CASTROL GREENDECK
Environmentally Friendly Lubricants

IT'S MORE THAN JUST OIL. IT'S LIQUID ENGINEERING.

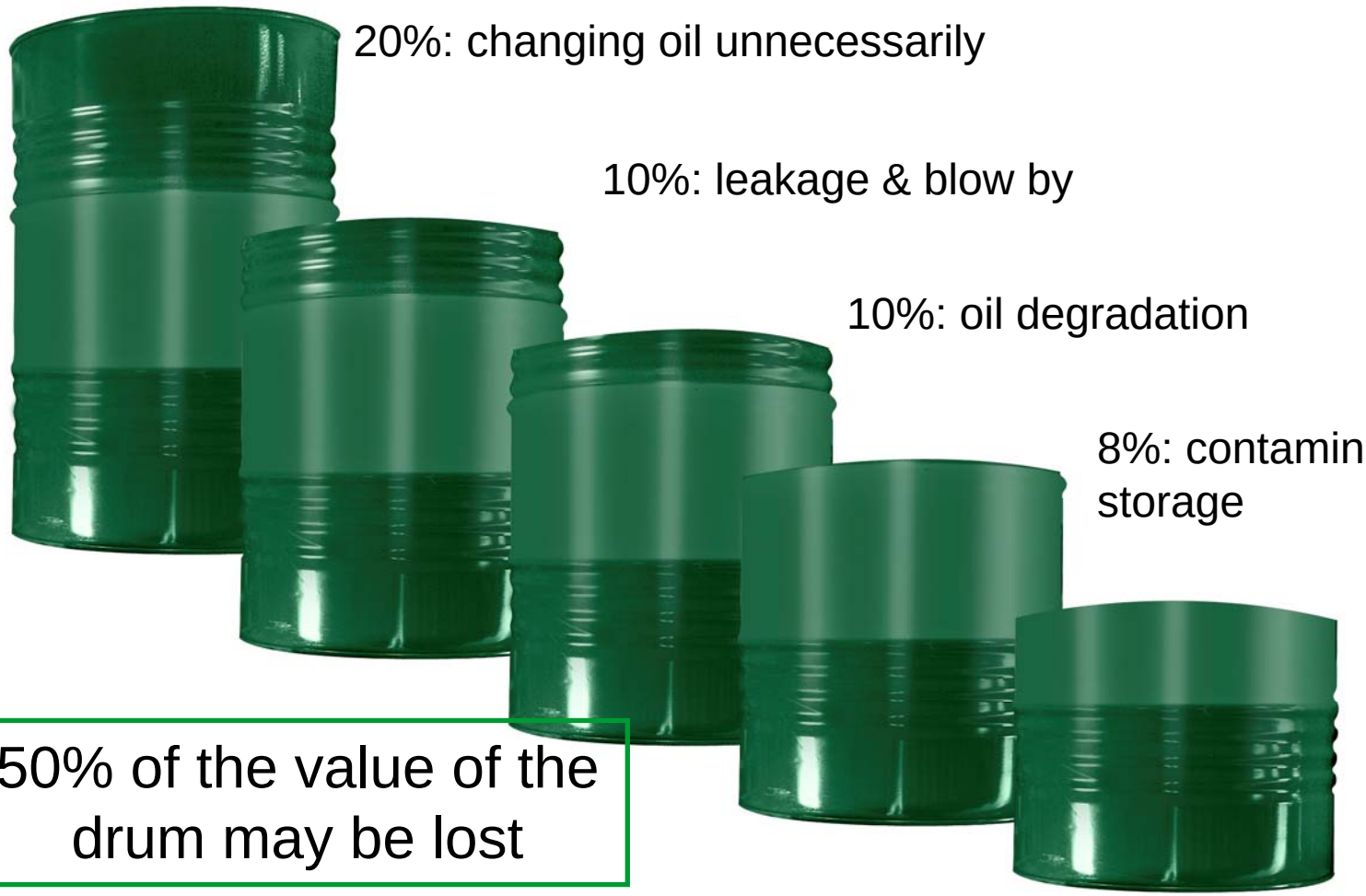
Castrol Marine

Harsh truth about oil leaks

- Ships leak lubricant – 120-140m litres a year during normal operations equivalent of 3 times Exxon Valdez spill
- Approx. 100,000 tonnes[1] of oil leak from ships during normal operations in ports and harbours each year
- Key factors:
  - Machinery failure
  - Human error

[1] Source: 2007 GESAMP report

Lubricant Management:
Hidden inefficiencies and wastage destroy the value of the lubricant



20%: changing oil unnecessarily

10%: leakage & blow by

10%: oil degradation

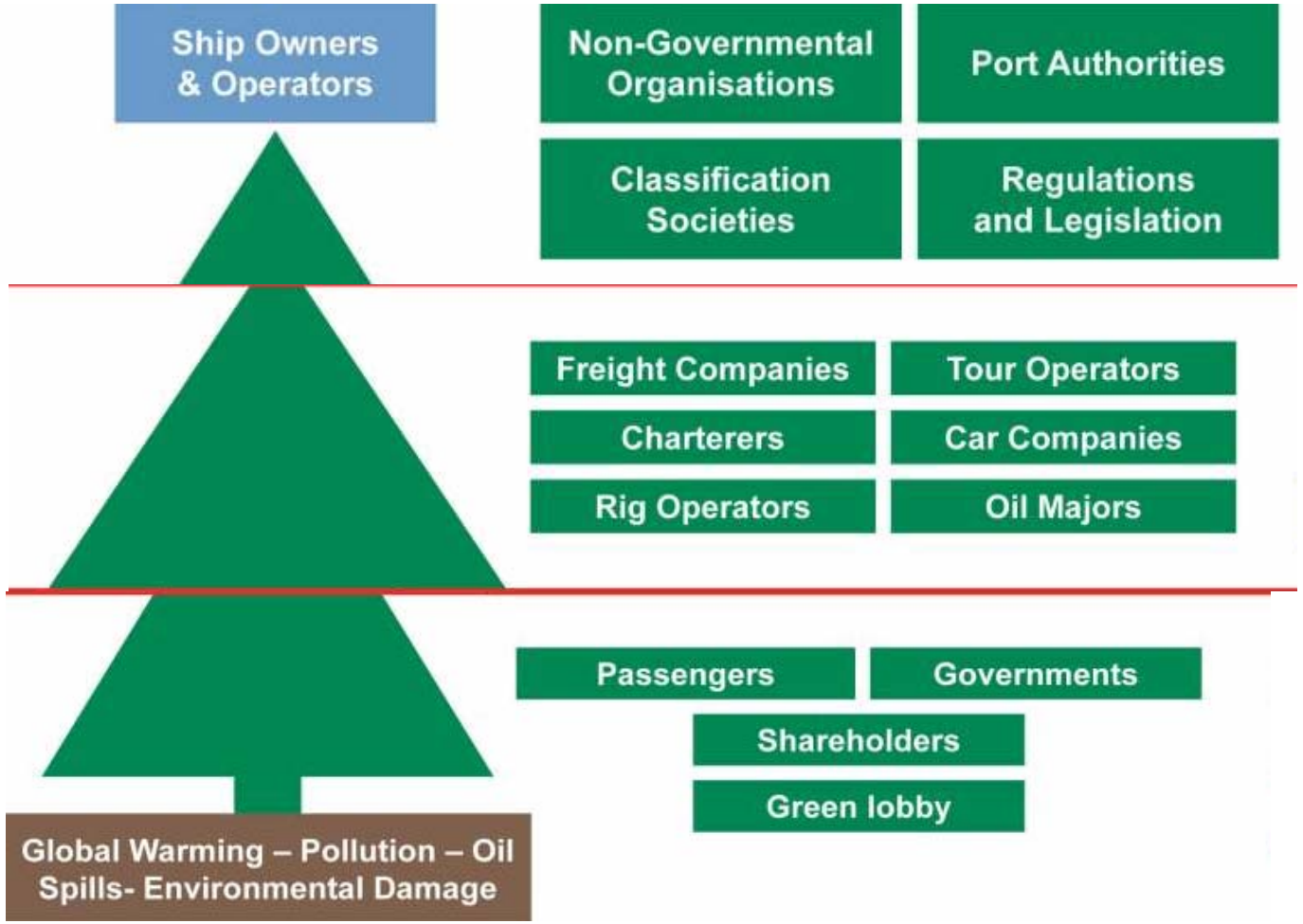
8%: contamination and poor storage

50% of the value of the drum may be lost

Steps to minimizing oil leaks

- Crew training
- Proactive equipment maintenance
- Select the right oil
- Effective Lubricant Management
- Correct disposal of used oil
- Take special care during operation at port

What are the drivers for green behaviour?



Drivers for Being Green

- **“Green” shipping companies are less likely to be targeted by Port and Regulatory bodies to provide time consuming paperwork and inspections and are less likely to be fined**
- **A strong desire to be Green as a result of the company culture and brand positioning (BP)- genuinely care about the environment**
- **It makes sound commercial sense to do so.**
- **Customer’s customers are looking to deal with suppliers and service providers that have strong to environmental credentials.**

bp

Very Green Example

VIKING LINE

THE "CLEAN SHIP" – a possible option

On the clean ship...

7. only environmentally adapted oil is used in the stern tube. The base oil is rapidly degraded in the environment, the additives do not have a high toxicity and they are not persistant nor have they shown to be bioaccumulating. The additives do not constitute a serious health risk and the oil is compatible with the seals that are used.

PORT OF GÖTEBORG

Very Green Examples

THE GREEN STAR DESIGN ADDITIONAL CLASS NOTATION AND LOGO

In April 2004 the Costa Mediterranea, Costa Atlantica and Costa Victoria received the prestigious Green Planet Award, which is assigned each year by Kuoni

Product Range – Environmental Credentials

Much more biodegradable than conventional mineral oils.

Readily biodegradable in the marine environment.

Far less toxic than conventional mineral oils.

Far less potential for bioaccumulation compared to mineral oils

Products leave a sheen to allow leaks to be detected – ethical approach

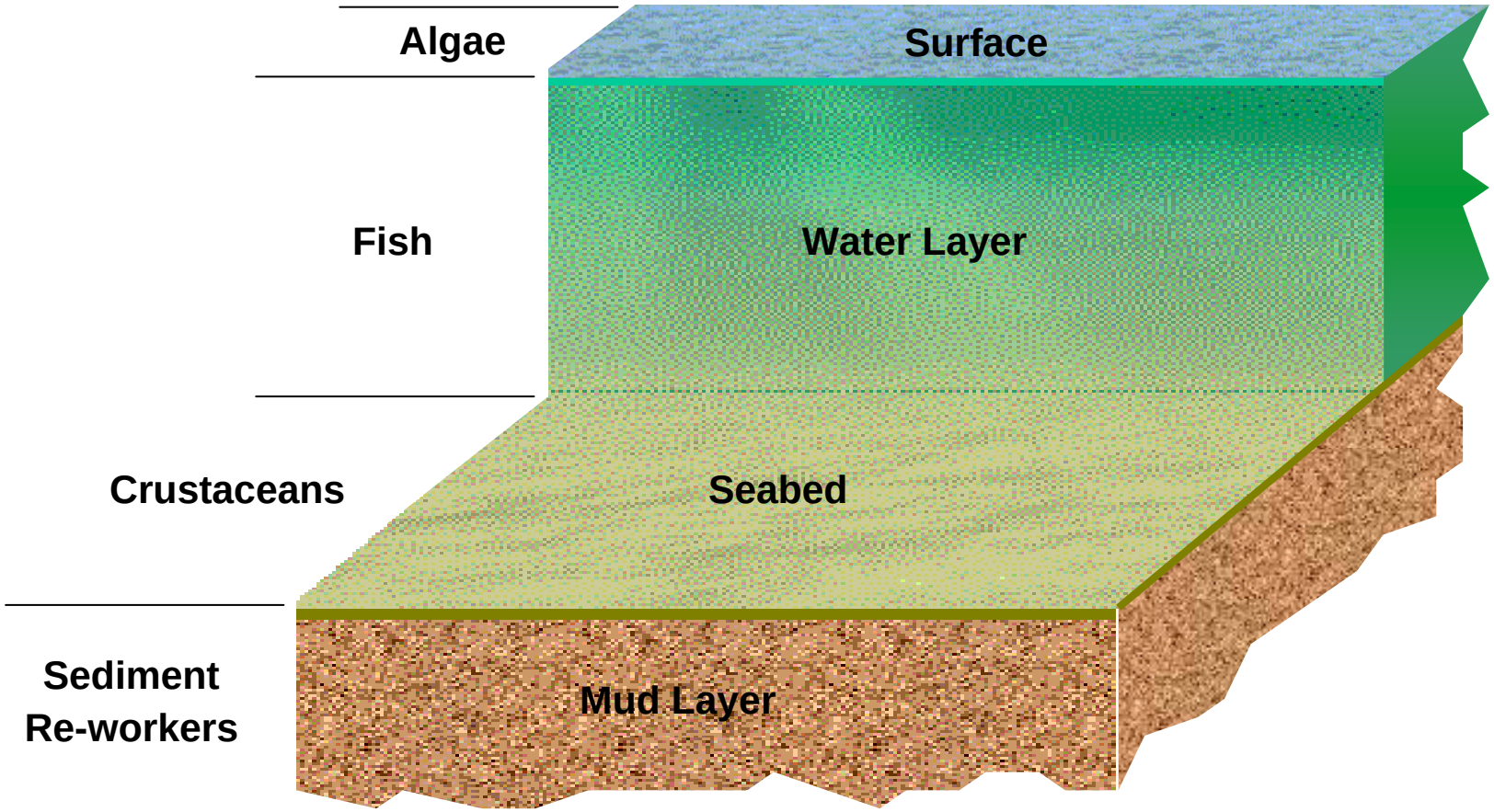
Significant proportion of products (30-80%) is derived from renewable resources

Biodegradation

The tendency of a substance to break down in the environment due to biological action

- Measured by establishing the rate of biodegradation of the substance in seawater over a 28-day period (test method OECD 306)
- Example: Biodegradation = 73% means the substance has biodegraded by 73% over a 28-day period
- The higher the test result the better (i.e. a result of 73% is better than 13%)

Marine Toxicity – Organisms Affected



Toxicity

Toxicity

- The ability of a substance to cause harmful effect.
- The toxic effects of a substance is assessed for all of the key components of the marine and food chain
- Algae – microscopic organisms living on or near the water surface which are the start of the aquatic food chain
- Daphnia- living in the water phase
- Fish - both bottom feeding and free swimming

- Standard test methods for toxicity
  - Algae- OECD 201
  - Daphnia - OECD 202
  - Fish- OECD 203

Environmental requirements

- Biodegradability:
  - A substance that can be broken down by micro-organisms into simple, stable compounds such as carbon dioxide and water

Lubricant + **Micro-organisms + water + oxygen** → **Carbon Dioxide, water + biomass**

  - >60% acc. OECD 306 (sea water) 301B (fresh water)
- Aquatic toxicity:
  - Acute fish toxicity (OECD 203): >100 mg/l
  - Acute Daphnia toxicity (OECD 202): >100 mg/l
  - Acute Algae toxicity (OECD 201): >100 mg/l
- Bioaccumulation:
  - Log Pow values 0-3 or 6-10 acc. OECD 117
- Renewability:
  - Increasingly importance (not in every standard yet); >65% of raw materials from a renewable source.

Product definition

- Base fluids 97-98%
- Additives
  - Anti-oxidants 1-1.5%
  - Metal protection 0.2-0.5%
  - Anti-wear 0.4-0.5%
  - Anti-foam 0.2-0.5%
- ***All additives components should be ashless***
- ***Environmentally acceptable lubricant performance ruled by choice and quality of base fluid***

Base fluids for environmentally acceptable lubricants

- **Vegetable oils**
  - **refined rapeseed, canola, soybean and high oleic sunflower oil breaded or genetically modified crops**
- **Synthetic esters**
  - **synthetic esters based on natural and renewable resources**
  - **fully synthetic esters based on petrochemical raw materials**
- **Synthetics**
  - **Polyalphaolefines (PAO)**
  - **Polyalkelyneglycol (PAG)**
  - **Hydrocracked mineral oil (low viscosity grades)**

Natural esters

- The 2 most commonly used natural oils for lubricants
  - Rapeseed oil
  - Sunflower oil
- Advantages
  - Cost
  - High biodegradability
  - Good lubricity and high load carrying capacity (FZG 10)
- Disadvantages
  - Quality can vary from year to year
  - Very poor oxidation stability for rape seed
  - Moderate to very poor low temperature characteristics

Oleochemical derived esters

- Advantages
  - Cover broad viscosity range (10cSt-1000cSt @ 40°C)
  - Good to very good biodegradability
  - Acceptable Log Kow values (10-25)
  - Not classified as dangerous for the environment
  - Not classified as harmful to aquatic organisms
  - Excellent shear stability
  - Good to excellent oxidation stability
  - Medium to very good low temperature characteristics
- Disadvantages
  - Medium oxidation stability for unsaturated esters
  - Medium biodegradability for dicarboxylic acid esters
  - Medium lubricity for dicarboxylic acid esters

Petrochemical esters

- Advantages
  - Cover broad viscosity range
  - Good to very good biodegradability
  - Excellent shear stability
  - Good to excellent oxidation stability
  - Very good low temperature characteristics
- Disadvantages
  - Under new Eco-label criteria, petrochemical esters will become useful only as co-base fluids and the amount that can be used in a formulation will be dictated by the application in which the lubricant will be used based on renewability

Biodegradability of lubricant base fluids

	% Biodegradability 28 days OECD 301B	% Renewability content
Vegetable oil	70-100	100
Mineral oil	20-40	0
PAO	20-60	0
Alkyl benzene	5-20	0
Diesters	40-75	0-80
Aromatic ester	5-60	0
Polyol ester	20-90	0-85
Complex ester	20-90	0-85
Polyalkylene glycol	10-70	0

- Biodegradability may vary significantly between the different classes of base fluids and is determined mainly by the chemical structure of the base fluid.
- Biodegradability tends to decrease with increasing chain length, branching, aromaticity and saturation and will be influenced by the nature of the structure.

Greendeck Product Range

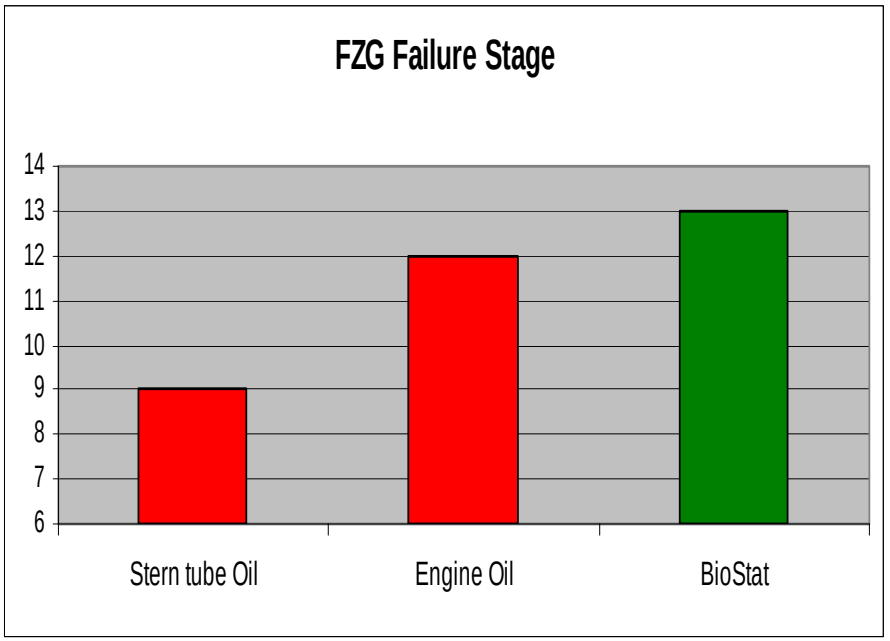
• BIOBAR	Hydraulic Oils
• BIOSTAT	Stern tube Oils
• BIOTRANS	Gear oils
• BIOTAC	Grease

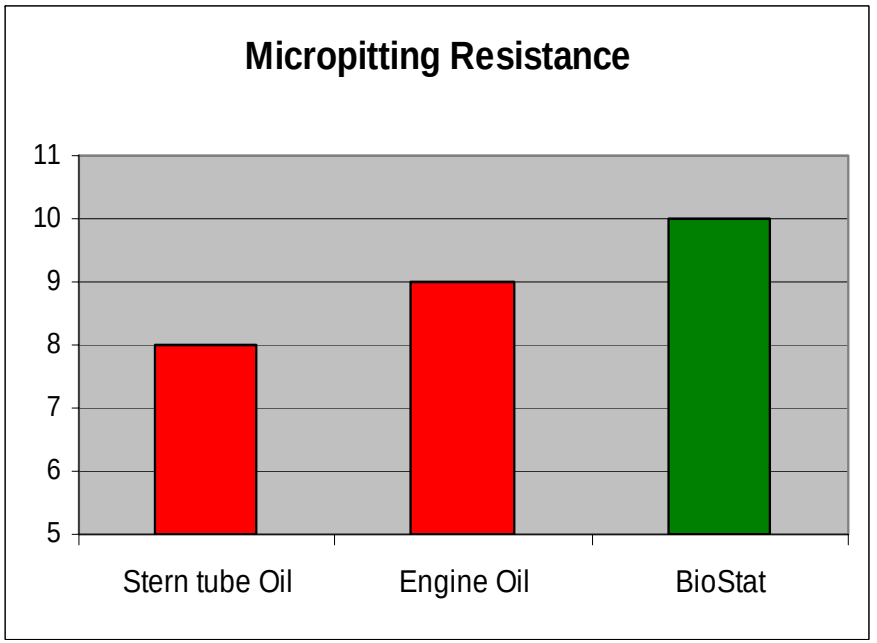
- First to Market with comprehensive range of 10 products
- First with ‘Global availability’
- First Oil Major to launch in Marine

Castrol BioStat Stern Tube oils

- **Product Range -** 68 | 100 | 220
- Specific benefits above and beyond mineral oils and competition
- **Brilliant Gear oil performance – easily exceeds FZG 12 gear benchmark and passes tough micro-pitting gear test. Extremely versatile as a stern tube and gear oil and provides high level of protection to heavily loaded bearings and gears.**
- **Emulsifiable with up to 20% water without compromising technical performance**
- **Lower coefficient of Friction – more energy efficient**
- **Excellent wear and corrosion protection, and oxidation stability providing long term machinery protection and extended oil life**
- **Miscible & Compatible**
  - **Other oils**
  - **Seals & Paints**
  - **Filters**
- **All products supported by relevant OEMs**
- **Meets all relevant performance specifications**

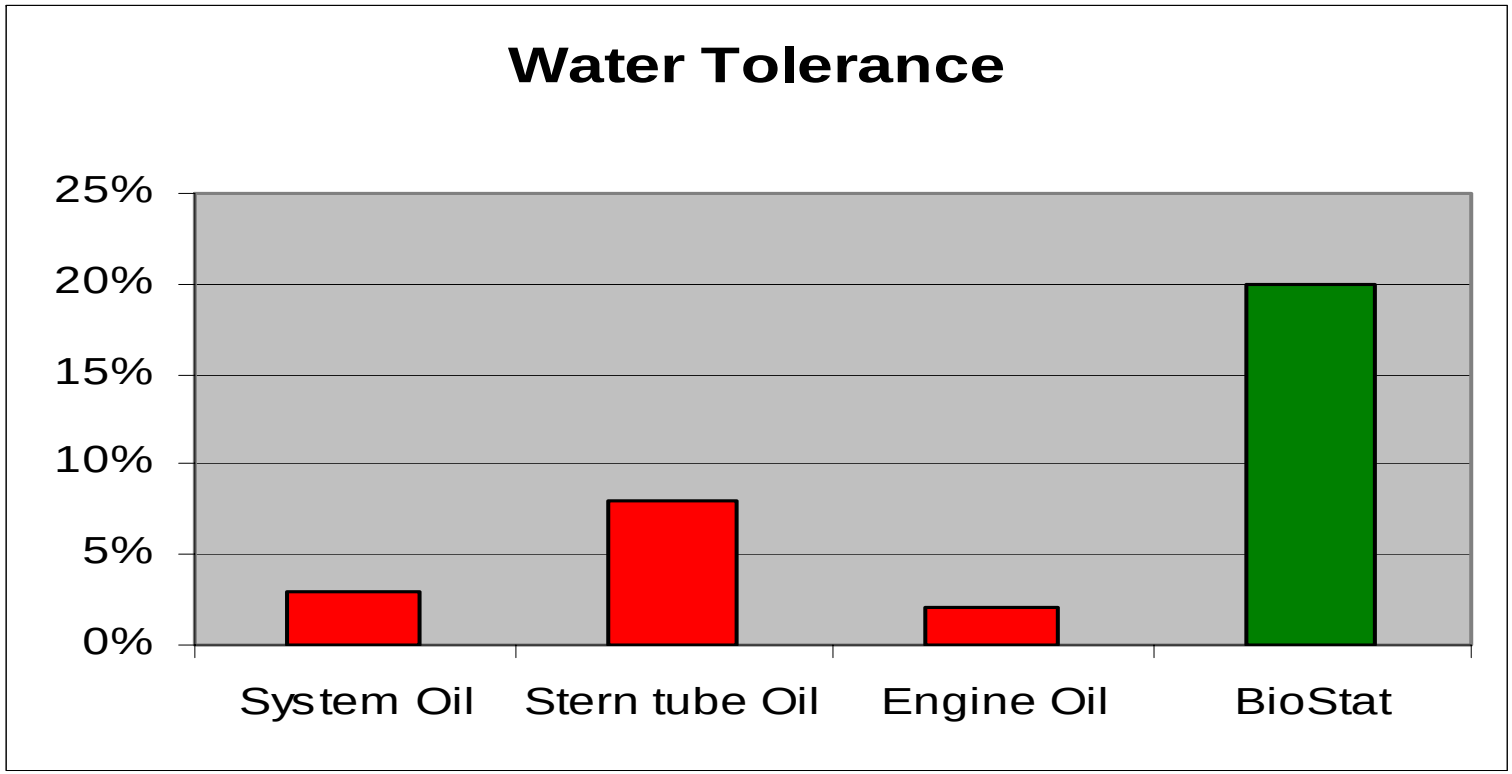
Castrol BioStat Stern Tube oils- Great Gear Oil Performance





Provides high level of protection to heavily loaded bearings and gears extending component life

Castrol BioStat Stern Tube oils – Effective Lubrication when ‘wet’



BioStat continues to provide effective lubrication even when containing up to 20% sea water providing far greater equipment and component protection than conventional oils

BioStat physical and performance test

	TEST METHOD	BIOSTAT 68	BIOSTAT 100	BIOSTAT 150	BIOSTAT 220
PHYSICAL TESTS					
Kinematic Viscosity, cSt @ 40°C	ASTM D445	70	100	150	220
Kinematic Viscosity, cSt @ 100°C	ASTM D445	13.27	16.44	22.44	30.1
Viscosity Index	**ASTM D2270**	**178**	**178**	**178**	**178**
Relative Density	ASTM D4052	0.9	0.93	0.95	0.95
Pour Point, °C	**ASTM D97**	**-36**	**-32**	**-30**	**-25**
Flash Point, °C	ASTM D92	> 240	>240	>240	>240
Steel Corrosion Distilled water Sea Water	ASTM D665	No rusting No rusting	No rusting No rusting	No rusting No rusting	No rusting No rusting
Copper Corrosion (100°C/3 hrs)	ASTM D130	1A	1A	1A	1A
Foaming properties - Seq1	ASTM D892	10/0	10/0	10/0	10/0
Foaming properties - Seq 2	ASTM D892	70/0	70/0	70/0	70/0
Foaming properties - Seq 3	ASTM D892	20/0	20/0	20/0	20/0
Flender foam test	Pass				
Demulsification time, mins	ASTM D1401	0/23/57 (30)	0/23/57 (30)	0/23/57 (30)	0/23/57 (30)
PERFORMANCE TESTS					
Oxidation stability (RPVOT)	ASTM D2272	320	320	320	320
FZG test A/8.3/90	**DIN 51354 Part 2**	**>12**	**>12**	**>12**	**>12**
FZG micropitting test	FVA No 54	>10	>10	>10	>10

Viscosity Range – OEM Approvals

68	100	150	220	320

BioStat Gear/Sterntube Oils

OEM Approvals:

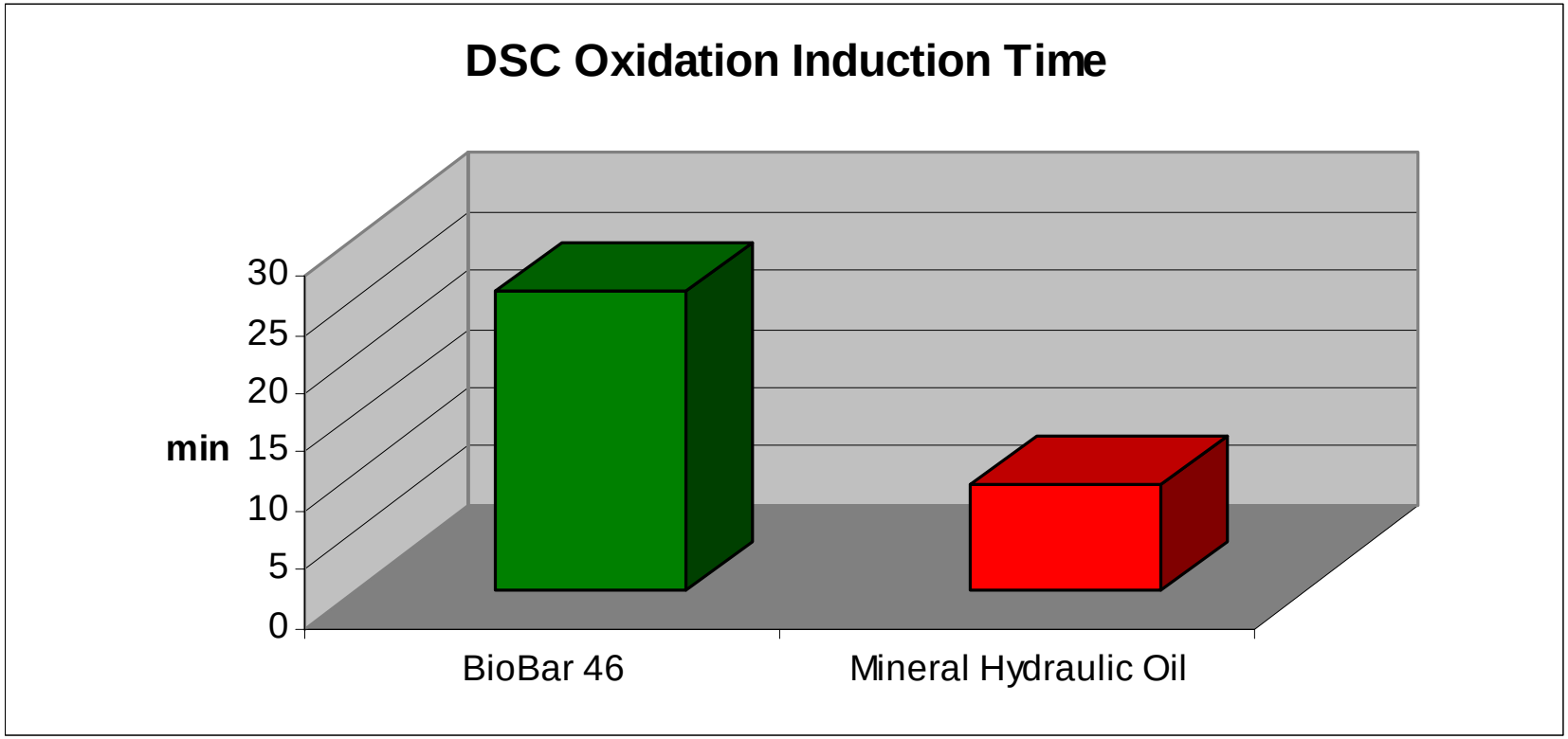
- KaMeWa
- Pusnes
- Rolls Royce (Bratvaag,Rauma)
- Hatlapa **
- Karmøy winch
- McGregor
- Natoil (Hydralift)
- Rolls Royce (Ulstein -Thrusters)**
- Hydramarine
- TTS Marine
- KGW
- Wartsila Railko

- NMF –Cranes
- Flender **
- Reintjes **
- Ja&K**
- Renk **
- Wartsila Propulsion **
- Scana Volda **
- Brunvoll **
- Deep sea Seals/JMT
- Kobelco
- Cedervall
- IHC Lagersmit
- Simplex (no objection letter and sea trial)
- Berg Propeller

Castrol BioBar Hydraulic Oils

- **Product Range -** 32 | 46 | 68 | 100
- Specific benefits above and beyond mineral oils and competition
- **Lower coefficient of Friction and superior density pressure characteristics – more energy efficient and more effective as hydraulic fluid**
- **Excellent wear and corrosion protection, and oxidation stability providing long term machinery protection and extended oil life**
- **High viscosity index and lower pour point compared to mineral oil equivalents allows start-ups at low temperatures and provides for a thicker lubricating film at high temperatures for additional anti-wear protection**
- **Miscible & Compatible**
  - **Other oils**
  - **Seals & Paints**
  - **Filters**
- **All products supported by relevant OEMs**
- **Meet all relevant performance specifications**

Castrol BioBar Hydraulic Oils – Oxidation



Greater oxidation resistance will give extended oil life

BioBar physical test results

	TEST METHOD	BIOBAR 22	BIOBAR 32	BIOBAR 46	BIOBAR 68	BIOBAR 100
PHYSICAL TESTS						
Kinematic Viscosity, cSt @ 40°C	ASTM D445	22	32	47.8	68	100
Kinematic Viscosity, cSt @ 100°C	ASTM D445	4.87	6.4	8.2	11	11
Viscosity Index	**ASTM D2270**	**139**	**145**	**146**	**150**	**150**
Relative Density	ASTM D4052	0.9	0.9	0.91	0.95	0.95
Pour Point, °C	**ASTM D97**	**-45**	**-45**	**-45**	**-30**	**-30**
Flash Point, °C	ASTM D92	226	232	232	230	230
Steel Corrosion Distilled water	ASTM D665	No rusting	No rusting	No rusting	No rusting	No rusting
Sea Water		No rusting	No rusting	No rusting	No rusting	No rusting
Copper Corrosion (100°C/3 hrs)	ASTM D130	1A slight tarnish	1A slight tarnish	1A slight tarnish	1A slight tarnish	1A slight tarnish
Air Release Value, mins	ASTM D3427	4	4	4.5	5	5
Foaming tendency/stability cm^3/cm^3	ASTM D892	20/0	20/0	20/0	50/0	50/0
Demulsification time, mins	ASTM D1401	43/37/0 (15)	43/37/0 (15)	43/37/0 (15)	43/37/0(20)	43/37/0(20)

Specification status

Specification	Hyspin AWH-M	BioBar
Denison HF-0, HF-2	✓	✓
Vickers Eaton I-286-S	✓	✓
Cincinnati Mil.68/69/70	✓	✓
Bosch Rexroth RE90 220	✓	✓
DIN 51524 ptII	✓	✓
AFNOR NF-E 48-603	✓	✓

Viscosity Range – OEM Approvals

22	32	46	68	100	**BioBar Hydraulic Oils**

OEM Approvals:

- Framo
- Pusnes
- Rolls Royce (Bratvaag,Rauma)
- Hatlapa
- Karmøy winch
- McGregor
- Natoil (Hydralift)
- Tenfjord
- Frydenbo
- Hydramarine

- KGW
- NMF –Cranes
- TTS Marine
- Berg Propeller (hydraulic)
- B&V Stabilisers (under testing)

Castrol BioTrans Gear Oils

- **Product Range -** 150 220
- Specific benefits above and beyond mineral oils and competition
- **Exceptional gear oil performance provides high levels of gear protection to maximise reliability and minimise maintenance costs**
- **Approvals from key OEMs for clutch compatibility – common on some deck machinery**
- **Excellent wear and corrosion protection, and oxidation stability providing long term machinery protection and extended oil life**
- **High viscosity index and lower pour point allows start-ups at low temperatures and provides for a thicker lubricating film at high temperatures for additional anti-wear protection**
- **Miscible & Compatible**
  - **Other oils**
  - **Seals & Paints**
  - **Filters**
- **All products supported by relevant OEMs**
- **Meet all relevant performance specifications**

BioTrans physical and performance test

Castrol BioTrans	-	**150**	**220**	**320**	**460**
Viscosity Grade	-	150	220	320	460
Density @ 15°C	kg/m³	960	960	960	970
Viscosity @ 40°C	mm²/s	150	220	320	460
Viscosity @ 100°C	mm²/s	21.6	29.3	38.2	50.5
Viscosity Index	-	170			
Flash point	°C	> 230			
Pour point	°C	-27	-24	-21	-15
Copper corrosion test (100 A 3)	-	1			
Corrosion test	-	0			
Foaming properties @ 25°C	ml	< 50/0			
Foaming properties @ 95°C	ml	< 50/0			
Foaming properties @ 25°C after 95°C	ml	< 50/0			
Flender foam test	-	passed			
SRV test	µ	0.08			
FZG test A/8.3/90	-	> 12			
FZG test A/16.6/90	-	12			
FZG micropitting test		> 10			

Viscosity Range – OEM Approvals

150	220	320	460

BioTrans Gear Oils

OEM Approvals:

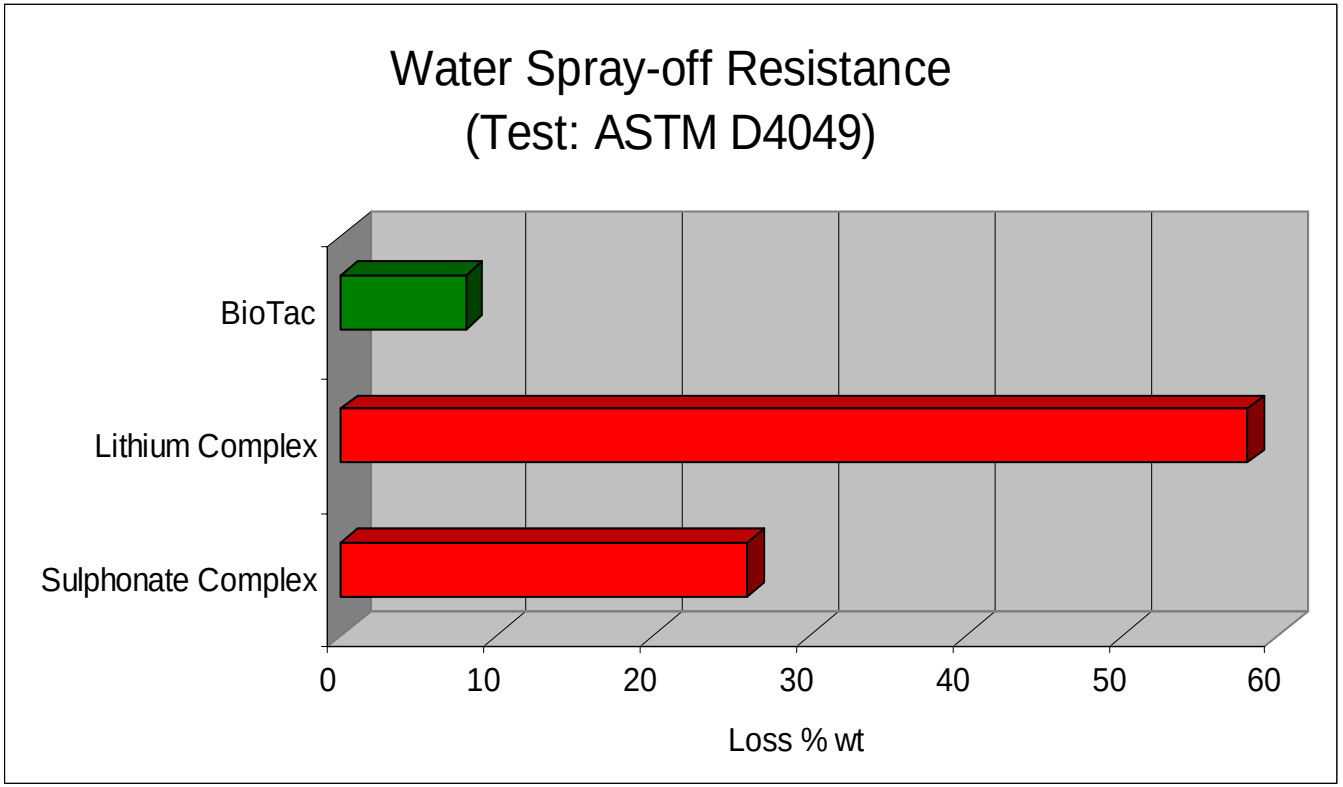
- KaMeWa
- Pusnes
- Rolls Royce (Bratvaag,Rauma)
- Hatlapa
- Karmøy winch
- McGregor
- Natoil (Hydralift)
- Rolls Royce (Ulstein) **
- Hydramarine
- TTS Marine

- KGW
- NMF –Cranes
- Ortlinghaus
- Stromag
- Flender
- Reintjes
- Ja&K
- Renk **
- Wartsila Propulsion
- Scana Volda
- Deep sea seals/JMT

Castrol BioTac EP 2 Grease

- **Product Range – NLGI 2 Grease**
- Specific benefits above and beyond mineral oils and competition
- **Good resistance against water spray off reducing the need for frequent application**
- **Good pumpability at low temperatures with operating temperature range from -35 to 120 °C providing excellent lubrication over wide range of climatic conditions**
- **Good Load carrying capacity and anticorrosion properties protecting equipment and reducing costs**
- **Fully compatible with normal sealing materials, as well as mineral oil based greases.**

Castrol BioTac - Water Spray-off Properties



Depending on operating conditions application frequency may be reduced by 50%

LOOKING AFTER YOUR OILS

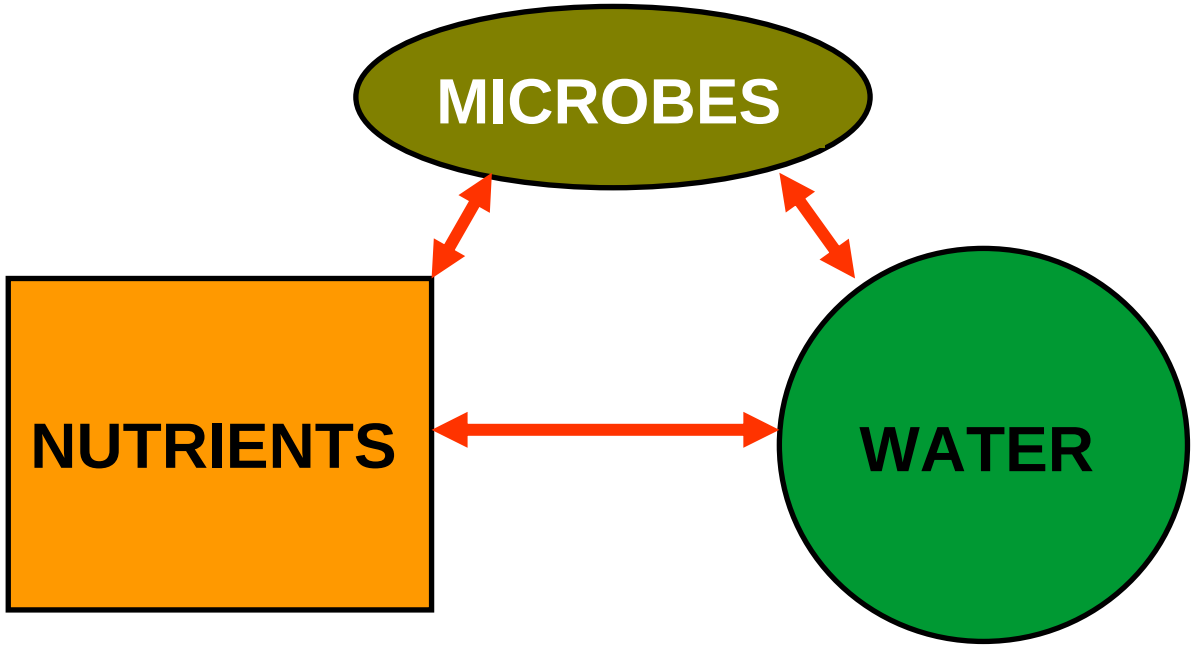
Greendeck

IT'S MORE THAN JUST OIL. IT'S LIQUID ENGINEERING.

Castrol Marine

‘Bugs’ in Oil

- Three most important factors:



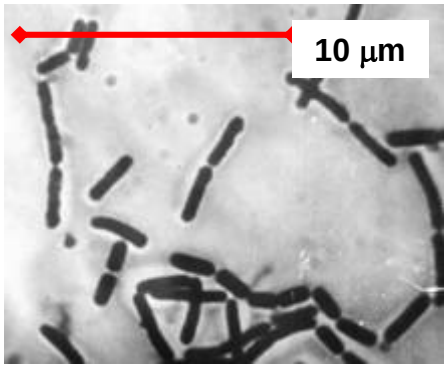
How Microbes cause problems in Oil

- Growth = System fouling
- Hydrocarbons are degraded selectively
- Additives are attacked and removed
- Acids are produced – alkalinity is reduced
- Microbes are surfactant and interfere with oil/water separation
- Microbial growth is corrosive
- Microbes can attack paints and other coatings

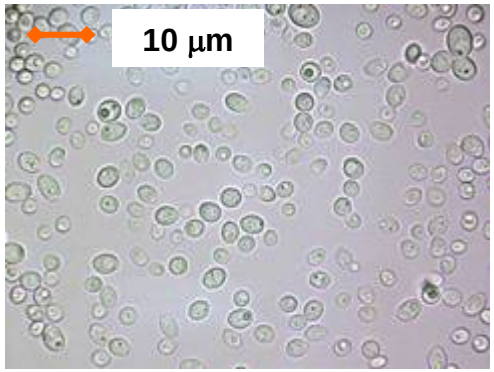
‘Bugs’ in Oil

- Microbes (Bacteria, Yeasts & Moulds) can cause problems with lubricants and fuels on board vessels if
  - Water is present
  - Temperature of oil is around optimum for bugs growth (25-40c)
  - Systems are poorly maintained
  - Parts of the system are not circulated regularly – ‘dead lines’

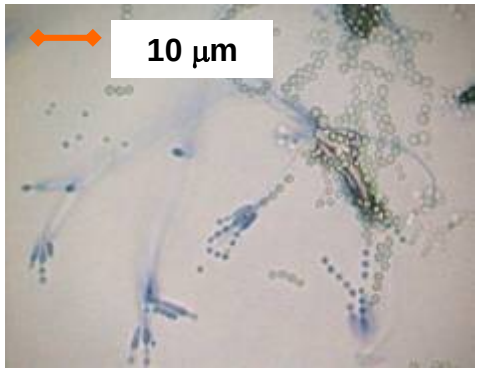
Bacteria



Yeasts

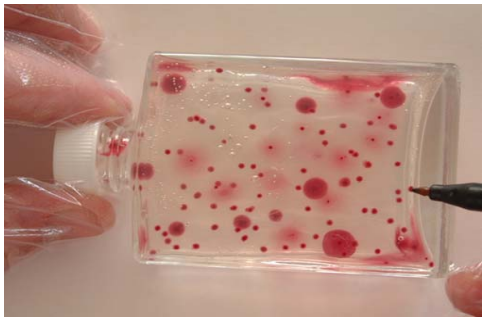


Moulds



We would therefore recommend that initially systems are sampled on a regular basis (monthly) or when other test results or other symptoms suggest infection may be present

‘Bugs’ in Oil



- Testing is recommended one a month for first three months but it is likely that this can be extended once we have gained more field experience.
- Test with MicrobMonitor^2 which has been developed by ECHA Microbiology Ltd. (already marketed by Air BP)
  - Simple to use
  - Can be used on-site / on-board
  - No specialist equipment / facilities required

MicrobMonitor^2 Test Procedure

Incubation

- For ambient temperature systems, incubate at 28 - 30°C for up to 4 days
  - Cheap incubators are available to assist in maintaining this range.
  - Otherwise use any warm location 25 - 30°C
  - A slightly longer incubation time may be required if temperature is below 28°C
  - Very heavy contamination can usually be detected after 1 day at 28 - 30°C
- For hot oil systems (>35°C) incubate at a temperature close to the system temperature

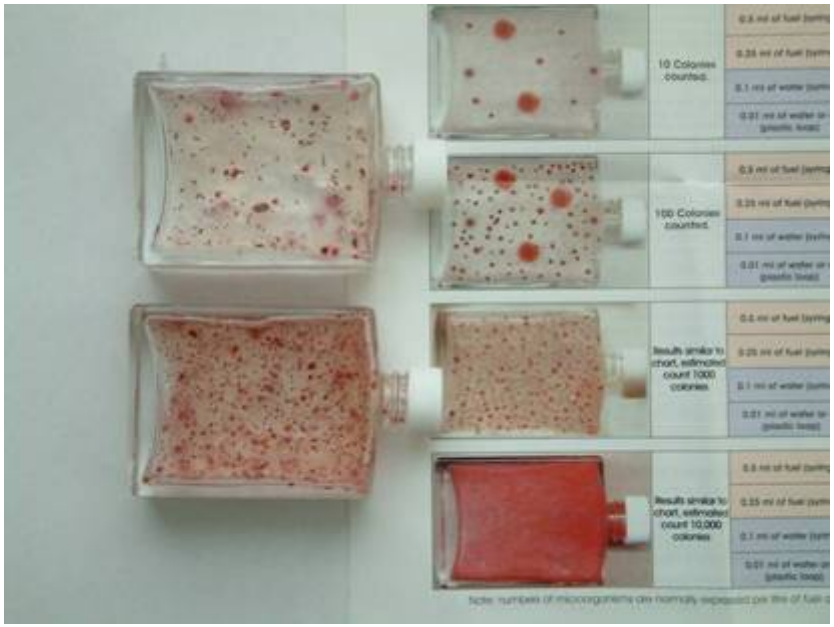
Reading **Microb**Monitor2 Results

For small numbers of colonies

- Count colonies
- Calculate contamination level as colony forming units (cfu) / ml
  - Colony count x 100 = number cfu/ml

For large numbers of colonies

- Compare test to chart
- Read the lower blue line corresponding to the picture showing similar appearance to the test.
- Read the number of cfu / ml in right hand column



Product range - performance benefits

- **Advanced synthetic base oil technology**
- **Superior technical performance**
  - Gears performance – Protection of components
  - Low friction coefficients – Energy savings
- **Wide temperature range**
  - Consistent equipment performance – Improved reliability
- **Miscible & compatible**
  - Other oils
  - Seals & paints
  - Filters
- **All products supported by relevant OEMs**
- **Meet all relevant performance specifications**

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