

Guidelines for Use and Handling of HFO-1234yf

HFO-1234yf can be described as being “mildly flammable” as measured by standard methodology. This descriptor is used to characterize the flammability in simplistic terms; however, properties such as minimum ignition energy, heat of combustion, and the burning velocity are assessed in order to arrive at such a descriptor. These measured properties, when applied to the laboratory setting can be useful in determining if laboratory or apparatus modification should be considered. Measurement of HFO-1234yf flammability properties indicates that a typical static discharge will not have sufficient energy to ignite HFO-1234yf. Available data appears below.

Upper Flammability Limit, Vol. % in air (21°C, ASTM E681-01)	12.3
Lower Flammability Limit, Vol. % in air (21°C, ASTM E681-01)	6.3
Minimum Ignition Energy, mJ at 20C and 1 atm (DuPont in-house method. Tests conducted in 12 liter flask to minimize wall quenching effects)	5,000-10,000
Autoignition Temperature, °C (EC Physico/Chemical Test A15, Measured by Chilworth Technology, UK)	405
Heat of Combustion, MJ/kg per ASHRAE Standard 34 (Stoichiometric composition 7.73% in air)	11.8
Fundamental burning velocity, cm/s (per ISO 817, Measured by AIST, Japan)	1.5

Risk assessment and risk minimization in facilities typically requires evaluation on a case-by-case basis since the outfitting of individual facilities may vary from one another in many ways. To assist the end-user in assessing and minimizing risk in association with the use of HFO-1234yf, a number of general guidelines can be applied.

GENERAL GUIDELINES

- **Read the HFO-1234yf Material Safety Data Sheet before beginning work with the material.**

Refrigerant with Air

- Fire or explosion may result if vapor-in-air concentrations are within the flammable range and an ignition source of adequate energy level is available.
- Avoid mixing HFO-1234yf with air, oxygen or other oxidizers at pressures above atmospheric pressure.

Cylinder Storage

- Smoking should not be allowed in storage or handling areas as a general rule. Smoking should be prohibited in storage, handling, and servicing areas where HFO-1234yf is used.
- Do not store HFO-1234yf cylinders near sources of open flames, ignition sources or at temperatures exceeding 125°F (51°C).
- Store cylinders in a cool, well-ventilated area with low risk of fire and out of direct sunlight. Ensure that cylinders are properly strapped into place, avoid dropping, denting or mechanically abusing containers.
- Protect cylinders from moisture and rusting during storage.

Contact with Hot-surfaces/High Energy/Ignition Sources

- Avoid contacting HFO-1234yf with white-hot or red-hot surfaces.
- Do not locate apparatus that produce ignition sources in proximity to air-conditioning systems, air-conditioning system test rigs, equipment or storage vessels that contains HFO-1234yf.
- Air-conditioning systems, test rigs, and service equipment should not incorporate components or devices that can generate discharges.
- Devices that generate sparks may need to be isolated, purged with inert gas (to minimize the probability of attaining concentration in air that are within the flammable range), or relocated.
 - Note that DC motors that use brushes will have potential for continuous spark generation. A fan that uses such a DC motor may have to be isolated, replaced with a non-sparking one, or purged with an inert gas such as nitrogen or with adequate air flow to minimize the quantity of refrigerant within the flammable range. If nitrogen inerting is used, route the exiting nitrogen gas to a local exhaust if practical, otherwise, the adjacent work environment may also have to be monitored for oxygen level so that an acceptable breathing atmosphere is maintained.
 - As spark energy data may not readily be available, electrical contactors, switches, relays, and other electrical or electronic devices capable of generating a spark that are located in proximity to probable leak sites should be subject to risk evaluation.
- Electrical equipment in and adjacent to the refrigerant charging and storage locations should be electrically classified according to applicable codes and regulations.
 - A typical 0.5 KVA 3-phase transformer with a 6-cycle breaker feeding shop utilization equipment can generate over 450,000 mJ before opening.
- In cases where NFPA 497 *Recommended Practice for the Classification of Flammable Liquids, Gases, or Vapors and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas 2008 Edition* can be applied, the following guidance is available:
 - Note that HFO-1234yf is classified as Group D or Group IIA (per NFPA 497): the autoignition temperature of 405 °C is consistent with use of a T2 temperature class per the National Electric Code (NFPA-70).
 - Electrical equipment within 5 feet of the charging location and within 3 feet above grade and 25 ft horizontally should be Class I, Division 2, Group D (Class I, Zone 2, Group IIA).
 - In pits or other below grade servicing areas, above which the refrigerant could be charged or within 25 ft of charging locations, mechanical ventilation should be provided with a pickup no more than 12 inches above the lowest level and the electrical equipment within the pit should be Class I, Division 2, Group D (Class I, Zone 2, Group IIA).
 - In unoccupied, non-ventilated pits within 25 ft of charging locations, the electrical equipment within the pit should be Class I, Division 1, Group D (Class I, Zone 1, Group IIA).
- Due to large energy capacity and circuit amperage, there is also a potential for ignition from the electric power source for hybrid vehicles. As a matter of general safety, isolation techniques or other suitable methods should be used to prevent battery and power system sparks/arcs. In areas where processes, procedures or upset conditions such as leaks have the potential to generate flammable HFO-1234yf vapor-in-air concentrations in proximity to hybrid vehicle electric power sources, isolation and/or ventilation should be used.

Service Areas

- HFO-1234yf is a heavier-than-air gas. Depending on the quantity released in air, the material can travel a considerable distance to a low-lying ignition point.
- HFO-1234yf can collect in floor pits. There is potential for asphyxiation in floor pits or confined spaces. Use adequate ventilation in these areas. Monitoring/measuring oxygen levels or refrigerant vapor-in-air concentrations prior to entry into floor pits or confined spaces is recommended. Note that applicable regulations may require measurement and/or monitoring of oxygen level in confined spaces as part of dictated confined space entry procedures.
- Refrigerant charging should be performed away from open flames or high energy ignition sources.
- Provide mechanical ventilation at filling zones and storage areas or other locations where leakage is probable. It should be determined if existing local ventilation is adequate for other operating and storage areas. The ventilation rate should prevent vapor-air concentrations from exceeding 25% of LFL. For example, NFPA 497 *Recommended Practice for the Classification of Flammable Liquids, Gases, or Vapors and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas 2008 Edition* defines adequate ventilation as a ventilation rate that affords either 6 air changes per hour, or 1 cfm per sq.ft. of floor area (0.3M3/minute per M2 of floor area), or other similar criteria that prevent the accumulation of significant quantities of vapor-air concentrations from exceeding 25% of LFL.
- Refrigerant leak detection equipment that provides continuous numerical vapor-in-air measurement provides a means for personnel to respond to a leak in a timely fashion. A detection level of 25% of the lower flammability limit is acceptable. Infrared leak detection devices capable of detecting R-134a at levels of 1,000ppm in air or lower are commonly available; typically, these may also be used. Performance may vary depending on device configuration. Consult the leak detection equipment manufacturer for additional information.
- In the event of a leak, air flow will tend to disperse leaked refrigerant and may be beneficial in reducing local concentrations. Exhaust ventilation can be used to reduce vapor-in-air concentrations. The aim should be to maintain concentrations below the lower flammability limit. For example, in a calorimeter room, it may be best to leave the room air circulating (room air handler “ON”) to disperse leaked refrigerant rather than shutting off room air flow. Note: This assumes that the charge is smaller than the amount needed to reach the 25% of the LFL in a well mixed room.
- In the event of a leak, nearby electrical contactors, electric controls, or other electric devices may create an undesirable spark in the affected area if the devices are shut off locally. In accordance with good engineering practices, interrupt power to systems and devices at a location that is removed (remote) from the environment where the leak is. Whenever possible, create a “zero demand” signal to electrical or electronic devices, for example, adjust a servo-controlled relay serving electric resistance heaters to eliminate demand. This is preferred to opening local contacts.
- Maintenance or construction work that can produce sparks, electrical arcs, or open flames must be performed in compliance with all applicable regulations pertaining to hot work. Welding, flame cutting, grinding, or other operations that can create an ignition source, must be carried out in compliance with applicable hot work procedures and permits.

Additional good engineering safety practices:

- Customer should perform their own
 - fire & safety review
 - building code review, and
 - discuss fire alarms, smoke detection,
 - suppression systems, fire extinguishers,
 - egress, fire separation, emergency response, emergency lighting

ASSOCIATED HFO-1234yf PRODUCT USE CHECKLISTS

Tank Car Unloading (Good Engineering Practices)

1. Is the following equipment available and used:
Wheel chocks?
Derailer?
Blue Flag?
Tank car Safety railings?
Grounding cable (free of corrosion)?
2. Are the tank car unloading hoses in good condition and constructed of compatible materials for HFO-1234yf?
- 2a. What type fittings are used? _____
3. Do fill lines or hoses have caps/plugs in place?
4. Are fill lines identified?
5. Are all elastomeric parts (seals, gaskets, etc.) compatible with the product?
6. Are railroad tracks bonded and grounded?
7. Are all electrical switches, lighting, etc. rated appropriately? HFC-1234yf - Group D

Tank Truck Unloading (Good Engineering Practices)

1. Is the roadway surface in good condition?
2. During inclement weather, can truck make delivery without possibility of getting stuck?
3. Is grounding cable available for delivery trailer?
- 3a. Is the grounding cable free of corrosion?
4. Is the electrical receptacle properly rated?
(Assumes the receptacle is within the 25 ft x 3 ft high radius. HFO-1234yf – Group D)
- 4a. Type of electrical receptacle _____
- 4b. Is the receptacle equipped with an electrical switch disconnect?
5. Is the bulkhead substantially anchored?
6. Is the bulkhead protected from impact (crash posts, etc.)?
7. Is the bulkhead located 15' or more from bulk tank?
8. Is the liquid line equipped with an Emergency Shutoff Valve (ESV) or Backflow Check valve?
9. Is the vapor line equipped with an ESV?
10. Can ESV's be actuated nearby, remotely, and automatically by fire (e.g. fusible link)
11. Do fill lines or hoses have caps/plugs in place?
12. Are fill lines identified?

Bulk Storage Tank (Good Engineering Practices)

1. Is tank design pressure adequate (at least 150 psig)?
2. Is the tank located at least 50 ft. from buildings or property lines?
3. Is there a minimum of 5 ft. between adjacent tanks?
4. Is the area free of combustibles (grass, weeds, etc.)?
5. Is the area fenced or protected from vandalism?
6. Is the tank adequately grounded?
- 6a. Is the grounding free of corrosion?
7. Is the grounding checked periodically?
8. Are all electrical switches, lighting, etc. rated appropriately?
HFO-1234yf - Group D
9. Are pump motors rated appropriately? (Non-sparking motors are acceptable if located more than 5' from delivery bulkhead.)
10. Are all elastomeric parts (seals, gaskets, etc.) compatible with the product?
11. Are the tank pressure relief valves (PRV's) equipped with 7 ft. vent stacks?
12. Are the tank supports fireproofed (cement, etc.)?
13. Are all tank bottom outlets equipped with ExcessFlow Valves?
14. Is the tank properly labeled as to contents?
15. Is a tank label visible?
16. Is the tank labeled "NOT ODORIZED"?
17. Does instrumentation (level gauge, pressure gauge, etc.) appear to be in good condition?
18. Is the tank exterior free of corrosion?

Piping (Good Engineering Practices)

1. Is the piping free of any signs of exterior surface corrosion?
2. Are all gasketing and valve internal materials compatible?
3. Is piping and other equipment grounded? (Piping systems with large filter elements can develop significant static charge separation. Generally, piping systems should be grounded unless an engineering evaluation determines that it is not needed.)
- 3a. Is grounding free of corrosion?
4. Is piping adequately supported?
5. Is valving designed to avoid trapping liquid between valves?
6. Is piping protected from impact?
7. Is piping leak checked on a regular basis?
8. Is piping labeled to identify contents?
9. Is piping inside the building constructed with a minimum of valves, fittings, etc.?
11. Is the diameter of the piping inside the building the minimum size required?
12. Are block valves provided at both ends of the pipeline to isolate a leak?

Cylinder Storage Area (Good Engineering Practices)

1. Is the cylinder(s) stored on a rack or firm foundation, i.e. concrete pad?
2. Is the cylinder storage located at least 10 ft. from other buildings? (For storage of more than 1-2 cylinders)
3. Is the storage area protected from excessive heat and adverse weather conditions?
4. Is the area fenced or protected from vandalism?
5. Is the cylinder adequately grounded?
Grounding free of corrosion?
Grounding checked periodically?
6. Are all electrical switches, lighting, etc. rated appropriately? HFO-1234yf - Group D
7. Are all elastomeric parts (seals, gaskets, etc.) compatible with the product?
8. Is the area properly labeled as to contents?
9. Are the cylinders stored upright?

Personnel Training

1. Do personnel know product hazards and have access to MSDS's?
2. Are personnel trained to handle flammables?
3. Is there a written emergency response plan?
4. Does each person know his/her responsibility in case of an emergency and is properly trained?
4. Do maintenance personnel know the materials of construction compatible with this material?

Disclaimer

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