



Test It, Don't Change It
On-site Oil Analysis Solutions

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SPECTRO INC.

Machine failures

are very costly...







sometimes spectacular,



...and the lubricant is a
common cause of failure

Mechanical causes of machine failure- oil wetted components

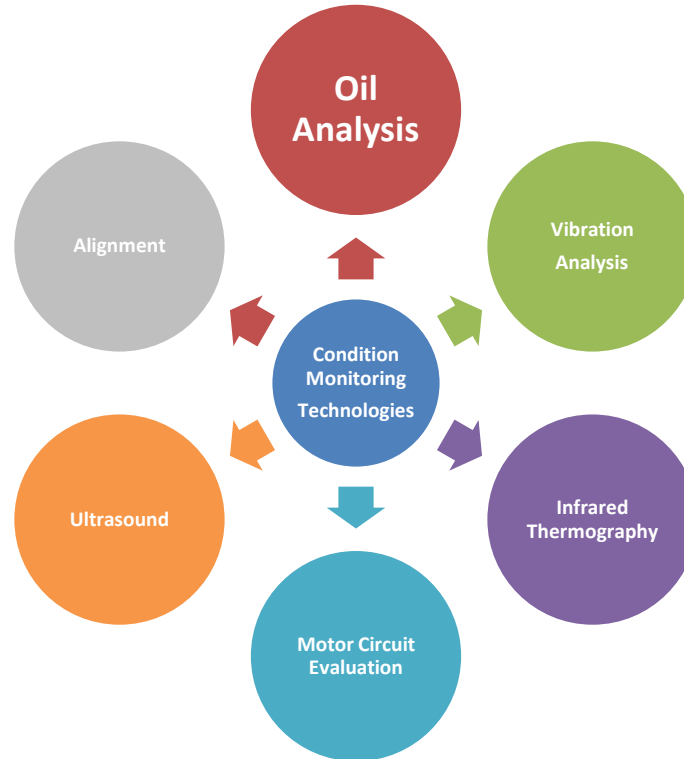
70% of equipment downtime is due to surface degradation - Corrosion and Wear

	ROOT CAUSES	MECHANISM	CAUSES	
20%	CORROSION	<i>water or other corrosive fluids chemically attacks and weakens metal surfaces</i>	Water in oil, degraded oil, process contamination, coolant, condensation...	
50% wear	ABRASION	<i>3-Body Cutting damage from abrasive particles between two moving surfaces</i>	Abrasive particles in oil, dirt, secondary wear, process contamination...	
	ADHESION	<i>Damage from metal surfaces dragging over each other</i>	Inadequate lubrication- low viscosity oil or no oil, high temperature, excess load, slow machine speed...	
	FATIGUE	<i>Damage from micro-cracks caused by cyclic loading</i>	Misalignment, imbalance, improper fit or assembly, secondary damage...	

Machine condition monitoring technologies

Industrial requirements for machine condition monitoring

- Non-intrusive measurements
- Early detection to reduce cost
- Multiple technologies for complete assessment



Oil condition monitoring is part of a comprehensive Predictive Maintenance program.

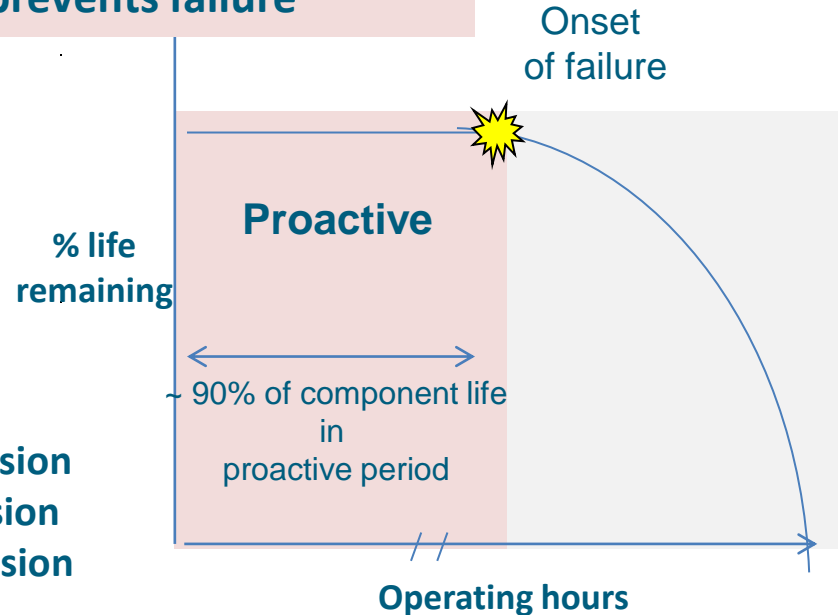
Complementary: vibration and oil analysis

Proactive maintenance -prevents failure

Reduce dynamic loads to extend machinery life & reduce **fatigue**

- Misalignment, imbalance, resonance, looseness and incorrect assembly cause mechanical damage

- Dust and other particles cause **abrasion**
- Water and other fluids cause **corrosion**
- Inadequate lubrication causes **adhesion**



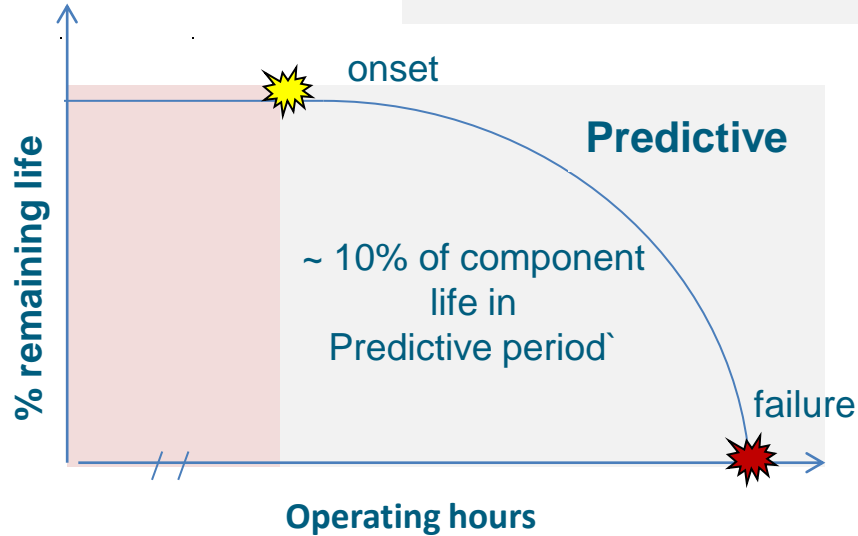
Vibration

Oil analysis

Eliminate root causes with proactive maintenance. No damage= long component life

Complementary: vibration and oil analysis

Predictive maintenance -failure has begun



Detection of incipient/initial damage

Monitor and trend from onset to predict failure

- Identify defects with vibration analysis (overall method and advanced analysis techniques such as PeakVue®)
- Monitor and trend key oil analysis parameters critical to machinery health to establish alarm levels

Vibration

Oil analysis

Eliminate root causes with proactive maintenance. No damage= long component life

In-service oil analysis

Oil analysis provides detailed information on the causes of surface degradation of lubricated machinery and:

- Reduces unexpected downtime
- Conserves oil
- Reduces maintenance costs
- Reduces environmental impact of waste oil disposal
 - oils and filters not replaced before end of service life



A comprehensive oil analysis program answers

Is it the right oil?

Viscosity, additives

Is the oil still clean?

No dirt, dust

Is it still dry?

Water, liquids

Is it still fit for use?

Viscosity, oil chemistry

Is the machine still OK?

Free of abnormal wear debris

How best to address these?

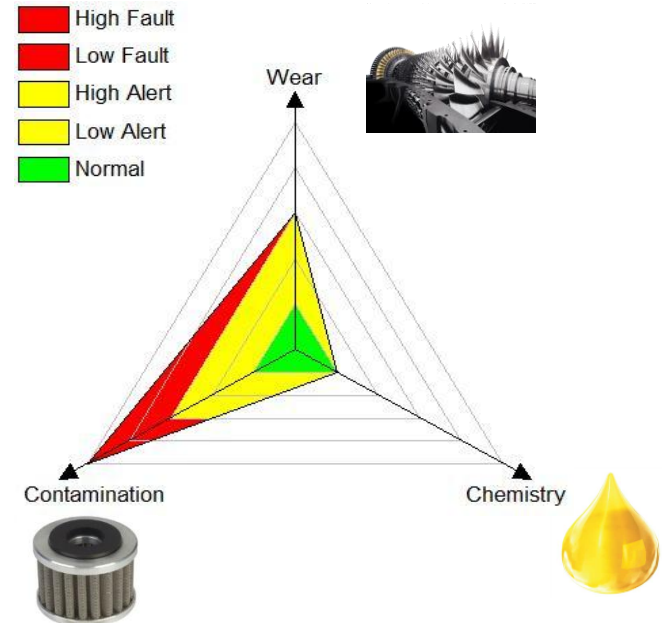
Oil analysis provides actionable information

Trivector™

- **Wear**
 - Particles in oil from normal and abnormal machinery wear
- **Contamination**
 - Dust/dirt accelerates wear
 - Water, glycol
 - Process fluids
- **Chemistry**
 - Oil degradation
 - Additives

& Physical: Viscosity

Change filter?
Dry oil?
Change oil?
Tear Down?




Let's address each of these...

Trivector is a trademark of Emerson CSI

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Oil analysis measurements—laser based particle counter

Wear	Contamination	Technique	Instrument
Component wear	Particulate contamination: <ul style="list-style-type: none"> Quantity & size distribution ISO codes 	Laser light blockage	
Component wear Automatic shape classification	<ul style="list-style-type: none"> Quantity & size distribution ISO codes 	Direct imaging laser. Good for dark and opaque oil.	

Oil analysis measurements– elemental analysis




	Technique / Instrument		
	Wear Metals	Contaminants	Additives
Elemental analysis	Aluminum	Boron	Barium
	Cadmium	Calcium	Boron
	Chromium	Potassium	Calcium
	Copper	Silicon	Chromium
	Iron	Sodium	Copper
	Lead		Magnesium
	Magnesium		Molybdenum
	Manganese		Phosphorus
	Molybdenum		Silicon
	Nickel		Zinc
	Silver		
	Tin		
	Titanium		
	Vanadium		
	Zinc		

Rotating Disk Electrode (RDE)
Spectroscopy (or ICP or XRF)



**Commonly analyze
23 Elements**






Oil analysis measurements– abnormal wear and ferrography

Wear	Technique	Instrument
<p>Large Ferrous wear measurement Fe Index</p> <p>PQ</p>	<p>Time resolved dielectric</p> <p>Magnetometer</p>	
<p>Automatic shape classification of wear</p>	<p>Laser Net Fines direct imaging laser</p>	
<p>Wear debris analysis / Ferrography</p> <p>Root cause analysis from shape (3D), size, color</p>	<p>Separation (patch, slide) and interpretation of wear and contaminant particles</p> <p>WDA software</p>	




Oil analysis measurements– water

	Contamination	Technique	Instrument
Water	Dissolved water	Wet chemistry Karl Fisher titration per ASTM D6304	 <i>Benchtop titrator</i>
	Free & emulsified water		
<i>Water increases corrosion and leads to adhesive wear</i>	Quantitative measurement of dissolved water, ppm	Handheld Direct IR with Integrated oil library	 <i>Handheld IR spectrometer</i>
	Detects free and emulsified water		

Oil analysis measurements– other liquids

Contamination	Technique	Instrument
Glycol	Fourier Transform Infrared Spectrometer	 <i>Bench top IR spectrometer</i>
Cross contamination	<i>Or</i>	
Wrong oil	Direct Infrared Spectrometer	 <i>Handheld IR spectrometer</i>
	Change in dielectric via RC circuit discharge of test chamber	 <i>Dielectric test port</i>




Oil analysis measurements– other liquids

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Oil Analysis measurements– chemistry

Oil degradation forms acidic by-products that lead to corrosion, varnish formation, sludge.

Must have TAN/TBN, or dielectric, to know if oil chemistry still fit for use

	Chemistry	Technique	Instrument
TAN/TBN	TAN, per ASTM D664 TBN, per D4739 or D2896.	Wet chemistry titration reagent with solvent rinse Trained technician	 <i>Titrator</i>
TAN/TBN	TAN, oxidation, water for machinery oils TBN, nitration, sulfation, oxidation, soot for engine oils Additive depletion	Handheld, Direct IR w/ oil reference library	 <i>Handheld IR spectrometer</i>
Dielectric	Measures changes in overall oil chemistry (chemical polarity)	Change in dielectric via RC circuit discharge of test chamber	 <i>Dielectric test port</i>

Oil analysis measurements– viscosity

	Contamination	Chemistry / Physical	Technique	Instrument
Dynamic viscosity	Wrong oil	Proper viscosity	Falling or Rolling ball viscometers, Resistance to flow measured at ambient temperature	
Manual, kinematic	Wrong oil	Proper viscosity	ASTM D445 stopwatch measurement	
Kinematic 40C	Wrong oil	Proper viscosity	Resistant to flow under gravity, transit time down capillary channel at fixed 40C temperature. Portable	

Challenges with industrial oil analysis

Outsourcing Oil Analysis

- Timeliness of oil analysis report for maintenance actions can be an issue
 - Loss of 'mindshare'
 - Outdated information
- Hard to integrate into other modern PdM techniques such as Vibration and Thermography
- Oil suppliers free oil analyses are rarely comprehensive



Challenges with on-site oil analysis

Effective on site oil analysis program

- Work process
- Equipment
- Training

Let's look at some case studies...

Cost justification for industrial oil analysis

Documented case histories and cost savings on-site oil analysis to monitor a wide range of industrial machinery. Realistic Return on Investment: 500%+

Reduce oil consumption

LESS OIL USED

“Test it, don’t change it”

Defer maintenance

Proactive CONTAMINATION CONTROL

Keeping oil clean, dry, and fit for use

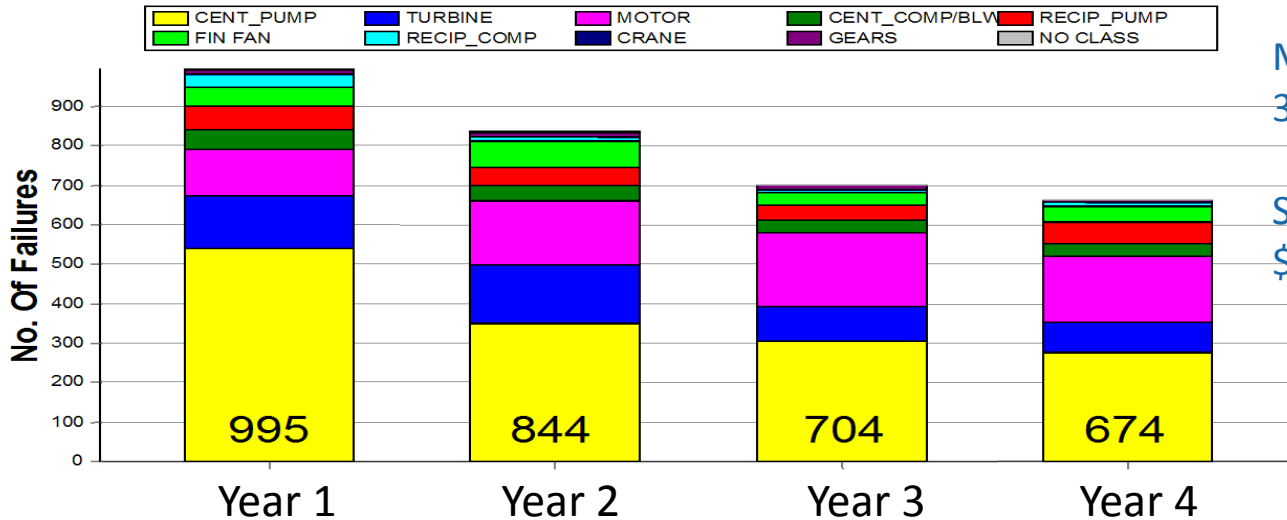
Eliminate reactive maintenance

Trend FAILURE PROGRESS

Predictive vibration & oil analysis

Refinery lubrication & oil analysis program

Rotating Equipment Failure Count by Equipment Types



Measurable results:
30% less failures

Savings of \$2.1M/year at
\$6,500/incident average cost

Assembly plant

Oil analysis program justification:
Gearbox failure caused 27 hour production outage.

Results:

- \$1.6 Million savings in 28 months
- 2 month payback period
- 738% ROI based on 20% IRR
- Improve Lubrication Quality
- Reduced Machinery Wear
- Extended Oil Change Intervals
- Reduced Oil Disposal Cost
- Reduced Oil Sample Cost
- Simple Cost Avoidance Methods

Estimates	Simple 5-Year Financial Analysis of Program Improvement					
	0	1	2	3	4	5
Savings						
Documented Savings (Yrs. 1 and 2)*	-	\$900,000	\$700,000			
Lubricant Expenditure Savings**		\$19	\$17	\$42	\$26	\$26
Projected Savings (Yrs. 3, 4, 5)**				\$500,000	\$500,000	\$500,000
Subtotal - Program Savings		\$900,019	\$700,017	\$500,042	\$500,026	\$500,026
Capital Purchases						
Initial Expenses	\$9,000					
IFH Storage Bins		\$10,000	\$20,000			
Lube Trucks						
Lab Equipment	\$55,000					
Expense Purchases						
Lubrication Training	\$16,000					
Oil Safe® Containers	\$5,700					
Material Handling Changes	\$4,550					
Tagging System	\$560					
Increase Lubricant Consumption						
Lab Equipment Training	\$10,000					
Subtotal - Program Expenses***	\$100,810	\$10,000	\$20,000	-	-	-
Depreciation Tax Shield ****		\$4,440	\$5,640	\$5,640	\$5,640	\$5,640
Total Cash Flows	\$(100,810)	\$894,459	\$685,657	\$505,682	\$505,666	\$505,666
Discount Rate (factor) *****	15% 1	0.8696	0.7561	0.6575	0.5718	0.4972
Discounted Cash Flow	\$(100,810)	\$777,790	\$518,455	\$332,494	\$289,116	\$251,405
Projected 5-Yr. Return						
	\$2,068,451					
Payback Term - Months		2				
IRR (based on 20%)		738%				
NPV 5-Yr. Estimate		\$2,068,451				

* Actual savings documented in formal cost program.

** Projected savings based on undocumented and anticipated savings.

*** Expenses include initial outlays and additional outlays during the first and second years.

**** Tax shield based on straight-line depreciation at a 30 percent corporate tax rate.

***** Discount rate equals the estimated target for returns on capital purchases.

Military On-Site Analysis

- Comparison to Lab Results
 - Test kits showed issues with TBN Measurements
 - FluidScan operates independently of manufacturer's specs
 - Higher accuracy=higher confidence=higher participation
- Significant Savings in Time & Money
 - 10-15 Man Hours saved per week
 - Saved labor costs=quicker payback
 - No Annual Recalibration Costs
 - No Hazmat Costs

There are some challenges implementing on-site oil analysis

On Site Oil Analysis

- Possible lack of on site oil expertise
- Perceived difficulty of oil analysis
- Integration of data
- Logistics management of waste disposal, solvent handling and training

Addressing the challenges of on-site oil Analysis

Possible lack of on site oil expertise

- Simple to use device with built in lubricant reference library and preset, adjustable alarm limits
- Correlates to lab FT-IR and Water/TAN/TBN titration

Perceived difficulty of oil analysis

- One drop of oil to test, One minute for results
- Immediate & actionable information

Logistics management of waste disposal, solvent handling and training

- Solvent free
- Easy to use flip top cell

Handheld Infrared Oil Analyzer

Helps determine if in-service oil is fit for use.

Measures degradation of the oil chemistry, and contamination by other liquids such as water.



Typical solutions for an industrial plant

Fluidscan Q1100 and Spectroil Q100...

“Expanding the Trivector” for Chemistry, Contamination and Wear

Walk-around portable viscometer and IR Spectrometer complements table-top Spectro 5200 Trivector minilab



Summary

- Oil condition monitoring is part of a comprehensive Predictive Maintenance program.
- On-site Oil Analysis programs provide timely, actionable, and cost effective information on in-service oil condition and machinery health



Illustration courtesy of Emerson



Thank You!

Q&A

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