High Performance new mineral and PAG hybrid turbine oil

Kumar , *Junya Iwasaki, - Idemitsu Lubricants America Corporation*

Hiroki Sekiguchi, Shirakura Yuuhei, *- Idemitsu Kosan Co., Ltd.*

Content

IDEMITSU

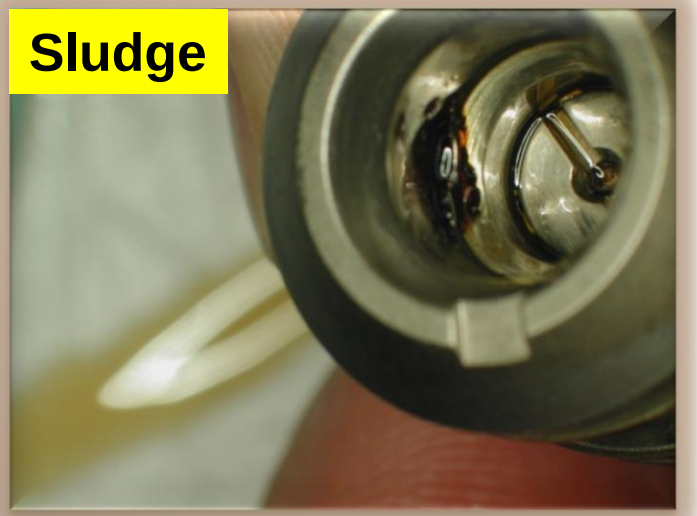
Background

➢ Requirements of modern turbine oils

In order to improve thermal efficiency,

current gas turbines must…

- ❑ Operate at higher temperatures
- ❑ Provide longer service life
- ❑ Ensure extended drain interval and superior performance, *i.e.*, minimizing varnish/sludge formation



IDEMITSU

Background

High Temperature and Long life Mineral Turbine Oil having EP Characteristics

- ❑ Long lifetime over 5 years
- ❑ Good water separability
- ❑ Reduced-sludge and varnish formation by optimizing AO and EP additives

New PAG turbine oil that enable easy management and exchange from mineral oil

- ❑ Good compatibility with Mineral Turbine Oil
- ❑ Low sludge and varnish formation
- ❑ Excellent solubility of sludge and varnish
- ❑ Good EP Characteristics

Expected Benefits of using hybrid oil

Benefits compared with mineral oil

1. Low sludge and varnish formation
2. Can solve precipitated sludge and varnish
3. Longer life and extended drain interval
4. Superior extreme pressure and anti-wear performance

Benefits compared with PAG oil

1. Lower cost and almost similar performance
2. Better water separation properties

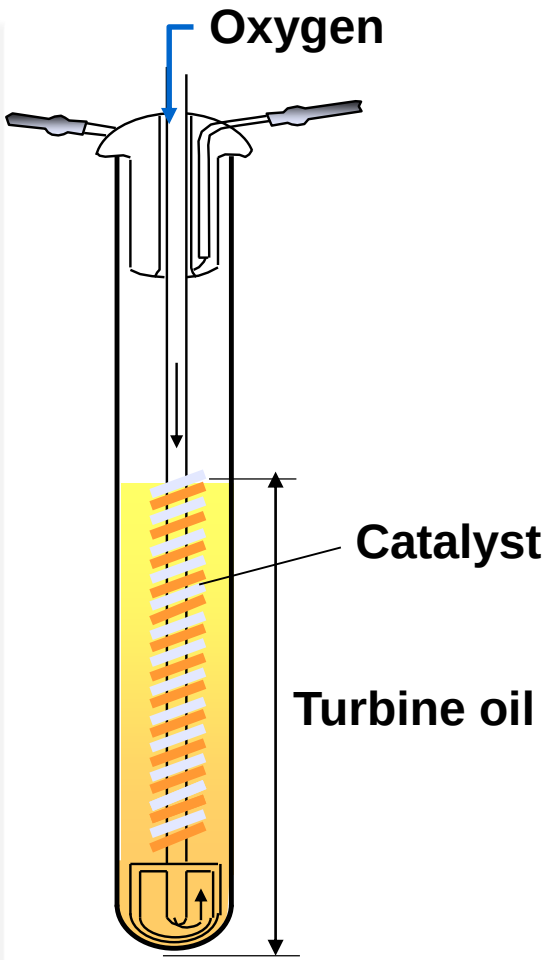
We evaluated hybrid oils in which Mineral Oil was blended with PAG Turbine Oil.
※Selected PAG Turbine Oil has compatibility with mineral Oil.

IDEMITSU

Developing Oils

		Mineral oil	Developing oil A	Developing oil B	PG25
Mineral Turbine oil	wt%	100	90	50	0
PAG Turbine oil	wt%	0	10	50	100
KV40C	mm2/s	31.36	28.09	25.34	23.86
KV100C	mm2/s	5.681	5.106	5.283	4.991
VI	-	123	112	128	140
D	g/cm3	0.8482	0.8581	0.9092	0.9905
Acid number	mgKOH/g	0.10	0.16	0.23	0.35

Test Method 1 (Dry-TOST, ASTM D7873)



Test conditions

Temperature: 120 ℃

Turbine oil: 360 ml, no water

Catalyst: Cu-Fe coil

Oxygen: 3 L/hr

Evaluation Items

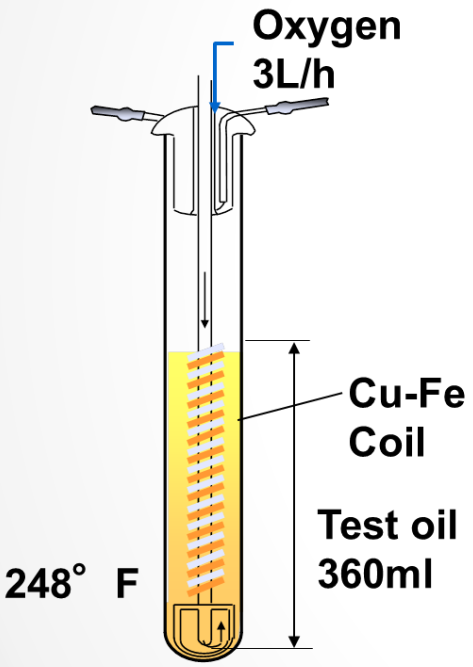
✓Millipore value(Sludge/Varnish) (mg/Kg)

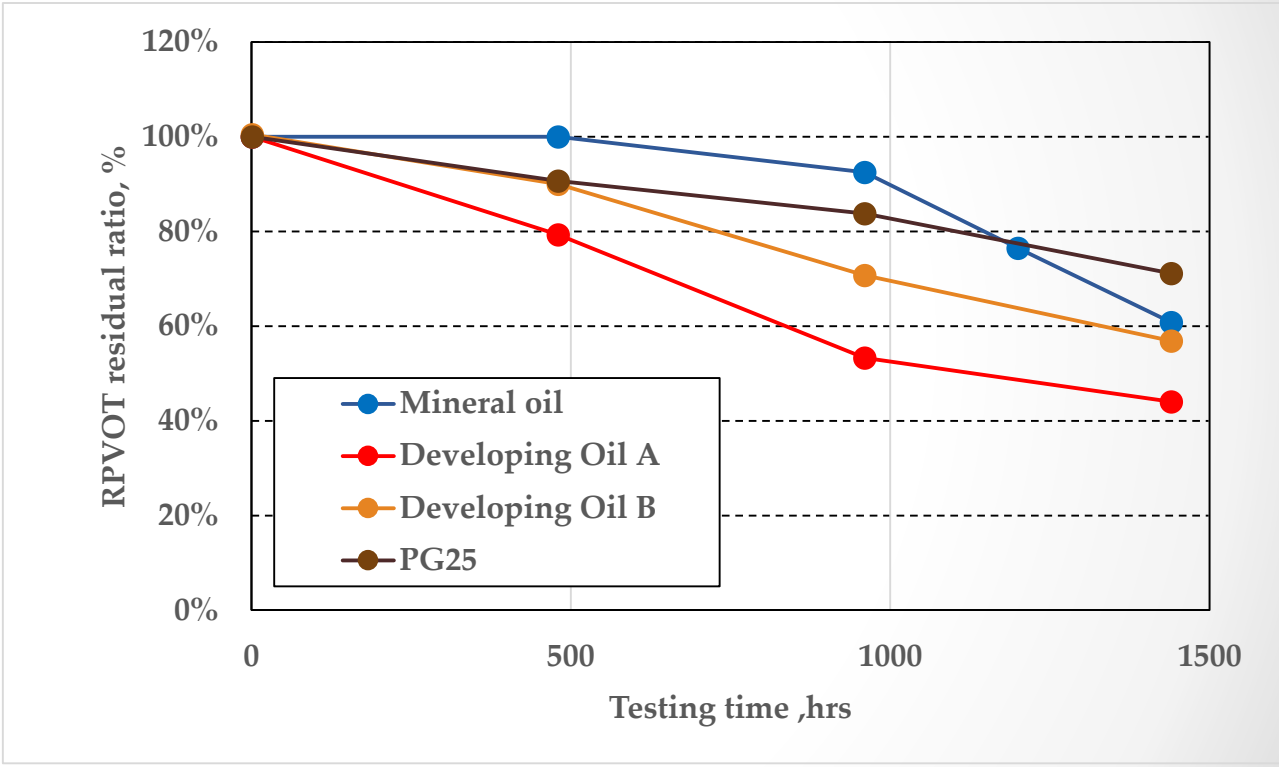
✓ RPVOT remaining ratio (%)

IDEMITSU

Dry-TOST (ASTM D7873)

Test Subject:
RPVOT remaining ratio(%)
Millipore (mg/100ml)





Developing Oil A and B indicates comparable life to Mineral Oil

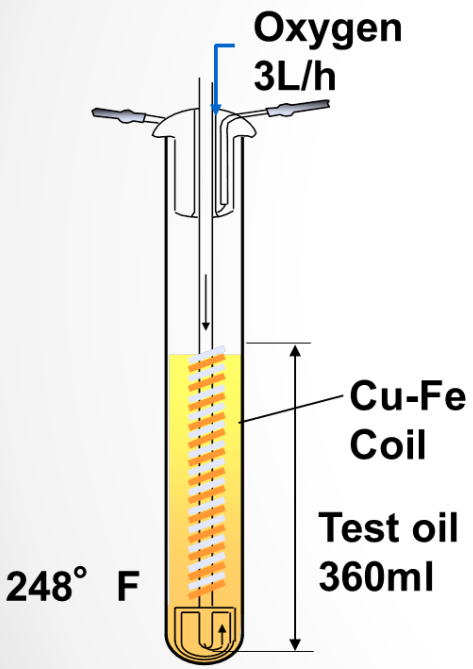
IDEMITSU

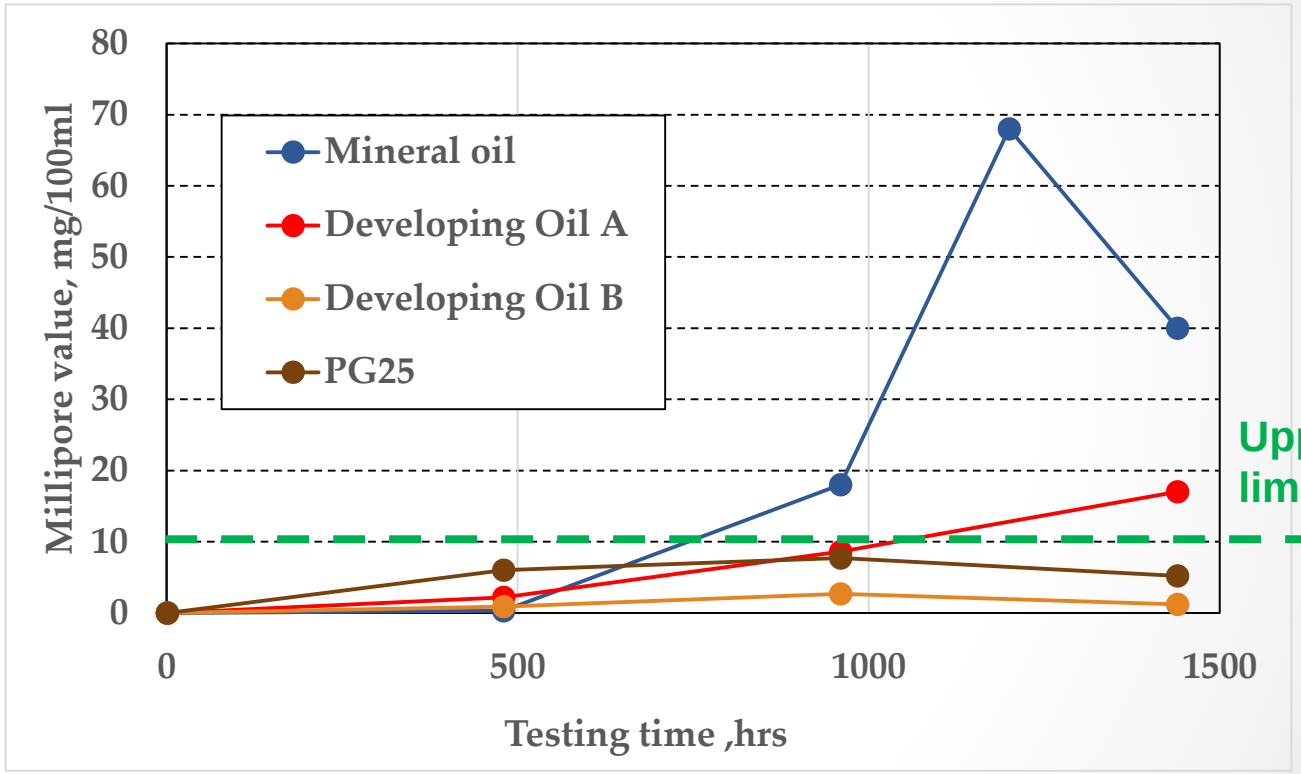
Dry-TOST (ASTM D7873)

Test Subject:

RPVOT remaining ratio(%)

Millipore (mg/100ml)

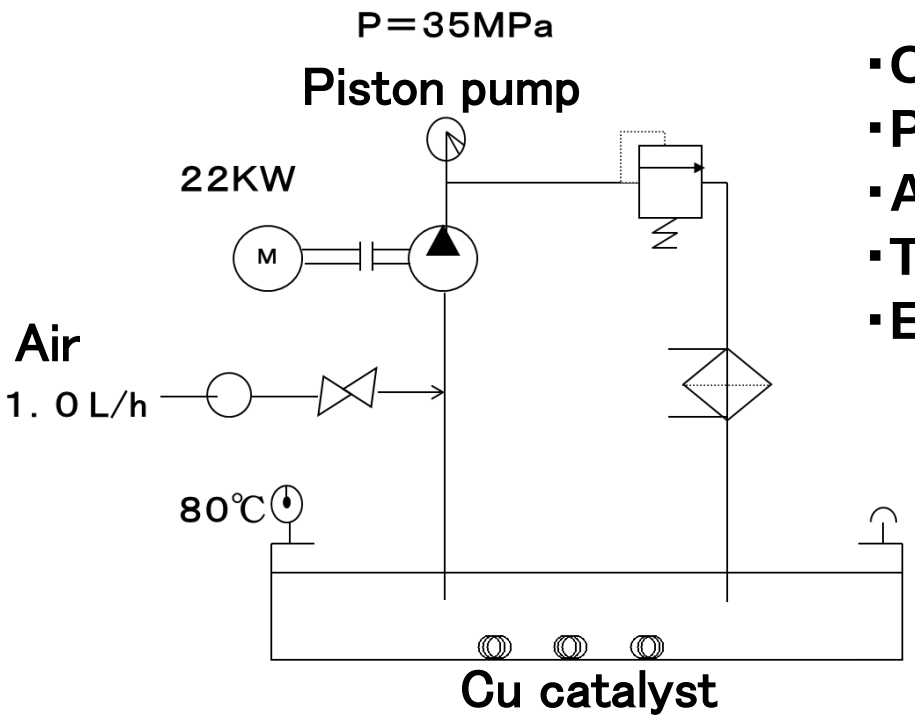




Developing Oil B indicates low sludge and varnish

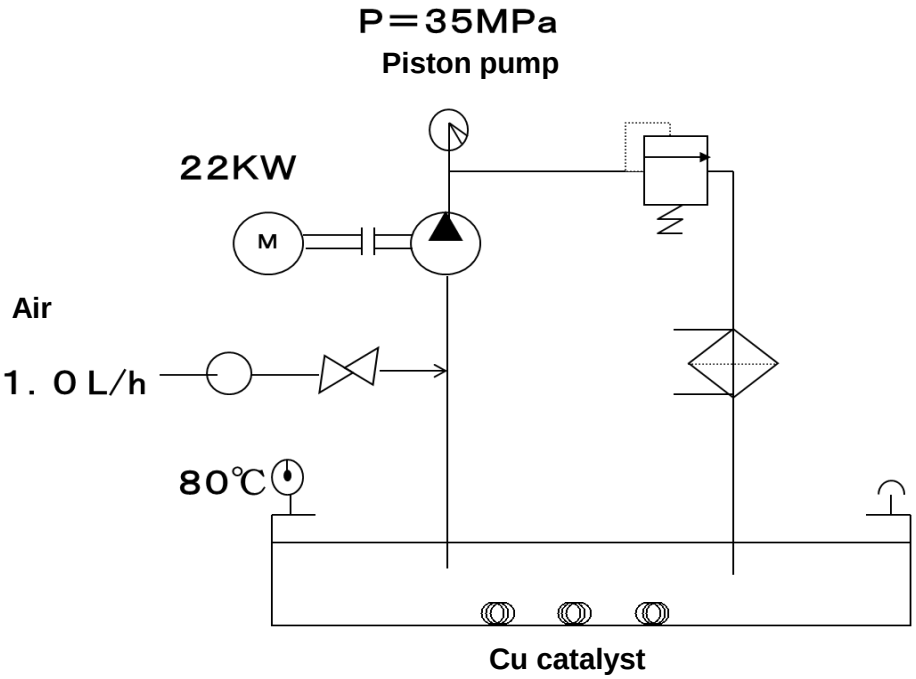
IDEMITSU

A2F pump test JCMAS P045



- Oil temperature 80℃
- Pump pressure 35MPa
- Air 1.0L/h
- Test time 1000h
- Evaluate: Residual ratio of RPVOT, and Millipore after the time

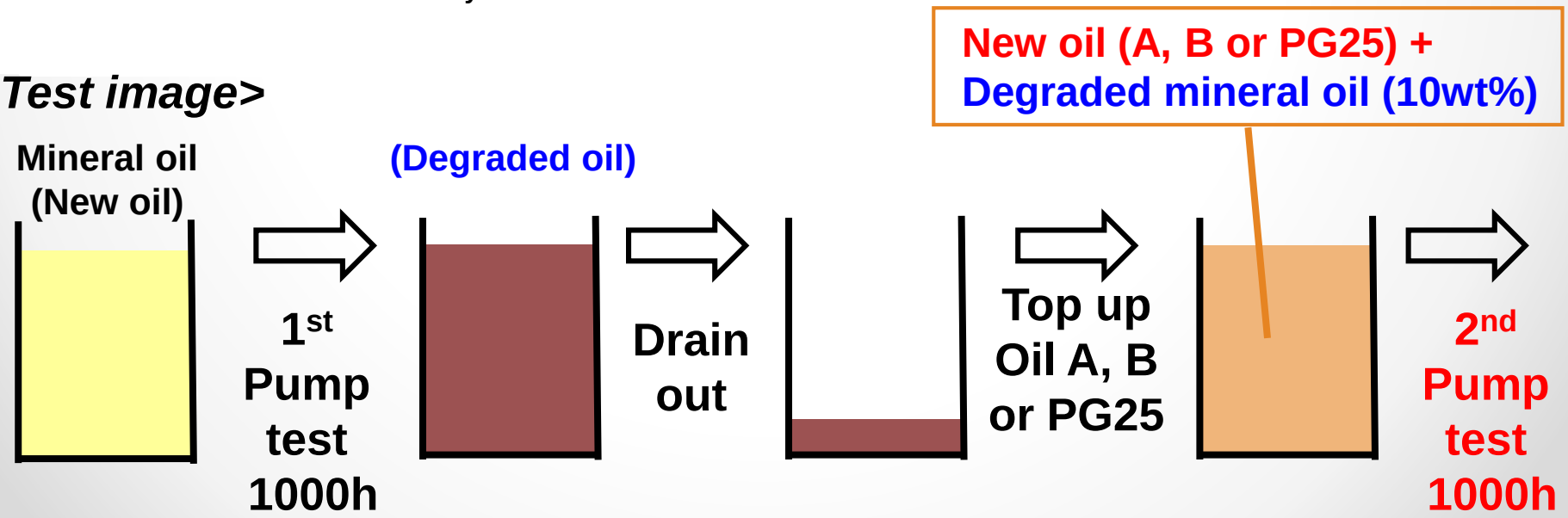
A2F pump test JCMAS P045



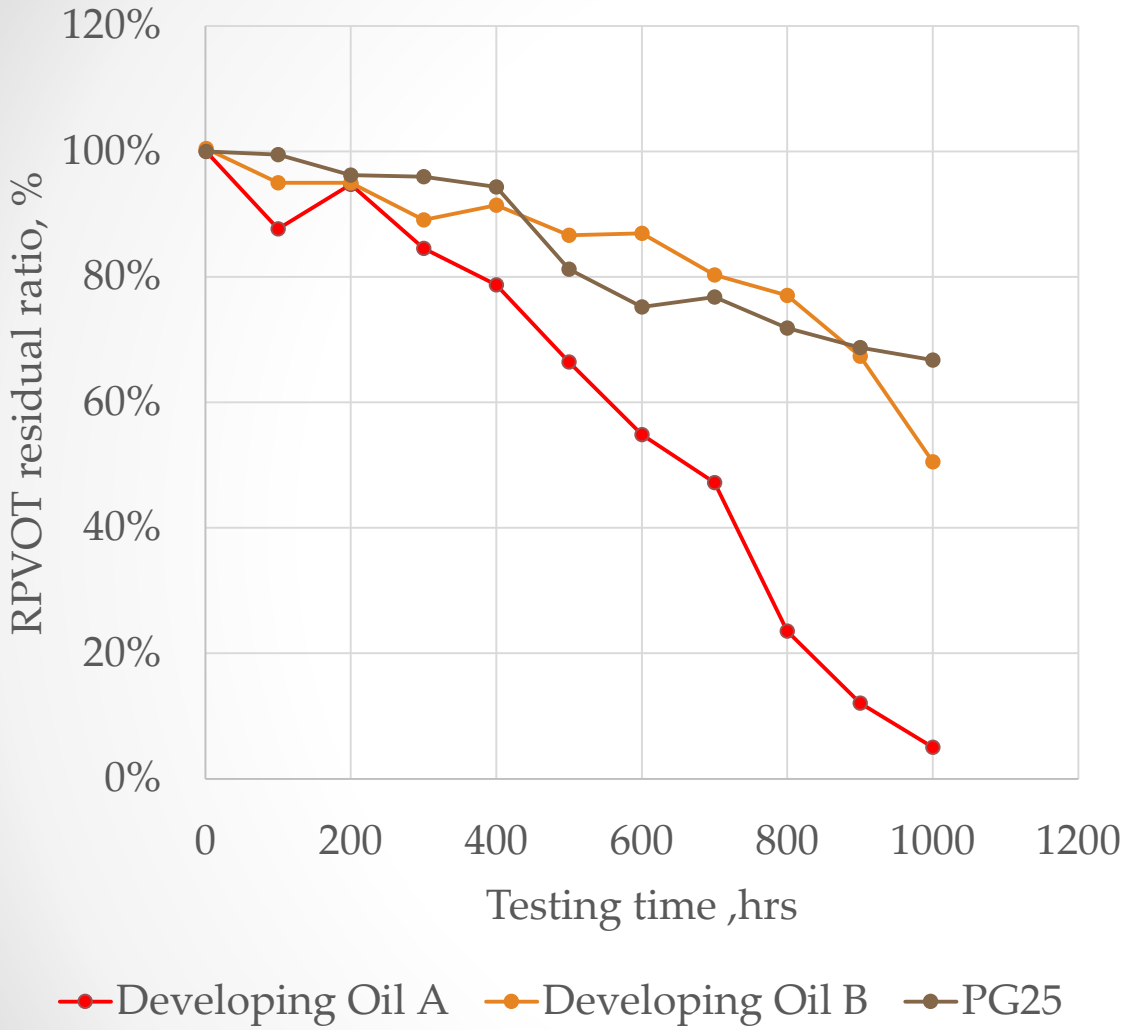
Test Condition

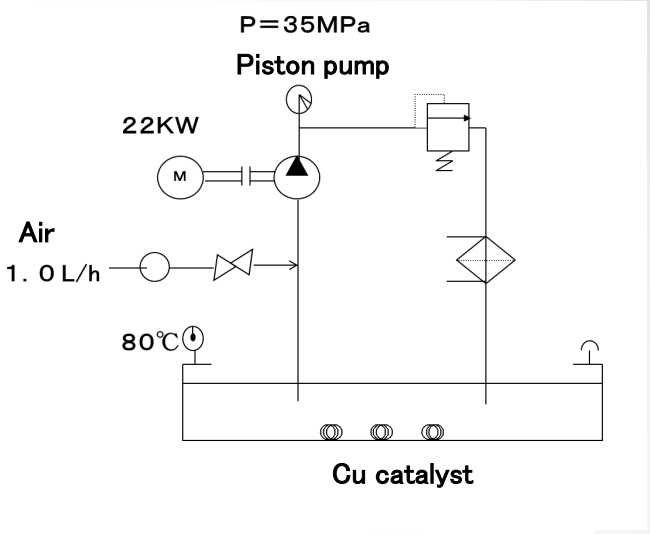
- Oil temperature 80℃
- Pump pressure 35MPa
- Air 1.0L/h
- Test time 1000h
- Evaluate: Residual ratio of RPVOT, and Millipore after the time

<Test image>



A2F Pump test (JCMAS P045)





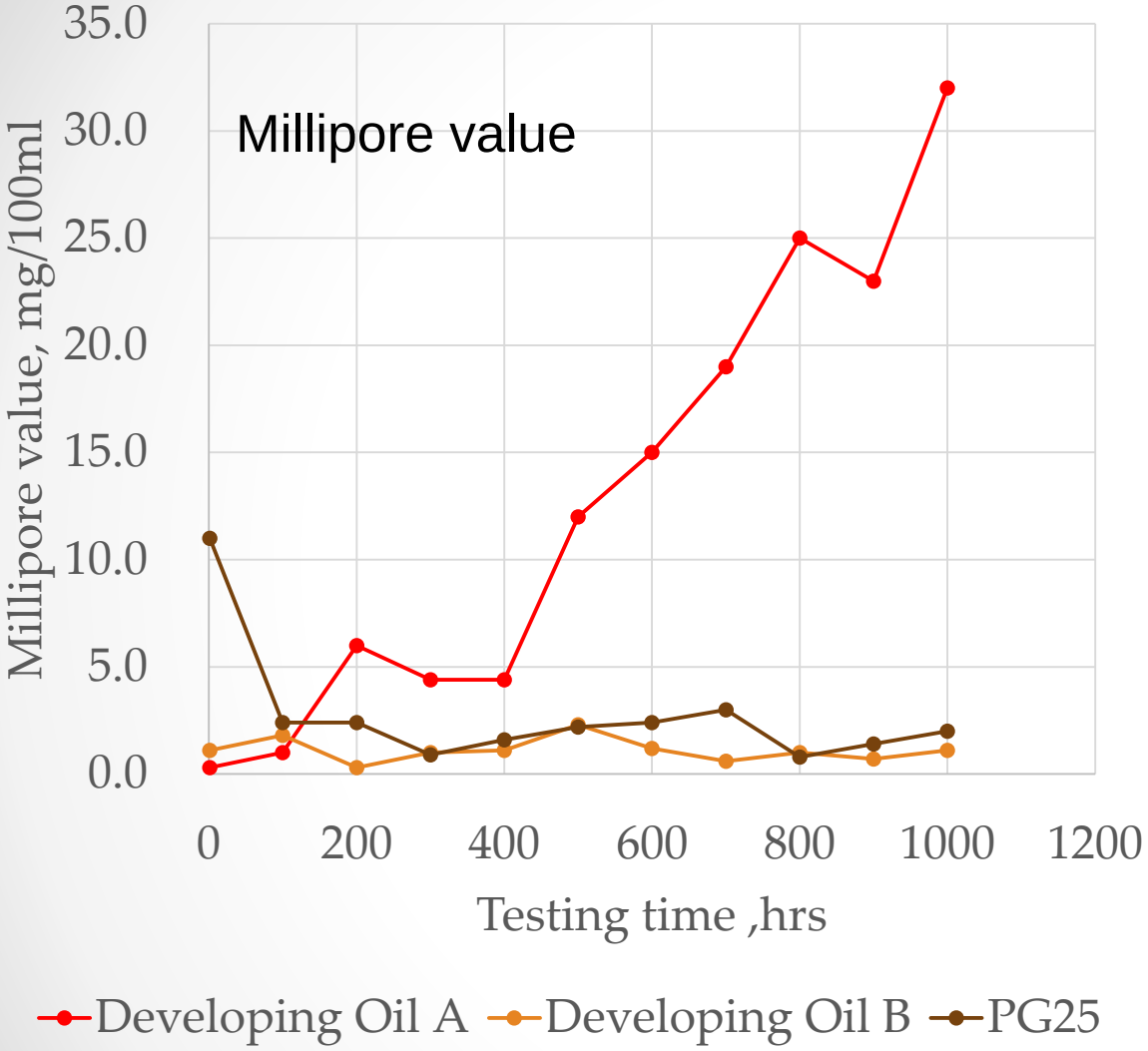
- Oil temperature 80℃
- Pump pressure 35MPa
- Air 1.0L/h
- Test time 1000h
- Evaluate:
  RPVOT residual ratio, TAN and Millipore after the time

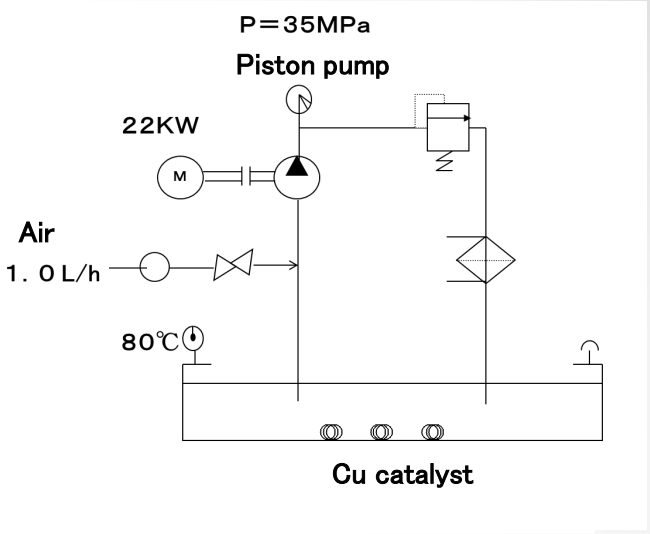
Fig. RPVOT residual ratio

Developing Oil B and PG25 has long life.

IDEMITSU

A2F Pump test (JCMAS P045)





- **Oil temperature 80℃**
- **Pump pressure 35MPa**
- **Air 1.0L/h**
- **Test time 1000h**
- **Evaluate:**
  RPVOT residual retio, TAN and Millipore after the time

Developing Oil B and PG25 has little sludge and varnish.

IDEMITSU

A2F Pump test (Color change)

Appearance after 2nd A2F pump test

	1h	100h	200h	300h	400h	500h	600h	700h	800h	900h	1000h
Developing oil A											
Developing oil B											
PG25											

Color change of developing oil A is milder than PAG turbine oil. The change in color of developing oil B and PG25 is due to solved sludge and varnish.

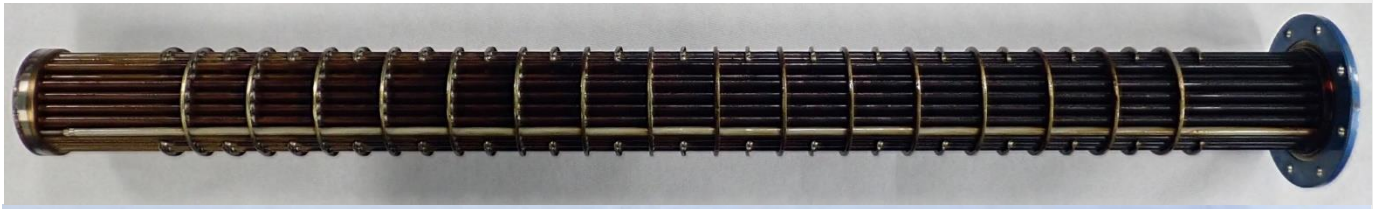
A2F Pump test (Color change)

Appearance of Oil Cooler after 1st A2F pump test (Before 2nd A2F pump test)

Mineral turbine Oil

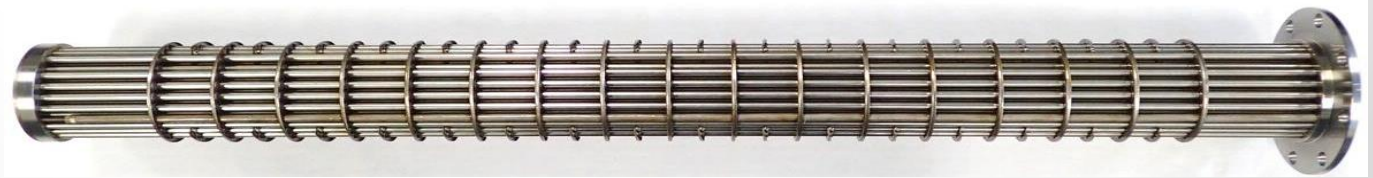
Appearance of Oil Cooler after 2nd A2F pump test

Developing turbine oil A



Developing turbine oil B

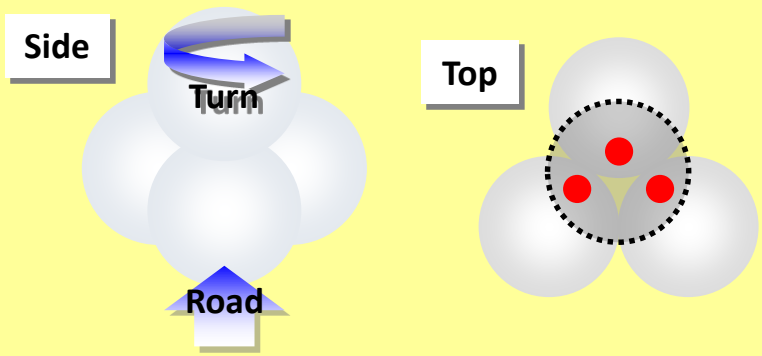
PAG turbine oil



Developing oil B and PG25 can wash sludge and varnish

Extreme pressure, load carrying capacity

Four ball weld test (ASTM D2783)



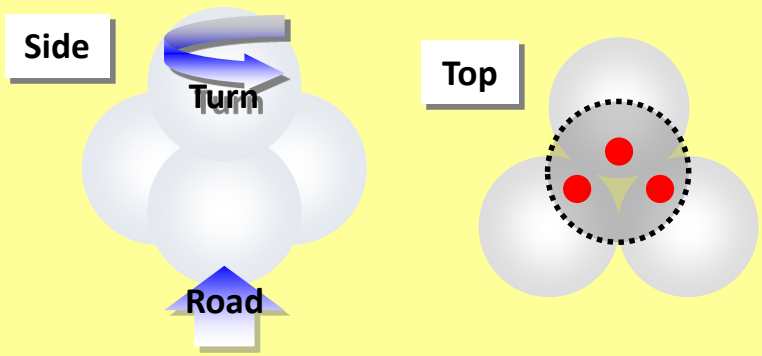
- ✓ Contact: 3points
- ✓ Operation type: Sliding
- ✓ Test ball: SUJ2
- ✓ Rotation: 1,800rpm
- ✓ Test time: 10 seconds
- ✓ Filling: room temperature

	Mineral turbine oil	Developing oil A	Developing oil B	PG25
LNL,N	392	392	392	314
WL,N	1236	1569	1236	1569
LWI,N	173	176	172	169

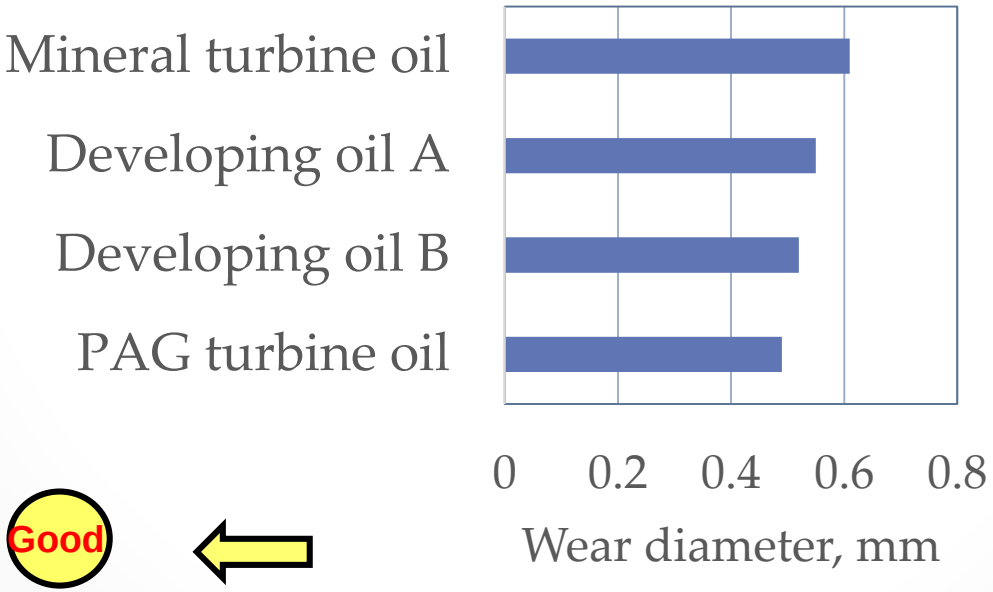
Developing oil B has strong EP performance

Anti-wear properties

Four ball wear test (ASTM D4172)



✓ Contact	3points
✓ Operation type	Sliding
✓ Test ball	SUJ2
✓ Rotation	1,200rpm
✓ Test time	60min
✓ Temperature	75℃
✓ Load	294N

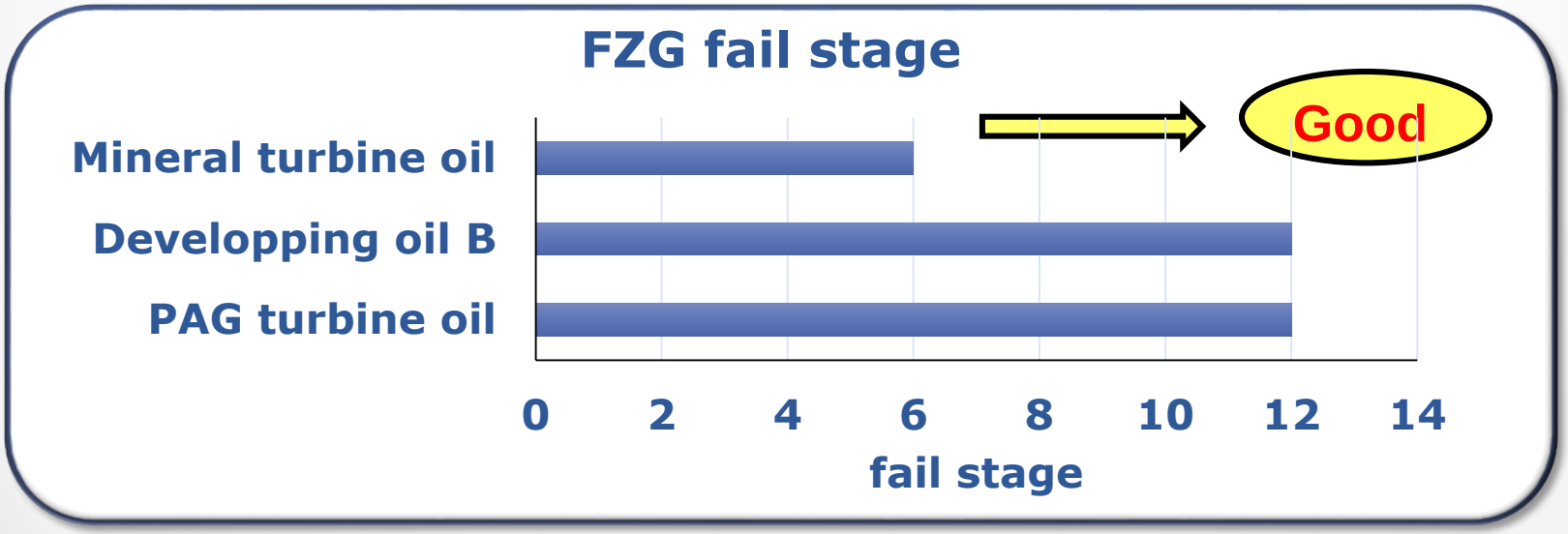


Developing oil B has good anti-wear properties like PAG turbine oil

Extreme pressure and anti-wear performance

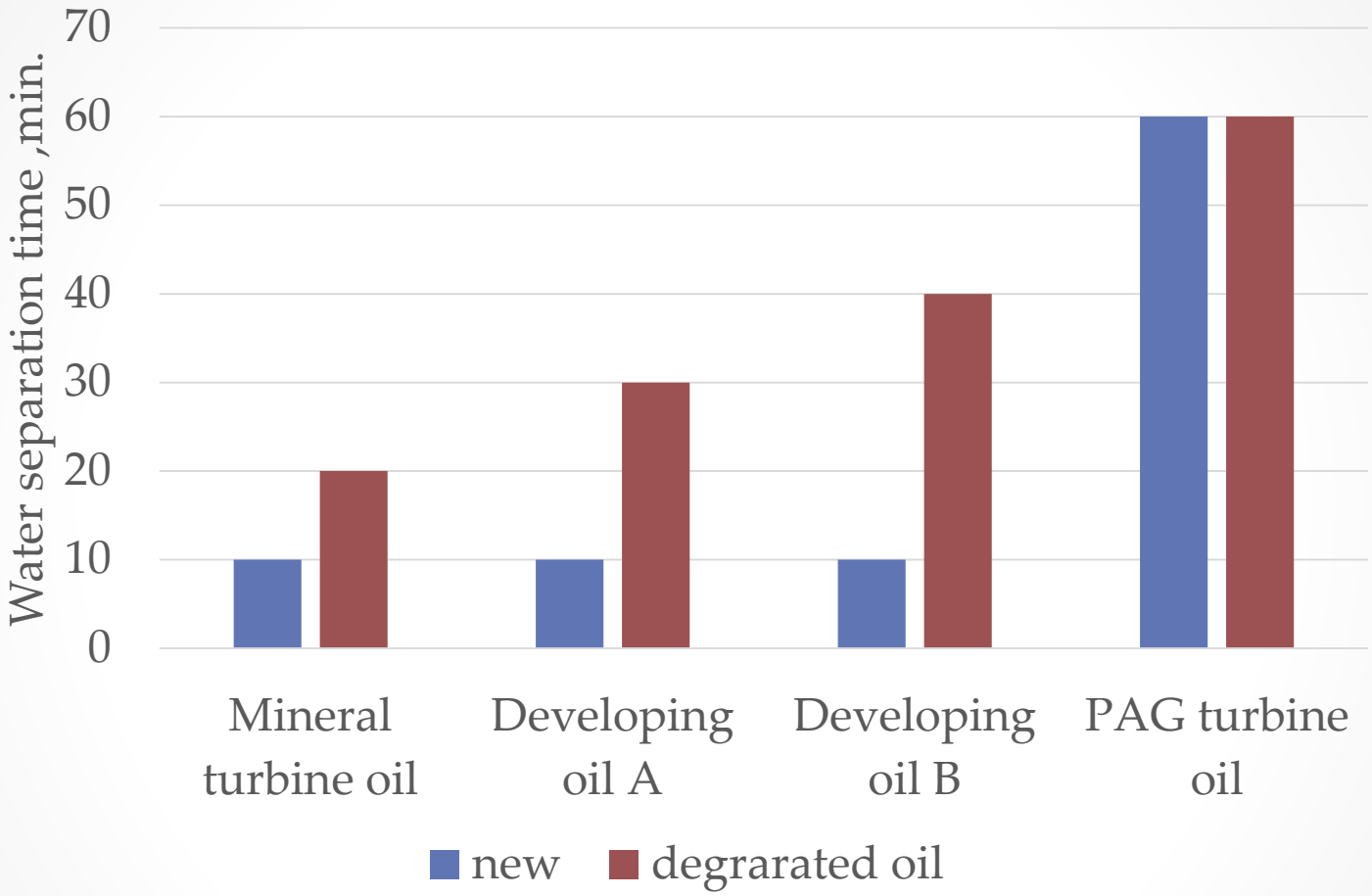
FZG Gear test (DIN 51354)

- ✓Load — Load stage 1～12 stage
- ✓Test time — 15min/load stage
- ✓Oil supply — Oil bath (90℃ start)
- ✓Evaluate — fail stages



Developing oil B has good anti-wear properties like PAG turbine oil

Water separabillity (ASTM D1401)



Developing oil B have good water separability like Mineral turbine oil

Conclusion

Benefits of developing oil B

1. Wash out precipitated sludge and varnish
2. Long life and good EP performance
3. Good water separation properties
4. Excellent cost performance

By mixing 50% of mineral turbine oil with 50% of PAG turbine oil, the same benefits as developing oil B can be expected.

IDEMITSU

IDEMITSU

Thank you