LVRA™ User's Guide
Laboratory Ventilation Risk Assessment

UCI University of California, Irvine

Developed for the University of California, Irvine

ECT, Inc.

Exposure Control Technologies, Inc.

Exposure Control Technologies, Inc.
231-C East Johnson Street
Cary, NC 27513

www.exposurecontroltechnologies.com

Table of Contents

Purpose

The **Laboratory Ventilation Risk Assessment** (LVRA) is a systematic process of evaluating laboratory practices and procedures to allow building managers to concurrently optimize energy efficiency and occupant safety. Through this process, laboratory settings are assessed across a wide array of categories that utilizes control banding techniques to provide a hazard assessment rating for which building ventilation can be properly customized. Application of the LVRA recommendations optimizes the operational effectiveness of labs, minimizes maintenance and performance problems, and enhances occupant safety and comfort.

The LVRA is intended to assist with determining appropriate measures to help control exposure to airborne contaminants and establish ventilation specifications. While the LVRA neither constitutes nor replaces a comprehensive risk assessment, it does provide an effective method for its intended goals.

This User Guide outlines the processes used to conduct and document the LVRA. In this document, you will be introduced to the LVRA process. Specifically, we will define the LVRA and its integral components (including various exposure control devices). We will also describe the steps followed in conducting the survey, the data entry methods, and how to interpret the overall results that are derived from the data.

The Laboratory Ventilation Risk Assessment

Researchers are potentially exposed to a wide variety of hazards. The hazards must be characterized and evaluated to determine the demand for ventilation, ensure appropriate exposure control devices and establish appropriate operating specifications and performance criteria. The working environment of the researcher must be considered for processes involved with the ECD and on the benchtops.

The Laboratory Ventilation Risk Assessment considers these aspects of the laboratory environment to assess risk, assign risk band control (RCB) values, and establish air flow requirements.

Working closely together with facility and safety staff, principal investigators and research lab staff allows for the determination of lab ventilation requirements by evaluating:

- The types of hazards and procedures
- Hazard generation characteristics (i.e. gases, vapors, mists, dusts, etc.)
- Quantity of materials used or generated during lab procedures
- Frequency and duration of hazard generation
- Exposure control devices (ECDs) in the lab, their use and appropriateness

The LVRA can be applied to existing ECDs or any space where potential exists for exposure to hazardous airborne contaminants. In addition, RCBs can be forecast to lab areas under design through application of pre-defined risk levels or through analysis of what is known or can be predicted about anticipated use or future scientific activities. In this way, the LVRA helps determine the demand for ventilation, assess risk and recommend lab ventilation design and operating specifications for new or existing spaces.

The LVRA Process

The LVRA process begins with a physical inspection of the laboratories and their ECDs. Chief tasks of the lab survey include: noting and documenting the primary processes, the general types and quantities of the current chemical inventory, and their potential for airborne generation. Activities and processes are noted within two primary environments - within the ECD itself, and outside of the ECD (but within the laboratory environment), such as (but not limited to) the benchtop environment. Most surveys are expected to require anywhere between 10 and 30 minutes per space; however, the time duration greatly depends upon several factors unique to each facility.

As part of the LVRA process, it is vital to gain the input of the researchers, students or professors currently assigned to the laboratory. Often, the intent and applicability of the LVRA is misinterpreted as a compliance inspection of some sort. By sharing the purpose and intent of the LVRA with the lab occupants, valuable information can be obtained about the lab space that will aid in the accurate establishment of various parameters in the risk assessment.

The LVRA process consists of 10 fundamental steps:

1. Survey the laboratory
2. Photograph lab, introduce oneself to researchers within the lab space
3. Identify and characterize ECDs
    i. Inventory and assess the ECDs
4. Conduct the ECT Risk Assessment
    i. If ECD involves work with airborne health hazards, proceed to step 5
    ii. If ECD involves physical or other safety hazards, note for later analysis or proceed to a HAZOP (beyond the scope of project)
5. Evaluate appropriateness of ECD
    i. See Appendix for a guide of appropriateness of ECD use

6. Recommend Installation or Utilization of Appropriate ECD
7. Assign RCB level to ECD
    i. Involves evaluation of multiple parameters associated with potential for effluent generation and accumulation of concentrations within the ECD. Risk levels can be applied to individual ECDs or a group of ECDs based on the worst case from the group.
8. Conduct Lab Environment Risk Assessment
    i. Identify potentially hazardous processes conducted outside ECDs. If process involves airborne health hazards, proceed to step 7
    ii. If process involves physical or other safety hazards, mark or note for later analysis or proceed to Hazard Operational Analysis (HAZOP)
9. Assign RCB level to space
    i. Involves evaluation of multiple parameters associated with potential for effluent generation and accumulation of concentrations within the ECD. Risk levels can be applied to individual ECDs or a group of ECDs based on the worst case from the group.
10. Evaluate if specifications are appropriate
    i. If the specifications are not appropriate, investigate mitigating the risk factors within the lab space and reevaluate the RCB
    ii. If mitigating the risk factors cannot be accomplished, then elevate the RCB or select and install an appropriate ECD for the lab
11. Assign risk level to lab and recommend final airflow specifications.

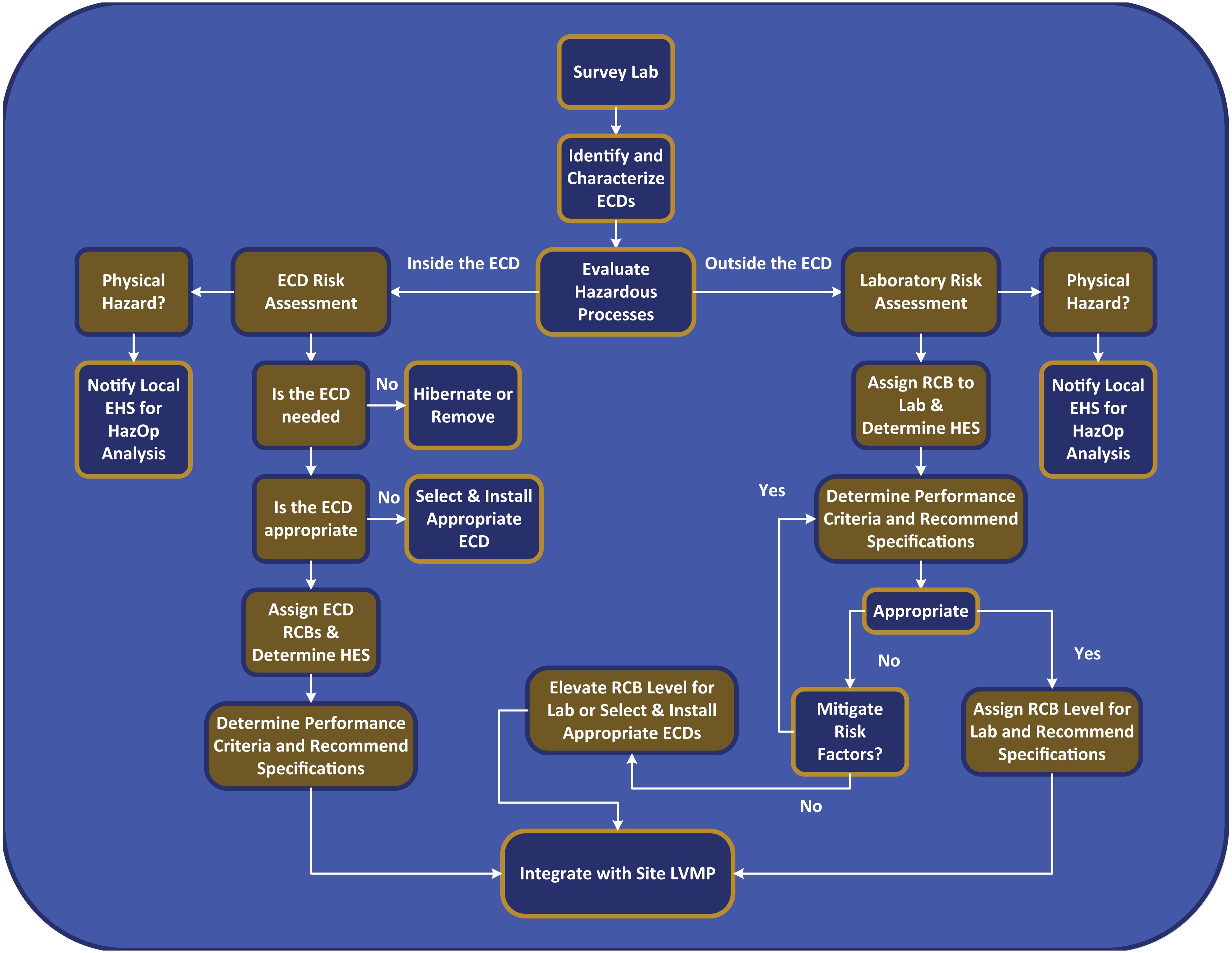


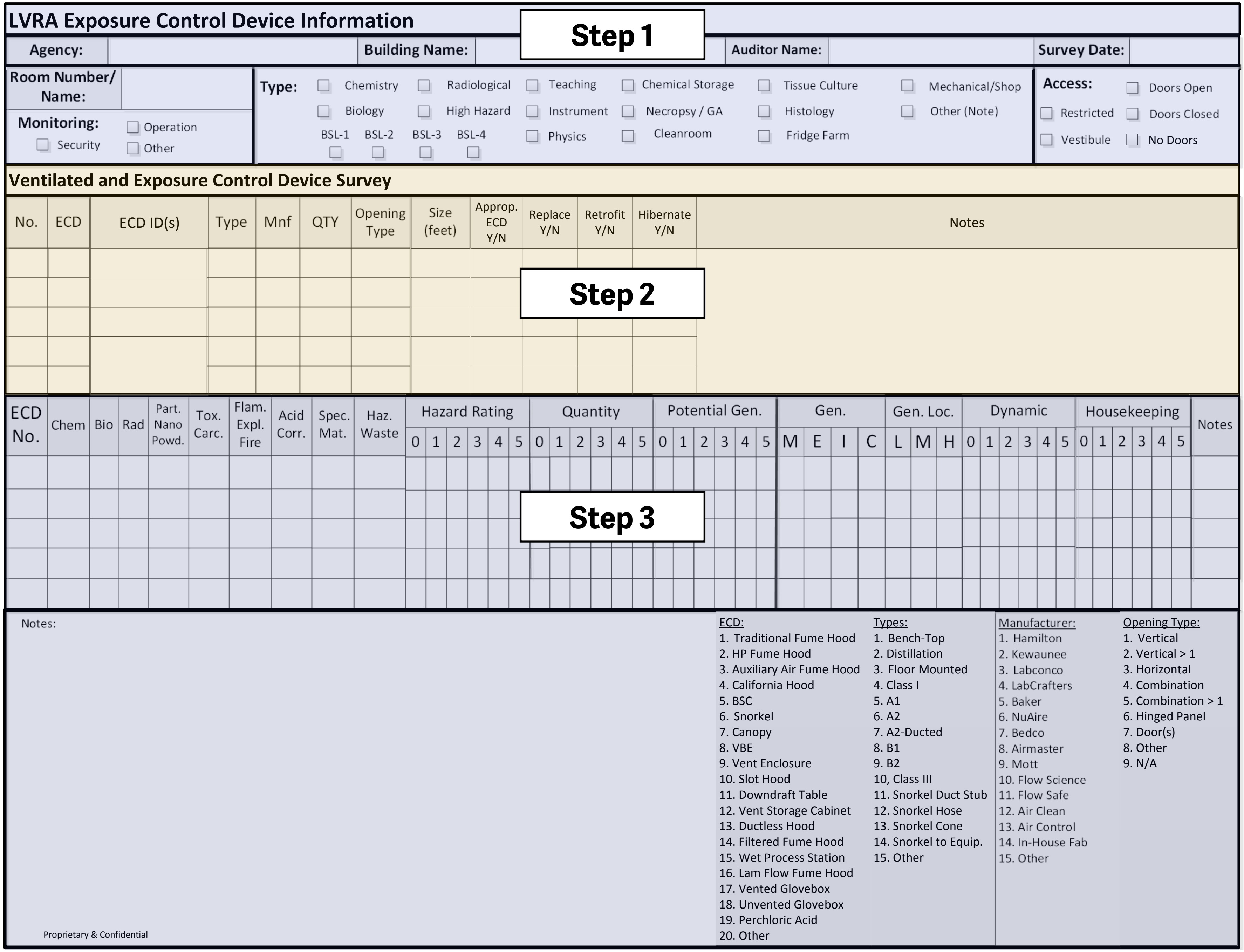
Figure 1 - Flowchart Depicting the Ten Steps of the LVRA Process

Performing the Survey

The LVRA is initially performed in large part by compiling information on a survey form. The survey form is to be completed on-site. Make physical observations and document conditions within functional spaces that meet the general qualifications as a laboratory.

The first page of the two-page form has three steps to follow and focuses on the ECDs within the laboratory. Step 1 focuses on the identification of the lab space, Step 2 is the compilation of the ECD inventory, and Step 3 is the risk assessment of the activities within the ECD. The second page references the fourth step of the field survey and concentrates on the risk assessment of the laboratory environment as a whole.

The following shows each of these four steps as they appear on the survey form, along with some more detailed information.



LVRA Exposure Control Device Information — Step 1

Agency:		Building Name:		Auditor Name:		Survey Date:	

Room Number/ Name:

Monitoring: ☐ Security ☐ Operation ☐ Other

Type: ☐ Chemistry ☐ Radiological ☐ Teaching ☐ Chemical Storage ☐ Tissue Culture ☐ Mechanical/Shop ☐ Biology ☐ High Hazard ☐ Instrument ☐ Necropsy / GA ☐ Histology ☐ Other (Note) BSL-1 ☐ BSL-2 ☐ BSL-3 ☐ BSL-4 ☐ ☐ Physics ☐ Cleanroom ☐ Fridge Farm

Access: ☐ Doors Open ☐ Restricted ☐ Doors Closed ☐ Vestibule ☐ No Doors

Ventilated and Exposure Control Device Survey — Step 2

No.	ECD	ECD ID(s)	Type	Mnf	QTY	Opening Type	Size (feet)	Approp. ECD Y/N	Replace Y/N	Retrofit Y/N	Hibernate Y/N	Notes

Step 3

ECD No.	Chem	Bio	Rad	Part. Nano Powd.	Tox. Carc.	Flam. Expl. Fire	Acid Corr.	Spec. Mat.	Haz. Waste	Hazard Rating						Quantity						Potential Gen.						Gen.				Gen. Loc.			Dynamic						Housekeeping						Notes
										0	1	2	3	4	5	0	1	2	3	4	5	0	1	2	3	4	5	M	E	I	C	L	M	H	0	1	2	3	4	5	0	1	2	3	4	5	

Notes:

ECD:
1. Traditional Fume Hood
2. HP Fume Hood
3. Auxiliary Air Fume Hood
4. California Hood
5. BSC
6. Snorkel
7. Canopy
8. VBE
9. Vent Enclosure
10. Slot Hood
11. Downdraft Table
12. Vent Storage Cabinet
13. Ductless Hood
14. Filtered Fume Hood
15. Wet Process Station
16. Lam Flow Fume Hood
17. Vented Glovebox
18. Unvented Glovebox
19. Perchloric Acid
20. Other

Types:
1. Bench-Top
2. Distillation
3. Floor Mounted
4. Class I
5. A1
6. A2
7. A2-Ducted
8. B1
9. B2
10, Class III
11. Snorkel Duct Stub
12. Snorkel Hose
13. Snorkel Cone
14. Snorkel to Equip.
15. Other

Manufacturer:
1. Hamilton
2. Kewaunee
3. Labconco
4. LabCrafters
5. Baker
6. NuAire
7. Bedco
8. Airmaster
9. Mott
10. Flow Science
11. Flow Safe
12. Air Clean
13. Air Control
14. In-House Fab
15. Other

Opening Type:
1. Vertical
2. Vertical > 1
3. Horizontal
4. Combination
5. Combination > 1
6. Hinged Panel
7. Door(s)
8. Other
9. N/A

Proprietary & Confidential

Figure 2 - The LVRA Form (Front Page)

LVRA Laboratory Space Information

Hazard

- ☐ Chemical
- ☐ Biological
- ☐ Nano
- ☐ Radioactive

- ☐ Gas/Vapor
- ☐ Particulate
- ☐ Other Aerosol
- ☐ Powder

- ☐ Reactive
- ☐ Sensitizer
- ☐ Explosive
- ☐ Corrosive
- ☐ Carcinogen
- ☐ Flammable
- ☐ Acute Hazard
- ☐ Reproductive Toxin
- ☐ Irrevocable Harm
- ☐ Other:

Hazard Rating

0	1	2	3	4	5

Quantity

- ☐ Chemical Storage
- ☐ Hazardous Waste
- ☐ Extreme Quantities (>40 L)
- ☐ Large Quantities (10-40 L)
- ☐ Medium Quantities (1-10 L)
- ☐ Small Quantities (<1 L)
- ☐ Negligible

Catastrophic Risk?

- ☐ Yes
- ☐ No

Quantity Rating

0	1	2	3	4	5

Generation Potential

- ☐ Pipetting
- ☐ Synthesis
- ☐ Extraction
- ☐ Heating
- ☐ Titration
- ☐ Distillation
- ☐ Weighing
- ☐ Digestion
- ☐ Acid Baths
- ☐ Dehydration
- ☐ Centrifuging
- ☐ Chromatography
- ☐ Mixing/Agitating
- ☐ Recrystallization
- ☐ Rotary Evaporation
- ☐ Other:

Generation Potential Rating

0	1	2	3	4	5

Methods of Production

- ☐ Shift
- ☐ Continuous
- ☐ Light equipment use
- ☐ Heavy equipment use
- ☐ No equipment use

Generation Methods

M	E	I	C

Generation Locations

0	1	2	3	4	5

Lab Design and Layout

ECDs Available

0	1	2	3	4	5

ECDs Appropriate?

0	1	2	3	4	5

Dynamic

0	1	2	3	4	5

Housekeeping

0	1	2	3	4	5

Vent. Effectiveness

0	1	2	3	4	5

Airflow Patterns

Short Circuit	
Misdirected	
Other	

Airflow Reduction Potential

0	1	2	3	4	5

Potential for Setback?

- ☐ Yes
- ☐ No

Further Risk Assessment?

- ☐ Yes
- ☐ Physical Hazards
- ☐ No

Notes:

Step 4

Recommendations:

Figure 3 - The LVRA Form (Back Page)

1 - Identifying the Lab Space

LVRA Exposure Control Device Information							
Agency:		Building Name:		Auditor Name:		Survey Date:	

Room Number/ Name:		Type: ☐ Chemistry ☐ Biology BSL-1 ☐ BSL-2 ☐ BSL-3 ☐ BSL-4 ☐ ☐ Radiological ☐ High Hazard ☐ Teaching ☐ Instrument ☐ Physics ☐ Chemical Storage ☐ Necropsy / GA ☐ Cleanroom ☐ Tissue Culture ☐ Histology ☐ Fridge Farm ☐ Mechanical/Shop ☐ Other (Note)	Access: ☐ Doors Open ☐ Restricted ☐ Doors Closed ☐ Vestibule ☐ No Doors
Monitoring: ☐ Security	☐ Operation ☐ Other		

Figure 4 - General Information

After taking pictures of the lab space, begin completing the LVRA form by identifying the basic location and surveyor information (as seen above). Determine the identifying room number and general function (type) of the lab. Note the corresponding BSL value if applicable. Some of the general categories and descriptions are noted in **Table 1** which require check marks (note that some of the categorizations allow for multiple selections).

Category	Description	Multiple Checks?
Monitoring	Relates to type of processes and nature of facility security needs	Yes
Type	Type of lab. See **Appendix A** for descriptions and pictures of each lab type	Yes
Access	How the room is entered	Yes

Table 1

2 - The ECD Inventory

Ventilated and Exposure Control Device Survey												
No.	ECD	ECD ID(s)	Type	Mnf	QTY	Opening Type	Size (feet)	Approp. ECD Y/N	Replace Y/N	Retrofit Y/N	Hibernate Y/N	Notes

Figure 5 - Ventilated and Exposure Control Device Survey

Begin summarizing the ECDs within the laboratory by the relevant categories. If there are no ECDs within the laboratory, simply note as "N/A." Some of these categories include:

Category	Description	Reference Table?
No	The assigned number to a unique ECD. The number will be used to reference the ECD in step 3.	No
ECD	Identify what the ECD is. See **Appendix B** for descriptions and pictures of various ECDs.	Yes - See **Table 3**
ECD IDs	ID number or information for the ECD	No
Type	Relates to whether the ECD is ducted, how it is mounted and various other identifiers. See **Appendix B** for details.	Yes - See **Table 3**
Qty	The amount of that ECD within the lab space	No
Opening Type	How is the ECD accessed?	Yes - See **Table 3**
Size (feet)	Width of the ECD	No
Approp. ECD Y/N	Is the ECD appropriate? Write Y for yes or N for no. See **Appendix B** for details on the appropriateness of ECDs.	No
Replace Y/N	Show the ECD be replaced? Relates to the condition of the ECDs integrity.	No
Retrofit Y/N	Can the ECD be retrofitted?	No
Hibernate Y/N	Can the ECD be hibernated?	No

Table 2

ECD	Type	Manufacturer	Opening Type
1. Traditional Fume Hood	1. Bench-Top	1. Hamilton	1. Vertical
2. HP Fume Hood	2. Distillation	2. Kewaunee	2. Vertical > 1
3. Auxillary Air Fume Hood	3. Floor Mounted	3. Labconco	3. Horizontal
4. California Hood	4. Class I	4. Lab Crafters	4. Combination
5. BSC	5. A1	5. Baker	5. Combination > 1
6. Snorkel	6. A2	6. NuAire	6. Hinged Panel
7. Canopy	7. A2 - Ducted	7. Bedco	7. Door's
8. VBE	8. B1	8. Air Master	8. Other
9. Ventilated Enclosure	9. B2	9. Mott	
10. Slot Hood	10. Class III	10. Flow Science	
11. Downdraft Table	11. Snorkel Duct Stub	11. Flow Safe	
12. Vent Storage Cabinet	12. Snorkel Hose	12. Air Clean	
13. Ductless Hood	13. Snorkel Cone	13. Air Control	
14. Filtered Fume Hood	14. Snorkel to Equip.	14. In-House Fabrication	
15. Wet Process Station	15. Other	15. Other	
16. Laminar Flow Hood			
17. Vented Glove Box			
18. Unvented Glove Box			
19. Perchloric Acid			
20. Other			

Table 3 - ECD Reference Table

Additionally, the surveyor should note the general visual condition of the ECD. ECDs that exhibit evidence of physical damage, obstruction, dysfunction, or other significant contributing factor should be considered for correction. Inappropriate ECDs, such as those that are inadequate for the current process, should be brought to the immediate attention of facilities and EHS personnel for considered for upgrade or improvements. Retrofitting of fume hoods is often effective at improving fume hood performance and safety. Hibernation of ECDs that are no longer in use is another capable way of realizing energy savings.

3 - ECD Risk Assessment

ECD No.	Chem	Bio	Rad	Part. Nano Powd.	Tox. Carc.	Flam. Expl. Fire	Acid Corr.	Spec. Mat.	Haz. Waste	Hazard Rating						Quantity						Potential Gen.						Gen.				Gen. Loc.			Dynamic						Housekeeping						Notes
										0	1	2	3	4	5	0	1	2	3	4	5	0	1	2	3	4	5	M	E	I	C	L	M	H	0	1	2	3	4	5	0	1	2	3	4	5	

Figure 6 - Ventilated and Exposure Control Device Risk Assessment

Once the ECD Inventory is completed, perform a risk assessment on each of the unique ECDs within the lab space. When performing a risk assessment, be thorough with investigation of chemicals and process performed in or around the ECD. For example, most fume hoods have a flammable storage or acid cabinet underneath which will influence the overall hazard rating in the fume hood. Asking the users of the ECD in the lab space can also help with understanding what sort of chemicals and processes are contained in the hood.

The categories within the ECD Risk Assessment are as follows:

Category	Description	Reference Table?
ECD No.	The assigned number to a unique ECD. Reference numbers assigned in Step 2.	No
Chem	Hazard associated with ECD is chemical in nature	No
Bio	Hazard associated with ECD is biological in nature	No
Rad	Hazard associated with ECD is associated with radioactive work	No
Pat. Nano. Powd.	Powder or nano particle work are associated with the ECD	No
Tox. Car.	Hazard associated with ECD is extremely toxic or carcinogenic	No
Flam. Expl. Fire	Material creates risk for fire or explosion	No
Acid Corr.	Material is acidic or corrosive in nature	No
Spec. Mat.	Special material	No
Haz Waste	Hazardous waste from processes performed is stored or associated with the ECD	No

Table 4 - ECD Hazard Categorization

Category	Description	Reference Table?
Hazard Rating	The rating associated with the highest hazard	Yes - See Table Below
Quantity	The rating associated with the largest quantity of material	Yes - See Table Below
Potential Gen.	The rating associated with the highest amount of generation potential from a process	Yes - See Table Below
Gen.	The method of generation. **M**anual; **E**quipment; **I**ntermittent; **C**ontinuous (Multiple checks possible)	No
Gen. Loc.	Location of generation relative to ECD. **L**ow; **M**edium; **H**igh (Multiple checks possible)	No
Dynamic	How often the work, materials and/or quantities change	No
Housekeeping	The organization of materials and processes within the ECD	No

Table 4 - ECD Hazard Categorization (Cont.)

LVRA Control Band	Exposure Limit	Hazard Examples
0	>500 ppm, >2000 mg/m3	Water, calcium chloride
1	50-500 ppm, 250-2000 mg/m3	Acetone, diethyl ether, hexane, methanol, xylene, toluene, pentane
2	5-50 ppm, 20 – 250 mg/m3	Ammonia, acetic acid, aniline, chloroform, cresol, dimethyl sulfide, acetonitrile
3	0.5 – 5 ppm, 2 – 20 mg/m3	Hydrochloric acid, formaldehyde, nitric acid, hydrogen peroxide, phenol, phosphoric acid
4	0.05 – 0.5 ppm, 0.5 – 2 mg/m3	Acrolein, benzene, bromine, bromoform, oxalic acid, phosgene, sulfuric acid
5	< 0.05 ppm, <0.5 mg/m3	Acrylamide, chromic acid, hydrazine, mercury, methyl isocyanate, nickel carbonyl, picric acid, sulfur pentafluoride

Table 5 - ECD Risk Parameters

LVRA Control Band	Amounts	Descriptions
0	Negligible	None used
1	Tiny	Less than 1 mL or less than 1 gram
2	Small	Between 1 and 100 mL or between 1 and 50 grams
3	Moderate	Between .1 and 1 liters or between 50 and 500 grams
4	Large	Between 1 and 10 liters or between .5 and 5 kg
5	Very Large	Greater than 10 liters or greater than 5 kg

Table 6 - ECD Quantity Parameters

LVRA Control Band	Amounts	Descriptions
0	Negligible	None
1	Tiny	Less than 0.1 liters per minute or 100 grams per minute
2	Small	0.1 - 1.0 liters per minute or 100 - 1000 grams per minute
3	Moderate	1 - 4 liters per minute or 1 - 4 kilograms per minute
4	Large	4 - 8 liters per minute or 4 - 8 kilograms per minute
5	Very Large	Greater than 8 liters per minute or greater than 8 kilograms per minute

Table 7 - ECD Generation Rate Parameter Description

4 - The Laboratory Environment Risk Assessment

The back page of the LVRA form is the risk assessment of the lab space. While most of the categories overlap, there are a number of differences and new categories. While the ECDs focus on containment of a hazard, the lab space must focus on the sweeping of air in order to remove the contaminant. As such, some categories changed and some new categories must be added. Furthermore, there are boxes under most categories to better describe hazards, quantities and processes discovered within the lab.

Hazard

☐ Chemical ☐ Biological
☐ Nano ☐ Radioactive

☐ Gas/Vapor ☐ Particulate
☐ Other Aerosol ☐ Powder

☐ Reactive ☐ Sensitizer
☐ Explosive ☐ Corrosive
☐ Carcinogen ☐ Flammable
☐ Acute Hazard
☐ Reproductive Toxin
☐ Irrevocable Harm
☐ Other:

Hazard Rating					
0	1	2	3	4	5

Quantity

☐ Chemical Storage
☐ Hazardous Waste
☐ Extreme Quantities (>40 L)
☐ Large Quantities (10-40 L)
☐ Medium Quantities (1-10 L)
☐ Small Quantities (<1 L)
☐ Negligible

Catastrophic Risk?

☐ Yes
☐ No

Quantity Rating					
0	1	2	3	4	5

Generation Potential

☐ Pipetting ☐ Synthesis
☐ Extraction ☐ Heating
☐ Titration ☐ Distillation
☐ Weighing ☐ Digestion
☐ Acid Baths ☐ Dehydration
☐ Centrifuging
☐ Chromatography
☐ Mixing/Agitating
☐ Recrystallization
☐ Rotary Evaporation
☐ Other:

Generation Potential Rating					
0	1	2	3	4	5

Methods of Production

☐ Shift
☐ Continuous
☐ Light equipment use
☐ Heavy equipment use
☐ No equipment use

Generation Methods			
M	E	I	C

Generation Locations					
0	1	2	3	4	5

Figure 7 - Laboratory Environment Risk Assessment

Category	Description	Reference Table?
Hazard Rating	The rating associated with the highest hazard	Yes - See Table Below
Quantity	The rating associated with the largest quantity of material	Yes - See Table Below
Generation Potential	The rating associated with the highest amount of generation potential from a process	Yes - See Table Below
Generations Methods	The method of generation. **M**anual; **E**quipment; **I**ntermittent; **C**ontinuous (Multiple checks possible)	No
Generation Locations	Number of generations locations within a lab space	No

Table 8 - Lab Environment Risk Parameters

LVRA Control Band	Exposure Limit	Hazard Examples
0	>500 ppm, >2000 mg/m3	Water, sodium chloride, calcium chloride
1	300 - 500 ppm, 1000 - 2000 mg/m3	Hexane, ethyl ether, ethyl acetate, octane, isopropyl ether
2	200 - 300 ppm, 700 - 1000 mg/m3	Toluene, methanol, isopropyl alcohol, methyl acetate
3	150 – 200 ppm, 650 – 700 mg/m3	Tetrahydrofuran (THF), ethyl bromide, acetaldehyde, dichloroethylene, isobutyl acetate
4	100 – 150 ppm, 450 – 650 mg/m3	Pentane, xylene, trichloroethylene, nitroethane, styrene
5	50 - 100 ppm, 400 - 450 mg/m3*	Methylene chloride, carbon disulfide, hydrogen cyanide, acetic acid, naphthalene, hydrochloric acid, isoflurane, benzene, formaldehyde, phosgene, chromic acid

Table 9 - Laboratory Environment Hazard Parameter Description

*Note: If a hazard’s exposure limit is lower than 50 ppm or 400 mg/m3, it must be moved into a ventilated device.

LVRA Control Band	Amounts	Descriptions
0	Negligible	None used
1	Tiny	Less than 4 liters or less than 4 kilograms
2	Small	Between 4 and 20 liters or between 4 and 20 kilograms
3	Moderate	Between 20 and 40 liters or between 20 and 40 kilograms
4	Large	Between 40 and 60 liters or between 40 and 60 kilograms
5	Very Large	Greater than 60 liters or greater than 60 kilograms

Table 10 - Laboratory Environment Quantity Parameter Description

LVRA Control Band	Amounts	Descriptions
0	Negligible	None
1	Tiny	Less than 0.05 liters per minute or 50 grams per minute
2	Small	Less than 0.1 liters per minute or 100 grams per minute
3	Moderate	Less than 0.25 liters per minute or 250 grams per minute
4	Large	Less than 0.5 liters per minute or 500 grams per minute
5	Very Large	Greater than 1.0 liter per minute or greater than 1 kg per minute

Table 11 - Laboratory Environment Generation Rate Parameter Description

In addition to rating these categories, it is also important to indicate specifics of what is being observed in the lab. Identifying qualities of the hazards and processes will assist with the interpretation of the LVRA.

The second half of the lab space risk assessment focuses on the overall design of the lab. See the figure and table below.

5 - Laboratory Design Assessment

Category	Description
ECDs Available	Are there ECDs available? 0 represents “yes” and 5 represents “no.”
ECD Appropriate?	Are the present ECDs appropriate? 0 represents “yes” and 5 represents “no.”
Dynamic	How often the work, materials and/or quantities change
Housekeeping	The organization of materials and processes within the ECD
Vent. Effectiveness	Represents the sweep of air through the lab space and the effectiveness of contaminant removal
Airflow Patterns	Represents issues with airflow patterns. Short circuit is when supply air is immediately exhausted into a hood or general exhaust. Misdirected supply air is directed away from the space or an appropriate exhaust source.
Air Flow Reduction Potential	Potential to reduce airflow in a space
Potential for Setback?	Can the lab be set back at night?
Further Risk Assessment?	Should this lab be flagged for further risk assessment by EH&S?

Table 12 - Laboratory Design Parameters

Lab Design and Layout

ECDs Available

0	1	2	3	4	5

ECDs Appropriate?

0	1	2	3	4	5

Dynamic

0	1	2	3	4	5

Housekeeping

0	1	2	3	4	5

Vent. Effectiveness

0	1	2	3	4	5

Airflow Patterns

Short Circuit	
Misdirected	
Other	

Airflow Reduction Potential

0	1	2	3	4	5

Potential for Setback?

☐ Yes

☐ No

Further Risk Assessment?

☐ Yes ☐ Physical Hazards

☐ No

Figure 8 - Laboratory Design Assessment

Data Entry

After collecting all of the pictures and data from the labs, the information must be inputted into a Lab Ventilation Risk Assessment Risk Matrix. This file contains tabs, formulas and graphs which contribute to the final interpretation of the LVRA data. It is imperative to carefully record the data in order to reduce input error. Double checking the ECD inventory and risk assessment numbers is important to create as accurate a report as possible.

1 - ECD Inventory

First, begin inputting each exhausted device inventoried in the lab space in the **ECD Inventory list** tab. Input the information under the headers as seen the table below. It is important to list each ECD found within the space. For example, if there were five 4-foot Kewaunee fume hoods in a lab, list each one of those individually in order to properly count the number of ECDs. The inventory is a crucial aspect of the risk matrix to accurately report, as this information has been coded to feed into the **ECD Count**, **Final Summary** and **ECD Banding Matrix** tabs.

Exhaust Device Inventory

Lab	ECD	Type	Manufacturer	Opening Type	Size (feet)	VAV?	Notes
101	Traditional Fume Hood	Bench-top	Hamilton	Vertical	6	N	
102	Traditional Fume Hood	Bench-top	Hamilton	Vertical	4	N	Heavy corrosion
103	BSC	A/B3	Nuaire	Vertical	4		
103A	Lam Flow Fume Hood	Bench-top	Air Clean	Vertical	2		
106	BSC	A/B3	Nuaire	Vertical	4		
107	Traditional Fume Hood	Bench-top	Hamilton	Vertical	6	N	Sash hard to move
109	Lam Flow Fume Hood	Bench-top	Air Clean	Vertical	2		
111	BSC	A/B3	Nuaire	Vertical	4		
111A	Snorkel	Snorkel Duct Stub	In-House Fab		0.5		Not used
113	Traditional Fume Hood	Bench-top	Hamilton	Vertical	6	N	
115	Traditional Fume Hood	Bench-top	Hamilton	Vertical	6	N	
117	BSC	A/B3	Nuaire	Vertical	4		
120	Traditional Fume Hood	Bench-top	Hamilton	Vertical	6	N	
120	Snorkel	Snorkel Cone	In-House Fab		0.5		Over benchtop process
120	Snorkel	Snorkel Cone	In-House Fab		0.5		
120	Snorkel	Snorkel Cone	In-House Fab		0.5		
121	Traditional Fume Hood	Bench-top	Hamilton	Vertical	4	N	
121	Traditional Fume Hood	Bench-top	Hamilton	Vertical	4	N	
121	Traditional Fume Hood	Bench-top	Hamilton	Vertical	4	N	
122	BSC	A/B3	Nuaire	Vertical	4		
122	BSC	A/B3	Nuaire	Vertical	4		
123	Snorkel	Snorkel Duct Stub	In-House Fab		0.5		Not being used
123	Snorkel	Snorkel Duct Stub	In-House Fab		0.5		
124	Traditional Fume Hood	Bench-top	Hamilton	Vertical	4	N	
125	BSC	A/B3	Nuaire	Vertical	4		
130	Traditional Fume Hood	Bench-top	Hamilton	Vertical	6	N	
131	Traditional Fume Hood	Bench-top	Hamilton	Vertical	6	N	
131A	Traditional Fume Hood	Bench-top	Hamilton	Vertical	4	N	
131A	Traditional Fume Hood	Bench-top	Hamilton	Vertical	4	N	
133	Snorkel	Snorkel Cone	In-House Fab		0.5		Over benchtop process
133	Snorkel	Snorkel Cone	In-House Fab		0.5		
133	Snorkel	Snorkel Cone	In-House Fab		0.5		
133	Snorkel	Snorkel Cone	In-House Fab		0.5		
	HP Fume Hood						

ECD Banding Matrix1 | ECD Riskagram | Lab Env Banding Matrix | Lab Riskagram | Hibernation Candidates | Retrofit Candidates | Short Circuiting | **ECD Inventory list** | ECD Count

Figure 9 - ECD Inventory Tab

After entering the correct information, cross reference each of the tabs listed above in order to ensure that the counts are all accurate. If there any discrepancies, be sure to correct them. Sometimes, if a lab number is unique or odd, such as A-23a, the coding within the **ECD Count** tab may not recognize it. If this occurs, the lab numbers must be entered manually. However, the coding which counts the ECDs should work regardless as long as the lab numbers are entered correctly on the leftmost column.

2 - ECD Control Banding

After entering the correct information, cross reference each of the tabs listed above in order to ensure that the counts are all accurate. If there any discrepancies, be sure to correct them. Sometimes, if a lab number is unique or odd, such as A-23a, the coding within the **ECD Count** tab may not recognize it. If this occurs, the lab numbers must be entered manually. However, the coding which counts the ECDs should work regardless as long as the lab numbers are entered correctly on the leftmost column.

ECD - Control Band Parameter Analysis

ECD Location	Type of Device	Hazard Rating	Material Quantity	Generation Potential	Method of Generation (M, E, I, C)	Generation Locations (L,M,H)	Dynamic	Housekeeping	Retrofit?	Hibernate?	Score	Control Band	Notes
		5	3	5	1	1	2	1					
121	Traditional Fume Hood	2	3	2	4	1	2	2			40	3	
122	BSC	1	1	1	2	1	1	1			19	1	
122	BSC	1	1	1	2	1	1	1			19	1	
123	Snorkel	0	0	0	0	0	1	0		Y	2	0	
123	Snorkel	0	0	0	0	0	1	0		Y	2	0	
124	Traditional Fume Hood	2	3	2	4	1	2	2		Y	40	3	
125	BSC												

Figure 10 - The ECD Population from ECD Inventory Stops

ECD - Control Band Parameter Analysis

ECD Location	Type of Device	Hazard Rating	Material Quantity	Generation Potential	Method of Generation (M, E, I, C)	Generation Locations (L,M,H)	Dynamic	Housekeeping	Retrofit?	Hibernate?	Score	Control Band	Notes
		5	3	5	1	1	2	1					
121	Traditional Fume Hood	2	3	2	4	1	2	2			40	3	
122	BSC	1	1	1	2	1	1	1			19	1	
122	BSC	1	1	1	2	1	1	1			19	1	
123	Snorkel	0	0	0	0	0	1	0		Y	2	0	
123	Snorkel	0	0	0	0	0	1	0		Y	2	0	
124	Traditional Fume Hood	2	3	2	4	1	2	2		Y	40	3	
125	BSC												

ECD Banding Matrix1 | ECD Riskagram | Lab Env Banding Matrix | Lab Riskagram | Hibernation Candidates | Retrofit Candidates | Short Circuiting | ECD Inventory

Figure 11 - Dragging Down Row 32 to Populate the Matrix with ECD Inventory Entries

ECD - Control Band Parameter Analysis

ECD Location	Type of Device	Hazard Rating	Material Quantity	Generation Potential	Method of Generation (M, E, I, C)	Generation Locations (L,M,H)	Dynamic	Housekeeping	Retrofit?	Hibernate?	Score	Control Band	Notes
		5	3	5	1	1	2	1					
121	Traditional Fume Hood	2	3	2	4	1	2	2			40	3	
122	BSC	1	1	1	2	1	1	1			19	1	
122	BSC	1	1	1	2	1	1	1			19	1	
123	Snorkel	0	0	0	0	0	1	0		Y	2	0	
123	Snorkel	0	0	0	0	0	1	0		Y	2	0	
124	Traditional Fume Hood	2	3	2	4	1	2	2		Y	40	3	
125	BSC												
130	Traditional Fume Hood												
131	Traditional Fume Hood												
131A	Traditional Fume Hood												
131A	Traditional Fume Hood												
133	Snorkel												
133	Snorkel												

ECD Banding Matrix1 | ECD Riskagram | Lab Env Banding Matrix | Lab Riskagram | Hibernation Candidates | Retrofit Candidates | Short Circuiting | ECD Inventory

Figure 12 - Matrix Properly Populated with ECD Inventory Entries

Next, begin inputting the ratings for each parameter for each ECD as well as any notes. The algorithm in the matrix will begin calculating the Risk Control Band (RCB) for each ECD. The Gen. and Gen. Loc are unique due to the possibility of multiple check marks. The parameter ratings for these two categories are as following in the tables below.

Generation Method	
Checked	**Rating**
M	1
M, I or E, I	2
E, C	3
M, E, I or M, E, C	4
M, E, I, C	5
Generation Location	
L	1
M	2
L, M	3
M, H	4
L, M, H	5

For the **Retrofit?** and **Hibernate?** columns, input Y if the device can be retrofitted and/or hibernated, and input N if the device cannot be. This information will form tables in both the **Hibernation Candidates** and **Retrofit Candidates** tabs.

3 - Lab Environment Banding

Enter the **Lab Env Banding Matrix** tab and begin inputting the lab space information. Because some lab spaces do not have ECDs, there is nothing populating these cells so the information must be entered manually. Input the parameter ratings like with the previous step.

The matrix for the lab environment contains two additional categories. One pertains to the maximum ECD rating within the lab. This relies on information from the previous step. If a lab has no ECD, a 0 should be inputted. The other additional category relates to the airflow patterns of the lab space. If there is short circuiting within the lab, indicate what kind of short circuiting. “Gex” is short circuiting of the general exhaust grilles and “FH” is short circuiting of the fume hood or ECD. If there is no short circuiting, leave the cell blank. This information will be linked to the **Short Circuiting** tab.

Finally, if there is an issue in the lab space that is not addressed in the parameters such as a need for additional ECDs or specific safety concerns, take note of them in the **Recommendations** section at the bottom of the form and input the observations under the **Notes** section. These recommendations are important for the interpretation of the LVRA.

After completing the lab space information, the data entry will be complete.

4 - Risk Control Banding

The **Lab Ventilation Risk Assessment Risk Matrix** contains a mixture of algorithms in order to automate and calculate as the data is being entered. The control banding algorithm relies on different weighting factors in order to determine a control band for each lab space or ECD. These weighting factors are shown in **Tables 13 & 14**.

These weightings can be altered in order to align with the tolerance levels of the facility for which the LVRA is employed. The weightings can be made more or less conservative depending on the desires of the facility.

ECD Control Parameter	Rating	Sample Weight Multiple	Total Max Score	Sample Sensitivity or Importance
Hazard	5	5	25	28%
Quantity	5	3	15	17%
Potential or Rate of Generation	5	5	25	28%
Method of Generation	5	1	5	6%
Generation Location	5	1	5	6%
Dynamic or Potential for Change	5	2	10	11%
Housekeeping	5	1	5	6%
Total Max Score	35	**ECD Weighted Score**	90	100%

Table 13 - ECD Parameter Weighting

Lab Control Parameter	Rating	Sample Weight Multiple	Total Max Score	Sample Sensitivity or Importance
Hazard	5	7	35	21%
Quantity	5	2	10	6%
Potential or Rate of Generation	5	12	60	36%
Method of Generation	5	1	5	3%
Generation Location	5	2	10	6%
ECD Availability	5	1	5	3%
Appropriate ECDs	5	1	5	3%
Ventilation Effectiveness	5	3	15	9%
Dynamic or Potential for Change	5	2	10	6%
Housekeeping	5	1	5	3%
Maximum ECD RCB	5	1	5	3%
Total Max Score	55	**ECD Weighted Score**	165	100%

Table 14 - Lab Parameter Weighting

Interpreting the LVRA

These weightings can be altered in order to align with the tolerance levels of the facility for which the LVRA is employed. The weightings can be made more or less conservative depending on the desires of the facility.

1 - ECD Risk Assessment Interpretation

The ECD banding matrix results form the graph in the tab **ECD Riskagram**. The graph displays the overall results of the ECDs in the building. This helps in understanding the overall risk for the processes being performed with the ECDs. Below is an example of how the ECD Riskagram may look like.

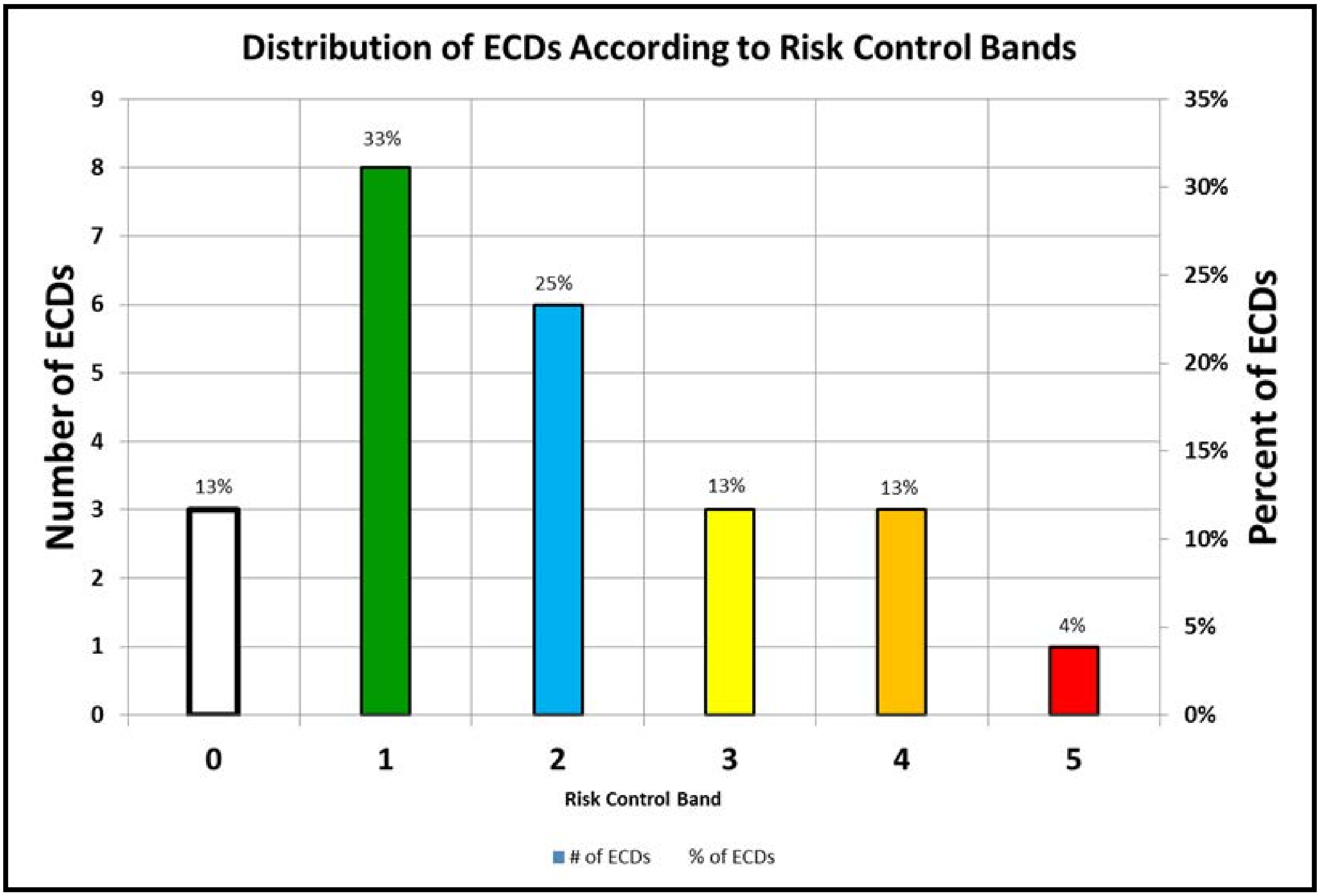


Figure 13 - ECD Riskagram Example

Each RCB assigned to a fume hood is associated with an operating specification. These specifications are one of the main end results of the ECD risk assessment and help the facility correctly set airflow for the fume hoods as well as help set maintenance and testing specifications for each fume hood based on its individual risk. If these specifications prove to be too costly for a facility, the LVRA also highlights which ECDs require further risk assessment and special attention in order to possibly decrease their RCB.

LVRA - Risk Control Bands & ECD Operating Specifications						
Laboratory Fume Hood Specification	**Risk Control Band**					
	0	**1**	**2**	**3**	**4**	**5**
ASHRAE 11 Tracer Gas Control Level	n/a	4 lpm AU < 0.1 ppm	4 lpm AU < 0.1 ppm	4 lpm AU < 0.1 ppm	6 lpm AU < 0.05 ppm	8 lpm AU < 0.01 ppm
Fume Hood Face Velocity	n/a	60 fpm[1]	60 fpm[1]	60 fpm[1]	80 fpm[1]	100 fpm
Cross Draft Velocity	n/a	< 30 fpm	< 30 fpm	< 30 fpm	< 30 fpm	< 30 fpm
Minimum Fume Hood Exhaust Flow w/Sash Closed	Turn off or Hibernate	Minimum for Containment	> 150 ACH_{FH}[2]	> 250 ACH_{FH}[2]	> 375 ACH_{FH}[2]	CAV
VAV Response Time	n/a	< 5 Secs.	< 5 Secs.	< 5 Secs.	< 5 Secs.	< 5 Secs.
VAV Stability (% Varitation)	n/a	< 20%	< 20%	< 20%	< 20%	< 20%
Fume Hood Duct Velocity	n/a	> 200 fpm	> 250 fpm	>300 fpm	>500 fpm	>1,000 fpm
Monitor	n/a	Yes	Yes	Yes	Yes	Yes

Table 15 - ECD Operation Specifications

Notes:

[1] Cal-OSHA Code of Regulations – Section 5154 requires 100-fpm average velocity. A variance would be required to reduce average face velocity for RCBs less than 5.

[2] The minimum flow resulting in the recommended minimum ACH must be sufficient to ensure proper hood containment with the sash closed and following sash movement.

Retrofit and hibernation potential for ECDs is also an important result of the LVRA. Retrofitting an ECD is not only beneficial for safety reasons but it can also decrease energy consumption. Hibernation of ECDs found to have an ECB of 0 also helps contribute to the overall energy savings of the facility. The **Hibernation Candidates** and **Retrofit Candidates** pull their respective information from the ECD Risk Matrix into a full list.

2 - Laboratory Environment Risk Assessment Interpretation

Similar to the ECDs, the lab environment risk assessment results also form a graph in the Lab Riskagram tab. The distribution of the riskagram is shown along with a sample floorplan with the lab spaces populated with their respective RCBs. This figure, as well as the RCBs in general, helps to indicate which lab spaces contain the highest risk. The results also provide the facility with a table of lab spaces experiencing short circuiting. This table is important in assisting a facility with proper, safe and efficient lab design.

Finally, similar to fume hoods, lab spaces have operating specifications. These specifications serve to assist with implementing with LVRA results which may serve to reduce airflow in overventilated labs and increase the airflow in labs where the low air change rates are a safety hazard.

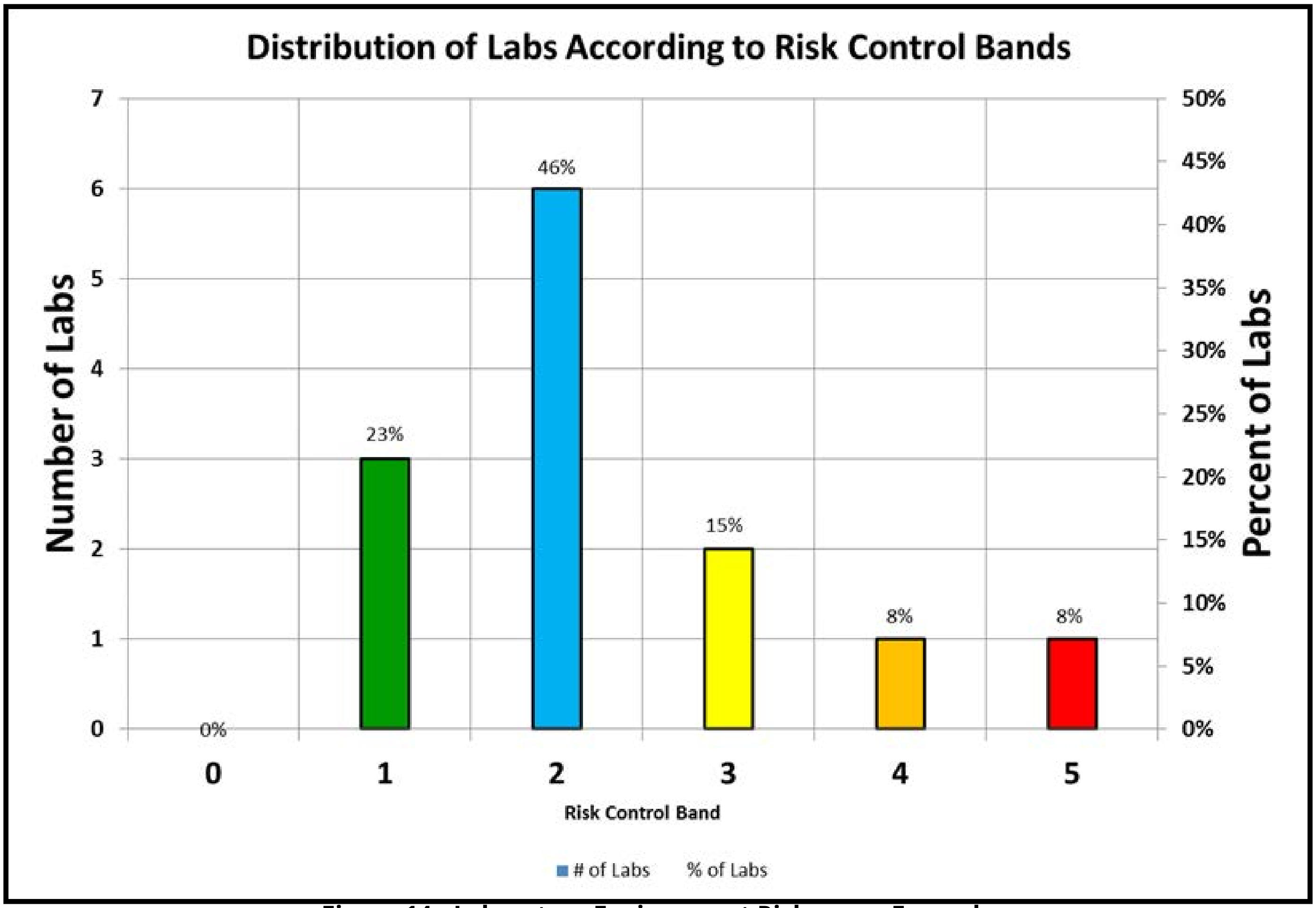


Figure 14 - Laboratory Environment Riskagram Example

LVRA - Risk Control Bands & Lab Operating Specifications						
Laboratory Specifications	Risk Control Band					
	0	1	2	3	4	5
Minimum Effective ACH	n/a	2	4	6	8	10
Recirculation of Lab Air	Yes	Yes	Filtered	Internal	Internal	No
Lab Pressurization "w.g.	Neutral	Neutral	< -0.005	< -0.01	< -0.05	= > -0.05
Room Monitor	n/a	n/a	n/a	Review	Yes	Yes
Airlock/Vestibule	n/a	n/a	n/a	n/a	n/a	Yes
Enthalpy Wheels	Yes	Yes	Review	Review	No	No
Flow Setback (DCV)	Yes	Yes	Yes	Yes	Review	No
Emergency Purge Mode	No	No	No	No	Review	Yes
Future Capacity for ECD		Snorkel	4-ft LFH	6-ft LFH	8-ft LFH	2 x 6-ft LFH
Additional Flow Capacity	n/a	100 cfm	480 cfm	780 cfm	1080 cfm	1560 cfm

Table 16 - Laboratory Environment Operating Specifications

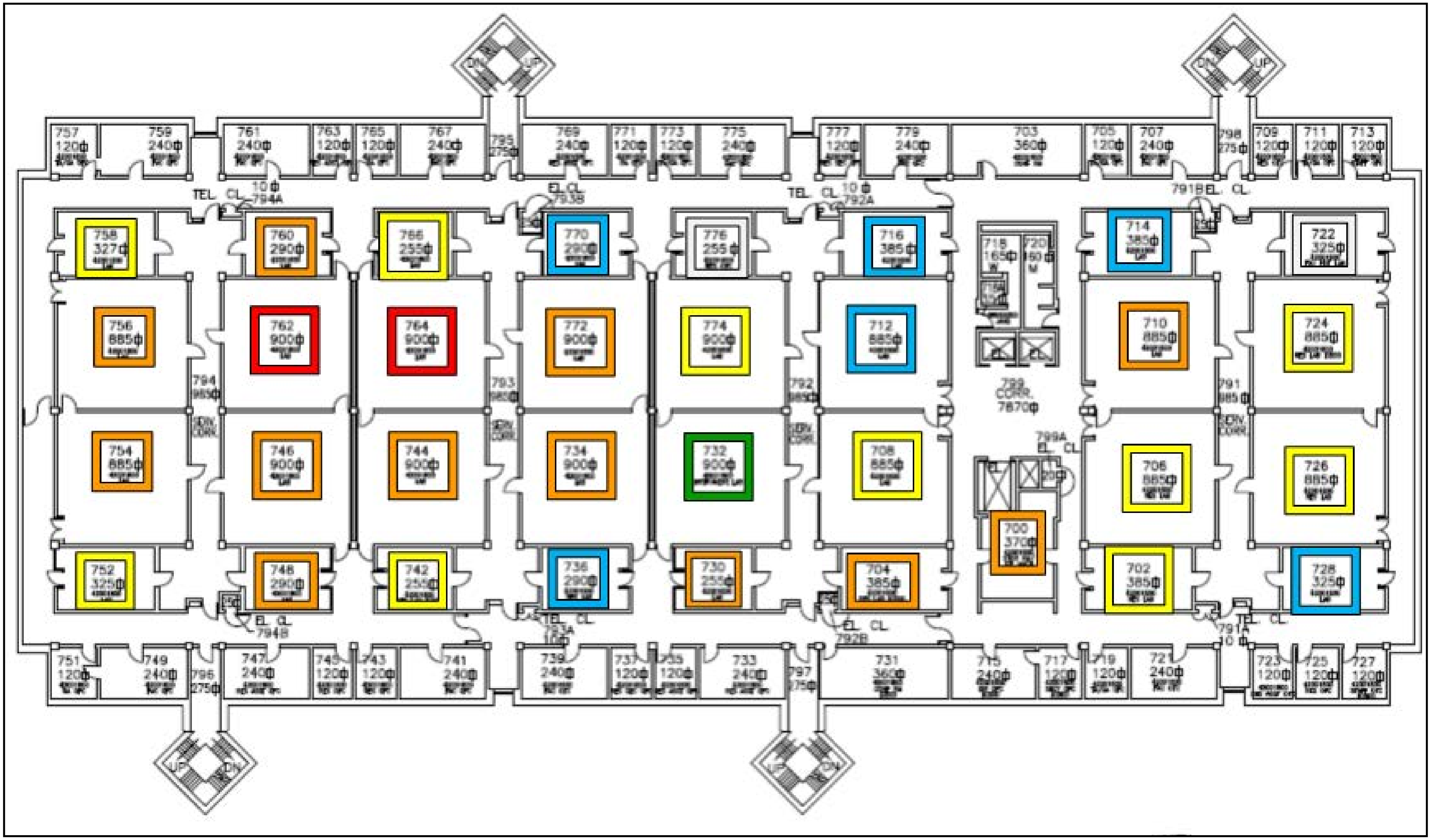


Figure 15 - RCB Floorplan for Lab Spaces

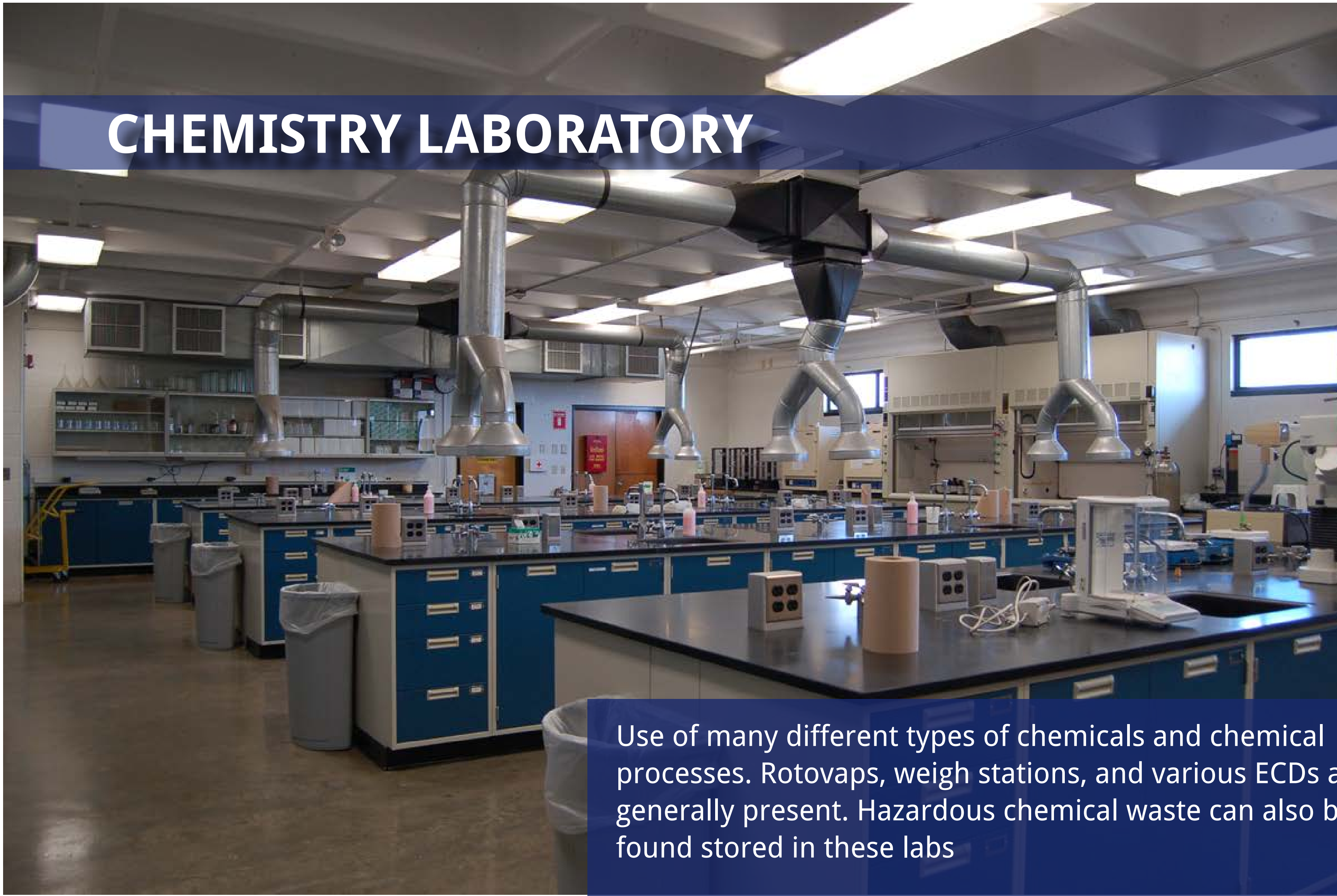
3 - Using the LVRA

A successfully completed LVRA provides the user a practical tool that can be utilized in the establishment of ventilation controls – either at the lab design phase or as part of the management of change – without sacrificing health and safety requirements. It accomplishes this by helping to establish appropriate operating specifications for current conditions in the lab environment. The risk control banding process allows for the development of proper recommendations for laboratory ventilation, relative to the laboratory processes both within the exposure control devices and elsewhere within the laboratory.

The LVRA serves an integral role in the development of overall ventilation effectiveness for the general lab environment. It is often conducted as part of a Demand for Ventilation Assessment (DVA) where ventilation systems are challenged and qualified. However, the LVRA is equally beneficial as a stand-alone process.

The end user should remember that ventilation effectiveness is the ultimate goal to be achieved, as a properly executed LVRA will result in the optimization of both ventilation systems and occupant safety. It also provides the basis for a long-term and sustainable ventilation management program.

Appendix A - Laboratory Types



CHEMISTRY LABORATORY

Use of many different types of chemicals and chemical processes. Rotovaps, weigh stations, and various ECDs are generally present. Hazardous chemical waste can also be found stored in these labs

BIOLOGY LABORATORY

There are 4 designations:

BSL1 - Minimal potential threat to researchers and environment.

BSL2 - Moderate potential threat to researchers and environment. Microbes present.

BSL3 - Lethal viruses and bacteria, but have a known cure.

BSL4 - Lethal viruses and bacteria with no known cure.

Focuses mainly on biological samples and experiments. There is mainly pipetting on benchtops and the presence of Bio-Safety Cabinets (BSCs) or laminar flow work stations for product protection.

RADIOLOGICAL LABORATORY

Presense of radioactive waste, radioisotopes, radioisotope hoods and radiation shields.

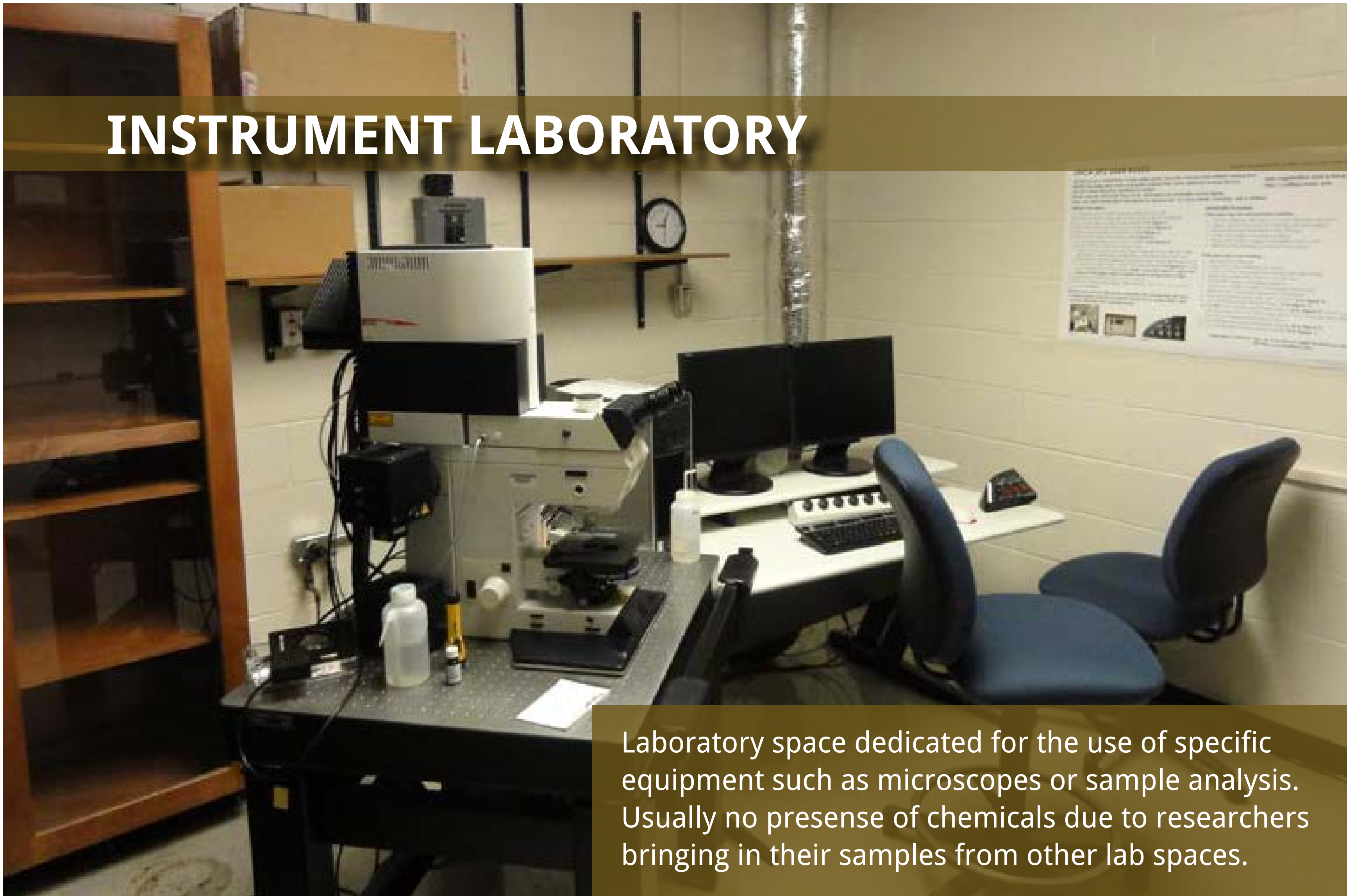
HIGH HAZARD LABORATORY

Presence of chemicals with extremely low exposure limits. These labs typically work with undiluted chemical warfare agents and require special access.

TEACHING LABORATORY

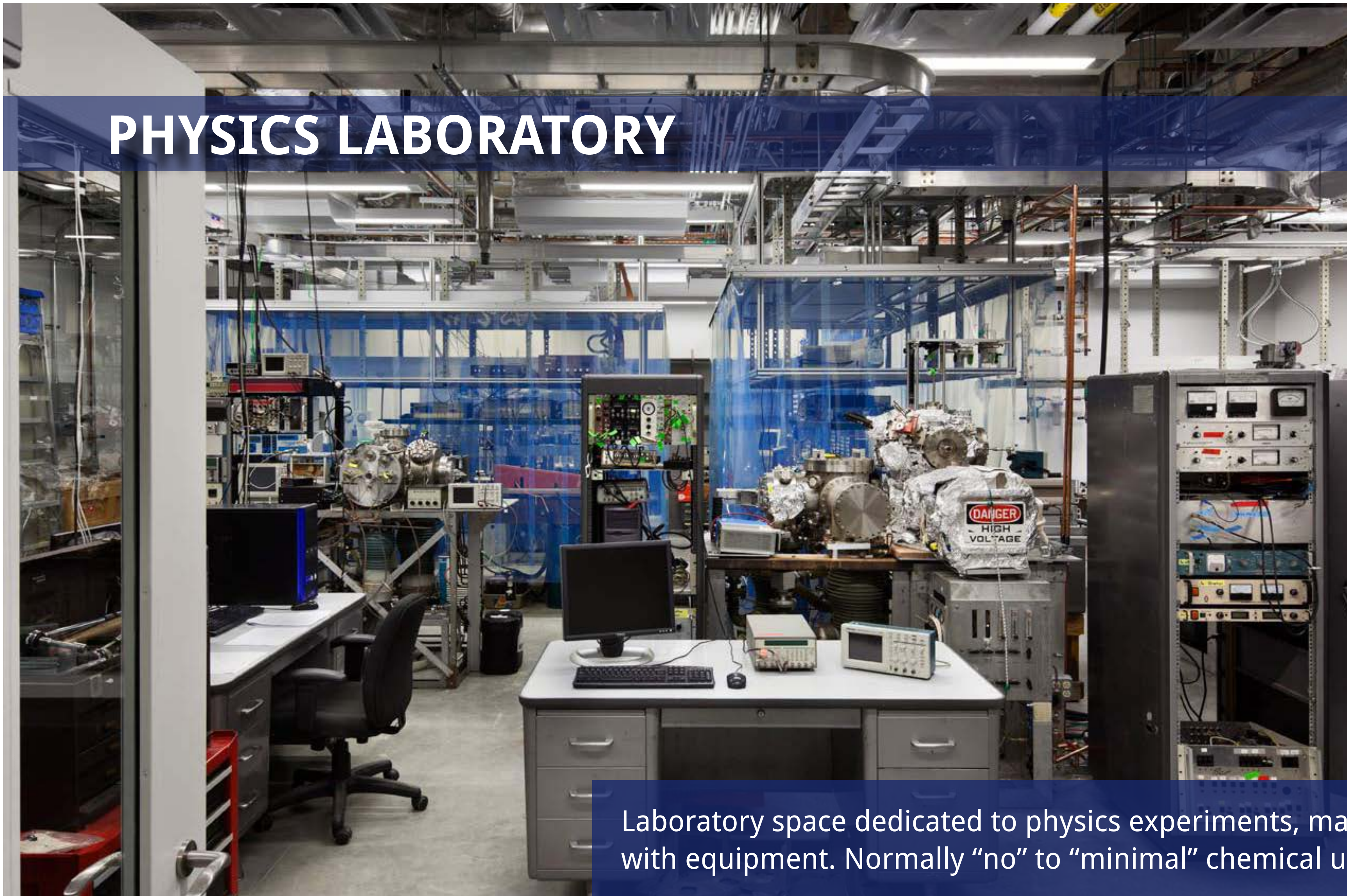
Laboratory dedicated to teaching students about chemistry. Typically have lower quantities of hazards and may have California or teaching hoods.

INSTRUMENT LABORATORY



Laboratory space dedicated for the use of specific equipment such as microscopes or sample analysis. Usually no presense of chemicals due to researchers bringing in their samples from other lab spaces.

PHYSICS LABORATORY



Laboratory space dedicated to physics experiments, mainly with equipment. Normally “no” to “minimal” chemical use.

CHEMICAL STORAGE

Rooms dedicated to storing chemicals. Typically have high quantities of low to high toxicities. May have weigh stations for weighing powders. Generally, no processes performed in storage room.

NECROPSY/GROSS ANATOMY LABORATORY

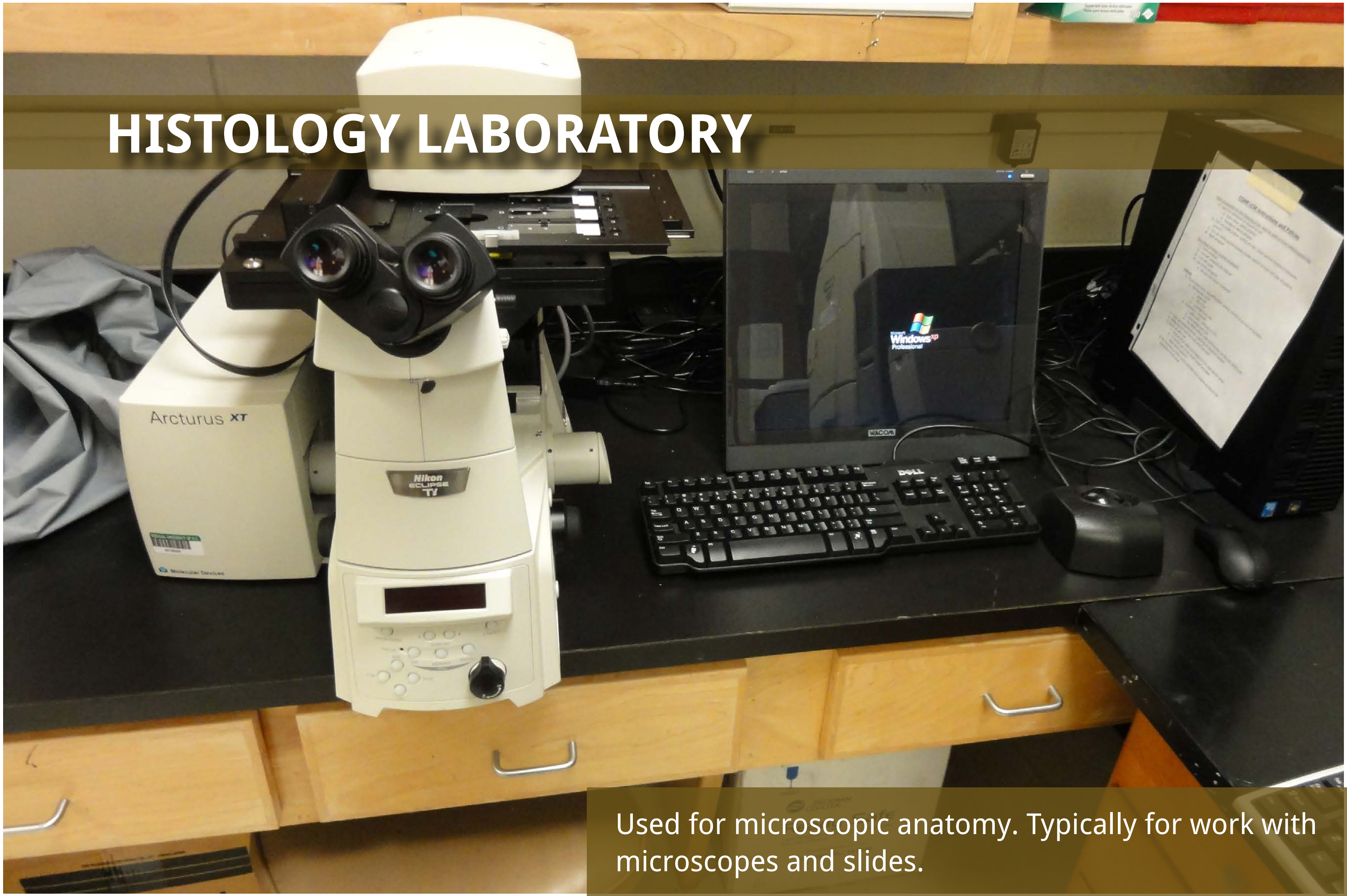
Dedicated to surgical procedures and/or dissection.

CLEAN ROOM

Contains very sensitive procedures, controlled environment, and work surfaces. Lab personnel typically must wear special gowns, gloves, shoe covers and possibly head and face protection.

TISSUE CULTURE LABORATORY

Used for growing tissue away from the host. Work is almost exclusively done in BSCs and under microscopes.



HISTOLOGY LABORATORY

Used for microscopic anatomy. Typically for work with microscopes and slides.

FRIDGE/FREEZER FARM

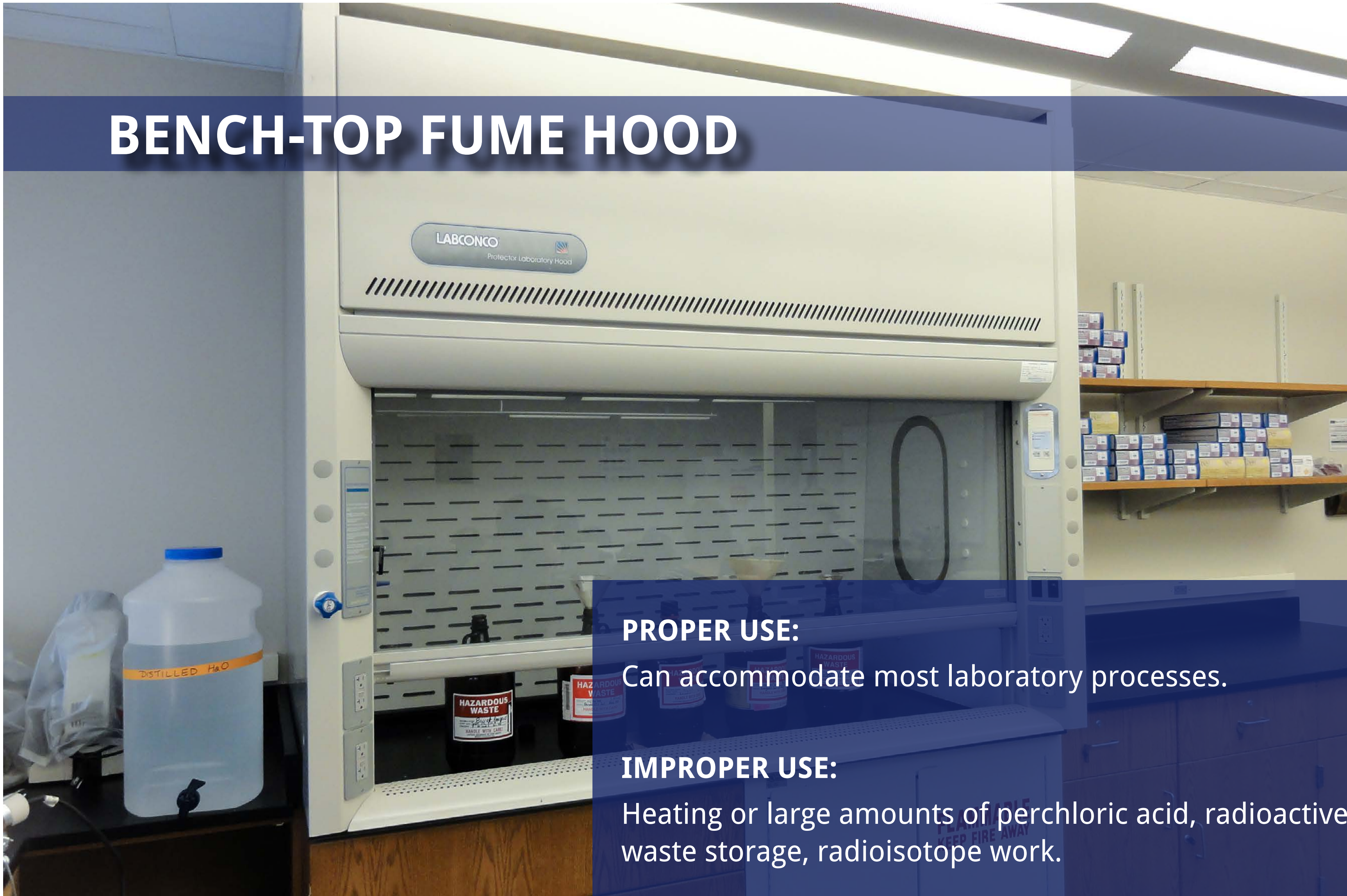
Room housing many refridgerators and freezers for storing samples. Typically, no chemicals. High heat load.

MECHANICAL/SHOP

Space dedicated to storage and maintenance of equipment. Typically no chemical storage or use.

Appendix B - Exposure Control Devices

BENCH-TOP FUME HOOD



PROPER USE:

Can accommodate most laboratory processes.

IMPROPER USE:

Heating or large amounts of perchloric acid, radioactive waste storage, radioisotope work.

FLOOR MOUNTED FUME HOOD

PROPER USE:

Mainly for larger processes or containers. Can accommodate most laboratory processes.

IMPROPER USE:

Heating or large amounts of perchloric acid, radioactive waste storage, radioisotope work, researchers walking into hood.

DISTILLATION FUME HOOD

PROPER USE:

Used most commonly with tall apparatus and procedures that involve small to medium quantities of low to high toxicity materials.

IMPROPER USE:

Heating or large amounts of perchloric acid, radioactive waste storage, radioisotope work.

RADIOISOTOPE FUME HOOD

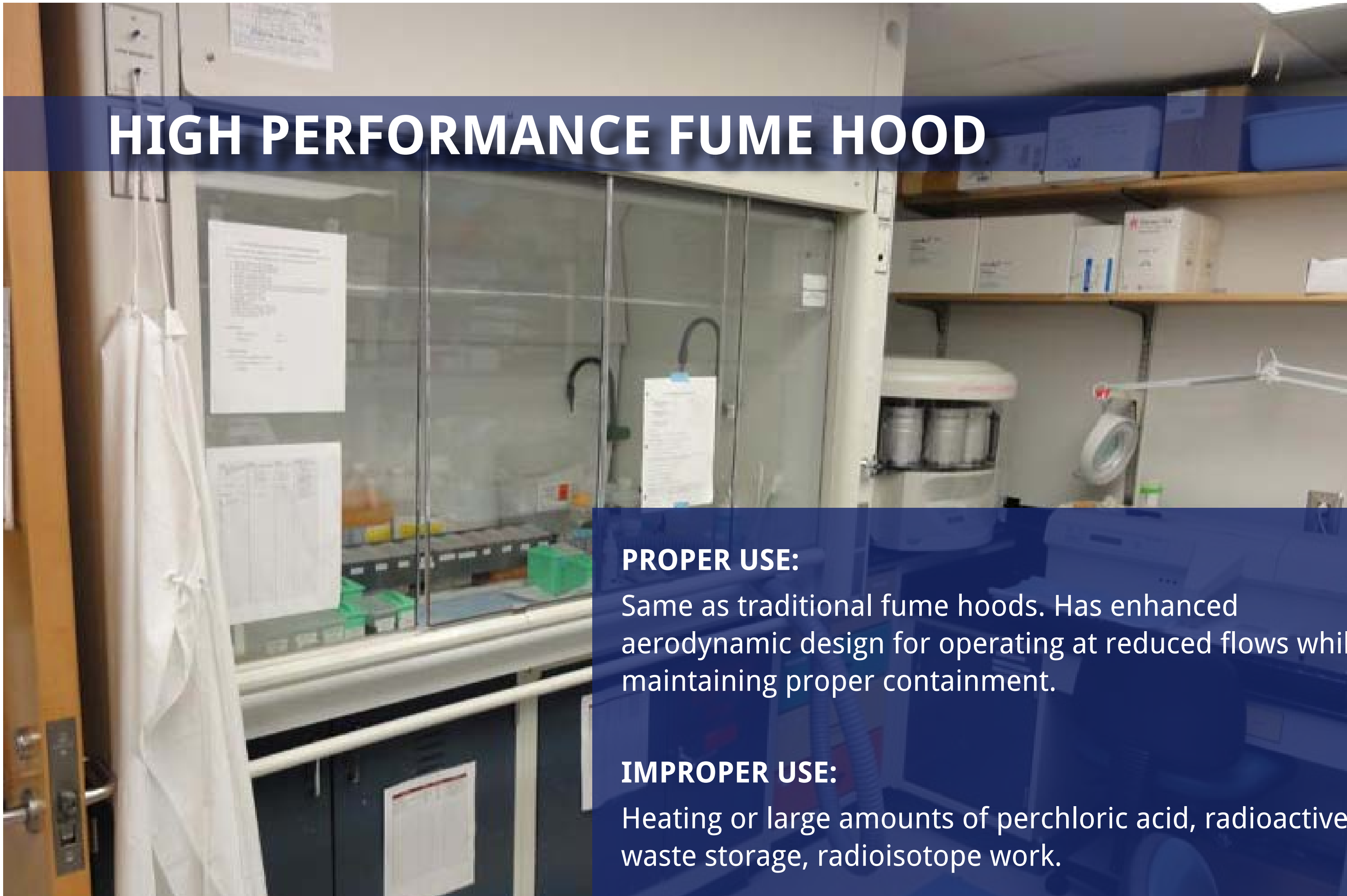
PROPER USE:

Used to isolate radioactive procedures.

IMPROPER USE:

Heating or large amounts of perchloric acid.

HIGH PERFORMANCE FUME HOOD



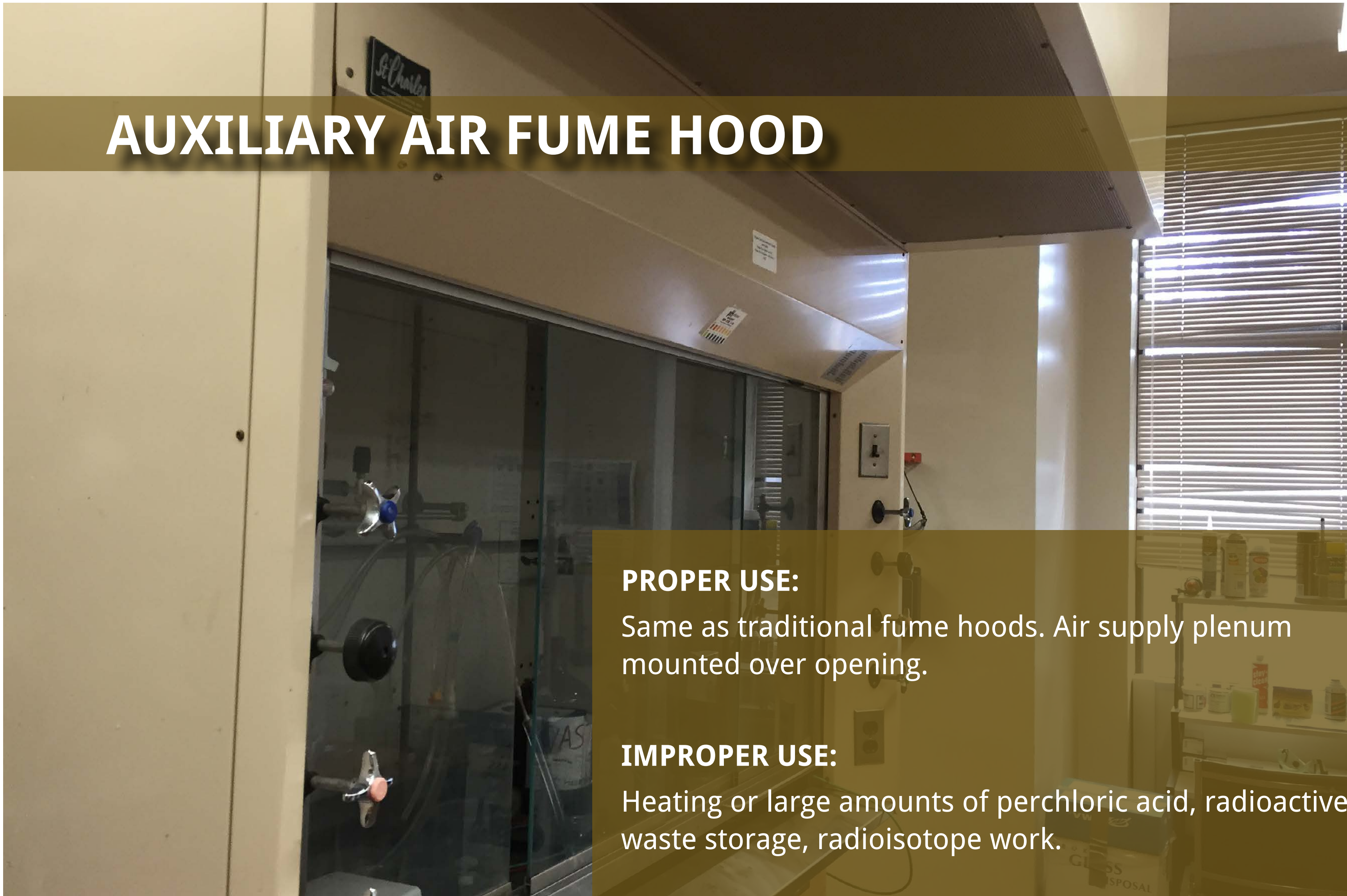
PROPER USE:

Same as traditional fume hoods. Has enhanced aerodynamic design for operating at reduced flows while maintaining proper containment.

IMPROPER USE:

Heating or large amounts of perchloric acid, radioactive waste storage, radioisotope work.

AUXILIARY AIR FUME HOOD



PROPER USE:

Same as traditional fume hoods. Air supply plenum mounted over opening.

IMPROPER USE:

Heating or large amounts of perchloric acid, radioactive waste storage, radioisotope work.

CALIFORNIA FUME HOOD

PROPER USE:

Mainly used for teaching labs.

IMPROPER USE:

Heating or large amounts of perchloric acid, radioactive waste storage, radioisotope work.

BIO-SAFETY CABINET (BSC) CLASS 1

PROPER USE:

Low risk agents, limited personal protection.

IMPROPER USE:

Toxic chemicals or radioactive materials.

Bio-Safety Cabinet (BSC) - Class 2, Type A2

PROPER USE:

Low to moderate risk agents, no product protection. Can be ducted.

IMPROPER USE:

Toxic chemicals or radioactive materials.

BIO-SAFETY CABINET (BSC) CLASS 2, Type B1

PROPER USE:

Low to medium risk agents. Minute toxic chemicals and trace radioactive material. Provides personal, product and environtmental protection.

IMPROPER USE:

Considerable amounts of toxic chemicals or radioactive materials.

BIO-SAFETY CABINET (BSC) CLASS 2, Type B2

PROPER USE:

Higher risk agents, toxic chemicals and radioactive material. Provides personal, product and environmental protection.

IMPROPER USE:

Extremely toxic materials, high quantities, high generating processes.

BIO-SAFETY CABINET (BSC) CLASS 3

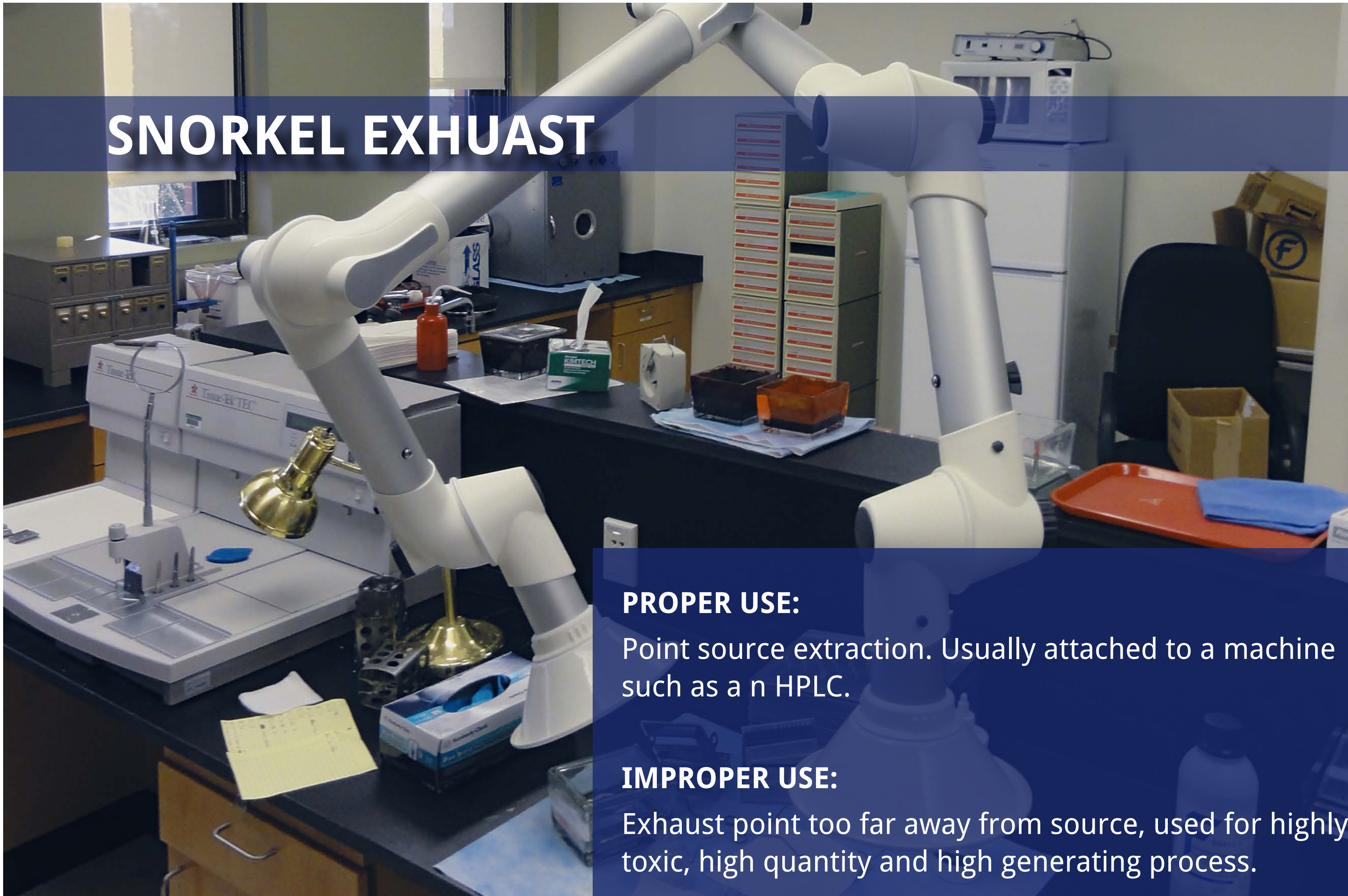
PROPER USE:

Low to medium risk agents. Minute toxic chemicals and trace radioactive material. Provides personal, product and environtmental protection.

IMPROPER USE:

Considerable amounts of toxic chemicals or radioactive materials.

SNORKEL EXHUAST



PROPER USE:

Point source extraction. Usually attached to a machine such as a n HPLC.

IMPROPER USE:

Exhaust point too far away from source, used for highly toxic, high quantity and high generating process.

CANOPY HOOD

PROPER USE:

Heat capture.

IMPROPER USE:

Processes or experiments involving toxic chemicals and high generation rates.

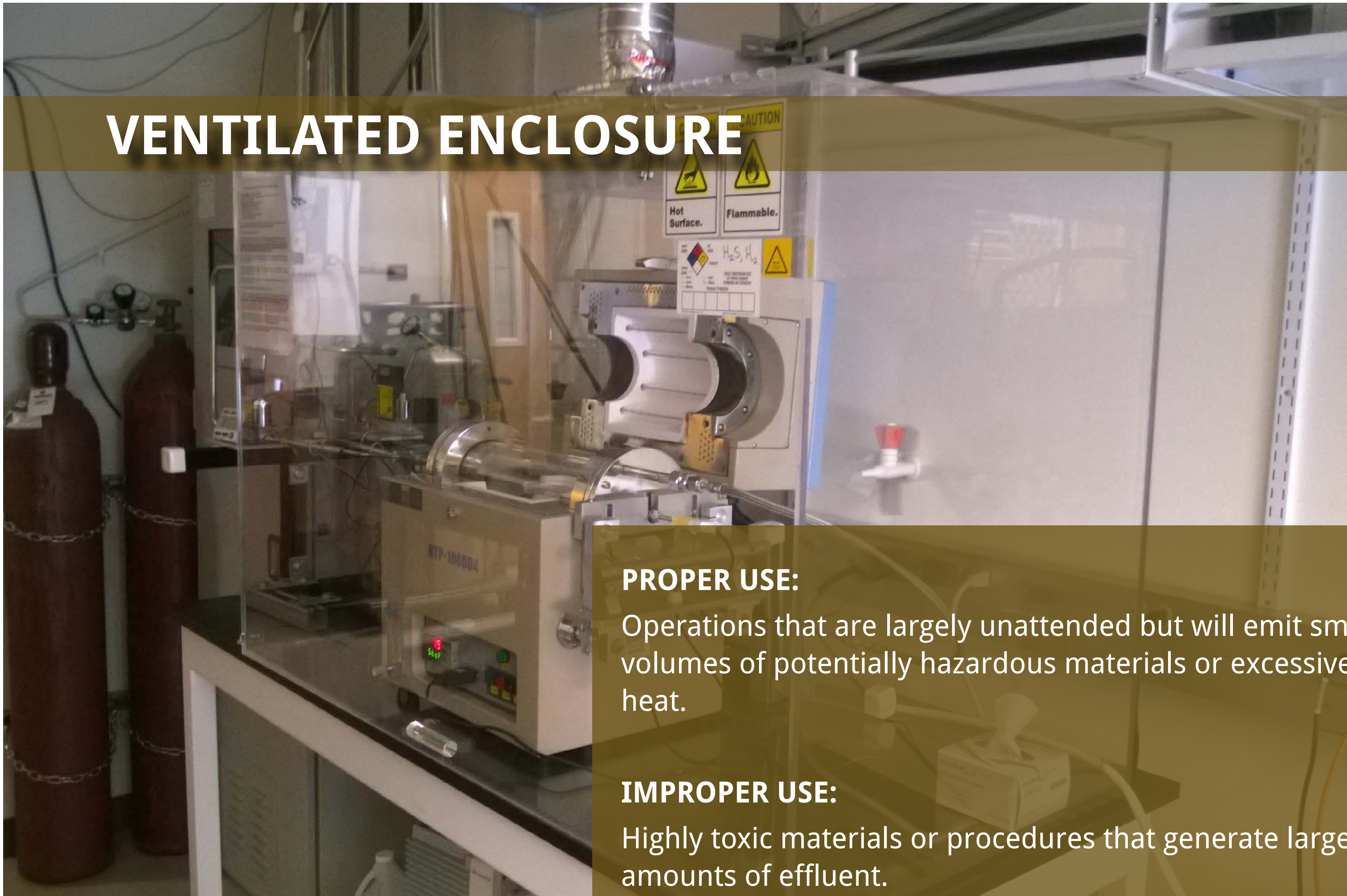
VENTILATED BALANCE ENCLOSURE

PROPER USE:

Weighing of hazardous materials.

IMPROPER USE:

Processes that generate chemical vapors.



VENTILATED ENCLOSURE

PROPER USE:

Operations that are largely unattended but will emit small volumes of potentially hazardous materials or excessive heat.

IMPROPER USE:

Highly toxic materials or procedures that generate large amounts of effluent.

SLOT HOOD

PROPER USE:

Controlling vapors.

IMPROPER USE:

Highly toxic material or procedures that generate large amounts of effluent.

DOWNDRAFT TABLE

PROPER USE:

Intended only for necropsy or similar surgical animal studies.

IMPROPER USE:

Toxic chemical processes.

VENTILATED STORAGE CABINET

PROPER USE:

Storage of flammable or toxic chemicals.

IMPROPER USE:

Extreme quantities.

DUCTLESS FUME HOOD

PROPER USE:

Relatively low hazards, rate of generation and quantities.

IMPROPER USE:

Toxic materials, large generation rate and quantities.

FILTERED FUME HOOD

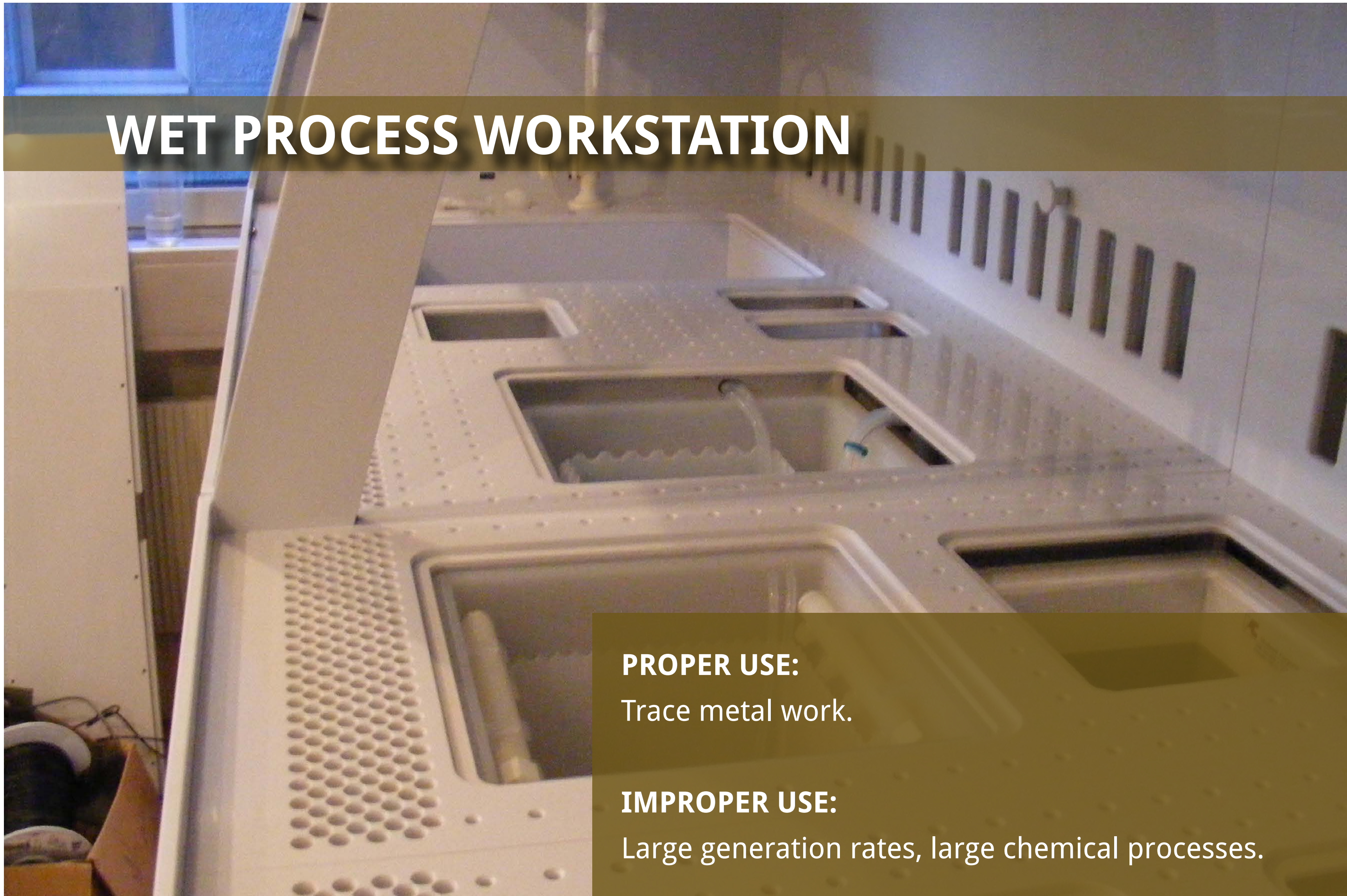
PROPER USE:

Relatively low hazards, rate of generation and quantities.

IMPROPER USE:

Toxic materials, large generation rate and quantities.

WET PROCESS WORKSTATION



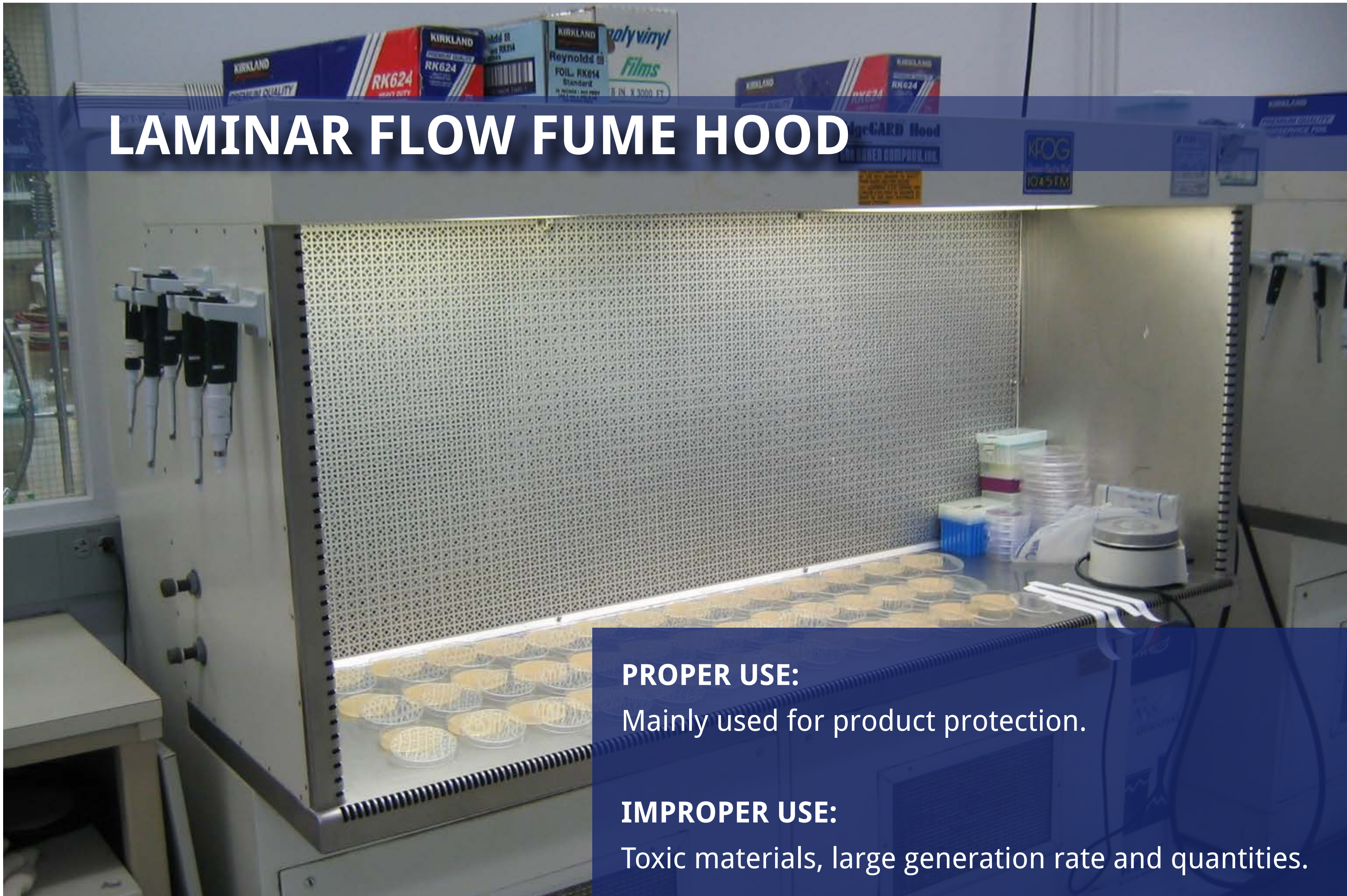
PROPER USE:

Trace metal work.

IMPROPER USE:

Large generation rates, large chemical processes.

LAMINAR FLOW FUME HOOD



PROPER USE:

Mainly used for product protection.

IMPROPER USE:

Toxic materials, large generation rate and quantities.

GLOVEBOX

PROPER USE:

Sensitive chemical and biological contaminants and processes.

IMPROPER USE:

Heating or large amounts of perchloric acid, radioactive waste storage, radioisotope work.

PERCHLORIC ACID HOOD

PROPER USE:

Experiments involving heating or large amounts of perchloric acid.

IMPROPER USE:

Radioactive waste and material.