Lube Oil Conditioner Unit

GE Energy

C.C. Jensen
Oil Filter Systems

Agenda

- **Functional Testing Results**
  - Sub Micron Particle Count
  - Patch Colorimetric Test
  - Gravimetric Analysis
- **Varnish Removal Method**
  - Adsorption versus Electrostatic Precipitators
- **Reliability, Design Life, and Maintainability**
- **Recommendations**

Lube Oil Conditioner Unit

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Providing Oil Filter Systems Since 1953

Lube Oil Conditioner Unit

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The Filter Division

Off-line Filtration Systems for Removal of Particles, Water, and Oxidation Deposits from Oil.

Lube Oil Conditioner Unit

Functional Testing

GE 7FA Gas Turbine

Calpine
Broad River Energy Center

Gaffney, SC

Run Time: December 13, 2005 to Present

Recommended Methods for Detecting Varnish

Patch Colorimetric Test

Provides a quantifiable scale to trend varnish potential

Scale: 0 to 100

0 to 40 = Normal

41 to 60 = Caution

61 to 100 = Critical

Sub-Micron Particle Count

Determines the effectiveness of removal of varnish particles (0.2 – 2 micron)

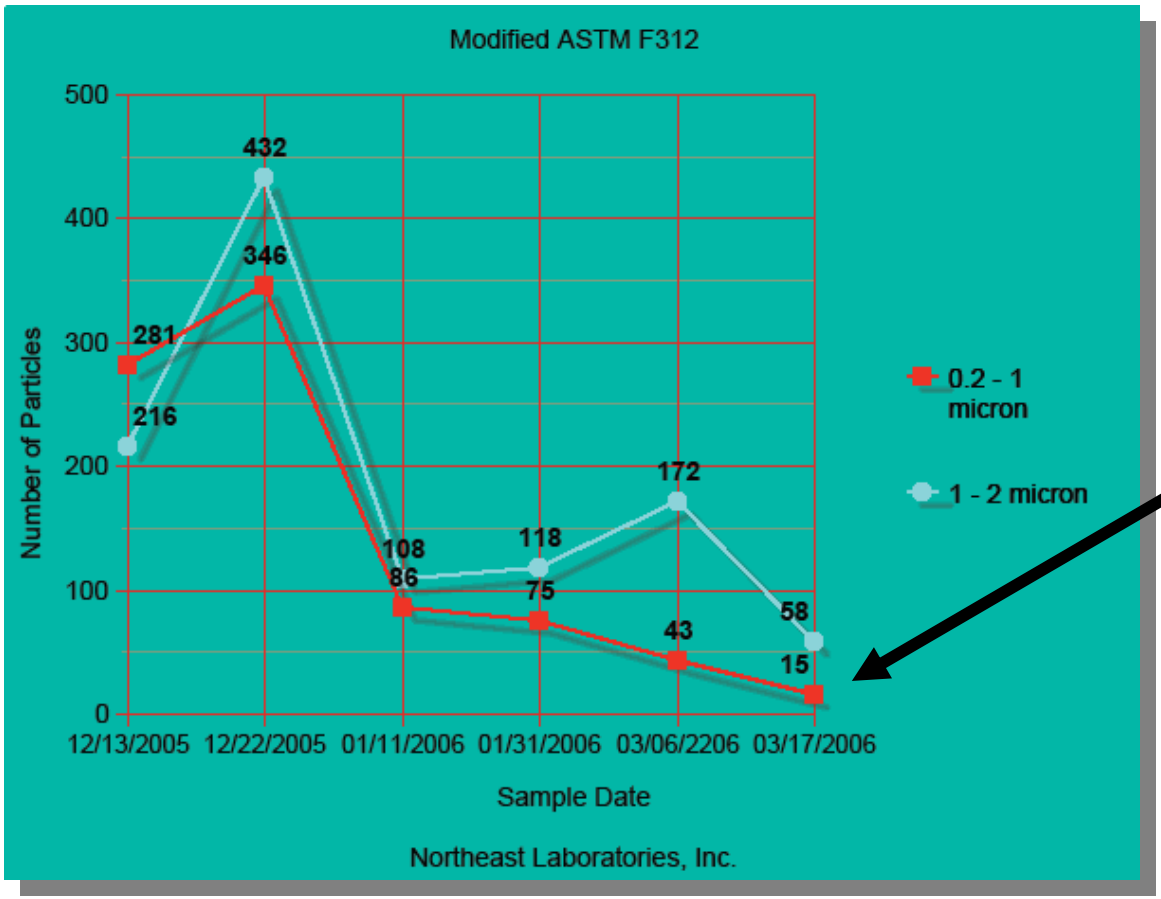
Test: ASTM F 312-97 Standard Test Method for Microscopical Sizing and Counting Particles from Aerospace Fluids on Membrane Filters

"It is recommended that both of these tests be used to monitor the performance of oil conditioning equipment."

GE Energy Services, Technical Information Letter, 1528-3

Lube Oil Conditioner Unit

Sub Micron Particle Count – Mod. ASTM F 312



95% Reduction

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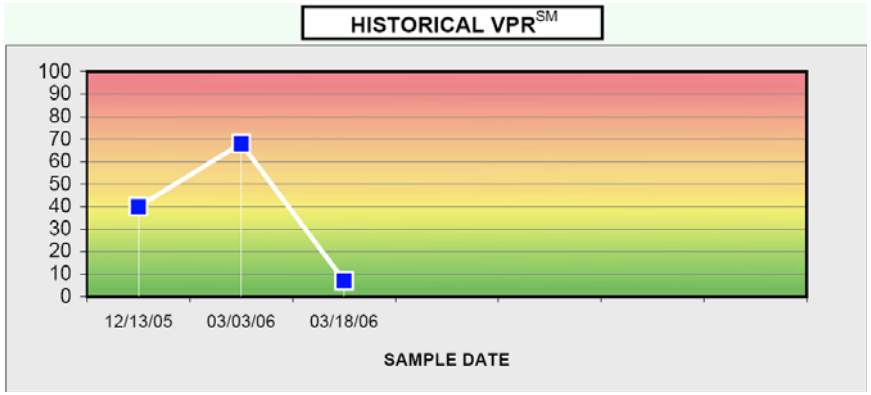
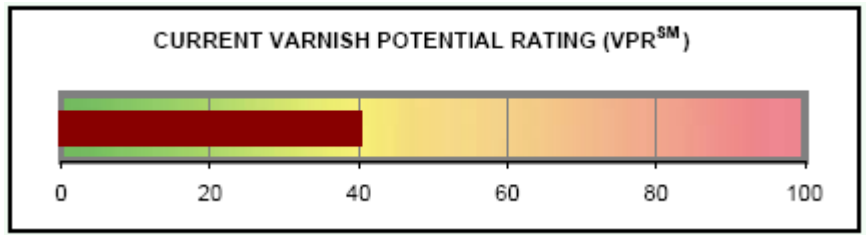
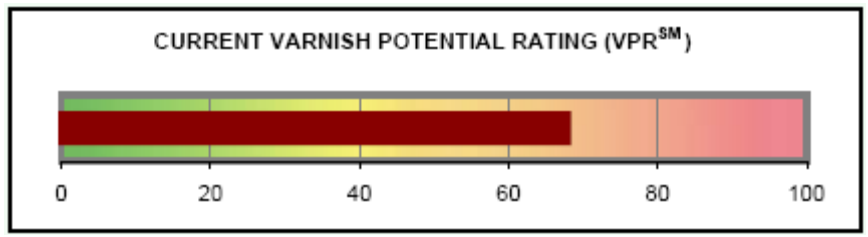
Patch Colorimetric Test



December 13, 2005



March 3, 2006



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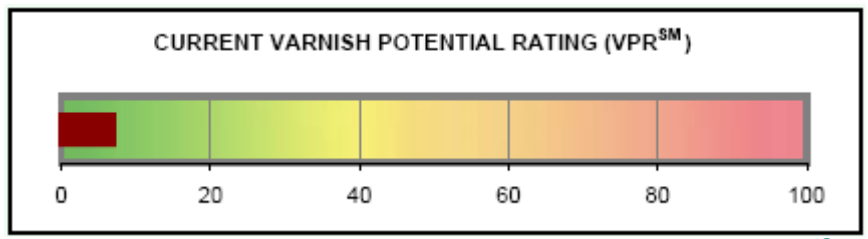

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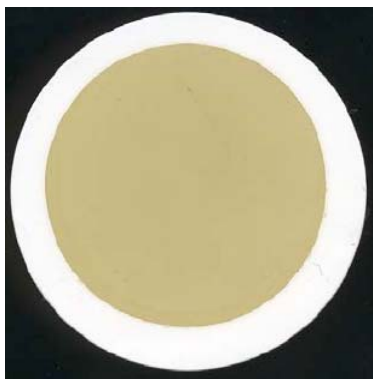

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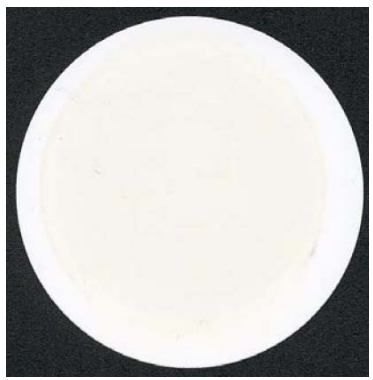

Gravimetric Analysis – Used Filter Inserts

A 27/27	INITIAL WEIGHT (g)	FINAL WEIGHT (g)	GAIN/LOSS
Flask	372	403	31
Filter	44	12	32
B 27/27	**INITIAL WEIGHT (g)**	**FINAL WEIGHT (g)**	**GAIN/LOSS**
Flask	381	395	14
Filter	26	10	16
Average (Filter)	***35***	***11***	***24***

Ratio of Filter Mass to Varnish Mass Removed: **1:2.18**

Lube Oil Conditioner Unit

Sent: Thursday, February 16, 2006 6:03 AM
To: 'Justin Stover'
Subject: RE: Progress Report

Justin,

Finally got a dispatch of several of our units. First time we have been called on to run in about 5 months. **Unit 3 (the one the CC Jensen unit is on) worked beautifully.** Unit 2 (treated by the ISOPur HR unit) failed to start due to a sticking IGV servo. When manually cycled several times the IGV servo began to work properly. We tested the servo for Unit 1 (which currently has a Kleentek unit running on the sump). This servo was very sticky and actually had to be replaced. We will need to send the servo off for reconditioning to eliminate the varnish build up. As a result of this inspection we removed the servo from Unit 2. It had varnish on it but not as bad as Unit 1. The last chance hydraulic filter was completely loaded with contamination that had been flushed into it from the header. **When we checked Unit 3 the IGV servo looked completely free of varnish and the last chance filter had absolutely no evidence of varnishing.** This is antidotal evidence which supports the lab results. Moving this unit to Turbine 1 to see what happens after Kleentek will be very valuable to you and GE.

Lube Oil Conditioner Unit

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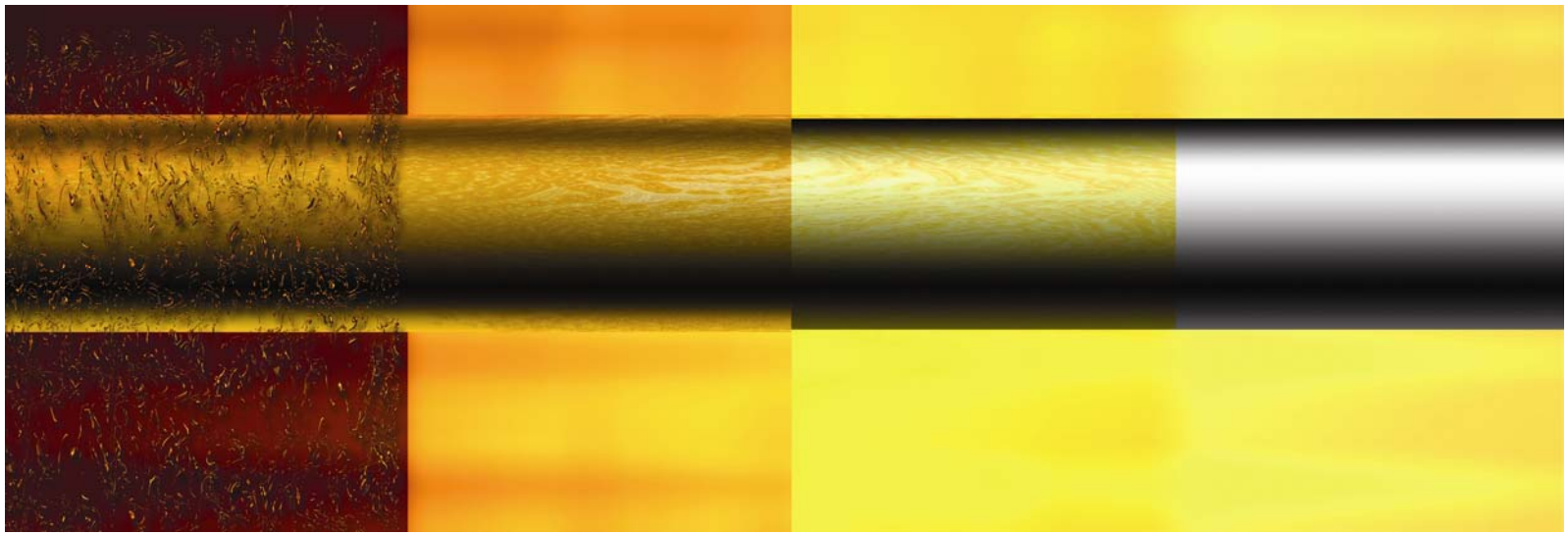
LATEST RESULTS
Sub Micron Particle Count – Mod. ASTM F 312

Sample Date	0.2 - 1 µ	1 - 2 µ	Total	% Removed	Notes
13-Dec-05	281	216	497	Baseline	*Unit Hours (Total / Test): 3,781 / 0*
22-Dec-05	346	432	778	-	
11-Jan-06	86	108	194	61.0%	
31-Jan-06	75	118	193	61.2%	
6-Mar-06	43	172	215	56.7%	
17-Mar-06	15	57	72	85.5%	*Unit Hours (Total / Test): 3,790 / 9*
1-Jun-06	2,123,610	4,260	2,127,870	-	*Unit Hours (Total / Test): 3,921 / 140*
13-Jun-06	2,552,080	1,756,740	4,308,820	-	*1 - A 27/27 Inserts added on 12-Jun-06*
23-Jun-06	130	108	238	52.1%	*8 - A 27/27 Inserts added on 23-Jun-06*
24-Jun-06	3,811	473	4,284	-	
30-Jun-06	43	129	172	65.4%	*Unit Hours (Total / Test): 4,040 / 259*

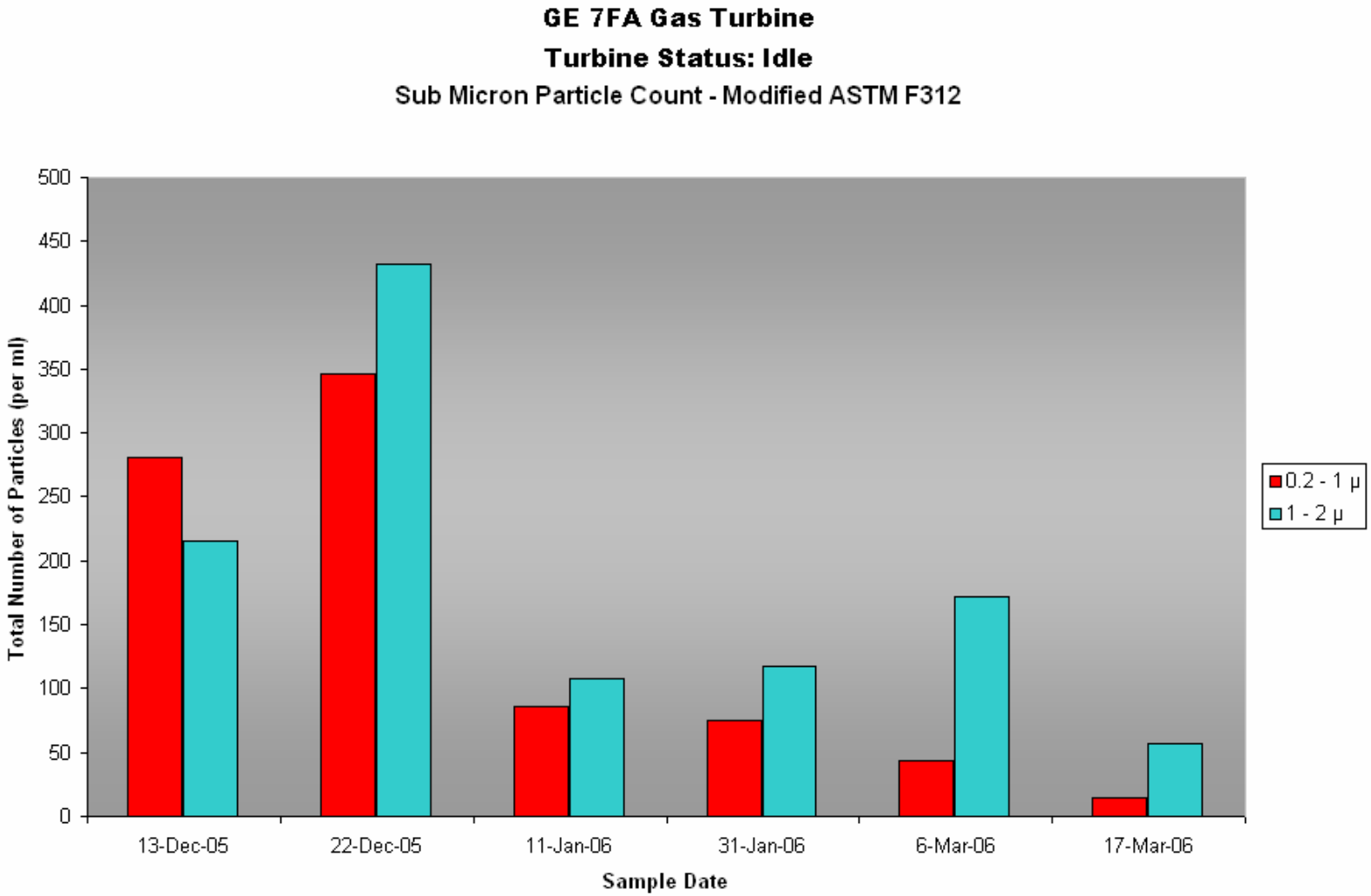
Adsorption Equilibrium

Removal of Varnish from Metallic Surfaces

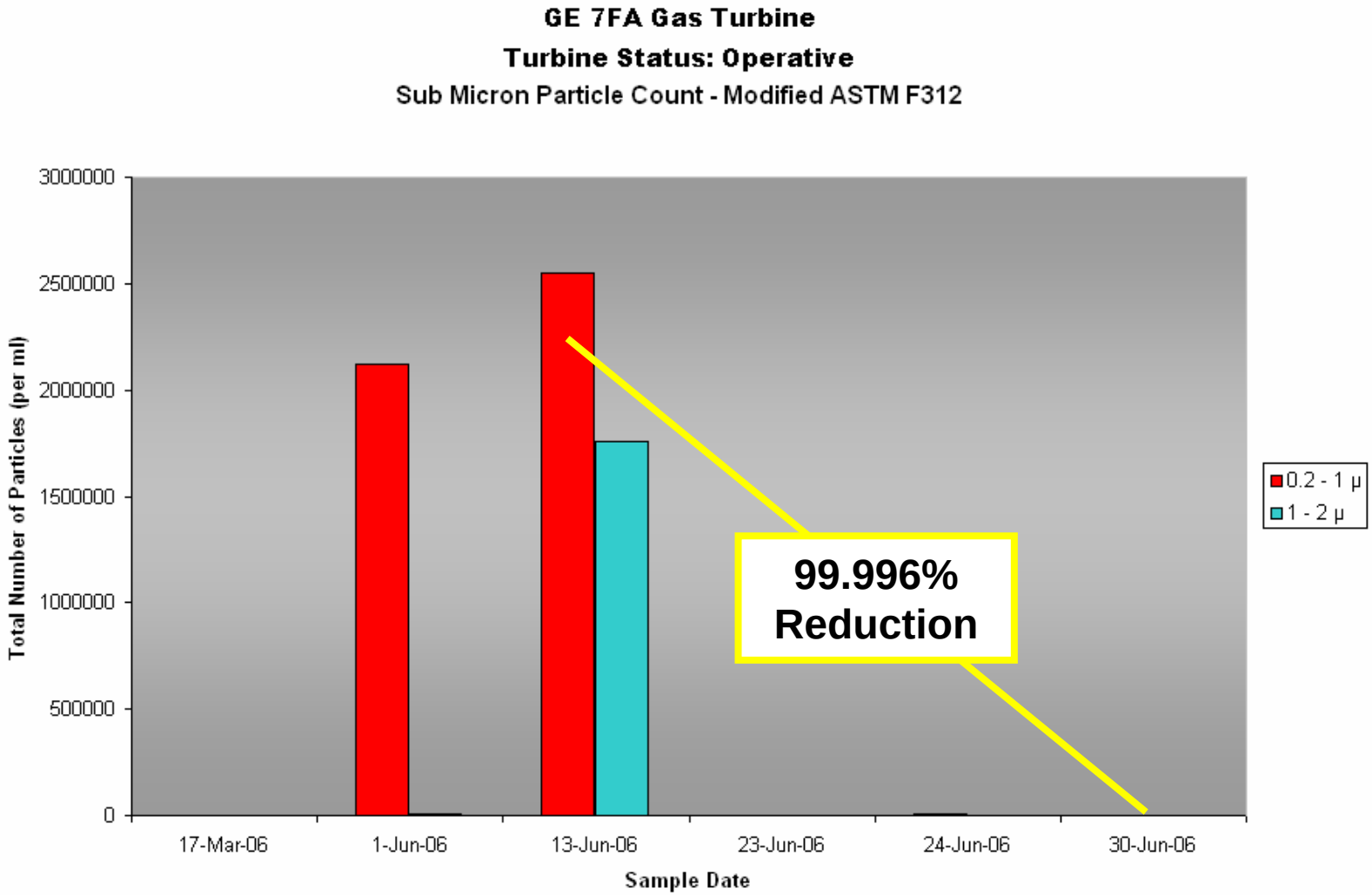


Adsorption Phase → *Clean Oil Phase* → *Desorption Phase* → *Maintenance Phase*

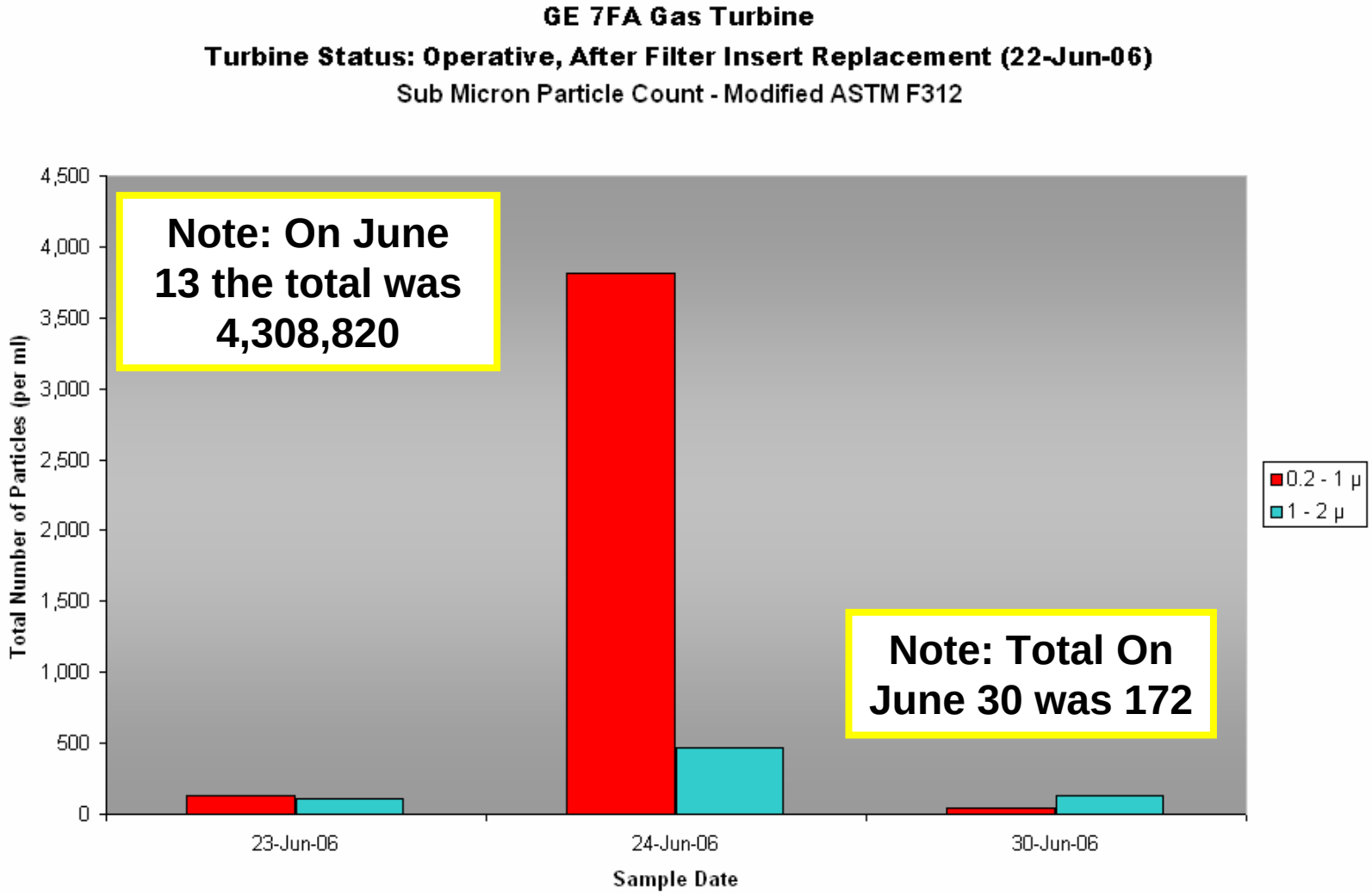
Lube Oil Conditioner Unit



Lube Oil Conditioner Unit



Lube Oil Conditioner Unit



Adsorption of Varnish in Cellulose Filter Inserts

- Most likely occurs by **physisorption**
- **Electrostatic forces** are phenomena that contributes to physisorption
- Electrostatic forces include polarization, field-dipole interactions, and especially **hydrogen bonding**

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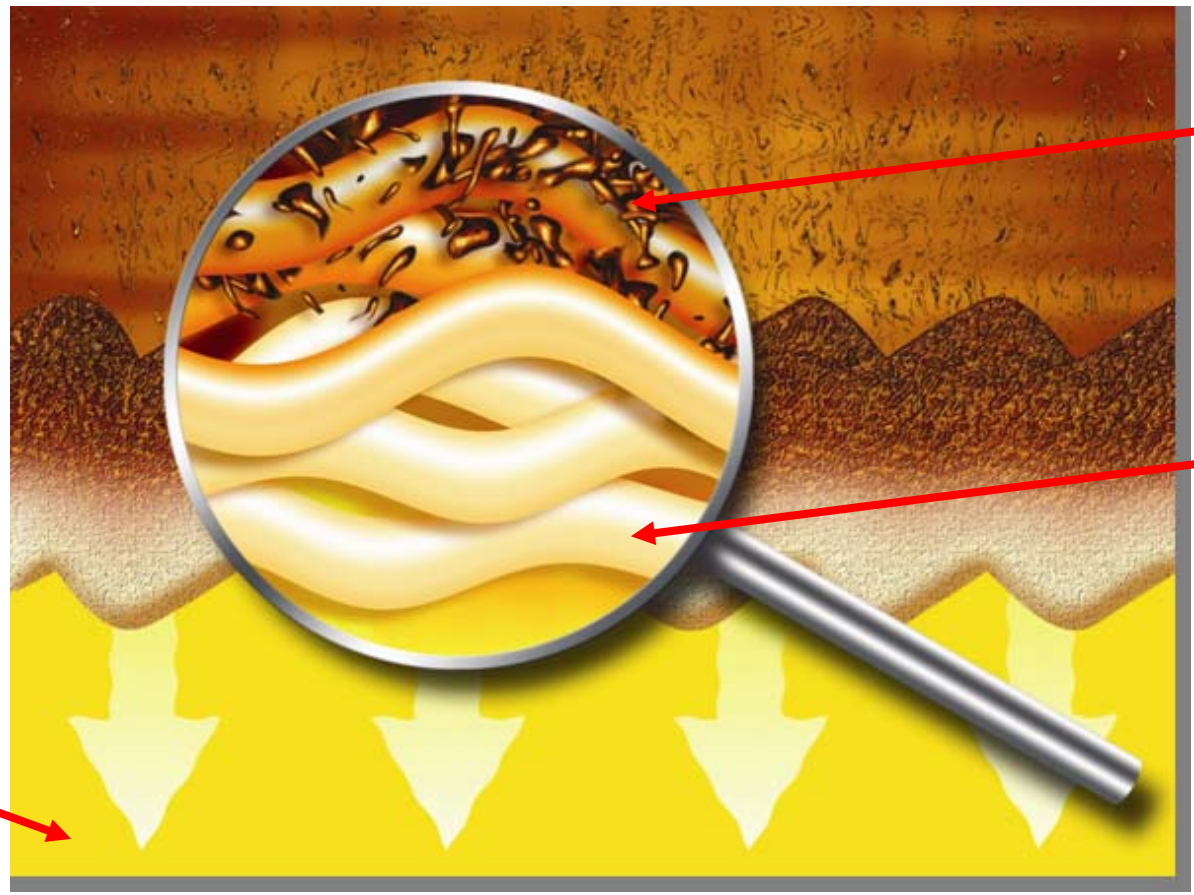
Adsorption of Varnish at Outset



Adsorption of Varnish Near Exhaustion

Adsorption - *What Happens Inside the Fiber?*

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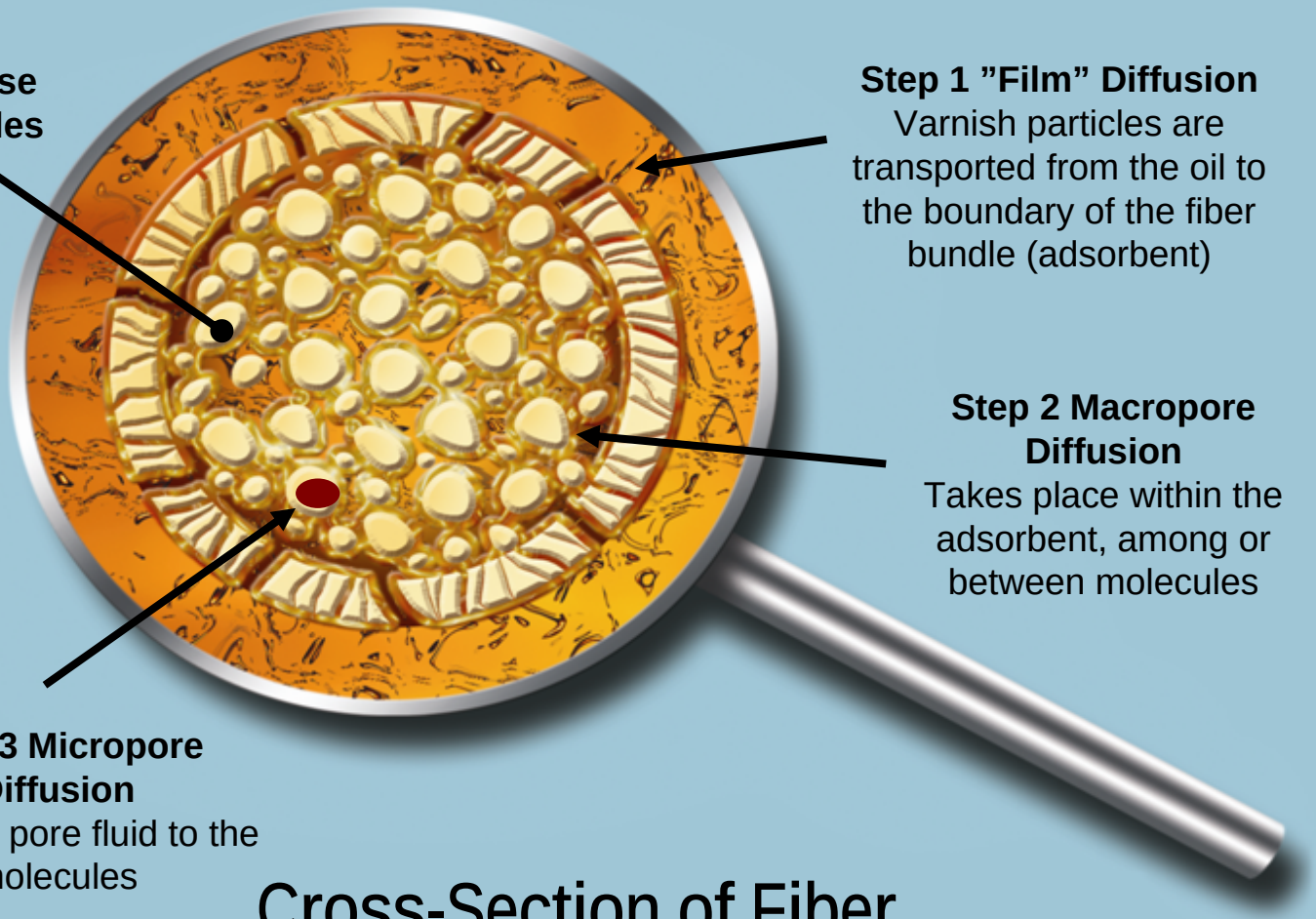
Adsorption - *What Happens Inside the Fiber?*



Advantages of C.C. Jensen Oil Filter Systems

- Simple to Operate and Maintain
- Utilizes Natural Forces
- Greater Reliability
- Higher Capacity
  - *8 Pounds of Varnish removed per Filter Insert*
- Lower Purchase Price

Lube Oil Conditioner Unit

Reliability and Design Life

Reliability
(based upon Calpine trial)

Mean Time Between Failures (MTBF)

MTBF = 4,368*

* From 12/13/05 to 06/13/06
182 Days = 4,368 hours

Design Life

30 Year Design Life

24/7/365 Operation