Lubrication…
how's that working for you?

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Overview

- Reliability – what does that mean for the system and the lubricant?
- Lubricants – how are they impacted and how can they help?
- Standards - how effective are they with respect to the lubricant?

Reliability

In general, **reliability** (systemic def.) is the ability of a system to perform and maintain its functions in routine circumstances, as well as hostile or unexpected circumstances.

Having some level of confidence that the components will operate efficiently and trouble free for the expected life of the gearbox

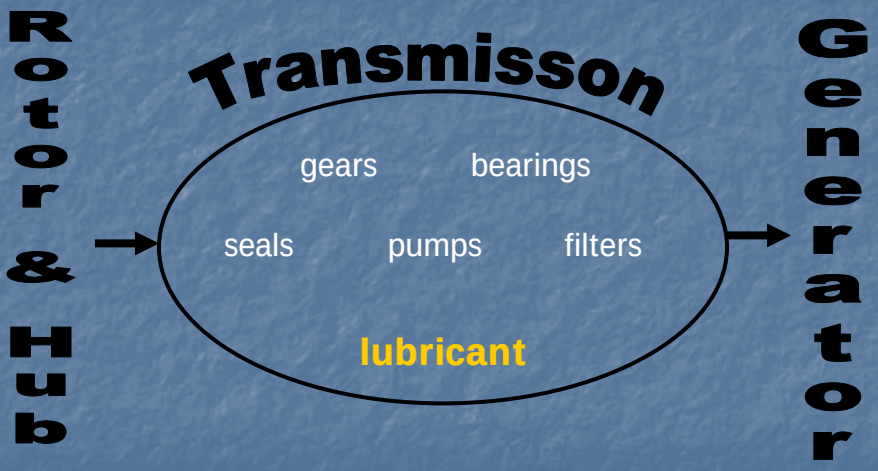
- Production is the end goal and is in part a function of reliability
- Reliability of the system is only as good as the weakest point
- Thus, reliability comes down to choices

Reliability and Choices

Depends on many factors

- Some we can control...
  - Choice of location
  - Choice of components
  - Maintenance schedule and monitoring

Some factors we can control through choice



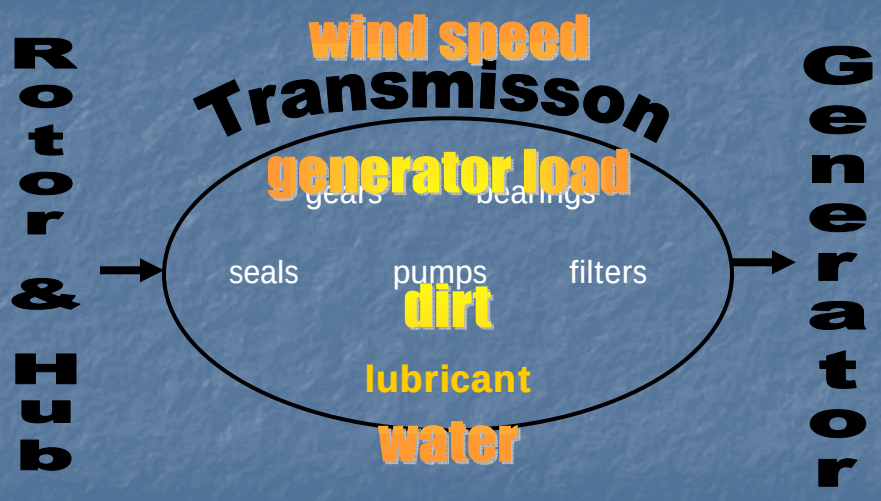
Lubricant choices

- Viscosity level
- Base oil type
- Additive type
- Supplements

Consequences of our choices

	High viscosity	Low viscosity	Mineral base oil	Synthetic base oil
Film thickness	+	-	+	-
Wear	+	-	+	-
Filterability	-	+	0	0
Low temp startup	-	+	-	+
Efficiency	-	+	-	+

Some factors we cannot control



Operational factors – impact on the lubricant

- Speed → produces shearing in the contact zone
  - Generates heat – lowers viscosity & increases oxidation rate
  - Shear could alter viscosity (polymer containing oils)
- Torque/Load → increases contact stress
  - Generates heat – lowers viscosity & increases oxidation rate
  - Higher stress leads to reduced fatigue life for gears and bearings

Operational factors – impact on the lubricant

External contaminants

- Water
  - Increases potential for corrosion
  - Reduces fatigue life of components
- Particulate
  - Increases rate of wear (abrasive)
  - Reduces fatigue life of components, especially bearings

How do we choose an appropriate lubricant?

- Define the application requirements
  - Define the fluid life expectancy
    - Give consideration for "unexpected circumstances"

Helping us get there

- Standards
  - AGMA 6006-A03 (wind turbine standard)
  - AGMA 9005-E02 (industrial gear lubrication)
  - IEC/ISO 61400-4 (under development)
  - Equipment supplier requirements (many)
- Experience
  - Priceless!

Standards for Lubricants

Mostly based on available methods

But we must ask ourselves...

Are the methods relevant for the application?

Relevance of methods…

- Some are…
  - Viscometrics (low and high shear)
  - Oxidation
  - Corrosion
  - Foaming
- Some are questionable…
  - Gear micropitting
  - Bearing life

Experience Highlights Some Gearbox Component Issues

- Gears
  - Although improved, gears are reported to continue experiencing micropitting
- Bearings
  - Planetary bearings are reported to have high failure rates in large turbines…size? rating? contamination?
- Contamination (water & particulate)
  - A continuing maintenance or design issue that impacts all of the above

And Some Oil Specific Issues

- Some oils (synthetics) are more expensive than others, but in some cases they do not appear to offer the end user the expected value.
  - Correct fluid for the application?
- Oil quality in service is currently monitored approximately 2x per annum using off-line analysis.
  - Relatively slow turn around time → Delays in resolving potentially damaging situations
  - Condemning limits are not always based upon experience of the application
- Adequate testing tools are not always available to the lubricant industry to develop high quality fluids required for this application

Is anything being done to address these issues? Yes.

- IEC/ISO Joint Working Group
  - Significant emphasis placed on resolving gear and bearing life issues
  - Defining impact of load on design
- An ISO committee has been formed to specifically address gear micropitting
- More effort from a number of sources to monitor oil health in real time via onboard sensors and diagnostics

IEC-ISO 61400-4 Main Elements

- Design and load specifications
- Gears
- Bearings
- Structures
- Lubrication
- Verification
- Testing

Lubrication Normative Clause (5.5)

- Describes the “shall” and “should” requirements of the lubricant
  - Type of lubricant
  - Lubricant characteristics
  - Method of lubrication
  - Oil quantity
  - Operating temperature
  - Temperature control
  - Lubricant condition monitoring
  - Lubricant cleanliness
  - Lubricant filters
  - Ports, plugs, breathers

Lubrication Annex (Informative)

- Designed to provide recommendations and guidelines
- Not a requirement to meet, just a reflection of the experience available in the industry
- Key elements
  - Fluid selection (viscosity selection)
  - Performance characteristics (recommended tests)
  - Lubricant life / condition (limits)

What about oil life?

How long will the oil last?

When does an oil need to be changed?

It depends…

Basis for oil change

- Fixed Time
  - When monitoring is too infrequent or not available
  - Accessibility to the site is limited due to seasonal or location constraints
  - Duration must be based on past experience and adjusted for the site conditions
- Condition Based
  - When online or frequent monitoring of the oil is available and considered reliable
  - Condemning limits must be established based on experience and knowledge about oil health

Proposed Guidelines for Limits (JWG)

Parameter	Method	Acceptable Level	Cautionary Level	Alarm Level
Viscosity (KV at 40°C	ISO 3104 ASTM D445	Nominal VG ±5%	Nominal VG ±8%	Nominal VG ±10%
Additive Elements	ASTM D5185	New ±10%	New ±15%	New ±20%
Wear Elements	ASTM D5185	Fe <50 ppm Cu <50 ppm Al <10 ppm	Fe: 50-100 ppm Cu: 50-75 ppm Al : 10-20 ppm	Fe >100 ppm Cu >75 ppm Al >20 ppm
Cleanliness	ISO 4406	-- / 16 / 13	-- / 17 / 14	-- / 18 / 15
Water	ISO 12937 ASTM D6304	<300 ppm	300 – 1000 ppm	>1000 ppm

So, how do we provide a more reliable lubrication system…

- Better assessment of needs
  - Be able to incorporate these needs into standards in the normative “shall” section
- Better test tools for the lubricant formulator
- Anticipation of extreme conditions
- More frequent monitoring