

February 12, 2005

These sheets were put together by a client of mine. If you wish more information, please contact me Rod Terry 541-754-0059 or rod@rodterry.com

FEEL FREE TO USE THE INFORMATION CONTAINED HERE. BUT THIS USE IS AT YOUR OWN RISK.

These specifications are not intended as a substitute for standard specifications, but as an addition to them. They will be part of the contract.

This house is being constructed as a healthy house.

The products specified herein are intended to be as free of harmful chemicals as are presently available and reasonably attainable. In using these products we are safeguarding, to the best of our ability, the health of future inhabitants as well as the workers involved in this construction. Our concern extends also to the workers involved in the manufacture of these products and to the environment at large.

You may encounter initial resistance from subcontractors who are reluctant to do things that are unfamiliar. Furthermore, some subcontractors may not understand or agree with the need for healthier products and techniques. For these reasons you, as the general contractor, will need to supervise the project more closely than in standard construction as well as to exercise your creativity, intelligence, and common sense in order to accomplish the goals of a well-built and healthy house. I have confidence that you are up to the task, and I look forward to working together with you to that end.

My health is in your hands. Since I feel good so much of the time, I am often lulled into believing I am not as sensitive as I once was. Then something comes along to burst that illusion and I know again that all of these healthy house practices are necessary. This morning I opened an envelope containing a 2" x 2" piece of furnace insulation that had been mailed to me by the manufacturer. I took out the piece, looked at it for about 5 seconds and put it right back in the envelope and back into the mailing envelope. Within 5 minutes my throat was dry and my skin was beginning to burn. Within 15 minutes my lips were numb, my head ached, and I was having difficulty concentrating. In about an hour I received a return phone call and could not remember why I had called the person. Now, 6 hours later my skin still burns and itches, my concentration is not great, and I feel somewhat ill. This reaction is stronger than most, not as strong as some, and a sufficient reminder of why I must be very careful about the materials that are used in this house and the way they are used. As a result of unhealthy materials in my current and former homes, I have been unable to sleep indoors anywhere for 5 years, I cannot stay long inside many buildings, especially new ones or recently remodeled ones, I cannot tolerate fragrances, manmade fabrics, some plastics, common cleaning products, and many other things, and I cannot even visit my two young grandsons because they live in a new house. With your help I am hoping and trying to create a house that will help me to heal and become strong enough to overcome these handicaps by having a place to be most of the time that contributes to my good health rather than adds to the burden of toxins in my environment. It is also my hope that by working

together on this house, you and some of your subcontractors will learn more about, and become advocates of, healthier building, and so will pass on the benefits to future homeowners for whom you work. Having said all of this, I hope you will understand if I sometimes come across as too particular and uncompromising, and instead of being irritated, you will be tolerant at worst and my advocate at best.

This house is also being built so as to preserve the natural setting

insomuch as is reasonably possible. Indeed, the forest is the reason we are building here. To this end the following guidelines will be followed by everyone on the job site, unless prior approval is obtained from the owner to the contrary.

The property is divided into three parts:

1. Private zone—the driveway, carport, shop, walkways, house, decks, and other structures.
2. Natural zone—the area that is being protected.
3. Transition zone—the space in-between, usually 5-15 feet, that allows the storage of materials and the work of building to be carried on.

A visual barrier will be placed at the outer edge of the transition zone to clearly demarcate where the natural zone begins. The natural zone is sacrosanct. Nothing will be allowed into the natural zone: nobody, no food, no materials, no concrete wash-out, no paint wash-out or run-off, no solvents, no cleaners, etc. Leftover paint, concrete, etc. will be carted off site. Never allow them to run under the fenced area. No equipment or materials will be leaned against trees; boards could girdle the trees, dirt piled up could suffocate them. Trees need protection of 1 foot per inch of tree diameter to protect roots. During the layout and installation of the septic pipe and septic drain field, the private and transition zones will be temporarily extended to include the necessary areas.

Special Project Procedures

The following project procedures will be adhered to at all times and by all persons on the job site.

1. Smoking is prohibited within or near any structure on the job site.
2. The use of gas-generated machinery and gas-or kerosene-fired heaters is prohibited within or near any structure on the job site, with the exception of the concrete carport pad.
3. No insecticides, herbicides or chemicals other than those specified may be used on the job site without prior written approval by the owner.
4. All materials are to be protected from contamination and moisture damage during storage and during and after installation.
5. Clean-up of spills and accidents will be done with approved cleaners only, and in such a way as to avoid worse contamination, i.e. do not clean up water-based paint spills with mineral spirits!

Procedures to Prevent Insect and Rodent Infestation

1. All food stuffs are to be disposed of in containers which will be removed from the job site at the end of each workday. If the same container is returned to the jobsite, it must be returned empty.

2. All non-foodstuff debris is to be removed from under, around and within the building premises and properly disposed of in a dumpster. The dumpster shall be emptied often enough that piles of debris do not accumulate on the ground around it.

Quality Control

1. The contractor shall perform and maintain the special project procedures with the same quality of workmanship as would be expected with standard materials and methods.
2. The contractor shall maintain a quality control program that ensures full protection of work against exposure to prohibited materials and practices.
3. Except as otherwise approved by the owner, the contractor shall determine and comply with the manufacturer's recommendations on product handling, storage, installation, and protection.
4. The contractor shall verify that, prior to installation, all materials are undamaged, uncontaminated, and free of acquired odors. Any products found to be defective shall not be used unless approved by the owner.

Prohibited Products

The use of substances listed below is prohibited.

1. Herbicides, fungicides, insecticides, and other pesticides, except as specified.
2. Composite wood products containing urea-formaldehyde binders.
3. Asphalt or products containing asphalt or bitumen except as specified.
4. Commercial cleaning products other than those specified.
5. Adhesives, paints, sealers, stains, and other finishes except as specified.
6. Any building materials contaminated by mold or mildew.
7. Any building materials or components that have been contaminated while in storage or during shipment.

Contact the owner for further instructions about any application where these substances would normally be used if information for a substitution is not in this document.

Product Substitution Procedure

1. Products may be substituted for the specified product only if agreed upon in writing by the owner.
2. An MSDS and product literature must be provided on any substitution in order for it to be considered.
3. A physical sample will be submitted to the owner whenever possible.

Contract Close-Out

At the appropriate times and before the home is handed over from the contractor to the owner, various tests will be run on the buildings in the presence of the general contractor and the owner. The various systems will be tuned and adjusted so that they operate as intended. Any detected errors and/or omissions will be corrected by the contractor or appropriate subcontractor. These tests include but are not limited to the following:

1. Testing with either air or water for plumbing leaks.

2. Testing for air leakage of the building envelope with a blower door test following the required protocol for a valid test according the appendix C of the 1994 *Super Good Cents Builders Guide*, or better, that indicates 1.8 air changes per hour (ACH) or less at 50 Pascals air pressure difference.

3. Pressure balancing of heating and HRV system.

4. Electromagnetic Field Testing with a gaussmeter while the house has a minimum load of three amps at the distal end of each electrical circuit. Any elevated magnetic fields greater than 0.5mG will indicate the presence of net current which will be the responsibility of the electrical contractor to locate and eliminate.

The general contractor will do a “walk through” with the owners in order to explain how the systems work and how the owners need to maintain and monitor them. The general contractor will provide owner manuals for all installed appliances, and “as-built” drawings that indicate any changes made in the course of construction and that locate any pertinent information not on the original documents.

Commercial Cleaning Products: See Appendix I for approved products.

Elimination, Separation, and Ventilation.

The 3 key strategies for building a Healthy House are Elimination, Separation, and Ventilation. The first, elimination of toxic materials and the use of inert, healthy, and no-or low-tox products instead, is chosen whenever such products are readily available, suitable, and practical for use without significantly complicating the construction or increasing the cost. Their use is most important *inside* the building. In cases where elimination is not feasible, separation is used, often achieved by building in an airtight manner and carefully using diffusion retarders to keep the offending material out of the indoor airspace. And finally, because the first 2 are never 100%, ventilation is used to dilute whatever toxicity is outgassed indoors, as well as the biological products of the inhabitants, and to provide them with fresh air. All 3 are necessary to create a Healthy House. Most of the following specifications will fall into one or more of these categories.

Site Work and Excavation

Tree stumps, large roots, and all dead wood and foliage will be fully removed from under the driveway, carport, shop, walkway, house, decks and other construction, and within the 5’ to 15’ transitions zone around them, and disposed of off site so they do not attract termites and/or other pests.

Damage to live trees and their root systems will be minimized during the preparation and installation of the septic system by using smaller equipment, creating trenches no larger than necessary, using drainage pipe no larger than necessary, designing the drain field with consideration of live trees, and using methods that minimize root damage whenever possible.

All other trees remaining on the site will be protected from damage during the excavation and construction process unless written permission is obtained to the contrary from the owner.

Good site grading is the first line of defense against moisture problems. Therefore water shall have positive drainage away from the buildings at all points along their perimeters. The ground shall slope away at a minimum of 4%, and soil used to grade around the building shall be of an impervious nature with high clay content. The Geotechnical Site Evaluation of Ronald J. Derrick, P.E., recommends "Perimeter footing drains are required around all up slope foundations and the building perimeter grades shall be sloped at least 2% away from the foundation. Water shall not be allowed to pond adjacent to the foundations. Dependent upon landscape design, placement of a French drain up slope of the residence should be considered to direct near surface seepage around the residence. A suitable French drain depth is expected to be 5 feet and the drain outlet shall be a minimum of 20 feet down slope of the residence." If a French drain is installed it will be below the level of the bottom surface of the footing and shall have perforated pipes installed with at least one set of holes facing downward. The perforated pipe shall be surrounded and set in a minimum 2" depth bed consisting of 3/4" minimum crushed stone free of smaller particles. The perforated pipe and crushed stone shall be surrounded by a filter membrane to prevent adjacent soil from washing into and clogging the French drain system. If another drainage system is chosen it shall have the approval of either Ronald J. Derrick or Pete Bambe and be done according to their instructions and/or best practices whichever is the higher quality way. Drainage should probably be directed to flow eventually into the drainage ditch along the east side of the property.

Site excavation shall be done in keeping with the recommendations of R. Derrick in his report, including the following. "The site has a forest topsoil zone that extends 30-36 inches below surface grade and requires overexcavation of at least this depth to expose subgrade soil suitable for an allowable bearing capacity up to 1,500 psf. The upper 3 to 4 feet of soil is susceptible to soil creep.... The building pad site shall require up to a 36 inch overexcavation to remove the forest topsoil zone and expose a weathered basalt subgrade that will consist of dark reddish brown clay with basalt fragments. Impact to the existing site vegetation shall be minimized as much as possible for construction of the residence. Live root systems tend to provide stability to slopes and reduce erosion. All foundations shall be founded in native soil, and it is recommended that a geotechnical engineer observe the foundation subgrade after overexcavation and prior to setting foundation forms. Permanent cut slopes are not recommended for this site, however, temporary construction cut slopes should be stable to a height of 6 feet provided they are laid back at 1:1 (horizontal:vertical). Site fill shall not be placed under structural foundations and should be confined to yard areas only. Fills in excess of 2 feet in depth should be placed in accordance with standard engineering practices, such as stripping of topsoil, toe keying and drainage, and compaction of the fill material. Surface water ponds shall not be created on the site and ponded water or excessive fill placement up slope of the site may induce movement of the underlying landslide debris. The drainage channel on the east side of the site shall not be blocked or filled in. Footings should be reinforced with at least three #4 steel reinforcing bars placed parallel in the footing." Other considerations may be recommended by Pete Bambe concerning placement, preparation, and construction of piers and footings for the majority of the house foundation, and shall be carefully followed.

Topsoil may be piled on site, but only where it will not adversely affect trees or their roots. Trees need protection of one foot per inch of trunk diameter. Any other excavation waste that is not needed for good grade contouring shall be hauled off site.

All lumber scraps, wood debris, stumps, etc., shall be kept out of the backfill around the foundations.

The soil shall not be treated with any manufactured chemical treatment. If pesticide treatment is deemed necessary, sand surfaces under floors and walkways may be treated with diatomaceous soil. (Inhaling dust from diatomaceous soil is hazardous and proper precautions should be used during application.) Additional termite protection can be achieved through the use of 4" sand barriers, metal shields, or placing wood portions of the buildings no closer than 18" from the soil. Most importantly, there should never be any direct contact between wood and soil unless the wood is termite resistant.

If means other than those outlined here are desired to accomplish the same ends, written permission from the owner may be sought.

Concrete slab foundation for the Shop

The slab shall be constructed in accordance with *Super Good Cents Builder's Guide* standards or better. This shall include a 4" radon removal tube that has small perforations along its length, connected to a non-perforated pipe that runs up through the slab and, at this stage, is capped. Later, if radon is detected inside the shop, a pipe can be connected to the stubbed pipe and vented to the outside with a fan. (For more information about radon removal, see pp.169-170 and 174 *The Healthy House* by John Bower, pp. 71-72 of *Healthy House Building for the New Millennium* by John Bower, pp. 49-50 (the last part of Chap. 3) of the *Super Good Cents Guide*, and the enclosed booklet entitled 'Building Radon Out.'). A 4"-5" layer of gravel meeting the requirements on pp. 49-50 (the last part of Chap. 3) of the *Super Good Cents Guide* shall be placed under the slab, then a polyethylene moisture barrier, 6 mil is preferred to 4 mil, followed by a 2" layer of sand or rigid insulation such as extruded polystyrene foam. To prevent cracks forming in the slab it should be reinforced in some way, either with rebar or welded-wire reinforcing fabric, and the concrete should be mixed with the proper amount of water and cured as slowly as is practical. If isolation joints are used, they should be made airtight by casting flexible waterstops between abutting slabs during construction. Since the shop will be heated, insulation will be required. Appropriate dampproofing and moisture barrier measures must also be taken around the perimeter or stem wall, and possibly insulation. All penetrations through the slab shall be sealed to create an airtight barrier. For a suggestion as to how to seal the toilet drain see pp. 70-71 of *Healthy House Building for the New Millennium* by John Bower or Chapter 6 of the *Super Good Cents Guide*.

Concrete

The concrete used as the *shop foundation, carport, and walkway from the carport to the house* may contain admixtures as are necessary and customary, but otherwise will be made as specified for the house foundation wall.

In order to prevent contamination of the house indoor airspace by the concrete in *the foundation wall along the north side of the house*, the concrete used there shall be as follows: Type I Portland cement produced in a kiln **not** fueled by coal, coke, or hazardous waste. Natural gas or electricity is preferred. Only clean, natural mineral aggregates are acceptable. Such other aggregates as crushed brick, crushed sandstone, crushed concrete slag, fly ash, cinder, and volcanic material (other than pumice) are unacceptable. Water suitable for drinking shall be used. Water stored in gasoline or oil cans should never be used. No admixtures shall be used unless approved by the owner. To avoid the need for them the concrete should be poured in warm enough weather and cured slowly.

New, unused forms are preferred. New forms may be lined with vegetable oil, such as Wesson oil; or Bio-Form, a release agent derived from canola oil by **Leahy-Wolf**, 1951 N. 25th Ave., Franklin Park, IL 60131, 847-455-5710 or 708-432-0020, www.leahywolf.com; or **Shaklee's** Basic H, 877-627-1804, 877-277-7188, 888-424-4074, or 877-4shaklee, www.shaklee.com. If the forms are removed the day after the concrete is poured and immediately cleaned, release agents may be unnecessary. If previously used forms must be used, and they have been treated with a release agent derived from a petroleum product, they shall be lined with plastic sheeting.

Special chemical curing compounds shall be avoided except for sodium silicate or potassium silicate mentioned below. Instead, the concrete should be kept damp for several days, such as by spraying it with water and covering it with a sheet of plastic, and cured slowly.

The concrete used for the *piers* may contain necessary admixtures for strength, frost-proofing, proper curing, water sealing, and the minimizing of cracks, but will otherwise be as for the house foundation wall.

Concrete Sealants

If a sealant is needed *for the house foundation wall* only sodium silicate or potassium silicate shall be used. Sodium silicate, also known as water glass, is widely distributed in hardware and ceramic supply stores. It reacts with the calcium in concrete and forms a crystalline structure in the surface. This not only seals the surface, but it helps to cure and harden the concrete as well. (It also seals a floor to minimize wear due to foot traffic.) A drawback is that some paints or sealers don't always adhere well to concrete once it's been coated with sodium silicate. Sodium silicate is available from **AFM**, American Formulating and Manufacturing, 3251 3rd Ave., San Diego, CA 92103, 800-239-0321 or 619-239-0321, www.afmsafecoat.com, in 2 consistencies, Penetrating Water Stop has a thin formula to soak in easily, Water Shield is thicker for use more as a surface coating. (AFM products are also available from Greater Goods, Eugene, OR, 541-485-4224, Environmental Building Supply, Portland, OR, 503-222-3881, www.ecohaus.com, and a new company in Corvallis, Your Green Home, 541-754-7336.) **Aqua Mix**, P.O. Box 4127, Santa Fe Springs, CA 90670, 800-366-6877 or 562-946-6877, www.aquamix.com, (or Home Depot and Lowe's) has a thin-bodied product called Penetrating Sealer, which is Potassium silicate. A very similar product is available from **Concure**, 330 Pusey Ave., Collingsdale, PA 19023, 800-925-7746 or 610-461-6490, www.concure.net; however, it is an admixture made of Potassium silicate which can be mixed into wet concrete or grout before it is placed (10 oz.

per 100 pounds of grout). **Concure**'s Concrete Flooring Sealant can be applied to concrete or grout after it has hardened.

Other sealants that may be used for the *shop floor and the piers* include Vocomp-25, a water-based acrylic concrete sealer made by **W.R. Meadows**, 865 Teal Drive, P.O. Box 907, Benicia, CA 94510, 800-342-5976 or 707-745-6666, www.wrmeadows.com; Weather-Bos Masonry Boss Formula 9, a water-reducible sealer for above-grade concrete and masonry surfaces by **Weather-Bos International**, 316 California Ave., Suite 1082, Reno, NV 89509, 800-664-3978, www.weatherbos.com; and Xypex Concrete Waterproofing, an EPA approved sealer for concrete potable water containers that protects concrete against spalling, efflorescence, and other damage caused by weathering and bleeding of salt by **Xypex Chemical Corp.**, 13731 Mayfield Pl., Richmond, BC, Canada V6V 2G9, 800-961-4477 or 604-273-5265, www.xypex.com.

And finally, care must be taken to avoid spills on concrete because it can be very difficult to completely remove all residual traces of the contaminant.

If means other than those outlined here are desired to accomplish the same ends, written permission from the owner may be sought.

Subfloor

Wherever the ground is within 6 feet of the joists under the subfloor, a groundcover with a perm rating of 1.0 or less and rugged enough to withstand foot and knee traffic, such as 6 mil polyethylene, will be properly laid with at least 6 inches of overlap. Because of the pier foundation, the subfloor will need to be well insulated, tightly constructed, and fitted on the interior side with a diffusion retarder. The pipes and ducts running under the floor will also need to be insulated, and the whole thing protected from animals, insects, spiders, etc. on the exterior side by covering it with a barrier such as exterior grade plywood or a rodent-proof fabric. Floor insulation shall meet the requirements of the 1994 *Super Good Cents Guide* or better. It may need to be upgraded to offset energy losses from the aluminum-framed windows. See Chapter 10 for its guidelines and methods. Charlie Stevens of the OR Department of Energy, 800-221-8035, recommends insulating with a structural panel floor, a 28' wide, polystyrene foam and plywood sandwich, 10" thick to give R-50 insulation. It would need support every 20', and the rodent-proof barrier.

The subfloor plywood shall be exterior grade. It shall have been aired out by cross stacking it onsite for a few days prior to installation. An acceptable alternative would be to use solid-wood boards. This usually involves 1x8s, laid diagonally, and nailed at each joist (with a small amount of space between each board to allow for expansion if the subfloor gets rained on while the house is still under construction), pp.233-234 Bower's *Healthy House*. It may be made airtight with foil-faced cardboard, and the wood floor laid directly on it. No interior grade plywood, particle board, OSB or similar wood products containing urea formaldehyde glue will be used.

Most of the house interior floor will be #2 maple, solid wood. A diffusion retarder will be installed under the wood. Under it may be a layer of asphalt impregnated felt paper (to seal nail holes) with a layer of builder's foil on top of that and just beneath the finish floor

wood. (This may seem excessive, but I need separation from the asphalt felt paper as well as from the insulation and plywood.) **Denny Wholesales Services**, 141 NW 20th St., Suite B9, Boca Raton FL 33431, 800-327-6616 or 561-750-3705, www.dennywholesale.com. makes Denny Foil, a light weight foil/kraft paper product, but it is fairly easily torn. It may be purchased from E.L. Foust Co., Inc., P. O. Box 105, Elmhurst, IL 60128, 800-353-6878, www.foustco.com; from The Living Source in Texas, 254-776-4878, or from Building For Health in Colorado, 970-963-0437. **Advanced Foil Systems**, 820 S. Rockefeller Ave., Suite A, Ontario, CA 91761, 800-421-5947 or 909-390-5125, www.afs-foil.com, offers a durable Aluma-Foil product that is lightweight foil-faced paper. (Their Super Plus, a sandwich of polyester and foil, is not recommended for chemically sensitive people.) Or, as an alternative to the asphalt paper and builder's foil, the considerably sturdier foil-faced cardboard may be used. All of these will need to be sealed together with an aluminum foil-faced tape, such as Polyken tape. It can be purchased from the same places as well as from local building supply stores. Also www.venturetape.com sells 5520 2mil aluminum foil tape, and 3520CW HVAC aluminum foil tape, both of which work well even at low and high temperature extremes. Samples may be obtained at 800-343-1076.

The floors in the bathrooms, utility room, mechanical room, mudroom/entry, and a section near the main double entry doors on the east side of the house will be ceramic or porcelain tile. Under the tile, a layer of water-resistant cementitious board such as Durock, Hardibacker Board, or PermaBase will be required, or possibly the lightweight, highly water-resistant Cemrock. Please see **Flooring** below for more information. Some provision will be made to protect the mechanical room and utility room from water leaking from major appliances, such as a floor drain or drain pans.

If the second story subfloor is also made of exterior grade plywood, similar diffusion retarding layers will also be necessary on top of it to prevent outgassing upward. To prevent outgassing downward either attach builder's foil to the bottom of the plywood or use foil-backed drywall on the ceiling. If the joists between the ceiling and floor are manufactured rather than solid, untreated wood, the foil-backed drywall will be used.

All penetrations of the subfloor, such as electrical, plumbing, and ducting, must be carefully and fully sealed to create an airtight barrier. Gaskets, aerosol foam, and caulking may be used as advised in the references.

If means other than those outlined here are desired to accomplish the same ends, written permission from the owner may be sought.

Airtight Drywall Approach

Houses are currently being tightly constructed for energy savings, freedom from drafts, and to solve moisture problems throughout. One approach to tight construction is variously called the "Advanced Drywall Approach," the "Airtight Drywall Air Barrier," or the "Airtight Drywall Approach," and collectively, "ADA." I have chosen it for the above reasons and because of its ease of use, applicability to our climate, and, most especially, the fact that, in conjunction with a diffusion retarder, such as foil-backed drywall, it greatly slows the entry of air pollutants emitted by building materials located in the insulated

cavities. The most important aspect of all airtight sealing is that it must be conscientiously applied so that the air barrier is continuous. Therefore, special measures must be taken at various stages throughout construction. Rather than attempt to cover every instance in this paper I refer you to the following references: pp. 150-156, and 232 and 234 of *The Healthy House* by John Bower; pp. 166-168 and 187-197 of *Healthy House Building for the New Millennium* by John Bower; and in the *Canadian Home Builders' Association Builders' Manual*, pp. 77-84 in Chapter 6, pp 101-110 and 114 (area under bathtub) in Chapter 8, and pp. 161-166 in Chapter 10, as well as pp.128-140 and 148-153 of Chapter 9 which covers foundations. Information about sealing and insulating engineered wood floor joists may be found on pp. 169-172 of the *Canadian Manual*. The *Super Good Cents Guide* has good explanations and illustrations throughout, but especially see Chapter 6 for instructions about plumbing penetrations and Chapter 9, Air Tightening Specialist. Note, however, that I prefer to use foil-backed drywall as the diffusion retarder instead of polyethylene sheeting. I urge you to thoroughly familiarize yourself with the recommended techniques before you let bids from your subcontractors, because some of the techniques will require their cooperation. (For example, John Bower, on pp. 112 & 191 of *Millennium*, recommends adhering 3/8" x 3/8" Sure Seal foam gasketing tape by **Denarco, Inc.** to the face of the bottom plate before hanging the drywall, then nailing it in order to compress the gasket tightly.)

The mechanical room, because it will contain gas appliances, several other major appliances, and will store cleaning and other chemicals I do not want in the house, will be effectively separated from the rest of the house with airtight sealing and diffusion retarding techniques. It will be insulated and have a separate ventilation system, and, if necessary, heating system.

I cannot overestimate the importance of the airtight concept. Even if everything else in the walls, ceilings and floors were completely healthy, the insulation alone with its high formaldehyde content would need to be completely closed off from the living space. And sealing holes is far more important than retarding diffusion. It is estimated that 99% of the moisture and pollution travels through holes in the structure because of air-pressure differences and only 1% because of diffusion through seemingly solid materials. So making sure things are effectively sealed throughout the construction process may be the most important thing you can do to make this a healthy house.

See also Appendix II, 'Good Cracks, Bad Cracks,' by Jim White.

Gaskets, aerosol foam, caulking, and adhesives

For a thorough discussion of these products, see pp. 278-280 of *The Healthy House* by Bower. Products acceptable to me include the following:

Caulking:

100% silicone in most applications

AFM Safecoat Caulking Compound, a water-based elastic emulsion. (See address for AFM under adhesives below.)

Silicone Plus, a paintable, water-soluble silicone sealant from **Dow Corning**, 800-634-8382.

DAP Titanium Kitchen and Bath Silicone Sealant where water and mildew resistance is desired, and **DAP** Paintable Kitchen and Bath Silicone Sealant. **DAP, Inc.**,’s customer service # is 800-327-3339 and their technical services # is 888-327-8477, www.dap.com.

Weatherall UV Guard Premium Caulking if necessary to provide UV protection. This is an acrylic/latex sealant. **Weatherall Co., Inc.**, 106 Industrial Way, Charlestown, IN 47111, 800-367-7068 or 812-256-3378, www.weatherall.com.

One-part urethane caulking is not acceptable.

All caulks shall be applied with plenty of ventilation.

Aerosol Foam: Most are acceptable once cured and since they are not directly exposed to the living space. Plenty of ventilation will be used during application.

Gaskets:

Sure Seal foam gasketing tape by **Denarco, Inc.**, 301 Industrial Dr., Constantine, MI 49042, 269-435-8404;

Shelter Supply, 151 East Cliff Rd., Suite 30, Burnsville, MN 55337, 877-207-7043, 800-762-8399 or 612-898-4500, www.sheltersupply.com, has EPDM synthetic rubber plate gaskets for sealing between the bottom plate and the wall plate that respond to building expansion and contraction to maintain airtight seal. They come in sizes 1” x 328’ for \$60.42 per roll, 3” x 164’ for \$83.66 per roll, and 5” x 82’ for \$55.78 per roll. Shelter Supply also sells Illbruck Window Flashing Tape.

Pages 94-94 of the *Canadian Builder’s Manual* gives desirable characteristics of gaskets.

Adhesives: Adhesives can be particularly polluting materials. Nevertheless, there are quite a few safe ones.

AFM, 3251 3rd Ave., San Diego, CA 92103, 800-239-0321 or 619-239-9321, www.afmsafecoat.com., produces a low-tox Safecoat 3-in-1 adhesive suitable for a variety of applications. For local suppliers see reference on p. 7 under Concrete Sealants.

Chicago Adhesive Products Co. (1105 S. Frontenac St., Aurora, IL 60504, 800-621-0220 or 630-679-9100, www.chapco-adhesive.com.) manufactures several adhesives that have low-VOC emissions, are non-flammable, and have anti-microbial properties. Their product line includes multi-purpose adhesives, a cove-base adhesive, pressure-sensitive adhesive, clear-spread adhesive, and a ceramic-tile adhesive. They contain no solvents or carcinogens.

Dap, Inc., 2400 Boston St., Suite 200, Baltimore, MD 21224, 800-543-3840, customer service, 800-327-3339, technical service, 888-327-8477, www.dap.com, has some low-tox adhesives. They have a white glue (Weldwood Hobby’n Craft Glue) and yellow glue (Weldwood Carpenter’s Glue) that can be used for general purpose projects or cabinet making. They also have a low-VOC water-based contact cement and a construction adhesive.

Elmer’s Products, Inc., 180 E. Broad St., Columbus, OH 43215, 800-848-9400 or 614-224-7689, www.elmers.com, makes several low-emission adhesive products, including a white glue (Elmer’s Glue-All), and yellow glue (Elmer’s Carpenter’s Wood Glue) that are

both widely used in cabinet making and general purposes. Elmer's Saf-T Contact Cement can be used to adhere plastic laminates to wood and with leather, polystyrene, and metal.

Franklin International, 2020 Bruck St., Columbus, OH 43207, 800-877-4583 or 614-443-0241, www.titebond.com, has a low-odor, water-based Titebond Solvent-Free Construction Adhesive that is actually stronger than many solvent-based products, and is well tolerated after curing. They also offer a solvent-free water-based contact adhesive that works well in a variety of applications. Other solvent-free products include a Cove Base Adhesive, an FRP Adhesive, a Subfloor Adhesive, and a yellow carpenter's glue (Titebond II Wood Glue) that is weatherproof, making it suitable for outdoor use.

OSI Sealants, 7405 Production Dr., Mentor, OH 44060, 800-321-3578, www.osiproseries.com, has a water-based subfloor and deck adhesive, SF550. Local hardware stores and large chains may also have it.

W.F. Taylor Co., Inc. (11545 Pacific Ave., Fontana, CA 92337, 800-397-4583 or 909-360-6677, www.wftaylor.com) produces a line of Envirotec Healthguard adhesives that contain no solvents, alcohol, glycol, ammonia or carcinogens. They have a Multi-Purpose Adhesive, Bond-N-Peel Pressure Sensitive Adhesive, Bond-N-Peel Top Bond Adhesive, Clear Thin Spread Adhesive, Latex Additive Floor Sealer, and Cove Base Adhesive.

All adhesives will be applied with plenty of ventilation.

Lubricants: These are often very odorous and they can contaminate the indoor air. Acceptable alternatives are:

E-Z-1 Inc. has the low-odor E-Z-1 Lubricant available in some hardware stores or it can be mail-ordered from **E.L. Foust Co. Inc.** (P.O. Box 105, Elmhurst, IL 60126, 800-353-6878 or 630-834-4952, www.foustco.com).

Pharmacy-grade mineral oil can be obtained through drug stores.

Whichever product is chosen, it will be applied according to the manufacturer's directions and only with plenty of ventilation.

If product substitution is desired, an MSDS will be provided, and, if possible, a sample to test. Written permission will be given by the owner if it is acceptable.

Windows

At this point, due to my undeniable reactions to both vinyl and fiberglass windows, and my reluctance to use wood windows because the wood requires preservatives, fungicides, pesticides, etc., as well as painting, it looks as if it will be necessary to use only aluminum framed windows. These of course should be of the highest thermal quality as is practical. This also means that extra thermal upgrades will be necessary in other parts of the house. The Advanced Drywall Approach described in Chapter 9, p. 174 of the *Super Good Cents Guide* should help here. It is also possible that the use of a high efficiency water heater and HRV/heating system will be considered in the equation. The Community Services Consortium in Corvallis, 752-1010, will be able to help calculate what measures can be taken to offset the energy losses from the metal-framed windows.

Vinyl windows may be used in the Shop.

Doors

I have chosen metal doors for the exterior doors because they are relatively inert, provide good insulation and sealing, and are low maintenance. These should be painted early in the building process so they can outgas before installation. Better still, they could be painted and baked on in an auto-body shop, if the manufacturer does not advise against it. To enhance security, exterior doors will have locks with strengthened strike plates and three-inch screws to hold the strike plates in place.

Interior doors will be made of primarily solid wood. Simpson wood doors with raised panels and/or glass are acceptable. These also should be ordered early, finished with an acceptable finish, and allowed to outgas before installation. Extra care will be taken to seal the top, bottom and side edges with the finish to prevent outgassing of noxious materials inside parts of the doors.

An inch of clearance between the bottom of each of the interior doors and the floor will be necessary for proper ventilation. See section on **Heating and Ventilation**.

Plumbing

Intake or supply lines will be copper unless otherwise approved by the owner. Good ventilation will be employed during use of solder and flux. According to the *Super Good Cents Guide*, "The best way to prevent pipe freezing is to locate pipes directly under the subfloor so that floor insulation is between the pipes and the crawl space. That way heat from the house keeps pipes warm even in the coldest weather. Keep pipe runs in exterior walls to a minimum. Pipes are less likely to freeze if high R-value insulation is placed between them and the exterior wall." Hot water pipes will be insulated, and any others wherever sweating or dripping from condensation may occur.

Drain lines and vent pipes may be plastic. Please use ABS rather than PVC pipe if practical. Good ventilation will be used during installation. Acceptable cleaners and glues include the LO-VOC versions made by **Oatey Co.**, 4565 Industrial Parkway, Cleveland, OH 44135, 800-321-9532 or 216-267-7100, www.oatey.com. **Oatey Co.**'s local distributor is Western State Sales in Washington, Tim is the one to speak with at 253-893-1695. They can also often be found at Home Depot, Lowe's and local hardware stores. Gorilla PVC glue made by **The Gorilla Group**, P.O. Box 848969, Hollywood, FL 33084, 888-367-4583, gorillapvc.com, may only be used on PVC pipe; it melts ABS pipe. It may be obtained through Thrifty Plumbing and Heating Supply in Eureka, CA, 707-443-8095. No cleaner and no primer are required before its use, but the pipes should be clean. Gloves should be worn. A week of ventilation is recommended.

Water was collected from the well on 10-30-1992 by M & H Well Drilling and tested by Waterlab Corp. in Salem, OR. The results showed slightly elevated pH levels, considerably elevated iron and iron-utilizing bacteria levels, and slightly elevated manganese. When the well flow test began a sulfur smell was detected. Therefore, some sort of water treatment will probably be needed, so plumbing provisions should be made. A pressure tank will also be required; the well will need a pump and insulated pump house; and a gas, sealed combustion water heater will be needed. The water heater will provide heat through a heating coil for the house furnace as well as for domestic use, so it will need to be sized accordingly.

The water heater will be high-efficiency, natural gas, sealed-combustion, direct-vent or power direct-vent with both a sealed intake air pipe and a separate sealed exhaust air pipe. It will have an electronic ignition instead of a pilot light, and a glass tank liner. Possible suppliers include

GlowCore A.C. Inc., 4007 Platinum Way, Dallas, TX 75237, 800-676-4546, www.glowcoreac.com, has a direct CPVC vent water heater, GWH150, with an electronic ignition, heat exchanger and blower. Glass-lined? They also sell boilers.

A.O. Smith Water Products Co., 600 E. John Carpenter Fwy., Suite 200, Irving, TX 75062, 800-433-2545 or 972-719-5900, www.hotwater.com, has a power direct vent water heater with closed combustion, glass-lined, (electronic ignition?) for \$1348 list price, available from Ferguson Enterprises in Corvallis, 757-4870. For more information contact Casey or Mike at 503-238-0313.

State Industries, Inc., 500 By-Pass Rd., Ashland City, TN 37015, 800-365-0024 or 615-792-4371, www.stateind.com, has a direct vent water heater with a glass liner and a power direct vent one with a glass liner. Electronic ignition? They distribute through GENSCO in Salem, 800-359-1743. For more information contact Oregon Cascade Plumbing, 503-588-0355.

Shelter Supply, 800-762-8399, www.sheltersupply.com, sells a variety of high efficiency Marathon water heaters.

“Plumbing walls contain penetrations to the crawl space for water and drain lines and penetrations to the attic for the vent stack. The penetrations create hidden air leakage routes. They’re called ‘thermal bypass routes’ because they can create cold chimneys in interior walls for airflow between the attic and crawl space. Air leakage through plumbing walls bypasses the home’s insulation system. Insulation in the floor or ceiling does not stop air currents moving through the plumbing wall. Only specific air sealing measures can stop air leakage. Care by the plumber can significantly reduce air leakage at plumbing penetrations. Big holes are hard to seal. Cut holes for plumbing penetrations carefully to closely match the size of the pipe. It makes air sealing easier. It’s hard to seal the tub penetration. But in energy efficient homes, it can be the largest single leak in the whole building. Air sealing the tub penetration cuts off a significant air path from the unheated crawl space into interior plumbing walls. If the tub is mounted on an accessible platform, with the p-trap above the floor, the tub penetration is much easier to seal.” 1994 *Super Good Cents Builder’s Field Guide*, p.123 (Chapter 6). See figures 6A and 6B of the *Guide*. “The tub penetration is difficult to seal once the plumbing and tub are in place. It’s best handled by the plumber during tub installation. See Chapter 6 for tub sealing details. If gaskets aren’t used, install a separate cover around the pipes by boxing them in with framing and sheathing to completely seal the opening.” p. 169 (Chapter 9) *Super Good Cents*. See also p. 114 in the *Canadian Builders’ Manual*. Vent stacks will also need to be sealed, preferably with flexible gaskets and sealant. Caulk or expanding foam will be adequate for most other plumbing penetrations. **Ryeco Products**, 1 Church St., #10, Keswick, ON, L4P 3E9, Canada, 800-263-2054 or 905-476-5336, www.oikos.com/esb/42/plumbseal.html, offers an off-the-shelf air sealing solution for pipes and vents. Plumb Seal is a 6” square of ABS plastic with a collar that clamps around pipes. Drywall presses against strips of neoprene foam to make an air seal—no caulking is necessary. The 1-1/2” model fits drain pipes, the 3” model fits vent

stacks. They have slits for slipping around pipes already in place. Both sell for \$2.99 to contractors.

The connection between the floor and the toilet can be made airtight by injecting a single-component polyurethane aerosol-foam insulation into the space under the flanges. When it is hard the excess may be trimmed and the toilet seated as usual with a wax seal.

A leak test will be performed in the presence of the general contractor and the owner at the appropriate times during plumbing installations.

Electrical

Wherever the interior walls, floors, or ceilings are penetrated, the holes will be carefully sealed airtight. Plastic airtight outlet and switch boxes will be used in the interior and all recessed can lights will have airtight housing. Airtight electrical boxes are sold by **Thomas & Betts**, 2233 Argentia Rd., Suite 116, Mississauga, ON, Canada L5N 2X7, 905-858-1010 (Nu-tek brand)--their U.S. Distributor can be reached at 800-816-7809; **Ryeco Products**, 1 Church St., #10., Keswick, ON, Canada L4P 3E9, 800-263-2054 or 905-476-5336, www.oikos.com. (R & S Enviro brand); and **Minnesota Electric Supply**, North Highway 29, Alexandria, MN 56038, 800-862-1671, 320-763-5131, www.mnelectric.com, (Union Airtight Boxes). However, if these airtight electrical boxes aren't sealed properly, or if they develop a leak after installation (perhaps resulting from a loose gasket) they can't be easily resealed—unless you tear out some of the drywall. There is a Lessco plastic box from **Low Energy Systems Supply Co., LLC**, W. 1330 Happy Hollow Rd., Campbellsport, WI 53010, 920-533-8690, www.lessco-airtight.com, that can be used to make a conventional plastic or metal electrical box airtight. If a Lessco box develops a leak, it can be made airtight by drilling a small hole next to the electrical box, and injecting some urethane foam into the space between the Lessco box and the electrical box. A variety of these types of energy-related construction products can be mail-ordered from **EFI**, 40 Washington St., Suite 2000, Westborough, MA 01581-1013, 800-876-0660 or 508-870-2277 www.efi.org; or from **Shelter Supply**, 151 East Cliff Rd., Suite 30, Burnsville, MN 55337, 877-207-7043 or 612-898-4500, www.sheltersupply.com. Since only *grounded metal* electrical boxes and bushings will be used in the 2 bedroom areas, the Lessco boxes will need to be used with those. An airtight electrical box is illustrated on p. 172 and explained on p. 174 of Bower's *Millennium*.

Most of the recessed ceiling lights on the market are quite leaky. They can allow excess heat and moisture from the living space to enter the attic, causing energy loss and damage. It's been estimated that a single leaky recessed ceiling light is responsible for \$5-\$30 worth of energy per year being lost. Therefore, all recessed ceiling lighting will be airtight. Airtight recessed fixtures are available from **Hubbell Lighting** (ICX7-ES, ICX&-ES2), 2000 Electric Way, Christiansburg, VA 24073, 540-382-6111, www.hubbell-ltg.com, or from Melcar NW, Portland, OR, at 503-233-8755, Debbie, Alan, or Tish; **Juno Lighting** (Air-Loc), 1300 S. Wolf Rd., P.O. Box 5065, Des Plaines, IL 60017-5065, 800-323-5068 or 847-827-9880, www.junolighting.com; distributors include, in Salem, EOFF Electric, 503-363-9251, and The Lighting Gallery, 503-354-2715; in Eugene, EOFF Electric, 541-342-1277, Brighter Home Lighting, 541-343-2556, and CED 541-683-2474; and **Cooper**

Lighting (Halo AIR-TITE), 1121 Highway 74-S, Peachtree, GA 30269, 800-334-6871 or 770-486-4800, www.cooperlighting.com.

The other issue with electrical wiring is electro-magnetic fields, EMF. While the effects of high voltage power lines on the body are well-documented, less is known about the effects of low level EMFs. A few people are unusually sensitive to electric and magnetic fields, and from them we have learned that even low-levels can be detrimental. The general consensus is that long-term exposure to low EMFs is more dangerous than short periods of higher EMF exposure, such as that encountered during the use of high energy appliances. For example, 8 hours of exposure to a 3mG. field is thought to pose greater risk than a few minutes of exposure to an 80mG. field. In late 1992 a major Swedish study found that children exposed over long periods to 3mG fields had almost four times the expected rate of leukemia as children in the general population. If wiring is properly done in a building, overall EMFs will be very low. However, prudent avoidance suggests one should avoid prolonged, unnecessary exposures whenever it is reasonable to do so. Therefore, extra measures will be taken as follows:

All wiring shall be performed in strict accordance with the National Electric Code.

All utilities, including telephone, cable TV, gas, and water, shall enter the house at approximately the same location, within a 4-foot radius.

All utilities entering the house shall be properly bonded immediately prior to entry in accordance with the electrical code.

Bonds or grounds shall occur at only one point along each utility in accordance with the electrical code.

All utilities shall be tested with a gaussmeter when the house power is turned off. If magnetic fields are detected, the owner shall be informed as soon as possible.

Panels and subpanels shall be configured so that hot and neutral field cancellation are possible. The following panels and subpanels are acceptable: Siemens EQIII, standard load center electrical panels, and subpanels with split neutral. **Siemens**, 2880 Sunrise Blvd., Rancho Cordova, CA 95742, 800-964-4114, www.sea.siemans.com, or **Siemens**, Mike Powers, 6427 NE 59th Pl. Portland, OR 97218, 503-335-7730. Siemens EQIII is also available in many home improvement store chains, such as Home Depot.

Hot and neutral wires from the same run are to be installed adjacent to one another.

Wire lengths shall be equal.

The ganging of neutral wires from different branch circuits is prohibited.

Edison circuits are prohibited. (Edison circuits occur when three-wire Romex is used to create two 110-volt circuits and the single neutral wire is shared.)

Bonding screws shall be removed from the neutral bus of all sub-panels per manufacturer's instructions.

When wiring a ½ switch outlet using two separate breakers for each half of the outlet, the two neutral wires must not make electrical contact. This is accomplished by breaking off the pre-scored conductive tabs between the two sections of the outlet per manufacturer's instructions.

Neutral wires on ½ switched outlets shall not be mixed. They shall remain paired with their corresponding hot wire.

When wiring enters an electrical box from more than one circuit, care shall be taken to ensure that the wires from the different circuits are isolated from one another so that

electricity return paths are not shared. One good way to ensure that return paths are not shared is to install electrical wiring so that all wiring entering an electrical box is from the same circuit.

Three-wire Romex shall be used between the switches when wiring a three-way switch. If alternate wire is used, it shall be twisted.

Each three- or four-way switch must be controlled by a single breaker.

All wiring for three- or four-way switches shall be contained in a single run of wire or a single metal conduit. All runs not in a conduit must be bundled.

Metallic gas and water lines shall have dielectric unions installed wherever they enter into contact with any electrical appliance, when it is permitted by code.

No dimmer switches will be installed in the house.

No ionizing smoke detectors will be installed, only the radiation free photoelectric smoke detectors are acceptable.

In addition the following precautions will be taken to reduce EMFs in the bedrooms even further:

The power panel, refrigerator, washer, dryer, TV, computer, etc. will be located as far from the bedrooms as is reasonable.

Wiring will not cross over, under, or behind the bed footprints or the west deck and balcony.

No wiring will run through the ceiling of the downstairs bedroom suite (bedroom, bathroom, and closet) because it is the floor of the upstairs bedroom suite.

No three- or four-way switches will be installed in the upstairs and balcony or in the downstairs bedroom suite and west deck, with the possible exception of stairwell lighting if no other good solution is available. All of the upstairs and balcony, and the downstairs bedroom suite and west deck wiring will be installed in grounded, metal conduit or grounded, shielded cable that is a 3-wire cable with an outer aluminum sheath. (Corra/clad MC cable has a Flexi-rib aluminum sheath, insulation, and copper connectors. It can be furnished with a PVC jacket over the sheath for use in corrosive environments or direct burial. It is manufactured by **Coleman Cable, Inc.**, 1530 Shields Dr., Waukegan, IL 60085, 800-323-9355 or 847-672-2300, www.colemancable.com.) If wiring is run through a metal conduit, the metal housing of the fixture must be in electrical contact with the metal conduit in order to shield the occupied space from electric fields.

Only grounded, metal electrical boxes and bushings will be used in the upstairs and balcony, and the downstairs bedroom suite and west deck.

Metal structures in these areas will be properly grounded, i.e. aluminum windows.

All of the upstairs and balcony will be on its own circuit with no tie-ins. A demand switch, provided by the owner, will be installed on this circuit beside the main breaker panel, in accordance with the NEC or the instructions of Robert Stellar of the International Institute of Bau-Biologie and Ecology, Inc., 905-525-9584. This will be done in such a way as to ensure a complete shutoff of electrical current to the bedroom area whenever desired.

The downstairs bedroom suite and west deck will likewise be on its own circuit with no tie-ins. The reason for this is so that in the future it will be simple to install a demand switch on this circuit as well.

If means other than those outlined here are desired to accomplish the same ends, written permission from the owner may be sought.

The Shop will need to be wired for at least the following uses:

1. 240 volt AC single phase outlets for 1-1/2 hp. vacuum system, and a future table saw;
2. 120 volt AC for various power tools: an orbital sander, 2 grinders, 2 drills, a sabre saw, a circular saw, a sawsall, a belt sander, and a shopvac;
3. 120 volt AC for power bench tools: a second belt sander, 2 more grinders, a drill press, a 10' table saw and a router table;
4. 120 volt AC for a ceiling mounted air filter system, switched;
5. Installation of an electric wall cadet-style heater;
6. Two zones of ceiling mounted fluorescent lights.

After wiring is completed, the electromagnetic field will be tested throughout the house (and shop) with a gaussmeter while the house (and shop) has a minimum load of three amps at the distal end of each electrical circuit. Any elevated magnetic fields greater than 0.5mG will indicate the presence of net current which will be the responsibility of the electrical contractor to locate and eliminate. (The National Electrical Code prohibits the production of net current.)

Heating and Ventilation

All ductwork will be clean galvanized metal with no insulation on the inside. **(No ductboard shall be used anywhere in the system.)**

If any oily residue is present inside the new ducts it will be cleaned off with water containing TSP (tri-sodium phosphate, a cleaner often sold in paint and hardware stores), and well rinsed, or at a car wash and well rinsed.

Duct air sealing and attachment will be in compliance with the latest *Super Good Cents* guidelines. Refer to Chapter 7 of the 1994 *Super Good Cents Builder's Field Guide* and to the specifications updates posted on the Energy Efficiency web site, www.bpa.gov or call 503-230-3158 for information. Include all supply and return ducts, the air handler, and the plenum connections, as well as all prefabricated joints, field joints, corners, longitudinal seams, and splices. All joints must be mechanically fastened. Various construction guides encourage the use of a water-based duct sealing mastic rather than either fabric or aluminum foil duct tape. If duct tape is used instead of mastic, it must be of high quality and used only on new and very clean surfaces. Please see p. 130 of *Super Good Cents*, p. 176 of Bower's *Millennium*, and pp. 316-317 of the *Canadian Builders' Manual*.

Acceptable duct sealing mastics are RCD #6 from **RCD Corp.**, 2850 Dillard Rd., Eutis, FL 32726, 800-854-7494 or 352-589-0099, www.rcdmastics.com (RCD #6 mastic may be purchased from the website or through GENSCO in Salem, OR, 800-359-1743, or GENSCO in Tacoma, WA, 253-926-2025); Kingco 11-600 from **Kingco Adhesives**, Div. of TACC, Air Station Industrial Park, Rockland, MA 02370, fax 800-233-8171, www.taccint.com; and Safecoat DynoFlex Textured Natural from **AFM**, 3251 3rd Ave., San Diego, CA 92103, 800-239-0321 or 619-239-0321, www.afmsafecoat.com. (AFM products are also available from Greater Goods, Eugene, OR, 541-485-4224, Environmental Building Supply, Portland, OR,

503-222-3881, www.ecohaus.com, and a new company in Corvallis, Your Green Home, 541-754-7336.)

Closed doors inside the house starve the return air ducts creating negative pressures. Therefore, free-flow will be created by either installing wall grilles or by cutting off the bottom of the doors so that 1-inch clearance remains. Super Good Cents recommends 1-inch of net free area for each cfm delivered to the room.

I have chosen to employ a combination Heat Recovery Ventilator (HRV), furnace, and filtration system made by Nutech Brands, Inc., 511 McCormick Blvd., London, ON N5W 4C8, Canada, telephone: 519-457-1904, fax: 519-457-1676, www.lifebreath.com, email: nutech@lifebreath.com. The nearest wholesale distributor is GENSCO in Salem, OR, 800-359-1743. The Lifebreath HRV replaces stale, polluted indoor air with an equal quantity of fresh air from the outside, allowing the two streams of air to pass on either side of an aluminum heat exchange core so the incoming cold air is warmed efficiently. The Lifebreath Clean Air Furnace uses hot water from the home water heater pumped to the furnace's heating coil where it warms the fresh air circulating through the furnace before sending it to registers throughout the house. Hot water is returned to the water heater where it becomes available for domestic consumption. The Lifebreath TFP (Turbulent Flow Precipitator) Air Cleaner removes particles from the air very effectively and efficiently. The addition of a carbon adsorption filter will remove fumes and odors from the incoming air as well. A space for this adsorption filter will be made by the installer.

Installation of the 3 units shall be in accordance with the manufacturer's instructions. Unless they are in conflict with the manufacturer's instructions, the following guidelines will be observed.

Supply air registers will be adjustable; exhaust air pick up registers will be adjustable; a warm side balancing damper will be installed in both the main supply and exhaust ducts.

The heating/ventilation/filtration system will be located in the insulated, and possibly heated, mechanical room; it will require a drain (for condensate), an electrical supply, and to be near the water heater (which will require a natural gas supply). It will be easily accessible for maintenance purposes.

All supply and return ducts shall be sealed with duct sealing mastic (or very high quality duct tape only on clean, new surfaces) at all joints, seams and splices in the ducts. The air handler and plenum connections at the air handler must also be sealed. All joints must also be mechanically fastened.

The control system should be capable of providing continuous low-speed operation as well as high-speed capabilities when needed, possibly manual override.

Air flow measuring stations shall be installed in the ducts such that all the supply and exhaust air can be measured; they shall be on the warm side of the HRV.

The 'cold side' ducts will connect the HRV to the outside, with one bringing in fresh air and the other exhausting stale air. The ducts should

- be as short and straight as practical;
- contain no kinks or depressions where condensate water might accumulate;
- be insulated on the outside with a minimum of R-2 insulation;
- be sealed from end-to-end (outside the insulation) with a vapor barrier;
- have their vapor barriers sealed to the vapor barrier of the house envelope;

be clearly marked as to which is for fresh air and which for exhaust air;
terminate in two accessible rain hoods, each equipped with a ¼-inch or coarser wire mesh bird screen. If finer insect screens are used, they must be accessible for regular cleaning.

The 'cold side' fresh air inlet should
be located according to the specifications supplied with the Lifebreath system;
be located away from sources of contamination such as carports, driveways, shop, garbage, dryer vents, central vacuum exhausts, plumbing vents, other vents, etc.;

The 'cold side' exhaust outlet should
be located according to the specifications supplied with the Lifebreath system;
be located away from walkways and other areas where ice accumulation could be a problem, and away from the fresh air inlet.

The 'warm side' ducts shall connect the HRV to the house, with one duct system distributing fresh air while a second collects exhaust air.

either an exhaust or a fresh air duct should be provided to every room and in accordance with the specifications supplied with the Lifebreath system;
duct systems should be designed to minimize their length and complexity;
only clean, unlined, galvanized metal ducts will be used;
where ducts run in unheated spaces they should be insulated to a minimum of R-11;
duct joints, seams, and splices shall be securely fastened and tightly sealed, as well as the air handler, and plenum connections at the air handler;

The 'warm side' exhaust ducts should
run from such areas as bathrooms, kitchen, utility room, and study (which rooms is open to discussion); (Low sone, high efficiency exhaust fans will be used, such as the Techgrilles or Quantum inline fan series from Nutech. Nutech also has one especially designed for use in the kitchen, apart from the range exhaust. Others may be acceptable as well.)

contain a filter in the duct or at the grilles if the HRV does not have a filter;
the general kitchen exhaust (connected to the HRV) must be at least 4 feet horizontally removed from the cooking surface.

The 'warm side' fresh air ducts shall distribute air throughout the house by the furnace fans.

The kitchen the range hood must **not** be connected to the HRV, but exhaust directly to the outside. The clothes dryer shall also be vented directly to the outside.

If means other than those outlined here are desired to accomplish the same ends, written permission from the owner may be sought.

Once the system is operational, the installer shall take the following steps:

Adjust the total airflow to provide the continuous ventilation rate at low speed as specified by the *Super Good Cents Guide*, or to provide 15 cfm per person (3 of us most of the time), or 1/3 of an air change per hour, whichever is greater; and increased capacity on a higher speed.

Balance the flow to equalize the flow rates of the fresh air and the exhaust air. This may be done by adjusting the warm side dampers in the main supply and exhaust ducts, and the registers at each supply air delivery port and the exhaust air pick-up points.

Ensure that the controls work as designed.

Mark the minimum ventilation settings on all dampers and speed controls so that they may be readjusted after the installation if necessary.

Instruct the owner in operation and maintenance and give her or the general contractor the warranty and instruction manuals for all of the system.

Central Vacuum

A central vacuum system will be installed that can reach into all areas of the house. Its dust receptacle will be in the mechanical room. The hose will have an on/off switch on the handle. Attachments shall include a bare floor brush, a power rug/carpet head, a furniture dusting brush, a fabric brush and a crevice device. A vac-pan is not needed.

Walls and Ceilings

See Appendix II page entitled “Good Cracks, Bad Cracks” by Jim White from p. 151 of Bower’s *The Healthy House*. It discusses the need to seal cracks in the building envelope exterior to the drywall. How to do this is further covered in the *Super Good Cents Guide*, the *Canadian Builders’ Manual*, and Bower’s books. While I do not mean to undermine the importance of sealing such cracks, I assume that the general contractor and subcontractors are familiar with this type of sealing. My primary concern is with building a nontoxic house; therefore, the rest of this section is only concerned with sealing the interior of the airspace.

Before adding the insulation or drywall, all wall cavities will be thoroughly vacuumed and free of debris.

Boric acid, Roach Prufe, or Victor Roach Killing Powder, will be sprinkled on the floor of all exterior walls of the entire house, inside the walls, to form a barrier to all roaches and ants that would enter.

The insulation may be chosen by the general contractor. All of the affordable ones are toxic, so regardless of the type used, an airtight barrier and a diffusion retarder will be required to prevent the insulation from polluting the indoor air.

A continuous airtight seal will be formed by a gasket or 100% silicone caulking placed between the floor and the drywall. A bead of caulking or a special gasket should have been placed on the subfloor before the wall frame was erected. Then, after the wiring, plumbing, insulation, etc., are installed, another bead of caulking or gasket is applied to the inside face of the lower 2 x 6 wall plate. When the drywall is installed, it will compress this second gasket, and will be sealed against the plate. So, by using just a few different materials, the floor is sealed to the lower wall plate, and the wall plate is sealed to the drywall, forming a continuous well-sealed surface. In order to compress the gasket tightly, extra nails should be driven through the drywall into the lower wall plate. It may also be necessary to drive

extra nails or screws into the flanges of the airtight electrical boxes in order to pull the drywall tightly against the gasketed boxes for an airtight fit.

Simply using paper tape and drywall joint compound in the standard manner will prevent air from moving between the sheets of drywall. With special provisions around electrical outlets, windows, doors, etc., this Airtight Drywall Approach can provide a continuous and tight air-pressure retarder. The foil backing on the drywall will create the diffusion retarder. It is much more important for the air barrier to be as nearly perfect as possible than for the diffusion retarder to be perfect. However, foil-backed drywall is a much better diffusion retarder than the sealing paints are, and much less toxic, so it will be used on all walls (and ceilings), both exterior and interior.

Please use metal corner beads on exposed outside corners, rounded rather than very square.

The drywall joint compound will be M-100 Hipo compound made by **Murco Wall Products, Inc.** It contains no antifreeze, adhesive, fungicide, preservatives, etc. It will probably have to be ordered direct from the manufacturer: **Murco Wall Products, Inc.**, 300 NE 21st St., Ft. Worth, TX 76106, 800-446-7124 or 817-626-1987, www.murcowall.com., local distributor is Murco Castaic, 30529 The Old Road, Castaic, CA 91384, 661-257-4296. The powdered compound is mixed with clean water on the job site, and it must either be used up each day or refrigerated. An approved equal that is also formulated with inert fillers and without formaldehyde, preservatives, adhesives, fungicides, etc., may alternatively be used.

If heat or dehumidification are required, electric appliances may be used. Heaters fueled by gasoline, kerosene, oil, or the like, are prohibited.

The joint compound will be completely dry before the application of primer.

In wet areas such as showers, and tub surrounds cementitious backer board without a paper backing will be used. Durock, Cemroc's low odor ultraboard, or an approved equal may be used. For more information see **Flooring** below.

All penetrations of the drywall, such as electrical, plumbing, or ducting, will be tightly sealed, whether in exterior or interior walls, or in ceilings.

Special measures will be taken to tightly seal around windows and doors, such as with gaskets, foam, caulking, etc. On pp. 191-192 of his *Millennium*, John Bower describes his use of single-component polyurethane aerosol-foam insulation to fill the space between the window frames and the wall framing. The next day he applied a Sure-Seal foam gasket around both sides and the top of the wall framing next to the window frame. Then when the drywall is attached to the sides of the window opening, it compresses the gasket, resulting in a perfectly airtight seal. To seal the space beneath the window sill, he suggests using foil-faced cardboard, taped with foil-faced tape around the perimeter for an airtight seal. The space between door frames and wall frames should be similarly filled with aerosol foam.

For suggestions for creating an airtight seal between walls and ceilings, please refer to Chapter 9 of *Super Good Cents*, especially pp. 174-176, 187-193, and, in Chapter 11, p. 216

entitled “Drywall Gaskets;” in the *Canadian Builders’ Manual* see pp. 231-235; and in Bower’s *Millennium*, see pp. 193-197. Please also see those references for suggestions about how to seal other wall and ceiling penetrations, because all penetrations of the drywall, such as electrical, plumbing, vents, or ducting, must be tightly sealed.

The Shop wall will be hung with drywall which will be sealed with tape and joint compound, but not smooth-finished or painted.

If means other than those outlined here are desired to accomplish the same ends, written permission from the owner may be sought.

At this point a blower door test will be performed according to the required protocol in the current *Super Good Cents Guide*. It can be found in the 1994 version, Appendix C. If it fails to pass the requirements for certification as specified in the current *Super Good Cents Guide*, remedial measures will be taken so that it does. Updated specifications may be found on the Energy Efficiency web site, www.bpa.gov. The required paperwork will be supplied so that the owner may take a deduction on her taxes.

The walls and ceiling will be primed and painted with approved products. (I am still in the process of choosing no-or low-tox paints.) Each coat will be thoroughly dry before the next coat is applied. Plenty of ventilation will be used. Electric heaters and/or dehumidifiers may be used as necessary.

Trim

All wood trim will be of solid wood, **not** a wood product such as MDF. Wood trim will be installed along the bottom of the walls and around all doors. The following windows will have surrounding trim: kitchen, great room, study, downstairs bathroom, and loft. Windows in the remaining rooms will have only wood sills and aprons: mechanical room, utility room, mudroom, downstairs bedroom and closet, upstairs bedroom, bath and closet.

Kitchen and Bathrooms

I am still in the process of finding cabinetry that I can tolerate. I am working with John Holdorf, a wood cabinetmaker, 38483 Plowshares Rd., Corvallis, OR 97330, 745-5158, fax 745-5221; and with **Kitchens and Baths by Don Johnson**, a company that specializes in metal and wood-faced cabinetry, 1375 Merchandise Mart, Chicago, IL 60654, 773-548-2436, fax 312-644-8139, www.healthycabinets.com. Another possibility is **Cervitor Kitchens Inc.**, 10775 Lower Azusa Rd., El Monte, CA 91731-1351, 800-523-2666 or 626-443-0184. I may end up with wood in the kitchen and downstairs bath, and metal in the utility room and upstairs bath.

The refrigerator and slide-in oven and range will be brought from our current house. The downdraft exhaust fan will be fabricated by Middleton Heating or other well-qualified manufacturer according to specifications designed by Rod Terry and Larry Hannah. (Please see p. 15 of Rod Terry’s design plans.) It will have a minimum capacity to ventilate of 600cfm. A close equivalent will be considered. The dishwasher has been purchased from Sears and will be delivered to the owners on April 20, 2005.

The countertops will be of solid-surface material, such as Corian, with an undermount 18 gauge stainless steel double sink, about 7-1/2 inches deep, with both sinks being similar sizes.

The bathroom counters and sink will be of one-piece cultured marble. The downstairs shower stall will be of one-piece, seamless fiberglass, including a molded seat, and frameless glass doors. It will have a grab bar that can be safely grabbed by a falling person. The upstairs bathroom will have a one-piece tub and shower combination, seamless, also of fiberglass. It will not have a door.

The clothes washer and dryer will come from our current house. Both are electric.

Other plumbing fixtures have not yet been chosen by the owners.

Flooring

The flooring in the majority of the house will be wood, #2 maple, refinished on site. I am working with Mike Joos to find an acceptable finish. A diffusion retarder will be installed under the wood. Under it may be a layer of asphalt impregnated felt paper (to seal nail holes) with a layer of builder's foil on top of that and just beneath the finish floor wood. (This may seem excessive, but I need separation from the asphalt felt paper as well as from the insulation and plywood.) **Denny Wholesales Services**, 141 NW 20th St., Suite B9, Boca Raton FL 33431, 800-327-6616 or 561-750-3705, www.dennywholesale.com, makes Denny Foil, a light weight foil/kraft paper product, but it is fairly easily torn. It may be purchased from E.L. Foust Co., Inc., P. O. Box 105, Elmhurst, IL 60128, 800-353-6878, www.foustco.com; from The Living Source in Texas, 254-776-4878; or from Building For Health in Colorado, 970-963-0437. **Advanced Foil Systems**, 820 S. Rockefeller Ave., Suite A, Ontario, CA 91761, 800-421-5947 or 909-390-5125, www.afs-foil.com, offers a durable Aluma-Foil product that is lightweight foil-face paper. (Their Super Plus, a sandwich of polyester and foil, is not recommended for chemically sensitive people.) Or, as an alternative to the asphalt paper and builder's foil, the considerably sturdier foil-faced cardboard may be used. All of these will need to be sealed together with an aluminum foil-faced tape, such as Polyken tape. It can possibly be purchased from the same places, as well as from local building supply stores. Also, www.venturetape.com, sells #5520 2mil aluminum foil tape, and 3520CW HVAC aluminum foil tape, both of which work well even at low and high temperature extremes. Samples may be obtained at 800-343-1076.

The flooring in the bathrooms, mechanical room, utility room, mudroom/entry area, and a small area just inside the guest entry door into the great room will be ceramic or porcelain tile. Some provision needs to be made to protect the mechanical room and the rest of the house in the event of a leaking water heater, pump pressure tank, or water treatment equipment, such as a floor drain or drain pans. The utility room floor also needs to be protected in case the washing machine malfunctions.

The tile will be laid on cementitious board.

The first choice is Durock, from **U.S. Gypsum**, 14643 Dallas Parkway, Suite 575, LB#78, Dallas, TX 75240, 800-527-5193 or 800-274-9778, customer service 800-232-2343, technical assistance 800-874-4968, www.usg.com. Durock may also be purchased in Albany at Home Depot, 541-812-0808, or Sharphs Twin Oaks, 541-928-3309, or in Eugene at Home Depot, 541-344-1312, Sharphs Building Specialty, 541-484-4185, or G.T.S., 541-607-7967.

Ultraboard, thin, dense, lightweight and low odor, is the second choice, made by **Cemplank, Inc.**, Excelsior Industrial Park, P.O. Box 99, Blandon, PA 19510-0099, 877-CEM-PLANK or 610-926-5533, www.cemplank.com.

Hardibacker Board, from **James Hardie Building Co.**, 26300 La Alameda, Suite 250, Mission Viejo, CA 92691, 800-426-4051 or 909-356-6300 or 949-348-1800, www.jameshardie.com is acceptable. It can often be found at Home Depot and Lowe's.

PermaBase, from **Unifix, Inc.**, National Gypsum Co./Gold Bond, 2001 Rexford Rd., Charlotte, NC 28211, 800-628-4662 or 704-365-7300, www.national-gypsum.com, is another possibility.

Acceptable thinsets are the following water-mixed thinsets without synthetic additives: C-Cure Floor Mix 900, Wall Mix 901, and Thinset 911 from **C-Cure Corp.**, 13001 Seal Beach Blvd., Seal Beach, CA 90740, 800-895-2874 or 562-598-8808, www.custombuildingproducts.com; or www.c-cure.com; Laticrete Additive Free Thinset from **Laticrete**, 1 Laticrete Park North, Bethany, CT 06524-3498, 203-393-0010, www.laticrete.com; or **C-Cure's** Multicure, which is a latex-enhanced, dry-set mortar with added bonding strength and flexibility for use over cementitious and plywood substrates.

The tiles should be laid as close together as possible to minimize the amount of grout that will be exposed to the indoor airspace.

Grout will be the least toxic available. The grout will be exposed to the living space, so this is very important. It may be homemade of Type I Portland cement, sand, lime (optional), and mineral pigment mixed with enough clean water to give the grout a medium heavy slurry consistency, slaked for 15 minutes, then remixed. It will need to damp-cure for 4 days or so. This involves covering the freshly grouted floor with plastic sheeting for 72 hours so it will retain moisture, perhaps after a few hours of air drying. The grout should be cleaned off the tile well enough while still wet that there will be no need for muriatic acid to remove any remaining haze. Bon-Ami and elbow grease may be used. Other acceptable grouts include commercially mixed ones that require damp-curing. This is because they are free of latex additives. No grout containing epoxy, furan, silicone or latex will be used. A Concrete Admixture, potassium silicate sealer, from **Concure**, 330 Pusey Ave., Collingdale, PA 19023, 800-925-7746 or 610-461-6490, may be mixed into the wet grout before it is placed to make the grout more resistant to stains.

The connection between the floor and the toilet can be made airtight by injecting a single-component polyurethane aerosol-foam insulation into the space under the flanges. When it is hard the excess may be trimmed and the toilet seated as usual with a wax seal.

Exterior siding

Exterior siding will be a fibrous-cement such as HardiPlank or a similar product.

Roofing

The roof will be a high quality standing seam galvanized-steel with a colored baked-on finish, or a similar product.

Balcony and west side Deck

I plan to sleep on the balcony during the summer, so it needs to be made of non-toxic material. This will be either untreated cedar or untreated redwood, of the kind that will last a long time without needing to be finished. The railing will be of metal fencing-type mesh with a wood handrail, top rail, rail posts, fascia, and rim and wood joists. The deck below will be similar. The metal on both the balcony and the deck will be properly grounded.

Deck on east and south

This deck will be of a low-maintenance material, such as Trex, or something similar. As with the deck and balcony on the east side, instead of balusters, a grounded, metal fencing will be used.

If means other than those outlined here are desired to accomplish the same ends, written permission from the owner may be sought.

Signatures

_____, as general contractor, do hereby agree to be responsible for the fulfillment of the above specifications, including Appendix I, in the building of the house, shop, carport, decks and balconies for the owners _____,

At _____, in conjunction with the rest of the building contract attached herewith.

Signed _____

Signed _____

Signed _____

Table of Contents

Healthy House Construction, Overview	1
Building to Preserve the Natural Setting	2
Special Project Procedures	2
Procedures to Prevent Insect and Rodent Infestation	2
Quality Control	3
Prohibited Products	3
Product Substitution Procedure	3
Contract Close-Out	3
Elimination, Separation, and Ventilation	4
Site Work and Excavation	4
Concrete Slab Foundation for the Shop	6
Concrete	6
Concrete Sealants	7
Subfloor	8
Airtight Drywall Approach	9
Gaskets, Aerosol Foam, Caulking and Adhesives	10
Lubricants	12
Windows	12
Doors	13
Plumbing	13
Electrical	15
Heating and Ventilation	18
Central Vacuum	21
Walls and Ceilings	21
Trim	23
Kitchen and Bathrooms	23
Flooring	24
Exterior Siding	26
Roofing	26
Balcony and West Side Deck	26
Deck on East and South	26
Signatures	26