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ASTM and Lubricant Monitoring

Using Best Data to Make Best Machine Decisions

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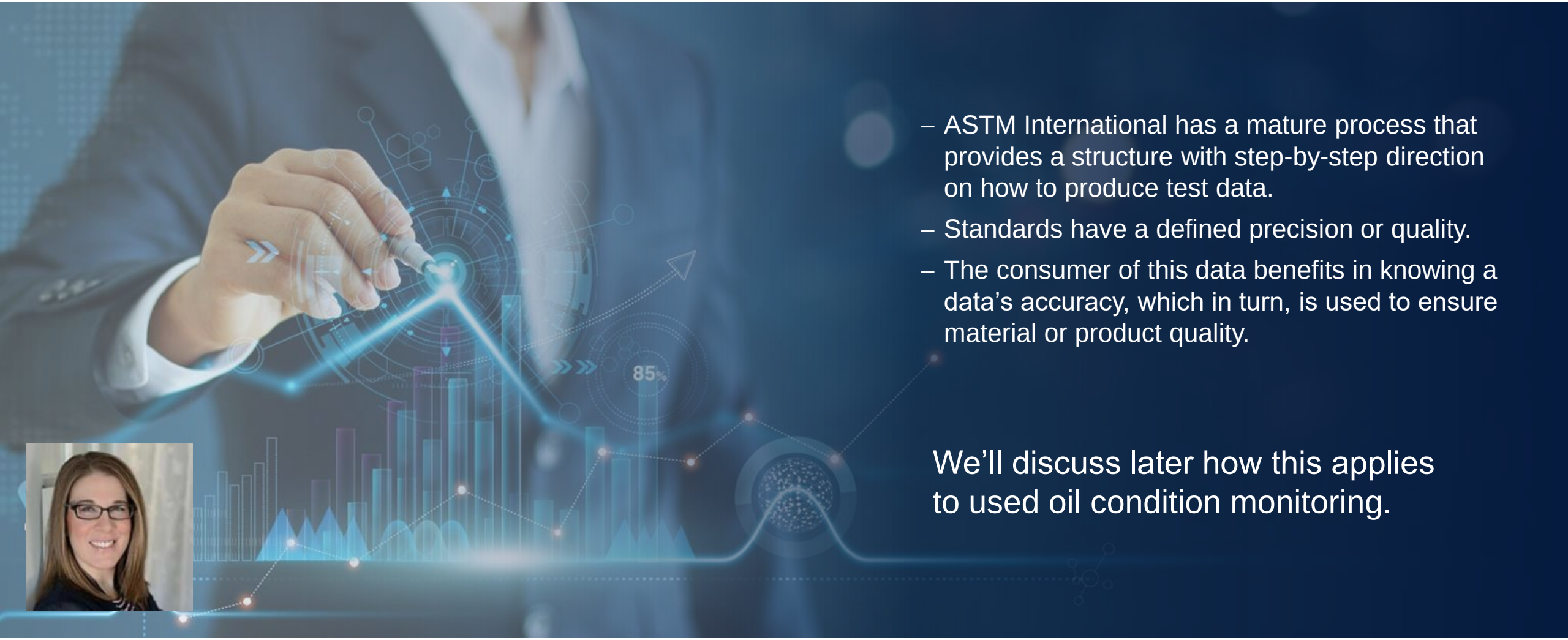
www.astm.org

ASTM International is a Global Standards Organization

- Members are unpaid volunteers, and many are considered to be international experts
  - ASTM International is inclusive and welcomes new members
- Industry is supported through ASTM's facilitation of volunteers that develop Standards.
  - Standards include test methods that are used to ensure a known quality of materials and products.
  - Standards may be structured to support Industry Practices.
  - Some standards provide guidance on particular topics of interest.
- Volunteers have the freedom to bring new requests to ASTM for action
  - These requests may result in revisions to existing standards or even the development of new standards
- ASTM has a host of technical publications
  - Can be used to educate the user
  - Help Industry

So why should you use ASTM Test Methods?



- ASTM International has a mature process that provides a structure with step-by-step direction on how to produce test data.
- Standards have a defined precision or quality.
- The consumer of this data benefits in knowing a data's accuracy, which in turn, is used to ensure material or product quality.

We'll discuss later how this applies to used oil condition monitoring.

Test Results — “Buyer Beware!”

- A test result should be uniquely defined by the **Test Method** that is used to produce it.
  - Standards have defined processing steps
  - Standards specify instruments, solvents, and peripherals needed to generate the data
- Conversely, some other available test data is produced without an industry-conscientious test method.
  - The use of this data is risky as variations in how the data is produced introduces uncertainty into the data.
  - Data from this type of source cannot be readily compared to ASTM standardized test data due to the uncertainty; therefore, its quality is unknown.
- The consumer of the test data can easily fall into a trap by assuming that test data is providing information that it really isn’t.

Consider the Importance of Details

- A test result is produced after a series of steps are performed.
- Some steps require the introduction of chemicals or other environmental conditions, such as temperature, to perform the test.
- The ordering and quantity of solvents matter.
- Some test steps may result from instrument settings or sequence of steps that the lab technician specifies for the instrument to perform.
- The calibration of tools or components of the test's set-up or instrument used as an impact on the data produced.
- Of course, every time someone new performs the test, their skills or bias can also effect the results produced.

Possible Negative End-use Outcomes when Applying Unknown Data Quality

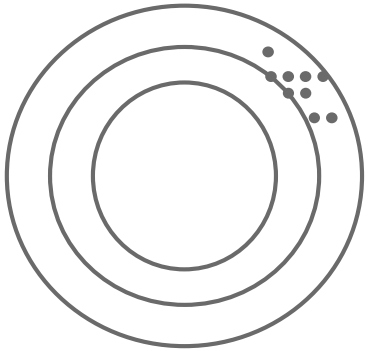
- The variation in the repeatability of the data from sample to sample may make the user believe that an adverse trend is occurring or worse yet, it may obscure a problem that requires action.
- The data may appear to reasonably repeat from sample to sample but could be incorrect
- The cost of the data may be out of line with the underlying reason for the test.
  - May cost too much

What is “Data Bias”

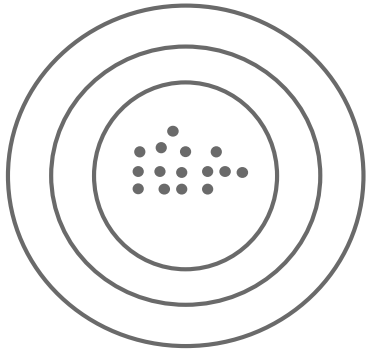
- To understand bias, we need to have a reference “standard material” to compare against future test performers.
- Bias may be determined as the average discrepancy between the “known” value and the reported values.
- Accepted references may come from:
  - Theoretical/established values or based on scientific principles
  - Experimental work of some national or international organization
  - Collaborative experimental work under the backings of a scientific or engineering group

Precision and Bias

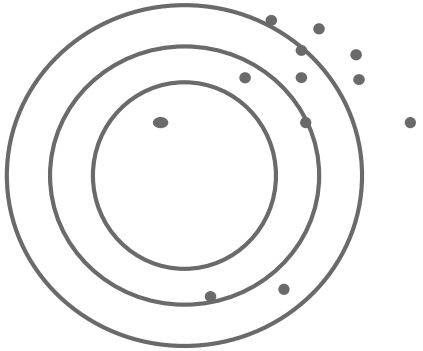
large bias + high precision = **low accuracy**



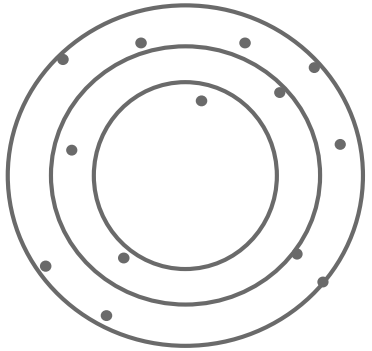
zero bias + high precision = **high accuracy**



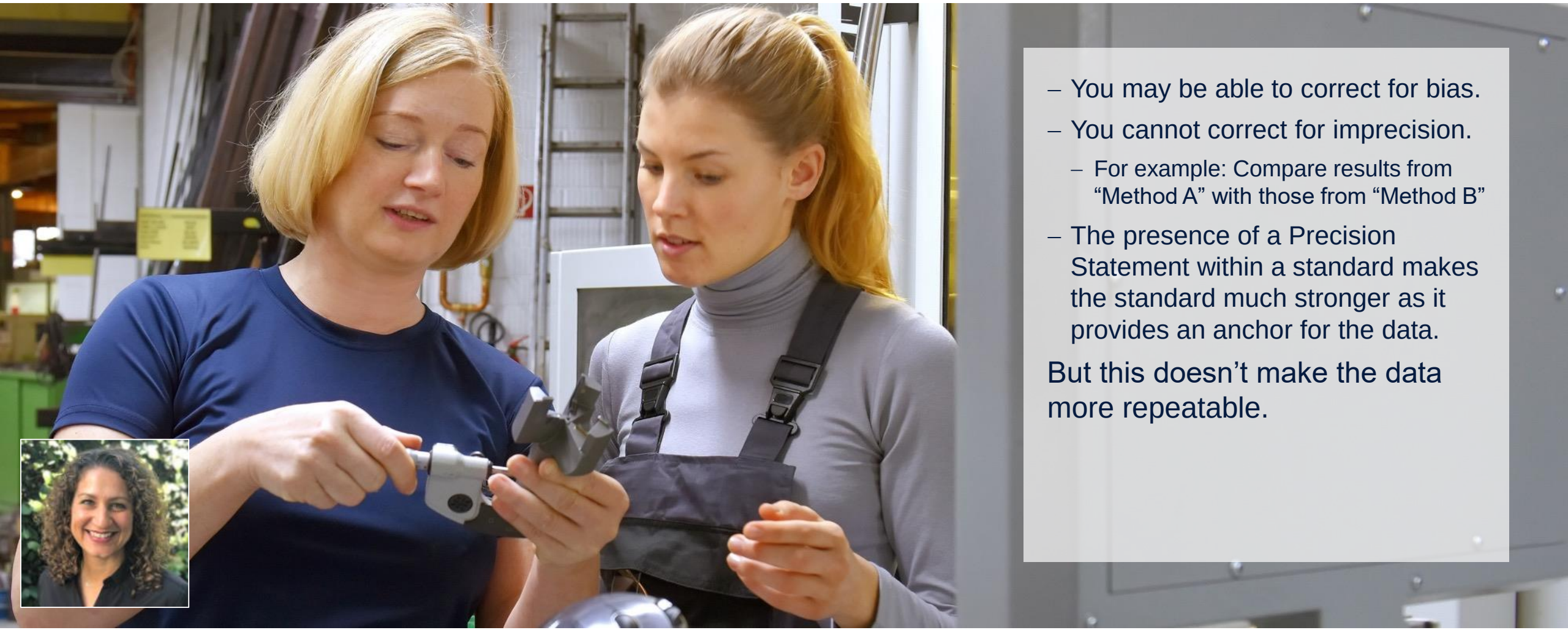
large bias + low precision = **low accuracy**



zero bias + low precision = **low accuracy**



Remember



- You may be able to correct for bias.
- You cannot correct for imprecision.
  - For example: Compare results from “Method A” with those from “Method B”
- The presence of a Precision Statement within a standard makes the standard much stronger as it provides an anchor for the data.

But this doesn’t make the data more repeatable.

Repeatability

- Precision of results from tests conducted within the shortest practical time period on **identical** material by the **same method** in a single laboratory with all known sources of variability **conditions controlled** at the same levels (E177).
- Variability may include operators, equipment, instruments, reagents, or environment

Reproducibility

- Precision of results from tests conducted on **identical material** by the same test method in **different laboratories** (E177).
- Results are obtained with the same method on identical test items in different laboratories with different operators using different equipment.

Interlaboratory Study (ILS)

An interlaboratory study (ILS) is a multi-lab study used to produce data for a Precision & Bias statement and Research Report to demonstrate the expected variability of a test method.

- *Form & Style Manual* (Blue Book): Precision and Bias (Mandatory)
- A statement on precision allows potential users of the test method to assess in general terms its usefulness in proposed applications.
- ***Every test method shall contain:*** (1) a statement regarding the **precision** of test results obtained in the same laboratory under specifically defined conditions of within-laboratory variability (**repeatability** conditions); and (2) a statement regarding the precision of test results obtained in different laboratories (**reproducibility** conditions.)

Introduction to Condition Monitoring

- Condition monitoring (CM) is the process of monitoring a parameter of conditions in machinery (vibration, temperature, etc.), in order to identify a significant change which is indicative of a developing fault.
- Major concept of **Predictive Maintenance**
- Normally used on rotating equipment and other machinery such as pumps, electric motors, internal combustion engines and presses.

Ref: https://www.corrosionpedia.com/definition/314/condition-monitoring-cm#:~:text=Condition%20Monitoring%20%28CM%29%20Definition%20-%20What%20does%20Condition,change%20which%20is%20indicative%20of%20a%20developing%20fault.

How is Oil Analysis being used today?

- Between 60 to 70% of industrial facilities in a recent reliability survey responded that they use **Oil Analysis** as an important component of their reliability programs.
- With On-site testing: Off-site services and sensor technology installed at the machine.
- Practitioners and end-users apply these technologies to understand the condition of both the oil and the machine.
  - Does operation meet expectations?
  - Comparable to a blood test for humans

Ref:
https://www.plantservices.com/articles/2020/2020-pdm-survey-results/

Introduction to Oil Analysis

- Oil analysis data is often part of an overall condition monitoring program for machine reliability that includes other predictive maintenance technologies such as infrared, ultrasound, motor circuit analysis and vibration analysis. Walkdowns are also considered to be condition monitoring.
- There are three categories of oil analysis: **Wear, Chemistry, and Contamination**
- Trending parameters in each of these categories allows for early detection of potential equipment failures and their precursors.

Economic Case for Condition Monitoring

Increase Asset Availability, Reliability, and ROI

- Reduce unplanned downtime
- Increase asset life
- Increase asset/machine utilization
- Reduce risk of catastrophic failures

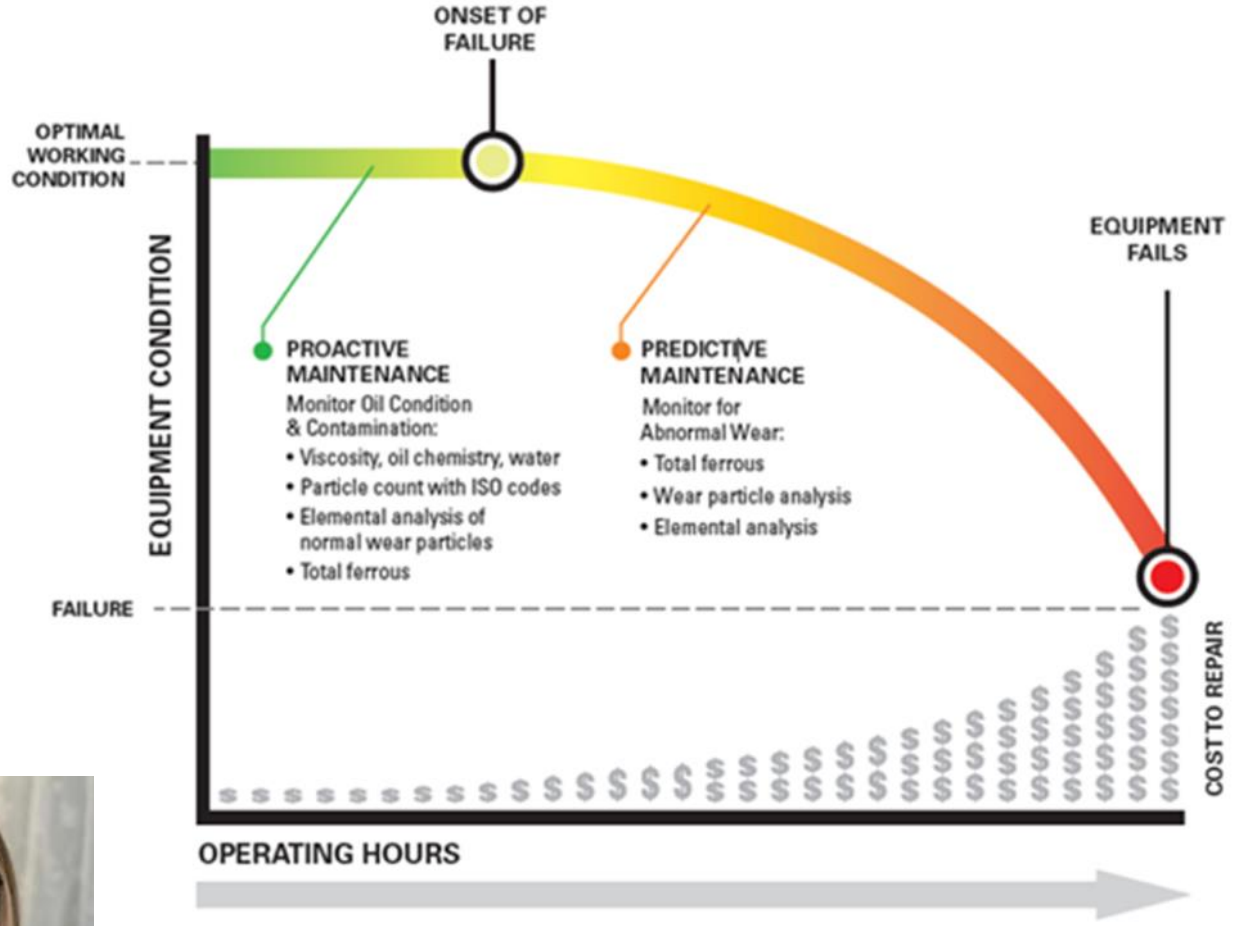
Reduce Operating Expenses

- Reduce usage of oil, greases, and other industrial fluids
- Lower maintenance costs
- Achieve environmental goals
- Reduce inventory

Enhance Productivity

- Improve first-time fix rates and mean time to repair
- Increase worker safety
- Increase maintenance resource productivity and utilization

Why is oil analysis an important part of a reliability program?



In-service oil analysis for machine condition monitoring

- Early identification and trending of machinery wear and failure modes allows maintenance before catastrophic failure occurs.
- Oil analysis complements vibration, thermography and predictive technologies.
- Increases confidence in decision to remove machinery from service.

Two Avenues of Oil Sample Testing

Condition Monitoring of Lubricants: Expanded into Two Major Options

The use of a **commercial laboratory** to manage and perform testing and convey the test data.

The purchase of instrumentation to set up and implement a **site-based** testing program.

Benefits of Commercial Laboratory Analysis

(Off-Site Testing by a Service Provider)

- Significant Testing Capabilities/Global Footprint
- Quality Assurance/Accreditations
- Objectivity/Unbiased
- Expertise/Consultation
- Data Collection/Trending
- Speed/Cost of Services

Commercial Lab/Off-Site Analysis

Testing Capabilities & Quality Assurance

- Accuracy when ASTM Standards are used
  - User should ask which ASTM standards are being used for their tests
- Use of Standards allow customer auditing
  - Data is based upon conscientious Round Robins
  - Uniform data, quality control, and validation
- Accreditations – ISO 9001/17025
- Legally defensible data

Commercial Lab/Off-Site Analysis

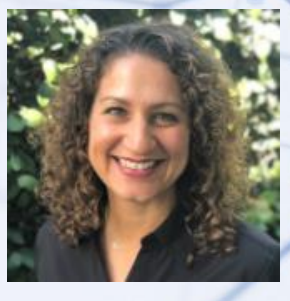
Objectivity & Expertise

- Unbiased personnel
- Expertise/Ability to Consult
- Accreditations – CLS/MLA
- Research & Innovation
- Many actively participate in ASTM
  - Be sure to ask your lab!

Commercial Lab/Off-Site Analysis

Data Management & Testing Fees

- Data trending
- Volume of data/data mining
- Comparison and collection over multiple fleets/units
- Quick turnaround time available
- Affordable fee for sample volume



On-Site Oil Analysis

Amplified benefits of performing routine oil analysis:

- Immediate feedback of findings
- Improve facility stakeholder knowledge
- Expanded program scopes are common
- Can be used to screen for “worst” samples to be sent off-site for expensive testing

These attributes provide strong correlation to:

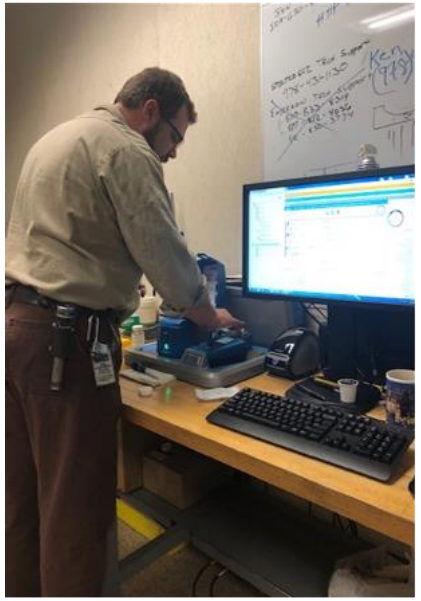
- Increased machine availability
- Extended equipment life
- A decrease total lifecycle costs

On-Site Oil Analysis: Immediate Feedback Enhances the Program

Problem machines quickly identified

- Immediate test results help with scheduling the needed repairs.
- May lead to immediate maintenance actions…

…or data may be used to justify deferring costly maintenance that may have otherwise been performed.



On-Site Oil Analysis — Direct Knowledge

The testing program creates some unexpected additional value

- Becomes an on-site learning center
  - The relationship of each test to what it monitors becomes clearer
  - Allows an addition of sensory inputs
    - A visual inspection of color or presence of particulate or water
    - Smell can also provide clues

Those closest to the machine have the highest ownership of their machines

- They will bring samples from machines not normally within the test program to be tested
- With on-site feedback, sensitivity to recommendations improve

Cost Benefits Associated with On-Site Testing

Increasing program scope becomes intuitive

- Test instruments and their maintenance have a fixed cost
  - Moderate additional costs in adding more samples
  - It's not uncommon for plants to increase the scope of their lubrication program testing by 10 times in the first year of on-site testing
  - Increased sampling intervals for monitored machines

Enhancements to Sample Testing Program

- Limits the samples that are sent off-site for more expensive tests
  - Sample screening skills improve
    - Fewer samples sent off-site for enhanced testing
    - Some examples of expanded testing may include: ferrography, RPVOT, water separability, Flash Point, Rust
- Can lead to improvements in the Quality Control Program for lubricants
  - Receipt inspection testing is an example
- Tests and instruments that perform these tests also available within the ASTM umbrella

Comparing On-Site/Off-Site Options

	Commerical Laboratory		On-Site Laboratory	
	Benefits	**Challenges**	**Benefits**	**Challenges**
Available test methods	Extensive Choices		Common tests accounted for	Must send out for others
Database/ Trending	Based upon extensive database	They have many customers	Custom Software available	
Turn-around time	Predictable Turn-around	Requires shipping and handling	Same day results possible	Testing limited by allocated site resources
Understanding the Machine Environment	Large database of similar machines	Commericial Laboratory won't know your machines as well	Direct site involvement include greater machine knowledge	
Enhancing site worker knowledge		The facility can rely on the laboratory	Site workers gain insight into tests, data and its effects on their machines	Can introduce a vulnerability if key personnel leave
Cost	Should perfom Ecoomic Analysis to make this determination			

How does ASTM help with Oil Analysis?

Condition Monitoring Background & How to's

- D7669 - Guide (How to trend data)
- D7720 - Guide (How to set Limits)
- D7874 - Guide (Applying Failure mode analysis)
- D7973 - Guide (Failure modes - bearings)
- D6224 - Practice (Monitoring Rotating Equipment)
- D4378 - Practice (Monitoring Turbines)
- D8185 - Guide (Viscosity)
- D7684 - Guide (Characterization of Wear Particles)

Chemistry

- D7418 - FTIR (Proper setup for FTIR Instrument)
- D7414 - FTIR (Oxidation), D7415 - FTIR (Sulfate)
- D7624 - FTIR (Nitration), D7686 - FTIR (Soot-Fixed Filter)
- D7844 - FTIR (Soot-Trend Analysis)
- D7889 - FTIR (Field Determination - General Info)

Test Methods

- D7918 - Grease Characterization and Testing
- D7843 - Varnish in Lube Oil
- D8092 – Field Determination of Kinematic Viscosity
- D445 – Kinematic Viscosity
- D7417 & D7596 - Integrated Testers

…and many others

Understanding the Differences in Test Data

ASTM Test data provides an expected data precision for the tests.

- This allows the selection of a test based upon a review of data sensitivity and cost.
- High level of data repeatability can be expected.
- Non-ASTM tests can introduce significant uncertainty to the data.

Examples of similar-–but different—test data

- For Wear Metals:
  - ASTM D6595 (Emission Spectroscopy),
  - ASTM D5185 (ICP Spectroscopy),
  - ASTM D8120 (ferrous Density),
  - ASTM D8182(ferrous Density),
  - ASTM D7670 (Membrane Filters),
  - ASTM D7690 (Ferrography characterization) and
  - D7596 (Direct Image particle characterization)

Viscosity: ASTM 445, ASTM D8092, ASTM D7279

Key Takeaways

1. It is vital that the consumer of the test data understand the limitations and accuracy of the test data.
   - Different test methods can produce different results. This is OK, provided that the data consumer understands the data and any bias, which may exist.
   - The use of ASTM test methods provides data certainty.
2. A testing Strategy should be based upon the relationship of the test-to-failure modes that are being monitored.
   - Both commercial and on-site testing accomplish this. Both are good choices. Each has unique benefits to the end user of the data.
   - ASTM standards are available to support both options.
3. The use of a lubrication condition monitoring program improves machinery reliability and availability.
   - ASTM has many other products that can help the end user develop a highly effective program.

Questions

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