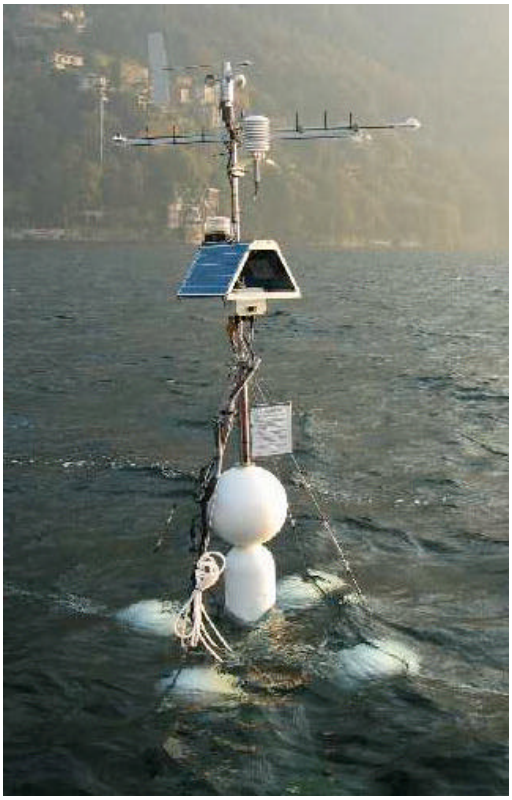
Lake Diagnostic System



LDS is a collaboration with the Centre for Water Research (CWR). CWR supplies data presentation and analysis services. LDS is a complete system for long-term water quality monitoring and management. LDS features real-time monitoring of water column temperature stratification, meteorological parameters, and water quality parameters. The data can be transmitted via cell phone, radio modem, or satellite. Data can be relayed to CWR's quasi real-time Online Lake and Reservoir Information System (OLARIS).

LDS Components

1. Station Main Frame
2. Data Logger
3. Single Cable Temperature Chain
4. Meteorology Measurements (wind speed, direction, radiation, air temperature)
5. Conductivity and Oxygen Sensors
6. Data Transmission
7. Shore or Office Station that receives and displays collected data

LDS Data can be used to

1. Monitor lake thermal regime
2. Design and control de-stratification systems with real-time numerical modeling validation
3. Automatically derive lake diagnostic parameters: inflow depth, layer thickness, mixed layer depth
4. Compute the mixing meteorological forcing
5. Validate numerical models

Contents

Centre for Water Research Services	pg. 3,4
LDS Shore Station	pg. 5
Station Main Frame	pg. 6
Temperature Chain	pg. 7,8
LDS Data Transmission	pg. 9,10
Data Logger	pg. 11
Meteorological Measurements	pg. 12-14
Conductivity and Oxygen Sensors	pg. 15
PME and CWR Contact Information	pg. 16

Centre for Water Research Services

The Lake Diagnostic System is designed in collaboration with Precision Measurement Engineering (PME) and Australian partner, Centre for Water Research (CWR). PME manufactures and provides the LDS hardware, while CWR offers additional services and software.

CWR Optional Services

1. On-Site System Installation
2. On-line real time web display
3. Optional water quality sensors: DO, salinity
4. Real-time management
5. Temperature Stratification Monitoring

The Centre for Water Research provides a range of services and software for the management of aquatic environments. Their team of professional engineers and scientists can deliver environmental solutions to customers, such as water authorities, environmental agencies, reservoir operators and research institutions. CWR offers a variety of research techniques such as field experiments, numerical modeling and laboratory investigations. Depending on the situation, CWR can create a custom solution and data analysis.

The software and services provided by CWR are optional and available world-wide by special contract. For more information on the services provided by CWR, please contact them at http://www.cwr.uwa.edu.au/contact/index.php.

CWR Services (http://www.cwr.uwa.edu.au/services)

On-Site Installation: CWR can provide a professional technician to facilitate on-site installation of the LDS as well as provide training on system features and interact with the customer to assist with any maintenance.

Project Control: Specialists are also available on a contract basis to undertake project work and provide custom designed model configurations.

Training: A range of training for commercial users is available upon request.

Real Time Management (RTM): RTM combines services, products and knowledge expertise in order to create a complete reservoir Decision Support System.

Other: CWR offers a wide range of services. Please contact for more information.

Centre for Water Research Software (http://melchior.cwr.uwa.edu.au/~ttadmin/)

CWR's software was created to run up-to-date simulations as well as provide comprehensive data analysis. Some of these programs can be coupled together for complete and accurate data analysis. For more information on CWR's software, please visit http://www.cwr.uwa.edu.au/~ttfadmin/.

CWR Software

Online Lake and Reservoir System (OLARIS): a web-based interface that provides visualization of real-time data, numerical simulation results, and sustainability indices for the lakes, estuaries and coastal waters.

Aquatic Real-time Management System (ARMS): collects data from LDS at the shore station. Data is put into CWR's LAKEMON software to predict DO, Mn, and Fe concentrations at depth in real time.

Estuary and Lake Computer Model (ELCOM): a three-dimensional model used for predicting the velocity, temperature and salinity distribution in natural water bodies subjected to external environmental forcing such as wind stress and surface heating or cooling.

Computational Aquatic Ecosystem Dynamics Model (CAEDYM): a simulation of the biological and chemical processes. It represents the major biogeochemical processes, such as the circulation of carbon and nitrogen between environment and the cells of living organisms, which can influence water quality.

Dynamic Reservoir Simulation Model (DYRESM): a one-dimensional hydro dynamics model for predicting vertical distribution of temperature, salinity and density in lakes and reservoirs. The model can be used to predict seasonal and inter-annual variation in lakes and reservoirs.

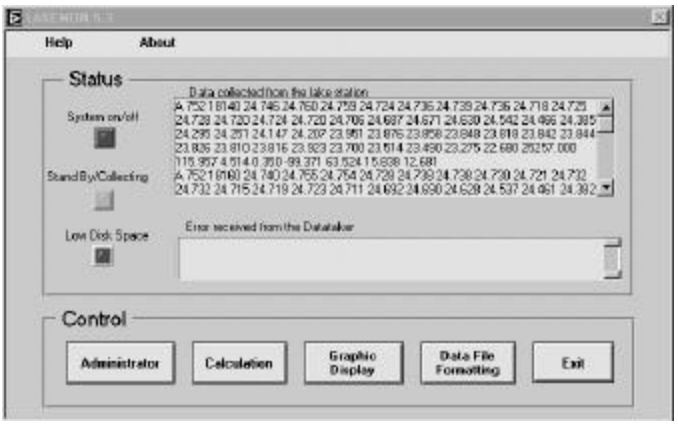
PME and CWR have a unique collaboration that provides the customer with a complete product solution. The solution begins with the measurement of the physical parameters and if the customer desires, can continue through complete analysis of the data and numerical modeling.

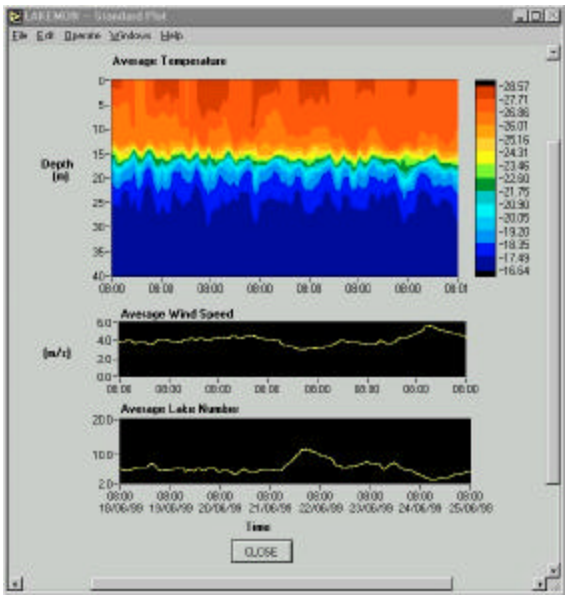
LDS Shore Station

The shore station consists of a MS Windows computer, the LAKEMON software, a modem, an antenna, if required, and an Internet connection. The telemetry type will depend on the site. The lake station is programmed to sample at one or several schedules and the data are stored internally. The logger and LAKEMON are programmed to transmit data to the shore station at regular intervals. Data acquisition, generation of log files, ftp'ing of data to a web page for ease of display among many users and monitoring of the LDS operation can all be a part of the LDS package.

The LAKEMON software interfaces with the data logger and the telemetry to control the sampling schedule and transmission of data to the shore station. The sampling and dial-up schedules can be user-specified. The software allows real time display of data at the shore station or data can be automatically ftp'ed to CWR's web site where it can be displayed via internet in a great range of views including both hardware diagnostic and lake diagnostic views.

LAKEMON can compute various parameters such as the Lake Number. If LAKEMON is calibrated with historical water quality data for the lake, then it uses the Lake Number to infer the water quality, including periods of anoxia and Fe and Mn metal concentrations.





Station Main Frame

The Station Main Frame is a free-floating balanced platform that is held in place by side anchors. It is designed for up to 20 meters of water level variation. It is constructed almost completely of type 316 stainless steel and will give years of service in fresh water.

Station flotation is provided by four large polystyrene floats (approximately 120 Kg of buoyancy) attached to the station cross arms just beneath the water surface. Two additional floats are attached to the central main mast. A large perforated disc is attached to the central mast about 3 meters below the surface and prevents the station from bobbing due to the surface waves.

The station supports the LDS instrumentation. The T-Chain hangs from one of the arms, metrology sensors are mounted at top, and the data logger is contained by a rectangular ‘holster’ just beneath the surface.

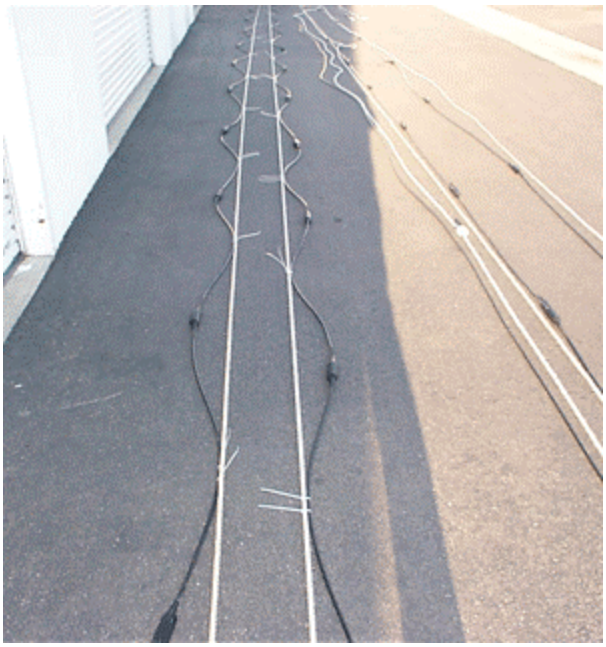
The station is weighted at the bottom so that it remains upright.

Features

1. Free-floating, vertically damped, instrumentation platform
2. Approximately 120 Kg available buoyancy
3. Two 10 Watt, 12 Volt solar panels, junction box, and regulator
4. Two top masts for metrology sensors
5. All wet parts constructed of 316 stainless steel

T-Chain

The T-Chain is a parameter sensing string of sensors that can collect detailed data on elements such as temperature and pressure. PME is currently designing T-Chain's oxygen sensor.



Temperature

The T-Chain produces detailed thermal data that can be used to determine water column stratification, mixing, internal tides, and other information.

The T-Chain consists of a single electrical cable with one or more temperature nodes molded at fixed, user-specified, locations. Each node contains a thermistor within an Inconel protective tube and electronics. Data are transmitted up the chain in a digital format. The chain can be connected to LDS, various PME loggers and circuits, and to some types of Campbell data loggers.

T-Chain Features

1. Wide thermal range, 0 to 36 degrees C
2. Rapid response to temperature, approximately 2 seconds
3. High measurement accuracy, +/- 0.010 degrees C
4. 16 bit resolution, approximately 0.0005 degrees C
5. Rapid data rate, 1 scan of all nodes per second
6. Low measurement noise, RMS sub-millidegree
7. Up to 60 nodes
8. 165 meter maximum depth

The T-Chain consists of a single polyurethane sheathed cable with Kevlar core. Digital thermistor nodes are located at user-specified intervals. The thermistor and electronics are housed in a hermetically sealed Inconel 625 metal tube and metal case, which is then molded into a polyurethane elastomer node. This provides the best possible mechanical protection and water proofing integrity, while maintaining a fast response time.

The T-Chain can be either a simple hanging type suspended from the water surface or a water-level adjusting type, where the thermistors are distributed in two sections at the top and bottom of the T-Chain, allowing coverage of the entire water column as the water level rises and preventing the T-Chain from laying on the lake bottom.

The single cable temperature chain can accommodate many nodes at user-specified intervals. This new design requires just one digital channel on a data logger, unlike other temperature strings that require one channel for each thermistor.

Parameter	Specification
Sensed Parameter	Temperature
Range	0 to 35 deg C
Accuracy	+/- 10 mdeg C
RMS Noise	less than 0.5 mdeg C
Resolution	approx 0.5 mdeg C
Maximum Data Rate	1 scan of all nodes per second
Sensor Time Constant	better than 2 seconds
Number of Sensors	up to 60
Total Length of Sensing Element	200m overall length
Maximum Depth of a Node	165m
Maximum Span between Nodes	30m
Minimum Span between Nodes	25cm

Pressure

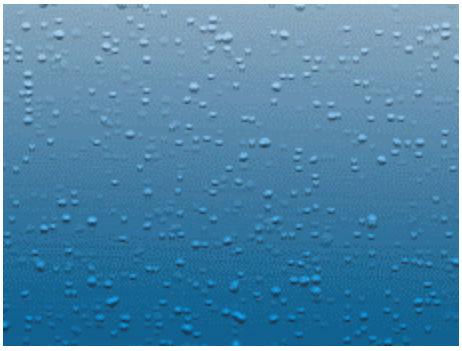
The T-Chain's Pressure Transducer is a strain-gage transducer that converts pressure into a format that can be uploaded along the T-Chain. This Pressure Transducer is only compatible with PME's T-Chain.

The Pressure Transducer is designed to be the last sensor on a T-Chain and must be located at the end of the T-Chain opposite the under water connector. This sensor is an absolute pressure sensor and is available in three pressure ranges.

Specifications

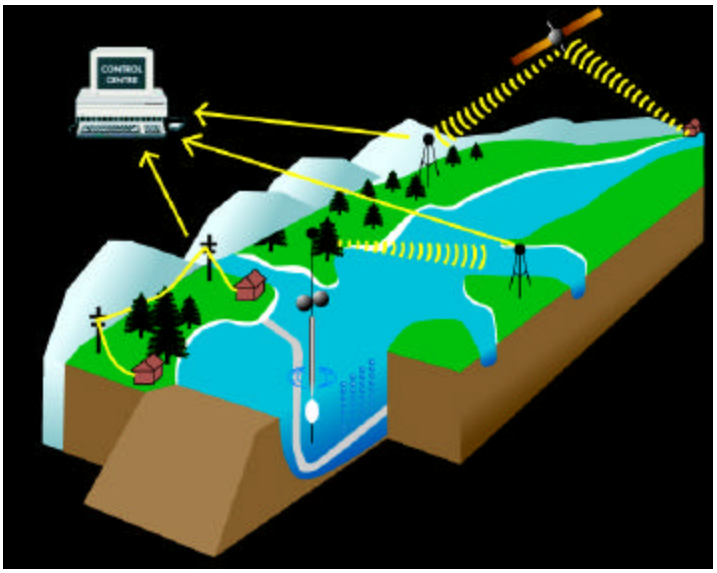
Full Scale Absolute Pressure	5, 10, 20 bar
Accuracy	0.5% FS (5, 10 bar) 1 % FS (20 bar)

Oxygen



The T-Chain Oxygen Sensor is currently being developed by PME. If you would like to be placed on our notification list please e-mail Kristin at kristinhead@pme.com.

LDS Data Transmission



Data are telemetered from the lake station via either cell phone, radio, or satellite to a customer operated shore station (MS Windows computer), and then optionally via ftp to Centre for Water Research for analysis and display.

Cell Phone Telemetry

There are three types of cell phone networks available: GSM, CDMA, or AMPS.

GSM – Global System Mobil Communications (GSM), which is digital, is used by phone companies such as AT&T, Cingular and T-Mobile in the U.S. It operates at either the 900 Megahertz (MHz), the current Australian allocation, or 1800 MHz frequency band. In locations where Cellular Phone Networks with data capabilities are available, small size and low power consumption GSM Modems are the best choice for telemetry. This is the usual LDS configuration.

CDMA – Code Division Multiple Access (CDMA) modems are country specific. Sprint and Verizon Wireless in the U.S. and Telus in Canada use CDMA, which is all digital. It usually operates at the 800 MHz frequency band, but is also country specific. This is not available with the standard LDS system, but can be implemented if required.

AMPS – Advanced Mobile Phone Service (AMPS) is a standard system for analog signal cellular telephone service in the United States and is also used in other countries. AMPS allocates frequency ranges within the 800 and 900 MHz spectrum to cellular telephone.

Radio Telemetry

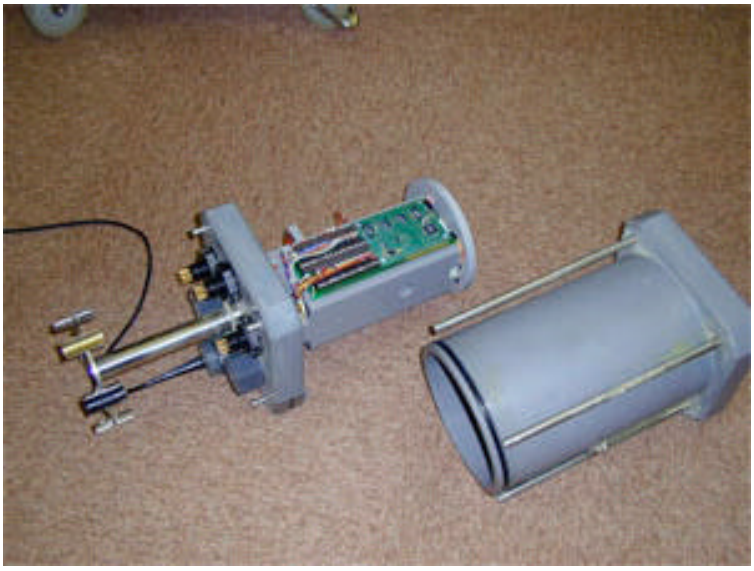
This type of telemetry is used if cell phone coverage at the lake station is not available. Line-of-sight is required and typically the lake station and the shore installation must be less than 15km apart. The system (Freewave modem) is commercial 915-928 Mhz spread spectrum modem configured as back-to-back RS232 links. Antennae used are 5dB omnidirections.

Radio telemetry is used to link the lake station to a shore installation. This installation may be the shore station, or it may be an intermediate where a modem is connected to telephone land line, or to a cell phone. Single or multiple lake stations can optionally be supported.

Satellite Telemetry

This type of telemetry is used if cell phone coverage or land-line telephone are not available. The Iridium satellite system is used. Contact CWR for more information.

Data Logger



The data logger is specifically designed for LDS. It is a multi-channel 16 bit logger with 2 MB of internal memory. The logger supports a simple measurement schedule.

The data are stored internally for the periods specified before being overwritten and are regularly transmitted to the shore station via telemetry. The user can communicate directly with the data logger while on the lake by connecting to the COMS box on the lake station mast.

The data logger, rechargeable battery, and modem are housed in a waterproof canister, which is attached to the station main frame just below the water surface.

Sampling Interval	40T T-chain + Met sensors
10 s	2 days
1 min	12.2 days
10 min	122 days
1 hour	733 days

Features

1. Designed specifically for LDS
2. 16 bit resolution
3. 2 MB internal memory
4. Real-time data telemetry via cell phone, radio modem, or satellite
5. Waterproof
6. 165 meter maximum depth

Meteorological Measurements

Wind Speed & Direction Sensor

This LDS sensor measures wind speed and direction at an elevation of approximately 2 ½ meters above the water surface. The sensor has a very low threshold of sensitivity that is required for detecting low wind speeds affecting lake mixing. Wind speed, together with water column stratification are useful in computing the overall stability of the water column.

The 34B is designed to operate within a temperature range of –30 to +70 deg C and with wind speeds up to 167 mph (269 kilometers/hr).

More information can be found at Met One Instruments, Inc. http://www.metone.com/meteorology.htm

Features Include:

- Wind speed and direction in a single sensor
- Compact design for minimum visual impact
- Long field life
- Stainless steel bearings
- Very low power operation
- Easy maintenance

Specifications

Wind Speed:
Range: 0-167 mph (0-75 m/s)
Starting Threshold: 0.9 mph (0.4 m/s)
Accuracy < 22.7 mph: .25 mph (0.1 m/s)
Accuracy > 22.7 mph: plus or minus 1.1% of true

Wind Direction:
Range: Mechanical 0-360 deg, Electrical 0-356 deg
Starting Threshold: 0.9 mph (0.4 m/s)
Accuracy: plus or minus 4 deg
Damping Ratio: .25 standard (.4 to .6 optional)
Resolution: < 0.5 deg

Output Signal:
Wind Speed: Pulsed contact closure
Wind Direction: Potentiometer output (0-10 kohms)

Weight:
Sensor Weight: 1lb. 12.5 oz (0.81 kg)
Shipping Weight: 4 lbs. 3 oz (1.90 kg)

Solar Radiation

The LDS Solar Radiation pyranometer is available in two separate types: the Hoskin Scientific EQ08 and the LI-COR Silicon Pyranometer. These pyranometers are instruments for measuring total down welling solar radiation. The sensor sums radiation arriving from above at all angles. This measurement is useful for determining the amount of solar radiation available at the water surface.

1) Middleton Solar EQ08
The Middleton EQ08 is a precision pyranometer for the measurement of global solar irradiance on a plane surface and incorporates a precision thermoelectric sensor.

Middleton Solar. EQ08 Solar Pyranometer.
http://www.middletonsolar.com/products/product4.htm

Model LI200X (c) 2001 Campbell Scientific (Canada) Corp.

2) LI-COR Silicon Pyranometer
The LI-COR Silicon Pyranometer with Fixed Multiplier measures sun plus sky radiation, waveband: 400 to 1100 nm, and uses a silicon photovoltaic detector. It is calibrated against an Eppley precision Spectral Pyranometer (PSP) to accurately measure sun plus sky radiation.

Campbell Scientific, Inc., LI200X-L Pyranometer.
http://www.campbellsci.ca/Catalogue/LI200X.html

Net Radiation

This sensor (actually consisting of two sensors, one facing upwards, one facing downwards) measures the net radiation in the 300 nano-meter to 60 micro-meter band. This measurement is useful in determining the heat flux into or out of the water surface.

Features Include: fast-response thermopile sensor, balanced shortwave and longwave sensitivity, balanced upward and downward sensitivity, bubble level on head, semi-rigid domes stay inflated, desiccated and sealed, and durable cast epoxy head, painted in white polyurethane.

Middleton Solar, CN1-R Net Pyrradiometer. http://www.middletonsolar.com/products/product7.htm

Relative Humidity and Air Temperature Sensor

This sensor measures the relative humidity and air temperature at an elevation of approximately 2 1/2 meters above the water surface. This measurement is useful in computing the sensible and latent heat fluxes at the water surface.

Vaisala, Inc. HMP45A with 3.5m cable, http://www.vaisala.com

Conductivity and Oxygen Sensors

Conductivity Sensor

The Greenspan Electrical Conductivity Sensors provide highly accurate conductivity measurements in a wide range of hydrological applications. Greenspan manufacture 3 types of Electrical Conductivity Sensors.

The Greenspan Electrical Conductivity Sensor EC250 offers an excellent combination of advanced features. The toroidal sensing technology eliminates electrode corrosion effects, guaranteeing long life and reduced field servicing. This sensor can be field calibrated with Greenspan's easy to use calibration software. The EC250 provides temperature measurement as well. The sensor contains a microprocessor, which controls temperature compensation and linearisation, to ensure highly accurate readings in demanding conditions. Separate conductivity and temperature outputs deliver raw conductivity or on-board normalization of conductivity at 25°C. The EC250 is available with either a delrin (plastic) or 316 stainless steel body and can be supplied in a variety of ranges.

Oxygen Sensor

The OxyGuard Model 525 is specially designed for use with data loggers in the field. It combines an OxyGuard dissolved oxygen probe and a transmitter with voltage output. It can be used to measure dissolved oxygen as well as oxygen in the air or other gas.

The power consumption and minimum operating voltage are low, enabling it to be powered by solar panel sources. The standard output is 0-2.5V, the input signal requirement for many data loggers, but the 525 can be delivered with other output voltages on request.

A whole series of outstanding specifications ensure accurate, trouble free measurements under all conditions and no matter how long the connections are.

A special feature of the 525 is a fast warm-up time to enable the use of effective power saving.

Precision Measurement Engineering, Inc.
2792 Loker Ave. West, Suite 105
Carlsbad, CA 92010
Phone: (760) 579-0300
Fax: (760) 579-0301
Toll Free: (888) 841-7464
www.pme.com

mhead@pme.com

Centre for Water Research
The University of Western Australia
M015, 35 Stirling Hwy, Crawley
Western Australia 6009
Australia
Phone: (618) 9380-2410
Fax: (618) 9380-1015
www.cwr.uwa.edu.au

services@cwr.uwa.edu.au