GD&T–Geometric Dimensioning & Tolerancing

סדנה בנושא GD&T לשכת המהנדסים 2020
ronenkom@gmail.com

רונן קומריאן,

עובד בקמ"ג בתחום הפיתוח, תכן הנדסי, ובעבר גם בעיבוד שבבי, משנת 1998 .
מלמד את נושא ה – GD&T במכללה להנדסה סמי שמעון, קמ"ג סאסא פלסן

<u>השכלה:</u>

תואר ראשון בניהול מהאוניברסיטה הפתוחה.
תואר ראשון בהנדסת מכונות, מהמכללה להנדסה SCE באר שבע.
תואר שני בהנדסת אנרגיה, אוניברסיטת בן גוריון (סיום 2019).

<u>קורסים:</u>

1. **ASME** - "Geometric Dimensioning & Tolerancing Fundamentals + Advanced Applications with Stacks and Analysis "- Course (2010)
2. **ASME** – "Dimensioning and Tolerancing Principles for Gages and Fixtures" - Course (2012)

<u>הסמכות:</u>

1. **GDTP - Geometric D**imensioning & **T**olerancing **P**rofessional – **Senior Level** - 3355
2. **GDTP - Geometric D**imensioning & **T**olerancing **P**rofessional - **Technologist Level** – 0842

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.1 **כתובת דוא"ל שלי ליצירת קשר.**

.2 **יהיו 2-3 הפסקות מובנות במצגת לשאלות .**

.3 **את השאלות תשאלו דך ה Q&A ולא דרך ה chat**

.4 **אאפשר לכם להוריד את המצגת.**

מטרות ההצגה:

.1 הצגה בסיסית והכרות של נושא ה – GD&T .

.2 דגש נרחב על החשיבות והצורך של הנושא לעומת שיטת הפלוס מינוס המוכרת

.3 החשיבות ביצירת שפה משותפת בין שלבי הפיתוח לייצור ולביקורת הממדית.

.4 החשיבות בהגדרות ברורות לייצור ולמדידה.

.5 התמקדות והגדרה מדויקת של position & profile

GD&T – international Drawing language

Geometric dimensioning and tolerancing, is an **international language**, Applied drawings to describe a mechanical parts, **with Rules, settings and tools** including dimensions, shape, orientation, location.

GD&T - precise language

Geometry dimensions and tolerances, is a precise language. **The designer conveys clearly on the drawing**. Manufacturers, use a method and produce the component. While Inspectors determine, define and measure the part as defined by the designer.

GD&T - language that provides uniformity

Uniform language, **and the same interpretation**, reduce disputes, guesswork and assumptions. The immediate effect is a clarity of the drawing. And follow the manufacturing process.
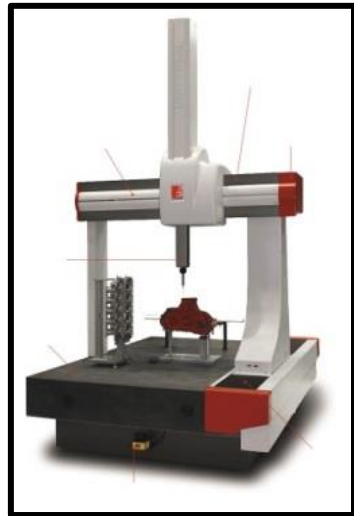
GD&T - **reducing costs** and processing time

The use of language, significantly **reduces production time, and time measurements**. Thereby increasing the production output and quality measurement.

GD&T - Principles of Design

The Standard presents the design principles. Today, many companies all over the world, use the standard and its appendices.
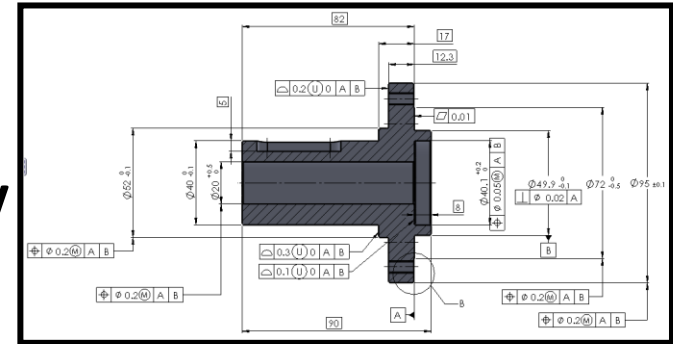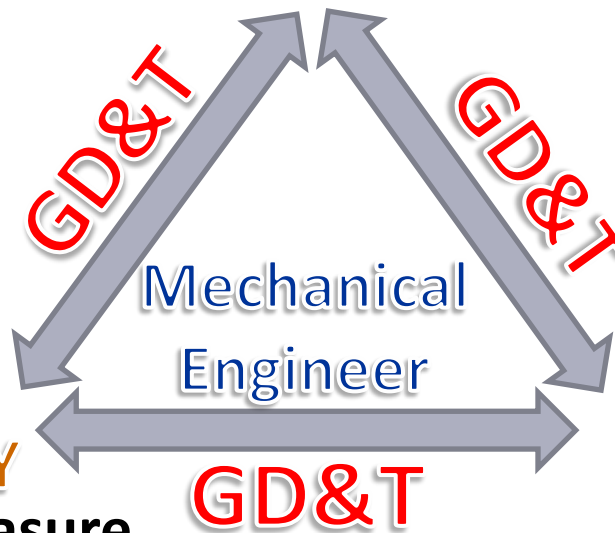
3

Geometry dimensions and tolerances is a precise language.

DESIGN
The information is define more clearly by the designer

MANUFACTURING
The part is better understood by the manufacturer

QUALITY
The Inspector measure the part as defined by the designer

GD&T

GD&T

GD&T

Mechanical Engineer

Product Design Impact

Product Design Effect on an Organization

Product Design

Manufacturing

Development

Customer

Machinists

Service

Vendors

Legal Staff

Reliability

Marketing

Materials

Assembly

Gage Planning

Inspection

Gage Planning

Engineering

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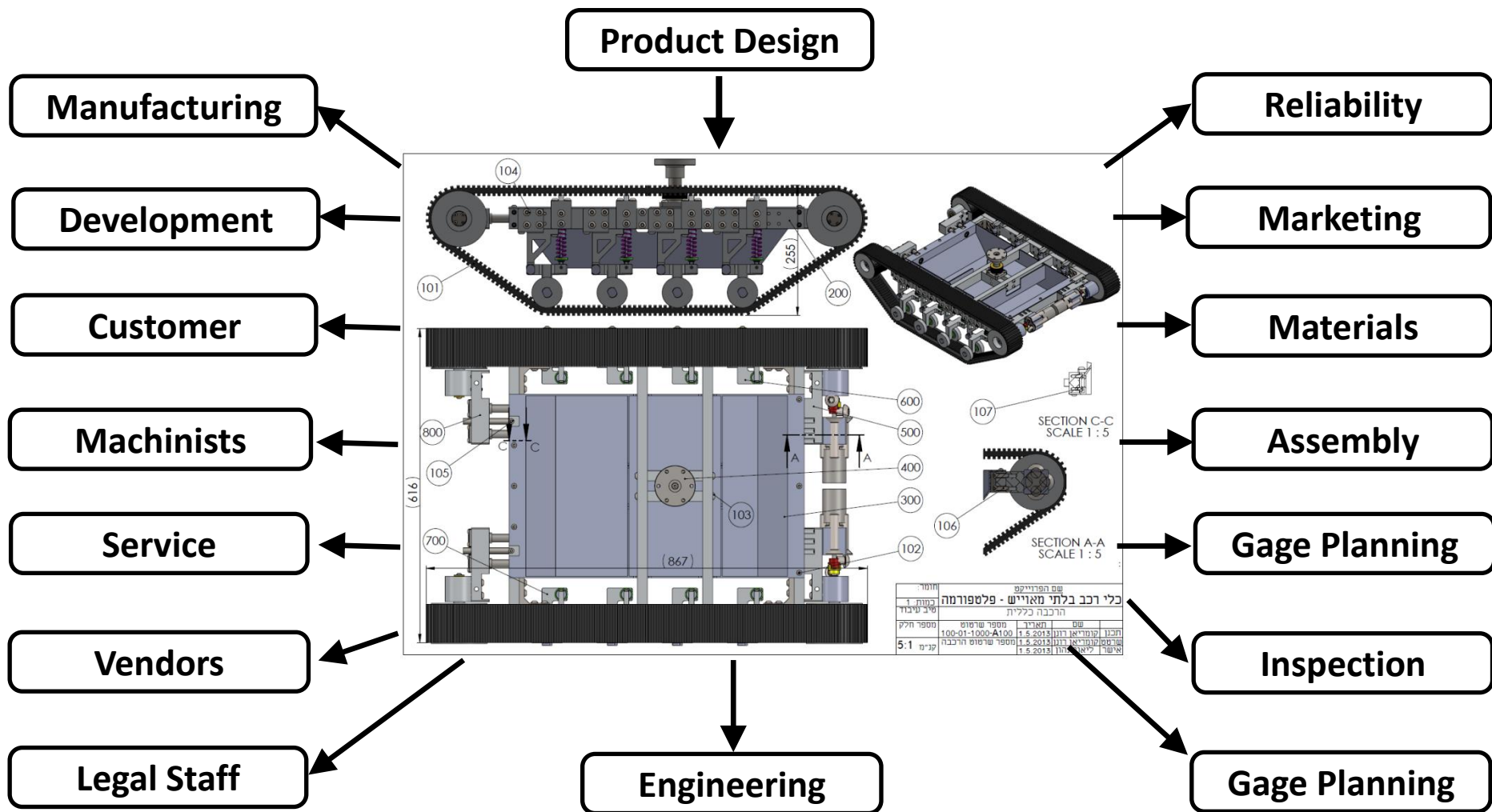
In many organizations, Each department in a company may use different methods of tolerancing for different project. **This has a negative impact on the organization**

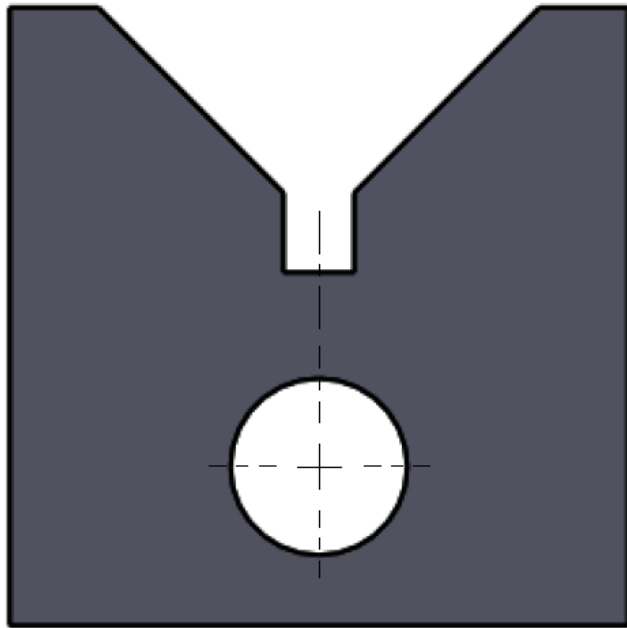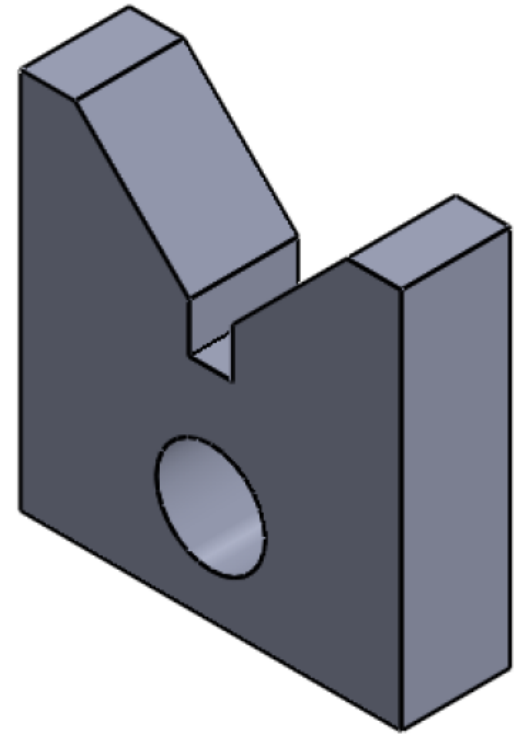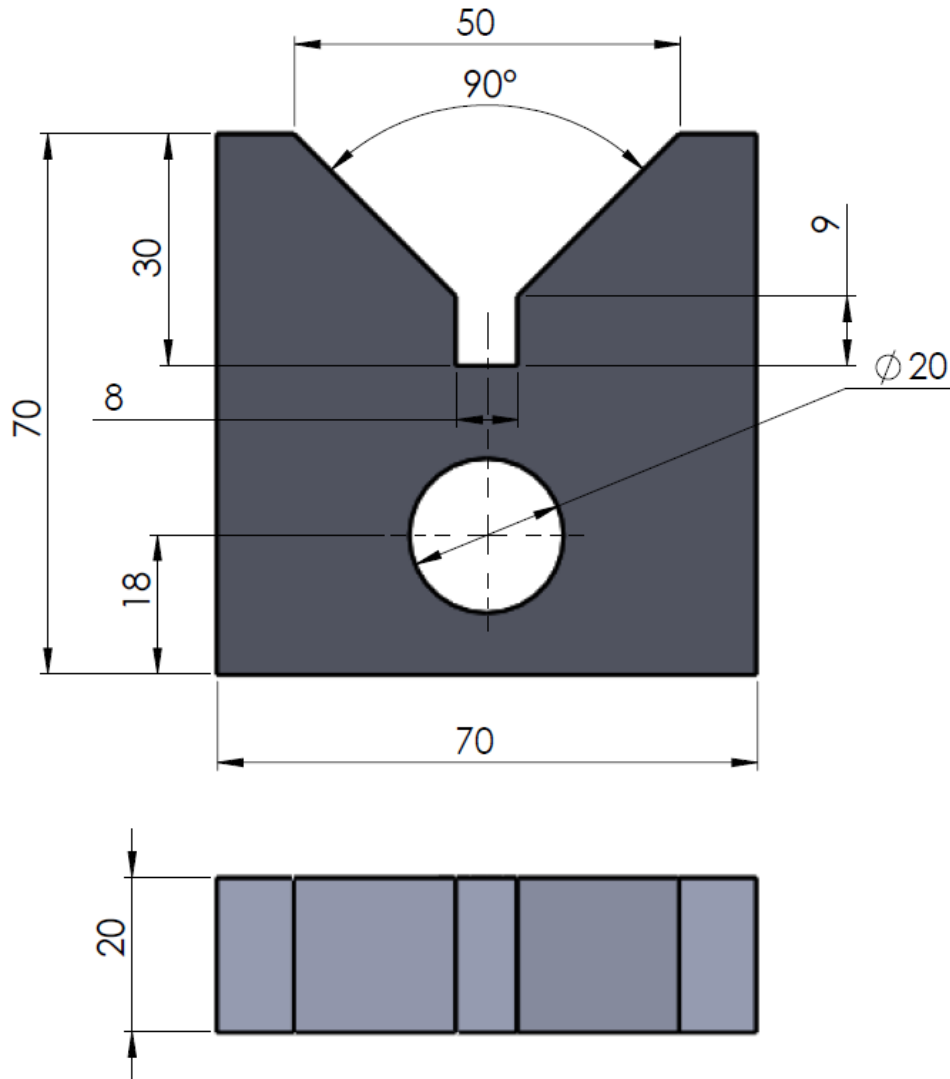|	
Common dimensioning perspective	**Mixed dimensioning perspective**
Organization achieve its goals : • with minimal effort. • Quickest.	Organization achieve its goals : • With more effort. • More time.

Application

V block

G**eometric**

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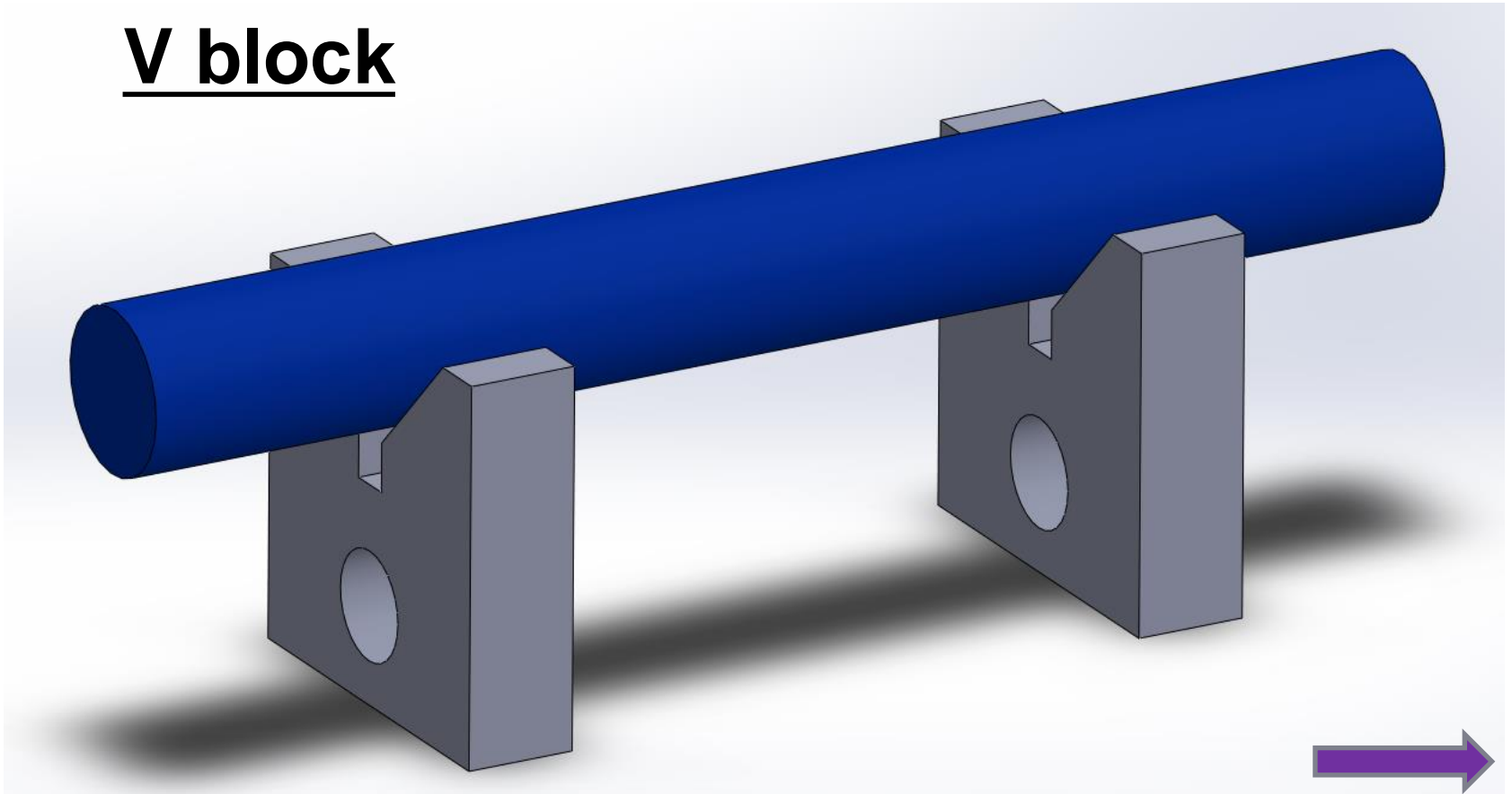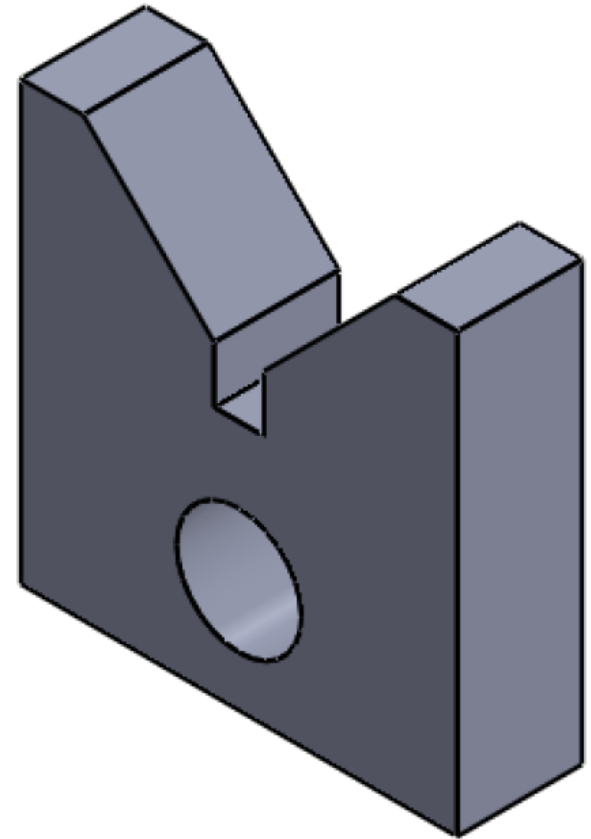
Dimension

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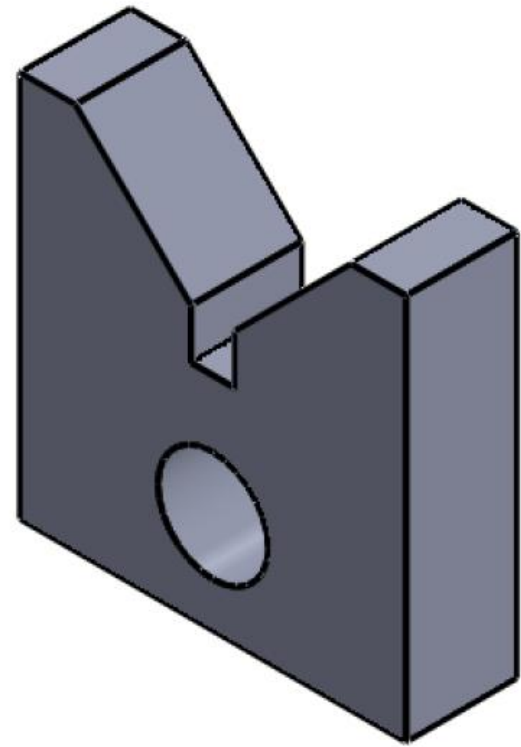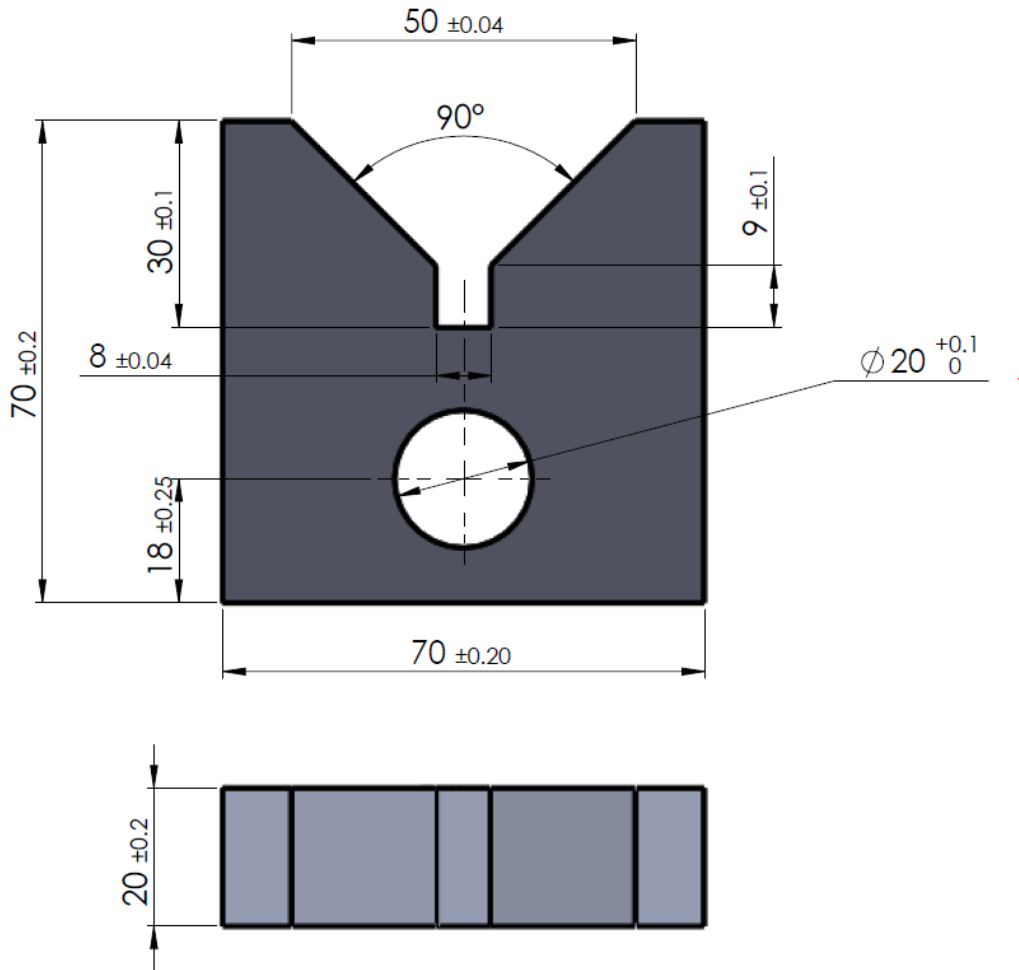
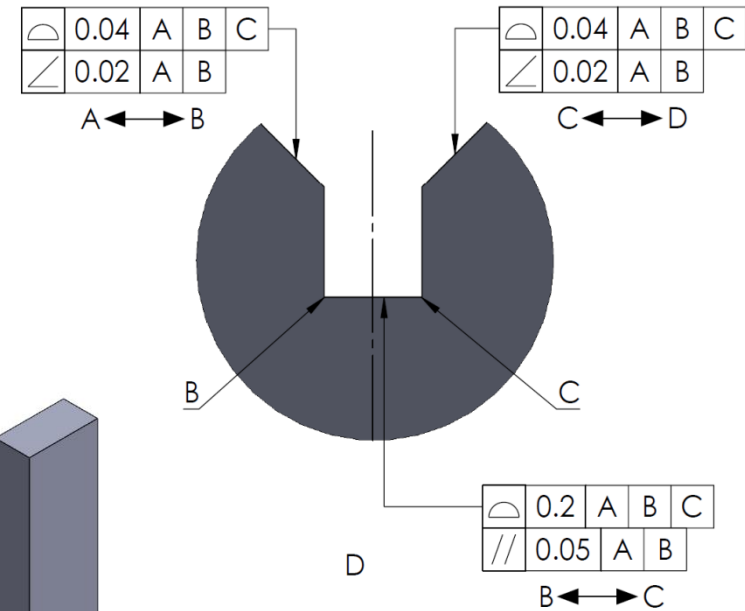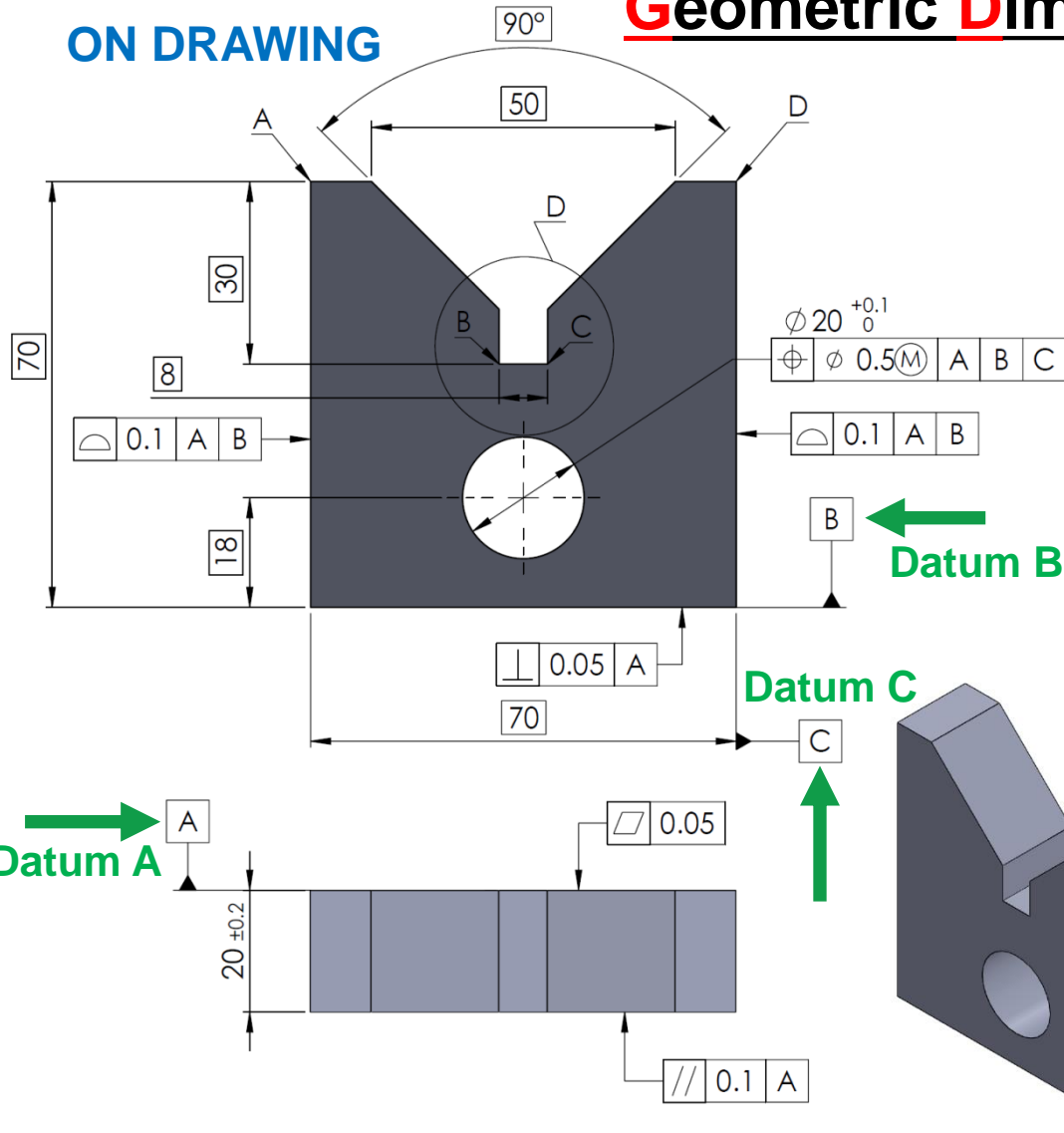# Tolerancing

All dimensions are set! But are the geometric relationships between the various elements defined? (Perpendicular, profile of surface, position, cylindrical, straight).

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Geometric **D**imensioning & **T**olerancing

ON DRAWING

90°

50

A   D

D

30

8

70

B   C

18

$\phi 20 \, {}^{+0.1}_{0}$

⊕ | ϕ 0.5 Ⓜ | A | B | C

⌒ | 0.1 | A | B

⌒ | 0.1 | A | B

△ | 0.04 | A | B | C
∠ | 0.02 | A | B

A ↔ B

△ | 0.04 | A | B | C
∠ | 0.02 | A | B

C ↔ D

B

Datum B

⊥ | 0.05 | A

70

Datum C

C

Datum A

A

20 ± 0.2

◇ | 0.05

// | 0.1 | A

B   C

△ | 0.2 | A | B | C
// | 0.05 | A | B

D

B ↔ C

11

What is required to design and manufacture this component

Third Datum Plane.
(Perpendicular to Datum A and Datum B)
D.O.F - X

MEANS THIS

D.O.F

Y

0.1 PROFILE
TOL ZONE

0.02
ANGULARITY
TOL ZONE

0.05
PARALLELISM
TOL ZONE

0.04 PROFILE
TOL ZONE

0.2 PROFILE
TOL ZONE

0.1 PROFILE
TOL ZONE

Second Datum Plane.
(Perpendicular to Datum A)
D.O.F –Y,w

First Datum Plane.
D.O.F - Z,u,v

X

Z

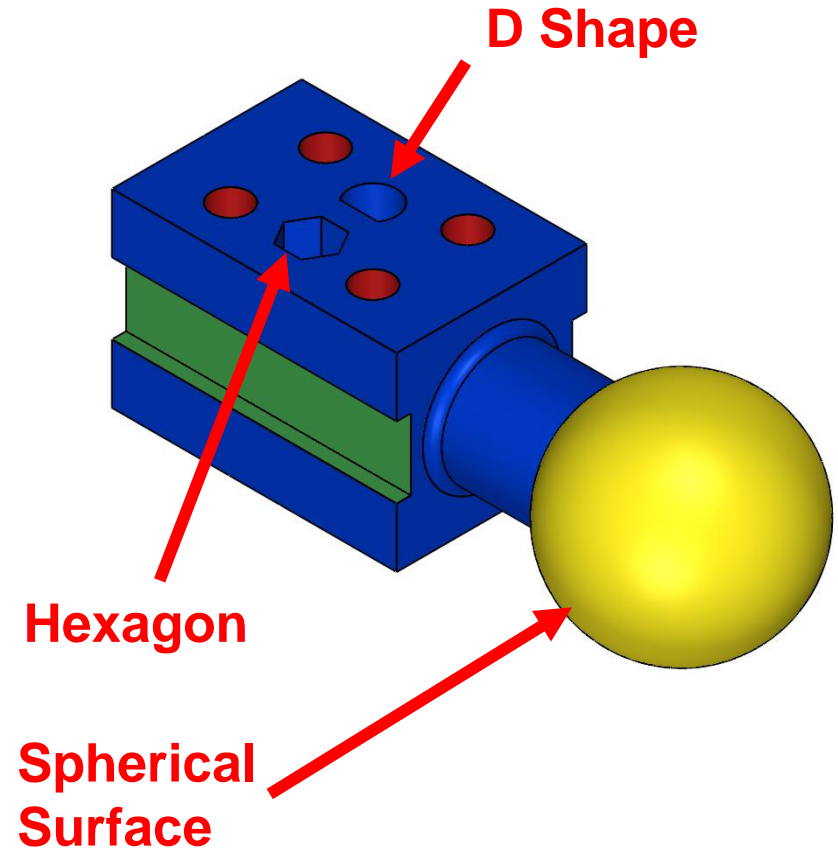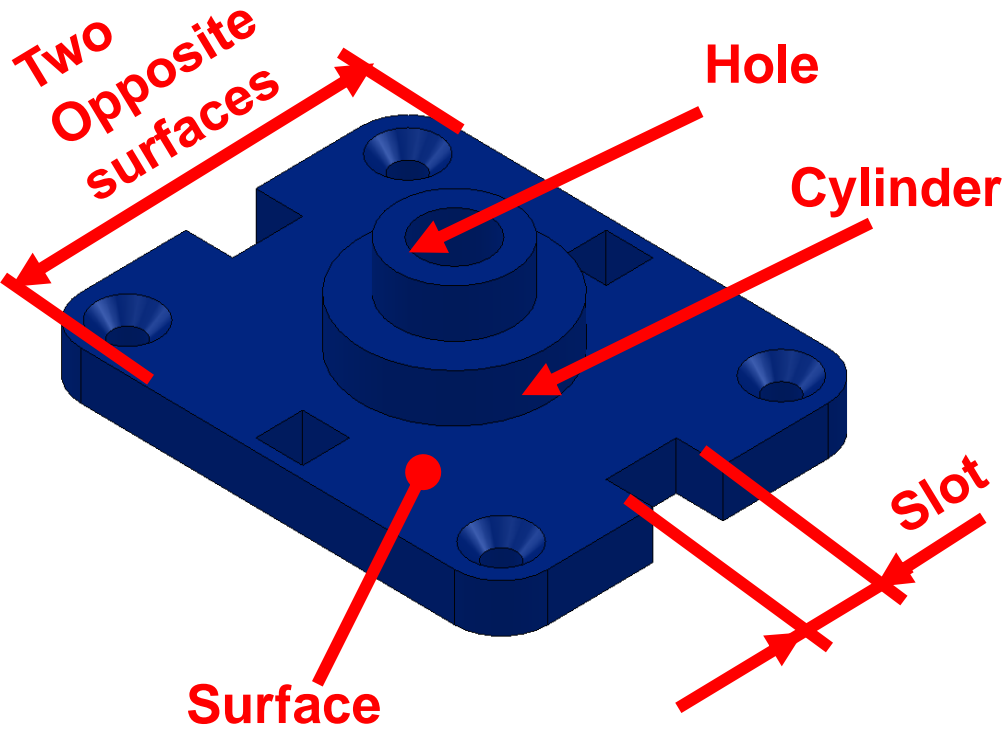**MEANS THIS**
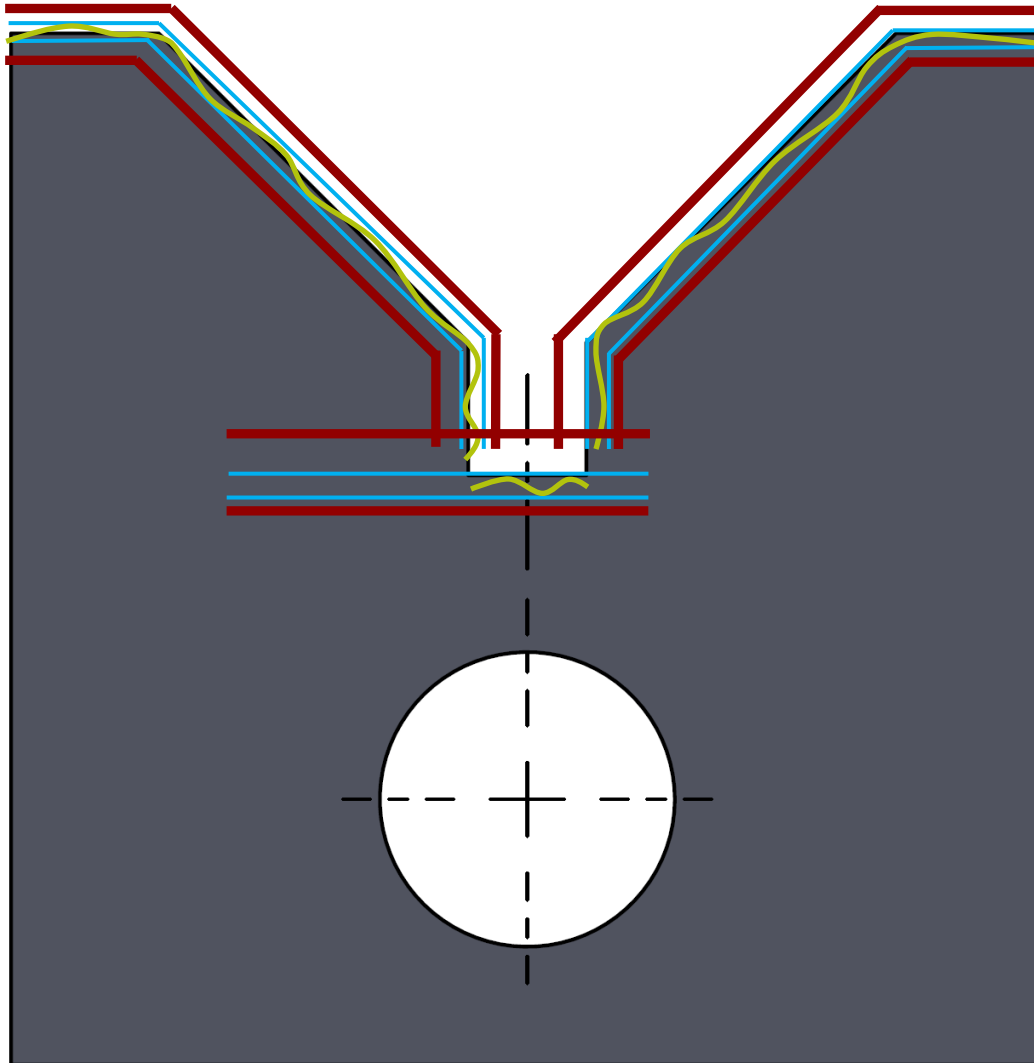
Application
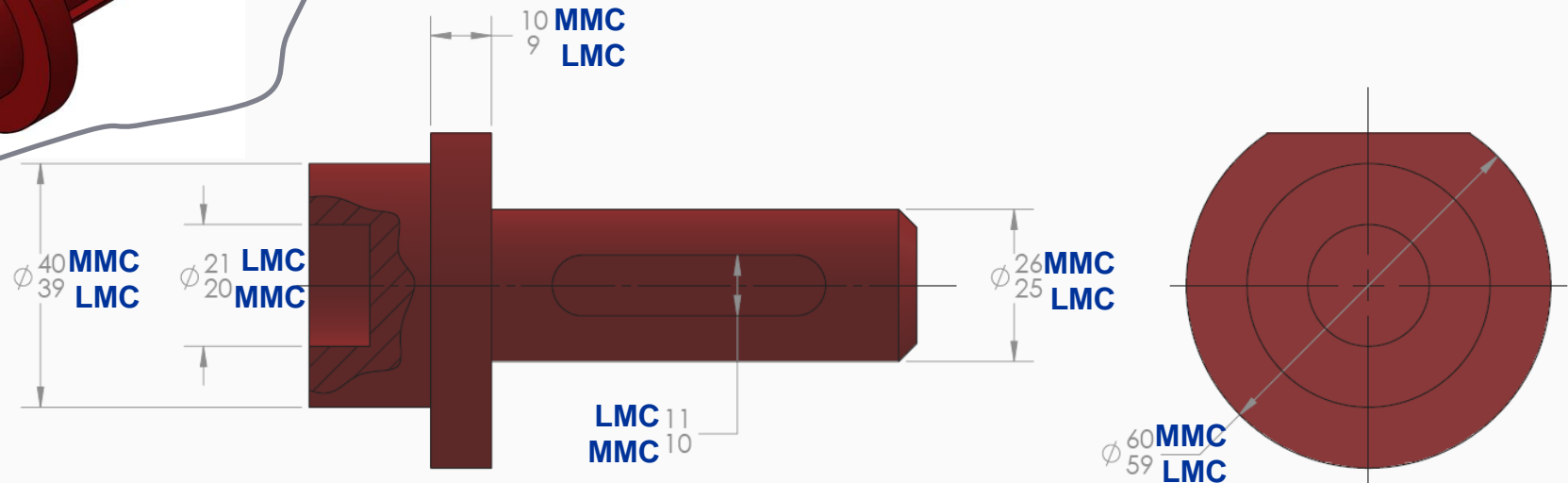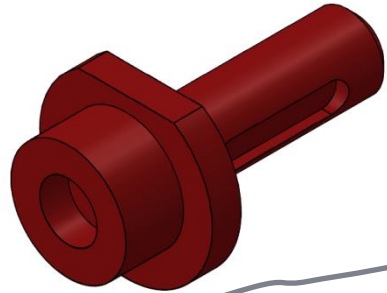
least material condition (LMC): the condition in which a feature of size contains the least amount of material within the stated limits of size (maximum hole diameter, minimum shaft diameter).
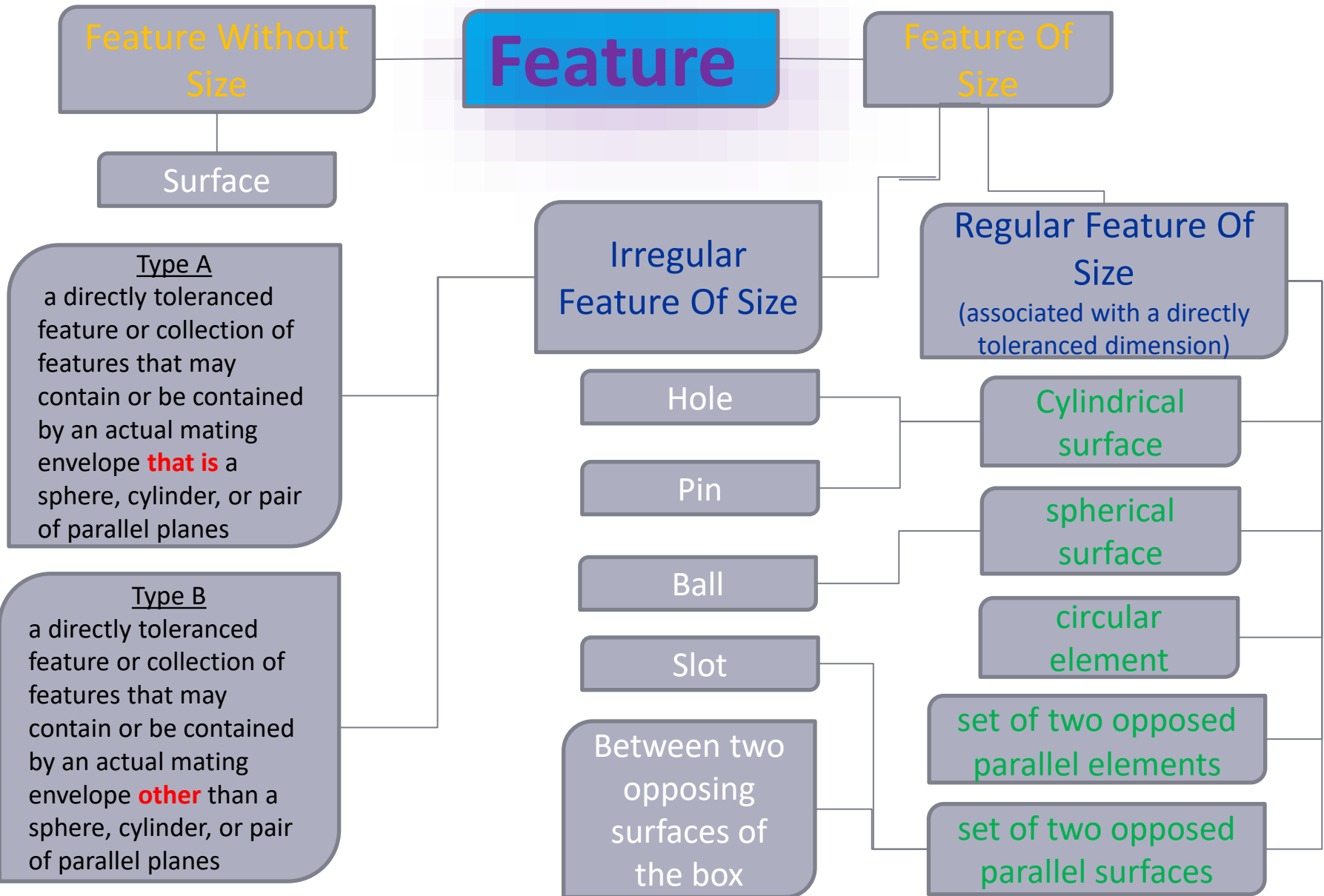
maximum material condition (MMC): the condition in which a feature of size contains the maximum amount of material within the stated limits of size (minimum hole diameter, maximum shaft diameter)

Feature

feature: **a physical portion of a part such as a surface, pin, hole, or slot or its representation on drawings, models, or digital data files.**
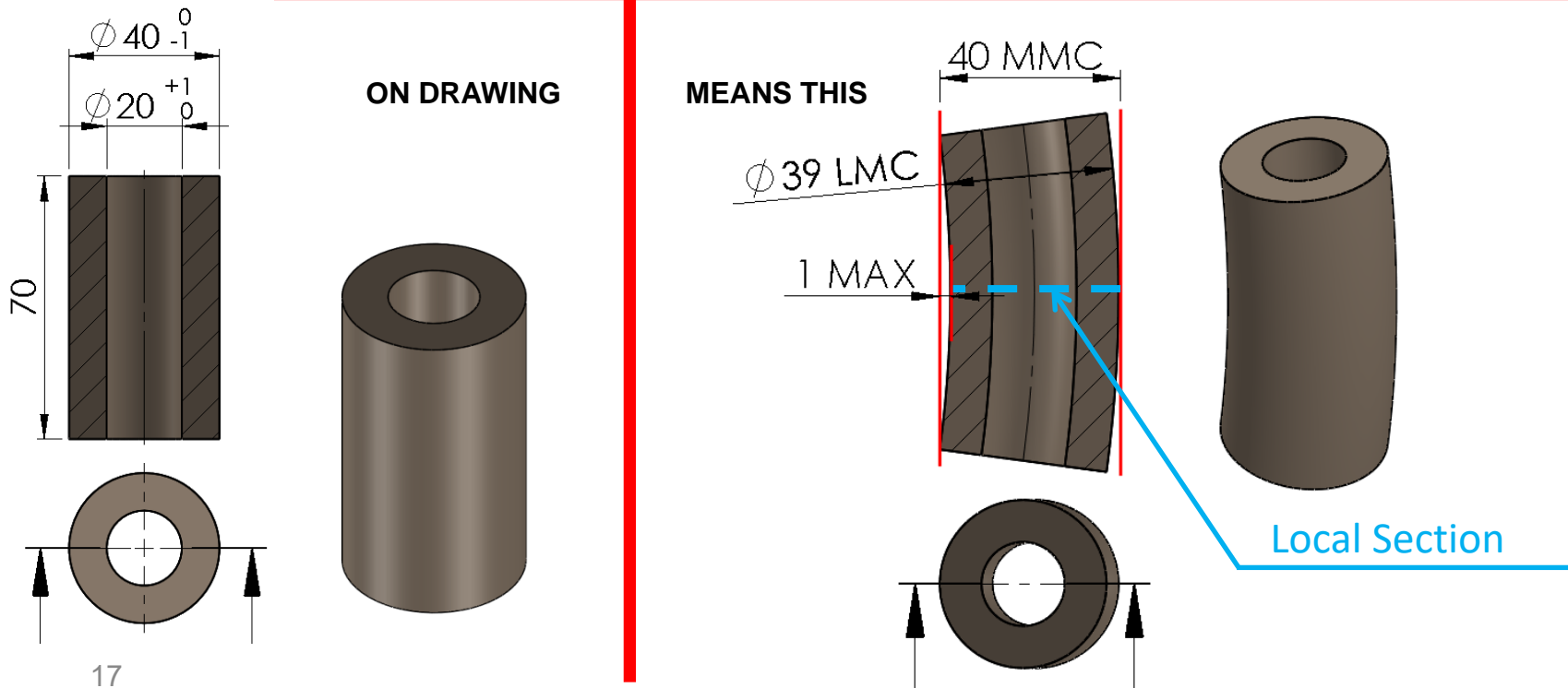

Two Opposite surfaces

Hole

D Shape

Cylinder

Slot

Surface

Hexagon

Spherical Surface

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Feature of size & Feature without size

Feature

Feature Without Size

Feature Of Size

Surface

Type A
a directly toleranced feature or collection of features that may contain or be contained by an actual mating envelope **that is** a sphere, cylinder, or pair of parallel planes

Irregular Feature Of Size

Regular Feature Of Size
(associated with a directly toleranced dimension)

Hole

Cylindrical surface

Pin

spherical surface

Type B
a directly toleranced feature or collection of features that may contain or be contained by an actual mating envelope **other** than a sphere, cylinder, or pair of parallel planes

Ball

circular element

Slot

set of two opposed parallel elements

Between two opposing surfaces of the box

set of two opposed parallel surfaces

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The surface of a regular feature of size shall not extend beyond a boundary (envelope) of perfect form at MMC. No variation in form is permitted if the regular feature of size is produced at its MMC limit of size.

Where the actual local size of a regular feature of size has departed from MMC toward LMC, a local variation in form is allowed equal to the amount of such departure.

$\varnothing\ 40\ ^{0}_{-1}$

$\varnothing\ 20\ ^{+1}_{0}$

70

ON DRAWING

MEANS THIS

40 MMC

$\varnothing\ 39$ LMC

1 MAX

Local Section

17

Actual **M**ating **E**nvelop

AME - Related

AME - Unrelated

18

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AME – Actual Mating Envelop – unrelated

Axis Feature
axis of The Unrelated Actual Mating Envelop
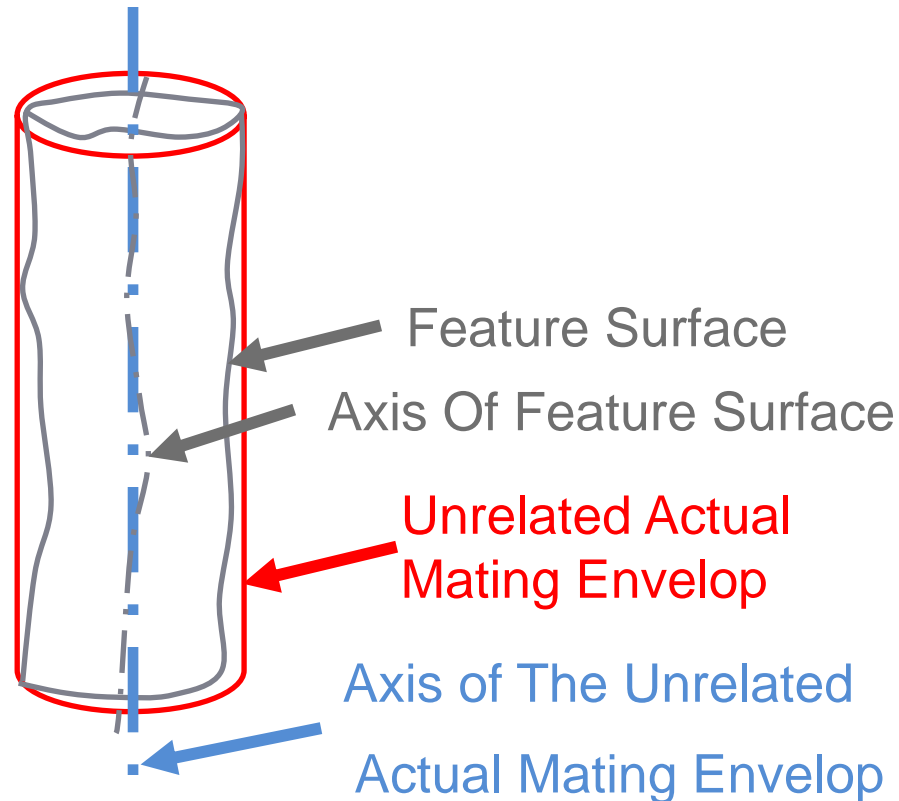
Center Plane of Feature
The Center Plane of Unrelated Actual Mating Envelop

Feature Surface
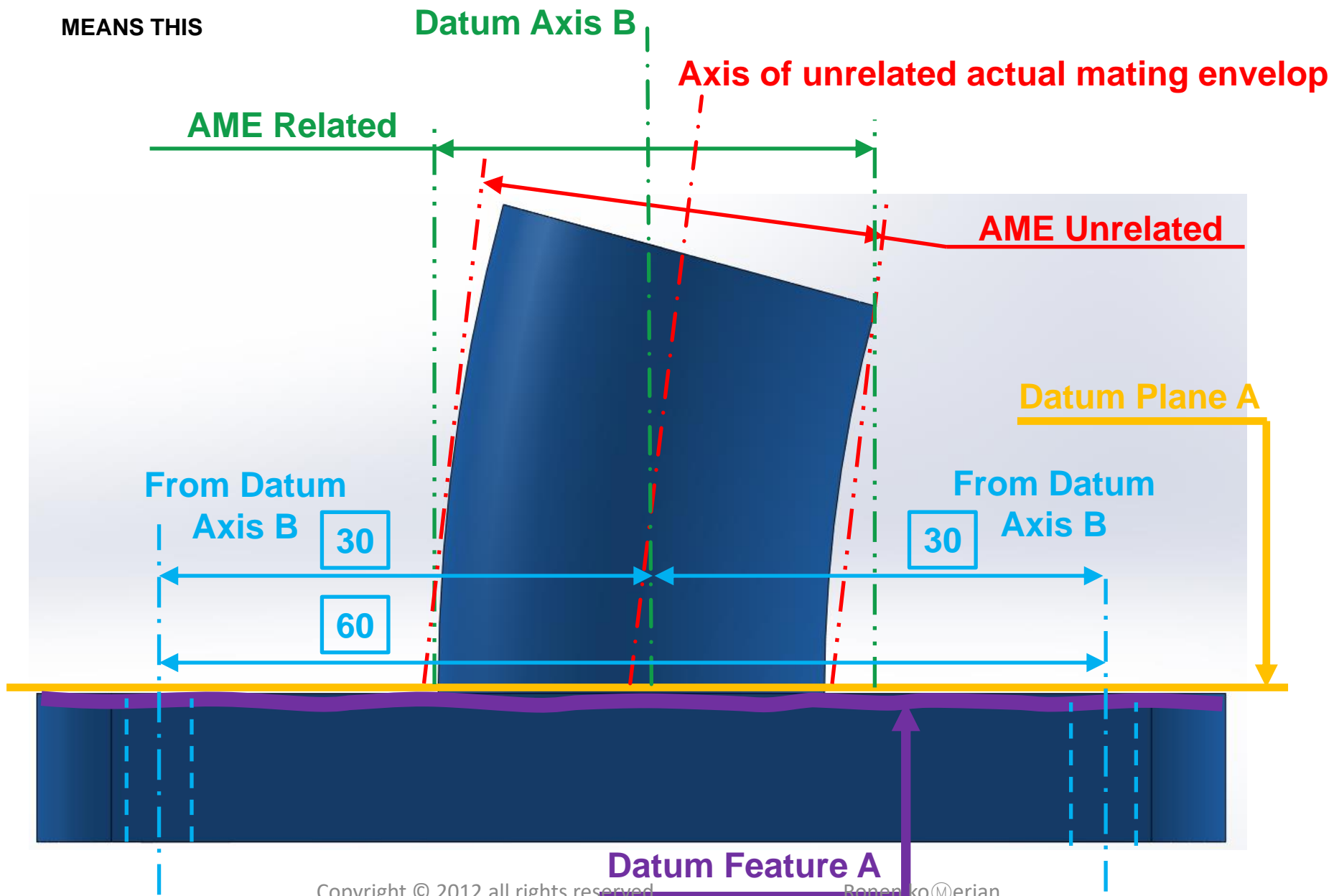
Axis Of Feature Surface

Unrelated Actual Mating Envelop

Axis of The Unrelated Actual Mating Envelop

Unrelated Actual Mating Envelop

Feature Surface

Center Plane Of Unrelated Actual Mating Envelop
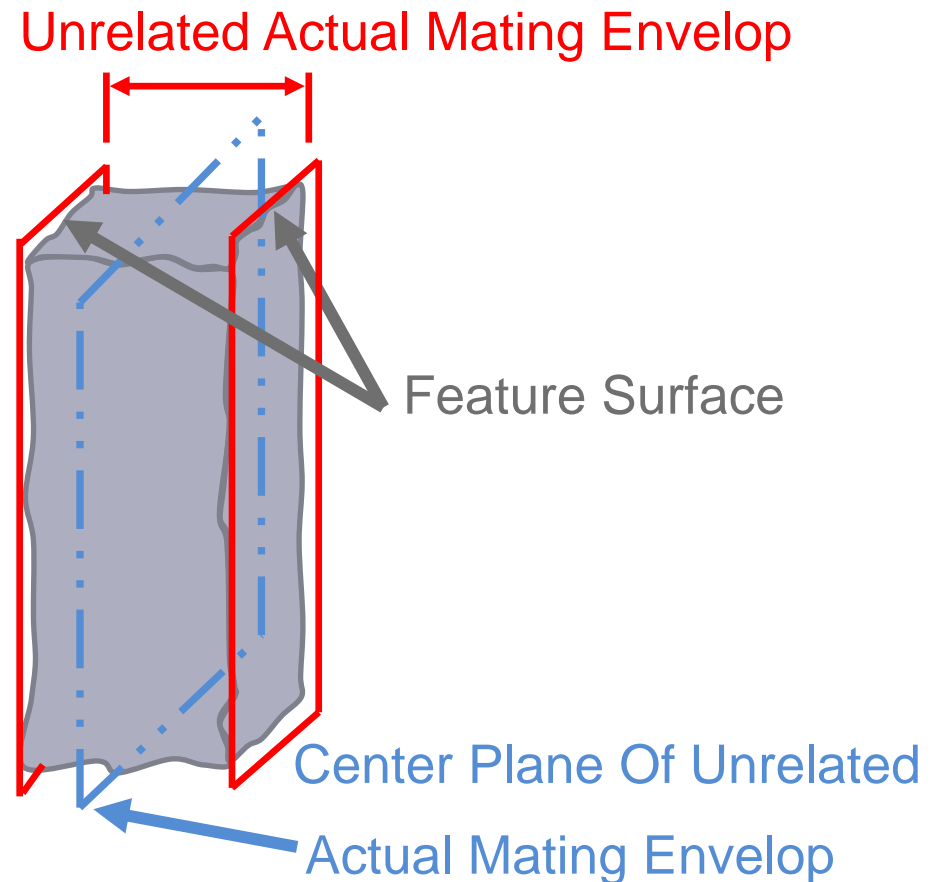
AME – Actual Mating Envelop

ON DRAWING

⌀26 +0.4 / 0

⊥ | ⌀ 0.2 | A

B

⌓ 0.2 | A

30

⌓ 0.2 | A

10

⌀ 0.15 | A

80

⌓ 0.1 | A | B

4X R5

4X ⌀6 +0.1 / 0

⊕ | ⌀ 0.2Ⓜ | A | B

60

40

60
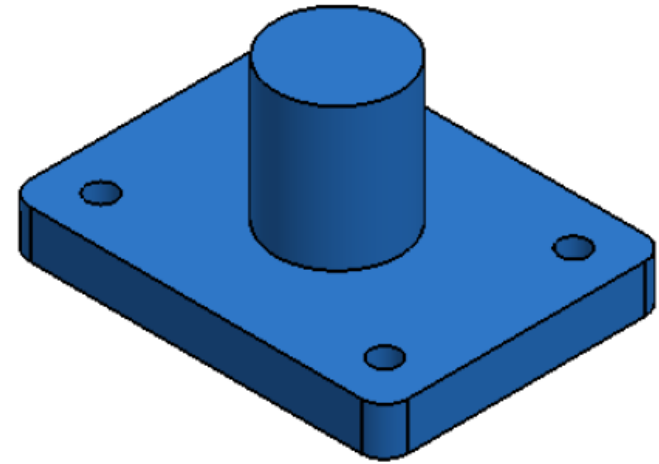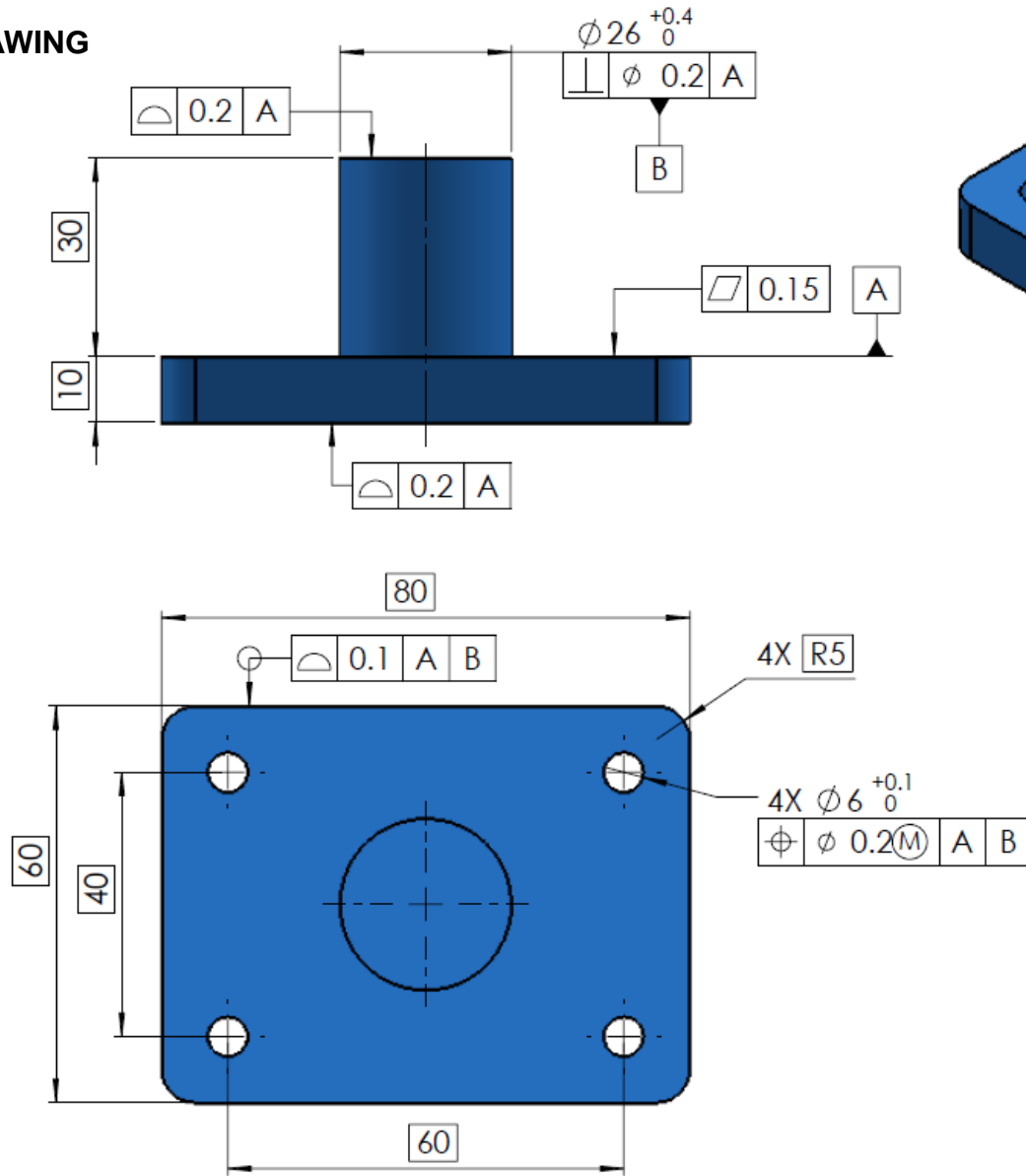
AME – Actual Mating Envelop

MEANS THIS

Datum Axis B

Axis of unrelated actual mating envelop

AME Related

AME Unrelated

Datum Plane A

From Datum Axis B 30

From Datum Axis B 30

60

Datum Feature A

TYPE	SYMBOL	Geometric Tolerance	Control
FORM	▱	FLATNESS	Control plane or center plane. **No Datum or DRF use**
	—	STRAIGHTNESS	
	⌭	CYLINDRICITY	Control Cylindrical or Cylindrical feature. **No Datum or DRF use**
	○	CIRCULARITY	
ORIENTATION	⊥	PERPENDICULARITY	Control Orientation Between feature. **Datum or DRF must be in use**
	∥	PARALLELISM	
	∠	ANGULARITY	
LOCATION	⊕	TRUE POSITION	Control positon Between feature. **Datum or DRF must be in use**
	◎	CONCENTRICITY	
	⹀	SYMMETRY	

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All Geometric Tolerancing 11-14

TYPE	SYMBOL	Geometric Tolerance	Control
RUNOUT	⌰⌰	TOTAL RUNOUT	Control RunOut Between feature. **Datum or DRF must be in use**
	⌰	CIRCULAR RUNOUT	
PROFILE	⌒	PROFILE OF SURFACE	Control a feature Profile. **Datum or DRF Most of the time be in use** "**SLOF**" – Size, Location, Orientation, Form
	⌒	PROFILE OF LINE	

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The FCF divided into segments according to the following specifications:

Second Datum Plane

First Datum Plane

Tolerance Zone

Modifier derived from Datum - MMB

$$\oplus \mid \phi\ 0.3\,\text{Ⓜ} \mid A \mid B\,\text{Ⓜ} \mid C$$

Modifier - MMC

Third Datum Plane

Geometric Tolerance
(1 from14)

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DATUM

→ **Surface**
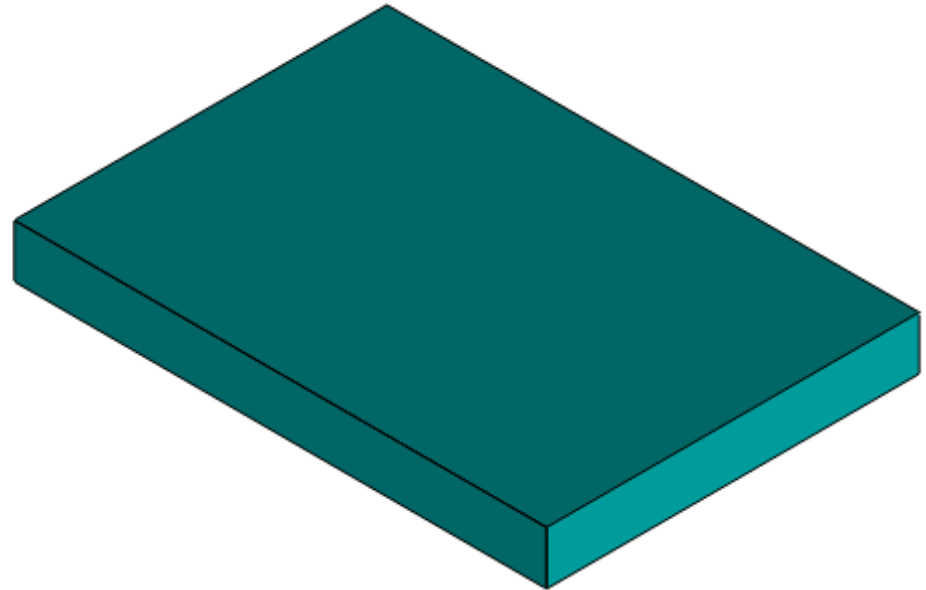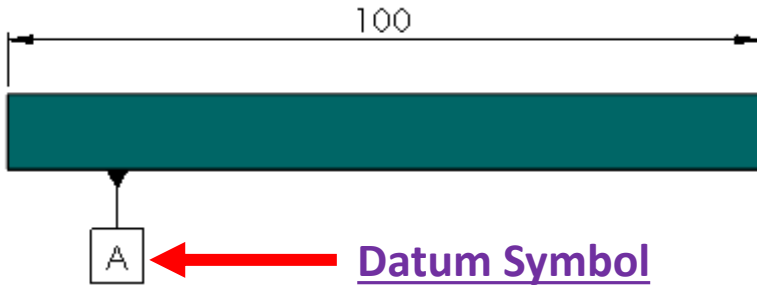
→ **Axis**

→ **Point**

DRF

ON DRAWING

100

Datum Symbol

A
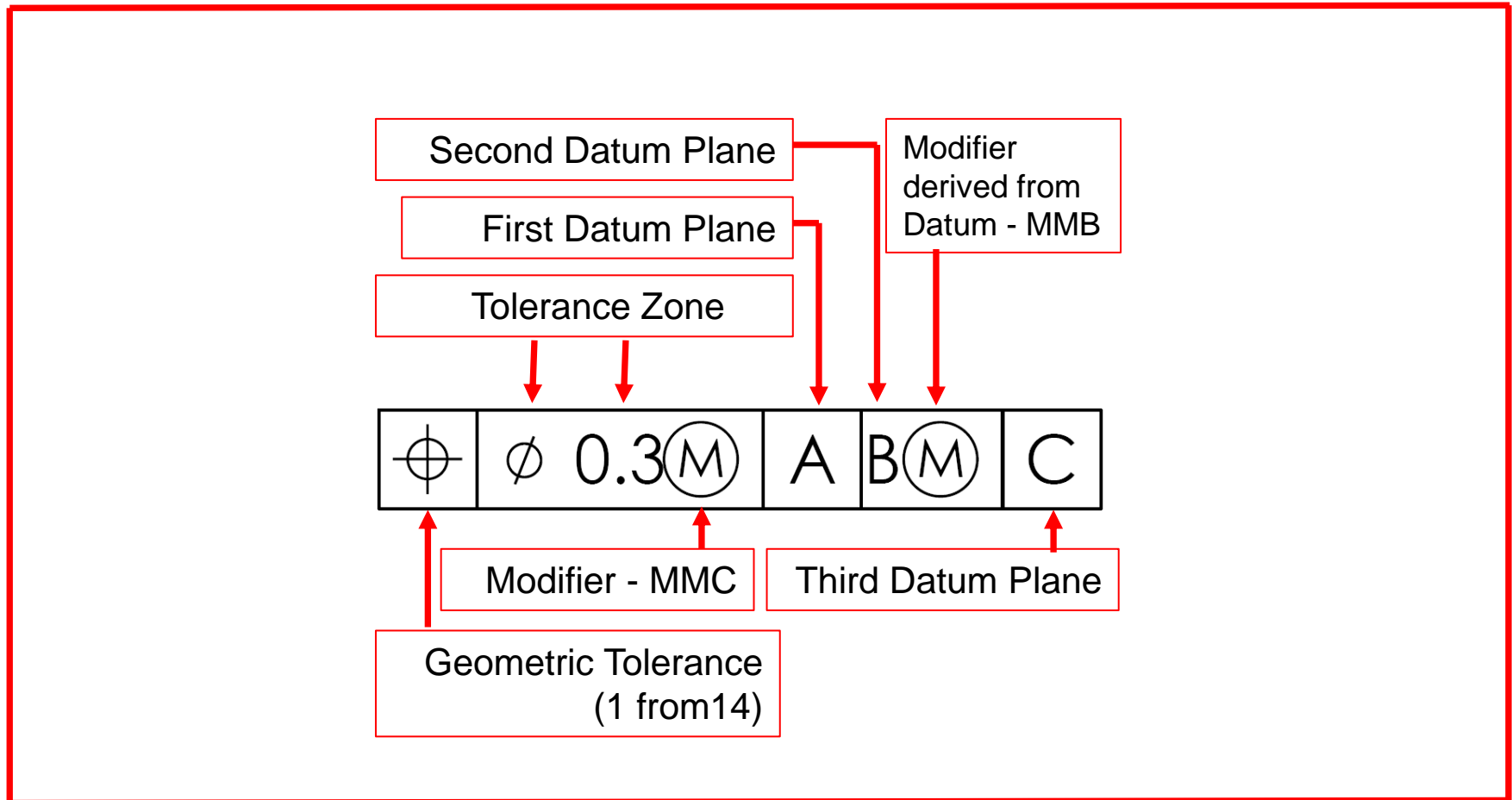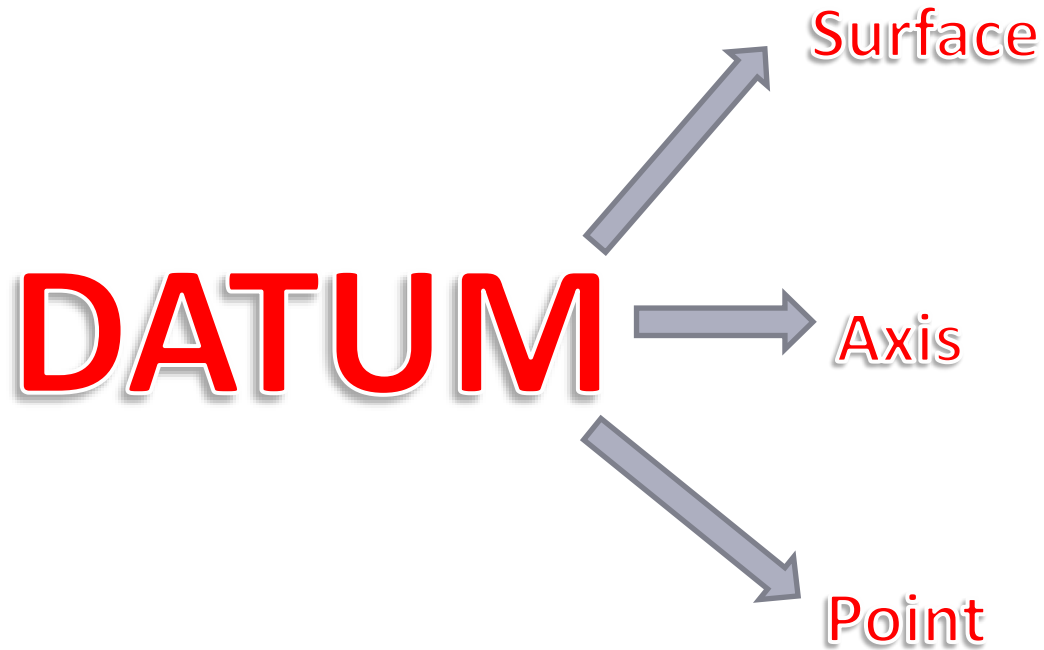
What is the datum meaning???

Datum Surface – Meaning

datum
a theoretically exact point, axis, line, **plane**, or combination thereof derived from the theoretical datum feature simulator.

datum feature
a feature that is identified with either a datum feature symbol or a datum target symbol

Datum Feature Simulator - Physical
the physical boundary used to establish a **simulated datum** from a specified datum feature.
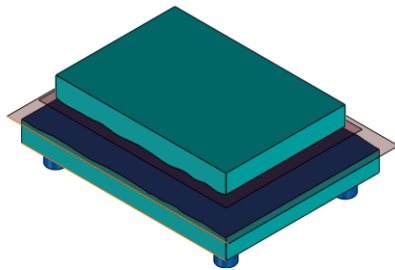
Datum Feature Simulator - Theoretical
the theoretically perfect boundary used to establish a datum from a specified datum feature.

Simulated Datum
a point, axis, line, or plane (or combination thereof) coincident with or derived from **processing or inspection equipment**, such as the following simulators: a **surface plate, a gage surface, a mandrel, or mathematical simulation.**

MEANS THIS

Datum
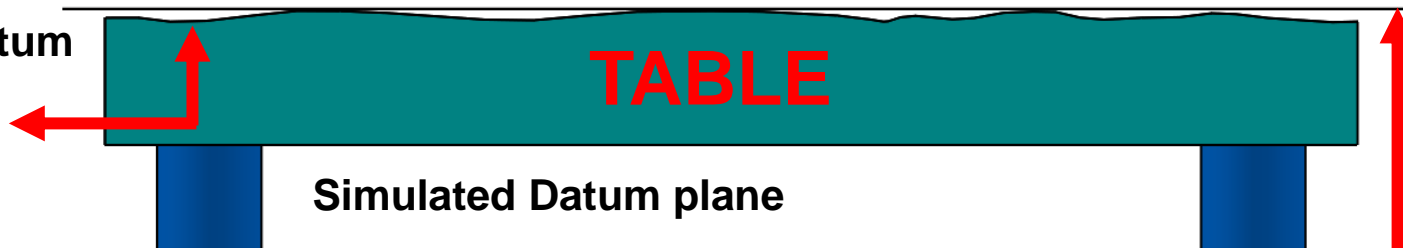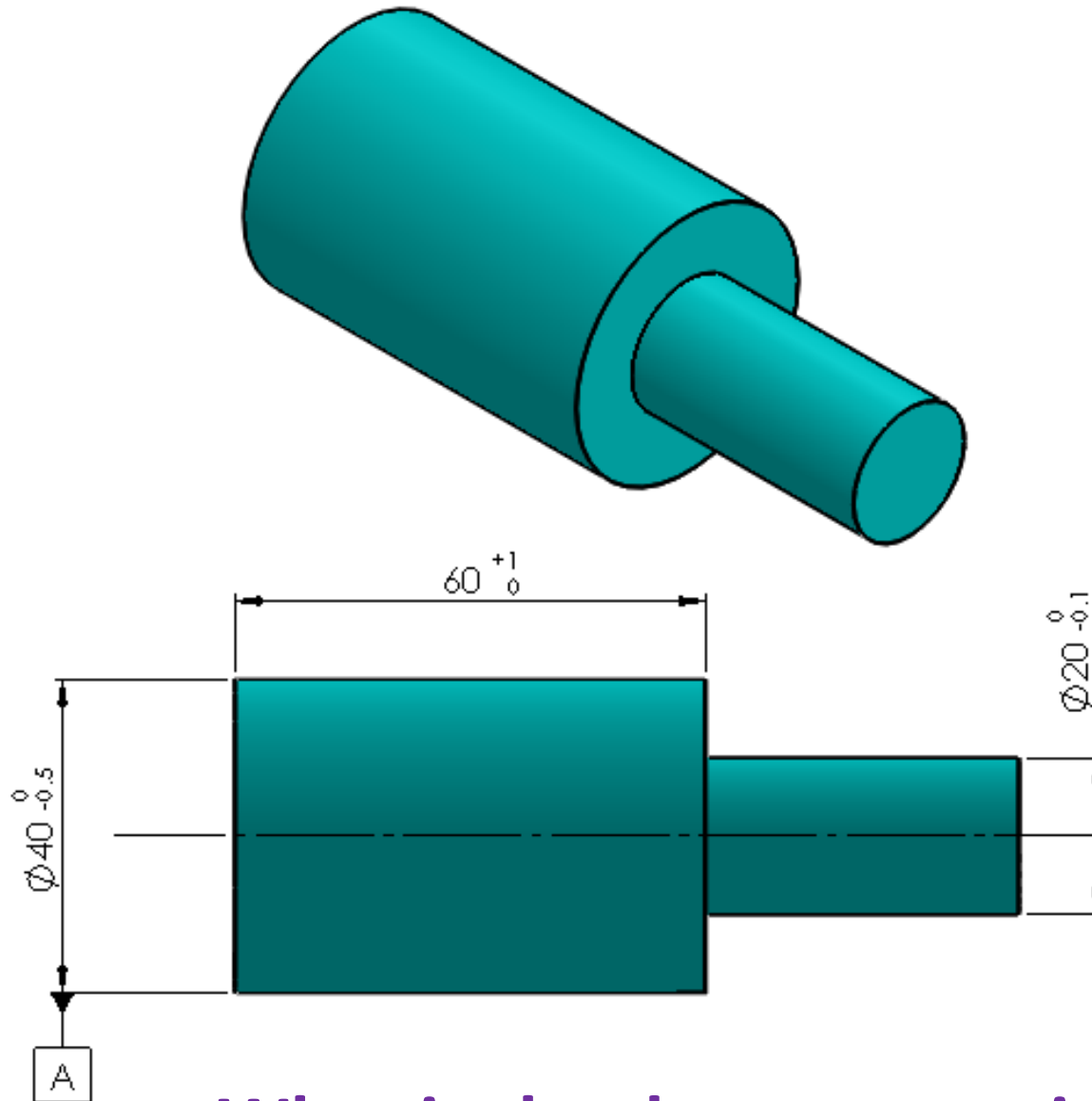
(Plane)

PART

Datum

Feature

Physical Datum

Feature

Simulator

(Table Surface)

TABLE

Simulated Datum plane

(plane derived from the Table Surface)

ON DRAWING

60 $^{+1}_{0}$

$\emptyset 20\,^{0}_{-0.1}$

$\emptyset 40\,^{0}_{-0.5}$

A

What is the datum meaning???

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Datum Axis – external

Theoretical Datum Feature Simulator

Datum Axis

Theoretical Datum Feature Simulator (AME)

61 min

PART

SMALLEST CIRCUMSCRIBED CYLINDER
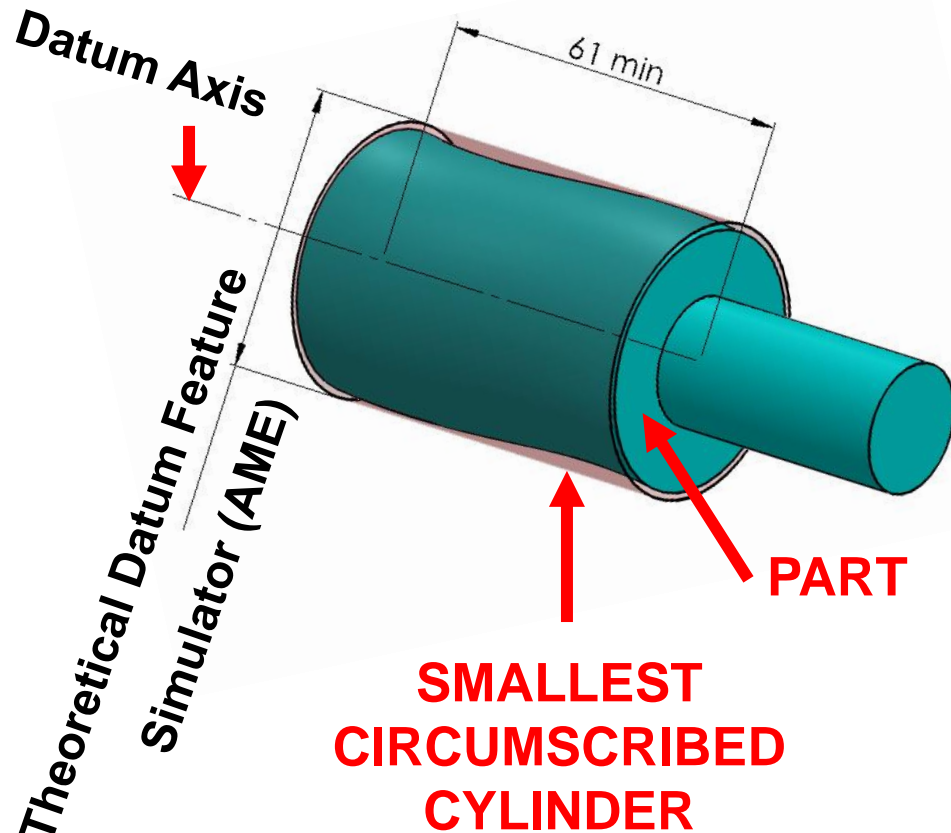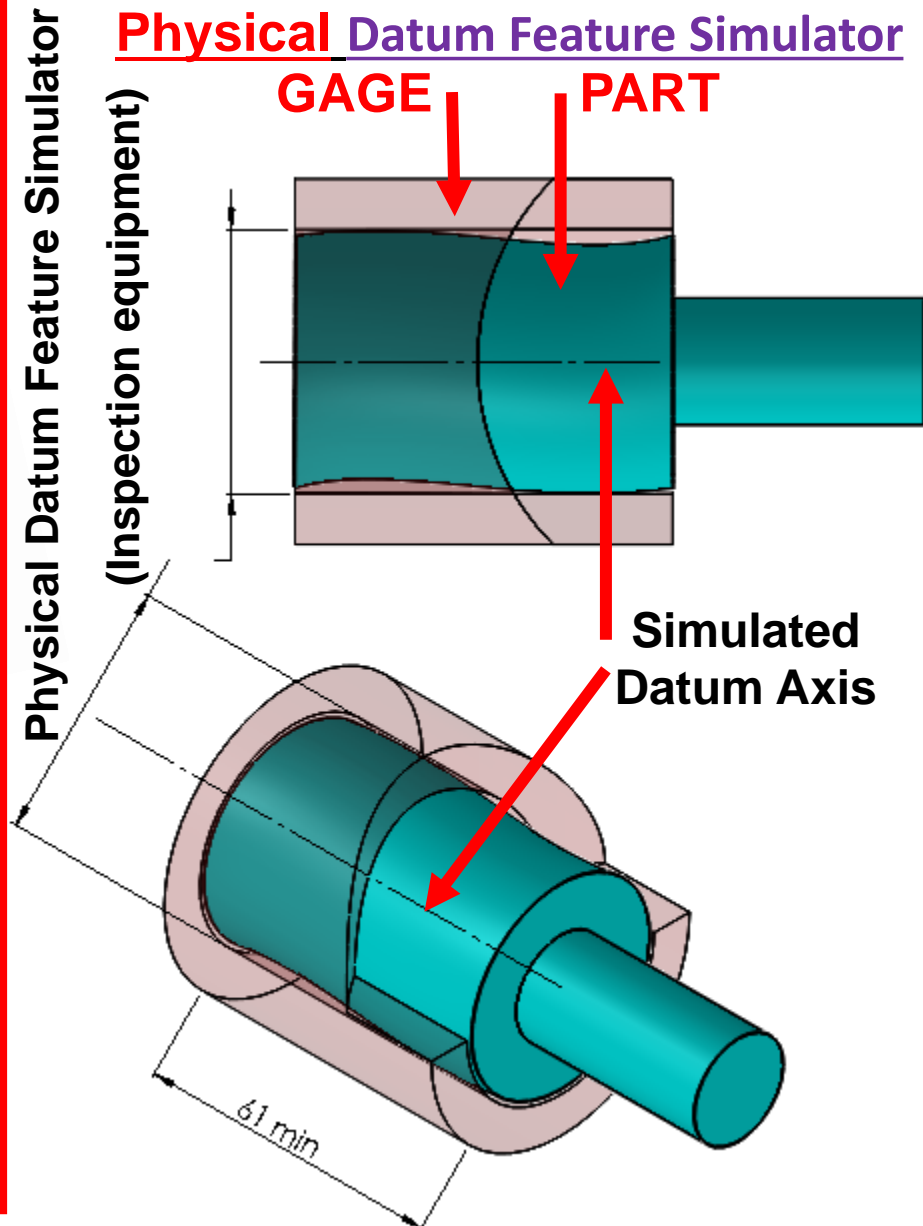
Datum Axis

the axis of a **datum feature simulator** established from the datum feature.

Physical Datum Feature Simulator

GAGE   **PART**

Physical Datum Feature Simulator (Inspection equipment)

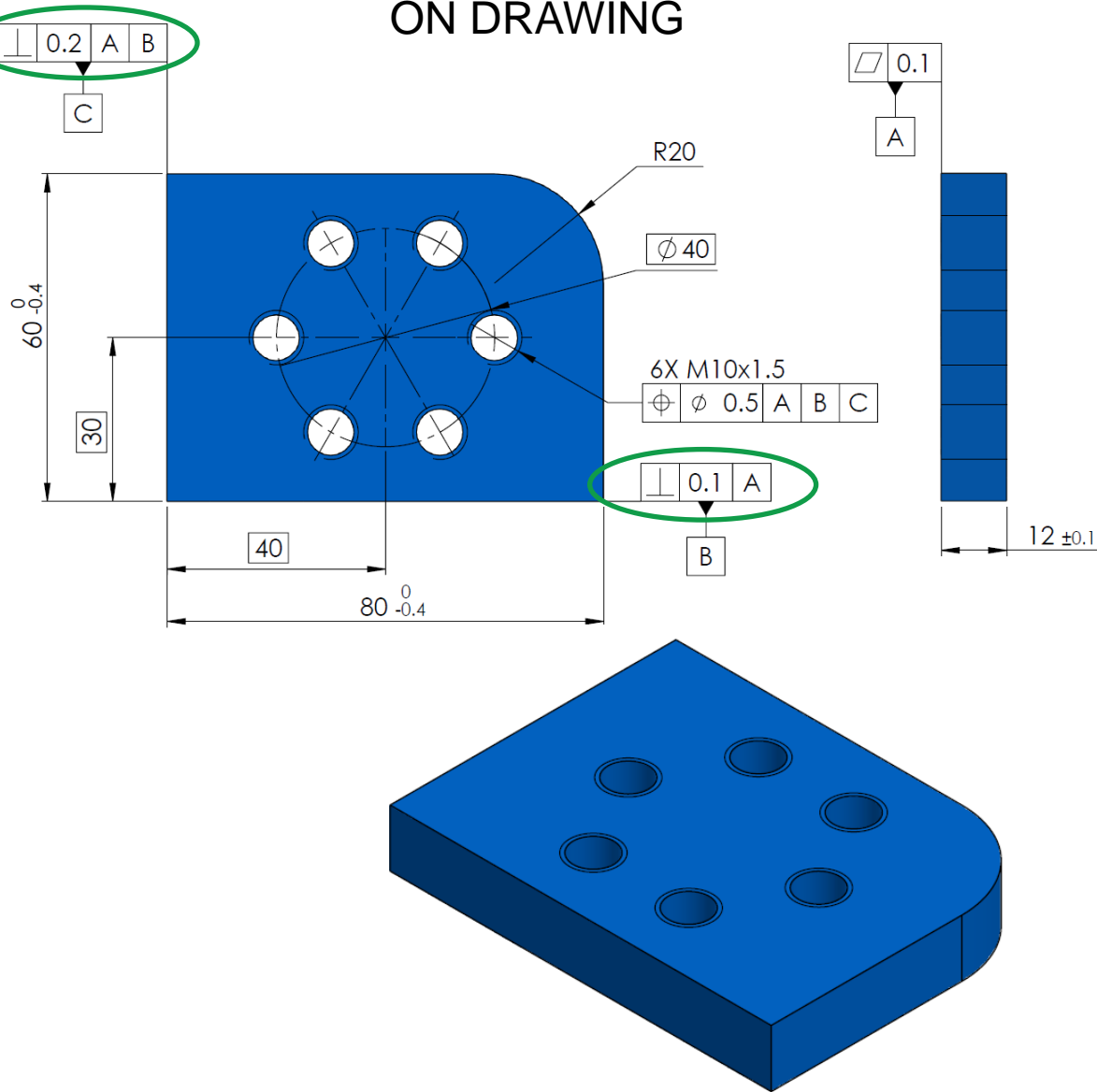**Simulated Datum Axis**

61 min

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- datum features are chosen to position the part in relation to **a set of three mutually perpendicular planes**, jointly called a datum reference frame.

- This reference frame **exists in theory only** and not on the part.

- Therefore, it is necessary to **establish** a method of simulating **the theoretical reference frame from the actual features of the part.**

- This **constrains** the applicable **degrees of freedom** between the part and the associated datum reference frame.
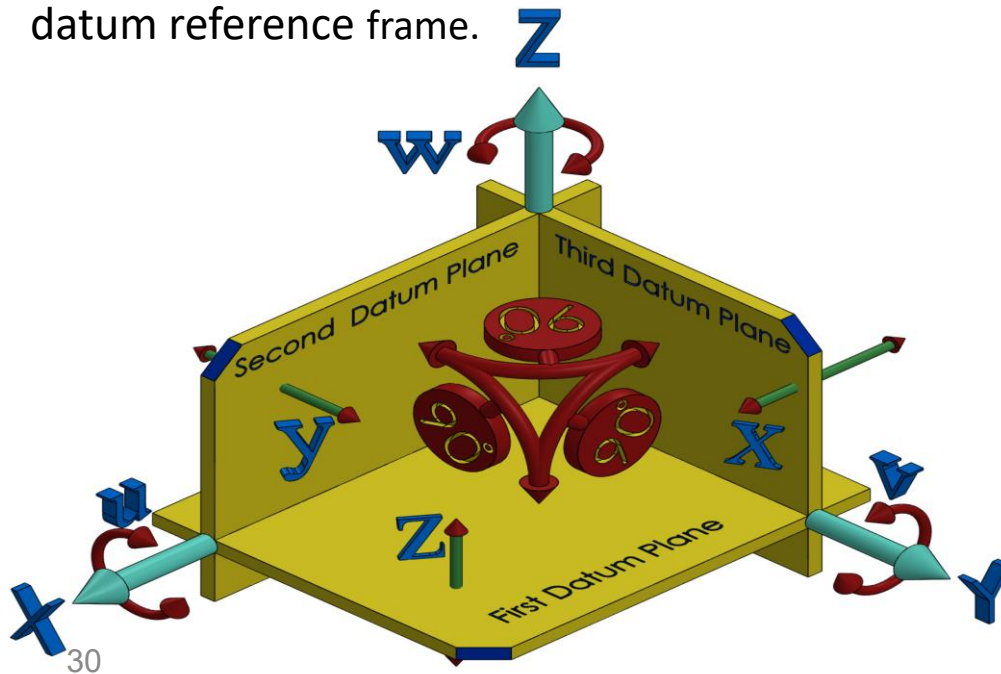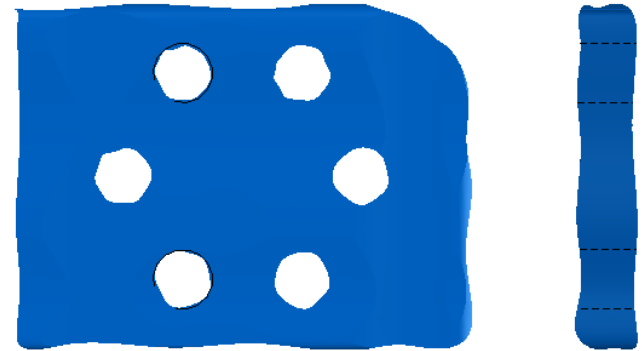
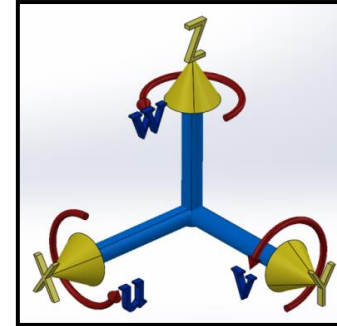| DOF – Degree Of Freedom	
Translational Freedom	**Rotational Freedom**
X – Along **X** Axis	**u** – About **X** Axis
Y – Along **Y** Axis	**v** – About **Y** Axis
Z – Along **Z** Axis	**w** – About **Z** Axis

30

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ON DRAWING

MEANS THIS

⊥	0.2	A	B

C

▱	0.1

A

R20

$60^{\ 0}_{-0.4}$

30

∅ 40

6X M10x1.5

⌖	∅ 0.5	A	B	C

⊥	0.1	A

B

40

$80^{\ 0}_{-0.4}$

$12_{\pm0.1}$

DRF – practical – 3 Plans

FIRST DATUM PLANE

Z

Z

X

DATUM FEATURE

Constrain - Z,u,v

D.O.F

SECOND DATUM PLANE

0.1 PERPENDICULARITY TOL ZONE

DATUM FEATURE

Constrain - Y,w

THIRD DATUM PLANE

Constrain - X

0.2 PERPENDICULARITY TOL ZONE

0.1 PERPENDICULARITY TOL ZONE

3-2-1 Principle

32

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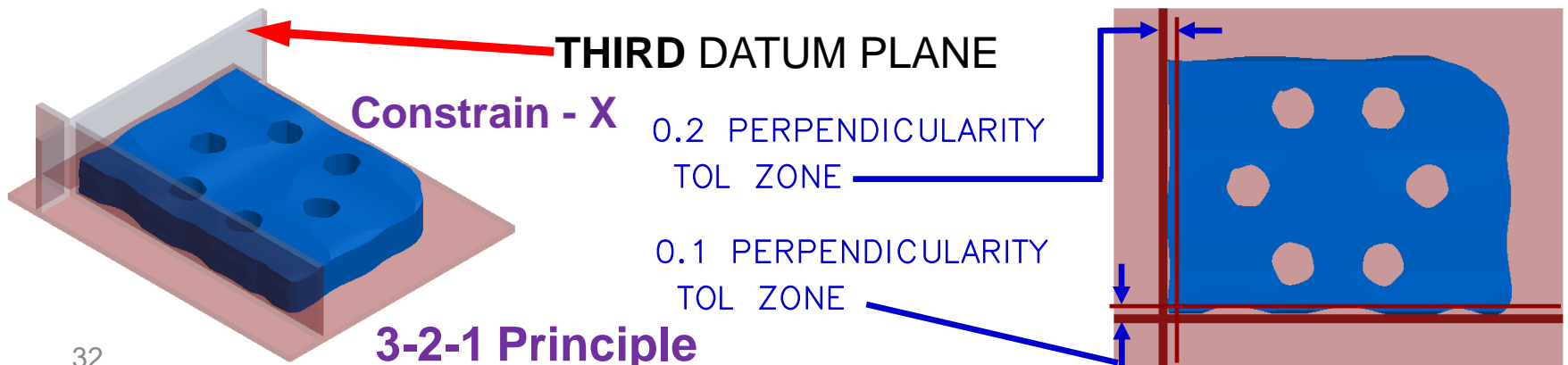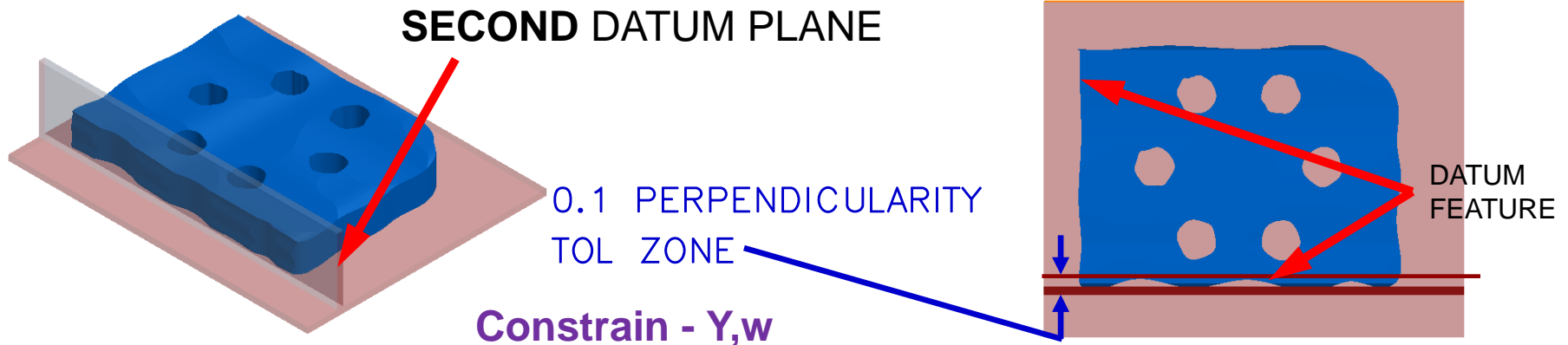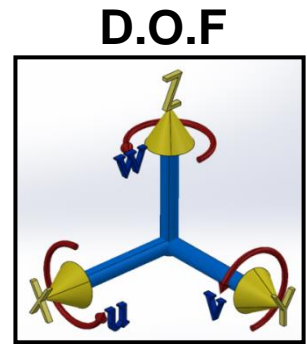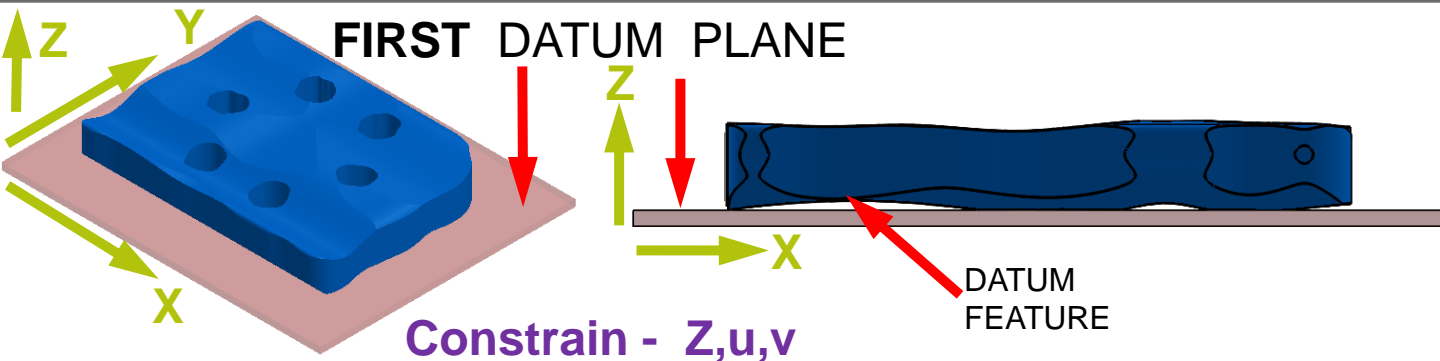
Datum System

part measuring

1. **locate and orient the part by DRF**
2. **One-way measurement direction**
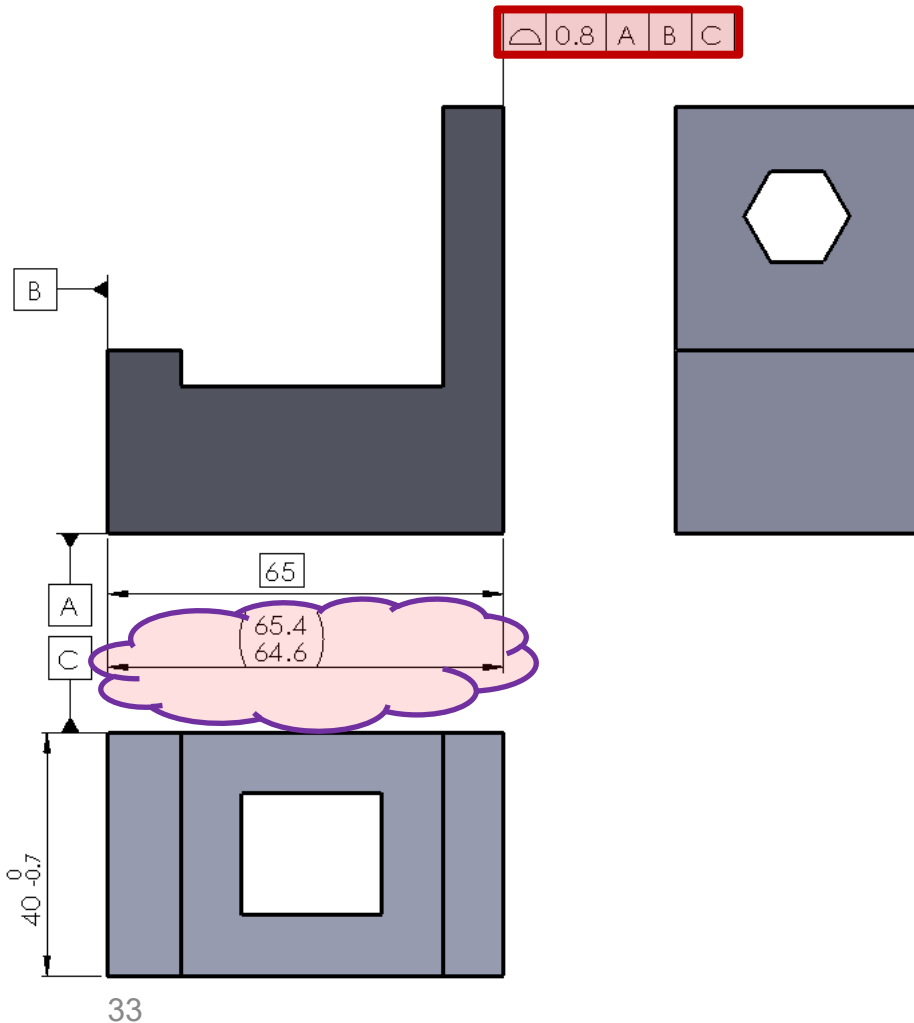
⌓ 0.8 A B C

B

65

A
C

65.4
64.6

$40 \begin{smallmatrix} 0 \\ -0.7 \end{smallmatrix}$

DRF Option

A	B	C
A	C	B
B	A	C
B	C	A
C	A	B
C	B	A

A	B
B	A
B	C
C	B
B	

DRF Simulator

.Datum B

.Datum C

.Datum A

Rohan komienan

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⌓	0.8	A	B	C

0.8 Tol zone

65.4

64.6
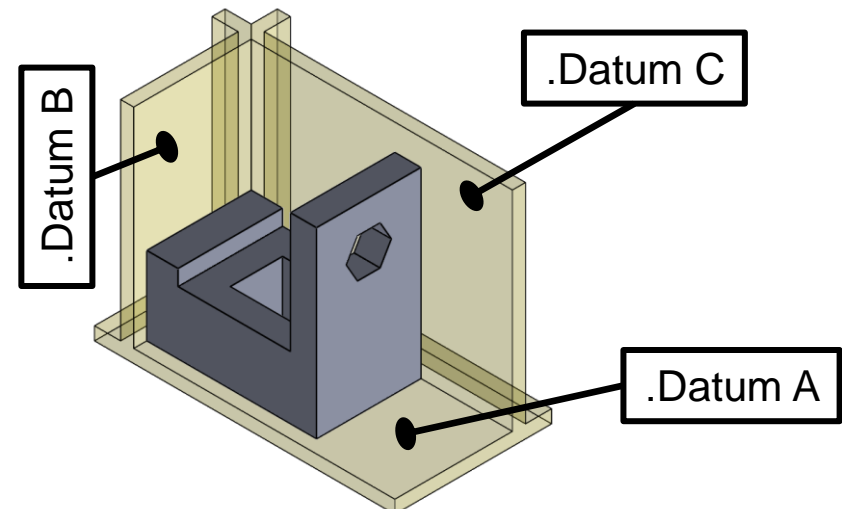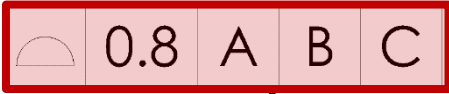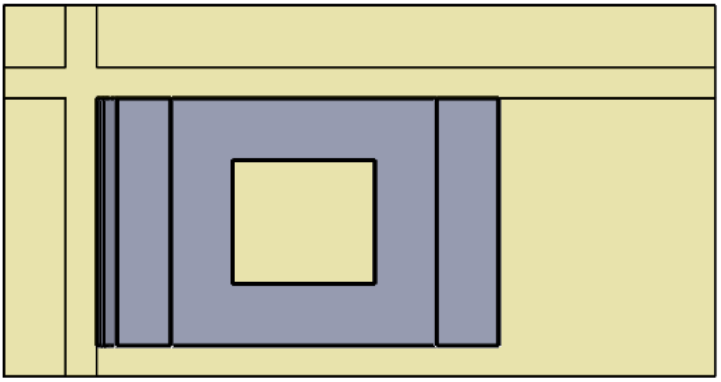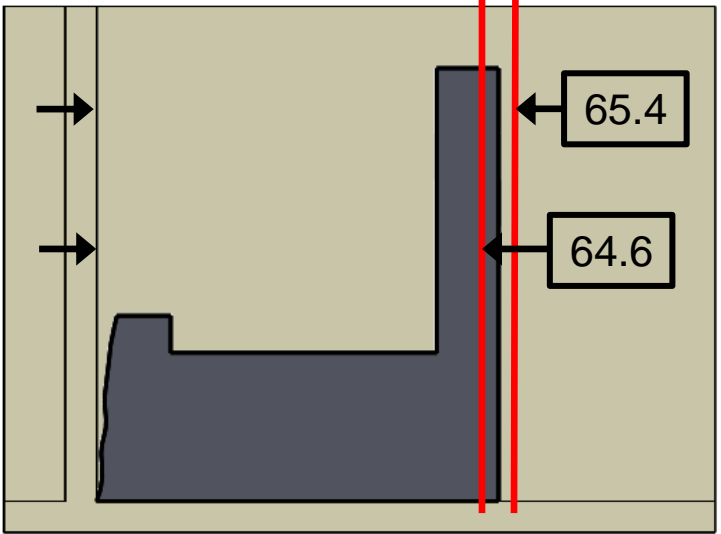
.Second Datum Plane – **B** (2 Points)

EXAMPLE 2-1

.Third Datum Plane – **C** (1 Point)

GOOD PART

.First Datum Plane – **A** (3 Points)

Datum System

0.8 Tol zone

| ⌒ | 0.8 | B | A | C |

First Datum Plane – **B** (3 Points)

.Third Datum Plane - **C** (1 Point)
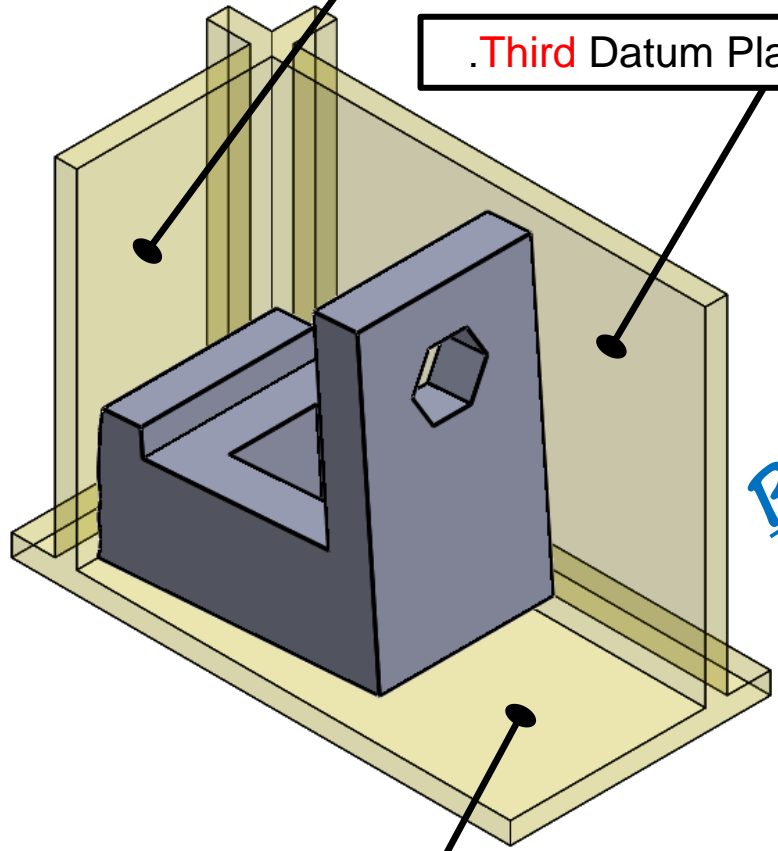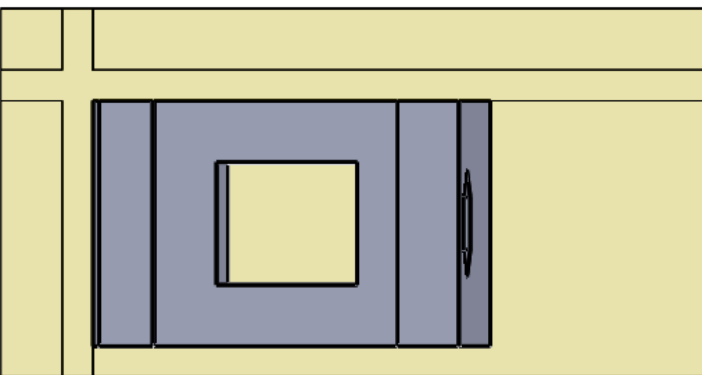
.Second Datum Plane - **A** (2 Points)

EXAMPLE 2-2

65.4

64.6

BAD PART
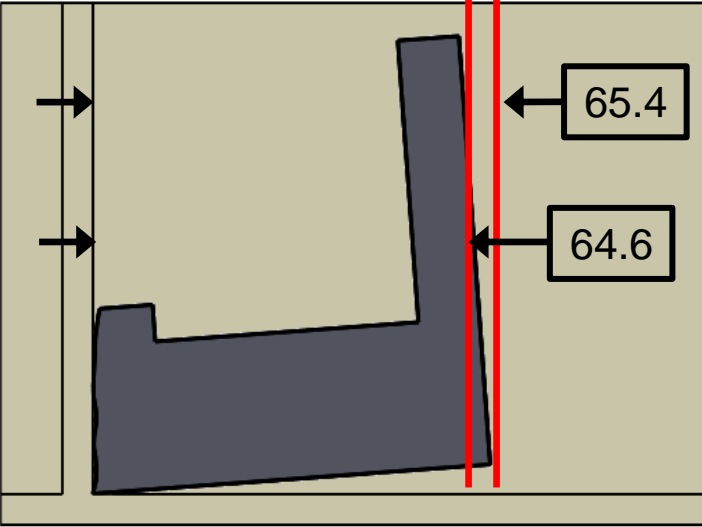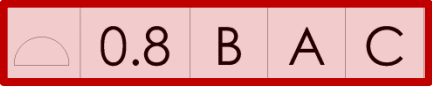
5 min Questions

POSITION

LOCATION

CONCENTRICITY

SYMMETRY
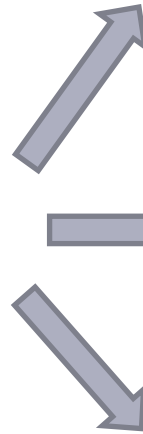
Position is the location of one or more features of size relative to one another or to one or more datums. (ASME y14.5)

what does it mean?

* Hole
* Cylinder
* Ball
* Two Opposite surfaces
* Slot

- location of one or more **features of size**

- relative to one another   **or**   to one or more datums

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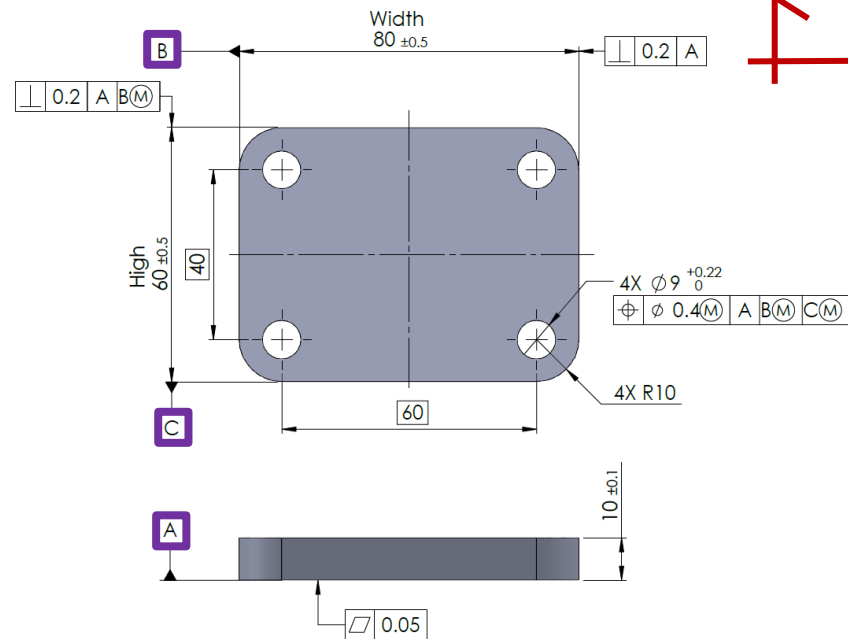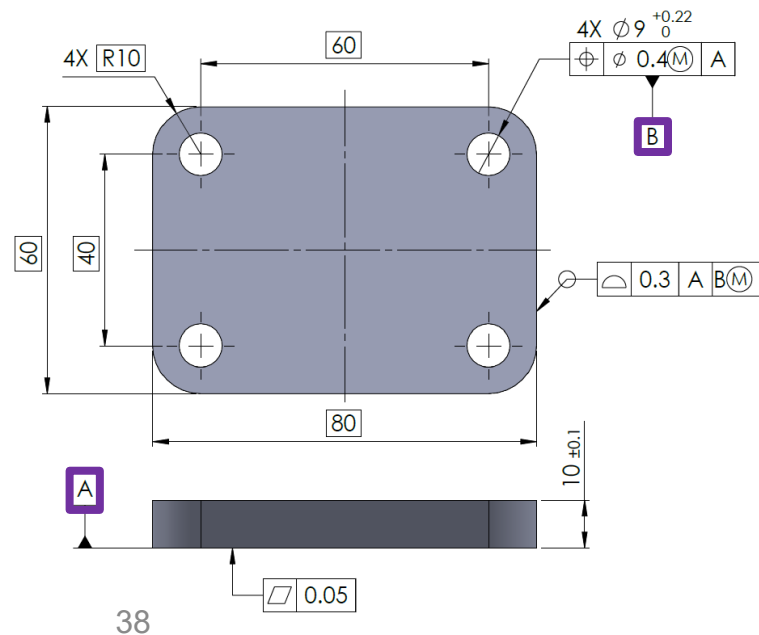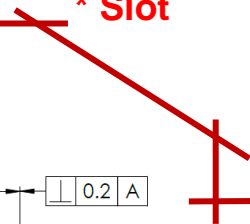
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True position:

the theoretically exact location of a feature of size, as established by basic dimensions. (ASME y14.5)

1 of 6 true position
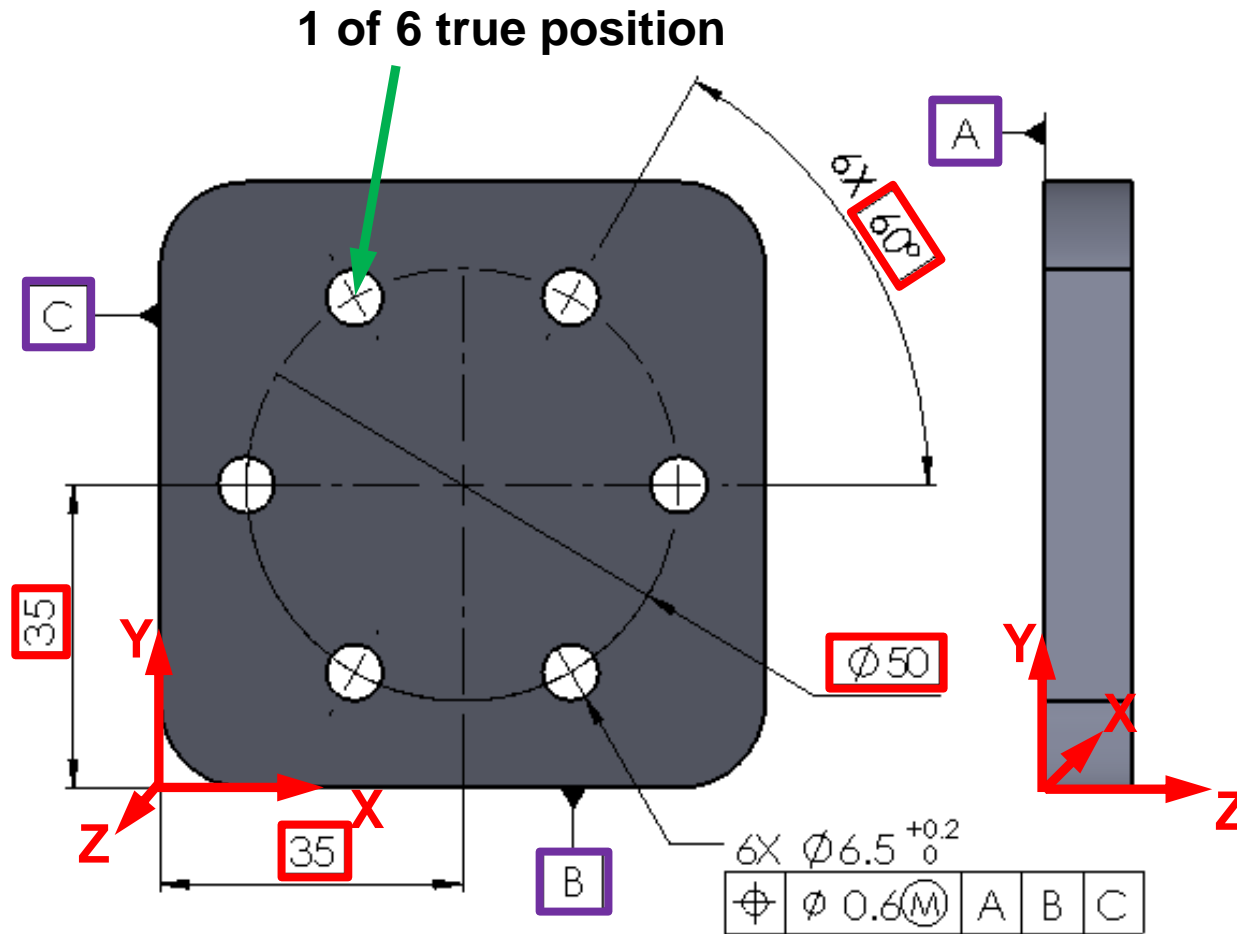
positional tolerance is indicated by:
- position symbol.
- tolerance value.
- applicable material condition modifiers.
- datum references placed in a feature control frame.

Modifier RFS OR Ⓜ OR Ⓛ

Second Datum

⊕ | ∅ 0.6Ⓜ | A | B | C

Position Symbol

First Datum

Tolerance zone

Third Datum

40

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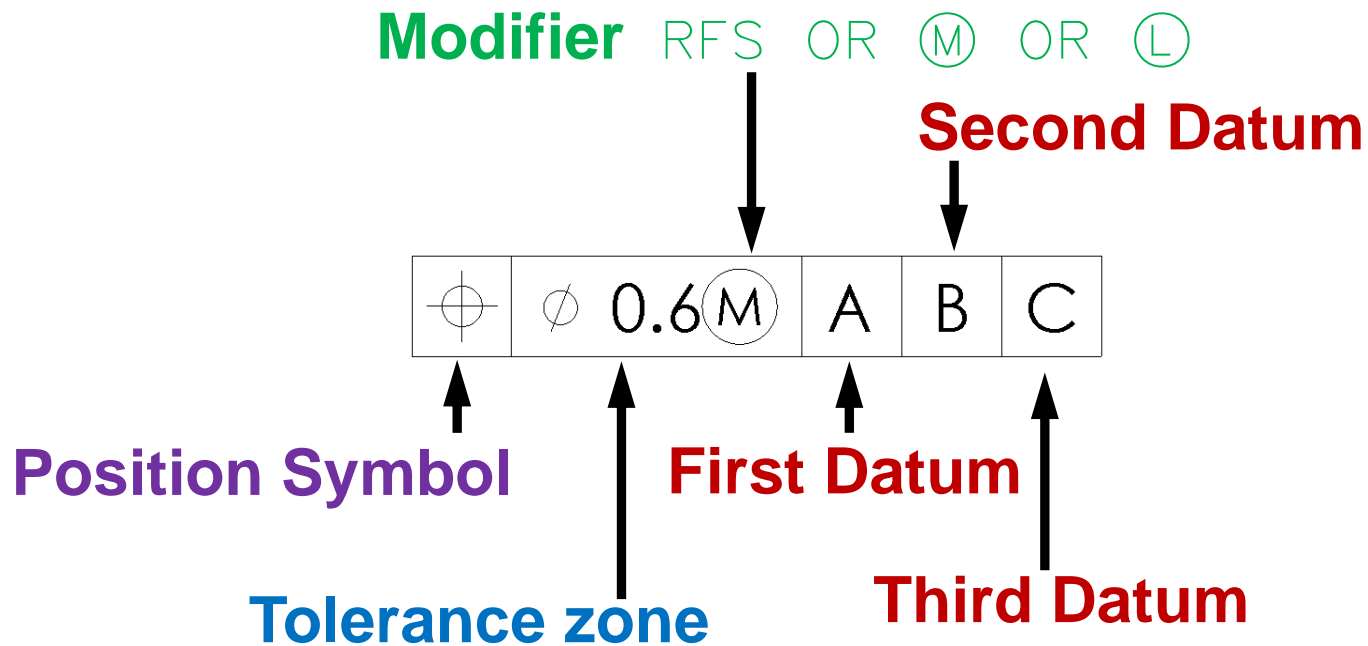
A) **a zone within which the, axis, or center plane of a feature of size is permitted to vary from a true position.**

ON DRAWING

MEANS THIS

First Datum Plane

Third Datum Plane

Second Datum Plane

SECTION A-A
SCALE 1 : 1

Detail A

DRF

4x ⌀9 +0.22 0

⊕ ⌀ 0.4(M) A B C

4x R10

60 ±0.5

40

10

10

60

80 ±0.5

10 ±0.1

⊥ 0.2 A B

C

⊥ 0.1 A

B

A

▱ 0.05

True Position

10

Third Datum Plane

Position Tolerance Zone

DRF

Actual Meating Envelop

Detail A
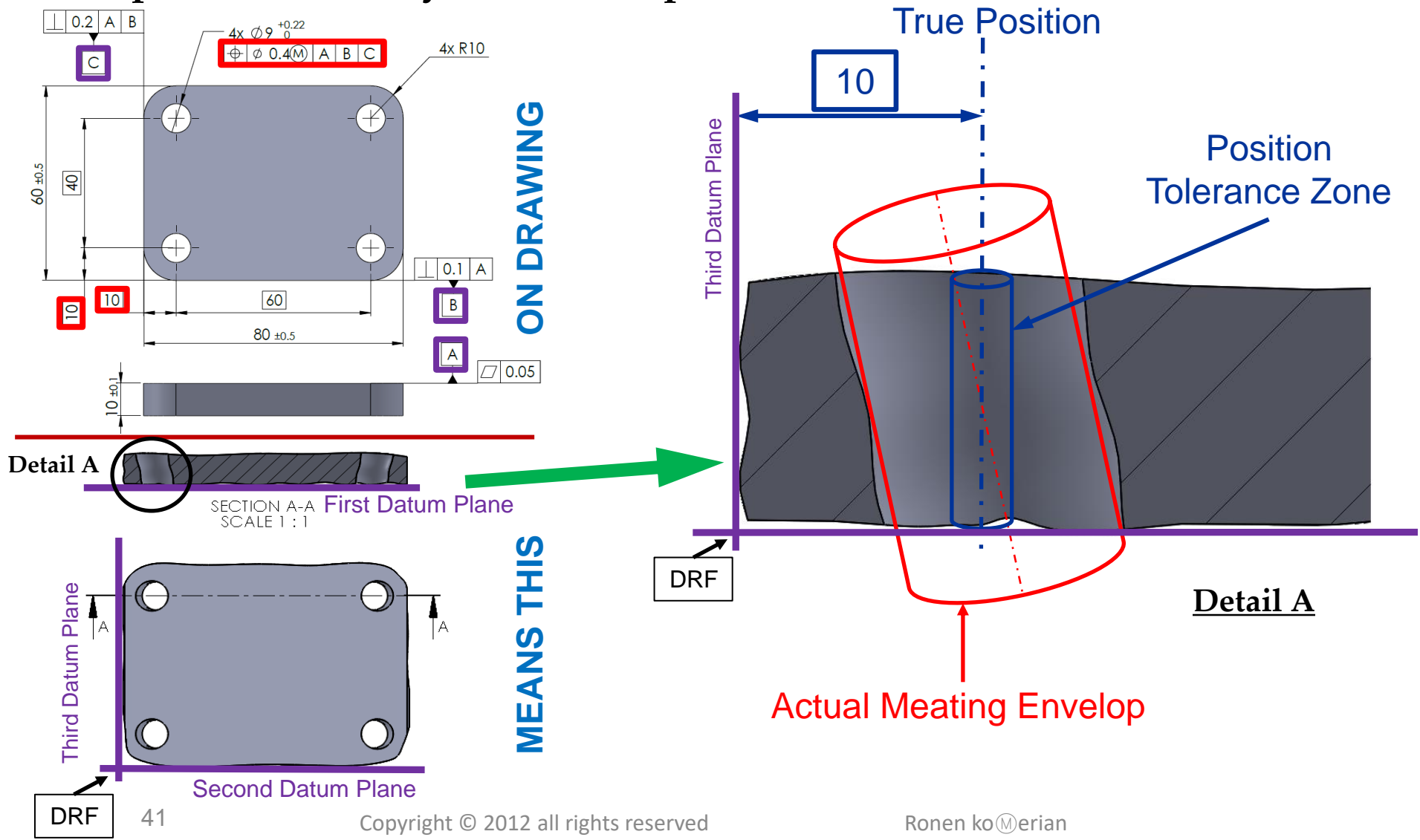
Position- Definition 5-5 (VC)

B) where specified on an MMC, a boundary, defined as the virtual condition, that may not be violated by the surface of the considered feature of size.

ON DRAWING

MEANS THIS

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APPLICATION

80 X 60 X 10

Plate 1

4X M8

Screw

Plate 2

4X M8 Thread
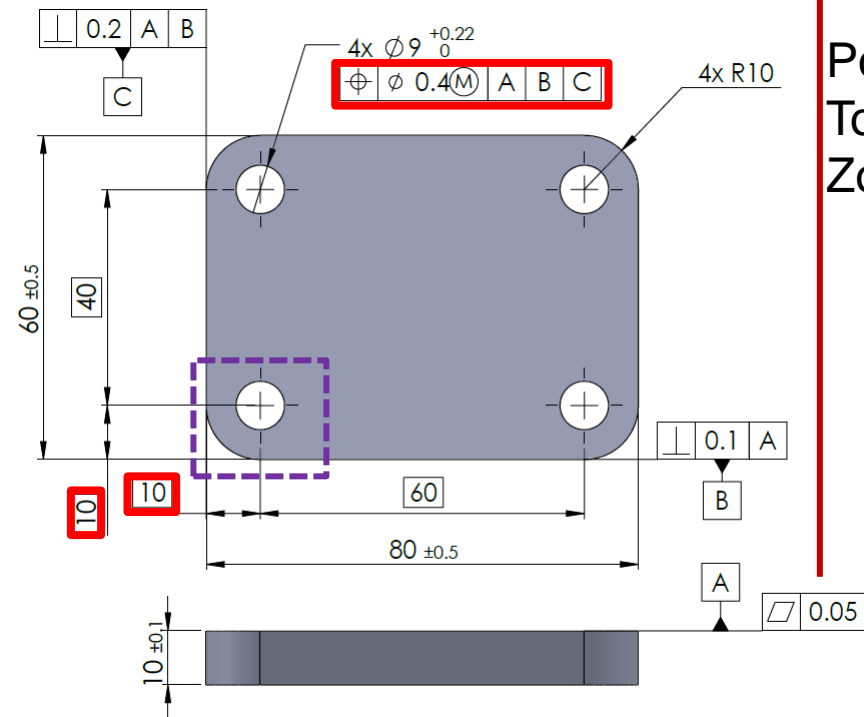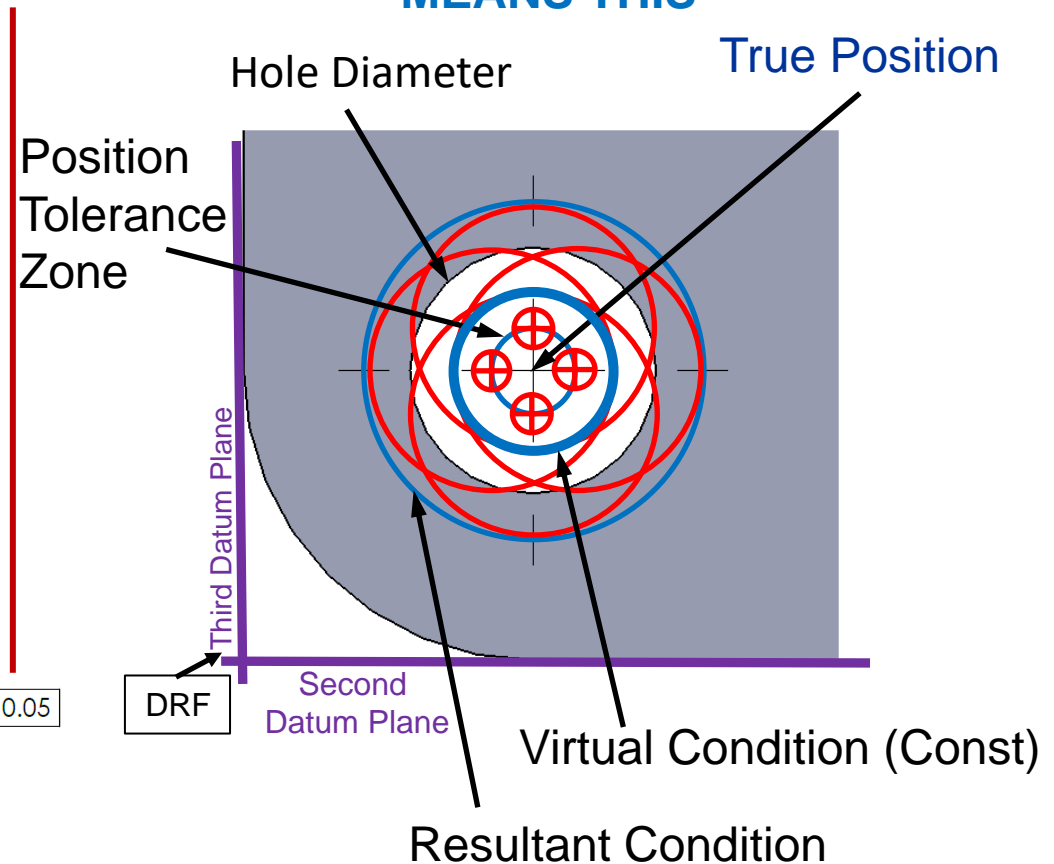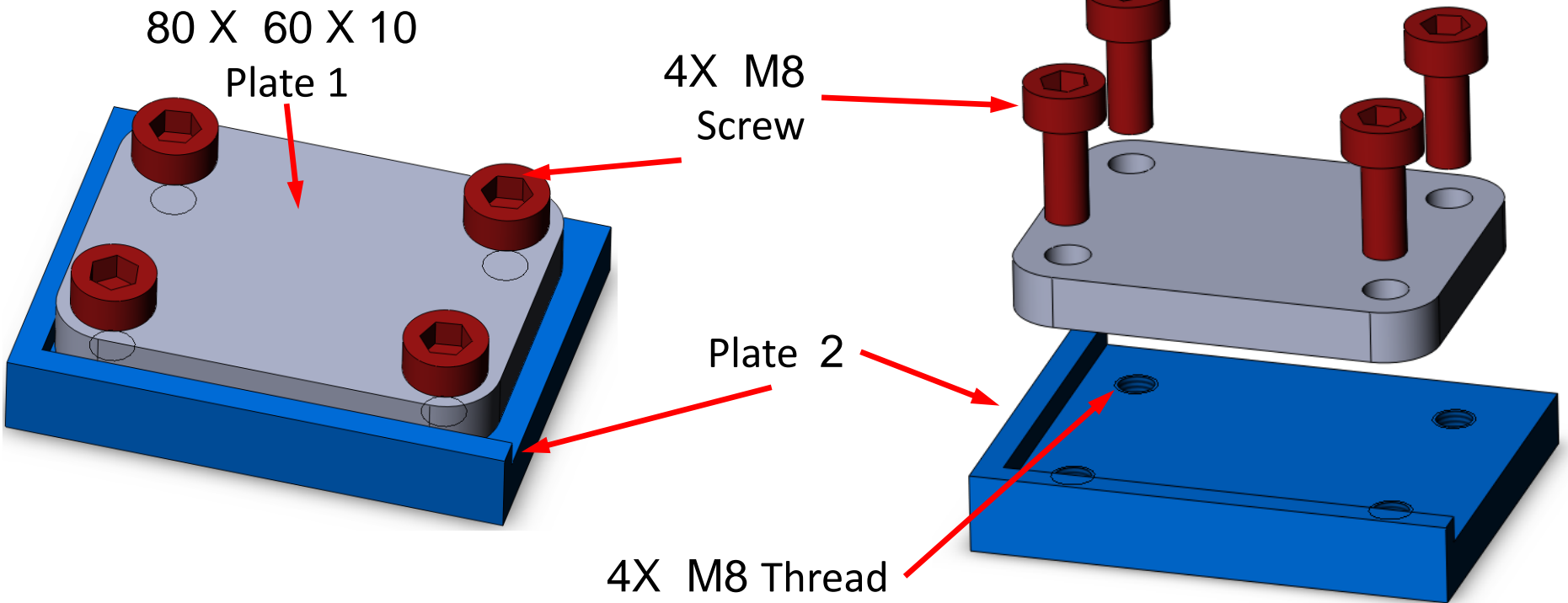
1. What is **hole diameter size** required?
2. What is **hole diameter tolerance** required?
3. What is **Hole position and modifier** required?
4. What is **Thread position and projected** required?

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Hole and Thread Position + Size Tolerances diagram

START → **Identify Thread Type and Size** → **M8** ←

1. **hole diameter size** required?
2. **hole diameter tolerance** required?
3. **Hole position and modifier** required?
4. **Thread position and projected** required?

$\varnothing 8.4^{+0.15}$ ← **Close** ← **Determine Hole Diameter Size**
According to B 18.2.8 – 1999 STANDARD → **Loose** → $\varnothing 10^{+0.36}$

→ **normal** $\varnothing 9^{+0.22}$

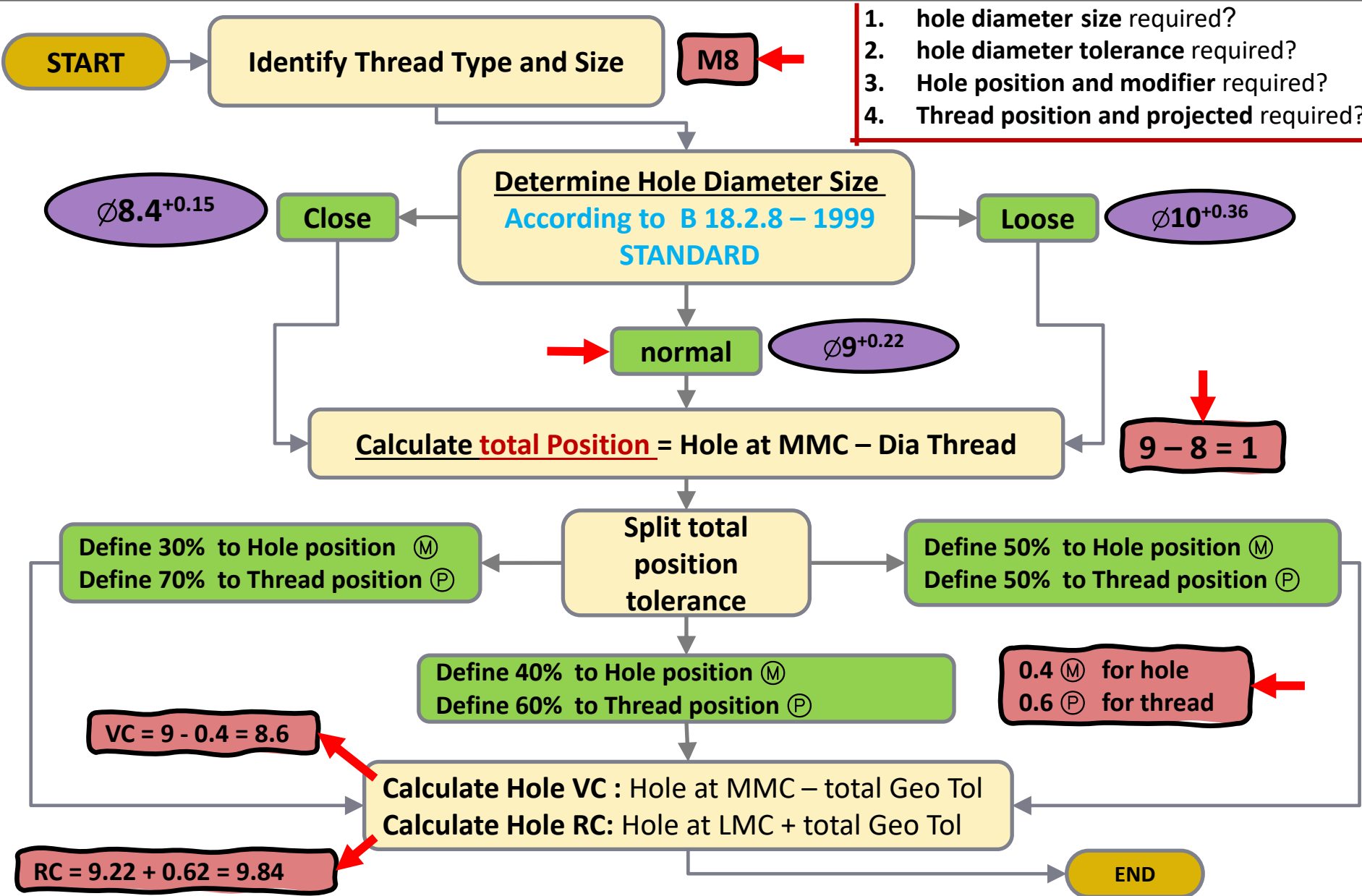$9 - 8 = 1$

Calculate total Position = Hole at MMC – Dia Thread

Split total position tolerance

Define 30% to Hole position Ⓜ
Define 70% to Thread position Ⓟ

Define 50% to Hole position Ⓜ
Define 50% to Thread position Ⓟ

Define 40% to Hole position Ⓜ
Define 60% to Thread position Ⓟ

0.4 Ⓜ for hole
0.6 Ⓟ for thread ←

VC = 9 - 0.4 = 8.6

Calculate Hole VC : Hole at MMC – total Geo Tol
Calculate Hole RC: Hole at LMC + total Geo Tol

RC = 9.22 + 0.62 = 9.84

END

ON DRAWING

A	B	C	D=B+C	E=A-D	F=A+D
Unrelated Actual Mating Envelop	Position Tolerance Zone	Bonus Tolerance	Total Position Tolerance Zone T.O.P	Virtual Condition VC	Resultant Condition RC
9 MMC	0.4	0	0.4	8.6	9.4
9.02	0.4	0.02	0.42	8.6	9.44
9.04	0.4	0.04	0.44	8.6	9.48
9.06	0.4	0.06	0.46	8.6	9.52
9.08	0.4	0.08	0.48	8.6	9.56
9.1	0.4	0.1	0.5	8.6	9.6
....	....	....	....	....	....
....	....	....	....	....	....
....	....	....	....	....	....
9.2	0.4	0.2	0.6	8.6	9.8
9.22 LMC	0.4	0.22	0.62	8.6	9.84

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Position– Definition

MEANS THIS

Detail A

SECTION A-A
SCALE 1 : 1

First Datum Plane

Third Datum Plane

A

Third Datum Plane

A

Second Datum Plane

DRF

True Position

10

Third Datum Plane

$\varnothing 0.4$ -:- $\varnothing 0.62$
Position
Tolerance Zone

DRF

Detail A

Actual Meating Envelop
$\varnothing 9$ -:- $\varnothing 9.22$

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ON DRAWING

MEANS THIS

True Position

Hole Diameter

Position Tolerance Zone

Third Datum Plane

DRF

Second Datum Plane

Virtual Condition $\varnothing$**8.6**

RC $\quad \varnothing$**9.22+** $\quad \varnothing$**0.62 =** $\quad \varnothing$**9.84**

Hole at LMC $\qquad$ Total T.O.P

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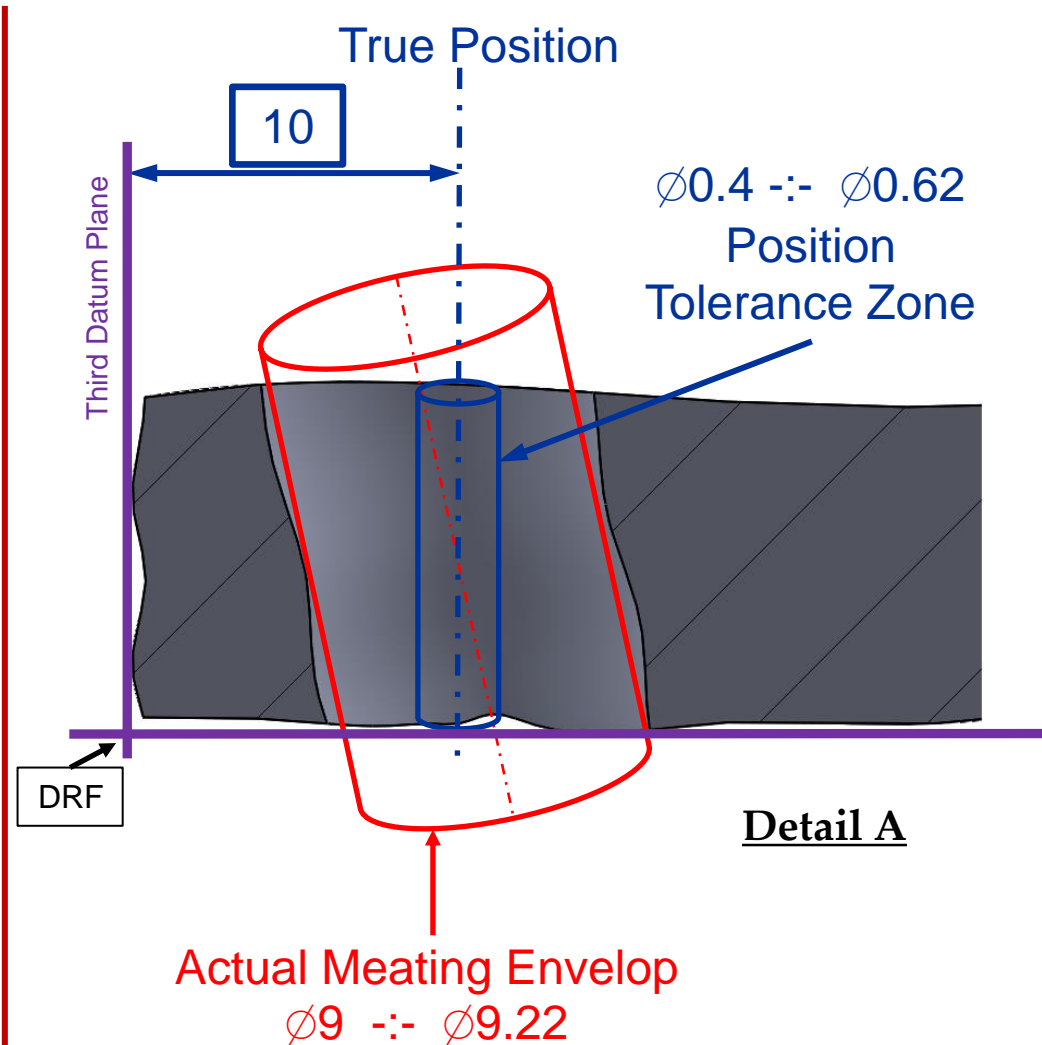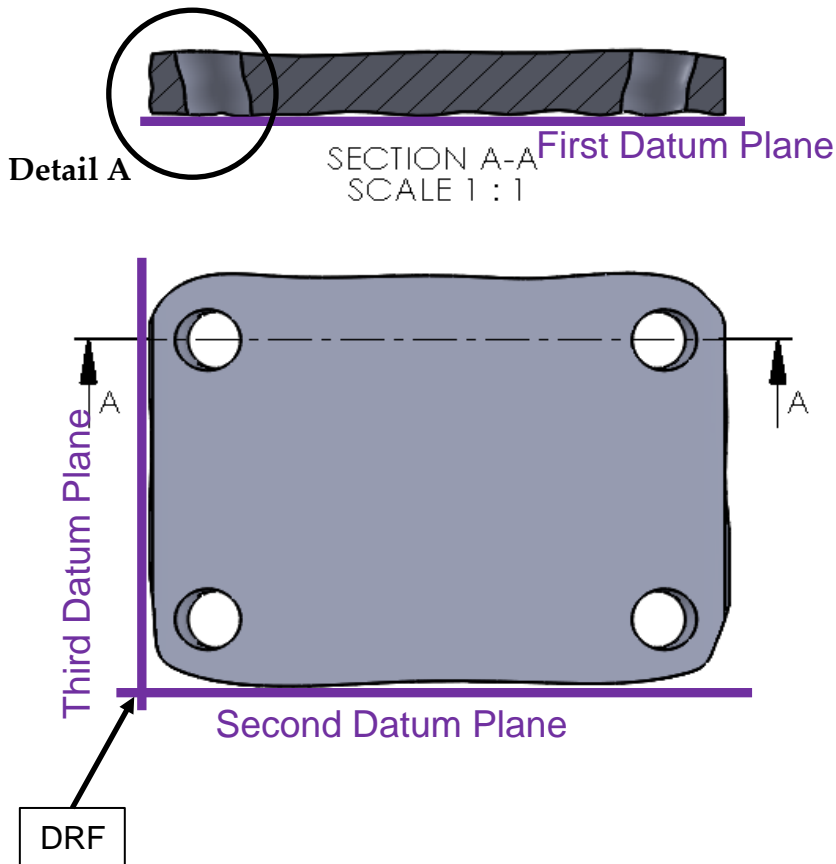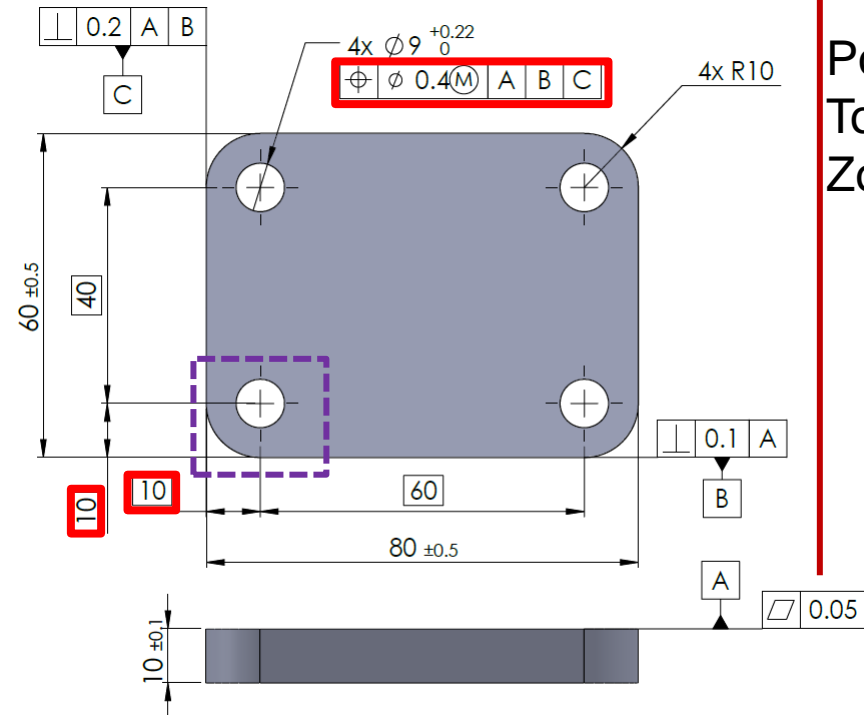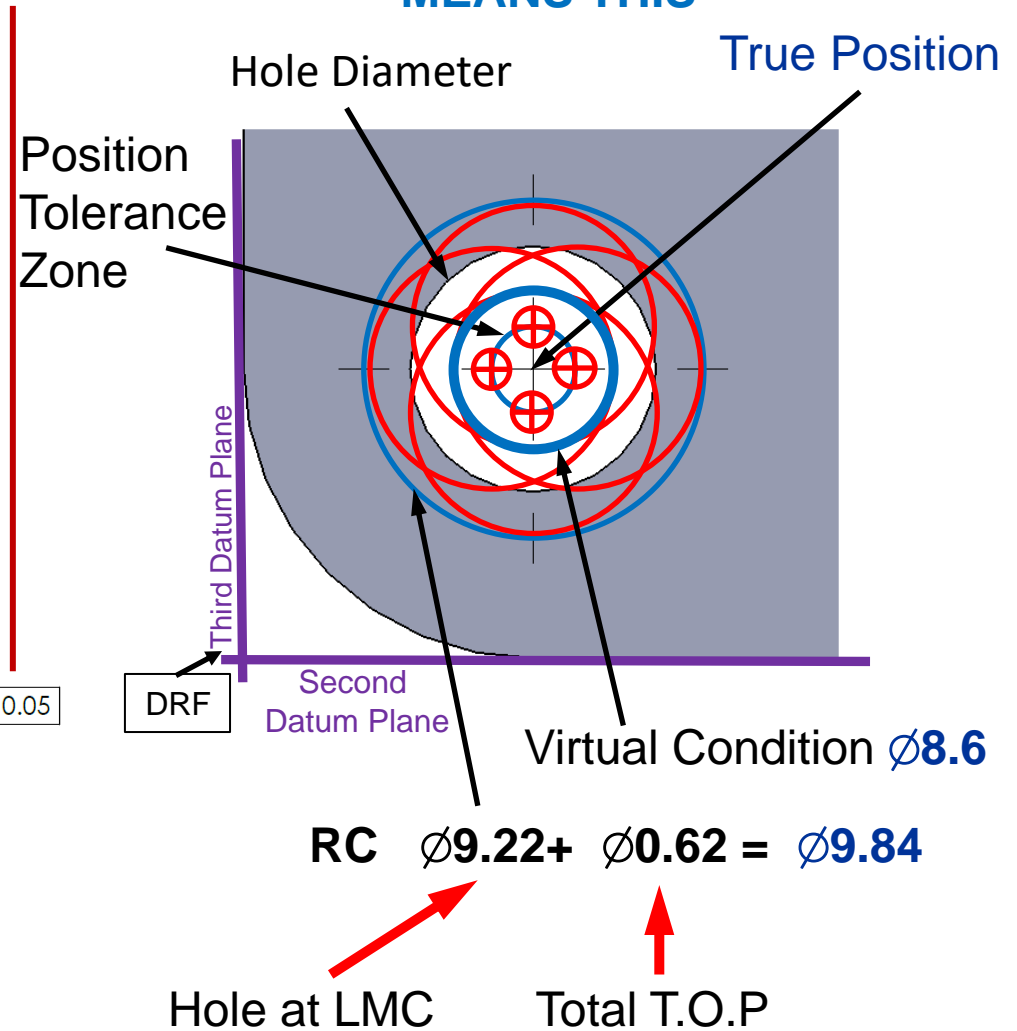
ON DRAWING

thread tolerance zone :
0.6 diameter tolerance zone
projected 10.1 [mm]

SECTION A-A
SCALE 1 : 1

| ⊥ | 0.2 | A | B |

C

85 ±0.2

| □ | 0.05 |

A

4x M8

| ⊕ | ⌀ 0.6 Ⓟ 10.1 | A | B | C |

⌀0.6 **Tolerance Zone**

Projected

10.1 **Minimum High**

65 ±0.2

40

10

10   60

| ⊥ | 0.1 | A |

B
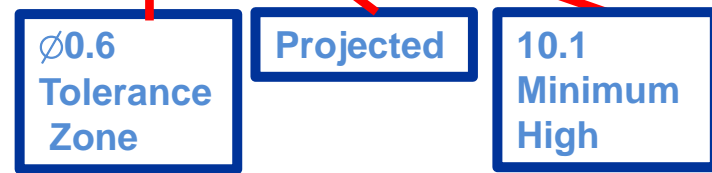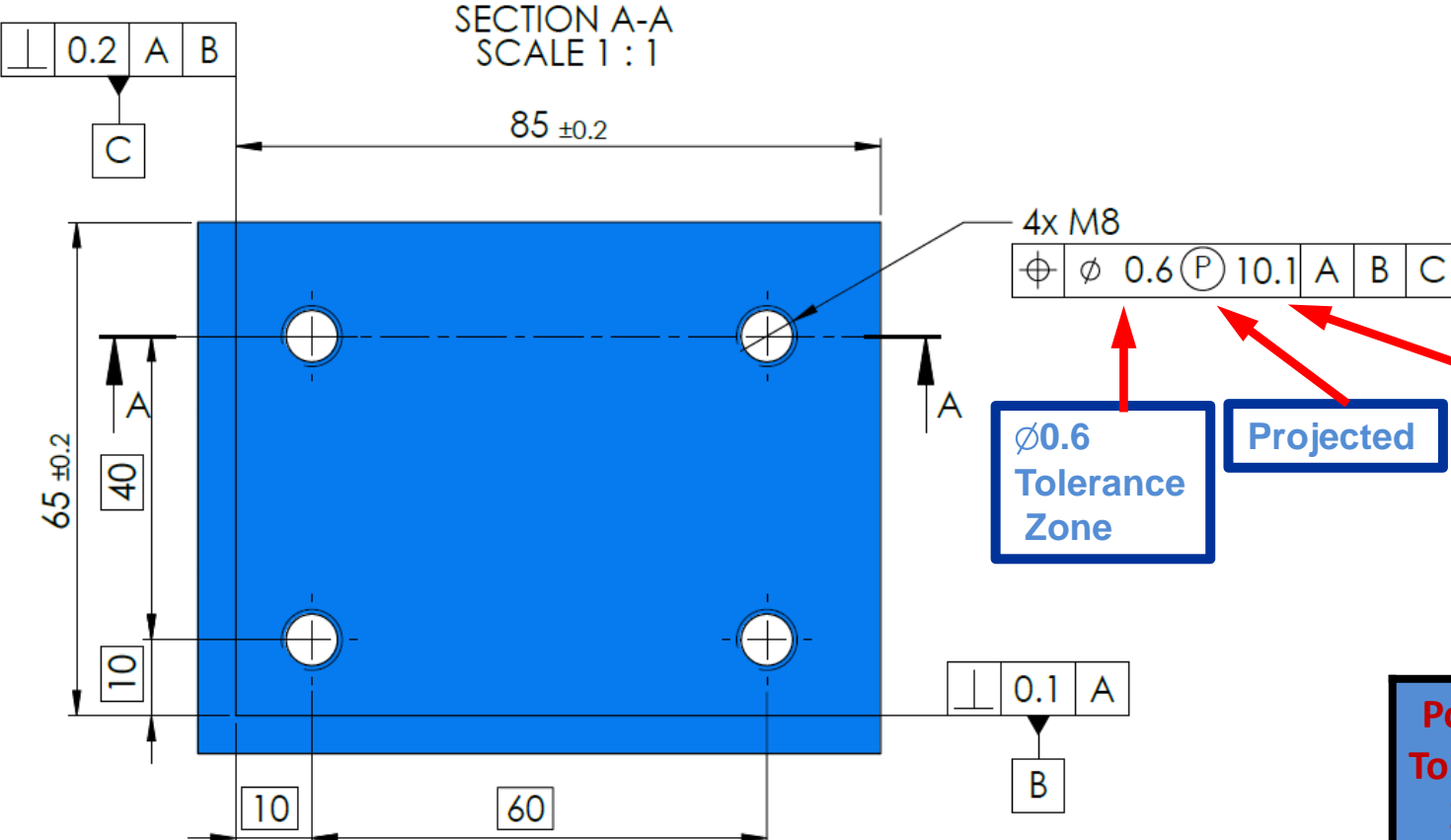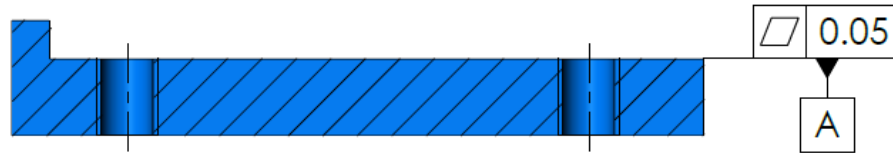
Position Tolerance Zone	M8 thread
0.6	M8

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MEANS THIS

Center line options

0.6 diameter
Projected Tolerance Zone

Four M8 thread

True Position

MEANS THIS

0.2

0- Distance

0.3

0.3 Dis
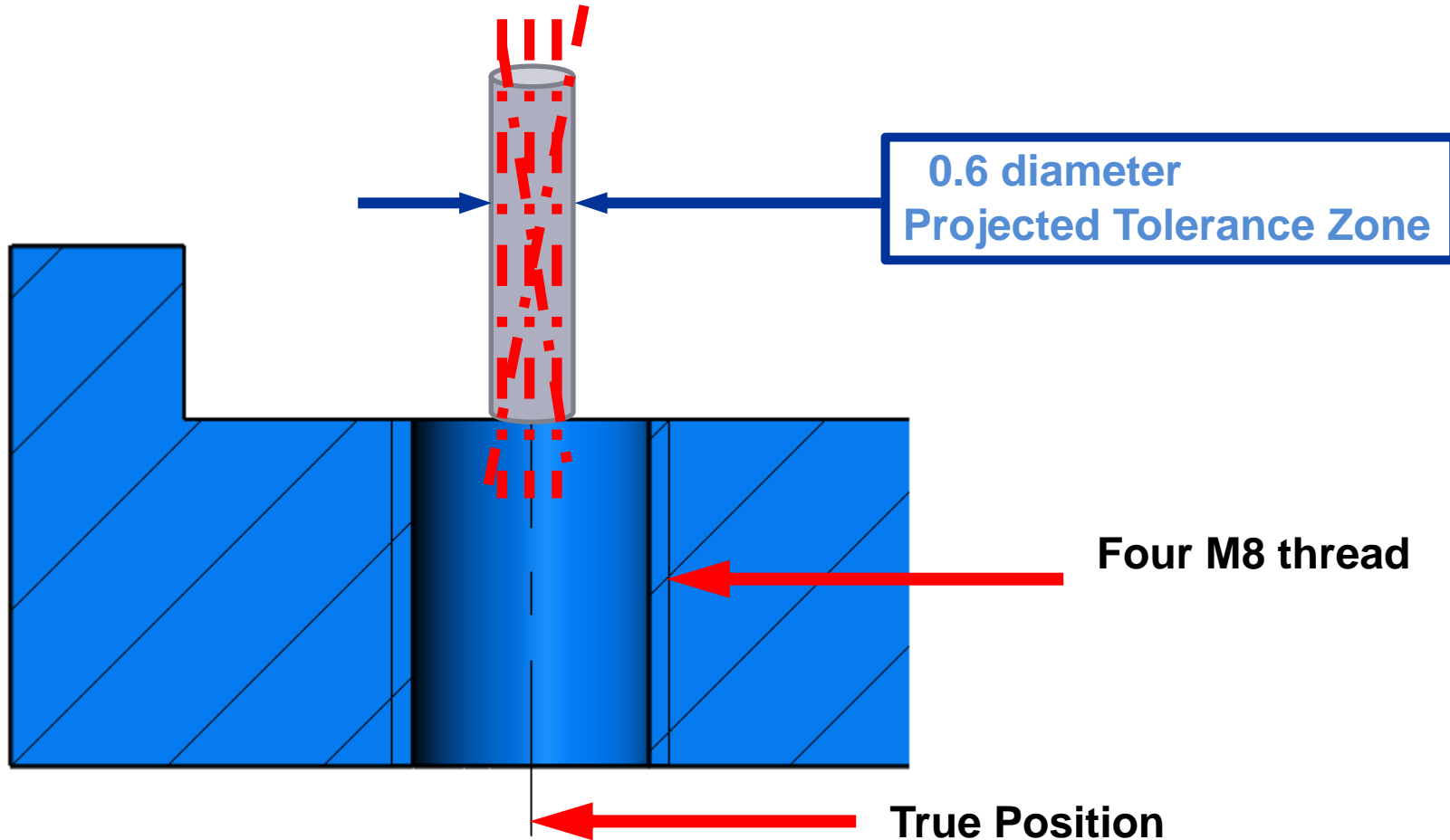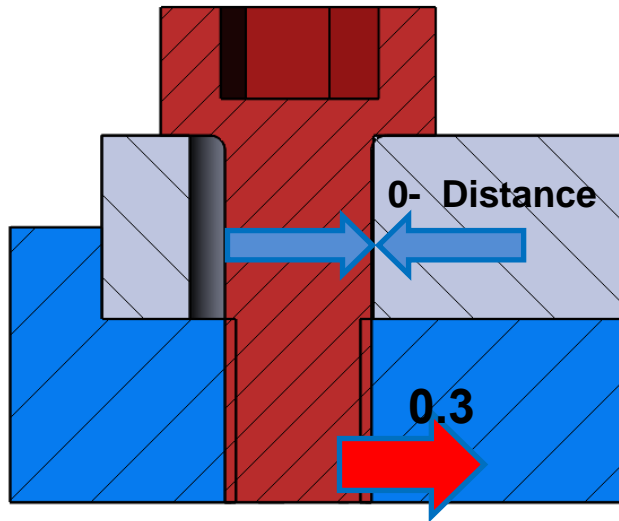
0.5 - Distance
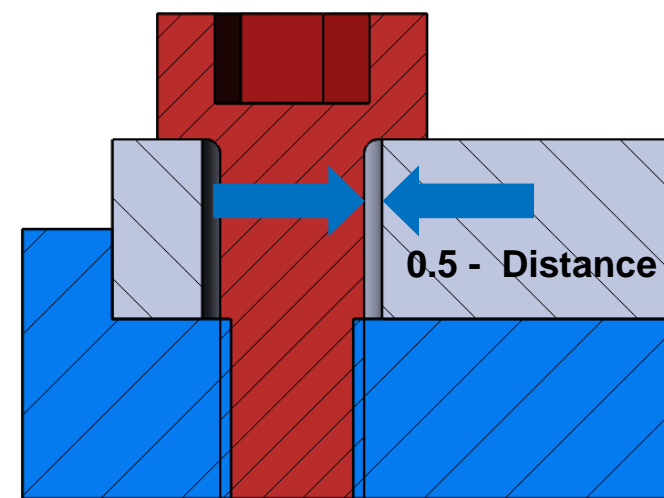
Situation2
0 radial distance
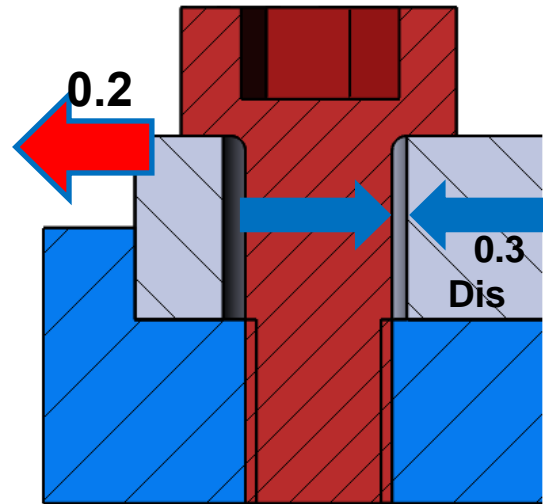
Situation2
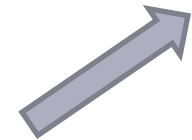0.3 radial distance

Situation1
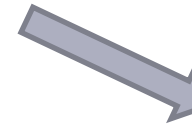0.5 radial distance

In this way, the design quality, ensures that all screws are in there position

5 min Questions

PROFILE

PROFILE OF SURFACE

PROFILE OF LINE

Profile

1. **A profile is an outline of a surface**, a shape made up of one or more features, or a two-dimensional element of one or more features.

2. **Profile tolerances are used to define a tolerance zone** to control form or combinations of size, form, orientation, and location of a feature(s) relative to a true profile.

3. Depending upon the design requirements, **profile tolerance zones may or may not be related to datums.**

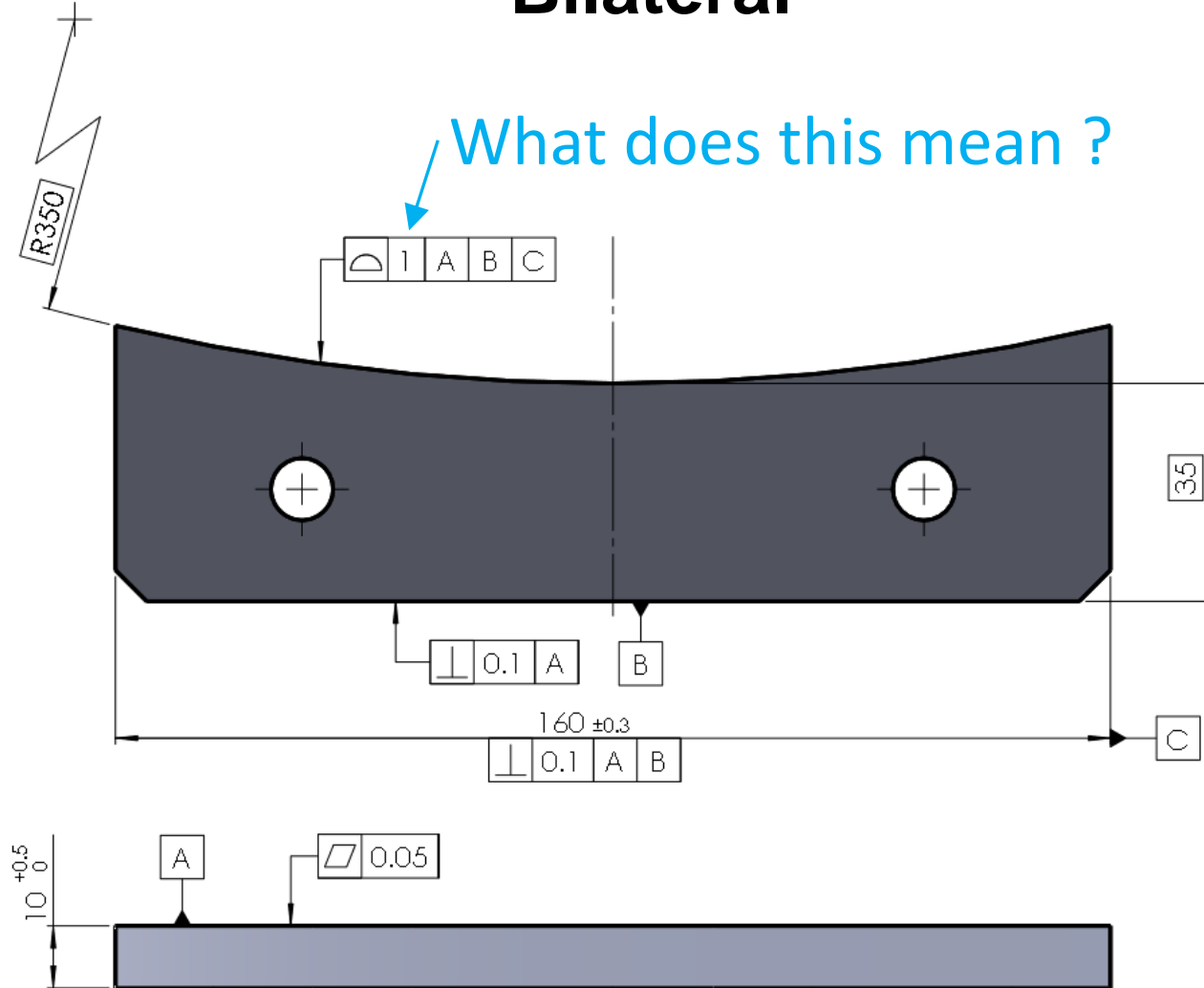**(From ASME Y14.5-2009**)

<u>Profile of a Surface</u>

1. The tolerance zone stablished by the profile of a surface tolerance is three dimensional (a volume), extending along the length and width of the considered feature or features.

2. Profile of a surface may be applied to parts of any shape, including parts having a constant cross section, parts having a surface of revolution or parts having a profile tolerance applied all over.

3. Where the extent of the application of the profile tolerance is unclear, the between symbol should be used.

(<u>From ASME Y14.5-2009</u>)

ON DRAWING

Bilateral

What does this mean ?

R350

| ⌒ | 1 | A | B | C |

| ⊥ | 0.1 | A | B

160 ±0.3

| ⊥ | 0.1 | A | B |

| C |

3.5

10 +0.5 0

| A | | ⬦ | 0.05 |

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MEANS THIS

Bilateral

1 Profile Tolerance zone

Manufactured Profile

R350 - Basic Profile

35

Datum A

Datum B

Datum C

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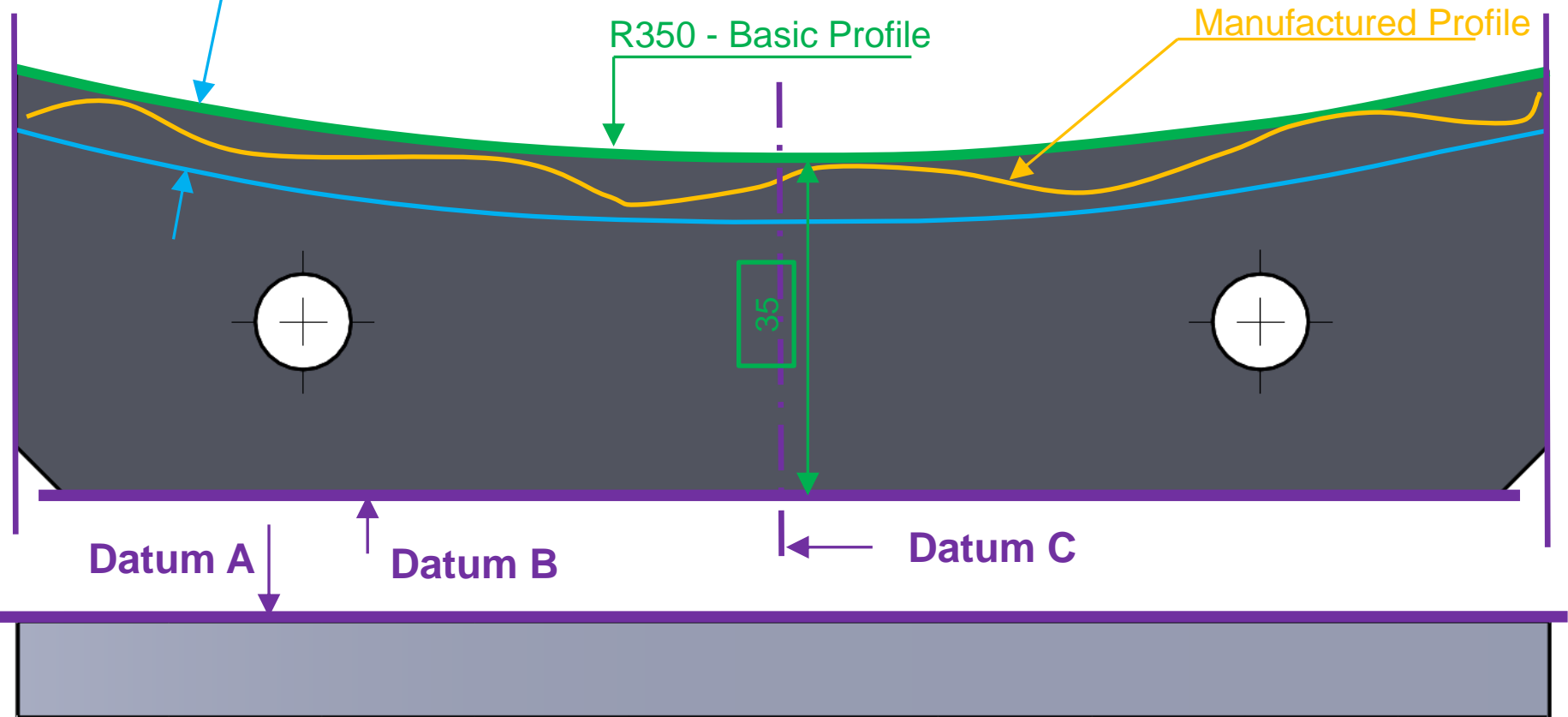
ON DRAWING

Unilateral – Zero Outside

What does this mean ?
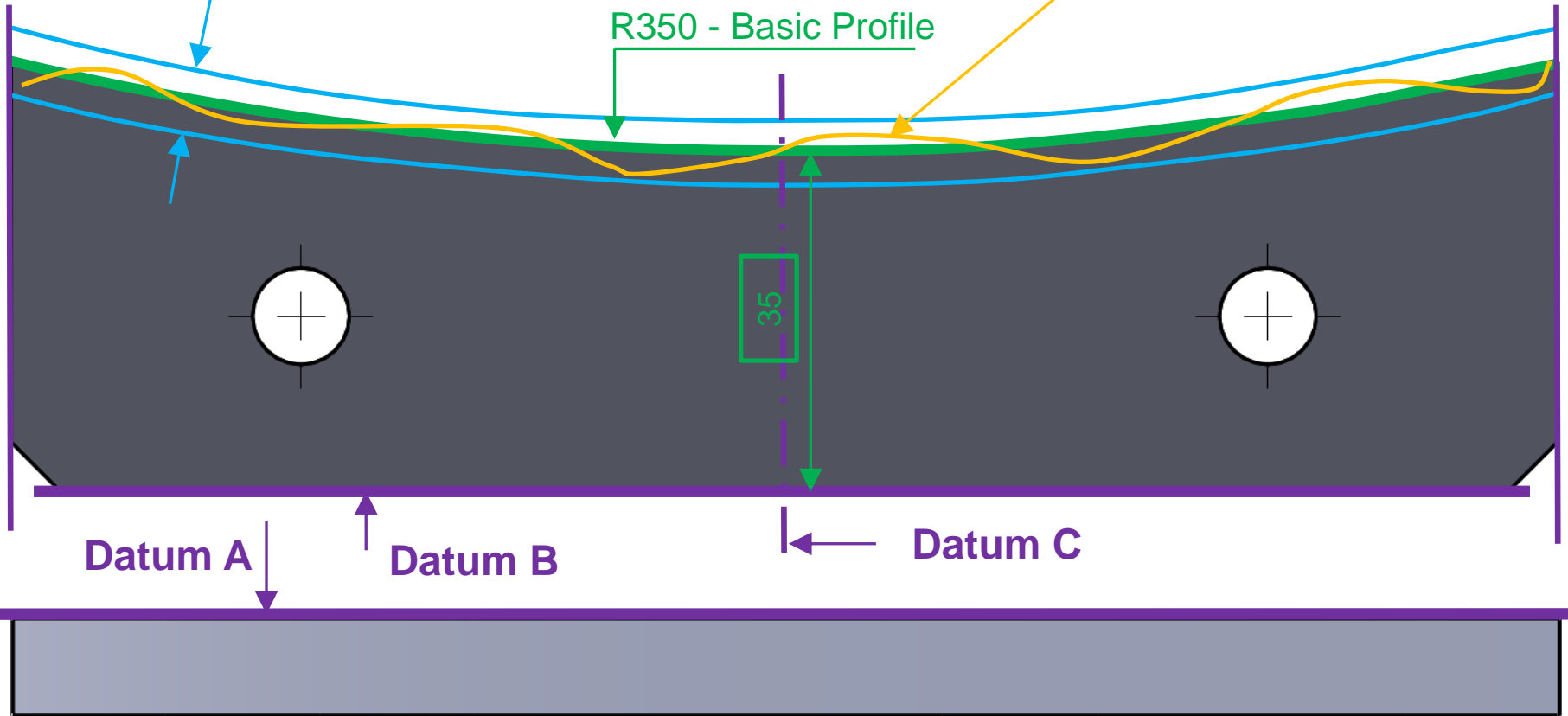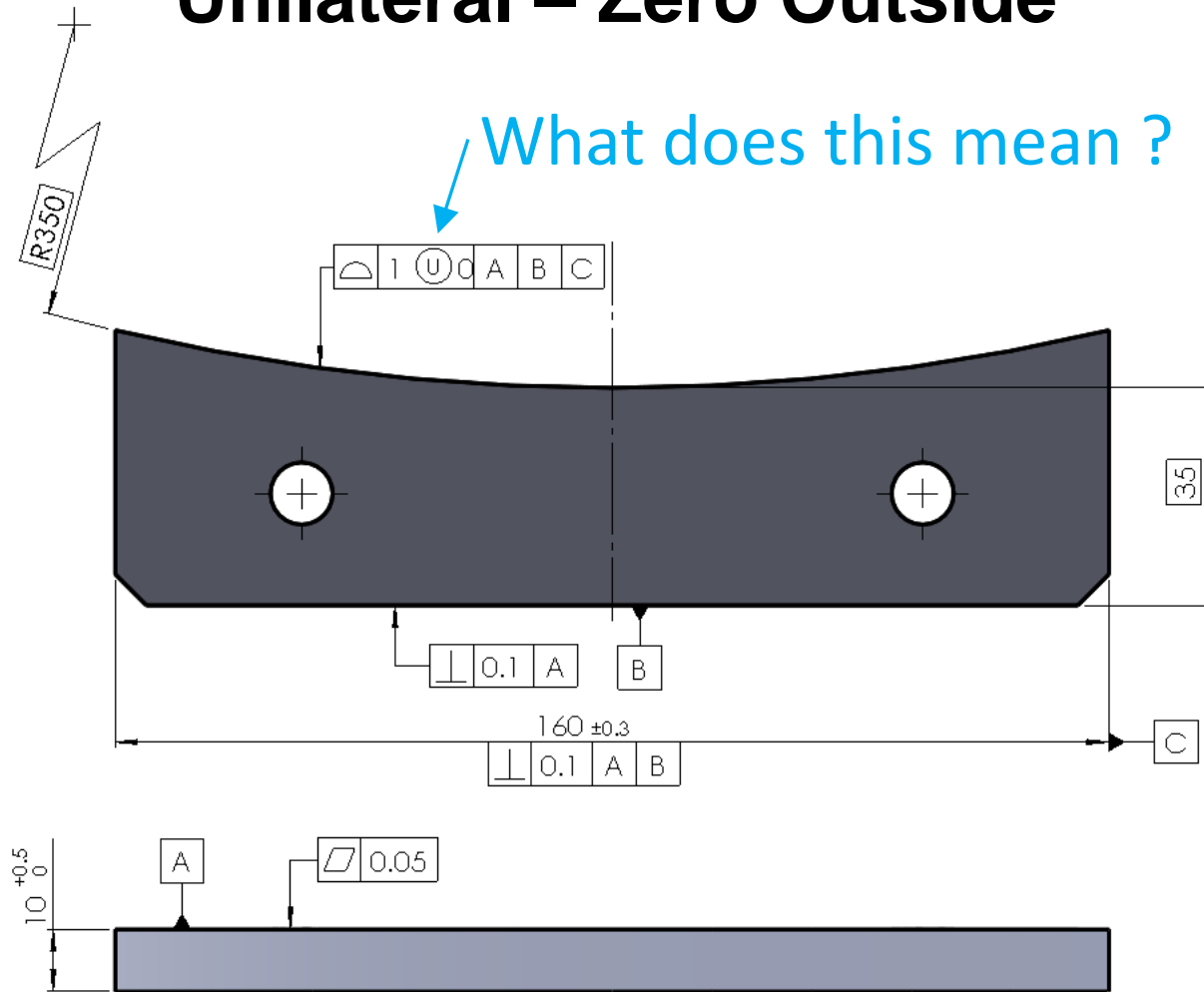
Profile of surface– Example 2

MEANS THIS

Unilateral – Zero Outside

1 Profile Tolerance zone

R350 - Basic Profile

Manufactured Profile

35

Datum A

Datum B

Datum C

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ON DRAWING

Unilateral – All Outside

What does this mean ?

R350

| ⌒ | 1 | Ⓤ | 1 | A | B | C |

3.5

| ⊥ | 0.1 | A | | B |

160 ±0.3

| ⊥ | 0.1 | A | B |

C

10 +0.5 0

| A |

| ▱ | 0.05 |

59

MEANS THIS

Unilateral – All Outside

1 Profile Tolerance zone

Manufactured Profile

R350 - Basic Profile

35

Datum A

Datum B

Datum C

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ON DRAWING

Non-Uniform, Inside and Outside

What does this mean ?

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MEANS THIS

Non-Uniform, Inside and Outside
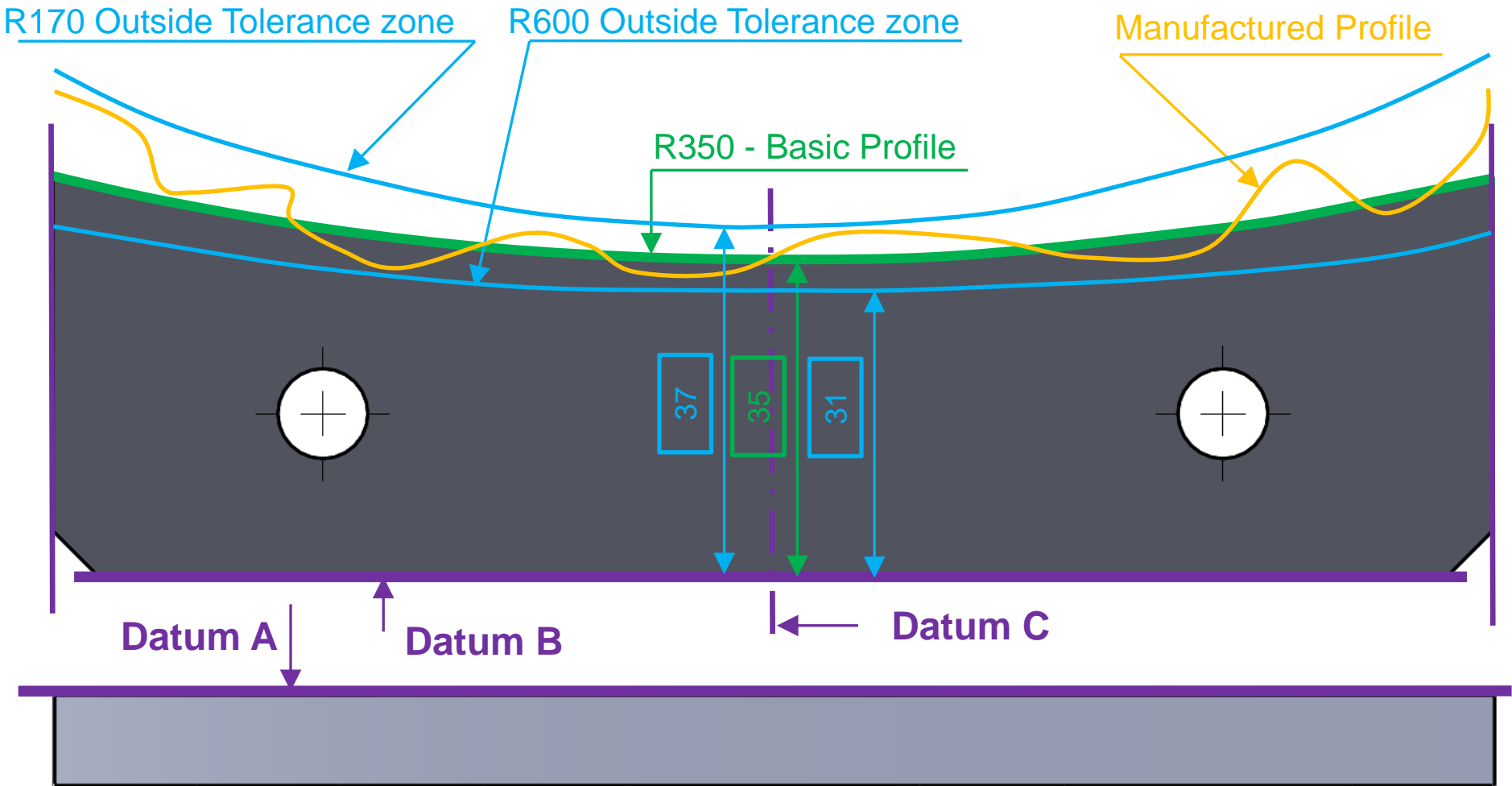
R170 Outside Tolerance zone

R600 Outside Tolerance zone

Manufactured Profile

R350 - Basic Profile

37 35 31

Datum A

Datum B

Datum C

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ON DRAWING

What does this mean ?

160

2X ⌀ 20 $^{+0.3}_{0}$

⊕ | ⌀ 0.3 Ⓜ | A

2x 20

2x 50

R40

2x R60

⌀ | ◠ | 1 | A

2x R15

2x R5

2x R5

60

30

2x 20

2x 8

20

80

2x R15

150

▱ | 0.05

A

30 $^{+0.5}_{0}$

200

MEANS THIS

Datum plan A

R16 **R14**

For Example

61

59

1 mm profile tolerance zone

90°
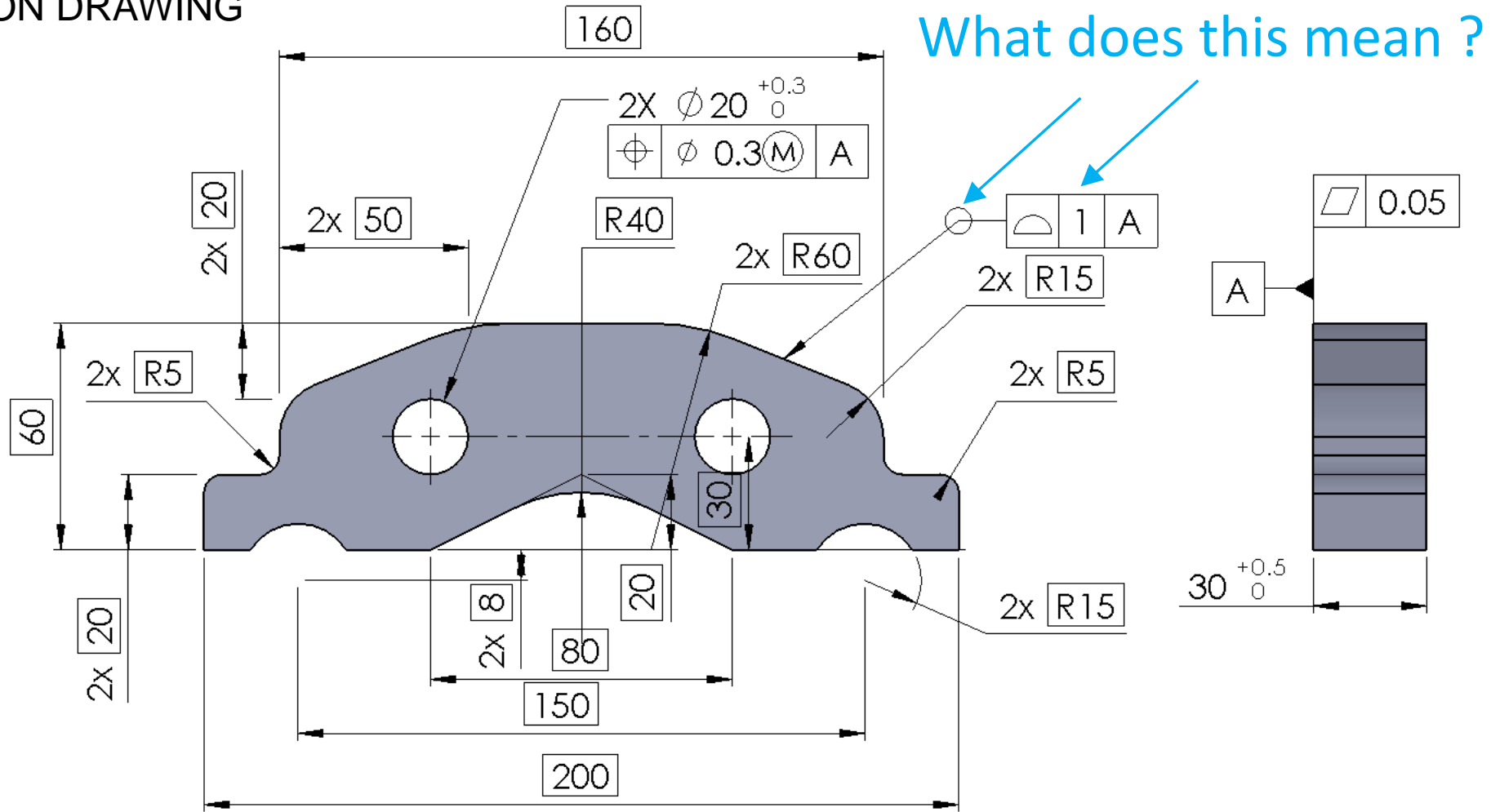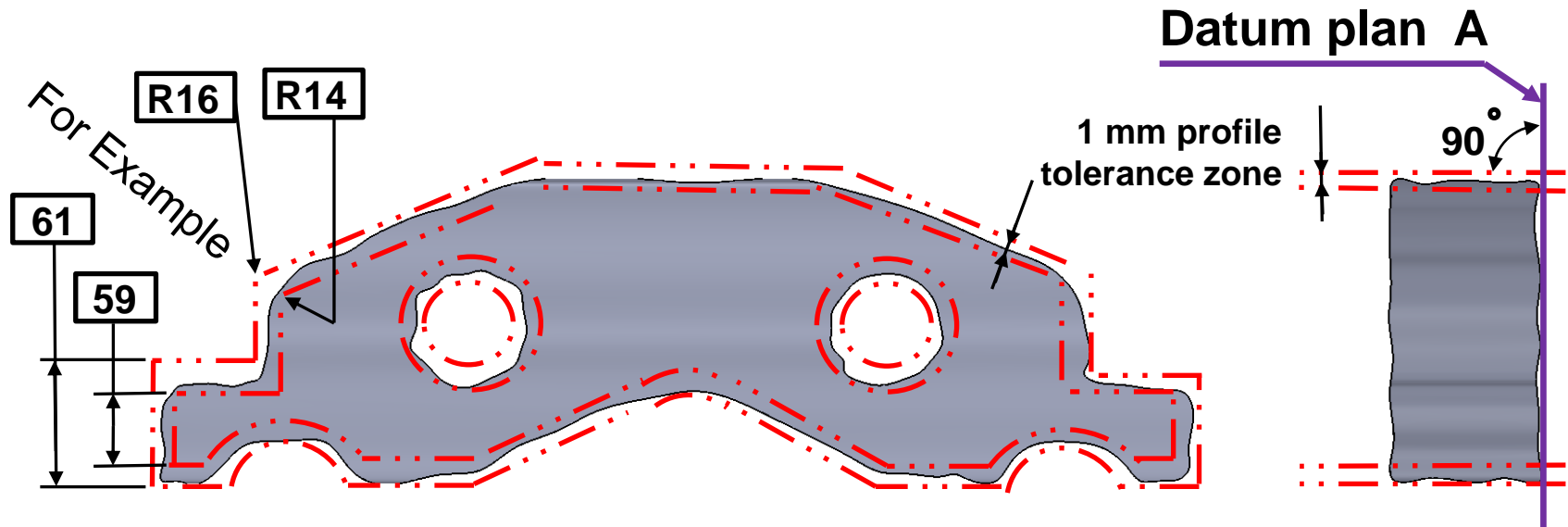
The surface, all around the part outline, must lie between two parallel boundaries 1 mm apart **perpendicular** to datum plane A

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THE END

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