United States
Department of
Agriculture

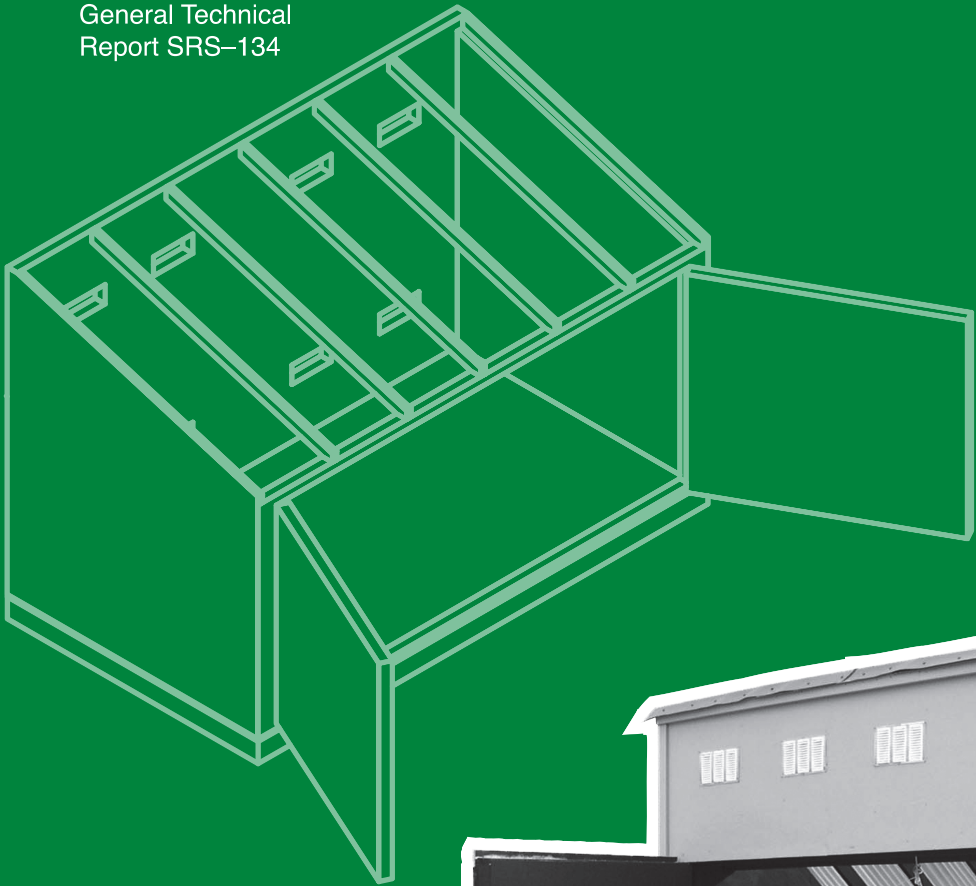
Forest Service

**Southern
Research Station**

General Technical
Report SRS–134

DESIGN AND OPERATION OF A SOLAR-HEATED DRY KILN FOR TROPICAL LATITUDES

Brian Bond, Omar Espinoza, and Philip Araman



Authors:

Brian Bond, Associate Professor and Extension Specialist, **Omar Espinoza**, Postdoctoral Associate, Virginia Polytechnic Institute and State University, Department of Wood Science and Forest Products, Blacksburg, VA 24060; and **Philip Araman**, Wood Scientist and Research Team Leader, U.S. Department of Agriculture, Forest Service, Southern Research Station, Blacksburg, VA 24060.

Product Disclaimer

The use of trade or firm names in this publication is for reader information and does not imply endorsement by the U.S. Department of Agriculture of any product or service.

January 2011

Southern Research Station
200 W.T. Weaver Blvd.
Asheville, NC 28804

Design and Operation of a Solar-Heated Dry Kiln for Tropical Latitudes

Brian Bond, Omar Espinoza, and Philip Araman

Design and Operation of a Solar-Heated Dry Kiln for Tropical Latitudes

Brian Bond, Omar Espinoza, and Philip Araman

Abstract

Lumber is usually dried to a specific moisture content prior to further manufacturing or use. While lumber can be air-dried, the ambient humidity in most localities prevents the lumber from reaching the moisture content necessary for dimensional stability and use, especially for interior use. Solar kilns are an inexpensive alternative to conventional steam-heated kilns, especially for small operations and communities. Solar-heated kilns have great potential in developing countries, especially in remote locations with little access to conventional energy sources. This publication describes the construction and operation of a solar kiln for lumber drying in tropical latitudes.

Keywords: Kiln drying, low-cost lumber drying, lumber drying, solar-heated lumber drying, tropical hardwoods, tropical wood drying.

INTRODUCTION

Lumber is usually dried to a specific moisture content (MC) prior to further manufacturing or use because wood changes its dimensions with changes in MC. The amount of water in wood is usually expressed as moisture content and can be directly measured or calculated. The MC of wood is defined as the ratio of the weight of water in wood to the dry weight of the wood material.[1] While lumber can be air-dried, the ambient humidity in most localities prevents the lumber from reaching the MC necessary for the dimensional stability, especially for interior use. Furthermore, wood is prone to biological deterioration at higher moisture contents.

Solar kilns are an inexpensive alternative to conventional steam-heated kilns, especially for small operations, like wood crafts makers. Solar-heated kilns have great potential in developing countries, especially in remote locations with little access to conventional energy sources. This publication describes the construction and operation of a solar kiln for lumber drying in tropical latitudes.

OVERVIEW OF SOLAR KILN DESIGN

The solar kiln described in this publication was designed, constructed, and tested at Virginia Polytechnic Institute and State University (Virginia Tech) in Blacksburg, VA. This design is based on 25 years of research and development on solar drying of lumber in the United States and foreign countries. Previous versions of this kiln were designed to hold up to 2,000 board feet (4.7 m^3) of lumber.[2] The version described here can hold between 500 and 800 board feet (1.2 to 1.9 m^3) of lumber and allows drying in conditions common in tropical countries. The pictures shown here were taken during the construction of the kiln at Virginia Tech, and depict some differences in design from the drawings (see appendix A), most importantly: (1) the roof angle shown in the pictures is 45 degrees, appropriate for Virginia's latitudes, while that of the roof shown in the drawings is 17 degrees; (2) doors are located in the wall opposing the equator in the kiln built at Virginia Tech, while the drawings show doors on the equator-facing wall (north face in southern latitudes).

While there are several different types of solar kilns for drying lumber, the kiln described here was designed with two major objectives: (1) inexpensive construction, and (2) simple operation. Drying lumber can be a complex process of attempting to accelerate drying while maintaining the quality of the lumber, and therefore, the process often requires extensive knowledge and experience. The kiln design explained here has the advantage of requiring no extensive knowledge, experience, or control in its construction and operation. The size of the collector keeps the kiln from overheating, thus minimizing checks and splits. The kiln is simple to construct and utilizes a passive solar collector, four insulated walls, and an insulated floor. The roof is made of clear, greenhouse-rated, corrugated polycarbonate.

SOLAR KILN DESIGN FUNDAMENTALS

The solar kiln can hold up to 800 board feet (1.9 m^3) of 1-inch (25.4 mm)-thick lumber per load, and can dry a charge in approximately 1 month of moderately sunny weather. The kiln is heated when solar energy enters the clear glazing and is absorbed by the black-painted interior surfaces. The solar energy heats the air in the collector space and is circulated through the lumber by fans. As the heated air circulates, it absorbs moisture from the surface of the lumber. The evaporated moisture increases the relative humidity of the air, and when the humidity in the chamber becomes too high, it can be vented from the chamber through the vents in the rear of the kiln. These vents also allow for fresh, dry air to enter the kiln.

[1] According to the equation: MC = [(Weight of water in wood) / (Weight of oven-dried wood)] x 100 percent.

[2] One board foot is a volume unit for lumber, equivalent to a piece of wood with dimensions 12 x 12 x 1 inch. A cubic meter of lumber contains approximately 424 board feet. To calculate the total number of board feet in a board, use the following equation: Board feet of lumber (BF) = length (feet) x width (inches) x thickness (inches) / 12.

Roof Design

The kiln design is similar to a solar greenhouse. A passive solar collector provides the kiln's drying heat, which is generated from the sunlight that passes through the glazed roof and strikes a solar collector inside the kiln. Many factors affect how much heat can be obtained from the sunlight. One is the slope of the roof, which in this design is 17 degrees to the north, measured from the horizontal, assuming a location in the southern hemisphere. The optimum roof angle is dependent on the kiln location and is optimally equal to the latitude. One difficulty in choosing the optimal roof angle is that the optimal angle for solar collection changes with the season because the angle of the sun with respect to the horizontal changes. If you are planning on operating the kiln during the winter months, you can improve your collector's performance by increasing the roof angle another 10 degrees. Very importantly, all references to the roof angle and walls orientation in this publication assume a location in the southern latitudes; if the kiln is located north of the equator, this should be considered in making the necessary changes (e.g., roof would face the south). Table 1 lists the latitudes of some cities in South America.

The type of transparent roofing material, or glazing, can also affect the amount of heat energy collected from the sun. The glazing must transmit sunlight through to the solar collector and not reflect it. It must also have some protection from degradation by the sun's ultraviolet rays. Many different glazing materials are possible, including glass, polymer plastic films, and fiberglass panels (see the References section for information on the different types of glazing). The kiln built at Virginia Tech uses a greenhouse-rated corrugated polycarbonate. For winter operation or in cooler climates, it is best to use two layers of clear glazing; these layers are separated by 1.75 inch (90 mm) rafters to help insulate the solar collection area (fig. 1). The roof is framed with widely spaced rafters that must accommodate the width of the covering material and any anticipated snow loads.

The most critical design feature of this solar kiln is that there is 1 square foot of collector for each 10 board feet of 1-inch-thick lumber in the dryer (or 4 m^2 for each m^3 of lumber). This ratio provides an appropriate amount of heat for oak (*Quercus* sp.) 1-inch (25.4 mm) thick, but may provide too much heat for oak 2 inches (50.8 mm) thick or thicker; and too little for pine or other fast-drying woods. Oak is one of the more difficult drying woods because if it is dried too rapidly, it will crack and check, and if dried too slowly, the sapwood may stain and discolor. In general, thicker lumber should be dried more slowly than thinner lumber. As an example, 2-inch (50.8 mm)-thick lumber that is 2 inches (50.8 mm) thick will take approximately 2 ½ times longer to dry than lumber of the same species that is 1 inch (25.4 mm) thick. The collector area can be increased to provide more heat for easier drying woods than oak by extending the roof and/or reducing the height of the north wall, or simply loading less material in the kiln. These changes increase the collector area-to-board foot ratio. An easy way to provide less heat is to reduce the collector area simply by covering part of the roof with plywood or other opaque material.

Table 1—Latitudes of some South American cities

City – country	Latitude
Santa Cruz – Bolivia	17d 46m S
Lima – Peru	12d 0m S
Bogota – Colombia	4d 32m N
Quito – Ecuador	2d 10m S

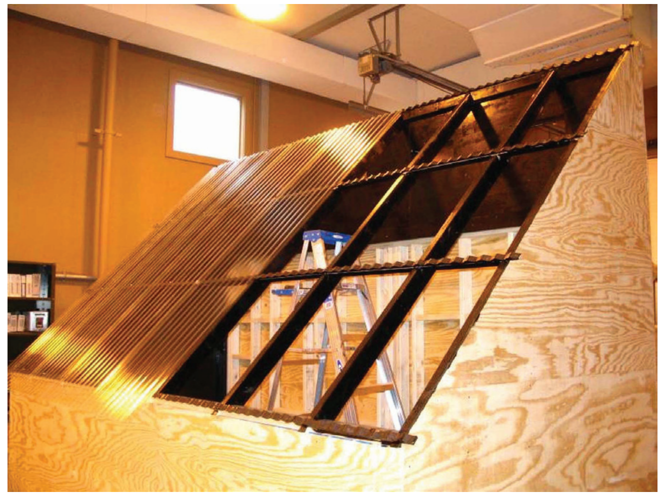


Figure 1—Painted interior, showing layer of glazing.

Basic Box Design

The kiln can be built with concrete blocks, brick and mortar, or other materials. The kiln described here is constructed using standard framing techniques (fig. 2). The first step is to construct the floor with 2- by 7-inch (40 by 170 mm) joists. The lumber used for the floor should be preservative treated to prevent rot because it will be close to, or in contact with, the ground. Next, install insulation material between the framing members (table 2). Cover the top of the fiberglass insulation with a sheet of 0.6 Mil plastic to prevent condensation from entering the insulation material. Finish the floor by placing exterior grade 3/8-inch (9.5mm) plywood across the joists. Next, construct the walls of the kiln using 2- by 4-inch (40 by 90 mm) studs, insulation material, and exterior grade 3/8-inch (9.5 mm) plywood on both the interior and exterior of the frame. The plywood inside the kiln is painted with two coats of black rubber-based concrete sealer, which when dry, acts as a vapor barrier and black solar collector. Another option would be to paint two coats of aluminum paint for vapor barrier and then a third coat of black paint to absorb the solar energy. Some examples of sealers are shown in figure 3.

Figure 2—Interior framing.

Table 2—Thermal resistance of some construction and insulation materials

Materials	Thickness	RSI[a] value
	inches – mm	*m2 x C°/W*
Glass fiber	1 - 25	0.55
Expanded poliestirene	1 – 25	0.65
Wood shavings	1 – 25	0.42
Air space	1 – 25	0.18
Pine wood	1.75 – 90	0.78
Concrete[b]	4 - 100	0.13
Concrete block	4 – 100	0.12
	12 – 300	0.22
Common brick	4 – 100	0.07

[a] RSI = Resistance to heat flow. The value of RSI increases proportionally with the material thickness.

[b] Density = 110 lb./ft^3 (1,760 kg/m^3).

The exterior of the kiln is painted with an exterior-grade paint to prevent weathering. Be careful not to use a vapor barrier like aluminum paint on the exterior, since any moisture that might migrate into the walls will not be able to escape to the outside.

The current design has large doors at the front of the structure for loading, unloading, and monitoring kiln samples. The example kiln at Virginia Tech has these access doors at the rear of the kiln, as shown in figure 4. Two access doors at each end (east and west walls) can be installed to permit the periodic examination of the lumber and measurement of moisture content. Another possible modification is a roof hinged to the south wall and the north wall hinged to the floor (again assuming a kiln built for the southern latitudes). This permits the roof to be raised and north wall lowered to facilitate loading and unloading. Regardless of the design, vents should be added to the south wall. The vents can be as simple as framed openings with a small piece of plywood to cover the vent when not needed, or you can purchase a commercial vent similar to those used for basement and crawlspace ventilation.

Figure 3—Coatings that can be used to seal the inside walls of the kiln and to coat the ends of sample boards. From left to right: aluminum roof coating, a commercial kiln coating, and rubberized roofing sealer.

The three fans used in this design are inexpensive, three-speed window fans with plastic blades (fig. 5). The fans are fastened to the roof framing about 20 inches (0.50 m) in front of the south wall with a plywood shroud or baffle around them extending downward 36 inches (0.90 m) below the roof and running the full length of the dryer in order to force the air through the lumber pile (fig. 6). Whenever the kiln is left empty, be careful that you do not leave the doors completely closed because the temperature of an empty kiln can exceed 200 ˚F (90 ˚C), which can damage the plastic fan blades.

OPERATION OF A SOLAR DRYER

Preparing the Lumber

Green lumber should be end coated with a rubber based basement sealer or other commercial end coating product immediately after sawing to prevent large losses from end

Figure 4—A solar kiln in the United States with rear doors. The drawings at the end of this publication depict a design that incorporates the doors at the front end of the kiln.

Figure 5—Front view of kiln showing fan placement.

checks and splits. End coating is ineffective when applied after the lumber has begun to dry. Lumber should then be stacked in the kiln with a 12-inch (0.30 m) clearance on either side of the stack (between the north and south walls and the stack) to permit adequate air circulation, and in well-constructed layers, separated by stickers or spacers running perpendicular to the lumber's length (fig. 6). Lumber in each layer must be uniform in thickness. If the sawn lumber is variable in thickness, one or both faces of the boards should be planed before drying to obtain a uniform thickness and reduce warping during drying. Green lumber should be stacked with stickers quickly after sawing or it may begin to stain, particularly in the warmer months.

Stickers used between each layer of wood are typically of 0.75 to 1 inch (19 to 25 mm) in thickness and 1 to 1.25 inches (25 to 32 mm) in width; and the length should be equal or slightly longer than the pile's width. It is

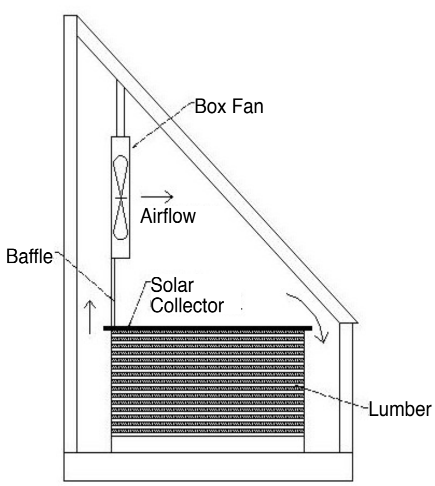


Figure 6—Diagram of solar kiln showing fans, baffle, solar collector, and spacing between lumber and walls.

important that stickers are uniform in thickness and kept dry. Stickers are placed perpendicular to the boards' length, every 12 to 18 inches (0.30 to 0.46 m) along the lumber's length, using narrower spacing for warp-prone species. The stickers should be placed directly above the stickers in the lower layers, in straight columns. If the lumber is of varying lengths, shorter boards are staggered by alternating them from one end to the other of the pile with the longest pieces always on the outside edges. The ends of every board should be supported with a sticker. The stickers hold the lumber flat, preventing warp, while allowing air to circulate through the pile and dry the lumber.

While the lumber is being stacked or prior to loading the kiln with pre-stacked lumber, several sample boards must be cut (see the section on Procedures for Cutting and Using Sample Boards). Periodically checking these samples will allow you to determine the moisture content of the lumber in the kiln and identify possible drying defects. After the lumber is stacked in the kiln, lay a final layer of stickers down and then a black-painted sheet of plywood to act as a cover and collector.

Monitoring the Process

Monitoring the MC during the drying process is important to avoid drying too rapidly, resulting in quality loss, and to know when the load has reached the desired MC. Sample boards are used to measure the MC each day and determine the daily rate of moisture loss. This loss should be compared with the safe drying rate for that species. If the drying rate is too fast, then it may be necessary to block off part of the collector, or else turn the fans off and open the vents during the hottest part of the day.

While the solar kiln described in this publication is designed to dry red oak without checking, you still want to monitor the drying process. Monitoring the moisture loss and quality of the wood during the drying process will help you to maximize the efficiency of the solar kiln. Lumber should be dried to the maximum safe drying rate. The safe drying rate refers to the moisture loss in one day, not the average loss over several days. Because the safe drying rate for most tropical species are not known, moisture losses and drying quality should be monitored daily and the process adjusted as necessary. Table 3 lists the safe drying rate for common North American hardwoods. Softwoods are typically able to dry at a much faster rate and moisture content losses above 10 percent per day are quite common.

When lumber has its highest MC (green lumber), it is most important to adhere to the safe drying rate. It is during the first one-third moisture content loss that most checking and splitting occurs. Once the lumber dries below 22 percent MC, the risk of creating new cracks and splits is low. The final MC should be as close as possible to the prevailing equilibrium moisture content (EMC) of the service conditions. This will limit the amount of dimensional changes that would occur when the wood is processed and

Table 3—Safe drying rates of some North American hardwoods

Species	Density	Maximum rate of MC loss per day	
		1-inch (25.4mm)- thick lumber	2-inch (50.8mm)- thick lumber
	g/cm^3 – lb/ft^3	*----------- percent -----------*	
Cherry	0.53 - 33.1	5.8	2.3
Beech	0.68 - 42.4	4.5	1.8
Red oak upland	0.62 - 38.7	3.0	1.5
Yellow-poplar	0.46 - 28.7	13.8	5.5

MC = Moisture content.

in service. As an example, table 4 lists the average outdoors EMC values for three locations in Bolivia.

If lumber is drying too rapidly, there are several ways to reduce the drying rate. The best method is to cover up part of the collector. Shutting the fans off will also reduce the drying rate but may result in temperatures high enough to melt the plastic fan blades.

It is impractical to weigh every board in the dryer to measure the moisture loss rate, and electric meters are not accurate above 30 percent MC. Use the sample board method to determine the MC of lumber in the kiln. This method uses short, carefully chosen sample boards sawn from larger pieces of lumber, and these sample boards are weighed periodically and estimated moisture contents are calculated. Since the wettest or slowest drying lumber in the kiln has the highest risk of splitting and cracking, the sample boards should represent this kind of lumber. Typically, samples should be cut from the most recently cut wood, the widest and thickest boards, lumber with the most heartwood, and boards that are quarter sawn.

The temperature inside the kiln will increase during the day until it peaks at mid afternoon and then cools at night. At night, as the air in the kiln cools, the relative humidity will increase significantly. The increase in humidity at night is beneficial in reducing or relieving the drying stresses that developed during the day. Fans should be turned off at night to allow the lumber to relieve stress.

Table 4—Average equilibrium moisture content (EMC) values in three Bolivian cities

City	EMC[a]
	percent
Cochabamba	9.7
La Paz	9.3
Santa Cruz	12.6

[a] Calculated using historic temperature and relative humidity data from the Bolivian weather service.

There are two simple controls that can make operating your solar kiln easier. A simple timer can control the fan operation. The timer can be set to come on at mid morning as the temperature in the kiln increases and to shut the fans off in the evening as the temperatures cool. A humidistat can be used to override the timer for the fans. The humidistat is used to keep the fans off during days when it is raining, causing high humidity, which is detrimental to the drying process.

Modifying the Design to Control Operation

As mentioned in the Roof Design section, the angle of the roof with the horizontal should be equal to the latitude of the location where the kiln is going to operate; thus, the most important adaptation is to give the roof the proper angle by lowering and/or raising the walls of the kiln. The collector area-to-lumber footage ratio should be maintained to approximately 1 square foot of collector for every 10 board feet of lumber.

One potential modification recommended for tropical countries is to make a clear north wall. This is not incorporated in the design presented here because there is a significant tradeoff between the area of the collector and the area of insulated, solid walls. The larger the collector size, the more solar energy is collected, however, the greater the heat loss in colder weather. In the present design, to make this change it is also necessary to move the doors to the wall facing south.

If you want to make your solar kiln entirely powered by solar energy, there are several options available. The two most common are to: (1) use a photovoltaic solar collector and a current converter to run the alternating current-powered fans on solar energy, or (2) use a photovoltaic solar collector and use direct current-powered fans. However, both options will significantly increase the cost of building a solar kiln. At the time of construction of the current kiln, powering the three fans with solar energy increased the construction costs by 50 to 70 percent. For more information on solar powering of fans, see appendix B.

PROCEDURES FOR CUTTING AND USING SAMPLE BOARDS

1. Select a few boards from the pack of lumber that represent the slowest drying material. Theses boards would be the widest and thickest and would have the highest MC. They also would contain the most heartwood or would be quarter-sawn.

2. Cut a 24- to 30-inch (0.60 to 0.76 m) sample that is free of knots and at least 12 inches (0.30 m) from the end of the board. Then cut two 1-inch (25 mm) moisture sections from the sample board's ends, as shown in figure 7. Make sure to number the two moisture sections and the sample board.

3. Immediately weigh the 1-inch (25 mm) sections within an accuracy of 1 g and record the weight. Measure weight rapidly after cutting because it is important that the sections do not lose moisture. Do not end-coat these sections.

4. Place the 1-inch (25 mm) sections in an oven at 215.6 ºF (102 ºC) and dry them for 24 hours. Reweigh them to obtain the oven dry weight.

5. Using equation 1, calculate the MC of each section and average the MC of the two sections to obtain the initial MC of the sample board.

$$\text{MC(\%)} = \left(\frac{\text{Weight of wet section}}{\text{Weight of oven dried section}} - 1 \right) \text{X } 100\% \quad [1]$$

6. End-coat the sample board with a rubber-based sealing compound or two coats of aluminum paint (fig. 8). Then weigh the sample board and record weight on sample (within 5 g accuracy). This is the weight of the wet sample board.

7. Using equation 2, estimate the oven-dry weight of the sample board using the average MC calculated in step 5 and the weight of the wet sample from step 6. Record this so it can be used for future moisture content calculations.

$$\text{Estimated oven dry weight (g)} = \frac{\text{Weight of wet sample board}}{100+\text{MC\%}} \quad [2]$$

8. Place the sample board in the lumber stack in a location where it will dry at the same rate as the rest of the lumber in the dryer (fig. 9).

9. To determine the MC at any time, reweigh the sample board and calculate MC using equation 3. Figure 10 shows an example of how MC can be recorded.

$$\text{Current MC(\%)} = \left(\frac{\text{Current weight of sample board}}{\text{Estimated oven dry weight}} - 1 \right) \text{X } 100\% \quad [3]$$

10. Stop the drying process when the current MC (percent) equals your target MC.

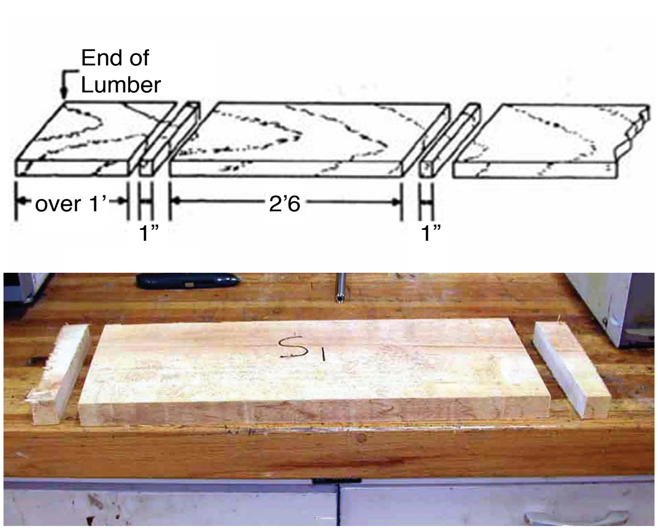


Figure 7—Dimensions and picture of sample board for controlling the drying process.

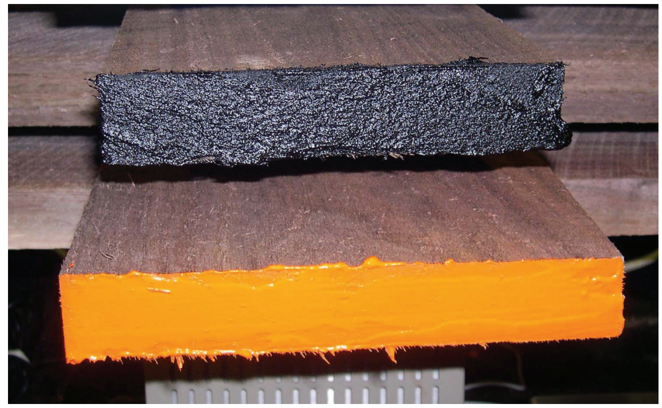


Figure 8—Sample boards with different end coatings.

Figure 9—Pack of lumber with sample boards.

				Sample boards						
Sample number		Moisture sections		Green weight (g)	Estimated OD weight (g)	Day				
		Wet weight (g)	OD weight (g)			1	2	3	4	.....
1	Weight									
	MC									
2	Weight									
	MC									
n	Weight									
	MC									

Figure 10—Sample of recordkeeping sheet for sample board data.

ACKNOWLEDGMENTS

Special thanks to those who assisted with the design and construction of the solar kiln: Rick Caudill, Kenny Albert, and Fred Albert. Some information for this publication was adapted from: Wengert, E.M. Solar Heated Lumber Dryer for the Small Business. MT # 20 Utilization and Marketing. Virginia Polytechnic Institute and State University, Virginia Cooperative Extension Service. Blacksburg, VA. April, 1980.

REFERENCES

Glazing Materials

Different types of greenhouse coverings. www.igcusa.com/TECHNICAL/Coverings.html. [Date accessed: April 30, 2010].

Giacomelli, G.A. Greenhouse glazings: What's new under the sun, under the glazing, and at the plant canopy. In: Southeastern United States Greenhouse Vegetable Growers Conference and Trade Show Proceedings.

Lumber Drying

These publications can be downloaded from www.fpl.fs.fed.us:

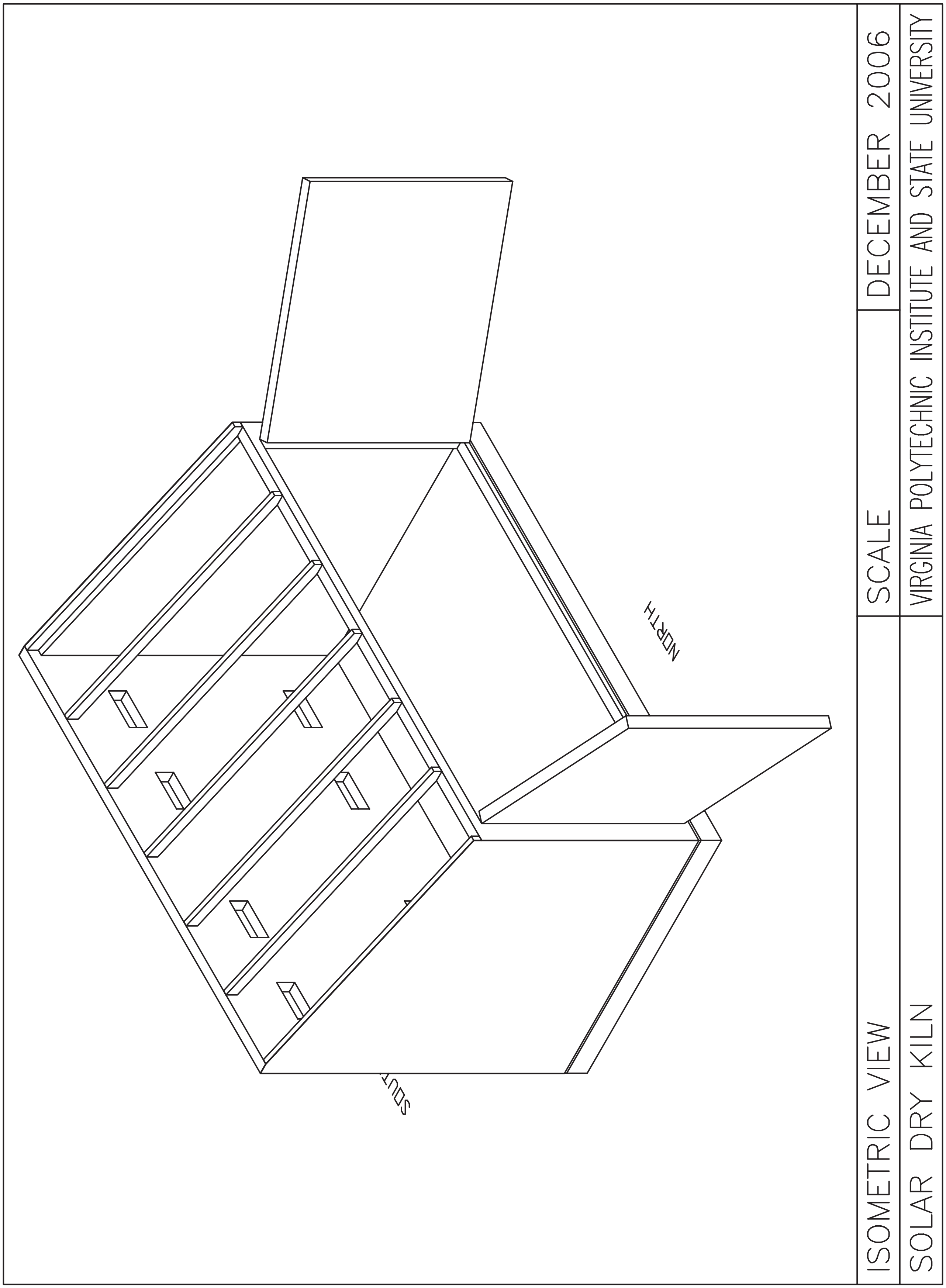
Simpson, W.T., ed. 1991. Dry Kiln Operator's Manual. United States Department of Agriculture Forest Service. Forest Products Laboratory. Agric. Handb. 188. Madison, WI: U.S. Department of Agriculture Forest Service, Forest Products Laboratory. 274 p.

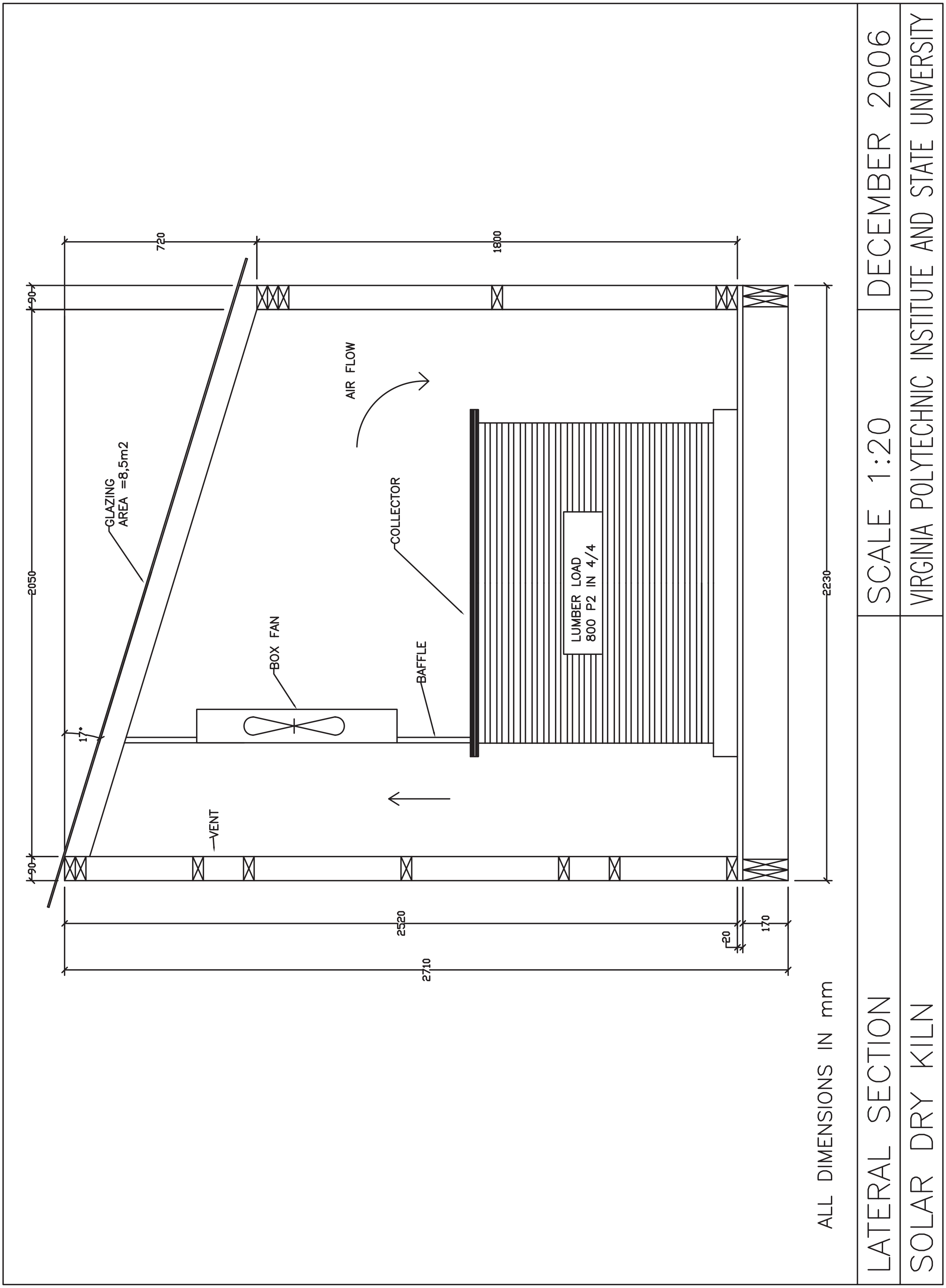
Denig, J.; Wengert, E.M.; Simpson, W.T. 2000. Drying hardwood lumber. Gen. Tech. Rep. FPL-GTR-118. Madison, WI: United States Department of Agriculture Forest Service. Forest Products Laboratory. 138 p.

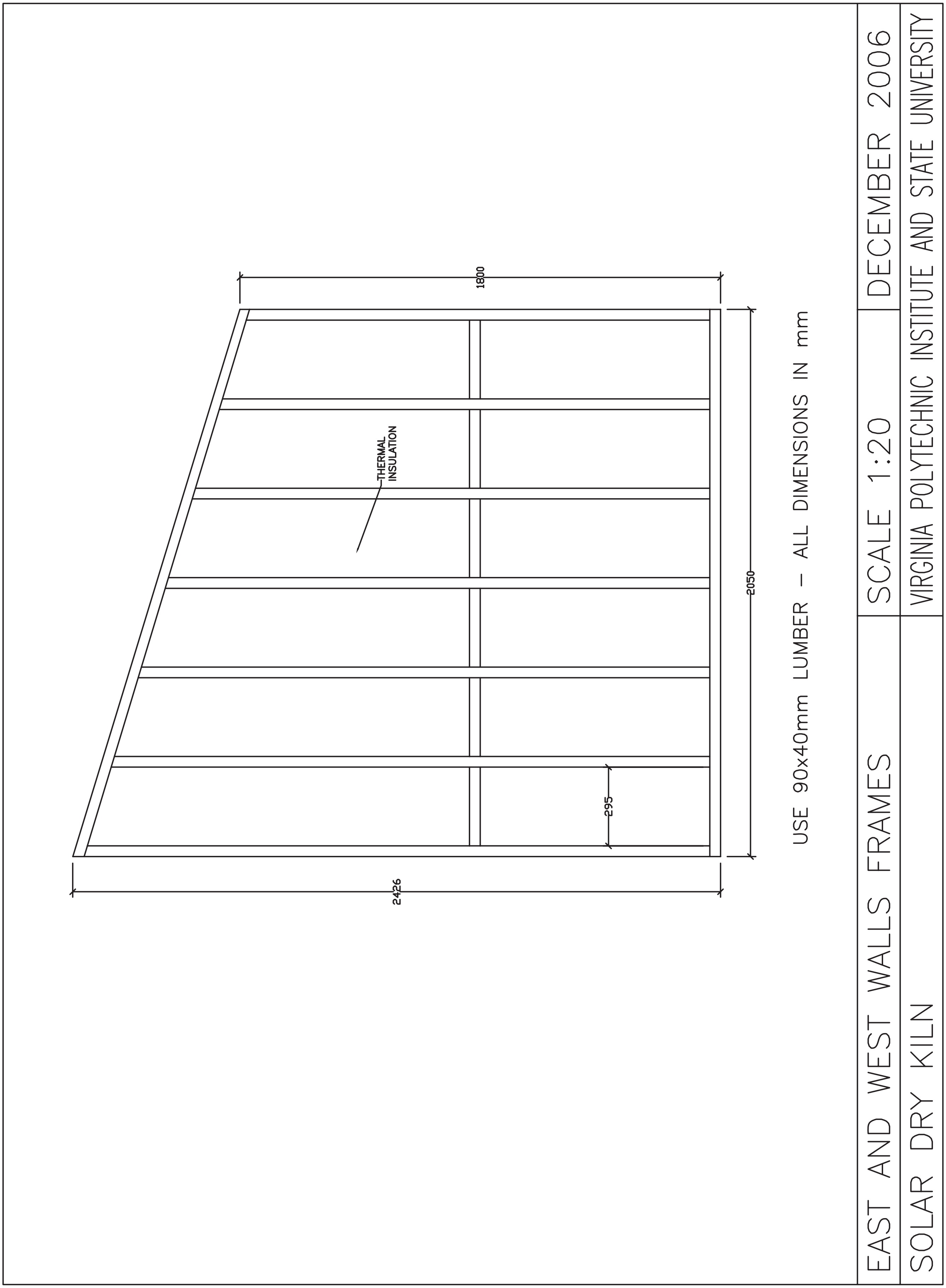
Forest Products Laboratory. Air drying of lumber. Gen. Tech. Rep. FPL-GTR-117. Madison, WI: United States Department of Agriculture Forest Service. Forest Products Laboratory. 62 p.

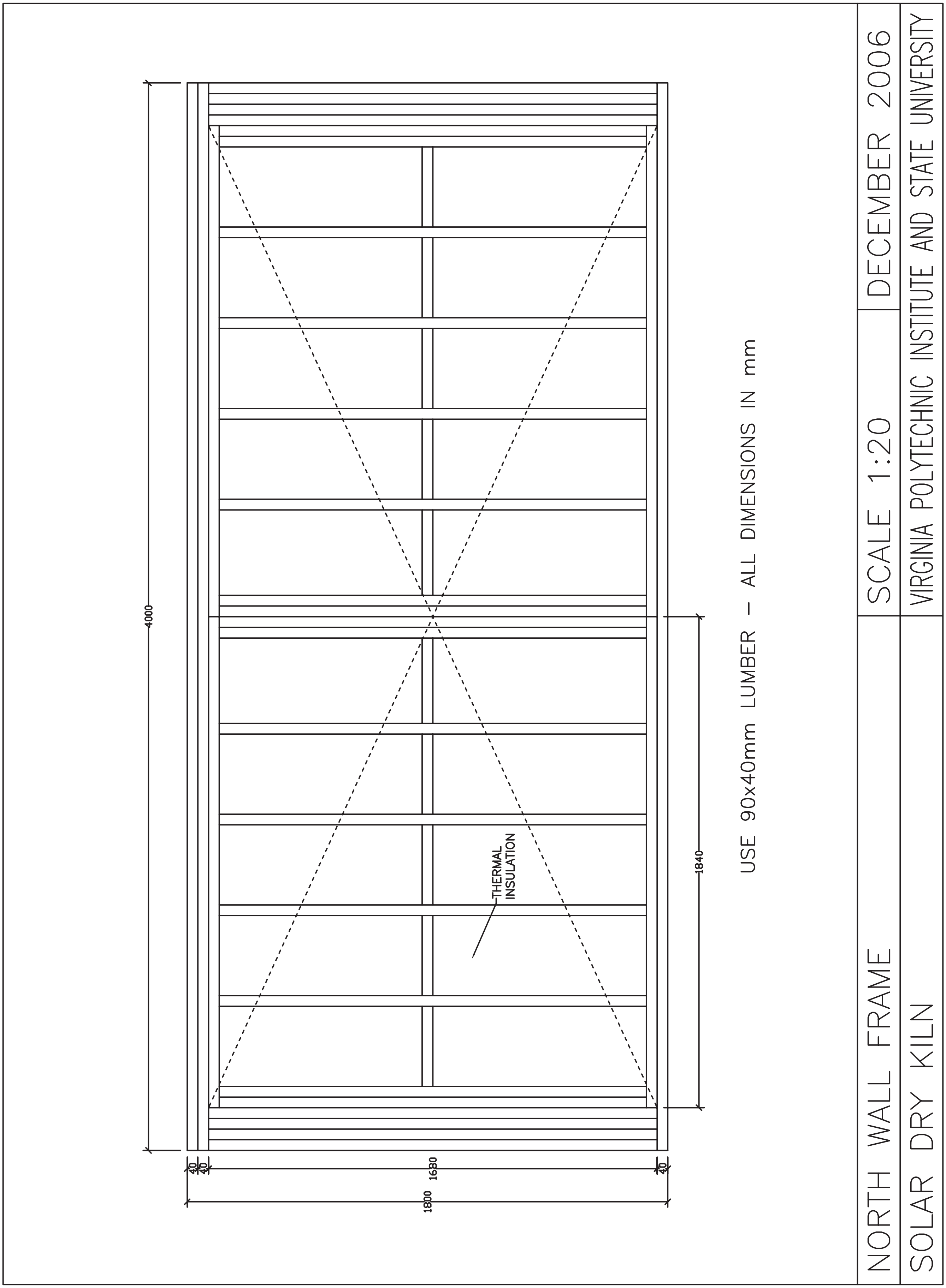
APPENDIX A

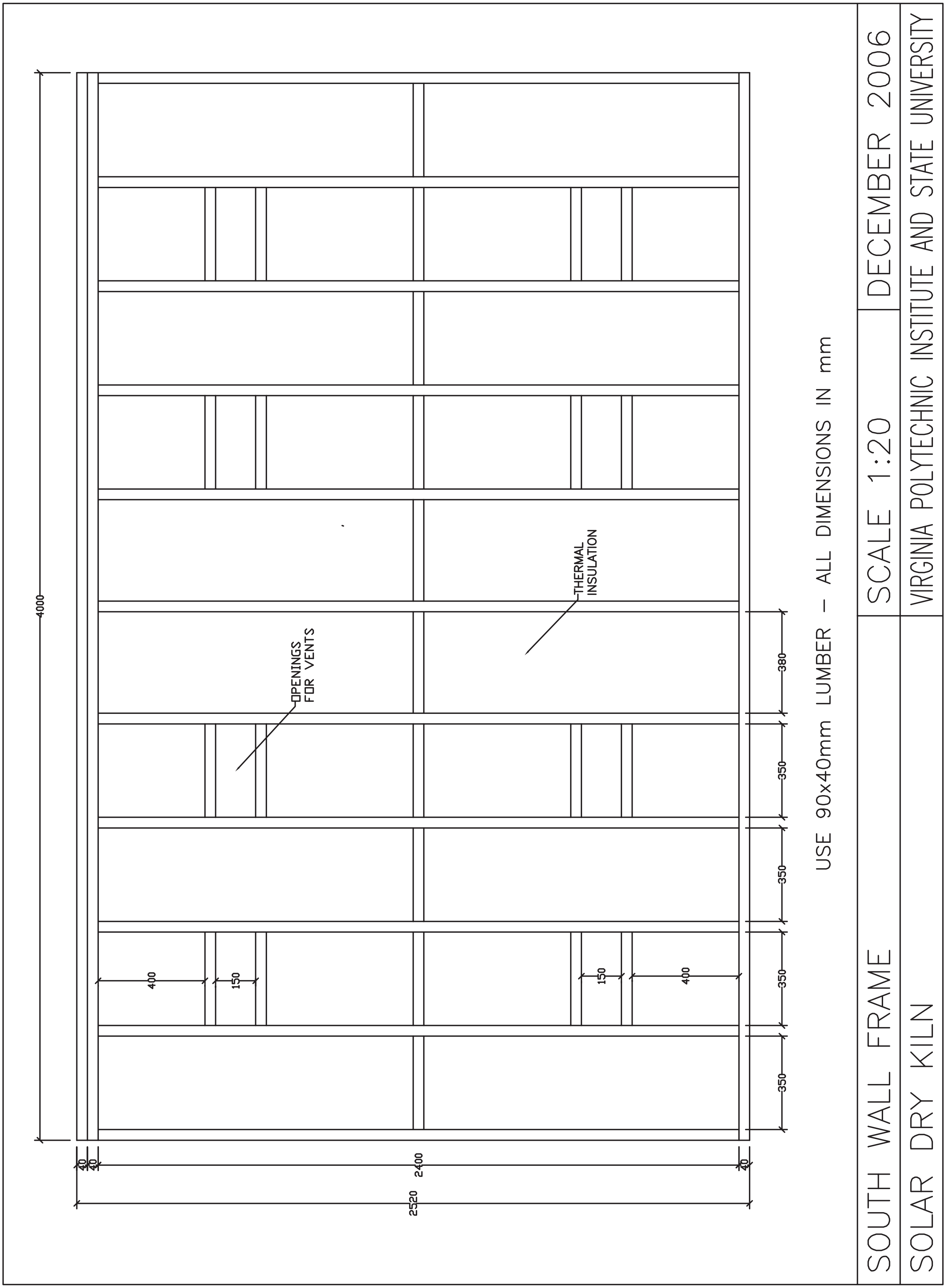
Design drawings for the solar kiln

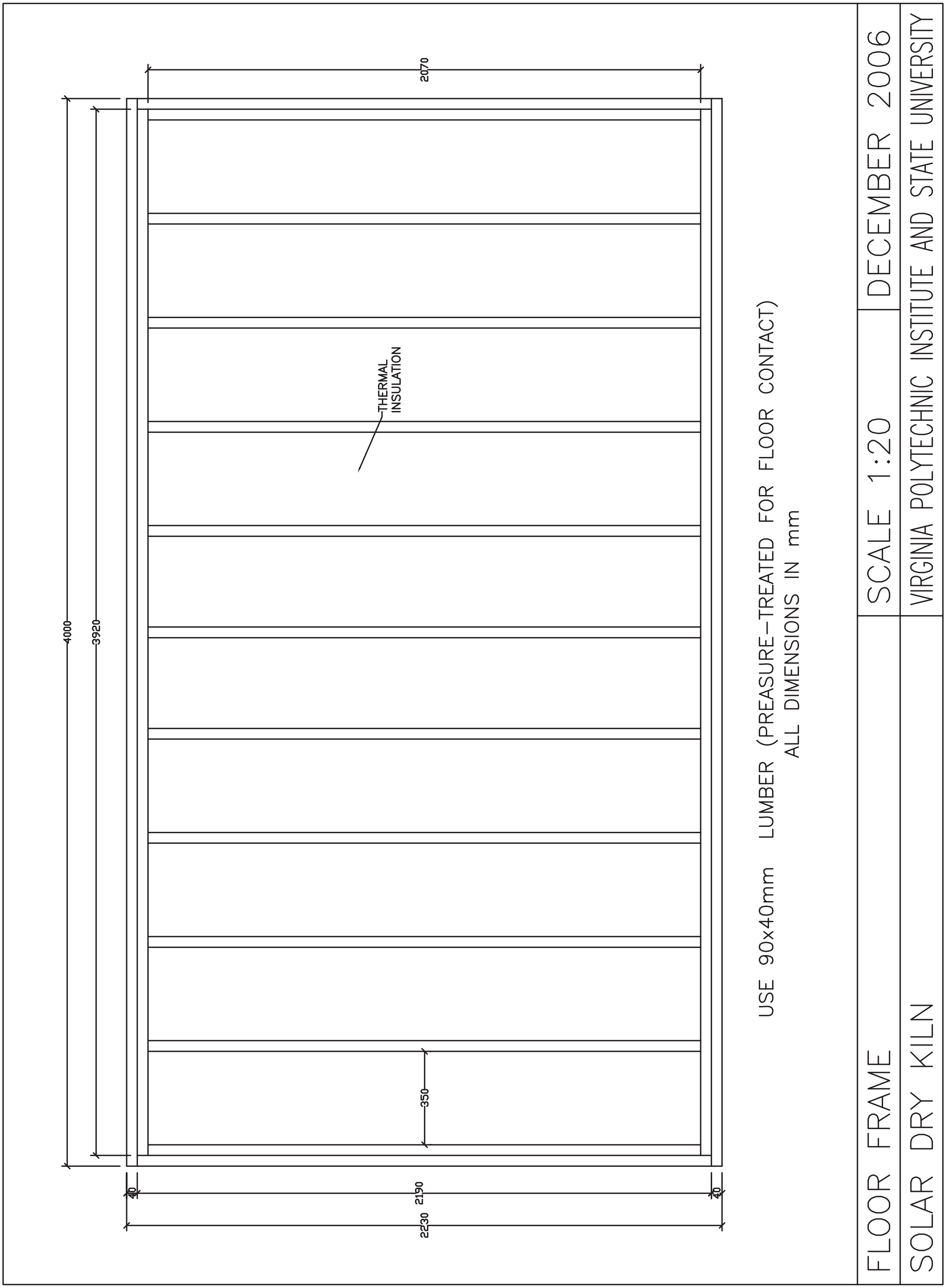



GLAZING
AREA =8,5m2
AIR FLOW
COLLECTOR
BOX FAN
BAFFLE
VENT
LUMBER LOAD
800 P2 IN 4/4
17°
720
1800
90
2050
2230
2520
2710
20
170
ALL DIMENSIONS IN mm
LATERAL SECTION
SOLAR DRY KILN
SCALE 1:20
DECEMBER 2006
VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY


1800
THERMAL INSULATION
2050
295
2426
USE 90x40mm LUMBER – ALL DIMENSIONS IN mm
EAST AND WEST WALLS FRAMES
SCALE 1:20
DECEMBER 2006
SOLAR DRY KILN
VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY


4000
1840
40
40
40
1630
40
1800
THERMAL
INSULATION
USE 90x40mm LUMBER – ALL DIMENSIONS IN mm
NORTH WALL FRAME
SOLAR DRY KILN
SCALE 1:20
DECEMBER 2006
VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY


SOUTH WALL FRAME
SOLAR DRY KILN
SCALE 1:20
DECEMBER 2006
VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY
USE 90x40mm LUMBER – ALL DIMENSIONS IN mm
OPENINGS FOR VENTS
THERMAL INSULATION
4000
2400
2520
40
40
40
380
350
350
350
350
400
150
150
400


FLOOR FRAME
SOLAR DRY KILN
SCALE 1:20
DECEMBER 2006
VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY
USE 90x40mm LUMBER (PREASURE-TREATED FOR FLOOR CONTACT)
ALL DIMENSIONS IN mm
THERMAL INSULATION
2070
4000
3920
350
40
2190
40
2230

APPENDIX B

Solar Powered Fans

Creative Energy Technologies Inc
2872 State Rte 10
Summit, NY 12175

Green Home: Environmental Store
850 24th Ave.
San Francisco, CA 94121
Fax: 415-752-6389

Bond, Brian; Espinoza, Omar; Araman, Philip. 2011. Design and operation of a solar-heated dry kiln for tropical latitudes. Gen. Tech. Rep. SRS-134. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station, 14 p.

Lumber is usually dried to a specific moisture content prior to further manufacturing or use. While lumber can be air-dried, the ambient humidity in most localities prevents the lumber from reaching the moisture content necessary for dimensional stability and use, especially for interior use. Solar kilns are an inexpensive alternative to conventional steam-heated kilns, especially for small operations, and communities. Solar-heated kilns have great potential in developing countries, especially in remote locations with little access to conventional energy sources. This publication describes the construction and operation of a solar kiln for lumber drying in tropical latitudes.

Keywords: Kiln drying, low-cost lumber drying, lumber drying, solar-heated lumber drying, tropical hardwoods, tropical wood drying.