

**REVIEW OF AUSTRALIA'S
HALON ESSENTIAL USES REQUIREMENTS**

**FINAL REPORT
MAY 2012**

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1 Background to Review

1.1 Overview

The Australian Government Department of Sustainability, Environment, Water, Population and Communities (the Department) manages a strategic stockpile of previously used and unwanted halons. The National Halon Bank (NHB) was established in 1993 to maintain halons for ‘essential uses’ until 2030.

Halons are fire-fighting agents that were introduced into Australia in the early 1970s. Halon 1211 was commonly used in portable fire extinguishers while halon 1301 was used for fixed fire protection systems. The production and consumption of ozone-depleting halons have been phased out under the Montreal Protocol. The import of newly manufactured halons into Australia has been prohibited since 1993, unless an “essential use exemption” for production or consumption has been authorised by the Parties to the Montreal Protocol.

The Australian Halon Management Strategy developed in 2000 summarises Australia’s approach to halon management. The halon stockpile is available for approved essential uses, such as for medical, veterinary, defence, industrial safety or public safety purposes, where no practical alternative exists. Requests for supply of halons from the stockpile are administered in accordance with the criteria established in the *Ozone Protection and Synthetic Greenhouse Gas Management Act 1989*. Alternatives are now available for most, but not all, halon applications. Halons are generally provided for fire protection systems in aviation and maritime applications where halon is still required and no practical alternatives exist.

An inventory conducted in 1998 determined that 70 tonnes of halon 1211 and 250 tonnes of halon 1301 would be required to meet essential uses until 2030¹. Current halon stock reserved for civilian essential uses, as of February 2012, is 73.4 tonnes of halon 1211 (plus another 27 tonnes in bulk storage awaiting reclamation) and 195.2 tonnes of halon 1301.

This project undertakes a review of Australia’s civilian halon essential uses requirements. In particular, it reviews elements of the strategy to investigate:

- The prospects and possible timeframe for transition of remaining civilian halon uses;

¹ *Australian Halon Management Strategy*, Environment Australia, February 2000.

- Whether a strategic stockpile of halon will be required beyond 2030; and
- The quantity of halon likely to be required for remaining civilian essential uses.

1.2 Project Deliverables

This final report provides the best available advice on the following:

1. Remaining essential uses of halon where no alternatives exists, both globally and in Australia;
2. Prospects for developing alternatives to current halon essential uses (globally and domestically);
3. Timeframe to completely phase out halon essential uses, globally and domestically;
4. The quantity of halon estimated to be required to meet Australia's essential use demands until essential use demands cease;
5. Sale price of halon internationally; and
6. The total amount of halon available within Australia, including in the NHB and company stockpiles.

1.3 Project Methodology

Energy International Australia Pty. Ltd. (EIA) has undertaken the following methodology for the review.

1. Desktop review of relevant Australian documentation
2. Desktop review of relevant international documentation.
3. Survey and/or interviews (via teleconference) of relevant key Australian stakeholders and halon user groups, and international stakeholders.
4. Preliminary advice (as a brief summary report) with estimates of future halon stock requirements based on information available and preliminary analysis by the end of February.
5. Draft report, covering the key project areas outlined.
6. Final report, taking into account comments and feedback from the Department by 23 May.

1.4 Final Report

A desktop review of relevant Australian and international documentation was undertaken, with key documents listed in the Bibliography and footnotes.

Surveys were circulated to halon special permit holders based on contact details provided by the Fire Protection Association Australia (FPA). Responses were requested at the latest by 15 March, after the preliminary advice was submitted, to provide adequate time for collation of data.

Data was also requested from the NHB and the FPA based on their existing records. The NHB provided data about halons 1211 and 1301 collected, decanted, stored and destroyed from 1998-2011. The FPA provided data based on reports from halon special permit holders for the years 2009 to 2011. Clarifications were made through discussions with the NHB and FPA respectively.

Interviews were conducted and/or email exchanges were made with a number of Australian and international industry experts. Special acknowledgment is given for contributions made by David Catchpole and Dan Verdonik (co-Chairs, Halon Technical Options Committee), US EPA, FPA, Coffey Environments and participating Australian industry.

The final report has been prepared based on an analysis of data available at 7 May 2012. As such, the report reflects EIA's best judgment based on information available to it at the time of preparation. Any use which a third party makes of this advice, or any reliance on or decisions to be based on the advice, are the responsibility of such third parties. EIA accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions taken based on this report.

Based on the information available, the report provides qualitative and quantitative assessments of future halon requirements for essential uses through discussion of current halon uses, available and future possible alternatives, industry trends in halon use, and forecasts of future halon use. Quantitative estimates of civilian halon availability, use and essential use requirements are determined using different approaches and data sources.

This report elaborates on the preliminary advice, and, seeks to, *inter alia*:

- Present findings from the analysis of information received from NHB, FPA and individual halon special permit holders by May 2012;
- Estimate civilian halon essential use requirements from different information sources and/or using different methodologies.

2 Remaining Halon Essential Uses and Status of Alternatives

Halon is no longer used in the majority of applications where previously it was considered important for fire protection. Remaining major halon essential uses in Australia are in aviation, maritime, and defence applications. In the recent past, there have also been small quantities used for research and specialist refrigeration purposes. The following sections describe briefly the major uses of halon in Australia, and the status of the development and introduction of alternatives.

2.1 Civilian Aviation Uses

Halon is used internationally in commercial aircraft and small private aircraft.

In *small aircraft* the usual application is in handheld extinguishers (containing halon 1211). Some jurisdictions require handheld extinguishers for aircraft certification, although an alternative (2-bromotrifluoropropene *aka* C₃H₂BrF₃ *aka* BTP) that meets US Federal Aviation Administration (FAA) Minimum Performance Standards (MPS) is available.

In *commercial aircraft* the applications are more complex. Halons are used to extinguish and suppress fires in four applications on commercial airplanes:

1. Lavatory extinguisher bottles (halon 1301) installed in airplanes prior to 2007;
2. Handheld fire extinguishers (halon 1211) located throughout the cabin, flight deck, crew rest compartments, and accessible cargo compartments;
3. Engines and auxiliary power units (APUs) (halon 1301); and
4. Cargo compartments (halon 1301).

Research into suitable replacements commenced at least 15 years ago, but suitable alternatives in three of the four main application areas have struggled to meet all civil aviation industry requirements.

2.1.1 Lavatory Extinguisher Bottles

Lavatory extinguisher bottles (lavex or potty bottles) use halon 1301 as a flooding agent.

A minimum performance standard (MPS) for lavatory extinguishers was defined in 1997. Two alternative fire protection agents (HFC-227ea and HFC-236fa) passed the MPS tests by end of 2000. Boeing completed production quality testing of component parts in September 2002 and approved an installation certification test plan in October 2002. Following FAA approval, HFC-227ea became standard on all in-production Boeing airplanes with standard lavatory configurations by the end of 2006. Boeing will have documentation available for the replacement of all halon lavex bottles, including for older aircraft, in 2012, allowing a progressive replacement of halon by aircraft owners.

The Kyoto Protocol defines HFC-227ea as a hydrofluorocarbon (HFC) greenhouse gas. HFC-227ea is a high global warming potential (GWP) HFC, and it is possible that future use may be restricted.

2.1.2 Handheld Fire Extinguishers

Handheld fire extinguisher bottles use halon 1211. An MPS for handheld fire extinguishers was defined in 2002. Three of seven agents tested passed the MPS tests: Halotron 1 (HCFC Blend B), FE-36 (HFC-236fa), and FM-200 (HFC-227ea) and were certified by Underwriters Laboratories (UL). These agents face a number of issues:

- The size and weight of the approved bottles for these agents are significantly larger than existing halon 1211 installations and may impose significant financial costs;
- The HCFC component of Halotron 1 is scheduled for US manufacturing phase-out in 2015;
- FE-36 and FM-200 have higher global warming potentials than halon 1211, are listed under the Kyoto Protocol and may face future restrictions;
- Toxicology concerns.

Boeing is pursuing the development of 2-bromotrifluoropropene (BTP), which has passed a series of performance tests US FAA MPS and UL711 5B, and studies on both material compatibility and atmospheric environmental effects. Handheld fire extinguishers using BTP are similar in size and weight to current halon 1211 extinguishers, which would reduce cost and on-board redesign imposts.

2.1.3 Engine and Auxiliary Power Unit Fire Suppression Systems

Engine and auxiliary power unit (APU) fire suppression systems use halon 1301. The FAA technical centre, in collaboration with the International Airplane Systems Fire Protection Working Group, developed an MPS for engine and APU fire suppression systems including minimum concentration standards for three halon alternative agents: HFC-125, CF₃I, and Novec 1230. Fire protection systems utilising these agents are significantly heavier and require larger volume than halon 1301, and may have issues due to their global warming potential or toxicological properties.

Boeing has been working on the development of a dry powder system for engines and APUs since 2007. In 2009 testing was suspended to revise the MPS to allow replacement of the baseline halon with a non-halon agent, reducing halon emissions in the test process. Testing resumed in 2010 and continued through 2011. Boeing is in the process of discussing agent certification with the FAA and with stakeholders, including airlines, engine and APU manufacturers.

2.1.4 Cargo Compartment Fire Suppression

Cargo compartment fire suppression systems use halon 1301. The Cargo MPS was updated in 2005 and specifies four test scenarios an alternative agent must meet to qualify as a suitable halon 1301 replacement. These scenarios include bulk-load fires, containerised-load fires, surface fires and aerosol can explosions. Several agents have shown promising results under testing in all areas except for the aerosol can explosion test.

By 2007, the only successful system tested by UL and International Civil Aviation Organization (ICAO) was a water mist/nitrogen suppression system. While the weight of water for this system would be comparable to that of a halon 1301 equivalent, there were expected to be significant challenges to scale-up.

In 2008 Airbus mentioned that it had commissioned testing of a similar technology based system utilising a combination of water mist and the exhaust from an on-board fuel cell.

It is expected that the certification with a non-halon alternative agent fire suppression system will be complex compared to the replacement of lavex extinguishers. Implementation on currently produced airplanes is at best several and, more probably, many years away.

2.1.5 ICAO Assembly Resolution A37/9 on Halon Replacement

At its 37th session in September/October 2010, the ICAO Assembly agreed in resolution A37/9 to establish a mandate for the replacement of halon in civil aviation for agreed timeframes for three of the application areas:

- In lavatory fire extinguishing systems used in aircraft produced after a specified date in the 2011 timeframe;
- In handheld fire extinguishers used in aircraft produced after a specified date in the 2016 timeframe; and
- In engine and auxiliary power unit fire extinguishing systems used in aircraft for which application for type certification will be submitted after a specified date in the 2014 timeframe;

This allowed for the future replacement of halon in these application areas, where previously ICAO had mandated its use in civil aviation.

Subsequently, in June 2011, ICAO Council approved amendments to the Chicago Convention, Annex 6 in 3 parts 1) *Operation of Aircraft, International Commercial Air Transport – Aeroplanes*, 2) *International General Aviation – Aeroplanes* and 3) *International Operations – Helicopters* and Annex 8 – *Airworthiness of Aircraft*. These amendments establish requirements and timeframes for the use of halon alternative fire extinguishing agents.

ICAO Council agreed that fire extinguishing systems shall use fire extinguishing agents that are not listed in Annex A, Group II of Montreal Protocol on Substances that Deplete the Ozone Layer, specifically for the following applications and dates:

1. Lavatory fire extinguishing systems for in-production aircraft no later than 31 December 2011;
2. Handheld systems for in-production aircraft no later than 31 December 2016 (this date was chosen to allow adequate time to leapfrog high GWP alternatives for this application); and
3. Engine/Auxiliary Power Unit fire systems for new designed aircraft (defined within the ICAO process as aircraft types for which an application for a type certificate is submitted to the State of Design) on or after 31 December 2014.

Notably, cargo compartments are not included in the decisions, reinforcing the less than optimistic outlook for finding replacements for this application in the short term. It is also worth noting that ICAO States are at liberty to interpret and implement resolutions differently. For example, the European

Union has its own rules that it will implement, and the FAA is uncertain about implementation of the ICAO changes at this stage².

2.1.6 European Union Halon Replacement Timeframes

The European Union (EU) banned all non-critical uses of halons in 2003. Critical uses include all current on-board uses of halons in aviation, as listed in the current Annex VI to Regulation (EC) No. 1005/2009. Annex VI was revised in 2010 and now contains “cut-off dates” for new type certification applications, and “end dates” when halon systems or extinguishers in a particular application must be decommissioned.

The ‘cut-off dates’ for new type certification applications mean the date at which new aircraft designs or substantial existing aircraft redesigns will no longer be certified if those designs include halon extinguishing systems. The ‘end-use dates’ are the dates at which halon use will no longer be permitted for aircraft in the designated application, and must be decommissioned.

Provisions for case-by-case derogations and for periodic regulatory reviews, to account for technological progress and the technical feasibility of retrofit, have been incorporated in the EU requirements to safeguard against adverse impacts on safety and excessive costs.³

	Lavatory	Handheld	Engine/APU	Cargo
Cut-off Dates for New Type Certification Applications	2011	2014	2014	2018
End-Use Dates for Current Production Airplanes	2020	2025	2040	2040

On 9 February 2012, the European Aviation Safety Agency (EASA) issued a Comment Response Document (CRD 2011-14) to the Notice of Proposed Amendment (NPA 2011-14) regarding the European Directive on replacement of halon on aircraft. This document indicates that while there appeared to be a degree of agreement regarding the feasibility of replacement of handheld extinguishers, responses to the proposed amendment in other areas included a number of stakeholders who were concerned that end use dates were being set before minimum performance standards had been approved and where no suitable alternatives had yet been identified. There was also concern regarding the lack of harmonisation between the dates for phase-out between

² David Catchpole and Dan Verdonik, co-Chairs Halons Technical Options Committee, personal communications.

³ UNEP 2010 Report of the Halons Technical Options Committee, March 2011, pg. 67.

the EU and the ICAO directives. A number of commentators stated that the 'end dates' (i.e. retrofit) established by EU requirements may neither be feasible, nor justified, comparing the cost of retrofit with the very small quantities of halon released by aviation into the atmosphere. It was suggested that there would be further discussion at the 38th ICAO General Assembly in 2013.⁴

2.2 Civilian Maritime Uses

Halon is used in Australian-flagged and international commercial shipping for fire protection and suppression. The International Maritime Organisation (IMO) under the 1992 amendments to the 1974 SOLAS Convention (resolution MSC.27(61)), prohibited new installations of halon fire-extinguishing systems from 1 October 1994 for Members acceding to the IMO treaties.

However, there was no requirement for halons to be withdrawn from existing systems and phase-out remains a matter for individual Flag States. While most Flag States allow existing halon installations, the European Union (including NOR/NIS, or Norwegian, Flagged ships) prohibited refilling or topping up of existing halon fire extinguishing systems after 31st December 2002 and prohibited use of halon on vessels after 31st December 2003, requiring that all fire protection systems and fire extinguishers containing halons be decommissioned and halons recovered by that date.

2.2.1 Australian Flagged Vessels

As an IMO treaty acceding member, new installations of halon in the Australian fleet has been prohibited since October 1994. There was no requirement for vessels with halon systems installed prior to the prohibition date to be removed.

Halon has been used to extinguish and suppress fires in two main applications on commercial shipping:

1. Handheld fire extinguishers (halon 1211) located throughout the vessel.
2. Fixed halon 1301 flooding systems in cargo and other areas.

Alternative fire suppression systems have been readily available for some time, but as there was no regulatory requirement to replace halon systems

⁴ European Aviation Safety Agency (EASA), Comment Response Document (CRD 2011-14) to the Notice of Proposed Amendment (NPA 2011-14), February 2012, <http://www.easa.europa.eu/rulemaking/docs/crd/2011/>.

phase-out has been by natural attrition: vessels reaching end-of-service or being on-sold out of the region, or by handheld extinguishers and fixed systems being replaced with alternative fire suppression systems when it became economically viable to do so. Nonetheless, because of the relatively early action of the IMO in prohibiting new halon installations and with a typical vessel lifetime of 30 to 40 years, the number of Australian flagged vessels with halon will have substantially decreased since 1994. This is consistent with information received from industry sources.

The Australian Shipowners Association, Australian Maritime Safety Association and National Marine Safety Council were requested to provide quantitative data on the number, size and type of halon fire protection systems still being used. This data was not available for the final report.

2.2.2 Foreign Flagged Vessels

Australia is the fifth largest global shipping nation in terms of tonnes of cargo shipped and kilometres travelled and hosts visits by significant numbers of foreign flagged bulk and containerised commercial shipping each year.

Visiting foreign flagged vessels requiring halon while in Australian ports can access halon through Australian fire protection companies with the necessary halon special permits required under the Act. Requests for supply of halons from the stockpile are administered in accordance with the criteria established under the Act. Halons can be provided for fire protection systems in maritime applications where halon is still required and no practical alternatives exist.

The IMO maintains a list of halon banking and reception facilities (IMO FP.1/Circ.42 31 January 2011). The list, circulated to Member Governments, provides information on the availability of halons at various ports of the world, to provide for the recharge of existing halon systems with recycled halons to comply with the relevant requirements of the 1974 SOLAS Convention. Australia is listed by the IMO as a Member government, and the NHB is listed as being able to supply halon for these purposes with the following remarks:

“In view of the stock of recycled halon 1301 now held by the Australian National Halon Bank, the supply of halon to a foreign flag ship in an Australian port can be guaranteed on request. Nevertheless, such a supply will be limited to a "one-off" provision essential for the safe operation of the ship.

The supply of halon from the Australian National Halon Bank will be subject to approvals from the Department of the Environmental and Heritage and the Australian Maritime Safety Authority. The Australian National Halon Bank will acquire these approvals on behalf of the foreign flag ship prior to supply.

The Australian National Halon Bank is committed to ensuring that a supply of recycled halon 1301 over and above that required for Australia's domestic needs will be retained for the purpose of meeting the emergency needs of foreign flag ships.

Recycled halon of the Australian National Halon Bank will meet the requirements of ASTM D5632 as adopted by the U.S. Department of Defense.

The Australian National Halon Bank can also safely dispose of contaminated halon, or halon removed from decommissioned fire protection systems."

Contrary to the possible interpretation that halon would be supplied to foreign flagged ships as a once only occurrence, the supply of halon to foreign flagged ships is not limited in Australia, other than by the general requirements set out in the Act and its regulations.

Since the end of 2003 the European Union and NOR/NIS flagged vessels have been required to decommission halon fire protection systems. To our knowledge no other jurisdiction has required decommissioning of systems that were installed before the IMO prohibition on 1 October 1994.

The lifetime of vessels is generally considered to be 30 to 40 years, after which vessels would be broken down and halon recovered. Therefore a significant, but decreasing, number of foreign vessels may still be equipped with halon fire suppression systems. As the number of Australian flagged vessels with halon fire suppression systems decreases, the major uncertainty in estimating future halon needs for the civilian maritime sector will be foreign flagged vessels that have a discharge incident en route to Australia or while serving Australian coastal routes. Additionally, in situations where a vessel enters a foreign port that does not have halon banking facilities, the IMO conventions allow the vessel to travel, under certain conditions, to another Member State where halon banking facilities are available. There is a precedent for this in Australia, but due to geographic location and the experience of the last 10 years, it is not considered likely that this would pose significant risks to Australia's halon essential uses stocks.

2.2.3 Halon Alternatives

Numerous alternatives are available to replace halon fire protection systems in maritime use. These include but are not limited to CO₂, water mist, foam, FM-200 and dry powder extinguishers. These and other technologies have replaced halon use in new vessels since 1994.

2.3 Defence Uses

This study investigates civilian halon uses and considers requirements for the strategic stockpile of halon to meet those needs. It specifically excludes quantification of Australian Defence Force's (ADF) uses of halon. During investigation of civilian halon use, it has become clear from interviews with industry experts that civilian halon, acquired from NHB stocks or via commercial fire protection services, is being used for defence purposes in some circumstances. There may be significant use of civilian halon for ADF purposes. This may present a potential risk to Australia's ability to maintain an adequate bank of halon for civilian essential uses. Hence, this study mentions, where relevant, the general impact ADF halon use may have on stocks of halon reserved for civilian purposes.

ADF uses halon 1211 and 1301 for aviation use (including maintenance of older F111 fleet), for land vehicles including tanks (M1 tanks) and armoured personnel carriers (particularly Australian Light Armoured Vehicles (ASLAVs)) and for naval use (Adelaide class frigates, ANZAAC class frigates and Collins class submarines). Industry sources suggest that halon supplied under longer-term service contracts would generally be sourced from ADF stocks but that one-off or *ad-hoc* requests might be supplied from civilian stocks.

Industry experts suggest that there are approximately 25 tonnes of halon in the ADF's bank at Morebank NSW. There is also some ADF storage at the NHB, and there may also be a smaller amount held by fire protection companies on behalf of ADF. It is believed that there is also an unknown and possibly significant store of halon in spare cylinders and extinguishers at bases and defence facilities around the country. Industry experts suggest that while there are some good estimates for the amount of halon in specific craft and in-service equipment, the overall size of the ADF stock of halon in active equipment, craft, buildings, spares and other amounts in storage, is not as well known.

Similarly, industry experts suggest that while specific areas of the ADF may have a good understanding of its immediate halon needs, there may be less understanding of future needs. Further, it has been suggested that quantifying these may be a difficult task.

Until the future ADF requirements are quantified, there remains a significant potential risk to Australia's ability to meet requirements for civilian essential uses. It is recommended that this be carefully considered prior to any decision regarding the halon essential use requirements and any destruction of existing civilian essential use stocks.

3 Future Trends in Halon Use

Alternatives to halon use in civil aviation and maritime uses have been briefly described earlier. This section describes future possible trends in remaining halon essential uses.

3.1 Civilian Aviation Uses

A number of alternatives have been identified, tested or introduced for civil aviation uses. The most technically acceptable or promising alternatives have been identified for three of the four civil aviation application areas, notably lavex, handheld extinguishers, and engine and APU compartments. However, commercial development of an alternative fire suppression system for cargo compartments is still in its early stages.

Unless there is a drop-in alternative that meets MPS (e.g. lavex systems), there is generally no simple way to retrofit halon alternatives into existing aircraft. Some retrofit of existing halon 1301 lavex systems with an HFC alternative has occurred during scheduled maintenance (e.g. Lufthansa) but most halon alternatives in aviation will most likely be introduced in new production aircraft. Due to the requirements for type certificates and maintaining individual aircraft certificates for air-worthiness, and probably also due to cost, weight and size implications, little retrofit is anticipated unless regulatory measures are introduced.

The Australian experience suggests that even when a near drop-in replacement is available (e.g. FM-200 handheld extinguishers) there is unlikely to be voluntary replacement because of added weight, cost, and risk of future restrictions due to the replacement's high GWP.

Investigations show the number of aircraft in major Australian-based airline fleets (i.e. regular public transport (RPT) aircraft, excluding freight only aircraft, of major Australian airlines) increased from 213 to 307 from 2005 to 2010, an average of approximately 8.8% annually. The number of aircraft in General Aviation and Regional Airline operations (excludes major Australian regular public transport (RPT) airline fleets, and freight only aircraft, and includes fixed wing, single engine, fixed wing multi-engine, rotary wing, and balloons and airships) has increased by an average of approximately 2.4% annually from 2005 to 2010⁵.

⁵ Bureau of Infrastructure, Transport and Regional Economics, www.bitre.gov.au/publications/ongoing/general_aviation_activity.aspx

With 20-30 year aircraft lifetimes and an increasing fleet size, continuing, and in the short term increasing, demand for halons 1211 and 1301 is expected for some time. Decreases over time are expected in line with attrition of the existing aircraft fleet at end-of-life and in-production installation of alternatives in new aircraft, except in cargo compartments where there are currently no suitable alternatives.

Halon 1301 is still likely to be installed in new production aircraft within the next 20-40 years. The expectation for halon 1211 may be different if BTP proves to be a suitable alternative, in which case halon 1211 extinguishers could be replaced in new and existing aircraft. The goal of the company promoting BTP is for US EPA SNAP approval by the end of 2012.

There is some hope that if BTP can meet requirements for handheld aviation extinguishers that it may also be suitable for some of the other on-board applications. However, even if a suitable halon alternative were found to be suitable for other on-board applications, it would still need to survive the long process of passing all performance and toxicology hurdles, certification, and industry acceptance. BTP is unlikely to be a solution in the near term for applications other than handheld fire extinguishers.

The conclusion is that halon 1301 use is likely to increase slightly over the next decade and plateau but will not reduce for some time. International expert opinion⁶ suggests that it may be at least 2050 before halon 1301 use decreases, and even then cargo bay use may still remain.

Despite the more positive outlook for halon 1211 replacement in aviation uses, continued caution to preserve banks of halons 1211 and 1301 for future civil aviation uses is considered prudent. International experts cautioned against the risks for civil aviation associated with destroying quantities of halon in the Australian halon bank.

3.1.1 Acquisition of New Aircraft and Disposal of Old Aircraft by Major Airlines

3.1.1.1 Large Passenger Aircraft Entering the Australian Major Airline Fleet

Data from Bureau of Infrastructure, Transport and Regional Economics (BITRE) for the years 2005 to 2010 show high variability for year-to-year growth in major airline aircraft numbers, ranging from 3.6% for 2006-2007 to 13.5% for 2007-2008. Total major airline fleet growth over this five year

⁶ David Catchpole and Dan Verdonik, HTOC co-Chairs, personal communications.

reporting period exceeded 44%, despite very challenging economic conditions.

There is a great deal of uncertainty in the industry, and none of the major airlines were willing or able to provide projections, on what Australian fleets would look like into the future. According to industry sources, while there are many uncertainties in future projections, passenger demand domestically and in the Asia-Pacific region is generally expected to drive the growth of fleets at a rate significantly in excess of Australian GDP growth for at least the next decade. The FAA (Forecast Fact Sheet - Fiscal Years 2011 to 2031) forecast an average annual increase in passenger enplanements for the Asia/Pacific region of 5.0% from 2011 and 2031. Combined with the introduction by manufacturers of new aircraft with lower running costs, significant fuel efficiency and associated environmental benefits, there appear compelling reasons for expectations of a high level of turnover in Australia's aviation mainline fleet over the next decade.⁷

In Australia, the major airlines either purchase new large passenger aircraft from the manufacturer outright or enter into a lease agreement with an aircraft-leasing firm. Of the largest airlines in Australia, to date, one has preferred mainly to purchase aircraft outright, while another mainly leases its aircraft but also purchases some new aircraft. There is no certainty that historical purchasing and leasing behaviour will continue into the future.⁸

We have been advised by one of the airlines that when a new large passenger aircraft is purchased from Airbus or Boeing that the halon necessary for the new aircraft's fire protection systems is sourced from Australia. It is anticipated that their fire protection services provider will supply halon to the airline, and then the airline will transport that halon to the airframe manufacturing facility to be installed on the new aircraft. This suggests that an increase in new large passenger aircraft purchases could draw additional quantities of halon from the NHB. This would only apply to aircraft purchased directly from the manufacturer. On the other hand, aircraft that are purchased by an international aircraft-leasing company, and subsequently leased to an Australian operator, would not have halon supplied from Australia but presumably by the international leasing company.

International experts have suggested that there may be a decrease in the amount of halon 1301 used on some of the new generation of large passenger aircraft due to the two-engine configuration versus four engines for 747

⁷ ICAO (April 2012), <http://www.icao.int/>. David Catchpole and Dan Verdonik, HTOC co-Chairs, personal communications.

⁸ Planespotters.net (April 2012) and personal communications.

aircraft. However, we understand from local industry that the new Boeing 787 series when compared to the Boeing 747 series may carry as much as three times more halon 1301 per passenger seat.

3.1.1.2 Large Passenger Aircraft Leaving the Australian Major Airline Fleet

The fate of large passenger aircraft removed from an airline's passenger fleet varies depending on airframe life stage and history and immediate company needs. A large passenger aircraft that is owned by an Australian-based airline and exiting its fleet may be on-sold or leased, often overseas, converted for cargo transport and used locally, or broken down for parts and scrap if it has reached the end of its airframe life, usually in the United States.

For the case of aircraft sold overseas or broken down, this effectively amounts to a net export of halon from the Australian installed bank.

Aircraft converted to cargo transport from passenger use can be expected to require quite significant additional quantities of flooding agent halon 1301 to meet fire protection requirements for much larger cargo volumes, with perhaps a decrease in the requirements for halon 1211.

At the termination of lease, an aircraft will simply revert to the leasing company, usually overseas. This has only a small net effect on Australian net halon with a small loss of halon used during the service life of the aircraft.

Overall, large passenger aircraft leaving Australia's airline fleet will tend to lead to a loss of halon from Australia.

3.1.2 Estimation of Future Civilian Aviation Halon Requirements

This section presents an estimation of future civilian aviation halon requirements based on an estimation of the quantities of halon installed in and emitted from civil aircraft in Australia (includes commercial passenger and freight, but excludes general aviation including unscheduled private or recreational aviation) from 2012 to 2060. Appendix 1 contains further information on general aviation, regional airlines and major airlines in Australia.

The numbers of commercial passenger (includes large and regional aircraft of more than 70 passengers) and freighter aircraft are estimated, and from that, the quantities of halon installed in and emitted from commercial passenger and freight aircraft are estimated.

The methodology used was based on that described by ICF⁹, using mainline and regional aircraft forecasts, and modified for the purposes of this study. Similar aircraft categorisations have been applied by assuming *mainline* aircraft are those over about 100 passengers (including all Airbus A320, A321, A330, A380 and Boeing 717, 737, 747, 767, 777 for Jetstar Airways, Qantas, Tiger Airways and Virgin Australia), and *regional* aircraft are those between 70-100 passengers (including, *inter alia*, Bombardier Dash 8, British Aerospace 146, and Embraer 170/190).

3.1.2.1 Commercial Passenger and Freighter Aircraft Numbers

The number and age of existing commercial passenger and freighter aircraft in service (either active or in storage) in mainline and regional categories at the end of 2011 were determined from online sources of aircraft data¹⁰.

Aging of the mainline passenger fleet assumed an average aircraft lifetime of 30 years (Penner *et al.*, 1999). For each subsequent year, the number of mainline passenger aircraft in each year likely to have been retired from the existing fleet in 2011 was calculated, and the total number of aircraft in service adjusted.

The numbers of new mainline passenger aircraft delivered each year from 2012 to 2060 were estimated for Australia. Projections of future annual average mainline passenger aircraft deliveries to Australia per year were estimated from the average of 20-year global forecasts of mainline passenger aircraft deliveries for 2011 to 2030 reported by Airbus¹¹ and Boeing¹². The Australian average annual deliveries for the 20-year period (25 per year) were estimated by the product of the forecasted average number of global mainline passenger aircraft deliveries per year and the proportion of Australian to global mainline passenger fleet for 2010 (average of Airbus and Boeing estimates for global mainline passenger fleets). An average rate of increase in the total number of Australian mainline passenger aircraft was assumed thereon, from 2030 to 2060, based on the constant rate of annual increase in estimated total Australian mainline passenger aircraft numbers between 2011 and 2030 (7%¹³). The total of new and existing mainline passenger aircraft in

⁹ ICF International, "Revised Draft Report: Estimated Usage and Emissions of Halon 1301, 1211, and 2402 in Civil Aircraft Worldwide," June 2006, made available through personal communication with Ms. Bella Maranion, USEPA.

¹⁰ Jetliner database (April 2012), <http://www.jetphotos.net/census/>; and Planespotters.net (April 2012), http://www.planespotters.net/Production_List/Country/Australia; and Qantas (April 2012), <http://www.www.qantas.com.au>.

¹¹ Airbus (April 2012), <http://www.airbus.com/company/market/forecast/>.

¹² Boeing (April 2012), <http://www.boeing.com/commercial/cmo/>.

¹³ Compared with 4.9% fleet growth expected in the United States according to FAA.

service in each year from 2011 to 2030 was taken as the sum of the number of remaining aircraft delivered in and prior to 2011 and the cumulative number of aircraft delivered each year from 2011 to 2030.

With a constant rate of annual increase applied from 2030 to 2060 to the number of total mainline passenger aircraft, the number of new mainline passenger aircraft delivered each year can be derived for these years. For 2030-2060, the numbers of new mainline passenger aircraft delivered in each year are estimated as the difference between the calculated total number of aircraft for that year and the total for the year prior. After 2040, the aircraft delivered in and prior to 2011 are fully retired.

The proportions for the number of commercial passenger and freighter aircraft in the mainline and regional categories for 2011 were used to project the yearly numbers of each of these aircraft types to 2060 based on the yearly total number of mainline passenger aircraft¹⁴. The same proportion of new to total number of aircraft for each year is assumed for regional passenger as for mainline passenger aircraft from 2011 to 2060.

Table 1 presents a summary of the total number of each type of aircraft estimated in service in 2011, or projected to be in service in 2020, 2030, 2040, 2050 and 2060.

Table 1: Estimated number of types of aircraft in service in Australia

	2011	2020	2030	2040	2050	2060
Mainline passenger aircraft	311	522	724	941	1158	1376
Regional passenger aircraft	229	384	533	693	853	1013
Mainline freighter aircraft	9	15	21	27	34	40
Regional freighter aircraft	10	17	23	30	37	44

3.1.2.2 *Estimated Quantity of Halon Installed in and Emitted from Global Civil Aviation*

The average quantities of halon installed in Australian commercial passenger and freighter aircraft in mainline and regional categories were estimated based on the global average quantities of halon installed for each fire protection application and aircraft type as reported by ICF. ICF based its analysis on an earlier study undertaken by O’Sullivan. Table 2 summarises the estimates of halon installed per application and aircraft type.

¹⁴ Ratio of mainline passenger: regional passenger: mainline freighter: regional freighter is about 56:41:2:2.

Table 2: Estimates of the Quantities of Halons 1211 and 1301 Installed in Commercial Passenger and Freighter Aircraft (kg)¹⁵

AIRCRAFT TYPE AND APPLICATION	Assumption (kg)
Mainline Passenger Aircraft	
Quantity of Halon 1301 for engine nacelles per aircraft	52
Quantity of Halon 1301 for APUs per aircraft	5
Quantity of Halon 1301 for baggage/cargo compartments per aircraft	14
Quantity of Halon 1301 for lavex systems per aircraft	0.5
Quantity of Halon 1211 for handheld extinguishers per aircraft	10
Regional Passenger Aircraft	
Quantity of Halon 1301 for engine nacelles per aircraft	20
Quantity of Halon 1301 for APUs per aircraft	4
Quantity of Halon 1301 for baggage/cargo compartments per aircraft	0
Quantity of Halon 1301 for lavex systems per aircraft	0.1
Quantity of Halon 1211 for handheld extinguishers per aircraft	6
Mainline Freighter Aircraft	
Quantity of Halon 1301 for engine nacelles per aircraft	52
Quantity of Halon 1301 for APUs per aircraft	5
Quantity of Halon 1301 for baggage/cargo compartments per aircraft	513
Quantity of Halon 1301 for lavex systems per aircraft	0.1
Quantity of Halon 1211 for handheld extinguishers per aircraft	4.5
Regional Freighter Aircraft	
Quantity of Halon 1301 for engine nacelles per aircraft	20
Quantity of Halon 1301 for APUs per aircraft	4
Quantity of Halon 1301 for baggage/cargo compartments per aircraft	103
Quantity of Halon 1301 for lavex systems per aircraft	0.1
Quantity of Halon 1211 for handheld extinguishers per aircraft	4.5

However, these estimates assume no change to average halon installed over time. Newer models of passenger aircraft will not necessarily have decreased total installed quantities of halon compared to older aircraft, nor will they necessarily have reduced halon per passenger seat, with these being dependent on aircraft design and configuration. Local industry information suggests that some new passenger aircraft may have increased total installed quantities of halon compared with older models (e.g. Airbus's A380 will have about two and a half times more halon 1301 per aircraft than the A330 and considerably more halon per seat in some configurations). A significant influx of new aircraft models is underway and will continue over the next

¹⁵ ICF International, "Revised Draft Report: Estimated Usage and Emissions of Halon 1301, 1211, and 2402 in Civil Aircraft Worldwide," June 2006

decade. For example, according to Boeing¹⁶, Qantas has ordered 50 of the Dreamliner aircraft. These changes are likely to influence the average quantities of halon per aircraft type and application.

Also, these estimates assume an average of halon installed in the global fleet that may not reflect the fleet composition in Australia. Information from local industry sources suggests that the current fleet of passenger aircraft has significantly higher quantities of halon installed per aircraft. For example, each A330 is reported to carry 15 kg halon 1211 and 158.2 kg halon 1301, and each A380 carries 38 kg halon 1211 and 360 kg halon 1301, which are both higher than the average global quantities of halon installed on passenger mainline aircraft. On the other hand, each Boeing 737-800 carries 7.5 kg halon 1211 and 37.34 kg halon 1301, which is lower than the average global quantities of halon installed on passenger mainline aircraft. An analysis of local fleet make-up and installed halon per aircraft type and application might be needed for a more accurate estimation of average halon quantities for the Australian fleet. Without a thorough study of fleet changes over time, and accurate information on halon by aircraft type, it may not be possible to predict accurately future halon requirements on aircraft in the Australian fleet.

The total quantities of halon 1301 and halon 1211 emitted each year were calculated based on estimated leakage and inadvertent discharge rates for each of the fire protection systems, as used by ICF. A leakage rate of 2% per year was used for each of the halon 1301 systems¹⁷. A leakage rate of 6% per year was assumed for halon 1211 handheld fire extinguishers¹⁸. Both of these assumed leakage rates also fall within the ranges estimated in the 2005 Intergovernmental Panel on Climate Change (IPCC) report (IPCC, 2005). The IPCC estimated the average in-service-life annual emissions rates (i.e., not including end-of-life emissions or decommissioned quantities) for halon 1301 fixed systems and halon 1211 portable systems as $2 \pm 1\%$ per year and $4 \pm 2\%$ per year, respectively.

3.1.2.3 *Estimated Total Requirements for Halons 1211 and 1301 in Australian Civil Aviation to 2060*

Two scenarios were generated by this study to estimate total requirements for halons 1211 and 1301 in Australian civil aviation to 2060, based on estimated total leakage of installed halons during this period. One scenario presents a

¹⁶ Boeing (April 2012), <http://Active.Boeing.com/commercial/orders>.

¹⁷ This is the leakage rate assumed for both total flooding and streaming systems in the US EPA Vintaging Model, as reported by ICF, 2006.

¹⁸ As reported by O'Sullivan, 2005, and used by ICF, 2006.

conservative “business-as-usual scenario” with on-going and unrestricted halon usage. The other scenario, the “retrofit scenario”, aims to predict changes to the aircraft fleet, installed halon and emissions, with the introduction of EU requirements for halon phase-out¹⁹. It also includes ICAO requirements for halon phase-out of lavex (halon 1301) and handheld fire extinguishers (halon 1211) in new aircraft production from 2012 and 2017 onwards, respectively. Other ICAO and EU requirements for engine, APU and cargo applications in new aircraft design were too complex and uncertain to incorporate into the model, and are not included.

Quantities of halon installed in Australian commercial passenger and freighter aircraft in each year from 2011-2060 were estimated from the product of numbers of aircraft for each year and the global average quantities of halon installed for each fire protection application and aircraft type. Total quantities of halons 1211 and 1301 installed are estimated as 5 and 34 tonnes, respectively, for 2011²⁰.

Emissions were calculated for each year by the product of estimated installed quantities and leakage rates for each application. Emissions from installed civil aviation equipment are estimated as 0.3 and 0.7 tonnes for halons 1211 and 1301, respectively, for 2011 (same for both scenarios)²¹.

Total emissions of halon 1211 for the business as usual scenario are estimated as 37 tonnes between 2011 and 2060. Total emissions of halon 1301 for the business as usual scenario are estimated as 93 tonnes between 2011 and 2060. Total emissions for halon 1211 for the retrofit scenario are estimated as 5 tonnes between 2011 and 2060. Total emissions of halon 1301 for the retrofit

¹⁹ Lavex retrofitted in 2020; handheld fire extinguishers retrofitted in 2025; engine, APU and cargo retrofitted in 2040.

²⁰ By comparison, one major Australian airline reported the quantities of installed halons 1211 and 1301 as 0.6 and 4.25 tonnes respectively. Similar information was not available from all airlines for the purposes of this study.

²¹ By comparison, based on average annual NHB halon sales, average annual consumption of halon 1211 and 1301 is estimated to be 1.12 and 1.61 tonnes respectively for the last decade (see later). Estimated emissions from the civil aviation model for 2011 are 27% and 43% of the estimated annual consumption data for halons 1211 and 1301 respectively. Even after taking into account general aviation, defence and maritime halon uses that would make up the remainder of consumption, this comparison might seem to imply that the aviation model under-estimates actual halon usage in commercial passenger and freighter aircraft. Further work might be needed to quantify defence halon usage to test further this implication. Also, this might reinforce our uncertainty in using the global average quantities of installed halon per aircraft type and application, which may be under-estimating total installed halon for the Australian passenger aircraft fleet.

scenario are estimated as 39 tonnes between 2011 and 2060. Results are summarised in Table 3.

Table 3: Estimated Total Emissions of Halons 1211 and 1301 in Australian Civil Aviation, 2011-2060 (tonnes)

	Halon 1211	Halon 1301
BAU scenario	37	93
Retrofit scenario	5	39

Total emissions can be taken to be the same as total halon requirements for the time period, given emissions relate to the refilling of in-service equipment. These results show the possible effect of implementation of the ICAO new aircraft production requirements and the EU retrofit requirements on future halon requirements in Australia. It should be noted again that these indicative results do not include halon usage for other general aviation aircraft in Australia, and do not account for any increased halon use in aircraft over time.

3.2 Civilian Maritime Uses

Due to early action, aided by implementation of phase-out dates by the IMO, the maritime use of halon appears to have declined dramatically. Maritime service companies, which were surveyed and responded, provided no quantitative annual historical data. According to our respondents the principal reason for this appears to be that no servicing of halon equipped vessels has occurred in the past two years. This was supported by conversations with representatives of the maritime safety organisations.

The experience of one respondent seems instructive of the current situation within the maritime sector. In the past, the company regularly serviced two oil tankers involved in coastal and international transfers. These vessels are no longer operating in Australian waters, and over the past two years they have seen no vessels with halon installed. They acknowledge that there are vessels operating internationally that still have halon systems but they have no real idea of when, or if, they are likely to visit Australia. They report that in their experience most, larger vessels operating in Australian waters have CO₂ systems either in bulk tanks or cylinders with a small percentage of FM-200. Smaller coastal vessels have predominantly CO₂, water mist, FM-200 or Novec 1230 systems with any older halon systems having been removed in the last decade. They have no contractual or regular agreement with any party involving the maintenance of halon systems for either marine or land-based systems and do not hold or carry any stocks of halon and they do not see the situation changing in the future.

With maritime use of halon decreasing, and with existing ships broken down at end-of-life, there are implications for the continued collection of recovered halon, as quantities recovered from decommissioned equipment decrease and eventually cease.

3.3 Defence Uses

There are alternatives and solutions for almost all halon uses in defence applications, meaning a manageable downward trend in defence use over time is achievable. Explosion suppression in occupied spaces of land-based vehicles could remain an area difficult to transition to alternatives, and where halon may remain important when there are specific needs for increased fire suppression capability. For M1 tanks, consideration is being given to maintaining halon use. This study does not consider defence uses of halon in Australia. However, the Australian fire protection experts that have been consulted consider halon consumption in the Australian defence sector to create uncertainty and pose risks when predicting future Australian halon essential use requirements. Many believe that there is inadequate information and understanding of current, and therefore also future, halon requirements in this sector.

4 Estimated Civilian Halon Availability and Essential Use Requirements

4.1 Survey of Halon Special Permit Holders

EIA surveyed halon special permit holders via email regarding historic halon storage and use patterns. Survey and background information are provided in Appendix 2. The Executive Officer of the Fire Protection Association of Australia provided halon special permit holders' contact details for the purposes of the survey.

Despite telephone and email prompting and follow-up, responses to the surveys were poor and did not provide adequate quantitative data for any type of useful analysis. This is probably because record keeping was not required until recently, and these types of data are not kept otherwise. From a total of 34 halon special permit holders that were surveyed²², there were 15 respondents, of which 12 provided some qualitative data, 14 supplied comments, and 10 supplied quantitative data for one year only.

²² One permit holder could not be contacted (apparently no longer active).

Telephone interviews with a number of key halon special permit holders and other historic halon users were used to gather additional information and local industry opinions about future halon usage patterns. Interviewees were very willing to assist and provided excellent qualitative information for the review, not without some considerable effort on their parts. Qualitative information provided via interview is incorporated throughout the report's descriptions of industry trends in halon usage.

4.2 Halon Special Permit Holders' Statutory Reports and Analysis

Under the *Ozone Protection and Synthetic Greenhouse Gas Management Act 1989*, halon special permit holders are required to report quarterly. FPA is authorised by the Department to collect quarterly reports from halon special permit holders. FPA provided EIA with quarterly aggregated data for all halon special permit holders, and also broken down into sectors, so as to extract data reported by the ADF and the NHB. The data reported by the ADF was incomplete for 2011, making proper analysis difficult at this time. The remaining data analysed here includes reports from main suppliers (fire protection companies) and aviation related companies.

There are six categories of reported data by halon special permit holders:

- Acquired, which is the quantity of new halon agent acquired, and includes quantities acquired from the NHB, the ADF bank, and fire protection companies by the user or by other fire protection companies (includes double counting);
- Recovered, which is the quantity of halon recovered from fire protection cylinders (a discreet quantity which excludes double counting);
- Supplied, which is the quantity of halon supplied, used or sold, and includes the quantity refilled (includes double counting);
- Refilling, which is the quantity of halon used for refilling cylinders (if known) (a discreet quantity which excludes double counting);
- Destroyed, which is the quantity of halon sent for destruction (a discreet quantity which excludes double counting); and
- On Hand, which is quantity on hand at end of reporting period.

An analysis indicates that data collected through the permit system does not lend itself well to an accurate estimation of activity in halon use. Data only covers 2009 to 2011, and includes double counting and omissions (due to non-reporting).

Acquired quantities can be acquired through multiple sources: the NHB, the ADF halon bank, or through other holders of halon such as fire protection companies or halon users with surplus halon. Due to double counting caused by halon trade and on selling between fire protection companies and halon users, the data corresponding to the categories of Acquired and Supplied are not considered further here.

The data for halon On Hand should in theory provide useful information on the amount of halon stored at the end of each reporting period by fire protection companies and halon users. However, based on our analysis, the quantity On Hand is not reconcilable with the other data from period to period, even taking into account double counting. This may be due to omissions or inaccurate reporting. Nevertheless, as an indication, for the years 2009 to 2011 the average total quantity of halons 1211 and 1301 held On Hand by fire protection companies and halon users were of the order of 2 and 6 tonnes respectively. This implies that these halon holdings are relatively small by comparison with the NHB. We do not consider this category of data further due to the probable inaccuracies.

4.2.1 Recovered Quantities of Halon

The category of Recovered provides a discreet quantity related directly to halons recovered from fire protection systems and extinguishers. From consultations with fire protection companies, these quantities are currently mostly returned into refilling, rather than being deposited in the NHB, and can be on sold in the process. Recovered halon must meet suitable standards for refilling purposes. One fire protection company has its own reclamation equipment to restore sub-standard halon to acceptable quality.

Data for Recovered quantities of halon have been analysed for the portion reported by fire protection companies and civilian halon users. This portion excludes quantities reported by the NHB and the ADF, but includes quantities recovered by fire protection companies providing services to the ADF.

Figure 1 shows the available data for halon 1211, where the quantities recovered range from 0.9 tonnes in 2009 to about 0.5 tonnes in 2011. It is not necessarily possible to infer a trend from 3 years of data. The annual average halon 1211 recovered from 2009 to 2011 is 0.6 tonnes.

Figure 1: Halon 1211 – Annual Quantity Recovered (excl. NHB/ADF data) (kgs)

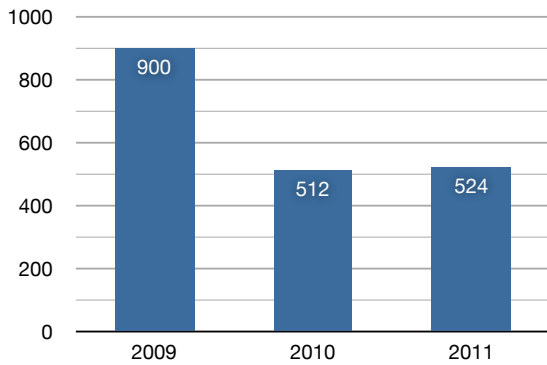
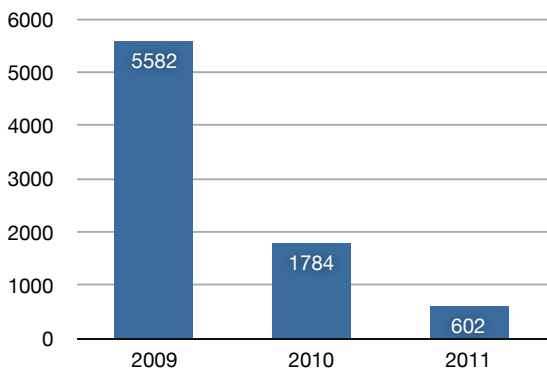


Figure 2 shows the available data for halon 1301, where the quantities recovered range from 5.6 tonnes in 2009 to 0.6 tonnes in 2011. It is not necessarily possible to infer a trend from 3 years of data. The annual average halon 1301 recovered from 2009 to 2011 is 2.7 tonnes. The larger annual variations in quantities recovered of halon 1301 may reflect the unpredictable nature of decommissioning of halon 1301 systems at end of life (for example, maritime or defence halon installations), and the variable size of those systems.

Figure 2: Halon 1301 – Annual Quantity Recovered (excl. NHB/ADF data) (kgs)



4.2.2 Refilling Quantities of Halon

The category of Refilling provides a discreet quantity related directly to the refilling of fire protection systems and extinguishers. Data for Refilling quantities of halon have been analysed for the portion reported by fire protection companies and civilian halon users. This portion again excludes quantities reported by the NHB and the ADF, but includes quantities refilled by fire protection companies providing services to the ADF.

Figure 3 shows the available data for halon 1211, where the quantities refilled range from about 0.9 tonnes in 2010 to about 0.45 tonnes in 2011. It is not necessarily possible to infer a trend from 3 years of data. The annual average halon 1211 refilled from 2009 to 2011 is 0.6 tonnes.

Figure 3: Halon 1211 – Annual Quantity Refilling (excl. NHB/ADF data) (kgs)

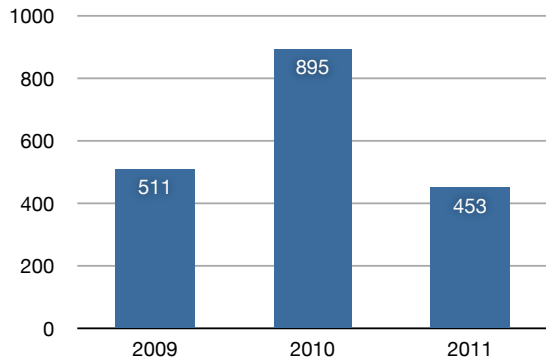
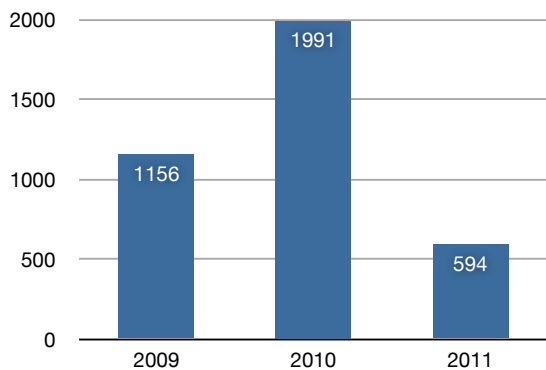


Figure 4 shows the available data for halon 1301, where the quantities refilled range from about 2.0 tonnes in 2010 to about 0.6 tonnes in 2011. It is not necessarily possible to infer a trend from 3 years of data. The annual average halon 1301 refilled from 2009 to 2011 is 1.2 tonnes. The annual variations in quantities of halon 1301 refilled may reflect the variable size of these systems.

Figure 4: Halon 1301 – Annual Quantity Refilling (excl. NHB/ADF data) (kgs)



4.2.3 Halon Quantities Sent for Destruction

The category of Destroyed provides a discreet quantity of halon sent for destruction, as reported by fire protection companies and halon users. For the years 2009 to 2011, the annual average quantities of halons 1211 and 1301 reportedly sent for destruction were 0.1 and 0.3 tonnes respectively. However, the potential for poor reporting among permit holders is higher than for the NHB. Instead this study prefers to use the quantities destroyed

reported by the NHB. The NHB is a more reliable source for information as it is the sole entity overseeing destruction activities. Also, some halon that is sent for destruction may instead be reclaimed by the NHB.

4.2.4 Comparison of Halon Quantities Recovered, Refilled and Sent for Destruction

Table 4 presents a summary of the annual average quantities of halon recovered, refilled and sent for destruction as reported by halon special permit holders (excluding NHB and ADF). It may not be possible to infer trends from the data. However, it might appear that halon 1211 recovery and refilling is currently approximately in balance among permit holders, with a slight overall net loss due to quantities sent for destruction. On the other hand, it might appear that more halon 1301 is being recovered than is being refilled or sent for destruction, resulting in an overall net gain in halon 1301.

Table 4: Annual Average Halon Quantities, Net Balance of Recovered, Refilled and Sent for Destruction Reported by Permit Holders, 2009-2011 (tonnes)

Category	Halon 1211	Halon 1301
Recovered	0.6	2.7
Refilled	0.6	1.2
Sent for Destruction	0.1	0.3
Net balance	-0.1	+1.2

However, NHB data analysis (see below) indicates annual average halon sales for halon 1211 and 1301 of 1.1 and 1.6 tonnes. Given stockpiles with halon special permit holders appear to be kept quite low, it is likely that quantities of halon withdrawn from the NHB are acquired to refill equipment. The NHB data appears not to include any direct sales to the ADF. The permit holder data reported by the ADF indicates that it only acquires, supplies or stores halon, and does not refill or recover its own halon. Therefore direct sales from the NHB to ADF would not explain the greater quantity of halon being sold by the NHB, and presumably refilled in equipment, than is reportedly refilled by permit holders. The disparity in the data implies that the reported quantities of halon refilled are not a true reflection of refilling activity.

The NHB sales data are possibly a closer indicator of actual annual consumption than data reported by permit holders, although possibly still an under-estimation given the recovery activities of fire protection companies and civilian halon users, in particular for halon 1301 where an overall net halon gain is reported. If it were to be assumed that the total halon recovered by fire protection companies and civilian halon users less the quantities sent for destruction was being entirely recycled back into refilling, then this

quantity could simply be added to the quantity of NHB halon sales to estimate annual halon consumption. Table 5 presents the annual average quantities of halon that might be potentially available for refilling from recovery activities of permit holders.

Table 5: Annual Average Halon Quantities, Net Balance of Recovered and Sent for Destruction Reported by Permit Holders, 2009-2011 (tonnes)

Category	Halon 1211	Halon 1301
Recovered	0.6	2.7
Sent for Destruction	0.1	0.3
Net balance	+0.5	+2.4

However, this does not fully take into account annual deposits to the NHB by fire protection companies and halon users, for offloading and/or destruction. Using the NHB data of halon collected during the years 2009-2011 (the same period as for the halon special permit holder reports), the average annual nominal²³ quantities of halon 1211 and 1301 collected were 0.8 tonnes and 3.0 tonnes respectively. These quantities equate closely to the reported annual average quantities of halon recovered by permit holders (assuming these are accurate and that nominal quantities are recorded). Therefore, in our further analysis, we have assumed that the quantities of halon being recovered and reported by permit holders are, on balance, deposited at the NHB. Further, we have assumed NHB sales alone to be a surrogate for annual halon consumption.

4.3 NHB Data and Analysis

The best data currently available to estimate halon availability and requirements comes from the NHB. Data covers the years 1998-2011, and includes key categories such as amounts collected, decanted and destroyed, and halon sales. Following meetings with the NHB, EIA is satisfied that the NHB has collected and analysed the data using consistent methods during 1998-2011, providing an invaluable dataset. The NHB clarified questions about anomalous data and definitions for data categories. The data with the greatest uncertainty relates to halon sales by end use categories, where knowledge of the destination of the halon is based mainly on the known business of the fire protection companies to which the halon was sold. Further uncertainty lies in the possibility of on selling of halon by fire protection companies.

²³ The nominal quantity of halon recovered relates to the quantity indicated on the incoming vessel containing the halon. The quantity actually recovered is the quantity decanted from the vessel. Since 1992, the average decanting rate is 88% for halon 1211 and 81% for halon 1301 at the NHB.

Data show, and consultations indicate, that ADF uses of halon are drawing down directly on the NHB reserves of halon for civilian uses. This is occurring through fire protection companies that purchase halon from the NHB to service ADF fire protection equipment. Fire protection companies under contract are also using ADF reserves. The relative extent of this crossover activity (ADF reserve versus NHB draw downs) has not been quantified.

4.3.1 Current Estimated Availability of Halon for Civilian Essential Uses

The NHB reserves of halon are likely to constitute the majority of halon available for civilian essential uses in Australia. Fire protection companies and a few halon users have small reserves (based on halon special permit holder reporting), and some surplus halon is also banked in equipment that has not yet been collected by the NHB.

Of the latter category of remaining halon banked in equipment, the NHB has roughly estimated that it has collected about 80% of the available halon in Australia²⁴. Since 1992, the NHB has collected and decanted 1279 tonnes of halon 1211 and 514 tonnes of halon 1301, which implies potential additional uncollected quantities of about 320 and 130 tonnes of halons 1211 and 1301 respectively (although it is hard to imagine that reserves of this size might remain). The true quantities of uncollected halons 1211 and 1301 remain unknown.

As at 22 February 2012, the total quantity of halon 1211 stored at the NHB is 100.548 tonnes. Of this, 73.407 tonnes is stored in 0.5 tonne cylinders, and banked in accordance with the AHMS. An additional 27.141 tonnes of halon 1211 remains in bulk storage tanks awaiting a decision by the Department whether to bank or destroy.

If the bulk storage material were to be banked, it would first need to be reclaimed due to probable stratification in the storage tank. Stratification has been observed previously in the other bulk storage tanks, separating out oil to the bottom of the tanks and making full recovery difficult. NHB estimates that reclamation losses may bring the total additional amount available for banking to 21-22 tonnes. Therefore, an estimated total of up to about 95 tonnes of halon 1211 is potentially available for civilian essential uses in Australia.

²⁴ Elvira Nigido, Coffey Environments, NHB

As at February 2012, the total quantity of halon 1301 stored at the NHB, and available for civilian essential uses in Australia, is 195.182 tonnes.

Quantities of halon at the NHB can increase and decrease with deposits (from decommissioned equipment) and withdrawals (as sales). We need to be mindful that bank deposits will continue as shipping and defence equipment, and eventually aviation systems, are decommissioned but will gradually cease. Based on NHB estimates of 80% collection rates, total potential available halon 1211 and halon 1311 could be very roughly estimated to be up to 415 tonnes and 325 tonnes respectively. However, to provide a conservative scenario based on the known available stocks, EIA has assumed that no additional halon will come into the system.

4.3.2 Estimation of Halon Requirements

EIA has analysed recent NHB sales data for halons 1211 and 1301, and used this information as a surrogate to estimate annual average halon consumption.

Figure 5 presents NHB sales of halon 1211 from 2001/2002 to 2010/2011, excluding one-off sales to the US Department of Defense (DoD) in 1999/2000. Sales of halon 1211 show a slight downward trend. The average of annual sales of halon 1211 is 1.12 tonnes from 2001 to 2011.

Figure 5: NHB Sales of Halon 1211, 2001-2010 (excludes sales to US DoD)

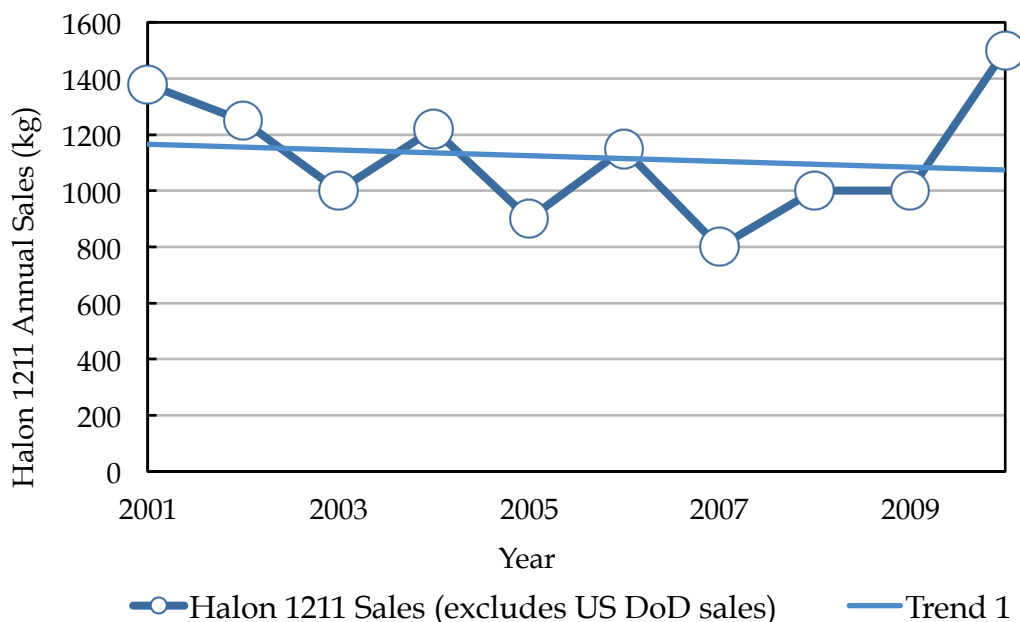
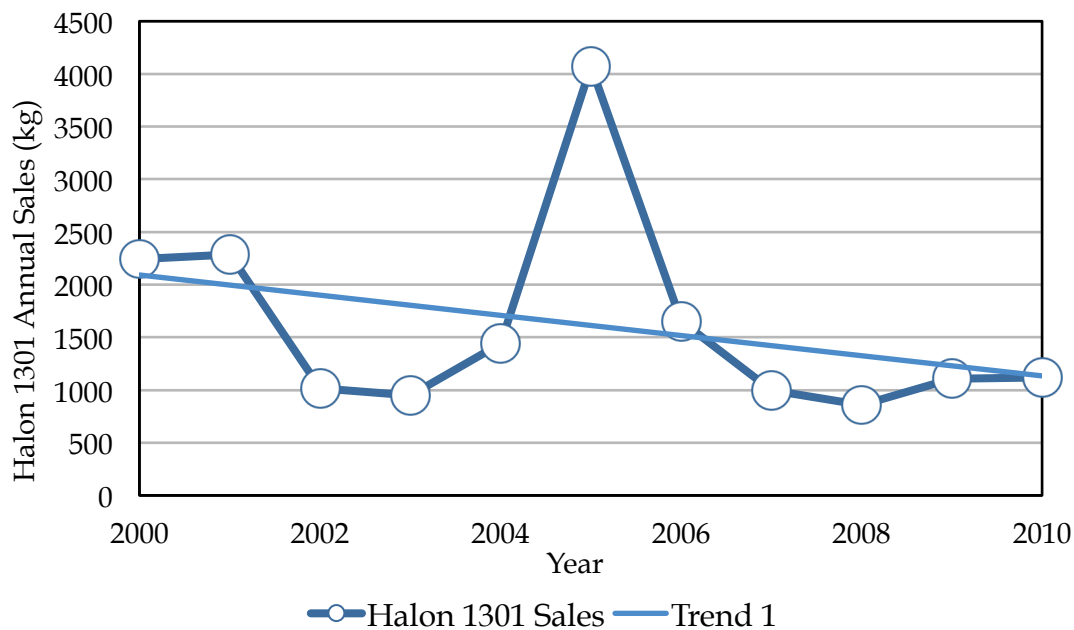


Figure 6 presents NHB sales of halon 1301 from 2000/2001 to 2010/2011. This excludes one-off sales to the US DoD that occurred in 1999/2000. Sales of halon 1301 also show a slight downward trend over the period but are more variable with occasional, large, one-off withdrawals, for example for the halon requirements of visiting international ships. The average of annual sales of halon 1301 is 1.61 tonnes from 2000 to 2011.

Figure 6: NHB Sales of Halon 1301, 2000-2010



Based on average annual NHB halon sales, average annual consumption of halon 1211 and 1301 is estimated to be 1.12 and 1.61 tonnes respectively for the last decade. This does not take into account ADF halon consumption from its own stocks, or separate consumption from privately held stocks, which may or may not underestimate total consumption. Although, as described earlier, we have assumed NHB sales are a surrogate for annual halon consumption.

For the purposes of this study, we have developed certain scenarios for halons 1211 and 1301 in order to project future halon requirements. These scenarios are based on the qualitative trends in halon use and their replacements described earlier, and the estimated average annual consumptions as starting points for 2010 onwards. One scenario assumes a variant of a conservative case where halon consumption does not cease until 2100 (Scenario 1). Another scenario assumes that the recent ICAO resolutions are implemented by aviation industry, and that EU requirements are not implemented directly in Australia but may trigger slower changes throughout the aviation industry (Scenario 2, which is an industry response scenario).

4.3.2.1 Scenario 1

For halon 1211, we have assumed static consumption at 2010 rates for another 10 years and then consumption rates decreasing to zero until 2100, as one possible conservative estimate of phase-out in use. Based on these assumptions, total estimated halon 1211 requirements to 2100 are 55.44 tonnes under Scenario 1.

For halon 1301, as a possible conservative scenario we have assumed an annual 9%²⁵ increase in consumption rates for another ten years, and then static consumption until 2050, decreasing to zero in 2100. Based on these assumptions, total estimated halon 1301 requirements to 2100 are 228.8 tonnes under Scenario 1.

4.3.2.2 Scenario 2

For halon 1211, we have assumed:

- 9%²⁶ rate of annual increase in consumption until 2017, the date when the ICAO resolution mandates new aircraft to be free of halon 1211 handheld extinguishers;
- Static annual consumption from 2017 to 2025, the latter being the date required by the EU for all aircraft to be free of halon 1211 in handheld extinguishers;
- Consumption decreasing to zero in 2040, which assumes 15 years to retrofit all aircraft from 2025.

Based on these assumptions, total estimated halon 1211 requirements to 2040 are 34.6 tonnes under Scenario 2.

For halon 1301, we have assumed:

- 9%²⁷ rate of annual increase in consumption until 2025. The ICAO resolution for lavex system mandates new aircraft to be free of halon 1301 by 2012, and for engine and APU in new design aircraft by 2015.

²⁵ 9% was selected as a worst-case aviation growth scenario based on the BITRE aviation fleet growth rate for 2005-2010.

²⁶ 9% was selected as a worst-case aviation growth scenario based on the BITRE aviation fleet growth rate for 2005-2010.

²⁷ 9% was selected as a worst-case aviation growth scenario based on the BITRE aviation fleet growth rate for 2005-2010.

Lavex makes up a smaller proportion of total halon 1301 use in aircraft, and a 10-year delay in the introduction of new design aircraft into production is assumed from 2015 to 2025. Halon 1301 use in cargo is assumed to continue.

- Static annual consumption from 2025 to 2050. International experts have indicated that halon 1301 may still be installed in aircraft between 2030-2050, and that halon 1301 use may not decrease until 2050. The year 2040 is the date required by the EU for all aircraft to be free of halon 1301 in engine, APU and cargo uses.
- Consumption decreasing to zero in 2060, which assumes 20 years to retrofit all aircraft from 2040.

Based on these assumptions, total estimated halon 1301 requirements to 2060 are 139.0 tonnes under Scenario 2.

Scenario 2 does not take into account prolonged ADF use of halon 1211 or 1301.

4.3.2.3 Conclusions

Table 6 presents estimates of future halon requirements based on the assumptions for Scenario 1 and Scenario 2 described above.

These rough estimates provide only an indication of possible future requirements. It is important to note that ADF uses are included in current consumption, but there may also be consumption from its own stock, and its on-going consumption is unknown. Until there is a better quantitative understanding of ADF uses and stocks it would be unwise to use these projections alone. When considering these rough projections, it will be important to include a safety margin before coming to any decision on stocks required in meeting future halon requirements.

Table 6: Estimated Future Halon Requirements

Total Halon (tonnes)	Halon 1211	Halon 1301
Scenario 1 ²⁸	55	229
Scenario 2 ²⁹	35	139
Potential NHB stocks	73-95	195

²⁸ Based on assumptions, Scenario 1 estimates halon 1211 and 1301 requirements up to the year 2100.

²⁹ Based on assumptions, Scenario 2 estimates halon 1211 requirements up to 2040, and halon 1301 requirements up to 2060.

Nevertheless, the different scenarios provide an interesting sensitivity analysis of the impact of possible policy decisions and industry response on future halon requirements. Using our scenarios, future requirements of both halons 1211 and 1301 can be almost halved by implementing measures that bring about aviation industry change. Faster change for industry would impose greater costs to the aviation sector, and lower costs to the Australian Government from NHB management. Slower change for industry, or at the very worst no change with business as usual, would impose greater costs to the Australian Government from NHB management for a longer period of time, and potential risks to the aviation sector of halon demand outstripping available stocks.

With change underway with ICAO and EU aviation requirements announced, and in the process of their refinement and implementation, and with government and aviation industry responses under development, it would be worth revisiting future halon requirements within the next 5 years.

A scenario reflecting an industry response to international requirements can also point to possible targets for the ADF, after which the ADF could be the final remaining halon user and therefore solely responsible for managing halon stocks for its future uses.

4.4 HTOC Halon Inventory and Emissions Estimates

The 2010 Assessment Report of the Halons Technical Options Committee (HTOC) re-presents the HTOC 2006 assessment of current estimates of inventories and annual emissions for halon 1211 and halon 1301. The model presents regional annual data from 1963 to 2030. Data are presented for Western Europe and Australia as a “region” based on similar economies and halon usage profiles and should be able to be devolved ratiometrically using GDP³⁰.

Utilising IMF GDP data for the European Union and Australia, this methodology produced 2011 Australian inventories for halon 1211 of 1,052 tonnes and for halon 1301 of 427 tonnes, and Australian 2011 annual emissions estimates for halon 1211 of 52 tonnes and 26 tonnes. Assuming no change to the 2011 GDP ratio, this methodology produced 2030 Australian inventories for halon 1211 of 418 tonnes and for halon 1301 of 140 tonnes, and Australian 2011 annual emissions estimates for halon 1211 of 21 tonnes and 8.5 tonnes.

³⁰ David Catchpole and Dan Verdonik, Halon Technical Options Committee co-Chairs, personal communications.

By comparison with data and information available from the NHB, permit holders, and other stakeholders, we believe that by using a simple GDP ratio the HTOC model significantly over-estimates the Australian inventory and annual emissions.

5 Sale price of halon internationally

The sale price of halon internationally varies greatly depending on location, supply and demand, contamination levels, and whether purchasing in bulk or not.

An estimated sale price for halon 1211 is US\$25 to \$39 per kilo, while the estimated price for halon 1301 is \$20 to \$39 per kilo. These estimates are for bulk purchases where the smallest bulk tank is 0.5 tonne³¹.

Most bulk purchases are by either large users, such as aircraft manufacturers or fire protection service companies. The latter would use the material to re-charge system cylinders (halon 1301) or portable extinguishers (halon 1211). The price charged to the customer would be significantly higher than the bulk price.

One company commented that Australian halon prices sometimes seem unreasonably high compared with international prices. This company described spot markets where significant equipment was decommissioned, resulting in relatively low local halon prices for a short period of time.

6 Recommendations

Recommendation 1 (Halon Special Permit Holders' Record Keeping): To consider appropriate measures to improve the quality of reporting by special permit holders, and, as a second step, to consider more specific record keeping by halon special permit holders (to allow for better analysis, eliminating double counting for data accuracy, and identifying sources and end uses for sector analysis).

Recommendation 2 (NHB Historic and Future Dataset): To maintain consistent record keeping and reporting practices in the operation of the NHB so as to preserve the historic dataset.

³¹ David Catchpole, co-Chair, Halons Technical Options Committee, personal communications.

Recommendation 3 (Defence Use): To quantify installed halon, annual halon consumption, and, if possible, historic trends in halon consumption, and to predict future halon requirements for Australian defence uses, and to identify and quantify the different sources of acquired halon for Australian defence purposes (to account for halon withdrawn from the NHB).

Recommendation 4 (Watching Brief for Aviation Use): To keep a watching brief on the global situation for aviation halon use for lavex, engine, APU, and cargo applications, and on the pace of introduction of alternatives in response to ICAO and/or EU requirements, to ensure the risk of long-term halon shortages can be avoided.

Recommendation 5 (Watching Brief for Defence Use): To keep a watching brief on the global situation for defence halon use and on the pace of introduction of alternatives to ensure the risk of long-term halon shortages can be avoided.

Recommendation 6 (Periodic Halon Review): To perform another review of Australian halon requirements in 5 years due to changes in aviation usage patterns that are now on the horizon and the need to factor in defence use.

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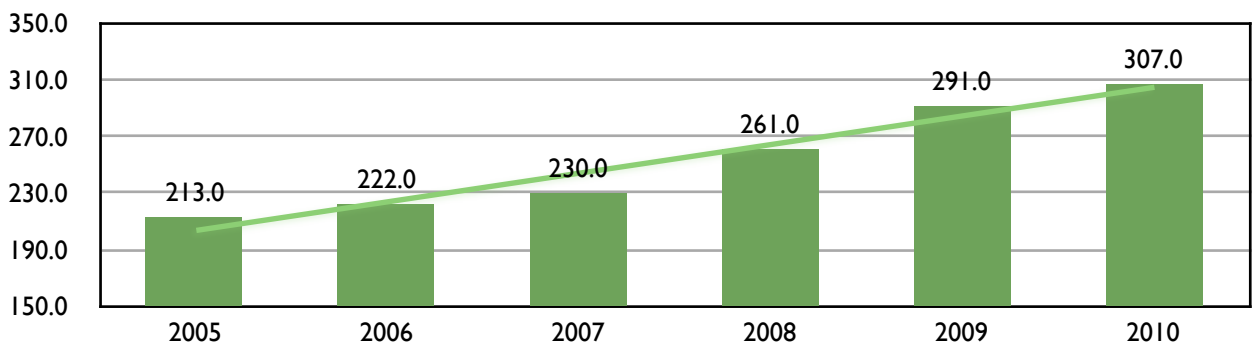
Waterline 50 – November 2011, Bureau of Infrastructure, Transport and Regional Economics, www.bitre.gov.au/publications/

Appendix 1: General aviation, regional airlines and major airlines

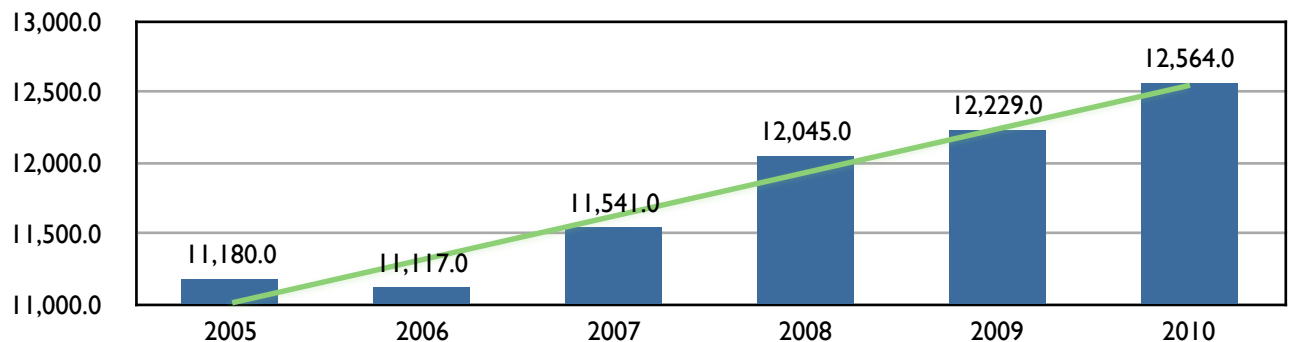
A1.1 General Aviation, Regional Airlines and Major Airlines

The Bureau of Infrastructure, Transport and Regional Economics (BITRE) produces statistics on the size of “General Aviation”, “Regional Airline” and “Major Airline” fleets. In 2010 BITRE lists 12,564 aircraft based in Australia in the categories of General Aviation and Regional Airlines and 307 aircraft based in Australia in the category of Major Airlines.

YEAR	2005	2006	2007	2008	2009	2010	Growth 2005-2010
MAJOR AIRLINE	213	222	230	261	291	307	44%
GENERAL AVIATION	11,180	11,117	11,541	12,045	12,229	12,564	12.4%



Source: General Aviation Activity 2010, Bureau of Infrastructure, Transport and Regional Economics



Source: General Aviation Activity 2010, Bureau of Infrastructure, Transport and Regional Economics

While other areas of this report deal with modelling of major airline installed halon use, there is no central register of halon use in the large number of aircraft outside the major airline category. We contacted a number of relevant organisations and individuals to try to ascertain an indication of usage in the various sub-categories of the general aviation fleet.

A1.2 Balloons and Airships

There are no verified quantitative data regarding the number and type of halon extinguishers used in balloons and airships. However, our conversations with industry sources suggest that most, if not all, have been replaced with non-halon alternatives and that there are few, if any, remaining users of halon in this sector.

A1.3 Recreational Aircraft

This category comprises single engine microlight and ultralight aircraft and includes home-built and factory-built aircraft numbering 3406 registered aircraft reported by Recreational Aviation Australia (RA-Aus) as of 31/12/2012. RA-Aus were of the opinion that very few, if any, of these craft would be equipped with halon fire extinguishers, and reported that CO₂ extinguishers were likely to be used where extinguishers were installed.

A1.4 Rotary wing

BITRE records 1,800 helicopters in the Australian fleet in 2010. While most larger helicopters can be expected to be fitted with halon fire suppression systems, the situation for the large number of smaller aircraft is uncertain. Industry sources noted that the necessity to maintain visibility in the pilot compartment meant that halon extinguishers were preferred for this application.

A1.5 Regional Airlines

Australian Airworthiness Directives require a minimum number of handheld extinguishers for passenger aircraft. Depending on configuration and type certification requirements, some aircraft may also require cargo and engine fixed extinguisher systems.

One extinguisher that is neither water-based nor dry powder is required in each pilot compartment and additional handheld extinguishers are required if aircraft are equipped with toilets, galleys and crew accessible cargo or baggage departments, where a fixed system is not installed. Depending on aircraft design if these areas are co-located, a single extinguisher with common agent compatibility may be able to serve multiple co-located applications.

Where there is a separate passenger compartment, Australian Airworthiness Directive (AD) AD/GENERAL/65 Amdt 5 requires the following minimum number of hand fire extinguishers depending on seating capacity:

Passenger Seating Capacity	Number of Extinguishers
6 to 30	1
31 to 60	2
61 to 200	3
201 to 300	4
301 to 400	5
401 to 500	6
501 to 600	7
601 or more	8

Where 2 or more extinguishers are required in the passenger compartment, at least 2 shall contain halon 1211 or a CASA approved equivalent.

It is reasonable to expect that many aircraft in this category will carry one or more halon handheld extinguishers. Some larger craft will be fitted with halon fixed systems for cargo and/or engines and auxilliary power units (APU).

Appendix 2: Survey of Halon Special Permit Holders and Interviews with Stakeholders

A2.1 Periodic Review of Australia's Halon Essential Uses Requirements: Survey

Halon Survey 2012

**Company
Year**

Please State Units	
Quantity Totals	
In Storage 1211	
In storage 1301	
In Equipment 1211	
In Equipment 1301	
Incoming 1211	
Outgoing 1301	
Sent to NHB	
Received from NHB	

Sector	End Use /Source	Please State Units	
		Quantity Outgoing by End Use	Quantity Incoming by Source
Civil Aviation	Total 1211		
	Total 1301		
Civil Maritime	Total 1211		
	Total 1301		
	Towage 1211		
	Towage 1301		
	Australian Registered 1211		
	Australian Registered 1301		
	Foreign Vessels 1211		
	Foreign Vessels 1301		
Defence	Total 1211		
	Total 1301		
	Army 1211		
	Army 1301		
	Navy 1211		
	Navy 1301		
	Air Force 1211		
Air Force 1301			

All Other End Uses or Sources	End Use /Source	Quantity Outgoing by End Use	Quantity Incoming by Source
Please list other end uses/source description			

Introduction

The Department of Sustainability, Environment, Water, Population and Communities is conducting a periodic review of Australia's halon essential uses requirements in the civilian sector. Helen Tope and Michael Atkinson, who are consultants with Energy International Australia Pty Ltd, have been engaged to assist in this review by gathering data and expert opinion from stakeholders.

We seek your assistance in providing data and your expert opinion and views. Data that you may provide will be aggregated with available data from other stakeholders into annual estimates and will be used to establish quantitative estimates of historical usage. Data will not be individually identified. Together with this data, we also seek your expert opinion and views to help project an estimate of future national needs. If you request it, data and views expressed by you will not be individually identified in the final report.

The Data Survey

The survey has been provided as a printable or electronic spreadsheet surveying one year per spreadsheet. We hope to survey years from 1998 to 2011. We seek as much detail and as many years of data from you as is readily available within the time constraints of the survey. If you have the data available in another format and it is easier for you to provide it "as is", we will gladly accept in that format.

In order to understand better the usage patterns and how future requirements may change and the influence of the various sectors, the spreadsheet allows for entry of sectoral and sub-sectoral end-use and source quantities, if you are able to provide this level of disaggregation. Please state your units for all entries.

Background to the Review

In 1998 Environment Australia published the *National Halon Inventory and Essential Use Requirements* documenting the holdings and anticipated uses of halon within the industry groups still using halon at the time. The report recommended setting aside 70 tonnes of Halon 1211 and 250 tonnes of Halon 1301 to meet Australia's essential use requirements until 2030.

The Australian Halon Management Strategy published in February 2000 states: "*The inventory on projected use will be updated periodically to provide an accurate basis for future policy decisions on halon.*"

Periodic reviews seek to ensure that the quantity of halon held in the reserve is adequate to meet demand, whilst ensuring that excessive stocks of halon, unnecessary to future needs, are not stored.

Burnbank Consulting submitted the first periodic review to Environment Australia in June 2002. Energy International Australia Pty Ltd (EIA) has been asked to conduct a further review in 2012.

An essential part of this review requires the collection of data on the past and current usage, collection, and stocks of halon, expected future usage patterns and other events that might effect Australia's storage requirements. Other events might include changes to technology or usage that might change future usage patterns, or incidents that might require higher stocks.

We also seek information on Halon pricing internationally.

SCOPE

We are seeking the following data from industry stakeholders:

1) Fire protection companies and major end users

- Annual records of quantities of stocks held of halons (1211 and 1301) (in storage, or in equipment for end users);
- Annual records of quantities of outgoing and incoming halons (1211 and 1301);
- Annual records of quantities of halons (1211 and 1301) passed on to the NHB;
- Annual records of end use supplied with halons (1211 and 1301), and detail about the quantities supplied and the end use (eg. for shipping whether for towage vessels, Australian registered trading or off-shore or international-flagged vessels);
- Any information on annual quantities of discharges by halon type and end use category.

2) Halon special permits

- Annual numbers of permits categorised by end use;
- Annual quantities of halons 1211 and 1301 held in equipment/possessed categorised by end use;
- Quantities of annual discharges by halon type and end use category (if recorded);
- Any other relevant information recorded through permit system.

3) Australian Defence Force's usage of civilian halon

- Annual quantities of any halon from NHB stocks for ADF purposes.

4) Technology transition towards halon phase-out

- Views and opinions about the current and future rate of transition to alternative non-halon technologies in Australia in remaining uses, and as compared to internationally;
- Views and opinions on the likely rate of change in halon usage as a result of alternative technology adoption.

5) Events that are influencing or might influence halon usage

- Any events that have or could change halon usage significantly, including major usage or accidental discharges, equipment commissioning and/or decommissioning, changes to Australian or international equipment or industry standards, major developments.

6) Halon Pricing

- Sale price of Halon internationally

Comments: This space is provided for your comments and views

Technology transition towards halon phase-out

- *Views and opinions about the current and future rate of transition to alternative non-halon technologies in Australia in remaining uses, and as compared to internationally;*
- *Views and opinions on the likely rate of change in halon usage as a result of alternative technology adoption.*

Comments: This space is provided for your comments and views

Events that are influencing or might influence halon usage

- *Any events that have or could change halon usage significantly, including major usage or accidental discharges, equipment commissioning and/or decommissioning, changes to Australian or international equipment or industry standards, major developments.*

Other Comments: This space is provided for your comments and views