Product identification and quality control of oils using eraspec oil spectral matching

In industrial maintenance and quality control, a persistent and critical challenge is verifying lubricant compatibility. Introducing an incorrect oil into a system can result in severe mechanical and chemical failures, including additive incompatibility, adverse viscosity changes, and significantly accelerated mechanical wear. To avoid these risks, industrial operations require a reliable, proactive verification method during incoming inspections to prevent costly misapplications before the lubricant ever reaches the machine.

Automated FTIR spectral matching offers an objective approach to positive product identification by cross-referencing an unknown lubricant sample's unique molecular fingerprint against a reference database. To evaluate the reliability and operational boundaries of this technique, testing was conducted using the era**spec oil**. era**spec oil** and era**spec oil X** are advanced mid-FTIR spectrometers specifically engineered for lubricant analysis and oil condition monitoring.

To enable automated spectral matching, a comprehensive reference database of fresh oils must first be established on the analyzer. Upon analyzing a new sample, the system automatically compares its spectrum against all database entries, calculating a similarity score to identify the optimal product match.

The reference database for this study was constructed using 19 distinct fresh oils provided by a major European lubricant manufacturer. To evaluate the system's matching performance, the manufacturer supplied three samples from different production batches for each of the 19 fresh oils. These batch samples were then evaluated against the reference database using era**spec oil**.

After the measurements the top three reference matches are displayed immediately in the main results window. More information about all the matches can be found under **“Matches”**. This menu displays the complete list of database entries, ranked from the highest to lowest similarity.

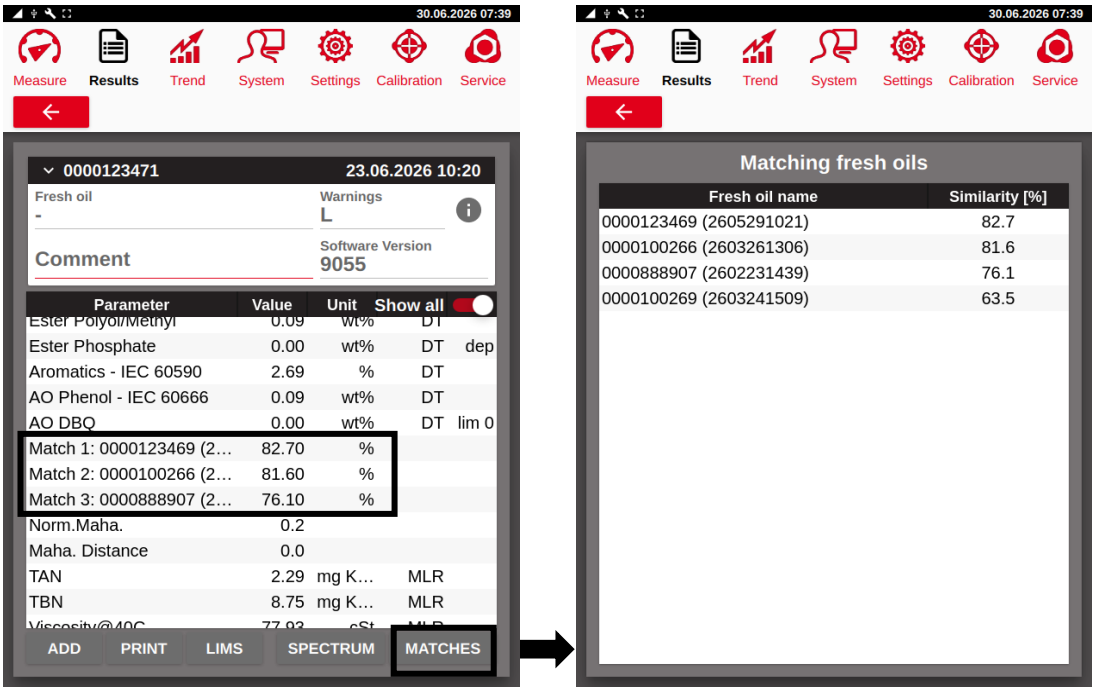

Figure 1: Top matches on the result screen of eraspec oil

The algorithm's robustness was evaluated using a reference set of 19 fresh oil formulations. To capture typical manufacturing tolerances, production batches for each oil were analyzed and cross-matched against all 19 reference spectra, generating a 19 x 19 cross-validation similarity matrix.

The robustness of the identification algorithm was evaluated using four objective performance metrics applied to the cross-validation data:

- **Spectral Similarity:** The baseline correlation between the sample and the reference.
- **Discrimination Margin:** The crucial "safety buffer" represents the statistical gap between the correct match and the closest false competitor.
- **Rank:** The position of the correct formulation within the results list.
- **Standard Deviation (SD):** The measure of stability against measurement repeatability and batch-to-batch variations.

The system demonstrated high resilience to instrumental noise and batch-to-batch variations, with an **overall measurement repeatability of approximately 0.5%**. 18 of the 19 evaluated oil formulations were successfully matched to their correct reference profiles, with the cross-validation matrix consistently yielding self-comparison similarity scores approaching 100% (Figure 2).

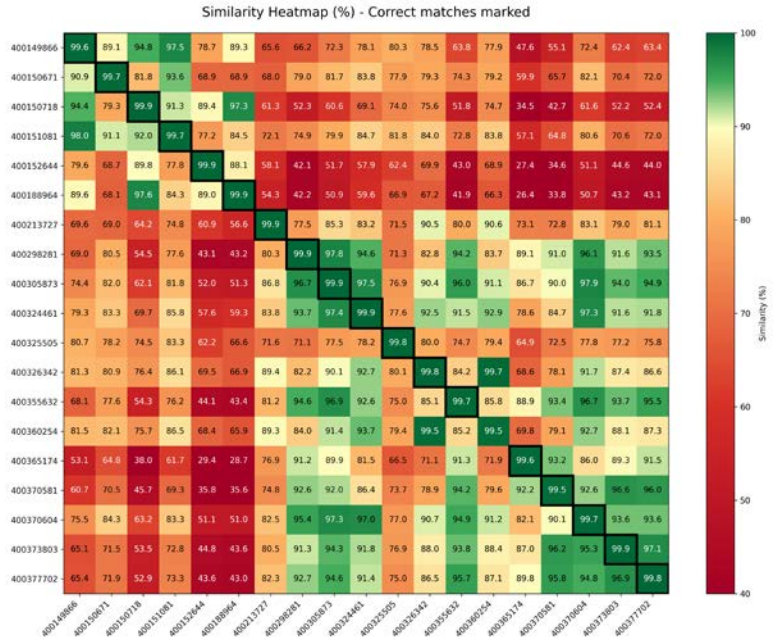

Figure 2: Cross-validation similarity matrix of pair-wise similarity scores S_{xy}.

While the algorithm effectively distinguishes most commercial lubricants, differentiating between “sister products” represents the physical limit of FTIR matching. This was demonstrated by the single mismatch in the validation study, where the target oil and its strongest false competitor featured near-identical chemical compositions, differing only in minimal variations in additive concentrations (Figure 3 – the red dot).

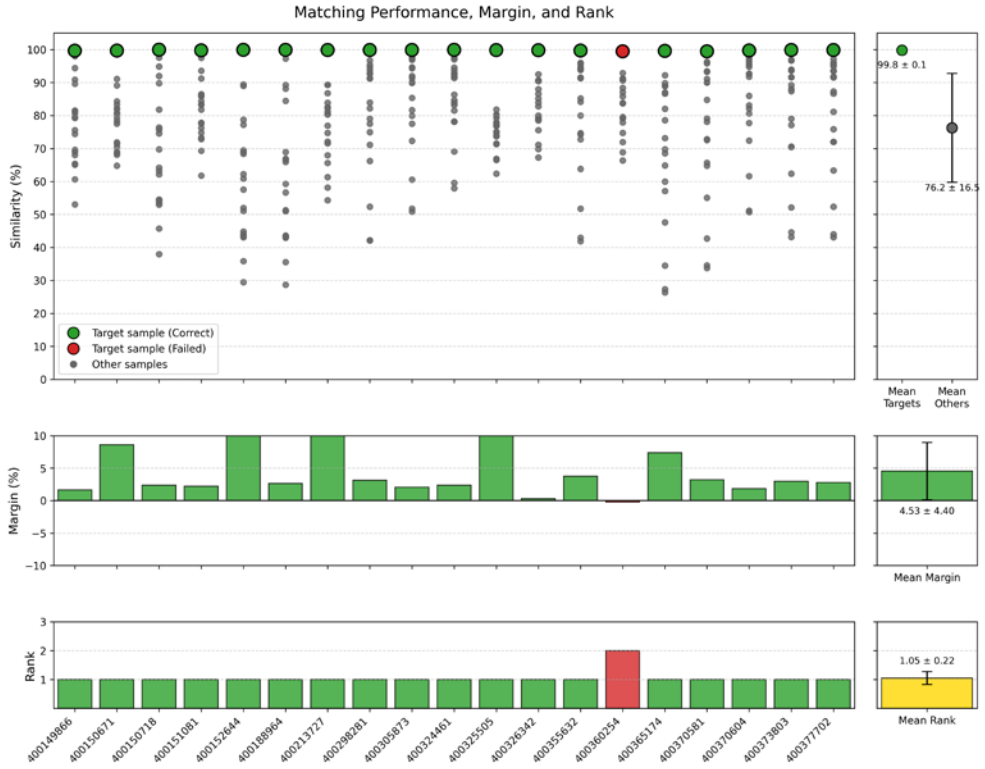

Figure 3: Spectral matching performance metrics. Top: Similarity scores of validation samples across all reference samples. Correct matches marked green. Middle: Discrimination safety margins across all reference samples. Bottom: Ranks of the target reference samples. Rank 1 indicates a correct match. Right column: Average similarity score of targets and false competitors (top), average safety margin (middle), average rank (bottom).

Validation data for the era**spec oil** demonstrate that automated FTIR spectral matching provides a robust, field-ready solution for industrial quality control. By adopting this technology for routine incoming inspections, facilities can transition to an objective, automated baseline for product verification. This optimization minimizes the operational risks associated with lubricant cross-contamination or misapplication, directly contributing to asset protection.

Integrating era**spec oil** into quality control workflow provides several advantages:

- **Securing Incoming Inspections:** Carrying out automated checks during routine incoming inspections provides an objective method to verify the identity of delivered products before they are deployed into machinery. This directly prevents product mix-ups from the very beginning.
- **Detecting Cross-Contamination in Pipelines:** At blending plants, different oil types often travel through the same pipes. If a batch of oil A is accidentally contaminated with a small amount of oil B left in the line, spectral matching will catch the foreign chemical peaks immediately, preventing an entire batch from being ruined or shipped.
- **Additive Package Verification:** Fresh lubricants rely on additives like anti-wear, detergents, antioxidants, and viscosity modifiers. era**spec oil** compares the fresh batch's spectrum against the master formulation from the database and instantly flags mismatched batches.
- **Catching Counterfeit Oils at the Loading Dock:** Because era**spec oil** is portable, rugged spectrometers, they can be deployed directly at the loading dock for incoming inspections. Distributors can instantly verify the authenticity of delivered premium lubricants by cross matching a sample's spectrum against the on-board reference database. Since counterfeit oils typically consist of cheap base oils lacking proprietary, high-performance additive packages, their spectra will not align with the premium reference. The algorithm will calculate a low correlation score, immediately exposing the counterfeit product.