

## **ASP Performance Data**

### **Introduction**

### **Results**

#### **TEST 1 - ASP Stirring Vs. Shaking**

#### **TEST 2 – ASP Repeatability and Re-Suspension Tests**

#### **TEST 3 – Carry-over**

*All tests were undertaken with USED Motor oil and Transmission fluid. All results are given in terms of maximum diameter (maximum chord length) rather than equivalent circular diameter.*

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## TEST 1- Re-Suspension by Shaking Vs. Stirring

### 15W40 Used Motor Oil

#### Shaking

**Table 1 – Used Motor Oil Manually Analyzed after Hand Shaking**

Sample	5-10 $\mu\text{m}$	10-15 $\mu\text{m}$	15-20 $\mu\text{m}$	20-25 $\mu\text{m}$	25-50 $\mu\text{m}$	50-100 $\mu\text{m}$	>100 $\mu\text{m}$
A	210075.84	14855.35	1489.94	411.95	276.28	23.67	3.15
B	224381.18	16020.79	1529.41	439.09	320.68	25.25	0.00
C	235974.11	16981.54	1512.14	441.55	288.61	12.63	1.58
D	227076.61	16158.53	1324.67	448.95	261.48	15.78	6.31
E	232340.25	16100.46	1529.41	441.55	310.81	28.41	3.15
Avg	225969.60	16023.34	1477.11	436.62	291.57	21.15	2.84
Stdev	9962.88	759.37	86.75	14.28	24.32	6.66	2.34
% RSD	4.41	4.74	5.87	3.27	8.34	31.49	82.42

#### ASP Stirring

**Table 2 – Used Motor Oil Analyzed by the ASP After Standing for 24 Hours**

Sample	5-10 $\mu\text{m}$	10-15 $\mu\text{m}$	15-20 $\mu\text{m}$	20-25 $\mu\text{m}$	25-50 $\mu\text{m}$	50-100 $\mu\text{m}$	>100 $\mu\text{m}$
A	222953.00	15892.72	1739.09	569.83	239.28	25.25	3.15
B	221260.64	14757.28	1250.66	399.62	254.08	26.83	4.73
C	221316.11	15096.47	1428.27	342.89	293.55	12.63	4.73
D	219414.77	14146.43	1499.81	370.02	219.55	23.67	3.15
E	212104.59	14480.63	1446.49	385.07	244.37	12.63	3.16
Avg	219409.82	14874.71	1472.86	413.49	250.17	20.20	3.79
Stdev	4271.42	668.02	175.83	89.88	27.33	7.00	0.86
% RSD	1.95	4.49	11.94	21.74	10.92	34.66	22.82

## Used Automatic Transmission Fluid

### Shaking

**Table 3 – Used Transmission Fluid Manually Analyzed after Hand Shaking**

Sample	5-10 $\mu\text{m}$	10-15 $\mu\text{m}$	15-20 $\mu\text{m}$	20-25 $\mu\text{m}$	25-50 $\mu\text{m}$	50-100 $\mu\text{m}$	>100 $\mu\text{m}$
A	11999.82	1876.13	564.95	81.41	22.20	1.58	1.58
B	12172.30	1820.25	488.47	29.61	41.94	7.89	0.00
C	12094.25	1931.56	542.74	29.61	22.20	1.58	0.00
D	12324.52	1791.87	646.36	29.61	19.73	1.58	0.00
E	12031.72	1826.34	653.76	51.81	39.47	1.58	0.00
Avg	12124.52	1849.23	579.25	44.41	29.11	2.84	0.32
Stdev	129.77	55.13	70.42	22.81	10.67	2.82	0.71
% RSD	1.07	2.98	12.16	51.37	36.66	99.32	223.61

### ASP Stirring

**Table 4 – Used Transmission Fluid Analyzed by the ASP After Standing for 24 Hours**

Sample	Max 5-10	Max 10-15	Max 15-20	Max 20-25	Max 25-50	Max 50-100	Max >100
A	11022.94	1823.60	564.95	56.74	17.27	3.16	0.00
B	11485.33	1385.56	476.13	32.07	27.14	6.31	0.00
C	11245.06	1572.93	535.34	64.14	44.41	4.73	0.00
D	11503.49	1774.28	510.67	56.74	56.74	1.58	1.58
E	11488.19	1550.77	572.35	44.41	39.47	4.73	0.00
Avg	11349.00	1621.43	531.89	50.82	37.01	4.10	0.32
Stdev	211.51	178.33	39.69	12.65	15.31	1.80	0.71
% RSD	1.86	11.00	7.46	24.89	41.37	43.82	223.61

## Test 2 – ASP Repeatability and Re-Suspension Tests

### Used Motor Oil

**Table 5 – Used Motor Oil Run Automatically with the ASP**

Samp Num	5-10 $\mu\text{m}$	10-15 $\mu\text{m}$	15-20 $\mu\text{m}$	20-25 $\mu\text{m}$	25-50 $\mu\text{m}$	50-100 $\mu\text{m}$	>100 $\mu\text{m}$
1	222621.11	15289.97	1428.27	456.35	246.68	11.05	1.58
2	219029.61	15659.65	1578.75	407.02	256.55	7.89	1.58
3	221964.61	15331.03	1334.53	411.95	246.68	22.09	1.58
4	221270.32	16016.42	1539.28	411.95	204.75	17.36	7.89
5	218968.73	14523.35	1319.73	337.95	189.94	14.20	3.15
7	222477.25	14726.90	1346.87	379.89	276.28	15.78	1.58
8	218405.77	15382.86	1408.54	377.42	296.01	12.63	1.58
9	214260.80	14327.90	1510.67	501.09	239.43	30.00	0.00
10	222837.05	14829.10	1341.93	402.09	259.01	22.11	6.31
11	195080.89	13536.28	1322.20	382.35	202.28	28.41	3.15
13	218327.52	15553.46	1499.81	446.49	229.41	22.09	0.00
14	217756.86	14523.78	1351.80	429.22	214.61	26.83	1.58
15	220618.34	14800.02	1421.80	385.07	234.50	22.11	1.58
16	195921.30	13114.02	1208.73	310.81	231.88	7.89	0.00
17	217669.68	14848.86	1285.20	355.22	199.81	14.20	1.58
19	218459.14	14815.38	1430.74	441.55	187.47	20.51	1.58
20	219676.32	15228.61	1361.67	434.15	266.41	23.67	1.58
21	215217.02	14759.34	1270.39	424.29	241.75	9.47	1.58
22	216664.25	14856.50	1401.13	389.75	244.21	18.94	3.15
23	217270.14	14866.56	1346.87	384.82	261.48	14.20	4.73
Avg	216724.84	14849.50	1385.45	403.47	236.46	18.07	2.29
Stdev	7635.80	673.41	93.97	43.28	29.47	6.65	2.01
% RSD	3.52	4.53	6.78	10.73	12.47	36.78	87.99

**Table 6 – Used Motor Oil Run Automatically with the ASP After Standing for 24 Hours**

Sample	5-10 $\mu\text{m}$	10-15 $\mu\text{m}$	15-20 $\mu\text{m}$	20-25 $\mu\text{m}$	25-50 $\mu\text{m}$	50-100 $\mu\text{m}$	>100 $\mu\text{m}$
1	222953.00	15892.72	1739.09	569.83	239.28	25.25	3.15
2	217769.07	16275.70	1535.35	446.78	251.78	14.21	3.16
3	223259.95	14908.28	1354.27	362.62	209.68	17.36	1.58
4	223509.07	14893.77	1386.33	399.62	219.55	18.94	0.00

ASP Performance							
5	209425.64	14704.26	1471.17	412.23	261.65	22.11	0.00
7	221260.64	14757.28	1250.66	399.62	254.08	26.83	4.73
8	220919.34	15109.33	1282.73	372.49	214.61	23.67	4.73
9	220703.95	14626.99	1262.99	441.55	204.75	25.25	1.58
10	217803.45	15404.47	1382.31	362.85	232.03	14.21	6.31
11	221316.11	15096.47	1428.27	342.89	293.55	12.63	4.73
13	214122.05	14580.44	1287.67	419.35	271.35	11.05	0.00
14	220425.36	15758.39	1292.60	370.02	207.21	11.05	1.58
15	216086.70	15705.07	1235.86	436.62	259.01	20.51	1.58
16	218644.07	14938.34	1319.73	357.69	246.68	17.36	6.31
17	219141.82	14475.49	1364.13	397.15	222.01	7.89	0.00
19	219748.75	14901.48	1467.74	387.29	209.68	18.94	0.00
20	219414.77	14146.43	1499.81	370.02	219.55	23.67	3.15
21	220672.68	15316.62	1265.46	367.55	283.68	26.83	1.58
22	219669.02	15573.48	1524.47	367.55	224.48	18.94	1.58
23	212104.59	14480.63	1446.49	385.07	244.37	12.63	3.16
Avg	218947.50	15077.28	1389.86	398.44	238.45	18.47	2.45
Stdev	3639.78	550.57	126.42	49.98	26.36	5.77	2.08
% RSD	1.66	3.65	9.10	12.54	11.06	31.25	84.93

**Table 7 – Used Motor Oil Run Automatically with the ASP After Standing 4 Weeks**

Sample #	5-10 $\mu$ m	10-15 $\mu$ m	15-20 $\mu$ m	20-25 $\mu$ m	25-50 $\mu$ m	50-100 $\mu$ m	>100 $\mu$ m
2	194819.25	13819.02	1401.26	365.12	239.30	15.79	4.73
3	183259.89	14232.08	1312.45	404.59	231.90	26.83	7.89
4	210409.07	15562.03	1495.01	424.33	276.31	12.63	0.00
5	209801.89	15398.35	1334.65	384.85	333.05	20.52	3.16
8	218065.34	15221.27	1364.26	421.86	291.11	22.10	1.58
9	201905.27	15181.82	1445.67	466.27	263.97	17.36	1.58
10	206500.68	15453.95	1485.14	416.93	246.70	26.83	3.16
13	184395.83	13810.52	1287.78	318.25	266.44	17.36	0.00
14	219292.80	15175.95	1346.99	357.71	259.03	26.83	0.00
15	206733.45	14783.07	1455.54	345.38	249.17	22.10	4.73
16	201492.23	14722.73	1470.34	367.59	249.17	20.52	0.00
17	208548.16	15755.76	1495.01	458.87	278.77	23.68	6.31
Avg	203768.65	14926.38	1407.84	394.31	265.41	21.05	2.76
Stdev	11479.82	662.16	75.86	45.52	27.40	4.63	2.70
% RSD	5.63	4.44	5.39	11.55	10.32	22.00	97.82

*Note: Only 12 samples could be analyzed further because of insufficient sample volume remaining in other containers.*

## Used Transmission Fluid

Table 8 – Transmission Fluid Run Automatically with the ASP

Sample	5-10 $\mu\text{m}$	10-15 $\mu\text{m}$	15-20 $\mu\text{m}$	20-25 $\mu\text{m}$	25-50 $\mu\text{m}$	50-100 $\mu\text{m}$	>100 $\mu\text{m}$
1	13063.14	2171.97	638.90	39.47	22.20	4.73	0.00
2	13935.92	1923.54	663.57	37.00	27.13	1.58	0.00
3	14188.13	2090.40	668.50	51.80	29.60	1.58	0.00
4	13814.56	1945.32	621.63	29.60	27.13	3.15	0.00
5	14051.06	2182.71	703.03	46.87	14.80	0.00	0.00
7	14265.30	2157.71	715.37	34.53	27.13	3.15	0.00
8	13491.24	2113.56	653.70	56.73	32.07	1.58	1.58
9	13463.56	2034.41	636.43	49.33	19.73	4.73	0.00
10	14260.27	2118.70	742.51	56.73	27.13	1.58	0.00
11	13729.88	2125.53	651.23	46.87	34.53	3.15	0.00
13	13817.21	1686.51	680.83	51.80	29.60	1.58	0.00
14	13460.83	1982.93	643.83	51.80	24.67	1.58	0.00
15	14017.52	1963.14	678.37	39.47	24.67	4.73	1.58
16	12960.24	2239.13	606.83	37.00	19.73	1.58	1.58
17	13511.63	1974.26	690.70	34.53	24.67	1.58	1.58
19	14273.20	2044.83	727.70	61.67	37.00	1.58	0.00
20	13370.79	1792.61	653.70	44.40	34.53	4.73	0.00
21	14285.98	2074.11	609.30	34.53	29.60	1.58	0.00
22	13920.14	1747.43	614.23	41.93	22.20	3.15	0.00
23	13196.95	1857.41	727.70	34.53	44.40	3.15	0.00
Avg	13753.88	2011.31	666.40	44.03	27.63	2.53	0.32
Stdev	419.77	151.94	41.20	9.10	6.77	1.39	0.65
% RSD	3.05	7.55	6.18	20.67	24.51	55.11	205.20

**Table 9 – Transmission Fluid Run Automatically with the ASP After Standing for 24 Hours**

Sample	5-10 $\mu\text{m}$	10-15 $\mu\text{m}$	15-20 $\mu\text{m}$	20-25 $\mu\text{m}$	25-50 $\mu\text{m}$	50-100 $\mu\text{m}$	>100 $\mu\text{m}$
1	13615.56	1989.05	688.23	34.53	27.13	0.00	0.00
2	13816.74	2195.13	737.57	54.27	24.67	1.58	0.00
3	13613.84	2120.14	732.63	39.47	19.73	1.58	0.00
4	13448.82	2191.93	759.77	39.47	32.07	6.31	0.00
5	13556.04	1838.33	690.70	34.53	37.00	0.00	0.00
7	14257.01	2294.70	673.43	39.47	32.07	1.58	0.00
8	14196.17	1956.56	688.23	24.67	27.13	4.73	0.00
9	13914.82	2023.03	698.10	27.13	41.93	3.15	0.00
10	14464.42	2026.68	737.57	56.73	32.07	0.00	0.00
11	13764.13	1973.42	695.63	44.40	44.40	4.73	1.58
13	14947.17	2076.16	668.50	41.93	19.73	0.00	0.00
14	13656.06	2014.75	698.10	51.80	27.13	6.31	0.00
15	14355.95	2060.95	712.90	49.33	22.20	0.00	0.00
16	13732.26	2071.94	705.50	54.27	32.07	1.58	0.00
17	13422.34	1875.47	653.70	37.00	32.07	3.15	0.00
19	13346.29	2184.38	688.23	39.47	27.13	0.00	1.58
20	13827.22	1896.16	693.17	76.47	34.53	0.00	0.00
21	13495.10	1989.88	648.77	29.60	39.47	0.00	0.00
22	13961.54	2045.48	680.83	34.53	24.67	0.00	0.00
23	13964.67	2336.06	1112.52	170.21	150.47	23.67	3.15
Avg	13867.81	2058.01	718.21	48.96	36.38	2.92	0.32
Stdev	405.71	131.65	96.96	30.97	27.71	5.35	0.83
% RSD	2.93	6.40	13.50	63.25	76.16	183.33	261.47

**Table 10 – Transmission Fluid Run Automatically with the ASP After Standing 2 Weeks**

Sample	5-10 $\mu\text{m}$	10-15 $\mu\text{m}$	15-20 $\mu\text{m}$	20-25 $\mu\text{m}$	25-50 $\mu\text{m}$	50-100 $\mu\text{m}$	>100 $\mu\text{m}$
1	11266.96	1422.36	631.55	44.41	27.14	1.58	0.00
2	12861.13	1520.14	611.82	83.88	61.67	4.73	0.00
3	13954.32	1612.38	712.97	66.61	64.14	4.73	0.00
4	12530.27	1648.02	757.37	96.21	86.35	11.05	1.58
5	12656.86	1687.92	690.76	93.75	76.48	9.47	3.16
7	13741.34	1918.66	678.43	113.48	83.88	18.94	1.58
8	14060.60	1487.84	752.44	108.55	83.88	20.52	6.31
9	13312.46	1396.91	700.63	86.35	51.81	9.47	1.58
10	12467.44	1609.32	690.76	86.35	71.54	6.31	4.73
11	12836.99	1298.41	643.89	76.48	46.87	9.47	1.58
13	12117.66	1437.69	518.07	69.07	81.41	6.31	1.58
14	13295.15	1396.87	606.89	108.55	106.08	12.63	7.89
15	13508.02	1679.98	584.68	78.95	64.14	11.05	1.58
16	12088.55	1428.99	629.09	81.41	44.41	11.05	1.58
17	13157.74	1751.30	717.90	103.61	91.28	15.79	3.16
19	13413.34	1582.76	587.15	56.74	81.41	14.21	1.58
20	13521.59	1749.18	609.35	113.48	59.21	7.89	0.00
21	12751.95	1593.08	621.69	98.68	71.54	9.47	4.73
22	12293.54	1551.57	641.42	66.61	61.67	11.05	3.16
23	12951.76	1576.74	624.15	96.21	61.67	7.89	0.00
Avg	12939.38	1567.51	650.55	86.47	68.83	10.18	2.29
Stdev	698.34	149.57	60.80	19.27	18.41	4.68	2.20
% RSD	5.40	9.54	9.35	22.28	26.74	45.96	96.13

**Test 3 – Carry-over****Determination of Baseline limit**



Table 11 – Base Oil Run Five Times

SampNum	5-10 $\mu\text{m}$	10-15 $\mu\text{m}$	15-20 $\mu\text{m}$	20-25 $\mu\text{m}$	25-100 $\mu\text{m}$	50-100 $\mu\text{m}$	>100 $\mu\text{m}$	Tot Part /ml
1	1428.02	136.69	14.80	0.00	0.00	0.00	0.00	1580.51
2	1899.10	184.69	0.00	3.70	3.70	2.37	0.00	2095.56
3	2161.40	141.10	7.40	0.00	7.40	0.00	0.00	2320.3
4	1610.76	138.07	0.00	0.00	0.00	0.00	0.00	1752.83
5	1868.33	118.22	14.80	0.00	3.70	0.00	0.00	2010.05
Average	1774.82	150.14	5.55	0.93	2.78	0.59	0.00	1937.30
Std dev	322.53	23.11	7.08	1.85	3.54	1.19	0.00	333.20
% RSD	18.17	15.39	127.66	200.00	127.66	200.00	na	17.20

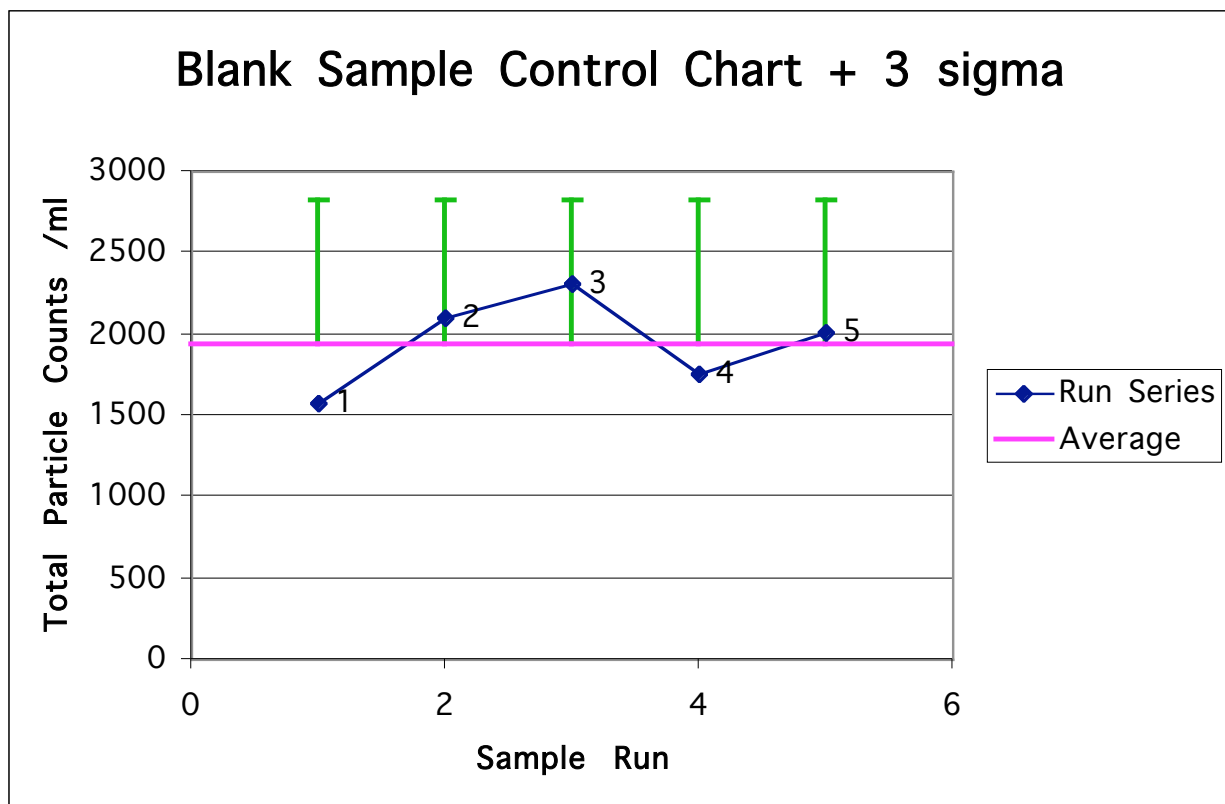


Figure 1 – Control Chart for Blank Samples

Upper Control limit - 2933.29 particles/ml



μ      μ

**Table 14 – Per Cent Change from First Run for Samples Allowed to Stand**

	5-10 μm	10-15 μm	15-20 μm	20-25 μm	25-50 μm	50-100 μm	>100 μm
<b>Used Motor Oil</b>							
Immediate Run	216724.84	14849.50	1385.45	403.47	236.46	18.07	2.29
After 24 hrs	218947.50	15077.28	1389.86	398.44	238.45	18.47	2.45
After 4 weeks	203768.65	14926.38	1407.84	394.31	265.41	21.05	2.76
<b>% Change</b>							
After 24 hrs	1.03%	1.53%	0.34%	-1.16%	1.13%	2.21%	7.00%
After 4 weeks	-5.98%	0.52%	1.59%	-2.31%	12.43%	16.61%	20.70%
<b>Transmission Fluid</b>							
Immediate Run	13753.88	2011.31	666.40	44.03	27.63	2.53	0
After 24 hrs	13867.81	2058.01	718.21	48.96	36.38	2.92	0
After 2 weeks	12939.38	1567.51	650.55	86.47	68.83	10.18	2.29
<b>% Change</b>							
After 24 hrs	0.83%	2.32%	7.70%	11.20%	31.88%	15.57%	0.00%
After 2 weeks	-5.92%	-22.06%	-2.40%	96.22%	149.37%	302.90%	na

**Table 15 – ISO Codes for the Racks of Used Motor Oil and Transmission Samples**

Used Motor Oil	Total >5 μm	Total >15 μm	ISO Code >5/>15 μm
Immediate Run	220260	2044	25/18
After 24 hrs	236070	2045	25/18
After 4 weeks	220783	2089	25/18
<b>% Change</b>			
After 24 hrs	1.05%	0.05%	
After 4 weeks	-5.5%	2.2%	
<b>Transmission Fluid</b>			
Immediate Run	16503	739	21/17
After 24 hrs	16729	804	21/17
After 2 weeks	15322	816	21/17
<b>% Change</b>			
After 24 hrs	1.37%	8.8%	
After 2 weeks	-7.15%	10.42%	

**Table 16 – Recalculation of Table 9 after Rejecting Sample 23.**

	5-10 $\mu\text{m}$	10-15 $\mu\text{m}$	15-20 $\mu\text{m}$	20-25 $\mu\text{m}$	25-50 $\mu\text{m}$	50-100 $\mu\text{m}$	>100 $\mu\text{m}$
Average	13862.71	2043.38	697.45	42.58	30.38	1.83	0.17
Std dev	416.17	117.36	28.81	12.36	7.03	2.25	0.50
RSD %	3.00	5.74	4.13	29.02	23.13	123.01	299.54

**Figure 2 – Image map of particles in Sample 23**

