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NATIONAL INDUSTRIAL CHEMICALS NOTIFICATION AND ASSESSMENT SCHEME

FULL PUBLIC REPORT

1,1,1,2,3,3,3-Heptafluoropropane (HFC-227ea)

This Assessment has been compiled in accordance with the provisions of *the Industrial Chemicals (Notification and Assessment) Act 1989* and Regulations. This legislation is an Act of the Commonwealth of Australia. The National Industrial Chemicals Notification and Assessment Scheme (NICNAS) is administered by Worksafe Australia which also conducts the occupational health & safety assessment. The assessment of environmental hazard is conducted by the Department of the Environment, Sport, and Territories and the assessment of public health is conducted by the Department of Human Services and Health.

For the purposes of subsection 78(1) of the Act, copies of this full public report may be inspected by the public at the Library, Worksafe Australia, 92-94 Parramatta Road, Camperdown NSW 2050, between the hours of 10.00 a.m. and 12.00 noon and 2.00 p.m. and 4.00 p.m. each week day except on public holidays.

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Director
Chemicals Notification and Assessment

FULL PUBLIC REPORT

1,1,1,2,3,3,3-Heptafluoropropane (HFC-227ea)

1. APPLICANT

Biolab Australia Pty Ltd, Factory 3, 61-63 Canterbury Road, Montrose Vic 3765.

2. IDENTITY OF THE CHEMICAL

Chemical name: 1,1,1,2,3,3,3-Heptafluoropropane

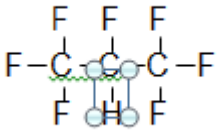
Chemical Abstracts Service CAS) Registry No.: 431-89-0

Other name: HFC-227ea
2H-Heptafluoropropane

Trade names: FM-200

Molecular formula: C_3F_7H

Structural formula:



Molecular weight: 170.03

Method of detection and determination: HFC-227ea may be detected by infrared spectroscopy or mass spectrometry.

Spectral data: An infrared spectrum was provided with major peaks at approximately 1125, 1220, 1240, 1305 and 1390 cm^{-1}.

A mass spectrum was also provided.

3. PHYSICAL AND CHEMICAL PROPERTIES

Appearance at 20°C and 101.3 kPa:	colourless gas
Odour:	odourless
Boiling Point:	-16.4°C
Specific Gravity:	1.46 (air=1)
Vapour Pressure:	84 kPa at -18°C kPa at 0°C kPa at 21°C kPa at 55°C
Water Solubility:	no data were submitted, but reference is made in the biodegradation test to a solubility of 0.26 g/L using Irmann's equation (1), water solubility is approximately 0.23 g/L
Hydrolysis as a function of pH:	the chemical contains no hydrolysable functionalities
Dissociation Constant pKa:	the chemical contains no readily dissociable groups
Reactivity/Stability:	reacts with strong oxidising agents
Ozone depleting potential:	negligible
Atmospheric lifetime:	42 years

Comments on physico-chemical data:

Data on partition co-efficient and adsorption/desorption were not provided. This is acceptable given the low water solubility and the gaseous state of the notified chemical.

Data for flash point, flammability limits, explosive properties and autoignition temperature were not provided. These data were not required for the notified chemical as it possesses fire extinguishing properties. Upon exposure to a flame or a hot surface >700°C, the notified chemical will decompose to hydrogen fluoride and other toxic or irritating vapours (2).

4. PURITY OF THE CHEMICAL

Degree of purity: ~99.6%

Toxic or hazardous impurity/impurities: none known

Non-hazardous impurity/impurities (> 1% by weight): none

Additives/Adjuvants:

Chemical name: nitrogen (gas)
CAS No.: 7727-37-9
Weight percentage: will vary with pressure requirements of firefighting system

5. INDUSTRIAL USE

HFC-227ea will not be manufactured in Australia. The chemical will be imported in pressurised, ready to use containers or tanks and used as a replacement gas for Halon 1301 in total flooding fire extinguishing systems. The notified chemical extinguishes fires by physically cooling the fuel and by the production of free radicals during decomposition which interfere with the combustion process.

Total flooding fire extinguishing systems are used in contained areas to protect such equipment as computer rooms and telecommunications switching facilities, oil production facilities, records storage facilities, aircraft cargo bays, flammable liquid storage facilities and laboratories, and public areas such as libraries, museums, shopping malls and tourist facilities. HFC-227ea is proposed to be used in industrial applications only, with typical firefighting applications involving dry electrical hazards, such as switching equipment, computer hardware and electrical circuits. It is estimated that

50 tonnes will be imported in the first year increasing to 150 tonnes by the fifth year.

6. OCCUPATIONAL EXPOSURE

Exposure to HFC-227ea may result during transportation, servicing or use.

As the notified chemical will be imported and distributed in pressurised containers or tanks (0.5 to 10 tonnes), exposure during transport should result only in the event of handling accidents. The types of workers likely to be exposed in these situations include dock workers, warehouse workers, transport drivers, police and rescue personnel as well as firefighters.

During servicing and recharging of fire systems, installation fitters and maintenance personnel may be exposed to the chemical in the event of leakages of compressed gas from the tanks. The notifier has indicated, however, that leakages should be minor, and workers will wear appropriate gloves and goggles during servicing of the equipment to avoid cold burns.

The greatest potential for exposure will be during firefighting procedures. The notified chemical will be used in total flooding systems installed in fixed enclosures. The extent of exposure during firefighting will be entirely dependent on the number of fire emergencies and the materials fuelling the fires.

In order for the gas to be effective as a fire extinguishant, it will be used and maintained at a concentration of at least 5.8% (3). Concentrations will generally be between 7 and 9% but may reach levels greater than 14%.

There is a potential for workers to be exposed during evacuation. A draft Australian Standard (2) describes maximum permissible flooding concentrations based on expected evacuation times. Generally speaking, workers should not be exposed for greater than 60 seconds to concentrations over 9.7% but no greater than 10.5%. A maximum of 30 seconds is recommended for concentrations greater than 10% but less than 14%.

In most cases, with the use of warning devices and time delay mechanisms, personnel will be evacuated before the extinguishant is released. Appropriate personal protective devices, such as

self contained breathing apparatus, will be required when worker exposure is anticipated.

7. PUBLIC EXPOSURE

Some leakage of the chemical is expected during extinguisher system servicing and recharging, however the notifier has indicated that this should be minor, and consequently there should be low potential for public exposure during these procedures. The notifier has indicated that any discharge testing of extinguisher systems would be performed with other AICS-listed gases, due to the expense of HFC-227ea.

Release of the chemical to the environment will normally occur only in the event of fire. Since the chemical is to be used in industrial, and not domestic applications, public exposure is unlikely in most situations.

8. ENVIRONMENTAL EXPOSURE

. Release

Use of HFC-227ea will entail inevitable atmospheric release in the case of fire. Minor amounts may escape during recharging of fire extinguishing systems, but economic considerations would be expected to minimise such losses.

State legislation prohibits discharge of halons during testing and training. A draft Standard (revised December 1993) (2) for HFC-227ea (FM-200) systems contains details of discharge testing, in which it is specified that "the test medium shall be FM-200". However, a consultant for the applicant has disclosed that other propellants would be used should any discharge testing be required, because of the high cost of HFC-227ea. The draft Standard should be updated accordingly.

High temperature incineration is recommended for any HFC-227ea that requires disposal. This would need to be preceded by export as such facilities do not exist currently in Australia. However, such situations are not expected to arise under normal use conditions as economic considerations will favour recovery.

. **Fate**

Given its high volatility, any HFC-227ea released to the environment will partition almost entirely to the atmosphere. Any traces entering water would not be expected to undergo biodegradation at significant rates as degradation by activated sludge in a closed bottle test (OECD Test Guideline 301D) (4) was minimal (28 day biological oxygen demand 1% of theoretical). The main degradation pathway in the environment is reaction with tropospheric hydroxyl radicals, which abstract hydrogen. The estimated atmospheric lifetime is 42 years (5).

Detailed atmospheric degradation pathways for HFC-227ea do not appear to have been elucidated. However, after the initial radical abstraction, further transformation and breakdown would be expected to lead to hydrophilic products that would be removed from the troposphere by dissolution in rain.

9. EVALUATION OF TOXICOLOGICAL DATA

9.1 Acute Toxicity

Data on oral and dermal toxicity, as well as eye irritation, skin irritation and skin sensitisation, were not submitted for the notified chemical. This is acceptable as these tests are inappropriate for gases.

However, a literature review (6) on related chemicals (1,1-dichloro-1-fluoroethane, 1-chloro-2,2,2-trifluoroethane and 1,1-dichloro-2,2,2-trifluoroethane) described these chemicals as being non to mild irritants when applied to the skin of rabbits or guinea pigs. They were reported to produce mild ocular irritation, mild to moderate conjuctival irritation and slight corneal opacity in the rabbit eye, but no skin sensitisation reactions when tested in guinea pigs.

9.1.1 Inhalation Toxicity I (7)

The acute whole body inhalation toxicity of HFC-227ea was assessed in 12 Crl:CD.BR rats (3/sex/dose) at static exposure levels of 121,267 ppm for 4 hours or 241,188 ppm for 4.5 hours. The high dose treatment was divided into two parts (with a 19 minute break between the two parts) to minimise any effects from

oxygen depletion and/or carbon dioxide accumulation. Control animals received air for 4 hours in a sealed chamber. Animals were monitored for a fourteen day period post exposure and terminally necropsied.

No deaths occurred during the study. There were no significant body weight changes, test material-related necropsy findings or lung weight differences in any of the animals during the course of the study. All animals receiving HFC-227ea exhibited anaesthesia, hypoactivity, bradypnea and/or ataxia during treatment. Signs of anaesthesia diminished after the animals received fresh air. Two test animals showed signs of salivation for one day.

The results of this study indicate HFC-227ea to have an acute inhalation LC_{50} of >241,188 ppm (24%) in rats.

9.1.2 Inhalation Toxicity II (8)

This study was conducted in accordance with OECD guideline No: 403 (9).

The acute whole body inhalation toxicity of HFC-227ea was assessed in 10 Crl:CD.BR rats (5/sex/dose) at an exposure level of 788,696 ppm. The test material was administered continuously in oxygen to the test chamber for 4 hours. Animals were monitored for a 14 day period post exposure and terminally necropsied.

No deaths occurred during the study and there were no significant lung weight differences in any of the animals during the course of the study. During the observation period, a decrease in mean body weight (1.4%) was observed in female animals, while males exhibited a reduction in mean body weight gain. All animals showed signs of anaesthesia during the study (including decreased motor activity, decreased respiration, ataxia and prostration). Lacrimation was observed in one animal and tail chewing in another. Necropsy revealed red foci in the lung of one animal, and a mottled lung in another.

The results of this study indicate HFC-227ea to have an acute inhalation LC_{50} of >788,696 ppm (79%) in rats.

9.1.4 Cardiac Sensitisation (10)

The potential of HFC-227ea to sensitise the heart to the effects of adrenalin was studied in 10 beagle dogs. Each dog was exposed to atmospheres of 0, 3.5, 7, 9, 10.5 and 14% HFC-227ea for a minimum of 30 minutes with at least 36 hours between each exposure. The animals were challenged with sequential doses of adrenalin (1.2, 2.4, 4.8 and 6 µg/kg intravenous bolus injections ~90 seconds apart) both before and immediately after each induction. Blood samples were collected for estimation of HFC-227ea after 25 minutes exposure. ECG data were recorded continuously during both adrenalin challenges.

After exposure to 9%, 10.5% and 14% HFC-227ea, evidence of cardiac sensitisation (specifically the occurrence of one or more premature ventricular contractions) was observed in 1/10, 5/10 and 6/10 animals respectively, after adrenalin challenge doses of 4.8 and/or 6 µg/kg. The severity of the cardiac responses increased dose-dependently. There were no treatment-related clinical findings.

The results of this study indicate that HFC-227ea sensitises canine heart to the effects of adrenalin only at atmospheric concentrations of $\geq$9% under the conditions of this study.

9.2 Repeated Dose Toxicity

No repeated dose toxicity data were submitted for HFC-227ea. The notifier has indicated that the results from a ninety day subchronic inhalation study as well as a developmental toxicity study are currently in progress.

9.3 Genotoxicity

9.3.1 Salmonella typhimurium and Escherichia coli Reverse Mutation Assays (11)

This study was conducted largely in accordance with OECD guideline Nos: 471 (12) and 472 (13).

The test substance was tested in the *Salmonella typhimurium* test strains TA 98, TA 100, TA 1535, and TA 1537, as well as *Escherichia coli* strain WP2*uvr*A, with or without metabolic activation.

One experiment was conducted (2 plates/strain/dose). All strains tested without S9 were exposed for 24 hours at 37°C with 500 ml HFC-227ea gas at concentrations of 0, 1.8, 4.6, 9.4, 17, 46 and 80% in air. Strains tested with S9 were exposed to concentrations of 0, 1.7, 4.6, 9.0, 18, 44 and 88% in air. The reference mutagens sodium azide (TA 1535; - S9), 2-(2-furyl)-3-(5-nitro-2-furyl)-acrylamide (TA 98, TA 100, WP2uvrA; - S9), 9-aminoacridine (TA 1537; - S9) and 2-aminoanthracene (all strains; + S9) were used as positive controls.

All positive controls showed an increase in revertant colonies compared to the negative control. No increase was noted with any concentration of HFC-227ea.

The results of this study indicate that HFC-227ea is not mutagenic against *Salmonella typhimurium* or *Escherichia coli* in this test.

9.3.2 Other Genotoxicity Studies

No other genotoxicity studies were provided for HFC-227ea. Data on the related chemical 1,1,1,2-tetrafluoroethane have been reported (14), and suggest negative results *in vitro* (Ames assay, human lymphocyte assay) and *in vivo* (Micronucleus, dominant lethal) for this chemical.

9.4 Overall Assessment of Toxicological Data

Animal tests suggest that HFC-227ea has low acute inhalational toxicity (rat LC_{50} >788,696 ppm (79%)). A genotoxicity study indicates that the chemical does not cause point mutations in *Salmonella typhimurium* or *Escherichia coli*. Studies involving related chemicals suggest that HFC-227ea may have minimal to moderate skin and eye irritancy potential, however there is no evidence to suggest potential for positive skin sensitisation, or mutagenicity potential in the literature.

The results of a cardiac sensitisation study in the dog showed the notified chemical to be capable of sensitising the heart to the effects of adrenalin at concentrations $\geq$9%.

10. ASSESSMENT OF ENVIRONMENTAL EFFECTS

No data were provided, with the omission justified by the lack of significant aquatic exposure to this volatile and sparingly soluble gas. Hydrofluorocarbons are stable substances that do not exhibit significant biological activity.

Volatile halocarbons can affect the atmosphere. The principal concern is ozone depletion. Halon 1301 has a particularly high ozone depletion potential of 10 (3). HFC-227ea contains neither chlorine nor bromine, and thus will not act as a source of ozone depleting halogen radicals in the stratosphere. Scientists from the US National Oceanic and Atmospheric Administration concluded recently that hydrofluorocarbons have negligible potential to destroy ozone (15).

Like other halocarbons, HFC-227ea makes a positive contribution to the global warming potential of the atmosphere. However, the atmospheric lifetime of 42 years is significantly shorter than that for Halon 1301 (110 years) (16). While this may suggest an easing of global warming hazard, in practice any improvements would be marginal as more of the replacement gas (a ratio of 1.7 by weight) will be required for equivalent performance (3).

11. ASSESSMENT OF ENVIRONMENTAL HAZARD

HFC-227ea is not expected to exert a direct effect on living organisms by analogy with other hydrofluorocarbons. The high volatility should ensure minimal exposure of aquatic and terrestrial compartments, and therefore minimal hazard to organisms inhabiting them.

Hazard to the atmosphere will be reduced when HFC-227ea replaces Halon 1301, as the replacement refrigerant has negligible potential to destroy ozone. However, the replacement retains significant global warming potential.

12. ASSESSMENT OF PUBLIC AND OCCUPATIONAL HEALTH AND SAFETY EFFECTS

Although dermal or eye contact is likely, given the expected duration of exposure and the physical state of HFC-227ea, skin and eye irritation should not be a significant concern.

Animal studies indicate that HFC-227ea may potentiate the effects of adrenalin at concentrations above 9%. In an emergency fire situation workers will have elevated blood adrenalin levels, while some workers may also be taking sympathomimetic agents such as bronchodilators or cold medications. As a result, these workers will be at risk of cardiac effects (such as cardiac arrhythmia) if exposed to concentrations above 9%. At higher concentrations, there is a risk the notified chemical may displace oxygen in the breathing mixture resulting in oxygen deprivation and possibly death. Workers exposed to the gas during a fire, will also be at risk of exposure to corrosive and/or toxic thermal decomposition products, such as hydrogen fluoride.

Under normal use conditions, however, all personnel will be evacuated before the firefighting systems are started, and workers will be required to wear adequate personal protective devices if exposure is anticipated. As a result the risk to workers should be minimal.

During servicing of the fire suppression systems, gas may escape from pressurised tanks. In these situations the expanding gas may cause 'cold burns' if it contacts the skin. With appropriate personal protective equipment, the risk will be minimal.

As the gas is denser than air, it may accumulate in confined or low-lying spaces and displace oxygen. Therefore the enclosures must be ventilated adequately prior to the return of personnel.

Public exposure to the notified chemical is unlikely when it is used in the proposed manner. HFC-227ea will, therefore, not pose a significant risk to public health or safety.

13. RECOMMENDATIONS

To minimise occupational, public and environmental exposure to HFC-227ea the following guidelines and precautions should be observed.

. Areas where HFC-227ea is used should have good general ventilation or local exhaust ventilation.

. Localised sources of high temperature in the region of the notified chemical should be avoided if possible. If welding

is necessary, appropriate protective equipment should be worn.

. If engineering controls and work practices are not sufficient to reduce exposure to a safe level and:

    . inhalation of HFC-227ea gas or its decomposition products is possible, respiratory protection conforming to Australian Standard 1715 (17) and AS 1716 (18) should be worn;

    . eye contact with the cold or expanding gas is possible, face shield conforming to Australian Standards 1336 (19) and 1337 (20) should be worn; and

    . skin contact with the cold or expanding gas is possible, impermeable thermal gloves (elbow length) conforming to Australian Standard 2161 (21) and protective clothing conforming to Australian Standards 3765.1 (22) or 3765.2 (23) should be worn.

. HFC-227ea is heavier than air and may displace oxygen. Care should be taken not to allow concentrations to accumulate in confined areas.

. After release of the notified gas, care should be taken when reentering sunken or enclosed areas. Any such areas should be marked and breathing apparatus conforming to Australian Standard 1715 (17) donned before entering.

. Workers who are taking sympathomimetic medication should be warned about potential cardiovascular sensitisation from excessive HFC-227ea exposure.

. Physicians treating a patient after exposure to high concentrations of notified chemical should not administer adrenalin or other sympathomimetic amine stimulants.

. A copy of the MSDS for products containing the notified chemical should be easily accessible to all employees.

To minimise public exposure to HFC-227ea the following guidelines and precautions should be observed.

. Extinguisher systems containing HFC-227ea should be routinely maintained to prevent gas leakages.

. Precautions should be taken to prevent public access to areas in which an extinguisher system is releasing, or has been released.

To minimise environmental exposure to HFC-227ea the following guidelines and precautions should be observed.

. Restrictions on discharge of halons, except in the case of fire, should be retained for HFC-227ea as it has significant global warming potential. This should be reflected in the Draft Standard for FM-200 (HFC-227ea) Total Flooding Fire Suppression Systems, which currently (revision of 1 December 1993) specifies that HFC-227ea shall be the test medium for any discharge testing that may occur.

14. MATERIAL SAFETY DATA SHEET

The Material Safety Data Sheet (MSDS) for HFC-227ea (Attachment 1) was provided in Worksafe Australia format (24). The MSDS was provided by Biolab Australia Pty Ltd as part of their notification statement. It is reproduced here as a matter of public record. The accuracy of this information remains the responsibility of Biolab Australia Pty Ltd.

15. REQUIREMENTS FOR SECONDARY NOTIFICATION

Under the *Industrial Chemicals (Notification and Assessment) Act 1989*, secondary notification of HFC-227ea shall be required if any of the circumstances stipulated under subsection 64(2) of the Act arise.

Secondary notification of HFC-227ea will be required if the results of the ninety day subchronic inhalation study or the developmental toxicity study (currently in progress) show any adverse effects attributable to the chemical.

16. REFERENCES

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