NPPTL
National Personal Protective
Technology Laboratory

Date Tested: 6/12/2020 – 6/19/2020

Respirator Model(s): Gerson 1730, Gerson 1740, 3M 1870+

Tests: Filtration with NaCl (modified version of STP-0059), Manikin Fit Factor with Static Advanced Headform, and Strap Integrity with Tensile Testing

Decontamination Method: VPHP

Decontamination Cycles: 5, 10, and 20 cycles

While decontamination and reuse of FFRs are not consistent with standard and approved usage, these options may need to be considered when FFR shortages exist. This assessment was developed to quantify the filtration efficiency and manikin fit factor[1] of an N95 respirator that has been decontaminated. This assessment is not to determine the effectiveness of the decontamination procedure at killing pathogenic microorganisms. The results provided in this report are specific to the subset of samples that were provided to NPPTL for evaluation. These results may be used to update the CDC guidance for Crisis Capacity Strategies (during known shortages).

118 respirators that were unworn and not subjected to any pathogenic microorganisms were submitted for evaluation. This included 28 respirators that were subjected to 5 cycles of the VPHP decontamination process, 30 respirators subjected to 10 cycles, 40 respirators subjected to 20 cycles, and 20 respirators that served as controls. Figure 1 photos document the procedures used. The samples were tested using a modified version of the NIOSH Standard Test Procedure (STP) TEB-APR-STP-0059 to determine particulate filtration efficiency. The TSI, Inc. model 8130 using sodium chloride aerosol was used for the filtration evaluation. For the laboratory fit evaluation, a static manikin headform was used to quantify changes in manikin fit factor. The TSI, Inc. PortaCount® PRO+ 8038 in "N95 Enabled" mode was used for this evaluation. Additionally, tensile strength testing of the straps was performed to determine changes in strap integrity. The Instron® 5943 Tensile Tester was used for this evaluation. The full assessment plan can be found here.

Filtration Efficiency Results: All respirators measured more than 95%. See Tables 1, 4, and 7.

Manikin Fit Factor Results: The manikin fit factor showed passing fit factors (greater than 100) for all samples of the following respirator models/cycles; Gerson 1730 (5, 10, and 20 cycles), Gerson 1740 (20 cycles), 3M 1870+ (20 cycles). The manikin fit test procedure did not show passing fit factors for all samples of the following model/cycle; Gerson 1740 (5 and 10 cycles). See Tables 2, 5, and 8.

Strap Integrity Results: No visual degradation of the straps was observed.

Inconsistent changes were shown between the top and bottom straps of the following; Gerson 1730 (20 cycles), Gerson 1740 (10 and 20 cycles). Decreases in top and bottom strap force were shown for the following; Gerson 1730 (5 and 10 cycles), Gerson 1740 (5 cycles), 3M 1870+ (20 cycles). See Tables 3, 6, and 9.

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[1]The American Industrial Hygiene Association defines the Manikin Fit Factor as "An expression related to the amount of leakage measured through the face or neck seal of a respirator mounted to a manikin under specified airflow and environmental conditions. If the challenge to the seal is an airborne substance, it is the ratio of its airborne concentration outside the respirator divided by the concentration that enters the respirator through the seal. If the challenge is airflow or air pressure, conditions and assumptions for quantifying leakage must be specified. Leakage from other sources (e.g., air purifying elements) must be essentially zero. The respirator may be mounted to the manikin without sealants; be partially sealed to the manikin; or be sealed to the manikin with artificially induced leaks."

Figure 1. Laboratory Test Photos

Table 1. Filter Efficiency Evaluation – Gerson 1730

Respirator Model, Decon Method, # of cycles	Treated Sample #	Flow Rate (Lpm)	Initial Filter Resistance (mmH$_2$O)	Initial Percent Leakage (%)	Maximum Percent Leakage (%)	Filter Efficiency (%)
Gerson 1730, VPHP, 5 cycles Min Fil Eff: 99.26% Max Fil Eff: 99.65%	**1**	85	10.1	0.507	0.519	99.48
	2	85	10.3	0.601	0.629	99.37
	3	85	10.7	0.357	0.347	99.65
	4	85	11.9	0.744	0.744	99.26
	5	85	10.5	0.654	0.675	99.33
	6	85	10.0	0.613	0.644	99.36
	7	85	10.2	0.577	0.577	99.42
	8	85	10.6	0.542	0.542	99.46
	9	85	10.4	0.669	0.687	99.31
	10	85	10.1	0.712	0.734	99.27
	Control 1	85	10.3	0.567	0.567	99.43
Gerson 1730, VPHP, 10 cycles Min Fil Eff: 97.77% Max Fil Eff: 99.44%	**1**	85	11.8	2.23	2.23	97.77
	2	85	10.0	0.557	0.557	99.44
	3	85	10.2	0.583	0.628	99.37
	4	85	10.0	0.710	0.710	99.29
	5	85	10.6	0.898	0.903	99.10
	6	85	11.7	0.640	0.640	99.36
	7	85	10.5	0.615	0.615	99.39
	8	85	10.1	0.716	0.716	99.28
	9	85	10.0	0.695	0.695	99.31
	10	85	10.0	0.654	0.654	99.35
	Control 2	85	10.4	0.690	0.690	99.31
Gerson 1730, VPHP, 20 cycles Min Fil Eff: 99.20% Max Fil Eff: 99.48%	**1**	85	9.3	0.654	0.689	99.31
	2	85	10.4	0.597	0.635	99.37
	3	85	9.7	0.583	0.603	99.40
	4	85	10.6	0.639	0.639	99.36
	5	85	10.1	0.662	0.662	99.34
	6	85	10.8	0.517	0.517	99.48
	7	85	11.3	0.757	0.757	99.24
	8	85	9.8	0.805	0.805	99.20
	9	85	10.3	0.601	0.601	99.40
	10	85	9.6	0.511	0.516	99.48
	Control 1	85	10.9	0.566	0.591	99.41
	Control 2	85	11.0	0.525	0.525	99.48

Notes:
- The test method utilized in this assessment is not the NIOSH standard test procedure that is used for certification of respirators. Respirators assessed to this modified test plan do not necessarily meet the requirements of STP-0059, and therefore cannot be considered equivalent to N95 respirators that were tested to STP-0059.

Table 2. Manikin Fit Evaluation - Gerson 1730

Manikin Fit Factor of Decontaminated N95s					
Respirator Model, Decon Method, # of cycles	Treated Sample #	mFF Normal Breathing 1	mFF Deep Breathing	mFF Normal Breathing 2	Overall Manikin Fit Factor
Gerson 1730, VPHP, 5 cycles Static Advanced Medium Headform (Hanson Robotics)	**11**	167	61	158	105
	12	183	82	145	122
	13	193	105	164	144
	14	141	72	169	111
	Control 3	194	100	159	140
Gerson 1730, VPHP, 10 cycles Static Advanced Medium Headform (Hanson Robotics)	**11**	180	117	149	144
	12	200+	146	200+	178
	13	200+	160	184	180
	14	161	88	122	117
	15	200+	200+	200+	200+
	Control 4	200+	87	200+	139
Gerson 1730, VPHP, 20 cycles Static Advanced Medium Headform (Hanson Robotics)	**11**	200+	156	200+	183
	12	200+	146	200+	178
	13	200+	196	200+	199
	14	164	92	118	118
	15	200+	199	200+	200
	Control 3	200+	107	175	150
	Control 4	200+	92	200+	144

Notes:
- Per OSHA 1910.134(f)(7), if the fit factor as determined through an OSHA-accepted quantitative fit testing protocol is equal to or greater than 100 for tight-fitting half facepieces, then the fit test has been passed for that respirator.
- This assessment does not include fit testing of people and only uses two exercises (normal and deep breathing) on a manikin headform.
- This assessment is a laboratory evaluation using a manikin headform and varies greatly from the OSHA individual fit test. This headform testing only includes normal breathing and deep breathing on a stationary (non-moving) headform; therefore, fit results from this assessment cannot be directly translated to using the standard OSHA-accepted test. Instead, this testing provides an indication of the change in fit performance (if any) associated with the decontamination of respirators.

Table 3. Strap Integrity Evaluation – Gerson 1730

Respirator Model, Decon Method, # of cycles	Straps from Treated Sample #	Force in Top Strap (N)	Force in Bottom Strap (N)
	Tensile Force in Respirator Straps of Decontaminated N95s (recorded force values are at 150% strain)		
Gerson 1730, VPHP, 5 cycles	1	8.555	9.500
	2	8.776	9.059
	3	9.417	9.269
	Decontaminated Strap Average	8.916	9.276
	Control 1	9.953	9.332
	Control Strap Average	9.266	9.657
	% Change ((Deconned - Controls) / Controls)	-3.78%	-3.95%
Gerson 1730, VPHP, 10 cycles	1	7.630	8.873
	2	7.069	7.541
	3	7.628	7.813
	Decontaminated Strap Average	7.442	8.076
	Control 2	8.579	9.981
	Control Strap Average	9.266	9.657
	% Change ((Deconned - Controls) / Controls)	-19.68%	-16.37%
Gerson 1730, VPHP, 20 cycles	1	6.909	6.469
	2	7.148	7.060
	3	5.973	6.758
	Decontaminated Strap Average	6.677	6.762
	Control 1	6.791	7.278
	Control 2	6.544	7.008
	Control Strap Average	6.668	7.143
	% Change ((Deconned - Controls) / Controls)	0.13%	-5.33%

Table 4. Filter Efficiency Evaluation – Gerson 1740

Respirator Model, Decon Method, # of cycles	Treated Sample #	Flow Rate (Lpm)	Initial Filter Resistance (mmH$_2$O)	Initial Percent Leakage (%)	Maximum Percent Leakage (%)	Filter Efficiency (%)
Gerson 1740, VPHP, 5 cycles Min Fil Eff: 98.82% Max Fil Eff: 99.35%	**1**	85	13.3	0.997	0.997	99.00
	2	85	12.5	0.753	0.753	99.25
	3	85	11.7	0.796	0.800	99.20
	4	85	12.0	0.651	0.651	99.35
	5	85	12.4	0.664	0.664	99.34
	6	85	12.3	1.03	1.03	98.97
	7	85	11.6	0.908	0.908	99.09
	8	85	12.0	0.906	0.918	99.08
	9	85	11.2	0.768	0.768	99.23
	10	85	10.1	1.17	1.18	98.82
	Control 1	85	11.4	0.870	0.871	99.13
Gerson 1740, VPHP, 10 cycles Min Fil Eff: 98.47% Max Fil Eff: 99.40%	**1**	85	12.2	0.873	0.873	99.13
	2	85	11.4	1.02	1.02	98.98
	3	85	12.1	1.07	1.07	98.93
	4	85	13.1	0.596	0.596	99.40
	5	85	11.1	1.13	1.13	98.87
	6	85	12.9	0.964	0.964	99.04
	7	85	11.3	1.07	1.08	98.92
	8	85	11.6	0.846	0.862	99.14
	9	85	11.4	1.53	1.53	98.47
	10	85	12.2	0.898	0.898	99.10
	Control 2	85	10.9	1.20	1.20	98.80
Gerson 1740, VPHP, 20 cycles Min Fil Eff: 98.58% Max Fil Eff: 99.36%	**1**	85	12.0	0.945	0.945	99.06
	2	85	11.8	0.832	0.832	99.17
	3	85	12.2	0.898	0.898	99.10
	4	85	12.2	0.814	0.815	99.19
	5	85	11.1	1.19	1.19	98.81
	6	85	12.5	0.639	0.639	99.36
	7	85	12.0	1.41	1.42	98.58
	8	85	10.9	1.14	1.15	98.85
	9	85	12.0	0.859	0.859	99.14
	10	85	12.4	1.01	1.03	98.97
	Control 1	85	12.2	0.715	0.838	99.16
	Control 2	85	12.8	0.663	0.663	99.34

Notes:
- The test method utilized in this assessment is not the NIOSH standard test procedure that is used for certification of respirators. Respirators assessed to this modified test plan do not necessarily meet the requirements of STP-0059, and therefore cannot be considered equivalent to N95 respirators that were tested to STP-0059.

Table 5. Manikin Fit Evaluation - Gerson 1740

Respirator Model, Decon Method, # of cycles	Treated Sample #	mFF Normal Breathing 1	mFF Deep Breathing	mFF Normal Breathing 2	Overall Manikin Fit Factor
Manikin Fit Factor of Decontaminated N95s					
Gerson 1740, VPHP, 5 cycles Static Advanced Medium Headform (Hanson Robotics)	**11**	171	83	112	112
	12	190	109	163	146
	13	200+	114	125	138
	14	105	72	93	**88**
	Control 3	133	86	123	110
Gerson 1740, VPHP, 10 cycles Static Advanced Medium Headform (Hanson Robotics)	**11**	196	89	139	127
	12	105	66	85	**82**
	13	72	56	79	**68**
	14	123	74	103	**96**
	15	200+	135	200+	173
	Control 4	130	80	135	109
Gerson 1740, VPHP, 20 cycles Static Advanced Medium Headform (Hanson Robotics)	**11**	136	97	127	118
	12	200+	200+	200+	200+
	13	200+	155	190	180
	14	185	95	115	122
	15	123	96	114	109
	Control 3	200+	133	189	168
	Control 4	187	101	133	132

Notes:
- Per OSHA 1910.134(f)(7), if the fit factor as determined through an OSHA-accepted quantitative fit testing protocol is equal to or greater than 100 for tight-fitting half facepieces, then the fit test has been passed for that respirator.
- This assessment does not include fit testing of people and only uses two exercises (normal and deep breathing) on a manikin headform.
- This assessment is a laboratory evaluation using a manikin headform and varies greatly from the OSHA individual fit test. This headform testing only includes normal breathing and deep breathing on a stationary (non-moving) headform; therefore, fit results from this assessment cannot be directly translated to using the standard OSHA-accepted test. Instead, this testing provides an indication of the change in fit performance (if any) associated with the decontamination of respirators.
- **BOLD** overall manikin fit factors < 100

Table 6. Strap Integrity Evaluation – Gerson 1740

Tensile Force in Respirator Straps of Decontaminated N95s (recorded force values are at 150% strain)			
Respirator Model, Decon Method, # of cycles	**Straps from Treated Sample #**	**Force in Top Strap (N)**	**Force in Bottom Strap (N)**
Gerson 1740, VPHP, 5 cycles	1	7.775	6.855
	2	8.359	7.178
	3	7.445	7.841
	Decontaminated Strap Average	7.860	7.291
	Control 1	9.080	7.902
	Control Strap Average	9.165	7.635
	% Change ((Deconned - Controls) / Controls)	-14.24%	-4.51%
Gerson 1740, VPHP, 10 cycles	1	9.080	7.602
	2	8.389	8.010
	3	8.823	8.635
	Decontaminated Strap Average	8.764	8.082
	Control 2	9.250	7.367
	Control Strap Average	9.165	7.635
	% Change ((Deconned - Controls) / Controls)	-4.38%	5.85%
Gerson 1740, VPHP, 20 cycles	1	7.140	7.253
	2	7.238	5.714
	3	7.530	6.151
	Decontaminated Strap Average	7.303	6.373
	Control 1	7.770	6.719
	Control 2	6.651	7.260
	Control Strap Average	7.211	6.990
	% Change ((Deconned - Controls) / Controls)	1.28%	-8.83%

Table 7. Filter Efficiency Evaluation – 3M 1870+

Respirator Model, Decon Method, # of cycles	Treated Sample #	Flow Rate (Lpm)	Initial Filter Resistance (mmH$_2$O)	Initial Percent Leakage (%)	Maximum Percent Leakage (%)	Filter Efficiency (%)
3M 1870+, VPHP, 20 cycles Min Fil Eff: 98.00% Max Fil Eff: 99.78%	1	85	7.5	1.58	1.77	98.23
	2	85	7.8	0.093	0.225	99.78
	3	85	8.3	0.655	0.762	99.24
	4	85	7.6	1.12	2.00	98.00
	5	85	7.3	1.12	1.22	98.78
	6	85	7.9	0.560	0.747	99.25
	Control 1	85	7.7	0.343	0.467	99.53
	Control 2	85	8.4	0.023	0.166	99.83

Notes:
- The test method utilized in this assessment is not the NIOSH standard test procedure that is used for certification of respirators. Respirators assessed to this modified test plan do not necessarily meet the requirements of STP-0059, and therefore cannot be considered equivalent to N95 respirators that were tested to STP-0059.

Table 8. Manikin Fit Evaluation - 3M 1870+

Manikin Fit Factor of Decontaminated N95s					
Respirator Model, Decon Method, # of cycles	Treated Sample #	mFF Normal Breathing 1	mFF Deep Breathing	mFF Normal Breathing 2	Overall Manikin Fit Factor
3M 1870+, VPHP, 20 cycles Static Advanced Medium Headform (Hanson Robotics)	7	200+	200+	200+	200+
	8	200+	200+	200+	200+
	9	200+	200+	200+	200+
	10	200+	181	200+	193
	Control 3	200+	200+	200+	200+
	Control 4	200+	200+	200+	200+

Notes:
- Per OSHA 1910.134(f)(7), if the fit factor as determined through an OSHA-accepted quantitative fit testing protocol is equal to or greater than 100 for tight-fitting half facepieces, then the fit test has been passed for that respirator.
- This assessment does not include fit testing of people and only uses two exercises (normal and deep breathing) on a manikin headform.
- This assessment is a laboratory evaluation using a manikin headform and varies greatly from the OSHA individual fit test. This headform testing only includes normal breathing and deep breathing on a stationary (non-moving) headform; therefore, fit results from this assessment cannot be directly translated to using the standard OSHA-accepted test. Instead, this testing provides an indication of the change in fit performance (if any) associated with the decontamination of respirators.

Table 9. Strap Integrity Evaluation - 3M 1870+

Tensile Force in Respirator Straps of Decontaminated N95s (recorded force values are at 150% strain)			
Respirator Model, Decon Method, # of cycles	Straps from Treated Sample #	Force in Top Strap (N)	Force in Bottom Strap (N)
3M 1870+, VPHP, 20 cycles	1	1.456	1.426
	2	1.600	1.372
	3	1.536	1.364
	Decontaminated Strap Average	1.531	1.387
	Control 1	1.886	1.639
	Control 2	1.728	1.737
	Control Strap Average	1.807	1.688
	% Change ((Deconned - Controls) / Controls)	-15.27%	-17.83%