duce moisture entry into the insulation and, further, means for permitting escape of moisture from the insulation must be provided (see Chapter 23).

It is common practice to specify performance of insulation by its conductance C, resistance R or overall heat transmission coefficient U. This permits all types of materials or a combination of them meeting the performance requirement to be included in specifications.

Thermal insulation should be considered in original building plans since it will reduce the winter heat loss and summer cooling load and thereby permit reduction in (1) size of heating and cooling equipment, (2) space required for this equipment, and (3) size of ducts and piping.

Future use or possible changes in use of the building as well as the possibility of future installation of air conditioning, should be taken into consideration. Insulation should be installed when the building is constructed because it can then be properly applied at the most economical cost.

There are certain general installation requirements which apply to all building insulation products. The insulation should be stored in a dry, safe place prior to its installation. Unless the insulation is a part of the building or must be applied along with the basic construction, such as perimeter insulation, it should not be installed until the building is closed in and reasonably weather-tight. All rough electrical, heating, and plumbing work should be completed and when required, inspected prior to installing insulation. Provisions should be made in attics to avoid blocking screen vents or openings in protecting roof eaves when insulation is installed.

The general practice discussion which follows is based on types of insulation products rather than on insulation of various building sections or classes of buildings. Some products can be used in many types of buildings in different ways while others are designed for, or restricted to, specific uses.

BATT AND BLANKET INSULATION

Batt and blanket building insulations are flexible or semi-rigid products composed of felted or matted fibrous materials (organic or inorganic) which may contain an adhesive binder or be held together by confining media. They are available (1) without membrane covering, (2) with a membrane on one side serving as a vapor barrier, or (3) completely enclosed within a membrane, one principal face of which is a vapor barrier. Extension of the membranes along the longitudinal edges provide stapling flanges. Materials are made in standard widths to fit between framing members and are available in thicknesses from 1 in. to 6 in. or more. The insulation batts are commonly 24 in. and 48 in. long, while blankets may be in 96-in. lengths or provided in rolls of various lengths depending upon their thickness.

Batts and blankets are applied by fastening the flanges to the framing members with staples driven flush and spaced frequently enough to assure continuous contact with framing. For best construction and maximum protection from water vapor, the flanges should be fastened to the face of the framing members at sides and ends (the batts or blankets are cut longer than the space to be insulated so that the membrane overlaps at the plates or headers) to minimize entrance of water vapor from the drying plaster or from the inside humidified space. When dry wall interior finish materials are used, an alternate method of applying insulation is to carefully staple flanges to the *sides* of the framing member. Where maximum protection is desired, a separate vapor barrier, such as a polyethylene film, should be applied over the entire inside wall area with a minimum of joints or perforations. Batts or blankets should be trimmed to fit narrow or odd shaped spaces. Small narrow openings around window and door openings should be filled with pieces of the batts or blankets and covered with a vapor barrier.

When insulating ceilings or roofs, the batt or blanket should be pushed over the wall plate between the joists making sure it does not block soffit or eave vents. The vapor barrier should face the warm-in-winter side of the construction. The ends of membrane covering should be stapled to the plate and the flanges to the sides of the joist. The batt or blanket should be fitted snugly around bridging.

When insulating a pitched roof, the insulation may be applied up the rafters and then between collar beams, or it may be applied between the ceiling joist from wall plate to knee walls; then between the vertical knee walls to the rafters; then up between the rafters and across collar beams. Space above collar beams should be ventilated.

Floor construction may be insulated with blankets or batts placing the vapor barrier up toward the warm-in-winter side. If necessary, they should be supported by the use of wire mesh attached to the sides of the floor joists with wood lath or by other means. If a separate vapor barrier is installed between the subflooring and the finished floor, the insulation may be installed with the vapor barrier toward the cold-in-winter side.

In new construction, floors may be insulated before subfloor is laid if precautions are taken to prevent insulation from becoming wet from rain before building is completely enclosed.

BOARD AND BLOCK INSULATION

Board and block insulations are composed of organic or inorganic fibrous, cellular, granular, or plastic-foam materials. They are available in rigid, preformed units of varying thicknesses, sizes, and densities depending upon use requirements. Some products provide structural strength, sound absorption, interior decoration as well as thermal insulation value. General practices pertaining to the various types are as follows:

Insulating Roof Deck is commonly used in flat or sloping open-beam ceiling type construction to provide the structural roof deck, insulation, and the interior finish. The standard size of one type is 2×8 ft and thicknesses are 1½, 2, and 3 in. while another type is 30 or 32 in. wide and up to 9 ft in length. Long edges are fabricated to form an interlocking joint or are butted together against a special gasket.

It is important to use the proper thickness of the product in relation to the spacing of the supporting roof beams. As a general rule, the framing is spaced no more than 16 times the thickness of the roof deck. The manufacturer's data should be examined for this requirement. The insulating roof deck is applied with the long dimensions at right angles to the framing members starting at the eaves. End joints occur over framing members and are staggered on alternate courses. Large headed nails should be used of sufficient length to penetrate framing members at least 1½ in. Nails are spaced on 4½ in. centers (8 in. centers at eaves, ridges, and around openings). Some products may be applied to steel framing with special clips.

Flat or moderately pitched roofs, up to slopes of 3 in. per foot, may be covered with coal tar pitch or asphalt built-up roofing applied according to the manufacturer's specifications. On steeper slopes, mineral surfaced roll roofing may be used or various types of rigid shingles applied with special nails, following the manufacturer's recommendations.

Roof Insulation is available in various sizes and in nominal thicknesses of ½ up to 3 in. or in thicknesses to meet commonly specified thermal conductances C of 0.36, 0.24, 0.19, 0.15, and 0.12.

Roof insulation may be applied by different techniques over a variety of decks, such as concrete, gypsum, steel, and wood. Most manufacturers recommend vapor barriers on decks of heated buildings where the average January temperature is below 45 F, and in all buildings in which excessive moisture conditions prevail such as textile mills, laundries, canning factories, creameries, breweries, etc. The manufacturer's instructions should be consulted for application of the roof insulation with coal tar pitch, asphalt, or by mechanical means.

Interior Panels such as building board, plank, and ceiling tile provide thermal resistance as well as interior finish, acoustical absorption or both. They are available in different thicknesses and sizes, and usually have fabricated edges which permit application with nails, staples, or by special methods. Installation should be made in the manner and under the conditions recommended by the manufacturer.

Insulation Sheathing is generally used over frame construction and provides structural strength as well as insulation value. When 4-ft wide sheets are properly applied, corner bracing may be omitted. They are usually integrally treated, impregnated, or coated to provide water and weather resistance. Products of high density are available to permit direct application of wood or asbestos shingles by use of special nails. Insulating sheathing is available in ½ and $^{25}/_{32}$ in. thicknesses and 2×8 ft or 4×8 and 4×9 ft sizes. Application is made to framing by means of large-headed nails (of length to penetrate framing at least 1 in.) spaced 3 in. at all edges and 6 in. at intermediate supports.

Shingle Backer serves as a backer strip or undercourse for wood or asbestos-cement shingles. The material is $^{9}/_{16}$ or ⅜ in. thick, 48 in. long, and in various widths depending upon the exterior shingle used. The method of application and type of nails may vary depending upon the type of sheathing on which the product is applied.

Insulation Backing for Exterior Finish includes products such as coreboard for wall panels or spandrels, insulating siding, and backer board for aluminum siding. Since the end use requirements vary, products are made in different thicknesses, sizes, shapes, densities, and have special physical characteristics.

Curtain wall panels include a variety of specialised constructions. It is suggested that the manufacturer be consulted for specific details.

Insulating Formboard provides thermal insulation in addition to a permanent form for reinforced gypsum or lightweight aggregate concrete poured-in-place flat roof constructions. It is usually 1, 1½, and 2 in. thick, in widths of 24 and 32 in. with lengths from 4 to 12 ft. The interior surface may be plain, factory-finished, or acoustically treated. Insulating formboard is placed on roof framing members, usually subpurlins, and the roof deck material is poured in place.

Block Insulation in thicknesses of 1 in. to 4 in. is available in various sizes for installation against any clean, dry surface, in masonry cavity wall space, or may be erected on a free-standing wall when the thickness of insulation is 4 in. or more. Irregular surfaces should first be built-up to a flat level area to receive the insulation blocks. If primers are used on the wall, they should be compatible with adhesive used. Insulation may be applied by different methods as follows:

In the hot erection method, the back and two adjacent edges are dipped in hot asphalt before applying to the wall. In the gob method, *the cold mastic is applied on the back of* the block and to two adjacent edges before installation to the wall. In the full backbed method, a uniform coating of cement or adhesive is troweled over the back surface and two adjacent edges. Wall surface must be plumb and smooth before installing the insulation. In the case of polystyrene insulation, no materials or adhesive containing solvents that will attack the insulation should be used directly with the insulation. Where unusually high inside humidity conditions may be encountered, it is advisable to seal the joints between units with special adhesive. Ceilings may be insulated by adhering blocks with adhesive or mechanical anchors. Refer to the section Types and General Installation Technique in this chapter.

Perimeter Insulation is generally 1 or 2 in. thick, of various sizes, and is of a waterproof material. It is applied against the foundation wall from the top to a depth usually about 2 ft below grade. An alternate method is to apply a section between a foundation wall and the edge of the concrete slab and then to extend the insulation horizontally, directly under the slab inward a distance of approximately 2 ft from the foundation wall (refer to Table 6, Chapter 26).

FILL INSULATION

Loose-fill insulation may be inorganic or organic materials in fibrous or granular form. Either may be poured or blown into the spaces to be insulated. In ceilings of new construction, all openings, such as those around electric outlets, vent pipes, or chimneys should be filled and sealed to prevent sifting of loose fill. When required, a continuous vapor barrier should be applied on the heated-in-winter side of the construction prior to the installation of the insulation. The insulation should be blown or poured into joist spaces to the specified depth and density uniformly over the entire ceiling area. Where eave vents are present, cardboard baffles or batts may be used to keep fill insulation out of the eave spaces. Scuttle hole covers should be insulated with batts.

In walls of new construction, all small spaces and cracks around windows and doors should be stuffed by hand. Loose fill may be blown or poured from either outside or inside through suitable openings. These should be closed when the job is completed.

In existing construction, ceilings may be insulated in the manner similar to new construction. Where attics may be floored, boards in selected areas should be removed to permit pouring or blowing of insulation material between the joists to the specified thickness. Flat roofs may best be insulated if access openings are provided in the ceiling and space is available for workmen to reach all areas under the roof to be insulated. If access openings must be made through the roof, the roofing manufacturer or licensed roof applicator should be consulted before an attempt is made to open the roof, because the roof may be bonded and carry a guarantee of performance. Provisions should be made to install screened louvered wall vents or roof vents in order to provide adequate ventilation between the insulation and the roof.

Walls of existing construction may possibly be insulated from above if open stud spaces are available in the attic area through which loose fill material can be installed. Sealed wall areas are usually insulated from the outside by removing exterior surfacing and then drilling holes through the sheathing to permit installation of the loose fill. These openings should be made at the top of the walls and below the windows to provide access to all hollow spaces between structural members. Each space should be tested for obstructions using a plumb bob. If obstructions are found in the space, additional openings should be made below the obstruction. The insulation *should be poured or blown into the wall spaces to* completely fill them at a sufficient density to prevent settling. After the cavity is filled, access holes may be covered and exterior surfacing replaced.

REFLECTIVE INSULATION

Reflective insulation is generally composed of aluminum foil or polished aluminum flake surface having low emissivity values which retard heat transfer by radiation. The effectiveness of reflective insulation is based on the utilization of a