Scientific Equipment & Furniture Association
Recommended Practices

SEFA 13 - V-ELF - 2023
Vertical Exhausting Laminar Flow Hoods

SEFA SPELLS SAFE

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1.0 Scope

These Recommended Practices (RP) provide a comprehensive single source of knowledge pertaining to Vertical Exhausting Laminar Flow (V-ELF) hoods. The V-ELF Recommended Practices details:

- Hood function.
- Hood components (material).
- Types of material construction.
- Applications and advantages.
- Chemical resistance for each type of material construction.
- ASHRAE, ISO, and IEST testing.

2.0 Purpose

The purpose of these Recommended Practices is to provide Architects, Engineers, Planners, Specifiers, Manufacturers, Testers / Air Balancers and End Users with industry standard practices for V-ELF hoods.

These Recommended Practices will include the design, construction, installation, testing, maintenance, and safe use of Vertical Exhausting Laminar Flow (V-ELF) hoods.

2.1 Description / Overview

A Vertical Exhausting Laminar Flow (V-ELF) hood is a special exposure control device that combines the characteristics of a vertical laminar flow clean bench with an exhausting chemical fume hood. It is intended for chemical processes that require an ISO Class 5 or better clean environment inside the hood chamber work area to minimize process and product contamination with safety concerns for potential generation of aerosolized inhalation hazards. HEPA or ULPA filtered air is supplied at the hood chamber ceiling to minimize air particulate contamination inside the chamber. This supply air is combined with room air inflow through the sash opening to provide containment, capture and exhaust of airborne hazards generated inside the hood. V-ELF hoods are connected to a laboratory exhaust system similar to a conventional exhausting chemical fume hood.

2.2 Uses

V-ELF hoods are designed to provide product protection (ISO Class cleanliness) and personal protection (ASHRAE hood containment) and are often used in Microelectronic, Trace Metals Analysis, Cleanrooms, Nanotechnology, and Pharmaceutical applications. V-ELF hoods are primarily found within cleanroom facilities where they can provide a higher level of cleanliness within the microenvironment of the hood work chamber.

3.0 Definitions

AI – As Installed

AM – As Manufactured

ANSI – American National Standards Institute

ASHRAE – American Society of Heating, Refrigerating and Air-Conditioning Engineers

ASTM – American Society for Testing and Materials

AU – As Used

CAV – Constant Air Volume

CFM – Cubic Feet per Minute (airflow volume)

CPVC – Chlorinated Polyvinyl Chloride

FC – Foot-Candle (illumination unit)

FM Global – Factory Mutual Global (insurance)

FPM – Feet Per Minute (air velocity)

GFI – Ground Fault Interrupt

HEPA – High Efficiency Particulate Air (filter)

HVAC – Heating, Ventilation, and Air Conditioning

IEST – Institute of Environmental Sciences and Technology

ISO – International Standards Organization

ISPE – International Society for Pharmaceutical Engineering

LED – Light Emitting Diode

NEC – National Electrical Code

NFPA – National Fire Protection Association

PFA – Perfluoroalkoxy

PP – Polypropylene

PVC – Polyvinyl Chloride

PVDF – Polyvinylidene Fluoride (Difluoride)

SEFA – Scientific Equipment & Furniture Association

SMACNA – Sheet Metal and Air Conditioning Contractors' National Association

SP – Static Pressure (air pressure)

TAB – Testing, Adjusting, and Balancing (HVAC)

UL – Underwriters Laboratories

ULPA – Ultra-Low Particulate Air (filter)

UV – Ultraviolet

VAV – Variable Air Volume

V-ELF - Vertical Exhausting Laminar Flow (hood)

W.C. – Water Column (air pressure)

W.G. – Water Gauge (air pressure)

4.0 V-ELF Hood Design

V-ELF hoods include a top structure with filter/blower motor assembly; a hood chamber with three fixed sides and a single face opening with a profiled entry sash; a perforated worksurface; and a sealed, leak tight, plenum tub located beneath the worksurface, which is exhausted via the rear exhaust plenum to the building exhaust system.

A blower motor assembly is located within the hood overhead top structure and is equipped with motorized supply fan(s) and HEPA/ULPA filter(s). The blower assembly intakes air from the area above or in front of the hood and supplies filtered air through the chamber ceiling vertically downward through the hood chamber to provide a laminar flow, low particulate clean process environment within the hood chamber. This supply air is exhausted through the worksurface perforations and/or chamber lower rear wall exhaust slots to the building exhaust system. Room air is drawn across the hood sash opening at the front of the hood similar to a conventional chemical fume hood, but this room air is drawn down through the perforations along the front section of the worksurface and into the sealed negative pressure exhaust plenum tub to prevent contamination of the remaining worksurface areas with unfiltered room air. These airflow patterns are designed to provide a net negative pressure environment inside the hood chamber, while maintaining clean particulate environment conditions at the middle and rear worksurface areas, to provide both process and personnel protection (positive clean air and negative exhaust). Refer to Figure 1 for hood arrangement and airflow schematic.

Laminar flow is unidirectional airflow. Both downward airflow direction AND filtration are required to create clean laminar flow to maintain the interior of the hood chamber clean for products and processes. A laminar flow hood can become turbulent and non-compliant if obstructions are present and disrupt airflow patterns.

Laminar flow takes place in layers without interaction between them, so that all parts of the flow move in one direction. Laminar flow is uninterrupted flow in a fluid (air) near a solid boundary in which the direction of flow at every point remains constant. Laminar flow is an orderly movement, without turbulence, where any given subcurrent moves in parallel with nearby subcurrents.

Additional hood design features include integral lighting in the chamber ceiling, an exhaust air monitoring device to ensure safe ventilating conditions for personnel protection, and a filter load pressure monitoring device to monitor supply air. V-ELF hoods may also include exhaust vented base cabinets for storage below the hood chamber.

V-ELF hoods provide optimal containment at 80 fpm (±5 fpm) inward sash face velocity.

In general, V-ELF hoods require higher exhaust volumes and higher exhaust airflow static pressure drops as compared to conventional “exhaust only” chemical fume hoods. V-ELF hood total exhaust is equal to the sash intake room air + the clean laminar supply air to the hood chamber.

$$\text{Exhaust}_{\text{Total}} = \text{Inflow}_{\text{Sash}} + \text{Supply}_{\text{Laminar}}$$

V-ELF hoods are typically configured for Constant Air Volume (CAV) exhaust design due to the need to provide a consistent clean particulate environment process condition inside the hood chamber and the need to maintain proper air balance between the vertical laminar clean airflow supply and the inward room airflow across the sash. In some circumstances, Variable Air Volume (VAV) design may be possible with reduced total exhaust airflows to provide potential energy saving associated with hood operations.

V-ELF hoods are constructed from non-shedding cleanroom compatible materials such as chemical/corrosive resistant polypropylene, PVC or stainless steel. Non-metal hood materials such as PVC, polypropylene and others may include flame/smoke resistant rated plastics, non-rated plastics, or a combination of both. Refer to Appendix A construction material selection guide.

Clean classification (“class”) is a critical element of laminar flow clean hoods. The air within the interior of the laminar flow workstations shall limit the concentration of particulates of 0.1µm, 0.3µm, 0.5µm, 1.0µm, and 5.0µm sizes (µm = micron) as defined for each ISO Class in ISO 14644-1 standards (refer to Table 2: ISO 14644-1 Airborne Particulate Cleanliness Classes (by Cubic Meter).

V-ELF hoods are typically designed to provide ISO Class 5 or better cleanliness level environments inside the hood chamber with the use of HEPA or ULPA filtration to filter out particulates for the laminar flow supply air.

- High Efficiency Particulate Air (HEPA) filters are designed to remove 99.97% of dust particles 0.3-micron in diameter (1-micron = one millionth of a meter).
- Ultra-Low Particulate Air (ULPA) filters are designed to remove 99.999% of dust, pollen,

mold, bacteria, and other airborne particles 0.12-micron (120 nanometers) in diameter or larger.

Other widely used terms to describe V-ELF hoods include Clean Hoods and Exhausting / Exhausted Laminar Flow Workstations.

4.1 Applications and Advantages

V-ELF hoods have two distinct functions:

1. Safety containment devices designed to capture hazardous effluents generated within the hood and direct these hazards away from lab personnel and exhaust them out of the building.
2. Provide a clean environment within the hood chamber for critical processes which require a particulate free environment to reduce potential particulate contamination from exposure to the environment.

V-ELF hood chamber environment cleanliness is typically defined by ISO 14644 / IES 002 with typical design of ISO Class 5 or better. Refer to Table 2 for ISO cleanliness table.

Advantages of V-ELF hoods include the use of materials that provide superior corrosion resistance and compatibility with chemical use and processes to provide a clean environment within the hood chamber and improve the resiliency and longevity of the hood.

The construction material selection guide in Appendix A is based on the following criteria:

1. Chemical (acid/solvent) Use – Chemical types, coupled with harsh conditions often present within these critical processing environments.
2. Temperature - Heated chemicals used within the hood.
3. Critical Process Environment – special requirements such as use with trace metals analysis, requiring metal-free environments.

It is critical to select the appropriate type of hood construction materials based on the above criteria when using the guide. It is common for hood construction material selection to include more than one type of material, with each material selected based on its respective requirement.

The construction material selection guide was designed to provide guidance, based on several factors specific to each laboratory and each specific hood:

1. Identify the specific acids / caustics or solvents.
2. Identify the concentration and volumes of chemicals.
3. Identify the temperature range at which chemicals can be used.
4. Identify the safety codes and concerns, including the UL94V-0 or FM4910 requirements. Identify the required Flame Spread and/or Smoke Index.
5. Identify the level of Cleanliness required – HEPA, ULPA, or Boron Free filtration.

It is recommended to review the chemical resistant charts in Appendix C:

1. Identify the specific acids and temperatures in the table.
2. Identify the recommended material used for construction based on chemical resistance levels.

It is recommended that materials used for chemical resistance be formed of solid core material to provide continuous resistance to chemical exposure throughout the thickness of the material, including any penetrations (such as piping, tubing, recessed equipment worksurface openings) and to provide long-term performance to surface scratches. Materials that are not inherently chemical resistant and are coated for chemical resistance should be avoided.

4.2 Other Types of V-ELF Hoods

The following types of V-ELF hoods include all the design and performance characteristic of a standard V-ELF.

4.2.1 Benchtop V-ELF Hoods

A benchtop V-ELF hood is generally placed on a benchtop or above separate storage base cabinets. Benchtop hoods are available in different sizes generally characterized by the overall width of the hood.

4.2.2 Perchloric Acid V-ELF Hoods

Perchloric acid V-ELF hoods have non-reactive corrosion resistant materials used for all surfaces exposed to the hood chamber and exhausted airways and extend throughout the mechanical exhaust ducted system. The entire exhaust air stream will normally require water washdown to prevent the accumulation of perchlorate crystals which may present an explosive hazard. The exhaust system washdown system is typically part of the mechanical design by others and include a control valve to supply washdown water supply to the hood. Hood washdown requirements include the hood worksurface, exhaust plenum tub below the worksurface, and exhaust baffle/plenum areas. In addition to the hood, an exhaust duct wash down system is used to rinse surfaces in the exhaust ducting, fans, and exhaust stacks. The hood wash down system will include acid resistant plastic piping and spray nozzles to wash down the hood baffle/plenum areas. The hood design includes a sloped-to-drain low-point collection area with drain outlet to direct washdown water to facility laboratory wastewater systems. The hood drain is typically located at the rear of the worksurface plenum tub and routed to the rear of the hood. Hood shall be designed to drain 5 to 15 gallons per minute of washdown water from the hood and duct washdown systems – typical water flow when one washdown spray nozzle is operating at a time.

4.2.3 Distillation V-ELF Hoods

Distillation V-ELF hoods have a greater interior hood chamber height for use with taller equipment and apparatus. The vertical sash design generally provides a larger opening for setup and moving apparatus in/out of the hood chamber. Care must be taken to determine the maximum allowable sash opening and required exhaust airflow to provide a safe operating condition and ensure effective fume containment.

4.2.4 Wet Processing V-ELF Hoods

Wet process V-ELF hoods are used where an ultra-clean environment is required, and complex processes are conducted within the hood chamber. The exhaust plenum tub located below the worksurface is often deeper than in conventional V-ELF hoods to accommodate the installation of equipment and processes through the worksurface. This allows for recessed installation of wells, heated and unheated tanks and baths, and process tools and equipment utilizing the area below the worksurface to improve ergonomics, safety, and source capture of fumes and assists to minimize air turbulence across the worksurface. Wet process V-ELF hoods may have expanded controller compartments, electrical distribution and chase-ways, and plumbing pass-throughs to accommodate the needs for controls, automation, and process piping systems.

Figure 1: Typical Configuration and Airflow for V-ELF Hoods

VERTICAL EXHAUSTING LAMINAR FLOW HOOD (V-ELF)

HEPA / ULPA FILTRATION - Clean Work Chamber (ISO 14644 Class 4 - 5)

ASHRAE 110 - Safe Work Chamber

V-ELF exhaust through partially perforated worksurface to building exhaust

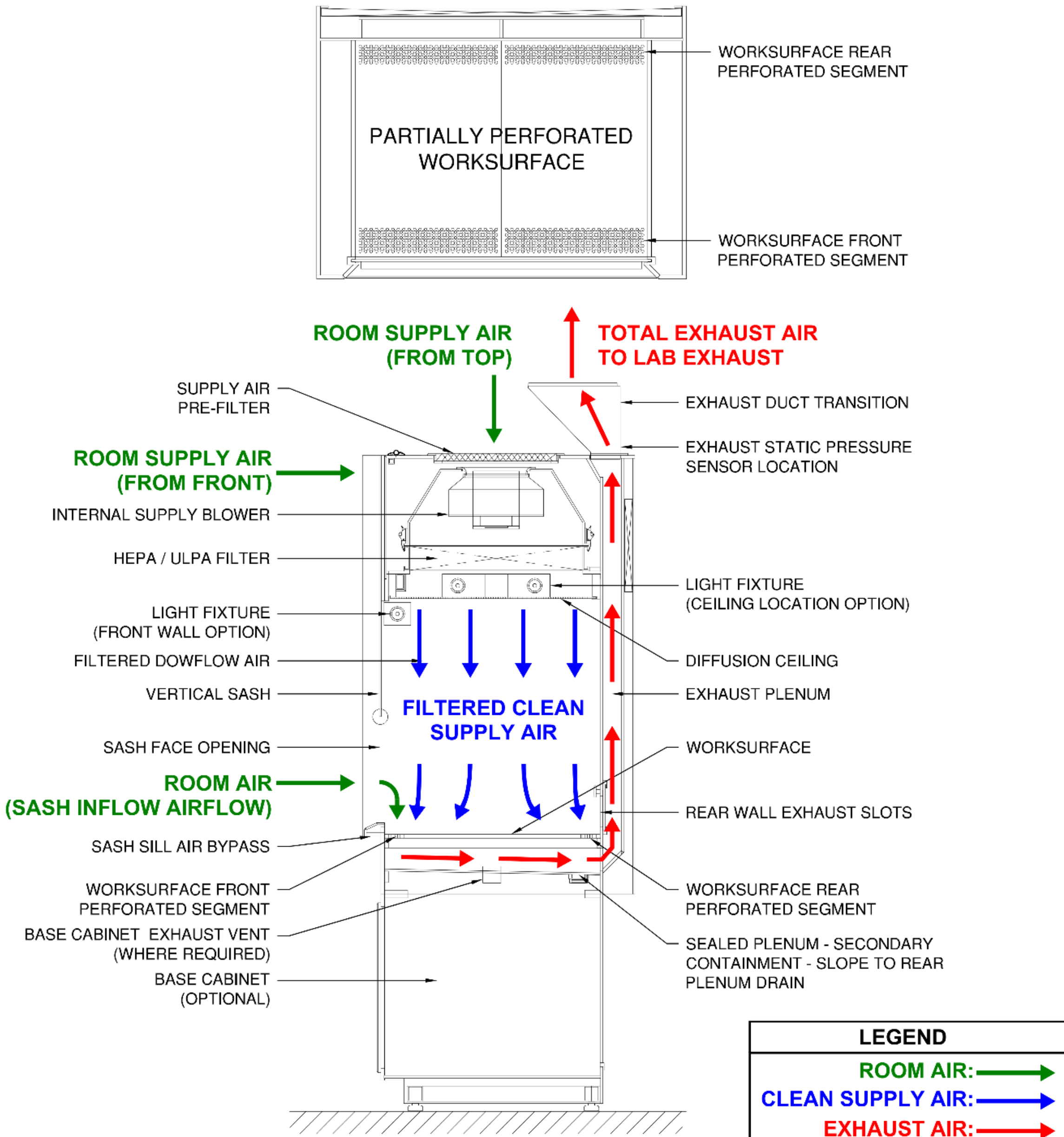


Table 1: Airborne Particulate Cleanliness Class Comparison

ISO 14644-1	FEDERAL STANDARD 209E (cancelled 2001)	
ISO Clean Class	**Class (English)**	**Class (Metric)**
ISO Class 1		
ISO Class 2		
ISO Class 3	1	M1.5
ISO Class 4	10	M2.5
ISO Class 5	100	M3.5
ISO Class 6	1,000	M4.5
ISO Class 7	10,000	M5.5
ISO Class 8	100,000	M6.5
ISO Class 9		

Table 2: ISO 14644-1 Airborne Particulate Cleanliness Classes (by Cubic Meter)

ISO Clean Class	Maximum Concentration Limits (particles/m^3) by Particle Size					
	0.1 Micron	**0.2 Micron**	**0.3 Micron**	**0.5 Micron**	**1.0 Micron**	**5.0 Micron**
ISO Class 1	10	2				
ISO Class 2	100	24	10	4		
ISO Class 3	1,000	237	102	35	8	
ISO Class 4	10,000	2,370	1,020	352	83	
ISO Class 5	100,000	23,700	10,200	3,520	832	29
ISO Class 6	1,000,000	237,000	102,000	35,200	8,320	293
ISO Class 7				352,000	83,200	2,930
ISO Class 8				3,520,000	832,000	29,300
ISO Class 9				35,200,000	8,320,000	293,000

5.0 V-ELF Hood Components

Refer to Figure 1 for general arrangement and typical components of V-ELF hoods.

5.1 Exterior

The hood external surfaces or "skin" is typically constructed of either non-metal plastic material (polypropylene / PVC / others) or stainless steel. The exterior front arrangement of the hood is an important design element of the hood to ensure proper fume containment and supply airflow. The design of V-ELF hoods directs supply air from the room/ceiling space to the upper filter/blower assembly either at the top (above hood) or at the front of the hood through grilles in the upper structure.

5.1.1 Front Sash

The hood sash is a transparent moveable panel provided on hoods to restrict the opening to the fume chamber and provide a safety barrier between the operator and interior of the hood to protect the operator from processes at the worksurface(s) that generate fumes/particulates in the fume chamber. The hood sash may be arranged in a vertical rising or horizontal slide configuration and may consist of a single or multiple sash panels. Vertical rising sashes are typically counterbalanced for ease of vertical movement for opening/closing. Regardless of configuration, the sash should be designed to move freely with minimal force by the operator and not rack or bind. The required force to open/close the sash should be reasonable for the size and weight of the sash. The design of the sash panels should maximize the area of transparency to provide a high degree of visibility for the operator to observe processes on the worksurface(s) and inside the fume chamber. The materials used for the sash should be evaluated for compatibility with chemicals and processes used inside the hood. V-ELF hoods typically use clear plastic materials compatible with chemicals used.

Vertical sash opening design heights are typically restricted in the range of 10-inch to 15-inch opening height for in-use operation and are based on manufacturer's design specifications. Sash openings higher than this may compromise both personnel protection (ASHRAE 110) for containment and product protection (ISO 14644 / IES 002) for cleanliness. Design sash opening height maintains the balancing of hood chamber supply airflow and hood chamber negative pressure, ensuring operator safety of containment and product protection with cleanliness.

Sash height limiting devices (also known as sash stops) are typically provided to limit the vertical opening of the sash at the maximum design operating height. Sash stops may also be used to limit sash opening based on conditions with limited available hood exhaust air volume to provide a safe operating condition. The sash opening height at which the sash stop limits the sash opening is called the "operating sash opening" or the "design sash opening". If the sash stop design includes a manual operator override, the sash may be further opened to the "maximum sash opening" or the "load sash position" to allow for access to the hood chamber for cleaning, maintenance, and equipment apparatus installation or removal.

Testing for ISO 14644 / IES 002 cleanliness and ASHRAE 110 fume containment should be performed at both the design sash opening and maximum sash opening with the hood supply air blowers operational. If the test results for fume containment are unacceptable when the sash stop is bypassed and the sash is raised to a higher opening, a label should be affixed on the V-ELF hood clearly identifying the maximum operating sash height for proper hood operations, along with potential hazards when bypassing the sash for higher opening heights.

5.1.2 Exhaust Collar

The V-ELF hood exhaust design typically requires a full width exhaust plenum at the rear of the unit from the worksurface vertically up to the top of the unit. An exhaust duct transition piece is provided to transition from the exhaust plenum top opening to one or more round duct collars for connection to the laboratory exhaust duct system. The exhaust duct collar should be made of corrosion resistant material appropriate for the V-ELF hood chemical use and processes.

The quantity and size (diameter) of exhaust transitions duct collars varies depending on the width and interior chamber depth of the hood. The design of the exhaust transition(s) is important to provide a smooth transition from the exhaust plenum to minimize exhaust airflow static pressure loss. The design of the laboratory exhaust duct system serving V-ELF hoods requires special consideration of the higher exhaust airflow volume requirements and higher static pressure losses associated with V-ELF hoods as compared to standard chemical fume hoods. The exhaust duct connection(s) to the V-ELF hood exhaust duct collar(s) should be properly secured and sealed airtight. Typical duct collar connection methods include slip (slide over) with mechanical fasteners and sealant, butt joint alignment with round duct sleeve drawband compression gasketed clamp connector, or bolted flange gasketed joint.

5.2 Supply Air Filter / Blower Assembly

The hood supply air filter/blower assembly is located within the hood overhead top structure positioned above the top of the hood interior work chamber. It is sealed and is an integral component of the V-ELF hood to provide a clean working environment inside the hood chamber. The blower fan assembly draws air inward from the area above or in front of the hood from the room or above ceiling space. The blower fan(s) discharge this supply air through the HEPA/ULPA filter(s) and work chamber ceiling diffuser to create a uniform vertical column of clean air directed downwards through the hood work chamber towards the worksurface. The hood work chamber includes a removable access panel for maintenance access and filter exchange. Pre-filters are typically included at the supply air blower inlet to remove larger sized particles to extend the life of the final HEPA/ULPA filters.

5.3 Interior

Hood construction typically consists of exterior and interior walls and surfaces. The hood interior materials may be flame or non-flame retardant and should be evaluated for corrosion resistance to chemical use and processes inside the hood.

5.3.1 Perforated Worksurface

The V-ELF includes a partially or fully perforated countertop worksurface, which is typically removable in sections to access the secondary containment plenum tub located below for cleaning and maintenance (refer to Figure 1). The perforated worksurface allows supply air from the hood chamber to pass through the worksurface in a vertical laminar flow pattern to the containment plenum tub below. Room air inflow through the hood sash opening is drawn down through perforations along the front section of the worksurface (within 6-inch of sash plane) and into the containment plenum tub so to not contaminate the remaining worksurface with unfiltered room air. The combined room inflow air and supply air is collected in the containment plenum tub and routed to the building exhaust system.

5.3.2 Secondary Containment Plenum Tub

Below the perforated worksurface is a sealed water-tight secondary containment air plenum tub spanning the full width and depth of the worksurface. The secondary containment plenum tub functions as a negative pressure air plenum to collect room and supply air from the hood chamber and direct it to the exhaust plenum at the rear of the hood. The containment tub also provides collection of any liquid and particulate spills through the perforated worksurface. The bottom of the containment tub is often sloped for positive liquid drainage to a central drain outlet or collection area located at the rear of the tub.

5.3.3 Hood Lights

Most V-ELF hoods are equipped with interior hood chamber lighting fixture(s) to illuminate the hood chamber and worksurface. The lighting fixture(s) may have a variety of designs depending on the use of the hood. The lighting fixture may be separated from the hood chamber by a vapor resistant clear panel or use sealed housing lamps. The light fixture(s) are located at the top of the hood chamber at the ceiling panel or on the interior front face of the hood chamber. Access to the lights should be from the hood exterior or front face of hood. The hood lighting design typically provides illumination levels of 50 to 100-foot candles (fc) at the worksurface. Lighting fixtures may use lamps and lenses to provide white color light or UV filtered color spectrum light (amber or red) to meet specific process lighting requirements. White light fixture lamps are typically furnished with 3,500K to 4,500K color temperature. Light fixture types include fluorescent and LED lamp options to meet specific process requirements and meet project energy goals.

5.4 Hood Services

V-ELF hood manufacturers can configure hoods with a variety of amenities and/or services. Factory installed services may include electrical receptacles, sinks and drainage, piping and fixtures for process gases, vacuum, and compressed air. To provide operator safety, controls for these services should always be accessible from outside the hood sash opening.

5.4.1 Service Fixtures

All service fixtures should be installed so that service supply piping lines and fixture connections are accessible and can be connected/disconnected by design of the pipe routing or through access panels located in the hood interior or exterior surfaces. All service control valves should be accessible for maintenance. All service fixture controls should be external to the hood interior, clearly identified with permanent labels, and within easy reach of the operator for safe operations.

All internal service fixture outlets should be corrosion resistant with non-particulate generating finish suitable for the application. (Refer to SEFA 7 –

Recommended Practices for Laboratory Fixtures.) Connections for services may vary depending on the point of connections of building services and number of fixtures. Service piping and conduits may be brought in from below the hood, down from the ceiling to the top of the hood, or from the back wall to the rear of the hood. All service surface penetrations in the interior hood chamber should be adequately sealed airtight.

5.4.2 Piping Services

NOTE: Check regional or local codes for jurisdiction and materials allowed for applications as requirements may vary.

Typical piping materials are as follows:

- Water: Copper, PVC, CPVC, Polypropylene, Polyethylene, Teflon.
- Pure Water: Polypropylene, PFA, PVDF.
- Compressed Air: Copper, Stainless Steel, Polyethylene, Teflon.
- Vacuum: Copper tubing, PVC, Polyethylene, Teflon.
- Natural Gas: Black Iron, Wrought Iron, Galvanized and Black Steel, Copper, Corrugated Stainless Steel Tubing (CSST).
- Specialty Gases: Copper, Stainless Steel.

5.4.3 Electrical Services

Hood electrical devices and wiring shall be installed in conformance with UL 61010-1 and NEC (NFPA 70) standards. All electrical receptacles should be readily accessible. Provisions should be made so that all electrical wiring is isolated and physically separated from vapors generated within the hood interior chamber. Electrical receptacles are typically installed on the front of the hoods at the apron or side posts. If electrical receptacles are within hood interior, they should be GFI type and installed with self-closing receptacle covers per NFPA and UL recommendations.

V-ELF hood design may include additional safety controls and logic to secure electrical power to the hood upon detection of insufficient exhaust system negative static pressure.

NOTE: NFPA allows electrics inside hood. (See: NFPA 45 Standard on Fire Protection for Laboratories Using Chemicals).

5.4.4 Fire Suppression Systems (when required)

Flammable materials may be used successfully in most V-ELF hoods. Sufficient air volume must be exhausted through the hood to adequately dilute flammable effluents below the maximum permissible percentage of the lower explosive limit (LEL) level. Refer to NFPA 45 for more information on minimum recommended exhaust volumes and air change rates within the hood chamber. When there is a high potential risk of fire, the hood should be constructed with flame retardant materials and a fire suppression system may be considered through risk analysis with the Owner along with applicable code and insurance requirements (such as FM Global).

Fire suppression systems used in a V-ELF hood should be compliant with local codes and regulations and NFPA 17 *Standard for Dry Chemical Extinguishing Systems*.

Fire suppression system should be rated for fire classes A, B, C with manual and thermal activation triggers. The use of an automated Carbon Dioxide (CO_2) suppression system is a common installation for fire suppression systems installed on hoods. Other water or liquid based systems may be acceptable if compatible and appropriate testing and certification are available.

5.5 Face Velocity / Exhaust Monitor

Due to the unique design airflows of V-ELF hoods with downward vertical supply airflow inside the hood chamber and room inward airflow through the sash opening, conventional fume hood face velocity anemometers located adjacent to the sash face opening will not be effective due to airflow patterns inside the hood chamber at the velocity sensor sample tube location(s).

V-ELF hoods should have a control system monitor to verify adequate exhaust airflow. The monitor and controls should provide an audible and visual alarm to indicate an unsafe condition to the operator when inadequate exhaust airflow conditions exist. The monitor may include a pressure monitoring gage sensing static pressure at the exhaust duct. The monitor and controls should provide clear indication to the hood user whether exhaust flow is within design parameters.

A simple visual indication of airflow direction such as ribbon taped to the bottom of the sash is not acceptable.

6.0 V-ELF Hood Testing

6.1 References

- ASHRAE 110 – Method of Testing Performance of Laboratory Fume Hoods
- ISO 14644-1 (Part 1) – Cleanrooms and Associated Controlled Environments – Classification of Air Cleanliness
- ISO 14644-2 (Part 2) – Cleanrooms and Associated Controlled Environments – Specifications for Testing and Monitoring to Prove Continued Compliance with ISO 14644-1
- IES-RP-CC-002 – Laminar Flow Clean Air Devices

6.2 V-ELF Hood Overview

The V-ELF hoods are designed to provide two (2) distinct functions:

1. Protection of the hood operator from dangerous chemicals and fumes used within the hood.
2. Protection of process/experiment by creating an ultra-clean (HEPA/ULPA filtration) hood interior working environment; providing critical processes requiring ISO clean classification environmental conditions.

Accordingly, the V-ELF hood should be tested as follows:

- Protection of Operator: ASHRAE 110
- Protection of Process: ISO 14644-1, ISO 14644-2, and IES-RP-CC-002
- Particulate Containment (where required): ISPE Good Practice Guide: Assessing the Particulate Containment Performance of Pharmaceutical Equipment

V-ELF hood testing conditions:

- As Manufactured (AM) – testing to be completed by the manufacturer.
- As Installed (AI) – testing to be completed following installation.
- V-ELF hoods should be routinely evaluated to ensure the continuing adherence to inflow face velocity and filtered supply air velocity.

The V-ELF hood is designed to contain dangerous fumes and chemical spills, preventing them from escaping the full-hood-width sash opening, consistent with conventional chemical fume hoods. The V-ELF hoods must be designed so that the incoming clean supply air does not create interior turbulence. This supply air enters the hood through the HEPA/ULPA filter (located at the top of the hood chamber). The positive (downward) and negative (exhausting) air dynamics within the V-ELF must be balanced through its design so that the hood is net negative pressure. This net negative pressure provides the operator protection and simultaneously provides positive pressure - clean filtered air into the hoods work area. In summary, V-ELF hoods provide containment (operator safety), while creating low particle counts (HEPA/ULPA filtration) within the hood interior work area.

6.3 ASHRAE 110 Testing

The ASHRAE 110 test is a method of testing the performance of V-ELF Hoods. ASHRAE 110 is the recognized method for evaluating the performance of the hood and its ability to contain chemical effluent and has defined three (3) modes:

1. As Manufactured (AM)
2. As Installed (AI)
3. As Used (AU)

ASHRAE testing should be conducted by an authorized testing agency for all test procedures.

The three (3) applicable ASHRAE 110 testing procedures for V-ELF hoods include:

1. Face velocity
2. Flow visualization
3. Tracer gas

ASHRAE 110 testing set up is critical and must be administered only after <u>ALL</u> the conditions listed below have been verified operating within design parameter, and continue operating during the ASHRAE 110 testing:

- Evaluate total exhaust airflow.
- Evaluate HEPA/ULPA filtered supply air velocity and uniformity.
- Ensure the calculated sash face velocity complies with the manufacturer's recommendations.

Refer to ASHRAE 110 for velocity measurement procedures. Note that V-ELF hoods are designed for lower face velocities than traditional bypass hoods. Refer to Figure 3 for test mannequin arrangement for ASHRAE 110 tracer gas containment testing. Note: It is anticipated that the measured sash face velocity will differ from the calculated sash velocity due to the nature of the vertical laminar flow dynamics inside the hood chamber and their effects on inflow sash air velocity vectors. Refer to Appendix B2.

6.4 HEPA/ULPA Filtered Supply Air Evaluation and Testing

V-ELF hoods provide clean/filtered air into the hood work chamber, with integral motorized fans pushing supply air through HEPA/ULPA filters into the hood interior.

The ISO 14644 parts 1 and 2 and IES-RP-CC-002 test procedures are the recognized method for evaluating the cleanliness level within a cleanroom or V-ELF hood. Through these tests, the hood interior is evaluated and quantified by the number of particles per cubic meter at a predetermined molecule size measurement. ISO testing should be conducted by an approved testing agency using the proper equipment for each of the test procedures.

ISO 14644/IES 002 testing procedures incorporate the following testing:

- Filter velocity testing
- Filter perimeter leak testing
- Filter face leak testing
- Vibration
- Sound power
- Particle counts at hood worksurface

As the supply filters load over time, V-ELF motorized fan(s) speed can be increased to maintain filter supply velocities at specified levels to extend the life of HEPA/ULPA filters.

Often V-ELF hoods are installed inside of cleanroom facilities. This will allow for critical processes, which require cleaner conditions which exist in the cleanroom itself. Both containment (ASHRAE110) and filter integrity testing (ISO 14644 / IES 002), should be designed for As Installed (AI) testing in the active cleanroom. When a V-ELF hood is located within a cleanroom facility, the room airflow dynamics occurring within the cleanroom area surrounding the hood, such as vertical laminar flow and cross drafts, will affect the performance of the hood. The airflow balancing, testing, and performance of the V-ELF hood is directly related to the airflow balancing, testing, and certification of the cleanroom facility.

If the V-ELF hoods are placed in a non-controlled (non-cleanroom) environment, more frequent filter changes may be required, resulting in potential higher operating costs to maintain filters. Failure to make more frequent required filter changes may minimize the V-ELF hood performance.

6.5 Annual Maintenance Guidelines

After initial testing is completed upon hood installation, annual testing should be performed to ensure the on-going performance and safety of hood operations.

It is recommended that internal protocols / procedures be established to implement annual testing for V-ELF hoods. The following are critical components for hood safety and performance:

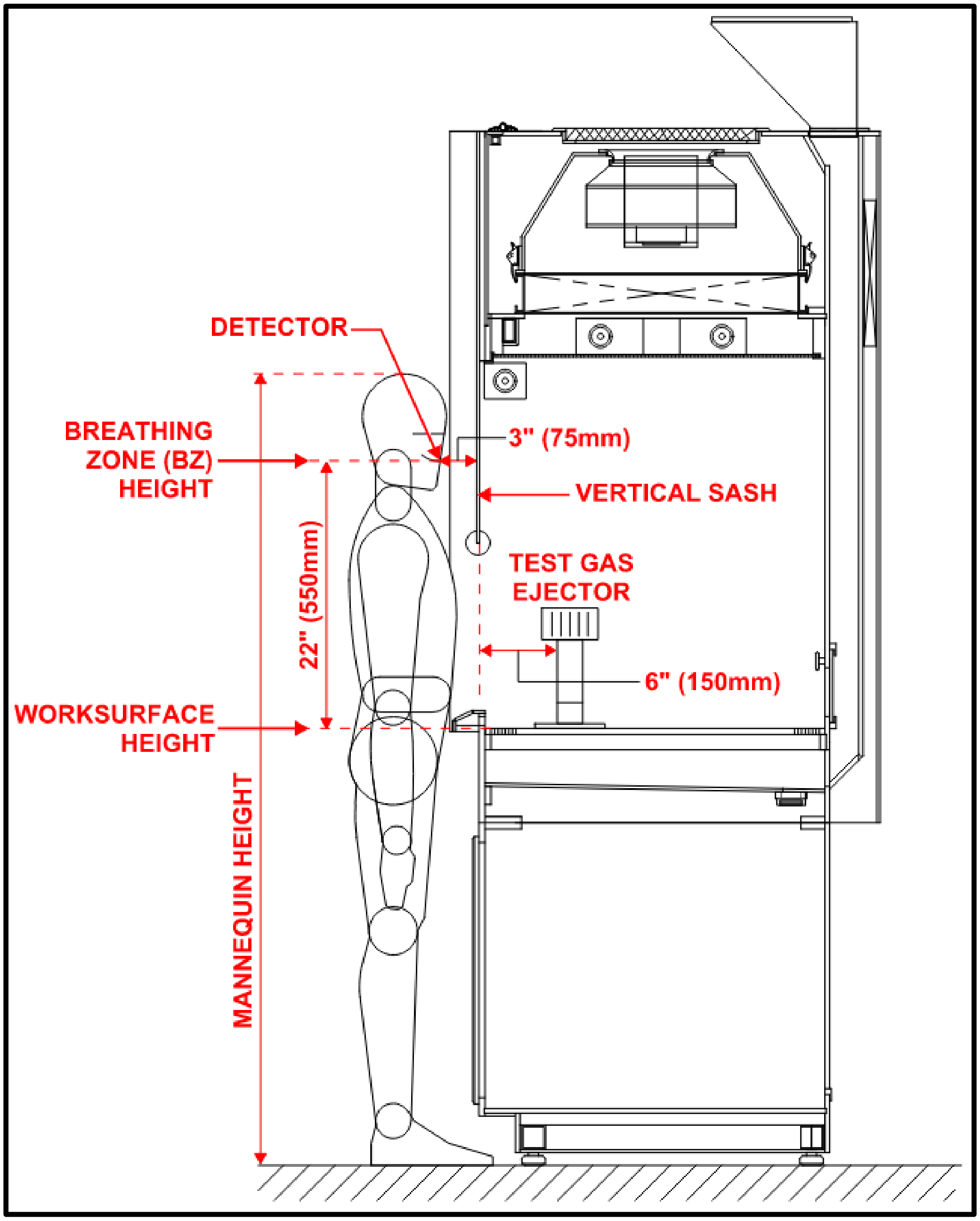
- Inspect and verify V-ELF hood integrity.
- Verify hood exhaust static pressure value is consistent with the initial as-installed testing value.
- The supply air downflow laminar flow velocity.
- Sash inflow face velocity measurement.
- Hood fume containment (smoke or dry ice visualization).

Refer to ASHRAE 110 for face velocity testing and ISO 14644 / IES 002 for supply air downflow velocity measurements.

6.6 Testing Protocol and Calculations

Refer to Appendix B for V-ELF testing protocol and calculations.

Figure 2: ASHRAE 110 Test Mannequin Arrangement



7.0 V-ELF Hood Safety and Other Considerations

7.1 Location in Laboratory

V-ELF Hood exhaust systems should be balanced with room exhaust systems and may be used in conjunction with room exhaust to meet the room ventilation requirements. Constant operation of a V-ELF hood will also provide fume control for the hood chamber and vented storage cabinets during non-working hours. When the laboratory air control system provides a proximity sensor at the hood to sense user presence to implement unoccupied reduced sash face velocity control strategies when users are not present, adequate exhaust ventilation and control must be maintained to ensure proper containment.

Locations of V-ELF hoods in the laboratory should avoid crosscurrents at the hood face due to airflows from the HVAC supply and exhaust air distribution.

Sufficient makeup air must be available within the laboratory to permit the hoods to operate at their design face velocities.

Other location factors to be considered are:

- Number and types of V-ELF hoods in the lab space.
- Location and number of ingress / egress aisles or laboratory space exterior doorways.
- Frequency and/or volume of expected users.
- Location of laboratory safety equipment.

7.2 Safety Considerations

V-ELF Hoods are potential locations for fires and explosions due to the types of experiments conducted in these units. V-ELF hoods should be located within the laboratory so that in the event of a fire or explosion within the V-ELF hood, exit from the laboratory would not be impeded. V-ELF hoods should be located away from high traffic lanes within the laboratory because personnel walking past the sash opening may disrupt the flow of air into the unit and cause turbulence, drawing hazardous fumes into the laboratory.

Sufficient aisle space should be provided in front of the hood to avoid disruption of the work or interference with the operating technician by passing personnel.

Safety devices such as emergency safety showers, eye wash stations, fire extinguishers, first aid kits and fire blankets should be located convenient to the hood operating personnel and plainly labeled as to their use and function.

Other safety factors to be considered:

- Type of research being conducted.
- Proximity to associated bench mounted or free-standing instrumentation machines.
- Type and number of associated hood enclosures.
- Number of research and/or student users in laboratory space.

Refer to SEFA 1 Recommended Practices for Installation.

Refer to SEFA 7 Recommended Practices for Laboratory Fixtures.

7.3 V-ELF Evaluation

Precondition for Testing: The test of the V-ELF should be performed after the installation is complete, the building ventilation and control system has been balanced with all connections made. Testing should be performed in conditions appropriate for occupation of the lab space.

It is recommended that the user make provisions to have the following test performed on all V-ELF hoods. These tests should be performed by qualified personnel to verify proper operation of the hoods before they are placed in use. Testing should be performed at least annually, or whenever a significant change in the hood or laboratory HVAC system occurs. Any unsafe conditions identified by these tests should be corrected before using the hood. It is recommended that all units be tested in accordance with ASHRAE 110 prior to placing the hood in service. Some form of annual certification should be incorporated at the owners' discretion.

The ASHRAE 110 standard is a method of testing the containment performance of V-ELF Hoods. There are three test procedures incorporated into the ASHRAE110 test: first is the face velocity grid test; second is the flow visualization or smoke test; and third is the tracer gas containment test. ASHRAE 110 is the recognized method for evaluating the performance of V-ELF hoods. ASHRAE has defined three modes of operation for testing: As Manufactured (AM); As Installed (AI); and as Used (AU). The ASHRAE test should be conducted by an authorized person proficient in each of the three test procedures.

ISO cleanliness testing is also required annually. Testing is at the filter face, located at the top of the hood chamber in the filter blower compartment.

Sample testing of 12"x12" segments of the filter face area is required to calculate the average filter face velocity. Typically, 55 – 75 fpm filter face velocity is required. Both face velocity and filter leak testing is required. The ISO test should be conducted by an authorized person proficient in each of the test procedures.

7.3.1 Room Conditions

Check room conditions in front of the hood using a thermal anemometer and a smoke source to verify that the velocities of cross drafts are less than 50% of the hood sash face velocity and do not to exceed 40 fpm. Any cross drafts that exceed these values should be eliminated before proceeding with hood testing. Significant cross drafts can have a detrimental effect on the ability of a hood to contain fumes within the hood chamber and exhaust air contaminants. Therefore, it is therefore to keep cross drafts in the vicinity of the face of a hood to a minimum.

7.3.2 Sash Operations

Check operation by moving sash(es) through its (their) full travel. Sash operation should be smooth with minimal resistance and easy to operate. Vertical rising sashes should be properly balanced with counterweights to hold at any sash height without creep up/down unless designed otherwise. Force to open the sash shall be reasonable for the size and weight of the sash. Typically, a 5-foot V-ELF with a vertical rising sash requires a maximum of five (5) pounds of force to operate the sash. An additional one (1) pound of force may be required for each additional linear foot of hood sash width.

7.3.3 Evaluation of Low Airflow

Verify that the airflow monitor functions properly and indicates unsafe conditions to the operator with both audible and visual alarms.

7.3.4 Face Velocity

V-ELF hoods provide optimal containment at 80 fpm (±5 fpm) inward sash face velocity. Average sash face velocity must meet specified value for all V-ELF hoods tested.

- Face velocity shall be adequate to provide proper fume containment.
- Face velocity performance alone is not a measure of safety.

Refer to ASHRAE 110 for sash face velocity measurement procedures.

It is anticipated that the measured sash face velocity will differ from the calculated sash velocity due to the nature of the vertical laminar flow dynamics inside the hood chamber and their effects on inflow sash air velocity vectors.

For more information on this topic, refer to SEFA 1- Section 12.0 Regulatory and Industry Consensus standards.

7.4 Troubleshooting

When test procedures identify improper performance, the cause is frequently due to insufficient quantity of air flowing through the hood, excessive room cross drafts flowing into/across the face of the hood, or a combination of both. It is also recommended to ensure that the HEPA/ULPA filters are leak tested and tested for differential pressure across the filter face.

The following suggestions are offered to help identify and resolve hood performance problems.

7.4.1 Insufficient Airflow

Insufficient airflow through the hood can be caused by one or more of the following conditions. Each condition should be checked, and eliminated, if possible, to determine which one or combination of conditions may exist:

- Double-check your readings.
- Check airflow velocity meter type. When was it calibrated last? Is the battery good? Was the instrument zeroed before taking readings?
- Check to make sure the instrument is recommended for low air velocities in the 50 to 150 feet per minute (0.25 to 0.76 m/s.) range.
- Verify that the filter does not need replacing, is not leaking, and has consistent pressure across the filter.

If possible, verify readings with another air velocity meter or by checking total air volume using a pitot tube traverse of exhaust duct. Low airflow through the hood can be caused by a large negative room static pressure because of inadequate makeup air supplied to the room. With the hood and other exhaust unit in operation, check the following:

- Verification of room static pressure using differential pressure measurement device.
- Check transfer of air into the room through an open door or window.
- Check ventilation system balance and verify the proper quantity of makeup air.
- Ensure that hood baffle openings are not blocked with large or bulky apparatus inside the hood chamber.
- Check for special or bulky equipment in the room that interferes with airflow through the hood.

- Improper sizing or operation of hood and room exhaust systems.
- Confirm exhaust fan rotation is correct. Size and capacity of exhaust fans is as specified.
- Supply voltage to exhaust fan is correct.
- Exhaust fan motor horsepower and speed is appropriate.
- Verify proper operation of exhaust fan(s).
- Exhaust unit inlet and outlet conditions are suitable.
- Check abatement unit or filter for blockage, clogging or restrictions.
- Verify that no control setbacks for building exhaust airflow have been initiated.

7.4.2 Room Cross Drafts

Cross drafts in front of the V-ELF hood face can cause the hood to lose fume containment and present a safety hazard to the hood operator and laboratory personnel. Cross drafts in front of the hood should be kept to a minimum to avoid an adverse impact on hood containment (typically 50% of face velocity). Each of these potential issues should be investigated when cross drafts are suspected of causing poor hood performance:

- Air moving through an open door located adjacent to the hood can cause cross drafts.
- An open window located adjacent to the hood can cause cross drafts.
- Room supply air diffuser(s) located to one side or across from the hood can cause disturbing cross drafts.
- High velocity air from ceiling room supply air diffusers can cause cross drafts or downdrafts.

Cross drafts can occur when thermal gradients in the lab space are caused by the introduction of supply air at a significant temperature difference compared to the ambient temperature in the laboratory space. The proper operation of the Building Automation System (BAS) controls, the location of the laboratory space thermostats, and the room supply air diffuser locations can all impact the development of thermal gradients in the room.

Room conditions such as these should be avoided with the location of the hood, HVAC design changes, or modifying the locations of supply air diffusers. The velocity of the cross drafts should not exceed 50% of the sash face velocity or 40 fpm.

7.4.3 Exhaust Unit and Duct Considerations

Where laboratory building design permits, the exhaust fan system should be located on the roof of the building to provide a negative pressure in the exhaust duct system located within the building.

The exhaust unit should be sized to exhaust the volume of air necessary to attain the design hood sash face velocity at the total exhaust system static pressure loss across the hood. Care should be taken to ensure the exhaust unit has sufficient stack velocity and orientation to reduce the possibility of re-entrainment of contaminated exhaust air into the laboratory building, or an adjacent building's supply air intakes.

Exhaust units should be sized to achieve the lowest practical angular speed of the fan, thereby avoiding high impeller tip speed and minimizing noise and vibration associated with fan wheel rotation.

Ductwork should be designed and constructed in accordance with approved standards and regulations (ASHRAE, NFPA, SMACNA), for minimal friction losses within the duct. Smooth interior duct surfaces are recommended.

Elbows, bends, and offsets in the exhaust duct system should be kept to a minimum and should be long-sweep design configuration to minimize air static pressure losses. When practical, a straight length of exhaust duct should be installed from the hood duct collar for as long a length as possible. V-ELF hoods shall not connect to air re-circulating HVAC systems; V-ELF hoods are 100% exhausting.

7.4.4 Make-up Air

Make-up air is a ventilation term indicating the supply of outdoor or room air to a building replacing air removed by exhaust ventilation systems. In general, laboratories require one (1) to twelve (12) total room air volume changes per hour (ACH). Cleanrooms can require up to 600 air changes per hour. Typical ISO 5 or 6 cleanrooms may require 180 to 400 air changes per hour. Refer to OSHA 1910.1450, Page 492 and NFPA 45 and ISO 14644. Special applications may require more air changes per hour.

Sufficient quantity of makeup air must be available to develop the design hood sash face velocities.

Consideration must be given to the makeup required for air changes in each specific laboratory involved. This data must be coordinated with the V-ELF and ventilation equipment.

To provide a balanced and functioning ventilation system, all factors such as exhaust air volume, air change rate, and makeup air volume must be considered.

Due to the possibility of toxic and/or hazardous material being handled within laboratories, air exhausted from these laboratories should not be re-circulated. Laboratories using chemicals should operate at a slight negative pressure relative to adjacent spaces in the building.

7.4.5 V-ELF Exhaust Airflow Control

V-ELF hoods are recommended for CAV exhaust airflow design. In some cases, VAV airflow strategies may be implemented; however, typically only 2 to 3 speed settings for variable airflow – not infinitely variable airflow operation. This is because 70% of the V-ELF total hood exhaust airflow is the HEPA/ULPA filtered supply air to the hood chamber, which will be 100% exhausted. The remaining 30% of the total hood exhaust airflow enters the hood through the sash face opening. The air through the sash opening is drawn in from the room and pulled down under the worksurface through the perforations located in the front of the worksurface so as not to contaminate the hood processes; and exhausted out of the hood.

The hood filtered supply air velocity at the top of the hood chamber cannot be lowered below 55 fpm, or sufficient back pressure across the HEPA/ULPA filter(s) will be lost and jeopardize the laminar flow conditions through the hood chamber. Because of this limit on reducing supply air to the hood chamber, the net savings with a VAV system is significantly reduced overall. In lieu of VAV airflow design, multi-position exhaust settings such as “At Rest” with the supply blowers off and “In Use” with the supply blowers on is a design strategy to achieve some energy savings if the hood processes allow for the downtime “dirty conditions” associated with the “At Rest” stage – which introduce “contaminated” room air across the entire hood worksurface.

7.4.6 V-ELF Inspection and Maintenance

Inspection procedures should include instrument verification of proper V-ELF hood face velocity, which should be equal to the velocity recorded at the time of the ASHRAE 110 performance test and hood commissioning.

Inspection procedures should consist of a physical examination of hood chamber liner condition, cleanliness, sash operation and condition, sash counter-balance cables, lighting operation, supply blow operation, and service fixture functions.

Inspection results should be recorded and reported to the proper authority for any required action. Where extremely hazardous or corrosive conditions exist or when filters are present in the exhaust air system, the inspection frequency should be increased appropriately. Velocity and pressure sensing detectors should be tested at each inspection. Low-flow or no-flow alarms of the visible or audible type should be tested for correct operation at each inspection.

7.5 Maintenance

V-ELF hood maintenance procedures consist, primarily of cleaning, adjustments, lubrication, and replacement of worn, damaged or nonfunctioning parts. Use good housekeeping by periodically cleaning sash surfaces, exterior and interior surfaces, including the light fixture panel. Replace lighting lamps periodically to maintain adequate illumination.

Cleaning of hood interior areas should be performed by, or under the supervision of, a knowledgeable lab safety officer and should include proper procedures to avoid exposure to hazardous materials.

Lubrication of sash guides, cables, pulley wheels, sprockets, chains, and other working parts should be performed as required or in accordance with manufacturer’s recommendations.

Flush all spills on the worksurface and in the plenum area below the worksurface immediately using neutralizing compounds as required and clean thoroughly.

APPENDIX A: V-ELF Construction Material Selection Guide

SEFA

SEFA 1 V-ELF

Construction Material Selection Guide

October 2022

Refer to chemical resistance charts to verify specific acids / solvents and temperatures (located at the end of the RP).

This guide is intended to assist with the construction material selection process. Use the criteria below and link to the specific acid/solvent.

- **STEP 1** - Material Resistance: Select based on whether acids or solvents are being used.
- **STEP 2** - Temperature Resistance: Select for chemicals to be used and match with acceptable material.
- **STEP 3** - Material Flammability and Smoke Propagation: Select based on code compliance and adherence.
- **STEP 4** - Degradation / Discoloration: Select based on construction material evaluation

NR = NOT RECOMMENDED

STEPS	SEFA	MATERIAL RESISTANCE						
		POLYPROPYLENE			PVC		PVDF	STAINLESS
		NON-FLAME RETARDANT	UL 94 V/0	FM 4910 (note 1)	UL 94 V/0	FM 4910	FM 4910	316L
STEP 1		**CHEMICAL TYPE**						
	ACIDS	✓	✓	✓	✓	✓	✓	NR
	SOLVENTS	✓	✓	✓	NR	NR	✓	✓
STEP 2		**TEMPERATURE RESISTANCE**						
	140ºF / 60ºC	✓	✓	✓	✓	✓	✓	✓
	176ºF / 80ºC	✓	✓	✓	NR	NR	✓	✓
	280ºF / 110ºC	NR	NR	NR	NR	NR	✓	✓
STEP 3		**MATERIAL FLAMMABILITY COMPLIANCE**						
	ASTM-E84 STANDARD	NR	NR	✓	✓	✓	✓	✓
	UL94 V/0	NR	✓	✓	✓	✓	✓	✓
	FM 4910	NR	NR	✓	NR	✓	✓	✓
STEP 4		**DEGRADATION / DISCOLORATION RESISTANCE**						
	ACIDS	✓	✓	NR	✓	✓	✓	NR
	SOLVENTS	✓	✓	NR	NR	NR	✓	✓

Note 1: FM 4910 Polypropylene is not recommended for highly concentrated acids or solvents, but offers excellent flame retardancy.

-Plastics offer excellent acid resistance throughout, even if the surface is scratched or chipped.

MATERIAL FLAMMABILITY COMPLIANCE / CODE ADHERENCE:

-ASTM-E84 may be required if International Building code (Safety code) compliance is required.
-FM 4910 may be required by Factory Global compliance is required.

ASTM - E84: Flame spread index of less than 25 AND a smoke rating of 450 or better.

UL 94 V/0: Does not meet flame spread index of 25 or the smoke rating of 450 or better, but DOES offer flame retardancy & acid resistance.

FM 4910: Meets flame spread index of less than 25 AND smoke rating of 450 or better (refer to Note 1).

V-ELF HOOD UL LISTINGS:

UL 1805: Fume hoods requiring E84 = requires flame retardant material or fire suppression; ASHRAE 110 and electrical testing.
- Flame retardant material required at the hood work chamber and rear plenum or fire suppression [NFPA-45].
- Fire sprinklers and/or CO2 fire suppression systems with non-flame retardant materials may be used to satisfy E84 requirement.

UL 61010-1: electrical complex wiring - requires flame retardant material or fire suppression - electrical enclosure only.

Review detailed Chemical Compatibility Charts located in Appendix C at the end of this RP.

The above LITERATURE is provided to be used as a guide ONLY.

APPENDIX B: Tester Guidelines for Vertical Exhausting Laminar Flow (V-ELF) Hoods

Testing Protocol and Calculations

B1: Calculation of V-ELF Exhaust Airflow Requirements (CFM)

After initial testing is completed, annual total airflow (cfm) V-ELF requirements are calculated as follows:

1. Calculate the HEPA/ULPA filter area or its diffuser material area just underneath filter.
    a. Example: 59 inches long x 24 inches deep divided by 144 = 9.8 ft^2 of filtered area.
2. Multiply filter/diffuser area by specified downflow air velocity in fpm (feet-per-minute) for V-ELF hood.
    a. Example: 9.8 ft^2 x 72 fpm average velocity through the filter/diffuser = 705 CFM.
3. Measure the sash face opening width and operating height. Calculate its area. NOTE: V-ELF hoods should have a sash stop at the safe operating height recommended by the manufacturer.
    a. Example: 50 inches wide opening x 14 inches high operating opening divided by 144 = 4.8 ft^2.
4. Multiply face opening area by specified inflow velocity in fpm for V-ELF hoods.
    a. Example: 4.8 ft^2 x 80 fpm average velocity through the operating sash opening = 385 CFM.
5. Add 50 CFM exhaust airflow for each vented base storage cabinets if the V-ELF has vented base storage cabinets connected to the hood exhaust.
6. Add the downflow, face, and base storage venting CFM exhaust airflow requirements together for hood total exhaust airflow requirement.
    a. Example: 705 CFM + 385 CFM + 50 CFM = 1,140 CFM Total (for a 5-ft wide V-ELF).

V-ELF Hood General Operations

The "dirtier" air entering the hood's work chamber from the room through the sash face opening is contained at the unit's front of worksurface perforated area. This air is then drawn underneath the worksurface into the under-work-surface spill containment/exhaust plenum tub, and then exhausted to building exhaust system. This design ensures that the room air will not contaminate the ongoing product/process inside the hood chamber, because it is pulled down before entering the work area.

The V-ELF work area is slightly negative to the outside. It is important to minimize cross drafts at the sash opening to less than 40 fpm and keep the vertical sash height at or below the manufacturer's safe operating height (typically 10–14-inch height).

V-ELF hoods provide optimal containment at 80 fpm (±5 fpm) inward sash face velocity. Properly designed V-ELF hoods should meet the design performance criteria established by the project or application for ASHRAE 110 testing and simultaneously maintain ultra-clean process conditions within the hood chamber at these lower sash face velocities. The V-ELF is designed to exhaust all the HEPA/ULPA filtered supply air plus the air which enters the hood through the front face opening (and base cabinet exhaust venting).

Exhaust static pressure drops are higher for V-ELF hoods than conventional bypass chemical fume hoods due to higher exhaust requirements. In general, V-ELF hoods commonly operate in the 0.5 – 0.85-inch w.c. static exhaust pressure (SP) range.

B2: V-ELF Hood Testing Set-Up (ASHRAE 110 / ISO 14644 / IES 002)

The following outlines recommended procedures for V-ELF testing set-up:

I. Verify Existing Conditions: Document existing operating conditions:

a) Prior to V-ELF hood testing, confirm the hood total exhaust airflow (cfm) has been previously measured and properly balanced to the hood design value during the hood installation and performance of TAB activities (by others). Document V-ELF hood TAB total exhaust airflow (cfm).

b) Document the V-ELF hood exhaust static pressure gauge/meter reading (in. w.c.).

c) Document the V-ELF hood filter differential pressure gauge/meter reading (in. w.c.).

II. Confirm Total Exhaust Airflow: Verify the total exhaust airflow with Direct Inflow Measurement (DIM):

a) Turn the V-ELF hood integral supply blower(s) OFF. Seal off the supply blower intake prefilter(s) with non-shedding plastic sheet or other material and tape joints airtight. Seal off base cabinet exhaust vents. Position the sash at design operating height.

b) Position flow measurement hood (Shortridge Model CFM-88L or equivalent) at center of the V-ELF hood sash opening resting flow hood top edge on sash sill at sash vertical plane. Seal off the remaining sash face openings that are outside of the instrument flow hood (left/right sides) with tape and non-shedding plastic sheet or other material. Seal off flow hood at sash plane along sides and top with tape.

c) Measure the inflow air volume rate (cfm) flowing from the room into the V-ELF hood with flow hood.

d) Compare the measured inflow air volume rate (cfm) from testing to the total exhaust airflow (cfm) set during TAB activities (see notes A & B below) to verify the V-ELF hood has proper exhaust airflow.

III. Measure Supply Airflow: Verify the supply downward laminar airflow with velocity measurements:

a) Remove the flow measurement hood and coverings for V-ELF hood sash openings, supply blower prefilter(s), and base cabinet vent opening(s). Turn the V-ELF hood integral supply blower(s) ON.

b) Using a hot wire anemometer or multi-point face velocity grid instrument, perform multiple velocity readings in a grid like fashion across the face of the supply air filter/diffuser material (typically 16 to 20 data points) located at the top of the V-ELF hood chamber. Instrument sample points should be located 4 to 6 inches below the filter or laminar flow diffuser material.

c) From the data points, calculate the measured average supply airflow velocity for the V-ELF hood chamber. Verify that all individual velocity measurement readings are within ±20% of the calculated average velocity. Calculate the total laminar supply airflow volume (cfm) based on the average supply airflow velocity and supply air opening area (sq. ft.).

d) Compare the measured average supply airflow velocity to the V-ELF hood design velocity to verify proper supply airflow.

e) If the measured average airflow velocity for the V-ELF hood supply air is higher or lower than the design value (typically in the range of 55-75 fpm – refer to manufacturer's design value for each V-ELF hood), adjust the hood integral supply blower speed controller as needed to achieve the design supply airflow. Repeat testing to validate blower speed adjustment. Document setting of speed controller.

IV. Calculated Inflow Sash Face Velocity: Calculate inflow sash face velocity:

a) Calculate the V-ELF hood inflow sash air velocity (fpm) by subtracting the measured hood chamber supply airflow (cfm) from the measured total exhaust airflow (cfm), divided by the sash face opening area (sq. ft.).

V-ELF Airflows (cfm): $\text{Inflow}_{\text{Sash}} = \text{Exhaust}_{\text{Total}} - \text{Supply}_{\text{Laminar}}$

$$\text{Face Velocity}_{Sash}\ (fpm) = \text{Inflow}_{Sash}\ (cfm) / \text{Area}_{Sash}\ (sq.\ ft.)$$

b) Compare the calculated sash inflow air velocity (fpm) to the V-ELF hood design sash velocity (fpm) to verify the hood has proper inflow sash face velocity.

V. Measure Sash Inflow Air Velocity: Direct measurement of inflow sash face velocity (for comparison):

a) Purpose: Although the calculated average inflow sash air velocity performed above should be used to validate proper V-ELF hood operation, there is value to document the measured average inflow sash air velocity at normal design operating conditions for comparison and future reference during spot check testing. This measurement is being performed to provide a reference point for future periodic V-ELF hood performance verification tests, avoiding the need for full flow hood verification testing to verify safe inflow sash face velocity. It is anticipated that the measured sash face velocity will differ from the calculated sash velocity due to the nature of the vertical laminar flow dynamics inside the hood chamber and their effects on inflow sash air velocity vectors.

b) Ensure the V-ELF hood integral supply blower(s) are ON. Position the sash at design operating height.

c) Perform multiple velocity readings across the sash face opening of the V-ELF hood (typically 16 to 20 data points) using a hot wire anemometer or multi-point face velocity grid instrument. From the data points, calculate the average measured sash face velocity (fpm).

d) Compare and document the measured sash face velocity to the calculated sash face velocity. Record to use for reference during subsequent tests.

VI. Performance Testing: Once the above procedures are satisfactorily completed, the V-ELF hood performance testing may proceed:

a) Conduct performance and filter integrity testing as outlined in ASHRAE 110, ISO 14644 parts 1 and 2, and IES-RP-CC-002.

b) ASHRAE 110 Testing: The applicable ASHRAE 110 testing procedures for V-ELF hoods include:

- Face velocity
- Flow visualization
- Tracer gas

c) ISO 14644/IES 002 Testing: Procedures incorporate the following testing:

- Filter velocity testing
- Filter perimeter leak testing
- Filter face leak testing
- Vibration
- Sound power
- Particle counts at hood worksurface

Notes:

A) The V-ELF hood measured total exhaust airflow should never be greater than the total exhaust airflow determined during TAB activities. This result indicates a problem with testing and/or a deviation of the actual total exhaust airflow from the TAB value at the time of testing.
B) Variation of calculated total exhaust airflow from the TAB total exhaust airflow value is expected due to testing methods and cumulative effects of inaccuracies from multiple measurements. A variation in the range of 5% to 15% is considered normal.
C) The V-ELF hood manufacturer should have particle count data available for each type and size of V-ELF hood offered. This is typically done during As Manufactured (AM) testing on a periodic basis at the factory and is not usually a part of As-Installed (AI) testing unless specified.

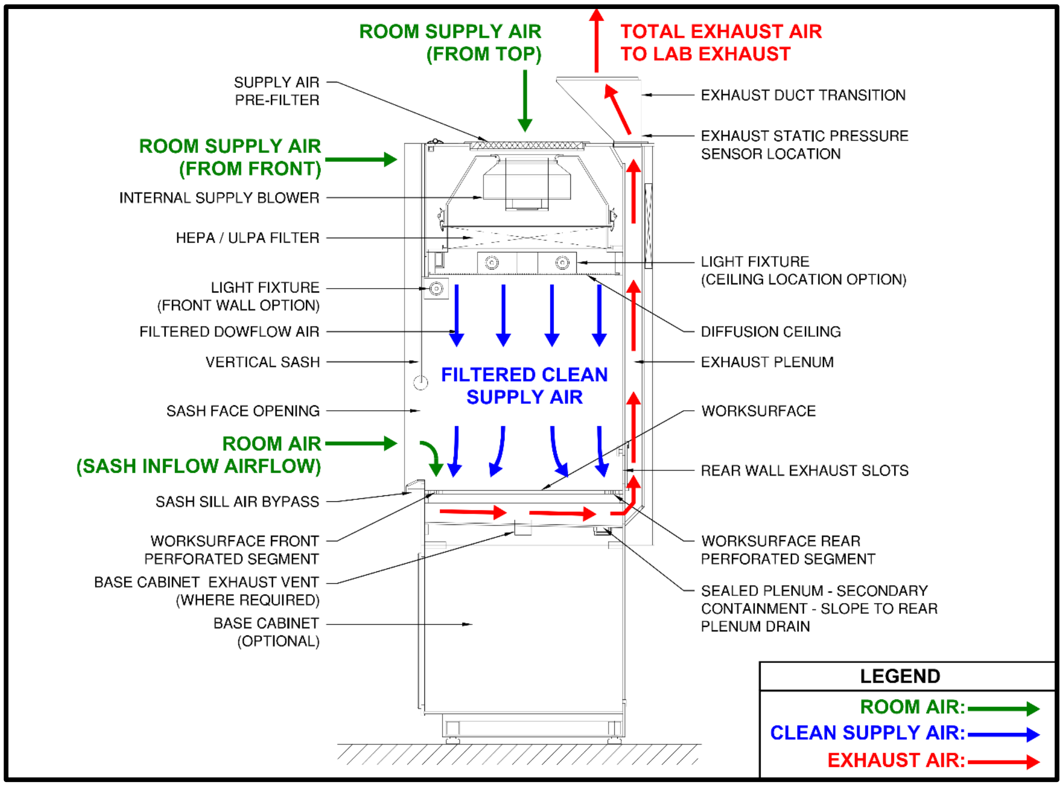


Figure B-1: Typical Configuration and Airflow for V-ELF Hoods

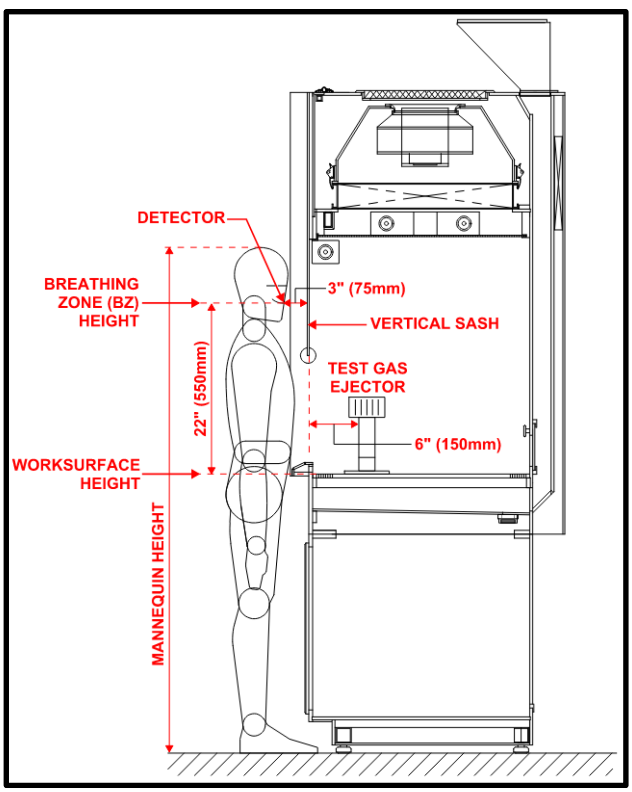


Figure B-2: ASHRAE 110 Test Mannequin Arrangement

SEFA Vertical Exhausting Laminar Flow Standard (2023)
V-ELF HOOD TESTING TEMPLATE
CONSULT SEFA V-ELF STANDARD APPENDIX B FOR TESTING VALUE RANGES

Test Report Prepared for:____________________________ (Client Name)

Name/Model # of Unit Tested:_____________________________________

Testing Date:______________________ Report No. ____________________

ISO 14644/IES 002 Initial testing: Compliant Comments Initials

- Verify Filter velocity testing - 12”x12 parameters
- – front and rear of the filter (4” – 6” off filter)
- Perform Filter perimeter leak testing
- Perform Filter face leak testing
- Particle Counts

ASHRAE110 – As Installed testing: Compliant Comments Initials

- Face velocity testing
- Flow visualization testing
- Tracer gas testing

ISO 14644/IES 002 Annual testing:

Internal protocols / procedures must be established to include:

- Inspect and verify V-ELF hood integrity.
- Verify hood exhaust static pressure value
- Verify Supply air downflow laminar flow velocity.

Testing Performed by: ____
Testing Company Name / Signature of Test Agent

General Characteristics:

V-ELF hoods provide optimal containment at 80 fpm (±5 fpm) inward sash face velocity.

The measured average airflow *(downflow)* velocity for the V-ELF hood supply air is typically in the range of 55-75 fpm

*The V-ELF Hood is designed to exhaust all the HEPA/ULPA filtered supply air **plus** the air which enters the hood through the front face opening (and base cabinet exhaust venting).*

Exhaust static pressure drops are higher for V-ELF hoods than conventional bypass chemical fume hoods due to higher exhaust requirements. In general, V-ELF hoods commonly operate in the 0.5 – 0.85-inch w.c. static exhaust pressure (SP) range.

Moving or modification to the hoods original operation / usage may require retesting with the steps summarized above for "Initial testing".

APPENDIX C: Material Chemical Exposure Performance Tables

Table C-1: Polypropylene Chemical Exposure Performance

NR = NOT RESISTANT | R = RESISTANT SEFA Cabinet Surface Finish Tests-Chemical Reagents	POLYPROPYLENE			
	Reg & UL94V0 Polypropylene, H	Max Temp (C)	FM4910- Polypro Flame Retardant FRP-3	Max Temp (C)
Acetate, Amyl	RS	20	NR	NR
Acetate, Ethyl	RS	20	NR	NR
Acetate Acid, 98%	R	50	NR	NR
Acetone	R	50	NR	NR
Acid Dichromate, 5%	RS	50	RS	20
Alcohol, Butyl	R	50	R	50
Alcohol, Ethyl	R	50	R	20
Alcohol, Methyl	R	50	R	20
Ammonium Hydroxide, 28%	R	20	R	20
Benzene	NR	NR	NR	NR
Carbon Tetrachloride	RS	20	NR	NR
Chloroform	NR	NR	NR	NR
Chromic Acid, 60%	RS	20	RS	20
Cresol	RS	20	NR	NR
Dichloracetic Acid	RS	20	RS	20
Dimethylformamide	R	50	R	20
Dioxane	NR	NR	RS	20
Ethyl Ether	NR	NR	NR	NR
Formaldehyde, 37%	R	50	RS	50
Formic Acid, 90%	RS	50	RS	20
Furfural	RS	20	RS	20
Gasoline	NR	NR	NR	NR
Hydrochloric Acid, 37%	R	40	NR	NR
Hydrofluoric Acid, 48%	RS	50	RS	50
Hydrogen Peroxide, 30%	R	20	RS	20
Iodine, Tincture of	R	50	RS	20
Methyl Ethyl Ketone	RS	50	RS	20
Methylene Chloride	NR	NR	NR	NR
Mono Chlorobenzene	NR	NR	NR	NR
Naphthalene	R	20	R	20
Nitric Acid, 20%	NR	NR	NR	NR
Nitric Acid, 30%	NR	NR	NR	NR
Nitric Acid, 70%	NR	NR	NR	NR
Phenol, 90%	NR	NR	NR	NR
Phosphoric Acid, 86%	RS	50	RS	50
Silver Nitrate, Saturated	R	50	RS	50
Sodium Hydroxide, 10%	R	50	R	50
Sodium Hydroxide, 20%	R	50	R	50
Sodium Hydroxide, 40%	R	50	R	50
Sodium Hydroxide Flake	R	50	R	50
Sodium Sulfide Saturated	R	50	R	50
Sulfuric Acid, 33 %	RS	20	RS	20
Sulfuric Acid, 77%	NR	NR	NR	NR
Sulfuric Acid, 96%	NR	NR	NR	NR
Sulfuric Acid, 77% & Nitric Acid 70% equal parts	NR	NR	NR	NR
Toluene	NR	NR	NR	NR
Trichloroethylene	NR	NR	NR	NR
Xylene	NR	NR	NR	NR
Zinc Chloride, Saturated	R	50	R	50

Credit: Provided by Simona America - May 2021

Table C-2: PVC Chemical Exposure Performance

NR = NOT RESISTANT | R = RESISTANT	PVC					
SEFA Cabinet Surface Finish Tests-Chemical Reagents	UL94V0 PVC	Max Temp (C)	FM4910 CPVC	Max Temp (C)	FM4910 CRP-1	Max Temp (C)
Acetate, Amyl	NR	NR	NR	NR	NR	NR
Acetate, Ethyl	NR	NR	NR	NR	NR	NR
Acetate Acid, 98%	R	20	R	20	CR	40
Acetone	NR	NR	NR	NR	NR	NR
Acid Dichromate, 5%	R	50	R	50	R	50
Alcohol, Butyl	R	40	RS	20	R	50
Alcohol, Ethyl	R	20	RS	20	R	30
Alcohol, Methyl	RS	20	NR	NR	RS	20
Ammonium Hydroxide, 28%	R	20	R	20	R	20
Benzene	NR	NR	NR	NR	NR	NR
Carbon Tetrachloride	R	20	R	20	R	20
Chloroform	NR	NR	NR	NR	NR	NR
Chromic Acid, 60%	NR	NR	NR	NR	NR	NR
Cresol	NR	NR	NR	NR	NR	NR
Dichloracetic Acid	R	20	RS	20	RS	20
Dimethylformamide	NR	NR	NR	NR	NR	NR
Dioxane	NR	NR	NR	NR	NR	NR
Ethyl Ether	NR	NR	NR	NR	NR	NR
Formaldehyde, 37%	R	50	R	50	R	
Formic Acid, 90%	NR	NR	NR	NR	NR	NR
Furfural	NR	NR	NR	NR	NR	NR
Gasoline	NR	NR	NR	NR	NR	NR
Hydrochloric Acid, 37%	R	60	R	60	R	60
Hydrofluoric Acid, 48%	NR	NR	NR	NR	NR	NR
Hydrogen Peroxide, 30%		NR	R	50	R	50
Iodine, Tincture of	NR	NR	NR	NR	NR	NR
Methyl Ethyl Ketone	NR	NR	NR	NR	NR	NR
Methylene Chloride	NR	NR	NR	NR	NR	NR
Mono Chlorobenzene	NR	NR	NR	NR	NR	NR
Naphthalene	NR	NR	NR	NR	NR	NR
Nitric Acid, 20%	RS	20	NR	NR	NR	NR
Nitric Acid, 30%	RS	20	NR	NR	NR	NR
Nitric Acid, 70%	NR	NR	NR	NR	NR	NR
Phenol, 90%	NR	NR	NR	NR	NR	NR
Phosphoric Acid, 86%	RS	50	RS	20	RS	50
Silver Nitrate, Saturated	RS	50	RS	20	RS	50
Sodium Hydroxide, 10%	RS	50	RS	20	RS	50
Sodium Hydroxide, 20%	RS	50	RS	20	RS	50
Sodium Hydroxide, 40%	RS	50	RS	20	RS	50
Sodium Hydroxide Flake	RS	50	RS	20	RS	50
Sodium Sulfide Saturated	R	50	R	50	R	50
Sulfuric Acid, 33 %	RS	50	RS	20	RS	20
Sulfuric Acid, 77%	NR	NR	NR	NR	NR	NR
Sulfuric Acid, 96%	NR	NR	NR	NR	NR	NR
Sulfuric Acid, 77% & Nitric Acid 70% equal parts	NR	NR	R	20	NR	NR
Toluene	NR	NR	NR	NR	NR	NR
Trichloroethylene	NR	NR	NR	NR	NR	NR
Xylene	NR	NR	NR	NR	NR	NR
Zinc Chloride, Saturated	R	50	R	50	R	50

Credit: Provided by Simona America - May 2021

Table C-3: PVDF Chemical Exposure Performance

NR = NOT RESISTANT | R = RESISTANT	PVDF					
SEFA Cabinet Surface Finish Tests-Chemical Reagents	**Homopolymer 740**	**Max Temp (C)**	**Copolymer 2850**	**Max Temp (C)**	**Copolymer 2800**	**Max Temp (C)**
Acetate, Amyl	R	50	R	40	R	40
Acetate, Ethyl	NR	NR	NR	NR	NR	NR
Acetate Acid, 98%	R	50	R	50	R	50
Acetone	R	25	R	25	NR	NR
Acid Dichromate, 5%	R	100	R	100	R	100
Alcohol, Butyl	R	110	R	110	R	105
Alcohol, Ethyl	R	140	R	110	R	100
Alcohol, Methyl	R	140	R	135	R	110
Ammonium Hydroxide, 28%	R	135	R	135	R	110
Benzene	R	75	R	75	R	75
Carbon Tetrachloride	R	135	R	110	R	110
Chloroform	R	50	R	50	R	50
Chromic Acid, 60%	RS	50	RS	65	RS	65
Cresol	R	65	R	65	R	65
Dichloracetic Acid	R	50	R	50	R	50
Dimethylformamide	NR	NR	NR	NR	NR	NR
Dioxane	NR	NR	NR	NR	NR	NR
Ethyl Ether	R	50	R	40	R	40
Formaldehyde, 37%	R	50	R	50	R	50
Formic Acid, 90%	R	120	R	120	R	110
Furfural	RS	25	RS	25	RS	25
Gasoline	R	140	R	135	R	110
Hydrochloric Acid, 37%	R	100	R	100	R	100
Hydrofluoric Acid, 48%	R	95	R	95	R	95
Hydrogen Peroxide, 30%	R	70	R	95	R	95
Iodine, Tincture of	R	65	R	65	R	65
Methyl Ethyl Ketone	NR	NR	NR	NR	NR	NR
Methylene Chloride	R	50	R	40	R	25
Mono Chlorobenzene	R	75	R	75	R	70
Naphthalene	R	95	R	95	R	95
Nitric Acid, 20%	R	50	R	65	R	65
Nitric Acid, 30%	R	50	R	65	R	65
Nitric Acid, 70%	R	50	R	65	R	65
Phenol, 90%	RS	50	RS	50	RS	50
Phosphoric Acid, 86%	R	105	R	110	R	110
Silver Nitrate, Saturated	R	140	R	135	R	110
Sodium Hydroxide, 10%	NR	NR	R	25	R	50
Sodium Hydroxide, 20%	NR	NR	RS	20	R	50
Sodium Hydroxide, 40%	NR	NR	RS	20	RS	25
Sodium Hydroxide Flake	NR	NR	NR	NR	NR	NR
Sodium Sulfide Saturated	RS	30	RS	20	RS	20
Sulfuric Acid, 33 %	R	120	R	120	R	120
Sulfuric Acid, 77%	R	95	R	95	R	96
Sulfuric Acid, 96%	R	50	R	50	R	50
Sulfuric Acid, 77% & Nitric Acid 70% equal parts	R	30	R	30	R	30
Toluene	R	80	R	80	R	80
Trichloroethylene	R	140	R	120	R	110
Xylene	R	95	R	95	R	95
Zinc Chloride, Saturated	R	120	R	120	R	110

Credit: Provided by Simona America - October 2022

Table C-4: Stainless Steel Chemical Exposure Performance

A: EXCELLENT **C: FAIR to POOR**
B: GOOD **D: NOT RECOMMENDED**

SEFA Cabinet Surface Finish Tests-Chemical Reagents	**STAINLESS STEEL 304 SS**	**Max Temp (C)**	**316 SS**	**Max Temp (C)**
Acetate, Amyl				
Acetate, Ethyl				
Acetate Acid, 98%				
Acetone				
Acid Dichromate, 5%				
Alcohol, Butyl	A		A	
Alcohol, Ethyl	A		A	
Alcohol, Methyl	A		A	
Ammonium Hydroxide, 28%	B		A	
Benzene	B		B	
Carbon Tetrachloride	B		B	
Chloroform	A		A	
Chromic Acid, 60%	D			
Cresol	A			
Dichloracetic Acid				
Dimethylformamide	A		B	
Dioxane			A	
Ethyl Ether	B		B	
Formaldehyde, 37%	A		A	
Formic Acid, 90%	C		C	
Furfural	B		B	
Gasoline	A		A	
Hydrochloric Acid, 37%	D		D	
Hydrofluoric Acid, 48%			D	
Hydrogen Peroxide, 30%	B		B	
Iodine, Tincture of	D		D	
Methyl Ethyl Ketone	A		A	
Methylene Chloride	B		B	
Mono Chlorobenzene	B		B	
Naphthalene	A		B	
Nitric Acid, 20%	A		A	
Nitric Acid, 30%				
Nitric Acid, 70%	A		A	
Phenol, 90%	A			
Phosphoric Acid, 86%	D		D	
Silver Nitrate, Saturated	B		B	
Sodium Hydroxide, 10%				
Sodium Hydroxide, 20%	B		B	
Sodium Hydroxide, 40%	B		B	
Sodium Hydroxide Flake				
Sodium Sulfide Saturated	B			
Sulfuric Acid, 33 %				
Sulfuric Acid, 77%	C			
Sulfuric Acid, 96%	A			
Sulfuric Acid, 77% & Nitric Acid 70% equal parts				
Toluene			A	
Trichloroethylene			A	
Xylene	B		B	
Zinc Chloride, Saturated	D		D	

Credit: Graco Chemical Compatibility Guide