Goodbye “Ghost Particles”

Improving Particle Counting Accuracy with the ASTM D7647 Dilution Method

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What if the same sample gave you four orders of magnitude different particle counts?

12
ISO codes of disagreement on a single sample (Mobil DTE 846)

4,000×
Dynamic range in reported particle counts from solvent choice alone

0%
Water-masking ability of Varsol, kerosene, or lamp oil — all permitted by D7647

- These are **not failures of the particle counter**, the operator or the calibration.
- They are **failures of the diluent** the operator was permitted to choose under ASTM D7647.

The right title — the wrong diluent list

ASTM D7647-24
Automatic Particle Counting of Lubricating and Hydraulic Fluids Using Dilution Techniques to **Eliminate the Contribution of Water and Interfering Soft Particles** by Light Extinction.

Diluent	Water-masking?	In precision statement?
75% Toluene / 25% IPA	Yes	Yes
DPnB	Yes	Yes
Lamp oil	No	Yes
Kerosene	No	No
Stoddard solvent	No	No
67% Lamp oil / 33% DPnB	via DPnB	Yes

Annex A1, Table A1.1 lists six permitted diluents.

Only two — 75/25 T/IPA and DPnB — actually dissolve water (§ 3.2.8.1).

Soft-particle (varnish, sludge, additive precipitate) solubility is not even mentioned in the standard.

An ILS participant can follow D7647 to the letter and still be 12 ISO codes off.

8 oils × 7 diluents × 2 dilution ratios = 126 analyses

Sample	Visc.	Status	Chemistry
Mobil DTE 846	ISO 46	Used	Group II mineral
Synthetic Compressor	ISO 46	Fresh	Group III mineral
Mobil DTE 10 EXCEL 46	ISO 46	Fresh	Group III mineral
Mobil Gear 600XP220	ISO 220	Fresh	Group II mineral
Mobil SHC Gear 320	ISO 320	Fresh	Group IV PAO
PC ATF D3M	ISO 46	Fresh	Group II+ mineral
IR SSR Ultra Coolant	50 cSt	Used	Group V PAG
PC Purity FG PAG	ISO 460	Used	Group V PAG
MTD CAL ± 1, 2% H_2O	ISO 15	Spiked	Group II mineral

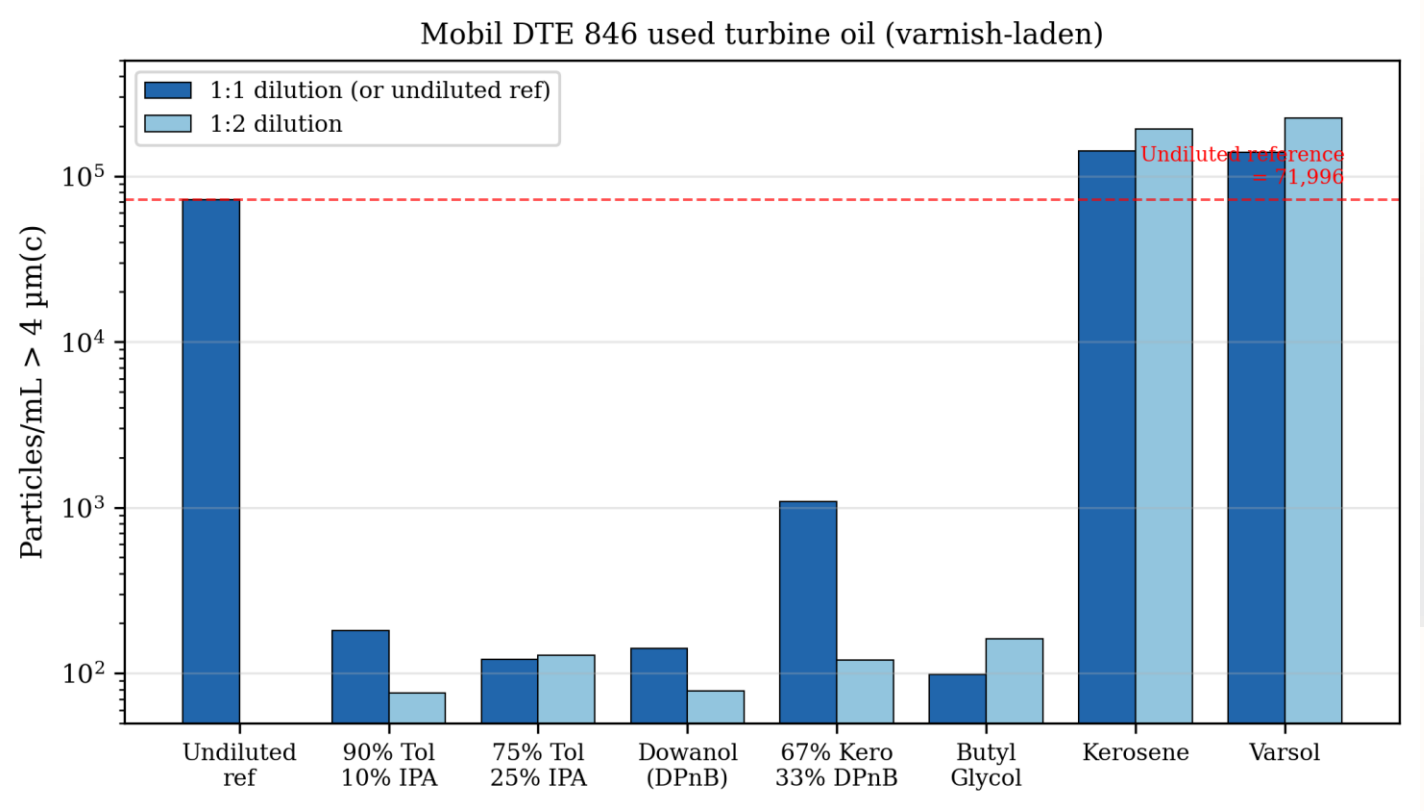
Diluent	In A1.1?	H_2O mask?
90% Tol / 10% IPA	New	Partial
75% Tol / 25% IPA	Yes	Yes
Dowanol (DPnB)	Yes	Yes
67% K / 33% DPnB	Equiv.	Partial
Butyl glycol	No	Partial
Kerosene	Yes	No
Stoddard (Varsol)	Yes	No

Instrumentation:

CINRG APC22M auto-diluting particle counter — Klotz 45/50 sensor — calibrated to ISO 11171

Two nominal dilutions: 1:1 (U-frac ≈ 0.5) and 1:2 (U-frac ≈ 0.3). Triplicate counts on the central 5 mL of three 7 mL fills.

Mobil DTE 846 used turbine oil (varnish-laden)



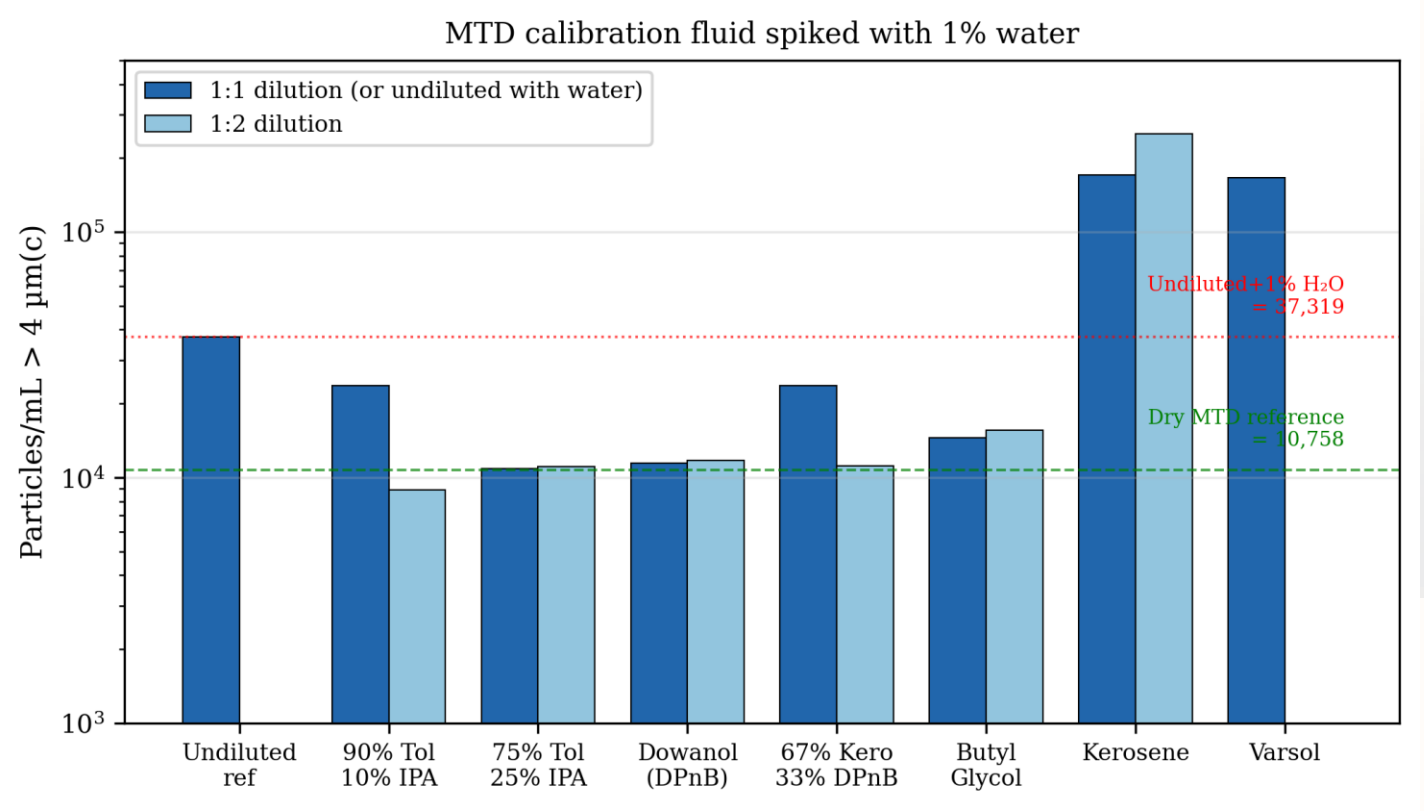
72k
Undiluted reference
(particles/mL >4 µm)

120
75/25 T/IPA at 1:2
— what dissolved varnish looks like

223k
Varsol at 1:2
— more dilution, MORE counts

Kerosene and Varsol counts INCREASE with dilution — the diagnostic signature of varnish precipitating from the diluted phase.

MTD calibration fluid spiked with 1% water



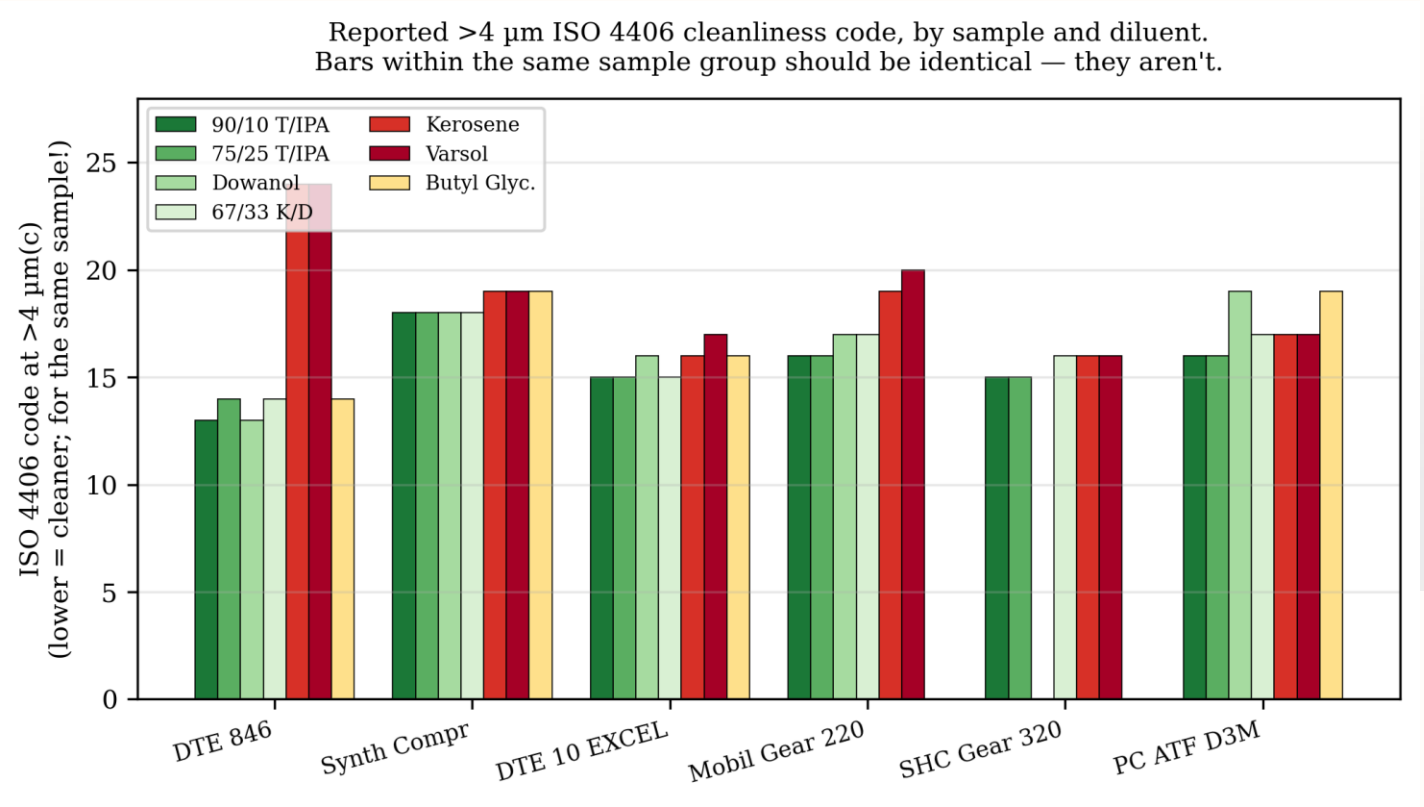
10,758
Dry MTD reference
(no water, no diluent)

11,117
75/25 T/IPA 1:2 on +1% water
— water FULLY masked

250,312
Kerosene 1:2 on +1% water
— zero water masking

75/25 T/IPA and DPnB return counts within 5% of the dry reference. Kerosene and Varsol fail catastrophically — ISO codes saturate at 25/25/25.

Same sample, same counter, same operator - only diluent varies



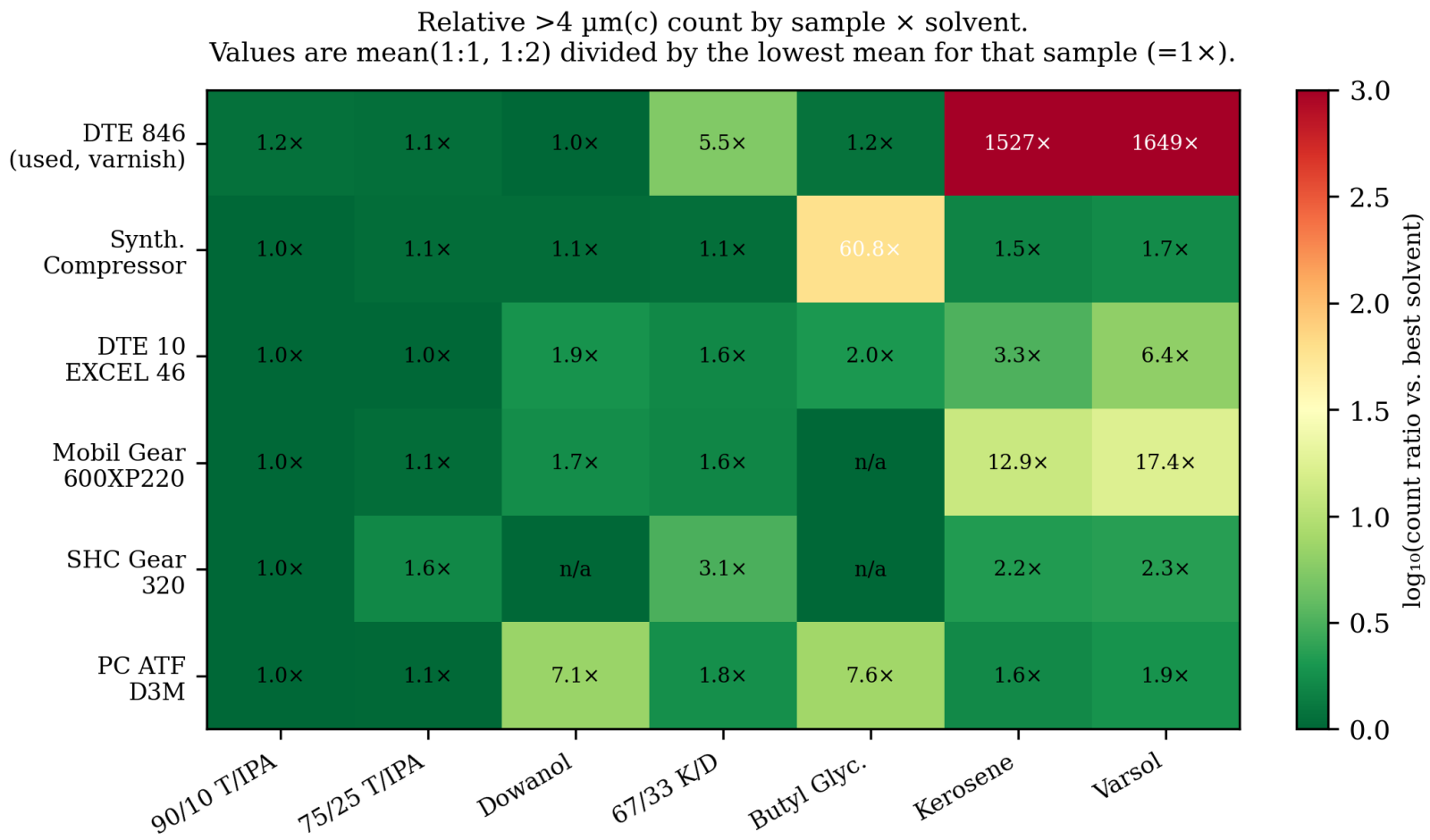
12
ISO codes range
on Mobil DTE 846

7
ISO codes range
on synthetic compressor

1.5
Published D7647-24
reproducibility limit

Diluent-driven disagreement runs 2× to 8× wider than D7647's own reproducibility limit — and it's a systematic bias, not random scatter.

90% Toluene / 10% IPA was first in 7 of 8 samples



Soft-particle removal

1st 90/10 T/IPA (7 of 8)
2nd 75/25 T/IPA
3rd Dowanol (DPnB)

Water masking

1st 75/25 T/IPA
2nd Dowanol (DPnB)
3rd 90/10 T/IPA (at 1:2)

Unsafe — remove

Kerosene, Varsol, lamp oil (both tests fail)

Two proposed changes to D7647

1. **Remove kerosene, lamp oil and Stoddard solvent from Table A1.1**
   These non-water-masking solvents fail both the water-masking test and the soft-particle test on the majority of samples. They cannot be used safely when sample water or soft-particle status is unknown.

2. **Add 90% Toluene / 10% Isopropanol as a permitted water-masking diluent** Lowest-counting diluent on 7 of 8 oil samples. Adequate water masking for the 0.5–1% free-water levels typical of in-service samples when used at 1:2 dilution. Add explicit dilution-ratio guidance.

These two changes would restore constancy with the standards own title and substantially improve method performance in terms of repeatability and reproducibility.

What to take home from this talk

1. Kerosene, Varsol and lamp oil create ghost particles

Counts on the same varnish-laden sample range from 76 (90/10 T/IPA) to 223,460 (Varsol at 1:2). Counts increase with dilution — the diagnostic signature of soft particles precipitating from the diluted phase.

2. Non-water-masking diluents fail catastrophically on water-bearing samples

On a 1% water spike, kerosene and Varsol return counts 15 × the dry reference. ISO codes saturate at 25/25/25. They are unsafe for any sample where water status is unknown.

3. 90% Toluene / 10% IPA is the best overall single diluent

First in 7 of 8 oil samples. Adequate water masking for 1% water at 1:2 dilution. Should be added to D7647 Table A1.1 in the next revision cycle.

4. 75% Toluene / 25% IPA remains essential for high-water samples

Masks both 1% and 2% water at both 1:1 and 1:2 dilutions. DPnB is an acceptable second choice but has solubility failures on PAO and PAG-rich samples.

Thank you

Questions welcome

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Full paper & dataset
Available in the LUBMAT 2026 proceedings

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