A White Paper on
Instrument Grade PCs
Designed for PC Based Instrumentation

Written By: Karen McCurry

Assistant Marketing Manager
Gage Applied Sciences, Inc.

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PREFACE

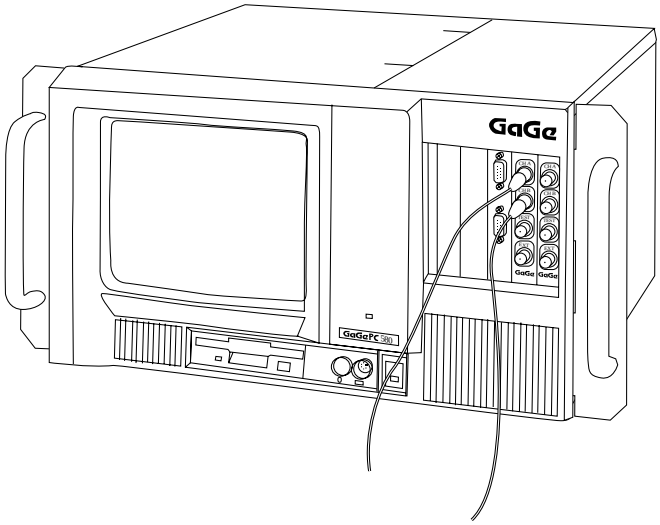
This white paper outlines the requirements of a PC based Instrument chassis, describes the architecture of today's typical PCI bus Personal Computer and discusses the benefits and limitations of Desktop and Industrial PCs as they relate to PC based Instrumentation and Data Acquisition. Finally, a revolutionary Instrument Grade PC, GagePC 580, is described and its benefits outlined.

INTRODUCTION

GagePC 580 is an Instrument Grade PC and forms an ideal platform for installing PCI and ISA based Instrument Cards. It has been designed from ground up for that purpose.

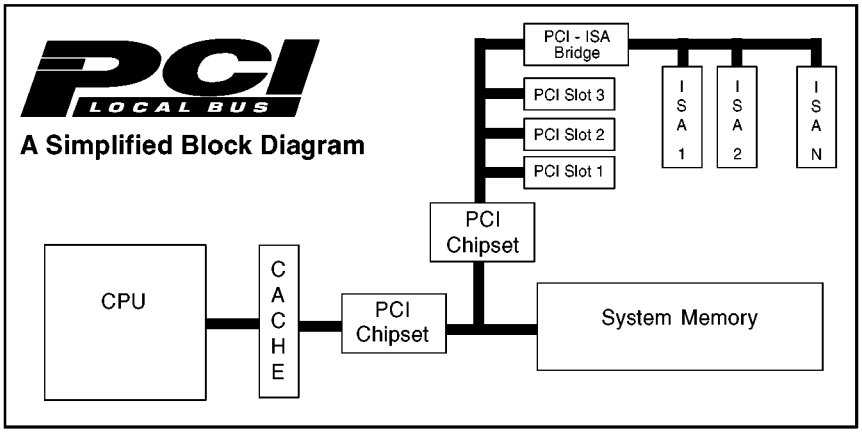
GagePC 580 allows the engineer to have an integrated PC based instrumentation solution with the benefits of a built-in color monitor and front access to all connectors. The system takes up less space on the desk or on the rack, and is much easier to transport.

Reliability and quality of measurements were the prime criteria for the design team of GagePC 580. No compromises which could adversely affect the performance of instrument cards were made during the design phase.



WHAT IS INSIDE A PC?

Inside almost all of today's Personal Computers is a very powerful, PCI bus based microprocessor system which can put some of yesterday's minicomputers to shame.



PCI (Peripheral Component Interconnect) bus is a processor independent, 32 bit, 33 MHz synchronous bus which allows data transfers between system devices at sustained rates exceeding 100 MB/s. This makes it possible to build very sophisticated, real-time systems using Commercial Off The Shelf (COTS) products.

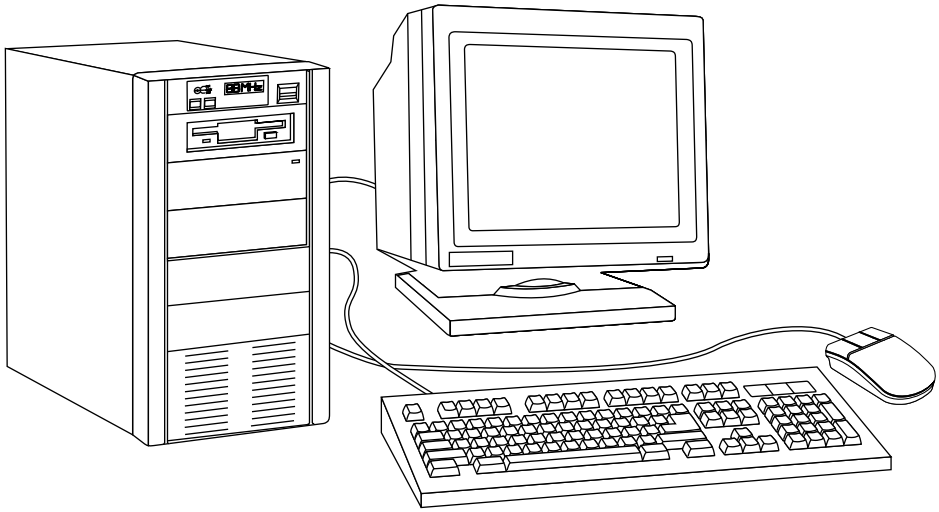
The tried and trusted ISA bus shares the backplane with PCI and allows up to 20 add-on cards to be plugged in, making it possible to build a very complex, high channel count system.

With a combined PCI / ISA backplane, Personal Computers offer a very attractive platform for PC-based Instruments.

Today's PCs are capable of running very sophisticated operating systems such as MSDOS, Windows 3.1, Windows 95, Solaris, QNX, Linux and Windows NT. Some of these operating systems provide capabilities such as multi-tasking, multi-thread and client/server architecture, while others provide real time operation.

In the following pages we will describe the various packaging schemes used to build Personal Computers and discuss their impact on PC based Instrumentation.

TRADITIONAL DESKTOP PCs



Desktop Computers are ideal for the office environment where they are used for word processing, spreadsheets or for file management. The major benefit of this type of PC is its low cost: it is possible to buy a Pentium based PC for approximately $1,500!

This low price is possible because of the very large quantities of Desktop PCs which are manufactured every year. The home and office markets around the world absorb millions of PCs sold by hundreds of manufacturers and the competitive nature of the marketplace drives the cost down.

An unfortunate, but understandable, consequence of this perpetual downward price trend is that manufacturers are forced to use cheaper and cheaper motherboards, power supplies, and chassis to reduce their cost of production: mostly at the expense of quality and reliability.

PC based Instruments and Data Acquisition Cards, such as CompuScope cards from Gage Applied Sciences, are designed to withstand the low quality power supplies found in most Desktop Computers: on-board power line filtering allows CompuScope cards to deliver exceptional signal quality in virtually any Desktop Computer.

Nonetheless, there are other parameters in a Desktop Computer which can adversely affect the performance of any high-end Instrumentation or Data Acquisition device. For example, almost all Desktop Computers come with virtually no cooling mechanism other than the CPU and power supply fans.

The nominal convection created by these fans is just enough to dissipate the heat generated by one high speed Instrument card such as the CompuScope 8500/PCI which can dissipate as much as 25 Watts.

Another limitation of Desktop Computers is the amount of current their power supplies can provide for the -12 Volt and -5 Volt lines. These are the voltages necessary for running very high speed, ECL based instrument cards such as CompuScope 8500/PCI.

The table below shows the current rating of a typical desktop computer power supply.

Voltage	**Current**	**Power**
+5 Volts	25 Amps	125 Watts
+12 Volts	6 Amps	72 Watts
-5 Volts	500 mA	2.5 Watts
-12 Volts	500 mA	6 Watts
Total Available Power		200 Watts

It should be noted that a simple ECL flip-flop can consume as much as 200 mA from the -5 Volt line!

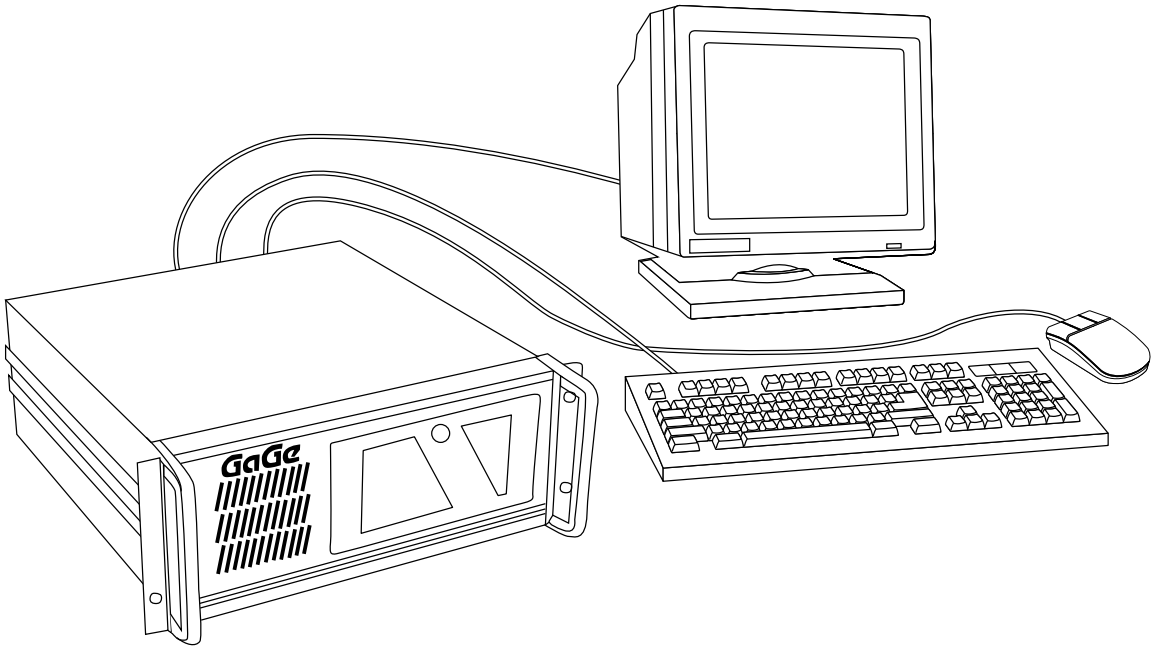
Once again, manufacturers of PC based instruments, such as Gage Applied Sciences, work around this limitation by using high efficiency DC-DC converters on-board the instrument cards. For example, the CompuScope 8500/PCI uses two separate DC-DC converters: one for the -5 Volt line and another for the -2 Volt line necessary for terminating ECL signals.

This discussion shows that Desktop Computers can safely be used for running a single PC based instrument card. However, when multiple cards need to be operated in the same chassis, Desktop Computers run out of gas. Lack of sufficient convection can cause heat pockets to build up, resulting in thermal runaways which can cause degradation of performance.

As a final note, it must be pointed out that Desktop PCs can reliably be used as PC based Instrument platforms for single-card applications as long as the PCs are built by a well-known, high-quality manufacturer.

INDUSTRIAL GRADE PCs

Some of the answers to the problems outlined above are provided by another type of Personal Computer: the Industrial Grade PC.



Industrial Grade PCs are usually packaged in a 19” rackmountable chassis and are typically built around a passive backplane and a single-card CPU, allowing for easy servicing and upgrading.

Another standard feature of Industrial Grade PCs is that they have at least one fan (86 CFM, typical) which blows air through the card cage, cooling the electronics on the add-on cards.

Industrial PCs are at least three to four times more expensive than a corresponding Desktop PC. As such, the quality of the CPU card and power supply is usually not compromised.

There still are some manufacturers who sell very low-quality Industrial Grade PCs at bargain-basement prices. These machines suffer from the same drawbacks as Desktop Computers for exactly the same reasons. A customer must, therefore, always make sure he or she is buying Industrial PCs from a dependable source.

Manufacturers of PC Based Instrumentation have successfully been packaging fairly large systems in high quality Industrial PCs. Multi-Card systems comprising as many as 8 CompuScope 2125 cards (250 MSPS A/D or Scope Cards) have successfully been packaged into a rackmountable Industrial PC for use in manufacturing test, research and imaging applications.

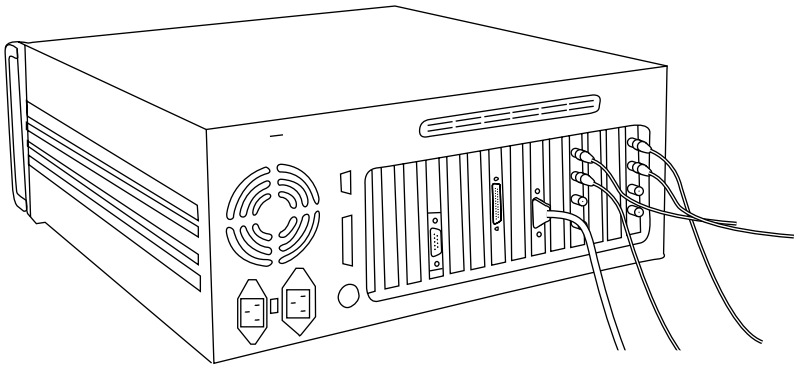
These Industrial PC based systems provide an 8 channel, 250 MSPS A/D and Digital Storage Oscilloscope (DSO) featuring simultaneous sampling, common triggering and very fast data throughput to the PC. Such features and channel counts are not available on any other platform, be it stand-alone DSOs or VXI.

Reliability of these PC based Instrument systems is equivalent to that of standalone instruments (such as DSOs) because system components are carefully selected and characterized. Systems are also burnt-in for 48 hours and tested using Gage's 48 point test standard.

The table below shows the current rating of a typical Industrial PC power supply.

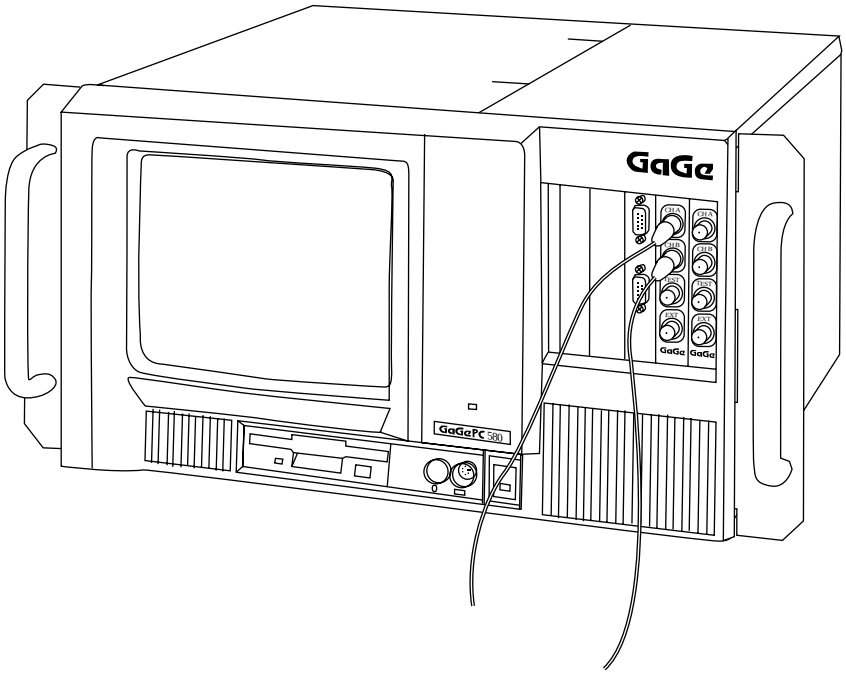
Voltage	**Current**	**Power**
+5 Volts	30 Amps	150 Watts
+12 Volts	8 Amps	96 Watts
-5 Volts	500 mA	2.5 Watts
-12 Volts	500 mA	6 Watts
Total Available Power		250 Watts

In spite of all the performance and reliability gains made by manufacturers such as Gage, the PC based Instrumentation user has had one constant complaint for the last few years: Instrument connectors come out the back of the Industrial PC chassis, making it difficult to connect and disconnect cables and probes.



GagePC 580 - AN INSTRUMENT GRADE PC

GagePC 580 is a revolutionary Instrument Grade PC designed from the ground up for housing ultra-fast, PCI and ISA bus based Data Acquisition and Instrumentation Cards.



Front Access for Instrument Connectors

Traditional Desktop and Industrial PCs force the engineers to access the connectors on the add-on cards from the rear of the machine.

This is very inconvenient in the case of Data Acquisition or Instrumentation Cards such as the CompuScope and CompuGen, as engineers repeatedly need to connect and disconnect their cables and probes.

GagePC 580, the world's first Instrument Grade PC, is very unique in that it allows front access for all connectors on add-on boards.

High Power, High Reliability Power Supply

Gage has designed the power supply in the GagePC 580 so it can provide reliable, low-noise power at both positive and negative voltage levels. Typical GagePC systems have more than enough power to run up to five CompuScope or CompuGen cards.

The table below shows the current rating of a GagePC 580 power supply.

Voltage	Current	Power
+5 Volts	36 Amps	180 Watts
+12 Volts	10 Amps	120 Watts
-5 Volts	3 Amps	15 Watts
-12 Volts	3 Amps	36 Watts
Total Available Power		350 Watts

It is obvious that the power supply used on the GagePC 580 is much more powerful, robust and reliable than the ones found in Desktop Computers, or even Industrial PCs.

The GagePC 580 power supply features an MTBF (Mean Time Between Failures) of over 120,000 hours.

Built-In Color Monitor

GagePC 580 also houses a 10-inch color monitor connected internally to a SVGA controller, thereby eliminating the need for an external CRT and cables. The resulting chassis is compact, rugged and highly integrated.

Industrial Grade Construction

GagePC 580 is designed to be rugged. An Industrial Grade, rackmountable metal chassis houses a multi-layer passive backplane, single-card Pentium CPU, heavy-duty power supply, shock-mounted disk drives and two 106 CFM fans for forced air cooling.

GagePC 580 features a standard ISA or PCI bus backplane with 0.800” inter-slot spacing. It allows for up to five add-on cards to be plugged into its backplane.

The custom designed backplane minimizes ground bounce on the PCI bus signals, thereby improving data integrity and lowering noise feed-through to the analog circuitry on Instrument Cards.

Cooling System

Many years of semiconductor device testing have shown that increased temperature will increase the likelihood of failure. This behavior fits the form of the Arrhenius equation:

$$FR \sim e^{-Q/KT}$$

where FR = Failure Rate, T = Junction Temperature

This clearly states that reliability decreases with temperature. In other words, semiconductor devices tend to exhibit their most limited performance at the highest operating temperature.

This means that keeping the components cool is a very important design and operating factor for ensuring that the system will be reliable.

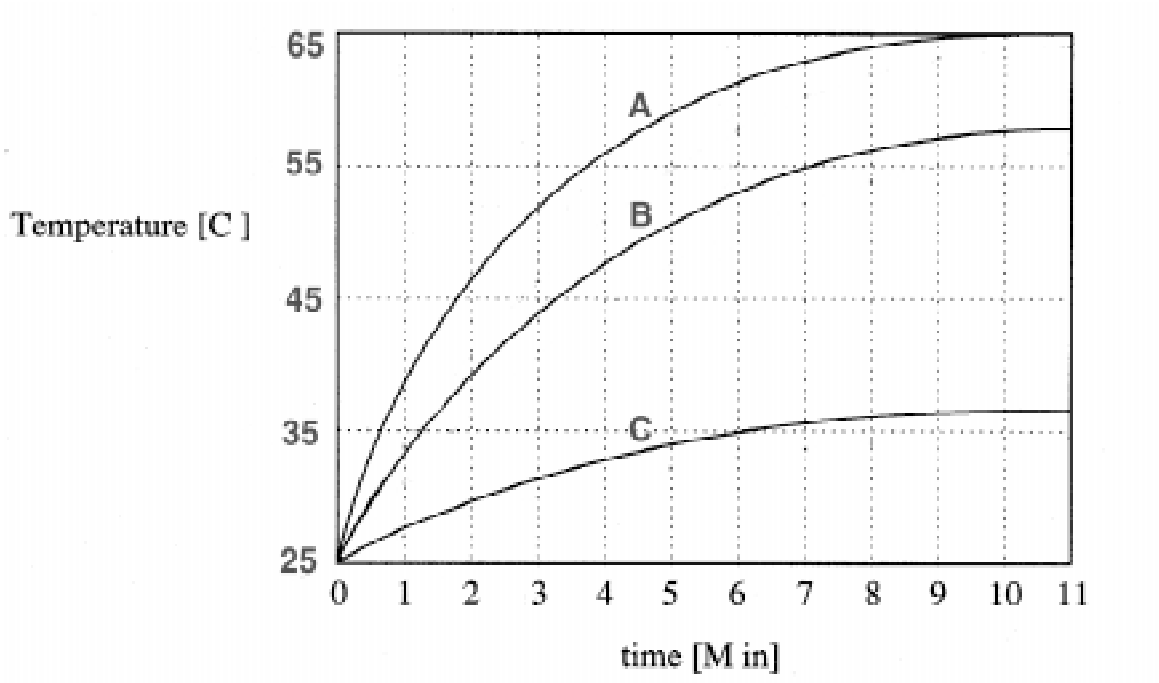


Figure: Temperature vs. Time, CS8012 Multi-Card System

In the figure shown above, three curves were recorded which represent the rise of temperature of the A/D chips on a CompuScope 8012 versus time in different chassis.

For Curve A, we installed three CompuScope 8012 boards in a Desktop Computer one slot (0.800”) apart on the motherboard. This setup is the worst for reliability and performance, because the A/D converters work at almost the absolute maximum operating temperature of the chip.

For Curve B, the boards were placed in every other slot of the same motherboard, so that they were 1.600” apart. The convection caused by the power supply fan could cool them somewhat, but still the temperature of the A/D chips was close to the absolute maximum.

Curve C represents the result of testing done on a GagePC 580 chassis. GagePC provides 106 CFM, high reliability fans which are mounted at the back of the boards to provide forced air cooling for the CompuScope cards. This resulted in a substantial reduction in the temperature of the on-board electronics.

In other words, operating the multi-card CompuScope 8012 system in a GagePC 580 will provide the most reliable operation.

GagePC 580 AS AN INSTRUMENTATION INVESTMENT

Engineering Managers are perfectly justified in demanding that the instruments they buy for the laboratory or for the production floor last a long time. GagePC 580 answers that need by providing an expandable and upgradeable platform for PC-based instruments.

PCI bus, around which the GagePC 580 is designed, has a bright future over the next few years. A 64 bit version of the bus will be available for engineering applications in 1998 and a 66 MHz, 64 bit version within a short time thereafter. All these versions will be backward compatible with the current 32 bit, 33 MHz bus.

This systematic and predictable growth of the PCI bus ensures complete security of investment made in the products purchased today.

GagePC 580 SYSTEM CONFIGURATIONS

The GagePC 580 allows for an almost infinite number of different configurations to cater to an engineer's application. Some examples are:

GagePC Configuration 100

- 4 channel, 12 Bit 100 MSPS A/D and Scope System
  or 8 channel, 12 Bit 50 MSPS A/D and Scope System
  (4 board, CompuScope 8012A Master/Slave System)

GagePC Configuration 101

- 2 channel, 500 MSPS A/D and Scope System with data throughput rates of 100 MB/s across PCI Bus
  (2 Board CompuScope 8500/PCI Master/Slave System)

GagePC Configuration 102

- 5 channel, 250 MSPS A/D and Scope System
  or 10 channel, 125 MSPS A/D and Scope System
  (5 board, CompuScope 2125 Master/Slave System)

GagePC Configuration 103

- 2 channel, 100 MSPS, 12 bit A/D and Scope System
  with one channel, 500 MSPS A/D and Scope System
  (One board, CompuScope 8012A with One board, CompuScope 8500/PCI)

GagePC Configuration 104

- 2 channel, 500 MSPS A/D and Scope System
  with 2 channels of 80 MSPS, 12 bit D/A or Arbitrary Waveform Generation
  (Two board CompuScope 8500/PCI Master/Slave System with Two board CompuGen 1100 Master/Slave System)

The possibilities are endless. An engineer can create his or her own configuration to suit a particular application.

GagePC 580 provides a very flexible and easily upgradeable system for any application.

GagePC 580 COMPONENTS

GagePC 580 is constructed using only high quality materials. Some of the components are :

- Pentium 166 MHz CPU
- Single Card CPU and Custom Built PCI/ISA Backplane
- Built-in 10 inch SVGA color Monitor
- 2 GB IDE hard disk
- 3.5 inch floppy disk
- 101 key keyboard
- PS/2 compatible mouse
- Two 106 CFM cooling fans
- One serial and one parallel I/O port
- MS-DOS and Windows (3.1, 95 or NT) operating system.
- Ruggedized transportation case
- Made in North America

Karen McCurry is the Assistant Marketing Manager at Gage Applied Sciences Inc.
Karen joined Gage in 1993 and is responsible for managing the marketing of Gage products.
She is also involved with helping customers solve their application requirements.
Karen holds a Bachelors of Commerce degree from McGill University in Montreal, Canada.

For further information, contact Karen McCurry at:

GAGE APPLIED SCIENCES, INC.
5610 Bois Franc
Montreal, QC H4S 1A9
Tel: **1-800-567-GAGE** or (514) 337-6893
Fax: (514) 337-8411
e-mail: kmccurry@gage-applied.com
web site: http://www.gage-applied.com

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