Ebac Ltd
COMMERCIAL DIVISION

Drawing No.	:-	TPC229
Issue	:-	2
Date	:-	23/12/03

EBAC LUMBER DRYER

OWNER'S MANUAL
KILN CONSTRUCTION GUIDE
TROUBLESHOOTING GUIDE

LD3000

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EBAC LD3000
TABLE OF CONTENTS

	PAGE
Warranty	i
Introduction	ii
Lumber Drying Principles	iii
Unpacking	1
Contents	1
KILN DESIGN & CONSTRUCTION:	
Dryer Capacities	2
Kiln Chamber	3
Lumber Stack Size	3
Chamber Interior Dimensions	4
Choosing Proper Insulation Thickness	5
Example Kiln Sizes	6
Construction of Chamber	7
Floor	7
Wall/Ceiling Construction	7
Door Construction	8
Fan Truss	8
Material List	8
INSTALLATION & TESTING	
Installation	15
Testing for Proper Operation	16
Universal Controller	16
Testing Two-Stage Overheat System	19
High Temperature Vent System	20
DRYING LUMBER:	
Preparation of the Lumber Stack	22
Kiln Operating Instructions	23
Dryer Control Settings	25
Additional Notes On Lumber Drying	26
APPENDIXES	
Oven Dry Method For Determining Equilibrium Moisture Content	27
Troubleshooting	29
Drawings & Diagrams	32

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Ebac LIMITED WARRANTY

Ebac Incorporated Lumber Dryers and Controllers carry a one year limited warranty against any defect in workmanship or material. This Warranty will cover all parts and labor required to repair your Ebac Lumber Dryer or Controller. This Warranty is invalid if the unit has been abused, damaged, whether intentional or accidental, or if any modifications have been made to the unit.

In addition, an extended warranty is provided for the evaporator coil and compressor for an additional two years (three years total). Under the extended warranty a new or remanufactured part will be supplied by Ebac, provided the defective part is first returned to Ebac for inspection. The replacement part assumes the unused portion of the warranty. The extended warranty does not include labor or other costs incurred for diagnosis, repairing or removing, installing or shipping the defective or replacement parts.

THE FOREGOING WARRANTY IS EXCLUSIVE AND IS ISSUED IN LIEU OF ALL OTHER WARRANTIES (WHETHER WRITTEN, ORAL, OR IMPLIED) INCLUDING THE WARRANTY OF MERCHANTABILITY AND THE WARRANTY OF FITNESS FOR A PARTICULAR PURPOSE. EBAC INCORPORATED DISCLAIMS ANY LIABILITY FOR CONSEQUENTIAL DAMAGES, LOST PROFITS, OR INCIDENTAL DAMAGES FOR BREACH OF ANY WRITTEN OR IMPLIED WARRANTY WITH RESPECT TO THE FOREGOING DESCRIBED MERCHANDISE.

Model: LD3000

Serial Number: _____

Date Received: _____

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INTRODUCTION:

You have probably never seriously considered kiln drying your own lumber before, believing it to be too expensive or too complicated to undertake on a small scale.

Prior to the introduction of the Ebac Small Scale Lumber Dryers this was true. Kiln drying was for the world of specialists: a confusing maze of kiln schedules, sampling techniques, relative humilities and complex controls – hardly inviting to the small woodworking business which merely wanted to be sure of a regular supply of quality wood at a reliable and consistent moisture content.

Ebac Small Scale Lumber Dryers have changed all that. Whether yours is a one-man business or somewhat larger, whether you are in the woodworking business or woodworking is just your hobby, you do not need any previous experience with drying. As well as being simple to install and operate, Ebac dryers are quiet and cause no pollution.

The Lumber Dryers themselves are installed in easily made chambers of the appropriate size.

This manual has been designed to guide you through the problems of choosing the correct size of wood dryer for your needs, constructing a suitable chamber and operating the kiln to obtain maximum output of wood.

Use it carefully and thoroughly and you will quickly find out everything you need to know.

For further information and details of constructions and applications not covered, we will be pleased to offer advice and assistance as required. Please do not hesitate to contact us.

LUMBER DRYING PRINCIPLES:

When lumber is being dried, the rate of moisture evaporation is dependent on the difference between the vapor pressure of the wet wood and the vapor pressure of the air. When the vapor pressures have equalized, no further drying occurs. This is the point at which the equilibrium moisture content of the wood has been reached. (See Figure 1).

One way of increasing this vapor pressure difference and encouraging rapid drying, is to heat the wood and increase its vapor pressure. Essentially this is what conventional steam kilns do.

EMC at 68°F (20°C)

(Figure 1)

Another way of increasing the difference between the vapor pressure of the air and that of the wood is to lower the vapor pressure of the air. This is what Ebac dryers do: encourage evaporation by removing moisture from the air surrounding the wood.

As damp air is drawn into the machine (see Figure 2) water condenses onto a refrigerated coil. The water is drained off and the dried air is re-warmed with the heat from the condenser coil. The air is re-circulated through the lumber stack, causing more evaporation. Moisture-laden hot air is not simply vented into the atmosphere as in energy wasteful steam kilns; this results in efficient operation.

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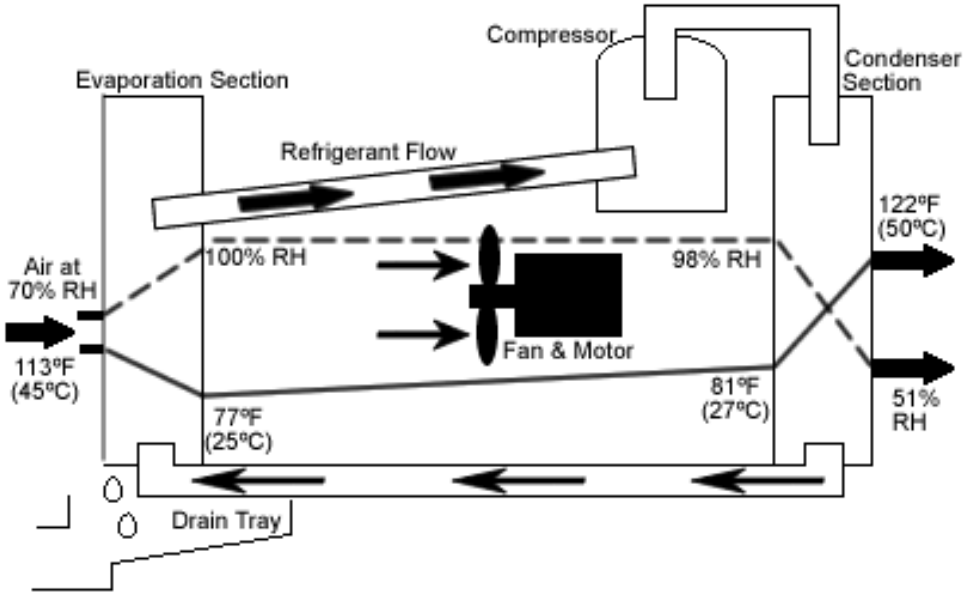
Drawing No.	:-	TPC229
Issue	:-	2
Date	:-	23/12/03

SIMPLIFIED SCHEMATIC DIAGRAM OF LUMBER COMPONENTS
Figure 2



Though the fastest drying is achieved at high temperature, the risk of degrade in the wood, particularly hardwood, increases at high temperature. The general rule is that the lower the temperature the better the quality.

Ebac dryers are designed to operate in the temperature range that is the best compromise between speed and quality – about 140°F (60°C) and lower. Drying at these temperatures insures that the wood is of the highest quality, and that the equipment is reliable.

UNPACKING:

Upon receipt of your LD3000, carefully inspect the shipping container and its contents for any damage. If damage is discovered, contact the Service Department for instructions.

CONTENTS:

Your LD3000 shipment consists of the following items:

1. LD3000 Lumber Dryer with Power Cord and Interconnecting Universal Controller Cord.
2. Discharge Hose
3. Universal Controller
4. (2) Wall Mounting Brackets
5. (2) 16 - inch Circulation Fans

DRYER CAPACITIES:

Table 1 below shows average drying times for the LD3000. Table 2 shows the optimum load capacities for the LD3000. If larger quantities than those shown in Table 2 are dried, drying speed will be proportionately slower. If small quantities are dried, the controls can be adjusted to allow for this.

Table 1 - Average Drying Time In Days *

		MOISTURE CONTENT RANGE			
FROM - TO		**50% - 8%**	**40% - 8%**	**30% - 8%**	**20% - 8%**
Type	**Thickness**	**Days**	**Days**	**Days**	**Days**
Hardwoods**	1”	50	37	25	13
	2”	90	68	45	25
	3”	158	119	81	43
Softwoods	1”	14	10	6	4
	2”	32	25	15	8
	3”	53	40	27	14

* Drying times may vary depending on species, starting moisture content, thickness, and size of load.

** Drying of Claro Walnut is not recommended.

Table 2 - Optimum Lumber Capacities In Board Feet

Lumber Type	Softwoods			Hardwoods		
Thickness (Inches)	1”	2”	3”	1”	2”	3”
LD3000	1440	3240	5400	3000	5150	8875

(Some capacities can be smaller or larger - consult Ebac)

Example 1: You wish to dry 4/4 Oak from a starting moisture content of 30% to 8%.

From Table 1, you see that it will take 25 days to dry 4/4 (1”) hardwood for 30% to 8%.

Then from Table 2, the optimum capacity for 1” hardwood for the LD3000 is 3000BF. Therefore, 3000 BF can be dried in about 25 day, and 42,000BF in a year. (365 ÷ 25 days = 14 loads per year x 3000 BF per load).

KILN CHAMBER

LUMBER STACK SIZE:

The first step in determining your kiln chamber size is to determine the moist suitable lumber stack size (or configuration) for your purposes. This will depend primarily on the longest length board to be dried. Normally, the length of the stack will be equal to the length of the longest board. If your lumber is in short lengths (i.e.: approximately 3 feet), then the stack length should be a multiple of these shorts.

The width and height of the stack can be adjusted to suit your conditions. The "stack" may actually be made up of two or more smaller stacks, or packs.

In order to allow air-flow through the lumber stack, each "layer" must be separated from that below by a spacer or "sticker" of ¾ to 1" thickness. The air spaces thus created must be included in the overall stack height when calculating volume.

Use this procedure to determine stack height and width: First, select an appropriate width and then calculate stack height including stickers. If this calculated height would result in an awkward height to width, select a new width. See example 2 which follows.

Example 2: Desired kiln capacity is 3000 BF of 1" hardwood, and the longest board is 16 feet. Add 10% to the lumber quantity to allow for non-uniformity in the stack. If that stack width is 6 feet, then each layer of lumber would contain:

BF per layer = 16' x 6' x 1" thick = 96 BF

$$\text{Layers required} = \frac{3000 \text{ BF} \times 1.1}{96 \text{ BF/Layer}} = 34.4 \text{ or } 35 \text{ layers}$$

Each Layer is 1" + ¾" sticker = 1 ¾" high

Stack height = 35 layers x 1 ¾" high = 61 ¼" high (rounded up to 5 ¼")

Thus, the stack size is:

16' long x 6' wide and 43 ¾" high

CHAMBER INTERIOR DIMENSIONS:

Having calculated the stack size, it is now possible to calculate the appropriate internal dimensions of the chamber. This is done by adding the required additional space around the stack for the dryer and fans as well as for good air circulation. Suggested additional space is:

Length: 1’

Width: 2 ½”

Height: 2’

Example 3: Using information from Example 2, where stack size was 12’ long and 3’ wide and 43 ¾” high, we can find required internal dimensions.

Length: 16’ + 1’ = 17’

Width: 6’ + 2 ½’ = 8 ½’

Height: 5 ¼’ + 2’ = 7 ¼’

Minimum Interior Dimensions 17’ L x 8 ½’ W x 7 ¼’ H

CHOOSING PROPER INSULATION THICKNESS:

The wall thickness (insulation) is very important and is related to the size (surface area) of the chamber.

After adding the requires internal clearances to the stack size, the internal dimensions are known, and the approximate chamber surface area can be calculated. Table 3 shows the recommended thickness of insulation (wall thickness) in relation to the total surface area of the walls, ceiling and floor of the chamber.

To determine wall (insulation) thickness we must now calculate approximate surface area of the chamber.

Example:

Kiln Dimensions:	8 ½' x 8 ½' x 18' (H x W x L)	
Ends:	8 ½' x 8 ½' x 2 pieces	145 sq. ft
Top and Bottom:	8 ½' x 18' x 2 pieces =	306 sq. ft
Front and Back:	8 ½' x 18' x 2 pieces =	306 sq. ft
		757 sq. ft surface area

Pick proper insulation thickness from Table 3.

Table 3 - Thickness OF Insulation

Surface Area of Chamber In Sq. Ft	500	800	1100	1400	1800	2100
Optimum R-Value	11	16	19	19	21	21

Fiberglass Insulation		Blue Styrofoam
R-11 = 3 1/2"	R-19 = 6"	R-7 = 1"

The thickness in the table are optimum for year-round operation. If you wish to increase efficiency during the winter in cold climates, increase thickness by about 50% and remove extra insulation during the summer. This extra insulation may cause the kiln to overheat in the summer.

EXAMPLE KILN SIZES:

If you would rather not design the dimensions of your kiln, simply choose the best size for your operation from Table 4.

All of the kiln dimensions shown below are exterior dimensions. The load sizes refer to 1" hardwood with ¾" stickers, and all wall thickness and air spaces have been added in.

Table 4
Example Kiln Sizes
(Height x Width x Length)

6' Lumber
2 Stacks - See 12' Lumber

8' Lumber
2 Stacks - Se 16' Lumber

10' Lumber
10 x 10 x 12 = 3000 BF
10 x 9 ½ x 12 = 2700 BF
9 ½ x 9 ½ x 12 = 2500 BF

12' Lumber
9 ½ x 9 ½ x 14 = 3000 BF
9 ½ x 9 x 14 = 2700 BF
9 x 9 x 14 = 2500 BF

14' Lumber
9 x 9 x 16 = 3000 BF
9 x 8 ½ x 16 = 2700 BF
8 ½ x 8 ½ x 16 = 2500 BF

16' Lumber
8 ½ x 8 ½ x 18 = 3000 BF
8 ½ x 8 x 18 = 2700 BF
8 x 8 x 18 =2500 BF

CONSTRUCTION OF CHAMBER:

FLOOR:

An insulated concrete floor is recommended.

- Start with a gravel base.
- Lay down 2" of rigid styrofoam.
- Pour 4" of reinforced concrete.
- Seal concrete with any commercially prepared sealer.

Notes: A slightly pitched floor leading to drain may be incorporated. This will be helpful if large amounts of softwood are to be dried.

Should an insulated concrete floor not be feasible, a well-built, insulated wooden floor will work.

See Figure 3.

WALL/CEILING CONSTRUCTION:

- Make a 2" x 4" studded frame.
- Cover exterior with ½" exterior grade plywood or waferboard.
- Insulate to proper R-Value.
- Staple or tack 4 mil. plastic over insulation prior to installing inside the wall. This vapor barrier protects insulation from moisture.
- Spray paint over staples to prevent corrosion.
- Hang ¼" exterior grade plywood as inside wall.
- Coat the inside wall and ceiling with a vapor barrier grade sealer. This protects the inside walls and ceiling from moisture and insures a long life for your kiln. (Aluminized mobile home roofing paint works well).
- Use a silicone caulk to seal up all cracks and seams.

See Figures 4 and 5.

DOOR CONSTRUCTION:

- The door section should be constructed the same as the walls and ceiling.
- Exterior plywood should overlap the door frame by three inches (3”). This will allow space to attach a rubber gasket and enable the door to be bolted to the kiln chamber. Anchor bolts are recommended for continued usage.
- For front loading kilns, hinged double doors are needed.

See Figures 6 and 7.

FAN TRUSS:

The LD3000 kiln accomplishes air circulation with the aid of two (2) supplemental overhead fans. These 110 Volt, 60 Hz fans are wired in separate from the drying unit.

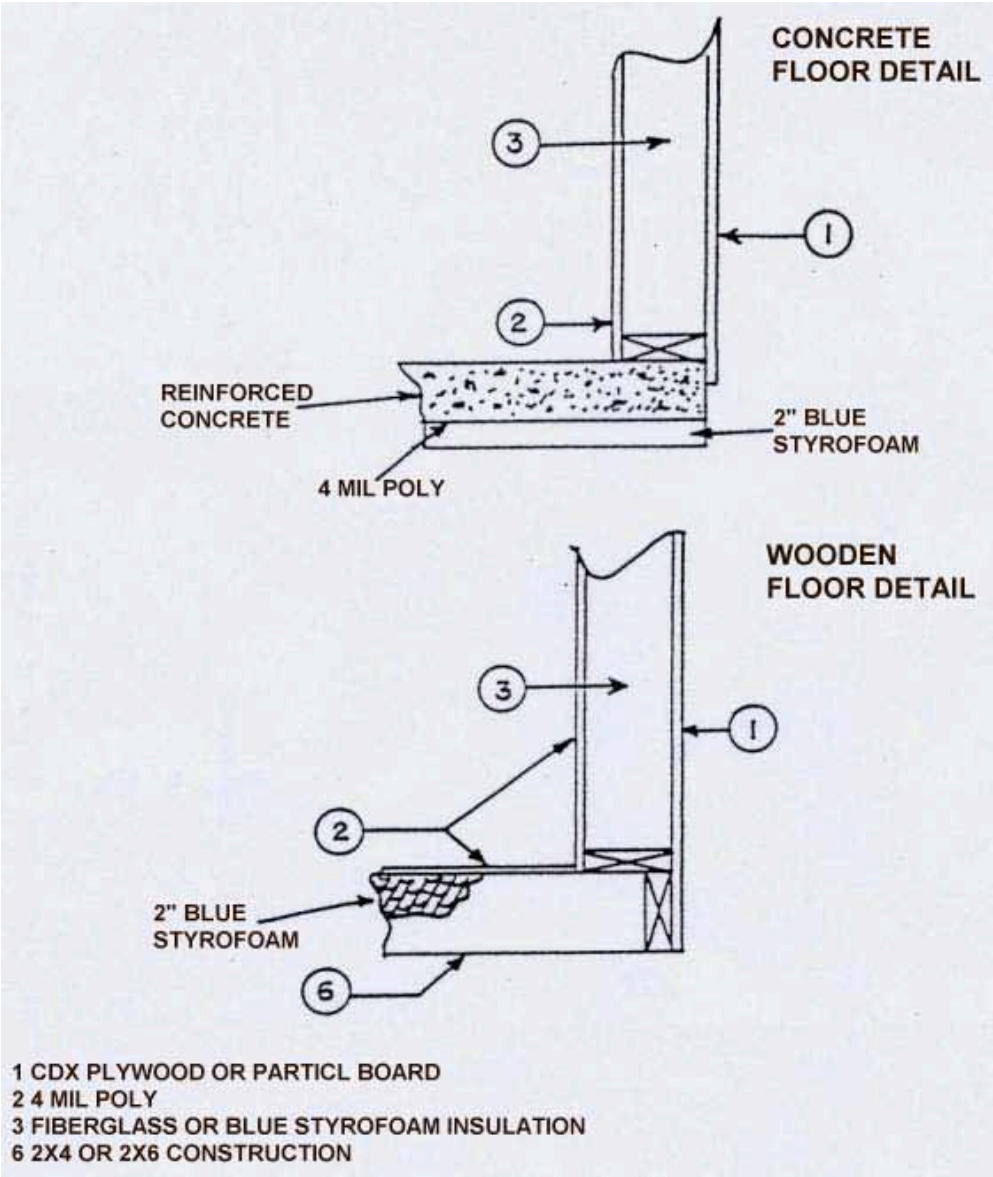
- The fan truss, which hangs from the ceiling, should run the length of the kiln.
- The truss should be located 18” from the front of the drying unit.
- The truss should be framed with 2” x 4” studs.
- The circulation fans should be evenly positioned within the truss.
- Air flow should move away from the dryer.
- Plywood or waferboard is used to cover the open area of the fan truss.
- For all dry kiln, baffles or curtains should be used above and to the side of the stack to force the air flow through the lumber stack, not around it. Heavy plastic is the most common baffling.

See Figure 8.

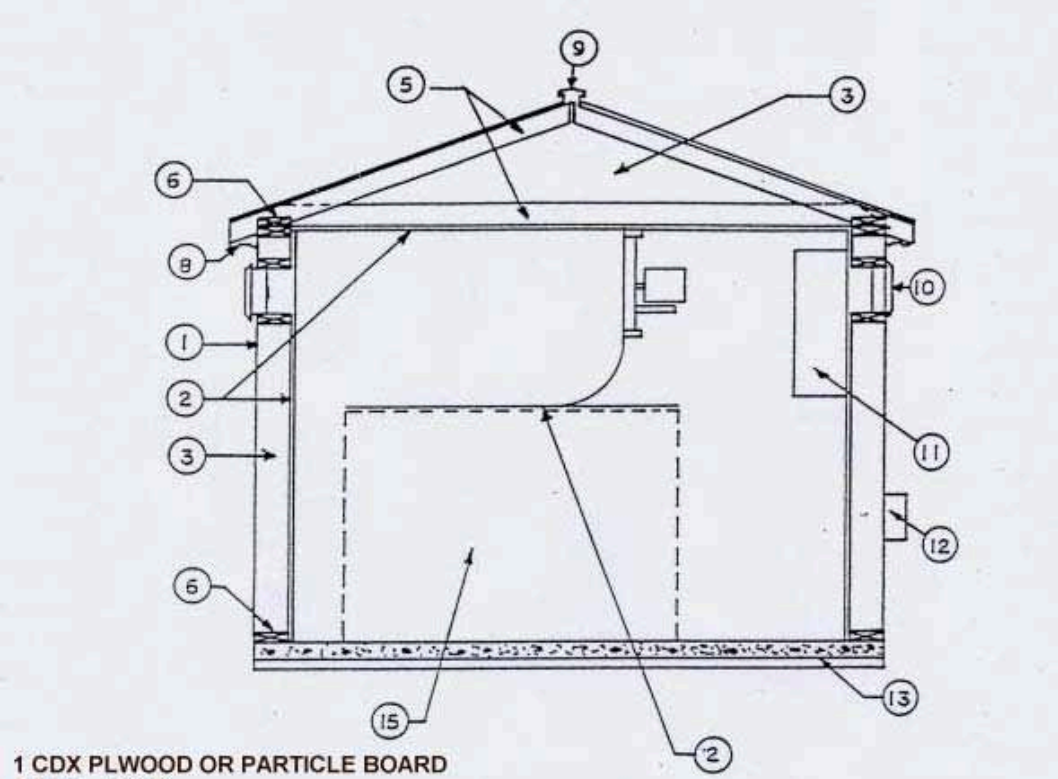
MATERIAL LIST: (Numbers correspond with drawings)

1. ¼” or ½” CDX plywood or particle board.
2. 4 mil. poly under CDX plywood or particle board.
3. Fiberglass or Blue styrofoam insulation.
4. Fiberglass or Blue styrofoam insulation.
5. 2” x 4” Construction
6. 2” x 4” or 2” x 6” Construction.
7. Rubber Gasket (Garage door seal works well).

LD3000 Kiln Floor Details (Fig 3)

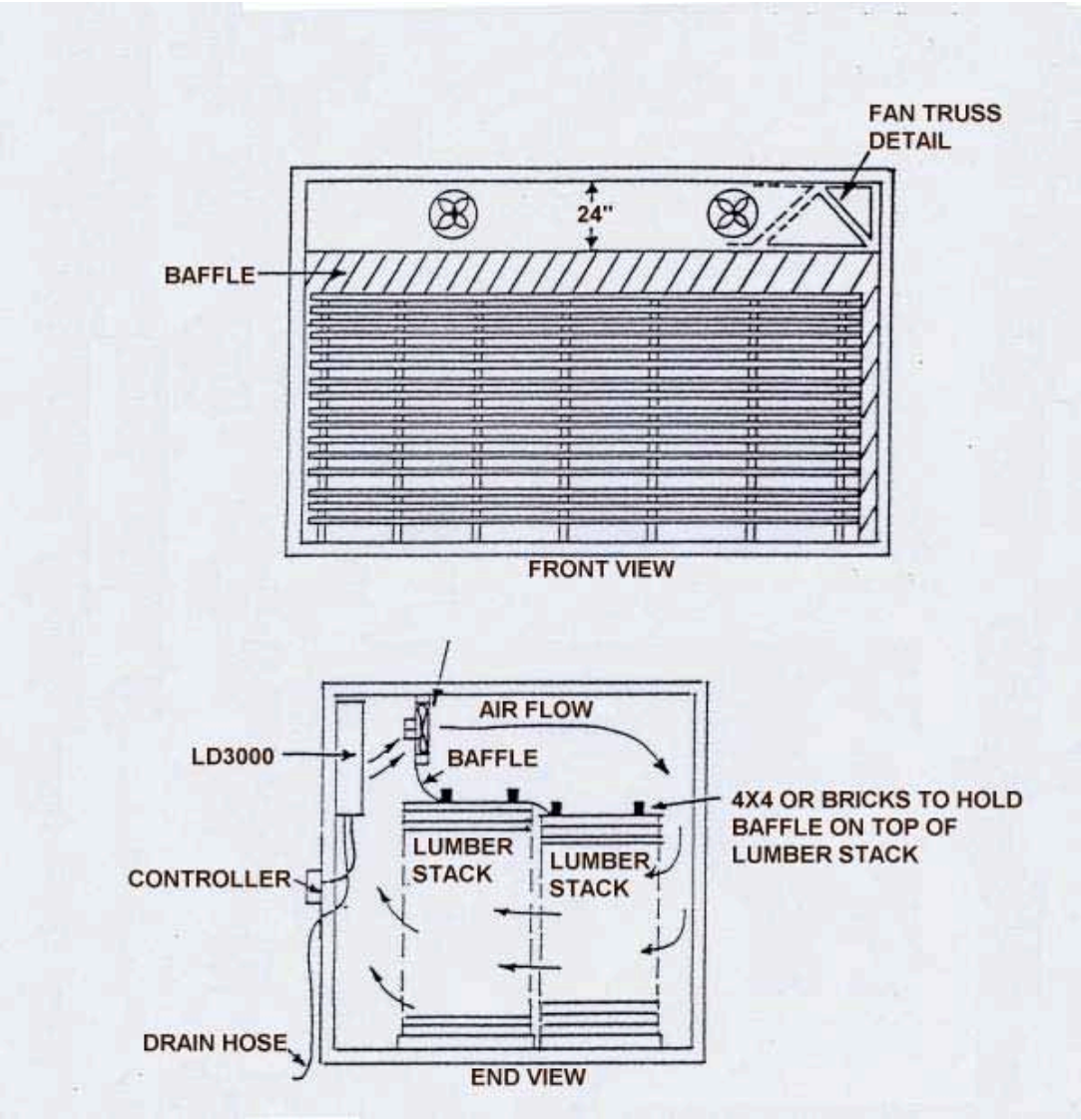


LD3000 Kiln Wall Construction (Fig 4)

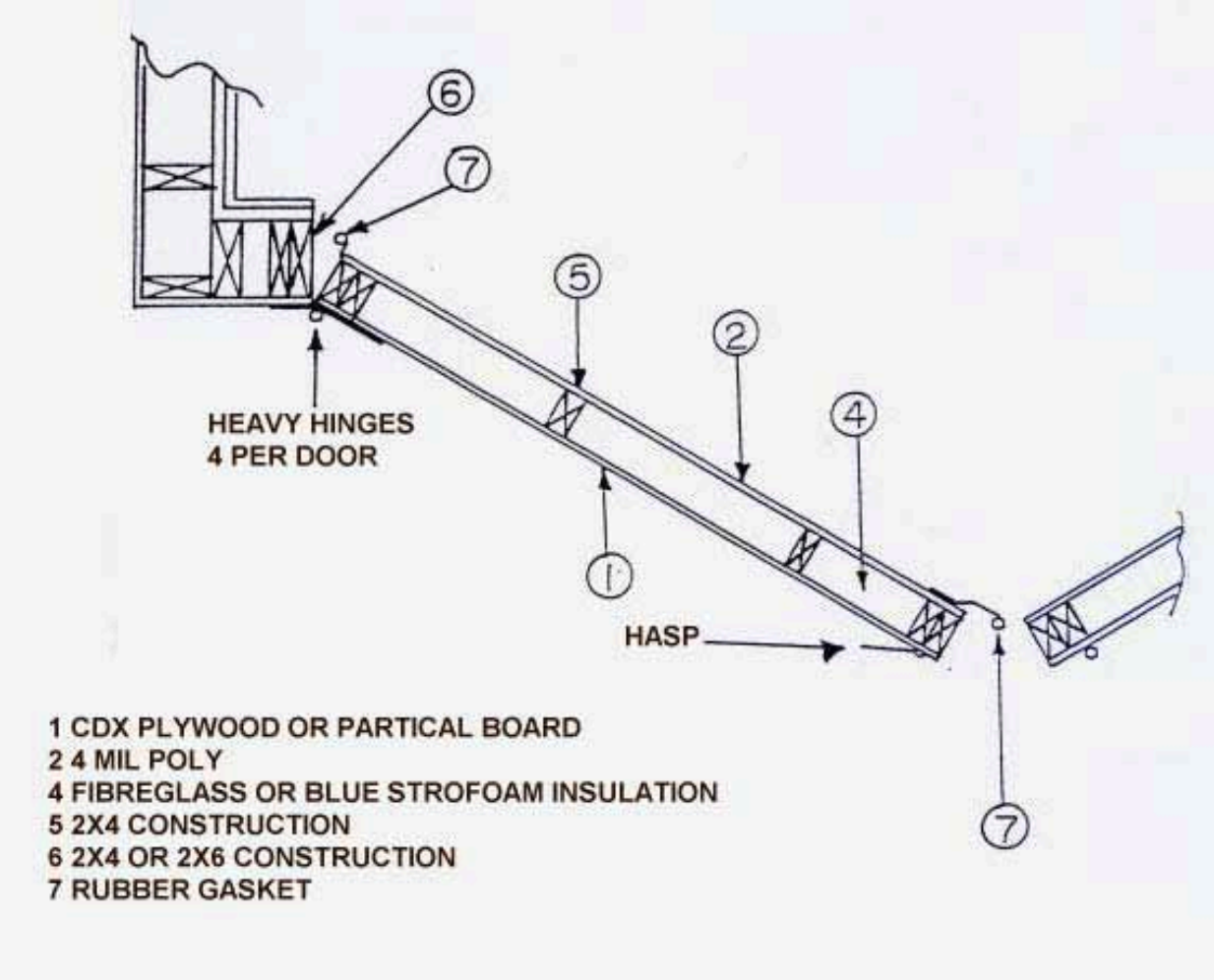


1 CDX PLWOOD OR PARTICLE BOARD
2 4 MIL POLY
3 FIBERGLASS OR BLUE STYROFOAM INSULATION
5 2X4 CONSTRUCTION
6 2X4 OR 2X6 CONSTRUCTION
9 RIDGE VENT
10 HEIGHT TEMP. VENT (OPT)
11 LD3000
12 UNIVERSAL CONTROLLER
13 4" CONCRETE

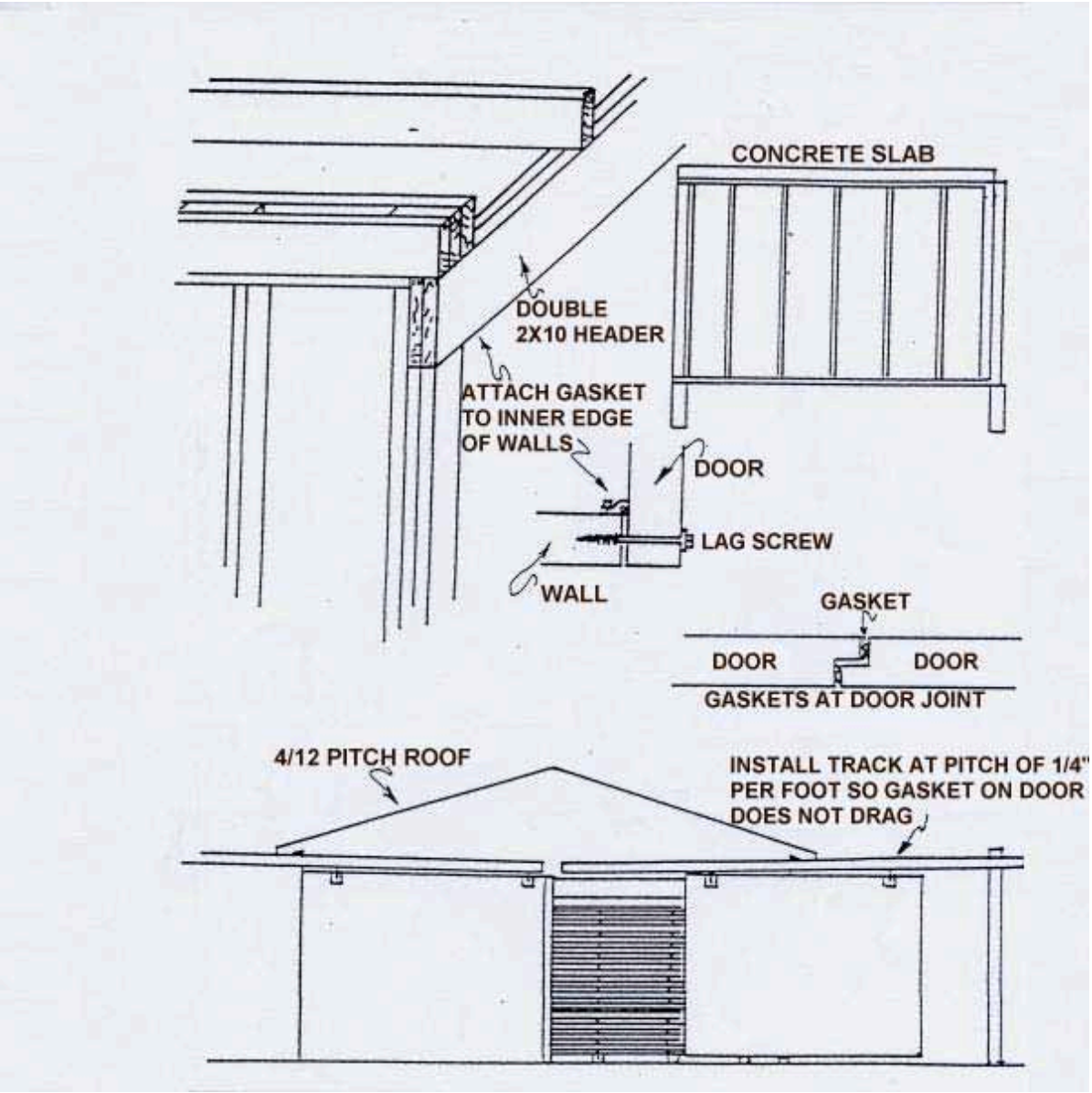
LD3000 Kiln Operating View (Fig 5)



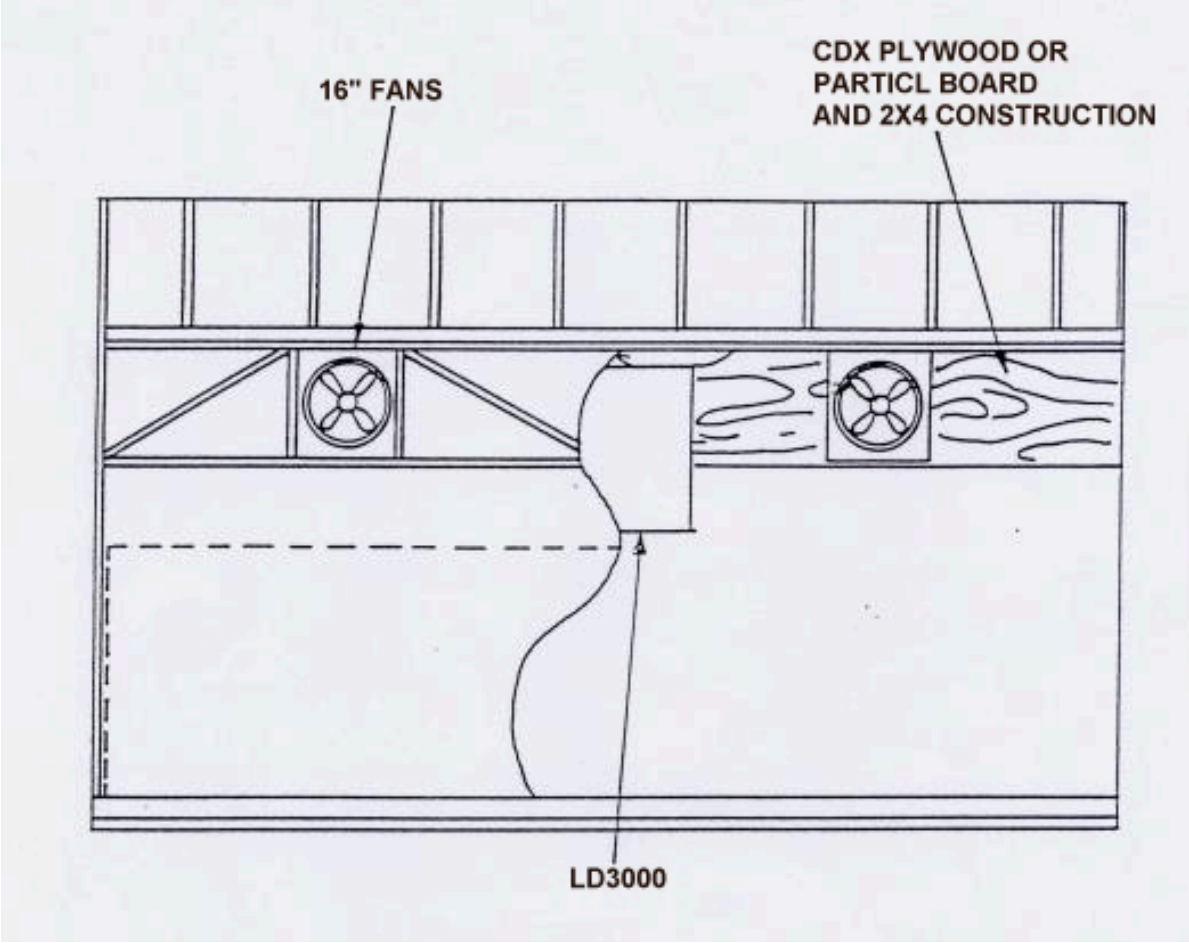
LD3000 Kiln Door Plan Section (Fig 6)



LD3000 Kiln Slide Door Detail For Forklift Handling (Fig 7)



LD3000 Kiln Fan Truss (Fig 8)



INSTALLATION AND TESTING

INSTALLATION:

All wiring should be carried out by a competent electrical contractor in accordance with local regulations.

The 16-inch circulation fans do not connect to the Universal Controller. They must be connected to separate switchgear.

> **Warning:** OSHA complying guards are strongly recommended when fans are installed within 7' of floor, working level, or within reach of personnel. Review OSHA codes.

Check the voltage at the power supply to insure correct voltage is 220 Volt ± 10%, 1 Phase, 60 Hz.

The LD3000 must be plugged into a suitable fused 220 Volt outlet.

Using the mounting brackets provided with the unit, mount the LD3000 4" - 8" from the ceiling, centered on the back wall.

Attach the discharge hose to the drainage nipple.

Locate and drill three (3) holes for the following:

Discharge hose -- ensure that water discharge will gravity feed from the kiln chamber.

Power cord and Controller cord -- Ensure that the power cord reaches the 220 Volt, 1 Phase, 60 Hz outlet, and that the Controller cord reaches the plug connection on the Universal Controller.

Use silicone rubber caulking or a similar material to seal the holes after proper installation of the discharge hose, power cord, and controller cord. This will aid in preventing heat loss from the kiln.

TESTING FOR PROPER INSTALLATION:

Remove the lower front panel by removing four retaining screws.

> **Warning:** Do not operate the LD3000 for an extended period of time with the covers removed. This will cause improper operation of the machine and may cause damage to the components.

Rotate the temperature control knob and the drying control knob on the Universal Controller counterclockwise until they stop.

Attach the controller cord to the Universal Controller and latch in place.

Plug the LD3000 power cord into the 220 Volt, 1 Phase, 60 Hz receptacle. (Insure that power to the receptacle has been achieved).

The fans in the LD3000 will start to rotate immediately. Set the drying control to C and the temperature control knob to 45°C.

The above settings will result in the following:

1. The heating element will produce heat.

2. After a 10 minute delay, the compressor will start to run.

When the compressor has been running for 10 minutes, the bare copper coils above the draintray should be covered with either frost or condensation. (The last two or three turns on the rear coils may not have frost or condensation because the refrigerant is picking up superheat for the return to the compressor).

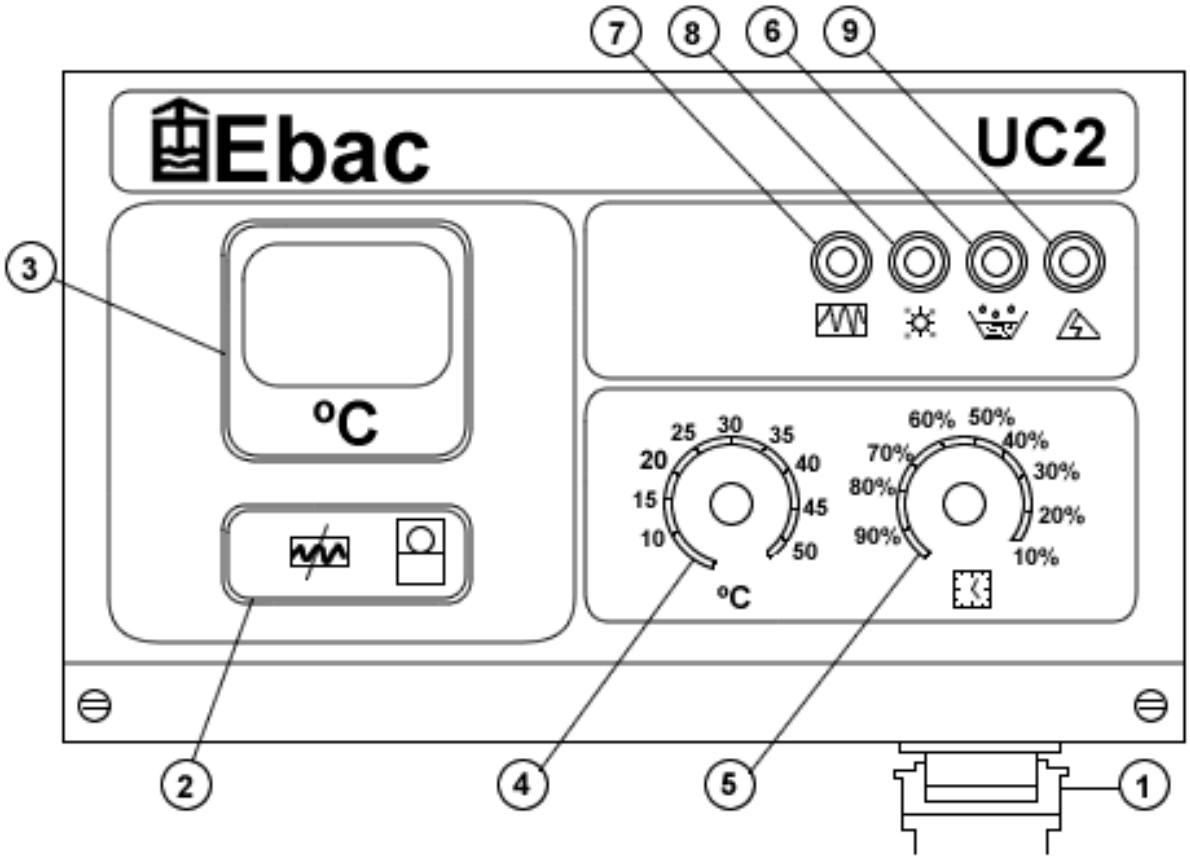
After insuring proper operation of the LD3000, disconnect the power cord and reinstall the lower front panel.

UNIVERSAL CONTROLLER:

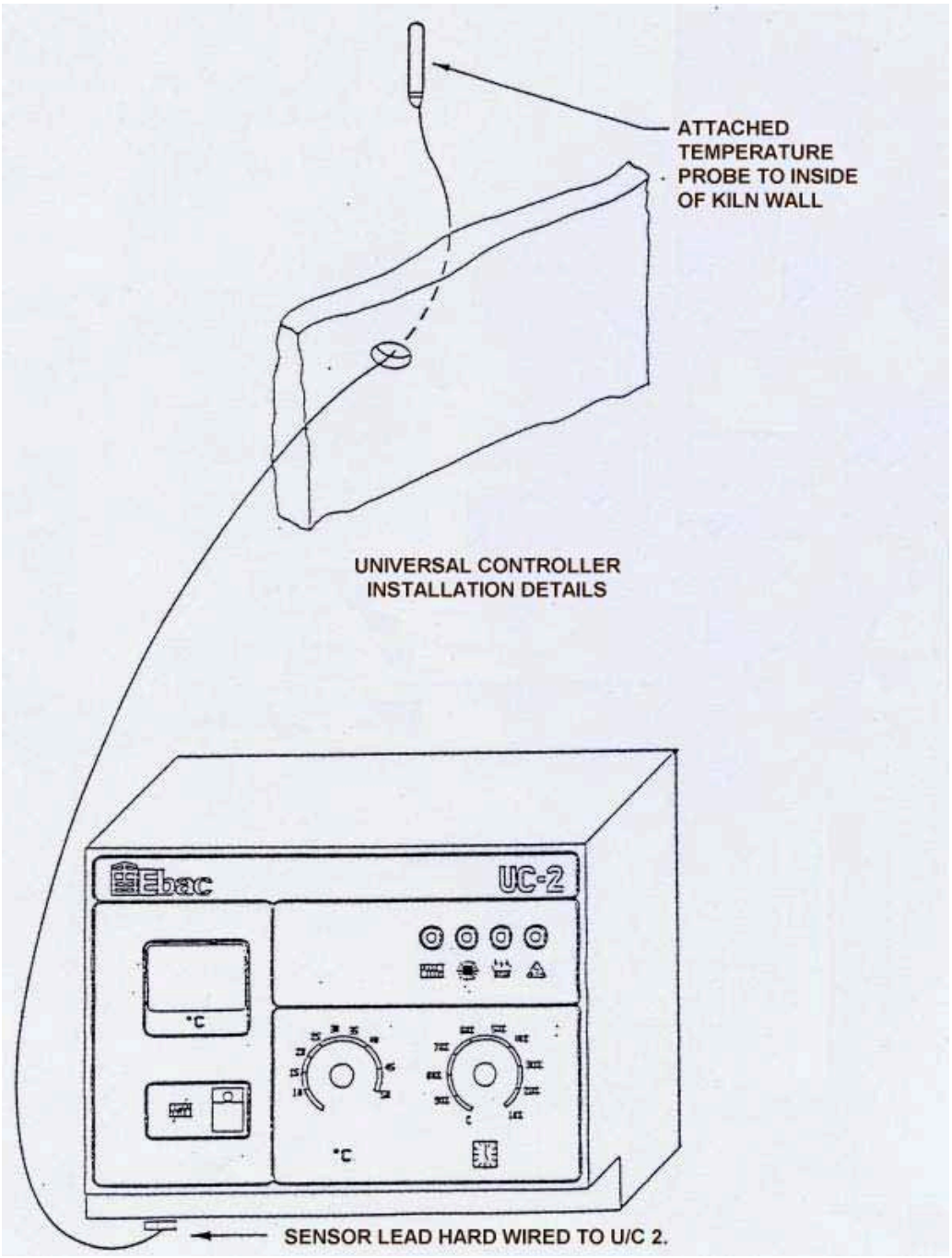
The Universal Controller incorporates a two-stage overheat protection system that protects the wood from damage resulting from kiln overheat. When the kiln temperature reaches the level preset on the Universal Controller, the heating element is switched off. If the temperature continues to rise because of heat produced by the compressor, the Universal Controller will switch off the compressor. The Controller parts are (See Figure 3):

1. Cord Attachment Plug
2. Heater By-Pass Switch
3. Temperature Display
4. Temperature Setting
5. Drying Control Setting
6. Compressor Indicator Light
7. Heater Indicator Light
8. Overheat Indicator Light
9. Not Used

Universal Controller (FIG 9)



UNIVERSAL CONTROLLER INSTALLATION DETAILS (FIG 10)



TESTING TWO-STAGE OVERHEAT SYSTEM:

Disconnect the power cord from the receptacle. Remove the top front panel by removing the six retaining screws. Reconnect the power cord to the receptacle.

> **Warning:** DO NOT reach into the electrical panel with your hand or with any tool. This may result in a severe electrical shock or death.

Set the drying control on the Universal Controller to C and the temperature to 45°C.

Gradually reduce the temperature control setting. When the temperature setting equals the temperature indicated by the temperature display, the heater will switch off. This can be verified by observing the C1 Contactor. When this contactor de-energizes, the heat is off. Reduce the temperature control further and the compressor will switch off when the temperature setting is 5° below the temperature display. This can be verified by observing the C2 contactor. When this contactor de-energizes, the compressor is off (See Figure 9).

Should you have any problems resulting from testing your LD3000 or Universal Controller, contact the Service Department for assistance.

HIGH TEMPERATURE VENT SYSTEM:

If the event you have purchased a vent system for your LD3000 kiln, please follow these instructions for installation and operation.

Exhaust vent fan, intake shutter motor, and thermostat should be wired by a licensed electrician in accordance with local codes. Assembly should be wired separately from all other Ebac equipment, to a 115 Volt, 1 Phase, 60 Hz, 15 Amp supply. Vent fan and shutters will engage automatically if the kiln temperature exceeds the setting on the thermostat control.

The differential on the thermostat has been pre-set at 3°F. This will insure proper operation and control the desired kiln temperature.

Vent fan and intake shutter cutouts are 13” square.

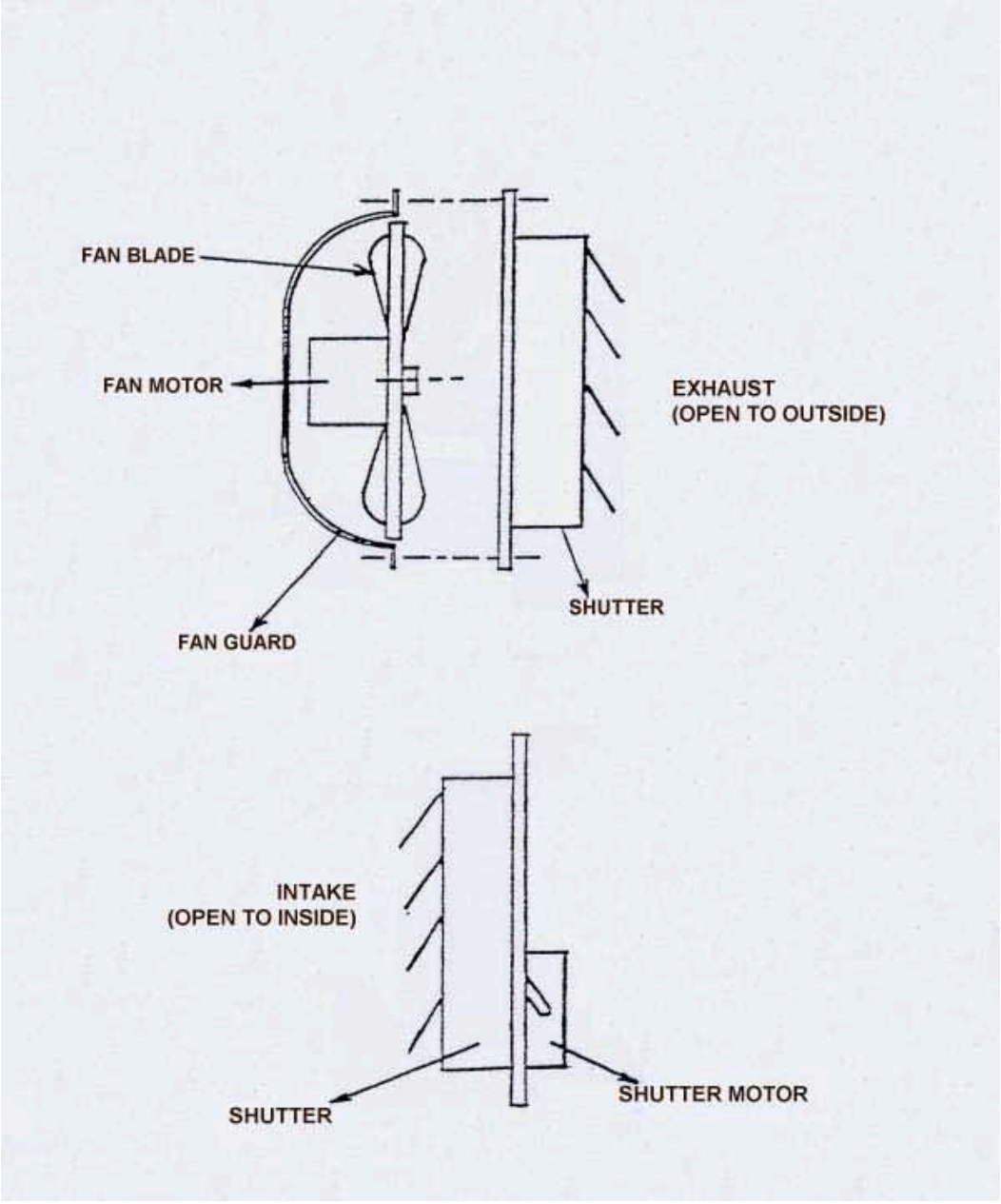
Both the vent fan and intake shutter should be mounted at least 3 ½ ft above the kiln floor. Positioning on the same kiln wall or at opposite ends of the kiln is acceptable. However, if positioned on the same wall, allow 6 feet minimum between shutter intake and kiln wall. The exhaust shutter open to the outside, the intake shutter open to the inside of the kiln.

Warning: OSHA complying guards are strongly recommended when fans are installed within 7’ of floor, working level, or within reach of personnel. Review OSHA codes.

Adjust the vent thermostat knob accordingly as you adjust your Universal Controller thermostat during the kiln drying run. The vent thermostat and the Universal Controller heater thermostat should be set at the same degree. A handy conversion chart has been included for converting °C to °F.

CENTIGRADE	FAHRENHEIT
10	50
15	59
20	68
25	77
30	86
35	95
40	104
50	122
	(Maximum for LD3000)

LD3000 HIGH TEMP VENT SYSTEM (FIG 11)



DRYING LUMBER

PREPARATION OF THE LUMBER STACK:

The best lumber drying results are obtained when the loads of lumber is of the same species, quality, thickness and initial moisture content. However, this is not always possible, particularly in small scale operations. In such situations the drying procedure should follow the slowest wood in the load -- i.e., the hardest, thickest, or wettest boards.

The layers of lumber are separated by stickers. The thickness of the stickers is determined by the thickness of the lumber most commonly being dried. Stickers of ¾" are generally used with boards up to 1 ½" thick and stickers for 1" for boards thicker than 1 ½ ". In practice, one set of stickers can be used in a kiln no matter what the lumber thickness.

The layers of stickers should be placed directly above each other to prevent distortion of the boards during drying. The space between columns of stickers should be approximately 18" to 30" for board thickness up to 1 ½" and 24" to 48" for board thickness' greater than 1 ½". Put a column of stickers at each end of the stack to support the ends and help reduce end checking. The important consideration is that the boards do not sag between rows of stickers.

Gaps in the stack cross-section are reduced by using boards of the same length, which otherwise would result in a non-uniform circulation at these spots. It is also important for good air circulation to fill the chamber to full capacity. If this is not possible, any gaps/spaces should be blocked with baffles so that air passes through the stack and not around it.

Before placing the lumber in the chamber, the initial moisture content of the wettest boards should be measured by means of an electronic moisture meter or the oven dry method (see Appendix 1). Ebac can provide a suitable moisture meter system to meet your needs at an additional cost.

KILN OPERATING INSTRUCTIONS:

1. Connect the main power cable to a suitable power supply.
2. Select the appropriate setting from the relevant drying control schedule as shown in Table 5. Settings are based on the amount and type of lumber to be dried.

> **Warning:** If the Table calls for a setting of "C" (Continuous), set the drying control at 90% at first, until the temperature reaches 38°C (100°F). Position "C" can then be selected.
>
> Below 38°C the dehumidifier requires the 10% off-time to defrost the ice formed on the heat exchanger (cold coil). Above 38°C (100°F), the condensation does not freeze, but drips continuously into the drain tray and out through the drainage hose.

3. Set the temperature control knob on the Universal Controller at the lower of the following:

   A. 5°C higher than the kiln temperature (shown on the digital display on the controller); or
   B. The maximum chamber temperature from the graph below.

   The temperature should be increased by 5°C (9°F) every 24 hours, but must NEVER exceed the temperatures shown on the graph below. If the temperature does not increase in accordance with the temperature control knob adjustments, (i.e., 24 hours after an increase of 5°C the temperature has risen by a lower amount, e.g. 3°C), this indicates that the heater is operating continuously but the temperature rise has not been achieved. This can be caused by the volume of wood being heated, cold weather conditions, or inadequate insulation. The next temperature setting should be 5°C above the kiln temperature as displayed on the temperature meter.

MAXIMUM SELECTED TEMPERATURE

Two things are very important:

A. THE RATE OF TEMPERATURE INCREASE MUST NOT BE MORE THAN 5°C (9°F) PER DAY.

Never set the thermostat more than 5°C (9°F) above the present kiln temperature.
Rapid temperature increases cause the relative humidity to suddenly drop leading to surface and end checking of the lumber.

B. THE KILN TEMPERATURE MUST NOT EXCEED THAT WHICH IS SAFE FOR THE MOISTURE CONTENT OF THE LUMBER.

The maximum chamber temperature, shown on the preceding graph, indicates the maximum safe kiln temperature at every stage of drying.

The temperature graph implies that you must measure the lumber moisture content each time before increasing the temperature when operating above 35°C (95°F). To determine if drying cycle is complete, the lumber moisture content must be actually measured using a moisture meter or the oven dry method.

4. To check that the drying rate is correct, allow the kiln about 3 days to stabilize after starting and then measure the water extracted during a 24-hour period. As the wood dries, the drying control and thermostat may be increased to maintain the water extraction rate.

COMPLETING THE RUN: When the drying cycle is complete, leave the wood for approximately 24 hours in the chamber with the Drying Control setting reduced to 10% and the thermostat reduced to its lowest setting. This will allow the residual moisture within the wood to become more evenly distributed.

TABLE 5

DRYING CONTROL SETTINGS

LD3000 LUMBER DRYER

CHAMBER LOAD -- SOFT WOODS									
Drying Control Setting	1" Cu Ft	4/4 Board Ft	25mm Cu Mtrs	2" Cu Ft	8/4 Board Ft	50mm Cu Mtrs	3" Cu Ft	12/4 Board Ft	75mm Cu Mtrs
C	120	1440	3.4	270	3240	7.7	450	5400	12.8
85	102	1224	2.9	229	2754	6.5	382	4590	10.9
65	78	936	2.2	175	2106	5.0	292	3510	8.3
40	48	576	1.4	108	1296	3.1	180	2160	5.1

CHAMBER LOAD -- HARD WOODS									
Drying Control Setting	1" Cu Ft	4/4 Board Ft	25mm Cu Mtrs	2" Cu Ft	8/4 Board Ft	50mm Cu Mtrs	3" Cu Ft	12/4 Board Ft	75mm Cu Mtrs
C	250	3000	7.4	429	5150	12.2	739	8875	21.1
85	212	2550	6.0	364	4377	10.4	628	7543	17.9
65	162	1950	4.6	278	3347	7.9	480	5768	13.7
40	100	1200	2.8	171	2060	4.9	295	3550	8.4

The above control settings will produce dried wood of good quality, higher than recommended settings can be used to give quicker drying if required. This may result in instances of degrade. If you are in any doubt select only the recommended setting.

ADDITIONAL NOTES ON LUMBER DRYING

As the wood dries, the daily volume of water extracted may decrease. The drying control setting may be increased to compensate for this fall-off in order to achieve a constant daily extraction of water.
When drying a mixture of thickness and/or species of wood, adjust the drying control to the setting applicable for the total load of wood as if it were comprised of the thickness or species requiring the lowest setting. e.g., a mixture of:

1000 BF of 1” Oak and

2000 BF of 3” Spruce

3000 BF (1000 + 2000) of 1” Oak requires a setting of “C”

3000 BF of 3” Spruce requires a setting of 65%

Therefore the correct setting for the mixed load is 65%

To prevent overheating during hot weather conditions, particularly if the drying chamber has been very well insulated, water extraction may occasionally be suspended to enable the chamber to cool. This is not a fault condition, however it is an indication that the chamber walls incorporate excessive insulation. This situation can be diagnosed by observing intermittent water extraction when the drying control is set to “C”.

In accordance with International practices, temperatures in these instructions are expressed in degrees centigrade (Celsius). The following scale can be used to determine the equivalent temperature in Fahrenheit.

°C	25	30	35	40	45	50	CENTIGRADE
°F	77	86	95	104	113	122	FAHRENHEIT

APPENDIX 1

OVEN DRY METHOD FOR DETERMINING EQUILIBRIUM MOISTURE CONTENT:

If an accurate moisture meter is not available, then moisture content can be determined using the oven dry method. The oven dry method is actually more accurate than moisture meters, but not very convenient. You do need an accurate scale for weighing the wood samples and an oven (a baking oven will do) to bake the samples.

Select a plank from the wood to be dried and cut 6 inches from each end and discard these cutoffs. (They will be much drier than the rest of the piece). Cut several one-inch pieces from one end until you have about a pound of weight. Weigh these and record the wet weight. Weigh the remaining portion of the plank and add it to the middle of the lumber stack in the kiln where it can be retrieved periodically to monitor equilibrium.

Place the 1" sample in a 225°F oven for 24 to 36 hours, then weigh again. This is the oven dry weight. Use the formula below to calculate the starting EMC of the sample.

$$EMC = \frac{\text{Wet Weight - Dry Weight}}{\text{Dry Weight}} \times 100\%$$

The moisture content of the lumber in the stack can now easily be monitored by periodically pulling the sample plank from the stack and weighing it. First, however, calculate the future dry weight of the plank by using the EMC just calculated.

$$\text{Plank Dry Weight} = \frac{\text{Wet Weight}}{1 + \frac{\text{EMC}}{100}}$$

Now having calculated the plank dry weight, use the formula above for determining EMC to monitor drying progress.

Example: You have weighed your 1" samples and they weigh 1.35 lbs. The remaining plank weighs 15.4 lbs and is added to the lumber stack in the kiln and the dryer can be turned on. After drying the samples 36 hours in an oven, you weigh them and the weight is 0.94 lb.

$$\text{Starting EMC} = \frac{1.35 \text{ lb.} - 0.94 \text{ lb.}}{0.94 \text{ lb.}} \times 100 = 44\%$$

Now calculate the future dry weight of the plank in the kiln:

$$\text{Plank Dry Weight} = \frac{15.4}{1 + \frac{44}{100}} = 10.7 \text{ lb.}$$

After a few weeks of drying, the plank is removed from the stack and weighs 12.2 lb.,

$$\text{Starting EMC} = \frac{12.2 \text{ lb.} - 10.7 \text{ lb.}}{10.7 \text{ lb.}} \times 100 = 14\%$$

APPENDIX II

TROUBLESHOOTING:

In case of trouble, first check that all instructions in the manual have been carefully followed. Next, go through the following chart. If the problem is still not resolved, call Ebac Incorporated. In most cases, a simple phone call will resolve the question.

SYSTEM OVERVIEW:

Air is drawn into the dryer where the moisture is extracted from it. Moisture is extracted when the air is passed through the evaporator coil. This coil is cooled to a temperature lower than the dew point temperature of the air and hence condensation forms on it. The dryer consists of 7 parts:

1. Fan motor to draw the air through the unit.
2. Compressor which drives the refrigeration circuit.
3. Evaporator coil – cold section of the refrigeration circuit.
4. Condenser coil – hot section of the refrigeration circuit.
5. Capillary tube – separates the hot and cold section of the refrigeration circuit with regard to gas flow.
6. Auxiliary heater.

The Universal Controller controls the power to the dryer and controls the amount of water to be extracted by operating the compressor in accordance with the drying control setting, i.e.: a 25% setting will run the compressor for 15 minutes in each hour. The fan runs continuously regardless of the drying control setting. The auxiliary heater runs only when the thermostat setting is greater than the kiln temperature, once the desired temperature is achieved, the heater shuts off.

Symptoms	Possible Fault
Unit completely Inoperative	1. No power at receptacle. Check fuse, etc., feeding receptacle.
Normal Operation but Low Water Extraction Kiln Temperature above 100°F (38°C)	1. Normal Start-Up. It usually takes 3 to 4 days for a new load of lumber to stabilize and for water output to reach normal levels. 2. Dry Lumber. As the moisture content of the lumber drops below about 10%, you will notice a drop in water extraction. If not at continuous, the timer may be advanced to maintain rate, but the moisture content of the lumber should be checked at this point to avoid over-drying. 3. Compressor Overheating. If the kiln temperature is over rating for unit, thermal circuit breaker in compressor may be opening. Reduce temperature by removing insulation, or lowering drying control setting. Do Not lower thermostat setting. 4. Refrigerant Gas Loss From Circuit. A refrigeration loss can be recognized by operating unit outside the kiln and check for severe freezing of a small proportion, less than half of the evaporator coil (cold coil) at temperatures above 68°F and relative humidity above 30%. Normally the coil freezes evenly. 5. Blocked or Frozen Drain Hose. Water may be flooding kiln.
Normal Operation But Low Water Extraction Kiln temperature Below 95°F (35°C)	1. IF drying control knob is set at continuous, coils may be icing up. Set back to 90% until temperature rises above 100°F (38°C). 2. At temperatures below about 75°F (35°C), lumber is slow to give up its moisture. Raise kiln temperature to maintain drying speed.

Symptoms	Possible Fault
Low Kiln Temperature Normal Water Extraction	1. As long as water extraction is normal, kiln temperature cannot be too low. In fact, the lower the temperature the better the wood quality. The insulation thickness' in Table 1 provides for 50°F (28°C) temperature rise over outside temperature at continuous drying control setting. Lower settings will give lower temperature rise.
Mold or Mildew on Lumber	1. This condition is not harmful to the lumber, but can be minimized with improved airflow or higher kiln temperature.
Bottom Layer or Two of Lumber Not Dry	1. This is caused by large temperature differences (greater than 5°F) from top to bottom of the kiln. Greater airflow or a better door seal will usually improve this.
Temperature in Kiln Continues to Rise Above Thermostat Setting.	** DO NOT LOWER THERMOSTAT SETTING ** 1. Thermometer on controller may need to be adjusted. If extraction maintains a normal rate, check temperature in kiln with another thermometer at the base of the dryer. If the temperature reads lower or higher than the thermometer needle on the controller, call Ebac for adjustment procedure. 2. If temperature reads the same and extraction ceases or slows substantially, you may have a "temporary over-insulation situation". Simply peel back a corner of insulation from the top of your kiln chamber. If this does not remedy the situation in 24 hours, call Ebac.

APPENDIX III

DRAWINGS AND SPECIFICATIONS

LD3000 SPECIFICATIONS

Height:	33”
Width:	43”
Depth:	12”
Weight:	167 lbs
Airflow:	600 CFM
Power Rating (Dryer):	1100W (Max)
Power Rating (Heater):	1500W (Operates Intermittently)
Power Supply:	208/230V, 60Hz, 1 Phase, 12 Amps
Maximum Operating Temperature:	50°C (122°F)
Finish:	Epoxy/Vinyl Coated Steel
Refrigerant Type:	R22
Refrigerant Charge:	1 lb. 6 oz.
Special Features:	Stainless Steel Water Collection Tray For Corrosion Resistance

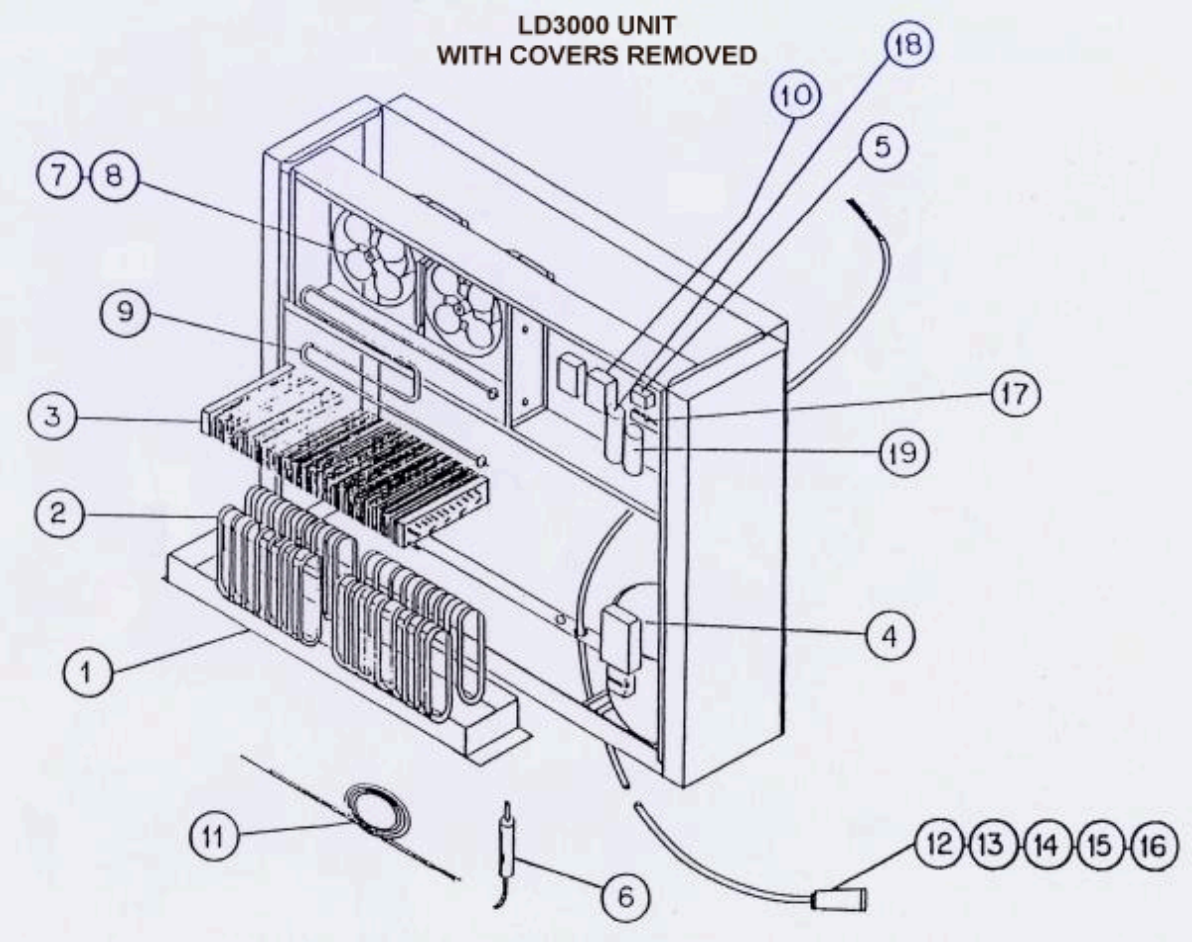
Ebac Ltd
COMMERCIAL DIVISION

Drawing No.	:- TPC229
Issue	:- 2
Date	:- 23/12/03

SPARE PARTS LIST LD3000

	DESCRIPTION	EBAC PART NO.	QUANTITY
1.	Drain Tray	2830225	1
2.	Evaporator Coils	2321701	2
3.	Condenser Coil	3020723	1
4.	Compressor	3022193	1
5.	Potential Relay	3930308	1
6.	Filter Dryer	3020909	1
7.	Fan Blade	3940001	2
8.	Fan Motor	3930102	2
9.	Heating Element	2830202	1
10.	Contactors	3033408	2
11.	Capillary Tubing (0.036 ID)	3014253	72”
12.	5 Core Cable	3831214	10’
13.	Crimp Contacts	3833912	5
14.	Hood	3833802	1
15.	Female Insert	3833801	1
16.	Cable Seal	3833803	1
17.	Terminal Block	3831403	1
18.	Start Capacitor (72-88 MF/330VAC)	3933502	1
19.	Run Capacitor (15MF/370VAC)	3933501	1

LD3000 MAJOR COMPONENTS LAYOUT (FIGURE)



UC2 SPECIFICATIONS

Height:	9 ½”
Width:	11 ½”
Depth:	6”
Weight:	2.2 lbs
Power Supply:	208/230V, 60Hz, 1 Phase
Outputs:	Heat Compressor
Display:	2 Digit 0.8” LED
Display Resolution:	1°C
Special Features:	1. Stage Overheat Protection. 2. Heat Disable Switch

Ebac Ltd
COMMERCIAL DIVISION

Drawing No.	:- TPC229
Issue	:- 2
Date	:- 23/12/03

SPARE PARTS LIST UC2

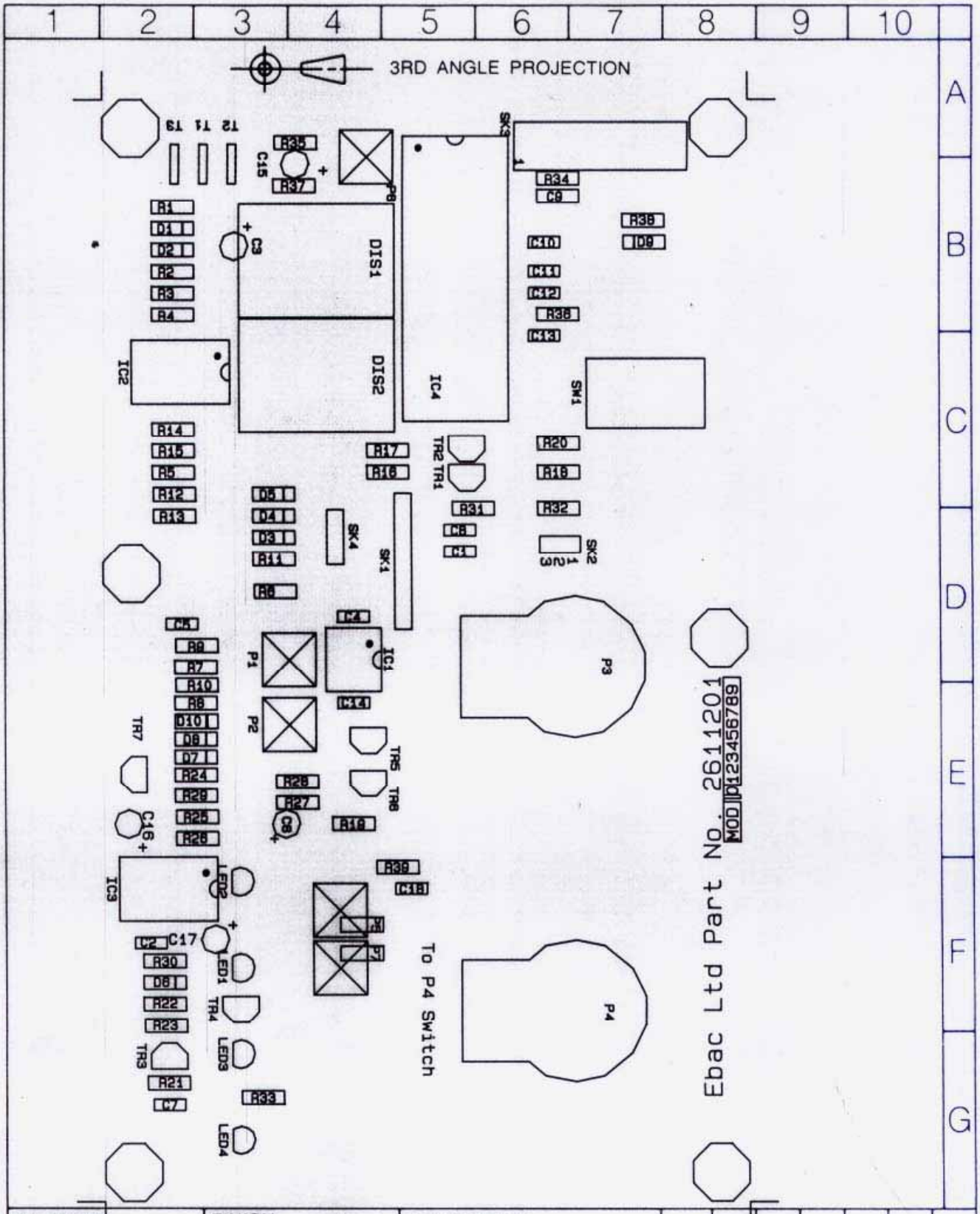
	DESCRIPTION	EBAC PART NO.	QUANTITY
1.	Universal Controller Housing	3250804	1
2.	Housing	3033812	1
3.	Male Insert	3033809	1
4.	1 mm Plug Contacts	3033814	7
5.	Power Supply PCB	1611300	1
6.	Display PCB	1611200	1
7.	Temperature Sensor	1350801	1
8.	Interconnecting Lead	1350802	1
9.	Knobs	3090611	2

Ebac Ltd
COMMERCIAL DIVISION

Drawing No.	:-	TPC229
Issue	:-	2
Date	:-	23/12/03

TEMPERATURE SENSOR SPECIFICATIONS

Temperature Sensor:	LM35DZ
Sensor Output	10 MV / °C
Supply Voltage:	120V DC



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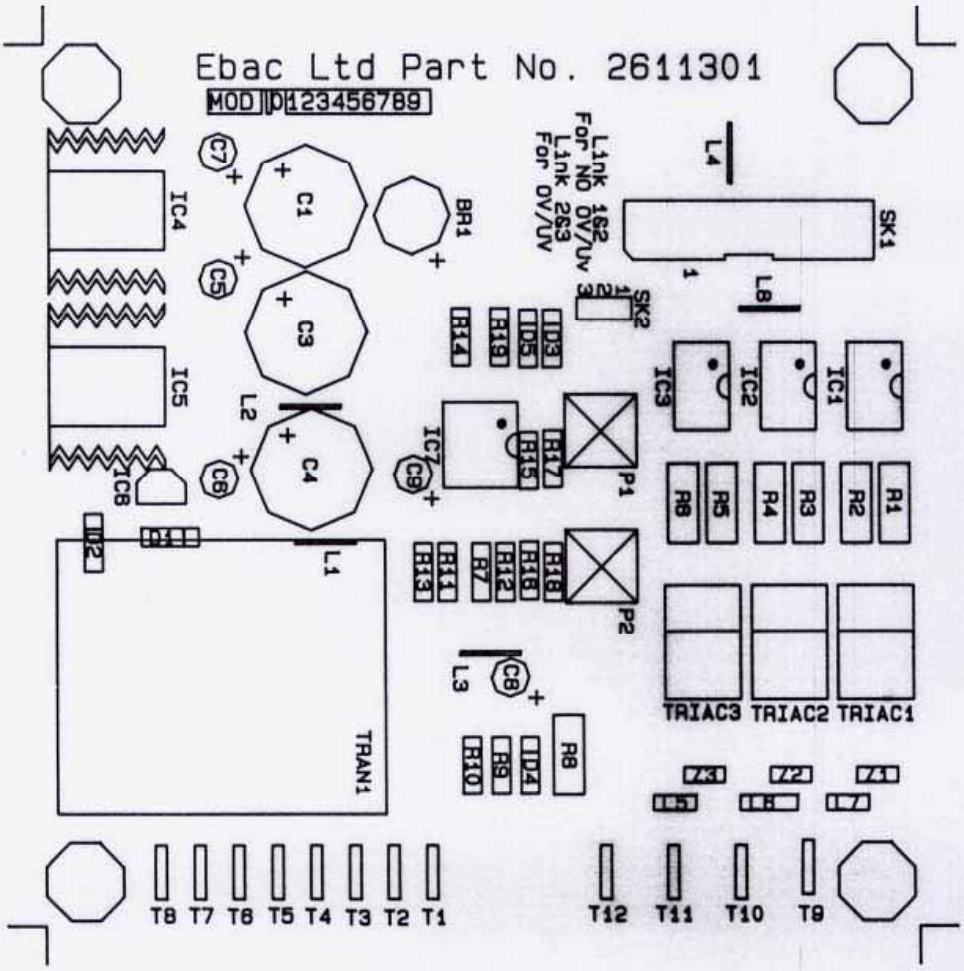
		DIMENSIONS IN m.m.	DATE	2 Aug 89								
SCALE 1:1	Ebac Limited		C/N									
DRAWN S Lilly			SECURITY CLASSIFICATION									
CHECKED S. Lilly	TITLE LLC2 DISPLAY SILK SCREEN		INSPECTION PROCEDURE									
APPROVED SRG			DRG. NO. 5029004									A4

1 2 3 4 5 6 7 8 9 10

3RD ANGLE PROJECTION

A B C D E F G



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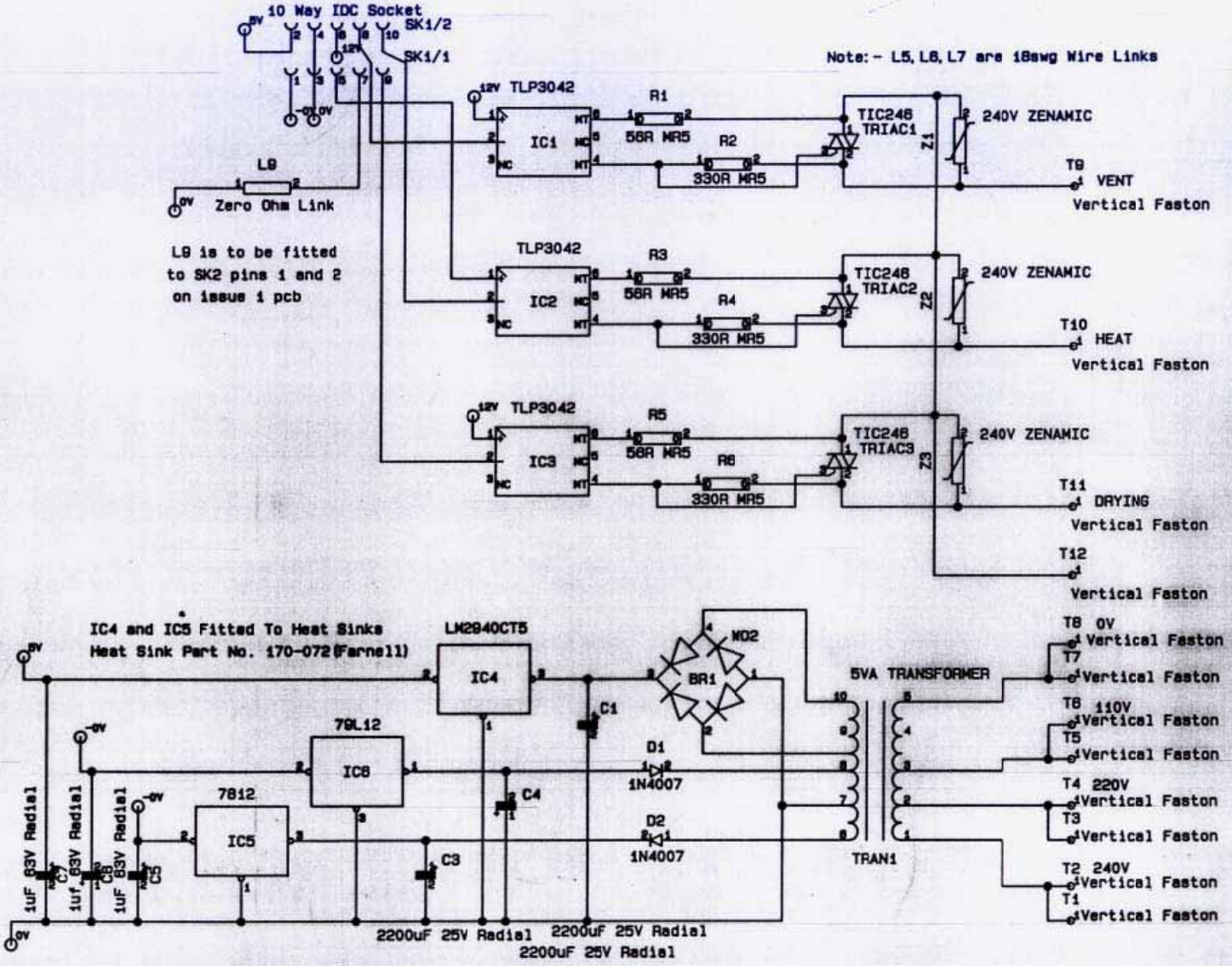
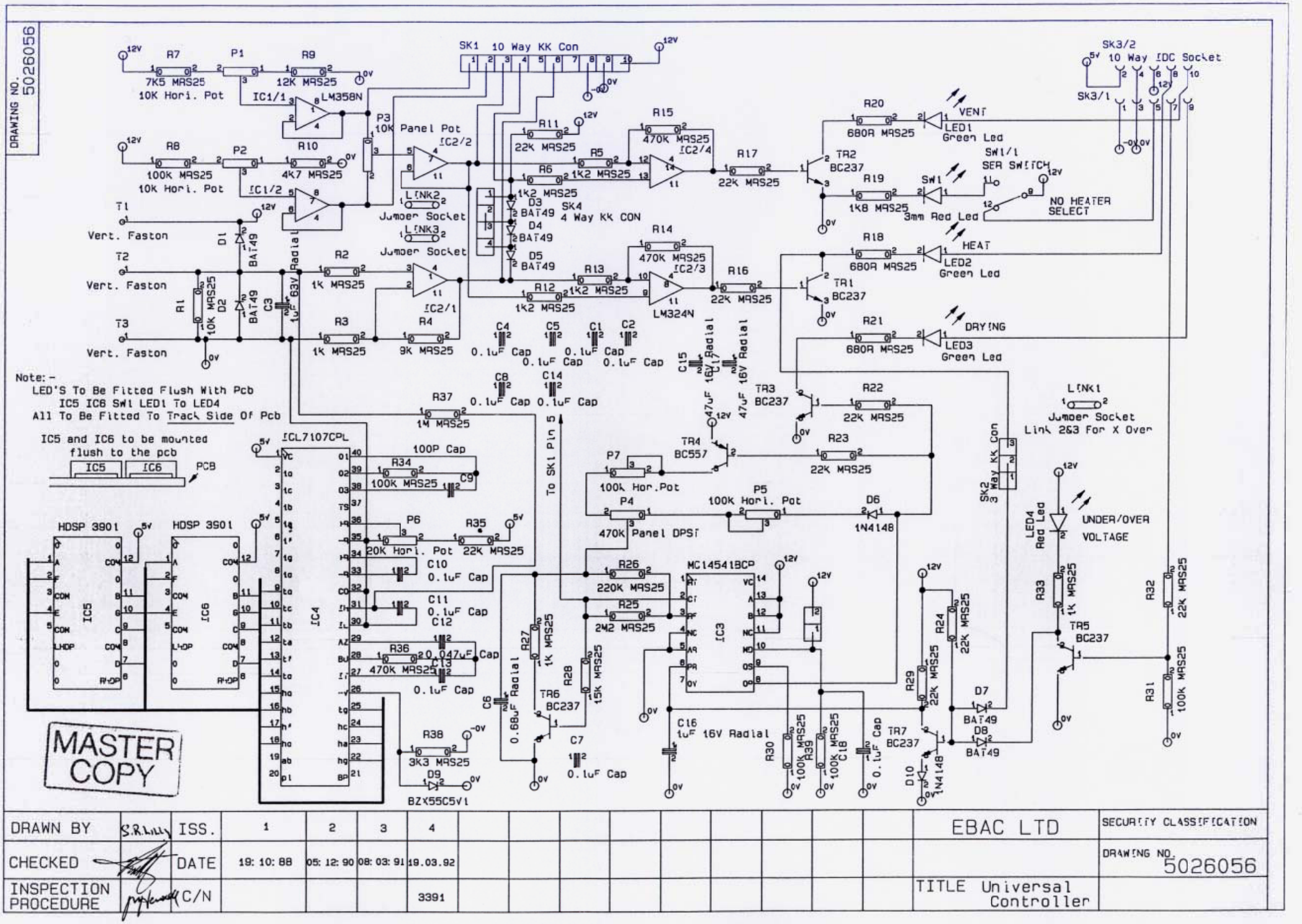
		DIMENSIONS IN m.m.	DATE	25 8							
SCALE 1:1	Ebac Limited		C/N								
DRAWN S. Lilly			SECURITY CLASSIFICATION								
CHECKED S. Lilly	TITLE		INSPECTION PROCEDURE								
APPROVED SRB	UC2 Power Supply Silk Screen.		DRG. NO. 5029005								A4

DRAWING NO. 5026058



DRAWN BY	S.Lilly	ISS.	1	2											EBAC LTD	SECURITY CLASSIFICATION	
CHECKED		DATE	------	05: 12: 90													
INSPECTION PROCEDURE		C/N													TITLE Uni.Controls	DRAWING NO. 5026058	


DRAWING NO. 5026056
SK1 10 Way KK Con
SK3/2 10 Way IDC Socket
SK3/1
R7 7K5 MRS25
P1 10K Hori. Pot
R9 12K MRS25
IC1/1 LM358N
R8 100K MRS25
P2 10K Hori. Pot
R10 4K7 MRS25
IC1/2
P3 10K Panel Pot
IC2/2
LINK2 Jumper Socket
LINK3 Jumper Socket
T1 Vert. Faston
T2 Vert. Faston
T3 Vert. Faston
D1 BAT49
D2 BAT49
C3 1uF 63V Radial
R1 10K MRS25
R2 1K MRS25
R3 1K MRS25
R4 9K MRS25
IC2/1
R11 22K MRS25
R15 470K MRS25
IC2/4
R5 1K2 MRS25
R6 1K2 MRS25
D3 BAT49
D4 BAT49
D5 BAT49
SK4 4 Way KK CON
R14 470K MRS25
IC2/3
R13 1K2 MRS25
R12 1K2 MRS25
LM324N
R17 22K MRS25
R16 22K MRS25
TR2 BC237
TR1 BC237
R20 680R MRS25
VENT LED1 Green Led
R19 1K8 MRS25
SW1 3mm Red Led
SW1/1 SER SWITCH
NO HEATER SELECT
R18 680R MRS25
HEAT LED2 Green Led
R21 680R MRS25
DRYING LED3 Green Led
C4 0.1uF Cap
C5 0.1uF Cap
C1 0.1uF Cap
C2 0.1uF Cap
C15 16V Radial
C17 47uF 16V Radial
C8 0.1uF Cap
C14 0.1uF Cap
R37 1M MRS25
TR3 BC237
R22 22K MRS25
TR4 BC557
R23 22K MRS25
47uF 12V
LINK1 Jumper Socket Link 2&3 For X Over
SK2 3 Way KK Con
Note: -
LED'S To Be Fitted Flush With Pcb
IC5 IC6 SW1 LED1 To LED4
All To Be Fitted To Track Side Of Pcb
IC5 and IC6 to be mounted flush to the pcb
IC5
IC6
PCB
ICL7107CPL
IC4
HDSP 3901
IC5
HDSP 3901
IC6
R34 100K MRS25
100P Cap C9
P6 20K Hori. Pot
R35 22K MRS25
C10 0.1uF Cap
C11 0.1uF Cap
C12
R36 470K MRS25
0.047uF Cap C13
0.1uF Cap
R38 3K3 MRS25
D9 BZX55C5V1
To SK1 Pin 5
P7 100K Hor.Pot
P4 470K Panel DPSI
P5 100K Hori. Pot
D6 1N4148
R26 220K MRS25
R25 2K2 MRS25
MC14541BCP
IC3
R27 1K MRS25
R28 15K MRS25
C6 0.68uF Radial
TR6 BC237
C7 0.1uF Cap
C16 1uF 16V Radial
R30 100K MRS25
R39 100K MRS25
C18 0.1uF Cap
TR7 BC237
D10 1N4148
R29 22K MRS25
R24 22K MRS25
D7 BAT49
D8 BAT49
LED4 Red Led
UNDER/OVER VOLTAGE
R33 1K MRS25
R32 22K MRS25
TR5 BC237
R31 100K MRS25
MASTER COPY
DRAWN BY S.R.Lilly
ISS. 1 2 3 4
19: 10: 88 05: 12: 90 08: 03: 91 19.03.92
CHECKED
DATE
INSPECTION PROCEDURE
C/N 3391
EBAC LTD
SECURITY CLASSIFICATION
DRAWING NO. 5026056
TITLE Universal Controller

ISSUE	DATE	AMENDMENTS
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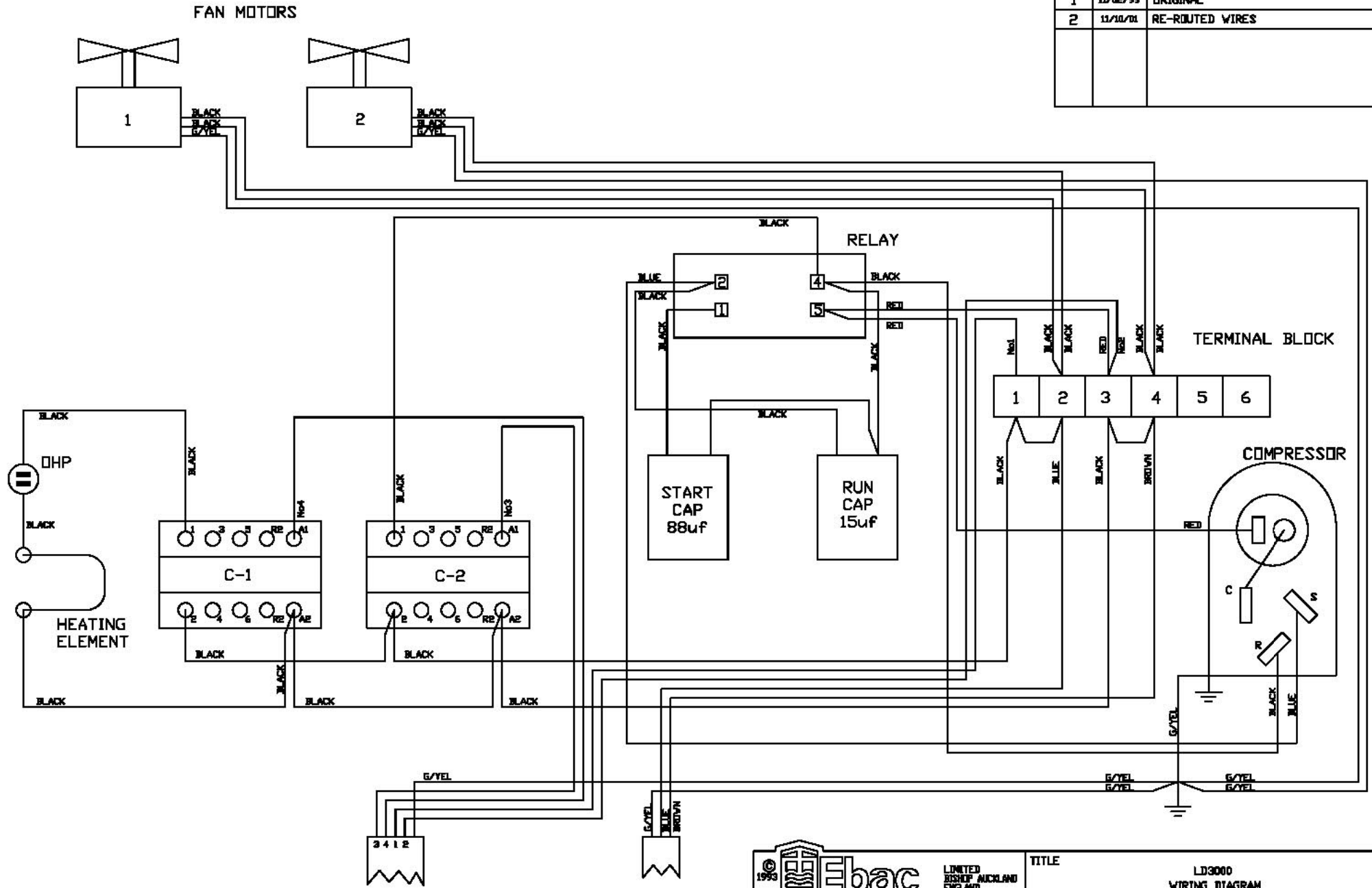
2	11/10/01	RE-ROUTED WIRES



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		FINISH:	DRG.NO. 5010276
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