Dense Pack Cellulose Insulation: Methods and Verification of Density

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This is Dense Pack Cellulose!

Dense pack has a density of 3.5 pounds per cubic foot or more (well, 3.2 is probably OK).

Photo source: Jim Fitzgerald

High Density Cellulose . . .

- Has the greatest advantage in houses with leaky walls, especially walls where one cavity is connected to the next (plaster and lathe). High R-values and reduces leakiness significantly.
- Has less of an advantage in tighter dwellings with drywall and sheet sheathing. High R-values, but does not reduce leakiness very much.

What We Will Talk About

- Pros and cons of dense pack cellulose.
- Insulation blowing machines.
- Wall drilling.
- Installing dense pack cellulose.
- The delivery system.
- Tubing tips.
- Power quality.
- Safety.
- Verification of insulation quality.

Methods of Installing Cellulose

- Two-hole with nozzle.
  - Straight.
  - Directional or cup.
- One-hole with tubing.
  - Summer grade.
  - Winter grade.
  - More?

Cellulose Grades

- Cellulose insulation from most manufacturers is available in at least two grades that are characterized by the fire retardant.
- The fire retardants are usually 1) a mix of ammonium sulfate and boric acid or 2) boric acid only (termed "borate only").
- Although it is about 7 to 10% more expensive, "borate only" grade is recommended because it is less corrosive.

Inspect and Evaluate House

- Use lead-safe practices.
- Conduct pre-weatherization blower door test.
- Inspect interior surfaces for holes and strength.
- Check for knob-and-tube wiring.
  - Check for voltage drop.
- Check for ducts or pipes in exterior walls.
- Check for location of electrical fixtures.
  - Respect all clearances.
- Watch for pocket doors.
- Check bathtub and plumbing openings.

Advantages and Disadvantages of Dense Pack Cellulose

Advantages of Dense Pack - 1

- No settling at top of cavity.
- Uniform R-value.
- Reduction of house CFM_{50}.
- Usually less wall open-up and close-up time.
- Greater safety for installation crew.
- Quieter indoors.

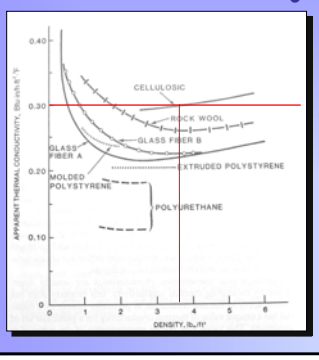
Advantages of Dense Pack - 2

- Better equipment and equipment maintenance required – insulation blowing machine and delivery system.
- Higher degree of professionalism required – more knowledge, greater care. Pays back in the long term.

Disadvantages of Dense Pack - 1

- More insulation is installed, so more time required to blow (this might be outweighed by wall open-up and close-up time).
- Greater possibility of damaging interior wall material.
- Reduction in R-value (from 3.4 at 2.5 lbs/ft^3 to 3.3 at 4.5 lbs/ft^3), but insignificant.

Thermal Conductivity vs. Density



Vertical axis is inverse of R-value. For example, 0.3 is equivalent to an R-value of 3.33.

Source: ASHRAE Handbook of Fundamentals 2001, p 23.4

Disadvantages of Dense Pack - 2

- Requires higher quality equipment – insulation machine, generator, delivery system.
- Requires higher degree of equipment maintenance.

Green Advantages of Cellulose

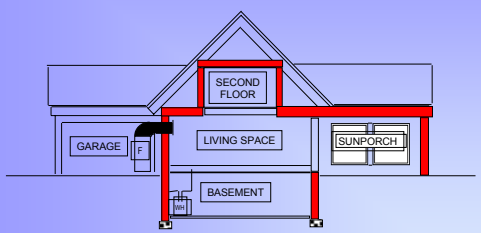
- Is probably the greenest of insulations available. About 80% post-consumer recycled newspaper by weight.
- Lowest of major insulations in embodied energy both in Btu/lb. and Btu per insulating unit.
- Negligible pollution results from manufacturing.

Basic Concepts

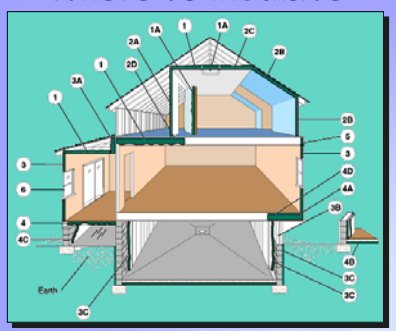
Basic Concept # 1

- If you don't have the EQUIPMENT and KNOWLEDGE to install insulation correctly in the first place, don't expect to be able to do it.

Defining the Thermal Boundaries



Where to Insulate



Basic Concept # 2

- If you don't have a WRITTEN STANDARD by which to install insulation, you can't expect you crews and contractors to achieve consistent high quality.

Insulation Blowing Machines

Basic Insulation Blower Types

- Through-the-fan, cellulose-only blower type.
- All-fiber blower, positive displacement air-lock type.
  - Can blow cellulose, fiberglass, or rock wool.
  - More powerful than cellulose-only types.
  - Examples include Intec Force 2 and Krendl

Krendl Blowing Machines

Model 2090

North Dakota Wx Trailer

Krendl 450

Krendl 590

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Krendl 200

"Bubble, bubble, toil and trouble . . ."

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Intec Blowing Machines

Force

Force 2

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Giesken Blowing Machines

Giesken 610

Giesken 510

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PTO Insulation Machines, Unisul

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Machine Metrics

- Capacity – pounds per hour of material.
  - Krendl 2000, 2400 to 3000 lbs/hr of cellulose.
- Number of blowers – 1 to 4 blowers.
- Static pressure level –
  - For dense pack a minimum of 2.9 psi or 80 IWC.
  - Measure air-only and then with agitator on also.
- Air flow
  - The more the air flow, more cellulose per hour, but not necessarily greater density.

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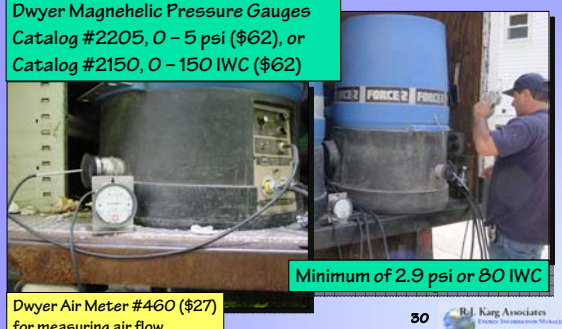
Checking Static Pressure

Dwyer Magnehelic Pressure Gauges
Catalog #2205, 0 – 5 psi ($62), or
Catalog #2150, 0 – 150 IWC ($62)



Minimum of 2.9 psi or 80 IWC

Dwyer Air Meter #460 ($27) for measuring air flow

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Working Out of a Pickup

Inadequate power supply!
For most machines, about 8,000 Watts is good.

Machine Settings

- The air-to-material ratio is very important.
  - Higher ratio will increase density.
  - Higher ratio will reduce material throughput.
  - Lower ratio will increase the chance of blockage in delivery system.
  - The trick is to achieve dense pack with the maximum throughput, without clogging. This is easier to do with a good machine.

Machine Calibration

- Use this method to maximize material feed for a dense pack (only works on high quality machines).
  - Set air on highest level that is appropriate for job.
  - Increase material until delivery system clogs.
  - Unclog delivery system and then set material feed back one notch.

First annual meeting of Fraternal League International of Persons with a Bifurcated Index Related Digits (FLIPBIRD), New England chapter, June 22, 2004.

Wall Drilling

Drilling to Install Cellulose

Angle fill hole in the direction the tube will go.

If tube will go up and down, angle fill hole up and down.

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Drilling

- Bits
  - Self-feed bits, 2 1/8 to 2 9/16 (Milwaukee, Lenox, DeWalt).
  - Carbide-tipped hole saw for interior drill, 2 ½ inches.

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Half-inch Drill with 2 1/8" Bit

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Drilling Walls

Hole saws are slower, but cleaner

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Where to Drill Fill Hole

- Bottom of cavity and fill up.
- Middle of cavity and fill up then down.
  - May fill down and then up, also.
- Top of cavity and fill down.
  - This can work well for tight walls (drywall) because the fill hole also acts as a pressure relief hole during the entire cavity fill.

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Installing Dense Pack Cellulose

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Requirements for Dense Blow

- Insulation machine with capacity.
- High quality power supply.
- Good insulation.
- Proper delivery system.
- Proper training and knowledge.
- Walls and ceilings that can withstand pressure.

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Installation of Dense Pack Cellulose

- Density of cellulose must be at least 3.5 pounds per cubic foot.
- Air-to-material ratio is very important.
  - Higher ratio increases density, but takes longer.
  - Lower ratio decreases density, but is faster.
  - Must find right setting for machine, delivery system, weather, installer, and cellulose.
- Up-down or down-up with tube?

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Blowing Walls

Click 3

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Probe 100% of Cavities

For probing up and down

For probing sideways

Click 1

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Dense Packing Wood Shingle Wall

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Interior Cellulose Blow

Don't blow inside without lead testing.

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Window Treatment, Interior/Exterior

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Knee Wall Cellulose Blow

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Bricks in the Wall?

Don't ignore diagonal bracing

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2nd Floor Perimeter Options

- Bag method at rim joist perpendicular to joists; on other two sides fill entire perimeter joist cavity.
- Drill and blow floor inside.
- Drill outside at rim joist and blow with directional (cup) nozzle.
- Others?

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Bag Method for Rim Joists

Click 4

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Cantilevered Rim Treatment

This blow went about 10 feet across the basement ceiling.

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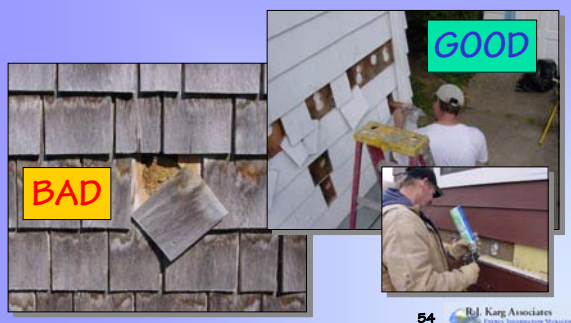
Plug Fill Holes Before Replacing Siding



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Dense Packing Cathedral Ceilings

- Don't dense pack complete cathedral ceilings in the north without mechanical ventilation operating continuously to keep indoor relative humidity to 35% or below during the winter.

The Delivery System

Insulation Delivery System - 1

System should be 100% leak-free.

- Static pressure at end of delivery system should be the same as at the machine takeoff. If not, find the leaks.
- Use double hose clamps and cut off tails rather than using duct tape.

Insulation Delivery System - 2

- Hoses.
  - Always use as large a hose diameter as possible for the job. This maximizes material throughput and minimizes friction.
  - Never use less than 50 feet of hose (3"), but over this, use as little as possible (2").
  - Use double hose clamps and cut off tails.
  - Attach 1 ¼ tube to 2 inch hose with a reducer.

Insulation Delivery System - 3

- Tubes (1 inch or 1 ¼ inch inside diameter).
  - Tubes MUST be the proper rigidity for the job.
  - Transitions should be gradual.
  - Bevel cut on end should be with natural curve of tube.
  - Wider cavities require more rigid tubes.
  - For very rigid tubing, use thin wall ABS (natural gas line), but be careful of static electricity.
  - Experiment with tubing types and rigidities.
  - Don't let tubes kink. Store in larger PVC pipes.

Delivery System Transitions

Always lap transition joins properly

Tubing

45⁰ bevel cut should be with natural curve of tube.

Source: *High Density Tubing Tips and Techniques*, Chris Allwein, 2000, Ohio Wx Program

If You Know it Works, Use it . . .

Vacuum cleaner hose

. . . but how do you know it works?

Cup (directional) nozzle and transition fitting

Operator Shut-off Valve or Not?

A Kinked Tube is a Bad Tube

Maine Wx Experiments

A more rigid 1 ¼ inch inside diameter tube is inserted in the left cavity. This turgid tube is much less likely to bend downward than the flaccid tube in the right cavity, ensuring a better insulation density.

Maine Wx Experiments

Rigid tube left, flaccid tube right

This photo shows the measured cellulose density in lb/ft³ at a different heights in the cavities for the less rigid tube on the right and the more rigid tube on the left.

Note: Cavity on right was blown with a less rigid tube that curved downward.

Note: Krendl 2090 machine with air on 7 for both blowers and feed set at 3.

Hopper Filling

- For many machines, a full hopper – increased weight – increases the rate of feed through the delivery system. Force 2 is an example.
- Full hopper can lead to problems if power quality is bad. Rather than running a partially filled hopper, fix power problems.

Tubing Tips

Tubing Tips – 1

- Drill fill hole within one foot of cavity bottom, or
- Drill fill hole at convenient spot for workers, perhaps siding course just under windows.
  - Fill up and then down (this is preferred).
  - Fill down and then up.

Tubing Tips – 2

- Use tubes that are long enough for the job – end of tube must reach to most distant spot.
- Cut an angle on the end of the tube.
- Use $2\,{}^{1}/_{8}$ to $2\,{}^{9}/_{16}$ inch self-feed bit. Angle hole.
- Use biggest i.d. possible, usually 1 ¼ inch.
- Rigidity of tube MUST be right for job.

Tubing Tips – 3

- Probe up and down with tube.
- Insert upward to plate, then pull out 12".
- Always blow air first to clear and straighten tube and to "drill" into existing cellulose.
- Typical cavity should fill in 2 – 4 minutes, about one 30 lb. bag for three cavities.
- Try to fill and drill at the same time.

Tubing

- Have a variety of tubing on hand, 1 ¼" and 1".
  - Two different summer grades (one braided).
  - Two different winter grades.
  - Avoid PVC due to static electricity.

J&R Products, Inc.
4695 East 200 North
Craigville, IN 46731
1-800-343-4446

Applied Energy Products & Sales
3920 State Street
N. Canton, OH 44720
1-800-255-7996

Blowing Caveats

Things of Avoid with Dense Pack

- Insulation over recessed lights or heat sources.
- Unsafe wiring (knob-and-tube, open junction boxes, etc).
- Blowing against chimneys.
- Contact with soil or plumbing leaks.
- Flat or cathedral roofs in high moisture buildings in the north without control of humidity, airflow, and water.
- Walls without building paper or sheathing.
- High occupancy dwellings without mechanical ventilation.
- Blowing into ductwork.

Cellulose Blow on Recessed Light

Photo source: Jim Fitzgerald

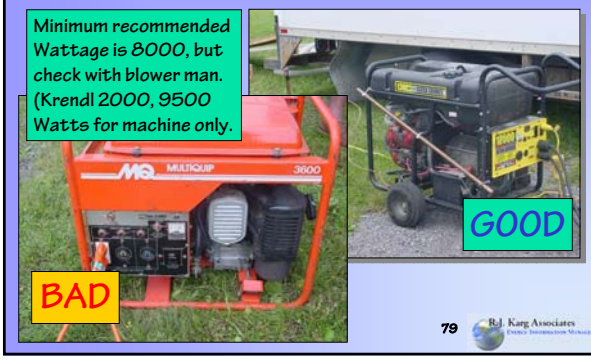
Be Safe with Knob-and-Tube

Voltage drop <10%

Power Quality

Generators

Minimum recommended Wattage is 8000, but check with blower man. (Krendl 2000, 9500 Watts for machine only.



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Generators

- Check the voltage from your generator at the generator outlets AND at the end of your extension cords.
- Karg has measured generator outlet voltage as low as 82 (should be at least 115).
  - This is hard on electric motors – tools – and reduces the capacity of your insulation machine.

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Be Prepared for House Hookup

SEVCA in Vermont

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North Dakota fun

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Safety

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Safety When Blowing – 1

- Use lead-safe and asbestos-safe practices.
- Use fiberglass ladders.
- Use ground fault electrical devices.
- Drill safety. Check interior for electrical fixtures before drilling.

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Safety When Blowing – 2

- Brace yourself securely before drilling. The larger the bit the greater the torque and danger.
- Connect safely to house electrical supply.
- Wear good respirators; use eye, ear, and head protection.
- Be aware of the effects of carbon monoxide if using a generator.
- Don't gas up generator while smoking.

Keep Generator Out of Box Truck

Karg has measured CO concentrations as high as 350 ppm in box trucks with generators running!

At least run exhaust pipe around corner to outside. Better yet . . .

Verification of Installation Quality

Verifying Cellulose Quality

- Insulation density cases (machine setup only).
- Core sampling (density, not coverage).
- Insulation bag count (density and coverage, sort of).
- Digit test (density, not coverage.
- Infrared analysis (coverage only, not density).
- Blower door test, pre- and post-weatherization (air sealing characteristics only).
- Zone Pressure Diagnostics (air sealing characteristics only).

Insulation Density Cases

Designed and fabricated by Gary Roundy,
130 Underwood Circle, Kodak, TN 37764
865-932-2548

Core Sampling

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Is this Cellulose?

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Bag Count

- For cellulose dense packing, one bag should almost fill three 8 feet high wall cavities in a 16 inch O.C. wall (25 to 30 pound bag).
- About one pound of cellulose per ft^2 of wall.
- For density/bag calculation sheet, go to www.karg.com/insulationdensity.htm.

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Digit Test

- Shouldn't be able to poke finger into fill hole OR a sample non-fill hole.
- Some people have been know to calibrate a digit to within 0.1 pound per cubic foot!

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Infrared to Test Installed Quality

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Blower Door Testing

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Zone Pressure Diagnostics

- These methods can help us determine the leakage to a zone – an attic – before and after it is air sealed and insulated.
- If we divide the flow in CFM_{50} by 10, we know the approximate square inches of leakage.

Another Way to Determine Density

. . . but method does have disadvantages.

How Can We Improve?

How Can We Improve?

- Manufacturer's listing of takeoff pressures.
- Rigidity ratings for tubes.
- Upgrade our machines.
- Measure machine static pressure often.
- Maintain machines regularly and properly.
- Check quality of power to machines.
- Improve our installation methods.
- Calculate density frequently.
- Core sample for quality assurance.
- Learn each machine's settings.

Resources

- Insulation machine manufactures.
- *High Density Tubing Tips and Techniques*, Chris Allwein, 2000, Ohio Wx Program.
- *Densepack Cellulose: Tools & Techniques, Jim Fitzgerald*, Affordable Comfort presentation, 2003 & 2004.
- Insulation Density Cases – Gary Roundy, 130 Underwood Circle, Kodak, TN 37764, 865-932-2548.

Ammonium Sulfate Test

- Put a handful of cellulose into a cup filled with water and a teaspoon of Drano. If you smell ammonia, the insulation contains ammonium sulfate.

Thanks to Bill Hulstrunk for this test method tip.

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