

# When "How Big Are My Particles?" Isn't a Simple Question

*Understanding particle counting rules and their impact on size distribution measurements*

If you work with particulate materials, you've probably needed to know your particle size distribution at some point. Maybe for quality control, regulatory compliance, or understanding why a batch didn't perform as expected.

Here's something that might surprise you: the answer you get depends significantly on *how* you count the particles—not just which instrument you use.

## The Counting Problem Nobody Talks About

A 2022 paper from researchers at BAM (Germany's Federal Institute for Materials Research and Testing) and the European Commission's Joint Research Centre demonstrated something striking. They took a single electron microscopy image of zinc oxide particles and applied four different, legitimate counting approaches.

The results ranged from **2 particles to 104 particles** counted in the same image. Mean particle sizes ranged from **43 nm to 255 nm**.

Same image. Same material. Dramatically different answers.

## Why Does This Matter?

For regulatory purposes, the 100 nm threshold often determines whether a material is classified as a nanomaterial—which triggers additional testing, labeling, and compliance requirements. Depending on which counting method applies to your situation, the same material could fall on either side of that line.

But beyond regulations, this affects anyone trying to understand their material:

- Manufacturing engineers troubleshooting batch-to-batch variation
- R&D; teams correlating particle characteristics with performance
- Quality control labs establishing meaningful specifications

If you're comparing results across suppliers, between labs, or over time, and you don't know whether the same counting methodology was used, you might be comparing apples to oranges.

## The Four Approaches (Simplified)

The paper identifies four counting rules used across different standards and regulatory frameworks:

1. **CR1: Count only individual, separated particles** — ignore anything that's clumped together
2. **CR2: Count clumps as single particles** — each agglomerate counts as one, regardless of size

3. **CR3: Resolve agglomerates into components** — but treat fused aggregates as single units
4. **CR4: Resolve everything possible** — count every identifiable particle within both agglomerates and aggregates

ISO standards tend to use approach #3 (CR3). EU regulatory definitions for nanomaterial classification require approach #4 (CR4). Neither is wrong—they're answering different questions.

## Impact of Counting Rule Selection

The table below shows results from the same TEM image of zinc oxide particles, analyzed using each counting rule:

Counting Rule	Particles Counted	Mean Min Feret (nm)
CR1 (Individual only)	2	43
CR2 (Clumps as one)	7	255
CR3 (Resolve agglom.)	41	113
CR4 (Resolve all)	104	73

Note how the mean size falls above or below 100 nm depending on the counting rule—directly affecting nanomaterial classification.

## What This Means for Your Analysis

When you need particle size distribution data, the conversation shouldn't start with "run XRD" or "do SEM imaging." It should start with: *What decision are you trying to make with this data?*

- **Regulatory classification?** You need to know which jurisdiction's rules apply.
- **Process troubleshooting?** You need consistency with your historical data.
- **Supplier qualification?** You need agreement on methodology before comparing results.

## The Bigger Picture

Image segmentation and particle size distribution analysis is one of the services offered by Cubic Labs, using SEM-EDX at Purdue University's electron microscopy facilities. But the real value isn't in generating images—it's in helping clients think through what analysis approach actually answers their question, and making sure they understand what the numbers mean when they get them.

If you're working with particulate materials and wrestling with characterization questions, feel free to reach out to discuss what might make sense for your situation.

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### Reference

Bresch, H.; Hodoroaba, V.-D.; Schmidt, A.; Rasmussen, K.; Rauscher, H. "Counting Small Particles in Electron Microscopy Images—Proposal for Rules and Their Application in Practice." *Nanomaterials* 2022, 12, 2238.

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