

Introduction

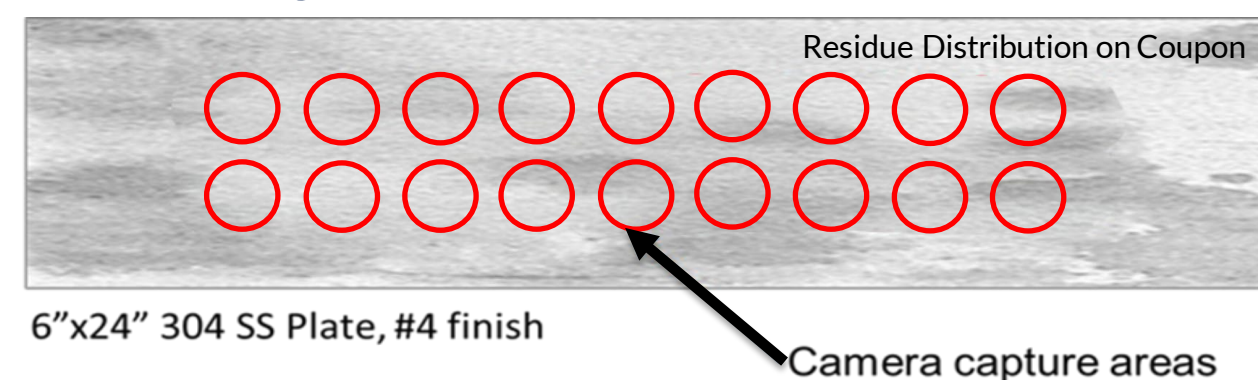
The cleaning of process and environmental residues is a crucial aspect of a contamination control strategy and is mandated by several cGMP regulations. Environmental residues, which remain on surfaces post-disinfection, can accelerate the deterioration of manufacturing area surfaces and pose safety hazards, such as slip and fall risks for operators. The accumulation of environmental residues can also have an impact on the performance of disinfectants and may harbor microorganisms.

Method

- Four common cleanroom surfaces tested:
 - Stainless steel (#4 finish)
 - Glass
 - Epoxy flooring
 - Vinyl panel (wall/floor)
- Two disinfectants tested:
 - Peracetic Acid (PAA)/Hydrogen Peroxide (HP) blend
 - Ethanol (EtOH)/Quat blend
- A fluorescent tracer dye was added to the disinfectants. One layer of disinfectant was applied via wiping by an automated device.
- Two residue removal solutions tested:
 - 70% Isopropyl Alcohol (IPA)/30% Deionized Water (DI)
 - 100% Deionized Water (DI)
- Removal performed using various mops or wipes. Wiping was performed via automated device.
 - Wipes/Mops were saturated at 60% of their respective sorbent capacity.
- Camera pixel analysis was used to measure the amount of fluorescence proportional to the disinfectant residue on the surface by image capture of the following conditions:
 - Clean, blank surface
 - Surface following disinfectant application and drying
 - Surface post-residue removal step
- Each trial included 5 replicates with 18 camera sampling locations per replicate.

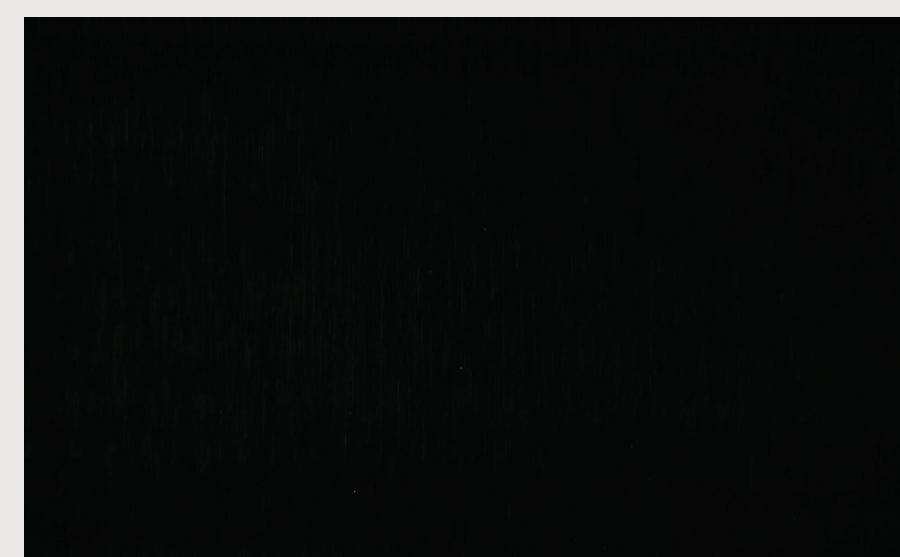
Coupons

- The coupons or coverage area used for testing were 6" x 24"
- Red circles: image capture

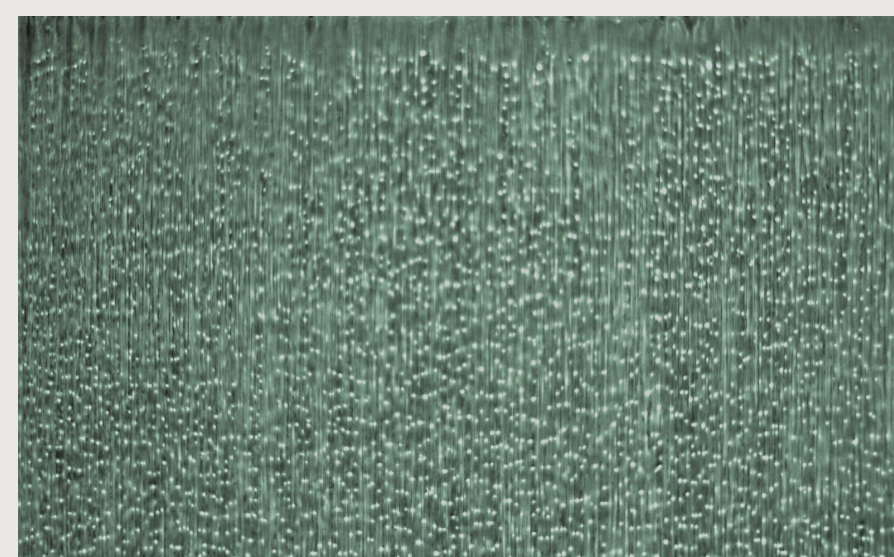


Results

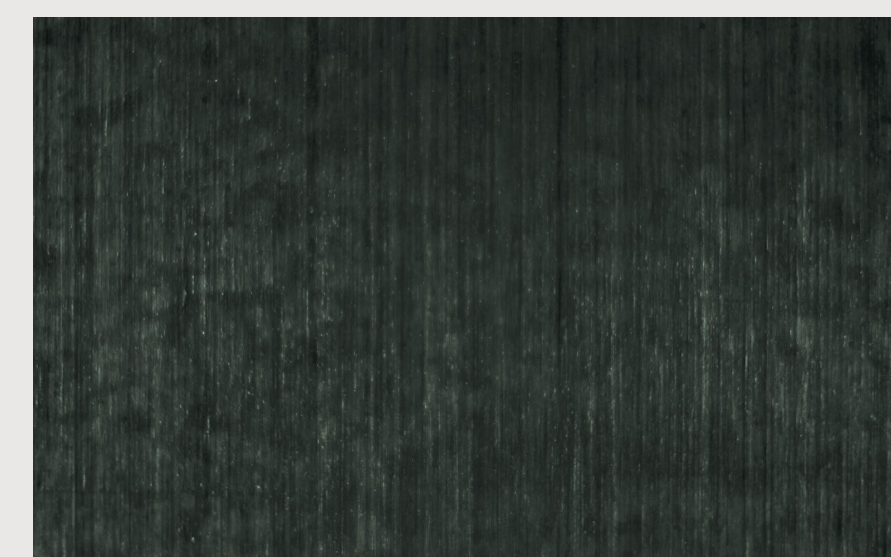
As shown in the image below, the camera analysis of the clean surface has no fluorescence present. The applied residue image depicts an example of a wiped and dried residue. The third image is an example of a surface after wiped with a textile saturated with 70/30 IPA/DI or 100% DI.



Clean surface

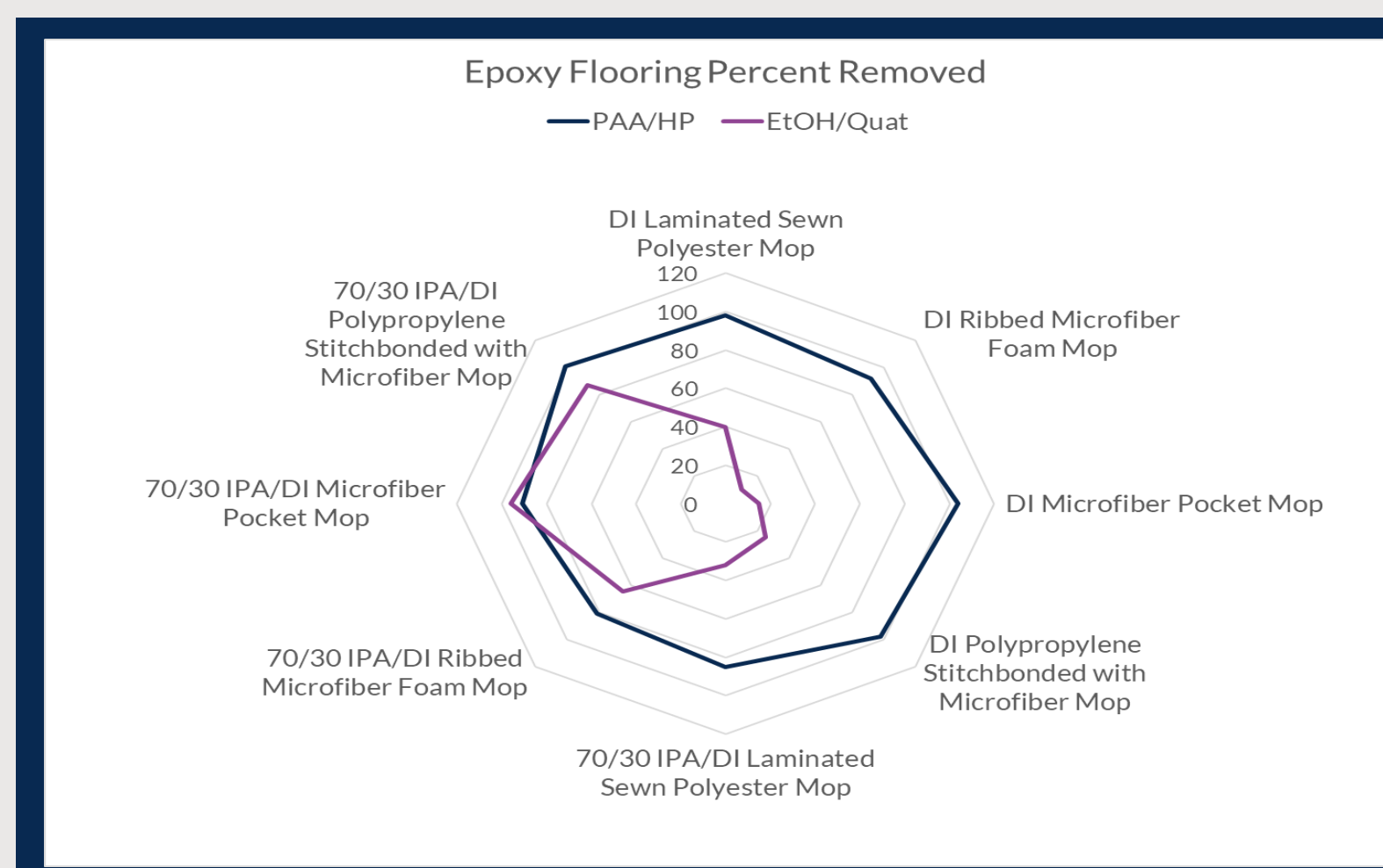
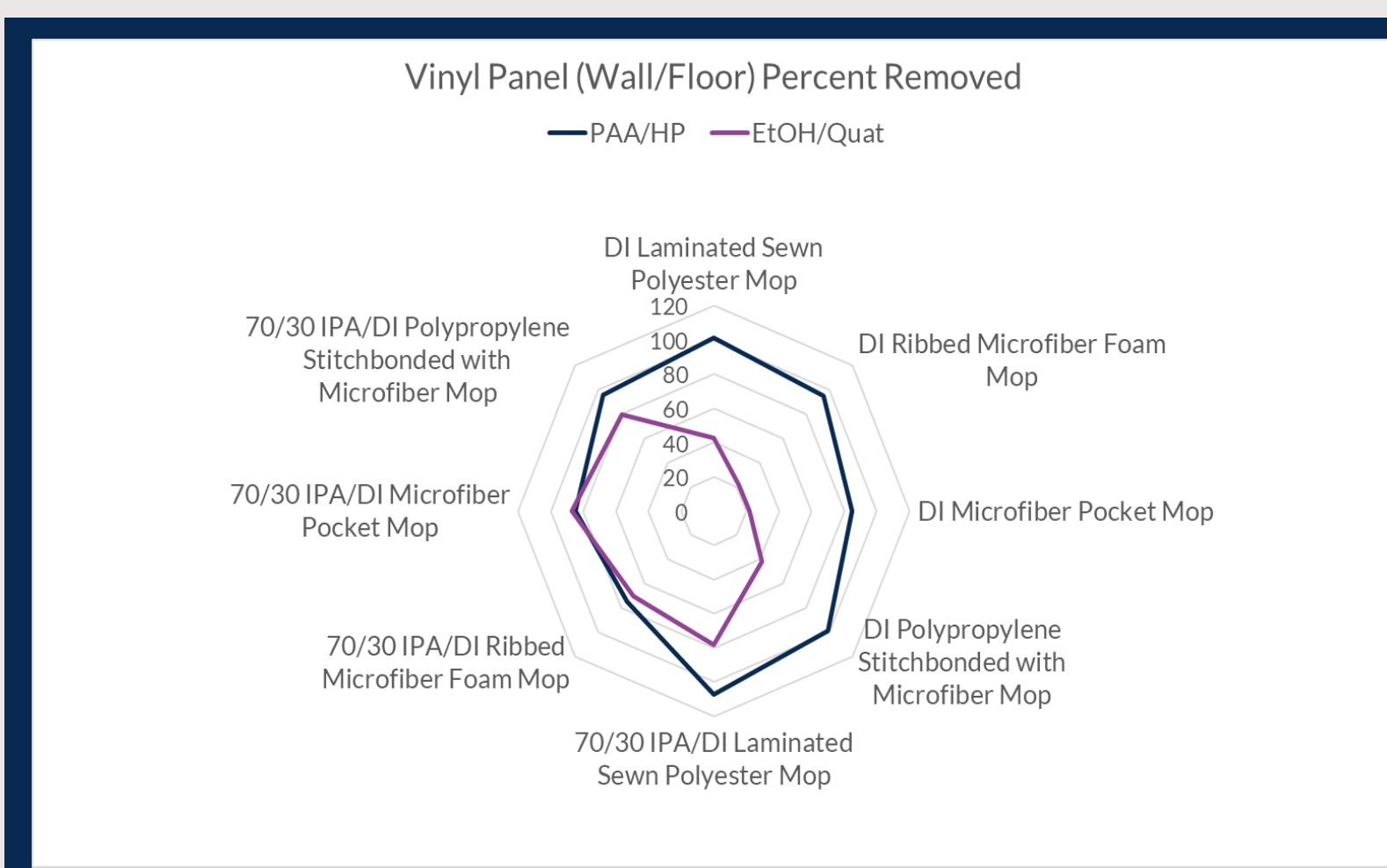
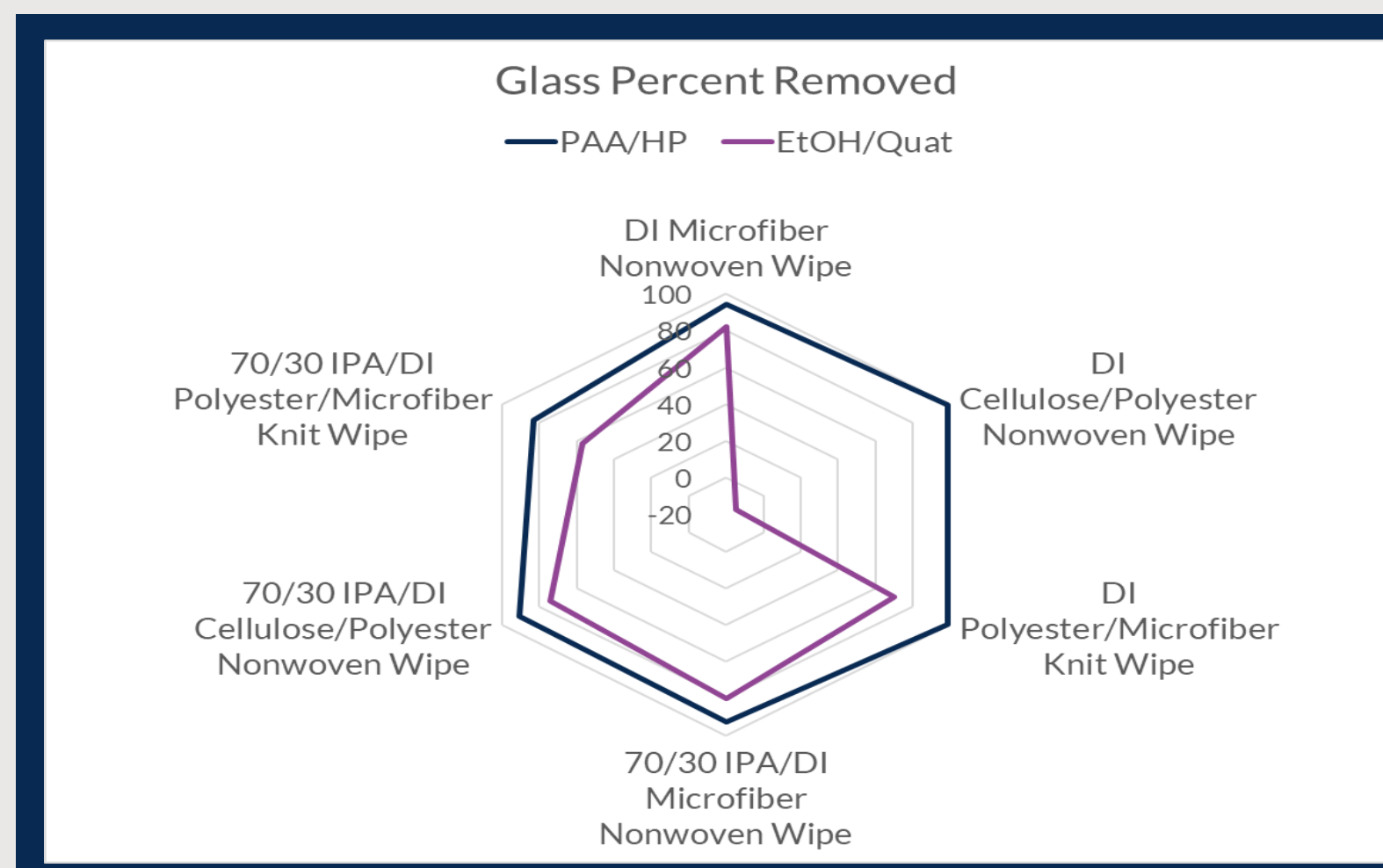
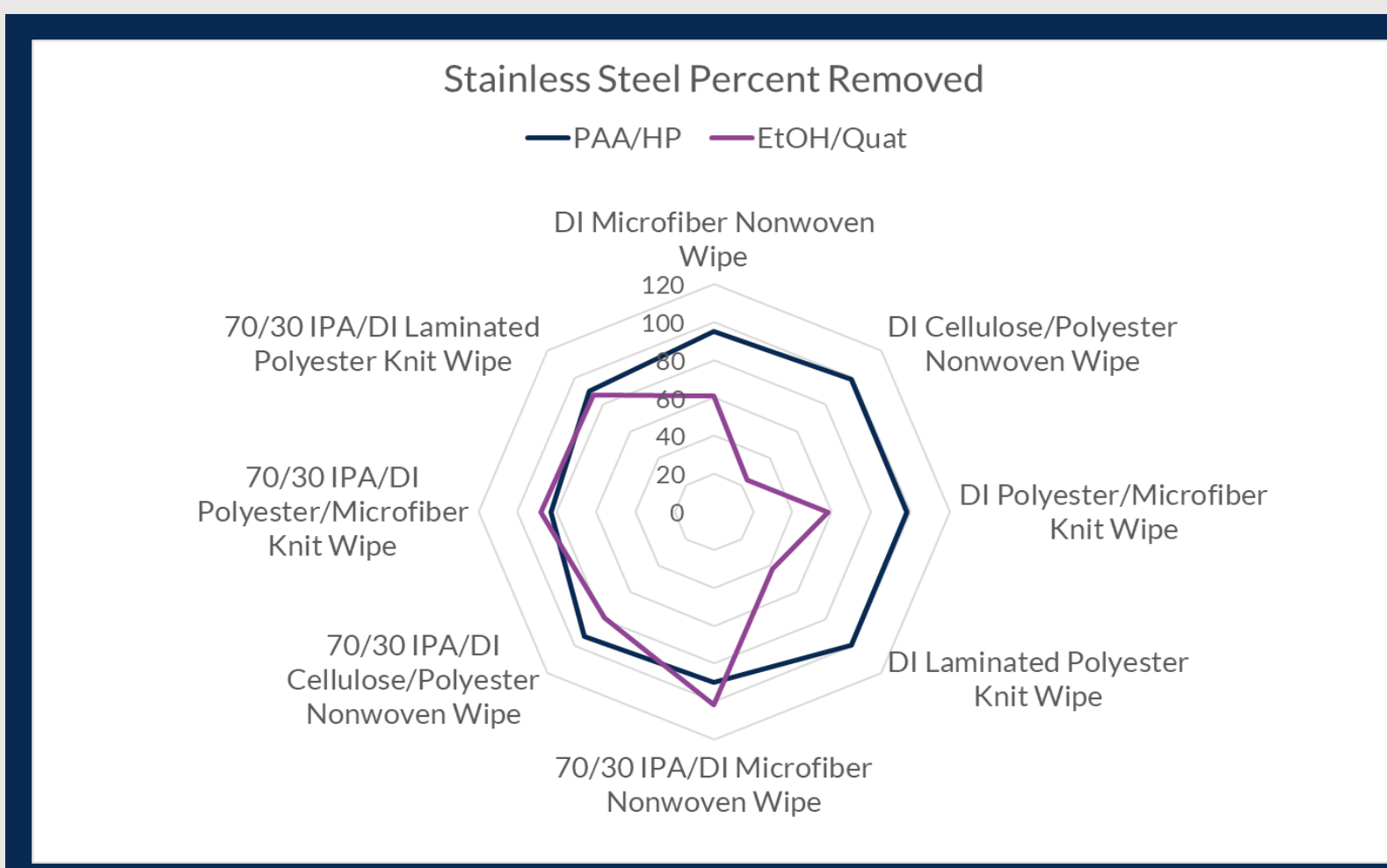


Applied residue



Wiped surface (70/30 IPA/DI or 100% DI)

The results are depicted in the spider charts below. Values shown are representative of percent removal.



Discussion

- Disinfectants tend to leave an irregular distribution of residue due to their uneven laydown. This effect can be seen more prominently on certain surfaces due to their surface tension. Multiple images were captured with this taken into consideration and correlated with what was observed visibly.
- Image analysis of the coupons was taken of the middle section of the continuous wiping path to eliminate variations caused by the start and stopping of the automated wiping motion.
- Textiles were saturated at 60% of their respective sorbent capacity to gather data on their performance mid-use.

Analysis

- The PAA/HP disinfectant tested is a water-based chemistry. While water was the most effective solution in general, in many cases, the IPA/DI water solution was also very effective at removing the residue.
- However, in the case of the EtOH/Quat disinfectant, which is alcohol based, in most scenarios, water was not a good choice as the solution for residue removal. IPA/DI water solution was much more effective in removing the residue.
- In terms of textiles used for residue removal, in many scenarios, microfiber and knit fabrics performed better at residue removal than polyester/cellulose nonwovens.

Conclusions

- The nature of cleanroom disinfectants leads to disinfectant residue accumulation if not routinely managed through an effective residue removal program. While the presence of residues is not new to cleanroom operations, the importance of residue removal has recently been highlighted in the 2022 revision of Annex 1:

"Cleaning programmes should effectively remove disinfectant residues."
-EU GMP Annex 1: Manufacture of Sterile Medicinal Products

- To develop a successful residue management program, it is imperative to understand the impact that various solutions and textiles have on disinfectant residues.
 - The type of solution used for residue removal matters. If the residue is from an alcohol-based chemistry, 70/30 IPA/DI is the better option. If the residue is from a water-based chemistry, water is the better option.
 - The type of material used to mop or wipe can make an impact. Microfiber and knit fabrics over all were more effective for residue pickup.
- It is important to take into consideration the grade and criticality of the environment when establishing a residue management program as not all textiles will be appropriate for more critical environments.