

Evaluation of Decontaminated N95 Respirators

Date Tested: 6/3/2020 – 6/11/2020

Respirator Model(s): 3M 1860, 3M 1870, 3M V-flex 9105

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

Decontamination Method: The reprocessing cycle was executed with a Steam Sterilizer using a gravity steam cycle consisting of an exposure temperature of 121°C and an exposure time of 30 minutes followed by 30 minutes of subsequent drying.

Decontamination Cycles: 3 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 factor¹ 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).

32 respirators that were unworn and not subjected to any pathogenic microorganisms were submitted for evaluation. This included 21 respirators that were subjected to 3 cycles of the Gravity Steam decontamination process and an additional 11 respirators that served as controls. Figure 1 photos document the procedures used. Photos of the samples and information received are shown in Figures 2 and 3. 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 Table 1.

Manikin Fit Factor Results: The manikin fit factor showed passing fit factors (greater than 100) for all 3M 1870 and 3M V-flex 9105 respirators evaluated. The manikin fit factor did not show passing fit factors for the treated 3M 1860 samples. See Table 2.

Strap Integrity Results: No visual degradation of the straps was observed. Increases in strap force were seen for both the top and bottom straps of the 3M 1860. Decreases in strap force were seen for the top and bottom straps of the 3M 1870, and inconsistent changes were shown between the top and bottom straps of the 3M V-flex 9105, with the top strap showing a slight increase and the bottom strap showing a decrease in force. See Table 3.

¹The 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.”

Other notes: Treated samples of all models evaluated (3M 1860, 3M 1870, and 3M V-flex 9105) had blurred, illegible, respirator information on the outer surface of the respirator. The 3M 1860 had increased roughness on the inner surface of the mask, including along the face seal area.

Figure 1. Laboratory Test Photos

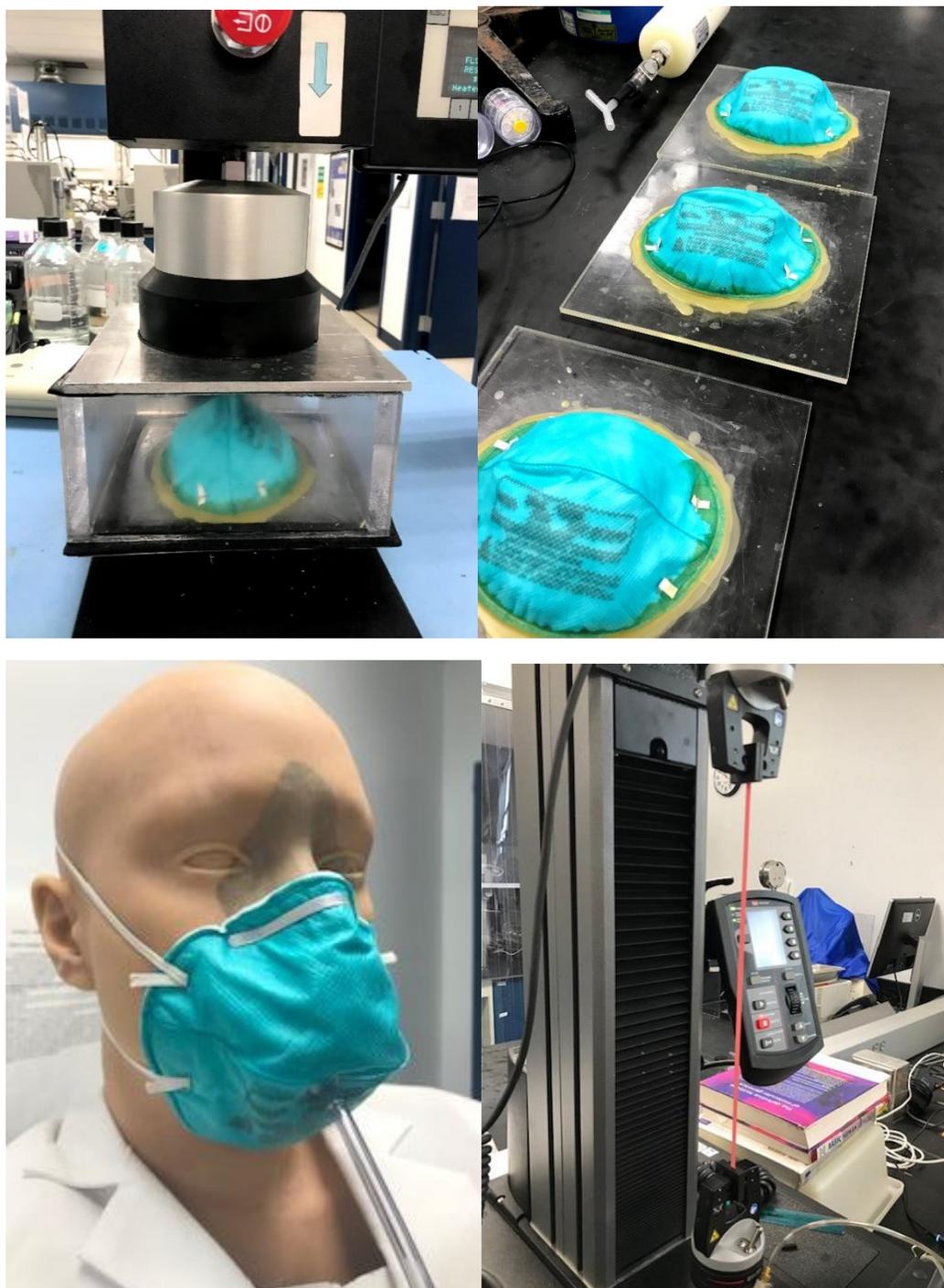


Table 1. Filter Efficiency Evaluation

| 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 1860, Gravity Steam, 3 cycles Min Fil Eff: 96.93% Max Fil Eff: 98.24% | 1 | 85 | 9.2 | 2.24 | 3.40 | 96.60 |
| | 2 | 85 | 8.8 | 1.92 | 3.07 | 96.93 |
| | 3 | 85 | 8.4 | 1.08 | 1.76 | 98.24 |
| | 4 | 85 | 9.1 | 1.52 | 2.54 | 97.46 |
| | 5 | 85 | 8.7 | 1.33 | 2.15 | 97.85 |
| | Control 3 | 85 | 8.4 | 0.503 | 0.811 | 99.19 |
| | Control 4 | 85 | 9.2 | 0.502 | 0.805 | 99.19 |
| 3M 1870, Gravity Steam, 3 cycles Min Fil Eff: 97.49% Max Fil Eff: 98.59% | 1 | 85 | 8.2 | 1.80 | 2.51 | 97.49 |
| | 2 | 85 | 8.4 | 1.01 | 1.41 | 98.59 |
| | 3 | 85 | 7.8 | 1.03 | 1.46 | 98.54 |
| | 4 | 85 | 8.3 | 1.56 | 1.98 | 98.02 |
| | 5 | 85 | 8.1 | 1.28 | 1.81 | 98.19 |
| | Control 3 | 85 | 7.8 | 1.03 | 1.10 | 98.90 |
| | Control 4 | 85 | 7.9 | 1.53 | 1.67 | 98.33 |
| 3M V-flex 9105, Gravity Steam, 3 cycles Min Fil Eff: 98.47% Max Fil Eff: 98.99% | 1 | 85 | 4.4 | 0.962 | 1.53 | 98.47 |
| | 2 | 85 | 4.1 | 0.650 | 1.01 | 98.99 |
| | 3 | 85 | 4.8 | 0.908 | 1.21 | 98.79 |
| | 4 | 85 | 5.9 | 0.803 | 1.28 | 98.72 |
| | 5 | 85 | 4.7 | 0.959 | 1.46 | 98.54 |
| | Control 3 | 85 | 4.6 | 0.355 | 0.622 | 99.38 |

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

| 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 1860, Gravity Steam, 3 cycles | 6 | 17 | 18 | 19 | 18 |
| | 7 | 21 | 17 | 23 | 20 |
| Static Advanced Medium Headform (Hanson Robotics) | Control 1 | 200+ | 200+ | 200+ | 200+ |
| | Control 2 | 200+ | 200+ | 200+ | 200+ |
| 3M 1870, Gravity Steam, 3 cycles | 6 | 200+ | 200+ | 200+ | 200+ |
| | 7 | 200+ | 200+ | 200+ | 200+ |
| Static Advanced Medium Headform (Hanson Robotics) | Control 1 | 200+ | 200+ | 200+ | 200+ |
| | Control 2 | 200+ | 196 | 200+ | 199 |
| 3M V-flex 9105, Gravity Steam, 3 cycles | 6 | 146 | 124 | 160 | 142 |
| | 7 | 153 | 123 | 116 | 129 |
| Static Advanced Medium Headform (Hanson Robotics) | Control 1 | 159 | 191 | 155 | 167 |
| | Control 2 | 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.
- **BOLD** manikin fit factors < 100.

Table 3. Strap Integrity Evaluation

| 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 1860, Gravity Steam, 3 cycles | 1 | 3.726 | 3.488 |
| | 2 | 3.822 | 3.628 |
| | 3 | 3.746 | 3.596 |
| | Decontaminated Strap Average | 3.765 | 3.571 |
| | Control 3 | 3.771 | 3.623 |
| | Control 4 | 3.082 | 3.370 |
| | Control Strap Average | 3.427 | 3.497 |
| | % Change ((Deconned - Controls) / Controls) | 9.86% | 2.12% |
| 3M 1870, Gravity Steam, 3 cycles | 1 | 1.452 | 1.755 |
| | 2 | 1.479 | 1.821 |
| | 3 | 1.471 | 1.640 |
| | Decontaminated Strap Average | 1.467 | 1.739 |
| | Control 3 | 1.867 | 1.844 |
| | Control 4 | 1.874 | 1.843 |
| | Control Strap Average | 1.871 | 1.844 |
| | % Change ((Deconned - Controls) / Controls) | -21.59% | -5.69% |
| 3M V-flex 9105, Gravity Steam, 3 cycles | 1 | 3.105 | 2.724 |
| | 2 | 2.990 | 2.885 |
| | 3 | 2.788 | 2.987 |
| | Decontaminated Strap Average | 2.961 | 2.865 |
| | Control 3 | 2.922 | 3.324 |
| | Control Strap Average | n/a | n/a |
| | % Change ((Deconned - Controls) / Controls) | 1.33% | -13.81% |