3.3.12* Cleaning. The act of removing soiling and contamination from ensembles and ensemble elements by mechanical, chemical, thermal, or combined processes.

A.3.3.12 Cleaning. Cleaning is considered separate from the use of disinfectants and sanitizers; however, some cleaning processes might also effectively remove biological contamination. Removal of biological contamination is covered under disinfection and sanitization.

3.3.12.1* ***Advanced Cleaning.*** The act of removing both soiling and contamination generally associated with products of combustion.

3.3.12.2* ***Specialized Cleaning.*** The act of removing hazardous materials, soiling associated with body fluids, or other forms of contamination.

A.3.3.12.2 Specialized Cleaning. This level of cleaning involves specific procedures and specialized cleaning agents and processes primarily for the removal of hazardous materials such as bulk chemicals and other designated substances but excluding disinfection or sanitization of microbial contamination. Different approaches can be used for removing specific types of contamination. Specialized cleaning can also be an enhanced form of advanced cleaning.

3.3.21* Decontamination. The act of removing contamination from or neutralizing contamination in protective clothing and equipment.

A.3.3.21 Decontamination. Decontamination is specific to the removal or neutralization of contamination whereas cleaning can remove both soiling and contamination. Decontamination might also apply to certain types of specialized cleaning where particular procedures are used to remove or neutralize contaminants other than products of combustion that are found on protective ensembles or elements. Decontamination might involve mechanical, chemical, thermal, or combined processes for removing or neutralizing contaminants. An example of a mechanical process is where brushing or wiping removes an exterior contaminant from the surface of the element. Chemical processes involve the use of detergents or other cleaning agents that react with or aid in the removal of contaminants from element materials. Heating is one type of a thermal process where higher temperatures could cause certain contaminants to evaporate out of the element materials. Laundering is a form of a combined process where the machine agitation, use of a detergent, and heated water all work together to remove contaminants from the element.

3.3.22* Disinfectant. A type of antimicrobial agent that destroys or irreversibly inactivates fungi and bacteria, but not necessarily their spores, on inanimate surfaces and objects.

A.3.3.22 Disinfectant. Disinfectants as an antimicrobial agent are considered a pesticide and thus subject to regulations established by the U.S. Environmental Protection Agency (EPA). All disinfectants must be registered with the EPA and meet specific labeling requirements. A listing of currently registered disinfectants can be found at www.epa.gov/pesticide-registration/selected-epa-registered-disinfectants. Disinfectants are required to be used as specified on the product label as determined by the EPA registration process. Disinfectants can either be used on hard surfaces such as helmet shells and eye and face protection devices, or be used as a presoak treatment for fabrics and textiles. Appropriately labeled and registered disinfectants can also be used for disinfecting laundry. The specific requirements for demonstrating acceptable performance are found in the following EPA Office of Chemical Safety and Pollution Prevention (OCSPP) product performance test guidelines:
(1) OCSPP 810.2200, “Disinfectants for Use on Hard Surfaces — Efficacy Data Recommendations”
(2) OCSPP 810.2400, “Disinfectants and Sanitizers for Use on Fabrics and Textiles — Efficacy Data Recommendations”

Both of these documents provide for different classifications of disinfectants for their intended use. Classification types include limited (primarily for household use), general or broad spectrum (used in commercial areas), and hospital or health care. Specific procedures and target microorganisms are utilized to demonstrate the effectiveness of the respective disinfectant. In general, a disinfectant must kill all target microorganisms.

3.3.83* Sanitizer. A type of antimicrobial agent that is used to reduce, but not necessarily eliminate, microorganisms from the inanimate environment to levels considered safe as determined by public health codes or regulations.

A.3.3.83 Sanitizer. Like disinfectants, sanitizers are considered a pesticide and thus subject to regulations established by the U.S. Environmental Protection Agency (EPA). All sanitizers must be registered with the EPA and meet specific labeling requirements. A listing of currently registered sanitizers can be found at https://www.epa.gov/pesticideregistration/selected-epa-registered-disinfectants. Sanitizers are required to be used as specified on the product label as determined by the EPA registration process. Sanitizers can either be used on hard surfaces such as helmet shells and eye and face protection devices, or be used as presoak treatments or laundry additives for fabrics and textiles. The specific requirements for demonstrating acceptable performance are found in the following EPA Office of Chemical Safety and Pollution Prevention (OCSPP) product performance test guidelines:

(1) OCSPP 810.2300, “Sanitizers for Use on Hard Surfaces — Efficacy Data Recommendations”

(2) OCSPP 810.2400, “Disinfectants and Sanitizers for Use on Fabrics and Textiles — Efficacy Data Recommendations”

Both of these documents provide for different classifications of disinfectants for their intended use. Classification types include sanitizers for food contact products and non–food contact products. Specific procedures and different target microorganisms are utilized to demonstrate the effectiveness of the respective sanitizer. In general, a sanitizer must reduce the number of microorganisms by 99.9 percent (a 3 $\log_{10}$ reduction).

A.7.1.3 *Body Fluids and Other Microbial Contamination.* Body fluids such as blood, vomit, and various secretions are often encountered in providing emergency patient care or rescue of victims at an emergency scene. These fluids must be treated as potentially infectious, therefore ensembles and ensemble elements contaminated with body fluids must be subject to sanitization or disinfection, where disinfection represents a greater efficiency in removing potentially infectious microorganisms. Other biological contaminants can include methicillin-resistant
Staphylococcus aureus (MRSA) and Clostridium difficile (C. difficile) from medical victim contact and Escherichia coli (E.coli) from flood water contact. These contaminants require disinfection or sanitization of ensembles and ensemble elements to reduce the microbial threat where exposure has occurred. Disinfection or sanitization might precede advanced cleaning or be part of the advanced cleaning process since soils associated with many body fluids must also be removed. It is important to recognize that disinfection or sanitization generally only affects the viability of the microbial contamination and might not remove other associated soils such as dried blood, body fluids, or other liquids/solids in which the microbial contamination is found.
A.7.3.3 Advanced cleaning is a thorough cleaning of ensembles and ensemble elements accomplished by washing them with cleaning agents. Advanced cleaning is prescribed for ensembles and ensemble elements that are soiled or contaminated, including those that have been subject to ordinary wear without contamination, those that have been contaminated in structural or proximity fire fighting by products of combustion, or those that have been exposed to blood and body fluids. Where highly hazardous or other designated substances are involved, specialized cleaning might be needed. Specialized cleaning differs from advanced cleaning in that an assessment of the contamination by an individual knowledgeable in the cleaning of fire-fighting protective ensembles and ensemble elements is needed for determining what type of cleaning, if any, is appropriate.
A.7.3.7.2 The pH for the product can be indicated on the product (detergent) container and should be the pH for the product in an undiluted form if it is a liquid. If the detergent is a powder, the pH will be reported at a specific concentration of the solid on a weight basis in water. If the pH is not listed on the product container, then the safety data sheet (SDS) should be requested from the product supplier. Most suppliers will normally provide the SDS for their respective products as part of the shipment, and it might also be possible to obtain a copy of the SDS online from the supplier's website. The pH for the product is typically listed in Section 9 of the SDS for the product's physical and chemical properties. The selection of the detergent should include a consideration of several factors in addition to the pH range. Foremost among these is demonstration by the supplier that the detergent is safe to use with fire fighter protective clothing. This demonstration consists of the following two parts:
(1) The effectiveness of the detergent in removing soils and other contaminants as indicated later in this section
(2) The impact of the detergent through multiple washings on the protective element
This information might be available from the supplier of the detergent, the manufacturer of the protective element, or the fabric suppliers. If there is uncertainty about a particular detergent or cleaning agent, the manufacturer of the protective element should be contacted. Organizations should be cautious about detergent or chemical suppliers that offer several different chemicals for cleaning protective elements. Many chemical suppliers will provide the organization with an automated dispenser that can feed liquid chemicals into the washer/extractor at no cost, on the requirement that chemicals are purchased from that supplier. Certain types of chemicals, such as alkali builders and sours, should be avoided. Alkali builders are used to significantly increase the pH of the wash water for enhancing the cleaning performance of certain detergents. These chemicals typically have pH values that are greater than 10.5. When alkali builders are used, the pH is usually brought to a lower level using a "sour," an acid based agent used to bring the wash water back to a neutral pH.

Sour cleaning agents are added toward the end of the wash formulation and almost always have pH values much lower than 6.0. The combination of alkali builders and sours is most often used in institutional laundering facilities but is not appropriate for protective elements unless the manufacturer of the respective protective element has indicated that these types of products can be used safely.

A.7.4.3 The contamination of protective ensembles or ensemble elements with body fluids or other potentially infectious materials, such as contaminated flood water, requires specific procedures for eliminating the health threats associated with microbial contamination. At a minimum, protective ensembles and ensemble elements should be subject to sanitization, where the levels of microbial contamination are reduced to acceptable levels, or disinfection, where all viable microbial contamination has been eliminated. In general, sanitization is most often applied to porous surface such as the fabrics and textiles associated with garments, helmets textile components, gloves, footwear, and hoods, whereas disinfection is applied to hard surfaces such as helmet shells. In many cases, disinfection or sanitization is initially applied to the ensemble or ensemble element to inactivate the microbial contamination and is then followed up by advanced cleaning to further remove the soils associated with the contamination (e.g., blood and body fluid solid residue). Any sanitizer or disinfectant that is used on the ensemble or ensemble element should be registered with the EPA, which has approval processes for different types of sanitizers and disinfectants.

The EPA has established guidelines for demonstrating the efficacy of both disinfectants and sanitizers. These procedures are established in the following publications:

(1) OCSPP 810.2200, “Disinfectants for Use on Environmental Surfaces — Guide for Efficacy Testing”

(2) OCSPP 810.2300, “Sanitizers for Use on Hard Surfaces — Efficacy Data Recommendations”

(3) OCSPP 810.2400, “Disinfectants and Sanitizers for Use on Fabrics and Textiles — Efficacy Data Recommendations”

A listing of currently registered disinfectants and sanitizers can be found at https://www.epa.gov/pesticide-registration/selected-epa-registered-disinfectants. However, in order to identify an appropriate sanitizer or disinfectant on the EPA’s directory, the EPA registration number, manufacturer name, or product name is needed. Many disinfectant and sanitizer products are rebranded and have a distributor number that appears after the primary manufacturer registration number. This listing also identifies specific disinfectants or sanitizers for effectiveness against specific types of infectious diseases. A recommended starting point is “List H. EPA’s Registered Products Effective Against Methicillin Resistant *Staphylococcus aureus* (MRSA) and Vancomycin Resistant *Enterococcus faecalis* or faecium (VRE).” Not all recommended listed disinfectants or sanitizers are suitable for protective ensembles or ensemble elements. Examine the product’s safety data sheet (SDS) for chemicals that might be harmful to the protective ensemble or ensemble element, particularly those with container pH outside the prescribed acceptable range of 6 to 10.5 specified in 7.3.7.2, or check with a verified ISP or the manufacturer of the ensemble or ensemble element for further advice. Where these product types are used, it is essential that instructions provided by the supplier be followed since the efficacy of their disinfection or sanitization is based on specific ratios of agent to water, residence time, and other application factors that were used to demonstrate the effectiveness of the product as a disinfectant or sanitizer. Use of too little product or under the wrong conditions might cause the product to be ineffective in achieving sanitization or disinfection. Unless specifically indicated as a laundry additive, many disinfectants and sanitizers are not to be used as part of the wash chemicals. In some cases, certain laundering procedures or supplemental additives such as ozone could be effective in providing sanitization of clothing. If used with garments, the textile components of helmets, or hoods, however, these procedures/additives must be qualified as effective by meeting the requirements in 11.3.7.5 where specific testing is conducted to demonstrate sanitization efficacy.

Since disinfection and sanitization only affects microbial contamination, it must be followed up with advanced cleaning to remove any soils associated with the body fluid or other infectious material.

A.7.4.4.1 Sanitization represents inactivation of microorganisms to a safe level. For textile-based products, sanitization is generally considered achievable, whereas disinfection involving the inactivation of all microorganisms might not be possible. Three different approaches can be used for the sanitization of garments: use of a soak tank, use of a washer-extractor, or use of ozone in an advanced cleaning process.

Use of Soak Tank. A tank or other vessel that is large enough to hold the number of sets of garments can be used for sanitization. In this approach, the vessel is filled with water and an EPA-registered sanitizer is added at the concentration specified by the supplier. The entire garment is placed in the sanitizer/water solution with all portions of the garment immersed. The garment is left in the tank or vessel for a period of time indicated by the sanitizer instructions, but typically periods of time ranging from 1 hour or more can be used. Extended soak times in excess of the sanitizer instructions are recommended since garments include multiple layers, pockets, and other features the sanitizer solution might not easily reach. Longer soak times should also be used when clothing is heavily contaminated. Following the end of the soak period, the garment should be subjected to advanced cleaning.

Use of a Washer/Extractor. Another recommended procedure for sanitization of protective garments involves using an EPA registered sanitizer as part of the cleaning formulation. In this approach, an EPA-register sanitizer or other product that has been demonstrated to be effective in sanitizing garments is used as a laundry additive. The garments are placed in an extractor with a special programmed formulation into which the sanitizer is added. The specific steps for this formulation are shown in Table A.7.4.4.1. One of the steps allows for the injection of the sanitizer at a concentration recommended on the sanitizer product label, which is typically 1 ounce per gallon of water added. This step should subject the garment to the sanitizer for at least 10 minutes, followed by extraction (drain and spin) and a rinse cycle at moderate temperature. Following this procedure, the garments should be subjected to normal advanced cleaning.

Use of Ozone in an Advanced Cleaning Process. The use of ozone injected into washing machines for the sanitization of linens has been demonstrated as effective in reducing microbial contamination. Special ozone-generating equipment is available that can be installed for adding appropriate amounts of ozone to the wash water in washer/extractors at specific steps in the cleaning process. The specific steps where ozone is added, the amount of ozone, and the overall configuration of the equipment to provide this capability depend on the ozone generating equipment, the washer/extractors involved, and the specific procedures in place at the facility where sanitization operations are carried out. Where these processes are used, the specific system should be verified for biological decontamination effectiveness as specified in 11.3.7.4. Other approaches for sanitization of garments can be performed that involve novel sanitizers or processes; however, before these approaches are used, biological decontamination effectiveness as specified in 11.3.7.4 should be demonstrated since there can be substantial differences between processes used for ordinary linens and garments as compared to fire fighter protective clothing.

A.7.4.4.3 It is not recommended that garment shells and liners be separated prior to sanitization in order to minimize the handling of the contaminated garment. Instead, the entire garment should be subject to the sanitization process first to address the microbial contamination and then separated for advanced cleaning. An exception to this approach would occur if the organization is relying on advanced cleaning to provide sanitization of the garments or if a laundry additive–based sanitizer is used as part of the advanced cleaning process. Regardless, practices for sanitization of garments should include minimum handling to avoid cross contamination.

A.7.3.9(4) At the time this edition was prepared, the technical committee recognized that, depending on the contaminant, the wash temperature maximum of 40°C (105°F) might not be the most effective temperature for cleaning those ensemble elements that can be subjected to higher wash temperatures in washer/extractors. However, even with this recognition, the technical committee was reluctant to increase the maximum wash temperature for advanced cleaning because it will occur more frequently than specialized cleaning or disinfection or sanitization and, to date, only limited testing has been done on the effects of multiple washings at 60°C (140°F) on garment ensembles and ensemble elements. Based on this work, there is a tradeoff between increasing the wash temperature for purposes of contaminant removal and the impact of the increased wash temperature for adversely affecting the performance properties of ensemble elements.

Effects of Increasing Wash Temperature for Removal of Contaminants.

Fire fighter protective ensembles and ensemble elements might be contaminated with soot and chemicals such as polynuclear aromatic hydrocarbons (PAHs), phenols, phthalates, hydrocarbons, heavy metals, and other hazardous materials during fire responses, various chemical compounds from hazmat responses, and microorganisms during medical responses or biohazard responses. Appropriate removal of these contaminants is necessary both for protecting the health of the fire fighter and for ensuring that the gear performance is not compromised. To assess appropriate turnout cleaning parameters, specifically wash temperature, it is useful to consider the cleaning recommendations for garments used in agricultural and health care applications because such applications involve hazardous materials to which ensembles and ensemble elements might also be exposed: pesticides and infectious agents. Extensive research has been performed to examine the effectiveness of different laundering procedures in removing pesticides. This information is relevant to fire fighter ensembles and ensemble elements because pesticide chemicals have a range of properties that are similar to fireground chemicals in terms of low volatility and often low water solubility. Research from several sources has shown that higher wash temperatures of up to 60°C (140°F) have greater efficacy at removing pesticide contamination. As a consequence of these findings, various organizations recommend the use of hot water at 60°C (140°F) as well as other laundering procedures for the optimum removal of pesticides from work clothing.

Similarly, a number of studies have addressed the efficacy of increased water temperatures in killing bacteria and other microorganism contaminants in hospital laundry. As a consequence of this research, the Centers for Disease Control (CDC) and the Healthcare Infection Control Practices Advisory Committee (HICPAC) have recommended the use of specific laundering practices that include even higher temperatures at 71°C (160°F) in combination with bleach. (Note: This practice is not appropriate for fire fighter protective ensembles and ensemble elements).

Clearly, high wash temperatures provide greater effectiveness in addressing many forms of contamination, but the use of higher temperatures must be weighed against its potential effects on the performance properties and continued service life of ensemble and ensemble elements. *Impact of Higher Wash Temperatures on Ensemble Element Materials and Components.* To investigate the potential of applying higher wash temperatures, the technical committee conducted several laundering trials on unused materials, components, and full clothing both at 105°F (40°C) and at 140°F (60°C) to compare the overall impact of multiple launderings (60 cycles) at these temperatures. Multiple samples at several different facilities were subjected to conventional laundering procedures using both wash temperatures, with comprehensive inspections and assessment of certain performance properties after 20, 40, and 60 cycles of laundering. The preliminary findings of this work shows that components can be adversely affected by increased wash temperature and the increased cycles of laundering. Higher wash temperatures and multiple launderings created loss of certain performance properties for the actual material layers, and particular durability concerns were noted.

At the time this work was conducted, it was not possible to fully conclude that safety issues would arise for protection of fire fighters; however, garment elements laundered multiple times and at the higher wash temperature would clearly require more frequent repair and replacement of components.

Specific Considerations for Frequent Advanced Cleaning, Sanitization, and Specialized Cleaning. Organizations are cautioned to be aware of the tradeoffs that exist for increased laundering at higher wash temperatures. Higher wash temperatures are likely to be more effective in removing many contaminants but will also likely reduce the service life of or increase the number of repairs to garment elements and other ensemble elements. Increased cleaning creates additional wear and tear on garments, but, if handled properly and coupled with frequent inspections, ensemble element service can be optimized for both effective cleaning and retention of performance properties.