Tribological Friction and Wear Loses -We Need to do Better

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History

With the 1964 UK Jost report, the Good Ship Tribology set sail. Did it sink in Canada? Studies have shown that about 2% of a nation's GDP is spend on friction and wear.

In Canada, we had the 1986 NRC report that over that $5 billion is lost annually. This had 10 recommendations that including more research but also better training and education as well as improving both information sources and co-ordination.

Tribology

This is from the Greek word tribos. Tribology is the science and engineering of interacting surfaces in relative motion.

It includes the study and application of the principles of friction, lubrication and wear.

This includes lubricants, but also seals, bearings, wear, metal working, condition monitoring and numerous related fields. Plus, ceramics, biomaterials, plastics and friction materials.

How are we doing?

Motor Failures

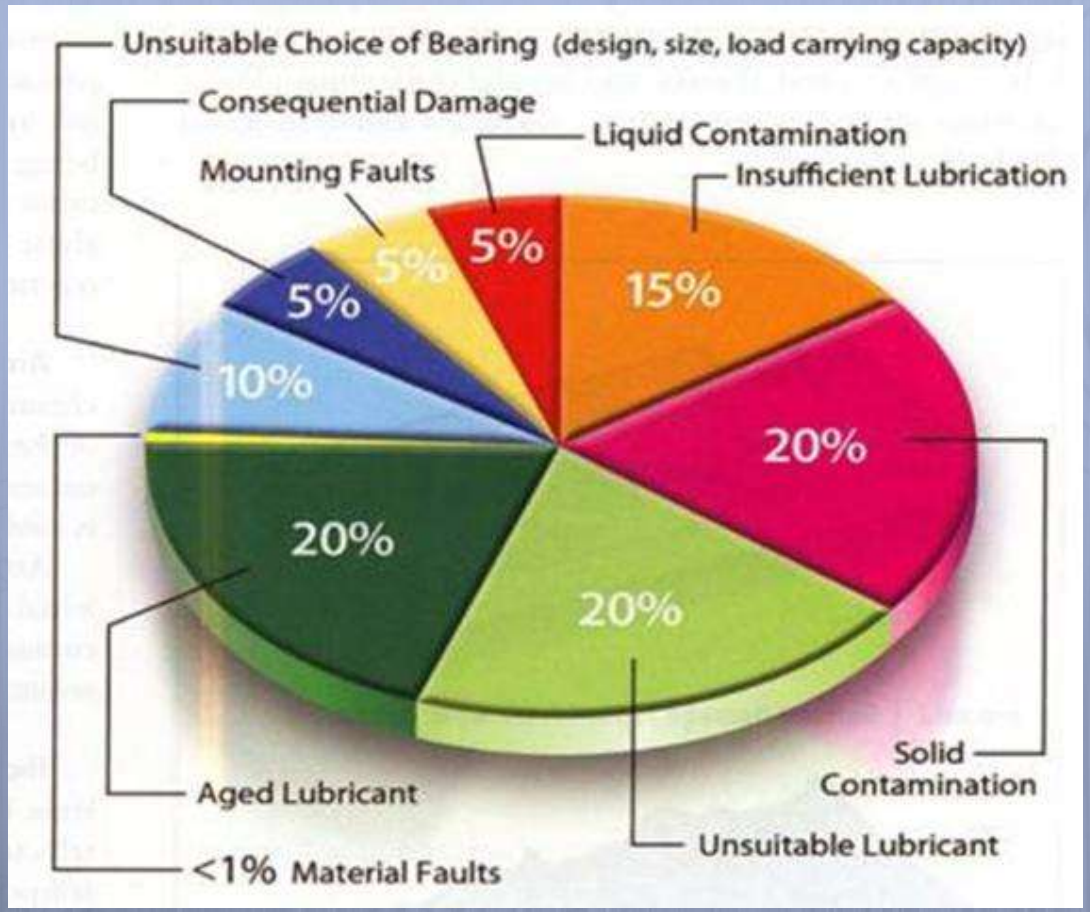
Bearing troubles account for 50 to 65 percent of all electric motor failures, and **poor lubrication practices** account for most of these bearing troubles.

Proper maintenance procedures, planning and the use of the correct lubricant can increase productivity by reducing these bearing troubles and motor failures.

Ref: http://www.machinerylubrication.com/Read/1125/electric-motor-lubrication

How Are We Doing?

Pump Failures



90% of these failures are preventable!

Ref: 'Lubricant management for non-circulating sumps', M. Johnson, TLT, August 2009 pp 16-23

Do We Design Correctly?
Ball Bearing Fatigue Lives - Now

New life theory (ISO 281:2007) takes into account the viscosity ratio of actual vs. required, type of bearing, type of loading and cleanliness of the oil.

$L_{naa} = a_1 a_{ISO}(C/P)^3$

L_{naa} = adjusted rating life in millions of revolutions

a_1 = life adjustment for reliability (i.e. 10% failure)

a_{ISO} = life adjustment factor based on new life theory

C = Basic load rating

P = Equivalent dynamic bearing load

Rolling Element Bearings Lives - Now

Life Modification Factor a_{ISO}

Among other things considers the influence of:

- ***Fatigue limit of the bearing material by the fatigue load limit C.***
- ***Grade of contaminations by the factor e_c.***
- ***Lubrication conditions by the viscosity ratio K.***

Note: *ISO 281:2007 does not cover the influence of wear, corrosion and electrical erosion on bearing life.*

Note: Using oil as supplied can reduce life by 50%!

Ref: www.cwbearing.com

Rolling Element Bearings

Unfortunately the leading causes of failures are reported to be improper lubrication and improper mounting.

‘These are preventable.’

Ref: Hafner, E.R., ‘Proper Lubrication-The Key To Better Bearing Life, Part 1: Selecting The Correct Lubricant’, Mech. Eng., pp 32-37, October 1977

How Are We Doing?
Rolling Element Bearings

Note: Only 3% reach their design life!

In real life it has been reported contaminants cause 50% of bearing failures.

Rolling Element Bearings

Remaining causes are;

Marginal lubrication	**30 %**
Other	**17 %**
Fatigue life	**3 %!!!**

It was reported that they typically fail at 20% of their catalogue life. Again this is a real waste.

Ref: NSK as reported in Machinery & Equipment MRO, p13 June 1999

How Are We Doing?
Hydraulic Systems

More than **3/4** of all problems can be traced back to **contaminated oil**. Monitoring **oil cleanliness** is therefore the most important factor in preventing system failures.

Monitoring hardware only detects around 20% of all unplanned downtimes.

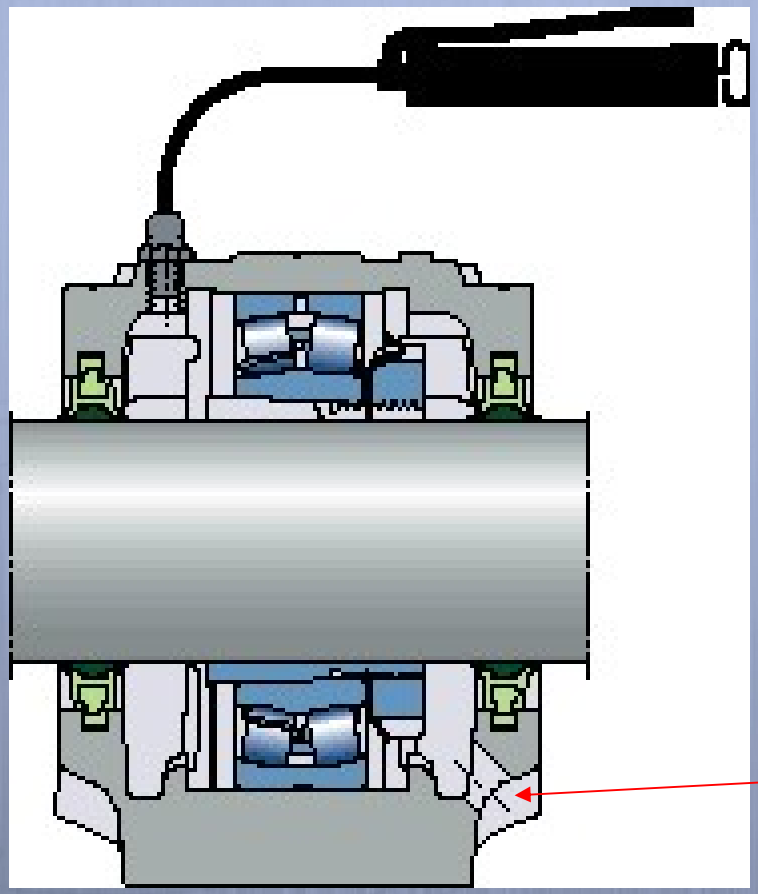
Ref: Rexroth Oil Contamination Booklet RE 08016 2011

Installation – Do They Have the Right Tools?

Proper sized adapter ring, impacts sleeves and a soft tipped hammer.

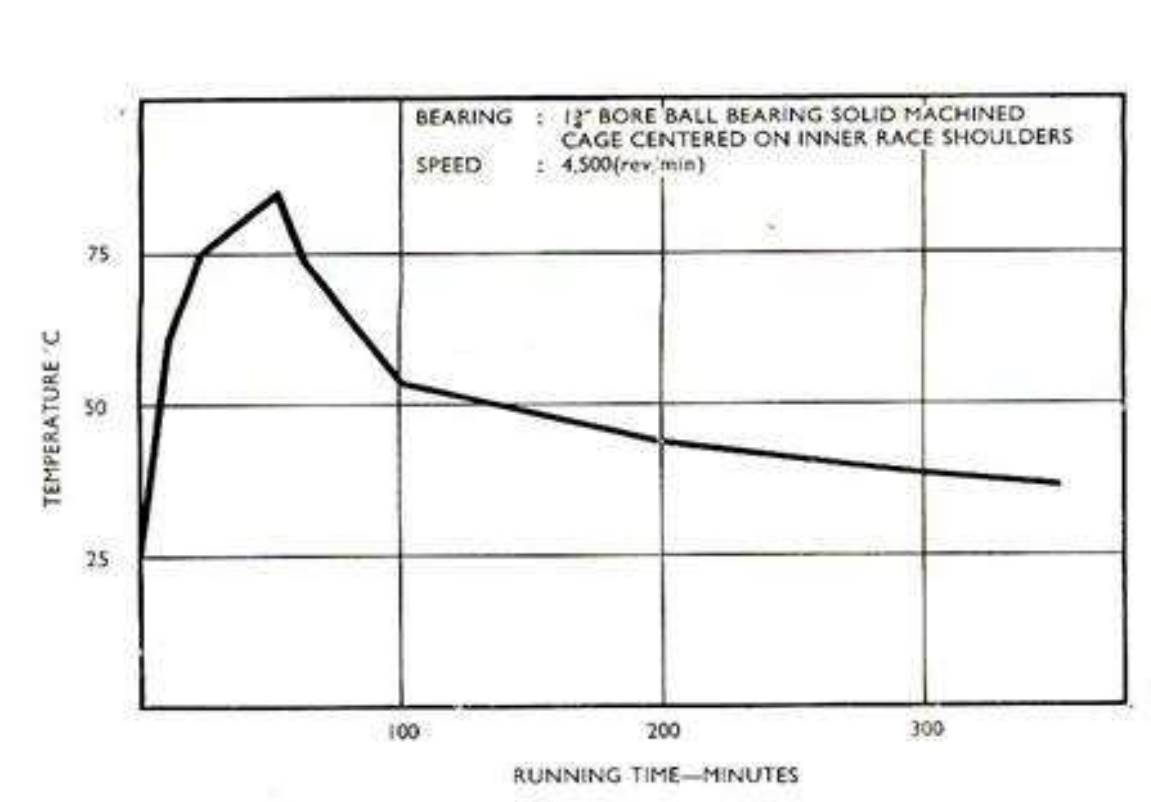
Ref: www.mapro.skf.com/products/

Do We Know How to Do it?
Greasing Bearings



Note: There are many many variations. Few have easy places for the spent grease to exit. Know how to do it in each case.

‘Normal’ Temperature Rise



Note:
Lubricators need to communicate with operators. Do not raise temperature limits or use less than required grease amounts.

Ref: Harris, A.F., ‘The Lubrication of Rolling Bearings’, p. 118, Shell Int’l Petroleum Co. Ltd., 1972

Grease Quantities – as a ‘bestguesstimat’

For replenishment from the side of a bearing;

Gp = 0.005 D B

For through the bearing outer or inner ring;

Gp = 0.002 D B

Gp = grease quantity, g
D = bearing outside diameter, mm
B = bearing width (thrust bearings use height H), mm

Note: Also check the manual and take into account any lessons learnt.

Ref: SKF 2007

Calculating Grease Quantity, Frequency

	Vertical	Horizontal
Amount (g)	33	35
Frequency (months)	**2**	8

Note: Frequency can vary considerably depending on orientation and with temperature, contaminants and speed.

Ref: Machinery Lubrication

Regreasing Amount Example

6316 ball bearing; ID 80, OD 170 mm Width 39 mm

It should get about 0.005 X 170 mm X 39 mm

= 33 g (1.2oz) of new grease.

With the 70MPa (10,000psi) high pressure grease guns often used, this can require 43 strokes.

Note: Verify delivery rate of the grease gun being used. Pump into a paper cup or onto a paper towel. Density of grease is about the same as water. In this case 33 g ~ 33 ml or 1/8 cup

How Are We Doing?
Causes Of Premature Engine Bearing Failure

	%
Dirt	44.9
Misassembly	13.4
Misalignment	12.7
Insufficient Lubrication	10.8
Overloading	9.5
Corrosion	4.2
Other	4.5

86% could be preventable!

Ref: Clevite AM-208-8

One Surrender Option – Sealed for life

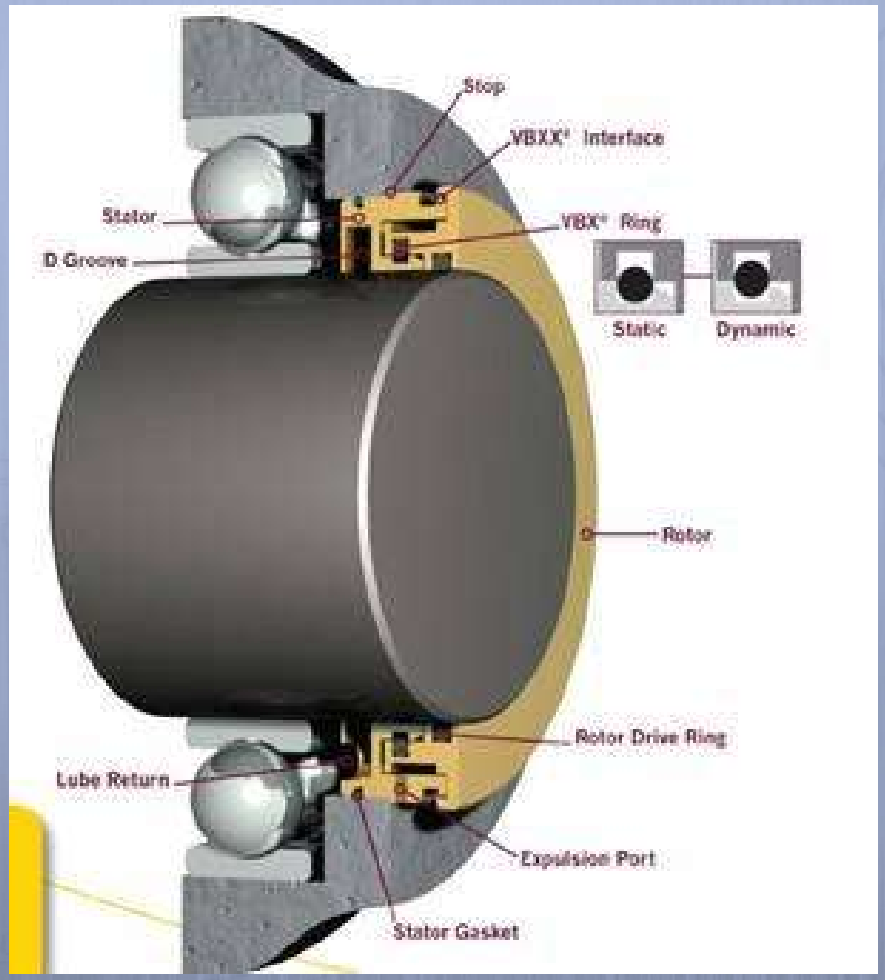
Pros

- Cheaper initially
- ‘Known life’
- Cannot be greased wrong

Cons

- More expensive
- Long or short life
- Can’t be regreased
- Higher temperature?
- Wear debris trapped
- Not a cure all!

Better Seals – What is being used?



Note: No rubbing contacts to wear out or increase temperatures.

Plus retains lube and excludes water and dirt.

Reducing Motor Bearing Failures

Shell Canada found that at one of their refineries, 91% of the problems with motors were the bearings.

They were able to achieve a 90% reduction in such failures, mainly by better control of lubrication.

Can you afford not to do it?

Make it easier to do it right

Provides for pressure-specific shut-off (for example, 20 psi). At the given shut-off pressure, the grease flow will stop.

$0.35 each

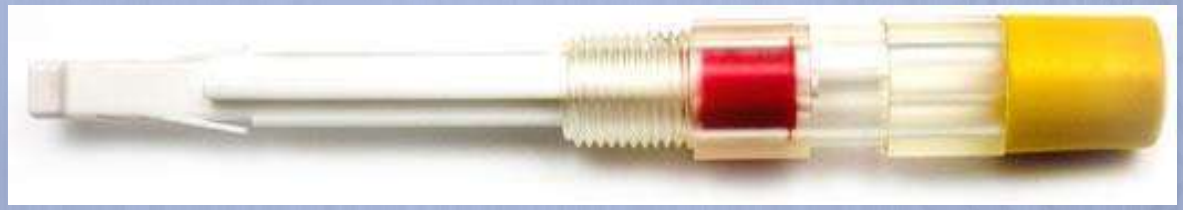
Coloured grease fitting caps

$0.20 each

When Is Enough or Not Enough?

Courtesy: EA Grease Caddy

How Do You confirm When?



Now getting a grease sample is just as easy as an oil sample. Just screw in place of the grease plug.

MRG Grease Thief

What to Test and When - Oils

This is best based on your specific equipment, lubes, skill sets and criticality but there are still good guidelines readily available.

Example: ASTM D6244 Standard Practice for In-Service Monitoring of Lubricating Oil for Auxiliary Power Plant Equipment

For gear/circulating oils, hydraulic oils, diesel engine oils, turbine type oils, air compressor oils, EHC (PO_4 esters) EHC Mineral Oils.

Are we getting better?

Still failures.

Less training and fewer skilled crafts.

More outsourcing.

More 'penny' control.

Less innovation.

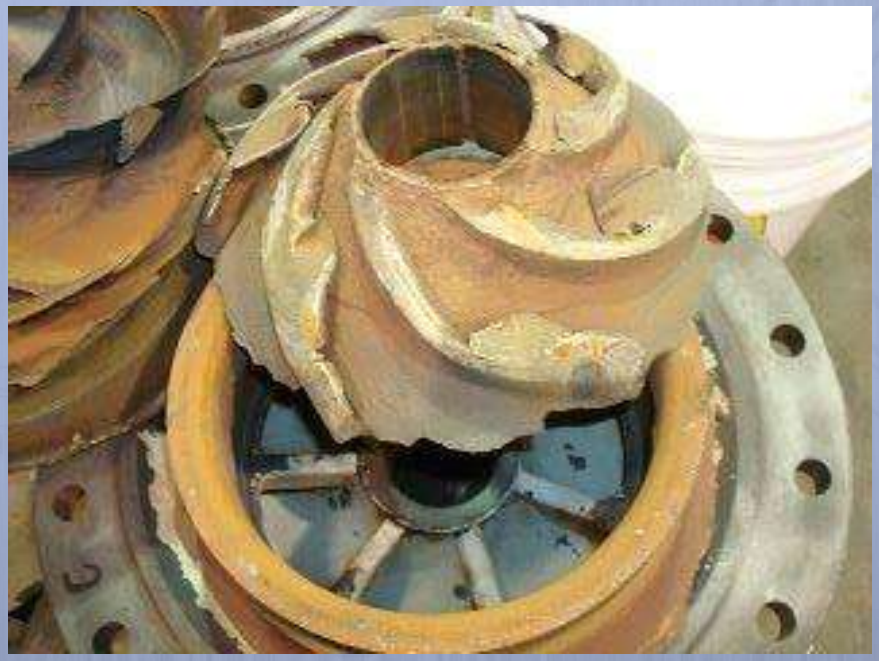
Less directed training.

Plus, counterfeit part issues.

Wind Turbines – expensive candles

Needs re knowing forces, lube requirements, maintenance and condition monitoring

Port Hope – water pumps



What happened, why and what warning signs were missed?

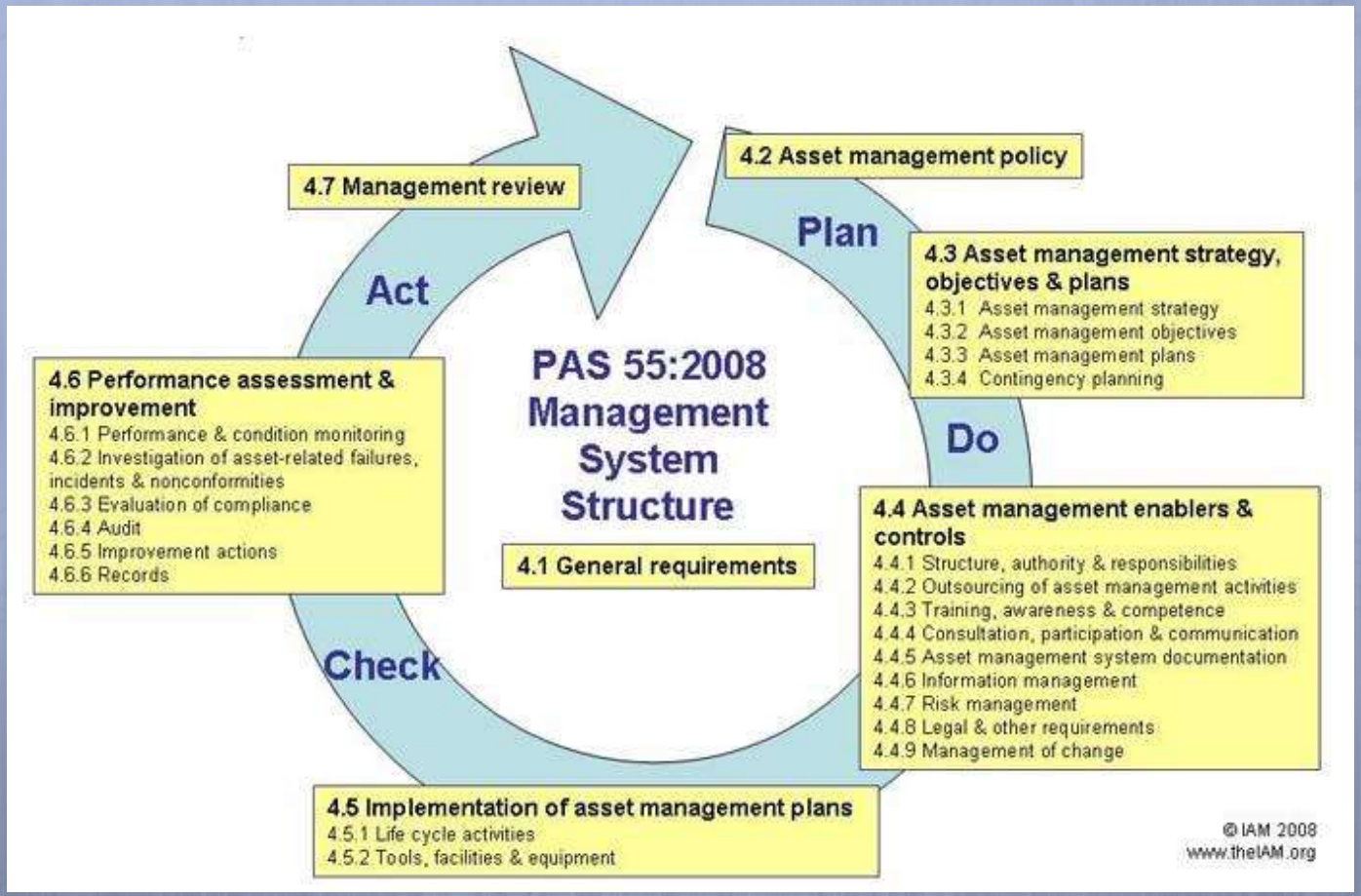
Wheel issue caused 2014 Brockville CN Rail train derailment, report finds

TSB blamed a combination of factors: the speed of the train, the type of car where the wheel issue manifested itself a 24-metre-long "centrebeam bulkhead flat car" and the worn condition of the side bearings.

Proactive – How Do You Compare?

Ref: IAEA-TECDOC-1551 Implementation Strategies and Tools for Condition Based Maintenance at Nuclear Power Stations

PAS55
(Publically Available Specification)
ISO55000



ISO 55000 Asset Management

ISO 55000:2014 Asset management - Overview, principles and terminology

- Provides an overview of asset management, its principles and terminology, and the expected benefits from adopting asset management.
- Can be applied to all types of assets and by all types and sizes of organizations.

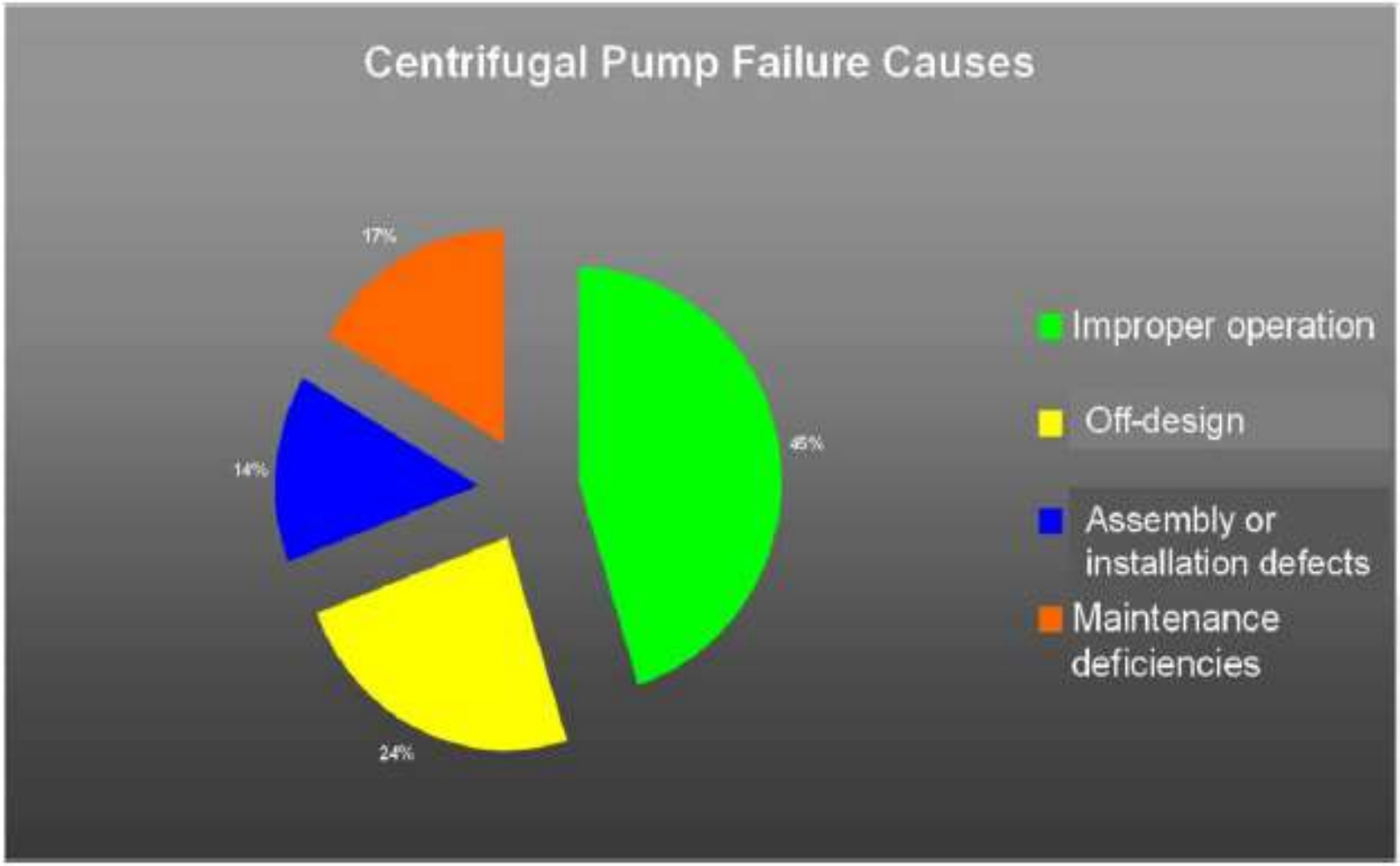
- **ISO 55001:2014 - Asset Management, management systems requirements**

- **ISO 55002:2014 - Asset Management, management systems guidelines for the application of ISO 55001**

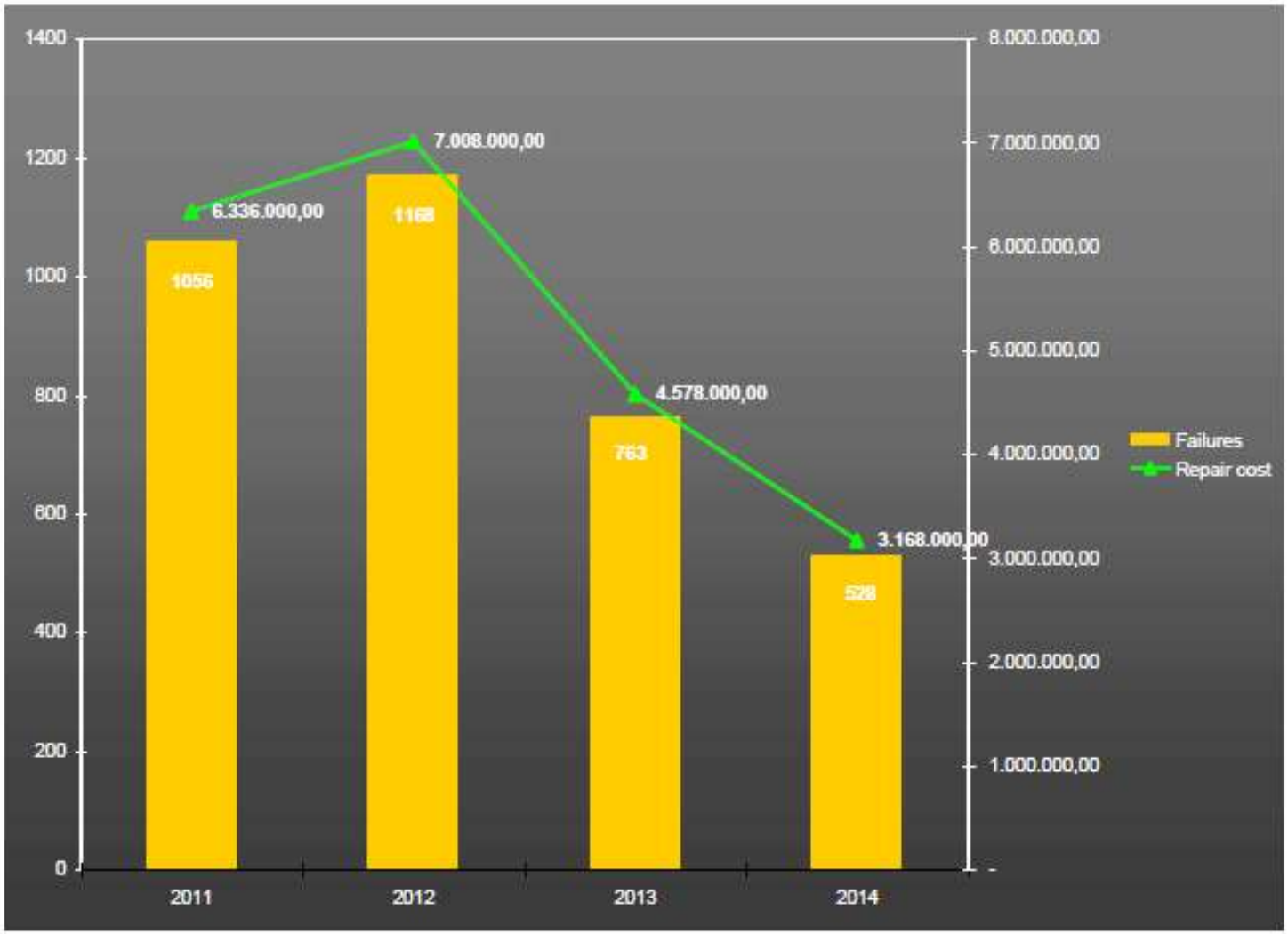
It contains explanatory text necessary to clarify the requirements specified in ISO 55001 and provides examples to support implementation

What Else?


44TH TURBOMACHINERY & 31ST PUMP SYMPOSIA
HOUSTON, TEXAS | SEPTEMBER 14 – 17 2015
GEORGE R. BROWN CONVENTION CENTER
500 centrifugal pump failures prevented using new prevention strategy
Bladimir Gomez
Supervisor,
Rotating Equipment Engineering
PDVSA CRP Refinery
PDVSA
TURBOMACHINERY LABORATORY
TEXAS A&M UNIVERSITY


Centrifugal Pump Failure Causes
17%
45%
14%
24%
Improper operation
Off-design
Assembly or installation defects
Maintenance deficiencies

Centrifugal Pumps Failures and Repair Costs for 2011-2014



Conclusion:

By expanding the inspections to the process conditions and contributing factors that occur prior to the potential failure, the equipment failure is prevented.

The three levels of inspection were applied to 4000+ centrifugal pumps in the refinery.

This resulted in a reduction of over 500 pump failures over two years of implementation, with savings of 4MM$.

No additional cost or resources were required.

To prevent failures, must reduce the contributing factors

My Summary

1. Most bearings do not reach their design life.

2. The leading cause of hydraulic system failures is contamination.

3. The leading cause of electric motor failures are the bearings.

4. Many failures can be easily prevented.

ACOT 1986 Recommendations

1. Strengthening of Industrial R&D in Tribology
2. Joint Government-Industry Support of “Mission-Orientated R&D Programme in Tribology
3. Strengthening of Consulting Service in Tribology
4. Human Resource Development
5. Strengthening Contract R&D in Tribology in Universities
6. Strengthening Research In Tribology in Universities
7. Strengthening of Information Services in Tribology
8. Strengthening of In-house Programmes in Tribology in the National Research Council Canada
9. Co-ordination of Tribology R&D Programmes
10. Promotion and Review

What Else?

Embrace or at least take advantage of any ‘green’ attributes;

Lasts Longer	No seasonal changes
Less required	Less make-up
Lower friction	Less wear
Less energy	Less heat
Safer	Lower disposal costs

Lower costs!

What's Required

1. Better training for engineers, trades, managers and accountants.

2. Commitment to ongoing training and certification.

3. Recognizing that change, as improvements, is both beneficial and necessary.

4. We can easily do better.

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