Filtering and Surface Texture

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What do you mean when you say “roughness”? 
Roughness?
Roughness?

Roughness?

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Roughness

- We have an intuitive “feel” for roughness and waviness
  - Roads, tables, walls, deserts, floors, etc.

Filtering

Books on a Table

- Long Wavelength
  - U-shaped
  - “Waviness” from the load

- Middle Wavelength
  - “Waviness” from lamination and adhesive thickness variations

- Short Wavelength
  - “Roughness” from the laminate texture
Filtering

- The wavelength content can be graphed
  - Mathematical terms: Fourier Transform

Books on a Table

![Graph showing the wavelength content with categories: Roughness, Waviness, and Form.]

Filters “Separate”

![Graphs showing Waviness and Roughness profiles.]

- Waviness Profile
- Roughness Profile
Gaussian Filtering

• A Gaussian-weighted moving average.

How much filtering?

Weighted, Moving Average

Waviness
Same Data Different Results

Waviness profile (red)

Long cutoff = “smooth” waviness
“higher” roughness

Roughness profile (blue)

Short cutoff = “bumpy” waviness
“smoother” roughness

What does this mean?

0.5

Note: this indication is not in accordance with ISO 1302-2002
Ra = 0.167 µm

Ra = 0.229 µm
Ra = 0.307 µm

Ra = 0.568 µm
Ra = 0.975 µm

Ra = 1.106 µm
What is the roughness?

- Ra = 0.167 µm
- Ra = 0.229 µm
- Ra = 0.307 µm
- Ra = 0.568 µm
- Ra = 0.975 µm
- Ra = 1.016 µm

Ra = 0.167 µm
Ra = 0.229 µm

Ra = 0.307 µm
Ra = 0.568 µm

Ra = 0.975 µm
Ra = 1.106 µm

Avoid the problem!

- Look at Primary/Waviness Profiles
- not Roughness Profiles
4.4 Roughness Cutoff or Sampling Length

Standard ratings are listed in Section 9 of ASME B46.1 with some selection criteria given in Section 3 of ASME B46.1. Drawings prepared six months after the date of issuance of ASME B46.1-1995 shall state the roughness cutoff or sampling length in position “c” of Fig. 3.

NOTE: Prior to the adoption of ASME B46.1-1995 the default rating was 0.8 mm if no other rating was stated.

ISO 1302-2002

- Upper (U) or lower (L) limit
- Transmission band (mm)
- Evaluation length
- Limit value (µm)

U “Gauss” 0.0025-0.8 / Ra5max 0.5
Typical Filter Cutoff Values

How do you choose?
Choose Wisely!

- Primary with Waviness:
  Does the filter “fit” your “function?”

![Wavelength Content Graph](image)

Choose Wisely!

- Wavelength Content Graph
Choose Wisely!

- Tables

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<thead>
<tr>
<th>Non-Periodic Profiles</th>
<th>Cutoff Length</th>
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<tr>
<td></td>
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<tr>
<td>Average Roughness (Ra)</td>
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<td>μm</td>
<td>λp (μm)</td>
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<tr>
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<table>
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<tr>
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<tr>
<td>Mean Spacing (λp)</td>
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<tr>
<td>μm</td>
<td>λp (μm)</td>
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<tr>
<td>1.000</td>
<td>4.00</td>
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</tbody>
</table>

Choose Wisely!

- Just because the surface is short. Don’t shorten the cutoff!!!
Short Surfaces / Spline Filters

\[ \lambda_c: 0.25 \text{ mm} \]
\[ Ra: \ 0.85 \mu m \]
\[ Wt: \ 6.52 \mu m \]

\[ \lambda_c: 0.8 \text{ mm} \]
\[ Ra: \ 1.16 \mu m \]
\[ Wt: \ 4.29 \mu m \]

Gaussian Filters Lose Ends

• Due to the “moving average” Gaussian filters lose the ends of the profile.
Spline Filtering Keeps Ends

- Spline filters use an equation not a moving average. Ends are not lost.

Two Flavors of Splines

- **“Form Following”**
  - (Tension = 0.0)
  - Overshoots: false peaks/valleys

- **“Gaussian-like”**
  - (Tension = 0.625242)
  - Poor edge following
Bandpass Roughness

![Graph showing 300:1 Bandwidth]

Sorting out Wavelengths

![Graph showing Roughness, Waviness, and Form]

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Terminology

- **Long Pass**
- **Short Pass**

Surface Texture Filter

ASME B46.1 Webinar

- \( \lambda_a \) "Short" Cutoff
- \( \lambda_r \) "Roughness" Cutoff
- \( \lambda_f \) "Form" Cutoff

(Typically 2.5 µm or 8.0 um) (Typically 0.8 mm or 2.5 mm) (Optional: typically \( \lambda_f \) = 10:1 ratio with \( \lambda_a \))

Roughness Isn’t Everything!

![Roughness Profile](image-url)
Roughness Isn’t Everything!

Now for some cool stuff...

- Pushed up material(?)
- Will it leak?
- Things that go bump
Pushed up material?

“False” Peaks
No False Peaks with “Robust”

Morphological Filtering

- Based on the interaction of a specific geometry with the measured data set.
Morphological Filtering

- Gasket Leak Detection

![Graphs showing morphological filtering results](image)

- Wvoid = 0.4 (µm²/µm)
- Wvoid = 3.7 (µm²/µm)
Morphological Filtering

• Stress Concentration Detection

Wcvx : “Waviness Convexity”

Morphological Filtering

• Cosmetic “Bump” detection
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