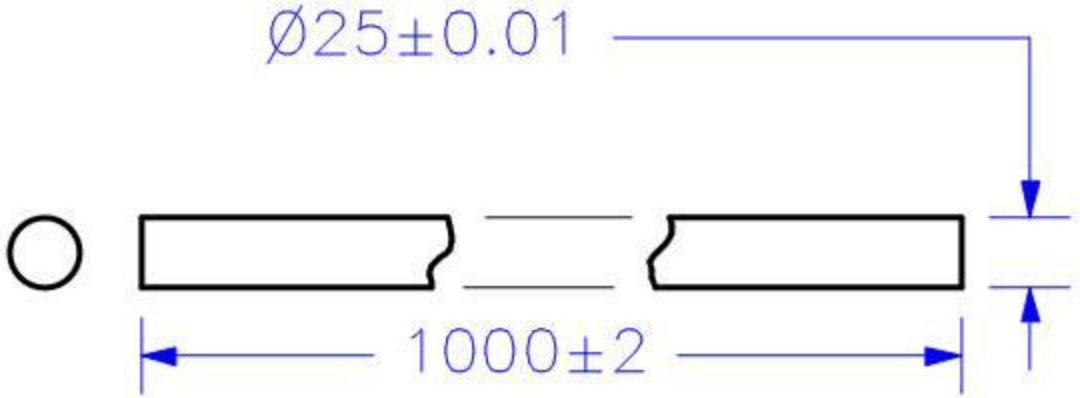
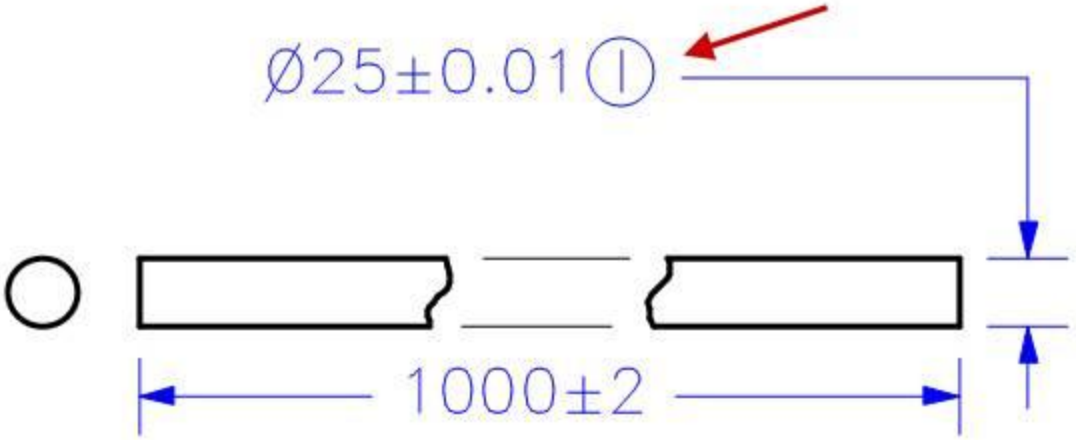


No ! because the automatically imposed **Envelope Rule** requires global Cylindricity of 0.02 mm, which is impossible in such a long shaft.

The Independency Modifier: Ⓘ

Example

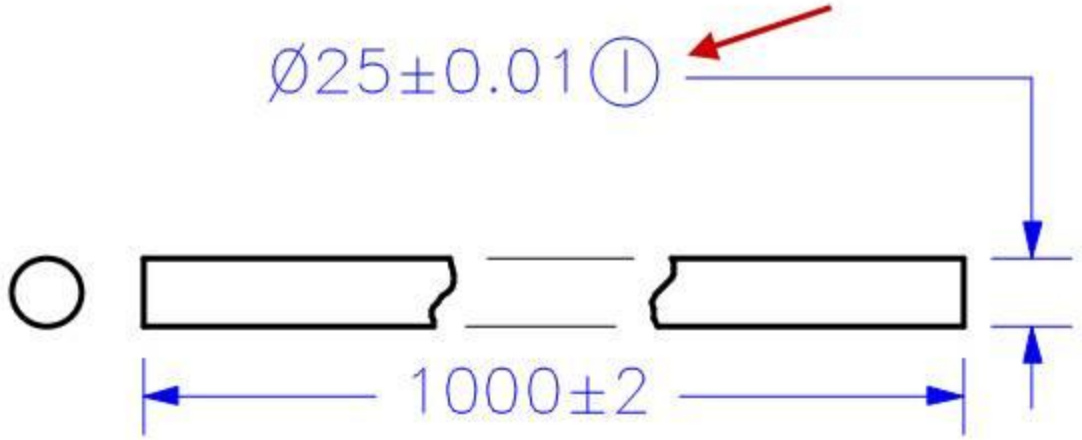
Does **this** make sense?



The Independency Modifier: Ⓘ

Example

Does **this** make sense?

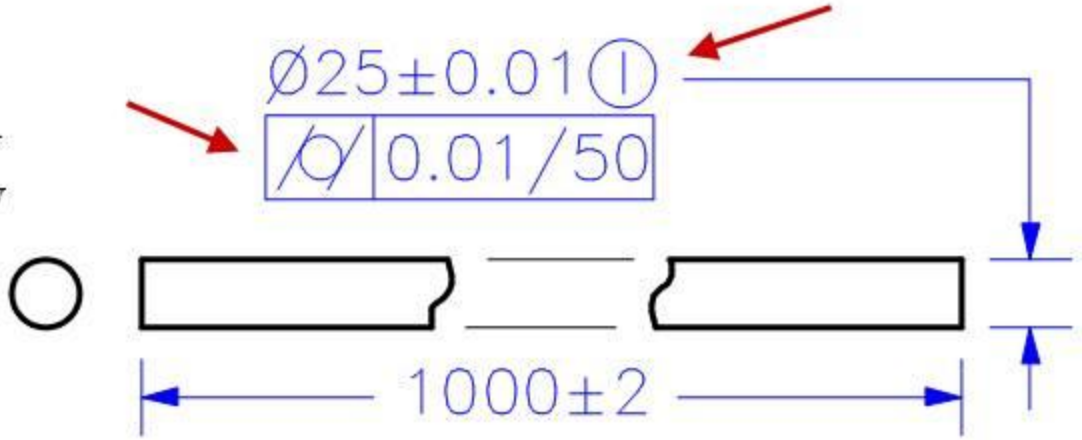


No ! Because without the **Envelope Rule** the shaft could turn into **a garden hose** !

The Independency Modifier: Ⓘ

Example

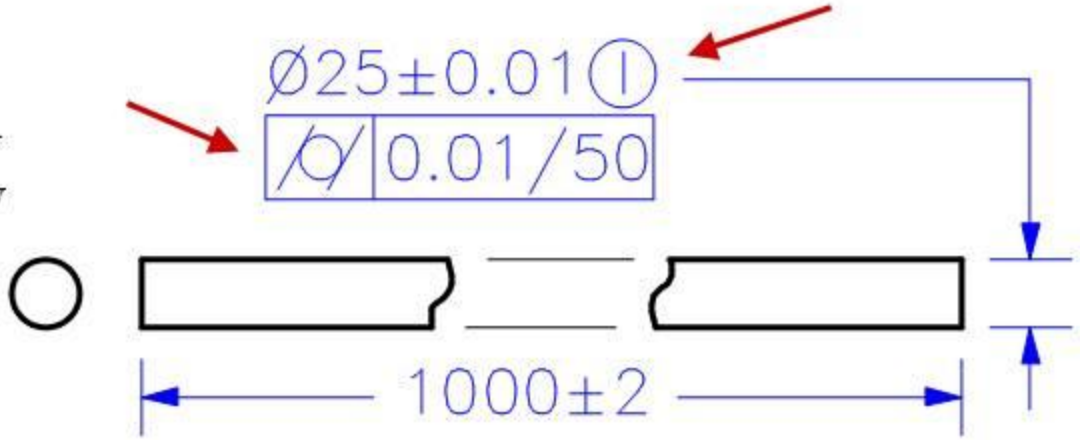
If we add Incremental Cylindricity



The Independency Modifier: Ⓘ

Example

If we add Incremental Cylindricity

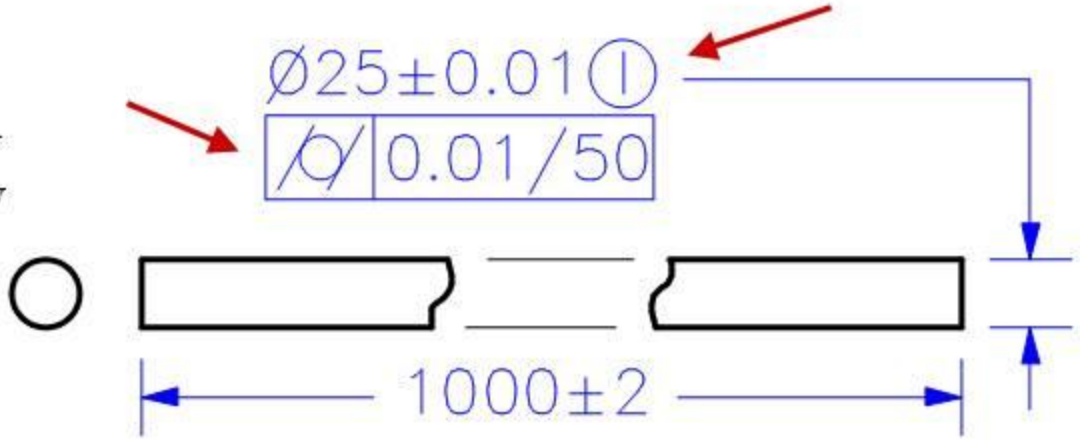


Does **this** make sense?

The Independency Modifier: Ⓘ

Example

If we add Incremental Cylindricity



Does **this** make sense?

Yes ! We have a thoroughly functional solution !

Concluding Remarks

Concluding Remarks

Multi Metrics, Inc.

is the home of

*Smart*GD&T™

Concluding Remarks

What is ***SmartGD&T*** ?

***Smart*GD&T** is a **rule-based**, process driven approach to either the ASME Y14.5M 1994 or ISO 1101 standard, which makes it possible to "**encode**" and "**decode**", rather than "interpret" GD&T, and get it right the first time.

Founded in 1975, Multi Metrics provides the following

Services

- *Smart*GD&T *Technology* Licensing
- Corporate GD&T Implementation Planning
- On-Site GD&T End–user and Trainer Training
- On-Site & Remote GD&T "Encoding" & "Decoding" Services

Products

- *Smart*GD&T *Pseudo-Code*
- Training Manuals & Presentation Materials
- Training Models
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Bill Tandler

Please Submit Questions

Type question in box and hit submit.

Thank you!

We apologize for this brief interruption but we are experiencing technical difficulties and will resume shortly.

Please stand by.