

**MONTREAL PROTOCOL  
ON SUBSTANCES THAT DEplete  
THE OZONE LAYER**



**UNEP**

**REPORT OF THE  
TECHNOLOGY AND ECONOMIC ASSESSMENT PANEL**

**SEPTEMBER 2018**

**VOLUME 2**

**DECISION XXIX/8 ON THE FUTURE AVAILABILITY OF HALONS  
AND THEIR ALTERNATIVES**



**UNEP  
SEPTEMBER 2018 TEAP REPORT**

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**Montreal Protocol**  
**On Substances that Deplete the Ozone Layer**  
Report of the  
UNEP Technology and Economic Assessment Panel  
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## **Foreword**

### **2018 TEAP Report**

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**DECISION XXIX/8 ON THE FUTURE AVAILABILITY OF HALONS AND THEIR  
ALTERNATIVES**

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## 1 Executive Summary

- Following a March 2018 planning meeting, the International Civil Aviation Organization (ICAO) formed an informal working group to determine the current and projected future quantities of halon installed in civil aviation fire protection systems, the associated uses and releases of halon from those systems and any potential courses of action to minimize unnecessary halon emissions as requested by Decision XXIX/8. The informal working group included representatives from commercial industry, civil aviation non-governmental organizations, the ICAO secretariat, the Halons Technical Options Committee and the Technology and Economic Assessment Panel.
- This report covers the efforts to update the current and projected future quantities of halon installed in civil aviation fire protection systems and efforts looking into the associated uses and releases of halon 1301 from those installed fire protection systems.
- The informal working group prepared a survey that was anticipated to allow a more accurate calculation of the annual amount of halon 1301 emitted from civil aviation worldwide. ICAO sent out “State Letters” in June 2018 to all States (equivalent to parties in the Montreal Protocol) with civil aviation halon 1301 service providers. After an initial review of the responses, there were many missing known service providers, so ICAO is following up with these companies and those that did not respond in an attempt to obtain additional and more complete survey responses.
- In addition, the amount of halon 1301 potentially available to support civil aviation is provided in Section 5 for the information of parties and others with an interest in this transition.
  - Using the estimated worldwide supply and demand of halon 1301, eight scenarios were modelled to estimate the availability of halon 1301 resources needed to service the existing aviation fleet, account for aviation growth through 2050, and service existing non-aviation applications. Each scenario assumes various annual emission rates from all halon 1301 aviation applications (i.e., 2.3%-2.8%, 5%, 7.6%, or 15%) and varying emission rates for non-aviation sources (i.e., between 0.1% and 5%), which were reevaluated and refined for this updated analysis.
  - Based on the results of this analysis, the estimated available halon 1301 supply for replacing the amount emitted from most existing fire protection systems in aviation and non-aviation applications (i.e., oil and gas facilities, nuclear facilities, and military installed/reserves) as well as new aviation demand is projected to run out by years 2032 to 2054, depending on the initial total worldwide supply in 2018 and annual emission rates.
  - The model shows the importance of the effect of the civil aviation emission rate. The high rate of 15% reduces the run-out date significantly, with all 8 scenarios falling between 2032 - 2035, thus confirming the need for the ICAO informal working group to continue to try to collect more accurate emissions data and if the rate is high, to see what steps can be taken to reduce it.



## **2 Mandate and scope of the report**

Decision XXIX/8 on the future availability of halons and their alternatives requests the Technology and Economic Assessment Panel, through its Halons Technical Options Committee:

- (a) To continue to liaise with the International Civil Aviation Organization on the development and implementation of alternatives to halons, and their rate of adoption by civil aviation, and to report thereon in its 2018 progress report;
- (b) To explore the possibility of forming a joint working group with the International Civil Aviation Organization to develop and thereafter carry out a study to determine the current and projected future quantities of halons installed in civil aviation fire protection systems, the associated uses and releases of halons from those systems and any potential courses of action that civil aviation could take to reduce those uses and releases;
- (c) To submit a report on the work of the joint working group, if established under paragraph 1 (b) above, before the Thirtieth Meeting of the Parties and the fortieth session of the Assembly of the International Civil Aviation Organization for consideration and potential further action;

The full text of the decision is available in Appendix A.

In response to Decision XXIX/8, the co-chairs of the Halons Technical Options Committee (HTOC) decided that they and a co-chair of Technology and Economic Panel (TEAP) who previously served as a member of the HTOC, would take on the assignment to continue to work with the International Civil Aviation Organization (ICAO) to explore the possibility of ICAO forming a joint working group. After initial consultations, ICAO decided to form an informal working group, which includes representatives from commercial industry, civil aviation non-governmental organizations, the ICAO secretariat, HTOC and TEAP. This report informs the parties on the activities of the joint working group and is a product of the HTOC and TEAP co-chairs participating in the informal working group. This report covers the efforts to update the current and projected future quantities of halon installed in civil aviation fire protection systems and efforts looking into the associated uses and releases of halon 1301 from those installed fire protection systems. This is not an official report from the ICAO informal working group. In addition, the amount of halon 1301 potentially available to support civil aviation has been taken up by the HTOC as part of the 2018 Assessment and is provided in Section 5 for the information of parties and others with an interest in this transition.

Initial work in coordinating with ICAO was performed by electronic communication. ICAO hosted a meeting at its headquarters in Montreal, Canada on March 7, 2018 to determine the path forward in responding to Decision XXIX/8. All subsequent work was performed by electronic communication. This report was prepared by TEAP members, Dan Verdonik, Bella Maranion and Adam Chattaway and HTOC Consulting Expert Tom Cortina. A draft was reviewed by the TEAP. A final version was submitted to the Ozone Sec for posting to the website.



### **3 Background**

#### **3.1 The Montreal Protocol and the Phase-Out of Halons**

The Montreal Protocol calls for the phase out of production and consumption of nearly 100 chemicals, including halons. In accordance with Protocol adjustments, production of halons in non-Article 5 parties ceased at the end of 1993 and halon production ceased in Article 5 parties at the end of 2009. Although new production has been phased out globally since 2009, the Protocol allows the parties to use and trade in previously used halons. To date, global supplies of banked and recycled halons have been sufficient to supply residual important uses, including the use of halons in aviation.

Over the last two decades, the HTOC has tracked the efforts that the parties and their respective users have made in transitioning away from the use of halons. One area of continuing concern, however, has been the continued reliance on halons by the civil aviation community. Halon is used in four major aircraft on-board applications: lavatory trash receptacles, hand-held extinguishers, engine nacelles/auxiliary power units (APUs), and cargo compartments. In addition to on-board aircraft applications, halon is also used in some aircraft rescue and firefighting (ARFF) or crash rescue vehicles on airport ramps. The parties through a number of decisions under the Protocol have requested the Ozone Secretariat as well as the HTOC to work with ICAO on the transition to alternatives to halons for aviation uses. Towards that end, the HTOC worked for several years with the ICAO Secretariat and ICAO stakeholders through the ICAO Halons Working Group. After several years of discussion, that group agreed that proposed timelines for halon replacement should be incorporated into ICAO Standards and Recommended Practices (SARPs), and ultimately be adopted by States in their national frameworks.

#### **3.2 ICAO Assembly Resolutions and EU Regulations on Halon Replacement**

Formed in 1944 with the signing of the Convention on International Civil Aviation (the “Chicago Convention”), ICAO’s mission is to promote the safe and orderly development of all aspects of international civil aeronautics and provides the forum for issues affecting civil aviation to be discussed. It is headquartered in Montreal, Canada, with seven regional offices throughout the world. At present, the Organization is comprised of 191 Contracting States.

In collaboration with Contracting States and industry, ICAO first introduced proposed actions for the international aviation community regarding halon replacement in 2007 at the 36<sup>th</sup> ICAO Assembly. This was done with the strong support of the U.S., which presented several formal working papers endorsing collaboration and cooperation throughout the aviation community to affect the transition beyond halon reliance. This resulted in a series of Assembly Resolutions from the past three ICAO Assemblies, held triennially, directing specific action to the ICAO Council based on the progress of developing and identifying halon replacements and implementing such replacements into aircraft fire suppression systems.

ICAO Resolution A37-9, adopted at the 37<sup>th</sup> Assembly in September 2010, mandates halon replacement in ICAO standards in lavatory trash receptacle fire extinguishing systems used in aircraft produced after December 30, 2011; in handheld extinguishers used in aircraft produced after December 30, 2016<sup>1</sup>; and in engine and auxiliary power unit fire extinguishing systems used in aircraft for which application for type certification will be submitted after December 30, 2014. However, these are not requirements that States must follow. Instead,

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<sup>1</sup> This date was changed to the 30<sup>th</sup> December 2018 at the 39<sup>th</sup> Assembly in October 2016

States. can and have filed “differences” indicating that they will not meet these standards and will continue to use halons or allow the use of halons past these dates. On the basis of this decision, ICAO adopted amendments to the international SARPs in two Annexes of the Chicago Convention. Annex 6 (“Operation of Aircraft”) and Annex 8 (“Airworthiness of Aircraft”) were amended to include the related dates and requirements for halon replacements for lavatory trash receptacle, hand held, and engine and auxiliary power unit fire suppression systems. Resolution A39-13, adopted at the 39<sup>th</sup> Assembly in September 2016, accepted the recommendation from the International Coordinating Council of Aerospace Industry Associations (ICCAIA) Cargo Compartment Halon Replacement Working Group (CCHRWG) and established 2024 as the date by which new designs (referred to as new Type Certificate in the civil aviation certification process) must use halon alternatives in the cargo bays. This means that all halon applications on civil aircraft have dates by which new designs require halon alternatives be used. None of these requirements calls for the retrofit of any halon systems in the current fleet.

Within the European Union, all current on-board uses of halons in aviation are listed as critical uses in Annex VI to Regulation (EC) No. 1005/2009. Annex VI was revised in 2010 as per Commission Regulation (EU) No 744/2010 of 18 August 2010 and contains “cut-off dates” for the use of halons in new designs of equipment or facilities and “end dates” when all halon systems or extinguishers in a particular application must be decommissioned. Other States have proposed or are considering regulations.

Table 1 below outlines a listing of international requirements for both new design and new production aircraft. This listing includes cut-off dates and end dates for halon use in civil aviation as directed by the EU and specified dates in the ICAO SARPs.

**Table 1 – Comparison of EU and ICAO halon Phase-out Requirements**

	Requirement	Lavatory	Handheld Extinguisher	Engine / APU	Cargo
New Design Aircraft	EC Cut-off Date	2011	2014	2014	2018
	ICAO	2011	2018	2014	NA
Current Production Aircraft	EC End Date (includes retrofit)	2020	2025	2040	2040
	ICAO	2011	2018	NA	NA

### 3.3 Long-term Halon 1301 Needs for Civil Aviation

Although ICAO has set dates after which all new designs for aircraft must use halon alternatives for all halon civil aviation applications, halon 1301 can and will, in many instances, continue to be used in new production of all existing designs. Since aircraft can have lifetimes of 30 years or more, the long-term needs of civil aviation became a concern of the parties to the Montreal Protocol, who agreed in Decision XXVI/7: Availability of recovered, recycled or reclaimed halons, to request the TEAP, through its HTOC, to approach

the International Maritime Organization<sup>2</sup> to estimate the amount and purity of halon 1211 and 1301 available from the breaking of ships and to report information on global stocks of recovered halons. In its Decision XXVI/7 report in 2015, the HTOC estimated global supplies of halons and halon 1301 needs for civil aviation and concluded that “if civil aviation does not stop producing new aircraft using halon 1301, they are already or soon will be producing aircraft that cannot be sustained over their economic lifetimes with existing supplies of recycled halon 1301.” The Decision XXVI/7 report estimated that civil aviation could run out of halon 1301 as early as 2036 in a worst-case scenario, later updated to 2034, and 2045 based on the best-case scenario depending upon how much halon becomes available to support civil aviation and the global aviation emission rate of halon 1301.

One of the limitations in making those estimates is that there is very little information available on the actual emission rates from civil aviation. Typically, estimates have been developed by applying an assumed emission factor of 3- 4 % per year to the estimated amounts installed on aircraft. That emission factor is based on estimated annual, average global emissions of halons developed from the HTOC model and from atmospheric measurements. It is not specific to civil aviation. Based on data and anecdotal information collected from a variety of sources, HTOC believes that it is possible that the civil aviation emission rate may be higher than this average emission factor, which can greatly affect the long-term amount of halon 1301 available to support civil aviation. The amount of halon 1301 potentially available to support civil aviation has been taken up by the HTOC as part of the 2018 Assessment and is provided in Section 5 for the information of parties and others with an interest in this transition.

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<sup>2</sup> It is believed that Shipbreaking represents a significant source of halon 1301 that can be recycled and could be available for the civil aviation sector.



## **4 Informal Working Group Activity**

As reported in the May 2018 TEAP Progress Report, following a March 2018 planning meeting, ICAO formed an informal working group to determine the current and projected future quantities of halon installed in civil aviation fire protection systems, the associated uses and releases of halon from those systems and any potential courses of action to minimize unnecessary halon emissions as requested by Decision XXIX/8. The working group initially consisted of representatives from airframe manufacturers Boeing, Airbus and Bombardier, civil aviation fire protection cylinder manufacturers Meggitt and United Technologies, the civil aviation non-governmental organizations the International Air Transport Association (IATA) and the International Coordinating Council of Aerospace Industry Associations (ICC AIA), the ICAO secretariat, and co-chairs of the HTOC and TEAP. The activities of the working group are summarised below.

### **4.1 Survey of Emissions in the Aviation Sector**

The informal working group prepared a survey that ICAO sent out officially in June 2018 as ICAO “State Letters” to all States (equivalent to parties in the Montreal Protocol) with civil aviation halon 1301 service providers. The State Letter and the survey are included as Appendix B. It was anticipated that the results of the survey would allow a more accurate calculation of the annual amount of halon 1301 emitted in civil aviation worldwide. The timetable agreed by ICAO and HTOC had been set to meet the Decision XXIX/8 deadlines to report back to the 30<sup>th</sup> Meeting of the Parties (November 2018) and the 40<sup>th</sup> ICAO General Assembly (September 2019).

### **4.2 Development of the Questionnaire**

The informal working group developed the questionnaire to be short and simple to increase the likelihood of responses. There are three sections in the questionnaire: 1) contact information and confirmation that the respondents perform halon 1301 servicing of civil aviation bottles/cylinders, 2) two questions that were designed to determine the amount of halon 1301 that needed to be replaced in the bottles/cylinders they received for servicing (i.e., the amount that was emitted from the bottles/cylinders), and 3) four additional voluntary questions to get a sense of the halon 1301 market and availability.

There was considerable discussion and debate on the choice of the questions that were designed to determine the amount of halon 1301 that was emitted from these bottles/cylinders. The members of the group from companies that performed servicing thought that it would be likely that most, if not all, companies that perform servicing would track or log the amount of halon recovered from the bottles (that would incur a cost to the company to get recycled/reclaimed) and the amount of recycled/reclaimed halon put back into the same bottles (that would be charged to the customer for the bottle). It was generally felt that for accounting purposes, these two items would be quantitatively tracked and recorded.

The additional voluntary questions were based on a previous survey done for the U.S. Federal Aviation Administration (FAA) Halon Aviation Rulemaking Committee (ARC), FAA (2014). The intent was to get some additional qualitative information on the halon 1301 availability and stability in the market place. The questions were on how much they have stored for future use, and trends in their usage, pricing of supplies and ease of availability. These questions were designed to give a better picture of the overall market. For example, if large amounts were being reported as stored for future use, it could indicate past uncertainty

in availability or changes in pricing, while small amounts would indicate confidence in availability and pricing.

Provisions were also made to keep the individual responses to the survey confidential. Only aggregated data would be reported and qualitative answers to questions would not be attributable to any company. ICAO contracted with the Executive Director of the Halons Alternatives Research Corporation (HARC) to perform this function.

The ICAO State letter dated May 15, 2018, requested that the survey be completed by June 25, 2018. After an initial review of the responses in early July, it became apparent that there were many missing known service providers, so the ICAO Secretariat kept the survey open until July 27, 2018. In addition, the Executive Director of HARC, (i.e., the organization performing the analysis and aggregation of the data) and the ICAO Secretariat started contacting individual companies to clarify their information or to obtain the survey information from known halon 1301 service provider companies that did not yet respond.

### **4.3 Survey Results**

A total of 53 surveys were received, of which 33 facilities confirmed servicing aviation halon 1301 systems. Of those 33 facilities, only 21 provided any data on halon usage or stocks. For the 21 facilities that did provide data, the average amount of halon 1301 filled in a year was 3,000 kg. The total halon 1301 stocks held by the 19 facilities that responded to this survey question was 58,000 kg, for an average of 3,000 kg per facility. There were 16 facilities that responded on halon availability, with 9 stating that there was no change in the availability of recycled halon and 7 saying there was a change. Of those 7, three stated that availability was lower, two stated there were delays, and one noted increases in the price of recycled halon. Other comments of note from respondents related to the difficulty of achieving the 99.6% halon 1301 purity requirement in ASTM D5632 / D5632M – 17, ASTM (2017), and the decreasing quality of available stocks.

One of the main goals of the survey was to obtain information on the difference between the amount of halon that comes into a facility in cylinders for servicing (recovered) and the amount that goes out of the facility in serviced cylinders (filled) as a way of estimating the size and rate of emissions. Unfortunately, many facilities do not keep these exact records and many facilities did not provide complete data, so it was not possible to make this type of determination. For the 10 facilities that did provide some data in this area, the difference between the amount of recovered halon and the amount filled ranged from 4% to 50%, with an average of about 14%. While it is not possible from this limited data to determine the relationship between the 14% data point and the actual emission rate, it does provide additional anecdotal information on top of that contained in the FAA Halon ARC report that the aviation emissions rate for halon 1301 may be significantly higher than the overall industry average of 3-4%, FAA (2014).

In reviewing the surveys, it was determined that a number of major aviation service companies have not responded and some that did provided data only from the facility that received the survey and not from all of the company's facilities. Seven of the survey respondents that do not service halon 1301 systems provided information on the companies that they contract to do the service. ICAO is following up with these companies and those that did not respond in an attempt to obtain additional and more complete survey responses.

## **5 Halon Needs for Civil Aviation**

The amount of halon 1301 potentially available to support civil aviation has been taken up by the HTOC as part of the 2018 Assessment and is provided in this section for the information of and timely consideration by parties and others with an interest in this transition (i.e., ICAO as the basis for a working paper for the ICAO 40<sup>th</sup> General Assembly).

### **5.1 Halon 1301 and Halon Civil Aviation Installed Base**

The halon 1301 installed base estimates for civil aviation were updated from the Decision XXVI/7 estimates using activity data and new fleet estimates, ICF (2018). The total worldwide fleet of mainline, regional, business jet and turboprop aircraft for 2018 is estimated to be approximately 52,500 rising to 82,250 by 2036. To estimate the halon installed base, the same activity data for engine nacelles, cargo compartments, APUs, and lavatory trash receptacle extinguishing systems (lavex) systems from previous analyses were used, as well as feedback from airframe manufacturers. It is estimated that for 2018, there is approximately 2,700 metric tonnes of halon 1301 installed across the civil aviation fleet. This is projected to rise to 4,900 metric tonnes in 2036.

### **5.2 Estimated Halon 1301 Supplies**

The 2018 HTOC model estimates the remaining worldwide bank of halon 1301 to be approximately 37,750 metric tonnes at the end of 2018. This remaining bank of halon 1301 is assumed to be currently installed in fire suppression equipment (e.g., in aviation, computer facilities, oil and gas, military, maritime, etc.), as well as in available stockpiles.

Of the estimated (rounded off) 37,750 metric tonnes of halon 1301 globally, approximately 16,250 metric tonnes are maintained by Japan and are not expected to be available to support other continuing uses of halon outside of Japan including aviation needs. The remaining 21,500 metric tonnes of halon 1301 are calculated as the difference between the global halon supply and Japan's halon bank. This remaining halon 1301 is comprised of the following estimated global uses and stockpiles in 2018:

- Military applications are estimated to have 4,500 metric tonnes in the installed base and reserves.
- Oil and gas facilities are estimated to have 1,500 metric tonnes.
- Nuclear facilities are estimated to have 200 metric tonnes
- The global aviation bank (100 metric tonnes) and installed base are estimated to be 2,800 metric tonnes.
- Marine (non-military) applications are estimated to be 1,500 metric tonnes, assuming each ship has an average 30-year lifetime, ICF (2015), which means this source of supply is projected to run out in approximately 2023.
- Electronics facilities, such as computer rooms and communications rooms, are estimated to be 11,000 metric tonnes.

The stockpiles and installed base for the military, oil and gas facilities, and nuclear facilities (i.e., a total of about 6,200 metric tonnes) are assumed not to be available to meet continuing uses of aviation needs. Furthermore, the amount of halon currently installed in aviation applications is accounted for in the worldwide supply, but also is not assumed to be available for future aviation needs, as it is already in use (i.e., an additional 2,700 metric tonnes in 2018 rising to 4,900 in 2036). This leaves about 12,500 metric tonnes of halon 1301 that could become available to support civil aviation if all of it went only to civil aviation. However,

many other on-going uses of halon 1301 will also need to share in this available supply to meet their ongoing needs to refill discharged systems and/or leaks.

To determine the potential availability of halon 1301 to support civil aviation, eight scenarios were developed to estimate halon 1301 resources needed to service the existing aviation fleet, account for aviation growth through 2060, and to also service continuing non-aviation applications. Each scenario assumes various annual emission rates from all halon 1301 aviation applications (i.e., 2.3%-2.8%, 5%, 7.6%, or 15%) and varying emission rates for non-aviation sources (i.e., between 0.1% and 5%), which were reevaluated and refined for this update. The highest annual aviation emission rate (i.e., 15%) was estimated using the global average annual halon emission rate of about 4% derived from halon 1301 emissions reported in Vollmer et al., (2016) and the proportion of halon emissions from the aviation sector. In addition, the HTOC is aware of anecdotal information that provides some support for this potentially high emission rate.

These scenarios do not model uptake of halon 1301 alternatives for engine nacelles, cargo compartments, or APUs in existing systems and newly manufactured aircraft, nor are retrofits included. Although ICAO requires new aircraft designs to use halon alternatives in engine and APU applications beginning on December 31, 2018 and for cargo bays beginning in 2024 (dates for the EU are even earlier), there are no aircraft designs currently available to meet that requirement. Starting in 2010, newly manufactured mainline aircraft are assumed to no longer use halon lavex systems, while a constant portion of the fleet still contains halon lavex systems (i.e., in aircraft manufactured before 2010).

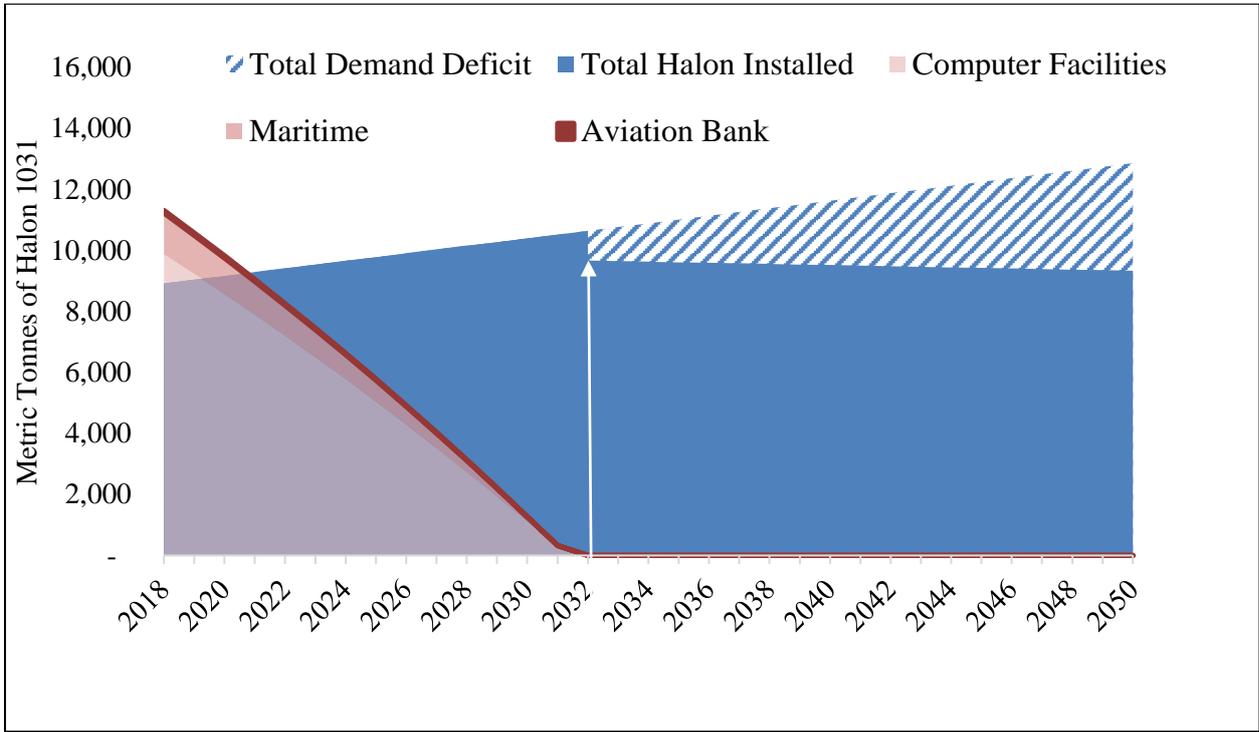
The eight scenarios model +/- 10% of the initial total available worldwide supply of halon 1301 as of the end of 2018 at 12,500 t (i.e., approximately 11,500 and 13,750 metric tonnes). The general assumptions for all scenarios modelled and the years in which the available halon 1301 is expected to be sufficient to meet demand in each scenario are summarized in Table 2. The best-case and worst-case scenarios are highlighted in yellow.

Table 2. Assumptions and Results for Eight Drawing Down Halon 1301 Scenarios

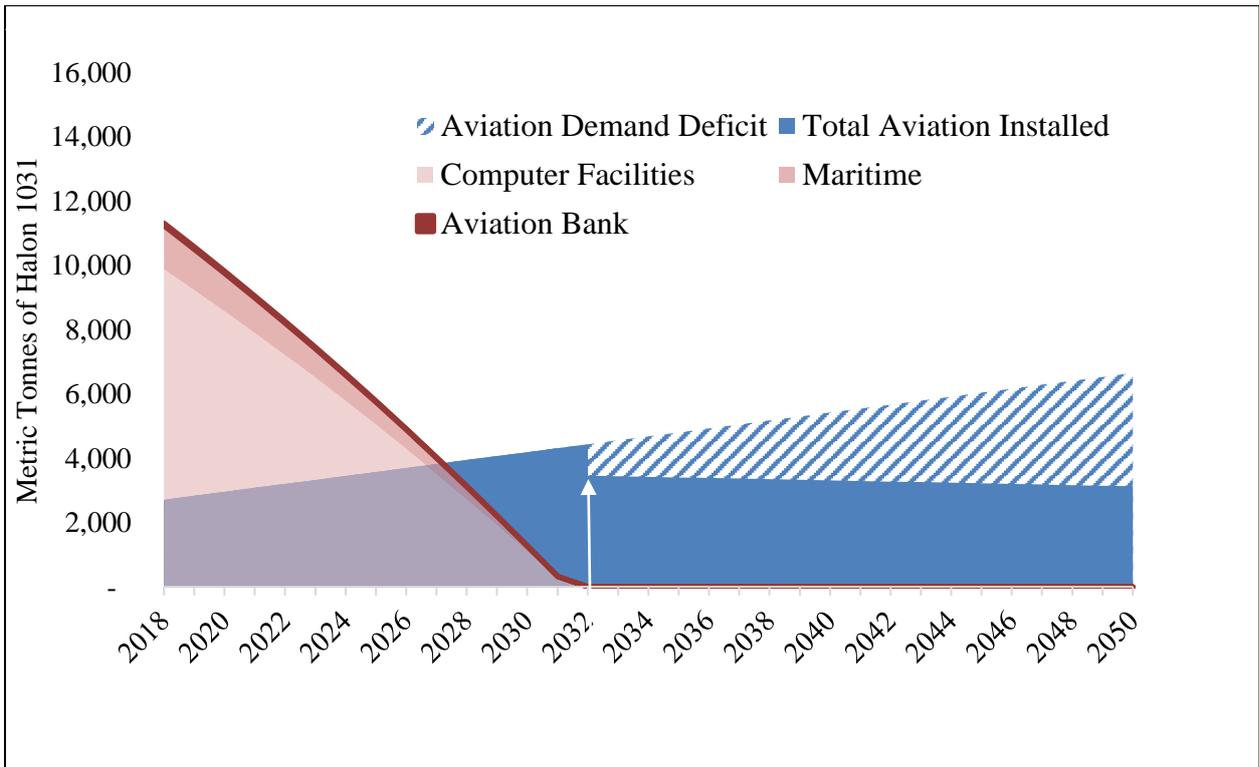
Scenario	Total Available Worldwide Supply in 2018	Annual Emission Rate (Aviation)	Annual Emission Rate (non-Aviation)	Global Overall Emission Rate	Year Available Supply Runs Out
1	11,500	2.3 – 2.8%	0.1 – 3%	1.6%	2048
2	11,500	7.6%	0.1 – 3%	1.9%	2038
3	11,500	5.0%	1 – 5%	2.3%	2040
4	11,500	15.0%	1 – 5%	3.9%	2032
5	13,750	2.3 – 2.8%	0.1 – 3%	1.6%	2054
6	13,750	7.6%	0.1 – 3%	2.0%	2042
7	13,750	5.0%	1 – 5%	2.3%	2045
8	13,750	15.0%	1 – 5%	3.8%	2034

Based on the results of this analysis, the estimated available halon 1301 supply for replacing the amounts emitted from most existing fire protection systems in aviation and non-aviation applications (i.e., oil and gas facilities, nuclear facilities, and military installed/reserves) as well as new aviation demand are projected to run out by years 2032 to 2054, depending on the initial total worldwide supply in 2018 and annual emission rates.

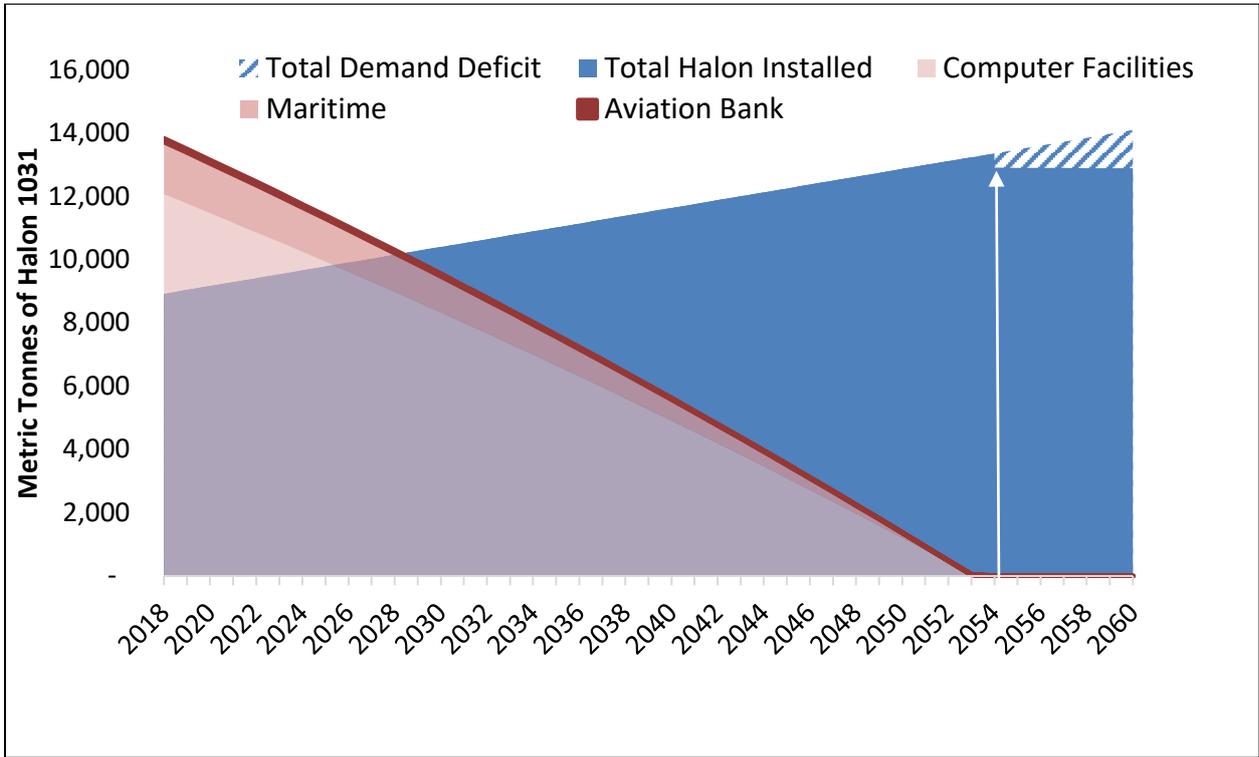
The model also shows the importance of the effect of the civil aviation emission rate. The high rate of 15% reduces the run-out date significantly, with all 8 scenarios falling between 2032 - 2035, thus confirming the need for the ICAO informal working group to continue to try to collect more accurate emissions data and if the rate is high, to see what steps can be taken to reduce it. The figures below present the run-out date results graphically for the worst-case scenario (i.e., Scenario 4) and best-case scenario (i.e., Scenario 5), respectively. The graphs also show “demand deficit,” which represents the amount of halon that would be needed for newly manufactured aircraft and to service existing systems.



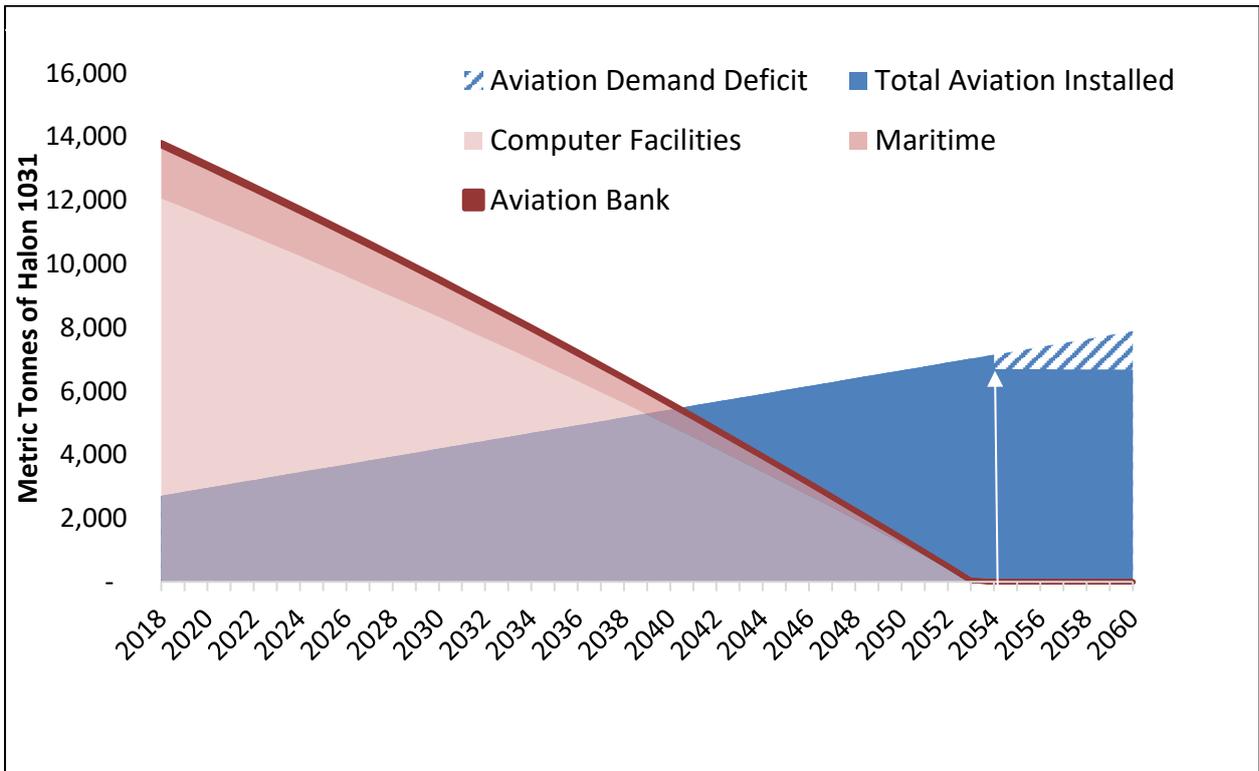
**Figure 1a** - Scenario 4: Drawing Down Halon 1301 Showing the Entire Available Supply (3.9% Overall Emission Rate; 11,500 metric tonnes of Available Supply)



**Figure 2b** - Scenario 4: Drawing Down Halon 1301 Showing the Available Supply and Civil Aviation Bank (3.9% Overall Emission Rate; 11,500 metric tonnes of Available Supply)



**Figure 2a** - Scenario 5: Drawing Down Halon 1301 Showing the Entire Available Supply (1.6% Overall Emission Rate; 13,750 metric tonnes of Available Supply)



**Figure 2b** - Scenario 5: Drawing Down Halon 1301 Showing the Available Supply and Civil Aviation Bank (1.6% Overall Emission Rate; 13,750 metric tonnes of Available Supply)



## **6 Potential for Smaller Global Halon 1301 Bank**

The above assessment was based on the estimated halon 1301 global bank based on the HTOC 2018 model. Atmospheric concentration-based emission estimates based on updated Vollmer et al. (2016) mean data through mid-2017 provide cumulative emissions of halon 1301 of 118,000 metric tonnes, which is more than was estimated previously in the 2014 HTOC Assessment Report, HTOC (2014). Based on the global total cumulative production data from the HTOC, which is also used by Vollmer et al., the mean values of the updated Vollmer et al. (2016) data through mid-2017 provide a remaining bank of only 30,000 metric tonnes versus the HTOC model estimate of approximately 109,000 metric tonnes of cumulative emissions and a remaining bank of 39,000 metric tonnes. Using the average of the two bank sizes, the difference in remaining banks is nearly 25%. This difference is becoming significant as the global bank (i.e., the amount halon that is available to support fire protection uses) becomes smaller over time. The updated Vollmer et al. (2016) data, also provides a much higher mean annual emission rate for 2016/2017 of about 4% of the bank/year than the approximately 2.5% composite rate used by the HTOC. The combination of a potential higher emission rate than assumed by the HTOC and a smaller bank of halon 1301 could also imply that there is going to be significantly less halon 1301 available to support civil aviation and others needs than estimated above.

As the supply of halons gets further reduced the likelihood of a significant disruption in supply increases dramatically. If civil aviation does not stop producing new aircraft using halon 1301, they are likely already producing and potentially designing new aircraft that cannot be sustained over their economic lifetimes with existing supplies of recycled halon 1301.



## 7 References

**ASTM (2017):** Halon 1301 Specification: <https://www.astm.org/Standards/D5632.htm>

**FAA (2014):** FAA Halon Aviation Rulemaking Committee (ARC) Final Report: [https://www.faa.gov/regulations\\_policies/rulemaking/committees/documents/media/hrarc-7022013.pdf](https://www.faa.gov/regulations_policies/rulemaking/committees/documents/media/hrarc-7022013.pdf)

**ICF (2015):** ICF International, Projections of Halon 1301 Supply and Demand for Aviation Applications, May 2015

**ICF (2018):** ICF International, Drawing Down Halon 1301 Inventories: Updated Analysis, September 2018

**Vollmer et al. (2016):** Vollmer, M. K., et al. (2016), Atmospheric histories and global emissions of halons H-1211 (CBrClF<sub>2</sub>), H-1301 (CBrF<sub>3</sub>), and H-2402 (CBrF<sub>2</sub>CBrF<sub>2</sub>), J. Geophys. Res. Atmos., 121, 3663–3686, doi:10.1002/2015JD024488

## Appendix A

Decision XXIX/8: Future availability of halons and their alternatives

## Decision XXIX/8: Future availability of halons and their alternatives

Recognizing that global production of halons for controlled uses was eliminated in 2009, but that some remaining uses, in particular for civil aviation, will continue to rely on stocks of recovered, recycled or reclaimed halons for fire safety for the foreseeable future,

Noting the adoption by the Assembly of the International Civil Aviation Organization of resolutions A37-9 and A38-9, in which the Assembly expressed an urgent need to continue to develop and implement alternatives to halons for civil aviation,

Taking note of Assembly of the International Civil Aviation Organization resolution A39-13, by which the Assembly encouraged the International Civil Aviation Organization to continue collaboration with the Secretariat, through the Halons Technical Options Committee of the Technology and Economic Assessment Panel, on the topic of alternatives to halons for civil aviation,

Recalling the information provided by the Panel as requested under decision XXVI/7,

Taking note of the progress report of the Panel that was provided to the parties before the thirty-ninth meeting of the Open-ended Working Group of the Parties to the Montreal Protocol on Substances that Deplete the Ozone Layer, including the need mentioned therein for better information on existing halon inventories and emissions in civil aviation,

1. To request the Technology and Economic Assessment Panel, through its Halons Technical Options Committee:

(a) To continue to liaise with the International Civil Aviation Organization on the development and implementation of alternatives to halons, and their rate of adoption by civil aviation, and to report thereon in its 2018 progress report;

(b) To explore the possibility of forming a joint working group with the International Civil Aviation Organization to develop and thereafter carry out a study to determine the current and projected future quantities of halons installed in civil aviation fire protection systems, the associated uses and releases of halons from those systems and any potential courses of action that civil aviation could take to reduce those uses and releases;

(c) To submit a report on the work of the joint working group, if established under paragraph 1 (b) above, before the Thirtieth Meeting of the Parties and the fortieth session of the Assembly of the International Civil Aviation Organization for consideration and potential further action;

2. To invite parties, on a voluntary basis, to reassess any national import and export restrictions other than licensing requirements with a view to facilitating the import and export of recovered, recycled or reclaimed halons and the management of stocks of such halons with the aim of enabling all parties to meet remaining needs in accordance with national regulations even as they make the transition to alternatives to halons;

3. To encourage parties to refrain from destroying uncontaminated recovered, recycled or reclaimed halons before they have considered their national and the global long-term future needs for halons, and to consider retaining uncontaminated recovered, recycled or reclaimed halons for anticipated future needs in a manner that employs best practices for storage and maintenance, in order to minimize emissions.

## Appendix B

### ICAO State Letter and Survey



International  
Civil Aviation  
Organization

Organisation  
de l'aviation civile  
internationale

Organización  
de Aviación Civil  
Internacional

Международная  
организация  
гражданской  
авиации

منظمة الطيران  
المدني الدولي

国际民用  
航空组织

Tel.: +1 514-954-8219 ext. 5151

15 May 2018

Ref.: AN 3/25.1- IND/18/5

**Subject:** Survey on halon 1301 estimate(s) of civil aviation halon emissions

**Action required:** Complete the online survey no later than 25 June 2018

Sir/Madam,

1. I have the honour to inform you that the 39th Session of the Assembly of the International Civil Aviation Organization (ICAO), held from 27 September 2016 to 7 October 2016 in Montréal, Canada, adopted Assembly Resolution A39-13 — *Halon replacement*, recommending that ICAO continue its collaboration with the Ozone Secretariat, through the Halons Technical Options Committee (HTOC) of the Technology and Economic Assessment Panel (TEAP) of the Montreal Protocol on the topic of halon alternatives for civil aviation. The Assembly also acknowledged the complexity of the development of alternatives to halon.
2. At the Twenty-ninth meeting of the Parties to the Montreal Protocol on Substances that Deplete the Ozone Layer that was held in Montréal, Canada, from 20 to 24 November 2017, Decision XXIX/8 was adopted on the future availability of halons and their alternatives. In the decision, the parties recognized that although global production of halons for controlled uses was eliminated in 2009, some remaining applications, particularly in civil aviation, would continue to rely on recovered, recycled and reclaimed halons for use in aircraft fire suppression systems for the foreseeable future.
3. As part of the work to be carried out on this subject matter, ICAO and HTOC are seeking to improve the estimation of civil aviation halon 1301 emissions. In this regard, a survey has been developed to obtain information from service providers in Member States. You are receiving this letter because your State has been identified as having companies that service and repair aviation halon 1301 systems/cylinders.
4. You are kindly requested to contact the companies that service and repair aviation halon 1301 systems/cylinders in your State (see Attachment B) and encourage them to complete the online survey. The online survey is accessible at <https://www.surveymonkey.com/r/NDJPGH3>.
5. A reference copy of the aforementioned survey can be found in Attachment A. If there are additional relevant service providers that are not on this list in Attachment B, kindly forward this information to them and request that they also complete the online survey.

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[www.icao.int](http://www.icao.int)

6. I would be grateful if your administration would encourage the completion of the online survey no later than **25 June 2018**.

Accept, Sir/Madam, the assurances of my highest consideration.



Fang Liu  
Secretary General

**Enclosures:**

- A — Survey on halon estimate(s) of civil aviation halon 1301 emissions
- B — List of service providers in your State

**SURVEY ON HALON ESTIMATE(S) OF CIVIL AVIATION HALON 1301 EMISSIONS**

**Introduction**

The International Civil Aviation Organization (ICAO) and the United Nations Environment Programme's Halons Technical Options Committee (HTOC) seek to improve the estimation of civil aviation halon emissions data. The questionnaire below is intended to elicit responses from service providers within Member States concerning existing companies providing servicing and/or repair of aviation halon 1301 systems/cylinders.

Responses to the questionnaire will be analysed to determine the current and projected future quantities of halon installed in civil aviation fire protection systems, the associated uses and releases of halon from those systems and any potential courses of action to minimize unnecessary halon emissions and to ensure the better management and preservation of existing halon reserves that civil aviation could take to reduce those uses and releases.

The questionnaire will be filled out in electronic form at <https://www.surveymonkey.com/r/NDJPGH3>. Questions 1 – 7 are mandatory. Please answer by checking the “Yes” or “No” boxes, as appropriate, and provide additional information where requested. Questions 8 – 11 are optional, however your responses to these questions will be highly appreciated.

Please note that responses to the questionnaire will be treated as confidential and will only be disclosed in aggregated form. Thank you for your participation.

1. Name of State or Country where facility is located: \_\_\_\_\_

2. Contact details of organization completing the survey:

Contact person: \_\_\_\_\_

Phone: \_\_\_\_\_

Email: \_\_\_\_\_

Website of service provider:  
\_\_\_\_\_

State/City of specific facility(ies) covered by the survey:  
\_\_\_\_\_  
\_\_\_\_\_

3. Does your facility perform the service and/or repair of aviation halon 1301 systems/cylinders?

Yes  No

If you have answered “No”, who does the service/repair for you? Please provide contact information:

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If you answered “No” to question 3, please proceed to Question 11.

4. For each of the last three years, if possible, provide the amount of halon 1301 you have recovered from bottle/cylinders during servicing?

*Year*                      *Amount (specify kilograms or pounds)*

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5. For each of the last three years, if possible, provide the amount of halon 1301 in kilograms or pounds (specify which) your facility used per year to fill aviation bottles/cylinders during servicing?

*Year*                      *Amount (specify kilograms or pounds)*

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6. Do you maintain a stock of halon 1301?

Yes       No

If yes, on average, at any given time, how many kilograms or pounds do you stock?

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7. The next section of the survey is optional. It is related to procurement and storage of halon at your facility. However, your response to these questions would be greatly appreciated.

8. Is your usage trending up, down or staying relatively steady?

trending up                       trending down                       staying relatively steady

Comments (if any):

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