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12 INCH, LOW SPEED, VARIABLE TEMPERATURE, RECIRCULATING WIND TUNNEL

Agere Systems, Inc.
Breinigsville, Pennsylvania

Serial No.: 34301
Purchase Order No.: ST0044706
Delivered: March 2001

12" LOW SPEED, VARIABLE TEMPERATURE, RECIRCULATING WIND TUNNEL

OPERATION AND MAINTENANCE INSTRUCTIONS

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1.0 SITE SELECTION AND ELECTRIC SERVICE

The wind tunnel should be located so that convenient access is available to both sides of the test section. Allow at least 3 feet (1.0m) of clear area around the large end of the tunnel to allow for servicing of the heater and heat exchanger. Proximity to the electric service and the intended location of the provided water chiller should also be considered.

This unit should be provided with a separate branch electric circuit. The fan motor "full load amperage" is shown on the motor name plate and on the wind tunnel serial number plate. The National Electric Code, Paragraph 430-22 specifies a branch circuit capacity of 140% of the motor nameplate "full load amperage" for a motor operating in this service.

The water chiller should be provided with a separate brank electric circuit. The chiller manufacturer states that a 208VAC/1ϕ/60Hz/20Amp circuit is required for chiller operation.

2.0 DESCRIPTION

2.1 GENERAL

The **Engineering Laboratory Design** 12" Low Speed, Variable Freestream Temperature, Recirculating Wind Tunnel has evolved to provide a qualification testing facility for the electronics industry. The wind tunnel system, including the freestream operating temperature process controls, provides the necessary environment for thermal characterization of electronic components.

System components include: flow ducts, test section, fan, motor with variable frequency speed controller, a chilled water heat exchanger, a resistance heater bank, a air cooled water chiller, and supporting frames. The system flow configuration recirculates a closed volume of air in a vertical loop.

Overall dimensions of the unit are: length, 15'-0" (4.57m); height, 7'-2" (2.18m); width, 3'-2.25" (97.15cm). Test section centerline height is 5'-8" (1.73m). The total weight of the wind tunnel is approximately 1,600 lbs (727kg). The dimensions of the chilled water unit are: height 30.25" (76.8cm); width, 21.25" (54.0cm); depth, 28.63" (702.7cm). The chiller weighs an additional 220 lbs (100kg)

2.2 CONSTRUCTION

2.2.1 FIBERGLASS DUCTS

The ducts bounding the air stream are fabricated of fiberglass reinforced plastic molded over precision tooling. Interior surfaces are mold smooth, white, gel-coat. Exterior surfaces are spray finished with a cream colored, polyester gel-coat enamel. Miter flanges joining the longitudinal corners of the duct sections, are fastened with stainless steel bolts, and sealed with elastomeric sealant. Face flanges, joining adjacent duct sections are sealed with resilient, open cell, high density, urethane foam gasket. The flanges are bolt fastened. Careful attention is paid to the fit and alignment of mating sections to insure that no leaks or flow disturbing discontinuities exist.

The contraction has a 6.25:1 area ratio, with a symmetrical cross section and analytically developed contours. The primary diffusion section expands with a total included angle of 5.7°.

2.2.2 TEST SECTION

0.75" (19mm) thickness, clear, GM grade, acrylic plexiglass is used to fabricate the top, sides and bottom of the test section. The interior dimensions of the test section are: length, 24.00" (61.0cm); width, 12.00" (30.5cm); height, 12.00" (30.5cm). The section is fitted with aluminum end flanges. The flanges are bolt fastened to the contraction and the diffuser ducts. The non-operator's side is removable and fitted with quick release fasteners. The test section features three (3) 10.00" (25.4cm) x 10.00" (25.4cm) interchangeable ports located in the ceiling, floor, and operator's sidewall. Flanged plexiglass plugs close the openings. The plugs are held in place with quick release

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clamps. A urethane foam gasket is used as a flange seal. The non-operator's sidewall is machined to accommodate fixtures and components as specified by a separate manufacturer.

2.2.3 FLOW CONDITIONING

The settling length, upstream of the contraction, is fitted with a precision, hexagonal cell, aluminum honeycomb section. Graduated mesh, high porosity (60%), stainless steel screens, mounted and tensioned in extruded aluminum frames are furnished. High efficiency, turning vane cascades, fabricated of galvanized steel are installed in each of the four circuit elbows.

A 1" X 2" (2.54cm X 5.08cm) wire mesh safety grid is provided at the downstream end of the primary diffuser.

A commercial (*Super Radiator Coils Model 30x30-1R-58/48*), aluminum fin/copper tube, single row, heat exchanger is installed between the third and fourth elbows. The heat exchanger requires a chilled water supply of 50°F (10°C), at a rate of up to 4 GPM (15.1 Lpm). The heat exchanger is intended to maintain the freestream operating temperature near ambient conditions 65°F (18.3°C), by removing the heat energy imposed on the flow by the fan/motor. Use of the device will also assist in quickly lowering the freestream operating temperature from elevated temperatures.

2.2.4 MODULATING VALVE

An electronic modulating valve (*SVF Model 1" R61166TTSE*) with a 4-20mA positioner and integral actuator (*Indelac Controls Model E300-W-5-E-C*), regulates the chilled water supplied to the heat exchanger. The positioner is controlled by a set point controller.

2.2.4 RESISTANCE HEATER BANK

Six (6), 1350 Watt, resistance heaters (*Watlow Model Finbar FSP3210WMF*) are installed between the third and fourth elbows. The heater bank is sized to provide elevated operating temperatures up to a maximum of 158°F (70°C). Output to the heaters is controlled by the set point controller. A high temperature limit (*Watlow Model 146E-2629-3000*) protects the circuit from overheating. The six (6) heaters are arranged for 208-230VAC/1ϕ/60 Hz and draw 27.4 Amps.

2.2.5 TEMPERATURE CONTROL

A single set point controller (*Watlow Model 989A-10CF-ARGG*) is used to control the operation of the heat exchanger's modulating valve and the power output to the resistance heater bank. The set point controller monitors the process temperature through input from thermocouples installed in the wind tunnel airstream. When Cooling is required, a 4-20mA signal is output to the modulating valve's positioner. The valve is, in turn, actuated to regulate the amount of cooling flow required to maintain the desired set point. When Heating is required, the set point controller regulates DC voltage output to an SCR (silicon controlled rectifier) (*Watlow Model DC1C-5024-C000*). The SCR uses burst firing to control power output to the resistance heaters and in turn maintain the airstream temperature. This configuration allows for a single, user input, temperature set point. Whether heating or cooling, the control system adjusts accordingly.

2.2.6 AIR COOLED CHILLER

A 17,219 BTU/hr (5,045 W) packaged chiller (*Neslab Merlin M-150D*), with a 0.5 gallon (1.8 L) reservoir, is provided to supply the cooling flow to the heat exchanger. The chiller features an integral circulating pump. Quick release fittings are provided to connect the supply and return hoses to the heat exchanger. The heat exchanger/chiller combination is intended to maintain the freestream operating temperature in a range near ambient 65°F (18.3°C) with ±1° resolution. The chiller employs R22 to cool the circulation fluid. Chiller circulation fluid temperatures below 50°F (10°C), and subsequently lower freestream operating temperatures, are attainable using a laboratory grade refrigerant (ethylene glycol) as the circulating fluid. **DO NOT USE AUTOMOBILE ANTI-FREEZE.** Use of automobile antifreeze will void the manufacturers warranty. The chiller operates on 220VAC/1ϕ/60 Hz/14 FLA.

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2.2.7 SUPPORTING FRAMEWORK

The duct sections and the fan are supported by frames fabricated of welded structural steel tubing. The frames are etched, primed, and spray finished with acrylic enamel paint. The frames are fitted with adjustable leveling pads. Rubber-in-shear mounts are used extensively to isolate the duct sections from room and fan vibrations.

2.3 FAN

A (*TCF*/Aerovent Model *14-355-BIA-CBD-1241-0.5*) backward inclined airfoil, in-line centrifugal, fan is used. The fan housing is covered with a low density, flexible, open-cell melamine, foam insulation. The insulation has an exterior PVC jacket and is secured to the fan housing with metal fasteners.

2.4 MOTOR AND CONTROLLER

The fan is belt driven by means of a 1/2 HP, TENV, AC induction motor (*Leeson Model 110032*). The motor is contained in an enclosure lined with acoustic foam to reduce the motor sound emissions.

A transistor invertor type, variable frequency drive *(Toshiba Model No. VFS9-2004PM-AN)* is provided to regulate the frequency output to the motor and in-turn the fan shaft RPM. A remote mounted control keypad is located near the test section. The inverter is arranged to operate either from a keypad input, or from a 0-10 VDC. Please refer to the **OPERATING INSTRUCTIONS** for further information.

Circuit protection is provided with a NEMA rated fused disconnect. Additionally, individual components are fuse protected according to the United States National Electric Code. The wind tunnel system is arranged for 208-230VAC/3ϕ/60 Hz/45A electric service.

A 15'-0" (4.6m) long neoprene covered service cord is furnished along with a twist lock plug and mating receptacle.

2.5 FLOW QUALITY

Speed, in a clear test section, was found to be continuously variable from less than 50 fpm (0.25 m/s) to greater than 1200 fpm (5.0 m/s). Velocity variation in an empty test section was measured across a grid of 121 points near the test section inlet. This verification testing determined the mean freestream velocity variation to be less than $\pm$ 1%. Copies of the test data are included at the end of this manual. Turbulence levels are estimated to be on the order of 0.25%.

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3.0 OPERATING INSTRUCTIONS

3.1 GENERAL

Before operating the wind tunnel, insure that tools and other loose objects have been removed from the test section and that all test pieces are securely mounted in their fixtures. Verify that the electrical branch circuit serving the wind tunnel is energized. New users should be familiarized with the equipment prior to first operation.

3.2 SPEED CONTROL

The test section speed is controlled by varying the RPM of the fan. The wind tunnel is designed to operate in a continuously adjustable speed range from less than 50.0 fpm (0.25 m/s) to greater than 1200.0 fpm (5.0 m/s). The inverter will respond to control signals from either the remote keypad, mounted on the face of the electrical enclosure, or an external 0-10VDC signal provided to the inverter control board.

3.2.1 OPERATION FROM INVERTER KEYPAD

1. Apply power to the inverter.

2. Enter the desired operating frequency by using the up and down arrows to scroll to a specific frequency.

3. Press the **ENT** button once the desired frequency is achieved. The display will flash between the frequency setting and "FC" indicating that the setting has been made.

4. Press the **RUN** button. The acceleration or deceleration to the new set speed designated by "FC" will be shown on the inverter's output. During operation , the **RUN** lamp will be lit.

5. Repeat steps 3-5 to change the frequency setting during operation.

6. To stop the drive, either enter an operating frequency of 0.0, or press the **STOP** button.

3.2.2 OPERATION USING AN EXTERNAL VOLTAGE SIGNAL

NOTE: The inverter can be set to run from either an external input of 0-10 VDC or 4-20 mA. Refer to pages 10 and 20 of the Toshiba manual for a description of the different settings required to operate using these control signals.

1. Insure that the following connections are made to the inverter control board:

   0-10 VDC Input
   Jumper between **F** and **CC**
   (+) external signal to **VIA**
   (-) external signal to **CC** (Please note that the two **CC**'s referred to are **not** the same. Connections are made to the **CC** on the left side of the terminal board.)

   4-20mA Input
   Jumper between **F** and **CC**
   (+) external signal to **II**
   (-) external signal to **CC** (Please note that the two **CC**'s referred to are **not** the same. Connections are made to the **CC** on the left side of the terminal board.)

2. Apply power to the inverter.

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3. Change the frequency setting mode parameter (F⌒od):

   Press **MON**
   Press ▲▼ until **Basic Parameters Group** is reached.
   Press **ENT**
   Press ▲▼ until **Frequency Selection Mode (F⌒od)** is reached.
   Press **ENT**
   Set the parameter value to **0** to accept inputs via the terminal block. (A parameter value of 1 indicates that control input is accepted through the up/down arrows.
   Press **ENT**
   Press **MON** twice to return to the frequency display.

4 Apply an external voltage/amperage signal within the chosen operating range. The inverter will proceed to run at a level that corresponds to the input control signal level.

5 The system can be stopped by discontinuing the input signal.

For a complete description of the inverter operating and programming characteristics, please refer to the TOSHIBA Industrial Inverter VF-S9 Series Instruction Manual and the TOSHIBA S7-OIS Quick Start Manual.

3.3 TEMPERATURE CONTROL

3.3.1 GENERAL

A *Watlow* set-point controller is employed to maintain the freestream air temperature at ±1°F (±1°C) through the range of 65°F (18.3°C) to 158°F to (70°C). The controller is labeled **TEMPERATURE SET POINT.**

The set-point controller has two displays. The lower display is the desired operating temperature (user input set-point), and the upper display is the actual process temperature that is sensed by the type T thermocouples located in the flow. Use the corresponding up and down arrows to increase or decrease the set point temperature as desired.

Operating temperatures significantly below 65°F (18.3°C) can be attained by utilizing a chilled water source with the appropriate volume flow and heat removal capacity. By using a laboratory grade refrigerant (ethylene glycol) in the provided chiller, the system can be operated at temperatures significantly below ambient conditions.

3.3.2 OPERATION FROM CONTROLLER KEYPAD

NOTE: The *Watlow* Series 989 Set Point Controller was been optimized by the wind tunnel manufacturer during the verification testing portion of production. The Auto Tuning procedure was used to establish approximate settings for the PID parameters. The auto-reset and rate parameters were then adjusted to more closely optimize the system. Due to significant effects of the ambient environment on this thermal system, the user may need to re-tune the controller, to optimize the thermal response. Please refer to Chapter 7 of the **WATLOW Series 988/989 User's Manual** for further instructions on tuning.

1. Turn on the power to the wind tunnel

2. Start the wind tunnel. Please see the section of this manual titled Operation from Inverter Keypad for operating instructions.

CAUTION: Operation the heating circuit without operation of the wind tunnel is not recommended. This condition may cause an extreme temperature rise and subsequent tripping of the High Temperature Limit.

3. Establish an operating temperature for the desired testing. The system is design to operate at temperatures between 65°F (18.3°C) and 150°F to (65°C).

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4. Using the UP and DOWN arrow keys on the face of the Series 988 controller, adjust the set point to the desired temperature.

5. The system will respond accordingly by operating the heating or cooling circuit. Heating operation is indicated by the blinking red LED labeled **L1**. Cooling operation is indicated by the blinking red LED labeled **L2**.

6. By pressing the key labeled **DISPLAY** the user may enter the display loop and monitor the instantaneous Deviation, **DEV**, from the set point and Percentage Output, **%OUT**, required by the process. A positive value of **%OUT** indicates power to the resistance heaters. A negative value of **%OUT** indicates a percent power to the modulating valve actuator.

For a complete description of the set-point controller operating and programming characteristics, please refer to the **WATLOW Series 988/989 User's Manual.**

3.3.3 REMOTE OPERATION

The set-point controller can be monitored and controlled remotely via an RS-232 interface. The RS-232 connector is located on the lower left side of the remote enclosure. A communications program by *Watlow*™ has been included with the *Watlow* Series 988 controller (3.5" floppy disk). A Windows™ based communications program is available as an accessory item from *Watlow*.

For a complete description of serial communications with the set-point controller, please refer to the **WATLOW - Data Communications with the Watlow Series 988 Family of Controllers - User's Manual.**

3.4 CHILLER OPERATION

3.4.1 GENERAL

A 17,219 BTU/hr (5,045 W) packaged chiller (*Neslab Merlin M-150D*), with a 0.5 gallon (1.8 L) reservoir, is provided to supply the cooling flow to the heat exchanger. The chiller features an integral circulating pump. Quick release fittings are provided to connect the supply and return hoses to the heat exchanger. The heat exchanger/chiller combination is intended to maintain the freestream operating temperature in a range near ambient 65°F (18.3°C) with ±1° resolution. The chiller employs R22 to cool the circulation fluid. Chiller circulation fluid temperatures below 50°F (10°C), and subsequently lower freestream operating temperatures, are attainable using a laboratory grade refrigerant (ethylene glycol) as the circulating fluid. The chiller operates on 220VAC/1ϕ/60 Hz/14 FLA.

3.4.2 FILLING/DRAINING PROCEDURE

3.4.2.1 Tools/Material Required

Distilled Water
Ehtylene Gycol

Towels

3.4.2.2 Filling Procedure

1. Connect the outlet line from the chiller to the supply side of the heat exchanger and the inlet line to the chiller to the heat exchanger return line. The modulating valve is connected to the heat exchanger return line.

2. A list of acceptable fluids with the associated normal operating ranges are provided on page 20 of the Neslab manual. Ethylene Gycol is provided with this unit.

3. Remove the reservoir access panel and the reservoir cap. Fill the reservoir with the desired operating fluid.

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4. Open the heat exchanger modulating valve by setting a set point temperature below the displayed operating temperature.

5. Apply power to the chiller. The capacity of the reservoir is smaller than the heat exchanger and circulating lines. As the chiller pumps liquid into the heat exchanger, additional fluid will have to be added to the reservoir.

3.4.2.2 Draining Procedure

1. A drain fitting is located on the back panel of the chiller. Connect the drain fitting to the drain with a suitable hose.

2. Insure that the heat exchanger modulating valve is open, and open the chiller drain valve.

3. Operate the chiller at brief intervals to draw the water from the heat exchanger.

3.4.3 OPERATION

1. Apply power to the chiller and use the I/O key to toggle the unit on or off.

2. To change the reservoir set point temperature, press the circular arrow key. At this point the thermometer indicator should flash. Use the up and down arrows to change the set point temperature. Press the circular arrow key to accept the new set point temperature.

3. If the wind tunnel is going to be operated at elevated temperatures for extended periods, the chiller can be shut off.

For a complete description of the chiller control and operation, please refer to the **NESLAB Merlin Recirculating Chiller (P/N U00659) Manual.**

4.0 CAUTIONS

1. Insure that all persons using this equipment have been familiarized with its operation.

2. Do not operate the system with the test section cover removed or wall ports open.

3. Verify that models and test fixtures are securely fastened in the test section before starting the fan.

4. Insure that the high temperature limit on the heating circuit is set at 165°F (73.9°C)

5. **DO NOT USE AUTOMOBILE ANTI-FREEZE** as the circulating fluid within the chiller. Use of automobile antifreeze will void the manufacturers warranty.

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5.0 MAINTENANCE

5.1 GENERAL

Users and maintenance personnel are urged to read the manufacturer's instructions applicable to the system components. Adherence to the fan lubrication schedule is particularly important. Consult the frequency control manufacturer's documentation for troubleshooting advice related to the speed control device.

5.2 FAN AND MOTOR

5.2.1 GENERAL

Grease bearings every six (6) months. Use #2 Grease. DO NOT OVER LUBIRCATE! Inspect V-Belt for tension and wear every six (6) months. Replace belt as necessary. DO NOT OVER TENSION!

For detailed instructions related to fan maintenance and service see manufacturer's BULLETIN IM-100.

5.2.2 ACCESSING MOTOR

5.2.2.1 General

The motor is contained in a sheet metal enclosure lined with acoustic foam to reduce the system operating sound power level. The enclosure must be removed to access the fan grease fittings or fan belt.

5.2.2.2 Tools/Material Required

Straight Screwdriver
7/16" Open End Wrench
7/16" Socket
Suitable Ratchet

5.2.2.3 Procedure

1. Insure that the main power for the wind tunnel is not energized.

2. Remove any articles placed on the wind tunnel working platform.

3. Remove the eight (8), No. 10 x 0.50" long S.S. Sheet Metal Screws that secure the working platform to the supporting framework. The screws are accessed from underneath the working platform angles (directly above the motor enclosure).

4. Remove the working platform from the supporting framework and set aside.

5. Using the 7/16" Open End Wrench or Socket, remove the 1/4-20UNC-2A x 0.50" long S.S. Hex Head Machine Screws (HHMS) that secure the platform angle to the supporting framework. Only remove the angle from one side of the supporting framework.

6. Remove the six (6), 10-24UNC-2A x 0.50" long S.S. Round Head Machine Screws (RHMS) that secure the motor sheet metal enclosure to the fan housing. These screws may be somewhat concealed by the insulation layer covering the fan.

7. Lift the motor sheet metal enclosure from the fan housing. While lifting, rotate the housing toward the side where the platform angle was removed.

8. The sheet metal enclosure can be replaced by repeating steps 3 through 7 in reverse order.

9. When replacing the sheet metal enclosure, insure that the flexible conduit from the electrical enclosure to the motor fits into the slot in the side of the sheet metal enclosure.

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5.3 DUCT SECTIONS/SUPPORTING FRAMEWORK

Dirt and grease marks may be removed from the laminated and painted surfaces using a detergent/water solution applied with a soft cloth and a sponge. Do not use abrasive cleaners.

5.4 TEST SECTION

The plexiglass test section components should be washed periodically with a mild detergent and clean water using a soft cloth. Remove residual water with fresh paper toweling. Care should be exercised to avoid scratching the test section surfaces. Fine abrasions and cloudiness may be removed by fine sanding and polishing. **ELD** recommends a scratch removal kit available from:

Micro-Surface Finishing Products, Inc.
Box 456
Wilton, Iowa 52788

Attempts to remove deep scratches are generally futile.

5.5 WATER CHILLER

The chiller reservoir should be inspected periodically. If cleaning is necessary, flush the reservoir with a cleaning fluid compatible with the circulating sytem and the cooling fluid.

The cooling fluid should be replaced periodically. The time between changes depends on the operating environment and the amount of usage. A wet-dry vacuum or siphon will be necessary to completely drain the reservoir. Care should be used to prevent damage to the reservoir float switch.

Periodic vacuuming of the condenser fins and the grille assemblies will be required to insure proper cooling flow through the condensor. Cleaning frequency will depend on the use and operation conditions.

To restrict the growth of algae in the reservoir, it is recommended that the reservoir cover be kept in place and the all circulating lines be opaque. An algacide can be introduced to the circulating fluid. A Chloramine-T is provided. The recommended mixing ratio is 3.5grams/liter.

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6.0 LIMITED WARRANTY

Engineering Laboratory Design, Inc. (ELD) warrants its new products to be free of defects in material and workmanship under normal use and service for a period of one (1) year from the date of acceptance of the product by the original purchaser. **Engineering Laboratory Design's** obligation under this warranty shall be limited to replacing at its own factory, any product, part, or parts thereof which is returned to **ELD** with transportation charges prepaid, and which upon **ELD**'s examination is determined to be in fact defective. In the event of warranty service, **ELD** reserves the right to substitute new or improved equipment as replacement components.

This warranty shall not apply to any product which has been repaired or altered, outside of **ELD**'s factory, in any way deemed to affect the product's stability or reliability, nor to any product having been subjected to improper installation by others, improper operation or storage, negligence, accident, abrasion, corrosion, electrolysis, improper electrical supply, careless handling, nor to any product subjected to other than normal use or service.

Engineering Laboratory Design will not grant any allowance for repairs or alterations made without written consent of authorized personnel. **ELD** shall in no way be liable or responsible for injuries or damages to persons or property, arising from or out of the use or operation of the product.

Engineering Laboratory Design reserves the right to make changes in design, or to make additions to, or improvements in, its products without imposing any obligation upon itself to install them on products previously manufactured.

Maintenance and service, at the purchaser's location, or maintenance and repair service for equipment for which the warranty has expired, can be contracted for by contacting **Engineering Laboratory Design, Inc.**, PO Box 278, 2021 South Highway 61, Lake City, MN 55041, (651) 345-4515. Alternatively you may contact **ELD** Inc. via fax at: (651) 345-5095, or e-mail to: eldinfo@eldinc.com or visit our website at: www.eldinc.com.

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