Fuel System Field Performance Using Particle Counters

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ENGINEERING YOUR SUCCESS.

Pass/Fail Limits

Location	Contaminant limit		Authority	Comments
	Water	Particulate		
Refinery production	Clear and bright	1,0 mg/l	DEF STAN. 91-91, JIG AFQRJOS	No quantitative limit for water
	Clear and bright		ASTM D 1655	
Distribution system	Clear and bright	0,5 mg/l	Kinder Morgan pipeline	
		1,0 mg/l	MIL-DTL-83133 (JP8/JP8+100)	US Air Force
		1,0 mg/l	MIL-DTL-5624 (JP4/JP5)	US Navy
Airport into-storage		2,2 mg/l	Canadian GSB 3.23-2005	
Into-plane	Clear and bright		IATA Guidance Material	After-fuelling check
	30 ppm	1,0 mg/l		Rejection limit for monthly equipment check
	Clear and bright	0,44 mg/l	Canadian GSB 3.23-2012	
	15 ppm (maximum allowable)	A2, B2, and G2 (Dry) A3, B3, and G3 (wet) 0,5 mg/l	ATA 103	Colorimetric interpretation of a gravimetric membrane

How can we effectively ensure in field performance qualified filters and systems?

- Current technology limitations -
  - Monthly Millipore & AquaGlo – Spot Check/Sporadic contamination in clean systems
  - Lab work required – Delay in obtaining results
  - Sampling integrity issues – 1 lt or 5 lt? Time?
  - Burst membranes
  - Subjective testing, lack of real definition
  - Negative results
  - Poor repeatability

So:

- Is particle counting a solution?
- Can we correlate with existing methods?

Gravimetric Review

Advantages of APC technology – or – Disadvantages of current methods

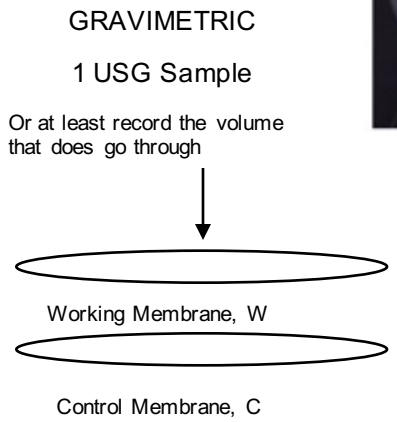
Current Method Limitations:

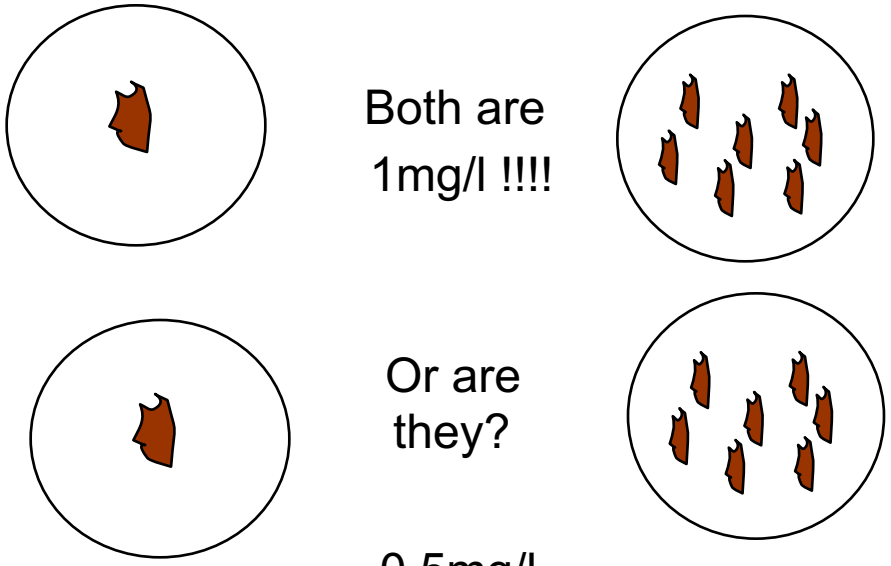
The eye can only detect particles >40 microns (30 micron(c)) unless present in very large amounts.

Gravimetric is not available in real time and sometimes is erratic and is non-informative in terms of condition monitoring.

Filtration time requires a laboratory environment.

Nobody knows where the current contamination limits come from – where is the technical justification?





EI-1581 Element Test Procedure

Test Description	Contamination Loading	Flow Rate	Time Run	Test Intervals	Comments
				Stop/Start	4 second Cycle - 1-2 close, 1-2 Open
Media Migration	Clean Fuel	3 GPM	30 mins	30	Element Conditioning
Low Water Conditioning	100 ppm Water	30 GPM	30 mins	5 **10 20 30**	Element Wetting
Solids Addition	19mg/lt A1/RIO (90/10)	30 GPM	75 mins	**15 30 45 60 75**	Solids Loading
Low Water Test	100 ppm Water	30 GPM	150 mins	2 5 15 **30** 45 **60** 75 **90** 105 **120** 135 **150**	Wetting prior to High Water Test
	3% Water	30 GPM	30 mins	2 5 **10 20 30**	High Water Test

Tests Run	Comments
D2276 Gravimetric	Test taken either side of Stop/Start. Avg result
D3240 AquaGlo	Test taken after resuming steady flow
IP564 - Particle Count	APC taken during stop/start. Avg of 3 tests

Test performed on:
Filter A
Filter B
Filter C

Filter A

TEST SEQUENCE	TIME (DOWNSTREAM)	CHANNEL	COUNTS/mL	ISO CODES	4 channel code	2276 RESULTS	AQUAGLO (DOWNSTREAM)
Solids Capacity 4.3.2.6	15 MIN	4	12.3	11	11/9/4/0	1st) -0.55mg/L 2nd) 0.00mg/L Average -.275mg/L	N/A
		6	4.7	9			
		14	0.1	4			
		30	0.0	0			
	45 MIN	4	9.7	10	10/9/6/0	1st) 0.00mg/L 2nd) -0.05mg/L Average -0.025mg/L	N/A
		6	3.7	9			
		14	0.4	6			
		30	0.0	0			
	60 MIN	4	5.1	10	10/8/0/0	1st) 0.00mg/L 2nd) 0.05mg/L Average 0.025mg/L	N/A
		6	1.6	8			
		14	0.0	0			
		30	0.0	0			
Low Water 4.3.2.7.1	15 MIN	4	18.0	11	4/6/14/0	N/A	1
		6	6.6	10			
		14	0.4	6			
		30	0.0	0			
	30 MIN (Upstream)	4	82782.5	99	99/99/21/14	N/A	1
		6	60001.3	99			
		14	12167.6	21			
		30	93.2	14			
	135 MIN	4	25.2	12	4/6/14/4	N/A	1.5
		6	10.0	10			
		14	1.1	7			
		30	0.1	4			

Test Condition	Time	ASTM D2276 mg/L	ASTM D3240 PPM	IP 564						ISO 4406 Code			
				≥ 4 µm	≥ 6 µm	≥ 14 µm	≥ 21 µm	≥ 25 µm	≥ 30 µm	4	6	14	30
A1 1.0 mg/L	0		0.6	6382.8	1884.1	5.2	0.6	0.3	0.0	20	18	10	0
	4	0.28		6184.2	1833.6	4.6	0.2	0.2	0.0	20	18	9	0
	6			6470.7	1889.4	4.3	0.4	0.1	0.0	20	18	9	0
	10			6431.7	1880.9	5.1	1.0	0.3	0.0	20	18	10	0
	12			6498.2	1901.0	4.1	0.1	0.1	0.0	20	18	9	0
	15			6473.9	1890.4	3.7	0.3	0.1	0.0	20	18	9	0
	19	0.13		6481.4	1915.7	3.0	0.1	0.0	0.0	20	18	9	0
	22			6485.3	1921.7	6.4	1.1	0.4	0.1	20	18	10	4
	24			6402.1	1901.5	3.9	0.6	0.3	0.1	20	18	9	4

Table A 7 – Evaluation 1 IP 564 particle count data for ISO 12103-1 A1 ultrafine test dust at 1.0 mg/L concentration.

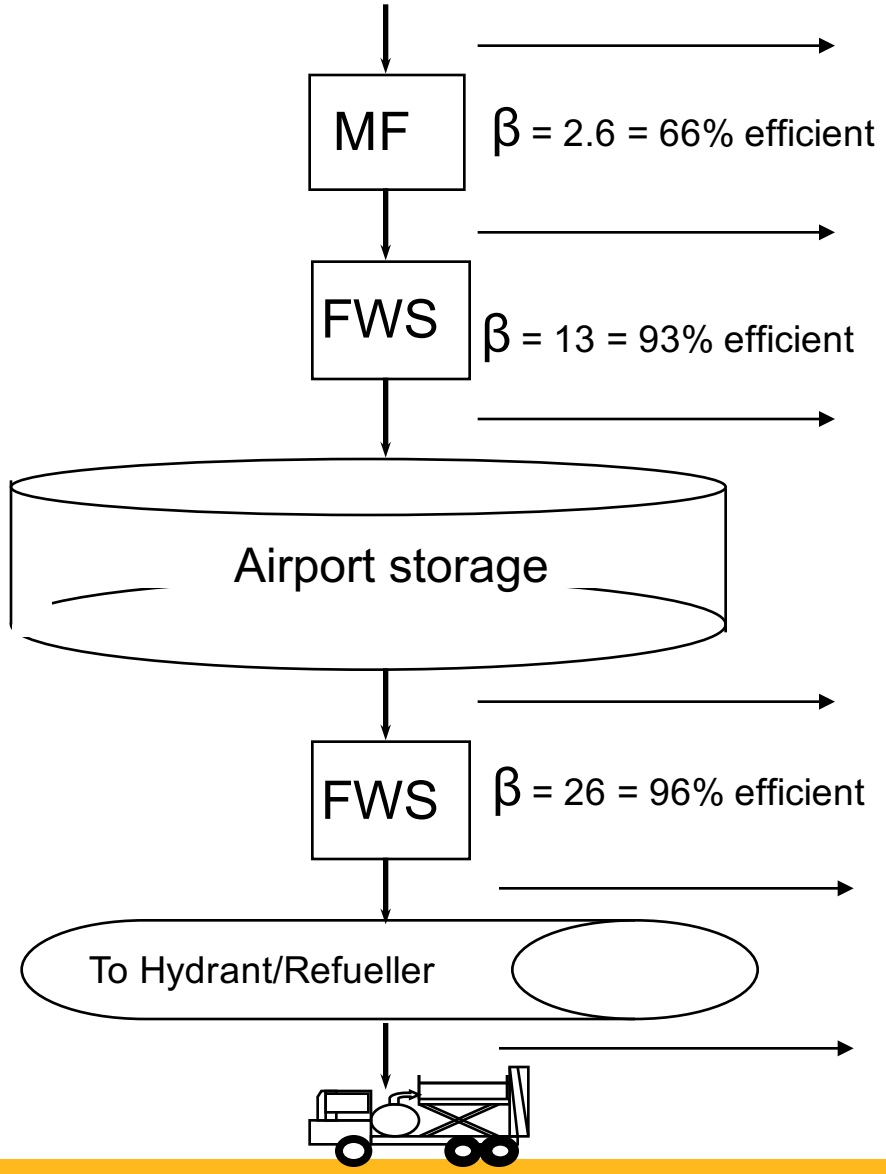
Test Condition	Time	ASTM D2276 mg/L	ASTM D3240 PPM	IP 564						ISO 4406 Code			
				≥ 4 µm	≥ 6 µm	≥ 14 µm	≥ 21 µm	≥ 25 µm	≥ 30 µm	4	6	14	30
RIO 1.0 mg/L	0		0.7	18805.1	3723.9	8.9	1.4	0.3	0.0	21	19	10	0
	7	0.27		18769.6	3704.4	8.4	0.9	0.2	0.0	21	19	10	0
	9			18903.0	3790.9	9.7	1.2	0.4	0.1	21	19	10	4
	11			18768.1	3707.9	6.7	0.2	0.0	0.0	21	19	10	0
	15			18845.2	3763.6	9.0	0.9	0.4	0.0	21	19	10	0
	17	0.20		18957.4	3757.1	8.1	0.9	0.4	0.0	21	19	10	0
	23			19426.1	3900.9	9.1	1.2	0.4	0.1	21	19	10	4

Table A 10 – Evaluation 1 IP 564 particle count data for red iron oxide test dust at 1.0 mg/L concentration.

Test Condition	Time	ASTM D2276 mg/L	ASTM D3240 PPM	IP 564						ISO 4406 Code			
				≥ 4 µm	≥ 6 µm	≥ 14 µm	≥ 21 µm	≥ 25 µm	≥ 30 µm	4	6	14	30
20 ppm Water	5		14.6	2182.9	1558.8	598.8	358.4	228.0	107.0	18	18	16	14
	10		18.5	2344.1	1672.9	658.0	399.7	257.9	125.1	18	18	17	14
	15		19.9	2344.1	1672.9	658.0	399.7	257.9	125.1	18	18	17	14
	20		15.2	2029.4	1461.5	569.8	347.1	221.6	102.4	18	18	16	14
	25		16.0	2545.4	1825.9	712.2	432.1	278.6	131.9	19	18	17	14
	30		19.3	2504.4	1805.9	701.6	427.3	269.8	133.9	19	18	17	14

Table C 16 - Evaluation 3 IP 564 particle count data for 20 ppm free water.

Field Data – Major International Airport



ISO CODE

>4µ(c)	>6µ(c)	>14µ(c)	>21µ(c)	>25µ(c)	>30µ(c)
2172.0	779.9	13.3	1.2	0.3	0.1

18/17/11

>4µ(c)	>6µ(c)	>14µ(c)	>21µ(c)	>25µ(c)	>30µ(c)
745.6	300.4	17.2	5.6	2.8	0.2

17/15/11

>4µ(c)	>6µ(c)	>14µ(c)	>21µ(c)	>25µ(c)	>30µ(c)
54.6	11.4	0.1	0.0	0.0	0.0

13/11/00

>4µ(c)	>6µ(c)	>14µ(c)	>21µ(c)	>25µ(c)	>30µ(c)
225.8	31.1	0.1	0.1	0.0	0.0

15/12/00

>4µ(c)	>6µ(c)	>14µ(c)	>21µ(c)	>25µ(c)	>30µ(c)
8.5	1.7	0.9	0.0	0.0	0.0

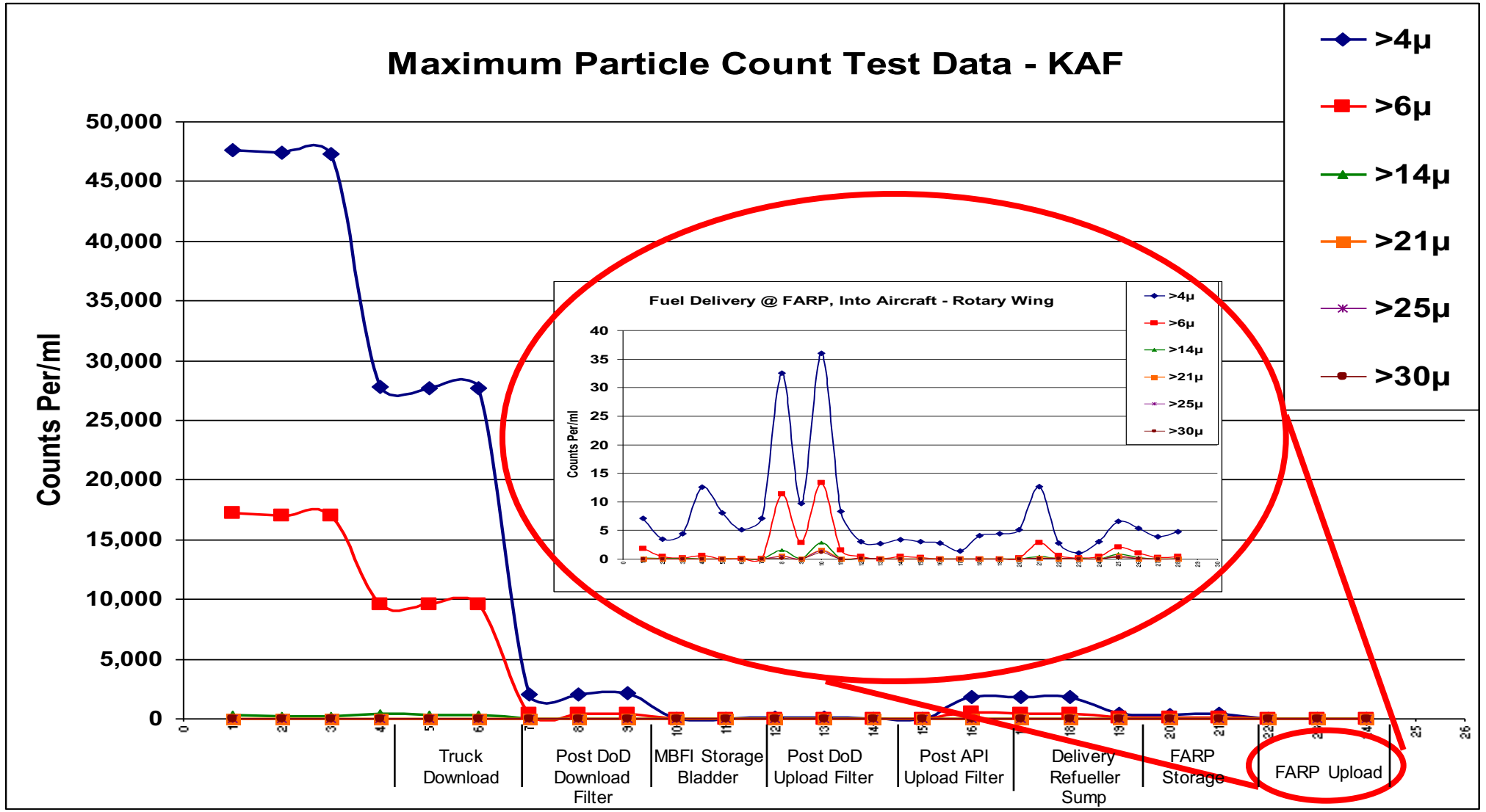
10/08/07

>4µ(c)	>6µ(c)	>14µ(c)	>21µ(c)	>25µ(c)	>30µ(c)
57.1	12.5	1.1	0.5	0.2	0.1

13/11/07

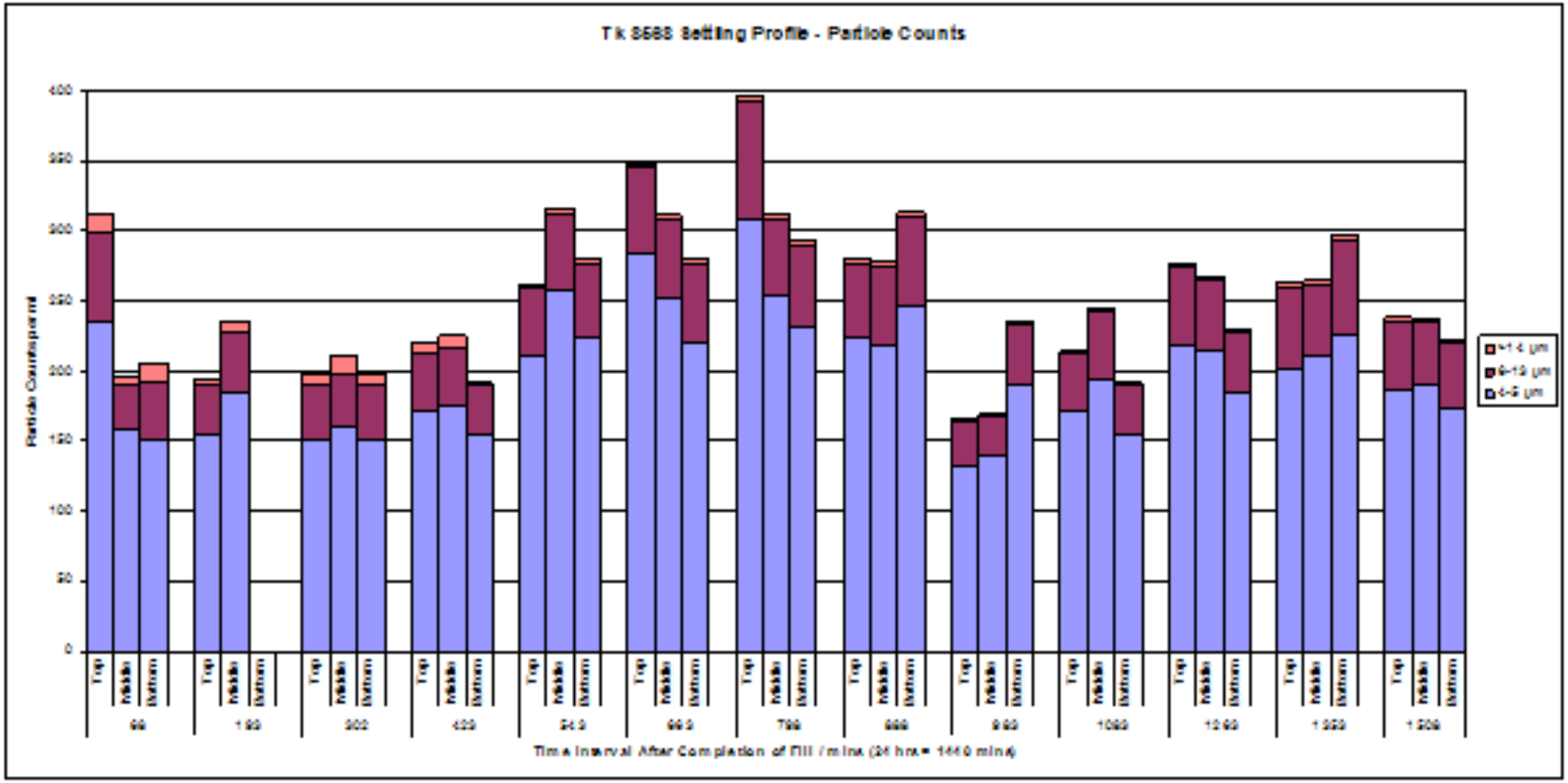
Spider Plate Alignment…can lift elements off their seats!

KAF – Supreme System Summary



- >48,000 counts Download
- Continual product cleanliness from receipt to delivery
- As low as 1 count >4µ Per/ml as upload into Aircraft
- 99.9% reduction in solid contamination
- World class system performance and cleanliness
- Particle Counting will only help maintain and improve system efficiency and performance

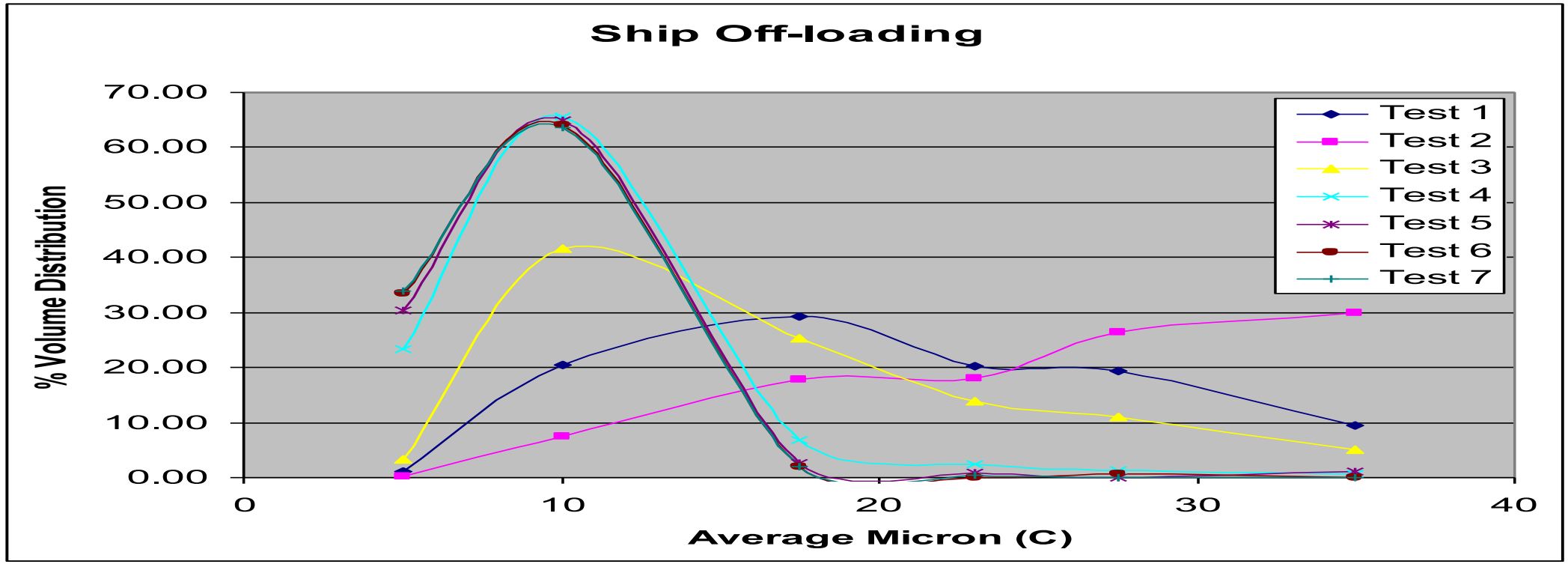
Tank Storage settling? Is it good to go NOW!



Laboratory & Field Data – Major International Airport

	>4µ	>6µ	>14µ	>21µ	>25µ	>30µ
Test 1	81058.3	62127.1	17817.6	6066.2	2477.4	474.2
Test 2	87834.5	74763.0	35454.1	18044.4	10277.7	3651.9
Test 3	51383.4	32796.9	4424.8	1213.4	440.5	81.1
Test 4	1593.3	422.7	9.6	1.7	0.5	0.1
Test 5	1226.1	261.5	2.4	0.4	0.1	0.1
Test 6	1085.7	210.9	1.3	0.1	0.1	0.0
Test 7	1037.9	198.7	1.3	0.1	0.0	0.0

First 3 measurements represent fuel from a previous cargo followed by a regular clean delivery, thus demonstrating the range of fuel cleanliness being experienced at this particular location.



Proposed Limits!

	Receipt	Vehicle Fuel Tank	Fuel Injector
Aviation Fuel			
DEF (AUST) 5695B		18/16/13	
Parker	18/16/13	14/10/7	
Pamas/Parker/Particle Solutions	19/17/12		
U.S. Army	19/17/14/13*		
Diesel Fuel			
World Wide Fuel Charter 4th		18/16/13	
DEF (AUST) 5695B		18/16/13	
Bosch/Cummins		18/16/13	
Donaldson	22/21/18	14/13/11	12/9/6
Pall	17/15/12	15/14/11	12/9/6 11/8/7

Table 1. Proposed Particle Counter Limits
***addition of 30 micron channel proposed by U.S. Army for detection of free water.**

Do our systems meet these specifications and should we continue to rely on Gravimetric?

Acknowledgements

- Joel Schmitigal – US ARMY TARDEC
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Thank You!

Questions?