N95 mask collection, UV decontamination and distribution processes implemented during COVID-19 pandemic

VCU Health™

VCU Health System

Contributors

VCU Health

Contributing departments/units

- Environmental Services
- High-level Disinfection
- Infection Prevention
- Orthopaedic Surgery
- Patient Care Services
- Plant Operations
- Supply Chain

Virginia Commonwealth University

Contributing departments

- VCU Ventures
- The da Vinci Center for Innovation

The Health Innovation Consortium

The Health Innovation Consortium is a platform developed by Virginia Commonwealth University, with founding partners VCU Health and Activation Capital, to support new technologies that improve health care for providers, patients and health systems.

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Rationale for UVGI Decontamination of N95 Respirators

The SARS-CoV-2 pandemic will create significant shortages of personal protective equipment (PPE), including N95 filtering facepiece respirators (N95 FFRs).

In an effort to increase the availability of N95 FFRs in our health system during an emergency shortage, we have developed a decontamination procedure for used N95 FFRs that utilizes ultraviolet germicidal irradiation (UVGI). This process aligns as closely as possible with recommendations published by the CDC regarding the reusability of face masks during a pandemic;[1] a similar approach from the University of Nebraska has been implemented by multiple academic medical centers and hospital systems throughout the United States.[2]

The rationale for utilizing UVGI includes:

1. UVGI has been demonstrated to effectively inactivate pathogens, including coronaviruses and other human respiratory viruses, on N95 FFRs.[3-10]
2. UVGI can be implemented safely (i.e. little risk to human operators.)
3. UVGI requires minimal time (minutes) to achieve decontamination.
4. UVGI devices (e.g. Tru-D) are available at VCUHS for immediate deployment.

Used N95 FFRs will be suspended three feet from a Tru-D SmartUVC device in a dedicated decontamination room. The room is coated with paint that is highly reflective for antimicrobial UV wavelengths (~254 nm), in order to maximize efficacy and to reduce turnaround time.[11] The room will be sealed and an auto-shutoff motion detector placed on the entry door prior to Tru-D cycle start to minimize the risk of UV injury to personnel.

The Tru-D SmartUVC is activated remotely for 16 minutes, delivering a minimum of 1000 millijoules/cm^2 of UV to the front and back of all masks. This dose is felt to be well in excess of the necessary dose to sterilize the masks for reuse. It is known that single-stranded RNA viruses (e.g. SARS-CoV-2) are generally inactivated by UVGI exposure of only 2-7 millijoules/cm^2 (140x less than VCU's process).[12] In addition, The University of Nebraska protocol (a model for many UVGI implementations) is using 300 mJ/cm^2 (1/3 of the planned VCU dose). In our process, the delivered UVGI dose is measured, logged, and monitored in real-time by the Tru-D SmartUVC during every decontamination cycle to ensure that target UV exposures are achieved. We have also placed an independent UV-C sensor with the masks during each decontamination cycle as an internal validation measure.

Contaminated or damaged masks will be discarded. Masks will not change ownership. Masks are to be labeled with a health care worker's (HCW) name, employee ID, unit, date and number of completed UVGI cycles. The masks will be returned to the HCW's designated pickup location following decontamination.

An ideal decontamination method would preserve the filtering capacity and structural integrity (i.e. elastic bands, nose piece) of masks for a maximum number of decontamination cycles, while simultaneously being effective at viral inactivation, affordable, safe to implement and scalable. We have considered the use of STERRAD vaporized hydrogen peroxide plasma machines (VCU has three units). However, their significantly-limited throughput and high use of consumables makes them less than ideal to address the scope of our need. In addition, the FDA recently approved an EUA for a method from Battelle that utilizes vaporized hydrogen peroxide (VHP). While VHP is effective, it is not suitable for all institutions because of a lack of appropriate hardware, space and/or scalability. Our institution

is projecting a need to decontaminate between 12,000 – 20,000 N95 masks per day. UVGI is a reasonable choice for VCU because of its efficacy and ability to scale rapidly to meet this demand.

Our approach is not without limitations. While impacts on particle filtration performance are minimal, repeated high-dose exposure to UV light could impact the structural integrity of N95 components.[13] Our process accounts for this degradation by limiting masks to a maximum of 10 decontamination cycles and incorporating manual checks for any signs of breakdown that would impact proper fit and function. We are also performing fit tests for each batch. As an additional precaution, extra care must be taken during donning and doffing of decontaminated N95 FFRs to aid in the maintenance of the masks' structural integrity.[14]

References

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N95 Collection Process

1. Communication of collection process to VCU Health employees

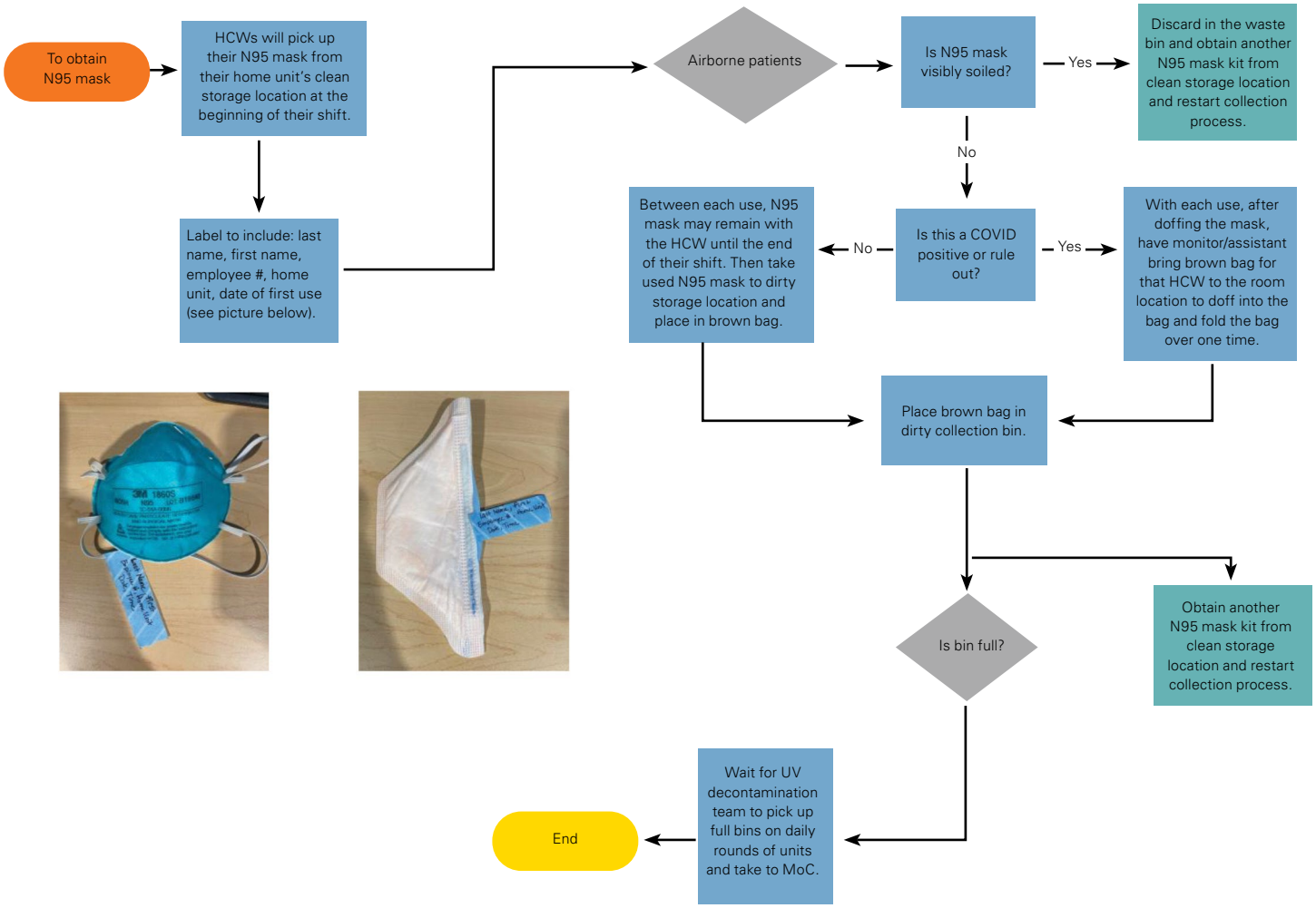
COVID19 is a marathon, not a sprint… It is imperative that we put process and controls in place so that we do not sprint through our PPE.

VCU Health is committed to protecting our team members. Assuming PPE is used appropriately and is not proliferated, VCUHS will continue to have supply of PPE; however, we must plan for what we will do if we are not able to obtain new disposable PPE.

- The efficacy of using UV-C light to decontaminate N95 masks has been demonstrated in the literature.
    - Single-stranded RNA viruses (e.g. SARS-CoV-2) are generally inactivated by UVGI exposure of only 2-7 millijoules/cm^2 (200x less than VCU's process).[12]
    - Nebraska uses a minimum of 300 millijoules/cm^2 of UV light on each side of mask.
    - VCUHS uses a minimum of 1,000-1,500 millijoules/cm^2 of UV light on each side of mask.
- A complete, evidence-based process for UV decontamination of N95s masks at VCU Health has been developed.
- CDC Crisis Standard of Care Decontamination Recommendation supports the use of UV-decontaminated N95s for all patient care activities when manufacturer or third-party guidance or procedures are available.
- CDC Crisis Standard of Care Decontamination Recommendation supports the use of UV-decontaminated N95s for all patient care activities except when performing or present for an aerosol generating procedure when manufacturer or third-party guidance or procedures are not available.
- VCUHS Infection Prevention has reviewed VCUHS' evidence-based design and process, including testing and safety controls, and has determined the VCUHS process for UVGI decontamination ensures decontaminated masks are safe for all patient care activities, including aerosol-generating activities.

N95 Collection Process Continued

2. Used N95 collection for healthcare workers process flow



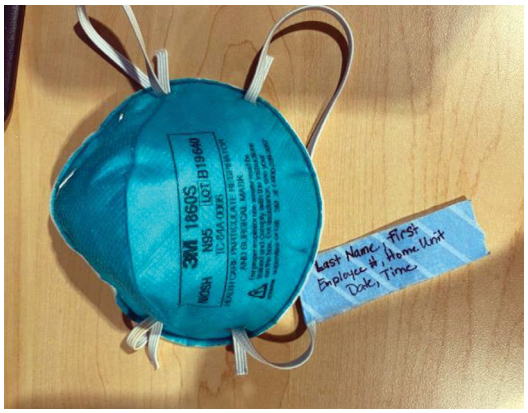
N95 Collection Process Continued

3. Step-by-step collection detail

Step 1

At beginning of the shift, label N95 mask and clean bag with decontamination tape.

- Both labels (for clean bag and N95) should be made using decontamination tape and include, written legibly:
    - Last name, first name
    - Employee #, home unit
    - Date, time
- "Home unit" is defined as the unit where you provide the most patient care.
- Supplemental Staffing team members should use "SS" as their home unit.
- Be certain to make labels large enough to include all information written legibly.
- N95 label should be placed on the centermost portion of the bottom strap.
- Should an inability to obtain new N95s exist, requiring the use of decontaminated N95s, HCWs receive a decontaminated N95 that only he/she has previously worn.



Step 2

Upon doffing, placed used N95 mask in brown bag and take bag to dirty storage area.

N95 Collection Process Continued

Step 3

Place brown bag in dirty collection bin.

Step 4

Is bin full?

Yes

Wait for UV decontamination team to pick up full bins on daily rounds and take to MOC.

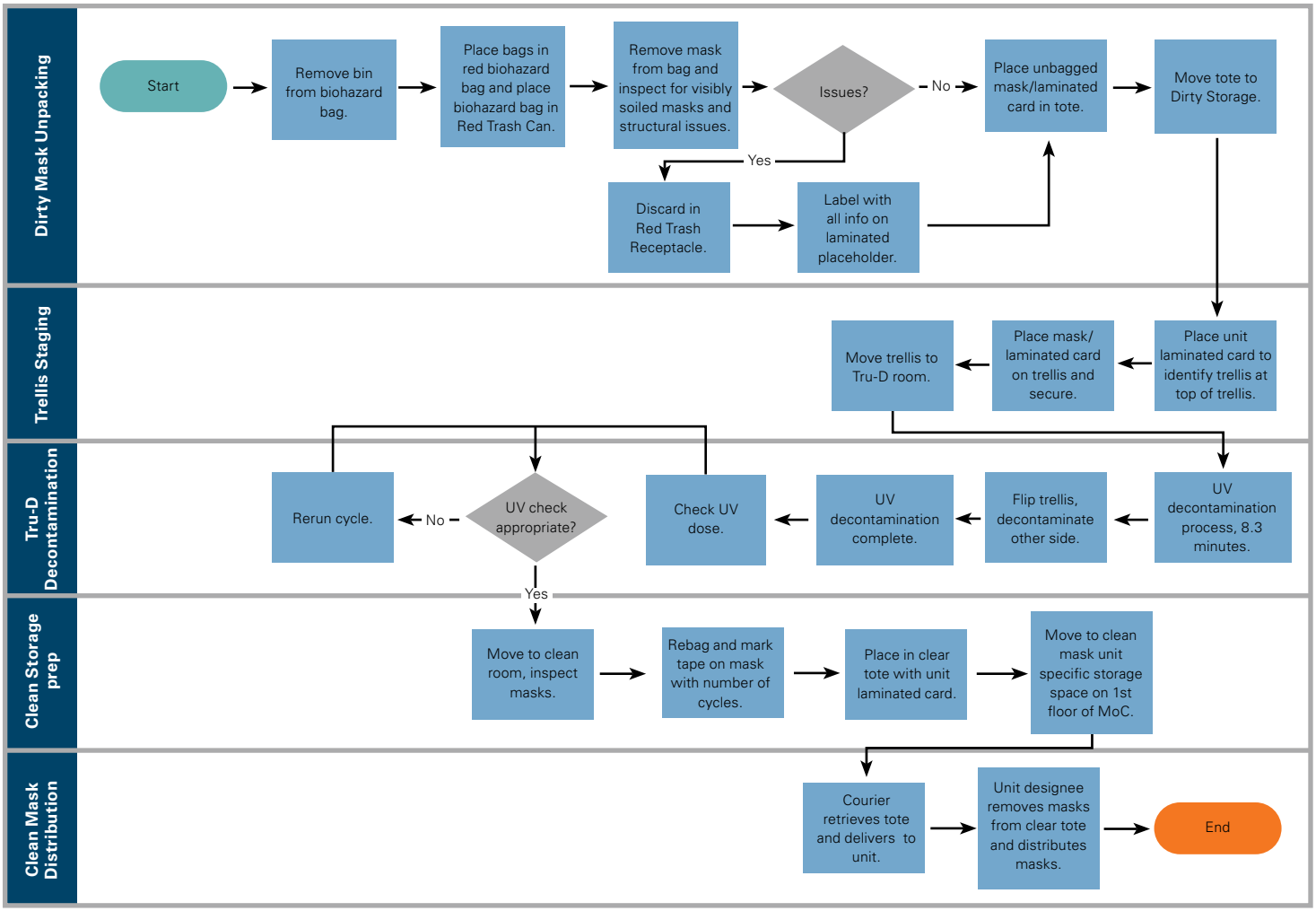
UV decontamination

Clean mask redistribution process

End

UV Decontamination Process

1. N95 UV decontamination process flow



UV Decontamination Process Continued

2. Step-by-step decontamination detail

Step 1

Dress in proper PPE.

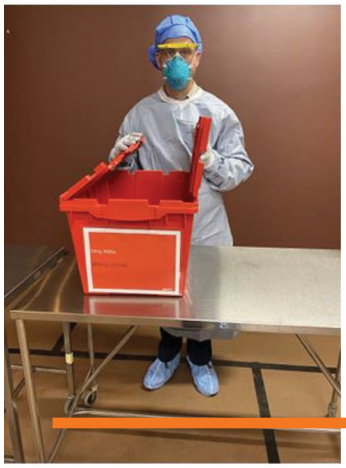
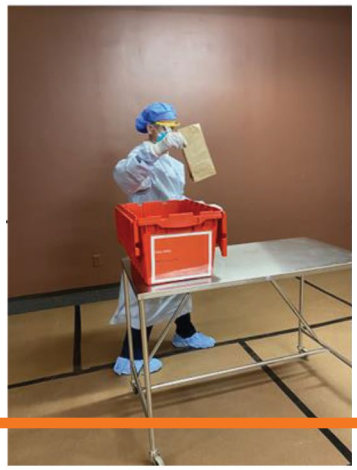
UV Decontamination Process Continued

Step 2

Dirty mask unpacking



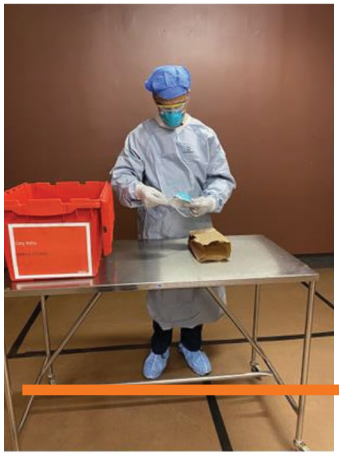
Remove tote from cart.


Open tote and remove brown bag from tote.

Step 2 Continued

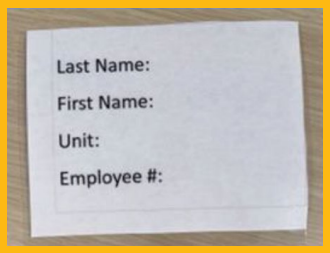
Continued dirty mask unpacking

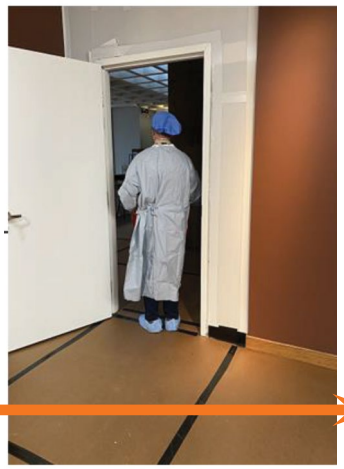


Remove mask from brown bag.

Inspect for visibly soiled masks and structural issues.

If visibly soiled, fill out laminated card.





Place unbagged mask in tote.

Move tote to trellis staging room by runner.

UV Decontamination Process Continued

Step 3

Trellis staging

Remove masks from tote and place masks on trellis and secure.

Place laminated unit card at top of trellis.

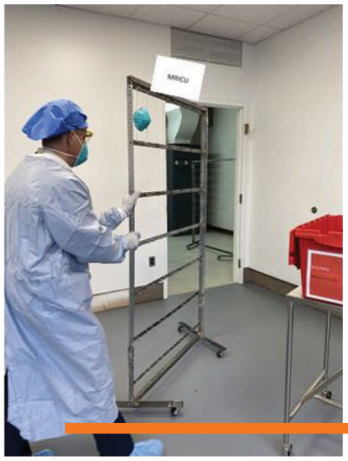
Place any laminated replacement cards with masks.

Fully loaded racks

UV Decontamination Process Continued

Step 4

Tru-D decontamination



Move trellis to Tru-D decontamination room.

Ensure trellises align with markings on the floor.

UV Decontamination Process Continued

Step 5

Start UV decontamination and check dose.

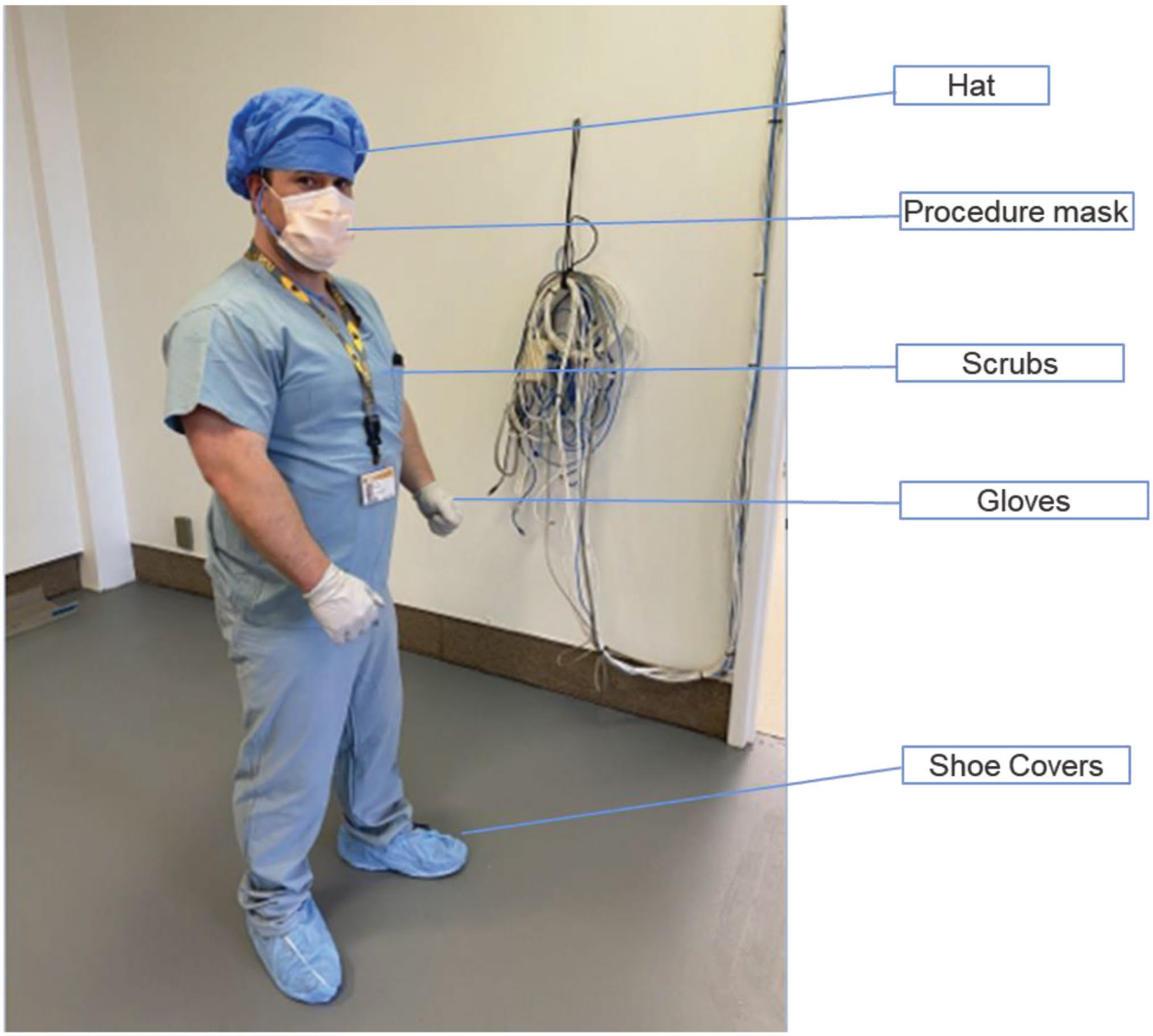
- 8.3 minutes decontamination time per side
- Safety check – check UV dose delivered to each side of the mask is ≥ 1,000 millijoules/cm^2
- Single-stranded RNA viruses (e.g. SARS-CoV-2) are generally inactivated by UVGI exposure of only 2-7 millijoules/cm^2
- Safety check – at least one mask from every batch is fit tested; masks fit tested are worn by workers of the N95 Decontamination Facility
- Fit testing is known as "gold standard"
- Safety check – a sample of masks receive a particle penetration test to ensure ≥ 95% of the particulates are blocked
- Safety check – a sample of masks receive testing for moisture levels
- Safety check – a sample of masks receive a breathability test to ensure air passes through mask

TECHNICAL NOTE FOR OTHER INSTITUTIONS

The uniformity and size of the UV dose ultimately delivered by the Tru-D SmartUVC device to the masks is dependent on a variety of factors, including the distance from the Tru-D to the trellises, Tru-D cycle time, the height of the masks on the trellises, the dimensions and surface materials of the decontamination room, and the orientation of the masks. If this process is implemented by another institution, it is critical that, at a minimum, an independent UV-C meter is utilized to measure and verify the accumulated UV dose (at all points representative of N95 mask positioning on trellises) during the selected Tru-D decontamination cycle. Further, VCU Health has deployed a system for measuring and logging the UV dose delivered to every batch of decontaminated N95s, for quality control purposes (e.g. detecting operator error, faulty bulbs). We recommend that other institutions implement a similar strategy, if possible.

Step 6

Dress in proper clean room PPE.



UV Decontamination Process Continued

Step 7

Clean storage prep.

Move trellis to clean room.

Inspect mask for any defects.

Then, drop clean mask into clear poly bag.

Step 8

Clean mask distribution

- Clean masks should be placed in a clear tote and then moved/stacked in the unit-specific zone of the clean area.
- Courier will retrieve clean tote and deliver back to unit.
- Unit designee removes masks from clear tote and distributes masks.

Redistribution Process

1. Step-by-step redistribution detail

Step 1

Bins of UV decontaminated N95s will be delivered to each unit.

- Bins will be delivered to units containing decontaminated N95s.
- Each decontaminated N95 will be labeled with:
  - Last name, first name
  - Employee #, home unit
  - Date, time
- Decontaminated N95s will be within unsealed, clear plastic bags to allow viewing of labels.
  - Do not seal bags, air must be able to reach mask.

Step 2

Units are responsible for distributing decontaminated N95s to team members.

- Units should identify a central location and dedicated team members responsible for:
  1. Organizing decontaminated N95s alphabetically
  2. Distributing decontaminated N95s to team members at the beginning of shift:
     - When doffing a decontaminated N95, the decontaminated N95 should be collected using the Collection of Used N95s process included in this document.

Appendix A: Purchasing List

Item	Quantity
Red totes (21.5”x15”x12.5”)	400 EA
Clear totes (21.5”x15”x12.5”)	400 EA
Thin tip sharpies	1,000 EA
Surgical tape	50 RL *(more available from Central Supply if needed)*
Brown paper bags	100,000 EA
Metal & welding material for trellis	$7,350 in welding supplies
Tru-D decontamination machine	1
Clear poly bags	50,000
Laminating pouches	1,000 EA
Dry erase markers	25 EA

Appendix B: Trellis Fabrication Specifications

1. Parts list: Below is an outline of commercially available parts needed to fabricate one (1) N95 trellis, as proposed by VCU Health.

- **Frame sides (2X)**
  - 1.5" X 1.5" X 60" perforated angle bar
- **Crossmembers (6X)**
  - 1" X 48" flat bar
  - For hanging masks
- **Frame feet (2X)**
  - 2" X 20" flat bar
  - To attach casters
- **Frame bottom (1X)**
  - 1.25" X 48" square tube
  - This wider tube was used as a base for the trellis, providing larger surface area to attach feet.
  - This part may be substituted for a 1" X 48" square tube.
- **Frame top (1X)**
  - 1" X 48" square tube
- **Mask stabilizer**
  - Roughly 60' of ⅛" stainless steel braided wire
  - Increases stability of masks between crossmembers.
- **Wire fastener (10X)**
  - 3/32" ferrules
  - For securing wire through frame
- **Wheels (4X)**
  - 2" swivel casters
- **Mask hangers (140+)**
  - #6 X 1.25" nuts and bolts
  - Top and bottom crossmembers have only one (1) row of nuts and bolts.
  - Middle crossmembers have two (2) rows of nuts and bolts.
  - The position of the bolts will be determined by the types of masks being used. Dependent on mask type, this frame may require more or fewer nuts and bolts.
  - VCU Health bolt position alternates 2.25" gap and a 4" gap to accommodate masks with appropriate spacing between:
    - See attached images for more details.
- **Crossmember Mounts (6X)**
  - 0.25" X 0.75" nuts and bolts
  - VCU Health original design incorporated a welded frame. You may need to increase the number of these bolts if not welding the frame.

Appendix B: Trellis Fabrication Specifications Continued

2. Additional hardware and fabrication notes

- Additional hardware for attaching the casters, feet, as well as top and bottom square tube to the side rails, may be required.
- All welding was done by Mig process with argon CO2 gas and 0.035 wire.

3. Visual aids

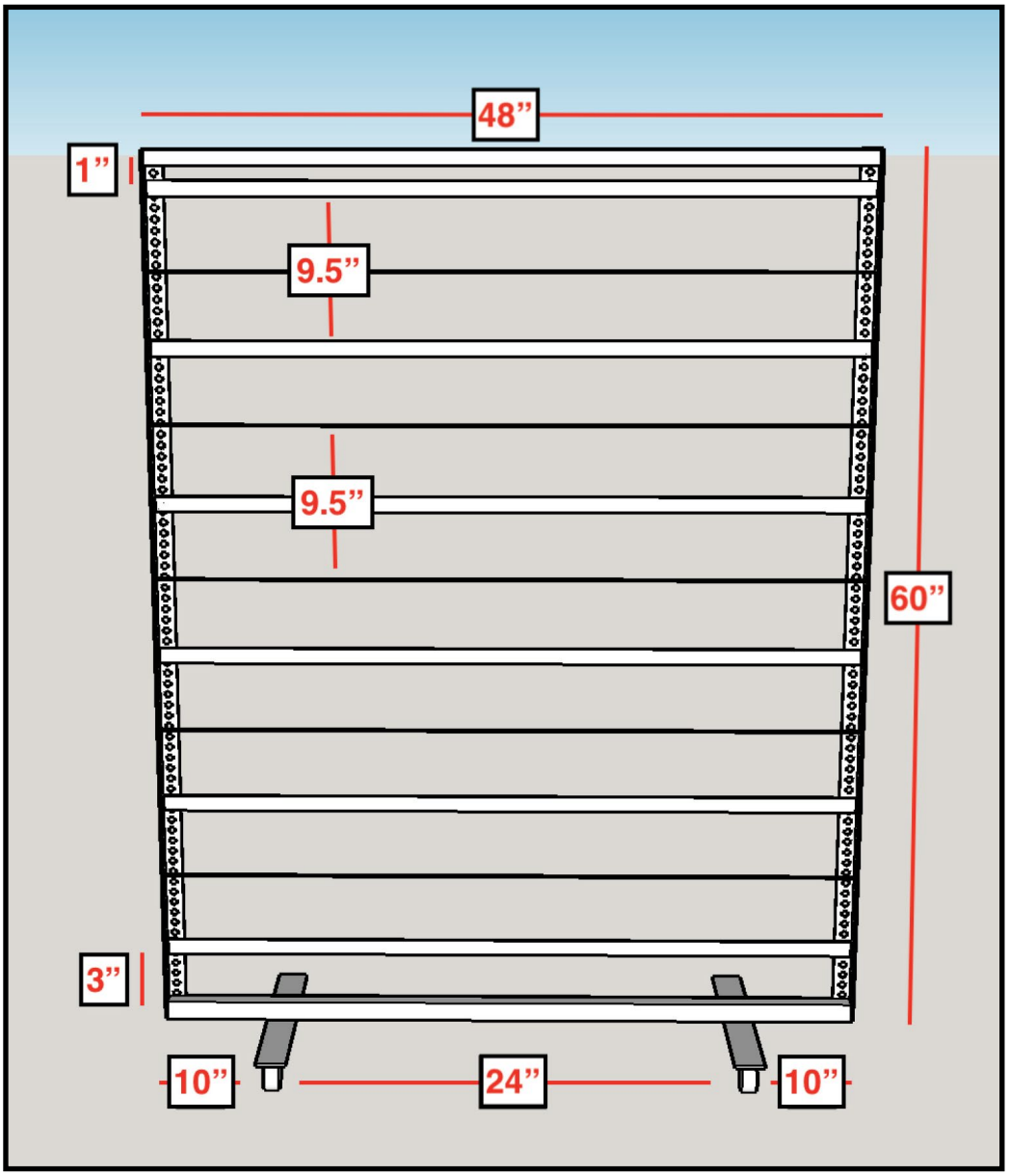


Figure A: Trellis dimensions

Appendix B: Trellis Fabrication Specifications Continued

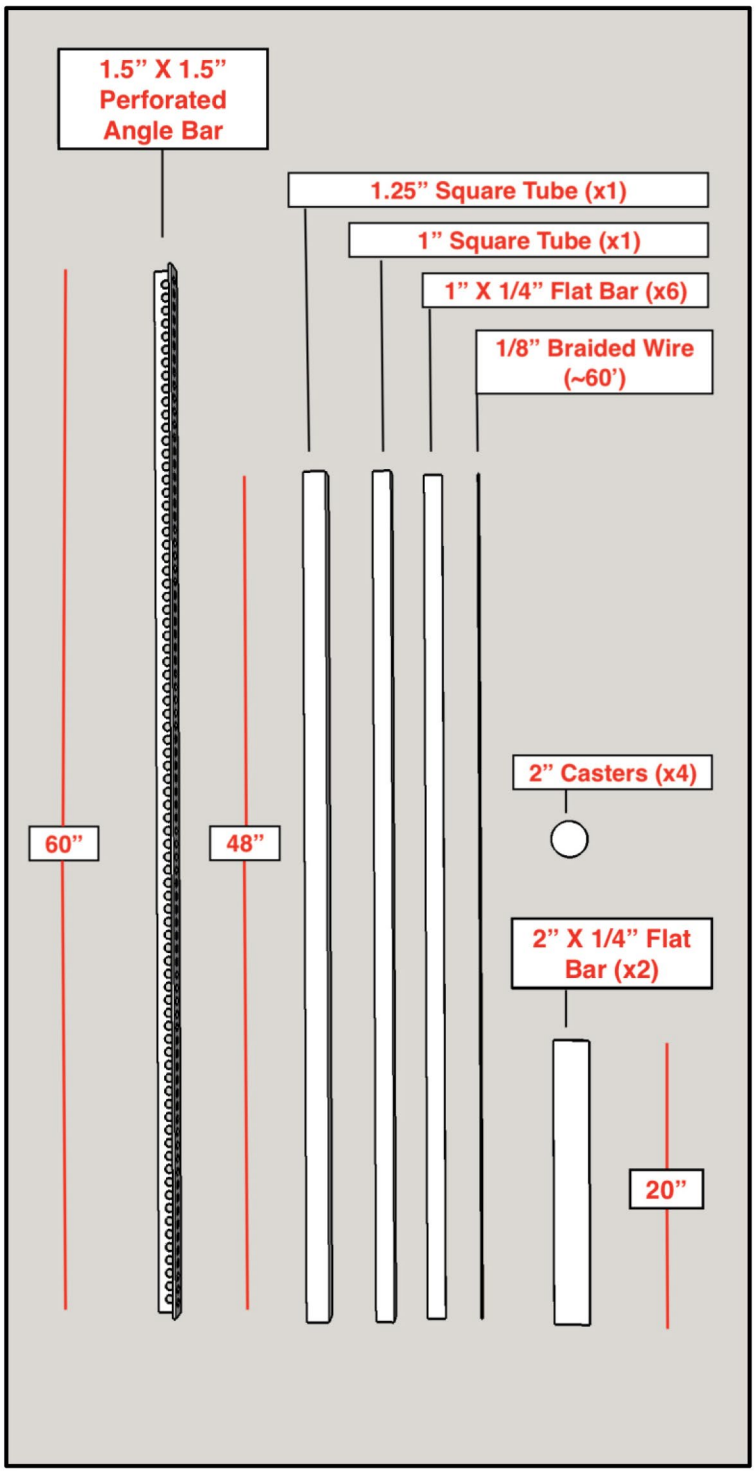


Figure B: Trellis parts dimensions

Appendix B: Trellis Fabrication Specifications Continued

Figure C: Trellis front

Appendix B: Trellis Fabrication Specifications Continued

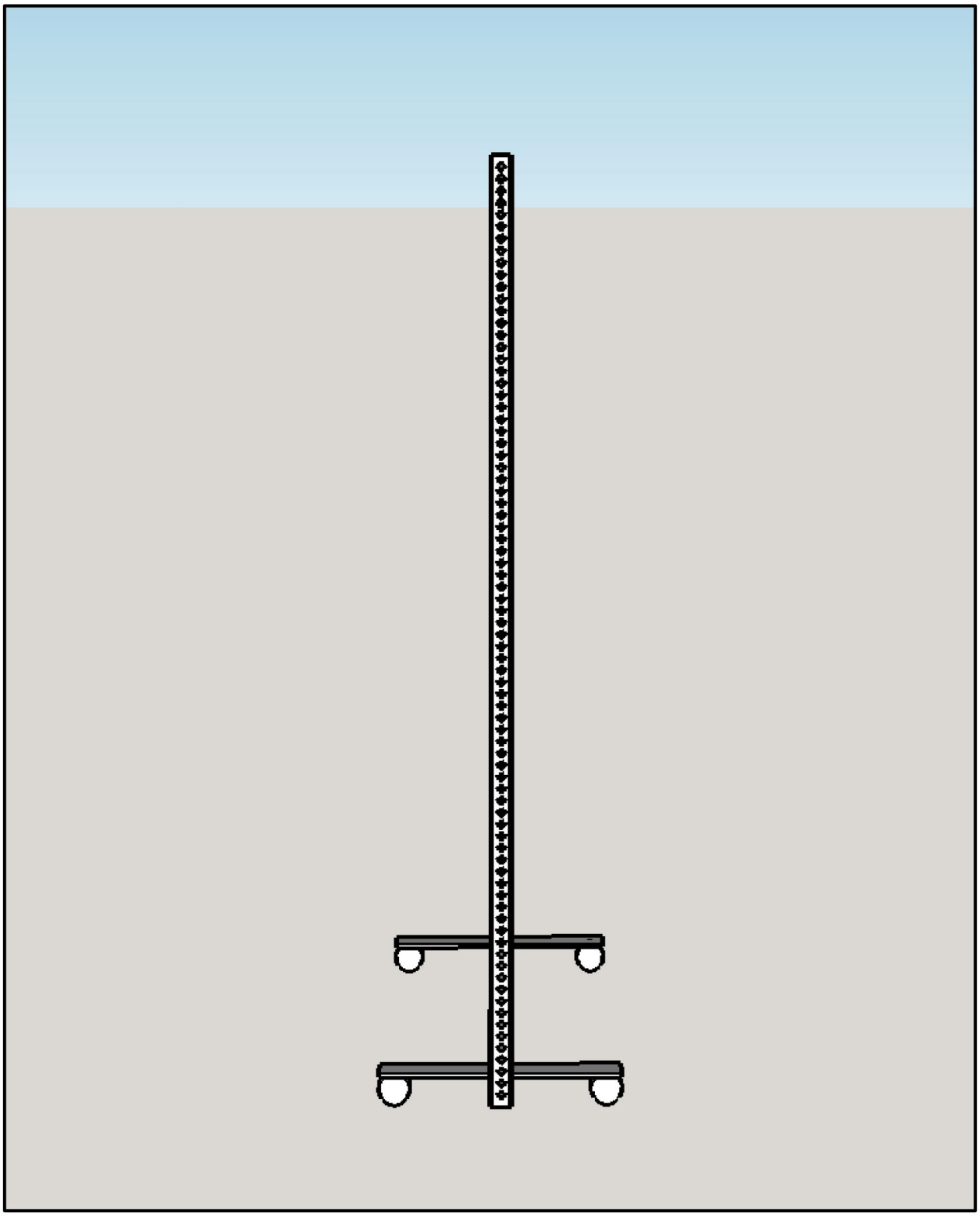


Figure D: Trellis side

Appendix B: Trellis Fabrication Specifications Continued

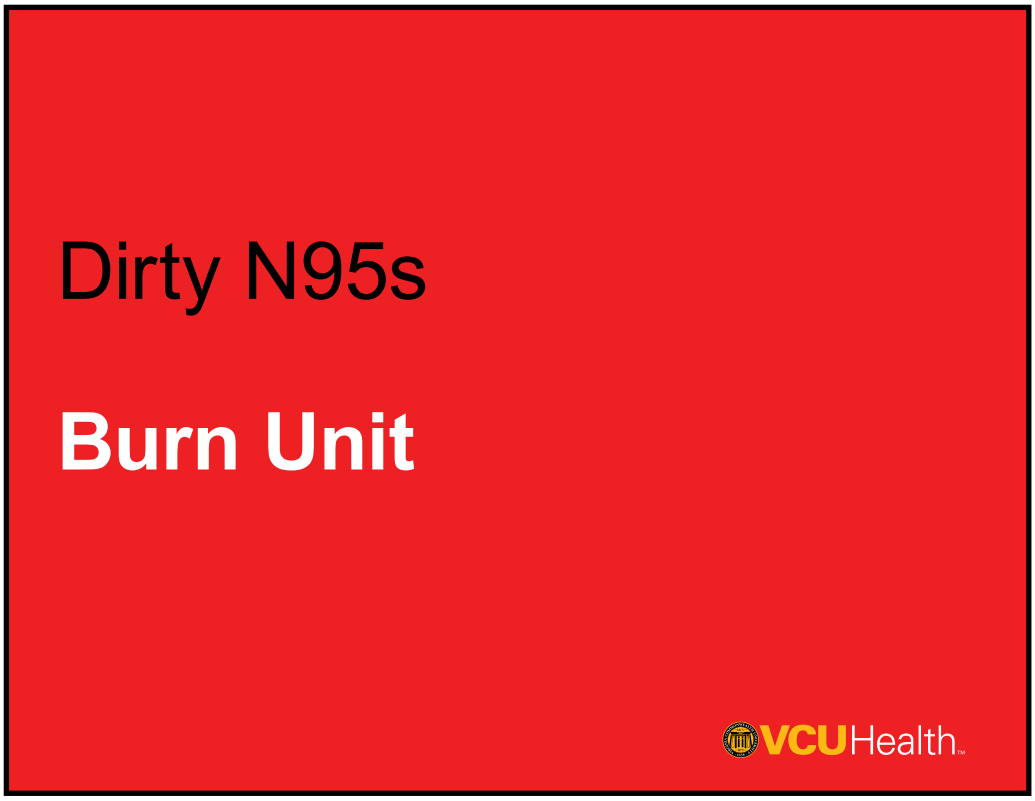
Figures E & F: Trellis photos

Appendix B: Trellis Fabrication Specifications Continued

Figures G & H: Trellis configuration in decontamination room

Appendix C: Tote Signage

On average, 10 signs per unit were printed and laminated. These were then posted to the front of red totes and rotated into the dirty utility room of each unit once the former tote was filled with used N95s.



Appendix D: Video Link

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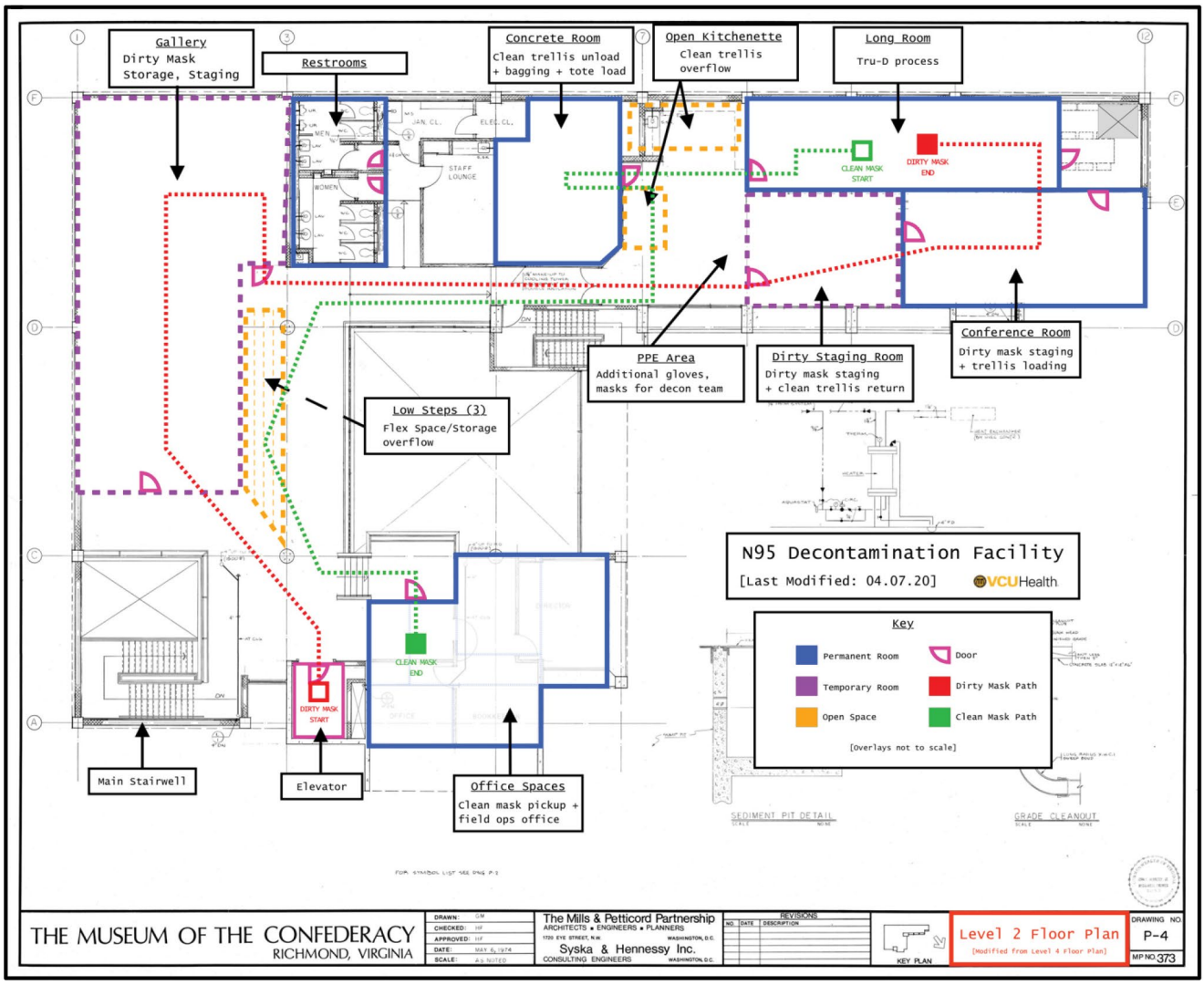
Appendix E: Floor Plan

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