Building Science Bootcamp Indoor Air-Quality (IAQ)

Effective and Efficient IAQ Strategies in Residential Buildings

Building Science Bootcamp
Indoor Air-Quality (IAQ)

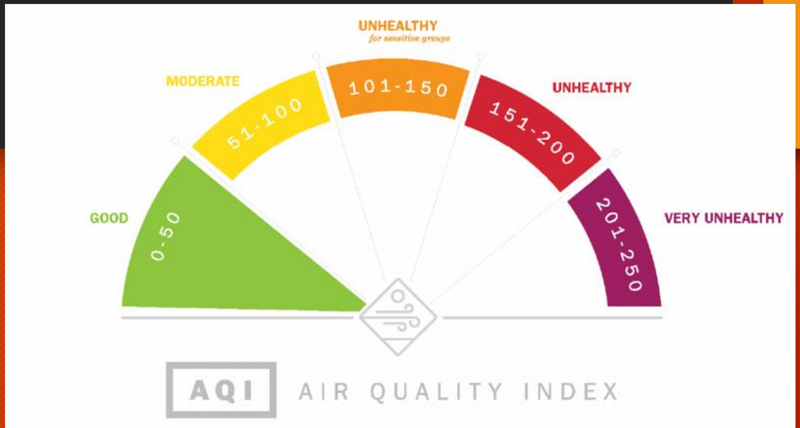
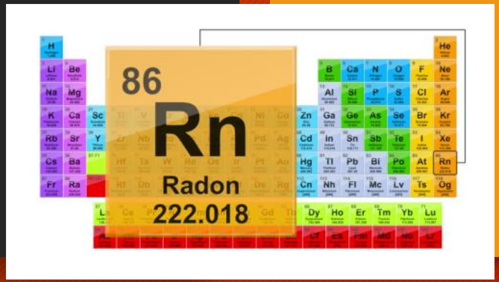


Table of Contents:

Building Science Bootcamp
Indoor Air-Quality - Radon



Radon Measurement Questions…

- Is radon testing mandatory in new construction after occupancy*?
- Do tighter homes need passive or active radon systems?
- Residential re-sale test required, *however…*
- Short-term test results vary widely by testing conditions.

** The answer is no, new homes are not required to test for radon after construction.*

Building Science Bootcamp
Indoor Air Quality in Tighter Homes

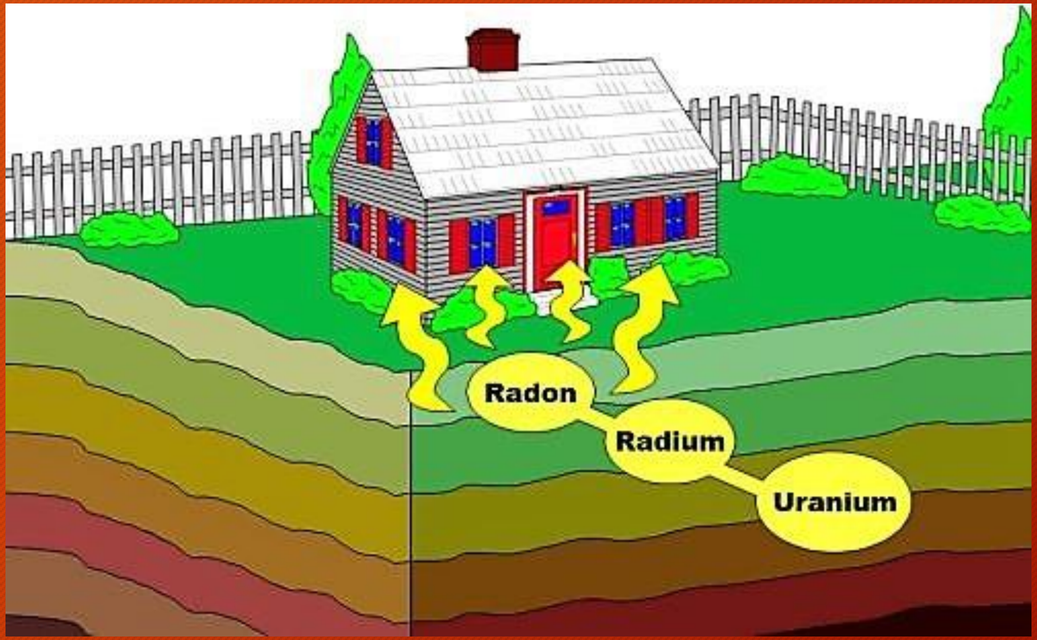
- *Tighter homes more readily depressurize when exhaust equipment is operated, making combustion appliances more prone to backdraft or spillage,*
- *Tighter buildings are also associated with elevated indoor radon concentrations, in addition to moisture problems,*
- *The US Environmental Protection Agency developed a protocol for guiding professional home energy upgrades while maintaining healthy IEQ for the occupants,*
- *However, the variability remains wide in the quality of energy-retrofitting services provided by weatherization contractors, which in turn affects indoor air quality in the retrofitted homes.*

Building Science Bootcamp
Indoor Air-Quality - Radon

What is Radon?

A radioactive isotope given off by decomposing trace-uranium, that when inhaled, has been shown in scientific studies to cause lung cancer.

Radon *"rides in"* with moisture vapor and depressurization, attaches to dust, and is 8 X heavier than air.



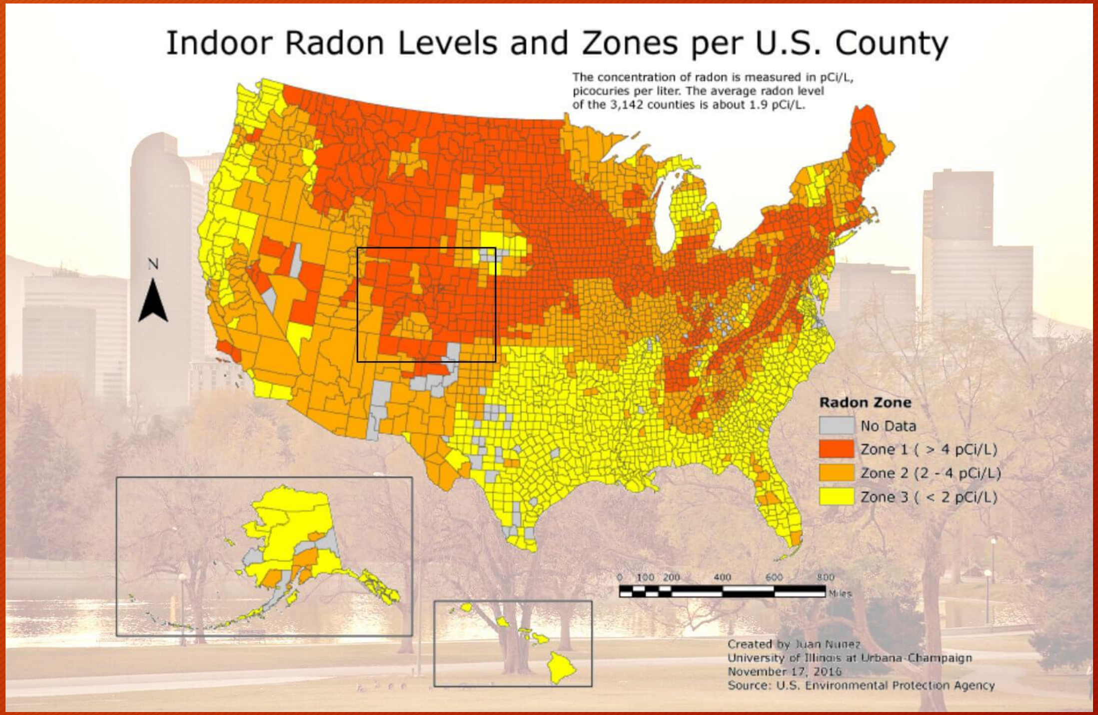
Interesting Fact:
While Geiger-counters detect a different particle-ray than radon, readings correlate closely with radon levels.

Building Science Bootcamp
Indoor Air-Quality - Radon

U.S. EPA Radon Threshold = 4 pCi/L*
Mountain West lies in a region w/very high radon levels. An average of 65% of homes tested in the Front Range have radon levels higher than the 4 pCi/L,

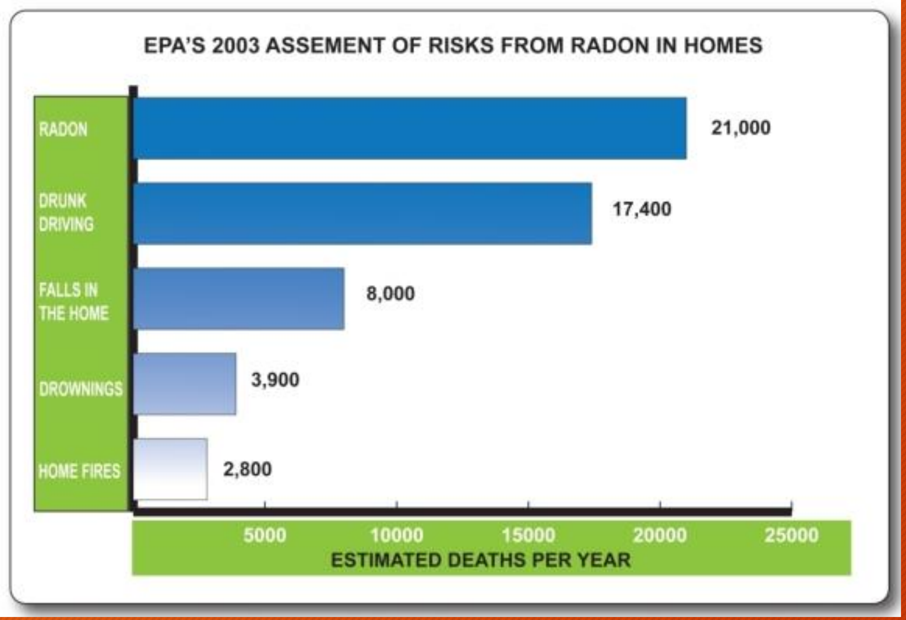
The EPA recommends testing homes with the *passive system* and if the radon level in elevated above 4 pCi/L, activating the system by adding a fan.

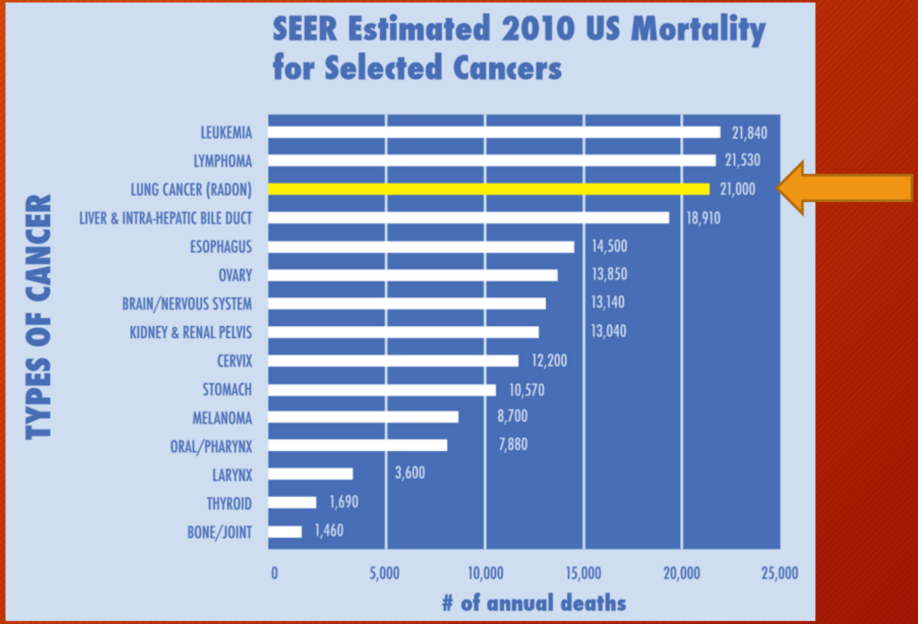
***pCi/L = picocuries per liter**



Building Science Bootcamp
Indoor Air-Quality - Radon

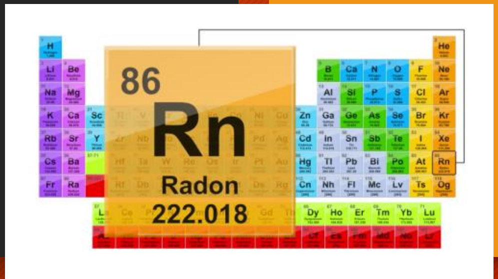
- Nationally, radon exposure is the second leading cause of lung cancer,
- Typical residential radon-mitigation systems cost **$1,500 - $2,500 per home**,
- Only 50% of Colorado residents whose homes test high for radon choose to mitigate,





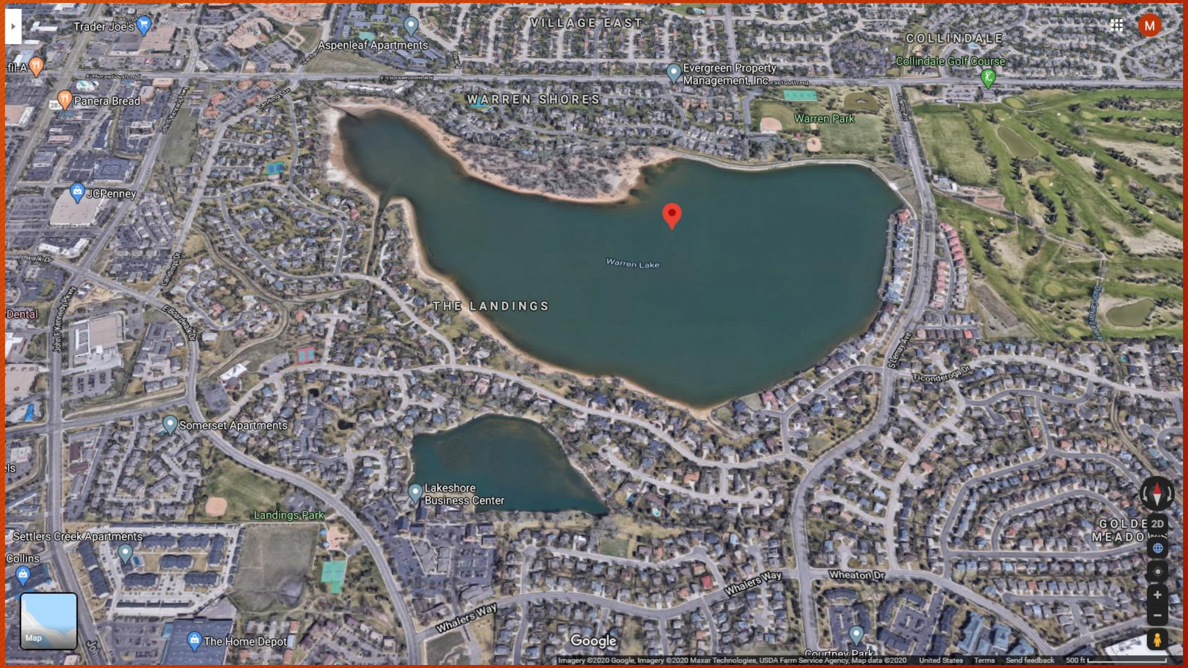
<u>Cost per life saved</u> = $35,000 nationally, for all radon mitigation systems & regulations.

Building Science Bootcamp
Indoor Air-Quality - Radon



Are Radon Levels Higher in Some Neighborhoods?

- Extensive site-excavation, like some mountain properties,
- Nearby lakes, and other high-water tables, with higher vapor diffusion into the home,
- Random other areas for less obvious reasons.

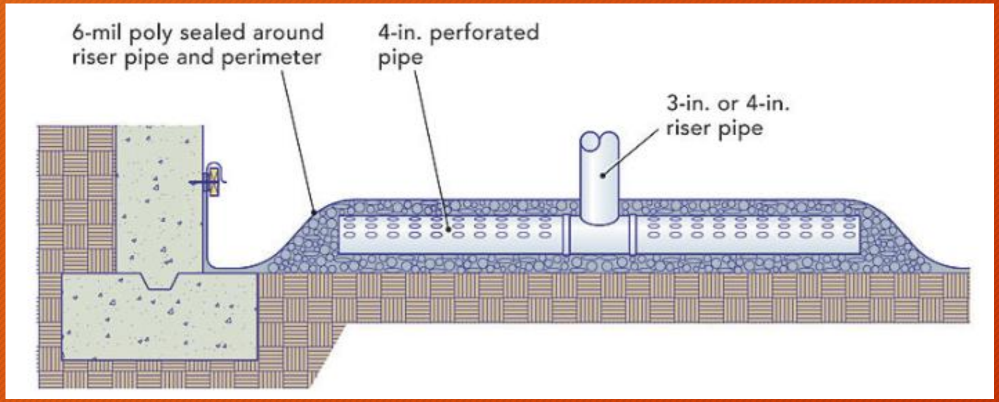


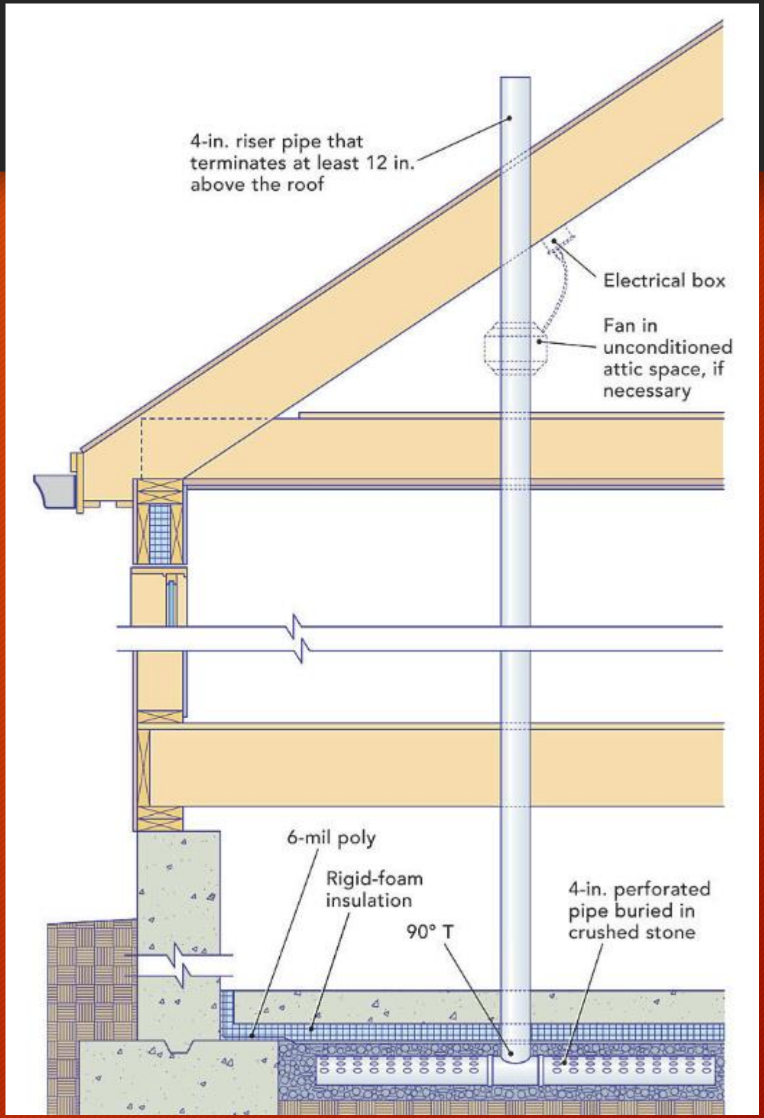
Building Science Bootcamp
Indoor Air-Quality - Radon

Radon Resistant New Construction:

- Granular drainage pad depressurized by passive draft action of warm vent stack located inside heated space, and/or active fan in attic,

- Avoid offsets or elbows in vent stack to maximize air-flow/draft whenever possible.

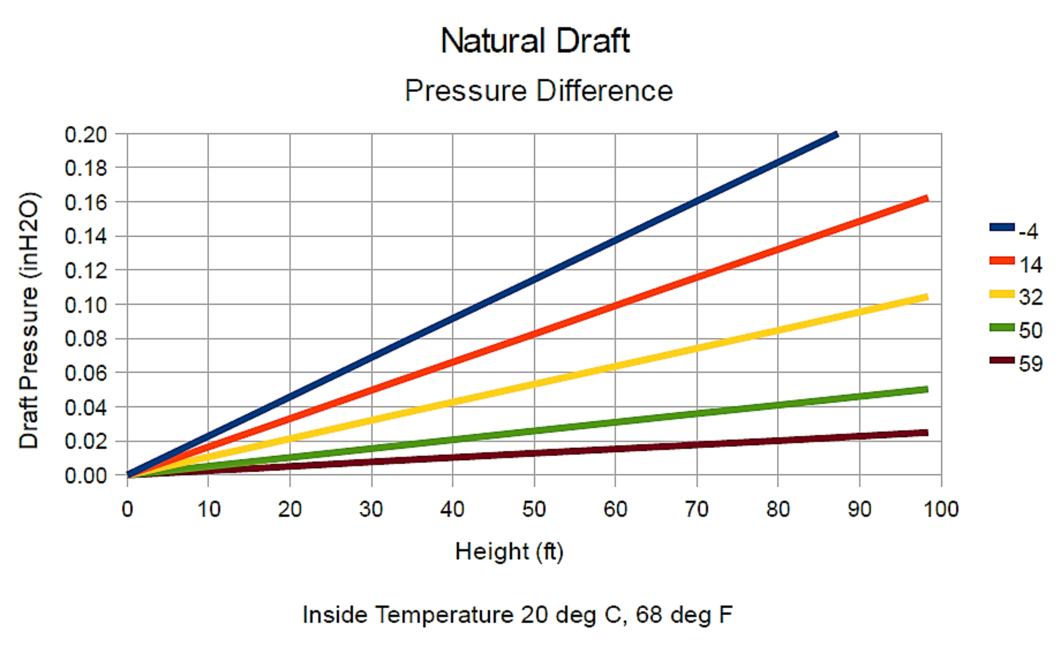




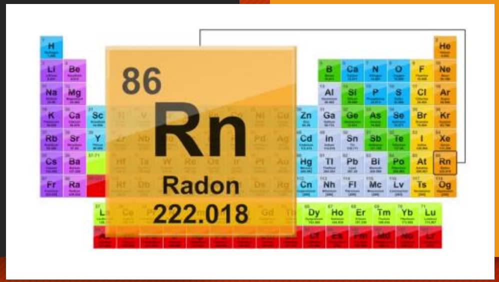
Building Science Bootcamp
Indoor Air-Quality - Radon

Passive Radon Systems:

- Depends on a number of factors:
- Height and straightness,
- The larger the temp difference between indoors and outdoors, the stronger the natural draft,
- Winter season is when the most drafting is needed, due to closed homes, warmer upper floors and colder basements.



Building Science Bootcamp
Indoor Air Quality - Radon



Building Code Follow-up Study:

The City of Fort Collins, a Northern Colorado community with a building requirement for passive radon control in new houses, conducted the largest study of “cap-on/cap-off” radon measurements in 2006.

These homes (new at the time) where twice as leaky on avg. as the current building-tightness code of 3.0ach, so radon levels could be higher now.

# of Houses	Cap-On	Cap-Off	Reduction
65	8.0 pCi/L	4.1 pCi/L	-50%

- Passive radon systems were shown to reduce radon levels by 50% (with vent pipe off),
- Short-term tests were conducted in the lowest level of house (i.e. a basement or crawlspace),
- The average of 6,900 existing homes in Fort Collins yielded a average of **7.1 pCi/L**

Building Science Bootcamp
Indoor Air-Quality - Radon

Better Passive Performance:
The single most cost-effective measure to improve natural-draft of passive radon systems, especially in the winter, is to ***insulate the exposed PVC pipe*** as it passes through the cold attic in winter.

Cost = $1 per linear foot:

Building Science Bootcamp
Indoor Air-Quality - Radon

Best Practice Radon Resistant Construction:

- **Circumnavigate the majority of the foundation area with perforated pipe/conduit,**
- Inadequate venting, *like short "T" stubs* without perimeter conduit, leads to ineffective sub-slab depressurization, poor radon control, and high-static pressures; this leads to noisy radon systems and more frequent radon fan burn-out.

Building Science Bootcamp
Indoor Air-Quality – Crawlspaces

Radon and Moisture Mitigation:

- Perforated conduit (French-drain),
- 10 -15 mil thick poly air-barrier,
- Sealed w/adhesives to foundation, with taped seams and penitrations,
- Perforated fiberglass insulation, with high vapor-permeability,
- Low-watt radon fan.

Note: Avoid vapor-proof below-grade foundation wall insulation (per code) to allow drying of building materials.

Building Science Bootcamp
Indoor Air-Quality - Radon

Radon and Moisture Resistant Construction in Commercial Buildings:

- Provide ample venting to achieve sub-slab depressurization,
- Meticulous vapor barrier sealing will yield lower radon & moisture levels,
- Methods and materials vary widely, so planning and training is important.

Building Science Bootcamp
Indoor Air-Quality - Radon

Energy-Use and Effectiveness:

- Radon fans do not tolerate high static-pressures,
- Causes *“noisy radon system” nuisance calls,*
- CFMs drop significantly: *166 cfm vs 3 cfm!*

SPECIFICATIONS

MODEL	FAN DUCT DIAMETER	WATTS	RECOM. MAX. OP. PRESSURE “WC	TYPICAL CFM vs. STATIC PRESSURE WC				
				0"	0.5"	1.0"	1.5"	2.0"
RP140*	4"	15-21	0.7	135	70	-	-	-
RP145	4"	41-72	1.7	166	126	82	41	3
RP260	6"	47-65	1.3	251	157	90	-	-
RP265	6"	95-139	2.3	375	282	204	140	70
RP380	8"	96-138	2.0	531	415	268	139	41

1 Suitable as designated by the Reducing Radon in New Construction Standard, RRNC 2.0. See chart p. 87.

See p. 22 for fan dimensions.

RADON FANS

RP PRO SERIES BY RADONAWAY®

RP FANS

SPECIFICATIONS

MODEL	FAN DUCT DIAMETER	WATTS	RECOM. MAX. OP. PRESSURE “WC	TYPICAL CFM vs. STATIC PRESSURE WC					RRNC 2.0 Radon Fan Type[1]
				0"	0.5"	1.0"	1.5"	2.0"	
RP140*	4"	15-21	0.7	135	70	-	-	-	RF1
RP145	4"	41-72	1.7	166	126	82	41	3	RF1, RF2
RP260	6"	47-65	1.3	251	157	90	-	-	-
RP265	6"	95-139	2.3	375	282	204	140	70	-
RP380	8"	96-138	2.0	531	415	268	139	41	-

1 Suitable as designated by the Reducing Radon in New Construction Standard, RRNC 2.0. See chart p. 87.

See p. 22 for fan dimensions.

HVI CERTIFIED

* Most Efficient 2019 RadonAway RP140

MADE IN USA Made in the USA with U.S. and imported parts.

ETL Listed

RadonAway® inline radon fans are covered by our 5-year, hassle-free warranty.

Indoor Air-Quality – Radon
Higher Pressures = Less Air-flow

For reference: 0.5 i.w.c.=126cfm

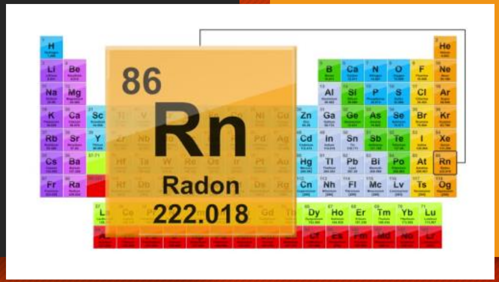
1.0 i.w.c.= 82 cfm

1.5 i.w.c.= 41 cfm

2.0 i.w.c.= 3 cfm

Flooded basement…lots of pressure, no air-flow

Building Science Bootcamp
Indoor Air-Quality - Radon



Consumer Radon Monitors:
- Affordable,
- Accurate long term readings,
- Real-time short term readings,
- *Costs only $130 - $150*

Building Science Bootcamp
Indoor Air-Quality – Outdoor Pollution

The Coloradoan, May 11th, 2018:
Northern Colorado air quality is among the worst in the country because of ozone, that smog-causing molecule.

Larimer County ranks No. 19 in the nation for high-ozone days, according to the latest ranking from the American Lung Association. Fort Collins ranks 10th worst nationally.

Ozone levels peak on hot summer days, and Fort Collins summers are getting hotter. The average number of 90-degree-or-more days has almost doubled, from about 18 per year between the 1960s and '90s to more than 32 per year since the turn of the century."

Mobile sources such as cars, trains, trucks and planes; and oil and gas activity. Each category accounted for about 30 to 40 percent of ozone production, with mobile sources taking the larger share in the region's southern reaches near Denver, and oil and gas taking the larger share closer to Fort Collins.

Indoor Air-Quality – Exhaust vs. Balanced Ventilation

ASHREA 62.2-2010 Ventilation:

Exhaust Only Continuous CFMs =

(0.01 x sq ft area) + (7.5 x #bedrooms +1)

(.01 x 2400) + (7.5 x 3+1) = 54 CFMs cont.

- Most consumers dis-able continuous operation after buying the home,
- Difficult to qualify for Energy-star or Builder’s Tax Credit with exhaust-only ventilation,
- De-pressurizes the building, possibly creating other issues.

Inexpensive, but does it work?

Indoor Air-Quality – Exhaust vs. Balanced Ventilation

Cost of Exhaust-Only Ventilation:

CFM of Exhaust per Year = 52,560,000 cft

BTU required to raise 1-year of air-leakage the average temp difference between inside outside = **23,297,225 BTU's**

Cost of exhausted-air = $233

Electricity cost of running fan = $60

Annual operational cost = **$293**

Heat Recovery Ventilation Cost Estimator		Exhaust Only Ventilation Cost Estimator		Fuel Type	Cost per Unit	Cost per Therm
Cost per therm of heating fuel	1.00	Cost per therm of heating fuel	1.00	Natural Gas -per CCF	1.05	$1.05
Cost per BTU of heating fuel	$0.00001000	Cost per BTU of heating fuel	$0.00001000	Oil - per gallon	2.75	$1.95
Full Speed CFM of Exhaust	100.00	CFM of Exhaust	100.00	Electricity - Per KWH	0.18	$5.27
Full Speed CFM of Supply	100.00			Propane - Per Gallon	2.75	$3.00
Hours Per Day of Run Time	24.00	Hours Per Day of Run Time	24.00			
Hours Per Year of Run Time	8,760.00	Hours Per Year of Run Time	8,760.00			
Yearly air leakage from unbalanced flow	0.00	CFM of Exhaust per Year	52,560,000.00			
Average Indoor Temperature	70	Average Indoor Temperature	70			
Community	Denver, CO		Denver, CO			
Average Outdoor Temperature	50.3	Average Outdoor Temperature	50.3			
AFUE of Heating Appliance	80.00%	AFUE of Heating Appliance	80.00%			
Average difference between inside and outside temperature	19.7	Average difference between inside and outside temperature	19.7			
Pounds of Air Leakage over 1 year	0.00	Pounds of Air Leakage over 1 year	3,942,000.99			
BTU required to raise 1 year of air leakage 1 degree	0.00	BTU required to raise 1 year of air leakage 1 degree	946,080.24			
BTU required to raise 1 year of air leakage the average temperature difference between inside and outside	0.00	BTU required to raise 1 year of air leakage the average temperature difference between inside and outside	18,637,780.66			

Community	Denver, CO		Denver, CO		
Average Outdoor Temperature	50.3	Average Outdoor Temperature	50.3		
AFUE of Heating Appliance	80.00%	AFUE of Heating Appliance	80.00%		
Average difference between inside and outside temperature	19.7	Average difference between inside and outside temperature	19.7		
Pounds of Air Leakage over 1 year	0.00	Pounds of Air Leakage over 1 year	3,942,000.99		
BTU required to raise 1 year of air leakage 1 degree	0.00	BTU required to raise 1 year of air leakage 1 degree	946,080.24		
BTU required to raise 1 year of air leakage the average temperature difference between inside and outside	0.00	BTU required to raise 1 year of air leakage the average temperature difference between inside and outside	18,637,780.66		
Total BTU adjusted for AFUE	0.00	Total BTU adjusted for AFUE	23,297,225.82		
Cost of Unbalanced Flows	$0.00	Estimated Cost of exhausted air	$232.97		
HRV Efficiency	85.00%				
Cost of HRV Efficiency	$34.95				
KWH electrical costs	0.11	KWH electrical costs	0.11		
Amp Draw of HRV Motor	1	Amp Draw of Exhaust Fan	0.5		
Electrical cost of running HRV	$115.63	Electrical cost of running fan	$57.82		
Total operational Cost of HRV	$150.59	Total operational Cost of Exhaust Only Ventilation System	$290.79	Savings per year	$140.20
				Cost Difference Between Systems	800.00
				Payback Period Years	5.7

Calculators for ventilation costs can be found online.

Balanced Ventilation – Heat Recovery Ventilators (HRV's)

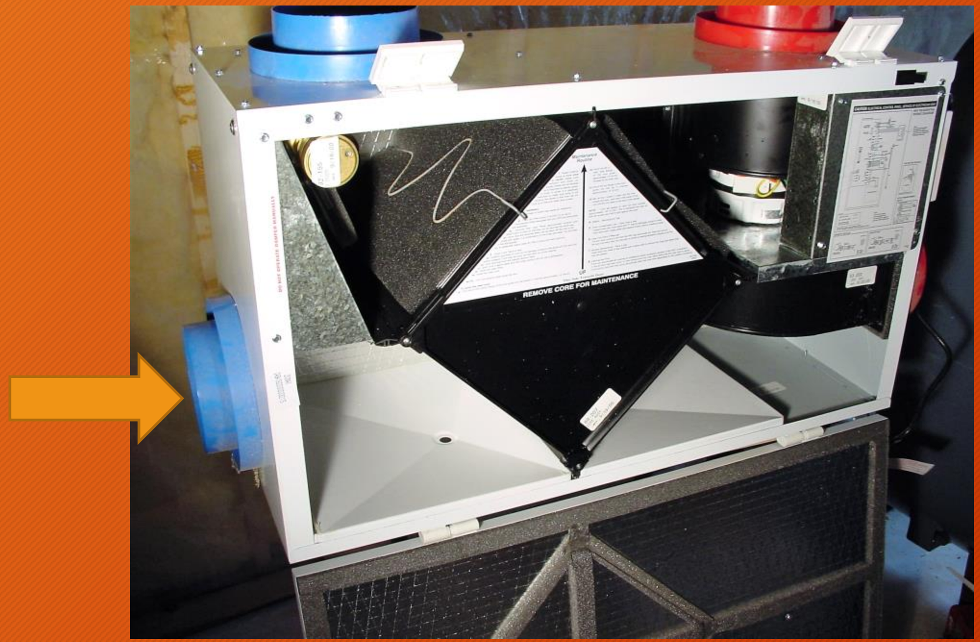
Balanced Ventilation, w/ Heat Recovery Ventilators

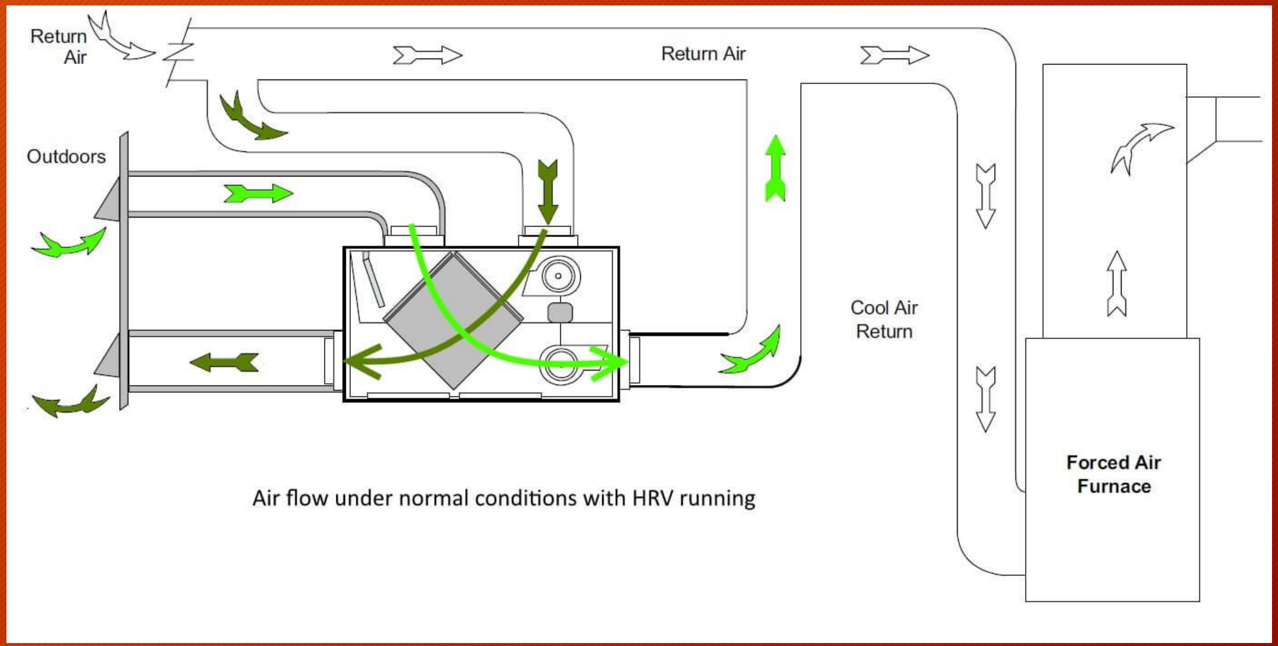
- Efficient heat transfer = 85%
- Annual electricity cost: $115 plus 15% loss = $150 annually,
- **Unit costs have dropped from *$2500 to $500 in 10-years*.**
- Quality of *"fresh-air"* can be controlled with schedule, when outdoor pollution levels are lower (like at night).

Saves about $150 per year in utility bills, and actually performs as intended.

Balanced Ventilation – Heat Recovery Ventilators (HRV's)

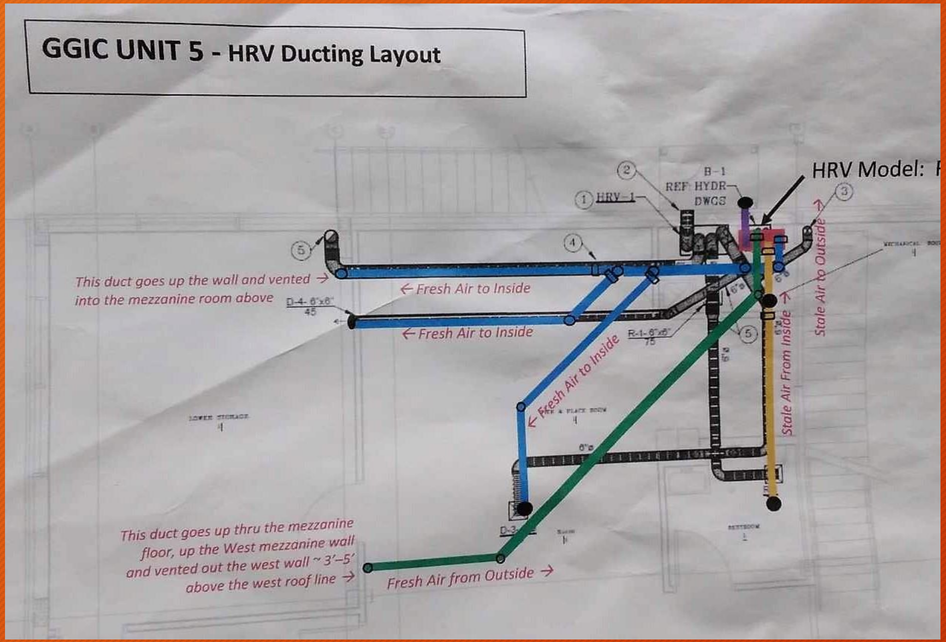
Technical Note: Stale-air exhaust must have a back-flow damper to prevent air from being pulled in through exhaust vents if/when HRV is not in operation.





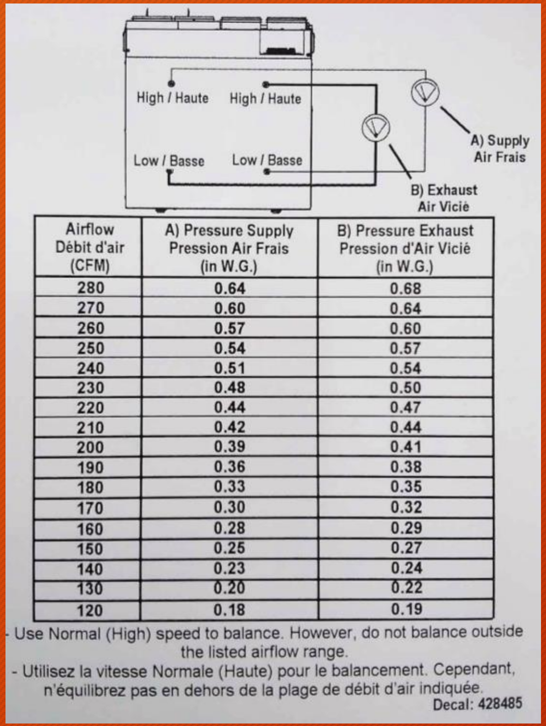
Indoor Air-Quality
Start-Up and Air-Balancing HRV's

Because heat-recovery-ventilators are connected to duct systems of ***unequal effective-lengths and static-pressures***, fan speeds must be adjusted to move equal amounts of intake and exhaust air:



Indoor Air-Quality
Air-Balancing HRV’s

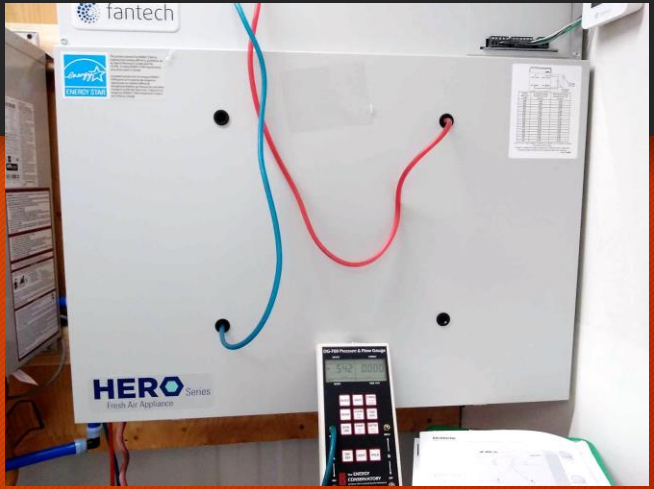
Balancing fan speed & air-flow with CFM & static-pressure settings:

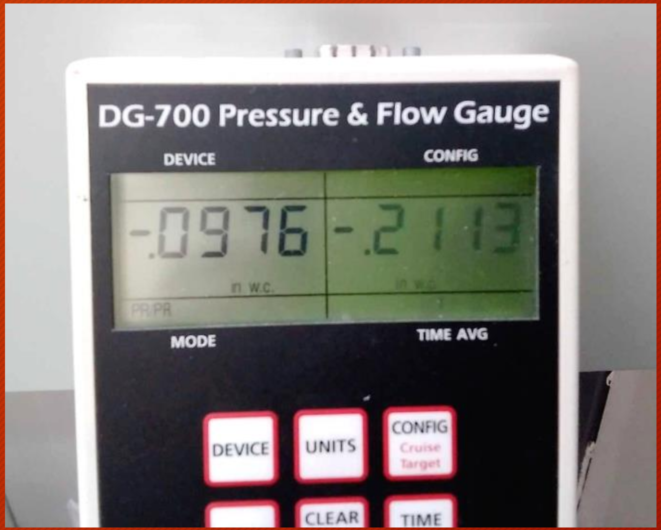


Airflow Débit d'air (CFM)	A) Pressure Supply Pression Air Frais (in W.G.)	B) Pressure Exhaust Pression d'Air Viciè (in W.G.)
280	0.64	0.68
270	0.60	0.64
260	0.57	0.60
250	0.54	0.57
240	0.51	0.54
230	0.48	0.50
220	0.44	0.47
210	0.42	0.44
200	0.39	0.41
190	0.36	0.38
180	0.33	0.35
170	0.30	0.32
160	0.28	0.29
150	0.25	0.27
140	0.23	0.24
130	0.20	0.22
120	0.18	0.19

- Use Normal (High) speed to balance. However, do not balance outside the listed airflow range.
- Utilisez la vitesse Normale (Haute) pour le balancement. Cependant, n'équilibrez pas en dehors de la plage de débit d'air indiquée.

Decal: 428485





Building Science Bootcamp
Indoor Air-Quality (IAQ)

To Learn More about Energy Codes or Green Building, please contact:

Community Development

https://www.larimer.org/building

Building: 970-498-7700 or

Planning: 970-498-7683

LARIMER COUNTY

COMMITTED TO EXCELLENCE

Presentation prepared by:
Michael C. Truitt
CarbonNeutralGroup.com
info@carbonneutralgroup.com
970-204-9931 / 719-850-1921

Carbon Neutral Group Consulting