|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | | | | | | | |  |  |  |  |  | **TEST NO.** | | **22-022-1D** |
|  |  | | | | | | | |  |  | **ISO 16890:2016**  **Air Filter Test Result Summary** | | | | | |
|  | 2820 S. English Station Road - Louisville, KY 40299 | | | | | | | |  |  |  | **Sections 2, 3 and 4** | | |  |  |
|  | Tel: (502) 357-0132 Fax (502) 357-0132 | | | | | | | |  |  |  |  |  |  |  | Page 1 of 4 |
| **Counter Information** | | |  | | TSI, Inc. | | | | | **Test Conditions** | | Test Flow Rate (CFM) | | | 1968 | |
| Manufacturer | | Test Aerosol | |  | Aerosolized KCl & DEHS | |
| Model No. |  | 3330 | | | | | Temperature (Deg F) | |  | 70.0 | |
|  |  |  | | | | | Relative Humidity (%) | | | 39.0 | |
|  |  | Barometer (in Hg) | |  | 29.32 | |
|  |  | Dust Type | |  | ISO Fine | |
| **Filter Description** | | | Manufacturer | |  |  |  |  | Parker HVAC Filtration Division | | |  | | | | |
| Filter Model | |  |  |  |  |  | type dp | |
| Part Number | |  |  |  |  | DP-M10-HC-242402 | | |
| Dimensions | |  |  |  |  | 24" x 24" x 2" | | |
| Type of Media | |  |  |  |  | Synthetic | | |
| Media Area | |  |  |  |  |  | 17.2 Ft² | |
| Construction | |  |  |  |  | Cardboard Frame | | |
| Filter/Media Electrostatic Charge | | | |  |  |  | No | |
| Media Color | |  |  |  |  |  | White | |
| Media Adhesive | | |  |  |  |  | N/A | |
| Sample Procurement | | |  |  |  |  | New | |
| Initial Filter Weight (g) | | |  |  |  |  | 482 | |
| Final Device Weight (g) | | |  |  |  |  | 620 | |
| Initial Arrestance (%) | | |  |  |  |  | 77.5 | |
| Initial Pressure Drop ("w.c.) | | | |  |  |  | 0.23 | |
| **DEHS Size .03 - 1.0 and KCL Size 1.0 - 10.0** | | | | | | | | | |  |  |  | | |  |  |
| Range (µm) | Geo. Mean | Initial Efficiency (%) | | Discharged Efficiency (%) | | Upstream Number of Particles | | | |  |  |  | | |  |  |
| Pre | | Post | |  |  |  |  |  | |  |
| 0.3-0.4 | 0.35 | 1 | | 2 | | 199245 | | 468831 | |
| 0.4-0.55 | 0.47 | 2 | | 2 | | 147828 | | 333441 | |  |  |  |  |  | |  |
| 0.55-0.7 | 0.62 | 3 | | 5 | | 78343 | | 170524 | |
| 0.7-1.0 | 0.84 | 9 | | 11 | | 74459 | | 159886 | |  |  |  |  |  | |  |
| 1.0-1.3 | 1.14 | 31 | | 35 | | 23251 | | 19418 | |
| 1.3-1.6 | 1.44 | 40 | | 45 | | 13187 | | 11134 | |  |  |  |  |  | |  |
| 1.6-2.0 | 1.88 | 52 | | 57 | | 29215 | | 24616 | |
| 2.0-3.0 | 2.57 | 66 | | 70 | | 14679 | | 11513 | |  |  | | | | | |
| 3.0-4.0 | 3.46 | 77 | | 79 | | 5770 | | 4078 | |
| 4.0-5.5 | 4.69 | 84 | | 83 | | 2708 | | 1938 | |
| 5.5-7.0 | 6.2 | 86 | | 86 | | 626 | | 459 | |  |  | | | | | |
| 7.0-10.0 | 8.37 | 88 | | 89 | | 295 | | 218 | |  |  | | | | | |
| **Comments** | | **Tested For:**  **Device Con** | | **dition** | **Parker HVAC Filtration Division**  **: New** | | | | | | |  |  |  |  |  |
|  |  | **Final Pressure Drop ("w.c.)** | | | | |  |  | **1.20"w.c.** | | **0.80"w.c.** | | | | | |
|  |  | **Total Dust Captured (gms)** | | | | |  |  | **138** |  | **103** |  |  |  |  |  |
|  |  | **Average Arrestance (%)** | | | |  |  |  | **85.7** |  | **83.3** |  |  |  |  |  |
| Test Operator Information | | | | Test Performed by: | | | CR | | Approved By: | | |  | Completion Date: 4-Mar-22 | | | |



|  |  |  |  |
| --- | --- | --- | --- |
| ***Reporting Data*** | | | |
|  | ***ePM 1*** | ***ePM 2,5*** | ***ePM 10*** |
| ***Minimum*** | ***4%*** | ***20%*** | ***--*** |
| ***Average*** | ***4%*** | ***19%*** | ***60%*** |
| ***Reported*** | ***N/A\**** | ***N/A\**** | ***60%*** |
| ***\* Any Reporting value of N/A shows the minimum efficiency is below 50% for that ePM value*** | | | |

FRM 5.4-322-04 ISO 16890-2, -3 & -4:2016 Rev:1 Date 5/12/2019

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **ISO 16890-1** | | | | | | | | | | |
| ***Data Entry Table*** | | | | | | | | | | |
| ***DEHS*** | | | | | | | | | | |
| ***d i*** | ***d i+1*** | | ***d m*** | **Δln *d i*** | ***E i*** | | ***E* D*,i*** | | ***E* A*,i*** | |
| ***0.30*** | ***0.40*** | | **0.35** | 0.29 | **0.9%** | | **1.8%** | | **1.4%** | |
| 0.40 | ***0.55*** | | **0.47** | 0.32 | **2.1%** | | **2.3%** | | **2.2%** | |
| 0.55 | ***0.70*** | | **0.62** | 0.24 | **3.5%** | | **4.7%** | | **4.1%** | |
| 0.70 | ***1.00*** | | **0.84** | 0.36 | **9.0%** | | **10.5%** | | **9.8%** | |
| ***KCL*** | | | | | | | | | | |
| 1.00 | ***1.30*** | | **1.14** | 0.26 | **30.8%** | | **35.3%** | | **33.1%** | |
| 1.30 | ***1.60*** | | **1.44** | 0.21 | **40.0%** | | **44.6%** | | **42.3%** | |
| 1.60 | ***2.20*** | | **1.88** | 0.32 | **51.9%** | | **56.7%** | | **54.3%** | |
| 2.20 | ***3.00*** | | **2.57** | 0.31 | **66.2%** | | **70.0%** | | **68.1%** | |
| 3.00 | ***4.00*** | | **3.46** | 0.29 | **76.5%** | | **78.9%** | | **77.7%** | |
| 4.00 | ***5.50*** | | **4.69** | 0.32 | **83.5%** | | **83.3%** | | **83.4%** | |
| 5.50 | ***7.00*** | | **6.20** | 0.24 | **86.1%** | | **85.8%** | | **86.0%** | |
| 7.00 | ***10.00*** | | **8.37** | 0.36 | **88.2%** | | **89.0%** | | **88.6%** | |
|  |  | |  |  |  | |  | |  | |
|  |  | |  |  |  | |  | |  | |
|  |  |  |  |  |  | |  | |  | |
|  | | | | | | | | | | |
| ***ePM 1 Calculations*** | | | | | | | | | | |
| ***d i*** | ***d i+1*** | ***d m*** | **Δln *d i*** | ***E* A*,i*** | ***q* 3u** | ***q* 3u\*Δln *d i*** | ***E* D*,i* \**q* 3u\*Δln *d i*** | ***E* A*,i* \**q* 3u\*Δln *d i*** | **Emin(PM1)** | **E(PM1)** |
| 0.30 | 0.40 | **0.35** | 0.29 | 1.4% | 22.627% | 0.065095 | 0.001198 | 0.000908 | ***4%*** | ***4%*** |
| 0.40 | 0.55 | **0.47** | 0.32 | 2.2% | 19.891% | 0.063343 | 0.001478 | 0.001414 |
| 0.55 | 0.70 | **0.62** | 0.24 | 4.1% | 15.837% | 0.038193 | 0.001797 | 0.001564 |
| 0.70 | 1.00 | **0.84** | 0.36 | 9.8% | 11.522% | 0.041097 | 0.004319 | 0.004008 |
|  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |
| **Sums:** | | | | | | **0.207728** | **0.008792** | **0.007894** |
|  | | | | | | | | | | |
| ***ePM 2,5 Calculations*** | | | | | | | | | | |
| ***d i*** | ***d i+1*** | ***d m*** | **Δln *d i*** | ***E* A*,i*** | ***q* 3u** | ***q* 3u\*Δln *d i*** | ***E* D*,i* \**q* 3u\*Δln *d i*** | ***E* A*,i* \**q* 3u\*Δln *d i*** | **Emin(PM2,5)** | **E(PM2,5)** |
| 0.30 | 0.40 | **0.35** | 0.29 | 1.4% | 22.627% | 0.065095 | 0.001198 | 0.000908 | **20%** | **19%** |
| 0.40 | 0.55 | **0.47** | 0.32 | 2.2% | 19.891% | 0.063343 | 0.001478 | 0.001414 |
| 0.55 | 0.70 | **0.62** | 0.24 | 4.1% | 15.837% | 0.038193 | 0.001797 | 0.001564 |
| 0.70 | 1.00 | **0.84** | 0.36 | 9.8% | 11.522% | 0.041097 | 0.004319 | 0.004008 |
| 1.00 | 1.30 | **1.14** | 0.26 | 33.1% | 8.503% | 0.022309 | 0.007884 | 0.007382 |
| 1.30 | 1.60 | **1.44** | 0.21 | 42.3% | 7.618% | 0.015817 | 0.007051 | 0.006692 |
| 1.60 | 2.20 | **1.88** | 0.32 | 54.3% | 8.022% | 0.025546 | 0.014475 | 0.013862 |
| 2.20 | 3.00 | **2.57** | 0.31 | 68.1% | 9.984% | 0.030966 | 0.021667 | 0.021083 |
|  |  |  |  |  |  |  |  |  |
| **Sums:** | | | | | | **0.302366** | **0.059870** | **0.056913** |
|  | | | | | | | | | | |
| ***ePM 10 Calculations*** | | | | | | | | | | |
| ***d i*** | ***d i+1*** | ***d m*** | **Δln *d i*** | ***E* A*,i*** | ***q* 3r** | ***q* 3r\*Δln *d i*** | ***E* D*,i* \**q* 3u\*Δln *d i*** | ***E* A*,i* \**q* 3r\*Δln *d i*** | **Emin(PM10)** | **E(PM10)** |
| 0.30 | 0.40 | **0.35** | 0.29 | 1.4% | 9.412% | 0.027077 | 0.000498 | 0.000378 | **61%** | **60%** |
| 0.40 | 0.55 | **0.47** | 0.32 | 2.2% | 8.395% | 0.026733 | 0.000624 | 0.000597 |
| 0.55 | 0.70 | **0.62** | 0.24 | 4.1% | 7.432% | 0.017924 | 0.000843 | 0.000734 |
| 0.70 | 1.00 | **0.84** | 0.36 | 9.8% | 7.014% | 0.025016 | 0.002629 | 0.002439 |
| 1.00 | 1.30 | **1.14** | 0.26 | 33.1% | 7.628% | 0.020013 | 0.007073 | 0.006622 |
| 1.30 | 1.60 | **1.44** | 0.21 | 42.3% | 8.833% | 0.018340 | 0.008176 | 0.007759 |
| 1.60 | 2.20 | **1.88** | 0.32 | 54.3% | 10.804% | 0.034406 | 0.019496 | 0.018671 |
| 2.20 | 3.00 | **2.57** | 0.31 | 68.1% | 13.726% | 0.042573 | 0.029788 | 0.028986 |
| 3.00 | 4.00 | **3.46** | 0.29 | 77.7% | 16.708% | 0.048067 | 0.037926 | 0.037351 |
| 4.00 | 5.50 | **4.69** | 0.32 | 83.4% | 19.542% | 0.062233 | 0.051870 | 0.051931 |
| 5.50 | 7.00 | **6.20** | 0.24 | 86.0% | 21.671% | 0.052261 | 0.044858 | 0.044929 |
| 7.00 | 10.00 | **8.37** | 0.36 | 88.6% | 23.143% | 0.082545 | 0.073431 | 0.073129 |
|  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |
| **Sums:** | | | | | | **0.457189** | **0.277213** | **0.273526** |
|  | | | | | | | | | | |
| Page 2 of 4 | | | | | | | | | | |

100%

80%

**Fractional collection**

**efficiency in %**

60%

40%

20%

0%

0.1 1.0 10.0

# Particle size in µm

Ei

ED,i

EA,i

100%

80%

**Fractional collection**

**efficiency / aerosol distribution in %**

60%

40%

20%

0%

0.1 1.0 10.0

# Particle size in µm

EA,i rural distribution

100%

80%

**Fractional collection**

**efficiency / aerosol distribution in %**

60%

40%

20%

0%

0.1 1.0 10.0

# Particle size in µm

EA,i urban distribution

100

90

Synthetic Dust Weight Arrestance (%)

80

70

77.5

## Dust Fed

**vs**

## Dust Weight Arrestance

83.0

86.4

93.8

1.40

1.20

1.00

## Dust Fed vs Resistance

1.20

60

Resistance (in WG)

0.80

50

40 0.60

30 0.40

20

10 0.20

0 0.00

0.23

0.27

0.49

0.80

0 20 40 60 80 100 120 140 160

Dust Fed (grams)

0 20 40 60 80 100 120 140 160 180

Dust Fed (grams)

**0.40**

## Air Flow vs Resistance Clean Device

**100**

## Initial Particle Size Removal Efficiency

**0.30**

0.33

**80**

**0.20**

Resistance (in WG)

0.15

**0.23 60**

**40**

**Removal Efficiency %**

**0.10**

**0.09 20**

0.04

**0.00**

0 500 1000 1500 2000 2500

Airflow Rate (CFM)

**0**

**0.1 1 10**

**Particle Diameter (um)**

Initial Efficiency (%) Discharged Efficiency (%)



Page 3 of 4

Blue Heaven Technologies

2820 S. ENGLISH STATION ROAD - LOUISVILLE, KY 40299 Tel: (502) 357-0132

|  |  |
| --- | --- |
| Airflow | Resistance |
| (CFM) | (in WG) |
| 0 | 0.00 |
| 492 | 0.04 |
| 984 | 0.09 |
| 1476 | 0.15 |
| 1968 | 0.23 |
| 2460 | 0.33 |

|  |  |
| --- | --- |
| Dust Fed  (gms) | Res  (in WG) |
| 0 | 0.23 |
| 24 | 0.27 |
| 74 | 0.49 |
| 124 | 0.80 |
| 161 | 1.20 |

|  |  |
| --- | --- |
| Dust Fed  (gms) | Arrestance  (%) |
| 0 |  |
| 12 | 77.5 |
| 49 | 83.0 |
| 99 | 86.4 |
| 143 | 93.8 |

ISO 16890-2,-3, -4:2016

Test Report

|  |  |  |
| --- | --- | --- |
|  | Test No. | 22-022-1D |
|  | Date: | 04-Mar-22 |
| **Data - Air Flow vs Data - Dust Fed vs**  **Resistance (Clean Data - Dust Fed vs Resistance**  **Device) Dust Weight** | |  |
| **Arrestance** |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
| The interpretation of test reports | | |
| This brief review of the test procedures, including those for addressing the testing of electrostatic charged filters, is provided for those unfamiliar with the procedures of this series of ISO standards. It is intended to assist in understanding and interpreting the results in the test report/summary. (For further details of procedures the full ISO 16890 document series shall be consulted). Air filters may rely on the effects of passive static electric charges on the fibres to achieve high efficiencies, particularly in the initial stages of their working life. Environmental factors encountered in service may affect the action of these electric charges so that the initial efficiency may drop substantially after an initial period of service. This could be offset or countered by an increase in efficiency (“mechanical efficiency”) as dust deposits build up. The reported, untreated and conditioned (discharged) efficiency shows the extent of the electrical charge effect on initial performance and indicates the potential loss of particle removal efficiency when the charge effect is completely removed and when at the same time there is no compensating increase of the mechanical efficiency. These test results should not be assumed to represent the filter performance in all possible environmental conditions or to represent all possible “real life” behaviour. This brief review of the test procedures, including those for addressing the testing of electrostatic charged filters, is provided for those unfamiliar with the procedures of this series of ISO standards. It is intended to assist in understanding and interpreting the results in the test report/summary. (For further details of procedures the full ISO 16890 document series shall be consulted). Air filters may rely on the effects of passive static electric charges on the fibres to achieve high efficiencies, particularly in the initial stages of their working life. Environmental factors encountered in service may affect the action of these electric charges so that the initial efficiency may drop substantially after an initial period of service. This could be offset or countered by an increase in efficiency (“mechanical efficiency”) as dust deposits build up. The reported, untreated and conditioned (discharged) efficiency shows the extent of the electrical charge effect on initial performance and indicates the potential loss of particle removal efficiency when the charge effect is completely removed and when at the same time there is no compensating increase of the mechanical efficiency. These test results should not be assumed to represent the filter performance in all possible environmental conditions or to represent all possible “real life” behaviour. | | |

Page 4 of 4

FRM 5.4-322-04 ISO 16890-2, -3 & -4:2016 Rev:1 Date 4/12/2019