An Informational Report on

Radon Resistant New Construction

The Indoor Radon Program
Bureau of Radiation Protection
Ohio Department of Health

Introduction

The Indoor Radon Program at the Ohio Department of Health (ODH) has created this document to provide you information we feel is necessary in order to make an informed decision about incorporating radon resistant new construction into your county building code. The information provided in this document comes from reliable and well respected sources such as The World Health Organization (WHO), the U.S. Environmental Protection Agency (U.S. EPA), the National Institutes of Health and ODH.

The Indoor Radon Program at ODH receives funding from the USEPA to implement the specific objectives of the U.S. EPA State Indoor Radon Grant. One objective is to educate state and local building code officials and residential builders about Radon Resistant New Constructions (RRNC). RRNC is considered to be an integral component of reducing the risk of lung cancer caused by exposure to elevated levels of indoor radon. Building homes with radon resistant features is the best economical way to achieve a reduction in the radon levels in a home and more importantly, to save lives.

Radon

Radon is one of the six noble gases listed on the periodic table of elements. Radon is a radioactive gas that comes from the decay of uranium that is found in soil and rocks. Radon gas is odorless, colorless and tasteless. Radon enters a home by migrating through cracks and openings in foundation walls and floors that are in contact with soil. Radon can also enter a home through crawl spaces, floor drains, sump pits and utility penetrations.

Radon and Lung Cancer

Exposure to elevated levels of indoor radon over the course of an individual's lifetime increases their risk of developing lung cancer. Radon gas consists of radioactive alpha particles. Alpha particles adhere to the lining of the lungs when an individual inhales. These particles will continue to decay and give off small burst of radiation. The radiation that is released when the particles decay causes damage to the DNA of cells lining the lungs. The damaged cells with the alter DNA will replicate and can eventually become cancer.

Extensive research on residential exposure to radon and the correlation of lung cancer has been done in several countries including the United States. In 1988, the International Agency for Research on Cancer classified radon as a human carcinogen. The U.S. Surgeon General released a health advisory in 2005 stating that exposure to elevated levels of indoor radon causes lung cancer. The U.S. Surgeon released this advisory based on research conducted in the United States including the 1999 BEIR VI report. The BEIR VI report concluded that exposure to radon in homes does cause lung cancer making it a risk for the general population. The report went on to state that reducing radon in homes would greatly reduce the risk of lung cancer.

The strongest evidence of the correlation between radon exposure and lung cancer was reported by the World Health Organization in the "Who Handbook on Indoor Radon" published in 2009. The handbook details data from all international residential studies as well as data pooling studies. All studies to date have concluded that exposure to elevated levels of indoor radon poses a significant risk of developing lung cancer.

Lung Cancer in Union County

The Ohio Cancer Incident Surveillance Program (OCIS) at the ODH collects data specific to cancer incidence and death. The most recent statistics regarding cancer incidence and death is based on data collected from 2006 to 2010.

According to the data, lung cancer is the most diagnosed type of cancer and causes the most cancer related deaths in Ohio. Every year approximately 9,435 Ohioans are diagnosed with lung cancer and 7,406 Ohioans die from lung cancer. The U.S. EPA estimates that 1,500 diagnoses or 16% of 9,435 lung cancer diagnosed are radon induced.

In Union County, lung cancer is the leading cause of cancer mortality and the second most diagnosed type of cancer. Breast cancer is the most diagnosed type of cancer and has a survival rate of approximately 83% for Union County unlike lung cancer which has a survival rate of approximately 10%.

Although we know cigarette smoking is the leading cause of lung cancer and according to OCIS approximately 25% of Union County residents are current smoker, it is also known that smokers who live in a home with elevated levels of radon have a 16 times greater risk of developing lung cancer. According to the National Cancer Institute (NCI), the majority of radon-related cancer deaths occur among smokers. However, NCI estimates that more than 10% of lung cancer deaths among non-smokers are caused by exposure to indoor radon.

Cancer Incidence

All Sites	Cases	Rate
Ohio	60,004	465.1
Union	211	484.8
Breast	Cases	Rate
Ohio	8,268	119.1
Union	29	119.2
Lung	Cases	Rate
Ohio	9,435	72.8
Union	**28**	**68.5**
Prostate	Cases	Rate
Ohio	8,224	139.7
Union	25	122.7
Colon	Cases	Rate
Ohio	5,992	46.2
Union	21	49.8

Cancer Mortality

All Sites	Deaths	Rate
Ohio	25,021	191.9
Union	72	180.4
Lung	Deaths	Rate
Ohio	7,406	57.1
Union	**26**	**66.4**
Colon	Deaths	Rate
Ohio	2,355	18.0
Union	7	16.9
Breast	Deaths	Rate
Ohio	1,812	24.7
Union	5	20.2
Prostate	Deaths	Rate
Ohio	1,189	23.6
Union	2	17.7

*Cancer data collected by OCIS 2006-2010

Radon in Union County

The Indoor Radon Program at ODH has been collecting radon testing and mitigation data of homes in Ohio since 1988. The University of Toledo receives funding from the Indoor Radon Program in order to manage, interpret and display the data collected by the program. The data collected by the program is received on a quarterly basis from Ohio licensed radon testers, mitigation contractors and labs that analyze radon test kits. Because the program collects this data, specific information about radon levels in Union County homes can be provided.

Union County has an overall average geometric mean indoor radon concentration of 3.3pCi/l and an arithmetic mean of 5.3pCi/l. The geometric mean (GM) and arithmetic mean (AM) are derived from 1,411 radon tests that have been performed in homes in Union County. However there are areas within Union County that have GM and AM that are higher than the overall County averages. Four zip code areas in Union County have a GM of more than 4.0pCi/l with the highest being 5.9pCi/l. The highest indoor radon level found in a home in Union County has been 62.7pCi/l.

Radon Statistics for Union County

Measurements are pico-Curies per liter of air (pCi/l)

Zip code	No.	Max	Min	AM	GM	SD	CV
43007	5	8.3	1.1	5.06	4.05	3.16	0.62
43036	6	10.2	1.4	6.83	5.86	2.98	0.44
43040	1063	63.5	0.1	5.28	3.28	6.13	1.16
43045	87	26.6	0.1	6.05	4.00	5.17	0.86
43060	51	62.7	0.2	8.24	4.51	11.03	1.34
43067	29	18.2	0.3	3.94	2.46	4.47	1.13
43077	4	5.4	0.1	2.23	1.12	2.25	1.01
43344	153	61.8	0.1	5.54	3.14	7.70	1.39

No. - Number of tests
Max - Maximum concentration measured
Min - Minimum radon concentration measured
AM - Arithmetic mean
GM -- Geometric mean
SD - Standard deviation
CV – Coefficient of variation
***This table represents all radon tests performed by homeowners and Ohio licensees from 1988 to 2012.**

The table to the right represents the number of radon test performed by Ohio licensed testers. This table best represents indoor radon levels found in Union County because licensed testers are trained in proper radon testing protocols and are required to test according to these protocols.

Overall, 53% of all homes tested in Union County between 2003 and 2012 had elevated levels of radon. This correlates with the overall Ohio average of approximately 50% of all homes tested every year in Ohio have elevated levels of radon.

HOMES DATA				
2003 to 2012 (last 10 years)				
YEAR	Total # of records	Geo Mean of total # of records (pCi/L)	# having radon concentration >=4 pCi/L	%
2003	90	2.76	43	48%
2004	23	3.07	11	48%
2005	79	2.34	24	30%
2006	64	4.08	36	56%
2007	25	4.11	16	64%
2008	67	4.04	36	54%
2009	131	3.96	72	55%
2010	88	4.23	47	53%
2011	195	4.04	109	56%
2012	138	3.9	81	59%
Total	900		432	53%

MITIGATION DATA			
2003 to 2012 (last 10 years)			
Year	Number of Records	Pre Mitigation Geo Mean	Post Mit Geo Mean
2003	4	8.9	0.7
2004	10	9.3	1.3
2005	6	6.9	1
2006	12	9.2	1.1
2007	10	8.4	1
2008	17	8.5	1
2009	23	11.2	1.3
2010	14	8	1.5
2011	19	8.2	1
2012	28	10.1	1.2
Total	143		

It is also important to note that during the same 10 years only one-third (1/3) of all homes with elevated levels of radon installed a radon mitigation system.

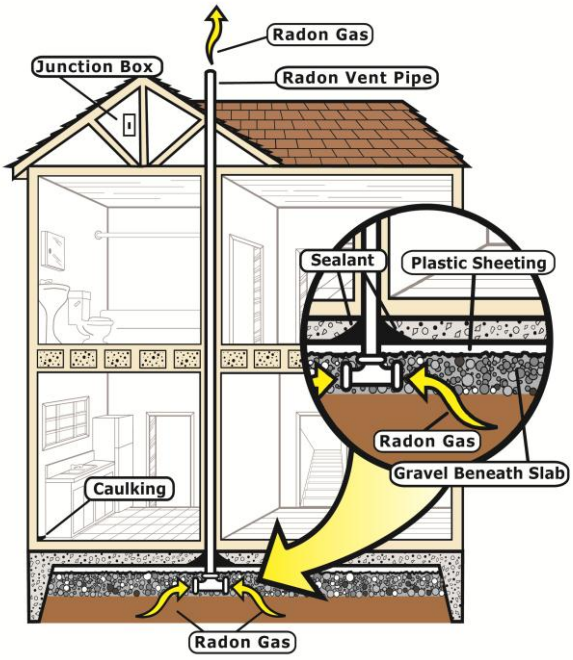
Although we have seen an increase in the number of homes being tested and the number of homes with elevated levels of radon, we are not seeing much of increase in the number of mitigation systems being installed in homes with elevated levels of radon.

The most common reason a homeowner does not install a radon mitigation system is the cost. Retro fitting a home with a radon mitigation system averages $1,200.00 for a basic system that has the fan on the exterior of the home. The cost of a radon system will increase if there is more than one foundation type that is required to be mitigated and if the homeowner does not want or is prohibited from having the fan and pipe on the exterior of the home.

Radon Resistant New Construction

Radon Resistant New Construction (RRNC) is defined as installation of a passive radon mitigation system during the construction of a home. This passive system can reduce the indoor radon levels about 50% and often to below the U.S. EPA action level. RRNC consists of five basic components a gas permeable layer, plastic sheeting, vent pipe, junction box and sealing and caulking. Most of these components are currently being used or are required to be used for moisture control and reduction.

The gas permeable layer consists of a minimum 4 inch layer of clean coarse gravel. This allows soil gases to move freely and is required under the Ohio Residential Code 4101:8-4-01 Section 405.2.1. It is highly recommended to install perforated pipe in this layer to increase the effectiveness of the passive system and especially if the system needs to be activated at a future date.



Plastic sheeting is placed on top of the gas permeable layer to help prevent soil gases from entering the home and from concrete clogging the gas permeable layer. This is also a requirement of the Ohio Residential Code 4101:8-4-01 Section 405.2.2. The sheeting would be place on top of the perforated pipe to prevent

the pipe from filling with concrete. The vent pipe should be 3- 4 inch diameter PVC and run perpendicular from the gas permeable layer through the interior of the house and vent out of the roof.

Installation of a junction box in the attic allows for future installation of a fan should the passive system need to be activated. This also is cost-effective for the homeowner should a fan need to be installed.

Sealing and caulking of all openings in the foundation floor and walls improves the effectiveness of the passive system and reduces the stack effect in the home. Reducing the openings where radon can enter is essential in reducing the radon levels in a home.

The U.S. EPA has estimated the cost of installation RRNC in a new home to be $350.00 to $750.00 which is less than one-half of the average cost of retrofitting a home. Given that the gas permeable layer and the plastic sheeting are already required by code, the additional cost to complete an RRNC installation would be for the PVC pipe, a wired 110v electrical junction box, sealing/caulking material and the additional labor. This is an example estimate of costs based on the home illustration above.

RRNC COST vs LUNG CANCER COST

The cost of RRNC is often compared to the cost of building a home and how the additional cost would impact the homeowner. While it is important to consider these facts, the cost of RRNC should actually be compared to the cost of lung cancer. The purpose of requiring RRNC is to reduce the occurrence of lung cancer by reducing the exposure to indoor radon.

The National Cancer Institute (NCI) released a study in January, 2011 regarding the cost of cancer. Overall, $124.7 billion was spent on cancer care in 2010 in the U.S. Lung cancer cost in 2010 was reported to be $12.12 billion. These figures do not include other inferred costs such as lost productivity by the patient and other caregiver family members.

NCI estimated that in 2013, 228,190 U.S. citizens would be diagnosed with lung cancer and 159,480 would die from lung cancer. Based on the total cost of lung cancer and the number of people diagnosed with lung cancer, the individual cost of lung cancer is approximately $531,136.00. While this is seems exceptionally high especially compared to the cost of RRNC this is not what a typical individual would pay and this does not include other costs such as travel to and from doctor appointments.

The other factor to consider is lung cancer survival rate. It is easy to see that the survival rate for lung cancer is very low. Nationally the five year survival rate for lung cancer is 17%. It is understood that the earlier lung cancer is diagnosed the better the outcome. Unfortunately, in Ohio 69% of diagnosed lung cancer is found in the late stages. In Union County over 60% of lung cancer was found in the late stage and as previously stated the leading cause of cancer mortality.

Summary

Building new homes with RRNC features provides a cost effective way to reduce the risk of radon induced lung cancer by passively lowering the radon level in a home. Homes built using RRNC features have the potential to reduce the risk of lung cancer to at least 50% of the homeowners in Union County.

The advantages of adopting RRNC are:
- reduces the risk of lung cancer
- most cost effective solution (less expensive than retrofitting)
- low-tech materials and easy to install
- most durable, longest lasting and visually atheistic option (no exterior pipe or fan)
- passive sub-slab airflow enhances moisture control and retards mold growth
- improves overall indoor air quality
- most effective way to reduce indoor radon exposure
- qualifies as a "building green" technology
-demonstrates a commitment by Union County to protect the health and well-being of current and future homeowners