Market Characterization of the U.S. Defense Spray Industry

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1. Summary

Defense sprays are aerosol-based sprays intended for self-defense, including pepper spray (a hot pepper-based spray for human to human self-defense) and animal sprays (pepper-based sprays labeled for protection against dog or bear attacks). Defense sprays contain capsaicin (oleoresin capsicum, as an irritant), an emulsifier, and an aerosol propellant. The defense spray industry historically used chlorofluorocarbons (CFCs) as a propellant and transitioned to hydrofluorocarbon (HFC) propellants as replacements to CFCs in the mid-1990s, specifically HFC-134a.

In 2020, approximately 290 metric tons (MT) of HFC-134a propellant was contained in defense sprays sold in the United States. The use of HFC-134a propellant in defense sprays in the United States is expected to continue due to its non-flammability and physical properties to provide adequate spray distance for foam, fog, and vapor defense sprays (Safariland 2017a, EPW 2020c). Efforts to reformulate are underway but the alternatives have not yet reached the desired specifications of the industry (EPW 2020a, EPW 2020b). Based on self-reported significant increases in recent product sales by the industry, a 10% growth rate is assumed, resulting in a projected HFC-134a use in 2025 of 467 MT.

2. Introduction

Defense sprays consist of aerosol-based sprays intended for self-defense, including pepper spray (a hot pepper-based spray for human to human self-defense) and animal sprays (pepper-based sprays labeled for protection against dog or bear attacks). Defense sprays contain capsaicin (oleoresin capsicum, as an irritant), an emulsifier, and an aerosol propellant. Defense sprays are utilized in situations involving law enforcement and/or where one's personal safety is at risk. These defense sprays must perform across a wide variety of scenarios and environments and maintain critical performance parameters including spray distance and volume, aerosol characteristics, and flammability. (EPW 2020a)

Defense sprays utilize four different delivery methods, including streaming, foam, fog, and vapor sprays. Of particular interest are defense aerosol sprays delivered as a fog, such as those used by law enforcement and in bear sprays. Fog formulations provide area coverage, discharging a cone pattern of spray between the user and assailant, and cover a larger area without requiring precise aiming. In the case of defense against a bear, the spray distance and volume must be maximized to ensure public safety (Safariland 2017a). The defense spray industry utilizes HFC-134a propellant due to its non-flammability, high vapor pressure, low boiling point, and solubility with the defense spray formulation. Manufacturers have found it challenging to replace HFC-134a and maintain acceptable performance of the defense spray (EPW 2020a, EPW 2020b).

The remainder of this report characterizes HFC use by the U.S. defense spray industry, including key market players and historical and current consumption of HFCs and other propellants in defense sprays.

3. Market Characterization

This section provides an overview of defense spray products and applications as well as the current defense spray market and key manufacturers.

3.1. Overview of Defense Sprays

Commercially available self-defense sprays contain a chemical irritant and a propellant. Self-defense sprays typically contain a lachrymator (i.e., an irritant that causes tearing) as the active ingredient, such as chloroacetophenone (mace), orthochlorobenzylidenemalononitrile (tear gas), or a pepper extract (Honeywell 2018). Pepper sprays utilize the oil oleoresin capsicum (OC) which is composed of several different capsaicinoids; the percentage of capsaicinoids determines the potency of the spray. Civilian and law enforcement sprays contain a range from 0.18% to 1.33% of capsaicinoids while bear sprays range from 1.0% to 2.0% of capsaicinoids (SABRE 2021a). Bear sprays are designed to be more potent than the pepper sprays designed for personal self-defense, and typically produce larger spray clouds going farther distances and leaving the spray can faster than products for use against dogs or for human defense. EPA regulates bear spray as a pesticide under the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA),[1] and requires registration and labeling consistent with 40 CFR 156.70 for human hazards associated with a product. Labels for bear sprays often contain language on hazards to humans and domestic animals similar to the following statement: “DANGER: May cause irreversible eye damage if sprayed in the eyes at close range. Contact through touching or rubbing eyes may result in substantial but temporary eye injury. Strongly irritating to nose and skin. Do not get in eyes, on skin or on clothing. Wash thoroughly with soap and water after handling. Remove contaminated clothing and wash clothing before reuse.” (EPA 2019). Bear sprays are not intended for use against people. Concentrations of propellant in a defense spray can range from 15% to 80% (Honeywell 2018).

3.2. Major Manufacturers

Manufacturers of defense sprays available in the United States are listed in Table 1 by product type.

Table 1. Manufacturers of Defense Sprays in the United States

Manufacturer	Type of Defense Spray Manufactured
Mace Security International	Pepper Spray Bear Spray Dog Spray
SABRE (Security Equipment Corporation)	Pepper Spray Bear Spray Dog Spray
UDAP Industries Inc	Pepper Spray Bear Spray
Defense Technology[a]	Pepper Spray
Fox Labs International Inc	Pepper Spray

[1] Not all uses of defense sprays are regulated under FIFRA, including pepper spray designed for human to human self-defense.

Manufacturer	Type of Defense Spray Manufactured
Zarc International Inc	Pepper Spray
Aerko International	Pepper Spray
Counter Assault	Pepper Spray Bear Spray
Cutting Edge Products, Inc.	Pepper Spray
Guardian Protective Devices, Inc	Pepper Spray

[a] Defense Technology was previously a business segment of The Safariland Group. In June 2020, The Safariland Group entered into an agreement to divest Defense Technology (Safariland 2020). The testimony given to the Senate Environmental and Public Works Committee by The Safariland Group was given prior to their divestment from Defense Technology.

4. Subsector Background and HFC Use

4.1. Current Propellants in Defense Sprays

Historically, defense sprays utilized CFC-12 propellant, which transitioned to HFC-134a in the mid-1990s. HFC-134a remains a common propellant, because of performance requirements across a wide range of scenarios and environments (Safariland 2017a).

Environmental characteristics of the current HFC propellant in defense sprays are summarized in Table 2.

Table 2. Environmental Characteristics of Current HFC Propellant for Defense Sprays

Propellant	ODP[a]	GWP[a]
HFC-134a	0	1,430

Note: GWPs are aligned with the exchange values used in the AIM act.
[a] Ozone Secretariat (1987).

According to Safariland, of the aerosol propellants listed as acceptable alternatives under EPA's Significant New Alternatives Policy (SNAP) program, the only feasible replacement for HFC-134a in a fog delivery system is hydrofluoroolefin (HFO)-1234ze. Other propellants listed (e.g., hydrocarbons) were not considered due to safety concerns (e.g., flammability), and the compressed gases were deemed unsuitable due to their inability to provide sufficient pressure and spray pattern. (Safariland 2017b).

Defense spray manufacturers have been testing HFO-1234ze as a replacement for HFC-134a in defense sprays. The main concerns from the manufacturers were:

Flammability: Initial formulations developed using the alternate propellants failed flame extension tests. Further testing demonstrated flammability of neat HFO-1234ze. This is a concern because of possible interactions with electrical discharge weapons (i.e., the spray ignites), which can lead to an increased risk to both the subject the spray is being used on and the officer in the case of law enforcement use. Flammability is also a concern in the bear spray market because many users work near oil and gas pipelines (EPW 2020a, EPW 2020b).

Lower Vapor Pressure: HFO-1234ze propellants have a significantly lower vapor pressure than HFC-134a, with HFC-134a having a vapor pressure of 666 kPa at 25°C and HFO-1234ze having a vapor pressure of 490 kPa at 25°C (DuPont 2004, Honeywell 2008). This results in

decreased spray distance and volume, essentially reducing the effective range of the sprays. Testing has shown a 35% reduction in deployment distance when formulated with HFO-1234ze in place of HFC-134a (EPW 2020a, EPW 2020b).

Formulation Stability: The solubility of the liquid formation with the propellant is key in being able to form an effective fog, foam, or vapor discharge. HFO-1234ze is noted as not forming a stable solution with the formulation ingredients, leading to ineffective discharge characteristics that affect the content, pattern, and discharge of the spray (EPW 2020a)

Boiling Point: The boiling point of HFC-134a is -26.1°C and -19°C for HFO-1234ze (DuPont 2004, Honeywell 2008). This allows HFC-134a sprays to operate at lower temperatures than HFO-1234ze sprays. Given the need for a great range of environments where defense sprays need to be able to be deployed, this is noted as a limitation (EPW 2020b).

Cost: The significantly higher cost of the alternatives (i.e., due to a limited number of suppliers) was noted by one manufacturer as potentially causing unfair trading conditions, especially for smaller players in the marketplace (Aerko 2021).

In 2019, Counter Assault marketed a new bear deterrent that uses a propellant other than HFC-134a (Counter Assault 2018). The name of the propellant is not publicly available. EPA's Office of Pesticide Programs indicated there are two additional bear spray products that do not use HFCs: one that has been approved by EPA but may not yet be on the market and one that is still under review. Four bear sprays are currently EPA pesticide registered; the Counter Assault product along with another are labelled as flammable.

Security Equipment Corporation, which manufactures defense sprays under the SABRE product line, estimates the defense spray industry uses approximately 125 MT of HFC-134a annually. The Safariland Group estimated an annual average of 58 MT of HFC usage per year and estimates that the industry as a whole uses 5-10 times the usage of Safariland Group, which would correspond to 290 to 580 MT of HFCs (EPW 2020c). UDAP Industries Inc. provided data on HFC-134a use in a comment on the proposed rule, *Phasedown of Hydrofluorocarbons: Establishing the Allowance Allocation and Trading Program under the American Innovation and Manufacturing Act,* reporting 50.5 MT of HFC-134a use in 2020 (UDAP 2021a). Based on this additional information, this analysis assumes that the lower end of the Safariland estimate of 290 MT of HFC-134a consumption in the defense spray sector to be an accurate representation of 2020 consumption.[2]

[2] In EPW (2020c), Security Equipment Corporation also estimated the defense spray industry uses 0.0006% of the 230,000 MT annually produced and imported in the United States or approximately 1.38 MT of HFC-134a; however, based on the magnitude of other supporting information provided (i.e., Safariland estimated annual usage of 58 MT of HFC-134a, and UDAP reported annual usage of 50.5 MT), it was assumed that the total market more likely uses 290 MT of HFC-134a annually.

Security Equipment Corporation indicated that HFC-134a use in the defense spray industry grew at approximately 5% over the last five years (i.e., 2015-2020). In 2020 there was a large increase in HFC-134a consumption that did not follow the anticipated growth rate estimated by SEC in the defense spray sector. The large increase in demand was partly due to an increase in demand for bear sprays given the large uptick in the number of people going to national parks and hiking, with 8.1 million more Americans going hiking in 2020 compared to 2019, an 8.4% increase (Outdoor Foundation 2021).

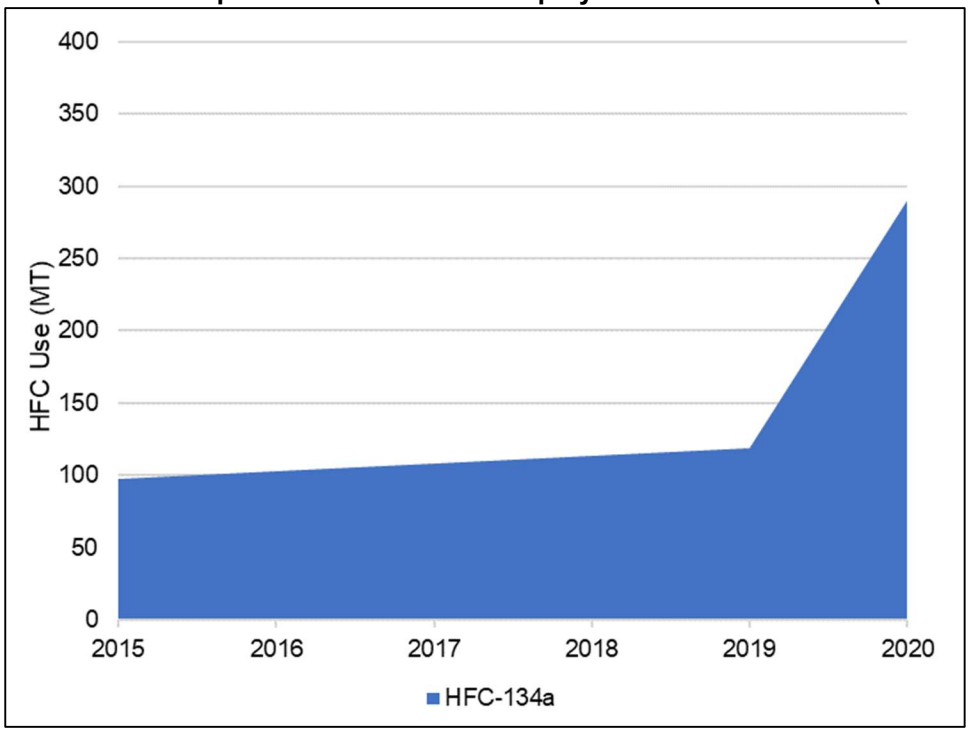
Due to the unanticipated growth in demand in 2020, total consumption rose from 119 MT to 290 MT. It is unclear if that spike in growth will be sustained. Table 3, Figure 1, and Figure 2 show the estimated amount of HFC-134a propellant used in defense sprays in the United States from 2015 through 2020.

Table 3. Historic HFC-134a Propellant Use in Defense Sprays in the United States (2015-2020)

2015	2016	2017	2018	2019	2020
Amount HFC-134a Used in Defense Sprays (MT)					
98	103	108	113	119	290
Amount HFC-134a Used in Defense Sprays (MMT CO_2 Eq.)					
0.14	0.15	0.15	0.16	0.17	0.41

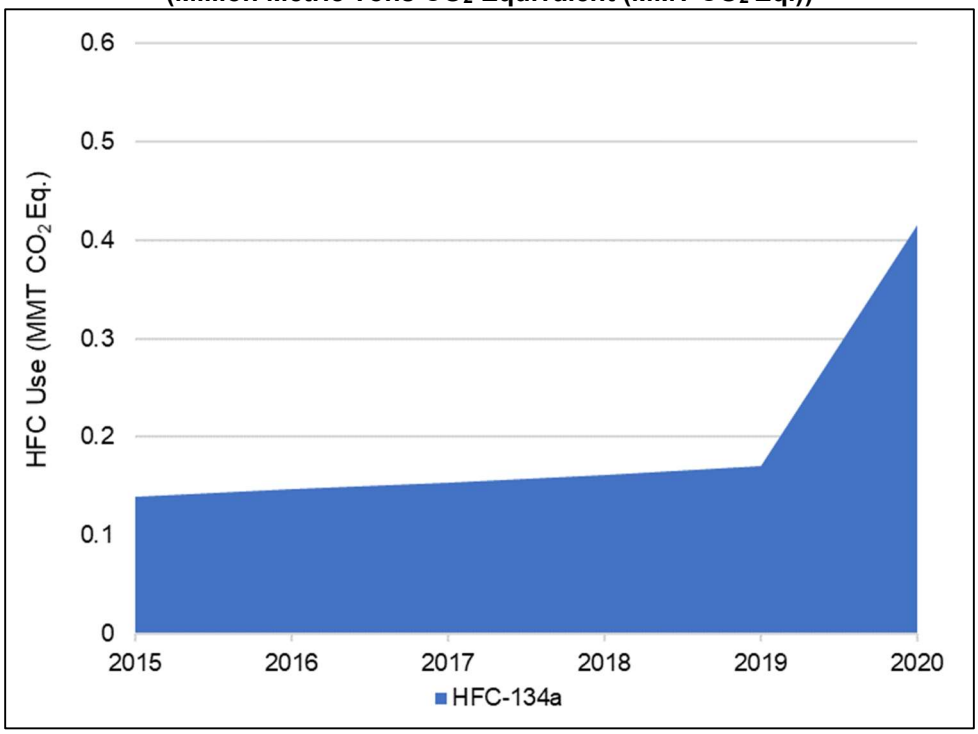
Source: EPW (2020c), EPA (2020).

Figure 1. Historic HFC Propellant Use for Defense Sprays in the United States (2015-2020) (MT)



Source: EPW (2020c), EPA (2020).

Figure 2. Historic HFC Propellant Use for Defense Sprays in the United States (2015-2020) (Million Metric Tons CO_2 Equivalent (MMT CO_2 Eq.))



Source: EPW (2020c), EPA (2020).

4.2. Projected HFC Use in the Defense Spray Subsector

In early 2020, industry estimated that demand for HFC-134a in defense sprays would experience modest growth over the next 15 years. Specifically, law enforcement and military usage of products would remain relatively constant or experience modest increases in demand and the bear spray market would be expected to increase over time as populations continue to encroach on bear habitats, increasing the incidence of encounters with bears (EPW 2020c). However, based on high growth in 2020, defense spray manufacturers now expect defense products to grow at a rate of 10-15% over the next several years (SABRE 2021b, UDAP 2021, Safariland 2021b). Given there is only one year with data at that higher level, it is not clear the 2020 sales represent a new sustainable level or 2020 was an anomaly.

In addition, industry notes that use of reclaimed HFC-134a in defense sprays is being considered by manufacturers and could reduce industry reliance on virgin material in the future (Aerko 2021, UDAP 2021).

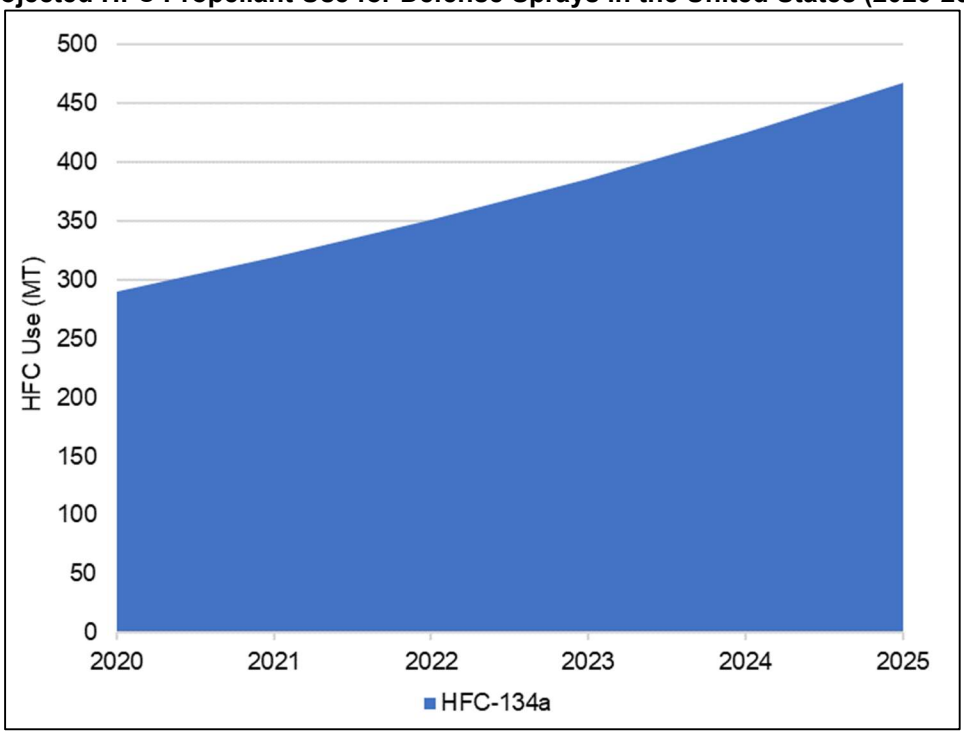
HFC-134a use is expected to grow at an average rate of 10% from 2020 through 2025, in line with industry anticipated market growth. The projected HFC propellant sold in defense sprays with a 10% growth rate can be found in Table 4, Figure 3, and Figure 4. In 2025, it is projected that approximately 467 MT of HFC-134a propellant will be used in defense sprays.

Table 4. Projected HFC-134a Propellant Use in Defense Sprays in the United States (2020-2025)

2020	2021	2022	2023	2024	2025
Amount HFC-134a Used in Defense Sprays (MT)					
290	319	351	386	425	467
Amount HFC-134a Used in Defense Sprays (MMT CO_2 Eq.)					
0.41	0.46	0.50	0.55	0.61	0.67

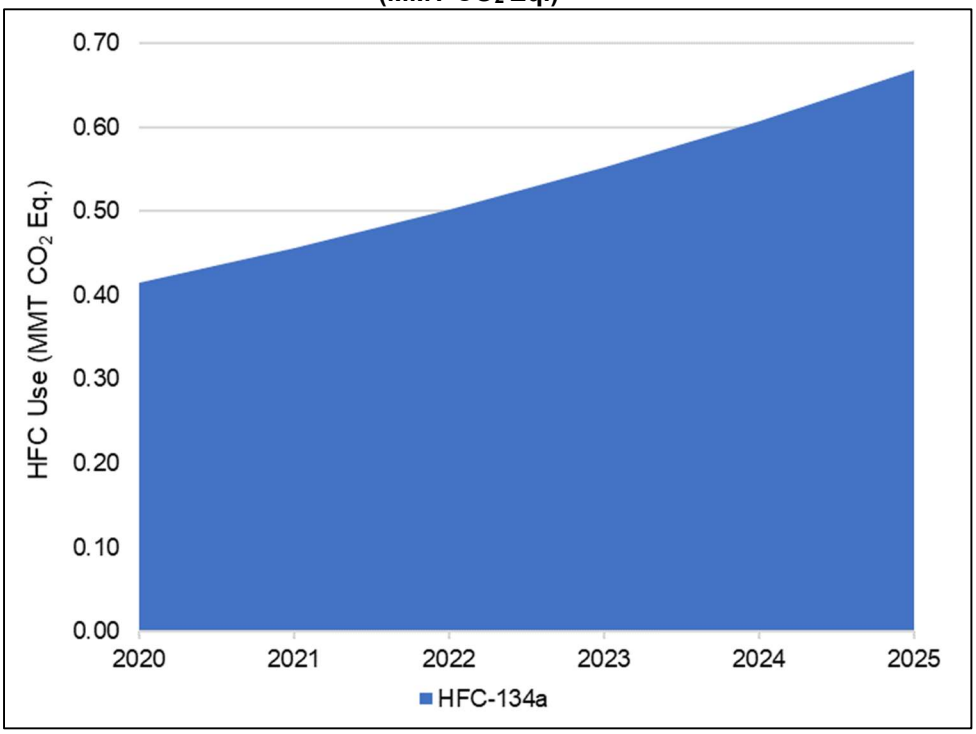
Source: EPW (2020c), EPA (2020).

Figure 3. Projected HFC Propellant Use for Defense Sprays in the United States (2020-2025) (MT)



Sources: EPA (2020), EPW (2020c)

Figure 4. Projected HFC Propellant Use for Defense Sprays in the United States (2020-2025) (MMT CO_2 Eq.)



Sources: EPA 2020, EPW 2020c

4.3. Imports and Exports of Defense Spray Products in the United States

Information about the import market for defense spray products in the United States was not available. U.S. manufacturers export defense sprays, with a percentage of the export market comprised of bear sprays exported to Canada (SABRE 2021b, Safariland 2021a)

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