RENSAIR

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REPORT BY THE DANISH TECHNOLOGICAL INSTITUTE

The following report is written by Stig Koust Hansen, Ph.D, Consultant at the Danish Technological Institute (DTI) about Rensair air cleaning technology. The DTI is a leading research and technology institute with 70 laboratories and 1,000 specialists. It works in close consultation with 800 research and development partners.

The purpose of the test was to determine the efficacy of the Rensair air purifier to reduce the concentration of particles of different sizes in the range 16 to 593 nanometres (0.016 to 0.593 micrometres). The air purifier was tested against two different types of particles, oil (Di-Ethyl-Hexyl-Sebacat (DEHS)) and salt (Potassium Chloride (KCl)) aerosols, respectively.

Kind regards

Christian Hendriksen
Co-Founder and CEO
Rensair

Air Purifier Efficacy

Report 107346

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Rensair

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Prepared for
Rensair
90 High Holborn
London, WC1V 6LJ
UK

Prepared by
Danish Technological Institute
Kongsvang Allé 29
8000 Aarhus C
Air and Sensor Technology

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Author:
Stig Koust Hansen, Ph.D.,
Business Manager - Clean Air Technology
stko@dti.dk

Quality Assurance:
Naja Villadsen, Ph.D.,
Consultant - Clean Air Technology
nvi@dti.dk

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1. Assignment

The purpose of the test was to determine the efficacy of the Rensair air purifier to reduce the concentration of particles of different sizes in the range 16 to 593 nanometres (0.016 to 0.593 micrometres). The air purifier was tested against two different types of particles, oil (Di-Ethyl-Hexyl-Sebacat (DEHS)) and salt (Potassium Chloride (KCl)) aerosols, respectively.

The tested air purifier was the Rensair air purification unit, model Q01B (Figure 1), that utilises HEPA13 filtration and UV-C photolysis. The device was tested on the lowest fan speed (Fan speed 1).

The test was performed at Danish Technological Institute on the 18th of November 2021.

2. Conclusion

During the first test, where DEHS aerosols were continuously dispersed into the test chamber, the Rensair unit achieved a 95% reduction of the concentration. It was found that all particle sizes in the range 16 to 593 nanometres were reduced significantly.

The Rensair unit achieved a 99.6 % reduction of the concentration of KCl particles during the second test, where aerosols were dispersed into the test chamber prior to switching the air purifier on. It was found that all particle sizes in the range 16 to 593 nanometres were reduced with more than 99%.

Figure 1: Device under test (image from Rensair website)

3. Methodology and Equipment

3.1. Protocol

The experiments are carried out in a closed non-ventilated test chamber of 20 m^3, where the walls are covered with Teflon foil to reduce the adsorption of particles. The test chamber is airtight and non-ventilated and is therefore suitable for testing air purifier efficiency.

The air purifier is tested in the configuration "Fan1" with "UVC" function switched on.

The following procedures were carried out in two different ways, for DEHS and KCl, respectively.

Oil aerosols (DEHS)

1. The test chamber was thoroughly cleaned and ventilated prior to addition of the oil aerosol
2. The test chamber was sealed and kept airtight, while measuring the background concentration of particles. An external floor ventilator was utilized to homogenous the air inside the test chamber
3. The oil aerosol was dispersed into the test chamber using an atomizer (TSI 3079A) for 50 minutes, corresponding to a particle concentration of 34,000 particles / cm^3.
4. When the desired concentration of the challenge aerosol was achieved the Rensair unit was switched on and was operating for 30 minutes in total.
5. The aerosol atomizer continued to operate during the period with the Rensair unit switched on.
6. The concentration of particles was continuously measured during all steps described above.

Salt aerosols (KCl)

1. The test chamber was thoroughly cleaned and ventilated prior to addition of the salt aerosol
2. The test chamber was sealed and kept airtight, while measuring the background concentration of particles. An external floor ventilator was utilized to homogenous the air inside the test chamber
3. The salt aerosol was dispersed from liquid suspension (3 % KCl) into the test chamber using a nebulizer (Palas AGK 2000) for 10 minutes, corresponding to a particle concentration of 100,000 particles / cm^3.
4. When the desired concentration of the challenge aerosol was achieved, the nebulizer was switched off.
5. The Rensair unit was switched on and was operating for 20 minutes in total.
6. The concentration of particles was continuously measured during all steps described above.

3.2. Particle Number Size Distribution

The particle concentration was measured using a TSI Scanning Mobility Particle Sizer system (TSI SMPS 3910, DMA 3081, UCPC 3776) set to a size range of 16 to 593 nanometres (0.016 to 0.593 micrometres) with a time resolution of 84 seconds. The particle concentration was measured in 101 different size bins. The individual size bins were grouped into 12 larger size bins for the further analysis.

4. Results

4.1. DEHS removal efficacy

The DEHS removal efficacy for the air purifier was determined using continuous dispersion of oil aerosols. In addition, a concentration of 34,000 particles / cm^3 was obtained prior to switching the air purifier on. DEHS was chosen as a suitable challenge aerosol, due to it being used in various standards for filter testing. The DEHS aerosols that was generated mainly had a size between 200 and 400 nanometres (0.2 and 0.4 micrometres).

The reduction was calculated as the difference between the total particle concentration immediately before switching the air purifier on, and the total particle concentration measured at progressing time steps after switching the air purifier on (see Figure 2 and Figure 3).

The results showed that a 95 % reduction in particle concentration was achieved after approx. 15 minutes of operating the air purifier. The reduction was accounting for two different activities. Namely, reducing the initial concentration of oil particles, which were present before turning the air purifier on, as well maintaining the reduced particle concentration, while particles was continuous dispersed into the air.

Additionally, the size dependent removal efficacy was calculated as the difference between the particle concentration for each size bin immediately before switching the air purifier on, and the particle concentration for each size bin measured after 30 minutes of operation (Figure 4 and Annex). It was found that the particle concentration for all grouped size bins was reduced with more than 90% during the 30 minutes of operation.

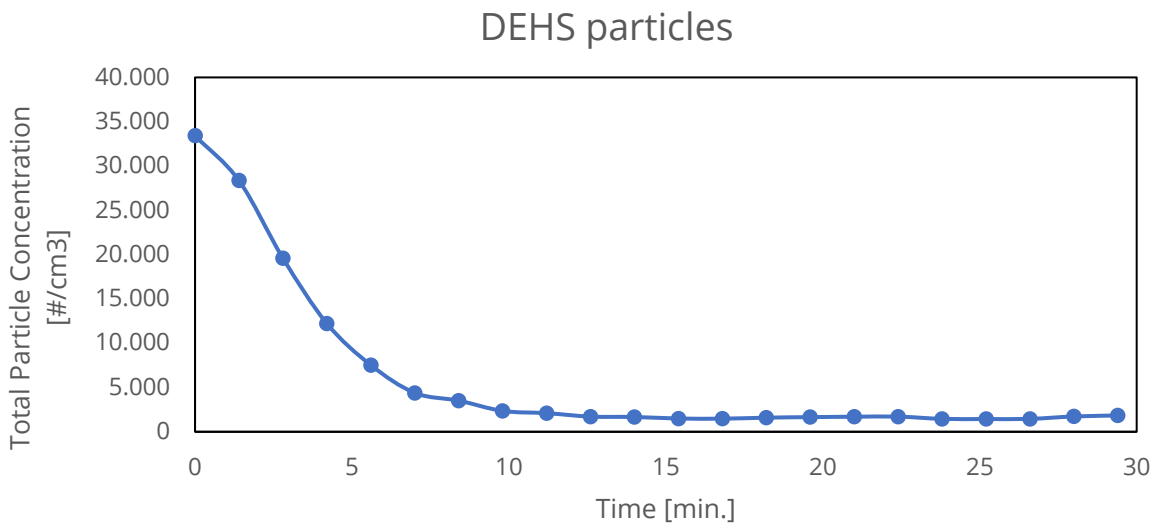

Figure 2: Total concentration of DEHS particles for the full size range (16 – 594 nm). The time scale on the x-axis was defined from the point of swithching on the air purifier (time = 0 min).

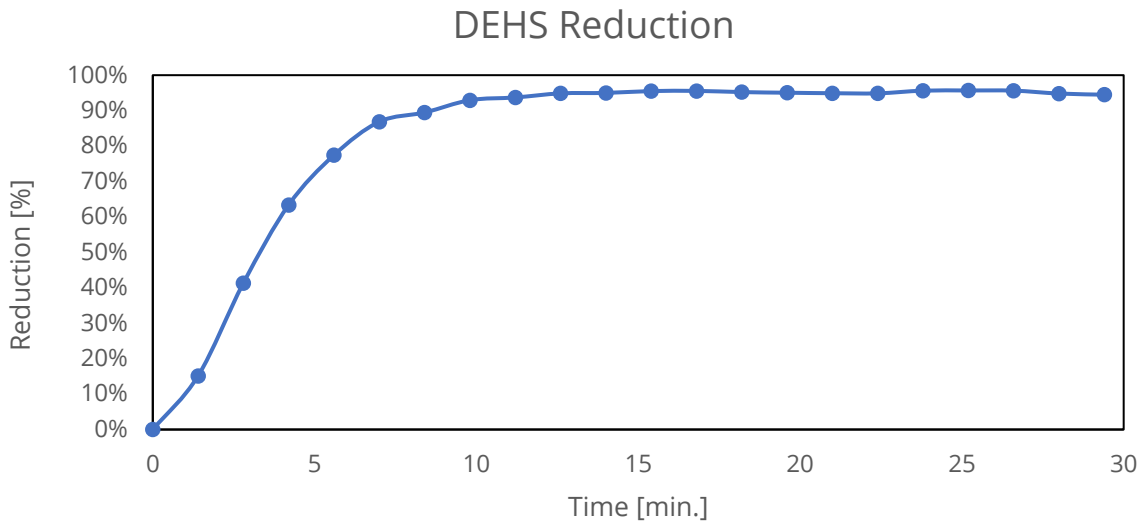

Figure 3: Reduction of DEHS particles for the full size range (16 – 594 nm). The time scale on the x-axis was defined from the point of swithching on the air purifier (time = 0 min).

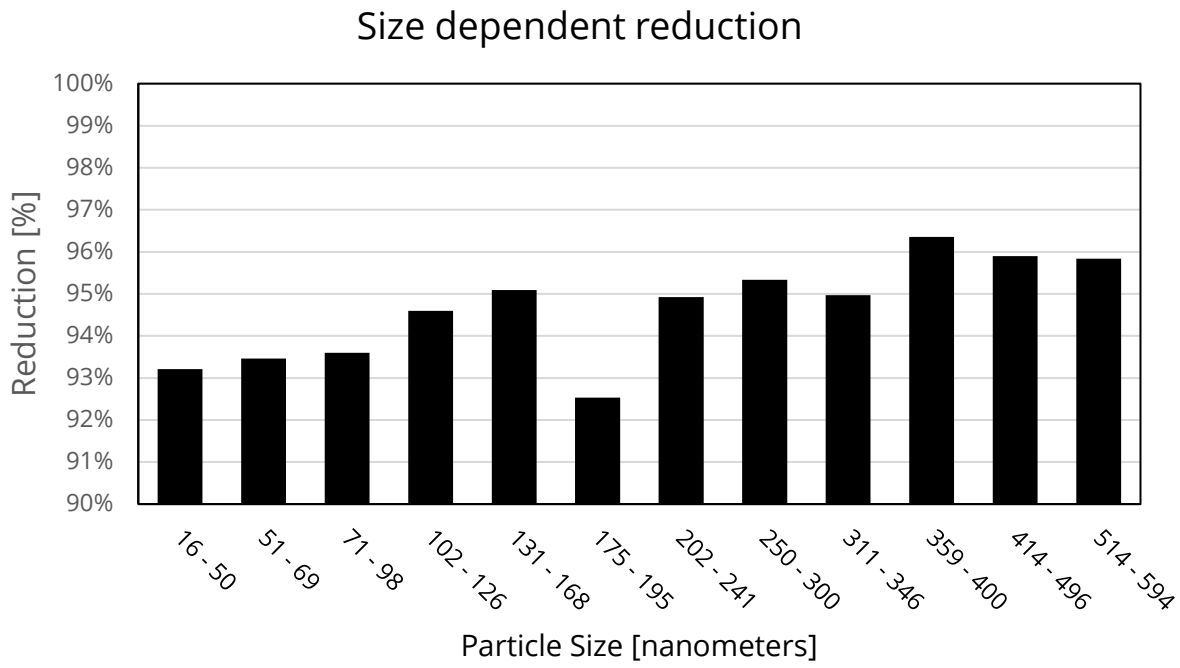

Figure 4: Reduction in particle concentration for different particle size ranges. The data have been grouped into larger size bins for clarity reasons (all individual size bins are presented in annex)

4.2. KCl removal efficacy

The KCl removal efficacy for the air purifier was determined using a high initial aerosol concentration (~100,000 particles / cm^3) and subsequent operation of the air purifier without any further dispersion of aerosols (see Figure 5).

KCl was chosen as a suitable challenge aerosol, due to it being used in various standards for filter testing. The main proportion of KCl aerosols that was generated had a size between 50 and 125 nanometres (0.05 and 0.125 micrometres).

The reduction was calculated as the difference between the total particle concentration immediately before switching the air purifier on, and the total particle concentration measured at progressing time steps after switching the air purifier on (see Figure 6).

The results showed that a 99.6 % reduction was achieved after 20 minutes of operating the air purifier.

Additionally, the size dependent reduction was calculated as the difference between the particle concentration for each size bin immediately before switching the air purifier on, and the particle concentration for each size bin measured after 20 minutes of operation (see Figure 7 and Annex). It was found that the particle concentration for all sizes was reduced with more than 99% during the 20 minutes of operation.

The natural decay of particles (e.g., sedimentation or agglomeration) have not been compensated in the calculation of the reduction efficacy.

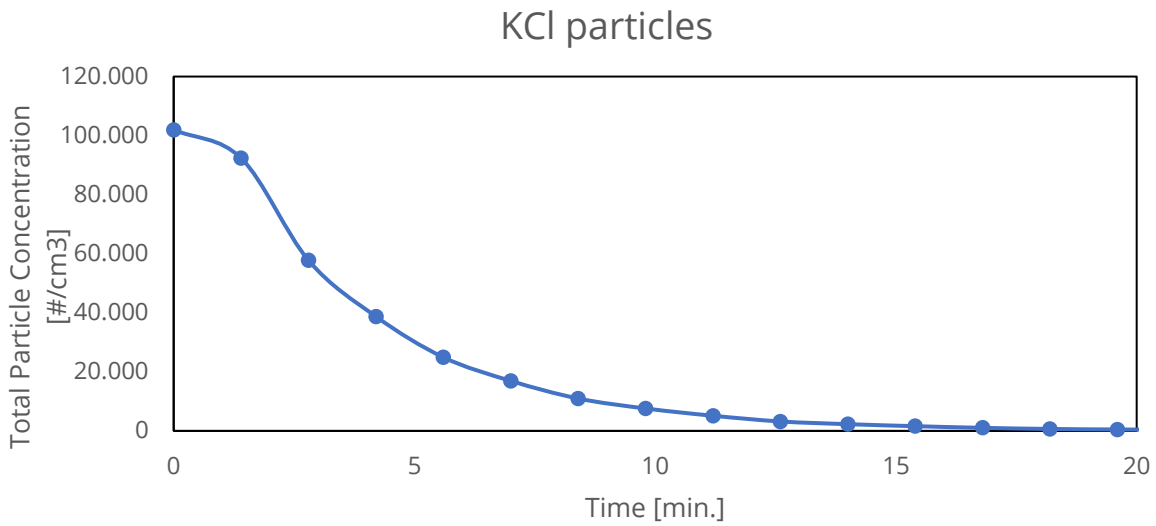

Figure 5: Total concentration of KCl particles for the full size range (16 – 594 nm). The time scale on the x-axis was defined from the point of swithching on the air purifier (time = 0 min).

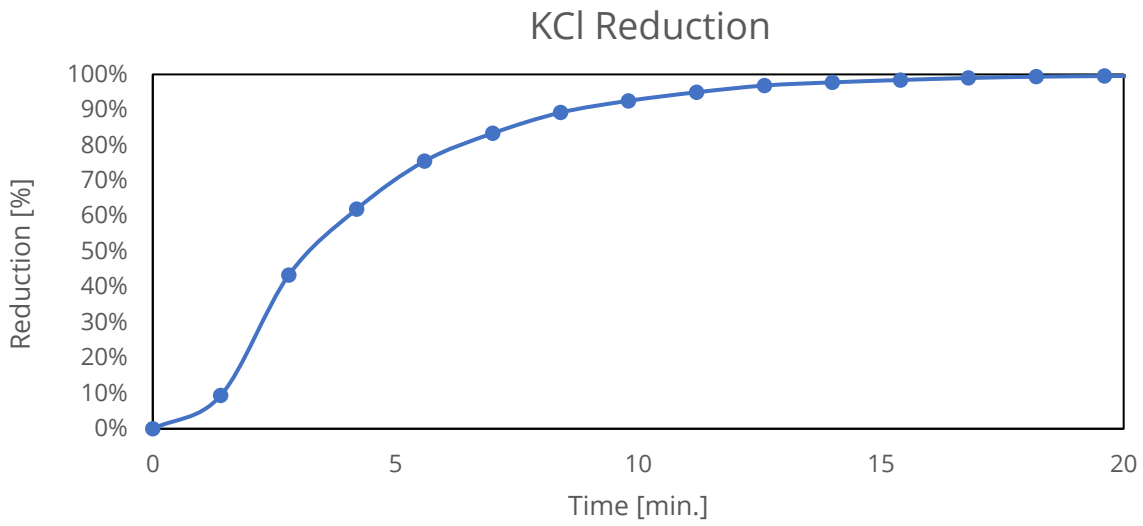

Figure 6: Reduction of KCl particles for the full size range (16 – 594 nm). The time scale on the x-axis was defined from the point of swithching on the air purifier (time = 0 min).

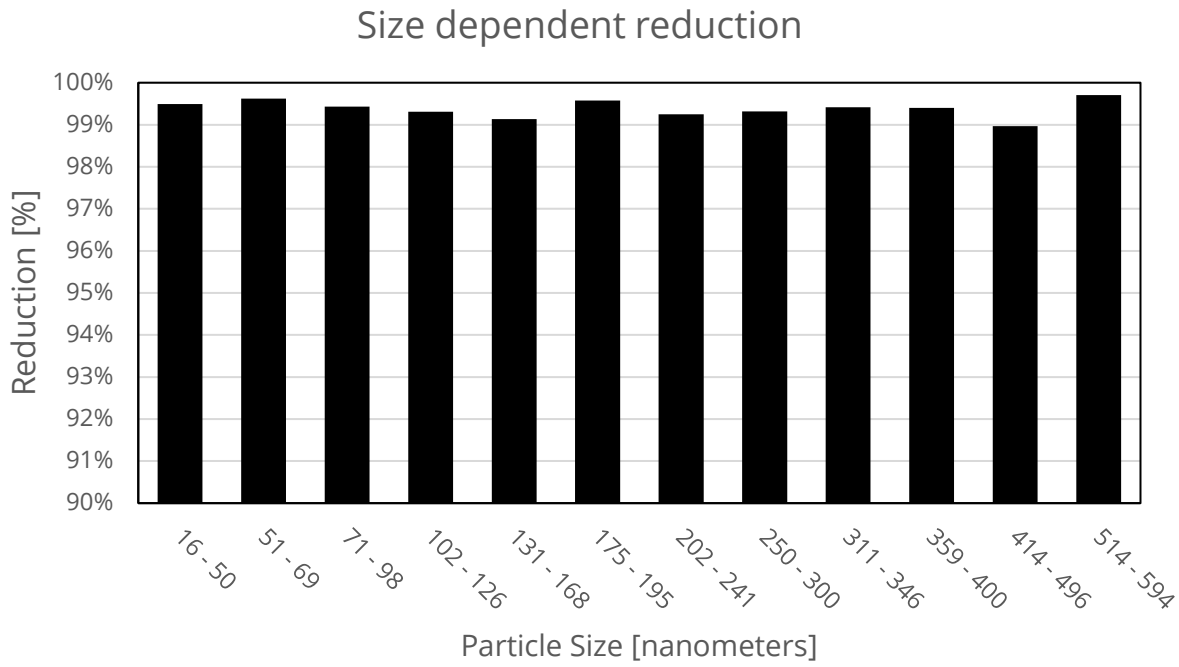

Figure 7: Reduction in particle concentration for different particle size ranges. The data have been grouped into larger size bins for clarity reasons (all individual size bins are presented in annex)

5. Annex

Table 1: Reduction achieved in 20 m3 test chamber during 30 minutes of operation for the Rensair unit. The reduction was calculated for each of the 101 size bins measured by the SMPS. Different test protocols were used for the KCl and DEHS tests, refer to section 3.1 for further details.

	Reduction	
Particle Size [nm]	KCl	DEHS
16,3	100,00%	89,52%
16,8	96,99%	95,58%
17,5	97,33%	97,70%
18,1	100,00%	92,28%
18,8	100,00%	85,14%
19,5	97,25%	95,03%
20,2	100,00%	97,37%
20,9	97,36%	93,12%
21,7	100,00%	89,08%
22,5	100,00%	100,00%
23,3	100,00%	92,21%
24,1	100,00%	88,78%
25	100,00%	100,00%
25,9	100,00%	94,58%
26,9	100,00%	100,00%
27,9	98,91%	100,00%
28,9	99,12%	100,00%
30	99,12%	91,28%
31,1	100,00%	84,18%
32,2	98,82%	93,02%
33,4	99,38%	95,31%
34,6	100,00%	100,00%
35,9	99,53%	88,81%
37,2	100,00%	92,35%
38,5	100,00%	100,00%
40	99,64%	78,26%
41,4	99,69%	74,85%
42,9	100,00%	86,84%
44,5	99,76%	83,47%
46,1	99,74%	89,79%

47,8	99,78%	90,57%
e49,6	99,34%	93,09%
51,4	99,60%	93,38%
53,3	99,81%	95,76%
55,2	99,67%	79,18%
57,3	100,00%	98,20%
59,4	99,33%	95,66%
61,5	99,24%	97,89%
63,8	99,51%	88,64%
66,1	99,74%	93,71%
68,5	99,71%	95,18%
71	99,60%	93,83%
73,7	99,58%	95,34%
76,4	99,45%	91,93%
79,1	99,57%	91,48%
82	99,09%	93,87%
85,1	99,45%	89,59%
88,2	99,90%	95,72%
91,4	99,11%	92,69%
94,7	99,22%	92,06%
98,2	99,35%	98,97%
101,8	98,98%	90,17%
105,5	99,48%	95,63%
109,4	98,44%	94,13%
113,4	99,71%	95,71%
117,6	99,56%	91,05%
121,9	99,51%	97,00%
126,3	99,63%	96,26%
131	99,13%	97,18%
135,8	98,93%	88,17%
140,7	99,31%	96,07%
145,9	99,33%	99,57%
151,2	98,56%	94,08%
156,8	99,83%	95,25%
162,5	99,55%	94,00%
168,5	98,30%	95,68%

174,7	99,13%	92,36%
181,1	99,57%	96,49%
187,7	99,65%	88,63%
194,6	100,00%	92,69%
201,7	99,16%	90,72%
209,1	100,00%	98,26%
216,7	99,56%	99,70%
224,7	98,20%	95,42%
232,9	99,76%	88,22%
241,4	98,65%	96,20%
250,3	99,23%	92,52%
259,5	98,68%	97,41%
269	100,00%	94,05%
278,8	99,29%	96,63%
289	99,18%	93,30%
299,6	99,49%	97,07%
310,6	98,82%	95,98%
322	99,24%	97,59%
333,8	99,58%	94,94%
346	100,00%	91,88%
358,7	100,00%	95,02%
371,8	99,19%	96,13%
385,4	99,68%	97,19%
399,5	98,55%	97,21%
414,2	99,31%	95,74%
429,4	99,14%	96,17%
445,1	99,20%	97,43%
461,4	100,00%	96,62%
478,3	96,11%	95,77%
495,8	100,00%	93,07%
514	100,00%	95,03%
532,8	100,00%	95,53%
552,3	100,00%	97,23%
572,5	100,00%	96,10%
593,5	98,45%	95,49%

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For additional information
please visit rensair.com or
email contact@rensair.com