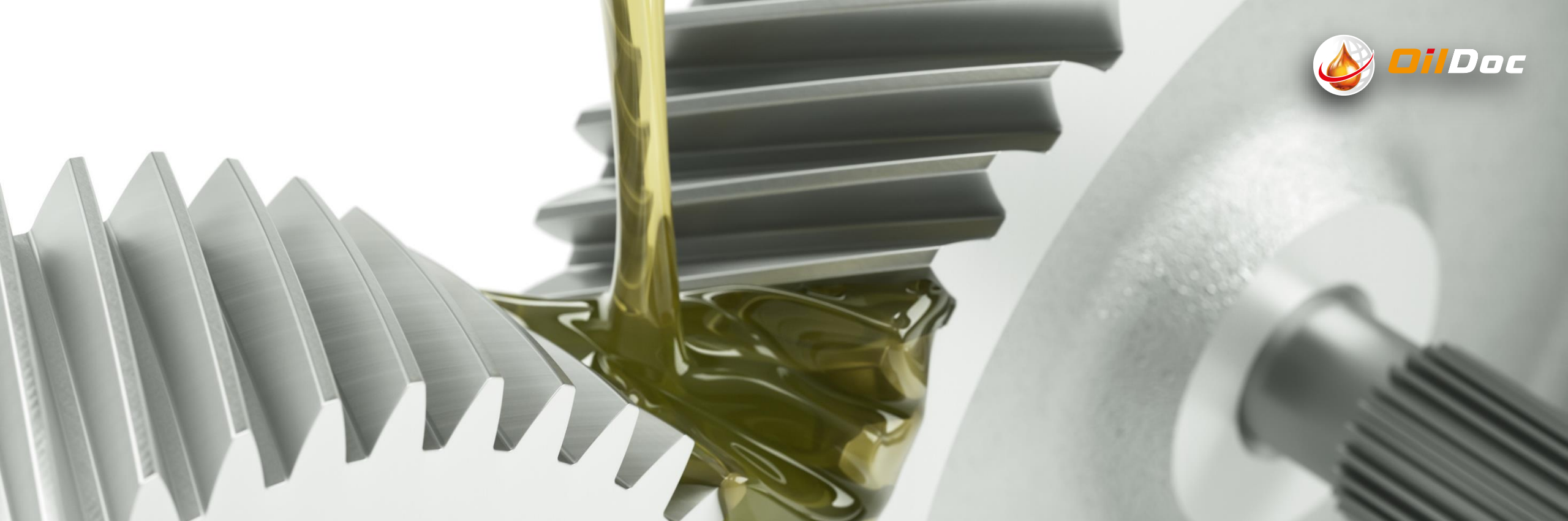


SUSTAINABILITY & LUBRICATION MANAGEMENT

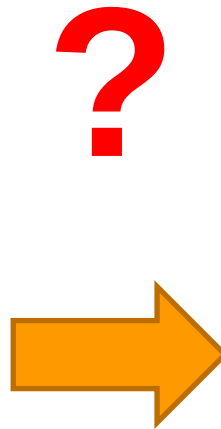
Systematic lubrication management: Sustainability and economic efficiency come together



- Sustainability in a nutshell
- Sustainability, tribology & lubrication
- Why lubricated components fail
- The right perspective
- Summary

Sustainability in a nutshell

- Mr. Hans Carl von Carlowitz (1645 – 1714)
 - “In the forest, only as many trees should be cut down as the forest can regenerate naturally in the foreseeable future.”
- Easy to understand in forestry
 - Easy to apply for hunting or fishing
- What about modern production plants?



Sustainability – the goal

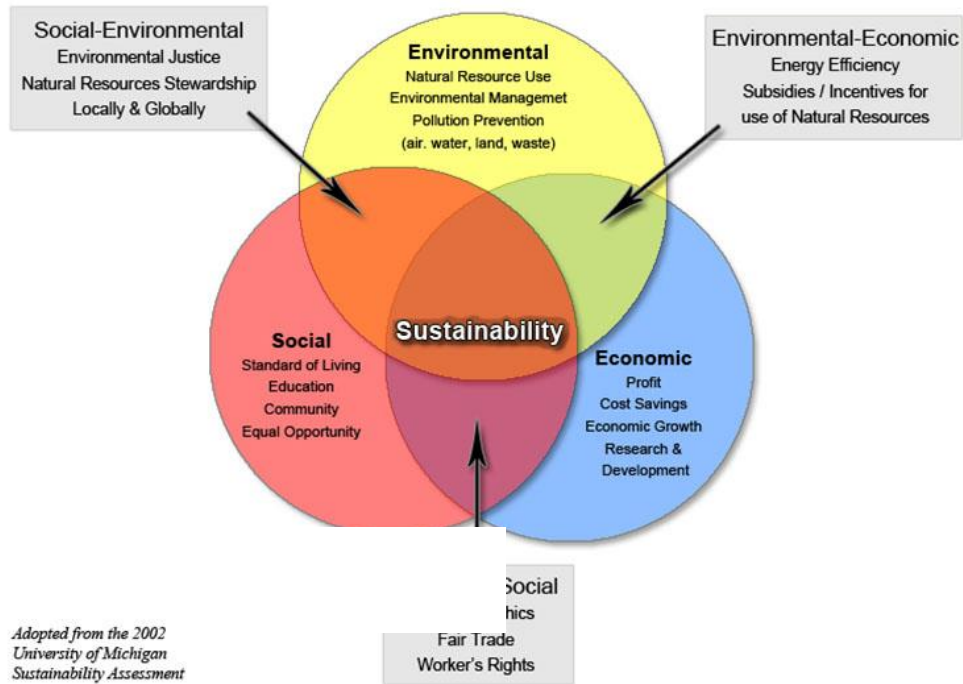


- Carl von Carlowitzsch:
 - Long-term preservation of our environment
 - Fundamental necessity for our existence
 - Ecological, social and economic aspects
- What about industrial companies
 - „Trees of the forest“?
 - Resources
- Resources of an industrial company
 - Humans
 - Environment
 - Energy
 - Assets (e.g. buildings, machinery...)
 - Raw materials, manufactured goods
 - Infrastructure
 - Finances
 - ...

Are products „sustainable“?



- Is a tree sustainable?
 - 100% renewable material
 - Highly biodegradable
 - ...
- Things, plants, animals...
 - (Lubricants too...)
 - Fulfil certain criteria for a sustainability more or less
 - „Assist“ sustainability more or less
 - Whole life cycle has to be considered
- Sustainability
 - Is not a thing
 - Is a life principle
 - (→ Management principle)
- Even a tree (or forest)
 - can be handled sustainable or not



(University of Michigan, Sustainability Assessment)

- Sustainability
 - Fundamental principle of life
 - To ensure our existence
 - (and that of companies)
 - in the long term
- Holistic approach brings together
 - Environment
 - Social life
 - Economics
- Not really sustainable
 - “Green washing”
 - Focussing on single aspects and...
 - Torpedoing the whole solution
 - Purely prestige projects
 - Nice visible, but without real significance



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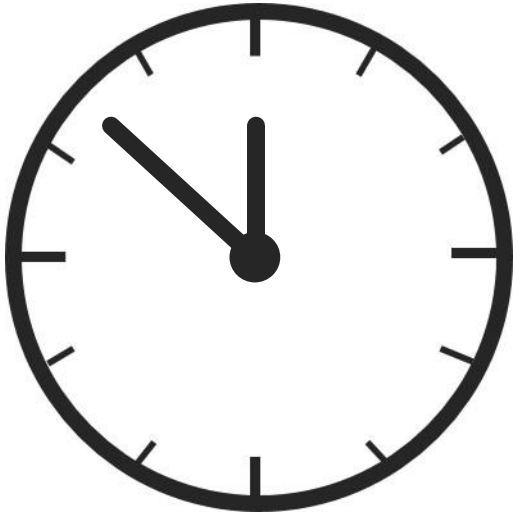
Study	Year of Publication	Energy Saving Potential		Economic Saving Potential of Reduced Friction and Wear
		% of energy consumption	In EJ related to the consumption of primary energy in 2017	% of GNP and in billion US-\$ related to GNP of 2017
Germany (GDR)	1960	—	—	1.25%
Jost (G.B.)	1966	5%	0.4 EJ	2% = 53.3 billion US-\$
O.T.A. of U.S. Congress	1976	—	—	>0.75% = >149 billion US-\$
A.S.M.E. (USA), Pinkus & Wilcock	1977	10.9%	10 EJ (93 EJ)	—
BMFT (Germany)	1976	—	—	2% > 73.1 billion US-\$
China (only 8 industrial branches)	2006	—	—	1.55% = 243.4 billion US-\$
A.R.P.A.-E (USA)	2017	24%	24.1 EJ (from 102.9 EJ)	

1 EJ= 10^{18} Joules; A.S.M.E.= The American Society of Mechanical Engineers; BMFT= Bundesministerium für Forschung und Technologie (German Ministry for Research and Technology: now named "German Ministry for Education and Research (BMBF)"); *Absolute economic costs for wear, maintenance, repair and overhaul. Total primary energy supplies (TPES) in 2019: global= 584 EJ. USA= 105.7 EJ. Germany 2019: 13.1 EJ; O.T.A.= Materials Group of the United States Office of Technology Assessment.

Source: M. Woydt, Matrilub
In Lubes'n'Greases EMEA, April 2020

- Several studies show impact on
 - Energy consumption
 - Economic Saving Potential
- How to do this
 - Energy → minimizing frictional losses
 - Material → pro-longed service life
- Today's overall measure for that
 - CO₂ footprint
- Main strategy
 - New machinery
 - More efficient
 - Materials of higher wear resistancy
 - Better lubricants
- *This is right and crucial*
- But is this all we can (should) do?

A realistic timeline



Even if we begin to replace ICE vehicles today with battery EVs, it will take 20-50 years before a significant impact on global warming can be achieved...

Michael P. Duncan STLE President in
TLT President's Report March 2020

- Average life of a passenger car (EU)
 - 8 – 12 years
- Average life of industrial equipment,
 - e.g. cement or power plants, refineries
 - XXL equipment
 - 50 – 60 years?
 - (even with partial updates it is not new)
 - Smaller components (gearboxes, pumps...)
 - 10 to 20 years
- Again
 - It is crucial to develop and produce better cars
- How to improve sustainability in meantime?
 - Modernisation (materials, drive concept...)
 - Better lubricants
 - More sustainable lubrication
 - Tailor made service concepts

How lubricants improve sustainability



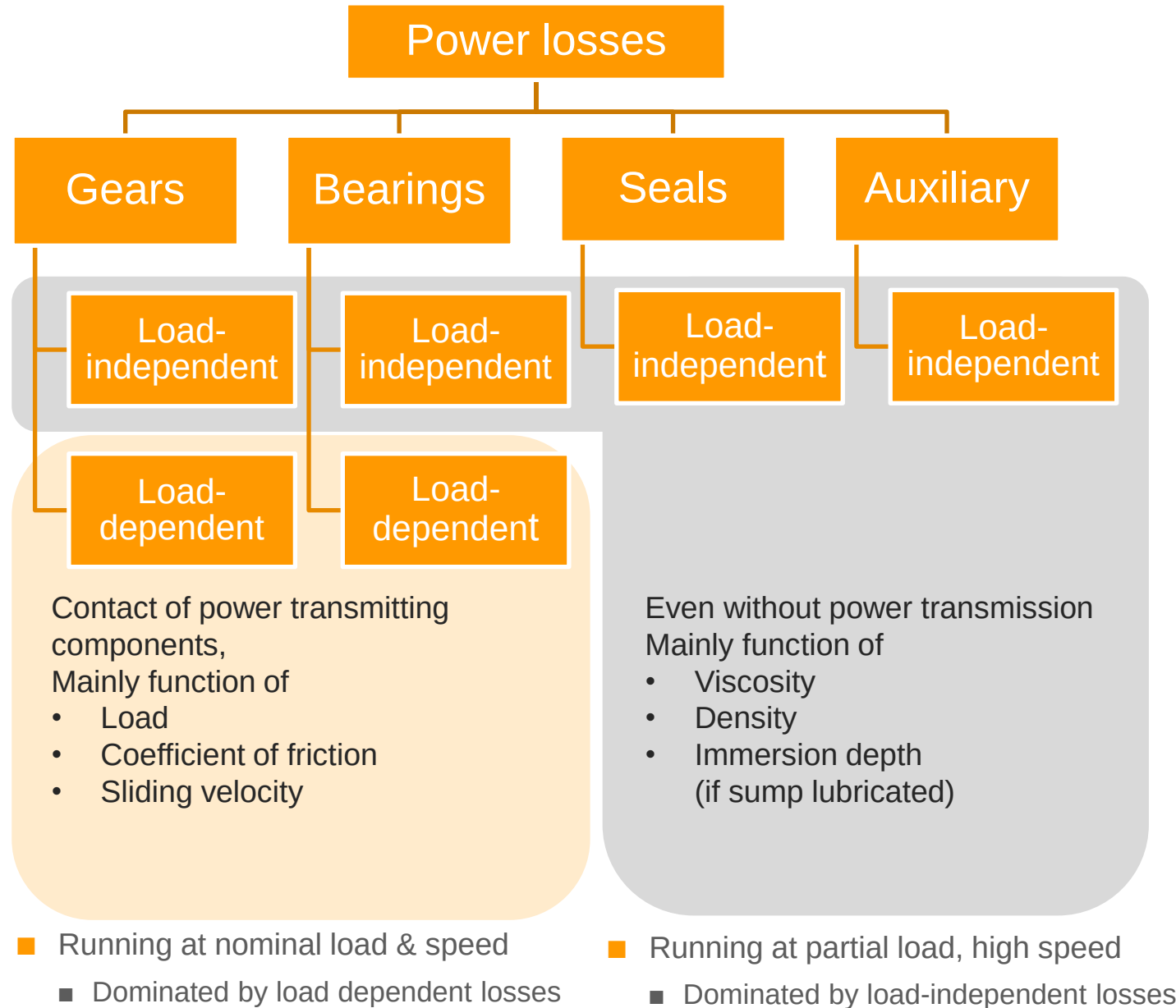
- Based on...
 - EAL (not only in total loss systems)
 - Recycled (reconditioned, re-refined...)
- Longer oil drain intervals
 - More saturated base oils
 - Effective anti-oxidant additives
- Lower internal friction
 - High Viscosity Index
 - Synthetic base oils
 - VI Improver additives
 - Lower viscosity (if possible in older machinery)
- Lower friction in mixed or boundary regime
 - Base oil (viscosity, VI, polarity)
 - Additives (Friction modifier, EP/AW)
- To be considered
 - Compatibility, (old) system condition...

Hydraulic Fluid and Energy Efficiency

- Efficiency increase up to 5... % possible by a „better“ hydraulic fluid
- Fluid-related efficiency of a hydraulic fluid depends mainly on
 - Viscosity, Viscosity Index *and* Density (!)
- A higher VI can be provided by
 - Mineral oil and VI Improver: VI ↑ Density ↑↓
 - Base oil of group III, IV : VI ↑ Density ↓ (!)
 - EAL base oil of group V: VI ↑ Density ↑ (!)
 - First indication: Compare the fluid temperature in operation
- Sustainability is more than efficiency:
 - Shear stability
 - Lubrication by additives
 - Oxidative, thermal and hydrolytic stability of base oil and additives ...
 - Oil drain interval
 - Material compatibility
 - Different service needs of the fluid (e.g. esters and moisture)
- The best solution depends on
 - Machinery design & operation

Influence factors on gearboxes power losses

Source: Klaus Michaelis, Bernd-Robert Höhn, Michael Hinterstoißer, Gear Research Centre FZG, Technische Universität München





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- **Why lubricated components fail**
- The right perspective
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- Lubrication best practice saves money!
 - 20% cost reduction for maintenance an refurbishment
 - 20% cost reduction for lubricant procurement
 - 13% less work for unnecessary repairs
 - 7.5% less energy consumption by „controlled“ friction
 - 5% cost reduction for purchase of new machines

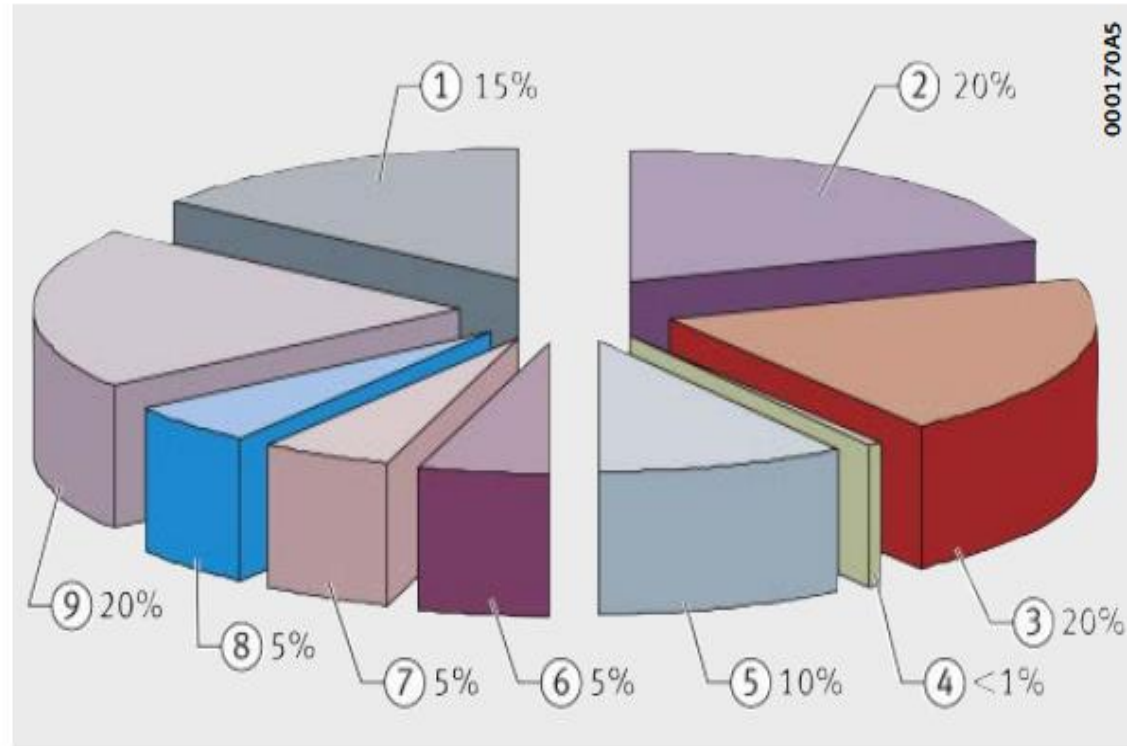
→ Lubrication practice ?

→ Lubrication has to be done (to be alive)

- Papier is patient (manuals, instructions...)
- Paper has not to be lubricated ☺
- We do not lubricate standards or specification, but we lubricate machines
- The difference always: people
- People with an eye for details, whitout loosing the view on the whole mission

- ① Lubricant starvation
- ② Unsuitable lubricant
- ③ Aged lubricant
- ④ Material and production defects
- ⑤ Unsuitable bearing selection
- ⑥ Secondary damage
- ⑦ Mounting defects
- ⑧ Liquid contaminants
- ⑨ Solid contaminants

Figure 1
Causes of failure for rolling bearings
Source: Antriebstechnik, 93



Sum it up:
Lubrication and contamination: 80%

Hydraulic pumps: Failure causes

Hydraulic pump failures are caused by:

- Design 2 %
- Manufacturing 6 %
- Installation 12 %
- **Maintenance and Operation 80 %**



Bad news about lubrication and failures

■ Failures are caused by lubrication, maintenance (operation)...

- Rolling bearings → 80%
- Hydraulic pumps → 80%

■ The *good* news:



- Following easy rules we can avoid the majority of our premature failures of lubricated components!



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The right perspective



- Not sustainable und not economical:
 - Lubricants are...
 - Consumables
 - Interchangeable because they are all "the same"
 - They are cheap and therefore not valuable
 - ... (and receive little attention)
- Sustainable and economical
 - Lubricants are...
 - Component of the machine (like a bearing)
 - Right type and size
 - Lubrication has to be done properly
 - Storage and handling
 - Assembling
 - Condition monitoring (?)
 - ...
- A change of perspective that pays off

Lubricants and Lubrication: The difference

■ The right lubricant (The “thing”)

■ Lubricant selection

- Type, viscosity
- Standards, specifications
- OEM approvals

■ Supplier selection

- Portfolio
- QM
- Service & support
- Delivery
- Prices
- ...

■ The right lubrication (The “do”)

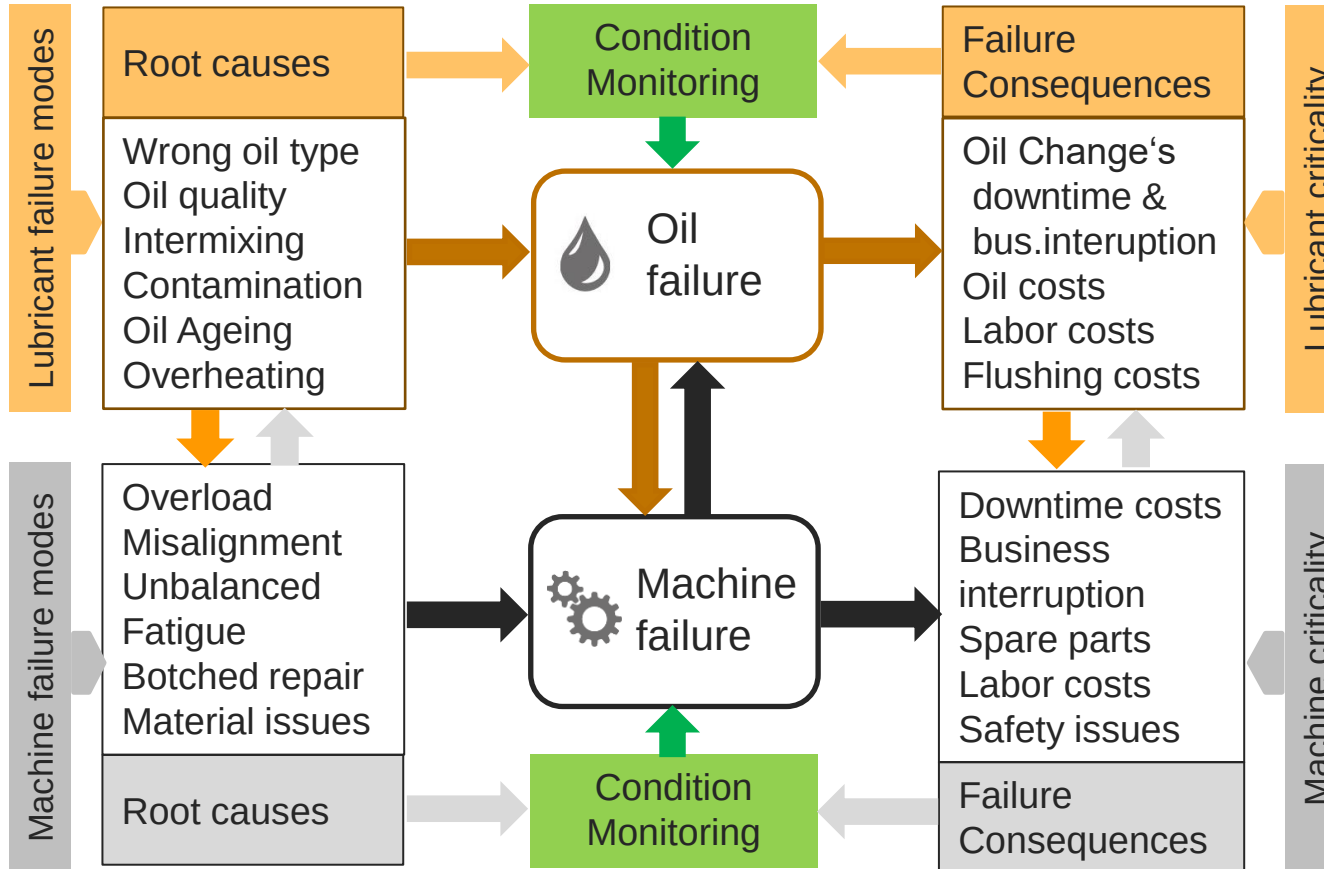
■ Lubrication

- has to be done
- Should be managed
- Sustainable (!)

■ Lubrication Management

- Selection
- Procurement
- Storage
- Dispensing
- Operation
- Inspections & Monitoring
- Top-up
- Oil change procedures
- Compatibility
- Disposal

Oil & Machine Condition Monitoring Concept





- Origin service concept of machinery
 - designed by the OEM
- Lubricant related tasks → described in the manual
 - Lubricant type or list of brand names
 - Drain intervals
 - Inspections
- Filtration
 - Standard concepts
 - Maintain a certain cleanliness level
- Pro-active sustainability improvement by
 - Special lubricants
 - Oil Condition Monitoring
 - Contamination Control
- Examples
 - → Next slides

Example EAL: Bio lubricants and hydraulic fluids



- Customer's voice
 - High costs
 - Performance doubts
 - Material compatibility issues
- Reality (HEES in comparison with HLP-HM)
 - EAL's → higher and shear stable Viscosity Index VI
 - Synthetic EAL's → higher oxidation stability
 - EAL → intrinsic high wear protection
 - Material compatibility is different, but viable
 - Hydrolytic stability can be improved by a suitable by-pass filtration
 - The cleaner fluid leads to a longer oil & component life!
- Sustainability is more than "Bio"
- Don't compare only by price tag!

“EAL – Hydraulic fluid in forest machinery”



Source: Kleenoil Panolin AG, Germany

**Special fluids
→ special concepts!**

- Use of „Bio“ hydraulic fluids (EAL) by law
- Owner of machinery: EAL are
 - Expensive
 - Shorten lifetime of components
 - ...
- Due to legal regulations the customer focus is on
 - „Bio“
 - It's a must
- Special concept of a smart EAL producer
 - Selling a high quality saturated ester
 - Our EAL is la lifetime lubricant, if
 - You use our oil condition monitoring concept
 - (by sensors and oil analysis)
 - You use our special in-depth by-pass filtration
 - (removes water, particles → the biggest enemies!)
 - You don't mix or top-up our fluid with others

Example: Cement Plant



■ Hydraulic system

- Clinker Cooler Drive
- 1200 L oil volume
- Mineral oil HLP-HM replaced by a PAO

■ Gearbox

- Main drive of a cement mill
- 2800 L oil volume
- Mineral oil CLP replaced by PAO

■ Results of energy conservation

- Hydraulic: 8.500 \$/a
- Gearbox: 41.000 \$/a

■ Result

- Sustainable! (Very long ODI, reliable operation)
- RoI less than 2 years!
- Now they earn money every year

Example Paper plant

“Lubrication dry section (paper machine)”



Source: OilDoc GmbH, Germany

**Special machinery
→ special concepts!**

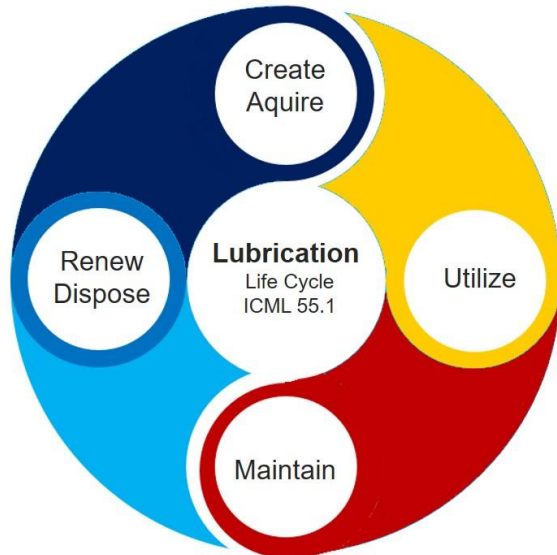
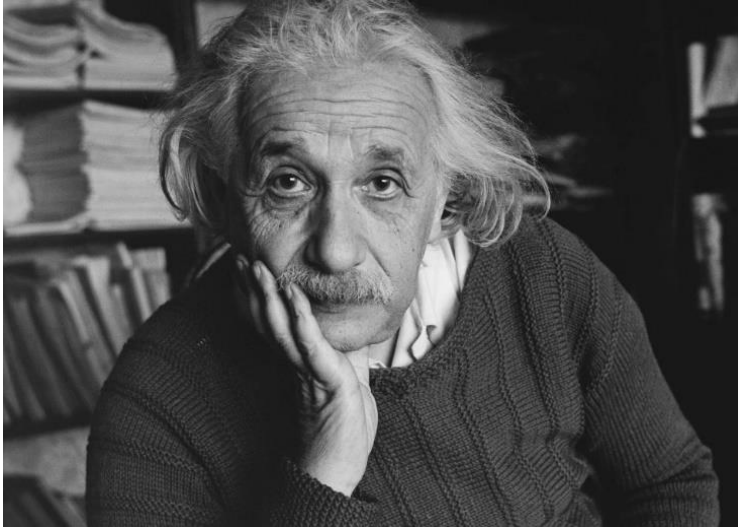
- Circulating system
 - Rolling bearings
 - Special, OEM approved oil (10.000 L)
- Applying
 - “Clean principle” to all lubricants, from storage to disposal
 - Monitor the oils on regular basis (sensors and oil analysis)
 - Renewing 1000 l oil every year (drain & top-up & recycle)
 - Clean-up the oil permanently by additional in-depth filtration
- Goal
 - To avoid total oil drains, system flushing etc. best
 - To minimize downtimes best
 - To prolong lifetime of the machine best
 - To prolong the oil drain intervals best



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Lubrication Management by Excellence: **Seven** „Right’s“

Right...	Tasks
Lubricant	Type & viscosity: → Lubricant selection for every lubricating point Consolidation: → Number of lubricants Supplier & QC: → Supplier selection, Quality Control
Place	Where? → Identification Labeling: → Lubricant container, tools and every lube point
Amount	How much? → Right volume Re-greasing, oil top-up, oil change, ...
Time	When? → Time & Frequency Interval and condition-based time for re-greasing, top-up & oil change
Method	How? → Application Tools, Lubricators, Lubricating systems
Condition	Fit for use? → Control & Care during delivery, storage & handling, operation Inspection, oil analysis, contamination control, filtration
People	Fit for lubrication? → Who lubricates? Background, skills, training, ownership



- “All is to be seen relatively, but nothing happens purely randomly.”
- Sustainable lubrication
 - Is a concept in managing lubricated assets
- Right done
 - Sustainability wins
 - Reliability increases
 - Costs decrease
- If you want to change something...
 - Do it!
- If you need assistance
 - Ask the experts
 - Ask for the right education course
 - Apply ICML 55.x