Runout Controls

- Runout (Circular Runout)
- Total Runout
Lathe Components

- Workpiece Held at One End
- Workpiece Held at Both Ends

Center Axis Datum of Size is Established*
Runout Controls

- Very common
- “Runout” is an error in “Eccentricity” and an Inspection Method as well
- Controls the functional relationship of surface features referenced to an established datum axis (Cylindrical Datum of Size)*
- Always cylindrically-shaped features
  - Often for parts that will have to operate at a high RPM*
  - Eliminate Wobble and Vibration*
  - Usually created and inspected on a lathe*
  - Always turned 360°*
  - Generally Inspected with a Dial Indicator
- Able to control form, orientation and location*
- Applied to a feature (not Feature of Size) & are RFS*
  - Are not able to make use of the LMC or MMC Modifiers
- Always references datum(s). Cylindrical Datum of Size.*
Runout Indirect/Embedded Controls

Runout (Circular Runout)

Control of Other Geometric Symbols

When Runout is called on a drawing, it also controls:

**Orientation** is controlled by Runout (not surface orientation though). Depending on which datums are used, your feature’s axis can be held parallel to a datum axis or perpendicular to a datum on a rotating face.

Runout controls the **Position** of cylinders by controlling coaxiality/concentricity. The location of your feature’s axis is held relative to the datum.

**Circularity** is the non-located version of Runout. The tolerance zone is the same, yet with Runout, your Circularity tolerance zone is located coaxially to a datum. If you use Runout on a part, you can ensure that the Circularity cannot exceed your Runout tolerance.

**Concentricity** is automatically controlled by Runout since your feature must be coaxial to its datum to avoid oscillating. Runout is simply a combination of Circularity and Concentricity.
Runout Controls

- Two Types

- Can be applied to any surface on the feature
If it Rotates or Vibrates, you probably want to put a Runout Tolerance on it.

2D Zone, Independent Inspections*

Runout (Circular Runout)

Overview

Runout Symbol:

On the GD&T Symbols Chart - Row # 17:

Relative to Datum: YES
Runout symbols always reference datums.

MMC or LMC:
No – RFS only

- Runout can be called out on any feature that is rotated about an axis. It is essentially how much “wobble” occurs when the part is rotated 360° around the datum axis.

- Runout is the 2D version of Total Runout and at least one datum must be used.

- Runout is also referred to as Circular Runout just to distinguish it from Total Runout. Circular Runout applies independently to each circular element of a diameter.

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“If it Rotates or Vibrates, you probably want to put a Runout Tolerance on it”
Runout (Circular Runout)

Drawing Callout

Runout of 0.03

- Runout controls the surface of any feature with a central axis. It can be applied on a drawing by either pointing to the surface or referencing the dimension of a feature of size.
- Runout must be specified with respect to at least one datum reference. There are specific requirements for establishing a runout datum that we will discuss.
- Runout is always applied RFS.
- The tolerance zone is not a cylinder so no diameter symbol (⌀) is used in the Feature Control Frame.

Note: Although Runout controls the surface of a feature – it can also be called out on a drawing by referencing the dimension (like a feature of size control).

Because it can control Position
Runout (Circular Runout)

**Tolerance Zone**

So the Drawing calls out 0.03 of Runout – what does that mean?

The cylinder’s surface (seen in red) is in tolerance as long as it entirely lies within the tolerance zone of 0.03 between the two coaxial circle boundaries (blue). The tolerance zone is located coaxially relative to the datum axis.

Runout is simply a “positioned” Circularity tolerance. The tolerance zone is the same shape, but now it has a specific location and orientation relative to a datum axis.*

_Tolerance Zone:_ Two coaxial circles – located on the datum feature axis.

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Runout (Circular Runout)

Taper is Not Controlled

Similar to Circularity, each cross section is controlled individually for Runout. The Runout of the tapered feature is controlled for Circularity and Concentricity. However, the angle and form of this taper is not controlled.

This means the gauge is reset each time it is moved along the axis. Your FIM measurement at location A is independent of location B. Only Rule #1 can control the form of the cylinder.

Note: Runout can apply to conical features; however it does not control the angle or location of taper.
Runout (Circular Runout)
Gauging / Measurement

Runout controls several geometric symbols; however, it is actually one of the easiest to measure!

**Typical Measurement:**

1. The part is mounted in a chuck or collet to simulate datum axis A. *(Datum Axis is Established)*

2. Then, a dial indicator is placed perpendicular to the surface of the diameter being inspected.*

3. The part is rotated 360° and the Full Indicator Movement (FIM) is determined.*

The dial indicator is then moved to another location on the diameter and another indicator reading is obtained. The number of circular elements to be checked is usually determined by the quality inspection plan.

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Circular Runout

- Individual/Independent checks
  - Dial Indicator is “Reset”
- 2-D zone
  - Two concentric circles (for cylinders)
  - Two parallel planes (for flat end of feature)
- Datum of Size A is established in chuck or collet
- Part is rotated 360°
- Dial indicator is kept perpendicular to feature being inspected
- FIM should not be greater than the tolerance value
Runout (Circular Runout)

Dual Coaxial Datum Features

As mentioned earlier, a dual coaxial datum reference is useful when individual datums would not provide a repeatable, accurate datum axis by themselves.

Dual coaxial datums are specified with a dash between them in the Feature Control Frame. This establishes a virtual axis between the two datums.

Even if both datums are not perfectly in line, a “unified” datum axis is established. Many parts establish their functional axis through two assembly points, and this is the best way to functionally mimic this in a measurement.

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(Part is Held at Both Ends on the Lathe)
Runout (Circular Runout)

When is it Used?

- When mass or volume balance is critical for a part that rotates – either radially or axially, Runout can be used.
- Runout is used to avoid oscillations, vibrations, and excess wear on high load components.
- Runout is commonly used in the automotive and machine industries where high rotational speeds/loads are quite common.

Most components in a transmission (clutch disks, gears, etc.) require Runout due to the high speeds and loads.

Common applications for Runout are:
- Critically balanced gears (even for pitch diameter).
- Bearing surfaces on rotating parts.
- Camshafts, input shafts, and output flanges.
- Drill, CNC, or machine components requiring high accuracy at high speeds.
- Car wheels or parts with high oscillation potential.

Gears and shafts almost always require Runout to avoid vibrations and noise.
Total Runout

3D Zone, Entire Surface is Inspected*

Total Runout Symbol:

On the GD&T Symbols Chart - Row # 18:

Relative to Datum: YES
Runout symbols always reference datums.

MMC or LMC:
No

- Total Runout can be called out on any feature that is rotated about an axis. It is essentially how much “wobble” occurs when the part is rotated 360° around the datum axis.

- Total Runout is the 3D version of Runout – It applies to the entire feature length, not just a cross section.

- The cross-sectional version of Runout (otherwise known as Circular Runout) is much more commonly seen than Total Runout. Unlike Circular Runout, Total Runout is able to control the taper of a feature in addition to the location, orientation and form and is able to control changes in size along the length of the feature.

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Total Runout Indirect/Embedded Controls

Total Runout

Control of Other Geometric Symbols

When Total Runout is called on a drawing, it also controls:

- **Cylindricity** is the non-located version of Total Runout. The tolerance zone is the same shape, yet with Total Runout, your Cylindricity tolerance zone is located coaxially to a datum. If you use Total Runout on a part, you ensure that the Cylindricity (and thus the **Circularity & Straightness**) are also indirectly controlled.

- **Concentricity** is automatically controlled by Total Runout since your feature must be coaxial to its datum to avoid oscillating. Total Runout is simply a combination of Cylindricity and Concentricity. **DML Straightness** is also indirectly controlled since Concentricity is controlled.

Total Runout is the 3D version of **Circular Runout**. The Runout of a feature is always controlled with Total Runout in addition to the amount of axial taper on the part.

Total Runout, just like Circular Runout, controls the **Position** of cylinders by controlling coaxiality/concentricity. The location of your feature’s axis is held relative to the datum.

**Axis Orientation** is also controlled by Total Runout in the same way it is controlled by Circular Runout. Depending on which datums are used, your feature’s axis can be held parallel to a datum axis or perpendicular to a datum face.
Total Runout
Drawing Callout

Total Runout of 0.03

0.03 A

A

- Total Runout controls the surface of any feature with a central axis.
- It must be specified with respect to at least one datum reference.
- Total Runout may also be applied to an axial face of a part to control the orientation of the face relative to the datum axis.
- Both Runout symbols are always applied RFS.
- The tolerance zone is not a cylinder so no diameter symbol (Ø) is used in the Feature Control Frame.

Note: Although Total Runout controls the surface of a feature—it can be applied on a drawing as either a surface or feature of size control.

Because It can control Position
Total Runout

Tolerance Zone

So the Drawing calls out 0.03 of Total Runout — what does that mean?

The cylinder’s surface (shown in red) is in tolerance as long as it entirely lies within the tolerance zone of 0.03 between the two boundaries (blue). The tolerance zone is located coaxially relative to the datum axis.

Runout is simply a “positioned” Cylindricity tolerance. The tolerance zone is the same shape, but now it has a specific location and orientation relative to a datum axis.

Tolerance Zone: Two coaxial cylinders — located on the datum feature axis. The roundness and straightness of the cylindrical surface is controlled and located.
Total Runout

- Checks entire surface
  - Dial indicator is swept from one end of the feature to the other
  - Part is being rotated 360°
  - Virtual Axis Datum A – B is established between two centering pins

- 3-D Zone*
  - Two concentric cylinders (for cylinders)
  - Two parallel planes (for perpendicular flat end of feature)
  - FIM should not be greater that the tolerance value
**Total Runout**  
**Gauging / Measurement**

The surface must lie between two coaxial cylinders, 0.03 apart and be located concentrically to a datum axis.

**Typical Measurement:**

1. The part is mounted in a chuck or collet to simulate datum axis A.

2. Then, a dial indicator is placed perpendicular to the surface of the diameter being inspected.

3. The part is rotated 360° - similar to Runout. However, now the dial indicator is slid down the part, always remaining perpendicular to the datum axis. The Full Indicator Movement (FIM) is determined over the entire surface.
Total Runout Controlling Perpendicularity

**Total Runout**

*Control of Other Geometric Symbols*

*When Total Runout is called on a drawing, it also controls the following:*

- **Surface Orientation** of an axial face is controlled by Total Runout relative to a datum axis (not by Circular Runout, though). Depending on which datums are used, a feature’s surface can be held parallel to an axial datum face or perpendicular to the main datum axis.

- **Flat End Surface is Controlled Perpendicular 0.1 to datum Axis A**

- **Inspects for Perpendicularity and Flatness**

*Since Total Runout can control the Perpendicularity of an axial face, the Surface Flatness & Straightness on an axial face are also indirectly controlled.*

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Total Runout

When is it Used?

- Total Runout is used to avoid oscillations, vibrations, and noise. However, it also ensures that the taper of the part is controlled.
- Total Runout is mainly seen when the cylindricity/straightness of an entire feature is critical to avoid uneven loading or wear.
- Total Runout is somewhat rare as it is a very tight control and not always required for function.

Even complex helical gears can require Total Runout on the pitch diameter to ensure the gear mating surface is located axially and radially with high precision.

Common applications for Total Runout are:

- Parts that are rotating and sliding at the same time (for example, a precision drill bit).
- Precision bearings that require a total surface form control in addition to normal Runout.
- CNC, or machine components requiring high accuracy at high speeds.
- Precision shafts that require an axial form control in addition to radial balancing.
Runout Example

Datums A, B and C are probably Functional Mounting Features

6X Functional Relationship with the Virtual Axis Created Between Datums A and B

Functional Relationship with Established Datum C