Cost-effective Biosafety and Biosecurity

ABSA

October 23, 2013

Barbara Johnson PhD, RBP

Biosafety Biosecurity International • Biocontainment Solutions

Places to Save

- Design
- Construction/Engineering Equipment
- Energy + Water Consumption
- Inefficient Labor Use/Lost Time
- PPE/Reagents Use

Works whether its new construction or renovation

Design and Right-size Facilites from the Start

- Pre-design meeting w/EHS to establish project Life Safety approach and protocols…Risk Assessment
- Break out exceptional procedures/activities that require higher levels of protection and isolate them.
- Establish minimal exhaust rates based on need (codes, heat load, equipment)… higher exhaust rate ≠ safer workplace.
- Establish the distinction between flexibility + adaptability (flexibility adds cost).



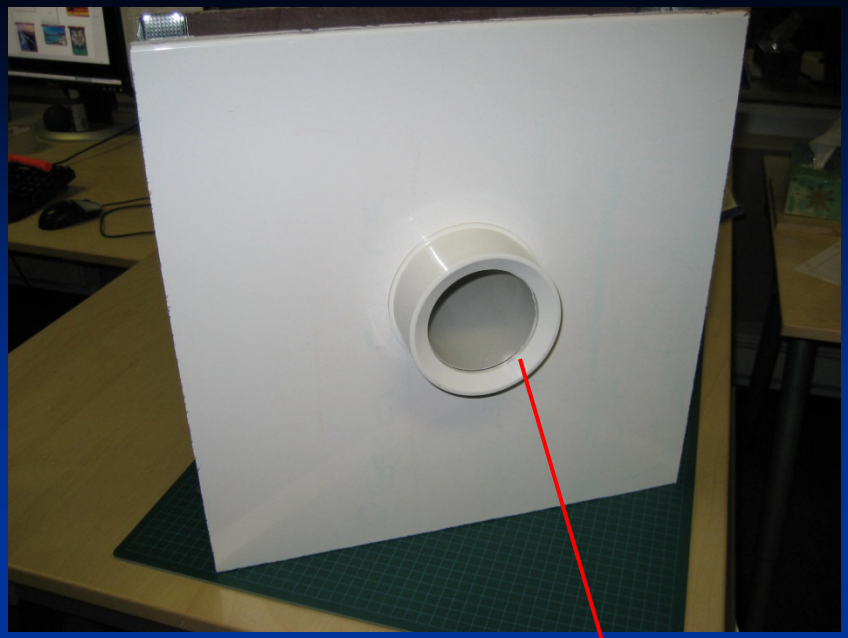

Design/Construction: Engineered Leaks

Adjustable
Door Seals

Backdraft
Dampers

PVC
Adjustable
Openings

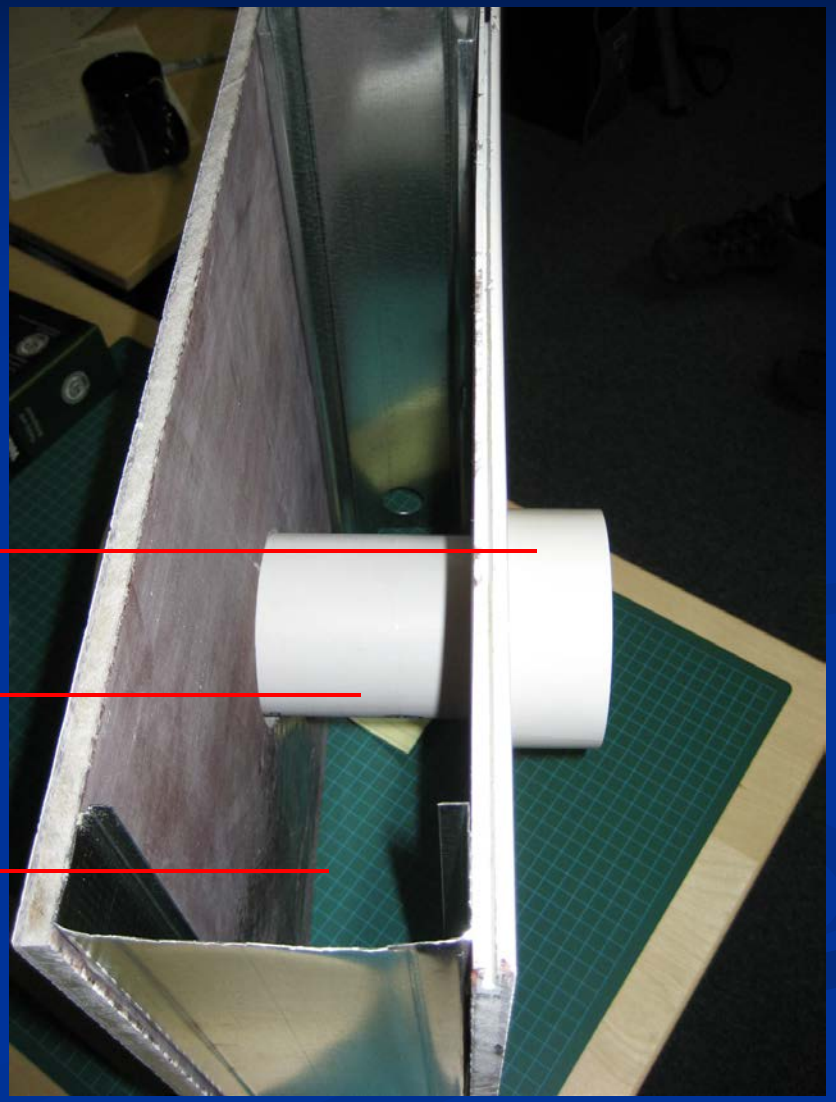
Filtered
Bypass



PVC bushing

PVC pipe

View inside wall cavity



HVAC Energy Recovery (standard): Runaround Coils

- Pro's- supply and exhaust air not required to be close together; can work on system without shutting down airflow
- Con's- Additional moving parts; poor efficiency <50%; little gain in the summer; requires larger building area for coils/pumps

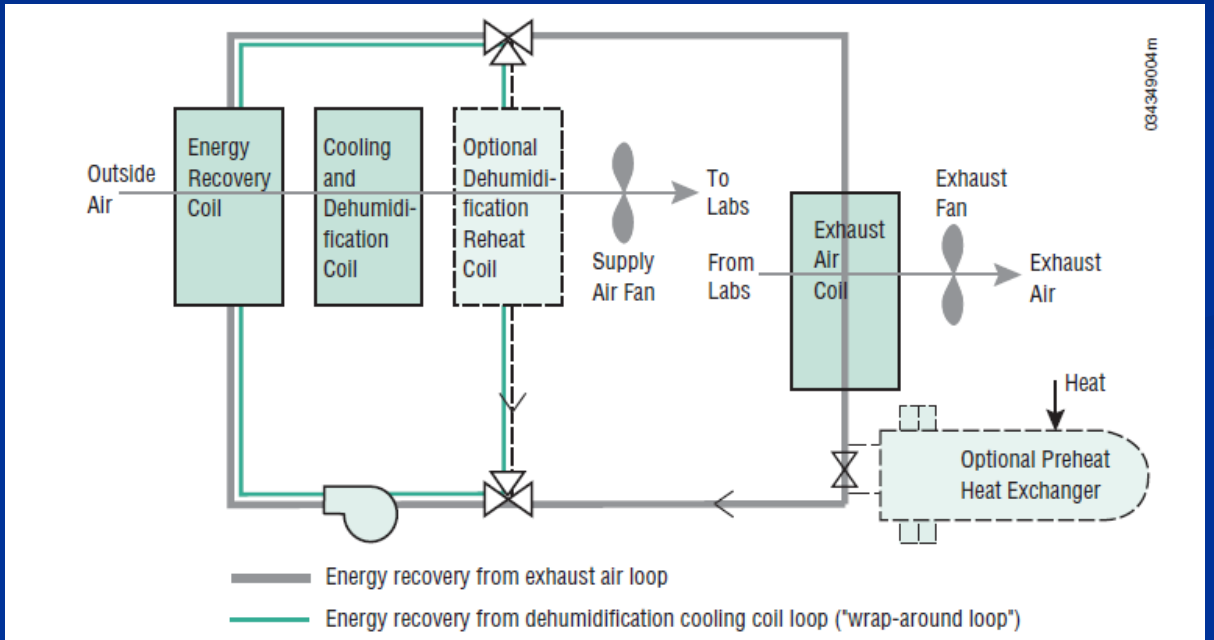


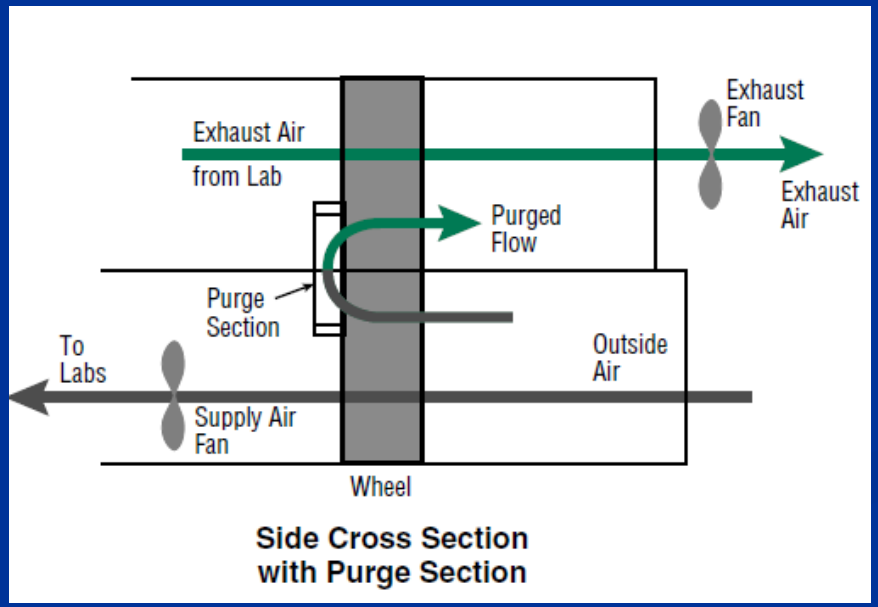
Figure 3. Run-around energy recovery loop with dehumidification

Laboratories For The 21st Century: Best Practices

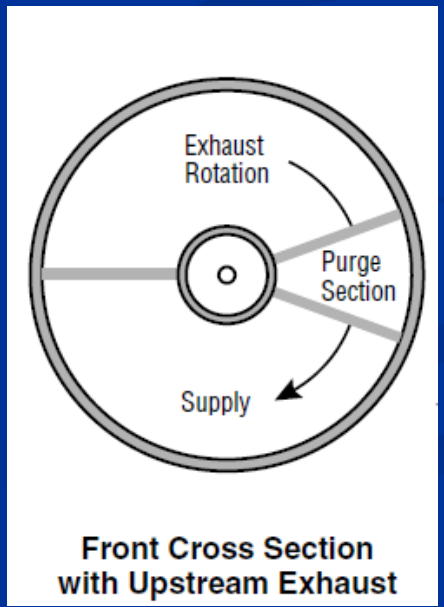
NEIDL. IRF, RML

HVAC Energy Recovery (up coming?): Enthalpy Wheels

- Pro's- most efficient up to 70% recovery summer and winter; good in humid regions; use in BSL-2 w/small BSL-3
- Con's- supply/exhaust must be nearby (often not done for BSL-3); some air purges from exhaust (post-HEPA) into supply (trepidation); ammonia odor from animals



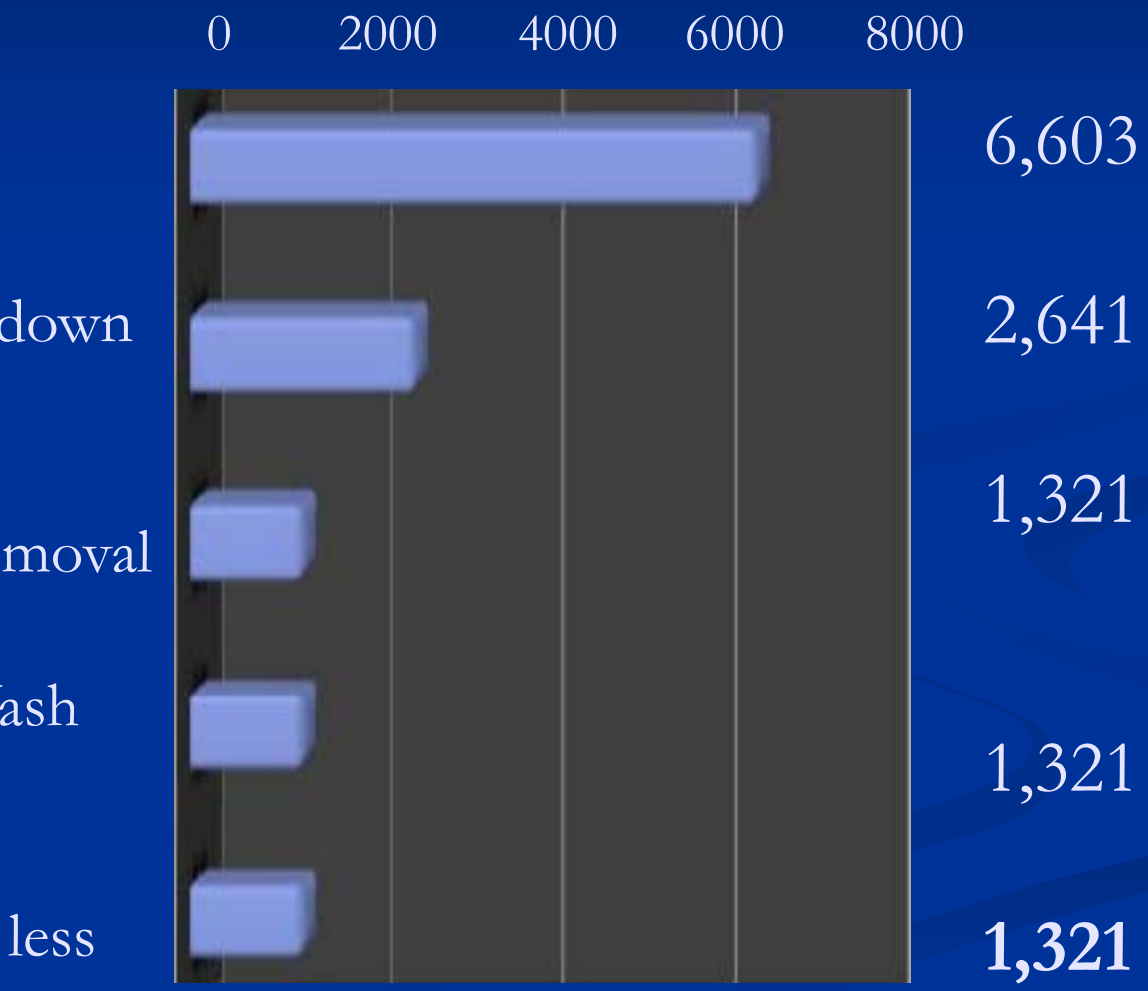
Side Cross Section with Purge Section



Front Cross Section with Upstream Exhaust

Emory Whitehead

Water: Animal Room Washdown



Tradeline- International Conf. on Biocontainment Facilities

Save Energy with Practices: BSL-3 Cagewash using Warm Water

- BSL-3 cages are autoclaved before wash…they are sterile
- No regulatory requirement for additional hot water wash and rinse once sterilized
- Reduce water temp and amount of detergent needed to perform final cage cleaning
- Store and use within 2 weeks

Cage Wash – Relatively Large Savings

Consider equipment offered with 'packaged' water conservation kits for sterilizers and cage wash,

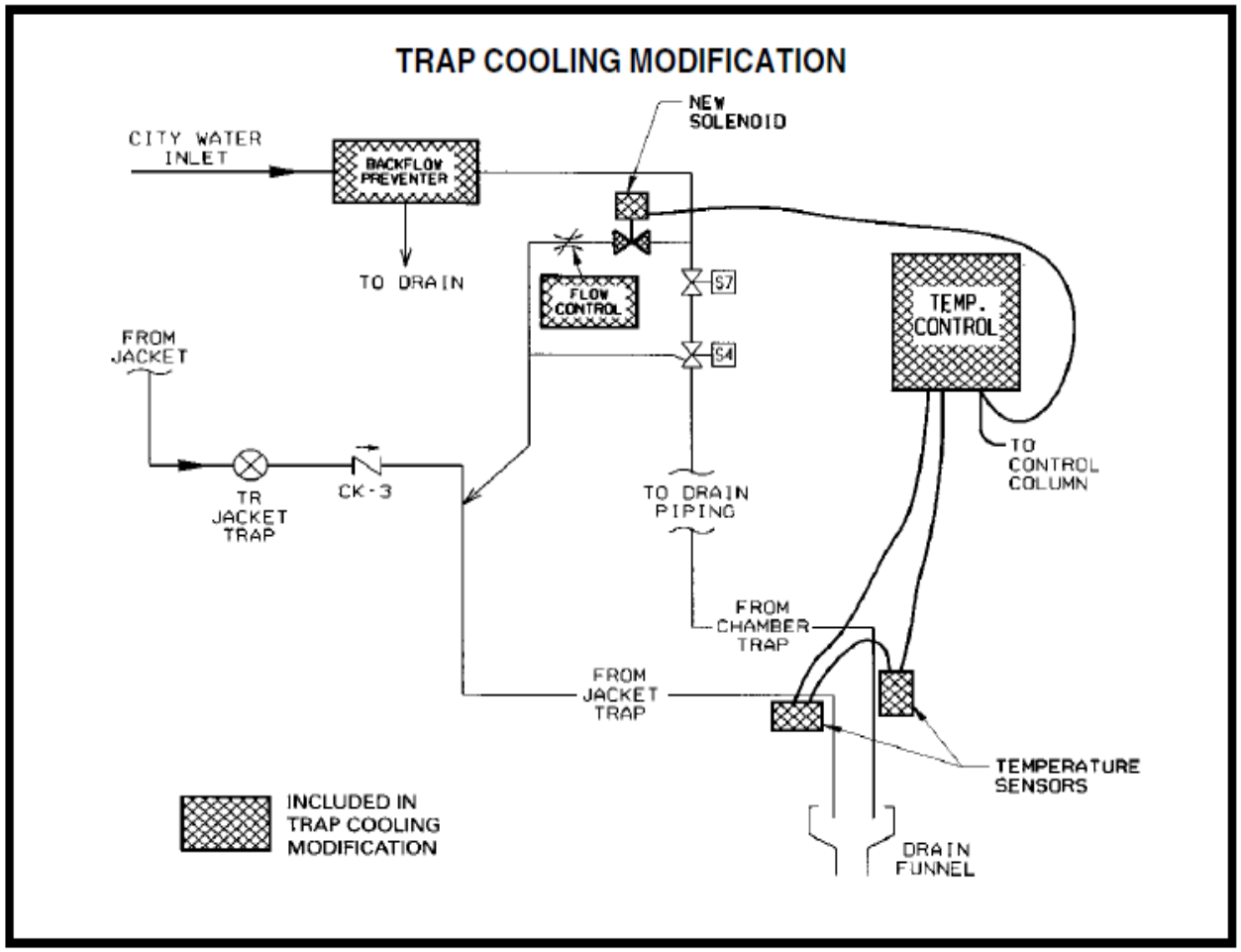
Typical features include:

- Modulating valves with temperature sensor rather than on/off solenoid valves,
- Heat exchangers using chilled water rather than domestic water,
- Use low water flow strainer,

Potential water reduction of 60%-80% whether running cycles at 6, 11 or 18 gal/min.

Retrofit: Water Conservation Kits

- Autoclaves generally small savings
- Reduce use from ~60 gal/hour to 23 gal/hour during idle periods (assume cooling occurs 24/7)



Annual energy savings: $4,537

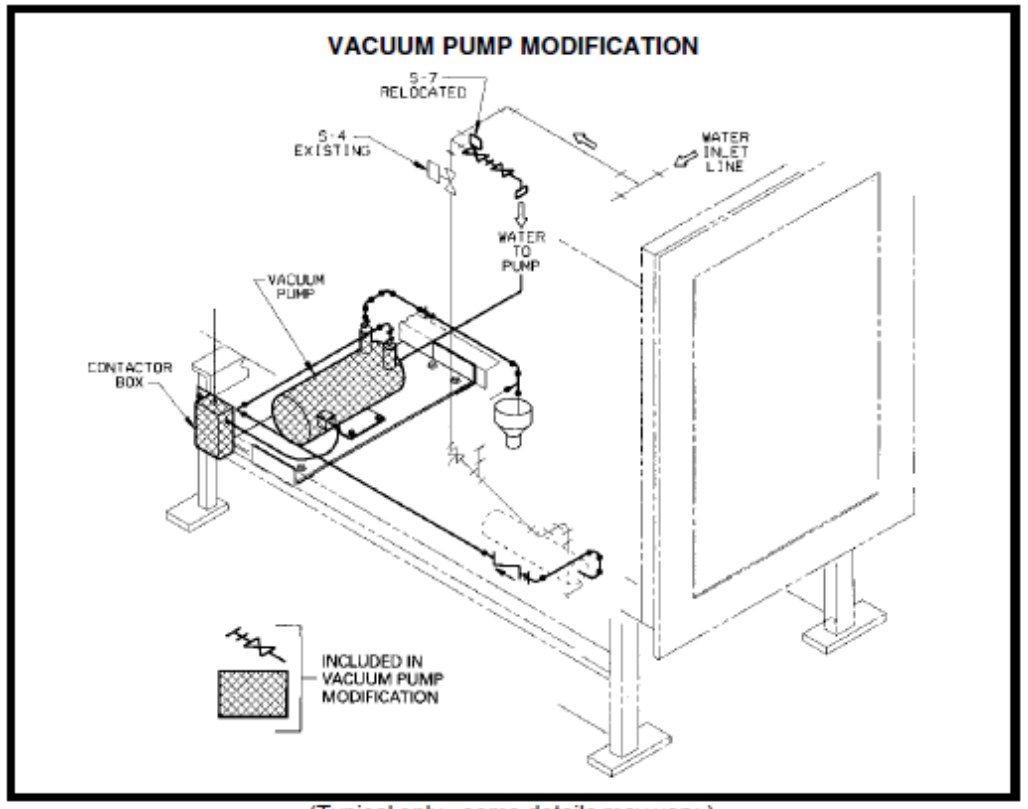
Water conserved: 324,129 gal/yr

Retrofit: Autoclave Vacuum Pump Mod

- Can drop Peak water from 6 gpm to 1.5 gpm.
- Can save ~90 gallons of water during a typical vacuum drying phase.
- 3-phase power required

Vacuum Pump Upgrade
Assume 25 cycles per week with 20 min drying+10 min prevac pulsing

Annual Energy Cost Savings- $2,457
175,500 gal/year



(Typical only - some details may vary.)

Water + Energy Savings: Glassware Washer

Consider equipment offered with 'vented' drying option:

- Thimble connected venting option allows for ↓ heat loss to room.
- Typical airflow reduction is approximately 200-250 cfm per glass washer.

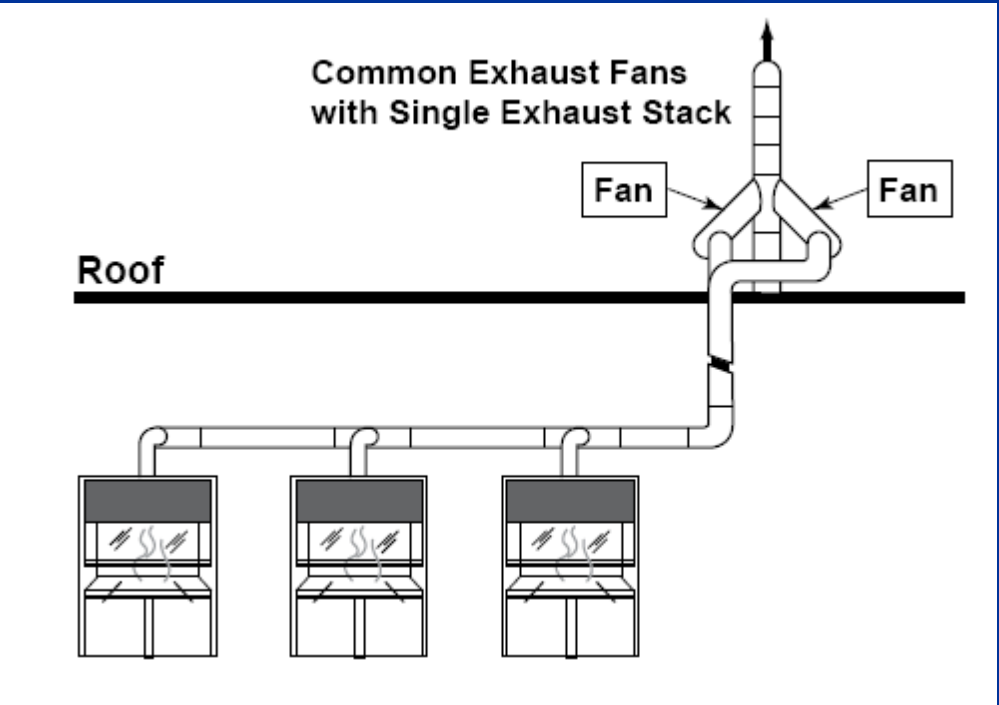
Heat recovery systems:

- Heat recovery from effluent and transfer to cold water used for next treatment, ↓ need for hot water utility/reduced cold water for effluent cooling

HVAC & 1º Containment: Manifold Exhaust System

- ↓ fan power due to ↓pressure drop in ductwork
- ↓ initial cost - easier installation ↓amount duct
- Exhaust fan requires 1 backup fan system;

redundancy = safety



HVAC & 1º Containment: Variable Volume Fume Hoods

- In-built damper restricts airflow based on sash opening
- ↓s airflow when not in use but still running i.e. process ongoing inside
- ↓size of building chiller (bonus savings)

Savings in reducing vertical opening and face velocity - $4480/yr

Location	New York City, New York, United States	New York City, New York, United States

ASSUMPTIONS	Hood 1	Hood 2	
Energy Prices [1]			
Electricity	0.1814	0.1814	$/kWh
Electricity Demand	120	120	$/kW-yr
Fuel	6.5	6.5	$/million BTU
Operation [2]	12	12	hr/day
Hood Opening (Horizontal)	60	60	inches
Hood Opening (Vertical)	28	18	inches
Face Velocity	100	60	ft/min
Fan Power (supply/exhaust) [3]	1.80	1.80	W/CFM
Cooling Plant Efficiency	1.00	1.00	kW/ton
Heating System Efficiency	70	70	percent
HVAC Supply Air Setpoints			
Heating	55	55	°F
Cooling	55	55	°F
Reheat Energy [4]			
Delivery Air Temp.	65	65	°F
Energy Type	Electricity	Electricity	

ANALYSIS	Hood 1	Hood 2	Difference
Flow Rate	1,167	450	717 CFM
Cooling & Air-handling			
Chiller Energy [5]	9,450	3,645	5,805 kWh/year
Fan Energy	9,198	3,548	5,650 kWh/year
Total	18,648	7,193	11,455 kWh/year
Total Power	6.3	2.4	3.9 kW/hood
of which Fan	2.1	0.8	1.3 kW/hood
of which Chiller	4.2	1.6	2.6 kW/hood
Heating			
Supply Load [5]	89	34	55 million BTU
Reheat Load	55	21	34 million BTU
Total Load	145	55	90 million BTU
Energy (fuel)	0	0	0 million BTU
Energy (electric)	16,170	6,237	9,933 kWh
Average Reheat Power	1.8	0.7	1.1 kW
Total Per-Hood Costs	**7,293**	**2,813**	**4,480 $/year**
Cost Per CFM	6.25	6.25	0.00 $

Does not include reduced (potential) cost for down-sized blower and chiller

IVC Rack: Reduced Room AC/H

Harvard Universities Campus Greening Initiative (Brown & Trent)

- Test: reduce room AC/H from 12-15 AC/H to 8-10 and IVC rack AC/H from 60 to 50 or 42
- Testbed - Retrofit 1 room w/9 IVC racks - cost $12K
- Ventilation reduction of 3,000 CFM (est. savings $24K /yr), investment return in 6 mths

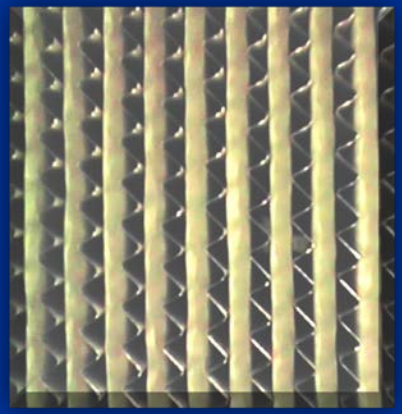
Room ACH and Offsets

- Not just for IVC
  - 10-12 ACH initially developed for labs working with volatile organic chemicals…need not validated for bio. Base ACH on heat loads and RA… 6-8 = the new 10-12.
- Off duty set-backs based on load calcs (used in Indonesia, Singapore, Thailand, Mexico.. now in US)
  - ↓ ACH
  - ↓ Conditioning of Temp/Humidity
  - ↓ Chiller size???

HEPA filter housing

- Use high capacity HEPA filter
  - Lower pressure drop across HEPA filter = energy savings

Standard



- 1,000 CFM @ 1.0”wg.
- 150 square feet of media

High Capacity

- 1,500 CFM @ 1.0”wg.
- 300 square feet of media

Vee-Bed Filter

- 2,400 CFM @ 1.0”wg.
- 430 square feet of media

Personnel/PPE Costs

- 2-person rule for BSAT biosecurity…does not mean must have 2 people 'in the room'
  - False security: Nuc-Chem weapons/surety origin – security should be by good mgmt and reliable people
  - Potentially less safe – 2 people exposed if spill or inadvertent aerosol
  - Reduced productivity- 2 salaries/PPE/showers for work efficiency of 1
- Best BSL-3 practices: 1 in lab; 1 in building (could be security/engineering during off-hours)
- Best BSL-4 practices: 1 in lab; 1 in control room

Personnel Training

- Training 'induction' w/senior staff
- Mentorship: demonstration of competency and confidence
- Mentorship by 'area/task' specialists
- Empowering workforce: on-the-spot correction 'time out'

Results

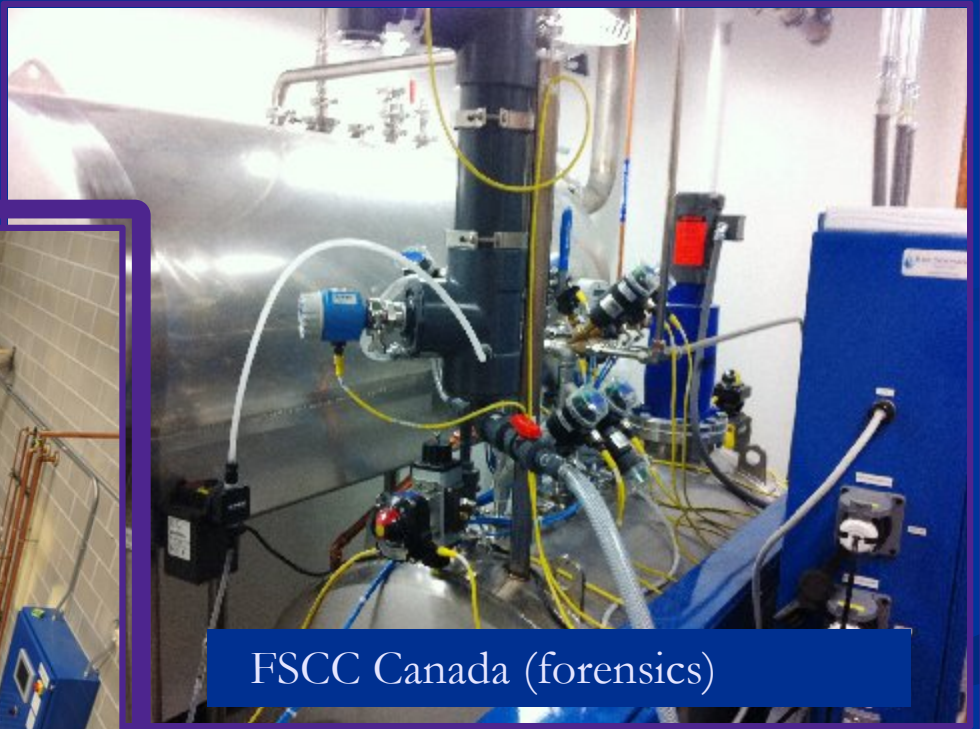
Less accidents = Decease lost labor time

Less errors = Decrease use of reagents/PPE

Both improve science + reinforce safety/security

EDS - Lower Temperature with Chemical Augmentation

- Facility has unreliable steam supply
- Budget constraints: need reduced capital cost
- Benefit of energy reduction
- Want flexibility



FSCC Canada (forensics)

University of Nebraska

Chemical EDS (no heat)

- Pro's- kill time 20 min or less; inexpensive fabrication; no PLC required (optional); energy savings; low operating cost; no clean-steam or stable electrical grid needed
- Con's- heavy solids load still difficult (must validate)
- Univ Pretoria and NCID (S Africa), Amplimmune (MD)

The Elephant in the Room

- Single Pass Air- the most expensive factor
  - BSC are annually certified/HEPA filtered and recirculate air into the room when working w/open cultures and possible spills, unintentional aerosols
  - HEPA filtered room air however is single pass? Isn't room air cleaner than BSC air? Where is the RA and scientific data?
- WHO allows it; discussed in conf's for years
- Mil Mobile and other mobile recirc air through HEPA