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# THE GEAR DRAWING ROUGHNESS SPECIFICATION

To avoid uncertainty, the complete roughness specification for the tooth flank and description of the contact stylus profilometer setup should be placed on the gear drawing.

**IN THE JANUARY MATERIALS MATTER COLUMN, "ROUGHNESS** Measurement of Precision Gear Teeth," the importance of accurate and repeatable roughness measurement of precision gear teeth flanks was explained. However, an accurate rough measurement cannot be repeatable if it is not explicitly specified by the designer for use by the gear manufacturer and end user. As smoother surface finishes, such as isotropic superfinishes, become more prevalent in the gear industry, the possibility exists for significant manufacturing error due to ambiguous roughness specification. The proper method to specify the roughness parameters, the limits, and the profilometer setup is to use a complete roughness diagram placed on the gear drawing. This roughness diagram is referred to in this article as the Check Mark Diagram.

## BACKGROUND

The gear drawing is the document used by the designer, manufacturer, and operator to specify all the technical requirements and features of a gear. In surveying a wide range of precision gear drawings, I have found that many of these drawings cite incomplete or incorrect roughness specifications. These incomplete or incorrect specifications can lead to quality, performance, and ultimately warranty issues. Examples of current precision gear drawings with incomplete or incorrect roughness specifications are found in Figure 1.

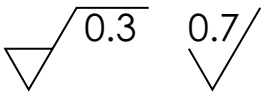


**Figure 1: Examples of incomplete or incorrect roughness drawing diagrams**

The diagrams in Figure 1 are, at the least, ambiguous. At the worst, they could lead to legal ramifications due to an alleged failure to meet design specifications. Fortunately for the gear designer and drafter of a gear drawing, a detailed approach for designation of a roughness specification can be found in ISO-1302 (2002), "Indication of surface texture in technical product documentation."

## EXPLANATION OF THE CHECK MARK DIAGRAM

If the gear designer closely follows ISO-1302, all roughness parameters, limits, and the proper profilometer setup will be specified within the Check Mark Diagram.

The following briefly reviews the evolution of the diagram. The basic symbol indicating that a surface texture requirement exists is a check mark graphic as shown in Figure 2.

**Figure 2:** Basic graphic

The complete graphical symbol that is used to specify a roughness parameter, limit, and measurement parameters will include a horizontal line extending from the longer arm of the check mark graphic as shown in Figure 3.

**Figure 3:** Complete graphic

To indicate whether material is or is not to be removed from the surface to achieve the specified roughness parameter, a bar or circle is added to the check mark as shown in Figures 4a and 4b.

**Figure 4a:** The bar indicates material is to be removed

**Figure 4b:** The circle indicates material is not to be removed

## ROUGHNESS, LIMITS, AND PROFILOMETER SETUP

To eliminate the possibility of uncertainty, all of the surface roughness parameters, limits, and profilometer setup parameters needed to complete the roughness specification must be placed in and around the Check Mark Diagram as shown in Figure 5.

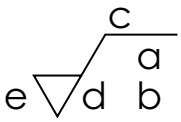


**Figure 5: Diagram indicating material removal with parameter locations**

(a) This location is for the surface roughness parameter, the roughness numerical limits, and the profilometer filter and sample length.
(b) This location is any secondary roughness parameter as found in (a); a third surface roughness parameter would be located below (b).
(c) This location is for the method of manufacturing of the designated surface (i.e., turned, ground, or isotropic superfinished).
(d) This location is the orientation of the lay, relative to the plane of the drawing.
(e) This location is for the required machining allowance, if any.

## CHECK MARK DIAGRAM FOR PRECISION GEARS

Following the format of Figure 5, a complete Check Mark Diagram for a precision ground gear with roughness limits of Ra < 0.4 µm and Rz < 2.4 µm can be found in Figure 6 with explanations shown in Table 1. Note that the orientation of the grinding on the tooth is parallel to the axis of the gear and the Ra/Rz values are displayed in µin.

Similarly, a complete Check Mark Diagram for an isotropically superfinished gear can be found in Figure 7. As mentioned in the January column, Ra, Rz, and Rmr are the recommended minimum roughness parameters to be used when specifying a gear surface (note that Rmr is missing from this Check Mark Diagram).

## ADDITIONAL REQUIRED ROUGHNESS INFORMATION

Any additional surface finish information not included in the Check Mark Diagram, but required to make the specification unambiguous — such as the number of measurements, location of measurements, or alternative stylus tip size — should be placed in a text box

| Number | Explanation |
|---|---|
| 1 | Designation of material removal; ISO-1302 (2002) |
| 2 | Indication of the required manufacturing process; ISO-1302 (2002) |
| 3 | Filter type to be used in the profilometer measurement; ISO-16610-21: (2011) |
| 4 | Ls; short-wave filter used in the profilometer measurement; ISO-1302 (2002) |
| 5 | Lc; long-wave filter used in the profilometer measurement; ISO 1302 (2002) |
| 6 | Surface texture parameter; see section 6.2 of ISO 1302 (2002) |
| 7 | Number of sample lengths; ISO 1302 (2002) and Tables 1-3, ISO 4288 (1998) |
| 8 | Specification limit; ISO 1302 (2002) |
| 9 | Limit value of specified parameter in micrometers |
| 10 | Orientation of the lay to the plane of the drawing; ISO 1302 (2002) |
| 11 | Secondary surface texture requirement following the format of #6 |

**Table 1**

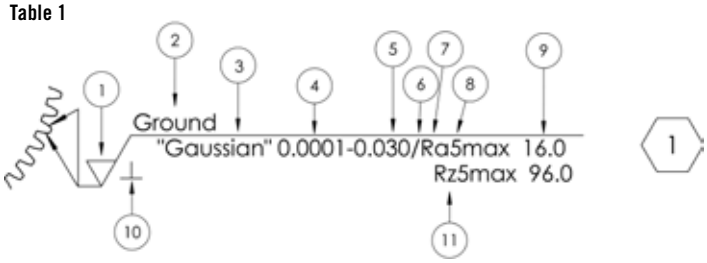


**Figure 6: Complete Check Mark Diagram for a ground gear with a reference to a text box note (1)**

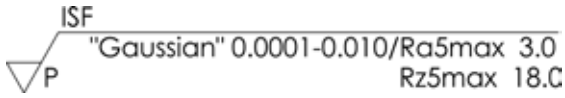


**Figure 7: Check Mark Diagram for an isotropically superfinished gear**



section of the gear drawing. The text box reference should be placed adjacent to the Check Mark Diagram for consistency (see Figure 6). Examples of additional information for insertion in a gear drawing text box can be, but not limited to, the following:

| | |
|---|---|
| 1 | 4 Roughness measurements; 2 teeth approximately 180 degrees; drive and coast side |
| 1 | Roughness measurements taken approximately across the pitch line and center face width |
| 1 | Profilometer stylus tip radius can be 5 µm or less |

## CONCLUSION

By following ISO-1302 (2002), a complete roughness specification can be designated with the Check Mark Diagram. As noted in the December Materials Matter column, "Gear Surfaces and Operational Performance," the surface of a gear has a profound impact on its performance. With this in mind, the importance of the correct use of a complete Check Mark Diagram to eliminate the ambiguity of surface roughness limits on teeth flanks is clearly seen.


**ABOUT THE AUTHOR:** Mark Michaud, president of REM Surface Engineering, is a leading expert in the field of isotropic superfinishing of engineered metal components. During his 35-year career at REM, he has worked in research, operations, sales, and management. Michaud has been granted over 100 patents, published numerous technical articles, and given lectures in the United States, Europe, and Asia. He has degrees in chemistry from Reed College and an MBA from the University of Hartford. He can be reached at mmichaud@remchem.com.