



# Snowy Technical Standards

**SHL-MEC-118**

***Hydraulic and lubricating oil tests and limits***

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## 1 Executive Summary

Routine oil analysis is performed to understand:

- Oil condition to ensure it is fit for service.
- Plant condition from monitoring of wear.

The purpose of this document is to provide the required tests to understand oil condition and wear and limits for these tests. The tests include:

- Assessing the oil chemistry that is important to plant integrity, such as viscosity and demulsibility.
- Assessing the remaining life of oil such as RPVOT.
- Assessing wear to understand potential plant issues, such as Tin or Antimony.
- Assessing contamination that can decrease the life of oil and life of plant, such as particle count and moisture

The limits should be used in conjunction with the [oil analysis flow charts](#). The test schedules referenced in the flowcharts are the Hydro test schedules.

## 2 Scope

This standard applies to hydraulic and lubrication oil used in Hydro plant and Gas turbines.

## 3 Applicable Standards

ASTM D4378 - 03	Standard Practice for In-Service Monitoring of Mineral Turbine Oils for Steam and Gas Turbines
ISO 4406	Hydraulic fluid power - Fluids - Method for coding the level of contamination by solid particles
ASTM Standards	Various tests as referenced in the test methods.

#### 4 Tests and Limits

Equipment	Test schedules			Limit Templates			
	2	3	4				
Hydro bearings	<a href="#">2</a>	<a href="#">3</a>	<a href="#">4</a>	<a href="#">Shell T68</a>	<a href="#">DTE HM 68</a>	<a href="#">Perfecto T46</a>	<a href="#">Perfecto T68</a>
Hydro governor, MIV & DV	<a href="#">2</a>	<a href="#">3</a>	<a href="#">4</a>	<a href="#">Shell T68</a>	<a href="#">DTE HM 68</a>		
Hydro other hydraulic gates & valves	<a href="#">2</a>	<a href="#">3</a>	<a href="#">4</a>	<a href="#">ISO 32 &amp; ISO 46</a>			
Colongra plant	<a href="#">C1</a>	<a href="#">C2</a>		<a href="#">Lubrication and Hydraulic Oil</a>			
Laverton Plant	<a href="#">L1</a>			<a href="#">Lubrication and Hydraulic Oil</a>			
Valley Plant				<a href="#">Mobil 254</a>	<a href="#">Mobil Medium</a>	<a href="#">Mobil Light</a>	

#### 5 Hydro plant tests schedules

Schedule 2	
Test	Method
Particle size distribution	ISO4406
Moisture Test ppm - Karl Fischer	ASTM D6304
PQ Index	PE981
TAN	ASTM D664
Oxidation	JOAP FT-IR
Viscosity @ 40°C	ASTM D7279
Inductive Coupled Plasma (ICP)	ASTM D5185

Schedule 3	
Test	Method
Particle size distribution	ISO4406
Moisture Test ppm - Karl Fischer	ASTM D6304
PQ Index	PE981
TAN	ASTM D664
Oxidation	JOAP FT-IR
Viscosity @ 40°C	ASTM D7279
Inductive Coupled Plasma (ICP)	ASTM D5185
Rusting Procedure A	ASTM D665
Foaming (Sequence 1, 2, 3)	ASTM D892
Demulsibility (Water Separability)	ASTM D1401
Viscosity @ 100°C	ASTM D7279
Viscosity Index (VI) Calculation only	ASTM D2270

<b>Schedule 4A &amp; 4C</b>	
<b>Test</b>	<b>Method</b>
RPVOT (4A)	ASTM D2272
Ruler (4C)	ASTM D2273

## 6 Colongra Lubrication and Hydraulic oil

<b>Schedule 1</b>	
<b>Test</b>	<b>Method</b>
Kinematic Viscosity @ 40°C	ASTM D445
KF Moisture	ASTM D1744
Cleanliness	ISO 4406
PQ Index	
Lead	ASTM D5185
Iron	ASTM D5185
Aluminium	ASTM D5185
Copper	ASTM D5185
Chromium	ASTM D5185
Tin	ASTM D5185
Silicon	ASTM D5185
Sodium	ASTM D5185
Vanadium	ASTM D5185
Magnesium	ASTM D5185
Zinc	ASTM D5185
Molybdenum	ASTM D5185
Calcium	ASTM D5185
Phosphorous	ASTM D5185
Potassium	ASTM D5185
Barium	ASTM D5185
Oxidation	ASTM E2412
Nitration	ASTM E2412

<b>Schedule 2</b>	
<b>Test</b>	<b>Method</b>
RULER Amines	ASTM D6971
RULER Phenols	ASTM D6971
MPC Varnish Potential	ASTM D7843

## 7 Laverton Lubrication and Hydraulic oil

Test	Method
KF Moisture	ASTM D6304
Viscosity @ 40°C cSt	ASTM D445
Oxidation Index	JOAP
PQ Index	ASTM D8184
TAN mg KOH/g	ASTM D974
Iron (Fe)	ASTM D5185
Chromium (Cr)	ASTM D5185
Copper (Cu)	ASTM D5185
Lead (Pb)	ASTM D5185
Tin (Sn)	ASTM D5185
Silicon (Si)	ASTM D5185
Aluminium (Al)	ASTM D5185
Sodium (Na)	ASTM D5185
Calcium (Ca)	ASTM D5185
Zinc (Zn)	ASTM D5185
Phosphorus (P)	ASTM D5185
Particle size distribution	ISO4406
RPVOT mins	ASTM D2272
Water Separability 54°C mins	D1401
Copper Corrosion	ASTM D130
Insolubles mg/100mL	ASTM D4898
Foaming Tend Seq 1	D892
Rusting Procedure A	ASTM D665

## 8 Tests Limits

**Normal** - Results are normal, no action required.

**Caution** - The results are not normal. Closer monitoring, resampling and/or corrective should be done.

**Severe** - Action/Alarm. Resampling and/or corrective work should be done as a priority.

The limits are based on recommendations from ASTM D4378, OEM specifications, Shell, Mobil, Pall Corporation & [Bently Tribology Services](#).

## 8.1 Hydro Bearings - Shell T68

Test	Normal		Caution		Severe	
	Min	Max	Min	Max	Min	Max
Aluminium	0	10	10	20	20	
Nickel	0	10	10	20	20	
Chromium	0	10	10	20	20	
Iron	0	10	10	20	20	
Copper	0	10	10	20	20	
Lead	0	10	10	20	20	
Tin	0	10	10	20	20	
Silver	0	10	10	20	20	
Titanium	0	10	10	20	20	
Silicon	0	5	5	25	25	
Sodium	0	5	5	25	25	
Potassium	0	5	5	25	25	
Molybdenum	0	5	5	25	25	
Boron	0	5	5	25	25	
Magnesium	0	5	5	25	25	
Calcium	0	5	5	25	25	
Zinc	0	5	5	25	25	
Phosphorus	0	5	5	25	25	
Barium	0	5	5	25	25	
Cadmium	0	5	5	25	25	
Vanadium	0	5	5	25	25	
Sulfur	0	5	5	25	25	
Antimony	0	5	5	25	25	
Moisture	0	100	100	200	200	
Viscosity @ 40	61 - 75		58 - 61	75 - 78	<58	>78
TAN	0	0.3	0.3	0.5	0.5	
PQ_Index	0	10	10	15	15	
Nitration	0	3	3	5	5	
Oxidation	0	5	5	10	10	
Cleanliness	0	20/16/14	20/16/14	22/18/16	22/18/16	
Viscosity Index	106	108	101	110	98	112
Viscosity @ 100	8.1	8.9	7.9	9.1	7.6	9.4
Rusting	Pass		Fail			
Foaming sequence 1	450/10		>450/>10			
Foaming sequence 2						
Foaming sequence 3						
Water Separability			<37, <37, > 3 (30)			
RPVOT		500	500	250	250	0

## 8.2 Hydro Governor, MIV, DV - Shell T68

Test	Normal		Caution		Severe	
	Min	Max	Min	Max	Min	Max
Aluminium	0	10	10	20	20	
Nickel	0	10	10	20	20	
Chromium	0	10	10	20	20	
Iron	0	10	10	20	20	
Copper	0	10	10	20	20	
Lead	0	10	10	20	20	
Tin	0	10	10	20	20	
Silver	0	10	10	20	20	
Titanium	0	10	10	20	20	
Silicon	0	5	5	25	25	
Sodium	0	5	5	25	25	
Potassium	0	5	5	25	25	
Molybdenum	0	5	5	25	25	
Boron	0	5	5	25	25	
Magnesium	0	5	5	25	25	
Calcium	0	5	5	25	25	
Zinc	0	5	5	25	25	
Phosphorus	0	5	5	25	25	
Barium	0	5	5	25	25	
Cadmium	0	5	5	25	25	
Vanadium	0	5	5	25	25	
Sulfur	0	5	5	25	25	
Antimony	0	5	5	25	25	
Moisture	0	100	100	200	200	
Viscosity @ 40	61 - 75		58 - 61	75 - 78	<58	>78
TAN	0	0.3	0.3	0.5	0.5	
PQ_Index	0	10	10	15	15	
Nitration	0	3	3	5	5	
Oxidation	0	5	5	10	10	
Cleanliness		18/14/12	18/14/12	20/16/14	20/16/14	
Viscosity Index	106	108	101	110	98	112
Viscosity @ 100	8.1	8.9	7.9	9.1	7.6	9.4
Rusting	Pass		Fail			
Foaming sequence 1	450/10		>450/>10			
Foaming sequence 2						
Foaming sequence 3						
Water Separability			<37, <37, > 3 (30)			
RPVOT		500	500	250	250	0

### 8.3 Hydro Bearings - DTE HM 68

Test	Normal		Caution		Severe	
	Min	Max	Min	Max	Min	Max
Aluminium	0	10	10	20	20	
Nickel	0	10	10	20	20	
Chromium	0	10	10	20	20	
Iron	0	10	10	20	20	
Copper	0	100	100	200	200	
Lead	0	10	10	20	20	
Tin	0	10	10	20	20	
Silver	0	10	10	20	20	
Titanium	0	10	10	20	20	
Silicon	0	5	5	25	25	
Sodium	0	5	5	25	25	
Potassium	0	5	5	25	25	
Molybdenum	0	5	5	25	25	
Boron	0	5	5	25	25	
Magnesium	0	5	5	25	25	
Calcium	0	5	5	25	25	
Zinc	0	100	100	200	200	
Phosphorus	0	150	150	250	250	
Barium	0	5	5	25	25	
Cadmium	0	5	5	25	25	
Vanadium	0	5	5	25	25	
Sulfur	0	7000	7000	9000	9000	
Antimony	0	5	5	25	25	
Moisture	0	100	100	200	200	
Viscosity @ 40	61 - 75		58 - 61	75 - 78	<58	>78
TAN	0	0.4	0.4	0.8	0.8	
PQ_Index	0	10	10	15	15	
Nitration	0	3	3	5	5	
Oxidation	0	5	5	10	10	
Cleanliness	0	20/16/14	20/16/14	22/18/16	22/18/16	
Viscosity Index	106	108	101	110	98	112
Viscosity @ 100	8.1	8.9	7.9	9.1	7.6	9.4
Rusting	Pass		Fail			
Foaming sequence 1	450/10		>450/>10			
Foaming sequence 2						
Foaming sequence 3						
Water Separability			<37, <37, > 3 (30)			
RPVOT		200	200	100	100	0

## 8.4 Hydro Governor, MIV, DV - DTE HM 68

Test	Normal		Caution		Severe	
	Min	Max	Min	Max	Min	Max
Aluminium	0	10	10	20	20	
Nickel	0	10	10	20	20	
Chromium	0	10	10	20	20	
Iron	0	10	10	20	20	
Copper	0	100	100	200	200	
Lead	0	10	10	20	20	
Tin	0	10	10	20	20	
Silver	0	10	10	20	20	
Titanium	0	10	10	20	20	
Silicon	0	5	5	25	25	
Sodium	0	5	5	25	25	
Potassium	0	5	5	25	25	
Molybdenum	0	5	5	25	25	
Boron	0	5	5	25	25	
Magnesium	0	5	5	25	25	
Calcium	0	5	5	25	25	
Zinc	0	100	100	200	200	
Phosphorus	0	150	150	250	250	
Barium	0	5	5	25	25	
Cadmium	0	5	5	25	25	
Vanadium	0	5	5	25	25	
Sulfur	0	5	5	25	25	
Antimony	0	5	5	25	25	
Moisture	0	100	100	200	200	
Viscosity @ 40	61 - 75		58 - 61	75 - 78	<58	>78
TAN	0	0.4	0.4	0.8	0.8	
PQ_Index	0	10	10	15	15	
Nitration	0	3	3	5	5	
Oxidation	0	5	5	10	10	
Cleanliness		18/14/12	18/14/12	20/16/14	20/16/14	
Viscosity Index	106	108	101	110	98	112
Viscosity @ 100	8.1	8.9	7.9	9.1	7.6	9.4
Rusting	Pass		Fail			
Foaming sequence 1	450/10		>450/>10			
Foaming sequence 2						
Foaming sequence 3						
Water Separability			<37, <37, > 3 (30)			
RPVOT		200	200	100	100	0



## 8.5 Hydro bearing - Perfecto T68

Test	Normal		Caution		Severe	
	Min	Max	Min	Max	Min	Max
Aluminium	0	10	10	20	20	
Nickel	0	10	10	20	20	
Chromium	0	10	10	20	20	
Iron	0	10	10	20	20	
Copper	0	10	10	20	20	
Lead	0	10	10	20	20	
Tin	0	10	10	20	20	
Silver	0	10	10	20	20	
Titanium	0	10	10	20	20	
Silicon	0	5	5	25	25	
Sodium	0	5	5	25	25	
Potassium	0	5	5	25	25	
Molybdenum	0	5	5	25	25	
Boron	0	5	5	25	25	
Magnesium	0	5	5	25	25	
Calcium	0	5	5	25	25	
Zinc	0	5	5	25	25	
Phosphorus	0	5	5	25	25	
Barium	0	5	5	25	25	
Cadmium	0	5	5	25	25	
Vanadium	0	5	5	25	25	
Sulfur	0	15000	15000	20000	20000	
Antimony	0	5	5	25	25	
Moisture	0	100	100	200	200	
Viscosity @ 40	61 - 75		58 - 61	75 - 78	<58	>78
TAN	0	0.3	0.3	0.5	0.5	
PQ_Index	0	10	10	15	15	
Nitration	0	3	3	5	5	
Oxidation	0	5	5	10	10	
Cleanliness	0	20/16/14	20/16/14	22/18/16	22/18/16	
Viscosity Index	106	108	101	110	98	112
Viscosity @ 100	8.1	8.9	7.9	9.1	7.6	9.4
Rusting	Pass		Fail			
Foaming sequence 1	450/10		>450/>10			
Foaming sequence 2						
Foaming sequence 3						
Water Separability			<37, <37, > 3 (30)			
RPVOT		225	225	100	100	0

## 8.6 Hydro bearing - Perfecto T46

Test	Normal		Caution		Severe	
	Min	Max	Min	Max	Min	Max
Aluminium	0	10	10	20	20	
Nickel	0	10	10	20	20	
Chromium	0	10	10	20	20	
Iron	0	10	10	20	20	
Copper	0	10	10	20	20	
Lead	0	10	10	20	20	
Tin	0	10	10	20	20	
Silver	0	10	10	20	20	
Titanium	0	10	10	20	20	
Silicon	0	5	5	25	25	
Sodium	0	5	5	25	25	
Potassium	0	5	5	25	25	
Molybdenum	0	5	5	25	25	
Boron	0	5	5	25	25	
Magnesium	0	5	5	25	25	
Calcium	0	5	5	25	25	
Zinc	0	5	5	25	25	
Phosphorus	0	5	5	25	25	
Barium	0	5	5	25	25	
Cadmium	0	5	5	25	25	
Vanadium	0	5	5	25	25	
Sulfur	0	15000	15000	20000	20000	
Antimony	0	5	5	25	25	
Moisture	0	100	100	200	200	
Viscosity @ 40	41 - 51		39 - 41	51 - 53	<39	>53
TAN	0	0.3	0.3	0.5	0.5	
PQ_Index	0	10	10	15	15	
Nitration	0	3	3	5	5	10
Oxidation	0	5	5	10	10	18
Cleanliness	0	20/16/14	20/16/14	22/18/16	22/18/16	
Viscosity Index						
Viscosity @ 100						
Rusting	Pass		Fail			
Foaming sequence 1	450/10		>450/>10			
Foaming sequence 2						
Foaming sequence 3						
Water Separability			<37, <37, > 3 (30)			
RPVOT		225	225	100	100	0

## 8.7 Hydro other hydraulic gates and valves - ISO 32 & 46

Test	Normal		Caution		Severe	
	Min	Max	Min	Max	Min	Max
Aluminium	0	10	10	20	20	
Nickel	0	10	10	20	20	
Chromium	0	10	10	20	20	
Iron	0	10	10	20	20	
Copper	0	10	10	20	20	
Lead	0	10	10	20	20	
Tin	0	10	10	20	20	
Silver	0	10	10	20	20	
Titanium	0	10	10	20	20	
Silicon	0	5	5	25	25	
Sodium	0	5	5	25	25	
Potassium	0	5	5	25	25	
Molybdenum	0	5	5	25	25	
Boron	0	5	5	25	25	
Magnesium	0	5	5	25	25	
Calcium	0	5	5	25	25	
Barium	0	5	5	25	25	
Cadmium	0	5	5	25	25	
Vanadium	0	5	5	25	25	
Antimony	0	5	5	25	25	
Moisture	0	100	100	300	300	
ISO 46 - Viscosity @ 40	41 - 51		39 - 41	51 - 53	<39	>53
ISO 32 - Viscosity @ 40	29 - 35		27 - 29	35 - 37	<27	>37
TAN	0	0.4	0.4	0.8	0.8	
PQ_Index	0	10	10	15	15	
Nitration	0	3	3	5	5	
Oxidation	0	5	5	10	10	
Cleanliness		22/20/17	22/20/17	23/21/18	23/21/18	
Viscosity Index						
Viscosity @ 100						
Rusting	Pass		Fail			
Foaming sequence 1	450/10		>450/>10			
Foaming sequence 2						
Foaming sequence 3						
Water Separability			<37, <37, > 3 (30)			
RPVOT		200	200	100	100	0

## 8.8 Laverton lubrication and hydraulic oil

Test	Normal		Caution		Severe	
	Min	Max	Min	Max	Min	Max
KF Moisture	0	100	100	200	200	
Viscosity @ 40°C cSt	43-48		41-43	48-50	<41	>50
Oxidation Index	0	8	8	18	18	
PQ Index	0	30	30	50	50	
TAN mg KOH/g	0	0.3	0.3	0.5	0.5	
Iron (Fe)	0	3	3	5	5	
Chromium (Cr)	0	3	3	5	5	
Copper (Cu)	0	3	3	5	5	
Lead (Pb)	0	3	3	5	5	
Tin (Sn)	0	3	3	5	5	
Silicon (Si)	0	3	3	5	5	
Aluminium (Al)	0	3	3	5	5	
Sodium (Na)	0	5	5	10	10	
Calcium (Ca)	0	5	5	10	10	
Zinc (Zn)	0	3	3	5	5	
Phosphorus (P)	0	5	5	10	10	
Particle size distribution	Less than 18/16/13		18/16/13	19/17/14	19/17/14	
RPVOT mins		600	600	300	300	0
Water Separability 54°C mins			<37, <37, > 3 (30)			
Copper Corrosion	1a		1b			
Insolubles mg/100mL						
Foaming Tend Seq 1	50/0					
Foaming Tend Seq 2						
Foaming Tend Seq 3						
Rusting Procedure A	Pass		Fail			

## 8.9 Colongra lubrication and hydraulic oil

Test	Normal		Caution		Severe	
	Min	Max	Min	Max	Min	Max
KF Moisture	0	100	100	200	200	
Viscosity @ 40°C cSt	43-48		41-43	48-50	<41	>50
Oxidation Index	0	8	8	10	10	
PQ Index	0	30	30	50	50	
Iron (Fe)	0	3	3	5	5	
Chromium (Cr)	0	4	4	9	9	
Copper (Cu)	0	9	9	18	18	
Lead (Pb)	0	3	3	6	6	
Tin (Sn)	0	3	3	6	6	
Silicon (Si)	0	3	3	5	5	
Aluminium (Al)	0	3	3	6	6	
Sodium (Na)	0	3	3	6	6	
Vanadium (V)						
Magnesium (Mg)	0	1	1			
Zinc (Zn)	0	5	5			
Phosphorus (P)	0	5	5			
Molybdenum (Mo)	0	1	1			
Calcium (Ca)	0	5	5			
Potassium (Pa)	0	1	1			
Barium (Ba)	0	1	1			
Particle size distribution	Less than 18/16/13		18/16/13	19/17/14	19/17/14	
Nitration		8	8	10	10	
RULER Amines	100%	65%	65	50	50	
RULER Phenols	0%					
MPC Varnish Potential	0	30	30	40	40	

## 8.10 Valley - Mobil 254

Test	Normal		Caution		Severe	
	Min	Max	Min	Max	Min	Max
Aluminium	0	3	4	6	7	
Nickel						
Chromium	0	6	7	9	10	
Iron	0	8	9	13	14	
Copper	0	12	13	19	20	
Lead	0	2	3	4	5	
Tin	0	20	21	25	26	
Silver						
Titanium						
Silicon	0	20	21	25	26	
Sodium	0	25	26	50	51	
Potassium						
Molybdenum						
Boron						
Magnesium						
Calcium						
Zinc						
Phosphorus						
Barium						
Cadmium						
Vanadium						
Sulfur						
Antimony						
Moisture	0	500	500	1000	1000	
Viscosity @ 40						
TAN	0	1.8	1.8	2.3	2.3	
PQ_Index	0	40	41	70	71	
Nitration						
Oxidation				255	255	
Cleanliness	Less than 20/17/15		20/17/15	21/18/16	21/18/16	
Viscosity Index						
Viscosity @ 100						
Rusting	Pass		Fail			
Foaming sequence 1						
Foaming sequence 2						
Foaming sequence 3						
Water Separability			<37, <37, > 3 (30)			
RPVOT						

### 8.11 Valley - Mobil Medium

Test	Normal		Caution		Severe	
	Min	Max	Min	Max	Min	Max
Aluminium	0	3	4	6	7	
Nickel						
Chromium	0	6	7	9	10	
Iron	0	8	9	13	14	
Copper	0	12	13	19	20	
Lead	0	2	3	4	5	
Tin	0	20	21	25	26	
Silver						
Titanium						
Silicon	0	20	21	25	26	
Sodium	0	25	26	50	51	
Potassium						
Molybdenum						
Boron						
Magnesium						
Calcium						
Zinc						
Phosphorus						
Barium						
Cadmium						
Vanadium						
Sulfur						
Antimony						
Moisture	0	100	100	200	200	
Viscosity @ 40	41 - 51		39 - 41	51 - 53	<39	>53
TAN	0	0.5	0.5	0.7	0.7	
PQ_Index	0	40	41	70	71	
Nitration						
Oxidation	0	5	5	10	10	
Cleanliness	Less than 20/17/15		20/17/15	21/18/16	21/18/16	
Viscosity Index						
Viscosity @ 100						
Rusting	Pass		Fail			
Foaming sequence 1						
Foaming sequence 2						
Foaming sequence 3						
Water Separability			<37, <37, > 3 (30)			
RPVOT		200	200	100	100	0

## 8.12 Valley - Mobil Light

Test	Normal		Caution		Severe	
	Min	Max	Min	Max	Min	Max
Aluminium	0	3	4	6	7	
Nickel						
Chromium	0	6	7	9	10	
Iron	0	8	9	13	14	
Copper	0	12	13	19	20	
Lead	0	2	3	4	5	
Tin	0	20	21	25	26	
Silver						
Titanium						
Silicon	0	20	21	25	26	
Sodium	0	25	26	50	51	
Potassium						
Molybdenum						
Boron						
Magnesium						
Calcium						
Zinc						
Phosphorus						
Barium						
Cadmium						
Vanadium						
Sulfur						
Antimony						
Moisture	0	100	100	200	200	
Viscosity @ 40	29 - 35		27 - 29	35 - 37	<27	>37
TAN	0	0.3	0.3	0.5	5	
PQ_Index						
Nitration						
Oxidation	0	5	5	10	10	
Cleanliness	Less than 20/17/15		20/17/15	21/18/16	21/18/16	
Viscosity Index						
Viscosity @ 100						
Rusting	Pass		Fail			
Foaming sequence 1						
Foaming sequence 2						
Foaming sequence 3						
Water Separability			<37, <37, > 3 (30)			
RPVOT		200	200	100	100	0



## 9 Notes

Oil type or compartment	Note

## 10 References

[Oil analysis flow charts](#)