# SPRAY IT:

## *TWO NEW APPROACHES TO HIGH—PERFORMANCE INSULATION*

# Spray Cellulose

by William Andler

*Spray cellulose fills stud cavities completely, sealing off most air leaks and preventing convection within the wall.*

Cellulose insulation is made by a milling process that grinds together two raw materials: paper stock and chemicals. The chemicals are fire retardants, corrosion inhibitors, and, in the case of spray products, adhesives and wetting agents.

There are two major types of cellulose: *loose-fill* and *sprays.* Loose-fill is blown into attics and existing closed walls. Cavity spray is applied to open framing bays in new or existing construction.

The cellulose used in residential cavity spray generally has a dry adhesive that is activated with water at the time it is installed. It also has a chemical called a *reactant,* which lets the cellulose instantly absorb the water that is added during spraying. Commercial sprays, on the other hand, use a wet adhesive and are typically applied to overhead surfaces and non-studded walls (metal or masonry surfaces). The wet adhesives are generally too expensive for residential use.

In attic applications, you must follow the charts on the bags in order to attain a specific R-value. These charts tell how many bags to use for a given area, based on the material's R-value after it settles (maximum settled density), which is about 3.5 pounds per cubic foot. This is necessary because settling will definitely occur in an open attic blow—typically 20 to 25 percent—depending on the thickness of the insulation.

Loose-fill cellulose installed in wall cavities should exceed 3.5 pounds per cubic foot to assure no settling. The equipment is designed to pump at this density, but a well-seasoned, conscientious applicator is still the best guarantee of a quality job. In general, two holes per stud bay yield a better job than a one-hole job, and an infrared thermal scan is advisable to locate hidden voids. So look for a reputable applicator and remember to get references!

For spray applications, the density should exceed four pounds per cubic foot (based on the weight of the material when dried to its equilibrium moisture content of about seven percent). We recommend four pounds because it is safely above the material's maximum settled density of 3.5 pounds per cubic foot. At higher densities, the cellulose has been mechanically compressed and therefore, will not settle. Rather, it pushes back on all surfaces.

### The Chemicals

The two main chemicals in cellulose are boric acid (a fire retardant), and borax (a corrosion inhibitor). However, manufacturers often substitute other less expensive chemicals to hold down costs. In particular, gypsum, lime products, and ammonium sulfate are often used to replace some of the boric acid.

These additives should never be used in a cavity-spray product. Ammonium sulfate is a particular problem because—when the water is added to make the spray—it will break down and form sulfuric acid. This smells foul and will eat away at copper. The other boric acid substitutes—gypsum and lime products—will not cause these kinds of problems, but they can be "washed out" of the cellulose by the water used during spraying.

The solution to the problem is to only use cavity sprays with the borate family chemicals—borax and boric acid. Also, use a cavity spray that uses a dry adhesive—not just water. The adhesive will not only make a good bond between the cellulose and the wall materials, it will also assure good adhesion of the chemicals to the cellulose fibers. In short, for spraying applications, use only material made specifically for that purpose.

### Scheduling

When freshly sprayed, the cellulose weighs in at seven or eight pounds per cubic foot, which is 40 percent water by weight. To dry to its equilibrium moisture content, which is about seven percent, takes no more than 40 days in a typical well-sealed wall, according to our experience. However, we feel that

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there is no reason why the wall cannot be closed up as soon as the spray cellulose is applied.

We do prefer that the siding is on before the cellulose is sprayed. Otherwise, the insulation could be loosened from the sheathing when the siding is nailed. Once the interior drywall is up, however, the banging of hammers on the exterior should not create any problem.

### Quality Control

All quality cellulose carries third-party inspection labels. A number of labs test cellulose, but we feel that testing by Underwriter's Laboratories (UL) offers the best guarantee of high quality. UL's inspection program conducts random bi-weekly inspections to ensure the quality of products bearing their lot numbers and the UL label.

### Bug Killer

One type of cellulose insulation—called IN-CIDE—serves double duty as an insecticide. The insecticide properties come from the high percentage of a specially-formulated boric acid called Reylon 2100 (HJH Chemical Corp., 50 N. 41st Ave., Phoenix, AZ 85009). It's highly effective against cockroaches, termites, carpenter ants and other nesting insects. Although the boric acid is less toxic to humans than table salt, it kills the insects because they ingest it and dehydrate. IN-CIDE has the highest chemical content (24 percent) in the industry, and carries state and federal Environmental Protection Agency numbers, UL listing, and state and federal test-approval numbers. Its biggest market is in multifamily projects in urban areas. It can be loose-filled, or spray applied

### Energy Performance

The R-value of most cellulose insulation is R-3.7 per inch. Some companies claim a higher value, but UL testing always seems to come up with R-3.7.

Many claims have been made for the tight seal that spray cellulose yields. The reason is that the spraying process fills the wall cavity completely, including any irregularities caused by oversized drill holes, bent lumber, sheathing gaps, and piping and wiring. There is no space left for air convection, which could erode the R-value of a fibrous insulation.

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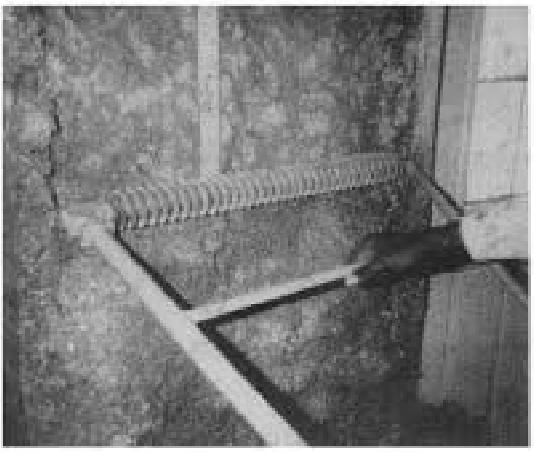
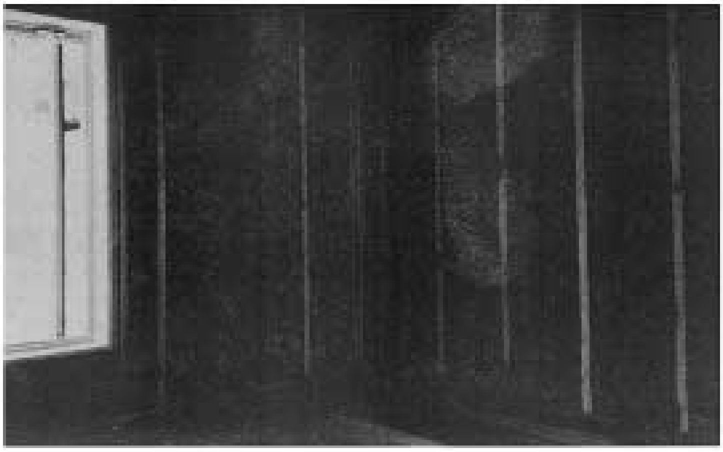
Although little research has been done to compare cellulose to fiberglass, a test conducted in Leominster, Mass., by the Massachusetts Executive Office of Communities & Development found that apartments insulated with cellulose (spray in the walls and loose-fill in the attics) were 30 percent tighter and used 33 percent less electricity than identical units using fiberglass. (The heating was not submetered, so the 33 percent figure is based on all-electrical usage.)





*After spraying the cavities, the excess cellulose is mechanically removed with a "scrubber," (above left) and fed back into the hopper. The result is a clean wall (above right) ready for vapor barrier and finish.*

The study's coordinator, Richard Piper, feels that it's reasonable to credit the cellulose with much of the increased tightness and energy savings. The ability of cellulose to block airflow, he said, was confirmed by a study done in 1984 by the Center for Energy and Environmental Studies at Princeton University. The study showed that cellulose was significantly better than blown fiberglass in stopping airflow through a test wall. The study also found that air-leakage rates were cut by 10 to 30 percent in houses retrofitted with cellulose in the walls.

Loose-fill cellulose costs about the same or less than loose-fill fiberglass. Cellulose spray costs about 2-1/2 times as much as fiberglass batts, based on the installed costs. Based on that price the payback on the Leominster apartments would be about one year.

The use of spray cellulose is growing very rapidly. Be safe and sure of the products you are using. Check for proper labelling and safe chemical loading. Call the manufacturer if you have any questions. ■

*William Andler is the vice-president of Northern Cellulose Insulation, in Beverly, Mass., which manufactures cellulose insulation for loose-fill and spray applications.*

# Spray Urethane

by Raymond Dewitt

*Urethane insulation is sprayed on in thin layers called "lifts" that build up to the desired thickness.*

**B**ecause of its good insulating qualities, urethane foams are used today as wall and roof insulation in residential and commercial structures.

Urethane foam is the generic name for a family of compounds formed by the reactions of two types of chemicals called isocyanates and polyols. A blowing agent, usually Freon, is used to give the foam a cellular structure. Cell stabilizers, combustion retarders, catalysts, and other chemicals can also be added. Each foam uses a specific recipe to give it the characteristics desired for a specific job.

One class of urethane foams, called polyurethane, was first used during World War II to strengthen and stiffen aircraft components, since it added strength with very little weight. The first commercial polyurethane plastics appeared in the early 1950s. In the building industry, polyurethane is used in spray applications and in some roof insulation panels. The roof panels are cut from large foam "buns" and may be tapered to create a slope on flat roofs.

Polyisocyanurate, which is chemically related to polyurethane but has greater thermal stability and lower combustibility, was introduced in the late 1960s. Polyisocyanurates are found in foil-faced boardstock such as Thermax, Energy Shield, and High-R Sheathing. Foil-faced boards are generally made by foaming the material in-place between the two facings.

The urethane foam used for building insulation is closely related to the flexible urethane foam found in mattresses and other upholstery cushions.

For building applications, polyurethane and polyisocyanurate can be field-applied by spray or pour techniques.

### Chemistry

The spray and pour foams used in the building industry use the same basic chemistry. Each combines isocyanates and polyols. When the two compounds react, they give off heat, which evaporates the Freon (the Freon typically used boils at about 70° Fahrenheit). As the Freon tries to escape it is captured in tiny bubbles, creating a cellular structure.

The special insulating properties of urethane depend on the cells' ability to trap the Freon gas long term. If it all were to escape, the foam R-value would be essentially the same as extruded polystyrene. However, the entrapped Freon does stabilize. The aged R-factor of field-applied, two-pound-density urethane is R-6.8 per inch—according to the manufacturer's data.

Spray foam typically has a Class II fire rating. A Class I rating, however, can be obtained by changing the chemistry.

### Spray Foam

For new construction, the spray technique is used. Spray-foam operations use specially designed spray guns that mix the two components under pressure and atomize the material as they spray. The foam can be sprayed against plywood, rigid foam sheathing, or almost any rigid material.

Since the foam components react quickly and give off heat, the spray is put on in layers, each 1/2- to 1-inch thick. Each layer skins over—helping to lock in the entrapped gas. On most surfaces, multiple layers can be applied almost immediately, since the foam bonds tenaciously to previous layers. If too thick a layer were put on at once, the heat build-up would be excessive. In extreme cases, it can ignite.

Spray foam provides both good insulation and a tight air-infiltration barrier. If applied to at least three inches, it will also make an effective vapor barrier.

Because the foam adds to the rigidity of a structure, spray foam also lets the builder depart somewhat from standard framing practices. For example, some builders have used staggered 2x3 studs—filled with urethane foam—to create a fully thermally-broken wall.

Others have used a modified 2x6 framing system that uses 2x6 studs, but 2x4 top and bottom plates and 2x4 cripples around doors and windows. The 2x4s (set flush with the interior side of the wall) allow the foam to prevent air leaks that might otherwise occur at these points.

Some builders have requested only two inches of foam—to get the airtightness benefit—and then fill the rest of the cavity with fiberglass insulation. While this system can achieve the desired building tightness, I am concerned about its potential for moisture damage. Continuous interior vapor barriers and low indoor humidity levels would be called for.

### Application

The following conditions must be

*Excess urethane insulation can be planed with a pneumatic device.*

considered when applying polyurethane foam. The temperature of the sur-

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face being sprayed must be kept at least 50° Fahrenheit and should not exceed 240° Fahrenheit. Lower temperature surfaces can be sprayed, but the job will be more costly, since more material will be used. In cold weather, we sometimes heat the building to 90° Fahrenheit or so the night before spraying to bring it up to temperature. Spraying against foam insulation will be warmer than spraying against plywood. If the surface is too cold, the chemicals will revert to a liquid form.

The surface to be sprayed should be treated as if it were going to be painted—that is, it must be free of oil film, dust, oxidation, and moisture. All surfaces that may come in contact with overspray must be masked. The foam will stick tenaciously to just about any surface except polyethylene film.

After they are applied, spray foams must be covered with a fifteen-minute fire-rated material such as 1/2-inch drywall, spray-on vermiculite, or other approved thermal barriers.

### Safety

During application, the spray mechanic should be wearing a full face mask with outside air being supplied by an oilless compressor. (Never supply air for breathing with a standard compressor!) Temporary spectators must have a particle respirator suitable for filtering organic vapors, and have adequate eye protection.

Fire is another concern. All flame-producing devices such as heating appliances, electric motors (except those rated as "explosion proof"), or welders must be shut off. Any other activity that may produce a spark must be halted during application. Due to the hazardous nature of the airborne particles, the building should be flushed with fans during the spraying process.

### Pour Foam

Pour-in-place techniques are used with existing construction. They are similar to spray, in that the components are mixed in a specialized mixing gun. They are dispensed, however, as a liquid stream rather than atomized. The liquid is injected into a cavity. After a short delay, the mixture expands to fill the void. Because of the pressure of the expanding foam, it may be necessary to restrain the cavity or wall components from being pushed out of place.

Excessive deflection can be prevented by a process called "frothing." Frothing means applying the foam in a partially pre-expanded state, similar to shaving cream. This is accomplished by selecting a type of Freon (the blowing agent) with a lower boiling point and introducing it to the foam components before they leave the gun. Frothing will let you fill narrow wall cavities with more uniform cell structure and less side pressures. Also, frothing will seal well around cracks, whereas the regular pour-in foam can leave voids (by leaking through cracks before the material expands).

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time, it helps bind the materials together and helps prevent water penetration into the interior. Pour foam has also been used successfully to fill the cores of concrete blocks, and to some extent in woodframe cavity walls. Other uses include freezer applications, shipbuilding, stressed-skin panels, and automotive manufacturing.

### Characteristics

Polyurethane and polyisocyanurate foams have a predominantly closed-cell structure that resists water absorption and condensation. The cells will not sag, buckle, pack down, or mat from ordinary use.

These foams have proven themselves in roofs and in walls, but should not be used in below-grade applications unless they are adequately protected from moisture and mechanical damage. The same goes for other foam plastics as well. Insects, moisture, frost action, and mechanical damage make the underground environment unsuitable for foams.

### Selecting a Contractor

When selecting a foam contractor, follow the same investigative process as with other trades. A start would be to call the Better Business Bureau to learn if any formal complaints have been filed against a particular firm or individual. Experience is an important factor. The number of years in the business as well as knowledge of your specific type of application should be considered. Attendance at training seminars given by major foam and equipment manufacturers is also a plus.

Ask for references and follow these up with phone calls to previous customers. Also ask to see a certificate of insurance, which every contractor should have. If possible, visit a job site to familiarize yourself with the specific procedures. Spray polyurethane will give many years of satisfactory performance only if it is applied correctly. We in the urethane industry urge designers, contractors, and consumers to become familiar with the product—its advantages and limitations. ■

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