Healthy, Safe & Efficient Buildings:

IAQ Successes on Many Levels

Rich Prill

WSU Energy Program, Spokane

Dave Blake

NW Clean Air Agency, Mt Vernon

Rich Prill

Building Science & IAQ Specialist

Washington State University
Spokane, WA

- 30 years IAQ experience
- Region 10 School IAQ Program technical resource
- Building Operator Certification IAQ instructor

COOPERATIVE EXTENSION
WASHINGTON STATE UNIVERSITY

Dave Blake

Indoor Air Specialist

Northwest Clean Air Agency
Mt Vernon, WA

- 15 years IAQ experience
- Most schools in NWCAA territory implemented TfS
- Responds to homes, offices, public buildings

northwest Clean Air agency


"We're number 1/1!"
northwest
Clean Air
agency

HOME
ABOUT US
CURRENT PROJECTS
- Building Science
- Climate Change
- Distributed Generation
- Industrial Services
- Renewables
- Resource Conservation Management
- Technical Assistance

ENERGY CODE
PUBLICATIONS
SOFTWARE
INDEX
EVENTS
TRAINING
LIBRARY
CONTACT US
Workforce
BUSINESS OPPORTUNITIES
Plant Operations

Indoor Air Quality (IAQ)

With funding from the U.S. Environmental Protection Agency, our specialists have assessed more than 300 Northwest schools and recommended practices and procedures to improve indoor air quality. For more information see our publication titled School Indoor Air Quality Assessment and Program Implementation (159k Adobe® &Acrobat® .pdf).

Our other IAQ activities include the EPA-sponsored HELP for Kids Project. As part of this effort, project organizers have developed a series of forms, checklists and handouts to help create healthier environments for children in schools, child care centers and homes.

3-Step School IAQ Program
(488k Adobe® Acrobat®: .pdf)

- School IAQ Resources

HELP forms, checklists and handouts

IAQ in Northwest Schools Newsletter

IAQ fact sheet Keeping Homes Dry (172k Adobe® Acrobat®: .pdf)

Why Measure Carbon Dioxide in Buildings?

"Regional and National Leader"

Washington: Ahead of the game

- State Ventilation and Indoor Air Quality Code -1991
- School Radon Action Team
- Capitol + Projects – 4 Buildings, Olympia
- American Lung Association of Washington: Master Home Environmentalist Program
- National leader in school IAQ and Tools for Schools adoption- 500 + SWT
- Led nation in national TFS award winners and attendees at initial TFS National Symposiums

Washington: Ahead of the game

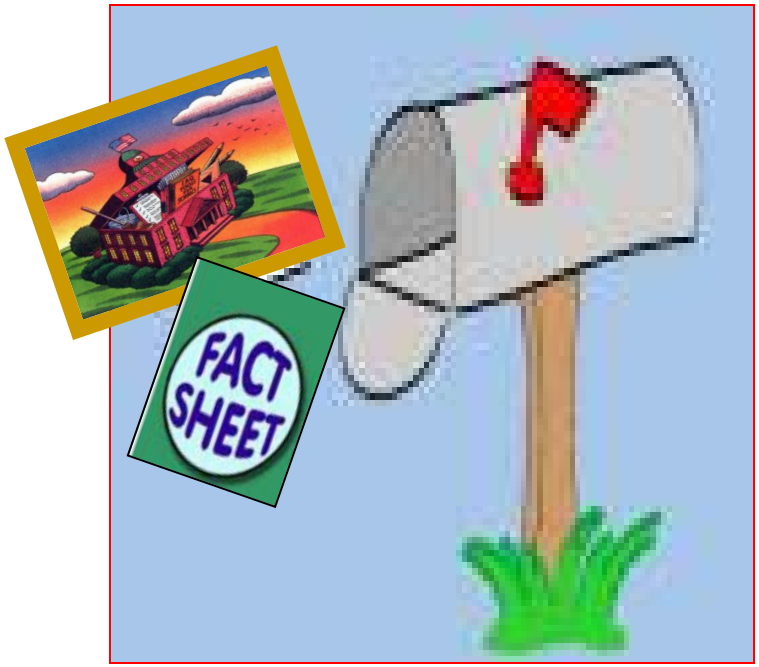
- 3-Step School IAQ Program *(Int'l IAQ Symposium)*
- Tribal IAQ Program
- Makah and Nez Perce Model Programs
- CO_2 and Attendance Study with LBNL
- DVD Videos: Virtual Walk-Through;
  Asthma;
  Mold;
  Duct Sealing
  - Available at www.nwcleanair.org

Washington IAQ All-Stars (short list)

- Dr. Harriet Ammann
- Eric Dickson, ESD 101 (Jim Kearns)
- Paul Clark, Moses Lake, SD
- Tim Hardin, Tacoma-Pierce HD
- Bryan Visscher, Wenatchee SD
- Gary Jefferies, Everett SD
- Butch Sweet & Ken Ames, Tumwater SD
- Mike Anderson & Chris Dean, B'Ham SD
- Mike Riddle, Sedro-Woolley SD
- John Webber, Vancouver, SD
- Many more ...

Getting Started: Trained Key People and Recruited Schools

- Publications
- Fact Sheets
- Web sites



Workshops

WSU Sponsored Infrared Level 1 Certification Trainings


'97 3 20


PING
ARIZONA STATE
SUN DEVILS

Brought Nationally Recognized Experts to the NW:

Terry Brennan
Bill Turner
Andy Streifel
MacGregor Pearce
Brad Turk
Steve Ashkin
John Tooley
Rob Spring
Russ Crutcher
Joe Lstiburek


High Performance School Buildings
The H.L. Turner Group Inc.
Concord, New Hampshire

“It’s been a long strange road . . . .”

EPA Tools for Schools Program

Contains an abundance of information

(can be overwhelming)


Indoor Air Quality


ROAD MAP

IAQ *Simplified*


Fear
Pollutants
Molds
Pollutants
Mistrust
Odors
Risks
IAQ

IAQ *Simplified*

Dry

Clean

Comfortable

Control pollutants *

Adequate ventilation

* Each pollutant needs a control strategy

EPA adopted our idea = “6 Technical Drivers”

Created "Three Step" Implementation IAQ Program

1. *IAQ Coordinator*
2. *Walk- Through Assessments*
3. *Adopt an IAQ Program*

3-Step IAQ Implementation

Your program will likely be

- Easier
- More Effective
- Less Expensive
- Personally Rewarding

Adoption of IAQ Programs

Public relations & communication

Establishes boundaries on "expectations"

Sets benchmarks and accountability

Documentation

Baseline conditions

Goals for improvements

Avoids claims of negligence

Attracts resources

Breaking the "schools will never let us inside" barrier

(down in CA, it still ain't broke)

Got BUY-in from key Administrators

(but didn't burn any bridges along the way if we couldn't)

Sold the pro-active approach

Walk-Throughs:

Non-threatening
Non-regulatory

The Power of The "Walk-Through"

- Identifies problems and deficiencies
- Provides *baseline information*
- *Shapes each IAQ Program's* content and priorities

Essential step to a practical & effective IAQ Program

use all day---the bus and paren
will need to line up outside.

- Don't forget to vote today!

March 8, 2001

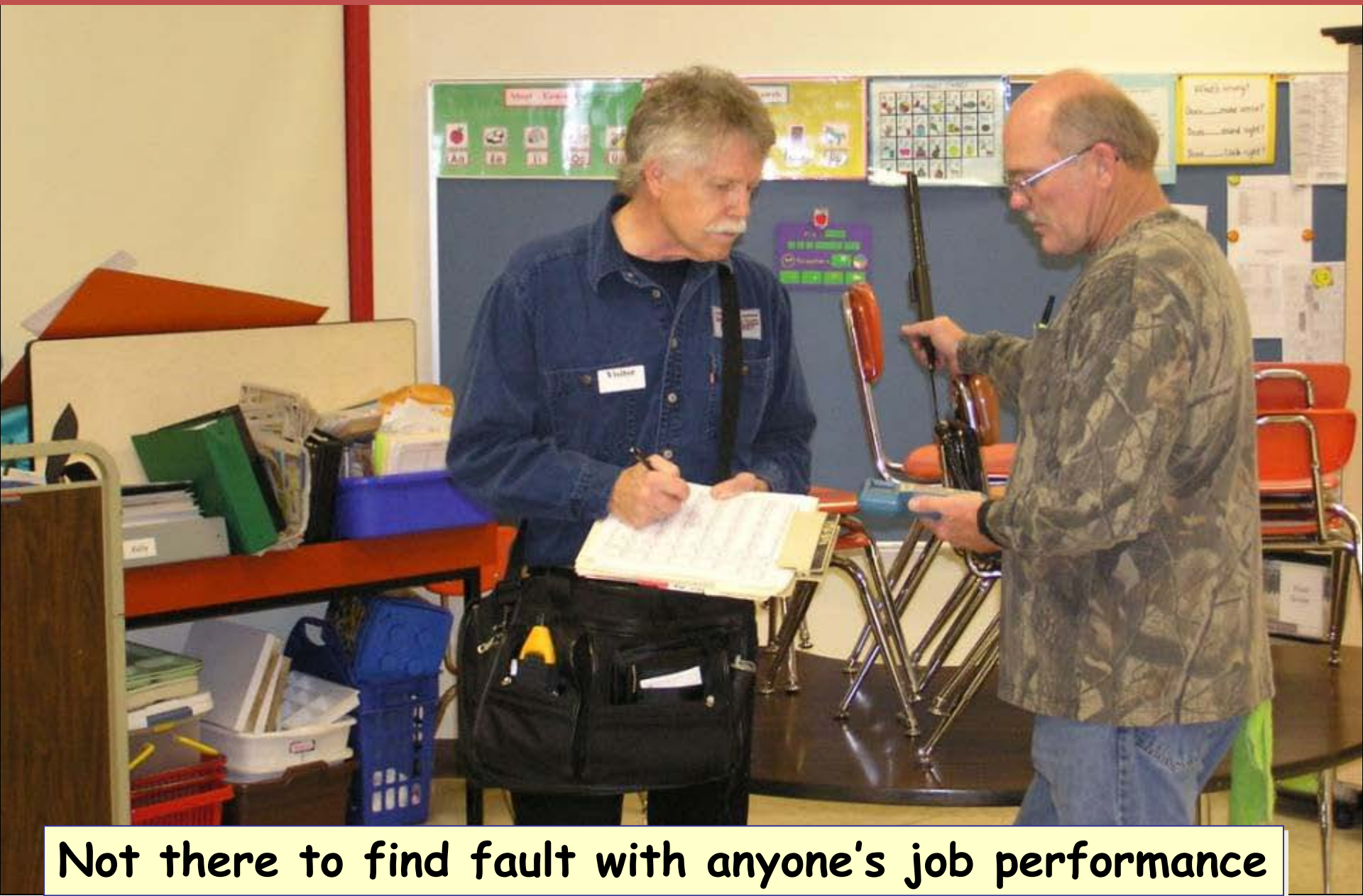
Good Morning Joyce,

Just letting you know, so that you can let your staff know, that on Tuesda
approximately 9:30 a.m., they again will be doing an indoor air quality wal
buildings (barring that we don't get snow again). Dave Blake, Northwest A
Cooper, Maintenance and possibly two others will be doing the walk throu
"tools for Schools" kit available.

If you have any questions please call John Cooper 507-8064.

Thank You,
Mary
Maintenance Dept.

Build relationships and skills



Not there to find fault with anyone's job performance

Send positive message to staff and parents: the right thing to do

A Practical Learning Opportunity

One-on-One skills training

Student involvement !

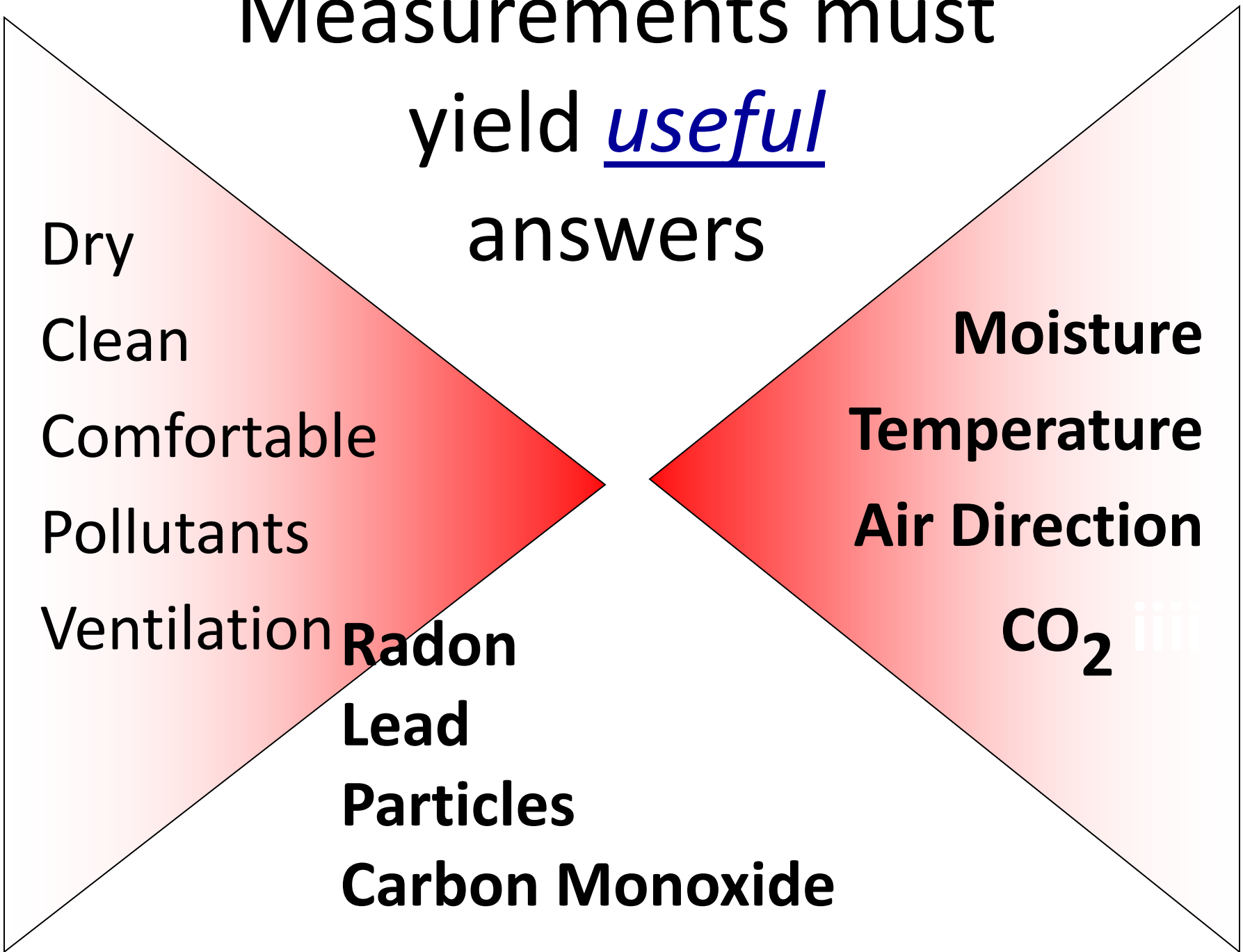
Student Involvement

National Recognition by EPA Tools for Schools Symposium

East Valley
Ephrata
South Whidbey
Hillsboro
Eugene

Compiled a practical IAQ Walk-Through Kit

Measurements must yield *useful* answers



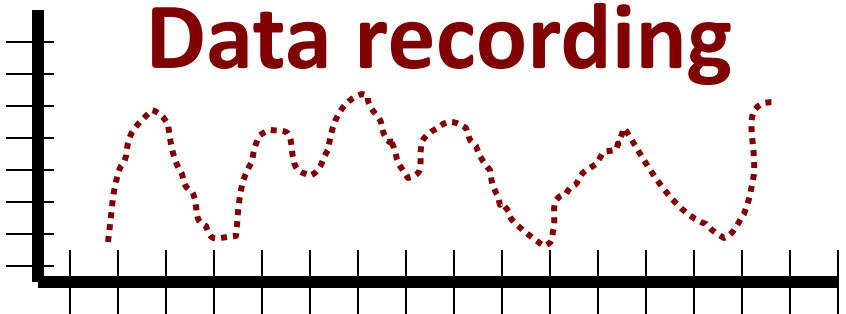
Multi-Function Meters:

Carbon Dioxide (CO_2)

Carbon Monoxide (CO)

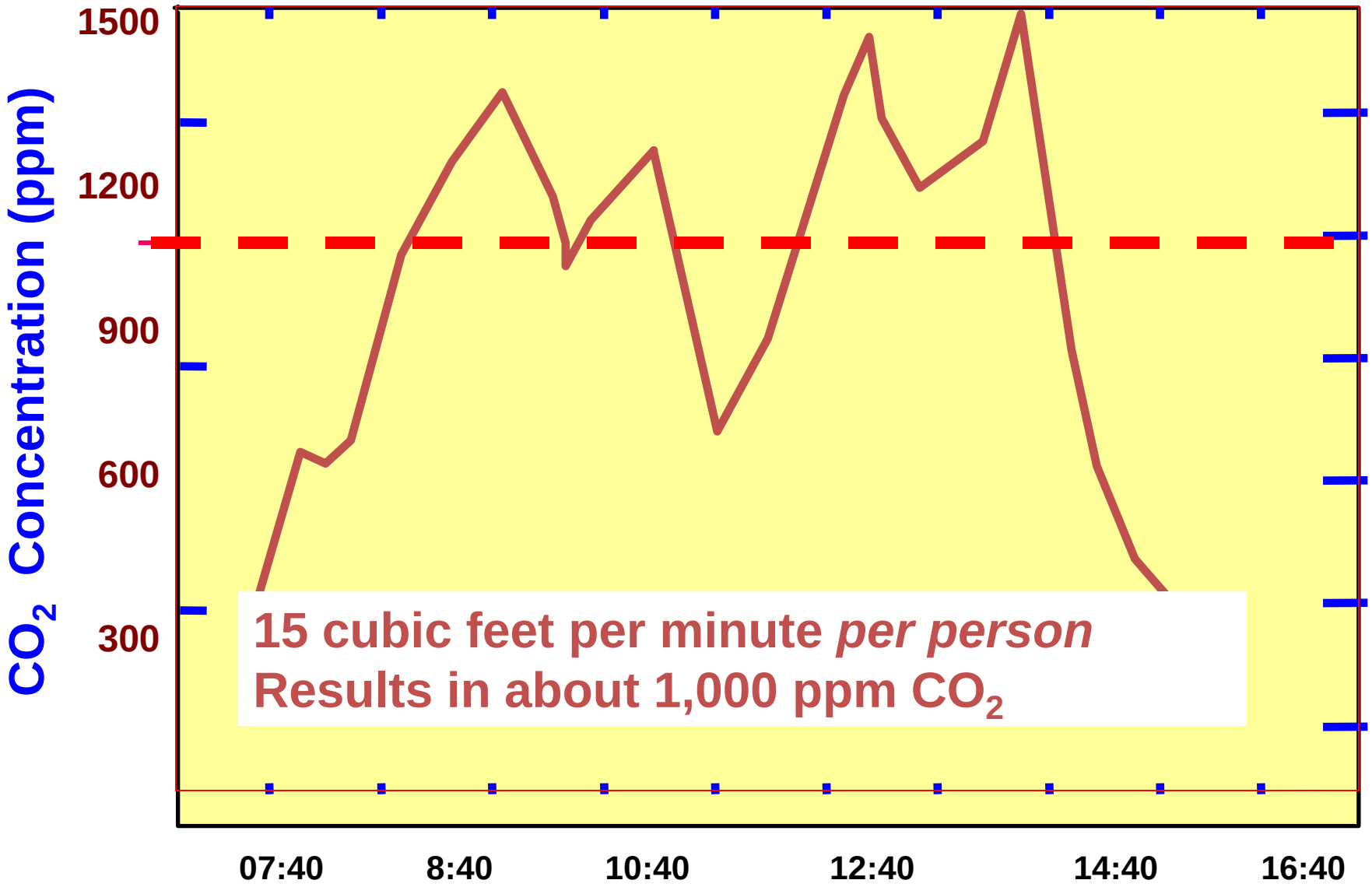
Temperature

Relative Humidity



Elementary School Classroom

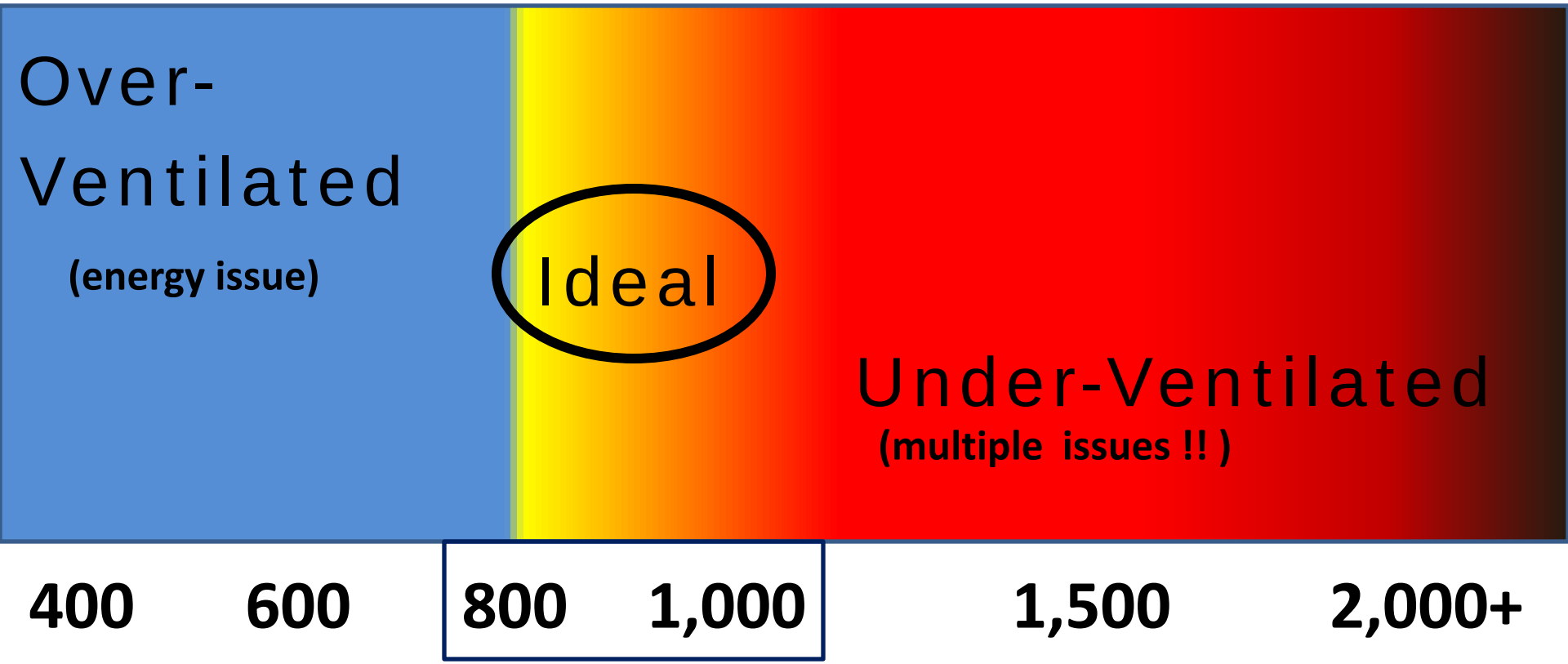
Continuous CO_2 Measurements



Carbon Dioxide vs. Ventilation

CO_2 (ppm)		Outside Air *(Ventilation rate)*	
2,400	---	5 cfm/p	Unacceptable
1,400	---	10 cfm/p	Poor
1,000	---	15 cfm/p	Classrooms
800	---	20 cfm/p	Offices
600	---	25 cfm/p	
~ 380	◄		Outdoors

CO_2 Estimate of Ventilation



Built In Awareness: Equipment Loan Programs

17 IAQ Monitoring Stations in Washington schools

Also an information kiosk

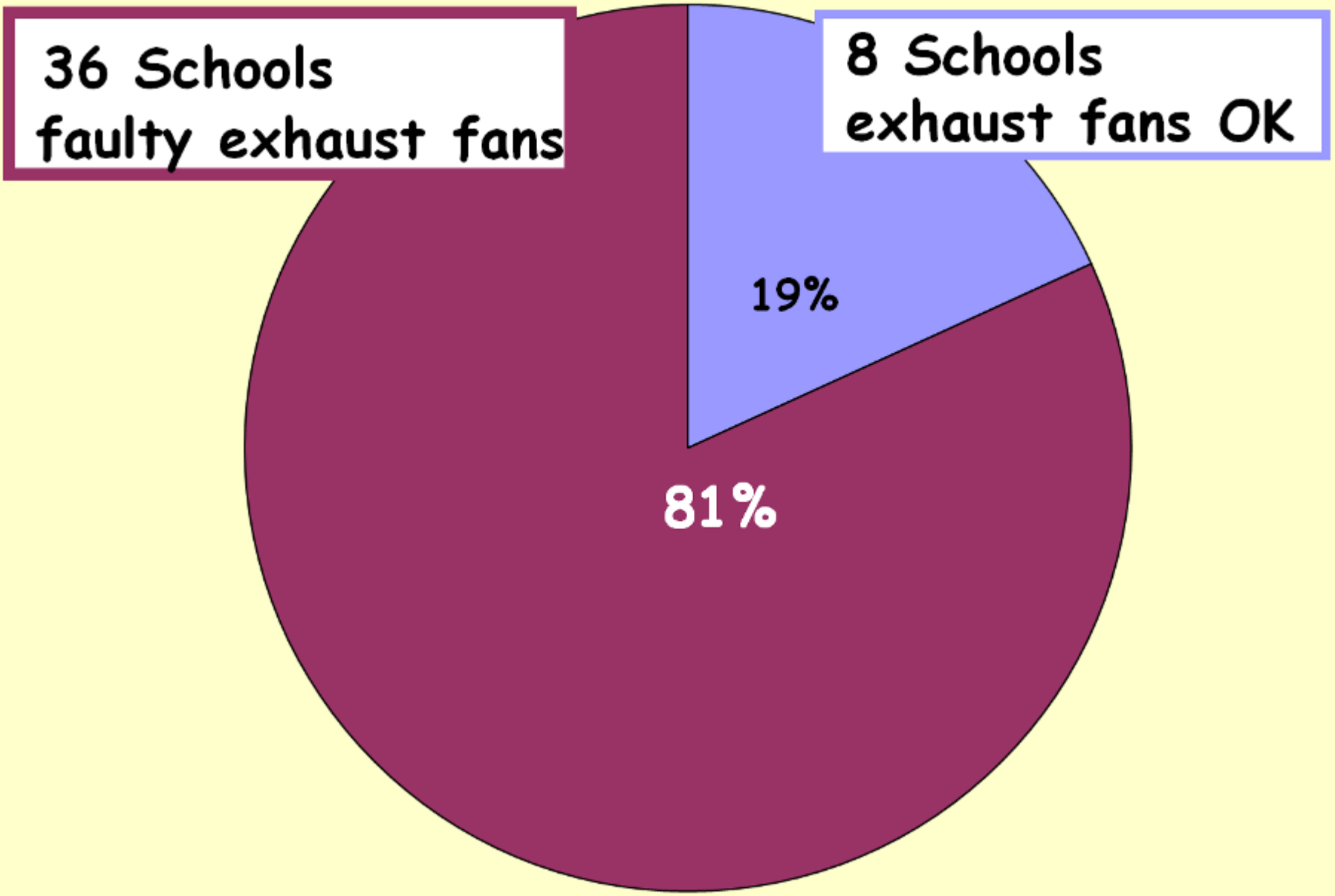
Cody Lee, WSU Intern

summer job assembled the IAQ Stations

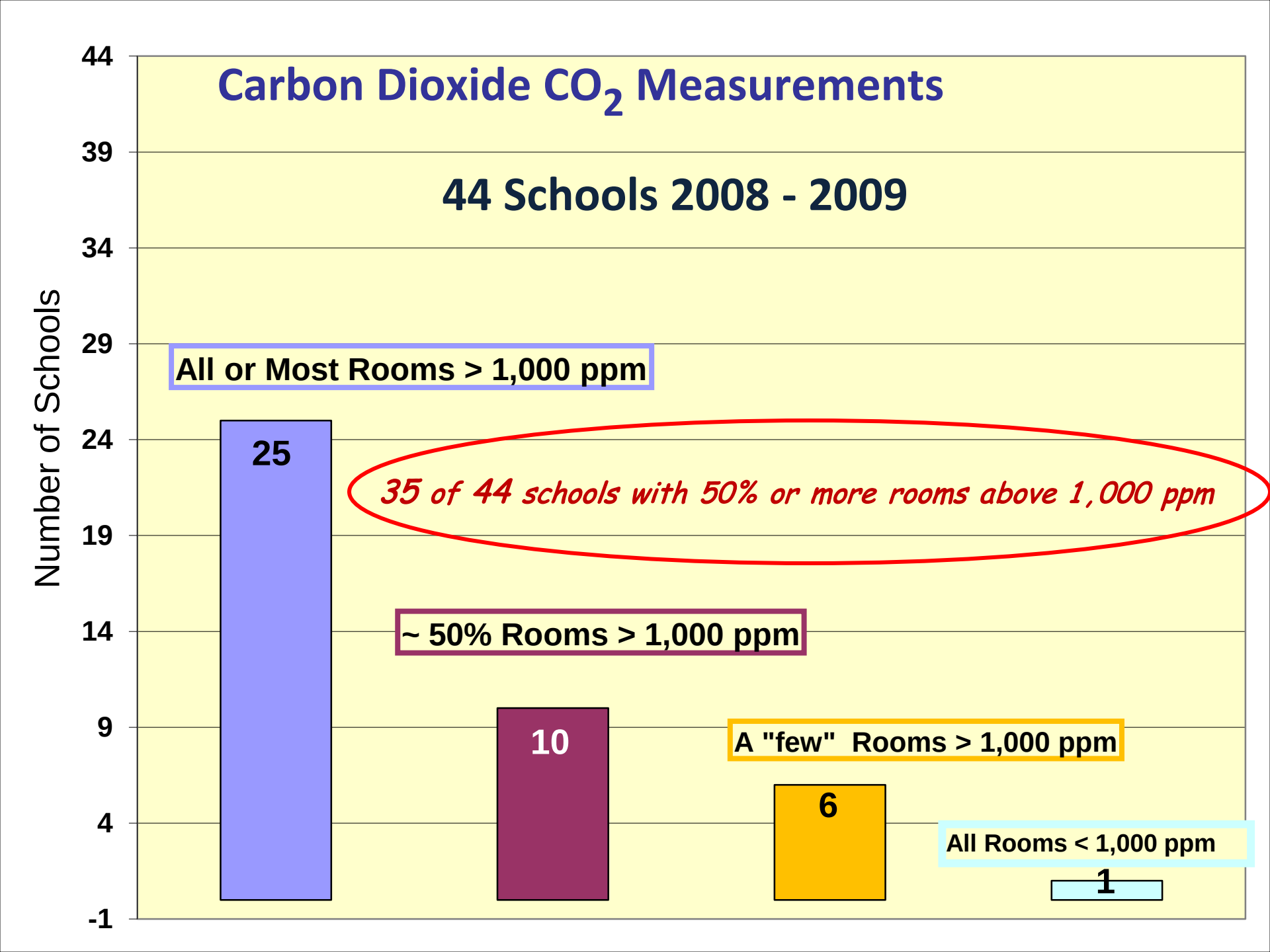
By and By . . .

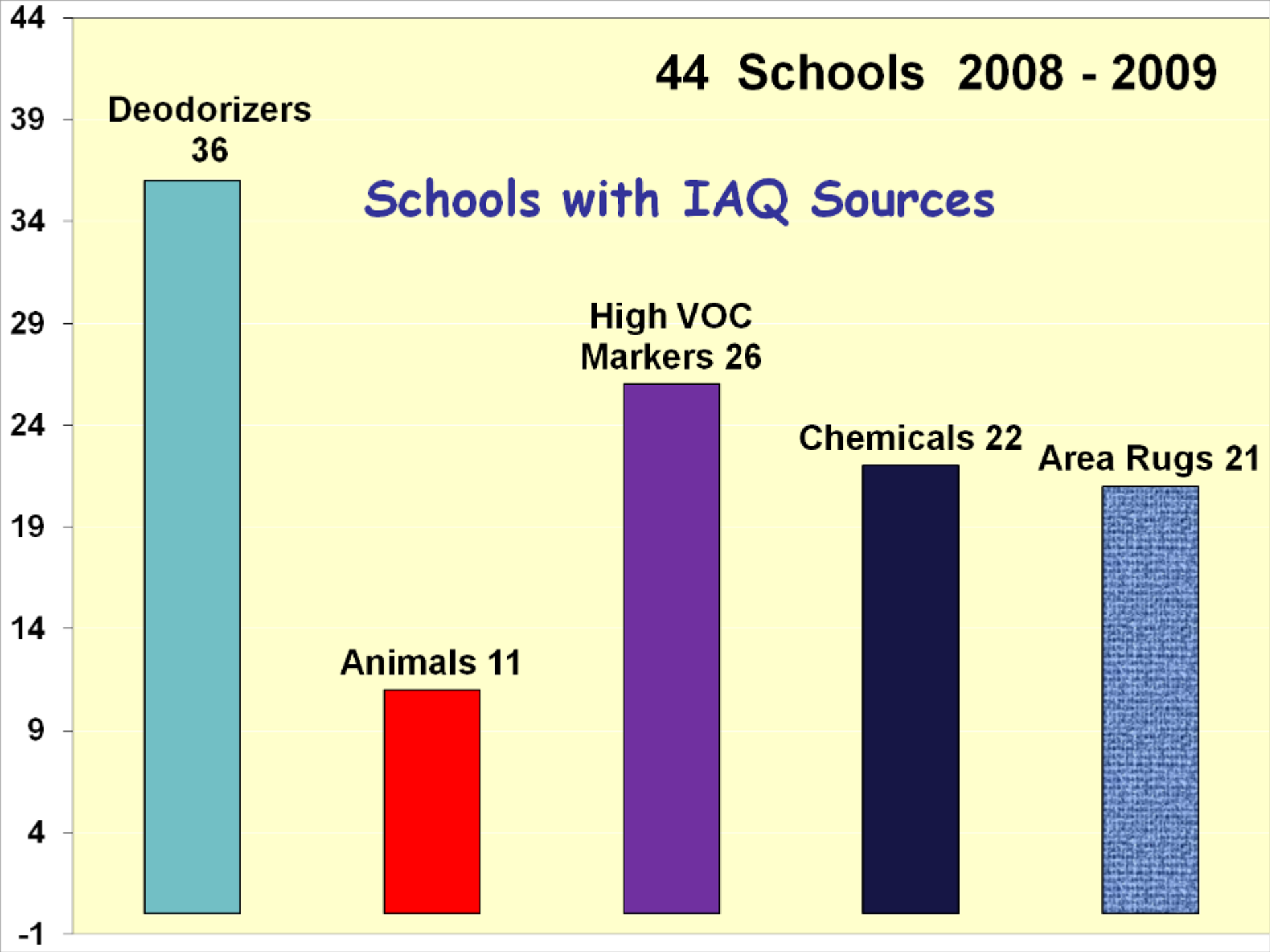
500 + School IAQ Walk-Throughs in the PNW

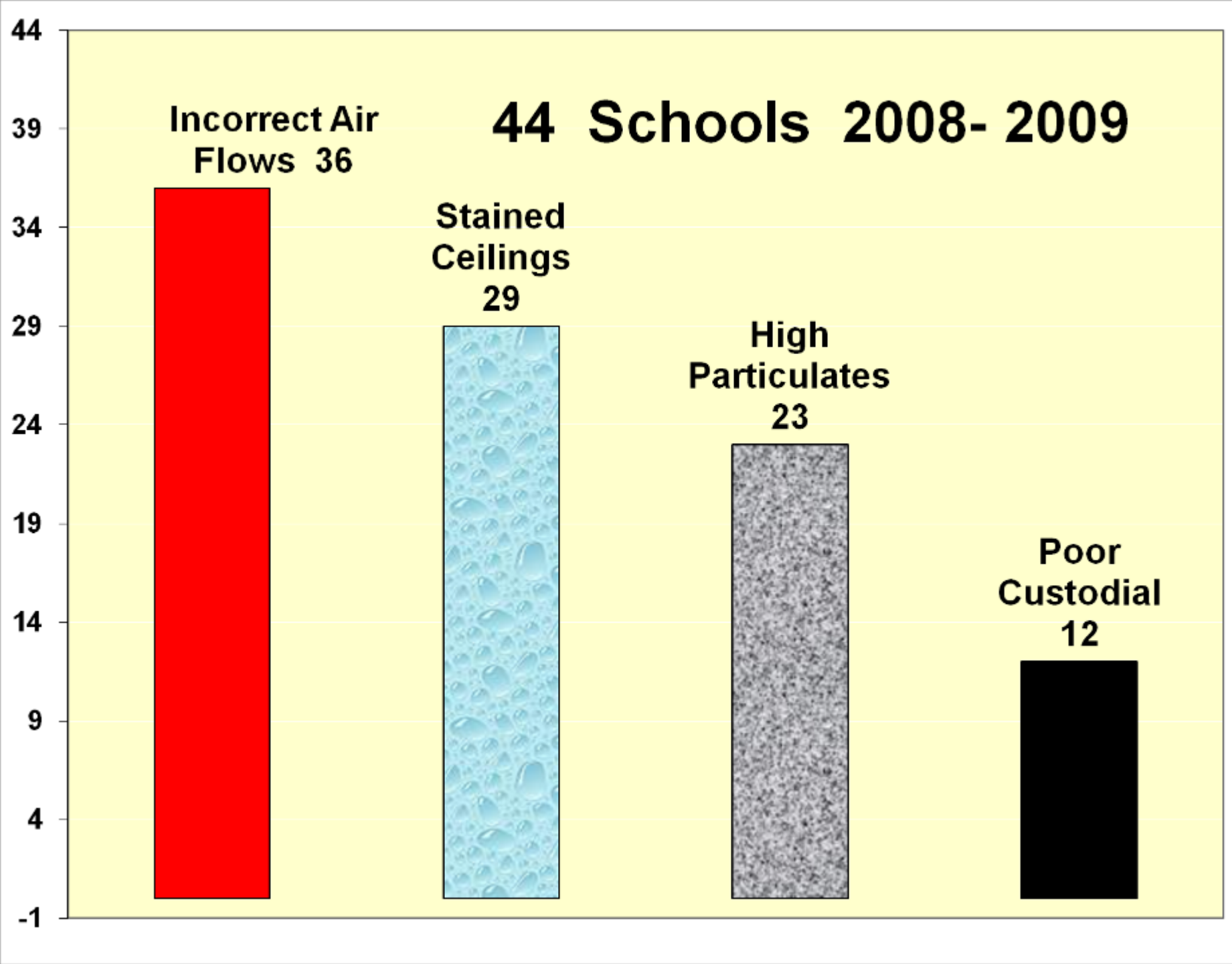
Every school and municipal building in Whatcom, Skagit, Island Counties

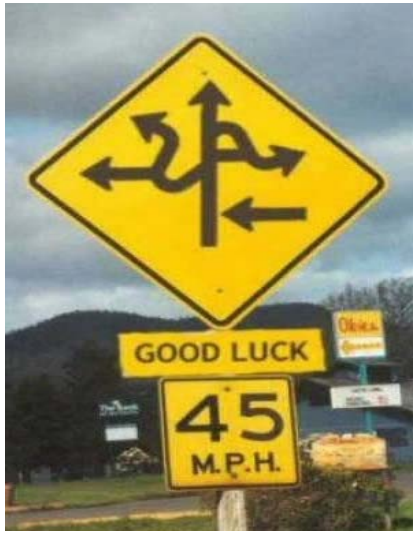


44 Schools 2008 - 2009


Carbon Dioxide CO_2 Measurements
44 Schools 2008 - 2009
Number of Schools
44
39
34
29
24
19
14
9
4
-1
All or Most Rooms > 1,000 ppm
25
35 of 44 schools with 50% or more rooms above 1,000 ppm
~ 50% Rooms > 1,000 ppm
10
A "few" Rooms > 1,000 ppm
6
All Rooms < 1,000 ppm
1

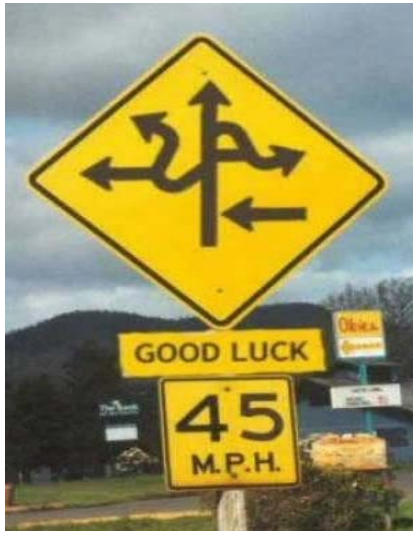

44 Schools 2008 - 2009
Schools with IAQ Sources
44
39
34
29
24
19
14
9
4
-1
Deodorizers 36
Animals 11
High VOC Markers 26
Chemicals 22
Area Rugs 21


44 Schools 2008- 2009
Incorrect Air Flows 36
Stained Ceilings 29
High Particulates 23
Poor Custodial 12
44
39
34
29
24
19
14
9
4
-1



OK, we're not done with IAQ

What to do?



OK, we're not done with IAQ

What to do?

Routine monitoring and benchmarking

Communication & "Marketing"

Integrate into "sustainability

Intake "out-takes":

Thousands of rooms 'freshened' by finding flaws

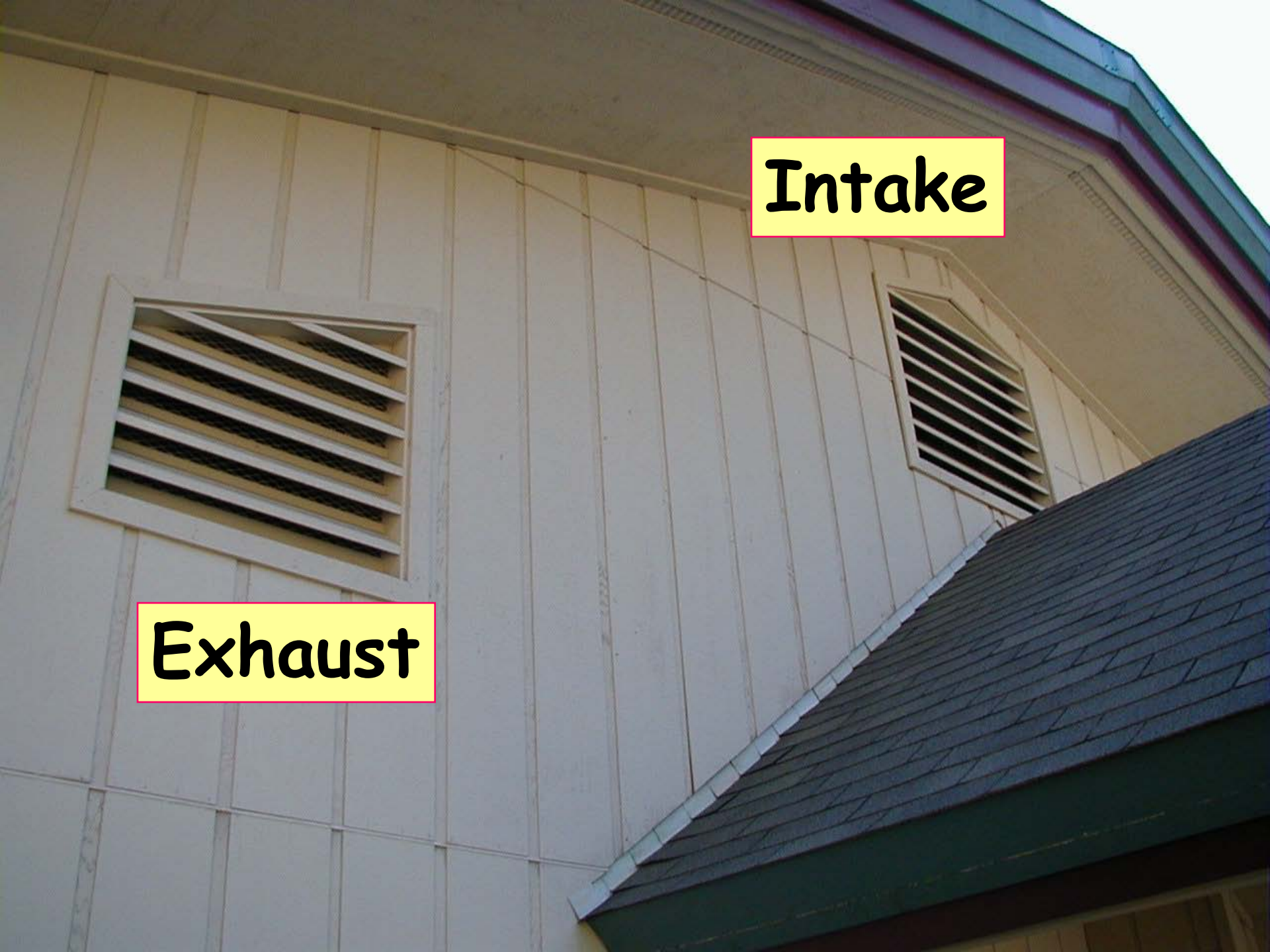

Air intake
Habitat for pests


Air Intake

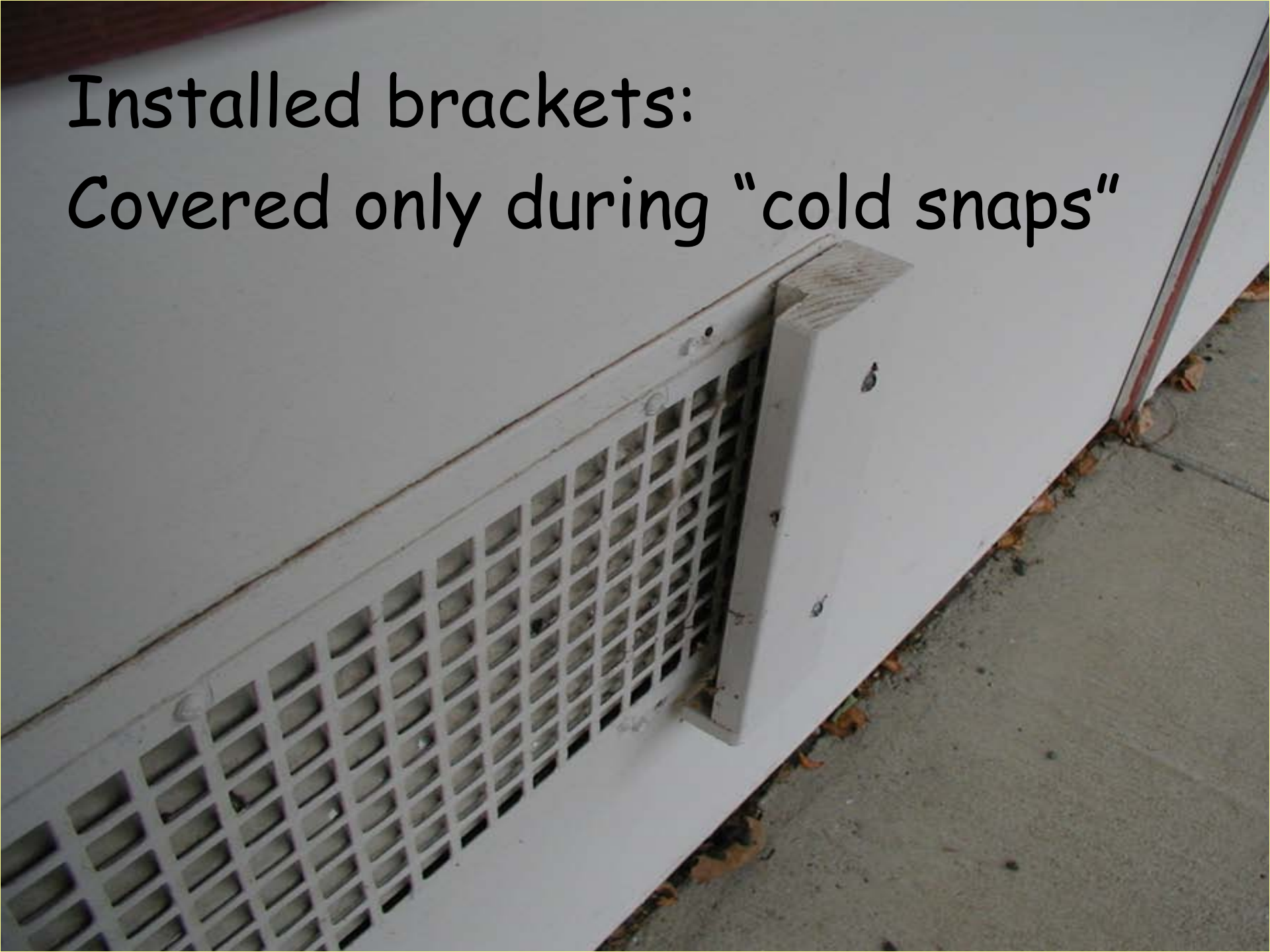

SCHOOL BUS
Air Intakes


BUS
S OP
BUS DRIVERS

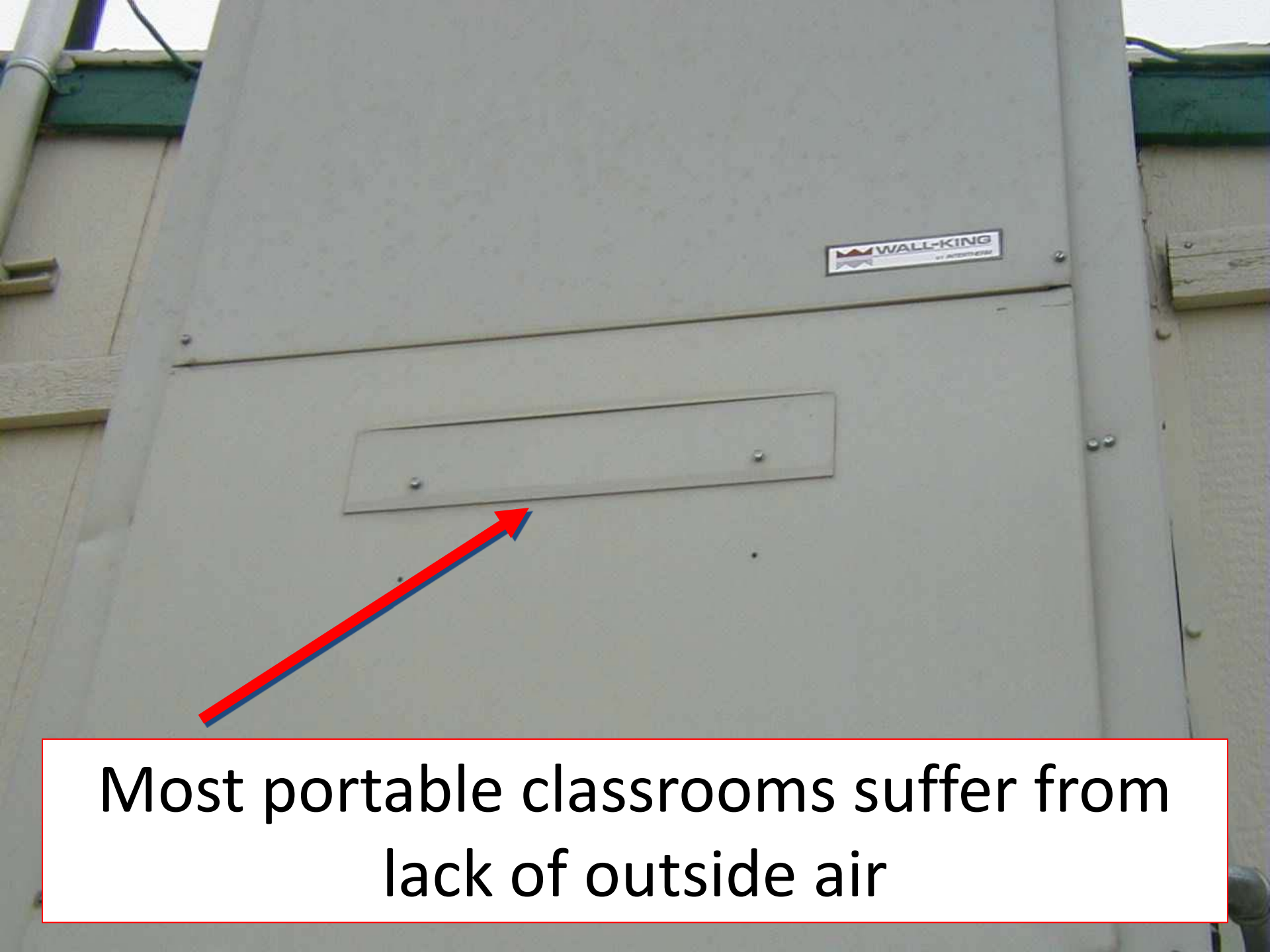

Air Intake
Exhaust


Intake
Exhaust

fresh air intakes covered for the “season”


Installed brackets:
Covered only during "cold snaps"

note conditions and ask questions



Most portable classrooms suffer from lack of outside air

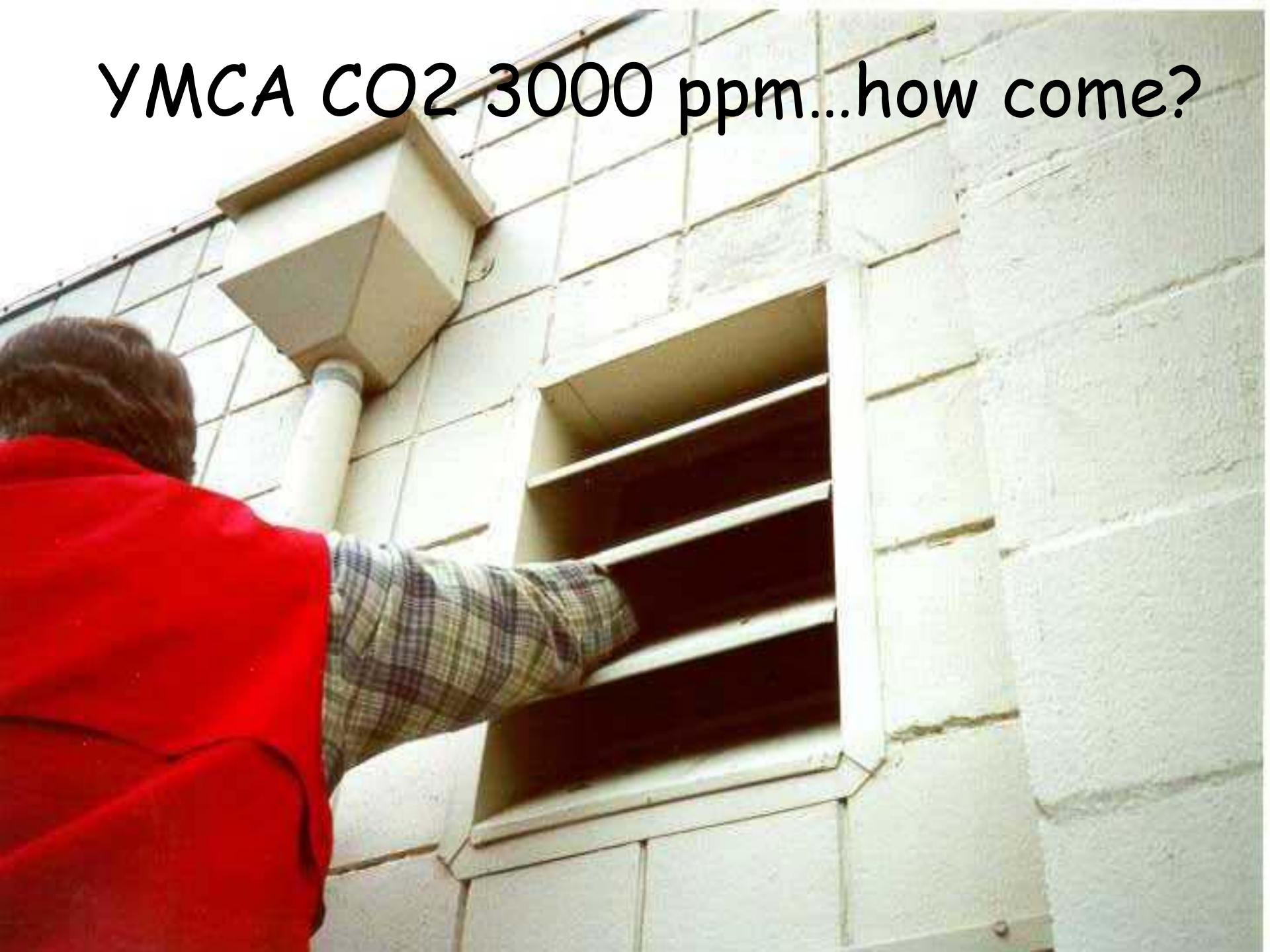
Hey, the dampers are open . . . but the CO2 is still too high

Pencil hole though plugged OSA grill

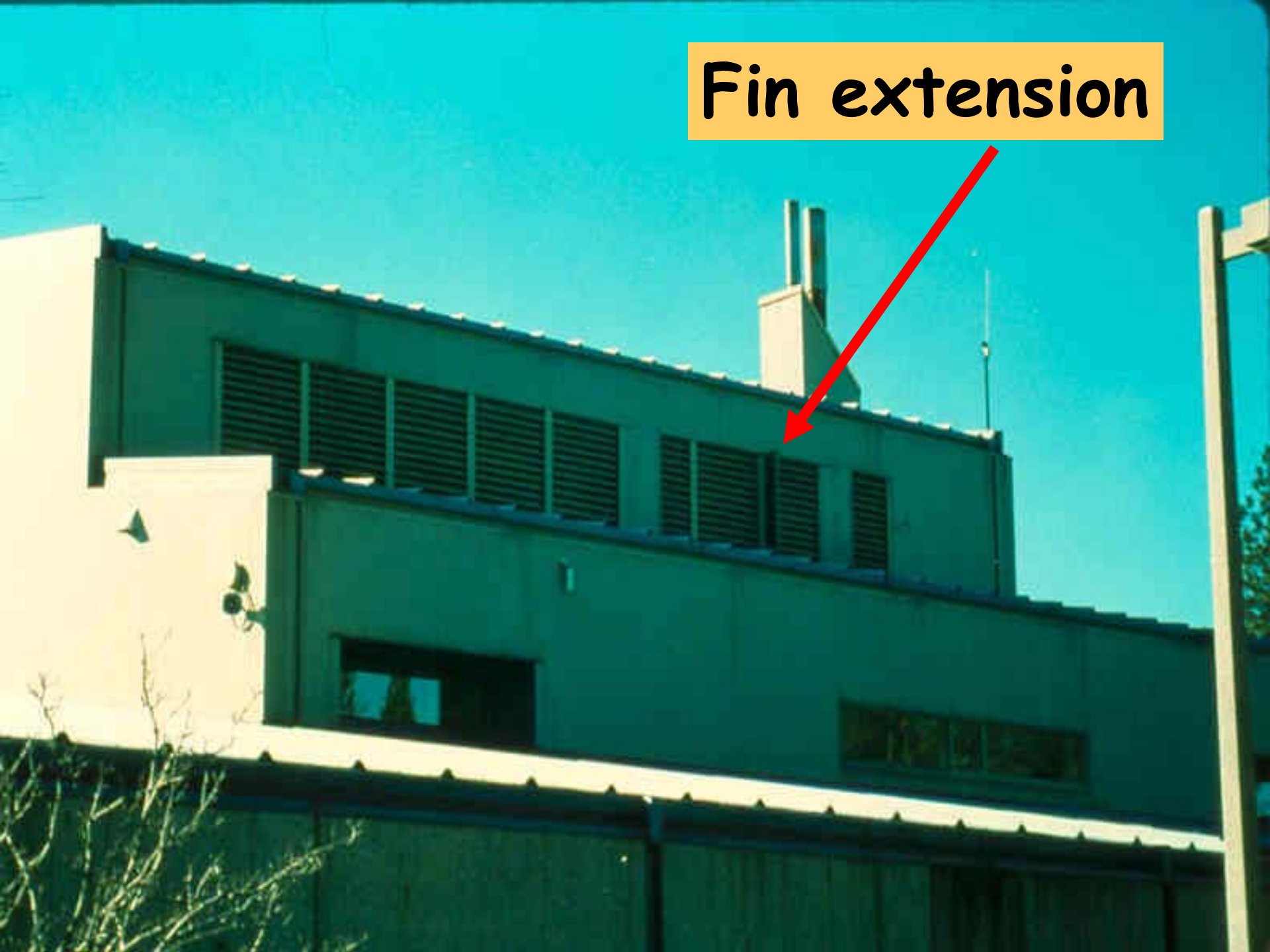

Air Intake

Clean the Air Intake

YMCA CO2 3000 ppm…how come?



Re-entrainment case study


Fin extension


intakes
exhausts


exhausts
intakes

Greater appreciation of comfort issues:
Temp and Relative Humidity

Science Kit
Boreal
Laboratories
110
100
90
80
70
60
50
40
30
20
10
0
-10
-20
-30

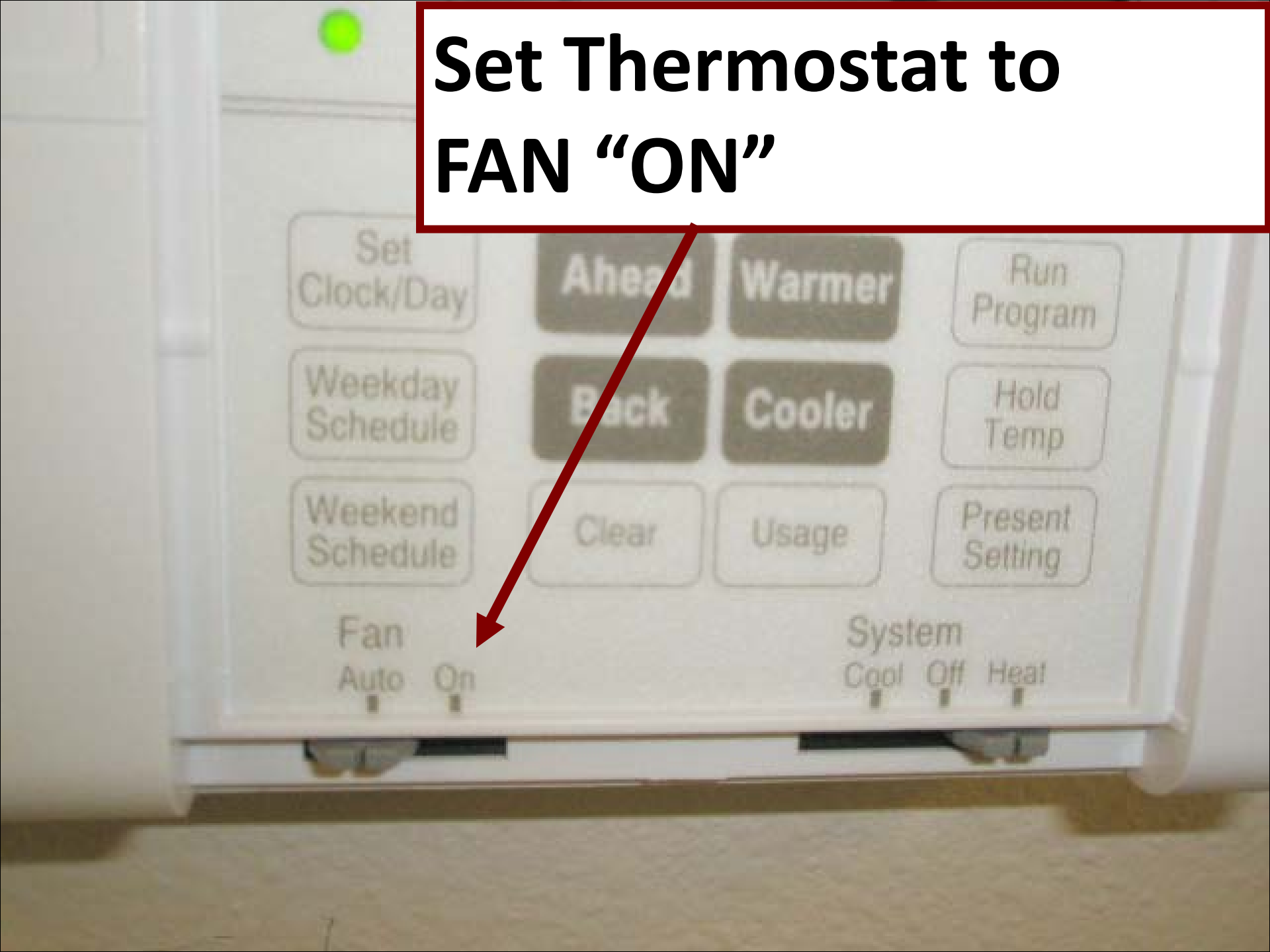
- Heat source near thermostats

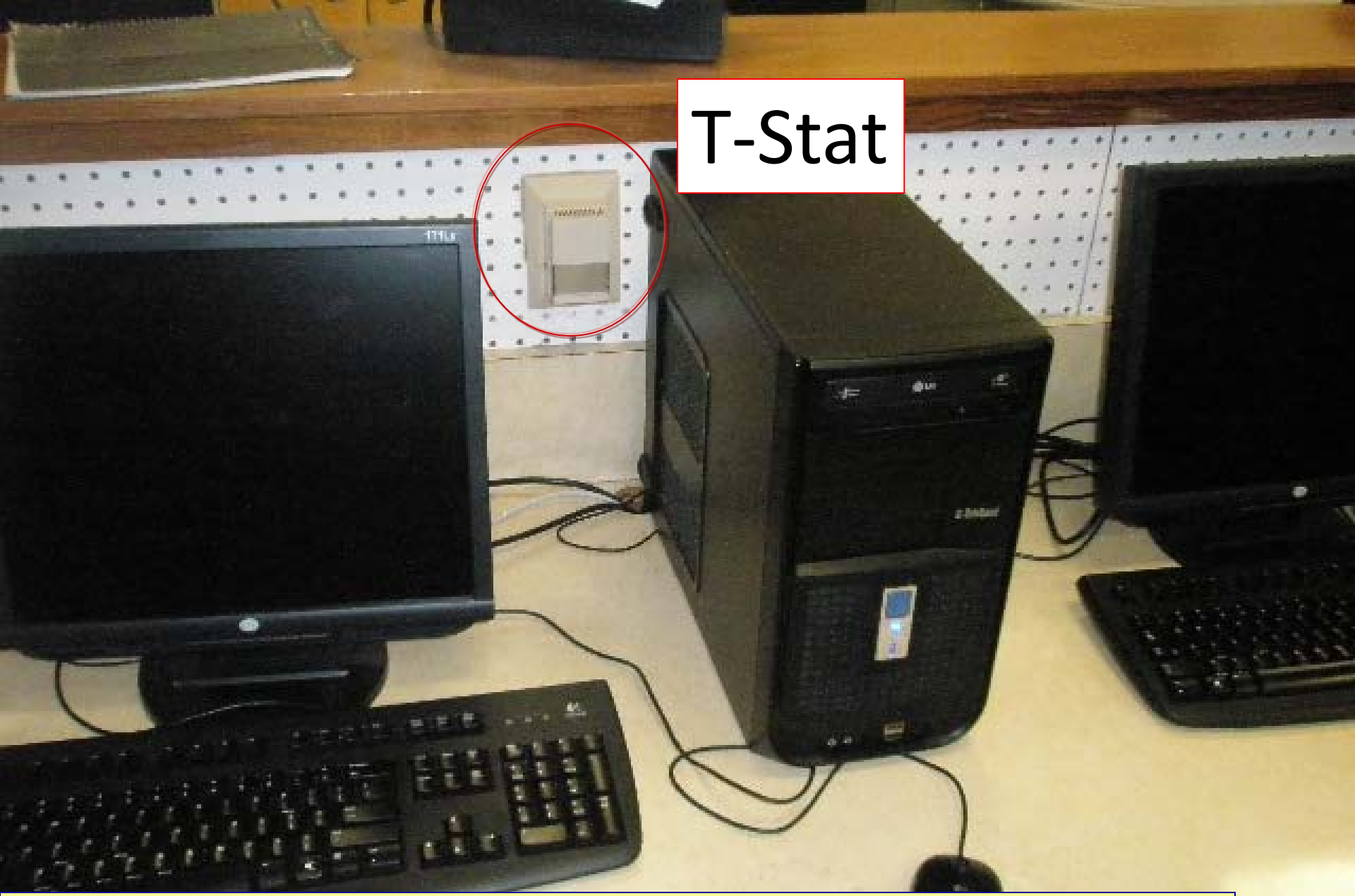
Temperatures in schools

Average speed of completing academic work *decreased* by approximately 1.1%

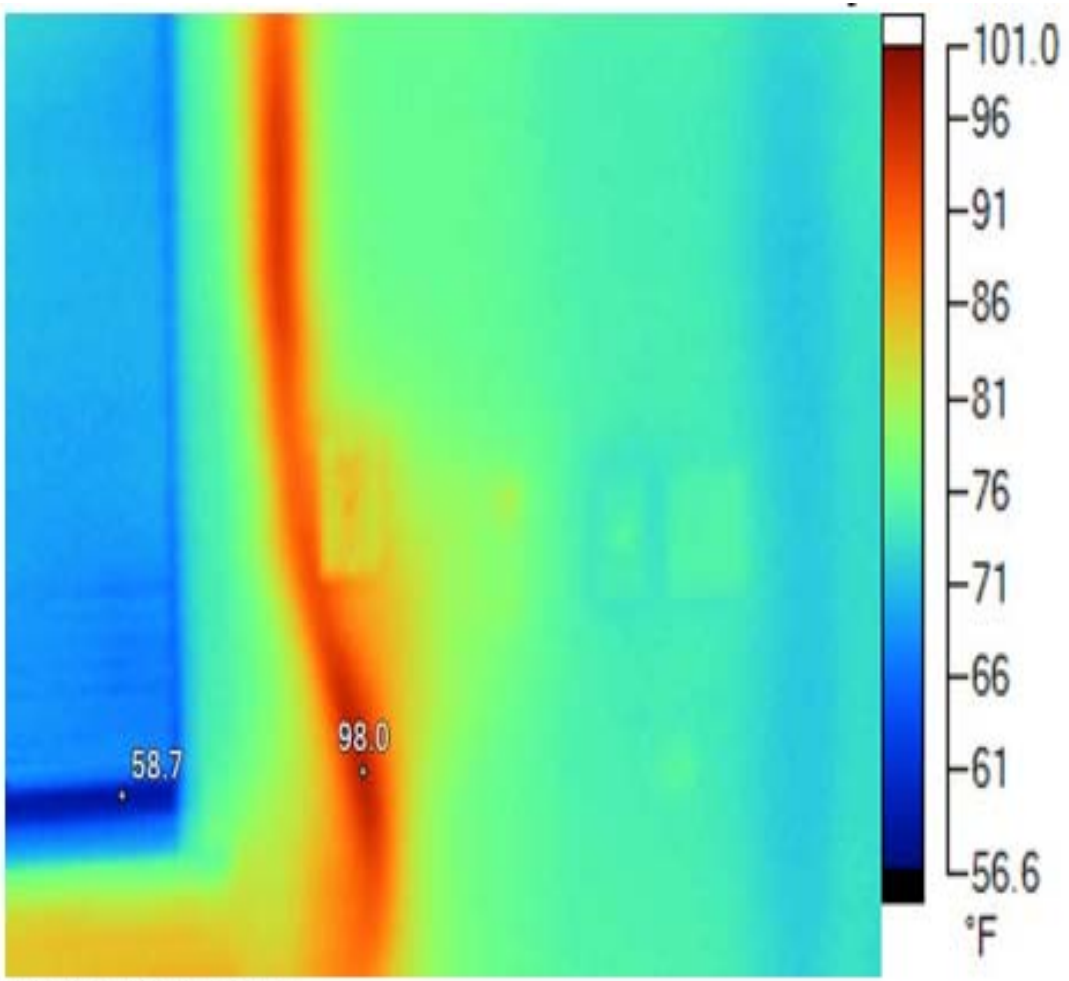
for each 1 °F temperature increase from 68 °F to 77 °F

(based on monitoring of performance of eight simulated school work tasks)


Set Thermostat to FAN "ON"
Set Clock/Day
Ahead
Warmer
Run Program
Weekday Schedule
Back
Cooler
Hold Temp
Weekend Schedule
Clear
Usage
Present Setting
Fan
Auto
On
System
Cool
Off
Heat



Classroom always too cold !



IR000802.IS2

Visible Light Image

Office always cold – IR scan easily identified a 98° F heat source in wall directly behind thermostat

(note 58° F window temp)

Importance of **Mean Radiant Temperature**

warm "objects" ***radiate*** to "cold objects"

Heat *from* person

Heat *to* person

Surface Temperatures (°F)

Ceiling 70°

Floor 65°

Wall #1 65°

Wall #2 68°

Wall #3 45°

Wall #4 55°

TOTAL 368 divided by 6 surfaces = 61.3 F°

- Radiant heat transfer is typically dominant over that of convection
- To create an environment with an effective comfort temperature of 70°F, for every one degree Fahrenheit that the average surface temperature is below 70°, need to raise the air temperature 1.4°F to compensate for the radiant cooling of those cooler surfaces

- Similarly, for every degree above 70° in MRT would allow us to reduce the air temperature by 1.4° and still maintain the same level of comfort.

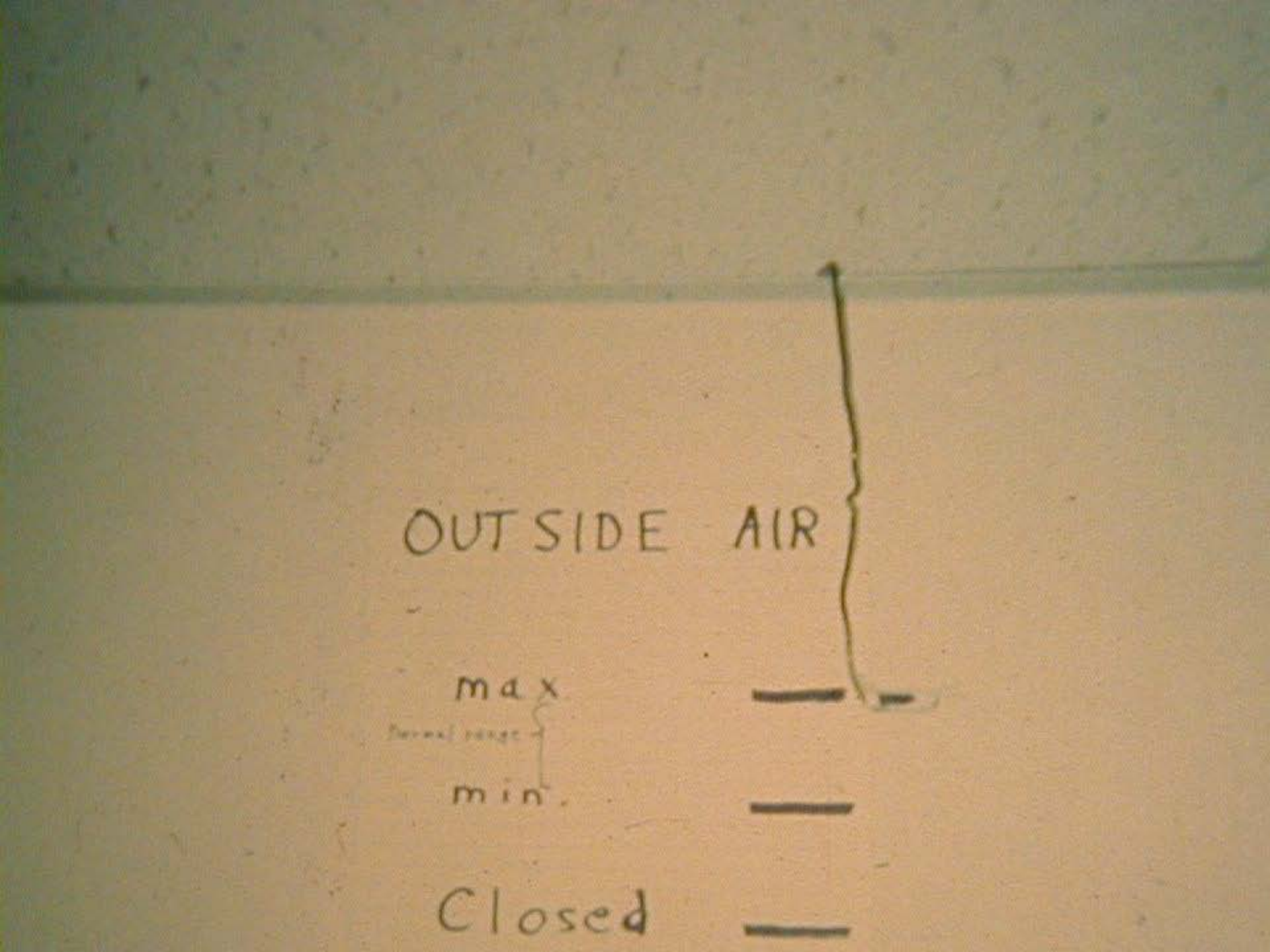
Equivalent MRT and Air Temperature for a feeling of 70 F

MRT	50	55	60	65	68	69	70	71	72	70	75	80
Air Temp	98	91	84	77	72.8	71.4	70	70	68.6	67.2	63	56

People want to be in control

Greater awareness
of the link
between adequate
fresh air
ventilation and job
performance


Be a
problem
solver
not a
problem maker.


OUT SIDE AIR
max
min
Closed

Discourage 'drive by balancing'

How Much of this air is "Fresh"?


Invention of the
PrillCo 2000

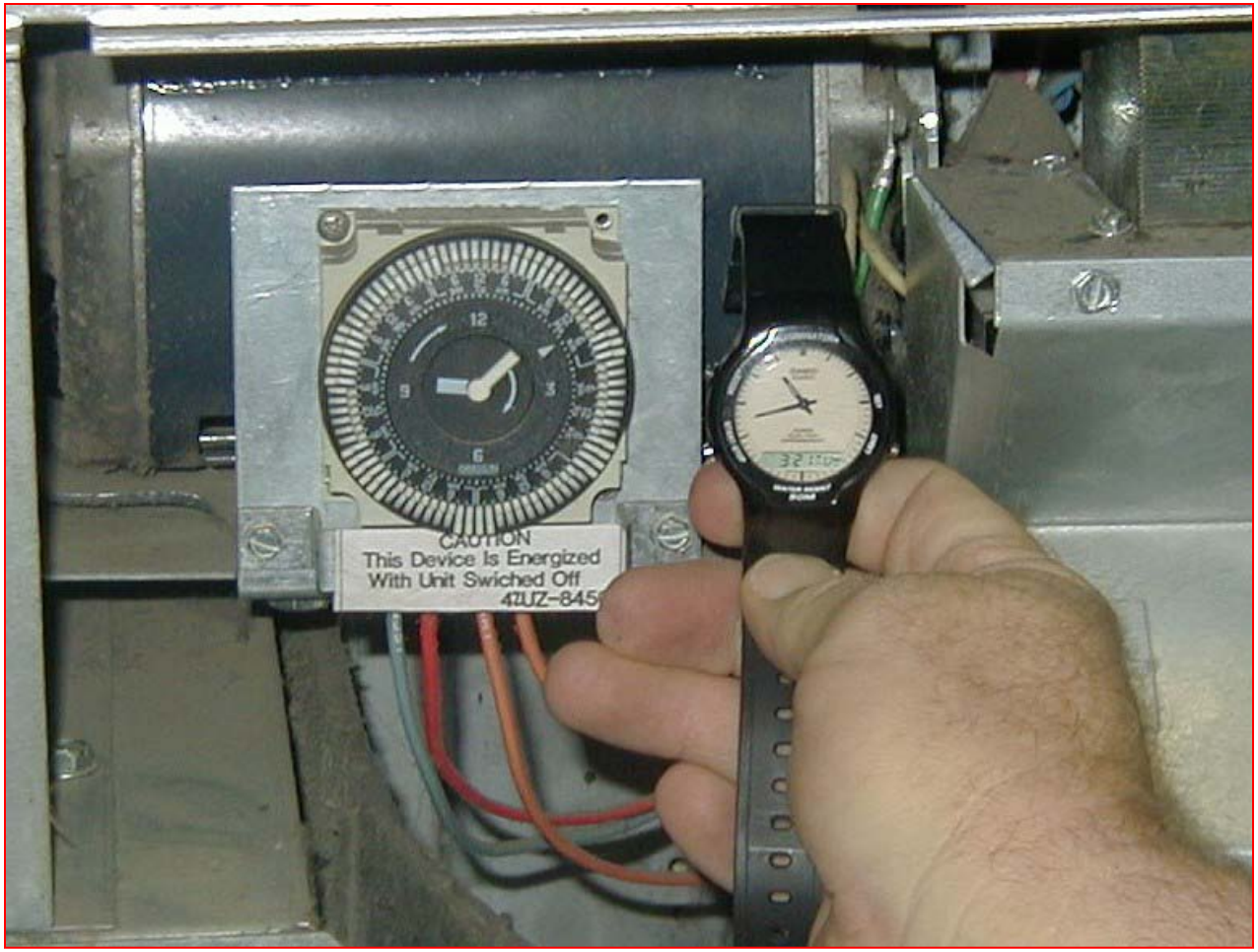

ECTION


Courtney
Cole
Pp

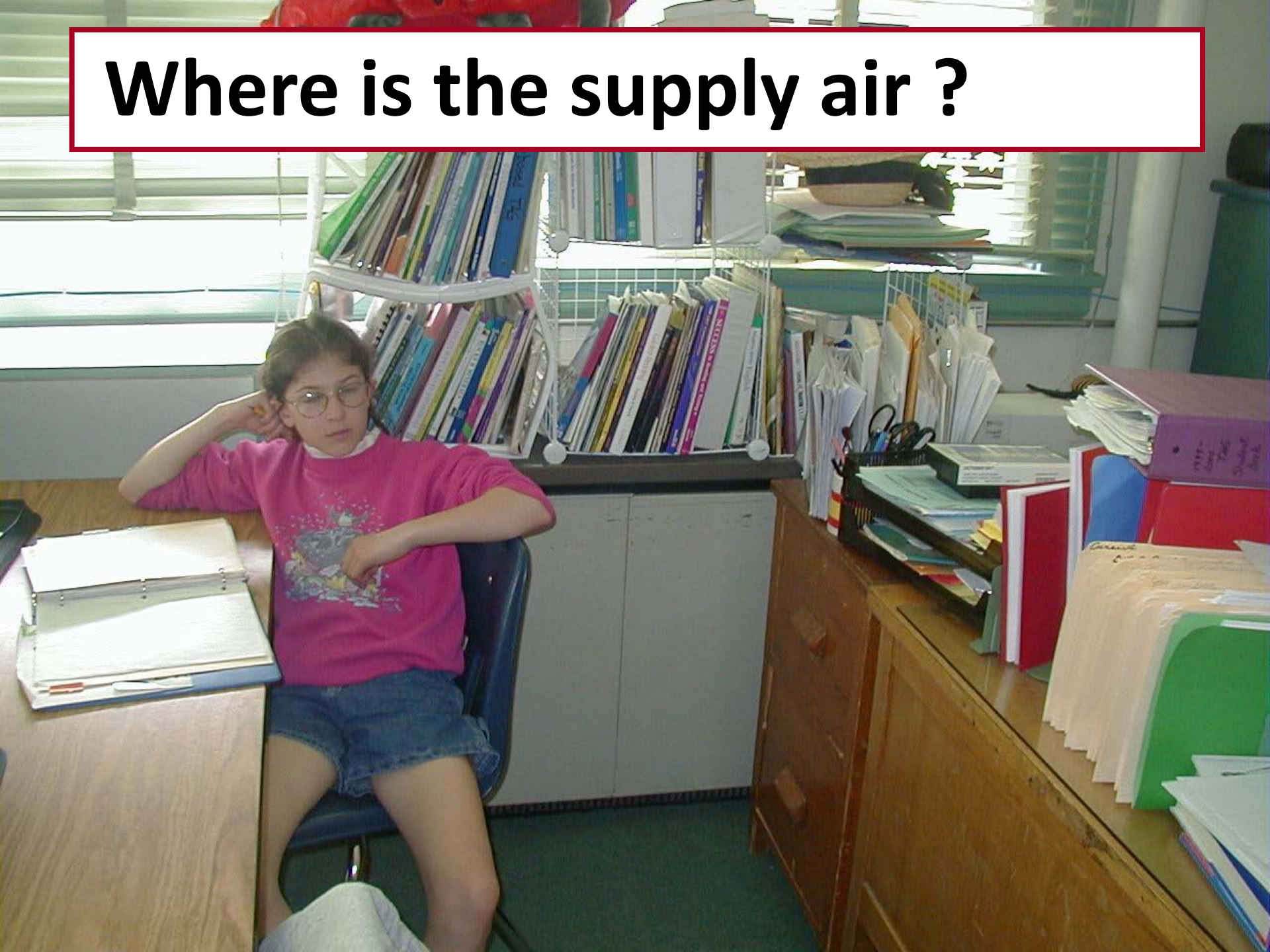

JANITOR

Fix it on the spot

Time clock out of synch



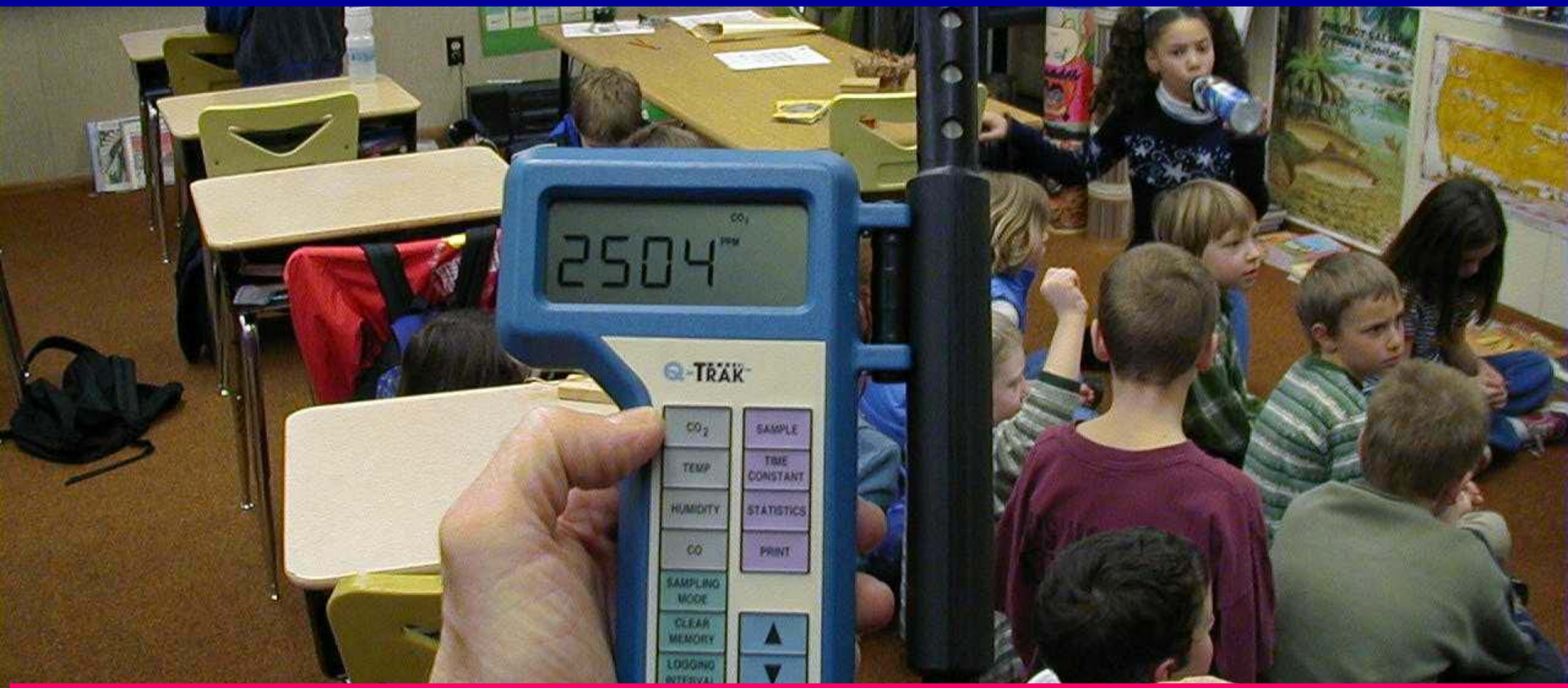
broken linkage


Where is the supply air ?


STREGA
Cross-Trekkers

- Carbon Dioxide -

CO_2 used to ***estimate*** the ventilation rate



CO_2 instrument = handy "fresh air meter"


DO NOT COVER VENTS

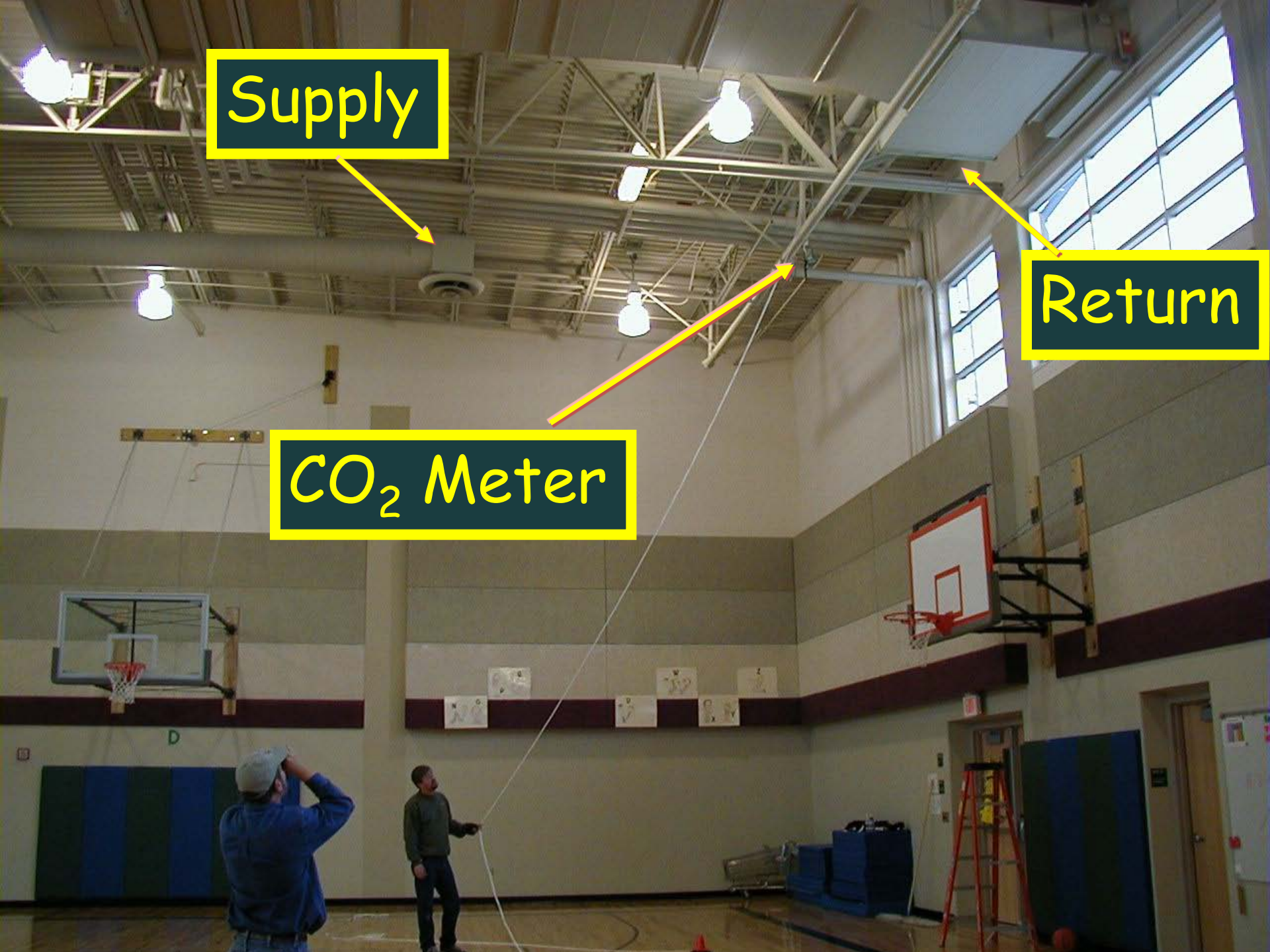
6th Graders “left behind”
high CO_2 affected their achievement ?

New Gym floor: strong floor finish odors for 6 months

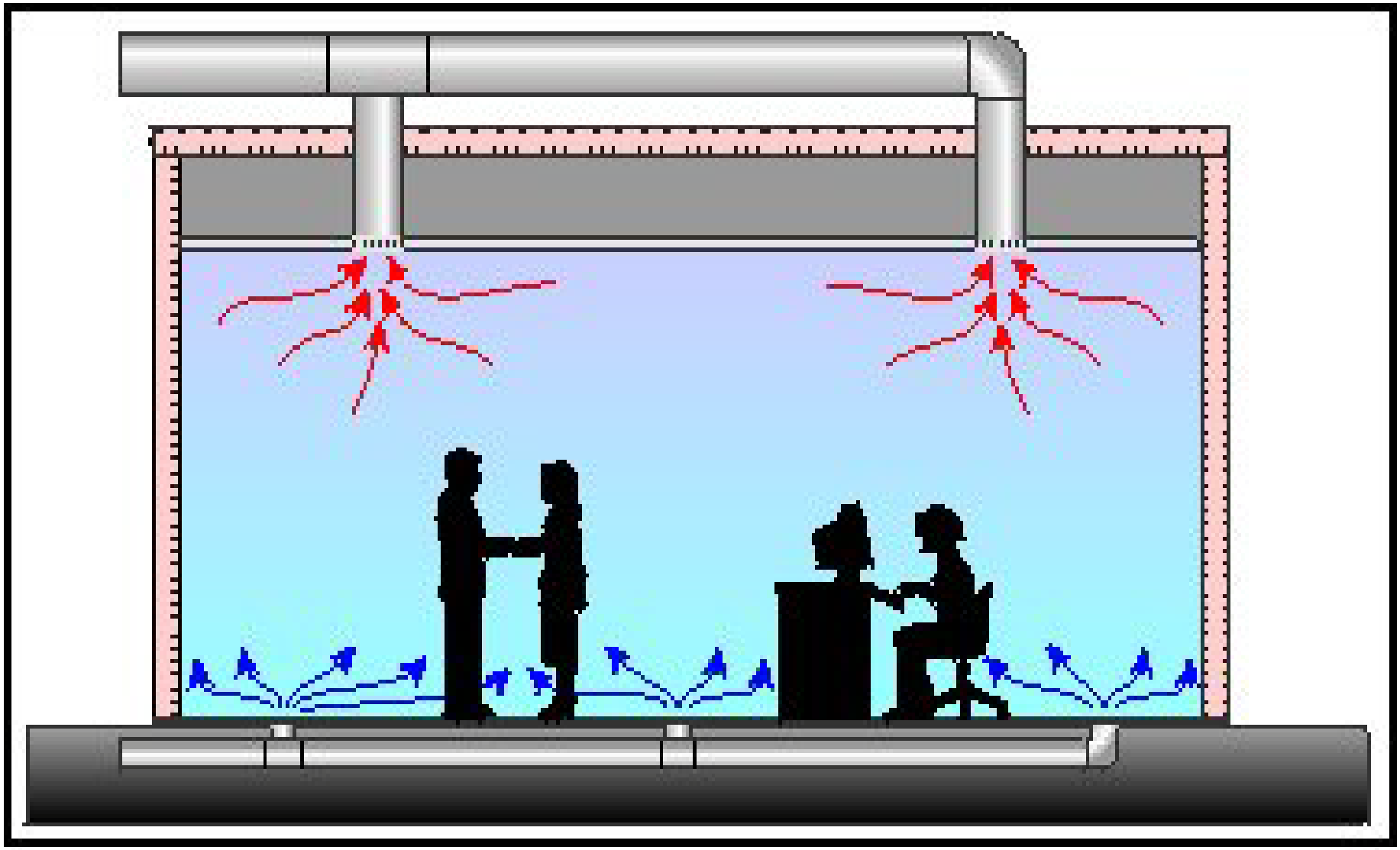
Fill gym with CO_2 = 2,000 ppm

1 hour later . . . CO_2 = 1,800 ppm


450 ppm
1,800 ppm

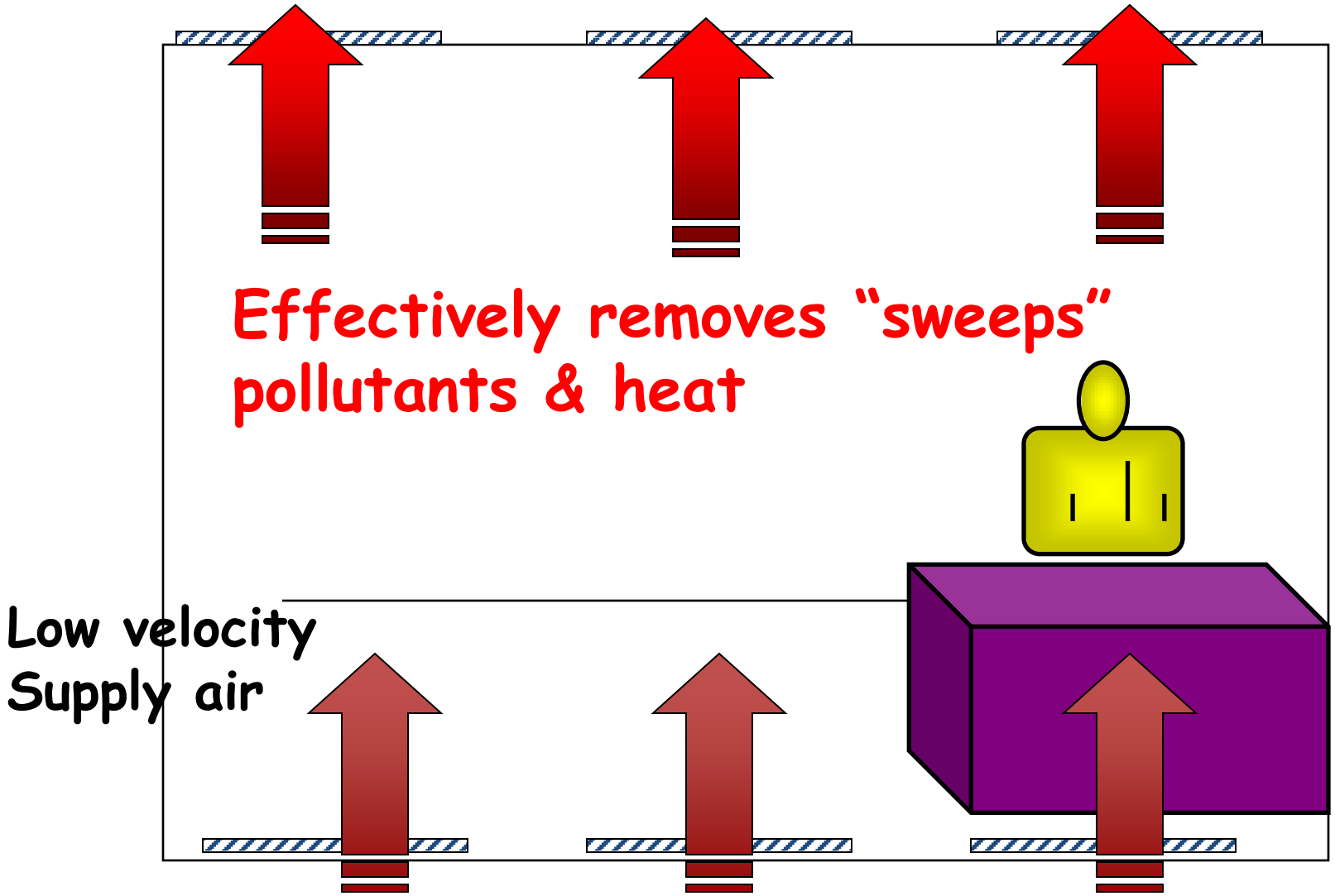

Supply
Return
CO_2 Meter

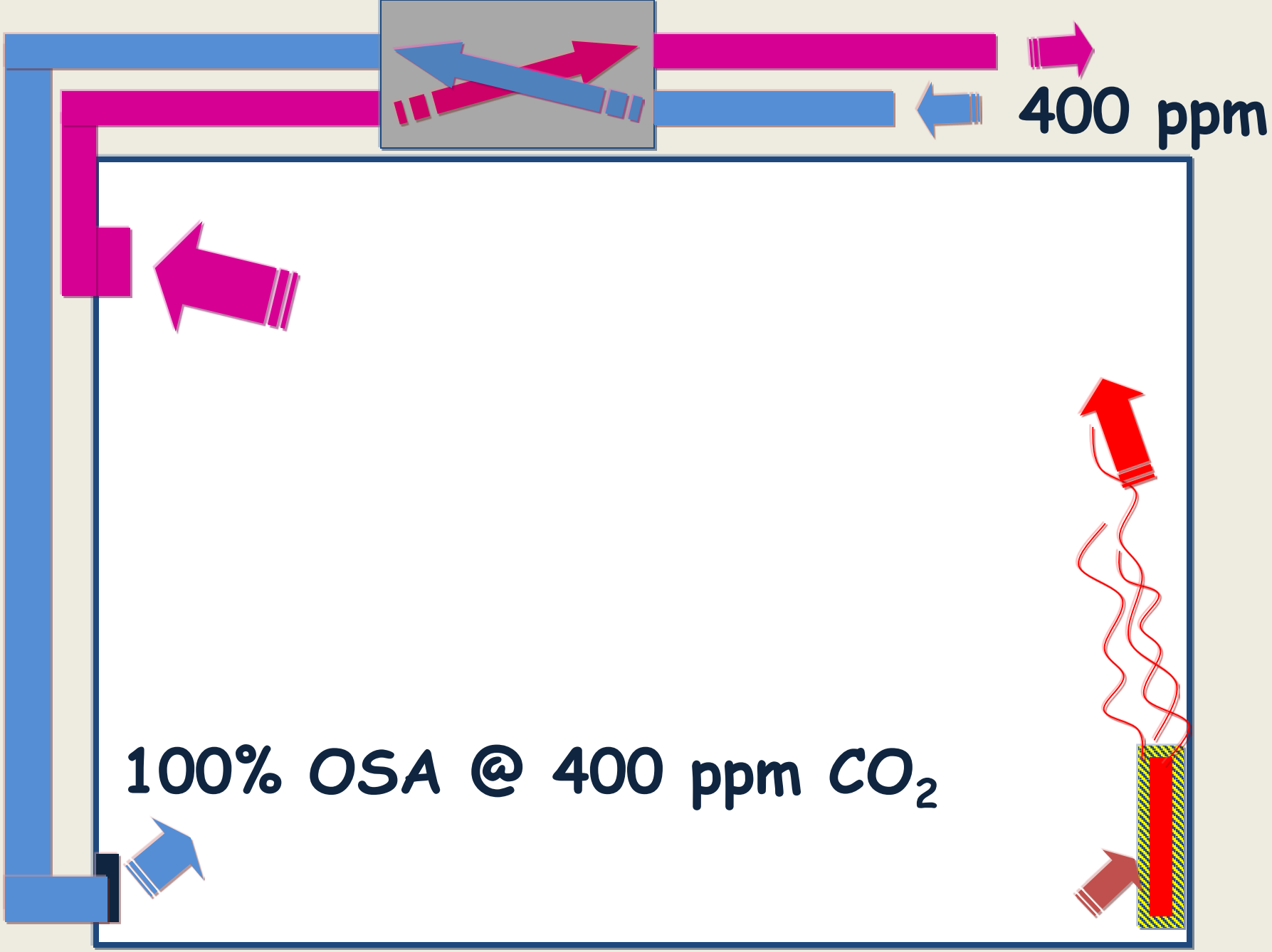

Another good argument
against flat roofs



Displacement Ventilation

Ventilation Effectiveness:
Displacement or "Piston Flow"




400 ppm
100% OSA @ 400 ppm CO_2


type dp 4-40
20x25x4

Carbon Dioxide Concentrations (ppm)

Time	Center of Room	Far Wall At Heat Register	Return grill
9:25	2250	2180	2150
9:30	1860	1930	1965
9:35	1560	1650	1800
9:40	1525	1500	1600
9:50	1135	1250	1450
9:55	1175	1122	1220
10:00	1050	1060	1120

Case Study: Public Pool complaints for years…


642


REZNOR

Carbon Dioxide sensor/controller

Controls outside air quantities to maintain
Indoor vs Outdoor CO2 differential of about ~ 700 ppm

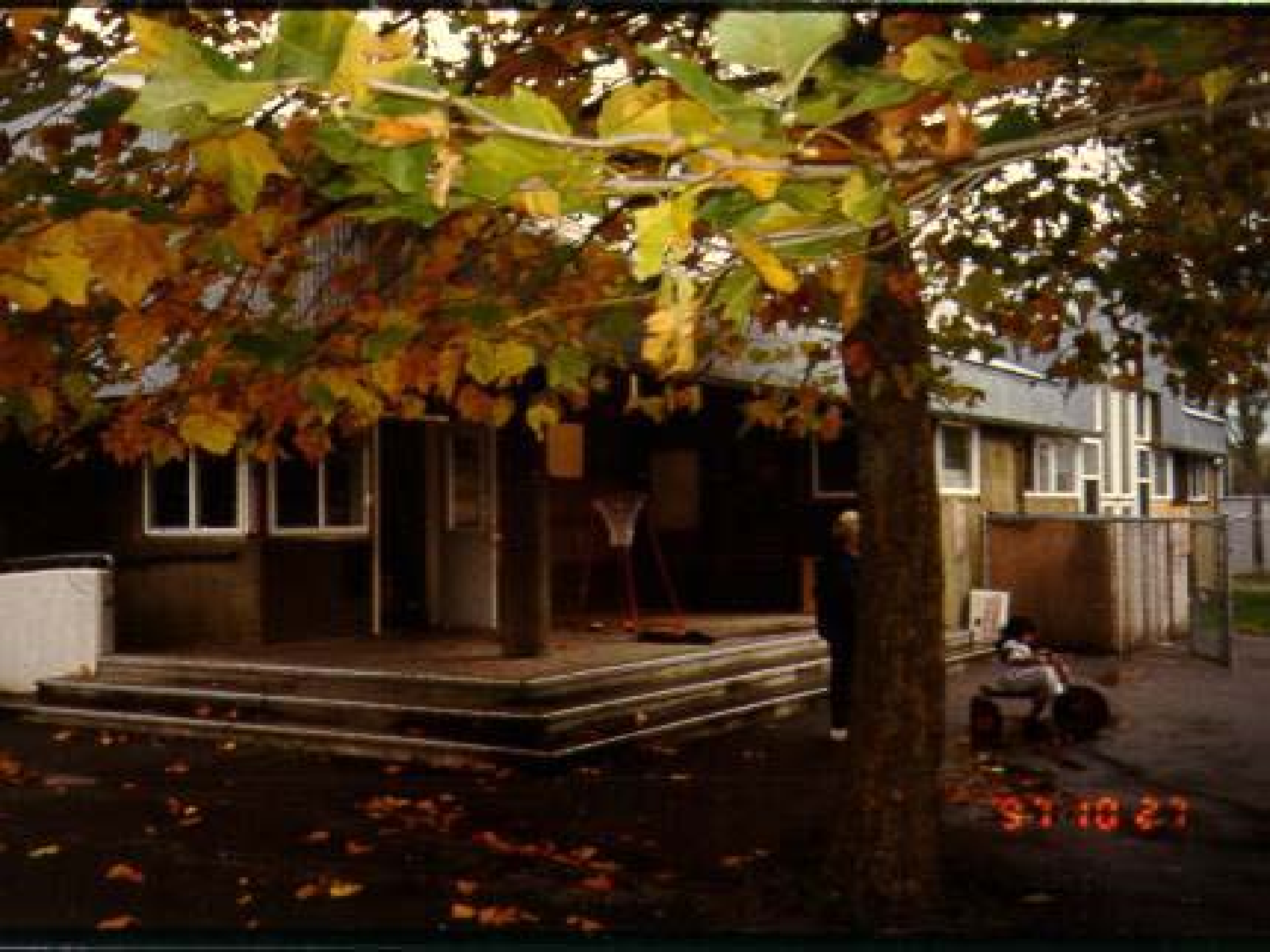
"Demand Control Ventilation"
CO_2 sensor opens/closes
Outside Air Dampers

Soot accumulation in one hour = CO too

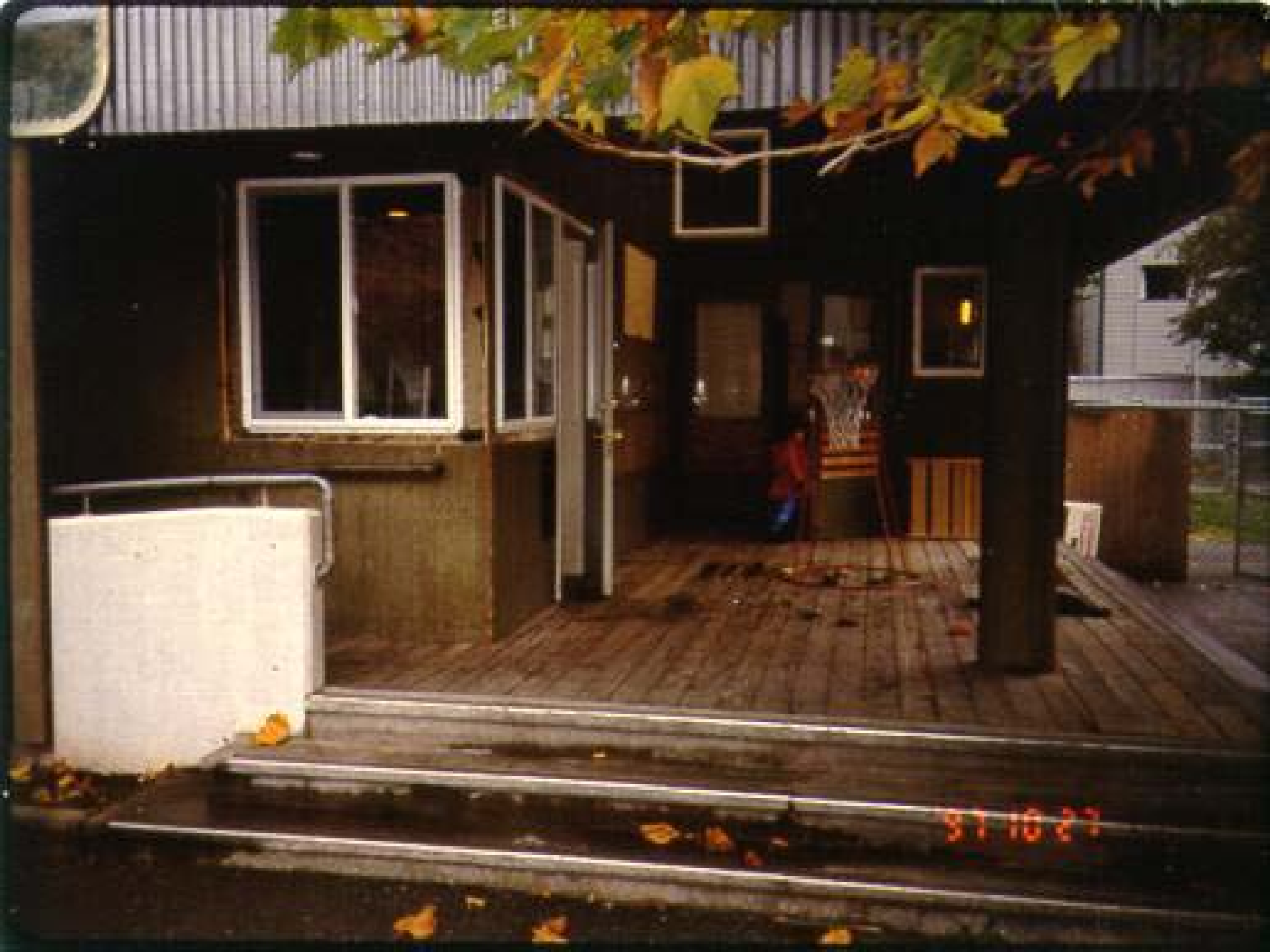

Library

Case study: Why the high CO2 level early morning in the basement of an unoccupied school?


38 12


97 10 27


'97 9 16


97 10 27


'97 10 21

97 9 16


97 10 27

Fun with filters


6 14 '99

Immediate Results

Orphaned Filter in Ceiling

Self-correcting filters


DANGER


Cat. No. 63K8901
Y G W R C
NOTICE
WARNING


PACE


NON-FLAMMABLE GAS


AAF


Filter by-passes
Pressure relationships
Crawlspace air entry


STAFF
STAFF
Be
Polite

The sun is brighter, the air is freshe

why?

Bob and Jim cleaned filters!

Date:	Time:	Signature:
Date: 12-6	Time:	Signature:
Date: 1-3-00	Time:	Signature:
Date: 2-3-00	Time:	Signature:

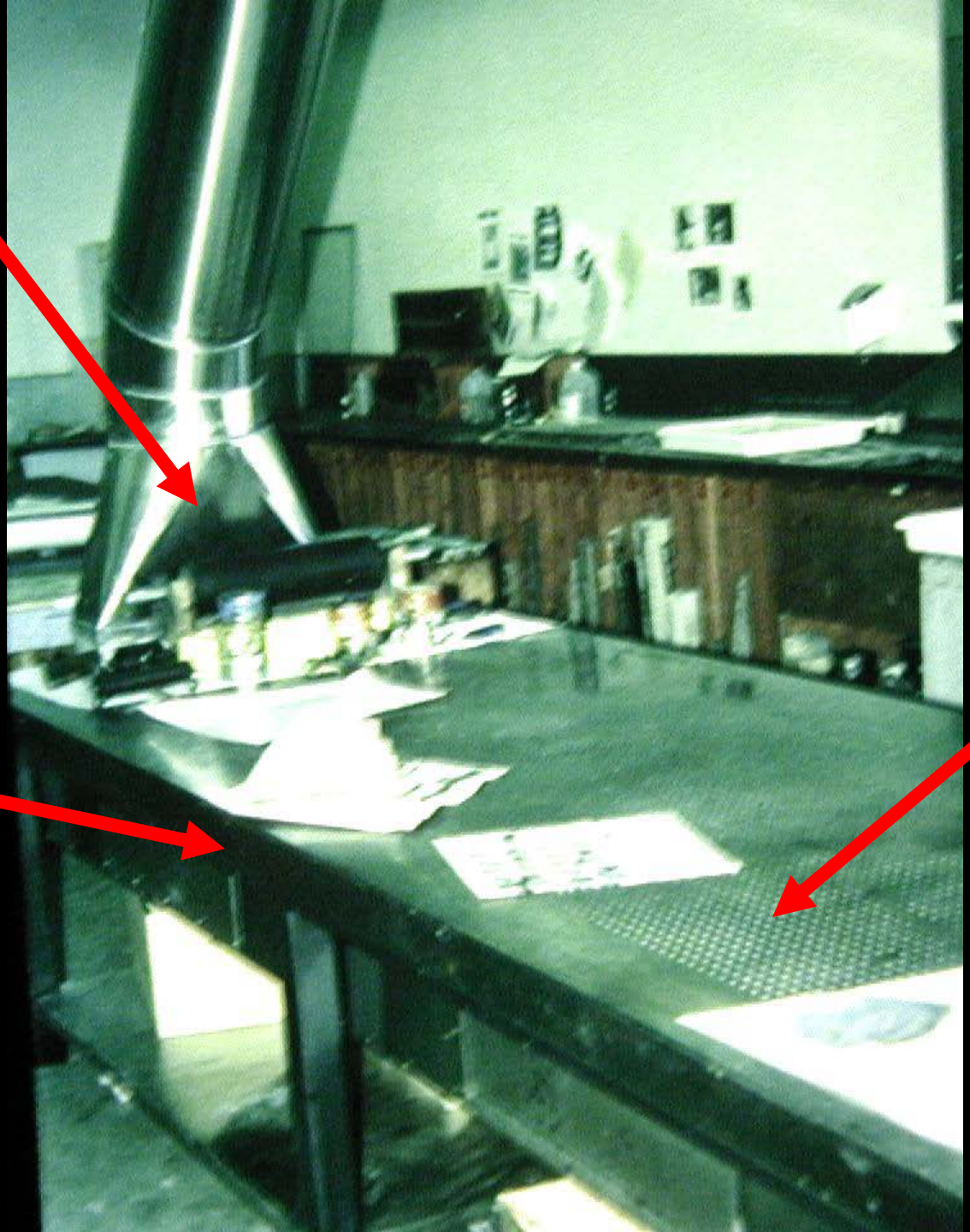
Better dust and fume exposure control via exhaust management: mechanical rooms, school art and shop rooms, office electronics, etc.

Check Air flow = Clean to Dirty ??

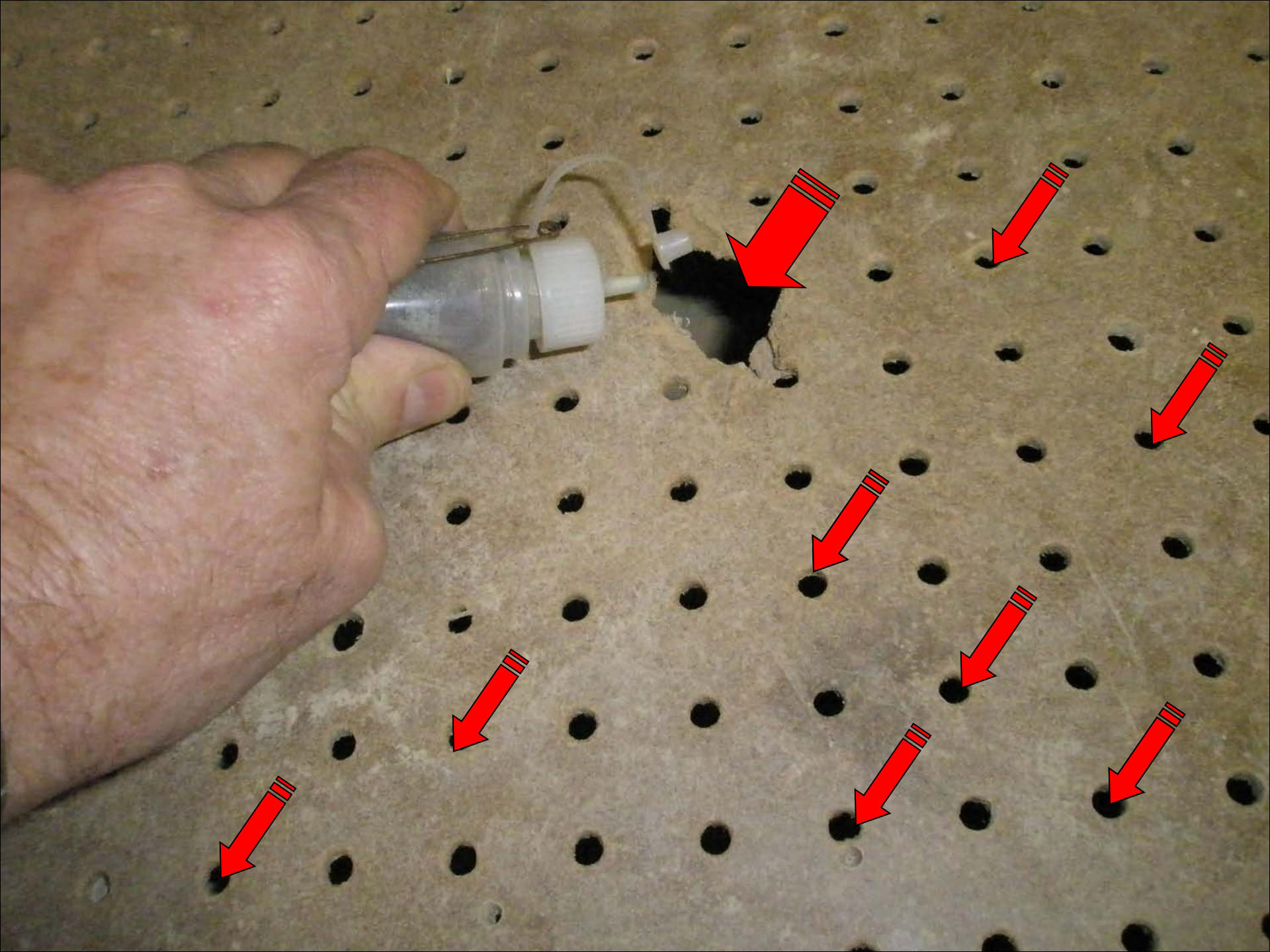
Check Air flow = Clean to Dirty ??

Faulty school shop exhausts


Clay dust


Exhaust
Hollow Work Table
Perforated Table Top


POWERMATIC




SAND PRO
DUST FREE
DOWNDRAFT SANDING STATION

EXIT


ATTENTION!!!
This machine is for
chool employee use
only. Thank you.

Vented kilns


STOP
FALSE

Please keep this door closed if the laminator is on or if fumes are evident, and please close the workroom door.


CHEMICAL
STOREROOM

Case Study: How can a staffer in one corner of a building on the first floor know when the biology lab is using chemicals on the second floor of the opposite side of the building?


'98 10 6

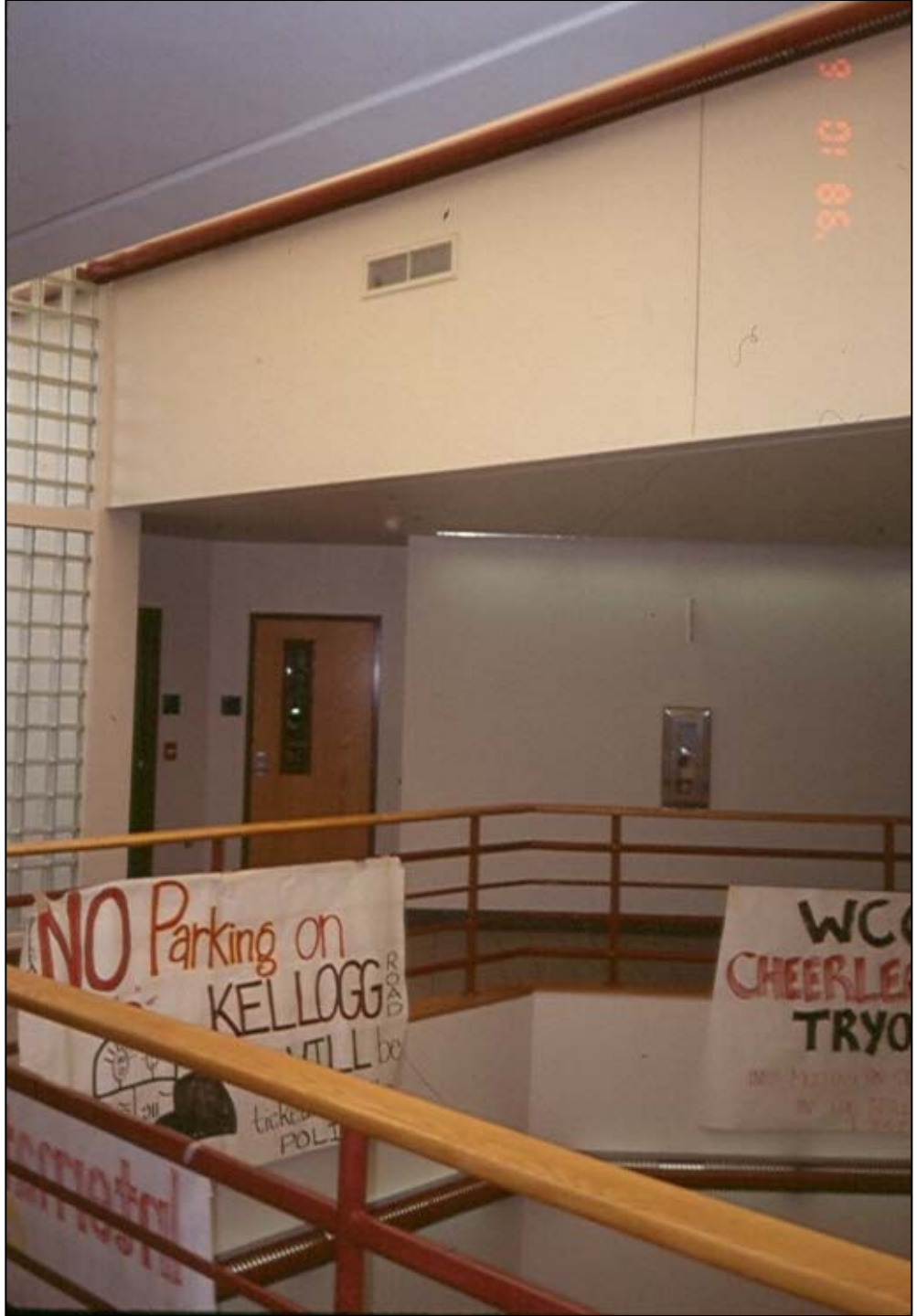

HEYGUYS.
WANNA
PICK UP
SOME GIRLS
'98 10 6


EXIT


EXIT
'98 10 6


98 8 26


WE RECYCLE
RECYCLABLE ONLY
NO TRASH, TOWELS, GLASS


NO Parking on
KELLOGG
ROAD
WC
CHEERLE
TRYO


WCC
CHEERLEADING
TRYOUTS
SCREAM
LOUD

Reduce and Remove Chemicals:

King County's "Rehab the Lab" program

Old photo chemicals


STANSI
METHYLENE BLUE
POISO

Careful disposal called for


Unit Ventilator !

Contain and Exhaust


LEMON SCENTED
Aerosol
ntolene
ust mop
eatment
• gathers dust
ay on dust mop or cloth
revents germfilled dust
from scattering
CHEMSEARCH
DROP DEAD™
A Combination of Insecticides
Offering Quick Knockdown and
Residual Kill of Crawling Insects
for up to Four Weeks.
KEEP OUT OF REACH OF
CHILDREN
BANI
Advanc
Urinal Mai
• Quickly removes
scale and buildup
salts
• Eliminates offensiv
• Use for
prevent


LPS
3

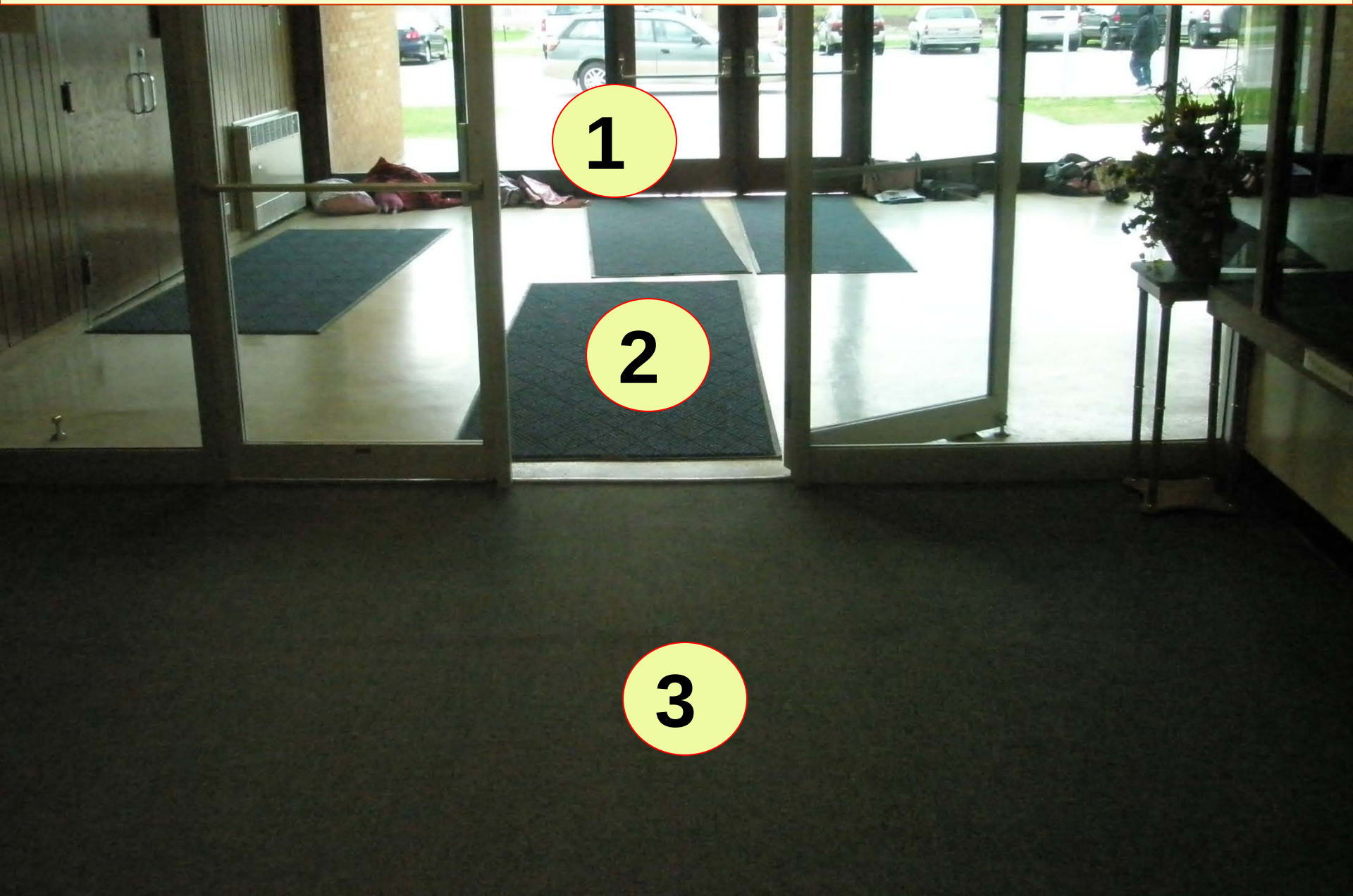
A renaissance in cleaning technology, if not in cleaning budgets

Cleaning for health
-- not just appearance

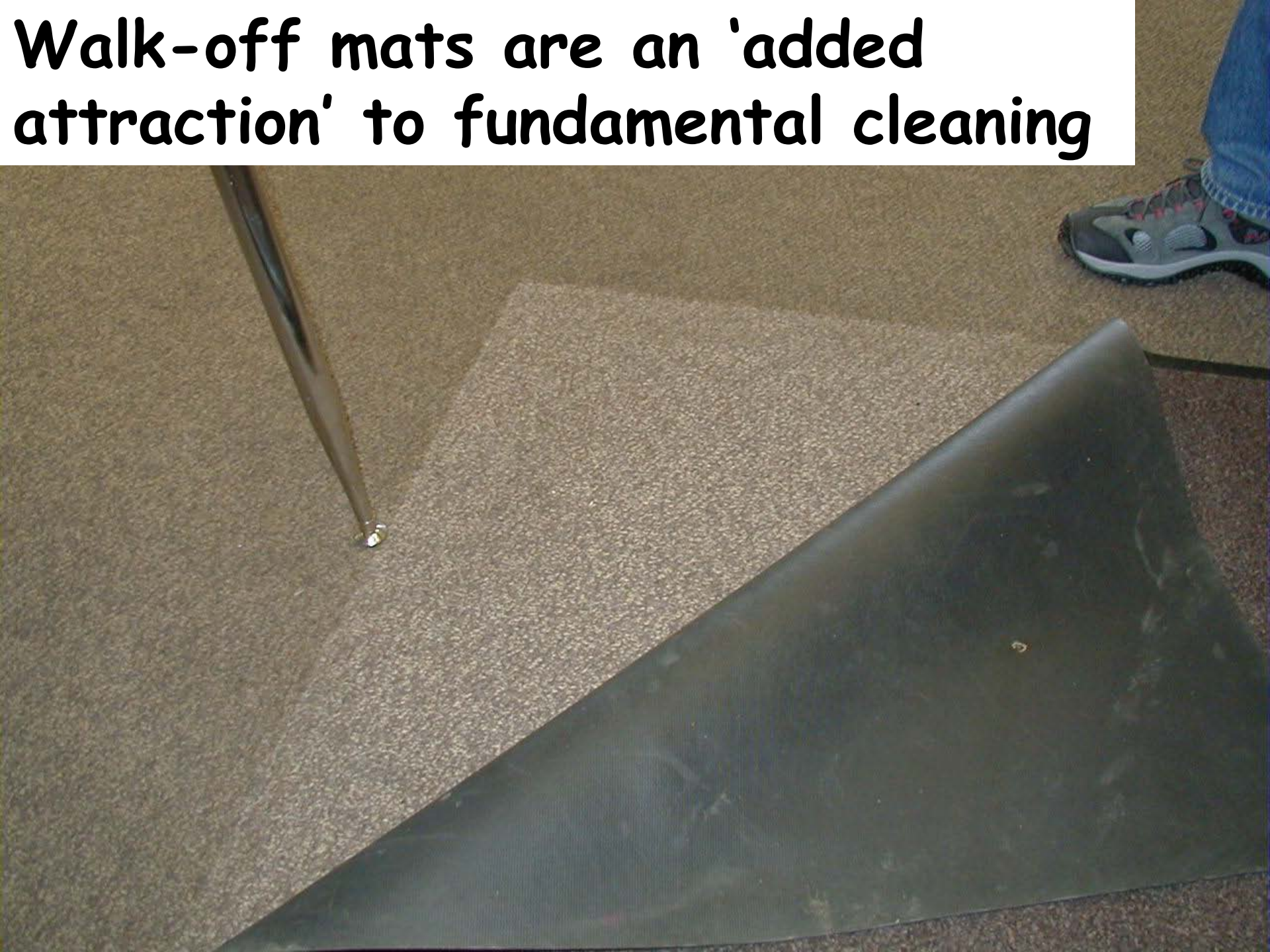
"Stop the dirt at the door"
but with mats that can be cleaned


“Step 1”

3-stage dirt control at entry



Walk-off mats are an 'added attraction' to fundamental cleaning

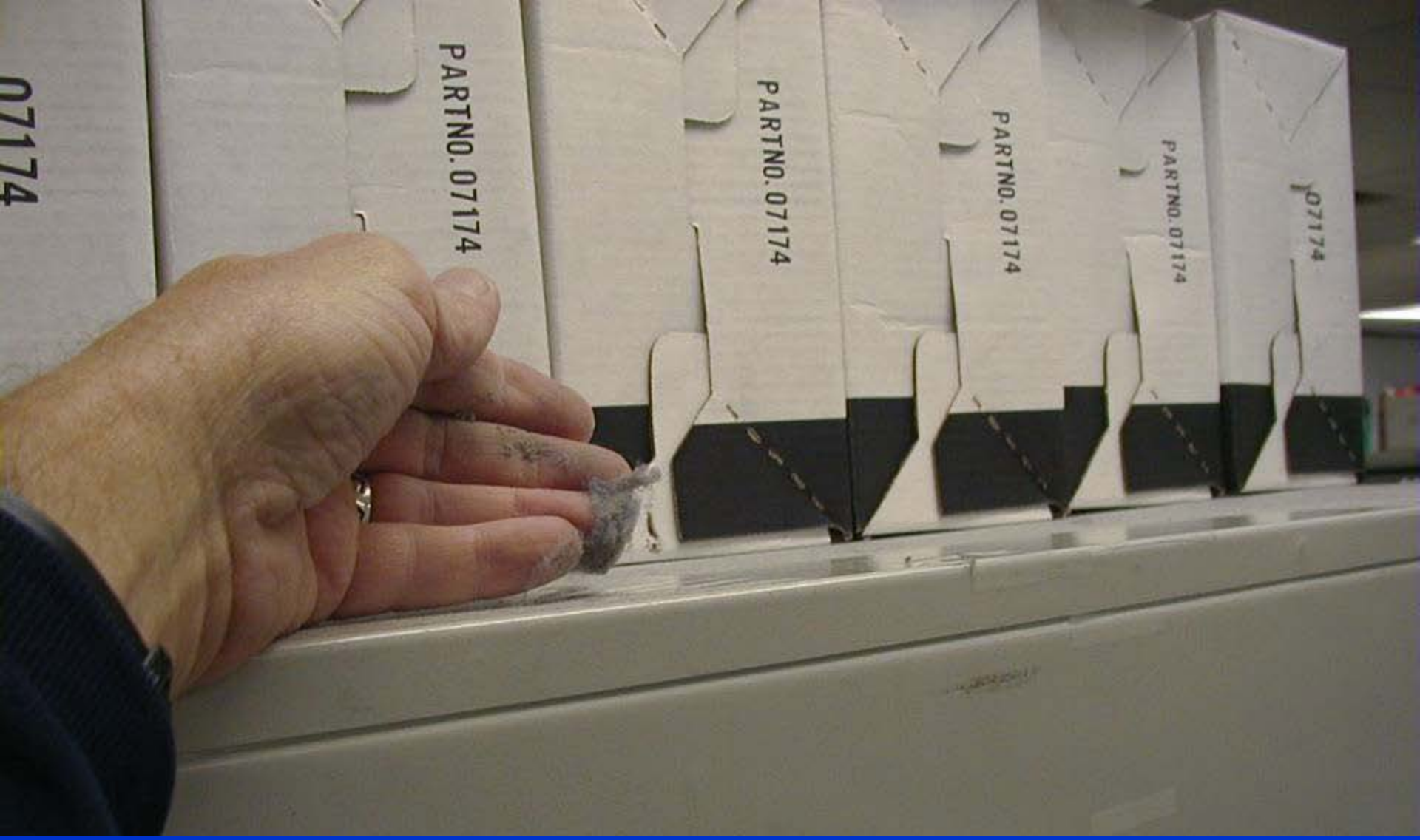


"composting carpet"

Is the school "cleanable" ?

Custodian's Nightmare


Clean Enough ?



Filters *<u>cannot</u>*
clean dirty buildings

No chemicals "from home"

“Unintentional” Asthma Triggers

...rean Cleaning Pilot Project


ANACORTES


WORLD BOOK
Notebooks


Purple
Not Sharpened
tiles
dinosaur counters
Unifix Cubes
Buttons
Teddy Bear Counters
Time
Money
Jewels
Pattern Block Activities
MathLand


ORY
CAIRN
SARAH
LOGAN

Green Cleaning:

Reduced chemical exposures

Reduced number of products used

NEA's very first C.L.E.A.N. Award Winner

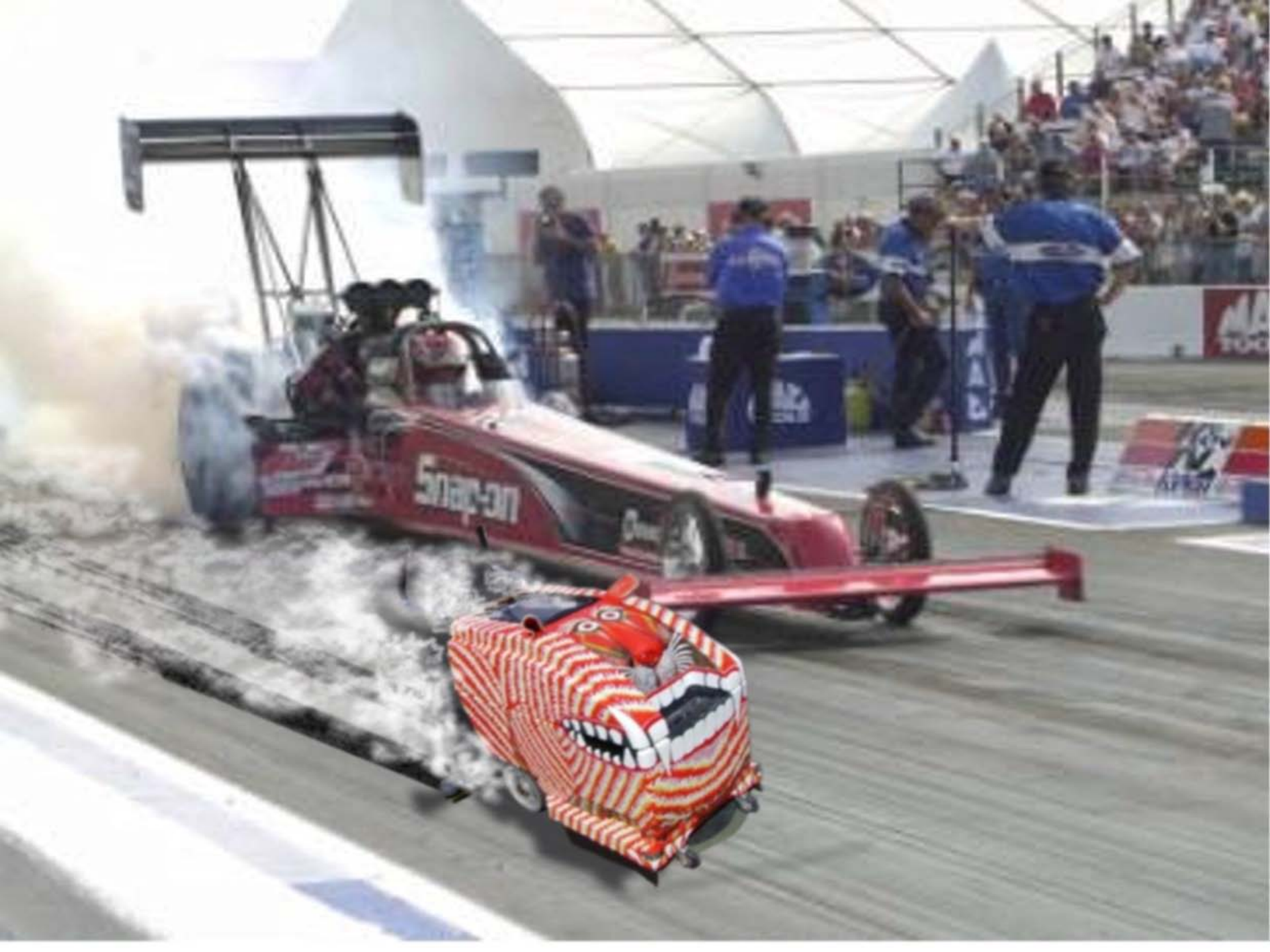
Pat Nicholson

Central Kitsap School District


FANG SAYS
"Pick Up
Your Stuff!"


OLDNAVY
94


SCHOOL BUS
BLUE
BUS DRIVERS



Asthma Trigger Reservoirs

Non-district furniture, rugs, blankets, pillows

What's outside gets inside . . .

What's inside piles up …


Ditch the old couches

“Unintentional” Asthma Triggers

BIRCHWOOD ELEMENTARY SCHOOL

INDOOR AIR QUALITY

APRIL 21, 2003

ACTIONS TAKEN BY BSD TO ADDRESS IAQ ISSUES:

Change Supply Air Filters Every Season

Use of Backpack Vacuums

1995, Replace Roof

Reduce use of chemicals/Install Automatic Mixing Stations

1996, Requested Health Departments help for IAQ

1997, Implementation of "Tools for Schools"

1998, Started using Unbleached Paper Products

1998, BSD initiated Annual Building Cleanliness Inspections

2000, Switched to using "Green" label products

2000, Replace windows in original building w/Insulated windows

2001, Purchased vacuums in Office/Staff Break room

Culture change happens

Provide Adequate Cleaning Supplies

Note cleaning techniques and equipment

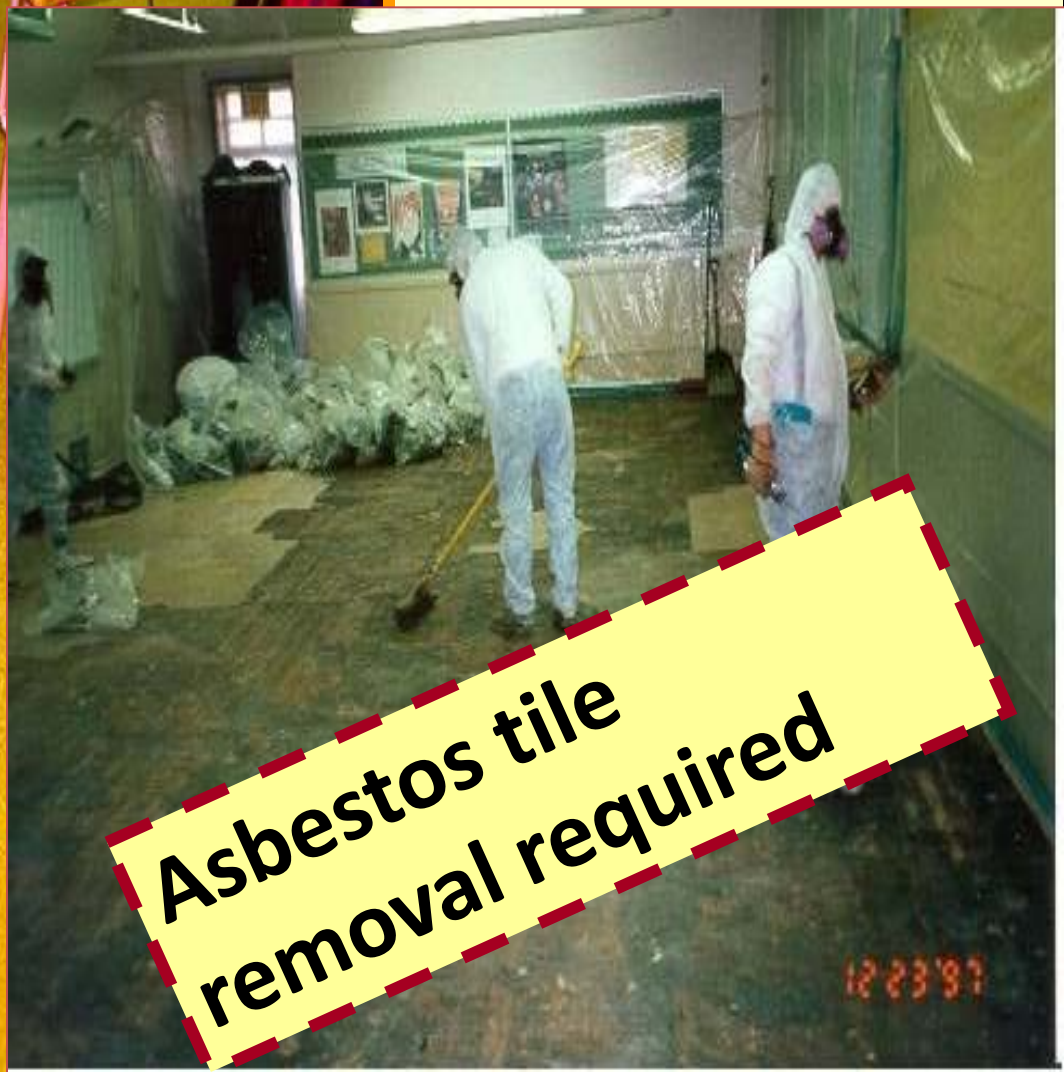
yesterday

today

Micro Fiber Products


Efficient &
effective
cleaning

Carpet Replacement

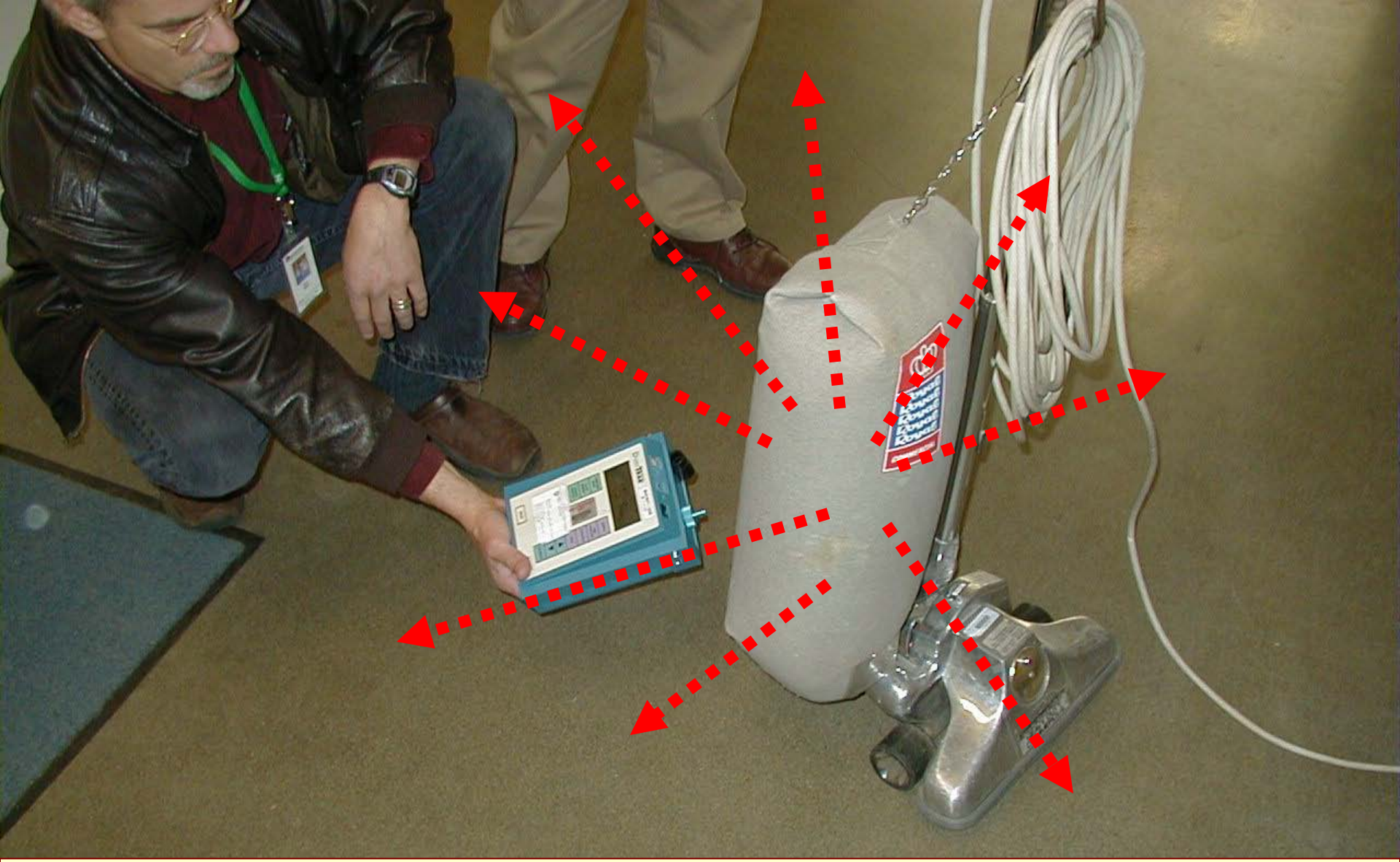



goat
rope
hope
hippo
soap
note
noble
so
no
know
47%


How's the carpet?
The "Sniff Test"

carpets *can* contain huge amounts of allergens and asthma triggers

detergent residue = exposure



use only **HEPA** rated vacuums:

settling of smallest particles takes ***days***


what gets measured gets controlled

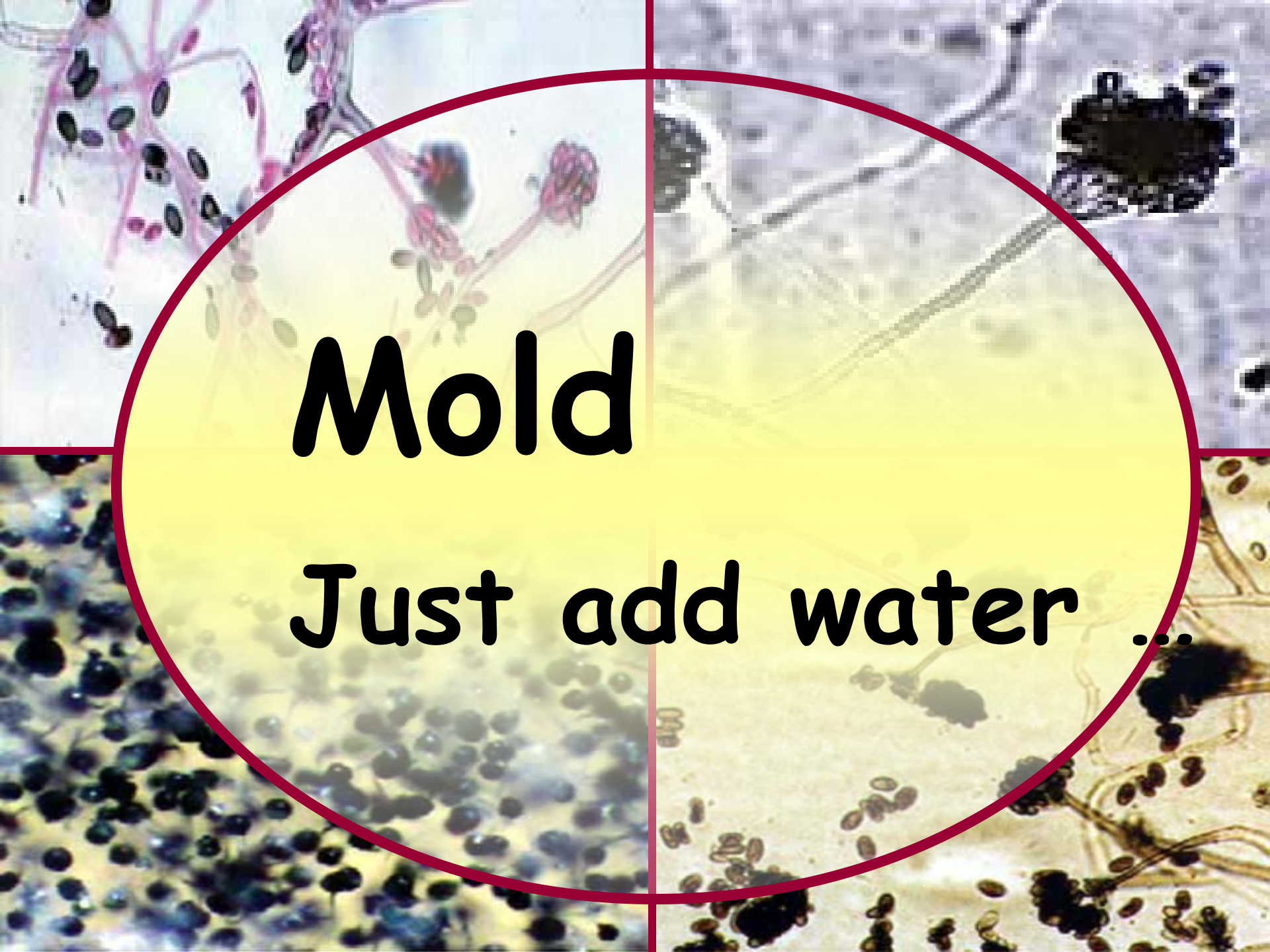
There ***is*** a difference between a true “HEPA-Vac” and vacuum with a “HEPA filter”

Particle Counts from School Vacuums – Fluke 983 Differential Mode 1 Liter Samples

Equipment	0.3	0.5	1.0	2.0	5.0	10.0
Back-pack 62-076757 (very clean filters)	47,748	5153	510	186	15	3
Back-pack 12579 (Dirty filters)	103,501	23539	5736	3230	506	109
Back-pack 12579 (Clean filters including hepa)	85,948	13948	2528	1493	401	120
Back-pack vacuum ID: 0116891 FXR "with dirty filter"	99,886	15819	1746	932	30	14
Back-pack vacuum ID: 0116891 FXR "with a clean hepa filter"	77,284	20902	3649	3278	651	196
Back-pack vacuum ID: 0117640 FXR "with dirty filter"	117,061	22666	1900	1026	71	16
Back-pack vacuum ID: 0117640 FXR "with a clean hepa filter"	93,133	13755	868	417	41	6
Back-pack vacuum cleaner #0116890 FXR dirty filter	281,750	67464	12918	6472	1707	995
Back-pack vacuum cleaner #0116890 FXR new filter	248,656	54535	13063	7259	1205	182
Back-pack 0116789 FXR (Dirty filters)	54,124	10971	1538	632	39	6
Back-pack 0116789 FXR (Clean filters)	40,701	8009	1247	571	73	16
Back-pack 0116788 FXR (Dirty filters)	24,482	3768	651	337	53	8
Back-pack 130822 (Dirty filters)	50,725	17418	4888	2491	316	69
Back-pack 130822 (Clean filters)	35,820	9391	2590	1290	171	29
Old Royal Vacuum Cleaner (rarely used)	19,518	4085	2580	2141	889	261
Back-pack 62-074935 (Dirty filters)	48,963	12401	3386	1996	662	223
Back-pack 62-074935 (Clean filters)	57,299	13846	3816	2317	661	167
Back-pack 62-034055 (Dirty filters)	53,213	14326	4016	2435	596	111
Back-pack 62-034055 (Clean filters)	58,022	15043	4281	2619	611	133
Back-pack #184163 (dirty filters)	149,427	23263	4385	2053	330	65
Back-pack #184163 (new filters)	88,125	15372	3655	1985	257	37
Up-right Windsor #131146 (very clean filter)	90,437	11513	1329	682	176	72
Up-right (dirty filter)	74,000	24,000	4,700	4,500	267	55
Up-right (dirty filter)	143,000	23,000	1,700	2,000	600	300
Back-pack (dirty filter)	101,000	25,000	2,200	736	0	0
Up-right (dirty filter)	29,000	4,200	480	460	40	15
Up-right (dirty filter)	42,000	9,500	1,000	589	250	345
Back-pack (dirty filter)	70,690	20,600	2,900	2,000	393	230
Up-right (old) (dirty filter)	45,000	20,000	5,000	6,000	1,000	400
"Pig" (dirty filter)	1,800	300	100	375	550	590
Up-right Windsor (dirty filter)	120,000	38,000	3,300	1,000	160	110
Hoover Wind-Tunnel Up-Right (residential model)	4,900	170	0	6	6	0
Up-right Windsor (dirty filter)	81,000	20,000	1,500	530	52	68
Back-pack (dirty filter)	47,000	10,000	1,000	700	160	160

Note 1: some rounding of values was peformed

Note 2: "dirty filter" means the unit was operated as-found with the used filter/bag in place


Mold
Just add water …

Water Leak in Attic

Evidence of moisture and/or mold may not be obvious


TRAMEX
Moisture
Encounter


“Blank” switch plate covering inspection hole


3" SLOCOMB ◆ ABS

Monitor relative humidity levels:

- Reduce generation
- Add ventilation
- Both !


1,898
guage III


'85 2

Increased separation between

tunnels/crawlspaces

and the humans

Crawlspaces, Tunnels, Etc.

Contaminated air enters occupied areas through *unplanned pathways*

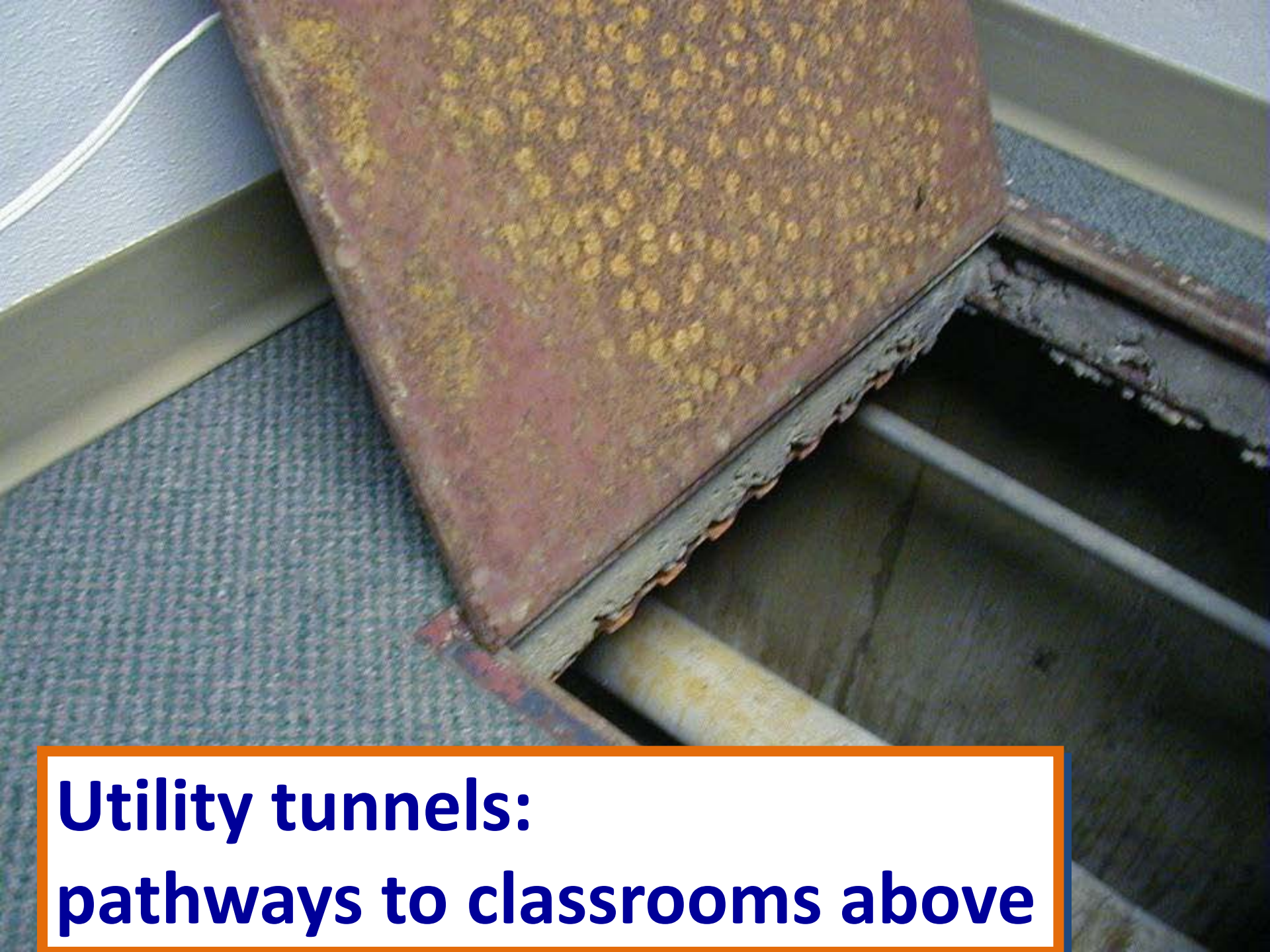
Check air flow direction at access covers or other penetrations and note on map


So, what's down there?
vent open to crawl space


'97 10 16


93 321

Disconnected Duct In Crawl Space

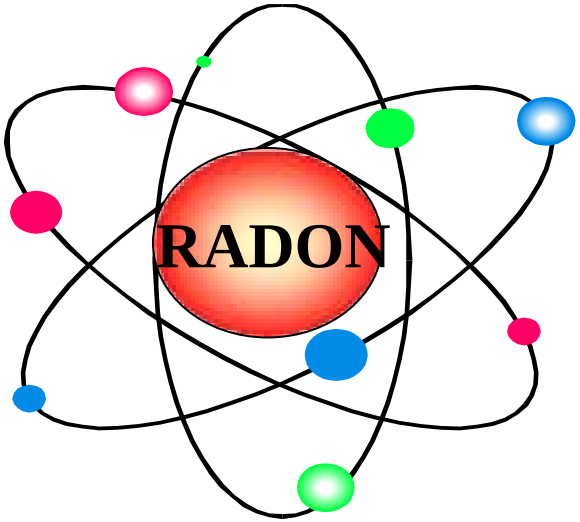


Utility tunnels:
pathways to classrooms above

Tunnel is air duct for school

Tunnel is air duct for school


Underground Air Ducts
= Radon & Asbestos



Naturally occurring radioactive gas

2nd leading cause lung cancer

From the soil (or private well water)

Tunnel open to "unit-ventilator"

Tunnel Depressurization Fan

Less than $150.$\underline{00}$ …

"no more mold complaints

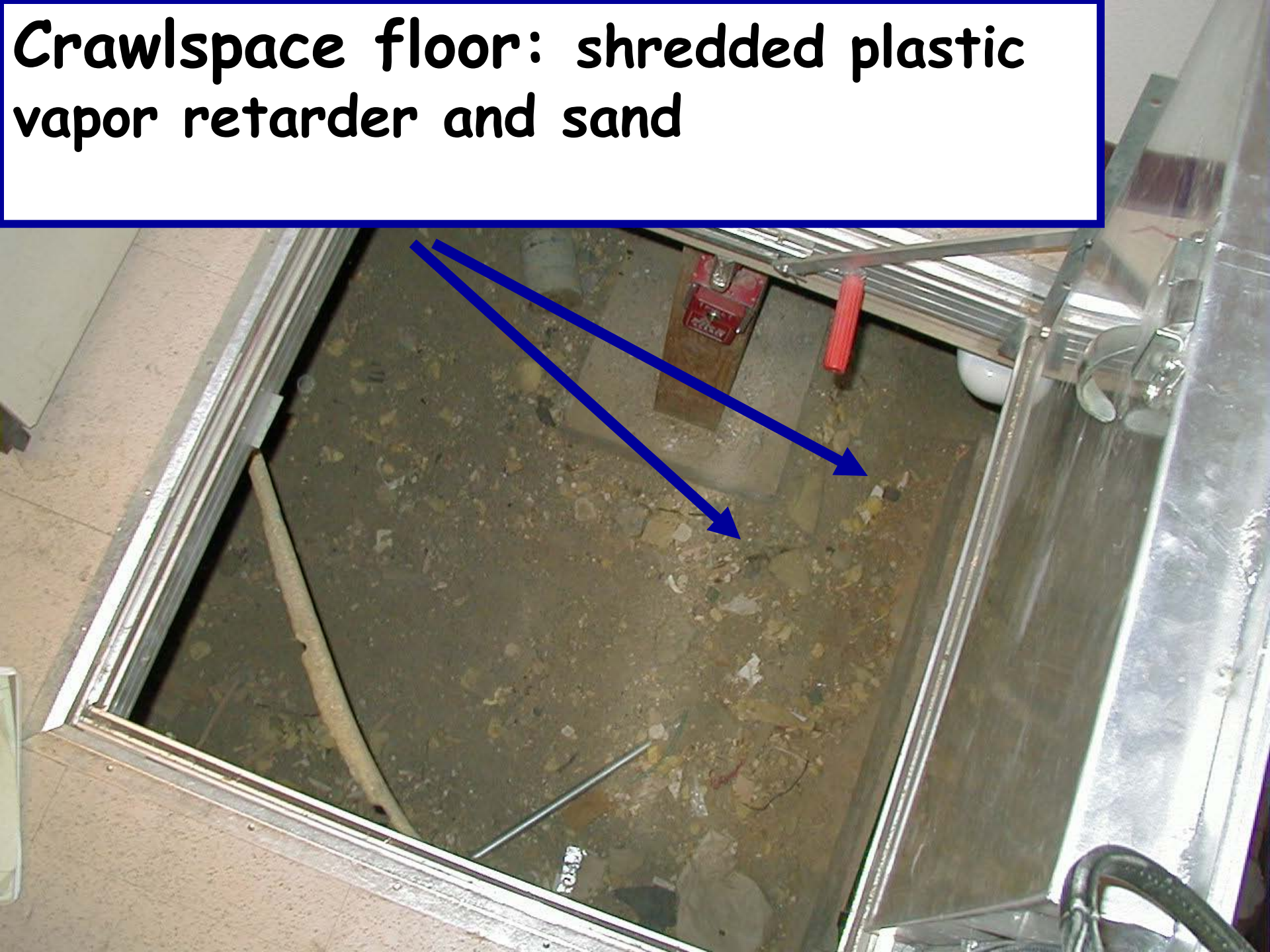
and the classroom windows don't fog up anymore !"

Seal openings to classrooms

exhaust fan depressurizes tunnel


air from “dirty” crawlspace
into “clean” school

Crawlspace floor: shredded plastic vapor retarder and sand




Crawlspace soil damp in a limited number of areas

Fog machine used to visually check air leaks from crawlspace to building


Crawlspace contains
abandoned ducts


Crawlspace "ceiling" sealed

Ozone Generator

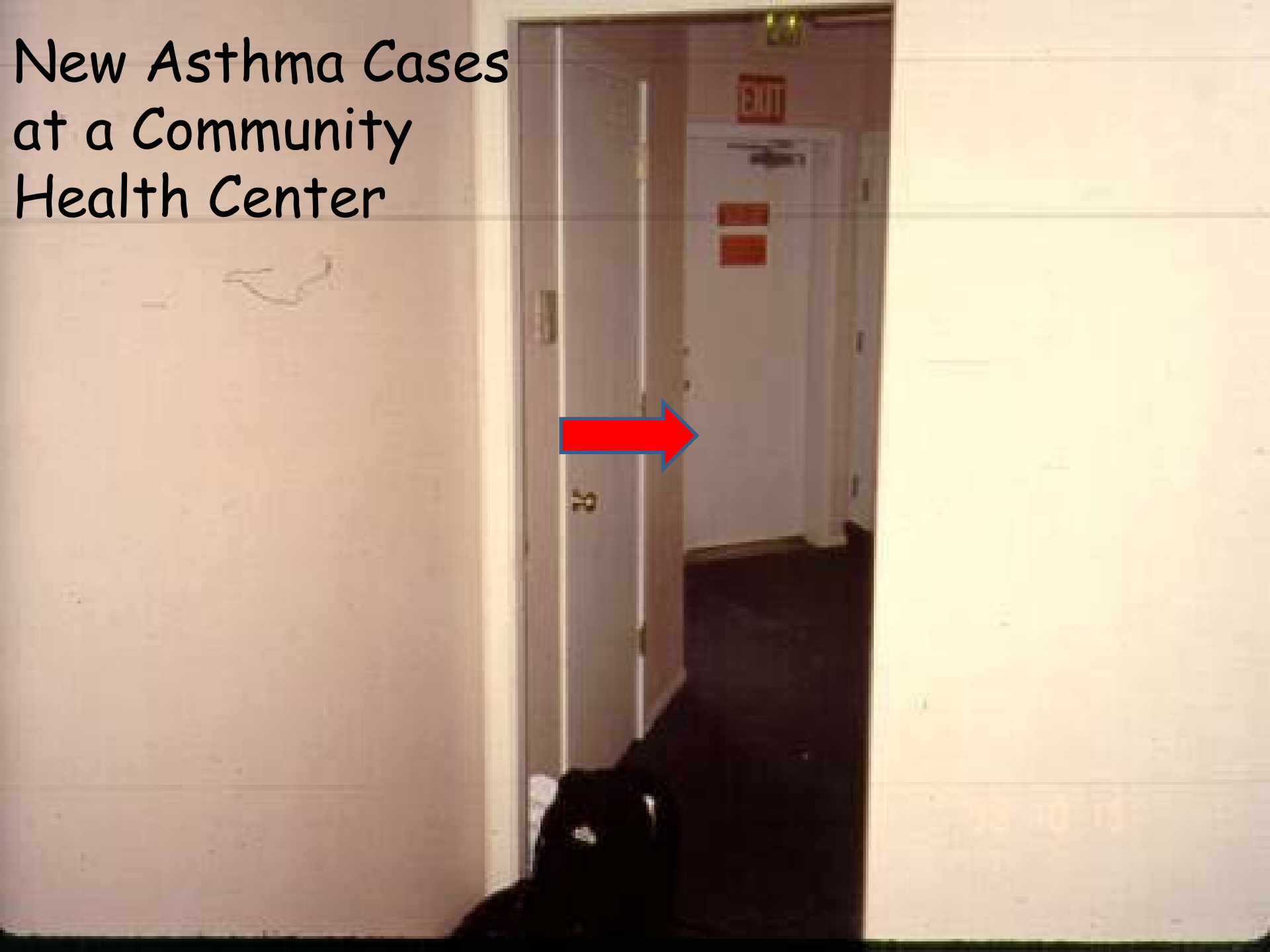
Ozone generators

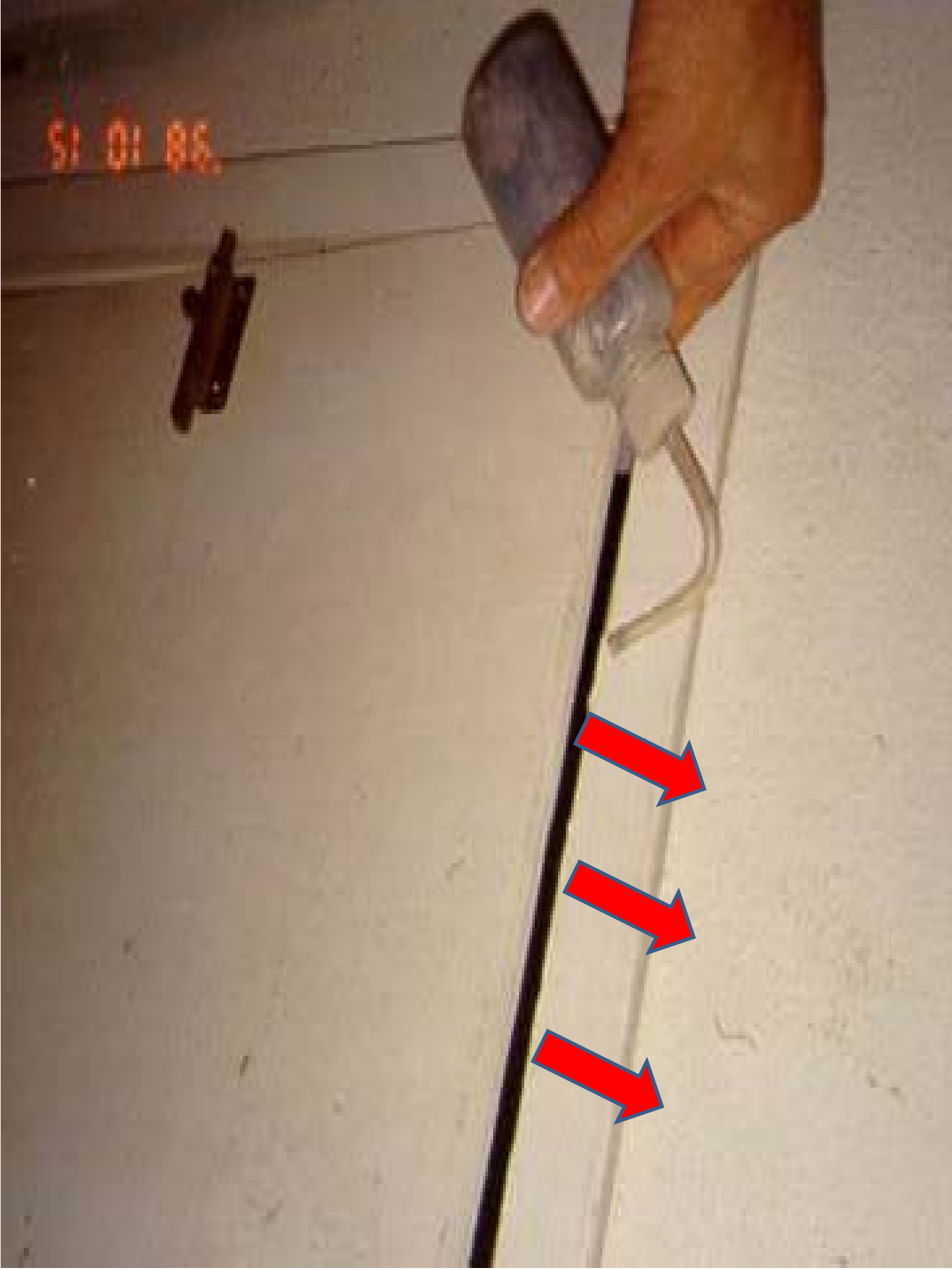
Not

recommended


Be a Germ-Bu
WASH YOUR
1.
WET
POWER
FAN
A.O.SM

New Asthma Cases at a Community Health Center




31 01 86.


'98 10


5: 01 86


31 01 86

'98 10 15

What is Indoor Environmental Quality?

What is an IEQ Success?

- ✓ _____
- ✓ _____
- ✓ _____
- ✓ _____
- ✓ _____
- ✓ _____
- ✓ _____

What is Indoor Environmental Quality? What is an IEQ Success?

- No known hazards or risks
- No complaints (real world … can't expect zero)
- Productive & Comfortable
- Energy efficient & sustainable
- Reduced exposures
- Asthma / allergy friendly
- Practical & reliable controls
- "Institutionalized" operation & maintenance
- Routine assessments/monitoring
- Communications & continuing education all levels

Questions

&

Discussions

Discussion…