



**Getting Heat  
Pumps Right**

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**Framing a  
12-Sided Turret**

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**Troubleshooting  
Steam Showers**

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On the cover: Mikey Lang of KJ's Cooling & Heating, based in Phoenix, installs the grille on a new Mitsubishi ceiling cassette. See the story on page 43. Photo by Steve Easley.

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BY CLAYTON DEKORNE

## Next-Generation Training

**A new training program** for the construction industry, On3 (online at on3.ai), has the potential to fundamentally change how we train the workforce. By “change,” I don’t mean it will necessarily displace effective programs or training providers. If anything, it is likely to enhance what they do. What excites me most about On3 is not the training materials or “content” on the platform, but rather the way those materials can be made by companies and delivered to workers.

Content is where most people focus because they are concerned about *what* a worker will learn. That’s certainly valid. We all, for as long as I can remember, have said that training the trades happens on the job. If a new hire has come through a trade school, or even another company, they still need to learn how things get done in a new organization. What makes On3 so smart, I think, is that it’s designed to allow each company that uses it to develop its own training material. “We are focused on ‘how’ training is distributed to users,” explains Bob Baldocchi, vice president of On3. The “how” is both the way the learner interacts with it and the way the construction company serving it up to the learner employs it.

### IF ONLY INSTAGRAM WAS MADE FOR LEARNING

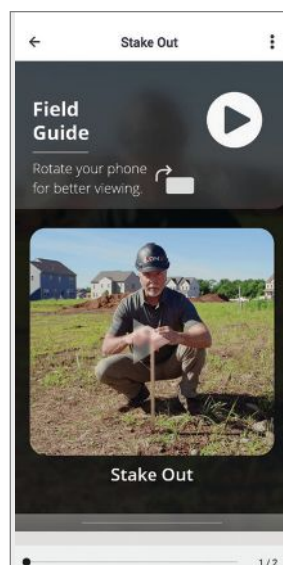
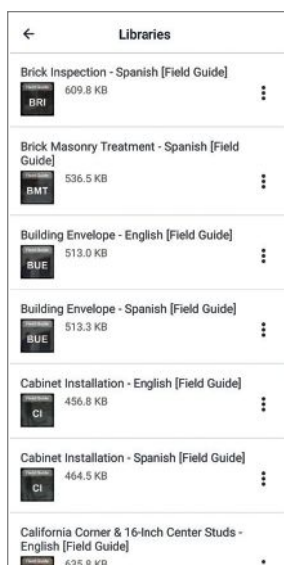
For years now, I have been impressed by what is happening on Instagram: A growing community of building professionals are shar-

ing what they do for the benefit of others. If you follow awesome framers, [mike\\_guertin](#), [stevenbaczekarchitect](#), [buildingsciencefightclub](#), [nielsencrestcarpentry](#), [jake.bruton](#), [catalystbuilt](#), [kasselconstruction](#), [carpentry\\_bymar](#), [aaronthomasquinas](#), [drywallshorty](#)—I am just scratching the surface of an immense group of passionate professionals who dedicate a lot of time posting content to help others build better—you know what I’m talking about. It’s an amazing community with enormous educational potential.

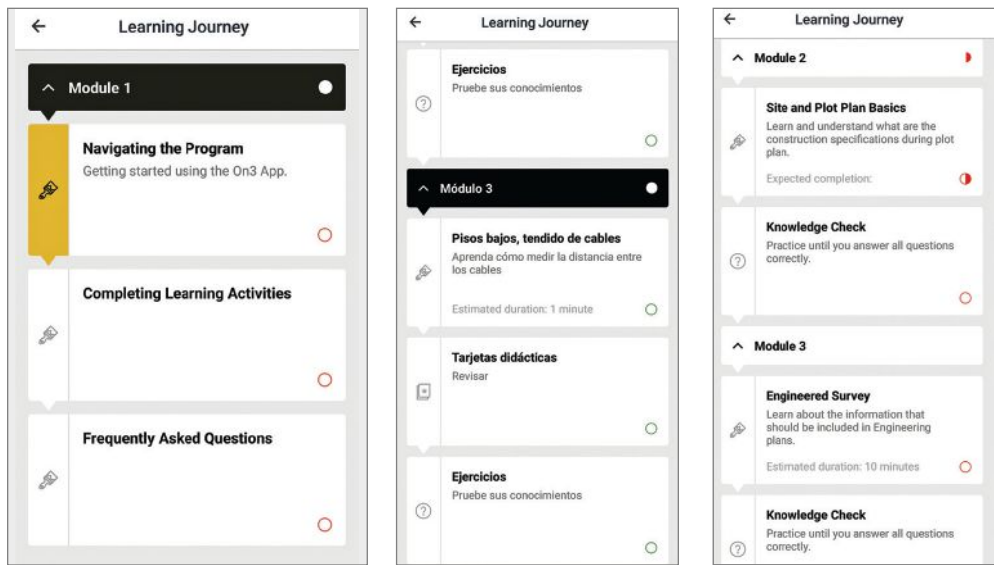
Only, Instagram is not searchable, so it’s frustrating if you kind of remember something one of these folks said and want to brush up on it. Good luck finding it again. As an educational experience, you have to be on it every day, learning constantly, which is not a bad thing, but it’s a big time suck. (That’s Instagram’s model: It doesn’t care if you’re learning, so long as your eyeballs are on it.)

### A DIFFERENT MODEL

In contrast, On3 has the potential to be a more exciting educational platform because it’s purposefully focused on the learning process. It can offer some of what Instagram provides—namely, short, relevant videos covering specific building lessons that can be created on site. But the learning channel that users post to offers so much more as an educational experience than just the video. Here are some of the features that stood out to me.



Subscribers to the program can get started right away by choosing from searchable libraries of materials organized in “field guide” videos. These can be used as field references or curated into learning modules that combine the video instruction with learning objectives, flash cards, and quizzes. Companies using this as a training tool for employees can train on what’s needed, including creating their own video content with On3 support.



No one is going to learn construction only online. On-the-job training needs to be exactly that—done on the job. On3 seems like one way to support on-the-job training and create a deliberate program for employees. Doing this requires each learner to follow a “learning journey,” not just watch a video. These screen grabs give an idea of some of the ways learning modules can be organized in On3 to create that path for individuals. Spanish-language learning is an option.

**Mobile-based.** Nothing for online training these days makes sense if it’s not accessible by phone or tablet. This makes it available anywhere, especially on the job. On3 materials can be downloaded in advance, so they can be accessed at those remote sites that might have spotty connections.

**Individualized.** The materials are organized in a library of “field guide” videos. Subscribers to the program can get started right away by choosing from existing videos in the libraries. This material is searchable, so it can be used for reference in the field, or it can be curated by the subscribing company into learning modules that combine the video instruction with learning objectives, flash cards, and quizzes. These elements create a “learning journey” for the individual employee, and company owners or managers can track each person’s progress.

**Strategic.** Companies using On3 as a training tool for employees can train on what’s needed. They build the modules they want their employees to learn. That can include videos the company creates and uploads to the libraries. (Companies can keep these proprietary, though it’s less expensive if you join the On3 community and contribute the videos to the On3 knowledge base). As Baldocchi explains, companies are able to use the platform strategically to train employees on “pain points,” such as the flashing details or other procedures that the crew or subs continually get wrong.

In addition, training can be developed for building awareness of new products that a company is rolling out. This is where the platform could be especially useful: As an industry, products are becoming more specialized, more “engineered,” even to the extent that ICC Evaluation Service Reports or other technical documents from manufacturers have become the accepted code requirements for installing more and more products. On3 could provide a way to get those critical technical details out to installers.

**Adaptive.** The “.ai” part of the On3 web address is an interest-

ing dimension to the tool. Each employee using it has their own learning path. Experienced users don’t have to slog through a bunch of basics if a company doesn’t want them to; they can be assigned more advanced materials. But the company doesn’t need to have an HR department tracking progress; the On3 program can do that. It will keep track of progress and even push out reminders to individual learners to retake a lesson they didn’t score so well on. It’s not a one-and-done sort of learning experience the way a lot of online training can be.

**Coachable.** If a company manager wants to step up their engagement with an individual’s training, they can assign themselves or someone else as coach to a learner. That person can then create a module for, or push one to, an individual. They can also ask a learner, for example, to create their own video as an assessment: “Tell me what you learned from this module” or “shoot a video of how you would lay that out,” or “make a checklist of what you need for that job,” or the like. The learner can make that video on their phone and upload it to the coach. This sort of dynamic interaction takes this way above the sort of flat, impersonal level of most online learning.

**BUILDING EXPERTISE**

We have been talking about moving the needle on the lack of skilled labor in the construction workforce for a long time. On3 is just one program, but it’s the first one I’ve seen that might be able to deliver on that. The trades are difficult to learn. You can’t march in and be productive if you don’t have a strong education, and there are very few institutions that offer that. On-the-job training is our only real option.

“The goal is to build expertise,” Baldocchi argues. “Once someone becomes an expert in their trade, they are much more likely to stick with it and not jump to another profession.”

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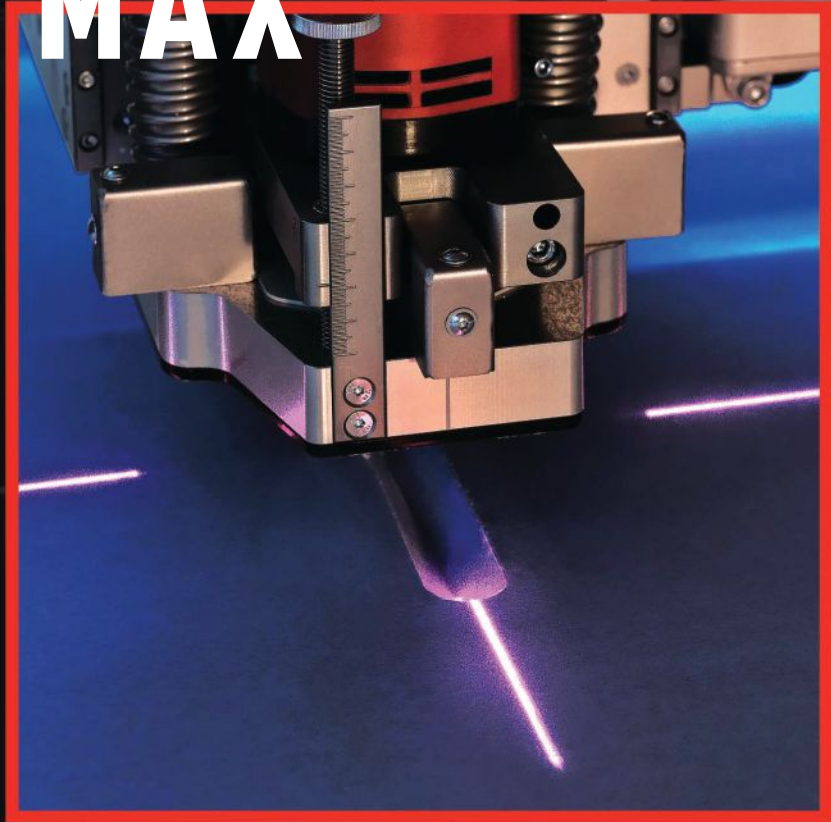
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**Q Are houses insulated with open- or closed-cell spray foam quieter than homes insulated with standard fiberglass batts? In general, what is the best insulation to use in terms of sound control, and does the choice of insulation play a large role in how quiet a wall is?**

**A** *Bonnie Schnitta, president of SoundSense, a company that specializes in acoustic engineering and consulting in Wainscott, N.Y., responds:* Here at SoundSense, our engineers are often asked about the acoustic properties of different types of insulation, specifically as they relate to how much sound the insulation will stop. While we have a list of preferred types and brands of insulation that we recommend to our clients, it's impossible to make informed choices about a specific product and method of installation without a firm understanding of acoustic fundamentals. Just how effective any acoustic material will be is dependent on the construction of the walls where it will be installed. If a wall is improperly configured, it may render any acoustic treatment ineffective.

**STC AND DB**

The Sound Transmission Class rating, or STC, of a wall assembly is a single-number rating calculated in a controlled ASTM-certified lab environment to quantify the ability of a material to block sound with strict control of any potential flanking, or acoustic leakage. When making recommendations for any project, we start with a target STC in order to select the appropriate materials and configurations to achieve any acoustic goals. (For more information about STC-rated wall assemblies, see *Noise Control Manual for Residential Buildings* by David A. Harris, or *Architectural Acoustics* by Marshall Long).

Generally, STC ratings can be interpreted as follows:

- 25 Normal speech can be understood quite clearly
- 30 Loud speech can be understood fairly well
- 35 Loud speech is audible but not intelligible
- 45 Loud speech is very faint
- 48 Some loud speech is barely audible
- 50 Normal speech is not audible, but amplified sound will be audible
- 60 Minimum requirement for amplified sound

When a field test is performed to determine the transmission loss of the partition, this test is referred to as ASTC (Apparent Sound

Transmission Class). Viewing the numbers above, it is easy to see that no matter how much sound a specific type of insulation will stop, if the STC when the insulation is added does not exceed 35, then there is a good chance that the client will not be pleased with the extra expense of the insulation. And although the STC or ASTC is a single number, the amount of sound that the wall stops can vary significantly in different frequencies, even if the STC is the same. As an example, walls with the same STC with only one layer of 1/2-inch gypsum board perform better in most of the higher frequencies, while that same configuration with 5/8-inch drywall will perform better in the lower frequencies.

Sound or noise (unwanted sound) is measured by decibels (dB), which is a logarithmic function, much like the Richter scale for earthquakes. One rarely hears of a 2 or 3 earthquake, but an earthquake of 5 or more makes the news. As sound increases or decreases, decibels increase or decrease logarithmically, not arithmetically; thus, a doubling of the volume of a sound shows only a 10-point increase in dB. For example, one TV set at a normal conversational level is about 60 dB. Ten TV sets at the same volume will sound twice as loud but only register another 10 dB, or about 70 dB.

**SUBJECTIVE PERCEPTION OF ACTUAL SOUND ENERGY CHANGE**

dB Change	Subjective Perception	Sound Energy Change
0-3 dB	Barely perceivable	50%
4-5 dB	Perceivable and significant	69%
6 dB	Double sound pressure	75%
7-9 dB	Major perceived increase	87%
10 dB	Double loudness, 10x power	90%

Loudness is the subjective perception of sound or acoustic pressure, which is caused by a sound wave moving through air, and which is measured in decibels (dB).

The standard acoustic rule of thumb is that any sound that exceeds the background noise level by 5 dB(A) or more has the potential to be an annoyance. By the same token, if a sound reduction measure does not provide at least a 4 dB improvement, there will not be a perceivable difference. SoundSense typically engineers walls with the guidelines shown in the table "STC Requirements and Recommendations," on the next page.

**FLANKING**

Sound will travel through any weak or incomplete junctions of a partition. For example, the STC rating of a wall may be reduced by as much as 10 points with something as seemingly minor as a 1-inch-square gap where the wall meets the floor. Even a wall on

**STC REQUIREMENTS AND RECOMMENDATIONS**

Speech Privacy Rating	Description - Classification
Very High Privacy	High Quality: STC 60+ Elevated speech barely audible. Amplified sound muted.
Confidential	Medium Quality: STC 55–60 Normal voice levels inaudible. Raised voices slightly audible but unintelligible.
Good	Minimum Quality: STC 50–55 Normal voice levels inaudible. Raised voices audible but unintelligible most of the time.

In the chart above, subtract 5 ASTC rating points from the STC ratings to approximate actual field performance due to the effects of flanking or acoustic leakage of a partition.

which the space between two sheets of drywall has not yet been taped and spackled has an STC rating that is up to 10 points lower than that same wall after finishing.

Like water, sound will take the path of least resistance. It will pass through even the smallest gaps, such as where drywall is not properly caulked at seams or a floor-wall intersection, the perimeter of doors, and recessed lights without an insulated can or a high-hat muffler. For this reason, acoustic leakage paths such as doors, outlets, plumbing penetrations, shared chases, conduits, ceiling-wall or floor-wall points of intersection, and the like in construction should be addressed so the wall or other partitions perform up to their designed STC ratings (see “Innovations in Sound Control,” *JLC*, Mar/06).

**REVERBERATION**

To determine what, if any, insulation should be used in a wall, it’s important to understand the phenomenon of reverberation amplification. Reverberation is sound persistence due to repeated boundary reflections, such as between two reflective parallel surfaces, even after the source of the sound has stopped. Most people are familiar with this phenomenon, as it is experienced in a noisy restaurant or in an echoey room.

When reverberation amplification occurs, sounds may be amplified to the point of disturbance. Putting insulation in a wall will inhibit any sound entering the cavity of a wall from having a direct reflection and help prevent reverberation amplification within the wall cavity.

**INSULATION**

The range of improvement for an uninsulated wall versus a wall with a single layer of standard fiberglass batt insulation will be between 3 and 11 STC points. The greater improvement is from such wall configurations as a double stud wall or a wall with add-

ed resiliency, such as from resilient clips, but it is also a result of the absorptive ability of insulation, its thickness, and its ability to disrupt reverberation amplification.

The speed of a sound wave is dependent on the properties of the material through which it passes; the more energy required to pass through a material, the less energy remains in the wave, also known as transmission loss. This means that the overall density of the insulation—whether from the thickness of the insulation or from its density—will improve transmission loss. This is on average about a 4 dB improvement, which is significant and perceivable.

Finally, considering how acoustic leakage can significantly degrade the ASTC of any wall, fully filling the wall cavity with a thick or dense insulation can potentially improve the transmission loss by at least 5 dB. Based on mass and density, we typically recommend mineral wool insulation, such as Safe’n’Sound and ComfortBatt from Rockwool, Johns Manville Mineral Wool Insulation, and Thermafiber from Owens Corning for the most effective sound control in an STC-rated assembly. Spray foam can solve acoustic leakage problems by filling the small holes previously discussed. If a high-STC wall is being used that is achieving its high STC by including resiliency in its configuration, then spray foam that hardens will short-circuit this configuration, unless the spray foam does not connect the two portions of the wall that have a resilient connection. If the spray foam is not rigid, then it has the benefit of filling holes and helps with the high STC design of a wall as long as the spray foam has the same density as that of sound batt.

**COMPARISON OF HOW INSULATION IMPROVES THE STC RATING OF A 2X4 PARTITION WALL WITH 1/2-INCH DRYWALL ON BOTH SIDES AND AN INITIAL STC BETWEEN 33 AND 35**

Insulation	Thickness	NRC	STC
Open Cell Polyurethane	3"	0.70	37–39
Closed Cell Polyurethane	2.75"	0.70	36
Rockwool Safe’n’Sound Batt	3"	1.05	45
Rockboard 60	3"	1.10	52
Owens Corning R-11 Batt	3.5"	0.95	39
Owens Corning Fiberglass 703	3"	1.10	52

Spray foam insulation is less effective at improving the STC rating of a wall assembly than other types of insulation that are denser and specifically designed for sound control.

For these reasons, we generally don’t recommend either closed-cell or open-cell spray foam insulation for sound control, unless there is attention to preventing a short circuit. As you can see from the chart above, neither insulation has a significant impact on the STC rating of a 2x4 partition wall. Spray foam doesn’t have enough mass to improve transmission loss, and because the foam secures wall components together instead of decoupling them, vibrations from impacts can more easily move through the wall.

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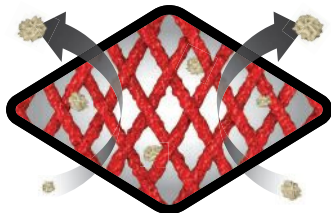


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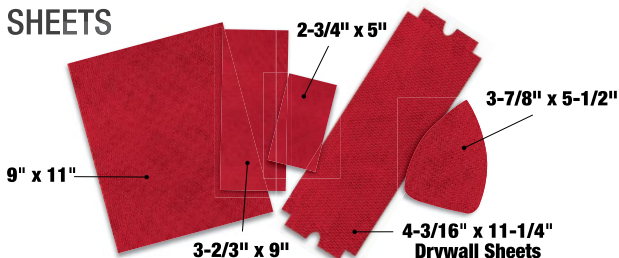
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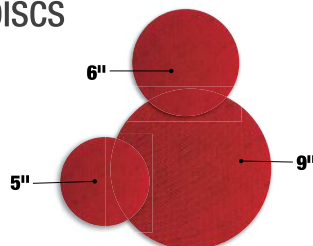
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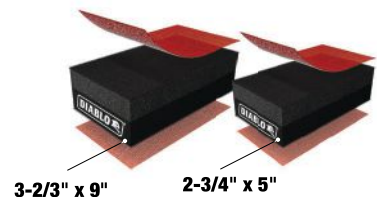
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## Rescuing a Round-Top Window

BY EMANUEL SILVA



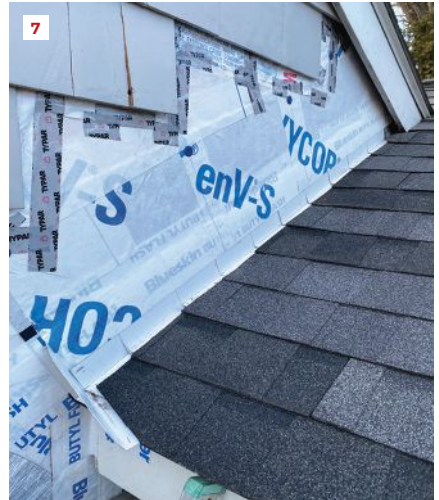
**From the exterior**, this clad round-top window looked to be in decent shape, trimmed with PVC that had been installed about five years earlier to replace the window's original wood trim. But inside the house, the reason the wood trim had required replacement was obvious: The dry-wall underneath the window had water damage and water was leaking into the basement below. During a rainstorm, water was funneled off the roof-to-wall intersection onto the window, where it flowed off the round-top flashing and down the sides of the window casing. Still, had the carpenter who replaced the trim not cut through the WRB underneath the siding, I don't think there would have been nearly as much moisture damage. Finding and fixing the existing problem was one of my goals, but I also wanted to do everything I could to prevent future problems with this window, which was clearly not in an ideal location.

**Framing fix.** A rooftop deck built when the window was first installed, as part of the same renovation project, made access a lot easier than working off ladders and staging. I started by removing the trim, which is when I discovered the problems with the underlying WRB. The only way to repair the WRB and properly flash the opening was to remove both the upper round-top window and the lower double-hung, along with the cedar shingle siding around the opening.

After removing the flashing and replacing the rot-damaged sill, I added a length of beveled siding to the rough opening for positive drainage. Next, I flashed the sill with DuPont FlexWrap NF, lapping it over the Henry Blueskin Butyl Flash self-adhering flashing tape that I had applied underneath the opening. Then I patched holes and tears in the WRB and completed wrapping the upper and lower openings with additional Blueskin flashing.

Water draining off the roof directly above the round-top window had penetrated behind the window casing, thanks in part to damage done to the water resistive barrier (WRB) during a previous repair (1). The author removed the upper and lower windows, repaired the damage, and carefully reflashed the opening before reinstalling the windows (2). The repair included removing roof shingles and siding and installing new peel-and-stick membranes on the roof deck and wall (3) in preparation for a new diverter flashing above the window (4).

Photos by Emanuel Silva



Fabricated from aluminum coil stock (5), the kickout diverter flashing was installed at the bottom of the roof-to-wall intersection (6). The author then reinstalled the roof shingles with new step flashing that he taped to the WRB (7). He used a plywood template (8) to cut the curved PVC window trim with a router and rabbet the inside edge so that the trim fit over the window cladding (9). The kerfed piece added to the back of the curved tracing was needed for sealing the window casing to the wall sheathing. The author assembled the trim as a single unit with pocket screws and PVC glue (10).

Prior to reinstalling the lower windows, I spread a bead of OSI Quad Max sealant around the opening to bed the flanges, leaving small gaps at the bottom for drainage. After installation, I taped the flanges to the WRB with Blueskin tape, lapping the tape up over the opening for the upper window. Then I installed the round-top in a similar fashion, taping its curved flange to the WRB with FlexWrap.

**Diverter flashing.** To keep rainwater away from the window as much as possible, I installed a kickout flashing at the roof-wall intersection above the window. To do that properly, I needed to peel back the wall shingles from the gable above the roof and

enough roof shingles to allow me to weave in new step flashing and the kickout diverter.

I used short lengths of Blueskin tape to flash the tricky area where the roof eaves meet the wall, including behind the fascia and in the gap between the end of the drip edge and the wall sheathing. Next, I covered the roof sheathing with Grace Ice & Water Shield membrane, sealing the membrane to the existing roof underlayment with more Blueskin tape and lapping the membrane up the wall sheathing and tucking it underneath the existing WRB covering the wall.



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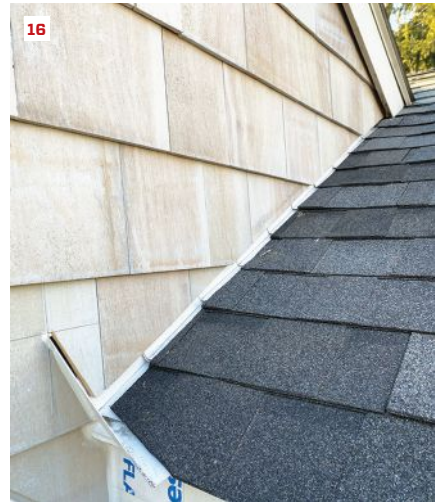
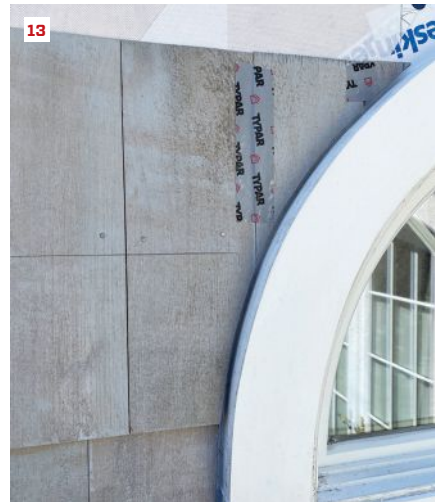
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The author also installed diverter flashings on both sides of the window casing to prevent water from flowing off the top and into the gaps between the trim and siding (11). A cardboard template sped up shingle installation around the round-top window (12), as did taping small, cut shingles together to form a larger unit (13). Careful layout was needed to fit the shingles around the kickout flashing (14, 15). The author placed a temporary spacer on the step flashing prior to installing the siding shingles to ensure a consistent gap for drainage (16).

From 8-inch-wide painted aluminum coil stock, I had fabricated new step flashing and the kickout diverter. After cutting and folding the diverter into the desired shape in an origami-like process, I riveted the folds together and sealed up the joints with clear silicone sealant.

I installed the kickout over a half-width of step flashing, which I had taped to the wall. Another half-width of step flashing installed over the kickout locks it in place. Then I installed a full step flashing over this assembly, taping the step flashing to the Grace membrane on the roof and wall and sealing up the roofing nail

heads with silicone. I installed the remaining step flashings conventionally as I reshingled the roof, leaving a 3/4-inch gap between the edges of the shingles and the upturned legs of the step flashings for good drainage and taping the step flashing to the WRB with Blueskin tape.

**Fabricating the trim.** I made a cardboard pattern of the round-top window and used it to trace the window's outline onto a length of Zip sheathing. Using a compass set to the 4 1/2-inch width of the trim and following the arc of the traced outline, I then scribed the trim's outside radius onto the sheathing. I carefully cut to the lines



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Installed during a previous remodeling job in a gable wall with virtually no roof overhang above to protect it and positioned beneath a lower roof that drains directly onto it, this round-top window provided a perfect entry point for rainwater. But the author's efforts to correctly flash the window and divert water away from it as much as possible have proven effective, with no leakage reported by the homeowners after more than two years (17, 18).

with a jigsaw to create a trim template, smoothing out the curves with a random orbit sander.

I used this template as a guide to cut out the round-top trim from two layers of 3/4-inch-thick PVC sheet stock that I had glued together with PVC cement. First, I traced the template outline onto the PVC stock and rough-cut to the lines with a jigsaw. Then I screwed the template down and used a flush trim bit in a router to trim the PVC to finished size. Because I wanted the trim to overlap the vinyl window frame, I used the router to cut a 1/2-by-1/2-inch rabbet around the inside edge of the trim piece.

Even though the trim piece was a full 1 1/2 inches thick, I still had to build it out with another curved length of 1-by-3/4-inch PVC applied to the back outside edge, like a back band in reverse. I couldn't bend this piece without breaking it or putting it into a bending oven (which I don't have), so I kerfed the inside edge with 5/8-inch-deep cuts spaced every 3/4 inch. This allowed the shim to flex evenly around the curved edge of the trim as I fastened it in place with PVC glue and 1 1/2-inch-long GRK trim screws.

Before installing the trim, I added straight legs to the assembly so that the trim would cover both the upper and lower windows. I joined the legs to the curved portion with pocket screws and PVC glue, then drilled pilot holes for the 3 1/8-inch trim screws that I would use to fasten the trim to the wall, first drilling 1/4-inch-diameter plug holes that I would later fill with PVC plugs. After installation, I filled the gaps between the trim and the wall, and the trim and the window frame, with a generous bead of OSI Quad Max sealant.

**Shingle installation.** Because I believed that water running off the round-top portion of the window and down the sides of the window casing caused a lot of the damage inside the wall, I folded up custom kickout flashings and applied them to the window casing while reinstalling the cedar shingle siding. To make installation easier around the curved portion of the window, I made reverse window patterns out of cardboard that I could use to mark the curved portions of the shingles on either side of the window.

When installing cedar shingles around curved or complex shapes, I find it helpful to join multiple shingles in a course together with flashing tape, which helps keep the smaller cut pieces properly oriented and spaced. The main thing is to stay level, plumb, and square as you shingle up from the row below, take accurate measurements, and scribe as much as you can around or along odd shapes, such as the diverter flashings that I installed on this project.

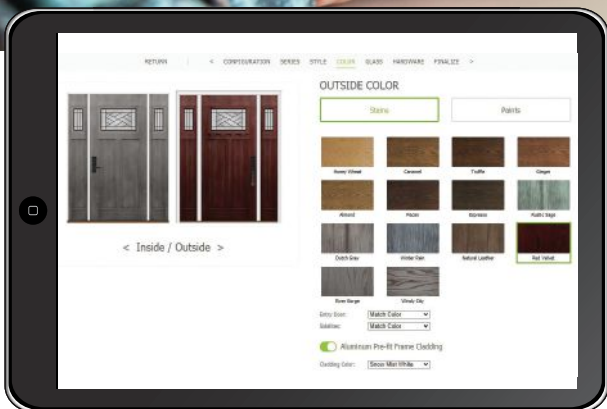
Along the roof-to-wall intersection, I installed the shingles butting up against a 3/4-inch-wide temporary spacer to create a consistent gap. Where possible, I caulked around locations water might penetrate between the shingles and other trim, such as around the kickout flashing at the eaves. I use sealant only where I know it will be hidden by an overlying shingle, and when I know that the sealant won't trap water.

*Emanuel Silva, a contributing editor to JLC, owns Silva Lightning Builders in North Andover, Mass.*

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# Hidden Defects Complicate a Simple Deck Replacement

BY MIKE WHALEN

**In late 2020, my company** was approached by a client who wanted to replace a small deck on the condo she had recently purchased. Measuring roughly 12 feet square and framed with pressure treated 2x8 joists with 2x6 PT decking, the deck had been built in the 1990s at the same time as her home, the end unit of a four-unit townhouse that's part of a 100-plus-unit condo development. Even after 25-plus years of service, the deck seemed structurally fine, but the owner wasn't happy with the 8-inch step up from the deck to floor level **(1)**.

When we began to demo the deck the following spring, we discovered that the deck's two ledgers had not been flashed properly. The home's vinyl siding was butted against the top of the decking on both the eaves and adjacent end walls, concealing that the deck-to-wall flashing was missing. The housewrap was just lapped over a narrow strip of building paper that had been tacked in place behind the ledger, with the top edge of the paper aligned with the top of the deck.

The outward appearance of the ledger connection seemed OK—the deck wasn't too wobbly—but when we removed the ledgers, we found that the OSB sheathing underneath was in bad shape **(2)**. The more vinyl siding we found, particularly on the condo's end wall **(3)**.

With little to no overhang and more surface area than the eaves wall, the end wall was more vulnerable to water damage from wind-driven rain. Compounding matters, the woven-type housewrap beneath the vinyl leaked like a sieve at various times and in different locations along this critical juncture.

**No rim boards.** Another hidden surprise was the floor system, which was framed without rim boards. When we removed the end wall's damaged OSB, the ends of the wood I-joists were just staring us in the face **(4)**. These 12-inch-deep I-joists run perpendicular to the end wall and parallel to the eaves wall, with 2x4 squash blocks run vertically on either side of the joists.

Along the end wall, the original builders had lag-screwed the ledger to the squash blocks, as well as to the wall's double top plate. On the eaves wall, where the outer I-joist "rim board" offered little help in terms of ledger fastening, the 2x8 ledger was only lagged at the double top plate. I sent pictures of our findings to an architect we frequently work with, and he was stunned.

We informed the homeowner what we discovered



While the existing deck displayed no outward signs of instability **(1)**, the ledgers had not been properly flashed and the underlying OSB sheathing was revealed to be water damaged upon removal **(2)**.



The end-wall sheathing was severely deteriorated **(3)**, and removing the water-damaged materials revealed that the floor framing had been installed without rim boards; a square hole (top right in photo) was cut into the outboard I-joist to verify floor framing direction **(4)**.

Photos by Mike Whalen

and inspected the interior of the home for signs of water damage and mold and found none. After removing all the rotted OSB sheathing (the bulk of which was from the end wall) and fiberglass batt insulation, we found that the underlying framing was in fairly good shape. So we applied a mold-inhibitor onto the affected areas, sistered a few new studs onto the studwall, and left the exposed stud bays open overnight and into the next day. Because it was early spring and still cold, we had to balance wanting to dry out the wall cavity and quickly buttoning everything up for heating purposes.

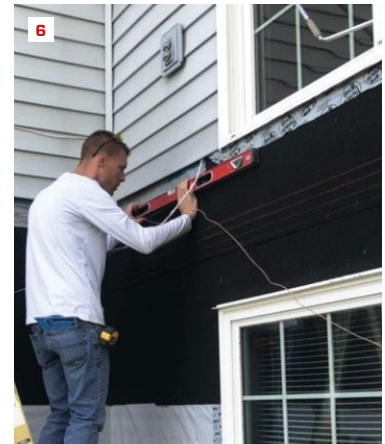
**A structural redesign.** The architect sent us a couple of ledger attachment scenarios for the planned deck: lagging the 2-by PT ledger to the existing house framing with staggered LedgerLok screws 6 inches on-center if the I-joists ran perpendicular to the eaves wall; or, if the I-joists ran parallel, installing four hold-down devices attached to joists with 1/2-inch-diameter threaded rod with nuts and washers. To see which scenario would apply, we cut a roughly 6x6 square into the web of the outboard I-joist running parallel to the wall, confirming that the floor joists were indeed parallel to the eaves wall.

In lieu of removing interior drywall to block out five joist bays for the hold-downs and threaded rod, we opted to build a less-invasive, free-standing deck. This decision was also prompted by the client's desire to raise the deck elevation to decrease the step down from the sliding door from 8 to 4 inches, which would have made securing a new load-supporting ledger along the eaves wall all the more difficult.

The new deck matches the original deck's footprint, but we increased the joist size to 2x10 stock, which helped with the ledger attachment issues to the house. At either end of the deck, we supported the joists with a pair of double PT 2x12 drop beams, which in turn are supported by four 6x6 posts on 18-inch-diameter by 48-inch-deep concrete piers. For lateral stability, we fastened the two 2x10 ledgers to the house framing with LedgerLok screws 16 inches on-center in a staggered pattern where feasible. At the eaves wall, the flush-framed joists are secured to the ledger with hangers.

We installed peel-and-stick membrane behind the ledgers and flashed them with L-shaped copper properly integrated with the WRB. After completing the free-standing deck, we reinstalled the existing vinyl siding (5-9). For a job that should have taken only a couple of days, this small deck project—with all its hidden problems—took two weeks.

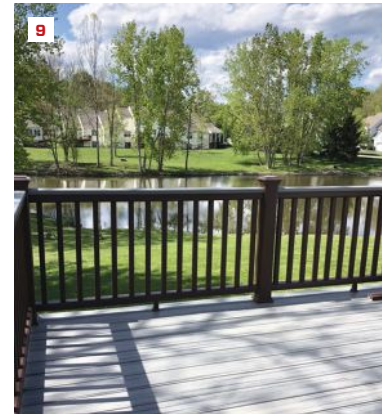
*Mike Whalen is a project manager at DBS Remodel, a design-build residential remodeling company based in Poughkeepsie, N.Y.*



After re-insulating (5) and resheathing the walls, workers installed a peel-and-stick membrane in the ledger area (6), running the membrane 6 inches above the new deck elevation and behind the WRB.



L-shaped copper flashing (yorkflashings.com) is installed on top of the ledger along the deck-to wall juncture. The new deck was raised 4 inches to decrease the step down from the sliding door (7).



The free-standing deck is supported by a pair of double PT 2x12 drop beams and four 6x6 posts (8). While the condo association approved the new Trex composite decking, the posts and railings needed to be dark brown to match the original deck (9).



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## Taking Charge of Your Cash

**Over my decades** in the construction industry, I've heard many discussions about profit. The relentless focus on the bottom line shunts aside another important issue, the need to manage cash as it flows through a company. That's understandable. Maintaining profitability in a construction business is hard. But profit and cash are not the same thing.

Cash management is what the legendary grandmother does for her farming family. Prices at market for the farm's apples are good. Much cash is coming home. Grandmother sets up a series of envelopes in her steel box with the hasp and lock. One is for the money to pay upcoming bills. Another is for charity, a third for holidays. A fourth is labeled "rainy day fund." It's for emergencies and hard times. A final envelope stores cash for purchase of a new tractor.

Grandmother takes each week's income and divides it among the envelopes. She's taken control of her farm's cash. She's managing it.

These days, when financial pros talk about business cash management, they use a "bucket" metaphor to describe a practice parallel to grandmother's use of envelopes. As cash is generated by a business, it is divided into a series of "buckets," just as grandmother divided her family's cash into envelopes. These buckets are in actuality accounts at financial institutions.

When starting out in the construction business, we may have only one bucket, a checking account at a bank. We deposit income from our projects into that account and pay our business and personal expenses from it. That's a practice that goes hand in hand with a financial mishap that often bedevils construction contractors. It encourages confusion of pay with profit. We see money piling up in our one account and take that as a sign that we are running a profitable business. But almost all of what we are perceiving as "profit" may, in fact, be the compensation that we will take for our work in the field and our office and use for personal expenses.

Our pay as a company owner is not profit. It is an expense to the company. Pay to anyone, including ourselves, who does work for the company is a company expense. Therefore, our pay must be deducted from company income to produce a valid number for profit.

To prevent the mistake of miscategorizing pay as profit, we take an initial step

toward cash management. Keeping the first bucket as a personal account, we set up a second bucket for business income and expenses. Going forward, when we take pay for our work in our company, we transfer it from the business to the personal account and record the pay as a company expense.

With one bucket in place for our personal pay and expenses and another for business operations, we have made a good start at cash management. To match grandmother's performance, we need more buckets. Next up, a bucket for tax payments. We'll regularly transfer funds into it from our business bucket. Failure to set aside money for taxes can result in unpleasant consequences. Suddenly, it's tax time. We don't have money to pay our taxes in either our business or personal accounts. So we don't pay them. Big fines can result—about \$150,000 in the case of a flooring contractor I once worked with.

As our business matures, we need a fourth bucket. That's the capital-reserves bucket. It's the construction pro's equivalent of grandmother's hard-times envelope. Hard times do come in construction, hitting in the form of what I call "profit costs" like those described in the sidebar "Profit Costs and Capital Reserves," on the next page.

With your capital reserves and other buckets topped up, you can establish a fifth bucket. It's my favorite. Let's call it the "good-times bucket." It's your storehouse of free cash—money not claimed by ongoing personal expenses or business needs. Some folks will spend it on a boat, travel, a grander home, or a vacation cabin. Others will

### PROFIT VS. CASH

The profit numbers reported by your accounting system can fool you. It may produce what financial professionals term "mismatches" between income and expense flows. That's especially a hazard in construction where we learn to "bill early and bill often" in order to avoid having completed a lot of work that a customer is then unwilling or unable to pay for.

Billing early, though prudent, can cause a problem. We take the payments and record them in our accounting system. But expenses associated with the payments may not yet be incurred, much less recorded. That is, we've got a mismatch.

For example, we've largely framed the walls for a project. We've received and recorded payment for all wall framing. But we have not yet recorded all costs for the associated labor and material—say, for blocking or other pickup work yet to be done or workers' comp premiums that will be coming due. As a result, profitability through the framing phase of a project looks better than it actually is. Cash is not so illusory. It's either in a financial account or it's not. You can think of profit as the bird in your sights. Cash is the bird in the freezer. —D.G.

opt to invest their free cash to secure financial freedom. That is my preference. Financial freedom is to me the best of all good times. Nothing beats being able to greet the day knowing you can go about your business from choice, not out of economic necessity.

By now you may be wondering, “where should I keep my cash and how much cash should I keep in each bucket?” Answers vary depending on the legal form and needs of your business. But generally, you want your cash in accounts at reliable financial institutions.

The initial all-in-one bucket that will become your personal account can be set up at a full-service local bank. Bucket #2, the business account, could be at the same bank. But that may foster errors like using the business account for personal expenses. Placing the business account in a separate bank can safeguard against that error.

Bucket #3, the tax account, can be housed at the same bank as either the personal or the business account. Rather than a checking account, it can be a savings account. As you determine the amount you need to set aside for taxes, you transfer funds from the business to the savings account and keep them there until tax payments are due.

For capital reserves, you may, for convenience sake, set up an account at the bank you use for your business account. Alternatively, especially as your capital reserves grow, you might prefer a financial institution where you can more readily place part of the reserves in “investment vehicles” such as CDs (or even, to a prudent extent, stock or bond funds). Thereby, you could capture earning power beyond what’s likely to be available from an account at a bank.

Bucket #5, your good-times account, should almost certainly be at a financial institution that serves investors. From there, you can deploy your money into whatever pleasures or investments suit you. One caution: You do not want to indefinitely leave your good-times money stored in the form of cash. Ray Dalio, the legendary investor and philanthropist, warns us that in the long run, “cash is trash.” Well, maybe not quite. But the purchasing power of cash does get eaten away by inflation. The dollars that today buy you a hamburger will eventually get you just the bun and the pickles.

That brings us to a last question: How much cash should you place in each of your five buckets? Answering it requires judgment calls.

The business account must retain enough to cover all ongoing costs for construction and for overhead. To calculate the amount, you must accurately project the income and outflow that your business will experience over coming months. Given the frequency and severity of profit costs that hit construction companies, you’d be wise to keep your projections on the safe side. Under-project income. Over-project expenses. Maintain a margin of safety.

You need to transfer enough money to the personal bucket to cover your ongoing costs of living. If you require a high-end lifestyle, the personal bucket will need to be fed a great deal of cash. If your priority is financial freedom, you will want to restrain the amount of cash going into the personal bucket and deploy more for investments.

The tax bucket needs to be fed enough cash to cover upcoming federal and state estimated tax payments. Determine what percentage of your profits you will be required to pay in taxes. As you complete a job—or on large projects, a phase of a job—calculate profitability. Set aside the determined percentage of the profits for taxes.

As for capital reserves, construction business advisors advocate varying amounts. Victoria Downing, president of Remodelers Advantage, urges having enough cash in reserve to cover half a year’s worth of overhead expenses, including owner’s pay.

I have long urged an even more conservative guideline, namely 10% of annual revenue as capital reserves. That’s \$100,000 at \$1 million revenue and \$1 million at \$10 million revenue. A builder I have interviewed for my books owns a company that was enjoying some \$10 million annually in revenue when a brutal recession hit. Over the next couple of years, he burned through about \$700,000 of his reserves to keep his company going. He was glad he had gone with 10%. His business survived and prospered again, refilling the buckets for capital reserves and pouring free cash into his good-times bucket.

For your good-times bucket, my answer to the “how much” question is, “as much as possible without compromising the strength of your company and the work it produces.” In a coming article, I will discuss the features of a strong and sustainable construction company.

With five buckets, each being fed an appropriate amount of cash, you have effectively assumed management of your cash. You want to do that. You do not want to stop at just recording and accounting for the money that flows through your business.

Accounting is about observation. Cash management is about command and control. You want to direct the flow of your cash. You worked steadily to acquire it, so be sure you take charge of it.

*David Gerstel is a builder and the author of several books on construction company management. This article is adapted from his newest book, Building Freedom: A Construction Pro’s Path to Financial Independence.*

### PROFIT COSTS AND CAPITAL RESERVES

In construction, we have three kinds of costs: the direct costs of construction at our jobsites, the off-site costs of running our companies, and what I like to call “profit costs”—those strikes out of the blue that can take a big chunk out of our profits.

Profit costs range from abrupt inflation in material prices during a job to lawsuits long after a project has been completed. The appendix of my new book, *Building Freedom*, contains a list of 35 profit costs.

With skilled management and luck, we might escape most of them. But we won’t escape all. Prudence requires that we be ready for them—with a topped-up capital-reserves bucket.

Judith Miller, a veteran financial advisor in the remodeling industry, underscores the point: Many construction contractors, she says, “fall prey to the arrogance of profitability.” Business is booming. They are on a roll. They fritter away their cash on speculative ventures and big boys’ toys. “They do that without realizing they are failing to develop a sufficient war chest of money for protection during bad times.” Over the course of her career, Miller has watched many builders suffer due to lack of the capital reserves needed to cover profit costs. —D.G.

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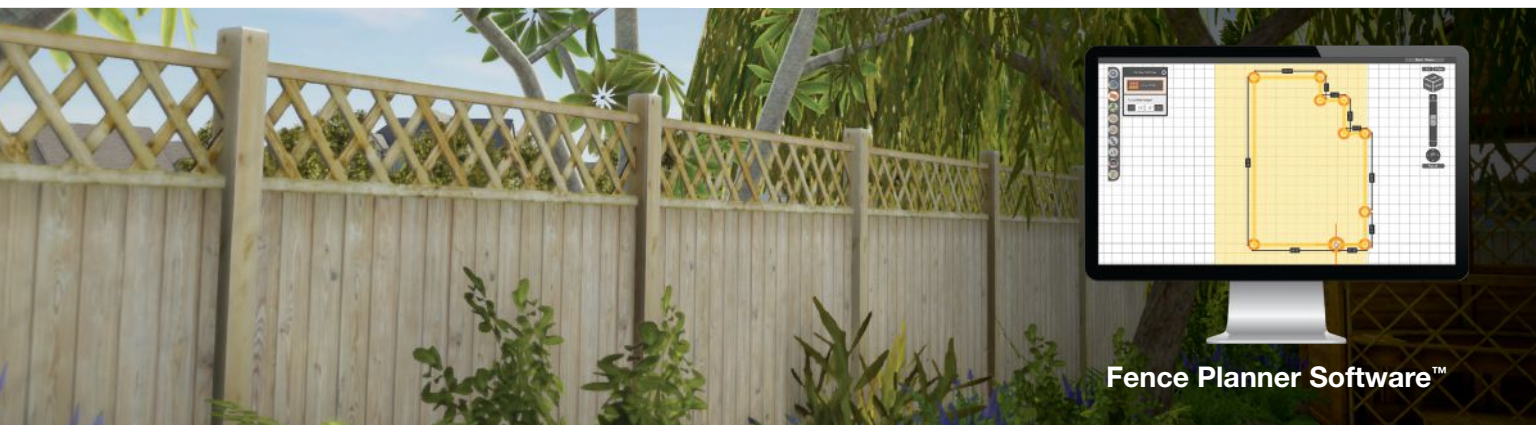
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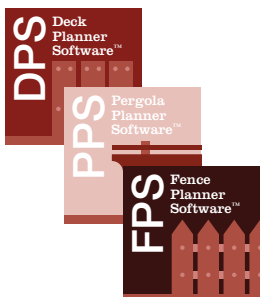
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BY CLAYTON DEKORNE

## Local Hero: A Conversation With Tom Kelly

**Bigger isn't always better.** In houses, it can impair building performance, but in business, it's usually preferred and almost always admired. In the remodeling world, the biggest firms are typically specialty firms that deal in a specific product line, like windows, siding, or bathroom facelifts. But a number of remodeling firms are able to scale high-quality renovation and design work, and Neil Kelly, a design-build remodeler and custom builder in the Pacific Northwest, has long been in that group of top firms. Still, I was surprised when Neil Kelly landed in the top position for design-build firms (and at No. 61 of all remodeling businesses) on *Qualified Remodeler's* "Top 500" ranking of the largest companies. Though a bit different from when I learned Elon Musk had become the richest person in the world, I found myself asking the same question: How did that happen?

On the eve of his retirement (later this summer), I connected with Tom Kelly to discuss this and the arc of his career as a whole.

### ***Your father started the business in 1947. How did you come into the business?***

I come from a big family, but my dad, even though I was one of the younger ones, identified me as the kid he wanted to have involved in the business. And so I worked summers with some of my siblings and drove delivery trucks and did cleaning-up jobs—all that sort of stuff. After college, I started in the company doing carpentry work and cabinetmaking. Toward the end of my college days, I did do one internship, in Washington, D.C., for a congressman from Oregon. But other than that, I have worked at Neil Kelly my whole career, my whole life.

I engaged in the leadership part of the company at the end of 1976. I was production manager, and in 1979, my dad had a couple of serious heart attacks, so I took over as president. That seems like a long time ago.

### ***Your son Garrett is now working in the company, also on the production side. Was it intentional that you put him in production to follow a similar path?***

You know, that's where he wanted to be, and I certainly didn't have any objections based on my own history. He's more of a natural production person than he is a salesperson. You play to people's strengths when you can. Currently, he's vice president of production. He's got a pretty big job in the company, there's no question about that, but he's 31, and I wasn't ready to move him into the leadership of the company, even though I was younger when I took



At 71, Tom Kelly is retiring from Neil Kelly, the company his father started in 1947.

over. It's a more complex company these days. Really, I look back at that: I was 27, and I'm just amazed that we managed to survive those years, when I was so young and inexperienced. Now we have four locations and 220 employees, and in those days, when I took over, we probably had 60 employees. But we were still a going concern.

### ***Certainly, 60 employees is a huge success by a lot of measures. To me, it is amazing that you're now the largest design-build remodeler in the country but also one of the best, in terms of quality. I don't necessarily equate large with quality in the building business.***

Largest by gross remodeling sales. But I think largest in the category is a fleeting moment because there's a lot of consolidation going on in our industry.

### ***You and I both sat in on a recent session of the Harvard Joint Center for Housing Studies, which had a panel that focused on that consolidation. I was surprised you were not on the panel when I learned while preparing for this interview that some of your growth came from the acquisition of smaller kitchen and bath companies. Or is that different from the consolidation happening now?***

These days, what's happening is big investment firms are starting to acquire remodeling companies—mostly specialty businesses, like siding or windows. Those companies are dynamic kinds of businesses that are different from how we typically work. We were never trying to do anything beyond being a regional company. Our business is localized. To try to be a national brand is not something we ever had any intention to do; I think it's almost impossible for a design-build firm, with its complexity, to be national. There are so



Neil Kelly has made home performance a centerpiece of its organization. It started in the 1970s doing subsidized weatherization work, but these days, the company's solar division does more work.

many great aspects to the business, but it's sometimes challenging to maintain communication in a large organization. As it is now, with four locations, it's a challenge for each location to get our DNA, to get what we're about. It takes constant attention. Though, of course, I do think we are doing pretty well.

***I read in a Building America case study that the home-performance side of your business helped lead you out of the last recession. How big has home performance and energy been to your business, and is it accurate that it led you out or helped with the challenges of the Great Recession?***

At the time, that was a fair statement. It started in the '70s: We had what we called our "insulation division." There were a lot of state and federal incentives then, and we had seven trucks running crews insulating homes. All the federal tax incentives went away when Ronald Reagan became president, but I've always been interested in the energy efficiency aspect of our business, and in 2005, we started an energy retrofit division. So when the 2008 debacle hit, ARRA [American Recovery and Reinvestment Act] funds helped stand up an energy retrofit industry in Oregon that was quite phenomenal. That lasted until about five years ago. We had a viable division doing energy retrofits with about 40 employees in it. The state funding slowly dissipated, and the state organization that was leading all that folded.

Since then, we have purchased a solar company. So if you call us today, we will still do home performance—we still use blower doors and have cultivated a number of people with great expertise. But now that sort of work is mostly solar. We love that part of the company, but in the Northwest, those kinds of projects are relatively few compared with other remodeling work. Homeowners won't do energy retrofits unless there are financial incentives, which is too bad. I strongly believe that energy retrofit work is a much better thing to do for climate change. Better than solar, though, of course, they're both good. Hopefully, we may see some of that come back.

***That's a good segue: I want to ask you about becoming a B Corporation, which is hard to get. How did that come about for Neil Kelly and what do you think that's done for business?***

We have a long history of being a progressive business organi-

zation, particularly connected with climate. We first became active around the time of the 2008 recession with the international organization called The Natural Step [a nonprofit focused on a scientific, systemic, and strategic approach to achieving sustainability, in part by aligning with "future-fit" organizations and role models for sustainable business in communities; [thenaturalstep.org](http://thenaturalstep.org)]. A strong contingent of businesses in Oregon were affiliated with The Natural Step, including Rejuvenation, a light fixture company that my younger brother had. Through that, he and I both became intrigued by B Corp. As a family, we are politically progressive people who care about the environment, care about reducing climate change. It helped that Oregon was pushing that and trying to get ahead of the climate. Oregon's a small enough state that it's possible to know the governor, and we all worked—a whole lot of other people working toward a network of businesses aiming at "people, planet, profit," that kind of stuff.

For me, B Corp was a wonderful tool to think about implementing into the organization—to develop corporate bylaws that measured our environmental and social impact and that we could stand behind. It is a lot of work. We have to renew every three years, and it's not a rubber stamp; you've really got to be committed. But it's a good way to get all those values buried into our company DNA. I expect that to be there long after I'm gone. So that was why it was such an easy decision for me to take that on.

Certainly, there is a B Corp community, but I would never recommend anyone do it as a marketing campaign. It hasn't necessarily brought a lot of business. That is not why we do it. But I will say it turned out to be a great recruitment tool: You attract people who share those values. They are intrigued by you because you're a B Corp, and that is so important. From the HR recruiting perspective, it's fabulous, and that is a real business benefit, especially in these times.

***Another perfect cue, as I want to touch on the lack of skilled labor: The whole construction industry has been in this labor crisis for at least a decade. I have always been intrigued that besides being a B Corp, Neil Kelly is also a union company, which is a rare bird in residential, to be sure. And I have long admired the United Brotherhood of Carpenters***



Neil Kelly's handyman division booked around \$9 million last year; it's the most profitable part of the company.

**for the training it offers through the apprenticeship program.**

Yes, our carpenters come from the union. Here in the Northwest, the union is mostly commercial oriented. We're the only union shop in Portland that does residential work, and we have a separate agreement, separate from the commercial companies; we couldn't afford to be union if we had to pay commercial rates.

If a young carpenter goes through the apprenticeship program, the training is pretty good, but there's a little bit too much emphasis, in our view, on commercial. So the training aspect is, well, I would give it a C. For what we need, I think they could do a lot better job with the carpenters we have. But the union does help: We pay our carpenters at the union rate, but the union then provides carpenters with their benefits. I was just down in our Eugene office for an employee reception, and a carpenter I was chatting with was raving about how important to him the benefits are. The health benefits, and a nice retirement package, are so much better than what anybody in our company who is not part of the union gets. The benefits package is second to none.

So through this labor period, it's still been hard recruiting carpenters, but we have had to do that less because we've basically been able to keep our staff. But even though we retain them, we still need to think about where the next generation is coming from.

**Do you run your own in-house training for carpenters?**

We're doing a better job of that. We have what we call Neil Kelly University that covers a whole lot—everything from teaching our design associates Chief Architect and sales and project management, and so on. And we now have a person whose main job is just training, and her next project is to develop a more complete carpenter training program. So we are improving. But already—I probably sound like I'm bragging—I think we have probably the strongest training capability in a modern company.

Training and retaining employees is a big part of it, but there are many aspects to how we build our production excellence. We're a

team-based organization, which has been a big part of our success. We developed our team program back in the '80s. This is different from what a lot of remodelers are doing; many are still doing some version of the lead carpenter program.

Our teams are made up of a couple of designers, a project manager, and then a design assistant, and everybody else on the team is a carpenter. They work together all the time; in some ways, they're like a small remodeling company.

I can't overstate how keeping that team together, working as a unit, is important because on every project, there is continuity from sales and design through production. If somebody were to ask me to list all the reasons why we've been able to get as big as we are, I would say that the team system we have is the most important.

**Help me understand why a team is better than having a lead carpenter who is on the job all the time.**

I think there are companies that have made the lead carpenter system work. But in my opinion, it's a limit to growth. We haven't been able to get skilled carpenters who are also skilled project managers, and that is necessary to make that system work. I think you're asking too much of one person. We do have a lot of carpenters who become project managers in our company, but we have a lot of carpenters who never will be.

This makes a big difference in how contractors can grow. It allows us to have a flat organization with fewer management layers. Keeping to a team structure, we have better coordination and communication. That is very different from a company that has a completely different organization chart.

**Are those teams running multiple, or overlapping, jobs?**

Yes. Our project manager might be running somewhere between three and eight projects. We do all sizes of jobs, even custom homes, but a lot of our jobs are smaller, in the \$200,000 range. That project manager is probably working with two sales designers and likely has somewhere between two and five carpenters on the team.

We are somewhat fluid; we share work around the teams. If one team is getting too busy, then we share work to another team. In Portland, for instance, we have around 11 teams. The project managers report to the vice president of production. And then we have a design director, who functions largely as the sales manager, and the designers report to her.

**That's all on the full-service side. You also have a handyman division, right? How is that going?**

Yes. I read an article last year by a contractor who was saying, don't do handyman, it's not profitable, just something to get better work, and that sent me into orbit. We billed somewhere around \$9 million worth of business last year. It's our most profitable division.

**Does it drive sales for bigger jobs?**

To an extent, but that's never been why we did it. I think it's important that each division is profitable. You should run every part of the business with the intention to do it well and make it profitable.



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**FIELD GUIDE**

## Steam Shower Lessons Learned

**Steam showers are a nice luxury.** We've found that most clients use their steam feature infrequently, but there are some who use it all the time—we have one client who uses theirs for half an hour every day. So when we install steam showers, mostly on bathroom remodels, we keep that heavy-use client in mind.

In this story, I'll discuss methods and materials my Northern Virginia-based company has found to be effective for trouble-free steam shower installations. In short, if you fully water- and vapor-proof the shower, provide ample space for the steam generator device along with a good safety pan and drain, and find a way to put ventilation in the shower, it will work for the long term.

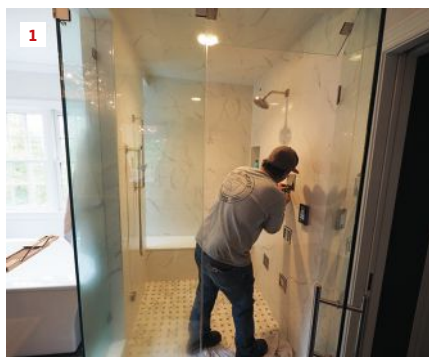
**Shower enclosure.** The enclosure should be vapor controlled on all sides, including the ceiling. Typically, it's tiled on all sides with a tempered-safety-glass door and panels run to the ceiling. Most of the glass doors we install are frameless, sealed at the perimeter with clear weatherstrip pieces.

Tile is fairly water resistant, but not totally. The water stops at the waterproofing, not at the tile and grout. The advent of waterproofing

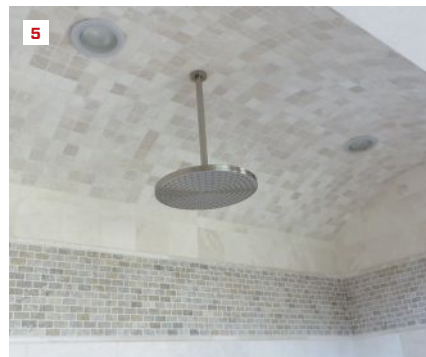
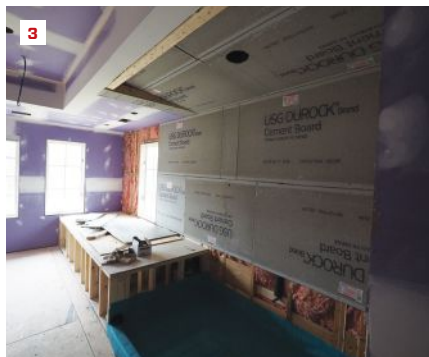
sheet and board materials has made it much easier to achieve a good barrier behind the tile on every side of a steam shower.

We generally use cement-board backers with a polyethylene sheet waterproofing applied to the shower side. Schluter Kerdi is the brand we most often see, but we've also used Laticrete Hydro-Ban Sheet, Noble Wall, Durock Brand membrane, and next week, I'm sure we'll see a different version. All of these are thick, flexible sheets manufactured with a fabric on each side. Thinset adheres well to the fabric; the waterproofing is applied to a coat of thinset on the substrate, then tile is applied to the waterproofing with thinset. We've had very few problems with this type of waterproofing—most tile crews in our area know how to apply it correctly, and we've found it's good enough to work as a steam shower vapor retarder too.

A relatively new option is foam backer board, a structural foam board with a coating that tile will adhere to with thinset. The Schluter version, Kerdi-Board, appears to be foam board with Schluter Kerdi applied to it in the factory; there are other brands



Enclosures for steam showers need to be fully water- and vapor-proofed on all sides. Surfaces, including ceilings, are typically tiled, and large areas of glass (door, side, and top wall panels) are used to let in outside light and increase ambiance (1). Here, insulated Kerdi Board is installed on an exterior wall, keeping the shower side warmer and providing a more comfortable bathing experience (2). A soffit hides the sloped ceiling on an in-progress installation (3). Curved ceilings are nice design features that allow for steeper sloping (4, 5).



Photos by Doug Horgan; illustration by Tim Healey

## Steam Shower Design

**Ventilation requirements** vary per manufacturer. To clear moisture, the author installs a fan inside the shower connected to a timer or humidity control. A remote fan with two inlets (one inside shower and one outside) is often used to vent both locations, simultaneously.

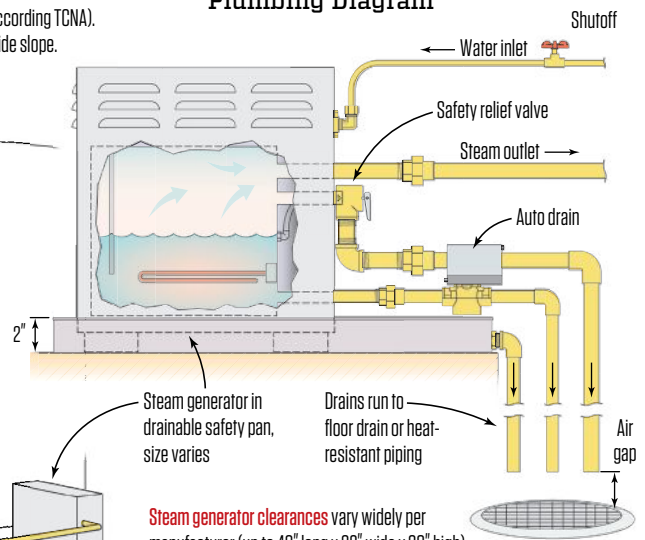
**Steam controls** inside shower installed 48" to 54" off floor, located away from steam head. Optional secondary control (without temp. sensor) may be installed outside shower to turn on unit.

**Shower enclosure.** Vapor controlled on all sides (including ceiling), tiled on all sides. Glass doors and panels typically used to fully enclose space.

**Ceiling slope.** Recommended 2" per foot (according TCNA). Soffit helps hide slope.

**Steam head clearance** distances vary from 6" to 18" above floor and 4 1/2" to 12" from corner (12" from glass). Locate steam head as far as possible from seating.

### Plumbing Diagram



**Steam generator clearances** vary widely per manufacturer (up to 40" long x 32" wide x 30" high). Space is needed to service the unit and to fit an electrical disconnect. For clearance, drainage, and maintenance, the author prefers to install steam unit in a mechanical room rather than a closet, soffit, or cabinet.

**Steam line** maximum length varies between 25' and 60' depending on manufacturer (some require to insulate line if length is greater than 10'). Pitch line toward either steam generator or shower (or both with a high point in the middle). Avoid low point or "trap" in steam line.

available too. Foam backer boards installed on exterior walls help keep the shower side warmer, providing a more comfortable bathing experience.

**Ceiling slope.** Steam shower companies used to recommend that ceilings be sloped so condensation on the ceiling would drip to the walls rather than falling on users' heads. The slope was called out usually in the 1-inch-per-foot range. However, depending on the shape of the tile joints, drips still fall at this slope.

These days, I see manufacturer slope recommendations anywhere from 2 inches per foot to "we no longer specify a slope." The Tile Council of North America (and one manufacturer that I know of) recommends a ceiling slope of 2 inches per foot, which is what we recommend, though it's not clear that a slope is required.

We typically provide a soffit around the shower to help hide the slope. For larger showers, we've sloped from two sides to a peak, which allows a much greater slope in a given total amount of run. We've also put in an arch ceiling, which seemed to work well, although gaps can occur where the light trims meet the curved ceiling, so they have to be properly sealed.

**Steam generator.** The generator is a smallish box that typically fits in an area roughly 1 foot by 2 feet with between 1 and 2 feet of height, although some manufacturers may require more clearance.

Generators require safety pans with drains due to their tendency to leak during their service time. Room is also needed to service the machine and to fit an electrical disconnect (see illustration, above).

Because our local water has a medium to high mineral content, we usually install an auto drain, or "flush kit," that drains the unit after every use. The auto drain helps clear any mineral sediment and reduce servicing. If a nearby floor drain is unavailable, a high temperature-capable drain line will be needed to expel the discharge water.

Owing to clearance, drainage, and maintenance requirements, a mechanical room is much more suited for the unit's location than a closet, soffit, or cabinet. If a mechanical room is not an option, we've had success installing steam generators in soffits with ample clearance space.

**Steam lines.** Most brands we've installed allow 50 or 60 feet of pipe from the generator to the shower, which helps with finding a good location for the steam generator. Because condensation will form in the steam line, it can't have a low spot that traps water, blocking steam. It should slope toward the shower, toward the steam generator, or toward both with a high point in the middle, as long as there's no low point.

**Steam diffuser head.** The steam flows through a copper pipe



A steam generator is housed in a spacious, roughed-in soffit, providing easy access to maintain the unit (6). The steam head, at the lower right corner of the shower wall, is roughed-in at 12 inches above the finish floor and 12 inches from a future glass wall panel (7). A plastic fan (visible behind the ceiling-mounted rain head) will help clear moisture from this enclosure (8).

from the generator and enters via a “steam head” fitting that mounts on a wall near the floor. Most heads blast steam downward, but one brand shoots it upward as well. Obviously, the hot steam shouldn’t blow onto people, so the head should be far from any seats in the shower. A lesson we learned was to not be coaxed into installing the steam head directly below the shower faucet, even if it looks cool to have everything in a vertical line. After a few burns—the shower handles were too hot to touch after the steamer was used—the clients who insisted on that installation relinquished the idea and had us relocate the steam head.

The steam unit controller is a thermostat, and the steam head shouldn’t be below the controller either. Steam is too hot for glass doors and should be a foot away from those. In a small shower, you may be limited in where to put the steam head.

**Clearing moisture.** In our climate, showers without fans stay damp and grow mold like crazy, which clients hate; we’ve solved several mold problems by installing a fan in the shower or adding a timer that makes it easy for the users to run the fan during and after their shower.

However, a fan in a steam shower can introduce problems and some steam generator manufacturers recommend against one. Because steam showers have so much moisture in them and tend to

be used longer than a regular shower, they can cause issues with fans and ducts. First, any steel components of the fan or ductwork can rust, drip brown gunk out into the shower, and ultimately fall apart. A few companies, such as Panasonic, now make fans with plastic bodies that help mitigate this. Second, absent a tight damper, moisture will enter ducts at the top of the shower and can condense inside the ducts, leading to biological growth, corrosion, and even drips or puddles of water, in the worst case.

We’ve been able to make fans work by insulating the fan and ductwork and sloping ductwork properly to reduce and handle condensation. Plastic fans, or a remote fan with an aluminum or plastic inlet in the ceiling, help prevent possible corrosion. It takes a bit of care and attention, but we’ve been able to get fans into showers, with definite benefits.

A fan outside the shower is also a good idea. If clients haven’t read the manual where it says to run cold water through the shower at the end of a steam, a cloud of moisture will roll out into the bath. We often use a remote fan with two inlets, one inside and one outside the shower, to handle both locations.

*Doug Horgan is vice president of best practices at BOWA, a design/build remodeling company in McLean and Middleburg, Va.*



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# FRAMING



## Framing a 12-Sided Turret

A dodecagon requires careful layout to get the angles right

BY ADAM RICCI

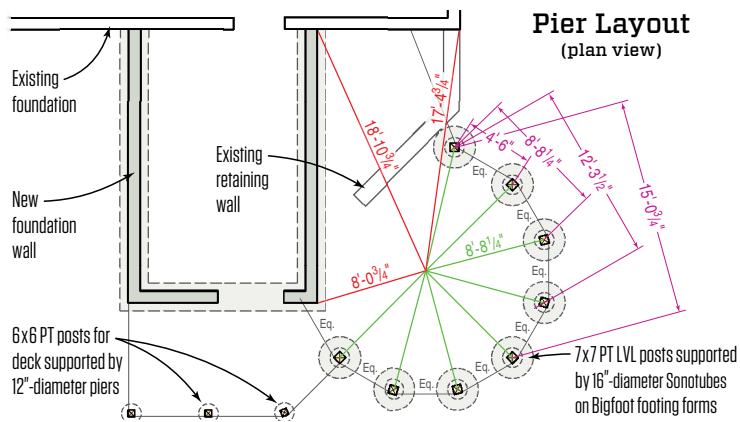
When my clients and their interior designer initially contacted us about a proposed addition, they had in mind a tall, tower-like structure with a vaulted ceiling and large windows overlooking their yard. During the design process, the project evolved into a larger space that included a small, conventional rectangular addition with a powder room and full basement joined to a faceted turret. While we considered designs ranging from eight-sided to 16-sided structures to fit within the circular footprint, we settled on a 12-sided dodecagon. This geometric shape seemed to offer the right number of segments for the window sizes and angle intensity that our clients envisioned.

Knowing that we wanted the maximum amount of glass area

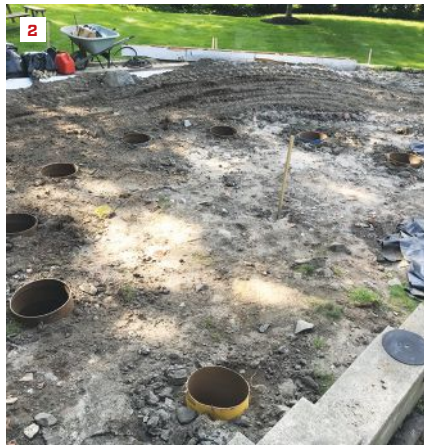
possible per facet, I searched for the widest casement window available and found Marvin's Ultimate clad casement window, which has a maximum size of 41 inches wide by 92 inches tall. To support the 13 foot 8 $\frac{1}{4}$  inch-tall wall needed to accommodate this window, the engineer specified double 5 $\frac{1}{4}$ -by-5 $\frac{1}{4}$ -inch PSL posts to be ripped to the dodecagon angle, then glued and screwed together with LedgerLok structural screws. Factoring in those dimensions with 2x6 jack studs determined the precise diameter of the dodecagon, which drove the rest of the design.

Going against our typical protocol, I decided to complete the construction documents on my own after my design partner Jay Rondeau finished the 3D conceptual design. On this project, I felt

## FRAMING A 12-SIDED TURRET



The author determined the center point of the dodecagon by pulling CAD measurements from three fixed points on the foundation (in red). A stake driven into the ground at this location acted as a fourth fixed control point for laying out the piers (in green). Measurements between pier locations taken from the CAD drawing (in purple) were used to double-check the layout and confirm that the footings were in exactly the right position.



The project included a new foundation for a small rectangular addition (1), which provided two of the three control points that the author used to locate the center of the dodecagon, as described in the drawing (top). The dodecagon is supported in part by the addition foundation, and by eight 16-inch-diameter piers (2). Each pier and the Bigfoot footing that supports it were reinforced with rebar and filled with a little less than a cubic yard of concrete (3).

it would be important that the person who drew the dodecagon in CAD was the same one to lay it out in the field. It was critical to precisely draw in every 2x6, layer of sheathing, window frame, and so on and then be able to bring my laptop to the field and pull measurements from that drawing during layout and construction.

### FOUNDATION

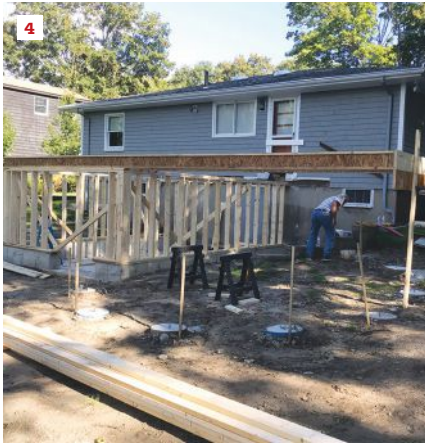
Because the foundation design needed to avoid disrupting a retaining wall and previous grading work to direct groundwater away from the basement, we decided to put the dodecagon on poured concrete piers—which probably also made the layout easier. First, though, we laid out and poured the rectangular portion of the addition. This was obviously the easy part, but it was also helpful, as it provided several measuring points for the dodecagon layout (1).

**Pier layout.** Working with the excavator and foundation sub, David Davis of Davis and Sons Excavating, we found the center of

the dodecagon by pulling the CAD measurements from three foundation points (shown in red in the illustration, above). There, we drove a stake into the ground as a fourth fixed control point to use for laying out the centers of the eight support piers (shown in green, above). We then double-checked all the measurements to the centers of the pier locations from the three foundation control points, as well as the measurements between piers (2).

As we dug, set, and backfilled eight Bigfoot footing forms and cardboard tubes one by one, we constantly double-checked all measurements against the four control points, then against each other.

**Concrete.** We used a pump truck with a boom to reach over the house and place the concrete for the rectangular formed foundation. To transport the concrete from the truck to the backyard to fill the Bigfoot forms and three additional deck piers, we used a tracked Toro Mud Buggy, which has a capacity of a little more than 1/2 yard of concrete. We ordered an 8-yard load, enough to fill each



A temporary post supports the triple-LVL girder and LSL rim joist of the first segment of the dodecagon (4). After installing the first pair of permanent 7x7 PT PSL columns (5), the crew framed the next segments in a similar manner (6, 7). To finalize the layout, the crew assembled the dodecagon's wall plates on top of the floor sheathing, which had been tacked in place, before tightening the bolts on the column base plates (8). Once the author was satisfied that the wall plates, floor framing, and piers were aligned, workers finished fastening the sheathing to the framing and trimmed it to fit (9).

dodecagon pier with about 0.85 cubic yard of concrete and each deck pier with about 0.35 cubic yard (3).

### FLOOR FRAMING

As with the foundation, it made sense to frame the rectangular portion of the addition first. This allowed us to install the floor system's 9½-inch I-joists, run them long where the footprints of the dodecagon and the rectangular addition overlapped, then cut the joists to fit the dodecagon shape after a careful layout.

**Floor layout.** The base of the first dodecagon segment that we framed was exactly parallel to the long walls of the rectangular addition. Per our CAD drawing, we determined the exact length of the long I-joists that would cantilever over the rectangular addition's wall and extend into the dodecagon, then framed that segment first

to use as a control for the rest of the dodecagon (4). We temporarily supported that segment as we installed its 9½-inch LSL rim joist and triple 9½-inch LVL girder, then measured and fit the 7x7 pressure-treated PSL posts that would support the assembly (5). Because of the many angles in the dodecagon, all the segments had to be exactly the same size, so prior to assembly we had pre-cut all the material for the triple 9½-inch LVL girders and LSL rim joists to length per the CAD drawing, production-style (6).

We followed the same procedure as we framed the remaining segments, extending the floor joists following the measurements on the plans and assembling each segment's rim joist and girder (7). We only tacked them in place with a couple of nails, though, so we'd be able to adjust their final position after the subfloor was installed. Then we propped up each segment temporarily to make

## FRAMING A 12-SIDED TURRET



The dodecagon's 12 double-LVL hip rafters hang from a custom-fabricated circular steel ridge (10). Working off the level floor deck made it easier to lay out the rafters (11). The plumb cuts where the rafters meet the ridge needed to be notched (12) to allow the rafters to fit over the connecting flanges at the ridge (13).

sure it was level before cutting and fitting the next 7x7 post.

As we continued with the floor joist installation, we waited to lock down the metal post-base plates that connect the 7x7 posts to the piers. This allowed us to tweak each post's final position after we had a chance to carefully check our layout on a plywood subfloor.

**Subfloor.** When installing the subfloor sheathing, we glued down and nailed off all the sheets over the rectangular addition but only dry-fit the plywood over the dodecagon. Working on the level rather than on the ground, we were able to locate the center point and lay out the dodecagon with more accuracy than when we were pouring the footings. We snapped perpendicular chalk lines that bisected two pairs of opposing segments and ran through the center of the dodecagon. Then we put a nail in the center and pulled measurements to the centers and corners of each segment to verify that they matched the plans and that all 12 sides were equal.

To complete the final, precise shape of the dodecagon, we cut 12 2x6 template plates to the exact same size, again per the CAD drawing. Following our chalked reference lines, we assembled the plates into an outline of the dodecagon on top of the sheathing, made slight adjustments to the segments and to the floor framing until we were happy with the layout, and marked the outline on the sheathing (8). Then we removed the 2x6 template plates and

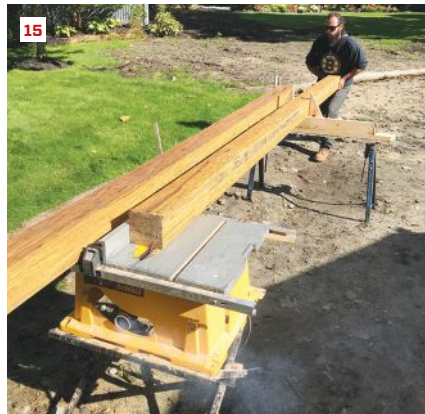
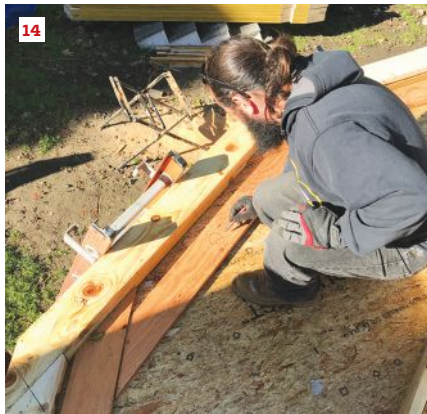
pulled up the sheathing so we could apply adhesive to the joists and nail the sheathing back down, running it long past the rim joists.

After installing the subfloor, we replaced the 2x6 templates on the completed subfloor, again checked the layout to make sure the reference lines marked on the sheathing aligned with the floor framing and rim joists underneath, and tacked the plates down to the sheathing. Using the plates as a guide, we cut out the final shape of the dodecagon on the plywood (9).

At this point, we were able to make final adjustments to the base plates connecting the 7x7 columns to the piers and finish nailing off the triple 9½-inch girders and the 9½-inch rim joists. To complete the assemblies, we fastened pairs of HL55 angle brackets to the top of each post to connect it to the girder it supports.

### RAFTER PREP

With a perfectly laid-out dodecagon on the subfloor and while we were close to the ground, we laid out, cut, and dry-fit the roof framing before framing the walls. Since the cathedral ceiling wouldn't have any collar ties, the engineer specified a custom circular steel ridge with 12 seats at the 5:12 roof pitch for 12 double 9½-inch LVL rafters (10). Each seat had a hole drilled through for a bolt to secure the rafter to the steel ridge. Working on the deck,



The crew precut the top-plate components out of 2x6 stock and  $\frac{3}{4}$ -inch plywood so that the triple top plate would interlock at the corners and tie the wall segments together (14). Each wall segment consists of a pair of PSL corner posts ripped with a 15-degree bevel (15, 16). Bracing and straps were used to temporarily hold the eight tall wall sections together (17) while the crew framed the floor system girders needed to support the shorter walls over the addition framing (18). Then the crew laid down a temporary floor system across the upper window openings that allowed them to finish installing the top plates and work on the roof framing; ratchet straps between opposing pairs of wall posts helped the crew to adjust the plate layout (19).

we were able to comfortably determine the exact length of the rafters and height of the steel ridge above the top plate (11).

Each of the rafter plumb cuts required a mortise to fit properly around the flanges at the steel ridge. We custom cut all the rafters, assembled and labeled them, and put them aside for later. We also saved the 2x6 dodecagon plate template to use for the top plate (12, 13).

### WALL FRAMING

We started by cutting all the dodecagon segment plates we would need to assemble the walls. There were more than usual, as we had decided to create a triple top plate by interlocking multiple layers of plywood and 2x6s. This would ensure that the top of the wall would never move (14).

Each 13 foot  $8\frac{1}{4}$  inch-tall wall segment consisted of two  $5\frac{1}{4}$ -by- $5\frac{1}{4}$ -inch PSL corner posts, with one side of each post ripped to 15-

degrees to create each 30-degree dodecagon corner (15). Because each of the eight full-height segments contained a lot of window area, there wasn't much exterior wall sheathing to brace the structure. Instead, the engineered design called for the connections between the window jack-stud assembly (made up of a 2x6 and  $\frac{3}{4}$ -inch CDX plywood ripped to  $5\frac{1}{2}$  inches wide) and the PSL corner posts to be made with LedgerLok structural screws (16).

Along with the rest of the framing that made up each wall segment, the resulting assembly was quite heavy. A co-worker and I were barely able to lift one segment into position, so after we framed the rest of the walls on the ground, we summoned the remaining crew to help lift them up onto the deck and raise them.

We didn't want to nail the dodecagon segments together until they were all raised, so we temporarily held them together with ratchet straps as we assembled the walls (17). This allowed us to

## FRAMING A 12-SIDED TURRET



The hip rafters are connected to the steel circular ridge with structural screws driven up through holes in the ridge into each rafter (20). Construction adhesive and structural screws were used to join the double-LVL hip rafters together (21). At the ridge, metal straps reinforce the connection between opposing rafters, while custom-fabricated brackets connect the hip rafters to the plates (22). Then the crew installed common rafters, subfascia, and roof sheathing (23).



check the layout with our precisely marked top plates.

Four of the 12 wall segments are shorter, because they are located where the dodecagon overlaps the rectangular addition, and are supported by wall framing or by LVL girders buried in the addition's ceiling framing. That meant that after raising the eight full-height segments, we needed to frame the rest of the addition's walls and ceiling joists before continuing with the dodecagon. But at this point, we could secure the straps specified by the engineer to tie in the 7x7 columns on the base plate, the 9 $\frac{1}{2}$ -inch triple LVL, rim joist, and newly raised 5 $\frac{1}{4}$ -inch PSL wall corners. We left the plates of the remaining four segments on the subfloor so we could pull those measurements up and also mark out the layout for the hardwood floor.

One thing we wanted to avoid was having columns interrupt the interior space. The structural engineer, Alan Vitukevich of Aberjona Engineering, had cleverly designed one 24-foot-long (and heavy) triple 1 $\frac{3}{4}$ -by-14-inch LVL beam that spans the entire length of the rectangular portion of the addition so that it would pick up loads from the roof structure on one of the three floating segments of the dodecagon that aren't directly supported by a pier or by wall framing. Another triple 1 $\frac{3}{4}$ -by-7 $\frac{3}{4}$ -inch LVL beam connected to the first structural beam picks up the remaining roof loads, and on the

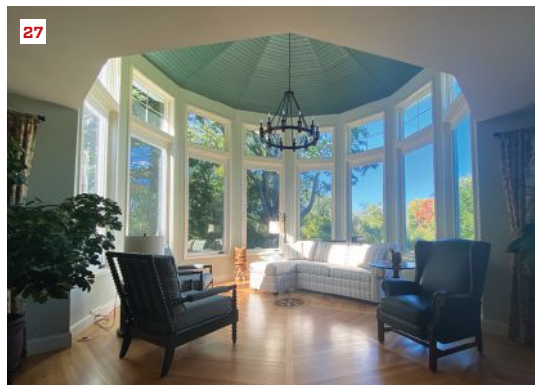
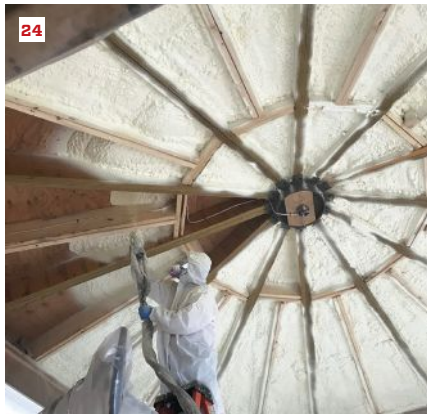
other side, supports the center of the addition's hip roof. Lastly, more triple 7 $\frac{1}{4}$ -inch LVL girders finish the shape of the interior floating portion of the dodecagon roof, all supported by 5 $\frac{1}{4}$ -inch PSL columns framed within the exterior walls (18).

Once the LVL supporting beams were in, we continued with the remaining dodecagon segments. These short segments were also framed with PSL corner posts with one side beveled 15 degrees.

When all 12 segment walls were installed, we built a temporary floor—to help us assemble the roof framing—by running 2x8 joists spanning the dodecagon through the upper windows. We positioned the precut 2x6 top plates on top of the walls, then used ratchet straps to adjust the wall positions relative to each other. The challenge was that moving one segment affected the others. To lock the walls in place once we had them in the right position, we kept the ratchet straps on until the rafters were installed and the roof sheathing was glued and nailed (19).

### ROOF FRAMING

After the three layers of precut top plates had been glued and screwed together, the dodecagon shape perfectly matched the shape on the subfloor. Then, to support the steel ridge at the right



The dodecagon's roof rafter bays and wall stud bays were insulated with closed-cell spray foam insulation (24). Over the subfloor, workers installed prerouted panels that accommodate tubing for a hydronic radiant heating system (25). The exterior was finished with PVC trim and cedar shingle siding (26), while the interior features a rift-sawn white oak floor with a central compass-rose inlay (27).

elevation, we built a temporary seat out of 2x4s that had to be carefully positioned around the ratchet straps. With that, it was time to install all the precut roof rafters, using construction adhesive and 3-inch LedgerLoks to fasten the double hip rafters together.

At the steel ridge, the mortises that we had made at the top of each roof rafter allowed the double 9½-inch hip rafter to sit around the steel flange on the seat it was designed for. We also used plenty of construction adhesive where the rafters meet the ridge and predrilled the hip rafters for 2½-inch LedgerLoks that we drove up into the rafters through predrilled holes in the steel ridge. At the top plate, we installed custom-fabricated right-angle brackets specified by the engineer to reinforce the connection between the hip rafters and the top plate (20, 21).

Once the roof rafters were complete, we nailed straps to the tops of the rafters over the steel ridge to further reduce chances of spreading. Then we installed ⅝-inch-thick roof sheathing (22, 23).

### SEALING THE ENVELOPE

After we finished trimming the dodecagon's eaves and installing the windows, the insulation sub filled the rafter bays in the ceiling with 7.1 inches of Icynene ProSeal LE closed-cell foam. This provides the vaulted and unventilated "hot" roof with an approved air barrier and R-49 insulation to meet local code requirements. To

insulate and air-seal the turret's floor system, the sub sprayed the joist bays with 4.3 inches of foam, for R-30 insulation. The walls received a minimum of 3 inches of foam, for R-21 insulation (24).

To match the existing house, we clad the turret and addition with prefinished white cedar shingles after trimming the windows and columns with PVC. On the interior, the walls were given a smooth veneer-coat plaster finish over a blueboard substrate. On the ceiling, we installed painted tongue-and-groove beaded ceiling boards.

We installed Viega Climate Panels over the subfloor to accommodate the new addition's radiant heating and cooling system. These are ½-inch-thick engineered wood panels with an aluminum backing designed to accept Viega's ⅝-inch PEX tubing for hydronic radiant systems (25).

To add a final distinctive touch to the room, our clients selected a round compass-rose inlay, which the flooring sub installed in the center of the dodecagon's floor. The rift-sawn white-oak strip flooring was then installed in a pattern that matches the ceiling boards and emphasizes the 12 facets of the turret (26, 27).

*Adam Ricci owns Ricci Design Build in North Reading, Mass., which he founded in 2005 after completing his B.S. in Architectural Building and Engineering at New England Institute of Technology and attending North Bennet Street School's carpentry program in 2001.*

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# HVAC



## Heat Pumps in the Age of Electrification To be successful, we need to better understand heat pumps

BY STEVE EASLEY

Photos by Steve Easley, except (1) by Ted Cushman

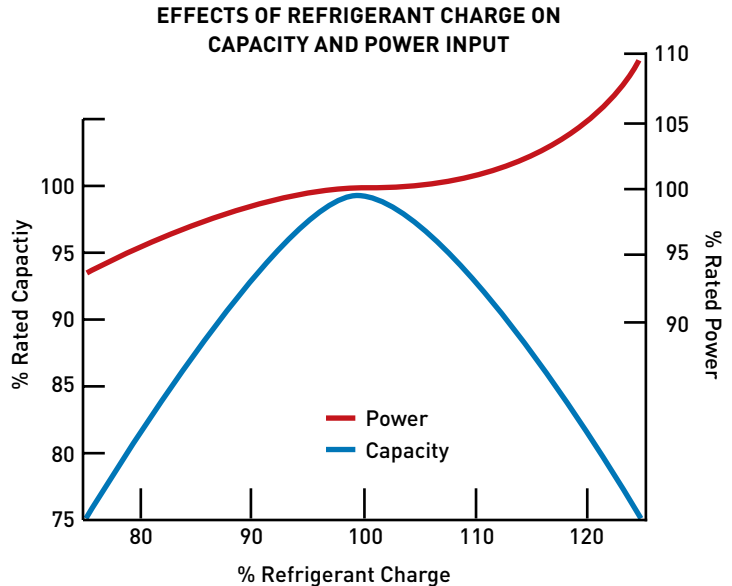
Concerns over climate change have sparked a movement toward electrification—the process of switching from fossil fuels for space heating, water heating, cooking, and transportation. Washington recently became the first state to mandate electrification by banning gas for new multifamily and commercial buildings, while legislatures in at least four states—Rhode Island, Massachusetts, New York, and Maryland—are vying for their state to be the next to impose similar bans that may include single-family homes. The move away from gas began at the city level, with Berkeley, Seattle, and New York City being the first to ban gas use for all new buildings. Some 60 cities in over 20 states have laws that ban gas, propane, and heating oil in new buildings.

But the issue has become intensely political, and there are now more than 20 states with counter laws that prevent cities from banning gas use in buildings, and 10 other states that prohibit electric utilities from encouraging customers to switch away from gas.

Regardless of how the politics play out, electrification is coming. In many U.S. cities, natural gas used in buildings is the second-largest source of emissions behind vehicles. About 20% of greenhouse-gas emissions across the U.S. comes from residential energy use. That doesn't include the leaks from gas lines. A study published in *Science* found there were enough natural gas (90% of which is methane, a potent ozone-depleting gas) leaks from U.S. oil and gas operations to fuel 10 million homes each year. In order to



Failure to charge an air-source heat pump to 100% has a severe impact on not only the unit's rated capacity but also on power draw, as shown in the graph at right. Pressure testing (1) ensures a leak-free refrigerant line.



move the needle on greenhouse-gas emissions, we will increasingly need to reduce fossil-fuel consumption at every level. It's happening with cars and trucks—the biggest source of fossil-fuel consumption—and it will happen with buildings, including homes.

We're on that path already: According to the Energy Information Administration (EIA), natural gas and electricity are the two biggest sources of energy used in U.S. homes. Figures from the EIA's Residential Energy Consumption Survey show that natural gas was used in 58% of homes in 2015 but that usage fell to 42% in 2020 and is now running almost neck and neck with the consumption of electricity, which has taken over as the biggest source of residential energy use, at 43%. Space heating accounts for about 43% of a home's energy use and water heating adds an additional 19%. Heat pumps offer a real solution—possibly the only technology solution we currently have—to providing the space and water heating portion because they make such efficient use of electrical energy.

## GETTING IT RIGHT

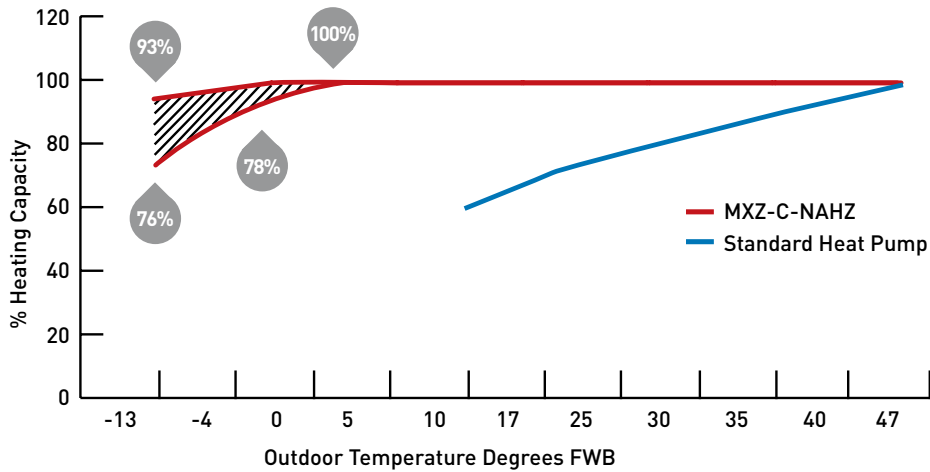
While the shift toward electricity is happening, not all of that electricity used to heat homes is helping the climate. Electric furnaces and strip-resistance heaters are sometimes called "efficient" (100% of the electrical energy coming into the heater is converted to heat), but it's only 100% efficient inside the building. The generation of that electricity at a power plant was probably 30% to 40% efficient after taking into account power grid and transmission losses, so the net efficiency is poor. The bottom line is it's easier clean up the emissions from a few power plants than from millions of furnaces and water heaters in buildings and homes. Fortunately, utilities are moving toward renewable energy sources for electricity generation in place of fossil fuels.

An air-source heat pump (ASHP) is essentially an air conditioner that runs in reverse, making it an ideal appliance for homes because the same piece of equipment can be used for both heating and cooling. In heating mode, an ASHP uses the refrigeration cycle to move heat from the outdoors to an enclosed space, gradually warming the indoor air. A kilowatt hour of energy consumed as electricity can pull the equivalent of 3 kilowatt hours of energy from outdoor air. That 1 kilowatt hour of energy the heat pump consumes is used to run a fan, compressor, and blower to run a refrigeration cycle; the heat itself is transferred from a refrigerant that releases energy that it absorbed from the outdoor air.

The compressor uses electrical energy to change the pressure and the temperature of a refrigerant. When the refrigerant changes state from a liquid to a gas, heat is absorbed. By exploiting the energy release from this phase change, ASHPs used for space heating can reach efficiencies of 200% to 400%. And if we use hydro-, solar-, or wind-generated electricity instead of climate-damaging, fossil-fuel-generated electricity, the net efficiency becomes even greater. That's what excites everyone about electrification, and why space heating and water heating is shifting over to heat pumps.

But for this to succeed, building professionals at all levels need to know how to design, install, operate, and maintain heat pumps. Otherwise, while trying to make a difference on the environment, we may just end up making homeowners more uncomfortable, with higher energy bills, and fail to save energy. If heat pumps don't perform as well as the old dinosaur burners they are replacing, the technology will lose favor with consumers, and the reduced emission goals won't be achieved. Certainly, there are other huge infrastructure challenges to making electrification work. In this article, I am going to focus only on what building professionals need to get right in homes, with the expectation that larger

## H2I MXZ HEATING CAPACITY AT LOW TEMPERATURES



An inverter-type heat pump can maintain 100% heating capacity down to 5°F and produce heat down to -13°F. The graph at left from Mitsubishi compares different models in its H2i series with a fixed-output heat pump that starts losing capacity below 47°F.

issues relating to the U.S. electric grid, and scaling non-fossil-fuel electrical production, can be solved.

### MEASURING HEAT PUMP EFFICIENCY

ASHP efficiency is measured a few different ways:

**Heating efficiency** of a specific heat-pump unit (not the efficiency with which a space is heated) is defined as the quantity of heating or cooling delivered by the heat-pump unit per the amount of energy required to run the unit. We measure that as a heating season performance factor (HSPF), which is equal to the total space heating (in Btu) provided by the ASHP over the heating season divided by the total electrical energy (in watt hours) consumed by the ASHP over that same heating season.

COP, the coefficient of performance, is another way heat pump efficiency is measured. A COP of 1 means that 1 kilowatt of energy consumed by the ASHP delivers 1 kilowatt of heat output—an efficiency of 100%. A COP of 3 means I get 3 kilowatts of heat output for every 1 kilowatt of input—an efficiency of 300%, and so on. These high efficiencies are possible because we are extracting that heat from the outdoor air. Even in winter, air at zero degrees still has quite a bit of heat in it. (Air has some heat all the way down to absolute zero—459 degrees below zero!)

**Cooling efficiency** is similar, except we are now looking at how much heat is removed. We measure this as an energy efficiency ratio (EER), which is equal to the heat removed in Btu/hour divided by the electricity used in watts. If an air conditioner puts out 48,000 Btu per hour and consumes 4,000 watts, then the EER would be 12. And the SEER, or Seasonal Energy Efficiency Ratio, is the energy efficiency ratio calculated over the entire cooling season, at an average temperature of about 83°F.

**Efficiency vs. capacity.** Conventional ASHP efficiency is related to outdoor air temperature. The colder the air, the lower the efficiency. Heating capacity is the output number of Btu. The heating cap-

capacity of a conventional ASHP starts to diminish when the outdoor temperature drops below about 50°F. Both the output capacity and the speed at which a conventional ASHP can heat a home or recover the heat lost from a home is also a function of the outdoor temperature: Colder outdoor air means diminished performance.

This becomes very clear to a homeowner when we switch out the heating appliance from a fossil-fuel furnace to a standard ASHP. Gas furnaces discharge air through the supply plenum at around 110°F to 140°F, regardless of the outdoor temperature. Homeowners are used to feeling this hot air. Particularly in a drafty house or one that's not well insulated, they look to this blast of sensibly warm air to feel comfortable. Typically, a conventional heat pump can provide air to the room at 15 to 25 degrees warmer than the room air temperature. But if the discharge temperature drops below the temperature of the body's skin, around 92°F, the air coming out of the unit doesn't feel warm at all, even though that air can raise the indoor air temperature. For this reason, in colder climates, conventional heat pumps have traditionally had to rely on resistance back-up strips, which are expensive to operate, to provide enough heat to maintain comfort.

### COLD CLIMATE HEAT PUMPS TO THE RESCUE

It is a myth that heat pumps can't work in subfreezing temperatures. Cold-climate heat pumps can maintain 100% heating capacity down to 5°F, and they can operate at lower capacity but still put out sufficient heat to warm the indoors at outdoor temperatures as low as -13°F to -15°F (see chart above for an example). These "inverter type" heat pumps have the ability to recover waste heat from the compressor to maintain output and recovery without depending on resistance back-up strips. They also monitor the set-point temperature and outdoor temperature and use an inverter-driven compressor that varies the compressor speed to match the exact load indoors, keeping the indoor air at an even



This sort of connection (2) is all too common with flex duct. The inner liner and the outer jacket must be taped separately and the connection mechanically reinforced (3). Keep ducts as straight as possible. A 90-degree turn is the smallest any bend should be; bends should not look like this (4). This metal duct has some, but not all, seams sealed, and it is not insulated (5)—conditions that will significantly lower the discharge temperature at the supply register.

temperature. This eliminates the huge temperature swings that occur when a conventional unit switches on when the indoor air falls below set point and switches off when it goes above that temperature. The compressor also operates at a much lower wattage draw because it isn't continually ramping up from a dead stop.

This technology has come a long way in the last 10 years, but misinformation persists in the marketplace. Bad experiences with conventional, or “fixed output,” ASHPs continue to be discussed, and the internet is full of blogs by HVAC contractors who might be pushing mini-splits for summertime air conditioning but downplaying them as a viable heating option in colder climates. In part this happens because the experience with a heat pump at low outdoor temperatures is not going to give you that satisfying blast of warm air, and contractors are shy about customer complaints. And because recovery times are slower, any ASHP is going to be much more sensitive to both building performance and system performance than fossil-fuel systems.

## ENSURING SYSTEM PERFORMANCE

If we expect to deliver the comfort and energy savings that customers expect, builders need to oversee heat-pump installations to ensure we get these details right:

**Enclosure.** First, be sure to pay close attention to the building enclosure and be diligent to air-seal and test for airtightness, as well as properly insulate the shell. This will make it easier for an ASHP to meet and maintain thermostat set points.

**Equipment sizing.** Correct unit sizing using ASHRAE Manual J, current version, is important for a fixed-output heat pump to match the actual loads. Generally, the unit should be sized no more than 10% greater than the Manual J load calculation, based on an ASHRAE-recommended design temperature. But one advantage of an inverter-type heat pump is that it operates at a speed to match actual loads. Oversizing these units does not create the typical penalties we see with single-speed equipment. They are more efficient when running at the lower end of their capacity



Smooth-wall ducts and all connections sealed with mastic will ensure efficient delivery of supply air (6). And after sealing, every duct installation should be tested for total duct leakage or duct leakage to the outside (7).

range. Larger equipment gets more expensive, though, so you still want to do a Manual J calculation to make an informed decision and to be sure you aren't undersizing the unit.

**Refrigerant charge.** Failure to charge an ASHP to 100% has a severe impact on not only the unit's rated capacity but also on power draw. As you can see in the chart on page 44, overcharging and undercharging can create a big drop-off in capacity and a surge in power consumption once you move off a 100% charge.

**Coil performance.** Keeping evaporator coils clean and unblocked helps maintain capacity. Be sure the filters are easily accessible to homeowners, and make sure homeowners understand their importance and timely replacement. Similarly, outdoor coils must be placed where they have plenty of room to move air efficiently and where they are not blocked by greenery or anything that is going to restrict air circulation. Also, keep outdoor units out of roof drip lines where they can ice over in winter. Refrigerant line sets must not be longer than the manufacturer's recommendations and must be fully insulated and be as straight as possible.

**Distribution.** Ductless mini-splits largely avoid problems with ducts. But some people don't like the indoor wall units. With the improvements in the technology of inverter-type outdoor units has come a lot of innovation with indoor distribution as well. In the house I am building now, I am using ceiling cassettes like the one being installed on the cover of this magazine. Four-way ceiling distribution modules are also available. Both types provide good circulation and are amazingly quiet. Inverter-driven units can also function with conventional ductwork to move air where it's needed and to match the comfort requirements that customers expect.

Ducts should be sized per Manual D calculations. All bedrooms need return air ducts, or jump ducts, and grilles designed to Manual D specifications. (Don't rely on undercutting doors. If you need 200 cfm of return air to a room, you would have to undercut the typical 30-inch-wide door 3.2 inches!) Be sure to seal ducts using mastic or an appropriate tape, and test to keep the total leakage below 5 cfm per 100 square feet of conditioned floor area or the amount of duct leakage to the outside under 4 cfm (these are minimums for tested leakage per the building code). You can do a lot better than this.

Ductwork outside conditioned space should always be insulated to at least R-8. This is even more important for heat pumps since they can have lower register discharge temperatures; poorly insulated ducts will drive winter discharge temperatures even lower.

How ducts are run through homes has an impact on both airflow and leakage. Keep runs straight with no kinks or crushed areas.

For heat pumps, it's even more critical to understand that duct leakage is not simply about losing conditioned air along the way and not delivering it to rooms. Duct leakage also creates pressure imbalances within the home. Supply-side leaks in an attic, basement, or crawlspace will create negative air pressures in the living space, which can pull outdoor air into the space and increase the loads and lengthen the amount of time the unit takes to reach the thermostat set point. Leaks on the return side will create positive pressures in the living space that will force conditioned air out of the building. This is no different than a forced-air system that burns fossil fuels, but again, because the recovery time is so much slower with an ASHP, the impact will be more noticeable.

Duct leakage, of course, becomes a much smaller problem when the ducts are brought inside the living space. Too often, they are running through an attic or crawlspace that is effectively at the outdoor air temperature in winter, and, in attics, significantly hotter than outdoor temperatures in summer.

Maintaining good airflow through the ducts is also essential. It's important that installers measure the airflow at supply registers to confirm the design airflow. Flex duct creates enormous air friction, which combines with tight bends and restrictions to drop airflow well below the desired flow rate. You might have the best unit in the world, but it's useless if you can't deliver conditioned air to rooms. When using flex duct, attach boots and couplers to framing members so you can stretch the duct to reduce friction loss. Make sure ducts are straight runs and have wide, smooth bends that keep static pressures low.

*Steve Easley is principal of Steve Easley Associates, a company based in Scottsdale, Ariz., that provides building-science consulting, training, and quality assurance for builders throughout North America.*

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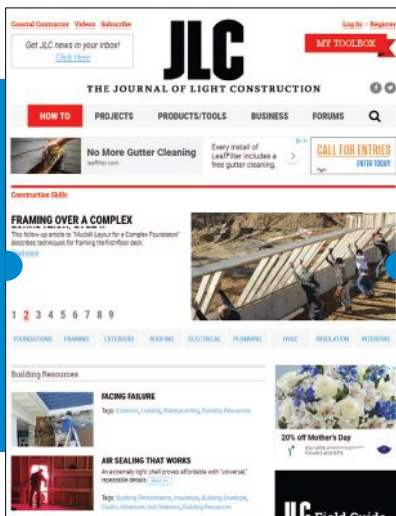
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Tropical Forest Products' Black Label brand of curated tropical hardwoods offers certified-sustainable ipe, cumaru, jatoba, garapa, angelim, pedra, and tigerwood. According to Tropical Forest Products, the lumber is "harvested legally from demarcated forests" and verified by an independent third party that certifies origin, harvesting, and shipping. [tropicalforestproducts.com](http://tropicalforestproducts.com)

### 2. Minimalist Drawer System

Grass America's Vionaro drawers travel on a Dynapro concealed undermount slide system, which the manufacturer says provides a low opening pull force and smooth running performance using a synchronization mechanism and abrasion-resistant nylon rollers. The drawers are offered in four heights, three colors, and two closing options. [grassusa.com](http://grassusa.com)



### 3. Inverter Heat Pump

The Deluxe wall-mounted single-zone system with H2i plus technology from Mitsubishi Electric Trane HVAC US comprises both a new indoor unit and a new outdoor unit. According to the manufacturer, the wall-mounted indoor unit has a high-performance coating that limits particle build-up on the heat exchanger, which reportedly helps maintain efficiency and reduce maintenance. The outdoor unit is equipped with inverter technology, which the maker says modulates to maintain a consistent indoor temperature and provides 100% heating capacity at outdoor temperatures as low as 5°F and upward of 76% capacity at -13°F. [metahvac.com](http://metahvac.com)



### 4. Versatile Residential ERV

Greenheck's Sync-180 is a low-profile, high-efficiency, cold-weather-rated ERV that offers a 75- to 200-cfm range with three high-speed options. Each airstream has an independent centrifugal blower powered by a direct-drive EC motor, which adjusts speed with increased static pressure to maintain flow rates as the filter or core gets dirty. Pairing with the company's PrecisionSync Controller allows the unit to measure the airflow capacity of the installation and dial-in a precise airflow. Available online for \$1,400. [greenheck.com](http://greenheck.com)

## Products

### 5. Recycled Waste Tile

Kohler Abstra tiles are made from nearly 100% recycled waste materials. The collection offers two styles: an abstract-patterned tile (Abstra Feature) and an unadorned field tile (Abstra Standard). Both are available in 3-by-12-inch, 4-by-4-inch, and 6-by-12-inch field sizes in brushed and matte finishes and are suited for any vertical dry interior application; tiles with the matte finish can also be used outdoors and in wet spaces, such as showers and submerged areas. [wastelab.kohler.com](http://wastelab.kohler.com)

### 6. Mobile 3D Imaging Technology

SketchUp for iPad, an app from Trimble, combines 3D modeling capability with the ease of sketching by hand to enable professionals to create and collaborate on projects from anywhere. SketchUp models that are stored in TrimbleConnect automatically sync across devices so project stakeholders can access details on any device. Features include Autoshape, which transforms doodles into 3D shapes and configurable components, and Markup, where users can capture real-time client feedback by overlaying annotations. A SketchUp subscription costs \$119 per year. [trimble.com](http://trimble.com)

### 7. Durable Exotic Hardwood Flooring

Solid kempas, which has an orange-brown hue, is the newest addition to Elemental Hardwoods' premium line of exotic hardwood flooring. Sourced under Forest Stewardship Council forest management standards, the select-and-better-grade kempas is 100% heartwood and has a Janka hardness rating of 1710, harder than domestic oak and maple, according to Elemental. The flooring comes prefinished with a 15% to 20% low-gloss finish and is available in 3/4-inch-by-3 1/2-inch boards in lengths of 1 to 6 feet, with 17.44 square feet per box. [elementalhardwoods.com](http://elementalhardwoods.com)

### 8. Stainless Steel Range Hood

The black stainless steel WM-590 Modern Series wall-mounted range hood from Hauslane is available in 30-inch and 36-inch options. The canopy-style hood has a single-blower motor with three speed settings—minimal, everyday, and heavy-duty—LED-lit buttons, and dishwasher-safe baffle filters. The hood's adjustable height makes it ideal for 9-foot kitchen ceilings; an extension kit for 10-foot ceilings is sold separately. MSRP is \$1,040. [hauslane.com](http://hauslane.com)





### 9. Curved Bathroom Faucet

The Curve collection of faucets from Isenberg features arched spouts that extend away from the wall and stretch out over sink basins. The faucets are offered with left or right installation configurations and with hands-free sensors or deck-mounted handles. The bathroom faucet is available in chrome, brushed nickel, matte black, and 20 ceramic-based color finishes. [isenbergfaucets.com](http://isenbergfaucets.com)



### 10. Rot-Preventing Deck Spacers

Deck2Wall Spacer model SWS is now approved for use with Spax Powerlags. The approved screws are available in 5/16-inch and 5/8-inch diameters and T-Star and hex-drive heads. The polypropylene spacers are designed to be installed between a deck ledger and the house to create a gap that allows water and debris to flow through, promoting circulation and drying while preventing rot and decay. A 12-pack of 5/8-inch-diameter spacers costs approximately \$28. [deck2wallspacer.com](http://deck2wallspacer.com)



### 11. Dark Continuous Insulation

Thermafiber RainBarrier Dark mineral wool insulation from Owens Corning sports an adhesively bonded dark-colored fiberglass facing meant to make the continuous insulation less visible in open-joint cladding applications. The maker says the facing material isn't prone to the cracking that can occur with more rigid materials. Like other RainBarrier products, Dark 45 and Dark HD are noncombustible, fire-resistant, and vapor permeable and contain a minimum 70% recycled content, according to the manufacturer. [owenscorning.com/rainbarrier](http://owenscorning.com/rainbarrier)



### 12. Secure Rooftop Rack Lock

The tumblers on Bolt Lock's One-Key Lock Technology Cable Locks are crafted to memorize a vehicle's ignition key with one complete turn of the key, allowing contractors to safely secure ladders on rooftop racks, without adding another key to the ring. Weatherproof and designed to repel dirt and moisture, according to the manufacturer, the cable lock has a 6-foot-long coil wire coated with 1/4-inch-thick black vinyl and a double ball-bearing lock mechanism. Locks are year/make/model specific and are available for most General Motors, Ford, Ram/Jeep, and Toyota vehicles. Contact a local retailer for pricing information. [boltlock.com](http://boltlock.com)

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# TOOLS

OF THE TRADE

## DeWalt DCD443B Cordless 20-Volt Stud and Joist Drill

BY IAN SCHWANDT

**For drilling big holes** in studs and joists, a corded heavy-duty right-angle drill has long been an important day-to-day workhorse for plumbers and electricians. But for carpenters and smaller general contractors, these big, powerful drills are often a luxury item, and a heavy, bulky one at that. Over the last five years, though, advances in cordless tool motor and battery technology have given us lighter weight and less expensive options that are within purchasing reach of even DIYers. Recently added to this list of cordless options is the DeWalt 20V Max XR DCD443B Cordless Stud and Joist Drill, which we tested at several TDS Custom Construction jobsites. Our crew already owns a range of DeWalt tools that work on the company's 20-volt battery platform, so we were interested to see if this heavy-duty drill would be worth its \$280 price tag (bare tool only).

The DeWalt Stud and Joist Drill is part of DeWalt's XR line of tools within the larger 20V Max platform. We were able to power the drill with our existing DeWalt Flexvolt batteries, but this particular model drill is optimized to work with the 20V XR series battery. Our drill was fitted with a 7/16-inch hex quick-change chuck that requires compatible drill bits. Another version of the drill (model DCD444B) is fitted with a conventional 1/2-inch keyed chuck and is designed specifically for use with Flexvolt batteries. We did not test that model.

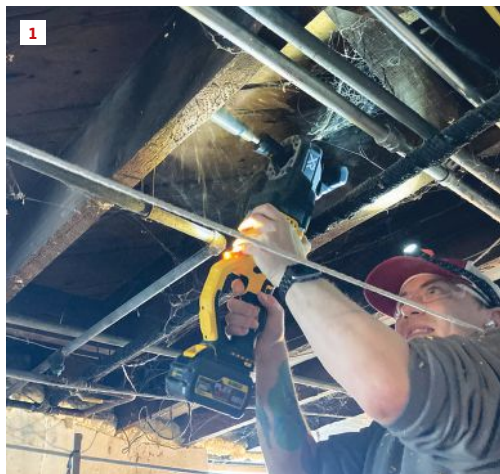
In addition to testing the drill on some typical carpentry tasks, we used it on a bathroom remodel project, where we had to change

the rough-in locations for all of the fixtures. This job required several 5-inch-diameter holes to be drilled in LVLs and 2x10 joists, a challenge for any drill. One thing we noted right away was that the drill's light weight of 8.75 pounds and compact length made it easy to maneuver in the tight joist cavities of the bathroom remodel. When we handed it off to our plumber to give it a spin, he noted that the drill had plenty of power and the brushless motor did not bog down or engage the E-clutch while drilling the 5-inch holes. He also liked the LED light but pointed out that the drill's lack of a rafter hook would make it challenging to use while working off a ladder.

In our use, battery life of the drill was a nonissue; when used in remodeling work, this type of tool doesn't see the sustained long periods of use that a circular saw or an impact driver would. According to the manufacturer, the DCD443B can drill up to 400 holes on one charge with a 7/8-inch-diameter auger bit in 2-by framing lumber when the drill is powered by the 8-Ah XR battery.

For plumbers, electricians, and carpenters who specialize in rough framing and new construction, this heavy-duty DeWalt drill offers plenty of power in a compact package for demanding day-to-day use. It would be handy for both small contractors and DIYers alike to have around for general remodeling work and is an especially good value if you already have DeWalt 20-volt batteries that are compatible with the drill. [dewalt.com](http://dewalt.com)

*Ian Schwandt is operations manager for TDS Construction in Madison, Wis.*



DeWalt's 20-volt DCD443B right-angle drill has a compact design that fits easily between joists and studs for drilling big holes through framing (1, 2). It has an electric clutch to prevent the powerful brushless motor from kicking back if the bit binds up and a 7/16-inch hex quick-change chuck (3). The drill is also available with a 1/2-inch keyed chuck.

Photo 1, Kevin Hayes-Birchler

# Festool FS-WA Angle Stop and FS-WA-VL Guide Extension

BY TOMMIE MULLANEY

**In my work** as a finish carpenter and custom woodworker, I value tools that provide precision and help me operate more efficiently. That's why I'm such a big track saw fan, which I use on a daily basis on my jobs. With the ability to produce clean, crisp, and accurate cuts in any location, this tool really excels, but efficiency suffers when it comes time to make repetitive or angle cuts. These cuts are easy to make on a miter saw when you're working with narrower stock but not with a track saw when you're cutting very wide stock or large sheet goods.

For many years, I used a TSO GRS-16 guide rail square ([tsoproducts.com](http://tsoproducts.com)), an aftermarket accessory that works with Festool, Makita, and Triton track-saw guide rails, to make 90- or 45-degree crosscuts with a track saw. But with Festool's new FS-WA angle stop, now I can make angled crosscuts up to 60 degrees in either direction, and with its specified detents, the stop can be quickly and accurately set to the most commonly used angles. Admittedly, it's not all that often that I find myself cutting sheet goods at an angle other than 90 degrees, but with this newfound ability, new ideas have come to mind, and I recently found myself using the angle guide's "common angles" when cutting plywood to

skin over a textured ceiling for an applied architectural detail.

Attaching an FS-WA angle stop to a Festool guide rail entails sliding it onto the rail's top and bottom groove, with no modifications to either the saw or to the guide rail. This angle stop can be placed anywhere along the guide rail, then locked into position with a quick clamping lever, allowing you to adjust it according to the width of the stock and the length of the guide rail. Once the angle stop has been secured to the guide rail and the guide rail placed on the material, you will notice a small foot on the side of the angle stop. This prevents the angle stop from falling off of the material and acts as a clamping surface, if necessary.

The FS-WA can also accept a clamp inside the T-slot underneath, though in the months I've been using the stop, I haven't taken advantage of this feature. I've found that the nonskid strips on the guide rails have sufficient holding power, while the wide surface area of the angle stop provides additional stability. But if you do need more holding power or are trying to reference the assembly off of a large radius, there are a pair of black positioning bolts attached to the top of the angle stop that can be slid up and out and repositioned anywhere along the bottom of the stop's T-track. And

if you're using any of Festool's MFT tables, these positioning bolts fit snugly into the 20mm holes on the MFT top.

The angle stop works with Festool's new FS-WA-VL guide extension to add repeatability to the mix. This accessory extends the angle stop up to 1,160mm (roughly 45½ inches), turning it into a parallel edge guide that allows you to easily make repeatable, accurate cuts. The guide extension has a scale and an adjustable stop and connects to the angle stop with Festool FSV/2 connectors using the self-aligning T-slots on the angle stop. This guide-rail connector is secured with eight 5mm bolts (four on each side) and is laser engraved to ensure that the connectors are in the correct order.

The FS-WA angle stop is available from Festool for \$175. The stop is also available as part of the SYS3 M 137 FS/2-Set—along with two screw clamps, a guide-rail deflector, a limit stop, two of the new FSV-2 guide-rail connectors, and the new style SYS3 M137 Systainer—for \$300. The FS-WA-VL guide extension for the angle stop costs \$90. [festoolusa.com](http://festoolusa.com)

*Tommie Mullaney owns Mullaney Woodworks in Ocala, Fla. You can visit his web page at [mullaneywoodworks.com](http://mullaneywoodworks.com) and follow him on Instagram at [@Mullaneywoodworks](https://www.instagram.com/Mullaneywoodworks).*



Fitting a Festool track-saw guide rail with the FS-WA angle stop and FS-WA-VL guide extension gives the saw the ability to make repeatable miter cuts at angles up to 60 degrees (1). The angle stop includes a pair of black positioning bolts that can be locked into the stop's T-track slots (2). The FS/2-Set includes the stop and other accessories and a Systainer (3).

Photos: Tommie Mullaney

## PamFast Cordless Autofeed Screw Gun

**FastenMaster has added** a pair of cordless motor options to its popular PamFast autofeed screw gun. A corded Milwaukee version of the tool is still available, but users who already are on the Makita LXT battery platform now have a cordless option powered by Makita's XSF05 18-volt LXT 2,500-rpm screw gun. Users who are on DeWalt's 20-volt Max platform can choose a PamFast tool powered by DeWalt's DCF622 20V Max XR Versa-Clutch 2,000-rpm screw gun.

When *JLC* contributing editor Tim Uhler reviewed the PamFast, Grabber SuperDrive, and Simpson Strong-Tie Quik Drive autofeed screw guns for *Tools of the Trade* back in 2017, he found the PamFast to be solid, reliable, and easy to adjust, as well as faster than the other two screw guns. He especially liked the proprietary PamDrive fasteners that the tool uses, which have a six-lobe design that increases the contact area between the bit and the screw head. In use, Uhler found that this reduced cam-outs and provided longer bit life compared with the fasteners in the other screw guns.

Uhler reports that the prototype version of the cordless PamFast screw gun fitted with the Makita LXT driver that he's been using for the past couple of years performs just as well as the corded version of the tool for installing subfloor sheathing. The tool comes with both a short driver for drywall fasteners and a longer extension for stand-up work installing sheathing or decking. Suggested list price is \$450 for the DeWalt version and \$500 for the Makita version. [fastenmaster.com](http://fastenmaster.com) —*Andrew Wormer*



The PamFast cordless autofeed screw gun is powered by either Makita or DeWalt drivers (left) and comes with long and short extensions (below).



New additions to the Milwaukee hammer lineup include a smooth-faced 16-ounce curved claw hammer (left) and 20-ounce straight-claw hammer (middle), and a 28-ounce straight-claw hammer with a milled face (bottom right). All three hammers have a magnetic nail-set (top right).

## Milwaukee I-Beam Hammers

**Though perhaps best known** for its corded and cordless power tools, Milwaukee has been expanding its hand tool offerings in recent years. As part of that effort, the company is building a new \$26 million manufacturing facility in West Bend, Wis., to produce tools for electricians and utility line workers. I don't know if Milwaukee plans to produce any hammers there, or if it makes them in any of the company's other U.S. facilities, but its steel hammers are well-engineered and have earned high marks from several online "influencers," who say that they are surprisingly vibration-free for a metal hammer.

In addition to the eight hammers currently in its lineup, the company is adding three new models, bringing its total offerings in this essential tool category to 11. All three have a steel I-beam handle design and what the company calls a Shockshield grip, said to reduce vibration. Another feature shared by all three hammers is a magnetic nail set, which allows you to set and drive a nail with one hand, a useful feature when working in tight quarters or in an awkward position. Milwaukee says that its hammers are engineered with an asymmetrical anti-ring claw design to reduce noise when striking hard objects.

The new 16-ounce hybrid claw hammer (model 48-22-9018) has a smooth face for finish work and is the lightest hammer that Milwaukee offers. It retails for \$20. Also new is a 20-ounce smooth-faced hammer with a straight rip claw, which retails for \$25. For heavy-duty work, there is a new 28-ounce framing hammer with a milled face, which retails for \$30. [milwaukeetool.com](http://milwaukeetool.com) —*A.W.*

BY JOHN CARROLL

## Mission Creep

In 2002, I was storing tools in the lower end of my North Carolina home's crawlspace. At the door, I could stand, stooped slightly, but the grade went up, and about 12 feet in, the headroom was about 4½ feet. I decided to dig out a 12-by-16-foot section near the door so I could store and retrieve my tools without stooping. At the same time, I'd beef up my underbuilt 50-year-old foundation. Then, after digging down about 2 feet, it occurred to me that by going down a mere 24 inches more, I could have a very nice space, with a concrete floor and a full 8 feet from the top of the concrete to the bottom of the floor joists. I decided to go for it (1).

And so began a 20-year odyssey. At first, I planned to dig out across the lower end of the crawlspace to create a nice, 12-by-32-foot half-basement. But then, I decided to go back another 6 feet to the next main beam of the floor system above. Around this time, a friend who came over to see the progress on the big dig observed that "this thing has become bigger than you." He was right, of course, and now I won't stop until I reach the full 54-foot length of my crawlspace.

I've divided the basement into nine sections (based on the structure of the frame it holds up). After excavating a section with a shovel and storing the soil in 5-gallon buckets until I can haul it away, I form and pour the footing for the next section of reinforced block retaining wall I'm building around the inside perimeter (2). This

wall is spaced 4 feet in from the existing brick crawlspace wall and capped with a concrete slab to provide useful storage and seal the space from moisture in the soil (3, 4). The slab floor for each 12-by-15-foot section requires about 3 yards of concrete from a ready-mix truck, while I mix up the concrete for the perimeter slabs—which require about 30 80-lb. bags of concrete each—by hand.

I recently completed the block walls for Section 7 and have excavated and poured the footing for Section 8—that wall will take about two weeks to lay up. I've now finished digging eight of nine sections and removed 18,000 5-gallon buckets of hard clay (5). As I've moved farther into the crawlspace, the grade has continued to rise. Now, at the farthest point, I need to dig down 74 inches to get to grade (6).

So far, I've gotten rid of all the clay without spending a cent and spent about \$8,000 on concrete, mortar, and blocks. By the time I get the final section done and pour the floor for the entire basement, I hope to have less than \$20,000 in the entire job. I've put a lot of man-hours in this project but always when I could squeeze them in between paying jobs. And though this has been hard-earned real estate, the end of the project is in sight.

*John Carroll, author of Working Alone, is a builder who lives and works in Durham, N.C.*



Photos: 1, Bill Phillips; 2-6, Matthew Navay



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