CLAIMS

What is claimed is:

1. A method of forming a fire fighting foam at or near a hazard comprising:

a) modifying a dilution water stream to include a base foam concentrate to form a first foam solution stream using a foam proportioning system;

b) foaming the first foam solution stream to provide a first finished foam;

c) modifying the first foam solution stream to include a fire suppression additive to form a modified foam solution stream using the foam proportioning system; and

d) foaming the modified foam solution stream to form a second finished foam.

2. The method of claim 1, wherein the fire suppression additive is a polysaccharide-based foam concentrate.

3. The method of claim 2**,** wherein the polysaccharide-based foam concentrate comprises:

a) a suspension system comprising water and at least one suspension agent;

b) a first polysaccharide that is soluble in the suspension system; and

c) a second polysaccharide that is insoluble in the suspension system but soluble in water alone.

4. The method of claim 3, wherein the at least one suspension agent comprises a glycol, a glycol ether, a polyethylene glycol, or a combination thereof;

the first polysaccharide comprises xanthan gum; and

the second polysaccharide comprises guar gum, konjac gum, tara gum, methylcellulose, or a combination thereof.

5. The method of claim 1**,** wherein the modified foam solution stream is substantially free of fluorine-containing additives.

6. The method of claim 1, wherein the modified foam solution stream is substantially free of any additive, which contains a perfluoroalkyl group.

7. The method of claim 1, wherein the fire suppression additive is a fluorine additive.

8. The method of claim 7**,** wherein the fluorinated additive comprises a poly-perfluoroalkylated polyacrylamide type fluorosurfactant, a poly-perfluoroalkylated

polyamino acid polymer, a C_6-short chain perfluoro-based fluoropolymer surfactant or a combination of two or more thereof.

9. The method of claim 7, wherein the fluorinated additive comprises a C_6-fluorotelomer-based nonionic fluorosurfactant, an alkyl sodium sulfonate type anionic fluorosurfactant, a fluoroalkyl ammonium chloride type cationic fluorosurfactant, a fluorotelomer sulfonamide alkylbetaine fluorosurfactant, a poly-perfluoroalkylated polyamino acid polymer, or a combination of two or more thereof.

10. A method of proportioning a finished foam at or near a hazard comprises:

a) proportioning and delivering a first finished foam to the hazard;

b) determining if the first finished foam extinguishes or suppresses the hazard;

c) if not, selecting an amount of a fluorine additive;

d) proportioning a foam solution with the selected amount of the fluorine additive to form a fluorinated finished foam comprising the selected amount of the fluorine additive; and

e) delivering the fluorinated finished foam with the amount of the fluorine additive to the hazard.

11. The method of claim 10, wherein step d) comprises:

d-1) weighing a fluorine additive container to obtain an initial weight or determining an initial pressure of the fluorine additive container;

d-2) proportioning a fluorinated foam solution with the amount of fluorine additive to form a fluorinated finished foam with the amount of fluorine additive;

d-3) weighing the fluorine additive container to obtain a final weight or determining a final pressure of the fluorine additive container; and

d-4) using the final weight and the initial weight or the initial pressure and the final pressure to determine a total amount of fluorine additive.

12. The method of claim 10 further comprising:

f) determining if the fluorinated finished foam with the amount of the fluorine additive extinguishes or suppresses the hazard;

g) if not, selecting an increased amount of the fluorine additive based on the type of hazard; and

h) proportioning a fluorinated foam solution with the increased amount of the fluorine additive to form a fluorinated finished foam with the increased amount of the fluorine additive.

13. A method of proportioning a finished foam comprising:

a) mixing a base foam concentrate and water in a foam proportioning system at or near a hazard to form a foam solution;

b) mixing the foam solution and air through a nozzle fluidly connected to an outlet of the foam proportioning system to form a first finished foam;

c) delivering the first finished foam to the hazard;

d) determining if the first finished foam extinguishes or suppresses the hazard;

e) if not, designating a Class B hazard profile and selecting an amount of a fluorine additive based on the Class B hazard profile;

f) mixing the amount of the fluorine additive, the base foam concentrate and water in the foam proportioning system to form a fluorinated foam solution; and

g) mixing the fluorinated foam solution and air through the nozzle to form a fluorinated finished foam.

14. The method of claim 13 further comprising:

h) delivering the fluorinated finished foam to the hazard.

15. The method of claim 13, wherein step d) comprises targeting the hazard using a non-fluorinated base foam concentrate and delivering a non-fluorinated finished foam to the hazard; and wherein step i) comprises delivering a fluorinated finished foam to the hazard without retargeting the hazard.

16. The method of claim 13 further comprising:

h) determining if the fluorinated finished foam extinguishes or suppresses the hazard;

i) if not, selecting an increased amount of the fluorine additive;

j) mixing the fluorine additive, the non-fluorinated base foam concentrate and water in the foam proportioning system at or near a hazard to form a fluorinated foam solution;

k) mixing the non-fluorinated foam solution and air through the nozzle to form a fluorinated finished foam; and

l) delivering a fluorinated finished foam to the target.

17. A method for proportioning a finished foam at or near a hazard comprising:

a) using a portable, mobile, or fixed foam proportioning system to proportion a base foam concentrate with Type I, Type II, or Type III applications for delivering a non-fluorinated finished foam for the purposes of Class B hazard response operations;

b) delivering a non-fluorinated finished foam to the hazard;

c) if the non-fluorinated finished foam is ineffective in extinguishing or suppressing the hazard due to chemistry and volatility of the hazard, designate a Class B hazard profile;

d) selecting an amount of fluorine additive to non-fluorinated base foam solution to enhance foam suppression and/or extinguishing performance based on the Class B hazard profile;

e) using the portable, mobile, or fixed foam proportioning system to proportion the base foam concentrate and the amount of fluorine additive with Type I, Type II, or Type III applications for delivering a fluorinated finished foam for the purposes of Class B hazard response operations; and

f) delivering the fluorinated finished foam to the hazard.

18. The method of claim 17, wherein the Class B hazard profile includes hydrocarbons and/or polar solvents.

19. A method of fighting a flammable liquid fire at or near a flammable liquid fire comprising:

a) foaming a first foam solution stream to provide a first finished foam, where the first foam solution stream comprises a base foam concentrate and a dilution water stream;

b) delivering the first finished foam at or near the flammable liquid fire; and

c) if the first finished foam does not extinguish or suppress the flammable liquid fire, modifying the first foam solution stream to include a selected amount of a fluorine additive using a foam proportioning system, thereby forming a fluorinated foam solution stream;

d) foaming the fluorinated foam solution stream to form a fluorinated finished foam; and

e) delivering the fluorinated finished foam at or near the flammable liquid fire.

20. A foam injection system comprising:

a foam concentrate pump fluidly connected to a foam concentrate supply;

a fluorinated additive pump fluidly connected to a fluorinated additive supply;

a water source; and

a flow controller comprising one or more processors and computer-readable instructions that when executed by the one or more processors, cause the one or more processors to:

determine a water flow rate outputted by the water source;

determine a foam concentrate flow rate outputted by the foam concentrate pump;

identify a target ratio of water and foam concentrate;

control the foam concentrate flow rate based on the water flow rate and the target ratio of water and foam concentrate;

identify a target ratio of water and fluorinated additive; and

control fluorinated additive flow rate outputted by the fluorinated additive pump based on the water flow rate and the target ratio of water and fluorinated additive.

21. The foam injection system of claim 20, wherein the flow controller determines the foam concentrate flow rate based on one or more of a foam concentrate pump speed of the foam concentrate pump, a discharge pressure of the foam concentrate pump, a displacement of the foam pump, and a volumetric efficiency of the foam concentrate pump.

22. The foam injection system of claim 20, wherein the water source is a water pump; and

the flow controller determines the second flow rate based on one or more of a water pump speed of the water pump, a differential pressure of the water pump, and a shaft input power of the water pump.

23. The foam injection system of claim 20, wherein the foam concentrate pump is a positive displacement pump.

24. The foam injection system of claim 20, wherein the foam concentrate pump has a manual override input.

25. A non-transitory computer-readable medium comprising processor-executable instructions that when executed by one or more processors, cause the one or more processors to:

determine a first flow rate of foam concentrate outputted by a foam concentrate pump;

determine a second flow rate of water outputted by a water source;

identify a target ratio of water and foam concentrate; and

control the first flow rate based on the second flow rate and the target ratio;

identify a target ratio of water and fire suppression additive; and

control fire suppression additive flow rate outputted by the fire suppression additive pump based on the water flow rate and the target ratio of water and fire suppression additive.

26. The non-transitory computer-readable medium of claim 25, comprising instructions that cause the one or more processors to:

determine the first flow rate based on one or more of a foam concentrate pump speed of the foam concentrate pump, a discharge pressure of the foam concentrate pump, a displacement of the foam concentrate pump, and a volumetric efficiency of the foam concentrate pump.

27. The non-transitory computer-readable medium of claim 25, comprising instructions that cause the one or more processors to:

determine the second flow rate based on one or more of a water pump speed of the water pump, a differential pressure of the water pump, and a shaft input power of the water pump.

28. A method of forming a fire fighting foam at or near a hazard comprising:

a) adding a base foam concentrate and fire suppression additive to a dilution water stream to provide a foam solution stream using a foam proportioning system; and

b) foaming the foam solution stream to form a finished foam.

29. The method of claim 28, wherein the base foam concentrate and the fire suppression additive are added sequentially to the dilution water stream.

30. The method of claim 28, wherein the base foam concentrate and the fire suppression additive are added simultaneously to the dilution water stream.

31. The method of claim 28, wherein the base foam concentrate comprises one or more additives selected from the group consisting of octyl sulfate salts, decyl sulfate salts, diethylene glycol butyl ether, alkylpolyglycosides, polyacrylamidomethylpropane sulfonic acid, alkyl sulfobetaines, lauryl dipropionate, polysaccharides, magnesium sulfate, potassium acetate, potassium carbonate, potassium citrate, potassium bicarbonate, disodium phosphate, and sodium sulfate.