Laboratory Equipment Design Standard

This Standard applies to the construction of new facilities and renovations to existing facilities in which chemical work is to be done at laboratory scale. Consultants shall review project requirements with University Facilities, Occupational and Environmental Safety (OES), and key Clemson stakeholders in the design process to ensure appropriate engineering and administrative controls are put in place as part of the project design. Deviations from this standard shall require approval from OES and University Facilities.

Sections:

- Chemical storage cabinets
- Chemical fume hoods
- Biosafety cabinets (BSCs) and laminar flow enclosures / clean benches
- Guidelines for Emergency Safety Showers and Eyewashes

Chemical storage cabinets

Chemical storage cabinets are used to store both solid and liquid chemicals such as flammables, acids, bases, toxics, and / or chemical wastes. Storage cabinets used for the storage of highly toxic, mutagenic, teratogenic and carcinogenic chemicals may need to be vented. There may also be a need to vent cabinets where highly odiferous chemicals are stored. If cabinets are not vented, all bungs on the cabinet must be kept securely in place. These requirements apply to stand-alone cabinets, under counter cabinets, and fume hood base cabinets. **Ventilation of cabinets must be evaluated and approved by OES**.

Flammable liquids storage cabinets*:* Flammable liquids (i.e. flammable solvents, reagents, etc.) should be stored in a flammable liquids storage cabinet (FLSC) when not in active use. FLSCs shall be constructed in accordance with the requirements of NFPA 30 and SC fire code. Modifications shall not be made to FLSCs aside from venting if approved by OES.

If a FLSC must be vented (due to storage of toxic / highly toxic chemicals, etc.), venting shall be in accordance with the requirements of NFPA 30. When not vented, FLSC bung caps shall remain in place at all times.

Corrosive chemical storage cabinets: Corrosive chemicals such as acids and bases should be stored in a corrosive chemical storage cabinet. These cabinets should be constructed of a resistant material for the chemicals to be stored. Metal storage cabinets should be lined with the appropriate resistant material. Corrosive storage cabinets are available from numerous suppliers. Corrosive chemical cabinets may be vented if meet the criteria (see above) and with OES approval.

Chemical fume hoods

Chemical fume hoods shall conform to the design specifications outlined in the *ANSI Z9.5-2022 Laboratory Ventilation* standard. Installation and placement of fume hoods shall be in accordance with the *Clemson Laboratory Ventilation Design Standard* and all relevant code requirements. Installation and removal of chemical fume hoods shall be reviewed and approved by OES.

Fume hood requirements:

- Chemical hoods shall be of the bypass type suitable for 2-position or VAV airflow operation. They shall be designed to contain at an average face velocity of 100 FPM at an 18-inch sash opening height.
- Proposed hoods must have previous satisfactory performance in real world environments (prototype hoods are unacceptable). OES will provide recommendations for approved hoods.

- Chemical hoods must have dedicated ductwork which is not integrated with other general ventilation ducts.
- Hood shall be equipped with a chemical resistant work surface, recessed for containment of spills.
- Hood shall have a fixed or locking baffle system (no manual adjustment required or possible). Factory tuned for optimal linear airflow is preferred.
- All new hoods shall have a screen(s) that prevents debris (tissue, gloves, foil, etc.) from getting behind the baffle.
- All hoods shall have an airfoil.
- Hood sash shall be vertical and shall be equipped with 3/16-inch thick tempered safety glass. NOTE: where hydrofluoric acid is used, sashes will be made of plastic or Lexan with a flammability rating of 25 or less when tested in accordance with ASTM E16276.
- All new hoods shall be equipped with sash stops. These should be set at 18" when the hood is installed.
- Hoods shall be equipped with a device providing visible and audible alarms for low velocity, have local alarm reset, hood exhaust feedback, and face velocity display. The alarm should be capable of detecting a drop or rise in airflow (not static pressure).
- Hoods shall not have on/off controls accessible to laboratory personnel. (Exception: non-laboratory hoods used on an as needed basis may have on / off controls with approval from OES).
- Plumbing fittings mounted on the hood superstructures shall be pre-plumbed. Electrical fixtures shall be pre-wired. The chemical hood superstructure shall be listed to UL Standards for Safety by Underwriters Laboratories, Inc. (UL). Final plumbing and electrical connections are part of installation.
- Hoods shall be equipped with color-coded spigots and plumbing for compressed air, water, vacuum and gas.
- Hood shall be equipped with at least one GFCI 110 volt outlet and at least one interior work light.
- Electrical outlets may not be installed inside chemical hoods
- Sinks that are incorporated into the hood surface should have a retaining edge surrounding them in order to prevent potential spills of hazardous materials from being inadvertently released to the sewer system, etc.
- Any under hood vacuum pump cabinets shall be vented.
- Chemical hoods shall be specified to meet "As Manufactured" ANSI/ASHRAE 110 defined performance tests conducted on a representative hood that demonstrates adequate hood containment.

Specialty hoods: In addition to standard chemical fume hoods that meet the criteria listed above, other requirements for specialty fume hoods include:

- *Radioisotope hoods* - Radioisotope hoods shall not be manifolded with standard fume hoods unless given specific clearance by the Radiation Safety Officer and Lab Safety Manager. Radioisotope hoods shall conform to design specifications outlined in ANSI Z9.5-2022.
- *Perchloric acid hoods* - Perchloric acid hoods shall not be manifolded with other fume hoods. Installation of perchloric acid fume hoods systems must be reviewed and approved by OES.
- *Auxiliary air hoods* - Auxiliary air hoods are not approved for use in Clemson laboratories.
- *Ductless fume hoods* - Ductless fume hoods are not approved for use in Clemson laboratories. In unique conditions, ductless hoods may be approved following a process and hazard analysis.
- *High performance / low velocity fume hoods* - These chemical hoods shall be designed to capture at a face velocity of 100 fpm and below, at an 18-inch sash opening height. Use of these hoods will be evaluated on a project-by-project basis and shall be allowed only after approval from Facilities Services and OES.

Example fume hoods: Labconco Extreme series

Biosafety cabinets (BSCs) and laminar flow enclosures / clean benches

Biosafety cabinets are safety devices primarily used for containment when manipulating infectious and biohazardous materials, and to maintain aseptic conditions when using cell cultures. Laminar flow / clean benches are product protection devices used for contamination control when manipulating materials requiring this level of control; including but not limited to pharmaceuticals, electronic equipment, and plants. They do not provide containment or user protection.

Class IIA2 biosafety cabinets are the most commonly encountered cabinets on campus and fulfill most research needs. Exhaust from these cabinets can be recirculated into the room or linked via a thimble or canopy connection to an appropriate exhaust. These cabinets are for particle containment only and must not be used with flammable or volatile chemicals or radioactive materials. Type B2 cabinets are 100% exhaust (no recirculation in the work area) that provide biological and some chemical containment.

If possible, the biosafety cabinet should be located in the laboratory away from air currents produced by ventilation inlets, opening / closing of the laboratory door(s), and away from areas of heavy traffic. An isolated tissue culture room is an ideal location.

All biosafety cabinets and laminar flow / clean benches must be certified by a contractor trained to National Sanitation Foundation Standard No. 49. Biosafety Cabinet users must ensure that Biosafety Cabinets are certified on an annual basis. Contact the OES Biosafety Officer for a list of available contractors that provide this service.

All biosafety cabinets and laminar flow / clean bench purchases must be approved by the University Biosafety Officer / OES.

Example BSC IIA2 (left) and laminar flow hood (right).

Guidelines for Emergency Safety Showers and Eyewashes

General Requirements:

- All laboratories where hazardous chemicals or biological substances are used, handled, or stored shall be equipped with an appropriate emergency flushing unit(s) as determined by a hazard assessment performed by OES.
- All emergency eyewash, eye/facewash, and shower/combination units shall conform to the ANSI/ISEA Z358.1-2014 Standard for Emergency Eyewash and Shower Equipment.
- Selection, placement, installation, and maintenance shall conform to all applicable federal, state, and local codes and standards.
- Clemson University Facilities Services Life Safety Shop will install units and perform annual certifications. Weekly function checks shall be performed by lab occupants or designated persons.

Definitions: The following definitions are included in the ANSI Z358.1-2014 Standard and can be used to assist in choosing units that are allowable in Clemson University laboratories. Images shown do not represent all available models or styles. Consult OES for questions relating to specific models.

1. Flushing fluid: Potable water, preserved water, preserved buffered saline solution or other medically acceptable solution manufactured and labeled in accordance with applicable government regulations.

2. Combination Unit: An interconnected assembly of emergency equipment supplied by a single source of flushing fluid. Flow rates based on shower and eyewash or eye/facewash values.

3. Drench Hose: A *supplemental device* consisting of a flexible hose connected to a flushing fluid supply and used to provide fluid to irrigate and flush face and body areas. A drench hose alone does not satisfy ANSI Z358.1-2014 requirements.

4. Emergency Shower: A device specifically designed and intended to deliver flushing fluid in sufficient volume to cause that fluid to cascade over the entire body. **Flow rate: 20 gal/min**.

5. Eye/Face Wash Equipment: A device used to provide fluid to irrigate and flush both the face and the eyes simultaneously. **Flow rate 3 gal/min**.

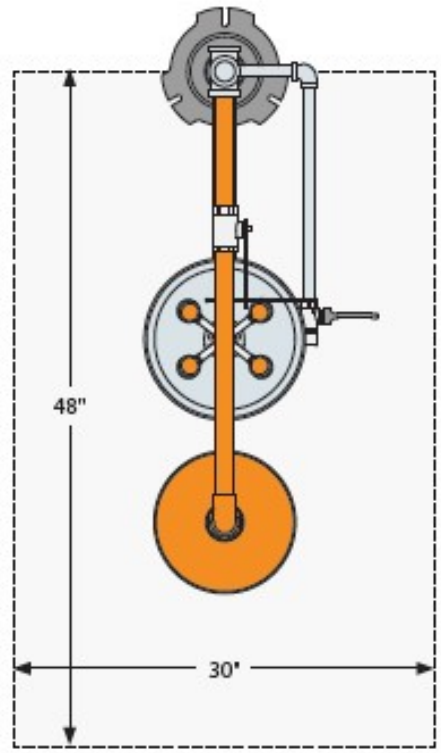
6. Eyewash: A device used to provide fluid to irrigate and flush the eyes. Some eyewash units contain an extendable hose to also serve as a drench hose. **Flow rate 0.4 gal/min**.

7. Portable eyewash station. A self-contained eyewash station useful for work where plumbed units are not readily available (not a substitute for plumbed eyewash where required). Require on-going maintenance and require monitoring of the fluid as the agents used to control bacteria expire after certain periods of time. Flow rate requirements for eyewash or eye/face wash apply depending on model/style.

8. Bottle eyewash: Used as *supplemental device* that supports plumbed and/or self contained units, by delivering immediate flushing fluid to the eyes or body.

Location: Location and placement of emergency showers and/or eyewash units shall conform to the following guidelines. A hazard assessment shall be conducted by OES to determine the optimum location of showers and/or eyewash units.

- Emergency showers and eyewashes must be located such that they are accessible from any point in the lab or work area and can be reached within 10 seconds (~55 feet) without obstructions (a door is considered an obstruction and therefore, a door cannot be located between the lab worker and the drench equipment).
- Where a highly corrosive chemical is used, an emergency shower and eyewash station may be required to be closer to the workstation. These units should be installed in such a way that they don't become contaminated from corrosive chemicals nearby.
- Drench equipment shall be located on the same level as the hazard and path of travel shall be free of obstructions.
- Emergency showers and eyewashes must be in a location that is highly visible and well lit. The sign should be in the form of a symbol that does not require workers to have language skills to understand it.
- Emergency showers and eyewashes must not be located directly over or within 5 ft. on either side of electric power sources such as outlets (unless they are GFCI), switches, data ports, telephones, thermostats, or power supply panels.
- New installations and renovations require a drain be located at the site of emergency showers and eyewashes.
- Compliance with the Americans with Disabilities Act (ADA) requires adequate clearance be provided for individuals in wheelchairs. The diagram below provides guidelines for adequate floor space clearance.



[1]

[1] *ANSI/ISEA Z358.1-2014 Compliance Checklist*, Guardian Equipment.

Performance and Design Requirements: Emergency showers, eyewashes, eye/facewashes, drench hoses, and combination units shall conform to the ANSI 358.1-2014 standard. Performance and design requirements to meet this standard are outlined below. Parentheticals refer to relevant section of ANSI Z358.1-2014. [1]

Shower

Water supply is sufficient to provide at least 20 GPM for 15 minutes. (Section 4.1.2, 4.5.5)

Hands-free valve activates in one second or less and remains open until manually closed. (Section 4.2, 4.1.5)

Shower delivers 20 gallons (75.7 liters) of water per minute for 15 minutes in the required pattern. (Section 4.1.2, 4.5.5)

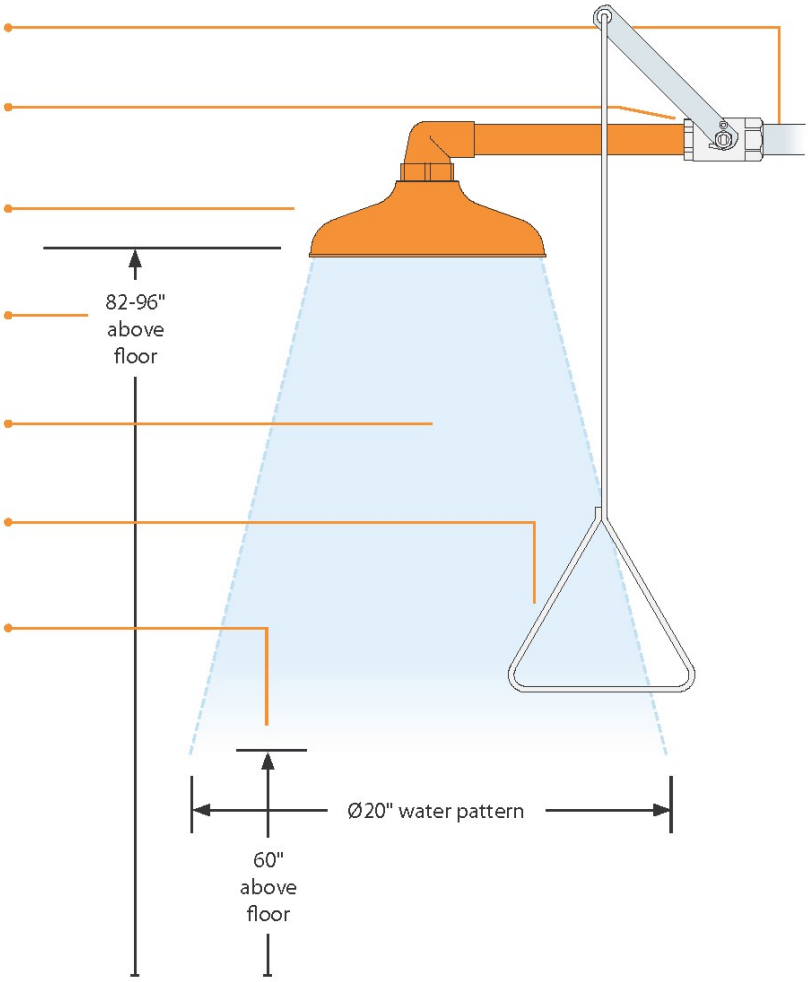
Height of water column is between 82″ (208.3 cm) and 96″ (243.8 cm) above the floor. (Section 4.1.3, 4.5.4)

Center of the water pattern is at least 16″ (40.6 cm) from any obstruction. (Section 4.1.4, 4.5.4)

Easily located, accessible actuator is no more than 69″ (173.3 cm) above floor. (Section 4.2)

At 60″ (152.4 cm) above the floor, the water pattern is at least 20″ (50.8 cm) in diameter. (Section 4.1.4)

If provided, shower enclosure has a minimum diameter of 34″ (86.4 cm). (Section 4.3)



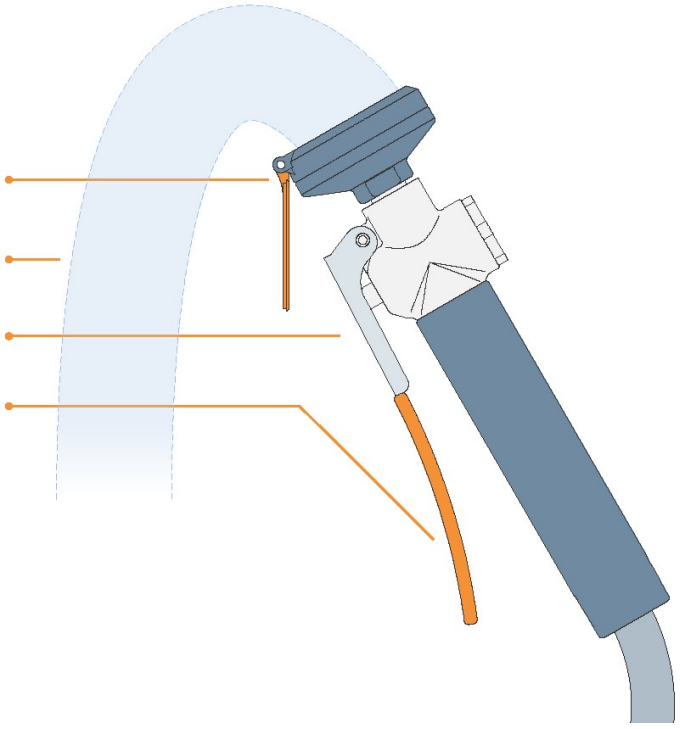
Drench hose

Drench hose unit supplements shower and eyewash units installed in vicinity. (Section 8)

Controlled, low velocity flow is not injurious to user. (Section 8.2.1)

Valve goes from 'off' to 'on' in one second or less. (Section 8.2.2)

Valve actuator is easy to locate and readily accessible to the user. (Section 8.2.2)



Eyewash

Controlled, low velocity flow rinses both eyes and is not injurious to user. (Section 5.1.1)

Water flow is sufficiently high to allow user to hold eyes open while rinsing. (Section 5.1.7)

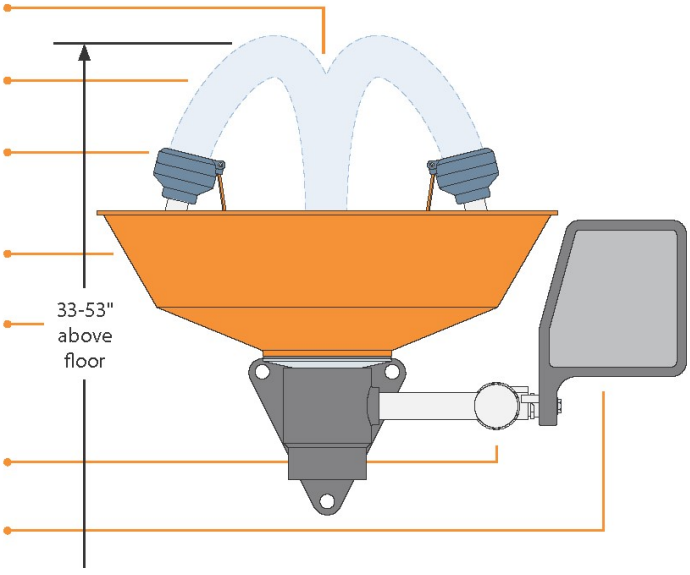
Spray heads are protected from airborne contaminants. Covers are removed by water flow. (Section 5.1.3)

Unit delivers at least 0.4 gallons (1.5 liters) of water per minute for 15 minutes. (Section 5.1.6, 5.4.5)

Water flow pattern is positioned between 33" (83.8 cm) and 53" (134.6 cm) from the floor and at least 6" (15.3 cm) from the wall or nearest obstruction. (Section 5.4.4)

Hands-free stay-open valve activates in one second or less. (Section 5.1.4, 5.2)

Valve actuator is easy to locate and readily accessible to user. (Section 5.2)



Eye/Facewash

Controlled, low velocity flow completely rinses eyes and face and is not injurious to user. (Section 6.1.1)

Water flow is sufficiently high to allow user to hold eyes open while rinsing. (Section 6.1.7)

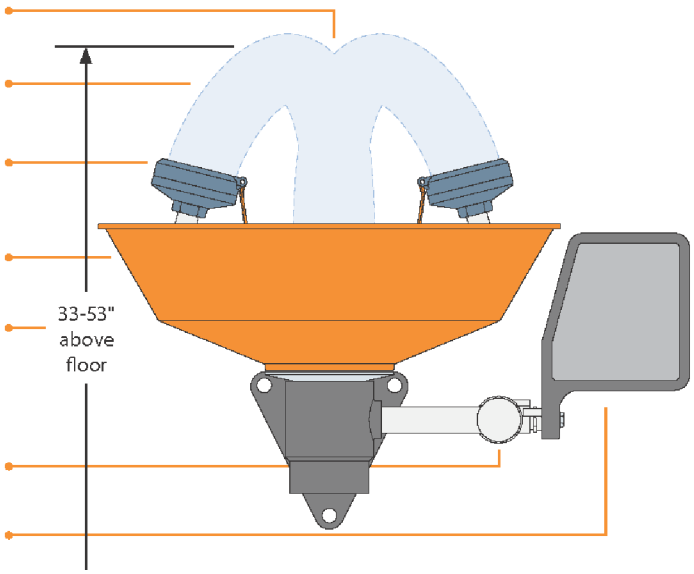
Spray heads are protected from airborne contaminants. Covers are removed by water flow. (Section 6.1.3)

Unit delivers at least 3.0 gallons (11.4 liters) of water per minute for 15 minutes. (Section 6.1.6, 6.4.5)

Water flow pattern is positioned between 33" (83.8 cm) and 53" (134.6 cm) from the floor and at least 6" (15.3 cm) from the wall or nearest obstruction. (Section 6.4.4)

Hands-free stay-open valve activates in one second or less. (Section 6.1.4, 6.2)

Valve actuator is easy to locate and readily accessible to user. (Section 6.2)



Combination unit

Water supply delivers required flow when shower and eye or eye/face wash are operated simultaneously. (Section 4.5.5, 7.4.4)

Hands-free stay-open valve activates in one second or less. (Section 4.2)

Height of water column is between 82" (208.3 cm) and 96" (243.8 cm) above the floor. (Section 4.1.3, 4.5.4)

Shower delivers 20 gallons (75.7 liters) of water per minute for 15 minutes in the required pattern. (Section 4.1.2, 4.5.5)

Easily located, accessible actuator is no more than 69" (173.3 cm) above floor. (Section 4.2)

Center of the water pattern is at least 16" (40.6 cm) from any obstruction. (Section 4.1.4, 4.5.4)

At 60" (152.4 cm) above the floor, the water pattern is at least 20" (50.8 cm) in diameter. (Section 4.1.4)

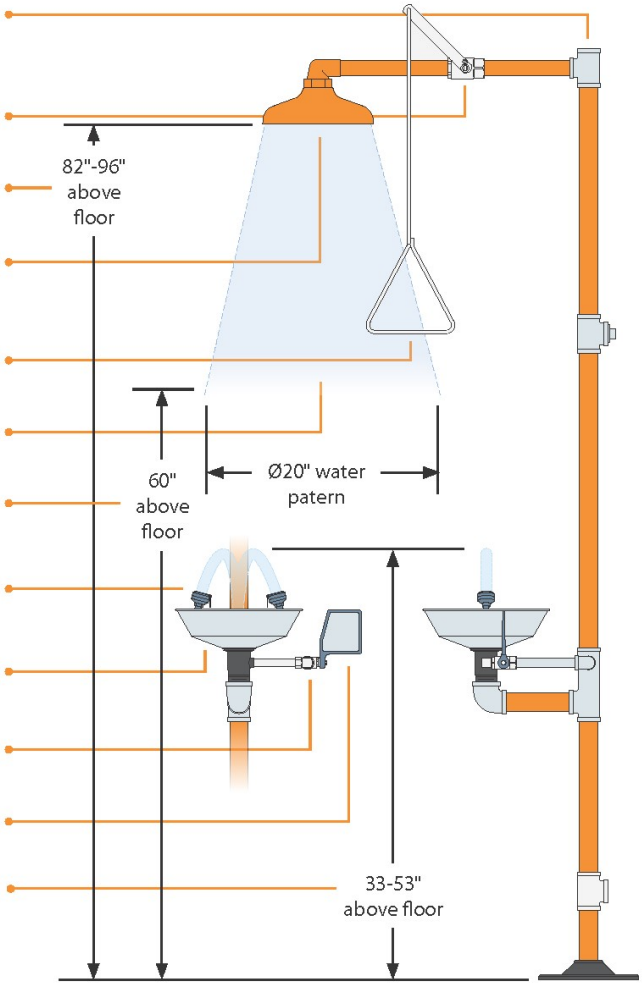
Spray heads are protected from airborne contaminants. Covers are removed by water flow. (Section 5.1.3, 6.1.3)

Unit delivers at least 3.0 GPM (11.4 liters) (for eye/face wash) or 0.4 GPM (1.5 liters) (for eyewash) for 15 minutes. (Section 5.1.6, 6.1.6, 6.4.5)

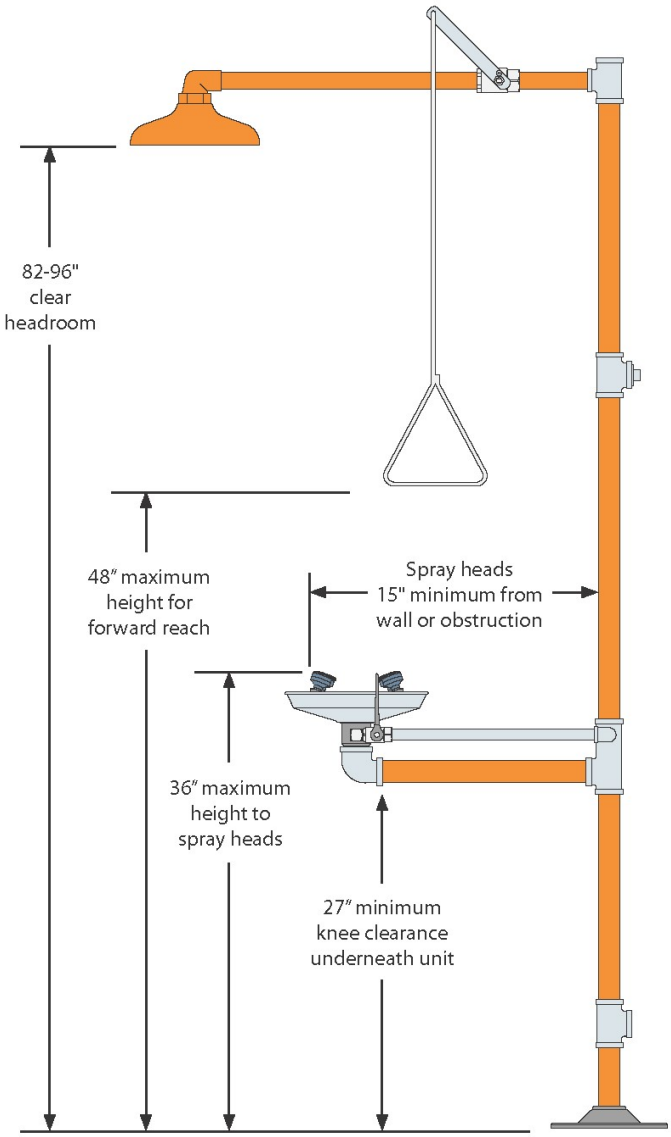
Hands-free stay-open valve activates in one second or less. (Section 5.2, 6.1.4, 6.2)

Valve actuator is easy to locate and readily accessible to user. (Section 5.2, 6.2)

Water flow pattern is positioned between 33" (83.8 cm) and 53" (134.6 cm) from the floor and at least 6" (15.3 cm) from the wall or nearest obstruction. (Section 5.4.4, 6.4.4)



ADA compliant combination unit



Plumbing:

- Plumbed emergency equipment must be connected to a potable water supply line with a minimum pressure of 30psi.
- All new installations must be supplied with tempered water. Tempered water is anywhere between 60°F and 100°F, with the ideal temperature being set at 85°F. If water temperatures are tested and found not to be between 60°F and 100°F, a specialized mixing valve should be installed. The mixing valve must be specifically designed for emergency eyewash and shower related products that include a shut-off to prevent accidental scalding, and a cold-water bypass to ensure the delivery of flushing fluids in the event the hot water supply fails.
- The tempered water service to emergency showers must have a shut off valve upstream of the unit to facilitate maintenance to the equipment. The valve must be accessible with a 6-foot ladder to provide shut off capability in order to service the fixture. The shut off valve shall have a removable handle or have the capability to lock the valve in the open position.
- Domestic cold and hot water lines to eyewashes and showers will be insulated to meet Clemson Standards. Provide PVC jacketing on exposed piping subject to damage.
- All new eyewash installations and renovations should be plumbed to a drain.
- Water supply lines shall meet the following minimum requirements:

    - 1/2" (1.27 cm) IPS for Eyewash Stations and Eye/Face Wash Stations.
    - 1" (2.54 cm) IPS for Drench Showers.
    - 1-1/4" (3.175 cm) IPS for Combination Eyewash Drench Showers.

Codes and Standards:

1. ANSI/ISEA Standard Z358.1 - 2014, American National Standard for Emergency Eyewash and Shower Equipment.

2. Building Codes of South Carolina (2015).

3. Plumbing Codes of South Carolina (2015).

4. Occupational Safety and Health Administration (OSHA).

5. South Carolina OSH Information Memorandum 06 x 57 (Rev)- Guide for Citing Eyewashes and Showers.

6. NFPA 70, National Electrical Code (NEC).

7. Building, Mechanical, Fuel Gas, Plumbing, Electrical, and Fire Codes of South Carolina as per Office of State Engineer

8. ANSI/AIHA Z9.5-2022, Laboratory Ventilation Standard

9. ANSI/ASHRAE 110-2016, Method of Testing Performance of Laboratory Fume Hoods

10. NFPA 45-2019, Standard on Fire Protection for Laboratories Using Chemicals

11. ACGIH, Industrial Ventilation: A Manual of Recommended Practice for Design, 27th Edition – Publication #2096 (© 2010); Industrial Ventilation: A Manual of Recommended Practice for Operation and Maintenance – Publication #2106 (© 2007)

12. OSHA Technical Manual, Ventilation Investigation, Section III, Chapter 3, http://www.osha.gov/dts/osta/otm/otm_toc.html

13. ASHRAE Laboratory Design Guide, 2015

14. American Chemical Society's Committee on Chemical Safety: Identifying and Evaluating Hazards in Research Laboratories, 2015

15. Institute of Laboratory Animal Resources, “Guide for the Care and Use of Laboratory Animals.”

16. Where codes and standards do not exist or are unclear, the design shall follow recommendations and guidelines set forth in the Clemson University Laboratory Safety Manual and Chemical Hygiene Plan.