MITIGATION INSTALLATION EFFICIENCY TECHNIQUES

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ABSTRACT

This paper presents the equipment and methodologies that will increase the installation efficiency and final system appearance of residential mitigation systems. The paper presents the experience of the author in regards to the type of equipment that he has found to be most useful, certain installation techniques that are important, charts for determining proper cut off lengths of pvc piping, and variations in performance between commonly used large hammer drills and bits in actual field performance comparisons.

INTRODUCTION

Radon Mitigation Systems designed by different experienced mitigation contractors for the same house typically have only small variations in how they would install the system. This has created a very competitive business climate throughout the country that requires each successful company to be highly efficient at installing a quality job that is effective while still being installed with minimum cost and intrusion upon the look of the house. The author over the last twelve years has been running a mitigation company that has installed over 3000 mitigation systems and has himself personally installed over 200 radon mitigation systems in the last two years.

EQUIPMENT & PARTS

Trucks

Although we have never installed a radon system out of the back of a station wagon, we have used a number of different vehicles over the years. Our final conclusion is that the most practical vehicle is a 14' long cube truck powered by a diesel. The diesel's one fault is they can be temperamental to start in the winter if they are parked outside. We have cured that problem by installing block heaters that get plugged in every night. To save energy the block heaters are controlled by a common water heater timer to come on two hours before the vehicle is started. While a gas truck with a 14' cube will only get 5 to 8 miles per gallon (mpg), our Isuzu NPR turbo, 4 cylinder diesel gets 12 mpg and our 6 cylinder Italian Iveco diesel gets 16 mpg. The Iveco can go over 400 miles with its 28-gallon tank! The down side of large foreign trucks is the hefty repair bills for such common repairs as brake work. The good news is that once you set up a cube, the whole cube can be transferred to a new truck if the old truck dies or is in a front-end accident. Anyone who has spent 100 hours setting up their truck will appreciate this.

An additional benefit to a cube van is they can be locked up with a big padlock with no windows to display their contents to someone who might want to pawn some tools for some quick cash.

Dollies

The cube needs a ramp that pulls out of the back. This is very convenient and allows use of a dolly to move equipment and tools into and out of the truck. This is especially helpful for heavy items like installing a radon in water job by yourself. The best dolly is a lightweight plastic fiber unit with pneumatic tires that allow one to move items up and down basement stairs without leaving marks. The dolly is outfitted with a rectangular plastic tub. Tools and parts are loaded into the tub and the shop vacuum is placed on top. The whole load is wheeled to the work location saving back pain and multiple trips to the truck.

In order to reduce the blank stare into space time while you're trying to remember what you came up to the truck to get, we keep a printed list on the inside wall of the truck of everything you will likely need for different portions of the job. (See Parts & Tools List at the end of this paper)

What's inside the Cube

When the cube arrives at the job site it is plugged into an outlet using a twelve-gauge cord. This provides power for a light inside the cube as well as a fan mounted on the wall for hot days, a heater for cold days, power for battery chargers and power to run any required tools. The cube is large enough to allow storage of assorted pvc and aluminum downspout fittings for two to three jobs including all the necessary pipe, electrical supplies, screws, power tools, assorted bits, cement, caulking, flashings, chimney caps, sump covers, and poly that you didn't realize you would need when you left the shop. In addition there is a workbench inside the cube that includes a grinder for sharpening bits and a large vise for un-sticking holesaw chucks or other odd jobs. The radio on the bench allows you to sing along as you wire a fan even though it is raining and windy outside. A pvc pipe holder, attached to the bench, allows cutting of aluminum downspout or pipe inside the truck for pre-assemble. Every individual part is stored in its own labeled container within easy grasp from the work bench and most importantly is returned to its own labeled container so the truck always stays organized or the boss will threaten to fire you. Most importantly, for those like myself who can't remember what day of the week it is, any items that are low in stock are marked on the convenient chalkboard mounted on the wall the minute you notice they are low. The next morning it's easy to re-stock by checking the chalk board and how full the individual fitting bins are. No job is difficult if you have all the necessary parts and tools on the truck. Nothing is as frustrating as not having what you need when you need it.

Safety Equipment

Safety equipment includes a first aid kit, although duct tape and paper towels will do in a pinch. Each cube truck has a medium sized water cooler that is elevated near the rear door of the truck. Besides providing drinking and hand washing water, it can provide a quick source of eye washing water if needed. We have found earmuffs to be easier to use then ear plugs and a must during drilling. I prefer the all-rubber kneepads though my foreman likes the leather ones. The

pads not only save your knees but save you money replacing blue jeans because of worn out knees.

Screws

Self taping ½" screws available in white or brown from roofing and gutter suppliers are the easiest way to quickly hang pvc pipe using plastic pipe hanging strap. The screws are attached with ¼" drivers and allow easy adjustment of the pipe after it is hung to give you a straight line. Angling the strap away from the pipe, after making a complete loop around the pipe, gives the pipe good sideways stability.

Outdoors we use either aluminum straps that we fabricate ourselves or stainless steel hose clamps attached with binding plates and coated deck screws. Small offsets can be made by scroll cutting pressure treated plywood.

Hanging fire collars in a drywalled garage ceiling can be a hassle. We use a drywall anchoring screw that threads right into the drywall and allows a drywall screw with a washer to be threaded into it, to easily hang the collar.

PVC Solvent

We've used low VOC solvent made by Weld-On for years and won't consider using normal pvc cement because of the nasty smell. The set up time is medium. The big draw back is cost. I pay $46 per gallon so we carefully pour it into quart cans. We only fill the cans ¼ of the way and then wiping the drips back into the can. If a ¼ filled can tips over it usually doesn't flow out unless it gets inverted which only happens when you're standing over a carpeted floor. The other trick is to use dippers that wedge into the top rather than screw in. The wedge-fit dippers are faster and will sometimes prevent a spill of this clear gold.

FAVORITE TOOLS

Boys and their Toys

Along the way we have been thorough numerous workers and tools who have not been able to stand up to the rigors of abuse that radon mitigation and/or my crew provides.

Caulking Guns

I've decided, after spending hundreds of dollars on AEG battery caulking guns ($250 apiece and now available with a Milwaukee label) and the newer less expensive plastic caulking guns that attach to your battery drill, that you really only need a good hand caulking gun. The ones we use are made in England, cost $15 to $25 apiece, and are well worth it. The trick with caulking is to keep the tubes warm. I made up a spackle bucket that holds 11 tubes of caulk with a rough service 100-watt light bulb in the center and a plunger wire attached to the side. On any cold day you just load up the bucket and plug it in when you get to the job. Nothing flows nicer than warm caulk on a cold day.

Right Angle Drills

Cutting headers (also called rim joists) can be a wrist-breaking event. Black and Decker or its sister company DeWALT makes a $300 long handled right angle drill called TimberWolf that gives enough leverage to allow the clutch to engage before your wrist is sprained. To cut a header I prefer to cut away the siding and score the header first with a 4 ½" hole saw. Then I use a hand drill with a ¼" bit to cut multiple holes around the score. This allows the hole saw to cut quickly through the header without causing excessive wear on the bit, drill and operator. A 4" sleeve gets tapped into the hole and secured with two screws. This allows your helper to start running pipe in the basement while you finish the fan installation on the outside.

Ladders

We carry four ladders on the truck; a small two step wooden ladder, a three jointed collapsing six foot step ladder with extension feet for extra stability, a 28 foot aluminum extension ladder that hangs on the outside of the truck and two eight foot long chicken ladders made from 1X3's that are screwed together. If we have to install a roof flashing on a roof that is over a 6/12 pitch then we climb up the aluminum ladder with the wooden chicken ladder and screw it right down to the roof using two coated drywall screws. When the job is done, the screws are removed leaving such a small hole that it will soon be melted shut by the heat of the sun on the shingles.

Vacuum Cleaners

What can I say but Sears makes a great vacuum cleaner. Don't leave home without it and if you use a dolly you won't even mind hauling it down into the basement. Cleaning out suction pits with a vacuum is the only way to go. Afterwards the vacuum filter gets tapped to unclog it and the debris gets dumped into a spackle bucket for easier hauling back to the truck. The wide suction adapter makes for a neat clean up of the basement floor that impresses the customer.

Leather Tool Pouches

Suggesting that a mitigator use a different style pouch than what they have been using for the last six years is like asking them to change their favorite beer. I like a single leather pouch that has four large front pockets to keep electrical parts in the top pocket, drill bits in the next, hand tools in the largest pocket, and screws in the front pocket. The utility knife and assorted small items go in the small side pockets. I keep my tape measure and hammer in separate holders on my belt for easier accessability. I carry tin snips and a plumb bob in separate leather pouches behind my back. Each of the individual pouches is attached to my tool belt with plastic ties so they are always in the same position so I can grab them without looking. I'm a small guy but I still have enough room on my belt for a leather battery drill holder which I find very handy, especially when you're on a ladder or hanging pipe. The only battery drill I've found that will not fall out of the holder is a 9.6 volt Makita.

Extension Cords

We only use 12 gauge extension cords to minimize voltage drop on our power tools. All of the extension cords have lighted female plug ends that help you locate them and let you know that they are energized.

Wet Core Drill

Although I own a Black & Decker Core Drill with a 5" diamond bit, I rarely use it because it's so heavy to carry into a basement, takes too long to set up and even longer to clean up the water mess after its done. The wet core drill was the only way to go, however, when it came time to cut a 5" hole through a fourteen-inch concrete floor and another hole through a pre-cast, rebar re-enforced concrete wall that we recently encountered in a Navy housing job.

Hammer Drills

In our glorious past we have seen the following drills die an early death; Makita, Bosch, AEG, Mitabo, and Milwaukee. Before buying your next big hammer drill, I would recommend you call all the rental shops in your town and asking what model hammer drill they rent. If a rental shop uses it, I would think it's got to be able to stand up to some serious abuse. I typically see Bosch or Hitachi drills at rental stores. Hitachi, (YE38, 8.0 amps, 380 rpm, $500), has been the only drill that seemed to consistently last for us. Some of my competitors, however, swear by Hilti. Of course you have to be willing to pay as much for a set of Hilti drills as your truck costs. Unfortunately we only had available, Hitachi, Hilti and a Milwaukee Thunderbolt (8.5 amp, 550 rpm) to test out. In general I think most 8 amp or better hammer drills being sold in the $400 to $850 range are fine for 3/4" carbide bits although how long they last will be an issue. See data on ¾" drilling at end of this paper. The comparison data shows that the fastest drill of a ¾" drill bit was 4.5 seconds per inch of concrete while the slowest was 8.5 seconds per inch. On the other hand if you want to be able to cut clean holes with a 5" carbide core bit then you need to buy a more powerful drill. The Hilti TE74 (10.5 amps, 255 rpm, $1150) is very capable of cutting a 5" core every day and it has a number of other nice features. We have found the Hitachi DH50SB (10.4 amp, 300 rpm, $900) very capable of running a 5" core bit and even out cut the Hilti 74 when using the same core bit. (See the core bit performance data to compare the difference between these drills).

Core Bits versus Drill Bits

Our first conclusion from our side by side tests of hammer drills and bits was the sharpness of the bit made more difference than the drill. My favorite 5/8" and 3/4" drill bit has a cross pattern of carbide that reduces the likely hood of the bit getting twisted into two pieces compared to the single straight carbide bit. A straight bit tends to catch on a stone in the concrete and twist your wrist 180 degrees. A 3/4" X 22" carbide spline drive bit made in Germany by DrilTec costs me $63.

There are two primary methods for cutting through the slab. The most common is the multi-hole method that uses a 5/8" to 7/8" hammer drill bit approximately 16" to 22" long. Any where from eight to fifteen of these holes are drilled through the slab within about a 5" circle. Each hole takes from 20 to 60 seconds to install. After the holes are drilled, a flat chisel is used to punch out the remaining concrete between the drilled holes. Although it takes longer to drill more holes, it shortens the amount of time you have to chisel the floor. In our hammer drill test we timed drilling this way through a slab using an 8.0 amp Hitachi drill and a brand new 3/4" drill bit. It took 9 minutes to cut and chisel through a 3" slab. The draw back with this method is the jagged sides of the hole, which tends to rip the flesh from the hole digger's hands as he excavates the sub-slab material. Real mitigators don't mind these nicks except when the glue

spills into an open cut. At the same time as the multi hole was being cut we drilled using the 10.4 amp Hitachi drill with the new 5" core bit. It took 4 minutes and 50 seconds to core and then chisel the last 1/4" through the slab. Almost half the time!

There are two costs associated with core bits. The first is you need a hammer drill capable of using a 5" core bit. The second cost is the bit. A 5" core bit with pilot and shank costs about $275 from DrilTec and from $375 to $550 from Hilti, depending upon what you negotiate. The average life-span of a core bit that is cutting an average 1.5 holes per job, five days a week is about three months. That's about 100 holes. Of course towards the end of its life it takes twice as long as compared to a new bit. See core bit performance data. The manufacturer of the bits makes a big difference in the performance. A 5" Hilti core bit with 25 holes of usage cut through 2 1/2" inches of concrete in 3 1/2 minutes. The same Hilti drill with a new 5" DrilTec core bit took 5 1/2 minutes to cut 2 1/4" of concrete. The Hitachi 50, however, using the same DrilTec 5" core bit only took 3 1/2 minutes to cut 2 1/2" of the same concrete. It apeears that the Hitachi 50 cuts faster than the Hilti but the Hilti 5" core bit cuts considerable faster than the DrilTec. Of course the Hilti bit is over $100 more expensive. Unfortunately we could not run the Hilti core bit in the Hitachi because the Hilti is SDS Plus drive and the Hitachi is the older spline drive design.

The Milwaukee Thunderbolt and the Hitachi 38 both took about 5 1/2 minutes to cut 1 3/4" of concrete with the same 5" DrilTec core bit. Not only was this tediously slow with these smaller drills but it felt like it was really hard on the drills because of their higher rpm rate. I do not recommend you use these drills for even the 3.5" core bit. You can however use these drills with a 2" core bit.

Although speed is an issue, core bits are most worth while for making clean horizontal cuts through a poured or block wall foundation, or through a brick veneer. I especially like using our 3 1/2" core bit with the Hitachi 50SB when I need to put a suction hole through a poured foundation. The 3 1/2" core bit cuts approximately 40% faster than the 5" core bit. Using the Hitachi 50 and a 3 1/2" core bit I can cut through an 8" poured wall in about 6 to 10 minutes. The 3 1/2" hole is just big enough for me to get my hand through the wall. I keep waiting for the day my arm gets stuck in a poured foundation and the local Fire Company has to jack hammer me free.

Floor Drains

The RMS requires that a floor drain be installed if the sump pit that is being sealed was the only method for draining water off a basement floor. I think recessing the sump cover lid so that a drain can be installed in the lid is a real pain to do. If you purchase a 2" core bit, however, you can cut a new hole through the floor in one to three minutes, depending upon which drill you own. I prefer to just drop in a one way floor drain without caulking it, so that it can be lifted out if serious flooding is taking place or easily cleaned if necessary. Since we can install the new drain anywhere, you can locate it next to the water heater which is the most likely spot a basment flood would originate from.

Digital Manometer

The final tool of the week is a self-zeroing digital micro-manometer that works great. Its made by the Energy Conservatory in Minneapolis. (612 827-1117) for about $600. Infiltec also has a self-zeroing model available for a similar price.

METHODS

Digging out the Hole

The one installation part of a sub-slab ventilation system that you can't check after the system is installed is the suction hole. As the boss, you can check out almost every item after the system is completed to see if your crew did it the way you told them to, except the suction hole. Your only evidence is to inspect the quantity of dirt or gravel that they brought back in the bucket. Of course if there is good gravel under the floor, it usually doesn't matter. If it's only dirt under the slab, then the dig out is critical. I like digging next to the footer and even better next to a sub-slab plumbing line. Notice that the word is "next to", not "on top of" the hidden plumbing line. Where the footer meets the underside of the slab is often a small void space that is best accessed with a flat screwdriver after at least half a spackle bucket of dirt has been picked and vacuumed out. The auger's sold by RCI work well but are tough on right angle drills. Someone should make one that is beefier and attaches to the hammer drill.

Cutting PVC Offsets

To facilitate pipe cutting I made up a pipe cutting table out of a folding metal saw horse and a piece of schedule 40 pipe. I cut the 4" pvc lengthwise into a half round piece and attached it to the top of the saw horse. It holds my schedule 20 4" pvc perfectly, allowing me to make straight, clean, cuts while standing up.

Installing pvc piping always requires determining the length between fittings. Most installers hold the fitting apart from the other fitting and measure the distance between them with another hand. You can make faster cuts that are closer to perfect if you instead measure the offset distance and then look up in a convenient table what the length in between should be. See offset drawing. Included at the end of this paper is a list of typically pvc lengths for different offsets and for different fittings. I set up a square jig to make careful measurements of the fittings we are commonly using ("M" Mueller) to determine the cutoff lengths we typically would use and the measurements for different fittings together. I also compared the difference between 6 different brands of 45 degree sharp elbows and found a slight difference between them. The actual formulae used to determine the lengths for four of the brands is included in the chart. Note that the measurements that are given in the chart for 45 degree angles have been reduced about ¼" to make up for off angled cuts. We have a copy of these offset dimensions on all our carrying tubs and pvc cutting horses.

Restocking the Warehouse

Back at the shop we have printed sheets for each supplier that includes all of their stocking numbers. When we need to re-stock, I simply fill out the necessary quantity in each

category on the sheet and then slip it into the fax machine, hit the speed dial for that supplier and the ordering is done.

CONCLUSION

Working out systems, organization, proper tools and materials to make the job installation more efficient generally improves the quality of the installation while taking less time and effort to install.

Credits

I would like to thank Tim Musser and Steve Asbath for their help making the field measurements of hammer drills and drill bit performance. Tim Musser was also responsible for many of the methods and equipment choices discussed in this paper.

Hammer Drills & Core Bit Comparison

Drill	Bit	Approximate Bit usage drilled holes	Drilling Speed sec's/inch	Operator	Pressure	Depth Inches	Time Seconds
Hilti TE74	5" Hilti core	25	85	Tim	Light	2.56	218
Hilti TE74	5" Hilti core	25	78	Bill	Moderate	2.38	185
Hitachi 50SB	5" DrilTec core	45	110	Tim	Light	2.50	276
Hitachi 50SB	5" DrilTec core	45	96	Bill	Moderate	2.44	233
Hilti TE74	5" Hilti core	150	171	Bill	Moderate	2.38	406
Hilti TE74	5" DrilTec core	new	151	Tim	Moderate	2.19	331
Hilti TE74	5" DrilTec core	new	150	Tim	Moderate	1.31	197
Hitachi 50SB	5" DrilTec core	new	79	Tim	Moderate	2.50	197
Hilti TE74	5" Hilti core	62	105	Tim	Moderate	1.88	197
Milw. Thunderbolt	5" DrilTec core	new	190	Steve	Moderate	1.75	332
Hitachi 38YE	5" DrilTec core	new	177	Bill	Moderate	1.88	331
Hitachi 50SB	3.5" DrilTec core	10	42.9	Bill	Moderate	2.8	118
Hitachi 50SB	3.5" DrilTec core	10	43.9	Bill	Moderate	2.7	118
Hitachi 50SB	2" DrilTec core	4	13.3	Bill	Moderate	3.0	40
Hitachi 50SB	2" DrilTec core	5	15.4	Bill	Moderate	3.1	48
Hitachi 38YE	2" DrilTec core	6	28.0	Bill	Moderate	3.0	84
Hitachi 38YE	2" DrilTec core	6	33.4	Bill	Moderate	2.9	98

Hammer Drills & Straight Bit Comparison

Drill	Bit	Approximate Bit usage drilled holes	Drilling Speed sec's/inch	Operator	Pressure	Depth Inches	Time Seconds
Hitachi 38YE	3/4" DrilTec	light	7.5	Bill	Moderate	4.0	30
Hitachi 50SB	3/4" DrilTec	light	4.5	Bill	Moderate	4.0	18
Hitachi 50SB	3/4" Hawera	light	4.8	Bill	Moderate	4.0	19
Milw. Thunderbolt	3/4" Hawera	light	8.5	Steve	Moderate	4.0	34
Hitachi 38YE	3/4" Hawera	light	7.5	Steve	Moderate	4.0	30
Hitachi 50SB	3/4" Hawera	light	5.5	Bill	Moderate	4.0	22
Hilti TE74	7/8" Hilti	heavy	8.1	Tim	Moderate	4.0	32.5
Hitachi 38YE	3/8" SDS bit	light	5.5	Bill	Moderate	4.0	22
Hitachi 50SB	3/8" SDS bit	light	2.5	Bill	Moderate	4.0	10
Hitachi 24VB	3/8" SDS bit	light	5.8	Bill	Moderate	4.0	23

Parts & Tools List

Common

Radio

Extension Cords
3 Way Adapter

PVC Pipe & Fittings
PVC Saw

Glue

Knee pads

Basement

Hammer Drill

5" - 3.5" - 2"
Core Bits

Short & Long chisel

SDS 3/8" Test Bit

Ear Muffs

Short Ladder

Bucket

Vacuum & Hose

Wide Vacuum
Attachment

Pipe Strap

Basement

Trash box

Coil of Wire

Wire Staples & Wire
nuts

Romex connector

Broom & Scraper

Backer Rod

Jig saw

Pressure treated
Plywood

Urethane & Silicone
Caulking

Floor Drain

Cleaner &
Paper towels

U-Tube & Label

Mico-manometer
& putty

Marking Pen

Outside Fan

Hole Saw

Smaller Hammer
Drill

1/4" x 12" test bit
3/4" spade bit

White Rubber Boots

Bracket

Hose Clamp

Six 2" screws

Conduit, Conduit
strap & Connectors

O/S Box, Switch &
Switch cover

Yellow wire nut

White Caulk

Label

Cleaner &
Paper towels

Attic

Fan

Strap

Rubber Boots

Saw Zall

Coil of wire
Blue elec box

Switch - Cover
& Label

Backer rod

Drop Lite

Window fan

Wire staples
& Wire nuts

1/4" X 12" test bit

Garage Route

Hole Saw

Small Hammer Drill

Folding Ladder

Fire collars

Drywall anchors

U-Tube & Label

PVC Lengths between 90° sweeps & 45 mitered fittings

Length Between minus 1/4"

offset inches	Two 3" or 4" 45°'s	90° & 45°	Two 22 ½°
4	3 5/8"		8 7/8"
5	4 3/4"		11 1/2"
6	6 1/8"	Subtract	14"
7	7 1/2"	3"	16 3/4"
8	9"	for 4"	19 1/4"
9	10 3/8"	fittings	21 7/8"
10	11 3/4"		24 1/2"
11	13 1/8"	←	27"
12	14 5/8"		29 3/4"
13	16"	Subtract	32 1/4"
14	17 3/8"	4"	34 7/8"
15	18 7/8"	for 3"	37 1/2"
16	20 1/4"	fittings	40"
17	21 3/4"		42 3/4"
18	23 1/8"		45 1/4"
20	26"		50 1/2"
24	31 3/4"		60 7/8"
30	40 1/4"		76 1/2"
36	48 3/4"		92"

Average Formula for length between Two 45°'s

M or U fittings

(offset – 2 3/8") + (offset inches * 0.43)

Colonial & UPC fittings

(offset – 1 7/8") + (offset inches * 0.405)

(4") 90° street into 90° bell = 9 1/4" offset

(4") 90° bell's butted = 11" offset

(4") Length between 90° bells (offset inches - 7 1/2")

(4") 90° street into 4" Tee = 7 3/4" offset

(4") 45° street into 90° bell = 5" offset
(Use middle col. above for lengths)

(4") Two 22 1/2° bell's
1 3/4" offset

(4") 45° street into 45° bell
2 3/4" offset

(4") 45° bell's butted
4 1/8" offset

(4") 45° street into 4" Tee
3 1/2" offset

(4") 45° bell butted into 4" Tee
5" offset

(3") 90° street into 90° bell
7 1/4" offset

(3") 90° bell's butted
8 3/4" offset

(3") 90° street into 3" Tee
6 1/4" offset

(3") Length between 90° bells
Offset inches - 5 3/4"

(3") 45° street into 45° bell
2 1/2" offset

(3") 45° bell's butted
3 1/2" offset

(3") 45° street into 3" Tee
3" offset

(3") 45° bell butted into 3" Tee
3 5/8" offset

(3") 45° street into 90° bell
4" offset

Typical Offset cuts