Health & Safety Considerations for Persons who Have Functional Limitations & Work in Laboratories

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AGENDA

Introduction to ADA & Functional Limitations

Identifying Hazards & Evaluating Risks in Labs

Access to and Egress within Laboratories

Improving Chemical Hood Safety & Testing

Recommendations

Introduction to ADA & Functional Limitations

Examples of ADA - Disabilities *Prior to Final Rule, Aug. 11, 2016*

- AIDS, and its symptoms
- Alcoholism
- Asthma
- Blindness/visual impairments
- Cancer
- Cerebral palsy
- Depression
- Diabetes
- Epilepsy
- Hearing & speech impairments
- Heart disease
- Loss of body parts
- Migraine headaches
- Multiple sclerosis
- Muscular dystrophy
- Orthopedic impairments
- Paralysis
- Complications from pregnancy
- Thyroid gland disorders
- Tuberculosis

Americans with Disabilities Guidelines, 2015, *ADA Standards*, 2010

Introduction to ADA & Functional Limitations

Disability & Functional Limitations have potential to increase risk to workers in laboratories

- Mobility impairments in lower body
- Fine motor impairments in upper body
- Visual impairment
- Hearing impairment
- Vocal/ verbal impairment
- Vestibular impairment
- Peripheral nerve damage
- Developmental disabilities
- Psychological impairment

Americans with Disabilities Guidelines, 2015, *ADA Standards*, 2010

Introduction to ADA & Functional Limitations

U.S. Census Data on Americans with Disabilities

56.7 M Americans with Disabilities, 2010

By age

8% Children 14 years and younger

21% Persons 15 years and older

17% Persons 21 years to 64 years

50% Persons 65 years and older

U. S. Census Bureau, Statistics, Department of Commerce, 2010

Introduction to ADA & Functional Limitations

U.S. Census Data on Americans with Disabilities

56.7 M Americans with Disabilities, 2010

By disability

30.6 M have difficulty walking & climbing stairs

12.0 M require assistance with everyday tasks

8.1 M have vision limitations, partial or total blindness
of whom **3.4** million are Legally Blind (CDC data)

7.6 M have hearing difficulty or total deafness
of whom **26.7** M ≥50 yrs have hearing loss (AMA data)

3.6 M use wheelchairs

2.4 M have Alzheimer's, senility, or dementia

U. S. Census Bureau, Statistics, Department of Commerce, 2010

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Identifying & Evaluating Risks in Labs

HAZARD TYPES	EXAMPLES
AGENT	Carcinogenic, teratogenic, corrosive, pyrophoric, toxic, mutagenic, reproductive hazard, explosive, nonionizing radiation, biological hazard/ pathogenic, flammable, oxidizing, self-reactive or unstable, explosive, reducing, water reactive, sensitizing, peroxide forming, catalytic, or chemical asphyxiate
CONDITION	High pressure, low pressure, electrical/ electrified, uneven surfaces, pinch points, suspended weight, hot surfaces, extreme cold steam, noise, clutter, magnetic fields, simple asphyxiant, oxygen-deficient spaces, ultraviolet radiation, laser light
ACTIVITY	Creation of secondary products, lifting, chemical mixing, long-term use of dry boxes, repetitive pipetting, scale-up, waste handline, transport of hazardous materials, glassware handling, sharp objects handling, heating, recrystallizating, extracting, and centrifuging chemicals

Table 3-1: "Examples of Hazards Commonly Identified for Research Activities", p. 18, 19
Identifying and Evaluating Hazards in Research Laboratories, American Chemical Society, 2015

Identifying Hazards & Evaluating Risks in Labs

- Chemical Safety Levels – Characterization Factors

HAZARD	FIRE	CONCENTRATION	REACTIVITY	ACUTE TOXICITY	CHRONIC TOXICITY	OTHER
CSL-1	Flashpoint above ambient temp (140 deg. F.)		No chemical changes expected in the process	All chemicals have known toxicities and OELs > 500 ppm	None known	
CSL-2	Flashpoint near ambient temp	Expected concentration < 10% LEL	No known incompatibilities between chemicals used	All chemicals have known toxicities and 10 ppm < OELs, < 500 ppm	Specific target organs or irreversible effects suspected	
CSL-3		Expected concentration > 10% LEL	Chemicals with known reactions or contamination hazards present	Unknown toxicities or OEL < 10 ppm	Specific target organs or irreversible effects probable	
CSL-4	Pytophorics, air, or water reactives, etc.		High hazard reactions in use	OEL < 1 ppm	Irreversible toxicities require use of designated areas	

Adapted from Table 8-2: "Approach to Using Raw Data to Assign Chemical Safety Levels", p. 36
Identifying and Evaluating Hazards in Research Laboratories, American Chemical Society, 2015

Identifying Hazards & Evaluating Risks in Labs

- Chemical Safety Level – GHS Hazard Statements

Materials with the following GHS hazard statements are presumed to be a high physical hazard (or health hazard) and subject to a risk assessment of its actual use			
H201	Explosive; mass explosion hazard	**H251**	Self-heating; may catch on fire
H202	Explosive; severe projectile hazard	**H252**	Self-heating in large quantities; may catch on fire
H203	Explosive; fire, blast, or projectile hazard	**H260**	In contact with water, releases flammable gases; can ignite spontaneously
H220	Extremely flammable gas	**H270**	Oxidizer; may cause or intensify a fire
H240	Heating may cause an explosion	**H271**	Strong Oxidizer: may cause fire or explosion
H241	Heating may cause a fire or explosion	**H300**	Fatal if swallowed
H242	Heating may cause a fire	**H310**	Fatal in contact with skin
H250	Catches fire spontaneously if exposed to air	**H330**	Fatal if inhaled

2. Definitions: High Hazard Materials (consider in application to chemical safety levels), p. 14
Identifying and Evaluating Hazards in Research Laboratories, American Chemical Society, 2015

Identifying Hazards & Evaluating Risks in Labs

Techniques to Evaluate Hazards Best Suited for the Research

1. Control Banding of Chemical Uses in Research Laboratories
2. Job Hazard Analysis
3. What-If Analysis
4. Checklists
5. **Structured Development of Standard Operating Procedures**
6. Nomograms

All of these methods rely upon having the right expertise to ask the right questions

Identifying and Evaluating Hazards in Research Laboratories, American Chemical Society, 2015

Identifying Hazards & Evaluating Risks in Labs

Techniques to Evaluate Hazards: **SOP**s
Standard Operating Procedures

- This comprehensive, structured approach to identify _failure points_ of both _single hazards_ and _combinations of hazards_ of an experiment _step by step_.
- Analyze each step separately then combined to reduce risk.
- Can incorporate other methods, but SOPs require more time and expertise than other methods.
- Do a collaborative process with all levels of workers.
- Start by identifying hazards and creating process steps.
- Evaluate hazards and steps one by one; repeat evaluation for combinations of hazards and steps. Write SOPs with results.

Section 12, pp. 81-89
Identifying and Evaluating Hazards in Research Laboratories, American Chemical Society, 2015

Identifying Hazards & Evaluating Risks in Labs

Technique: **SOP**s – Table of Contents (sample)

1. Master SOP for writing quality management documents

SAFETY

2. Procedure in case of spill of specimens in an AFB microscopy laboratory
3. Procedure in case of spill of infectious material within the biological safety cabinet
4. Emergency procedure in case of major biohazard incident outside the BSC
5. Fumigation of a biological safety cabinet
6. Emergency procedure in case of fire
7. Use of personal protective equipment in an AFB microscopy laboratory
8. Use of personal protective equipment for culture and drug susceptibility testing
9. Use of disinfectants

USE & MAINTENANCE OF EQUIPMENT

10. Use and maintenance of class I and class II biological safety cabinets
11. Use and maintenance of an autoclave
12. Use and maintenance of an electromagnetic balance

Manual on Biosafety for Laboratories Involved in Tuberculosis Diagnostic Activities, W.H.O.

Identifying Hazards & Evaluating Risks in Labs

Technique: Standard Operating Procedures (example)

USE & MAINTENANCE OF EQUIPMENT (continued)

13. Use and maintenance of a centrifuge
14. Use and maintenance of a freezer
15. Use and maintenance of a refrigerator
16. Use and maintenance of an incubator
17. Use and maintenance of an inspissator
18. Maintenance of a light microscope
19. Maintenance of a fluorescence microscope
20. Use and maintenance of a pH meter
21. Use and maintenance of a water distiller

PREPARATION OF REAGENTS

22. Preparation of reagents for microscopy
23. Preparation of reagents for culture, drug-susceptibility testing
24. Preparation of plain egg-based media
25. Preparation of Löwenstein–Jensen drug-containing media

Identifying Hazards & Evaluating Risks in Labs

Technique: Standard Operating Procedures (example)

PROCEDURES

26. Ziehl–Neelsen staining
27. Auramine staining
28. Rechecking acid-fast bacilli smears for external quality assessment
29. Sample conditions and transport for culture procedure
30. Specimen processing for culture
31. Drug susceptibility testing, proportion method
32. Identification of Mycobacterium tuberculosis
33. Niacin test
34. Catalase test
35. **Nitrate reduction test**
36. Growth on PNB medium
37. Maintenance of mycobacterial strains

Manual on Biosafety for Laboratories Involved in Tuberculosis Diagnostic Activities, W.H.O.

Identifying Hazards & Evaluating Risks in Labs

- Technique: **SOP**s - Standard Operating Procedures

  Procedure - 35. Nitrate reduction test (example)

Table of Contents

Manual on Biosafety for Laboratories Involved in Tuberculosis Diagnostic Activities, W.H.O.
Jenny Allen, MD, and Janet Baum, December, 2009

Identifying Hazards & Evaluating Risks in Labs

Technique: **SOP**s - Standard Operating Procedures

EVALUATE EACH STEP & TASK	HAZARD IDENTIFICATION (known hazards, safety constraints & restrictions)	SPECIFIC ISSUES IDENTIFIED	RISK ASSESSMENT (what's most likely to go wrong & most severe consequences)	LITERATURE SEARCH & CONSULTATION (with experts & experienced supervisors)	STRATEGIES TO ELIMINATE, CONTROL OR MITIGATE HAZARDS	ELIMINATE, CONTROL OR MITIGATE PLAN A	ELIMINATE, CONTROL OR MITIGATE PLAN B	WILL STANDARD PRECAUTIONS BE ADEQUATE? (develop criteria in writing)
REGULATORY CONCERNS								
HUMAN FACTORS								
FACILITY								
MATERIALS								
EQUIPMENT & LABWARE								
PROCESS								
EFFECT OF CHANGE IN DESIGN OR OF CONDITIONS								
POSSIBILITY FOR ADDITIVE OR SYNERGISTIC EFFECT								
POSSIBILITY OF UNKNOWN EFFECT								
EFFLUENT/ WASTE MANAGEMENT								
AVAILABILITY OF PPE								
EMERGENCY RESPONSE RESOURCES								
POTENTIAL FAILURE POINTS								
ROUTINE ACTIVITIES WITH HIGH RISK OF HARM								

Table 12-1 "Structured Development of SOPs - Work from Detailed Scientific Protocol", pp. 84-85
Identifying and Evaluating Hazards in Research Laboratories, American Chemical Society, 2015

Identifying Hazards & Evaluating Risks in Labs

Techniques to Assess Risk

- Equation
  - Evaluate Severity of Consequences Value [CV]
  - Estimate Probability of Occurrence Value [OV]
  - Risk Rating [RR] = [CV] x [OV]

Appendix B, pp. 93-97
Identifying and Evaluating Hazards in Research Laboratories, American Chemical Society, 2015

Identifying Hazards & Evaluating Risks in Labs

Techniques to Assess Risk

- Evaluate Severity of Consequences Value [CV]

CONSEQUENCE VALUE

RATING	VALUE	PERSONNEL SAFETY	RESOURCES	WORK PERFORMANCE	PROPERTY DAMAGE	REPUTATION
NO RISK	**1**	No injuries	No impact	No delays	Minor	No impact
MINOR	**2**	Minor injuries	Moderate impact	Modest delays	Moderate	Potential damage
MODERATE	**3**	Moderate to life impacting injuries	Additional resources required	Significant delays	Substantial	Damaged
HIGH	**4**	Life-threatening injuries from single exposure	Institutional resources required	Major operational disruptions	Severe	Loss of confidence

It is important to select an appropriate value scale that meets the institution's priorities and risk management

Appendix B, pp. 93-97
Identifying and Evaluating Hazards in Research Laboratories, American Chemical Society, 2015

Identifying Hazards & Evaluating Risks in Labs

Technique to Assess Risk

- Estimate Probability of Occurrence Value [OV]

Select an appropriate value scale that meets your lab's & institution's priorities for risk management

OCCURRENCE VALUE RATING	VALUE	PERCENT
NOT PRESENT	0	0%
RARE	1	1 - 10%
POSSIBLE	2	10 - 50%
LIKELY	3	50 - 90%
ALMOST CERTAIN TO OCCUR	4	90 - 100%

Adapted from Table B-2: "Probability of Occurrence with Standard Linear Scaling"
Identifying and Evaluating Hazards in Research Laboratories, American Chemical Society, 2015

Identifying Hazards & Evaluating Risks in Labs

Technique to Assess Risk: [RR] = [CV] x [OV]

SEVERITY OF CONSEQUENCES [CV] / **PROBABILITY OF OCCURANCE [OV]**

	Acceptable Risk	Tolerable Risk	ADD Strict Controls & Oversight	Intolerable Risk
	CV - 1	**CV - 2**	**CV - 3**	**CV - 4**
OV - 0	Not applicable: Material or process is NOT PRESENT in the lab. RR = 0			
OV - 1	RR = 1 Acceptable	RR = 3 Acceptable	RR = 3 Acceptable	**RR = 4 Tolerable**
OV - 2	RR = 2 Acceptable	**RR = 4 Tolerable**	**RR = 6 Tolerable**	**RR = 8 ADD Strict Controls & Oversight**
OV - 3	**RR = 3 Acceptable**	**RR = 6 Tolerable**	**RR = 9 ADD Strict Controls & Oversight**	**RR = 12 Intolerable**
OV - 4	**RR = 4 Tolerable**	**RR = 8 ADD Strict Controls & Oversight**	**RR = 12 Intolerable**	**RR = 16 Intolerable**

Adapted from Table B-3: "Example of Hazard Risk Rating with Standard Linear Scaling of Values"
Identifying and Evaluating Hazards in Research Laboratories, American Chemical Society, 2015

Identifying Hazards & Evaluating Risks in Labs

Technique to Assess Risk: Nomogram Method

- Software & web applications available
- Semi-quantitatively measures risk
- Easy to visualize risk severity
- Able to manipulate probability, exposure and consequence possible

"The Electronic Risk Score Calculator"
http://www.safetyrisk.com.au/free-safety-and-risk-management-downloads-page-1
Identifying and Evaluating Hazards in Research Laboratories, American Chemical Society, 2015

AGENDA

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Access to and Egress within Laboratories - TURNS

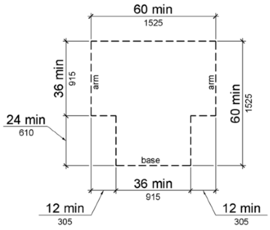


Figure 304.3.2
T-Shaped Turning Space

90° to 360° TURNS
for wheelchair users

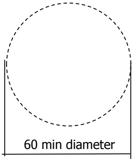


Figure
O–Shaped Turning Space

ADA Standards for Accessible Design, 2010, Dept. of Justice, September 15, 2010, p. 107

Access to and Egress within Laboratories – PATHWAYS

Level **PATHWAYS** with clear widths 42" and 36" allow 180° turns for wheelchair users

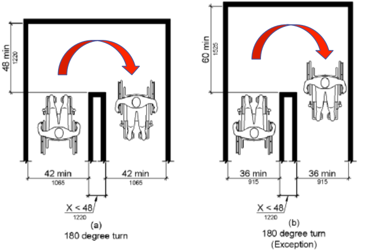


Figure 403.5.2
Clear Width at Turn

ADA Standards for Accessible Design, 2010, Dept. of Justice, September 15, 2010, p. 118

Access to and Egress within Laboratories – DOORS

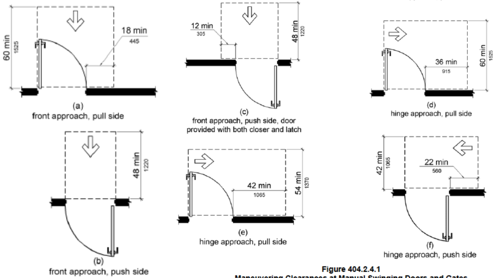


Figure 404.2.4.1
Maneuvering Clearances at Manual Swinging Doors and Gates

ADA Standards for Accessible Design, 2010, Dept. of Justice, September 15, 2010, p. 121

Access and Egress within Laboratories – EXIT ROUTES

OSHA 1910.37(a)(2)

"EXIT ROUTES must be kept free of explosive or highly flammable furnishings or other decorations."

"EXIT ROUTES must be arranged so that employees will not have to travel toward a high hazard area, unless the path of travel is effectively shielded from the high hazard area by suitable partitions or other physical barriers."

Laboratory Standard 1910.1450 (OSHA, 2013), Occupational Safety & Health Administration
Guidelines for Laboratory Design: Health, Safety, & Environmental Considerations, 4th Ed., 2013, p. 70.

Access Within Laboratories and Egress

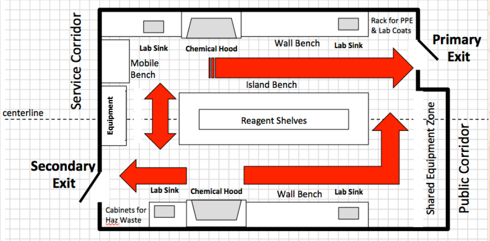
Hazard Zoning Concept – *Guidelines for Laboratory Design: Health, Safety, and Environmental Considerations*, 4th Ed., DiBerardinis, Baum, First, Gatwood, Seth

"The safest arrangement for laboratory egress is for each required exit door to open into a separate fire zone and for each exit to be located so the pathways within the laboratory or laboratory suite are separated, as far apart as feasible. Thus, when an accident or other emergency makes one laboratory escape pathway impassable, the second can provide an alternative safe route out to another fire-rated building egress pathway."

Guidelines for Laboratory Design: Health, Safety, & Environmental Considerations, 4th Ed., 2013, p. 70.
Occupational Safety & Health Administration, *Laboratory Standard* 1910.1450 (OSHA, 2013)

Access to and Egress within Laboratories

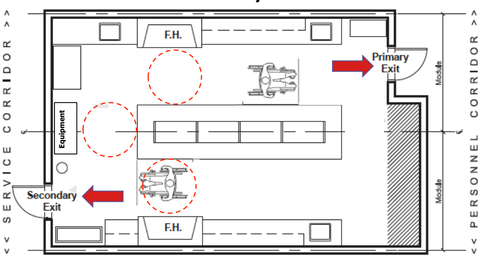
Hazard Zoning Concept – GLD, 4th Ed., 2013



Guidelines for Laboratory Design: Health, Safety, & Environmental Considerations, 4th Ed., 2013
Laboratory Standard 1910.1450 (OSHA, 2013), Occupational Safety & Health Administration

Access to and Egress within Laboratories

Wheelchair Accessibility



2010 ADA Standards for Accessible Design, Dept. of Justice, September 15, 2010

Guidelines for Laboratory Design: Health, Safety, & Environmental Considerations, 4th Ed., 2013

Access to and Within Laboratories and Egress

Wheelchair Accessibility – Height & Reach Limits: FORWARD

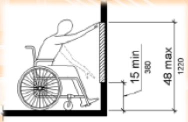


Figure 308.2.1
Unobstructed Forward Reach

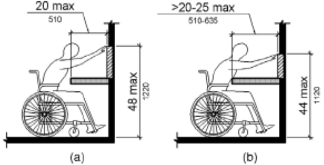


Figure 308.2.2
Obstructed High Forward Reach

ADA Standards for Accessible Design, 2010, Dept. of Justice, September 15, 2010, p. 114

Access to and Within Laboratories and Egress

Wheelchair Accessibility – Height & Reach Limits: SIDE

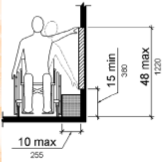


Figure 308.3.1
Unobstructed Side Reach

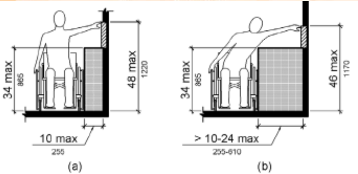


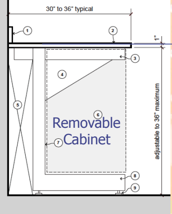
Figure 308.3.2
Obstructed High Side Reach

2010 ADA Standards for Accessible Design, Dept. of Justice, September 15, 2010, pp. 115, 116

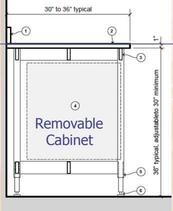
Access to and Within Laboratories and Egress

Wheelchair Accessible Lab Benches

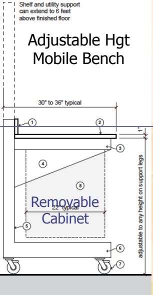
Adjustable Hgt.
C -Frame



Adjustable Hgt.
Table Frame



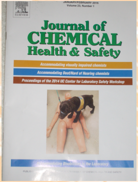
Adjustable Hgt
Mobile Bench



Guidelines for Laboratory Design: Health, Safety, & Environmental Considerations, 4th Ed., 2013

Access to and Egress within Laboratories

Articles - Accommodating visually impaired and deaf chemists



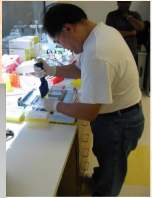
"The Value of Safety & Practicality: Recommendations For Training Disabled Students in the Sciences with a Focus on Blind & Visually Impaired Students in Chemistry Labs" By Nepomuceno, Decker, Shaw, Boyes, Tantillo, and Wedler

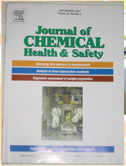
"Chemical and Biological Research with Deaf and Hard-of-Hearing Students and Professionals: Ensuring a Safe & Successful Laboratory Environment" By Smith, Ross, and Pagano

Journal of Chemical Health & Safety. January/February, 2016, Volume 23, No. 1
pp. 5 – 11 and pp. 24 – 31 respectively

Access to and Egress within Laboratories

Ergonomic Challenges





"There are 2 components for the long-term solution to reduce the observed awkward postures associated with sample preparation tasks:

- *Work Station Design* and
- *Implementation of Stretching Program*

Due to the variations amongst the 6 observed tasks, workstation design considerations need to be tailored to the individual tasks."

"An Ergonomic Assessment of Sample Preparation Job Tasks in a Chemical Laboratory" by M. Mork, S. Choi, Journal of Chemical Health & Safety. July/August, 2015, Volume 22, No. 4, pp. 23 – 32

Access to and Egress within Laboratories

Sight Impairment

703.4 Installation Height and Location. Signs with *tactile characters* shall comply with 703.4.

703.4.1 Height Above Finish Floor or Ground. *Tactile characters* on signs shall be located 48 inches (1220 mm) minimum above the finish floor or ground surface, measured from the baseline of the lowest *tactile character* and 60 inches (1525 mm) maximum above the finish floor or ground surface, measured from the baseline of the highest *tactile character*.

EXCEPTION: *Tactile characters* for elevator car controls shall not be required to comply with 703.4.1.

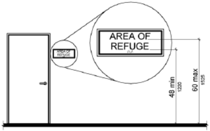


Figure 703.4.1
Height of Tactile Characters Above Finish Floor or Ground

2010 ADA Standards for Accessible Design, Dept. of Justice, September 15, 2010, pp. 189

Access to and Egress within Laboratories

Hearing Impairment

703.7.2.4 Assistive Listening Systems. *Assistive listening systems* shall be identified by the International Symbol of Access for Hearing Loss complying with Figure 703.7.2.4.

Figure 703.7.2.4
International Symbol of Access for Hearing Loss

2010 ADA Standards for Accessible Design, Dept. of Justice, September 15, 2010, pp. 194

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Improving Chemical Hood Safety & Testing

WHY Study Chemical Hood Containment?

Images provided by Farhad Memarzedeh, Ph.D., P.E., National Institutes of Health

Improving Chemical Hood Safety & Testing

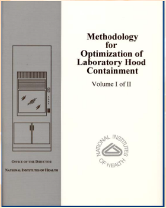
WHY Study Chemical Hood Containment?

Images provided by Farhad Memarzedeh, Ph.D., P.E., National Institutes of Health

Improving Chemical Hood Safety & Testing

NIH Study of Chemical Hood Containment & Performance

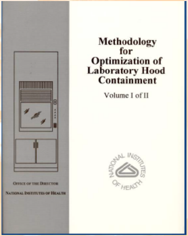
http://orf.od.nih.gov/PoliciesAndGuidelines/Bioenvironmental/



National Institutes of Health, Farhad Memarzedeh, Ph.D., P.E.
Methodology for Optimization & Testing of Laboratory Hood Containment, Volumes 1 - 11

Improving Chemical Hood Safety & Testing

Project Approach for NIH Study FH Containment

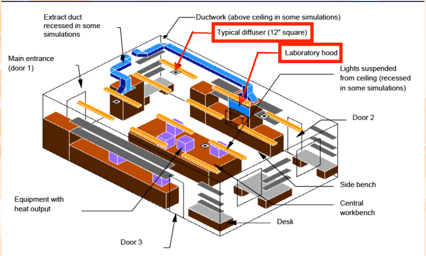


National Institutes of Health (NIH) recognized that numerical modeling could be used to look at many configurations and therefore allow a more comprehensive study.

- Uses airflow modeling to undertake a sensitivity study of >**250** lab configurations. This represents over **1M measurements for each configuration**.
- Provides good understanding of ventilation and containment performance of chemical hoods.
- Provides a **scientific comparison** of >250 different configurations for containment.

Improving Chemical Hood Safety & Testing

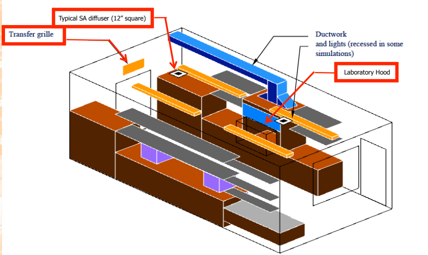
Lab 33 ft. by 22 ft.- 1 chemical hood on long wall



National Institutes of Health, Farhad Memarzedeh, Ph.D., P.E.
Methodology for Optimization & Testing of Laboratory Hood Containment, Volumes 1 - 11

Improving Chemical Hood Safety & Testing

Lab 22 ft. by 11 ft.- 1 chemical hood on long wall



Improving Chemical Hood Safety & Testing

Other Experimental Configuration Parameters

Diffusers:	Location, Number, and Type (square, radial, perforated, laminar, or displacement)
Supply Air:	Temperature 50° F. to 63.5° F., and Velocity
Ventilation Rate:	6 to 34.7 Air Changes per Hour (ACH)
Hood Face Velocity:	50 fpm and 100 fpm
Heat Source (chamber):	5.16 watt/ft^2 to 12 watt/ft^2
Make-Up Air Position:	Door crack and Transfer grill
Make-Up Air Quantity:	0 CFM to 542 CFM
Scientist in front of FH	Presence or Absence
Equipment in front FH	Presence or Absence

Improving Chemical Hood Safety & Testing

Project Methodology for NIH Lab Hood Study

Computational Fluid Dynamics (CFD) is:

Computational – computer software to solve equations

Fluid – substances that cannot remain at rest under shearing stress

Dynamics – study of object in motion and forces involved.

1) Numerical work: Air Flow Modeling with CFD.

- Equations represent fundamental physics of conservation of mass, momentum, & energy.
- Particle Tracking – The air flow conditions to which particles are subjected to are calculated using an Eulerian frame of reference.
- Post-Process Analysis

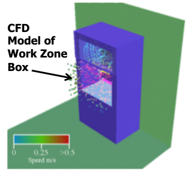
2) Empirical Work - Validation of FH on site

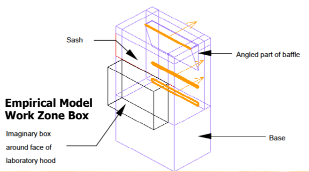
3) Validation Procedure - Over 13M experimental measurements were collected to confirm the methodology and results of the numerical work.

Improving Chemical Hood Safety

Containment Analysis of NIH Study - **Hood Leakage**

Diagrams of Experimental Test Set-up





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Containment Analysis of NIH Study - **Hood Leakage**

Chemical hood is filled with tracer gas (SF_6). Outward flow of tracer gas is measured twice and assessed

1) From the face of the hood sash into the working zone box

AND

2) From the working zone box into the laboratory, away from the chemical hood and into workers' breathing zone.

Industrial Hygienists can use Sash Leakage Factor (SLF) to **calculate the actual leakage given a known source & rate of contaminant generated in the chemical hood**.

National Institutes of Health, Farhad Memarzedeh, Ph.D., P.E.
Methodology for Optimization & Testing of Laboratory Hood Containment, Volumes 1 - 11

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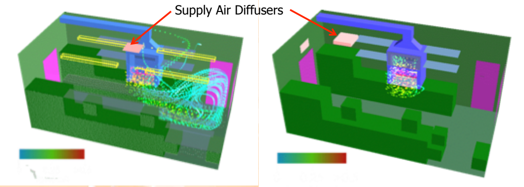
Containment Analysis of NIH Study - **Hood Leakage**

Diagrams of COMPUTATIONAL Test Set-up #1 of SA Diffusers



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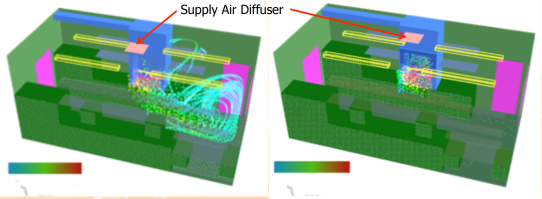
Containment Analysis of NIH Study - Hood Leakage

Diagrams of COMPUTATIONAL Test Set-up #3 of SA Diffusers



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Containment Analysis of NIH Study - **Hood Leakage**

- SASH LEAKAGE FACTOR (SLF) is the concentration, as a fraction of the hood flow, that leaks outwards, against the flow and out of the hood sash opening into the working zone or box.
- BOX LEAKAGE FACTOR (BLF) is the concentration, as a percent of the hood flow out through all 5 faces of the box into the laboratory, away from the chemical hood.
- BOX/SASH LEAKAGE FACTOR is BLF ÷ SLF = percent measurement of the hood's ability to scavenge the working zone to retrieve contaminants leaked through the sash opening by other actions (i.e. motion of the scientist working at the sash, or fluctuation in the ventilations system, or a person passing by the front of the chemical hood).

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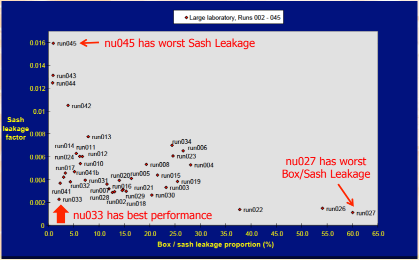
Sash Leakage Factor ÷ Box/Sash Leakage Proportion



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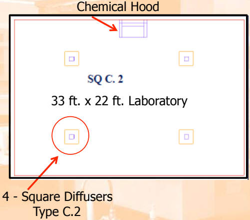
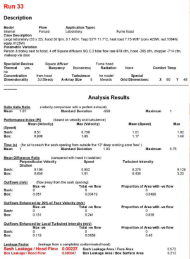
Sash Leakage Factor ÷ Box/Sash Leakage% - **Trial Run #33**





Run 33

Description

Model Internal | **Flow** Forced | **Application Types** Laboratory | Fume hood

Case Description
Large laboratory (33 x 22), hood 50 fpm, 8.1 ACH, Tsup 53°F 11.7°C, heat load 7.75 W/ft² (conv.420W, rad.1084W, equip.4125W)

Parametric Variation
Person & trolley next to hood, 4 off Sqaure diffusers SQ C.2 total flow rate 979 cfm, hood -365 cfm, dropper -714 cfm, makeup via door

Specialist Devices Square diffuser Fume hood
Thermal yes **Buoyancy** Boussinesq **Radiation** None **Comfort Temp** no
Concentration from hood **Turbulence** ke model **Special**
Dimensionality 3d Steady **A-Array Size** 5 Mwords **Grid Dimensions:** X 60 Y 48

Analysis Results

Dalle Valle Ratio (velocity comparison with a perfect exhaust)
Mean 1.01 **Standard Deviation** -999 **Maximum** 1

Performance Index (PI) (based on velocity and turbulence)

	Mean (Velocity)	Max (Velocity)	Mean (Speed)	Max (Speed)
Sash:	0.51	0.756	1.01	1.02
Box:	0.906	1.65	1.17	1.46

Time (s) (for air to reach the sash opening from outside the 13" deep working zone 'box')
Mean 1 **Standard Deviation** 1.03 **Maximum** 5.75

Mean Difference Ratio (compared with hood in isolation)

	Perpendicular Velocity	Speed	Turbulent Intensity	Dilution
Sash:	0.196	0.952	0.276	0.128
Box:	0.656	1.01	0.438	3.23

Outflows (m/s) (flow away from the sash opening)

	Max -ve	Total -ve flow	Proportion of Area with -ve flow
Sash:	0	0	0
Box:	0.051	0.00479	0.0498

Outflows Enhanced by 20% of Face Velocity (m/s)

	Max -ve	Total -ve flow	Proportion of Area with -ve flow
Sash:	0	0	0
Box:	0.151	0.241	0.659

Outflows Enhanced by Local Turbulent Intensity (m/s)

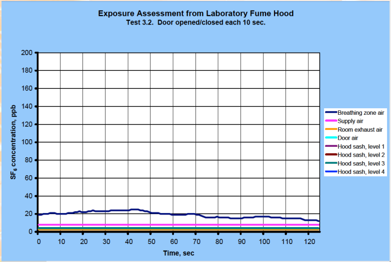
	Max -ve	Total -ve flow	Proportion of Area with -ve flow
Sash:	0	0	0
Box:	0.119	0.0859	0.46

Leakage Factor (leakage from a completely contaminated hood)

Sash Leakage / Hood Flow	**0.00227**	Sash Leakage Area / Face Area	0.572
Box Leakage / Hood Flow	0.000047	Box Leakage Area / Box Surface Area	0.212

Improving Chemical Hood Safety & Testing

Exposure Assessment on Fume Hood – Test 3.2



Lab door opens & closes every 10 sec.

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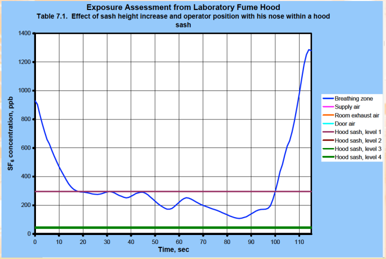
Exposure Assessment on Fume Hood – Test 7.1

FH Operator raises sash to nose height



Improving Chemical Hood Testing - ASHRAE / ANSI *Standard 110-1995* vs. NIH *Laboratory Fume Hood Specifications & Performance Test Requirements*, 2012

ASHRAE/ANSI Std 110	NIH Lab FH Performance Test, 2012
Qualitative test	Quantitative test
No standard for pass/fail	Value standards for pass/fail
Real conditions ignored	Real conditions simulated •Items within FH chamber •Items on benches in lab •Heat sources on benches
No dynamic challenge	Dynamic challenge – walk-by

ASHRAE/ANSI Standard 110, 1995
National Institutes of Health, Farhad Memarzedeh, Ph.D., P.E.
Methodology for Optimization & Testing of Laboratory Hood Containment, Volumes 1 - 11

AGENDA

Introduction to Disabilities

Identifying Hazards & Evaluating Risks in Labs

Access to and within Laboratories and Egress

Improving Chemical Hood Safety & Testing

Recommendations

Appendices

RECOMMENDATIONS -

Principal Investigators, Lab Managers, Scientific Director

- Require - Hazard Identification Process
  - For the entire laboratory, all workers & tasks
  - For functionally limited lab workers & their specific tasks
  - Include ergonomic analyses for all workers
- Require Risk Analyses for all experiments
- Support – Compliance to laboratory with *2010 ADA Standards Accessible Design*, Dept. of Justice, September 15, 2010
- Seek safety, IH, & engineering expertise for selection of chemical hoods and testing protocols, and changes in lab.

RECOMMENDATIONS -

Laboratory Health and Safety Professionals

- Promote and conduct further research on chemical hoods to improve containment & safe operations of FH
- Promote and conduct further research on operating procedures commonly performed in chemical hoods and improve operators' compliance with safe standards.
- Address safe FH specific performance considerations for persons with disabilities who operate hoods.
- Cooperate with and contribute to work of FH testing agencies to develop more accurate, quantitative, science-based FH testing procedures.

Health & Safety Considerations for Persons who Have Functional Limitations & Work in Laboratories

THANK YOU FOR YOUR ATTENTION.

QUESTIONS?

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