European Technology Center
Topaasstraat 5 - Postbus 54
7550 AG HENGELO – THE NETHERLANDS
Telephone : +31(0)74 242 81 09
e-mail : info@triple-r-nl.com

DIESEL FUEL FILTRATION TEST

Date	:14-01-2010
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Document name	:Aggreko01
Technical advisor	:Gert van Vliet

CONTENTS

1. INTRODUCTION

1.1 Background of the project

Brief history

After meeting with Jan van Laar (Operations Manager Benelux) at Aggreko Netherlands to discuss the possibilities of Triple R depth filtration systems in relation to fleet benefits, Jan van Laar advised us to contact Tom Sreeves (Managing Director). Regarding system changes, innovations and new built generators Aggreko Manufacturing is leading within the Aggreko Group.

Aggreko is interested in additional filtration of fuel of their larger aggregates. the maintenance costs of their fuel pumps (Bosch) and their injectors are considerably high.

After consultation on site by Aggreko Manufacturing, Craig Williams and Gert van Vliet (European Technology Center) there has been decided to examine in advance:

"What are the results of the cleanness levels of fuel by using Triple R depth filtration systems"

2 DISCRIPTION OF THE PROJECT

2.1 Goal

Aggreko is interested in additional filtration of fuel for their larger aggregates. the maintenance costs of their fuel pumps (Bosch) and their injectors are considerably high.

After consultation on site by Aggreko there has been decided to examine in advance;

"What are the results of the cleanliness level of fuel by using Triple R inline filtration ?"

3 PROJECT APPROACH

3.1 Project setup

It was impossible to send different fuel samples to Hengelo (the Netherlands) to start a filtration test. Therefore there has been decided to start a test with 4 fuel samples, taken at 4 different filling stations in the Netherlands

In advance 4 different fuel samples of 100 liter diesel each were tested on contamination level. The fuel was supplied in clean barrels.

In our European Technology Centre(E.T.C.) in Hengelo each barrel was well mixed by using a double working air-membrane pump. During this process samples were taken. These 4 samples have been sent to an independent analysis agency (Filtrex) to be analysed on:

1. Level of contamination (NAS)
2. Water (PPM)
3. Aging products (..%)

We requested Filtrex to sent us a membrane of the different oil samples as well. This to generate a visual reproduction of the cleanliness level in relation to the different samples.

3.2 Sample analyses

Based on the analyses results coming from Filtrex we have a reliable overview of the different types of diesel. NAS, PPM and aging products are well documented and analyzed.

Results:

Tinq-station 1 (LAB REF: 092744)
- NAS 10, light brown coloured membrane.
- aging products 15%
- water quality 88 PPM
-

Polar Bear station (LAB REF: 092744)
- NAS 9, light brown coloured membrane
- aging products 30%
- water quality 46 PPM

The White Pump (LAB REF: 092744)
- NAS 9, light brown coloured membrane
- aging products 10%
- water quality 24 PPM

Tinq station 2 (LAB REF: 092744)
- NAS 9, light brown coloured membrane
- aging products 20%
- water quality 42 PPM

On the next pages you will find a detailed overview of the different Lab analyses.

LABORATORY REPORT.

LAB REF.	:	**092744**
COMPANY	:	**Triple - R Nederland BV**
ATTN.	:	**Gert van Vliet**
SAMPLE NO.	:	**1**
NO. SAMPLES	:	**4**

FILTREX SERVICES POSTBUS 912 -2300 AX -LEIDEN - TEL (0031)(0)71-528 8688

LAB REF.: 092744 **SAMPLE NO.: 1**

Customer	: **Triple - R Nederland BV**		
User	: **Tinq Hengelo**		
Make machine	:	Type machine	:
Type of oil	: **- Normale Diesel -**	Serial number	: **1**
Sampling place	: **from drum**	Date	: **23-12-2009**

PROCEDURE TO ESTIMATE THE NUMBER OF PARTICLES.

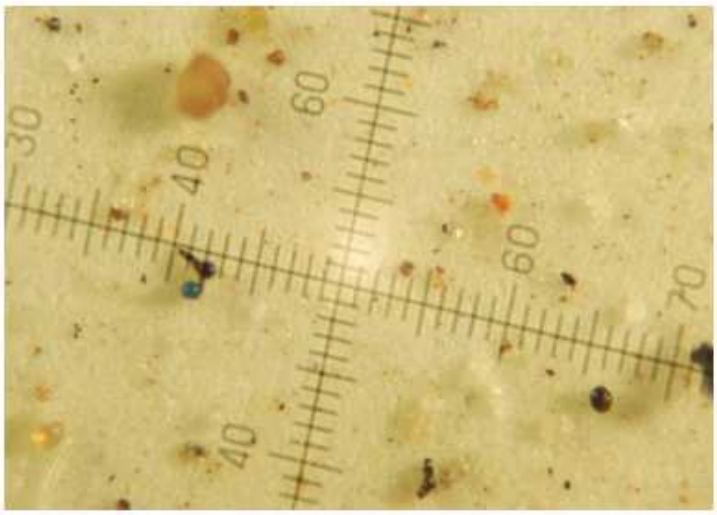
Pore size filter disc	: **0,8 micron**
Sampled volume	: **100 ml (Standard volume = 100 ml)**
Method of particle count	: **NAS / Microscope**

PARTICLE COUNTING.

NUMBER OF PARTICLES PER 1OOML	> 2 µm	**304954**
	> 5 µm	**137561**
	> 15 µm	**18310**
	> 25 µm	**3219**
	> 50 µm	**1410**
COLOUR TEST FILTER DISC		**l. brown**
NAS CLASSIFICATION ACC.NAS AS 4059		**10**

PARTICLES IDENTIFICATION.

Black metal	:	**65 %**
Weld. sparks	:	**%**
Bright metal	:	**5 %**
Rust	:	**%**
Sand	:	**5 %**
Fibres	:	**5 %**
Synthetics	:	**5 %**
Cupper	:	**%**
Resin	:	**15 %**



1 Div = 15 Micron

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LAB REF.: 092744 **SAMPLE NO.: 1**

WATER DETERMINATION TEST .

Water concentration: **88 PPM** (accuracy <5 PPM) Normal
Disapproval app. **0,05 %** Methode Karl Fischer Coulometric

REMARKS / ADVICE.

The oil is contaminated with metal, sand and plastic particles.

The degradation by-product level of the oil in the form of varnish is found to be at: 30 %
The varnish level is scaled as:

Low	0 - 30%
Medium	30 - 60%
High	60 - 100%

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LAB REF.: 092744 **SAMPLE NO.: 1**

Customer	: **Triple - R Nederland BV**	User	: **Tinq Hengelo**
Make (machine)	:	Type (machine)	:
Date	: **23-12-2009**	Executed by	:

CONTAMINATION CLASSIFICATION
ACCORDING NAS AS 4059
CLASS : 10

CLASS	Max. number of particles per 100 ml fluid after their size ranges.				
	>2	>5	>15	>25	>50
000	195	76	14	3	1
00	390	152	27	5	1
0	780	304	54	10	2
1	1.560	609	109	20	4
2	3.120	1.220	217	39	7
3	6.520	2.430	432	76	13
4	12.500	4.860	864	152	26
5	25.000	9.730	1.730	306	53
6	50.000	19.500	3.460	612	106
7	100.000	38.900	6.920	1.220	212
8	200.000	77.900	13.900	2.450	424
9	400.000	156.000	27.700	4.900	848
10	800.000	311.000	55.400	9.800	1.700
11	1.600.000	623.000	111.000	19.600	3.390
12	3.200.000	1.250.000	222.000	39.200	6.780

RECOMMENDED CONTAMINATION LEVEL FOR HYDRAULIC SYSTEMS.

4-6	Silt sensitive systems aerospace or laboratory.	5,5 kg*
6	Critical systems general servo systems.	11 kg*
7	High quality general proportional valves.	22 kg*
8	Medium pressure systems.	44 kg*
9	Low pressure systems with large clearances.	90 kg*
>10	Not suitable for hydraulic systems.	>190 kg*

* "If the oil passes through a pump with the capacity of 200 ltr/min., 8 hours a day, 230 working days per year the amount of dirt passing the pump per year is listed above with coresponding NAS code" .

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LAB REF.: 092744 **SAMPLE NO.: 2**

Customer	: **Triple - R Nederland BV**		
User	: **IJsbeer Deurningen**		
Make machine	:	Type machine	:
Type of oil	: **- Normale Diesel -**	Serial number	: **2**
Sampling place	: **from drum**	Date	: **23-12-2009**

PROCEDURE TO ESTIMATE THE NUMBER OF PARTICLES.

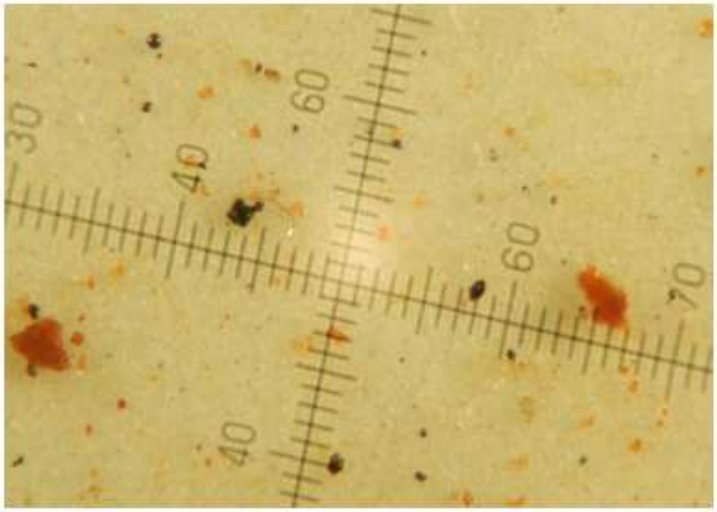
Pore size filter disc	: **0,8 micron**
Sampled volume	: **100 ml (Standard volume = 100 ml)**
Method of particle count	: **NAS / Microscope**

PARTICLE COUNTING.

NUMBER OF PARTICLES PER 100ML	> 2 µm	**223184**
	> 5 µm	**123136**
	> 15 µm	**9425**
	> 25 µm	**2697**
	> 50 µm	**767**
COLOUR TEST FILTER DISC		**l. brown**
NAS CLASSIFICATION ACC.NAS AS 4059		**9**

PARTICLES IDENTIFICATION.

Black metal	:	**55 %**
Weld. sparks	:	**%**
Bright metal	:	**5 %**
Rust	:	**%**
Sand	:	**5 %**
Fibres	:	**5 %**
Synthetics	:	**%**
Cupper	:	**%**
Resin	:	**30 %**



1 Div = 15 Micron

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LAB REF.: 092744 **SAMPLE NO.: 2**

WATER DETERMINATION TEST .

Water concentration: **46 PPM** (accuracy <5 PPM) Normal
Disapproval app. **0,05 %** Methode Karl Fischer Coulometric

REMARKS / ADVICE.

The oil is contaminated with metal, sand and plastic particles.

The degradation by-product level of the oil in the form of varnish is found to be at: 40 %
The varnish level is scaled as:

Low	0 - 30%
Medium	30 - 60%
High	60 - 100%

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LAB REF.: 092744 **SAMPLE NO.: 2**

Customer	: **Triple - R Nederland BV**	User	: **IJsbeer Deurningen**
Make (machine)	:	Type (machine)	:
Date	: **23-12-2009**	Executed by	:

CONTAMINATION CLASSIFICATION
ACCORDING NAS AS 4059
CLASS : 9

CLASS	Max. number of particles per 100 ml fluid after their size ranges.				
	>2	>5	>15	>25	>50
000	195	76	14	3	1
00	390	152	27	5	1
0	780	304	54	10	2
1	1.560	609	109	20	4
2	3.120	1.220	217	39	7
3	6.520	2.430	432	76	13
4	12.500	4.860	864	152	26
5	25.000	9.730	1.730	306	53
6	50.000	19.500	3.460	612	106
7	100.000	38.900	6.920	1.220	212
8	200.000	77.900	13.900	2.450	424
9	400.000	156.000	27.700	4.900	848
10	800.000	311.000	55.400	9.800	1.700
11	1.600.000	623.000	111.000	19.600	3.390
12	3.200.000	1.250.000	222.000	39.200	6.780

RECOMMENDED CONTAMINATION LEVEL FOR HYDRAULIC SYSTEMS.

4-6	Silt sensitive systems aerospace or laboratory.	5,5 kg*
6	Critical systems general servo systems.	11 kg*
7	High quality general proportional valves.	22 kg*
8	Medium pressure systems.	44 kg*
9	Low pressure systems with large clearances.	90 kg*
>10	Not suitable for hydraulic systems.	>190 kg*

* "If the oil passes through a pump with the capacity of 200 ltr/min., 8 hours a day, 230 working days per year the amount of dirt passing the pump per year is listed above with coresponding NAS code" .

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LAB REF.: 092744 **SAMPLE NO.: 3**

Customer	: **Triple - R Nederland BV**		
User	: **Witte pomp Deurningen**		
Make machine	:	Type machine	:
Type of oil	: **- Normale Diesel -**	Serial number	: **3**
Sampling place	: **from drum**	Date	: **23-12-2009**

PROCEDURE TO ESTIMATE THE NUMBER OF PARTICLES.

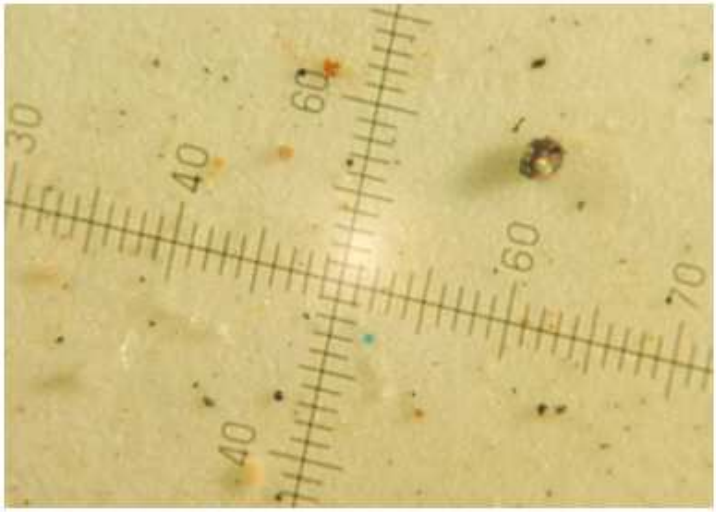
Pore size filter disc	: **0,8 micron**
Sampled volume	: **100 ml (Standard volume = 100 ml)**
Method of particle count	: **NAS / Microscope**

PARTICLE COUNTING.

NUMBER OF PARTICLES PER 100ML	> 2 µm	**307071**
	> 5 µm	**113901**
	> 15 µm	**8286**
	> 25 µm	**3619**
	> 50 µm	**519**
COLOUR TEST FILTER DISC		**l. brown**
NAS CLASSIFICATION ACC.NAS AS 4059		**9**

PARTICLES IDENTIFICATION.

Black metal	:	**70 %**
Weld. sparks	:	**%**
Bright metal	:	**5 %**
Rust	:	**%**
Sand	:	**5 %**
Fibres	:	**5 %**
Synthetics	:	**5 %**
Cupper	:	**%**
Resin	:	**10 %**



1 Div = 15 Micron

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LAB REF.: 092744 **SAMPLE NO.: 3**

WATER DETERMINATION TEST .

Water concentration: **24 PPM** (accuracy <5 PPM) Normal
Disapproval app. **0,05 %** Methode Karl Fischer Coulometric

REMARKS / ADVICE.

The oil is contaminated with metal, sand and plastic particles.

The degradation by-product level of the oil in the form of varnish is found to be at: <10 %
The varnish level is scaled as:

Low	0 - 30%
Medium	30 - 60%
High	60 - 100%

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LAB REF.: 092744 **SAMPLE NO.: 3**

Customer	: **Triple - R Nederland BV**	User	: **Witte pomp Deurningen**
Make (machine)	:	Type (machine)	:
Date	: **23-12-2009**	Executed by	:

CONTAMINATION CLASSIFICATION
ACCORDING NAS AS 4059
CLASS : 9

CLASS	Max. number of particles per 100 ml fluid after their size ranges.				
	>2	>5	>15	>25	>50
000	195	76	14	3	1
00	390	152	27	5	1
0	780	304	54	10	2
1	1.560	609	109	20	4
2	3.120	1.220	217	39	7
3	6.520	2.430	432	76	13
4	12.500	4.860	864	152	26
5	25.000	9.730	1.730	306	53
6	50.000	19.500	3.460	612	106
7	100.000	38.900	6.920	1.220	212
8	200.000	77.900	13.900	2.450	424
9	400.000	156.000	27.700	4.900	848
10	800.000	311.000	55.400	9.800	1.700
11	1.600.000	623.000	111.000	19.600	3.390
12	3.200.000	1.250.000	222.000	39.200	6.780

RECOMMENDED CONTAMINATION LEVEL FOR HYDRAULIC SYSTEMS.

4-6	Silt sensitive systems aerospace or laboratory.	5,5 kg*
6	Critical systems general servo systems.	11 kg*
7	High quality general proportional valves.	22 kg*
8	Medium pressure systems.	44 kg*
9	Low pressure systems with large clearances.	90 kg*
>10	Not suitable for hydraulic systems.	>190 kg*

* "If the oil passes through a pump with the capacity of 200 ltr/min., 8 hours a day, 230 working days per year the amount of dirt passing the pump per year is listed above with coresponding NAS code" .

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LAB REF.: 092744 **SAMPLE NO.: 4**

Customer	: **Triple - R Nederland BV**		
User	: **Tinq Deurningen**		
Make machine	:	Type machine	:
Type of oil	: **- Normale Diesel -**	Serial number	: **4**
Sampling place	: **from drum**	Date	: **23-12-2009**

PROCEDURE TO ESTIMATE THE NUMBER OF PARTICLES.

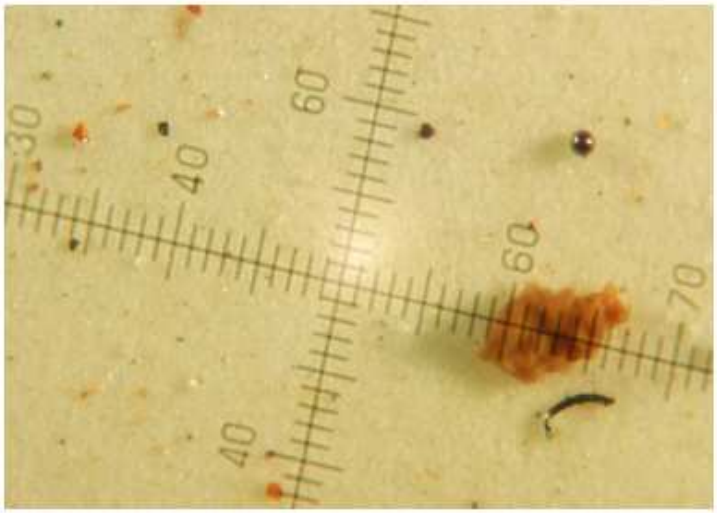
Pore size filter disc	: **0,8 micron**
Sampled volume	: **100 ml (Standard volume = 100 ml)**
Method of particle count	: **NAS / Microscope**

PARTICLE COUNTING.

NUMBER OF PARTICLES PER 100ML	> 2 µm	**141413**
	> 5 µm	**51948**
	> 15 µm	**6967**
	> 25 µm	**2839**
	> 50 µm	**750**
COLOUR TEST FILTER DISC		**l. brown**
NAS CLASSIFICATION ACC.NAS AS 4059		**9**

PARTICLES IDENTIFICATION.

Black metal	:	**60 %**
Weld. sparks	:	**%**
Bright metal	:	**5 %**
Rust	:	**%**
Sand	:	**5 %**
Fibres	:	**5 %**
Synthetics	:	**5 %**
Cupper	:	**%**
Resin	:	**20 %**



1 Div = 15 Micron

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LAB REF.: 092744 **SAMPLE NO.: 4**

WATER DETERMINATION TEST .

Water concentration: **42 PPM** (accuracy <5 PPM) Normal
Disapproval app. **0,05 %** Methode Karl Fischer Coulometric

REMARKS / ADVICE.

The oil is contaminated with metal, sand and plastic particles.

The degradation by-product level of the oil in the form of varnish is found to be at: 25 %
The varnish level is scaled as:

Low	0 - 30%
Medium	30 - 60%
High	60 - 100%

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LAB REF.: 092744 **SAMPLE NO.: 4**

Customer	: **Triple - R Nederland BV**	User	: **Tinq Deurningen**
Make (machine)	:	Type (machine)	:
Date	: **23-12-2009**	Executed by	:

CONTAMINATION CLASSIFICATION
ACCORDING NAS AS 4059
CLASS : 9

CLASS	Max. number of particles per 100 ml fluid after their size ranges.				
	>2	>5	>15	>25	>50
000	195	76	14	3	1
00	390	152	27	5	1
0	780	304	54	10	2
1	1.560	609	109	20	4
2	3.120	1.220	217	39	7
3	6.520	2.430	432	76	13
4	12.500	4.860	864	152	26
5	25.000	9.730	1.730	306	53
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9	400.000	156.000	27.700	4.900	848
10	800.000	311.000	55.400	9.800	1.700
11	1.600.000	623.000	111.000	19.600	3.390
12	3.200.000	1.250.000	222.000	39.200	6.780

RECOMMENDED CONTAMINATION LEVEL FOR HYDRAULIC SYSTEMS.

4-6	Silt sensitive systems aerospace or laboratory.	5,5 kg*
6	Critical systems general servo systems.	11 kg*
7	High quality general proportional valves.	22 kg*
8	Medium pressure systems.	44 kg*
9	Low pressure systems with large clearances.	90 kg*
>10	Not suitable for hydraulic systems.	>190 kg*

* "If the oil passes through a pump with the capacity of 200 ltr/min., 8 hours a day, 230 working days per year the amount of dirt passing the pump per year is listed above with coresponding NAS code" .

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3.3 Selection of the medium

Based on the analysis results of the diesel samples we chose to conduct the filtration test on the most highly contaminated diesel;

Tinq-station 1 (LAB REF: 092744)

- NAS 10, light brown coloured membrane.
- aging products 15%
- water quality 88 PPM

3.4 Filtration of the Tinq-station 1 diesel

To filter the medium a test unit was made at the E.T.C. based on the Triple R SE 100 series (Motor/ pump combination filtration unit).

Due to the poor liquid we had to fit in a special pump to generate a better flow of the medium.

Specification on the used hoses (Return/ suction) as follows;

- Return ¼"
- Suction 3/8"

After configuring the filtration system the unit was placed above the barrel with the medium (image 1)

(*image 1*)

The filter housing of the SE series filtration unit is fitted with a Triple R D-100 filter insert (image 2 gives the specifications of the filter element).

The suction hose is placed on the bottom of the barrel and the return hose is exiting the barrel below the liquid/ fluid level.

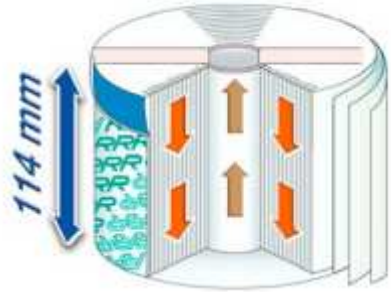
Starting the SE 100 filtration system a 3L(liter) flow per minute is generated resulting in a 1,5 BAR pressure @19°C (image 3). After 60 minutes of constant filtration a sample was taken and sent to Filtrex.

During sampling the flow of the SE 100 filtration system is still 3L per minute and 1,5 BAR pressure @19°C.

(Image 2)

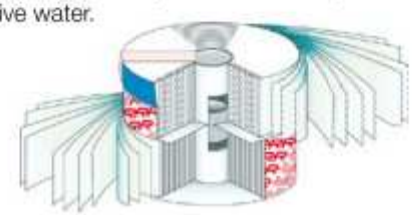
The Triple R 3-stage filtration concept.

- The axial flow creates a **114 mm** thick filter buildup.
- The combination of Triple R's special cellulose material and the thickness of the element allows absorbing of water and sludge.
- The lower part is compressed by a carton box, creating an even finer filter medium.



1. Big particles stay on top of the element.
2. Smaller particles are captured in the upper non-compressed part.
3. The smallest particles are captured in the lower compressed part.

Our filter elements are designed to *cleanse* industrial oils, removing everything from **solid particles** to **water** to **sludge, varnish and oxidation residues**. All within a single element - a *Triple R* unique, unmatched by any filter manufacturer worldwide.

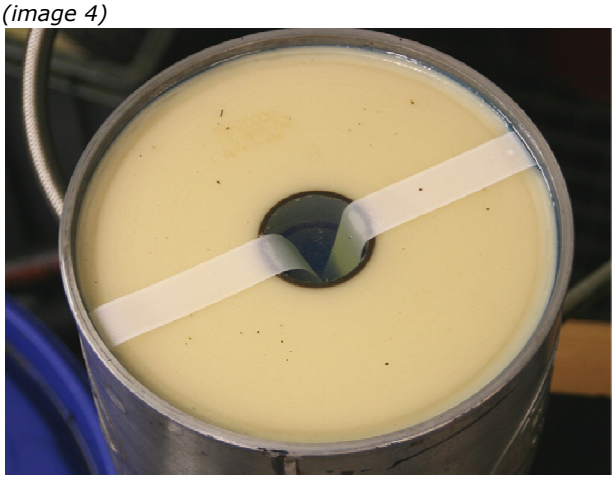
	D-series - β_2 >75	
Model	**D100**	**D300**
Article nr.	TR-20000	TR-20515
Dimensions	Ø179 x H114	Ø303 x H114
Triple R Filter system	BU100/200/300E SE100 up to SE600 AL100, OSCA AL-series SU/SS102, SU/SS103	SS305
Element height **114** mm		
	Features: - 2µ absolute filter elements. - 2 stage build, with M-filter medium at the upper part and X-filter medium at the lower part. Separated by a non-woven disc, to protect the lower part in case of excessive water. 	

Gauge showing the pressure during filtration process (image 3)

3.5 Visual inspection after filtration

Visual inspection of the D-100 filter element after filtration shows dirt particles on top of the element (image 4 & 5)

(image 4)



(image 5)

The oil sample taken from the filtered medium looks impressively clean (image 6)

(image 6)

4 FINAL RESULTS

4.1 Cleanliness level/ number

The analysis report is very satisfactory. The cleanliness level from the diesel after filtration changed from a NAS 10 to a NAS 5. The analyses report coming from Filtrex (LAB REF: 100102e) gives a clear picture.

LABORATORY REPORT.

LAB REF.	:	**100102e**
COMPANY	:	**Triple - R Nederland BV**
ATTN.	:	**Gert van Vliet**
SAMPLE NO.	:	**5**

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LAB REF.: 100102e **SAMPLE NO.: 5**

Customer	: **Triple - R Nederland BV**		
User	: **Tinq Hengelo**		
Make machine	:	Type machine	:
Type of oil	: **- Normale Diesel -**	Serial number	: **5**
Sampling place	: **from drum**	Date	: **31-12-2009**

PROCEDURE TO ESTIMATE THE NUMBER OF PARTICLES.

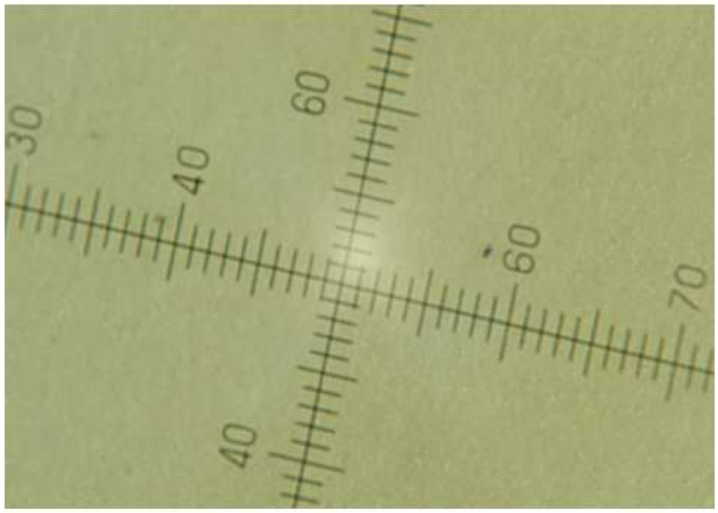
Pore size filter disc	: **0,8 micron**
Sampled volume	: **100 ml (Standard volume = 100 ml)**
Method of particle count	: **NAS / Microscope**

PARTICLE COUNTING.

NUMBER OF PARTICLES PER 1OOML	> 2 µm	**3463**
	> 5 µm	**2308**
	> 15 µm	**598**
	> 25 µm	**198**
	> 50 µm	**21**
COLOUR TEST FILTER DISC		**white**
NAS CLASSIFICATION ACC.NAS AS 4059		**5**

PARTICLES IDENTIFICATION.

Black metal	:	**70** %
Weld. sparks	:	%
Bright metal	:	**15** %
Rust	:	%
Sand	:	%
Fibres	:	**5** %
Synthetics	:	**5** %
Cupper	:	%
Resin	:	**5** %



1 Div = 15 Micron

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LAB REF.: 100102e **SAMPLE NO.: 5**

WATER DETERMINATION TEST .

Water concentration: **33 PPM** (accuracy <5 PPM) Normal
Disapproval app. **0,05 %** Methode Karl Fischer Coulometric

REMARKS / ADVICE.

Contamination level of the oil reviewed as good.

The degradation by-product level of the oil in the form of varnish is found to be at: <10 %
The varnish level is scaled as:

Low	0 - 30%
Medium	30 - 60%
High	60 - 100%

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LAB REF.: 100102e **SAMPLE NO.: 5**

Customer	: **Triple - R Nederland BV**	User	: **Tinq Hengelo**
Make (machine)	:	Type (machine)	:
Date	: **31-12-2009**	Executed by	:

CONTAMINATION CLASSIFICATION
ACCORDING NAS AS 4059
CLASS : 5

CLASS	Max. number of particles per 100 ml fluid after their size ranges.				
	>2	>5	>15	>25	>50
000	195	76	14	3	1
00	390	152	27	5	1
0	780	304	54	10	2
1	1.560	609	109	20	4
2	3.120	1.220	217	39	7
3	6.520	2.430	432	76	13
4	12.500	4.860	864	152	26
5	25.000	9.730	1.730	306	53
6	50.000	19.500	3.460	612	106
7	100.000	38.900	6.920	1.220	212
8	200.000	77.900	13.900	2.450	424
9	400.000	156.000	27.700	4.900	848
10	800.000	311.000	55.400	9.800	1.700
11	1.600.000	623.000	111.000	19.600	3.390
12	3.200.000	1.250.000	222.000	39.200	6.780

RECOMMENDED CONTAMINATION LEVEL FOR HYDRAULIC SYSTEMS.

4-6	Silt sensitive systems aerospace or laboratory.	5,5 kg*
6	Critical systems general servo systems.	11 kg*
7	High quality general proportional valves.	22 kg*
8	Medium pressure systems.	44 kg*
9	Low pressure systems with large clearances.	90 kg*
>10	Not suitable for hydraulic systems.	>190 kg*

* "If the oil passes through a pump with the capacity of 200 ltr/min., 8 hours a day, 230 working days per year the amount of dirt passing the pump per year is listed above with coresponding NAS code" .

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4.2 Comparing the figures

If we compare the different analyses reports we get an interesting view on the situation.

Below you will find a comparison of the dirt particles in size.

Report 092744/1

Before initiating the filtration process

Solid particles > 2µ, 304954 are found.
Solid particles > 5µ, 137561 are found.
Solid particles > 15µ, 18310 are found.
Solid particles > 25µ, 3219 are found.
Solid particles > 50µ, 1410 are found.

- NAS 10, light brown coloured membrane.
- aging products 15%
- water quality 88 PPM

Report 100102e

After the filtration process

Solid particles > 2µ, 3463 are found. Approximately 88x cleaner!
Solid particles > 5µ, 2308 are found. Approximately 60x cleaner!
Solid particles > 15µ, 598 are found. Approximately 30x cleaner!
Solid particles > 25µ, 198 are found. Approximately 16x cleaner!
Solid particles > 50µ, 21 are found. Approximately 67x cleaner!

- NAS 5, blank membrane.
- aging products 5%
- water quality 33 PPM