



# GTEN 2021 Virtual Symposium

October 18<sup>th</sup> & 19<sup>th</sup>, 2021

## Considerations for the Fleet Management of Gas Turbine Lubricants

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# AGENDA

- Existing approach to turbine lubricant maintenance
- Oxidation and Varnish – Managed or Unmanaged?
- Tools for GT Lube oil maintenance
- Considerations for fleet management





CURRENT APPROACH



# TURBINE LUBRICANT MAINTENANCE

- Typical turbine oil life: 2-5 years (ASTM D4378)
- Flushing often required at time of replacement
- Oil replacement criteria based on combination of low antioxidants (<25%) and high acid number

# ASTM D4378-20 (GT AND ST LUBE OILS)



ASTM INTERNATIONAL

The screenshot shows the ASTM International website. The header includes the ASTM logo, the text "ASTM INTERNATIONAL Helping our world work better", a search bar, and navigation links: "PRODUCTS & SERVICES | GET INVOLVED | ABOUT | NEWS". There are also links for "Languages", "Contact", "Cart", and "SIGN IN".

The main content area is titled "ASTM D4378 - 20" and "Standard Practice for In-Service Monitoring of Mineral Turbine Oils for Steam, Gas, and Combined Cycle Turbines". It notes that this is an "Active Standard" developed by Subcommittee D02.C0.01. A "Book of Standards Volume: D5.02" is also mentioned.

Format	Pages	Price	
PDF	19	\$58.00	<a href="#">ADD TO CART</a>
Hardcopy ( <a href="#">shipping and handling</a> )	19	\$58.00	<a href="#">ADD TO CART</a>
Standard + Redline PDF Bundle	38	\$69.00	<a href="#">ADD TO CART</a>

Below the table, there is a section for "Reprints and Permissions" with a link to "VISIT COPYRIGHT CLEARANCE CENTER". At the bottom, there is a link for "Historical Version(s) - view previous versions of standard".

On the right side, there is a "Recommended" section with links to "Standards Tracker", "Standards Subscriptions", and "Customers frequently also buy:" followed by a list of related standards: D2500, D83, D4304, D6439, D2272, D7590, and a "See All" link.

# CURRENT APPROACH

- Maintenance programs focus on particulate removal
- Nothing being done to manage oxidation levels
- Fill, Forget, Dump, Flush, Repeat
  - Unoptimized, wasteful, and does not manage risk
  - Creates uncertainty on high value production assets
- Process is not working
  - Normal to have fail-to-starts and production losses of >24 hrs/year (and in many cases much worse)



# SURVEY RESPONSES FROM 7FA

IF USING VARNISH  
REMOVAL EQUIPMENT,  
WHEN WAS IT INSTALLED?

28%: AFTER FAILURE  
60%: AFTER A POOR  
LAB RESULT  
12%: WITH NEW OIL

IS THE CORRECT  
MPC TEST METHOD  
BEING USED?

87%: NO  
13%: YES

ANNUAL PRODUCTION  
LOSSES RELATED  
TO OIL

14%: >24 HOURS  
5%: <24 HOURS  
81%: <12 HOURS

MPC VALUES  
(VARNISH TEST)

3%: >35  
20%: 15-35  
77%: <15

OIL LIFE

10%: 2-5 Years  
30%: 5-9 Years  
60%: >9 Years

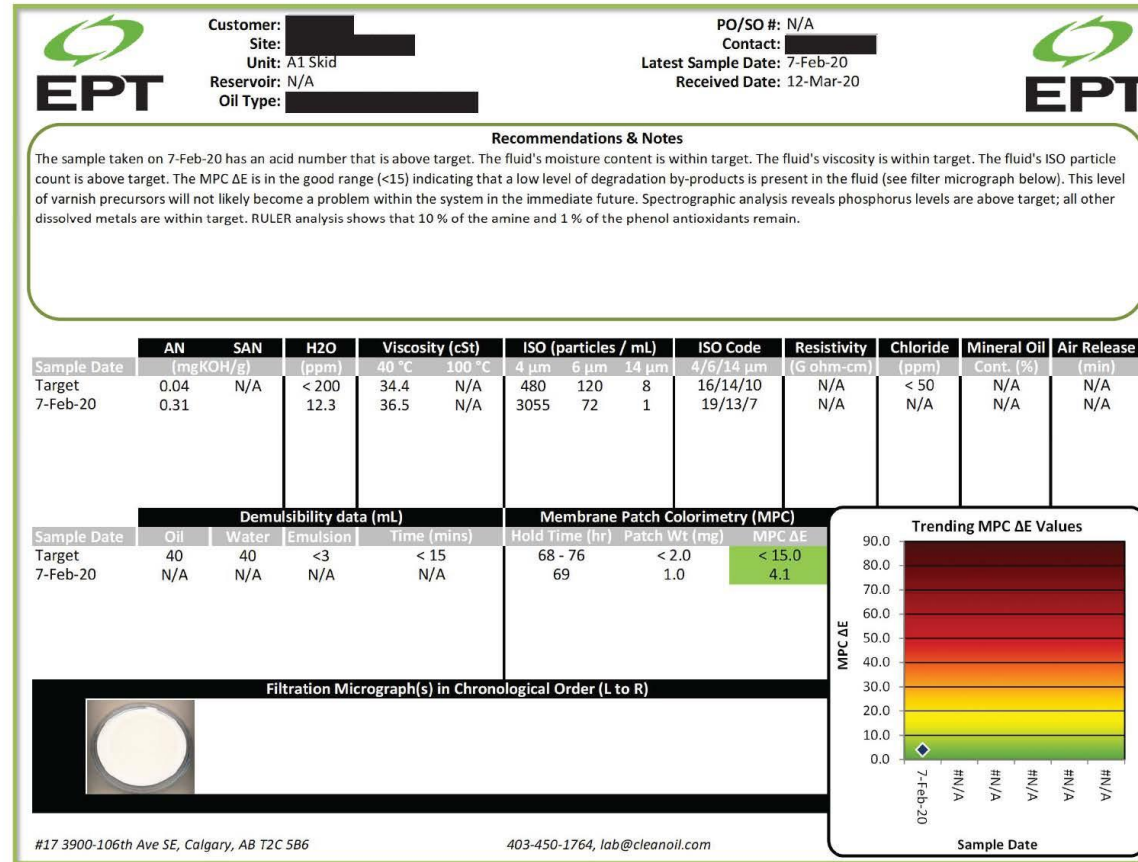
# >97% AVAILABILITY HIDES THE PROBLEM

- Frame 7E (60 Hz)
  - Production value: \$80,640 – \$368,640/day
- Rate of failure relating to varnish
  - 2 incidents/year totaling 24 hours downtime/year
- Lifecycle costs relating to varnish
  - \$2.0-9.2 million over life of the turbine
  - Avoidable for \$250,000 or about \$10K per year

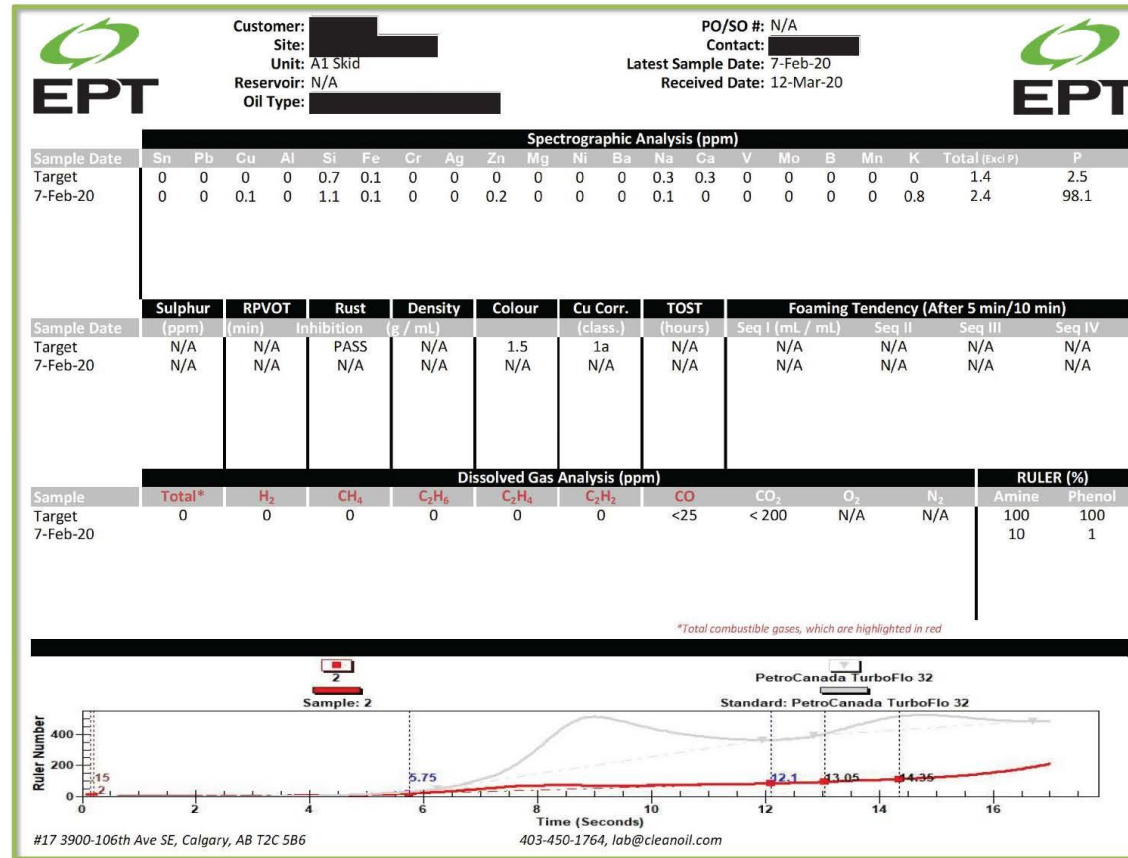




# WESTERN CANADA USE CASE



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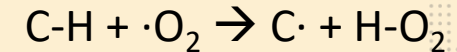
OXIDATION AND VARNISH



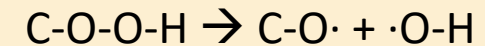
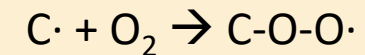
# OXIDATION

- Attacks all molecules
  - Oil hydrocarbons, additives, etc.
- O<sub>2</sub> initiates free-radical chain reaction
- Oxidation by-products:
  - Alcohols, esters, acids etc.
  - Normally all SOLUBLE (dissolved)

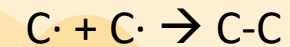
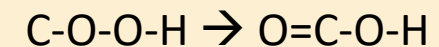
## INITIATION



## PROPAGATION

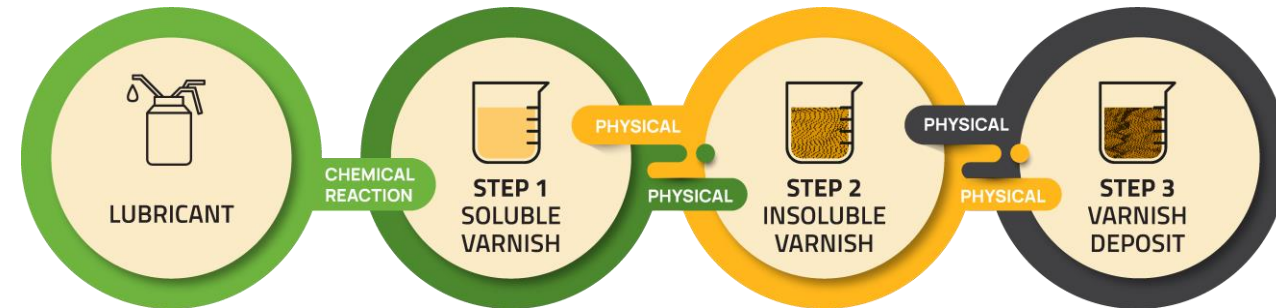


## TERMINATION



# WHAT CAUSES VARNISH?

- Once oxidation products accumulate past the point of saturation, they convert from a soluble form to an insoluble form creating deposits referred to as varnish
- The saturation point is temperature-dependent
  - When the oil is near saturation, varnish can be insoluble at low temperatures and soluble at elevated temperatures





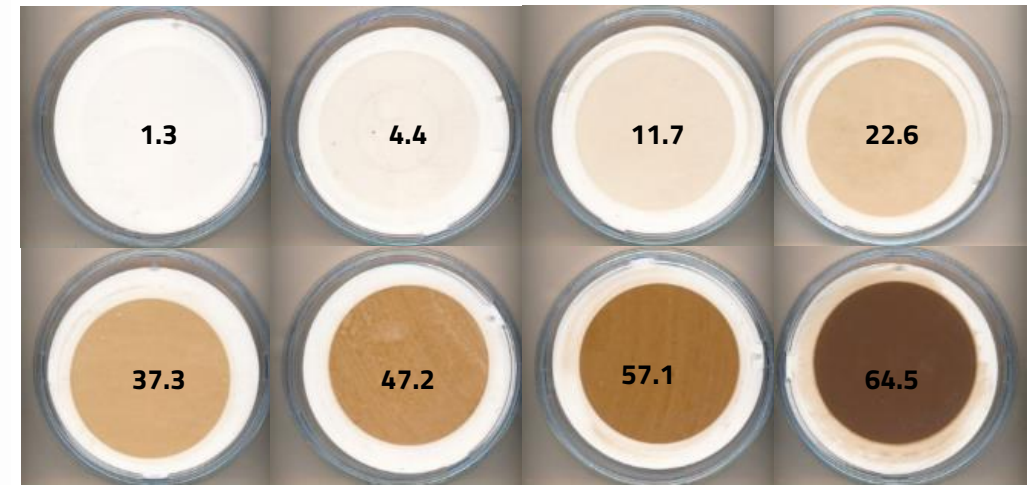


VARNISH MEASUREMENT



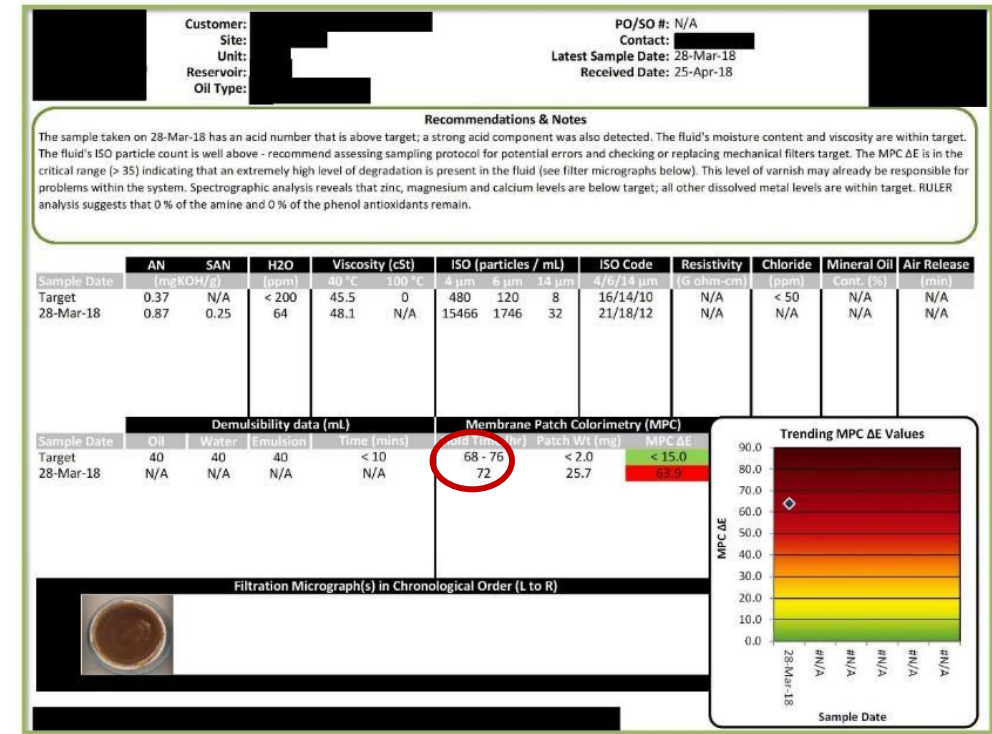
# MEASURING VARNISH POTENTIAL: MPC

- ASTM D7843-21



# ASTM D7843-21 KEY POINTS



- Prior to testing heat oil to 140F/ 60°C for 24 hrs
- After heating, hold sample for  $72 \pm 4$  hrs
  - "Resets" sample and allows soluble varnish to be detected





# ASTM D7843-21 TEST RESULTS

- Oil filtered with and without the 72-hour hold period:

Trial	60°C Heating Period (hours)	20°C Incubation Period (hours)	Patch Photo	MPC $\Delta E$
A	0	0		3.0
B	24	72		22.1

- Soluble varnish is dissolved
  - It will pass through a 0.45  $\mu\text{m}$  patch
  - After 72 hours, some will become insoluble (measurable)
- Demonstrates the criticality of 72-hour hold period





OIL TREATMENT AND FILTRATION



# VARNISH REMOVAL

- If you prevent oil saturation, you can prevent varnishing
- Varnish formation is a reversible physical change of contamination from one form to another (dissolved to solid)
- Equilibrium chemistry dictates that if you return oil to an unsaturated condition by removing dissolved contamination, varnish deposits will be forced back into solution



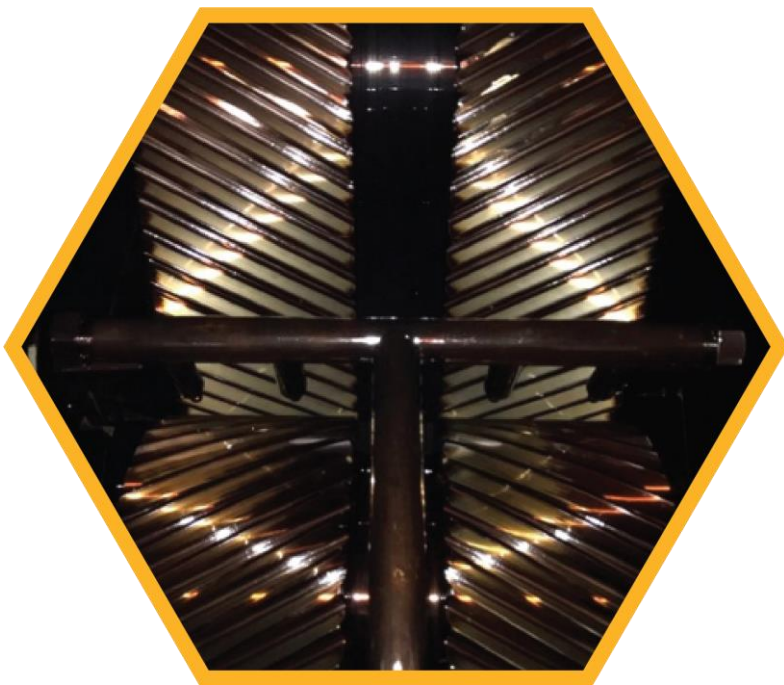


# MANAGE THE UNMANAGED

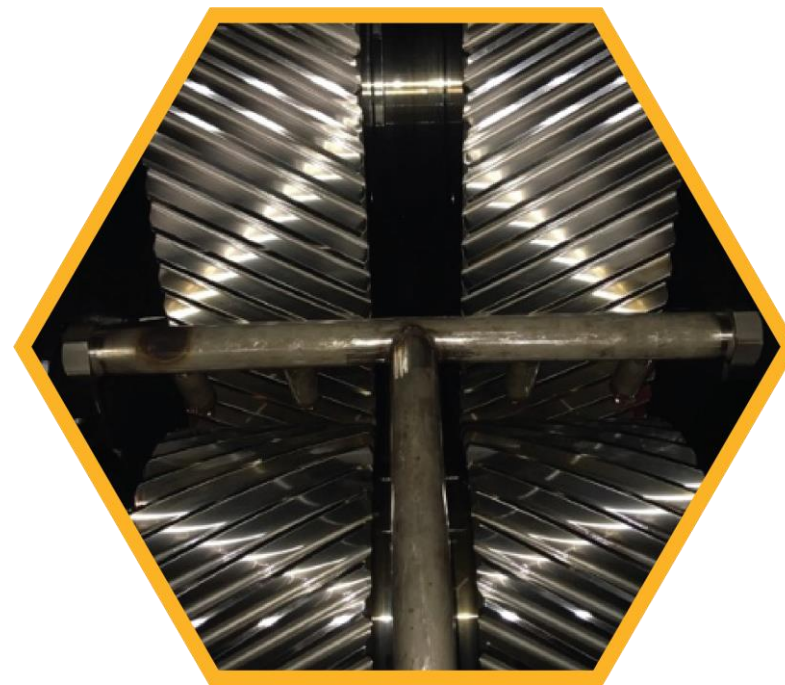
- Proactively manage lubricant chemistry
- Manage the root cause of lubricant breakdown, oxidation, and the consequences
- Reverse chemical damage that results from oxidation and avoid unnecessary pain
- Eliminate the varnish formation cycle

# A CHEMISTRY SOLUTION FOR A CHEMISTRY PROBLEM™

Before  
SVR™ & ICB™



After  
SVR™ & ICB™





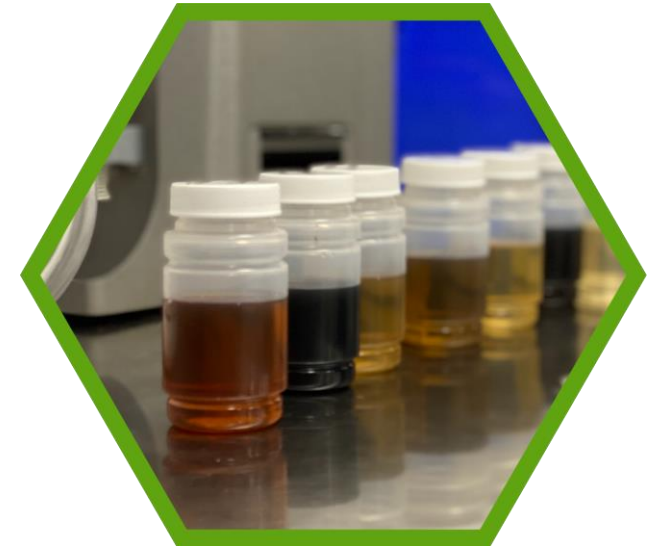


# CONSIDERATIONS FOR FLEET MANAGEMENT



# LONG-TERM OIL MANAGEMENT

- Oil Analysis Programs
  - Lubricant testing updated to follow ASTM
  - Interpret data to predict end of life
  - Compare with available maintenance windows
- Fleet assessments to rank all units
  - Maintain / return quality to target levels
    - Priority rank with focus on bottom 25% and so on
  - Compare rates of additive consumption across fleet
    - Observations





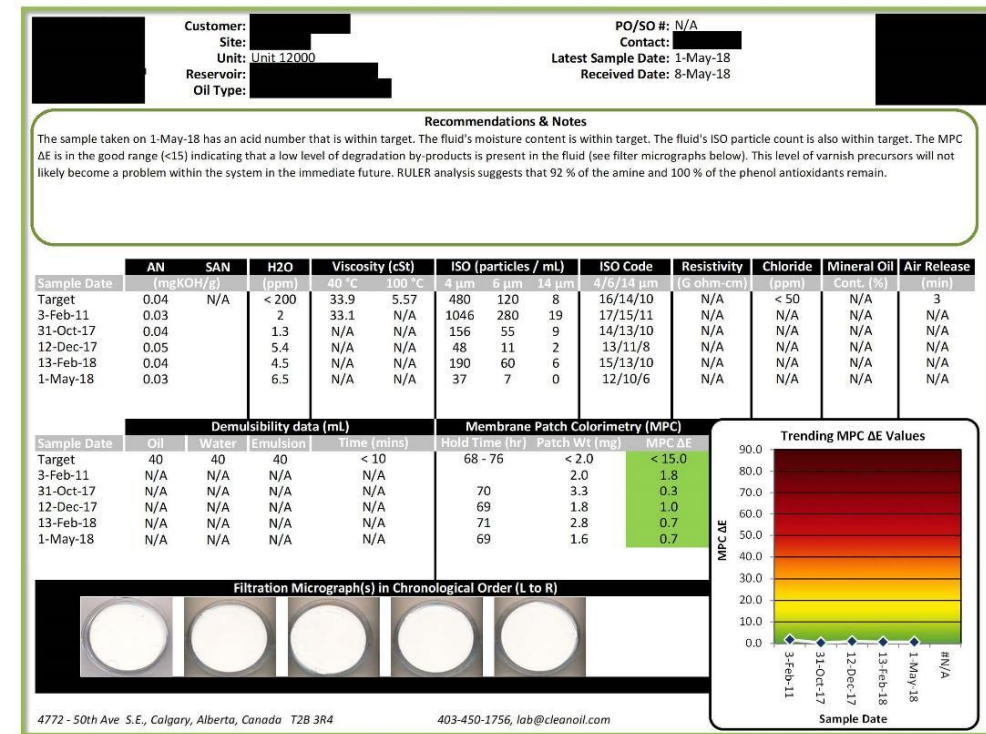
# LONG-TERM OIL MANAGEMENT

- Lubricant life cycle management
  - Expand maintenance programs to include chemistry management
  - Since fluid replacement is based on a combination of low additives and high acid number, start managing these
    - ICB fluid conditioning –Full time basis
      - Remove varnish and its precursors (acids)
    - 5% annual top-up strategy
      - Effectively maintain antioxidant levels



# CASE STUDY

- 9-year-old GT oil with ICB™ conditioning system installed from Day 1:
  - Greatest AN observed: 0.04 mg KOH/g
  - Greatest MPC observed:  $\Delta E = 1.8$





# CASE STUDY

- 9-year-old GT oil with ICB conditioning system installed from Day 1:
  - 8% antioxidant consumption over 9 years (< 1%/year)
  - With 5% annual top-up, oil life projected to > 25 years (life of turbine)

Sample Date	Sulphur	RPVOT	Rust	Density	Fluid	Cu Corr.	TOST	Foaming Tendency (After 5 min/10 min)			
	(ppm)	(min)	Inhibition	(g / mL)	Colour	(class.)	(hours)	Seq I (mL / mL)	Seq II	Seq III	Seq IV
Target	316	2700	PASS	0.86	1	1a	10000	0/0	15/0	0/0	N/A
3-Feb-11	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
31-Oct-17	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
12-Dec-17	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
13-Feb-18	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1-May-18	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

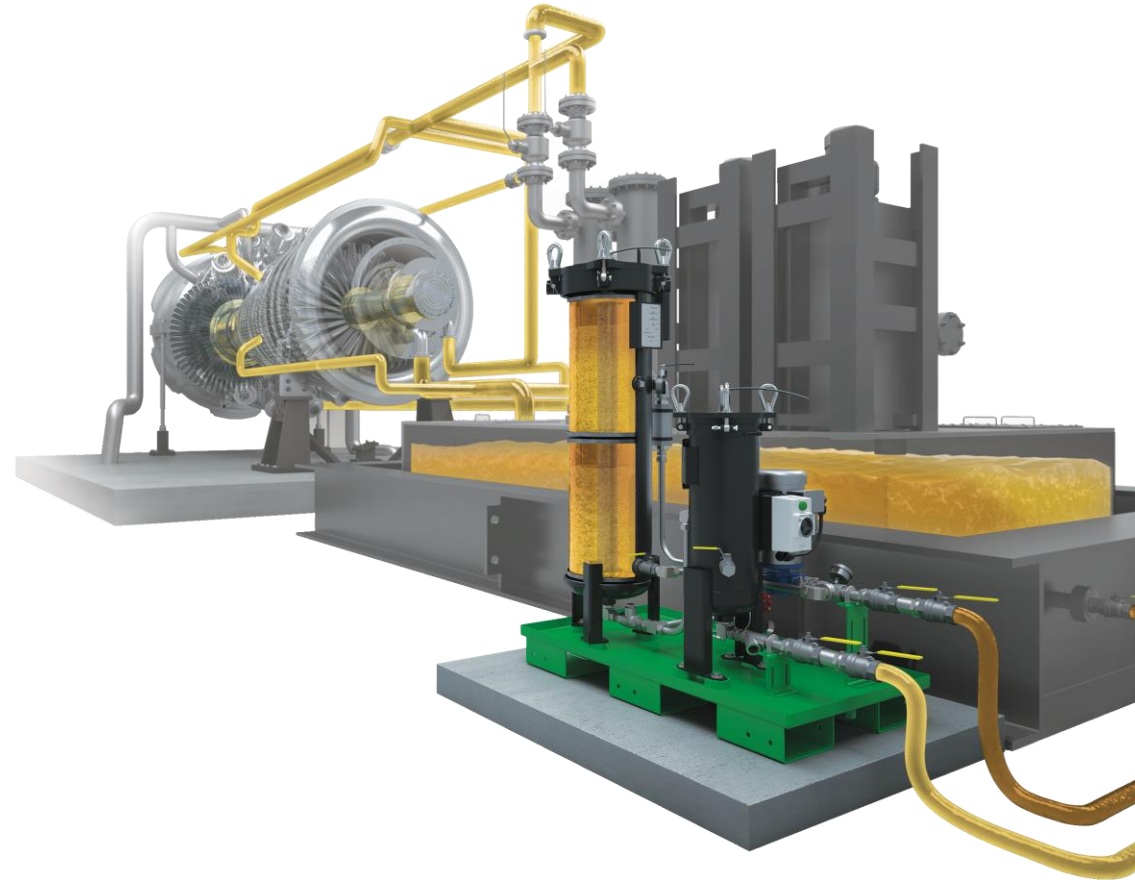
  

Sample	Dissolved Gas Analysis (ppm)										RULER (%)	
	Total*	H <sub>2</sub>	CH <sub>4</sub>	C <sub>2</sub> H <sub>6</sub>	C <sub>2</sub> H <sub>4</sub>	C <sub>2</sub> H <sub>2</sub>	CO	CO <sub>2</sub>	O <sub>2</sub>	N <sub>2</sub>	Amine	Phenol
Target	0	0	0	0	0	0	<25	< 200	N/A	N/A	100	100
3-Feb-11											81	100
31-Oct-17											84	82
12-Dec-17											94	100
13-Feb-18											92	100
1-May-18												

\*Total combustible gases, which are highlighted in red

# SUMMARY

- Treat your lubricant like an asset, not a consumable
- Understand and use tools at your disposal to manage that asset:
  - Complete oil analysis done to ASTM standards
  - Use conditioning system to manage oxidation
  - Consider 5% top up per year







# THANK YOU!

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