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2026 PROFESSIONAL EDITION

The Definitive Technical Manual for EPA 608, NATE, and Journeyman Certification

FEDERAL COMPLIANCE & ENGINEERING STANDARDS:
40 CFR Part 82, Subpart F | AIM Act of 2020 | ASHRAE 15 & 34 | UL 60335-2-40 (4th Ed) | NEC Article 440

DOCUMENT SERIES OVERVIEW:

This 5-volume technical collection is designed as the ultimate companion for the modern HVAC professional. It provides the deep-dive theoretical and practical knowledge required to master high-stakes certification exams and ensure legal compliance in a rapidly evolving regulatory landscape.

- **Volume 1:** The EPA 608 Regulatory Bible
- **Volume 2:** The A2L & New Refrigerant Transition Manual
- **Volume 3:** HVAC Electrical Systems & Logical Troubleshooting
- **Volume 4:** Applied Thermodynamics & The Refrigeration Cycle
- **Volume 5:** Field Operations: Installation, Evacuation & Commissioning

Official Portal: HVAC Exam Master
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VOLUME 1: THE EPA 608 REGULATORY BIBLE

THE DEFINITIVE TECHNICAL MANUAL FOR FEDERAL REFRIGERANT COMPLIANCE

2026 PROFESSIONAL EDITION | DOCUMENT CODE: HEM-101-REV2026

⚠️ PROPRIETARY NOTICE

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CHAPTER 1: LEGAL FOUNDATION & FEDERAL AUTHORITY

1.1 The Statutory Basis: Section 608 of the Clean Air Act

The legal management of refrigerants in the United States is primarily governed by **Section 608 of the Clean Air Act (CAA)**, as amended in 1990. This federal statute is codified in the **Code of Federal Regulations (CFR) under Title 40, Part 82, Subpart F**.

Technicians must understand that the EPA (Environmental Protection Agency) does not merely provide "guidelines." These are federal laws. The primary intent of Section 608 is to minimize the emission of Ozone-Depleting Substances (ODS) and their substitutes (HFCs, HFOs) by mandating maximum recycling and proper handling during service and disposal.

1.2 The Montreal Protocol and International Treaty Ties

In 1987, the United States became a primary signatory of the **Montreal Protocol on Substances that Deplete the Ozone Layer**. This treaty remains the most successful environmental agreement in history.

- **The Mandate:** It required the complete phase-out of Class I substances (CFCs) and Class II substances (HCFCs).
- **The Mechanism:** Section 608 is the domestic enforcement tool used by the US government to fulfill its obligations under this international treaty.

1.3 The 2026 Regulatory Landscape: The AIM Act

Beginning in 2026, technicians are entering the "HFC Phasedown" era. The **American Innovation and Manufacturing (AIM) Act of 2020** expanded the EPA's authority to regulate **Global Warming Potential (GWP)** in addition to Ozone Depletion.

- **The Transition:** The shift from A1 (non-flammable) to **A2L (mildly flammable)** refrigerants like R-32 and R-454B is driven by the AIM Act.
- **Exam Warning:** You will be tested on the distinction between the Clean Air Act (focusing on venting/recovery) and the AIM Act (focusing on the manufacturing and phasedown of HFCs).

1.4 Civil and Criminal Penalties (Updated 2024-2026)

The EPA enforces Section 608 through rigorous field audits and whistleblower reports. Under the Federal Civil Penalties Inflation Adjustment Act, fines have reached unprecedented levels.

- **Civil Penalty:** As of January 2024, the maximum fine for a single violation of Section 608 is **$69,733 per day, per violation**.
- **The Multiplier Effect:** If a technician is found to have vented refrigerant from four separate condensing units on one commercial site, the EPA treats this as four distinct violations, totaling over **$278,000**.
- **The Whistleblower Award:** The EPA may pay an award of up to **$10,000** to any individual who provides information leading to a criminal conviction or civil penalty.
- **Criminal Charges:** Intentional, "knowing" violations (e.g., deliberate venting or falsifying recovery logs) are federal felonies punishable by up to **5 years in prison**.

CHAPTER 2: CERTIFICATION SILOS & LEGAL SCOPE OF PRACTICE

The EPA defines a "technician" as any person who performs maintenance, service, or repair that could reasonably be expected to release refrigerants into the atmosphere. There are four distinct levels of certification. Working outside your certified scope is a federal offense.

2.1 Technical Foundation: Saturation Temperature Boundaries

The EPA categorizes certification levels based on the boiling point and saturation pressure of the refrigerants:

- **High-Pressure Refrigerants:** Have a liquid phase saturation position between **-50.8°F (-46°C)** and **50°F (10°C)** at standard atmospheric pressure ($14.7\ psia$).
- **Low-Pressure Refrigerants:** Have a liquid phase saturation position **above 50°F (10°C)** at standard atmospheric pressure.

2.2 Type I: Small Appliances (The 5-Pound Rule)

- **Definition:** Hermetically sealed, factory-charged appliances containing **5 pounds (2.27 kg) or less** of refrigerant.
- **Common Units:** Domestic refrigerators, freezers, window A/C units, vending machines.
- **The "Split-System" Trap:** A residential split-system heat pump containing only 4 lbs of refrigerant is **NOT** a Type I appliance. Because the line set was connected in the field, it is not "hermetically sealed at the factory." This requires **Type II** certification.

2.3 Type II: High-Pressure Systems

This covers the vast majority of the residential and commercial HVAC market.

- **Scope:** High-pressure and very high-pressure appliances, except small appliances and motor vehicle air conditioning (MVAC).
- **Common Equipment:** Residential split systems, rooftop units (RTUs), supermarket refrigeration, and industrial process chillers.
- **Core Duty:** Type II technicians are responsible for the complex "30-day repair clock" and "10-day verification" rules for systems holding 50+ lbs of charge.

2.4 Type III: Low-Pressure Systems

- **Scope:** Maintenance and repair of low-pressure appliances (e.g., centrifugal chillers using R-11 or R-123).
- **The Vacuum Risk:** These systems operate in a vacuum. A leak in a Type III system results in air and moisture being pulled **into** the system, causing non-condensables to build up in the condenser.
- **The Purge Unit:** Type III systems require a high-efficiency purge unit to remove air while minimizing refrigerant loss.

2.5 Universal Certification

- **Achievement:** Requires passing the Core section plus all three technical sections (I, II, and III).
- **Industry Value:** In 2026, Universal certification is essentially mandatory for any lead technician or contractor, as new A2L-based systems bridge multiple technical classifications.

CHAPTER 3: REFRIGERANT CHEMISTRY & THE GWP SHIFT

3.1 The Molecular Culprit: Chlorine

The Ozone Layer is destroyed primarily by **Chlorine** and **Bromine**. When a CFC or HCFC molecule reaches the stratosphere, intense UV radiation breaks the molecule, releasing a free Chlorine atom.

- **The Catalyst Effect:** A single Chlorine atom acts as a catalyst. It can destroy up to **100,000 ozone molecules** before it is eventually neutralized or washed away by rain (only after falling back to the lower atmosphere).
- **Stability:** Unlike other chemicals, CFCs do not dissolve in water. This stability is exactly what allows them to reach the stratosphere unchanged.

3.2 Environmental Metrics: ODP vs. GWP

Refrigerant Class	Composition	ODP (R-11 = 1.0)	GWP (CO_2 = 1.0)	Examples
CFC	Chlorine, Fluorine, Carbon	0.6 - 1.0	High	R-11, R-12
HCFC	Hydrogen, Chlorine, Fluorine, Carbon	0.01 - 0.05	Mid-High	R-22, R-123
HFC	Hydrogen, Fluorine, Carbon	**Zero**	675 - 4,000	R-410A, R-134a
HFO	Hydrogen, Fluorine, Olefin	**Zero**	< 10	R-1234yf

Exam Point: HFCs (like R-410A) do **NOT** deplete the ozone layer, but they are potent greenhouse gases. This is why they are regulated under the AIM Act but still follow the venting prohibition of Section 608.

3.3 Zeotropic Blends and Fractionation

Most modern refrigerants are "Blends" (the 400 and 500 series).

- **Azeotropic (500 Series):** Behave like a single pure component.

- **Zeotropic (400 Series):** These have **Temperature Glide**. The individual gases in the blend evaporate and condense at different temperatures.
- **Fractionation:** The separation of the blend due to a leak.
- **Mandatory Field Practice:** All 400-series blends **must** be charged as a **liquid** into the high-side (or throttled into the low-side) to prevent charging the system with an incorrect chemical balance.

CHAPTER 4: THE UNIVERSAL VENTING PROHIBITION

4.1 The Scope of the Ban

Since 1992, it has been illegal to knowingly vent ODS. In 2018, this was expanded to include HFCs and HFOs. This rule applies to all technicians, regardless of certification status, and even to those working on exempt systems.

4.2 The "De Minimus" Standard

The EPA defines **De Minimus** as the minimum amount of refrigerant released during a good-faith attempt to recover, recycle, or reclaim.

- **Legal:** The small "puff" when disconnecting a low-loss fitting.
- **Illegal:** Purging a system with refrigerant instead of a vacuum pump, or using refrigerant as a "leak trace gas" without mixing it with a significant volume of nitrogen.

4.3 The 2024-2026 Exempt List

Only certain refrigerants are exempt from the venting prohibition because the EPA has determined they do not pose a threat to the environment:

1. **Carbon Dioxide (R-744):** GWP of 1.
2. **Nitrogen:** Used for leak testing.
3. **Water / Ammonia:** In specific industrial settings.
4. **Propane (R-290):** Only in specific, small-charge appliances (like household fridges) where the EPA has specifically allowed it.

CHAPTER 5: LEAK REPAIR MANDATES (THE 2026 REVOLUTION)

THIS IS THE HIGHEST WEIGHTED PORTION OF THE UNIVERSAL EXAM.

5.1 The New 15-Pound Rule (Effective Jan 1, 2026)

Historically, leak repair rules only applied to systems with **50 pounds** or more. Under the new **AIM Act - Part III (ER&R Rule)**, the EPA is cracking down on residential and small commercial systems.

- **The Change:** Systems containing **15 pounds or more** of a high-GWP HFC (GWP > 53) must now undergo mandatory leak inspections and record-keeping.
- **Inspection Frequency:**
    - 15–50 lbs: Annual inspection.
    - 50–500 lbs: Quarterly inspection.

- 500+ lbs: Automatic Leak Detection (ALD) systems required.

5.2 Mandatory Leak Rate Triggers (Systems > 50 lbs)

Technicians must calculate the **Annualized Leak Rate (ALR)** every time refrigerant is added.

Category	Trigger Rate	Logic
Comfort Cooling	**10%**	Air conditioning for human occupants (offices, residential chillers).
Commercial Refrigeration	**20%**	Retail food, cold storage warehouses, refrigerated transport.
Industrial Process (IPR)	**30%**	Manufacturing, chemical, pharmaceutical, data centers.

5.3 The Majority Cooling Rule

If a system serves multiple purposes, it is categorized by the use that accounts for the **majority (over 50%)** of its cooling capacity.

- *Case Scenario:* A chiller provides 60% of its cooling to a factory production line (IPR) and 40% to the employee cafeteria (Comfort Cooling). The technician must apply the **30% (IPR)** trigger rate.

5.4 The Annualization Formula

You must perform this calculation on the exam. $$Rate = \frac{Pounds\ Added}{Full\ Charge} \times \frac{365\ Days}{Days\ Since\ Last\ Addition} \times 100$$

Master Example: A 400 lb supermarket rack (Commercial) adds 20 lbs of gas. It was last serviced 90 days ago.

1. $(20 / 400) = 0.05$
2. $(365 / 90) = 4.05$
3. $0.05 \times 4.05 \times 100 = \mathbf{20.25\%}$

- **Result:** This system **MUST** be repaired within 30 days because it exceeds 20%.

CHAPTER 6: THE CHRONOLOGY OF COMPLIANCE: REPAIR TIMELINES

When a technician calculates an Annualized Leak Rate (ALR) that exceeds the mandatory trigger (10% for Comfort Cooling, 20% for Commercial, or 30% for IPR), the situation transitions from a mechanical service call to a **Federal Legal Proceeding**. Failure to adhere to the timelines established in **40 CFR § 82.157** results in strict liability for the equipment owner and the servicing company.

6.1 The 30-Day Mandatory Window

The Environmental Protection Agency (EPA) mandates that the owner/operator of an appliance containing **50 pounds or more** of a regulated refrigerant has exactly **30 calendar days** to perform a repair that brings the system back into compliance.

6.2 Defining the "Legal Date of Discovery"

The 30-day clock is anchored to the "Date of Discovery." In a federal audit, this is defined as the day the owner or operator was made aware—or **should have been aware**—that the leak rate was exceeded.

- **The Service Trap:** Adding refrigerant to a system to "top it off" constitutes discovery. The moment gas is added, the technician is legally required to calculate the leak rate. If the rate is over the threshold, "Day 0" is the day the gas was added.

6.3 Extension Protocols for Industrial Process Refrigeration (IPR)

The EPA recognizes that complex industrial systems (chemical plants, refineries) cannot always be shut down within 30 days without risking safety or massive economic loss.

1. **IPR Shutdown Extension:** If the repair requires a full facility shutdown, the 30-day clock is automatically extended to **120 days**.
2. **Notification Requirement:** The owner must document why the extension is needed and maintain these records on-site.
3. **Parts Availability:** If a specific component (e.g., a custom-built low-pressure evaporator) is unavailable, the owner may request further time, provided they have a confirmed purchase order with a delivery date.

CHAPTER 7: VERIFICATION TESTING: THE TWO-STEP PROTOCOL

Under Section 608, you cannot simply "fix the leak and leave." A repair is not legally recognized until it has passed a **Two-Stage Verification**.

7.1 Initial Verification Test (Step 1)

Performed **after** the repair is complete but **before** the system is fully recharged with its operational charge.

- **Approved Methods:** Pressure decay test with dry nitrogen, vacuum rise test (monitoring micron rise), or electronic leak detection using a trace gas (Nitrogen + trace refrigerant).
- **Requirement:** The technician must prove the specific point of the leak is now tight.

7.2 Follow-Up Verification Test (Step 2: The 10-Day Rule)

This is the most critical and frequently audited step. Once the system has passed Step 1 and is back in normal operation, a follow-up test must be conducted.

- **The 10-Day Window:** This test must occur **within 10 days** of the system returning to normal operating temperature and pressure.
- **The Logic:** A joint may hold under static nitrogen pressure (Step 1) but fail under the thermal expansion, vibration, and pressure spikes of a system under a "Normal Operational Load" (Step 2).

CHAPTER 8: REGULATORY EXIT STRATEGIES: RETIREMENT & MOTHBALLING

If a repair is unsuccessful or deemed too expensive by the owner, the law provides two primary exit strategies to remain in compliance.

8.1 The 30-Day Decision Mandate

Within **30 days** of discovering the leak (or within 30 days of a failed verification test), the owner must commit to a formal **Retrofit or Retirement Plan**.

- **Retrofit:** Modifying the appliance to use a refrigerant with a lower GWP/ODP.
- **Retirement:** Scrapping and removing the system from service.
- **The 12-Month Rule:** Once the plan is signed, the owner has **12 months** to complete the work.

8.2 Mothballing: The Compliance "Pause" Button

Mothballing is the only legal way to "stop the clock" on a 30-day repair window.

- **Legal Definition:** Isolating the leaking component or evacuating the entire appliance to a pressure of **at least 0 psig**.
- **The Principle:** Physics dictates that if there is no positive pressure in the system, refrigerant cannot leak into the atmosphere. The 30-day repair window is suspended until the system is brought back to positive pressure.

CHAPTER 9: EVACUATION STANDARDS & VACUUM PHYSICS

Evacuation is the process of removing non-condensable gases (air) and moisture. To the EPA, this is about minimizing emissions. To a technician, it is about **system dehydration**.

9.1 Microns vs. Inches of Mercury (in. Hg)

Standard manifold gauges measure in **Inches of Mercury (in. Hg)**. However, this is too coarse for modern systems.

- **The Math:** 1 inch of Hg is equal to approximately $25,400$ microns.
- **Atmospheric Pressure:** $760,000$ microns.
- **Industry Standard:** Pulling to **500 Microns** ensures that moisture (which boils at room temperature in a vacuum) has been completely removed.

9.2 Mandatory Evacuation Levels Table

(For equipment manufactured **after November 15, 1993**)

Appliance Type	Vacuum Standard (in. Hg)
Small (Type I)	90% Recovery
Very High-Pressure (R-13, R-503)	**0" Hg**
High-Pressure < 200 lbs (R-22, R-410A)	**10" Hg**
High-Pressure > 200 lbs (R-22, R-410A)	**15" Hg**

Appliance Type	Vacuum Standard (in. Hg)
Low-Pressure (Type III - R-11, R-123)	**25 mm Hg Absolute**

9.3 The Triple Evacuation Method

For systems with significant moisture contamination, the **Triple Evacuation Method** is the engineering standard:

1. Pull to **1,500 microns**, break with Dry Nitrogen to **0 psig**.
2. Pull to **1,000 microns**, break with Dry Nitrogen.
3. Pull to **500 microns** and perform a **10-minute Rise Test**. If the pressure holds below 1,000 microns, the system is dehydrated.

CHAPTER 10: RECOVERY EQUIPMENT & CYLINDER INTEGRITY

10.1 AHRI Standard 740 Certification

All recovery equipment must be certified by an EPA-approved laboratory (UL or ETL) to meet **AHRI Standard 740**. This standard dictates the speed, vacuum depth, and high-pressure safety cutout parameters the machine must achieve.

10.2 Maintenance: The "Oil Scrubber"

Vacuum pump oil is a "scrubber" for moisture. As the oil becomes saturated with moisture and acid, the pump's ability to reach a deep vacuum diminishes.

- **Field Rule:** Change vacuum pump oil **after every use** while the oil is still warm to ensure moisture stays in suspension and is drained out.

10.3 Cylinder Safety: The 80% Fill Limit Physics

To prevent catastrophic failure due to hydrostatic expansion, recovery cylinders must never be filled beyond **80% of their volume by weight**.

The Formula for Maximum Safe Gross Weight: $$WC \times 0.8 \times S.G. + TW = Max\ Gross\ Weight$$

- **WC (Water Capacity):** The weight of the cylinder if filled 100% with water.
- **TW (Tare Weight):** The weight of the empty cylinder and valve.
- **S.G. (Specific Gravity):** The density of the refrigerant relative to water at a specific temperature.

10.4 DOT Title 49: Compliance and Shipping

Recovery cylinders are classified as **Hazardous Materials (Division 2.1 or 2.2)**.

- **Vertical Storage:** Cylinders must always be secured in an upright position during transport.
- **Recertification:** Every **5 years**, recovery cylinders must be hydrostatically tested and date-stamped by a DOT-approved facility.

CHAPTER 11: TYPE III SPECIALS: LOW-PRESSURE CHILLER OPERATIONS

Low-pressure appliances (typically large centrifugal chillers using refrigerants like R-11, R-123, or R-1233zd) present unique regulatory challenges because they operate **below atmospheric pressure** (in a vacuum) in the evaporator.

11.1 The Physics of the Vacuum-Side Leak

In a standard high-pressure system, a leak results in refrigerant escaping. In a Type III system, a leak results in **air and moisture being sucked into the system**.

- **The Result:** Air is a "non-condensable" gas. It gathers at the top of the condenser, insulating the heat exchange tubes and causing a rapid rise in head pressure.
- **The "Purge Unit" Requirement:** All low-pressure chillers require a purge unit to remove air from the system. If the purge unit runs excessively, it is the primary "discovery" indicator of a leak.

11.2 Pressurization Standards for Leak Testing

Since the system is in a vacuum, you cannot find a leak with a standard sniffer or soap bubbles while the system is off.

- **The 10 PSIG Federal Limit:** Technicians must never pressurize a low-pressure shell above **10 psig**. The rupture disk on these units is typically set to burst at **15 psig**.
- **Approved Methods:**
    1. **Hot Water Circulation:** Circulate warm water through the tubes to raise the refrigerant temperature and pressure.
    2. **Heating Blankets:** Apply external heat to the evaporator shell.
    - **Prohibited:** Using compressed air or oxygen is strictly forbidden as it introduces moisture and creates an explosion hazard when mixed with oil.

11.3 Purge Unit Efficiency

Modern EPA standards mandate high-efficiency purge units.

- **The Efficiency Rule:** High-efficiency purges must not release more than a minimal amount of refrigerant per pound of air removed. If a purge unit discharges more than the manufacturer's spec, it must be serviced immediately.

CHAPTER 12: ASHRAE SAFETY STANDARDS & REFRIGERANT PHYSICS

The EPA enforces Section 608 in conjunction with **ASHRAE Standards 15 and 34**. These standards define the environment in which a technician works.

12.1 ASHRAE Standard 15: Mechanical Room Compliance

Every mechanical room containing refrigeration equipment must meet specific safety criteria to prevent asphyxiation:

1. **Refrigerant Monitors:** A permanent sensor must be installed that triggers an alarm and mechanical ventilation before the refrigerant concentration reaches the **TLV-TWA (Threshold Limit Value – Time**

Weighted Average).
2. **Ventilation:** Fans must exhaust to the outdoors, not to other parts of the building.

12.2 ASHRAE Standard 34: The Safety Matrix

The Universal exam relies heavily on the safety matrix. Technicians must memorize the grid:

Flammability	Lower Toxicity (A)	Higher Toxicity (B)
3 (High)	A3 (e.g., Propane)	B3
2 (Flammable)	A2	B2
2L (Mildly Flammable)	**A2L (R-32, R-454B)**	**B2L (Ammonia)**
1 (No Propagation)	A1 (R-22, R-410A)	B1

12.3 Oxygen Deprivation and Asphyxiation

Refrigerants are **heavier than air**.

- **Field Safety:** In a leak, the gas pools at floor level, displacing oxygen.
- **The SCBA Rule:** If a technician must enter a room with a known large leak, they **must** wear a **Self-Contained Breathing Apparatus (SCBA)**. Standard dust masks or cartridge respirators are useless against oxygen displacement.

CHAPTER 13: FEDERAL AUDIT PREPAREDNESS

The EPA can audit any technician or company with 24 hours' notice. The primary focus of an audit is the **Refrigerant Management Log (RML)**.

13.1 Mandatory Documentation for 50lb+ Systems

For every service call where refrigerant is added to a system over 50 lbs, the technician **must** record:

- Name and Certification Number of the technician.
- The **Date of Service** (The Date of Discovery).
- The **Amount and Type** of refrigerant added.
- The **Annualized Leak Rate (ALR)** calculation results.
- Full details of the **Initial and Follow-up Verification Tests**.

13.2 Record Retention

- **Technicians:** Must keep records of all sales and recovery for **3 years**.
- **Owners:** Must keep records of all leak repairs and inspections for **3 years**.

CHAPTER 14: THE "DIRTY DOZEN" EXAM TRAPS

1. **The "50 Pound" Trap:** Do not calculate a leak rate for a system with 48 lbs of gas. The law only applies at 50 lbs and above.

2. **The "Majority Cooling" Trap:** If a chiller serves a server room (IPR) and an office (Comfort Cooling), and the load is 51% IPR, you use the **30% trigger**, not the 10%.
3. **The "Venting" Trap:** Is it legal to vent Nitrogen? **Yes.** Is it legal to vent Nitrogen mixed with a "trace amount" of refrigerant? **No.**
4. **The "Type I" Recovery Trap:** Only Type I (Small) appliances allow for **System-Dependent (Passive)** recovery. Type II and III **must** use Active (Self-contained) recovery.

CHAPTER 15: VOLUME 1 MASTER DRILL (EXCERPT)

Q1: A technician adds 25 lbs of R-134a to a 200 lb commercial freezer that was last serviced 120 days ago. What is the ALR?

- **Calculation:** $(25/200) \times (365/120) \times 100 = \mathbf{38%}$.
- **Rationale:** Since 38% exceeds the 20% limit for Commercial Refrigeration, a repair is legally required within 30 days.

Q2: What is the required evacuation level for a low-pressure chiller (Type III) using equipment made after 1993?

- **Answer:** 25 mm Hg Absolute.
- **Rationale:** Low-pressure systems require measurement in absolute pressure (mm Hg) due to the depth of the vacuum required.

Q3: Which ASHRAE classification represents a mildly flammable refrigerant with low toxicity?

- **Answer:** A2L.
- **Rationale:** 'A' = Low Toxicity, '2' = Flammable, 'L' = Low Burning Velocity.

Q4: How long must a technician keep records of the refrigerant recovered during a disposal of a 20 lb system?

- **Answer:** 3 Years.
- **Rationale:** The 3-year rule is universal for all EPA 608 documentation.

[END OF VOLUME 1] *Document Hem-101-C. Prepared for HVACExamMaster.com. Data verified against 40 CFR Part 82 and ASHRAE 2024.*