TEE INERGW APPROACH

Ansul Fire Protection
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THE INERGEN APPROACH

INTRODUCTION

The health and environmental concerns of today's consumers have led manufacturers to pursue evermore environmentally friendly products. It is no longer acceptable for globally conscious corporations to produce products which exhibit questionable environmental impact. Although many products are sold on the merits of "what they will do," more and more products are attracting customers because of "what they will not do," to people or the environment.

The fire protection industry has also increased its environmental awareness with its search for a replacement for Halon 1301, the gaseous fire extinguishing agent widely used to protect data processing centers and other normally occupied areas where equipment is either sensitive or irreplaceable. Although Halon 1301 was considered safe for people or high value equipment, it is now considered a threat to the environment due to its ozone depleting characteristics.

The goal of the fire protection industry has been to find agents with the advantages of Halon 1301 while eliminating the environmentally destructive characteristics. That goal has been realized with the development of INERGEN. INERGEN agent will extinguish class A and B fires and has demonstrated inerting capacity. Because INERGEN is derived from atmospheric gases it has no impact on the environment. It has no ozone depletion potential or greenhouse warming potential. Similarly, when properly installed, INERGEN will not harm sensitive or irreplaceable equipment. It forms no toxic or corrosive decomposition products.

The gas mixture comprising INERGEN is 52% nitrogen, *40%* argon and eight percent carbon dioxide. INERGEN behaves much as carbon dioxide in the extinguishment of fire. Both gases act in lowering the oxygen content below that which supports combustion. However, INERGEN acts to stimulate respiration and oxygen transfer within :he human body. This principle is important in distinguishing INERGEN from ocher inerting gases. The addition of argon to the mixture creates a density gradient for INERGEN which works to promote air/INERGEN mixing.

INERGEN CLASS A FIRE CAPABILITY

Initial evaluations of the class A capability of INERGEN were carried out using the following test protocol.

The class A fire test consisted of a modification of a UL fire test. The fuel load consisted of a cubical wooden crib eight inches on a side. The 32 members were comprised of pine one inch by one inch by eight inches long. The total surface area of the crib was *846* in’ resulting in a surface area to volume ratio 3.4:1. The crib was soaked in charcoal lighter fluid for thirty minutes prior to ignition, then placed on a load cell and lighted with a propane torch. Computerized data acquisition gave rapid readings of all parameters, including oxygen and CO, levels from a Nova gas analyzer.

After establishing the burning rate of the fuel it was determined that **a** minimum of 25% to 35% weight loss was sufficient and reproducible in establishing a condition of “flaming“ combustion when using a wooden crib. The success of extinguishment was measured when a steady-state was achieved on the weight loss

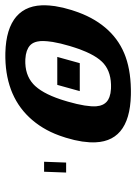
What Is INERGEN™

INERT GAS + NITROGEN

COMPOSITION

- Nitrogen 52%
- Argon 40%
- Carbon Dioxide 8%

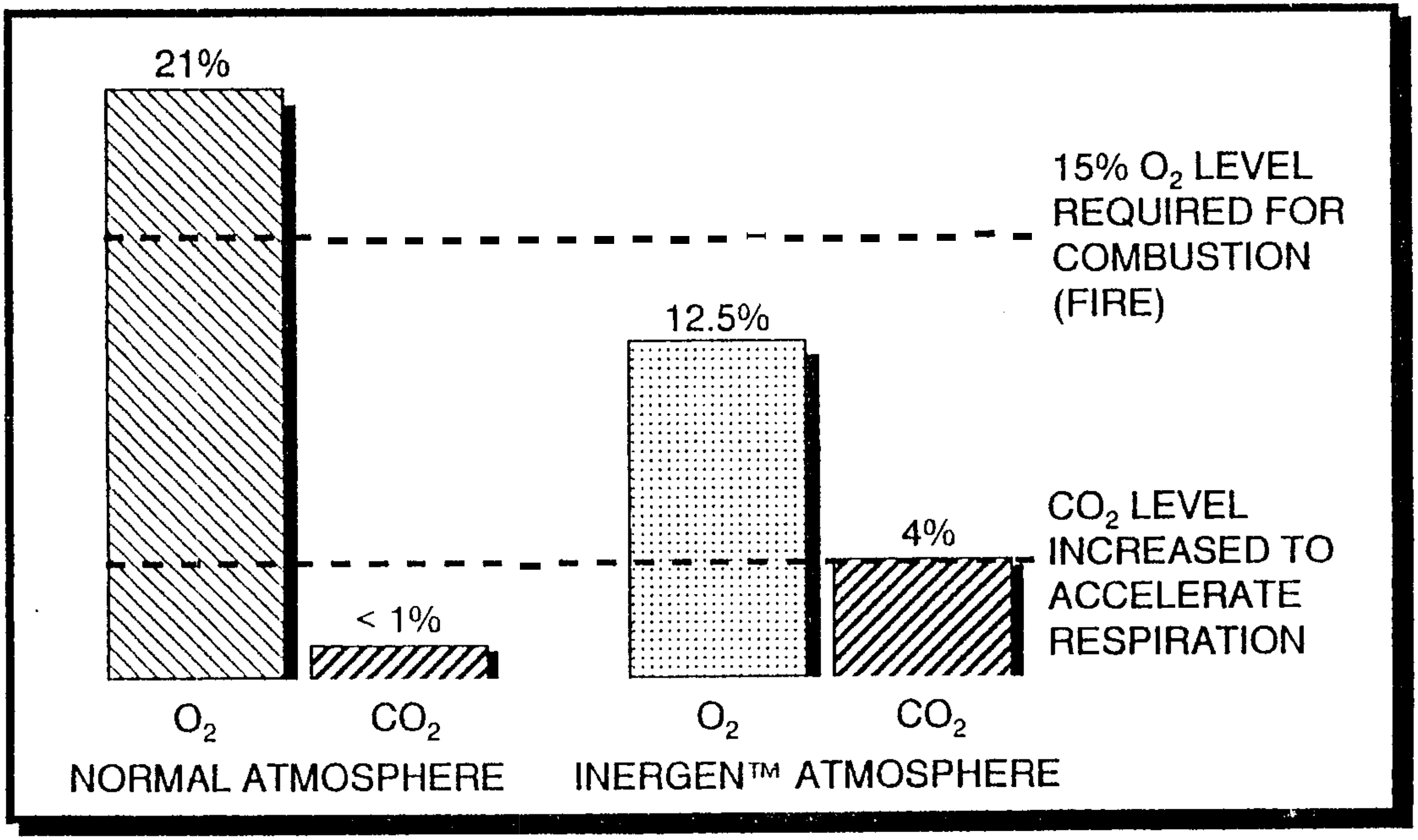
N_2



Ar

CO_2

How Does INERGEN™ Work



Class 'A' Fire Protocol

- 32 Member Crib
  - 1 inch x 1 inch x 8 inch Pieces
- 256 Cubic Feet Lexan Test Enclosure
- Labtech Notebook Data Acquisition
- NOVA Analytical
  - O_2 - CO_2 Gas Analyzer
- Hanging Load Cell
- Omega Thermocouples

Why INERGEN™

ADVANTAGES

- Contains Only Naturally Occurring Gases
  - ➧ *Zero Ozone Depletion Potential*
  - ➧ *No Global Warming Potential*
  - ➧ *No Hazardous Decomposition Products*
  - ➧ *Non-Toxic, No Cardiac Sensitization*
- Clean, Dry, Electrically Non-Conductive
- Effective On All Common Types Of Fires
- Simplified Flow Calculations

curve. This could be verified by observing the temperature curve over the **same** period. Successful extinguishment would result in a negative sloping temperature profile. A positive slope at the end of the soak period indicated deep-seated burning and would correlate to a continued weight loss.

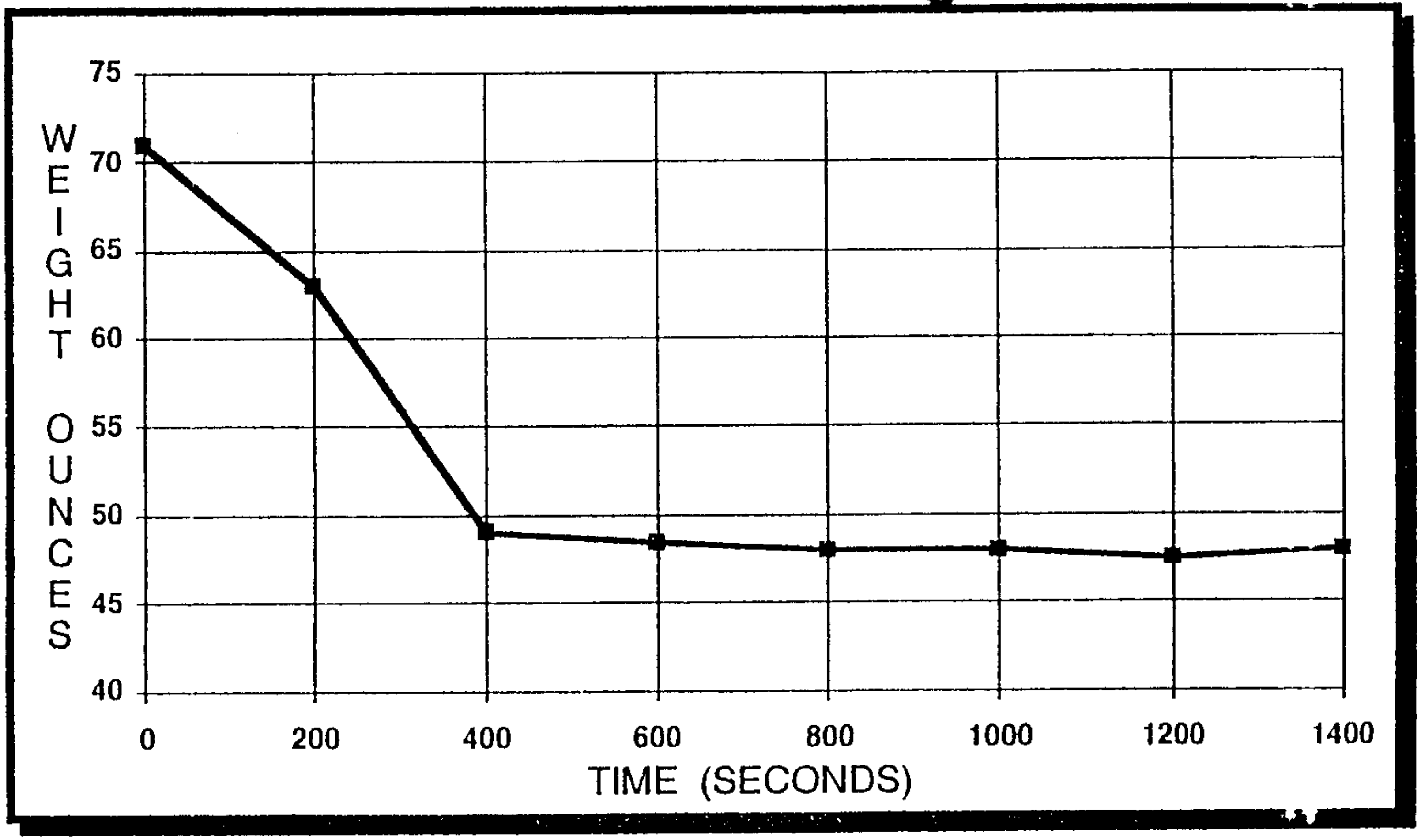
The test chamber vas constructed to form a volume of ***256*** cubic feet (8'X8'X4'). Construction vas such that three vertical walls were made of Lexan with the back, top and bottom made of *3/4* inch plywood. Centered **at** floor level of the side opposite the entry is a circular air inlet (4" diameter). Diagonally opposite is a 4" exhaust vent capable of *800* cfm. A load cell is suspended in the center of the box. This cell is capable *of* measuring weight loss to one ounce. A wire mesh basket is supported from the load cell and used to contain all fuels. This basket has dimensions of 12" diameter by 12" height. Located in the ceiling *of* the test chamber is one three-eighths inch **INERGEN** nozzle.

The vent and blower were left on during the pre-burn period. At the desired veight loss fan power vas stopped and the inlet vent vas closed to simulate fire detection. The agent was discharged, fire out time was noted, and the soak time measured. The soak period began from the point in time when the box achieved a 15% O_2 concentration. At the end of the soak period the blower vas again powered **up** and the inlet vent opened. Temperature and weight loss were monitored for the duration of the soak time and for an additional ten minutes during the power up period.

Test results from a 30% weight loss test are shovn in this slide. Measured parameters included veight loss, O_2, CO_2 and CO concentration, fuel temperature and extinguishment tine. Typical results for some of these parameters are shown in the following graphs.

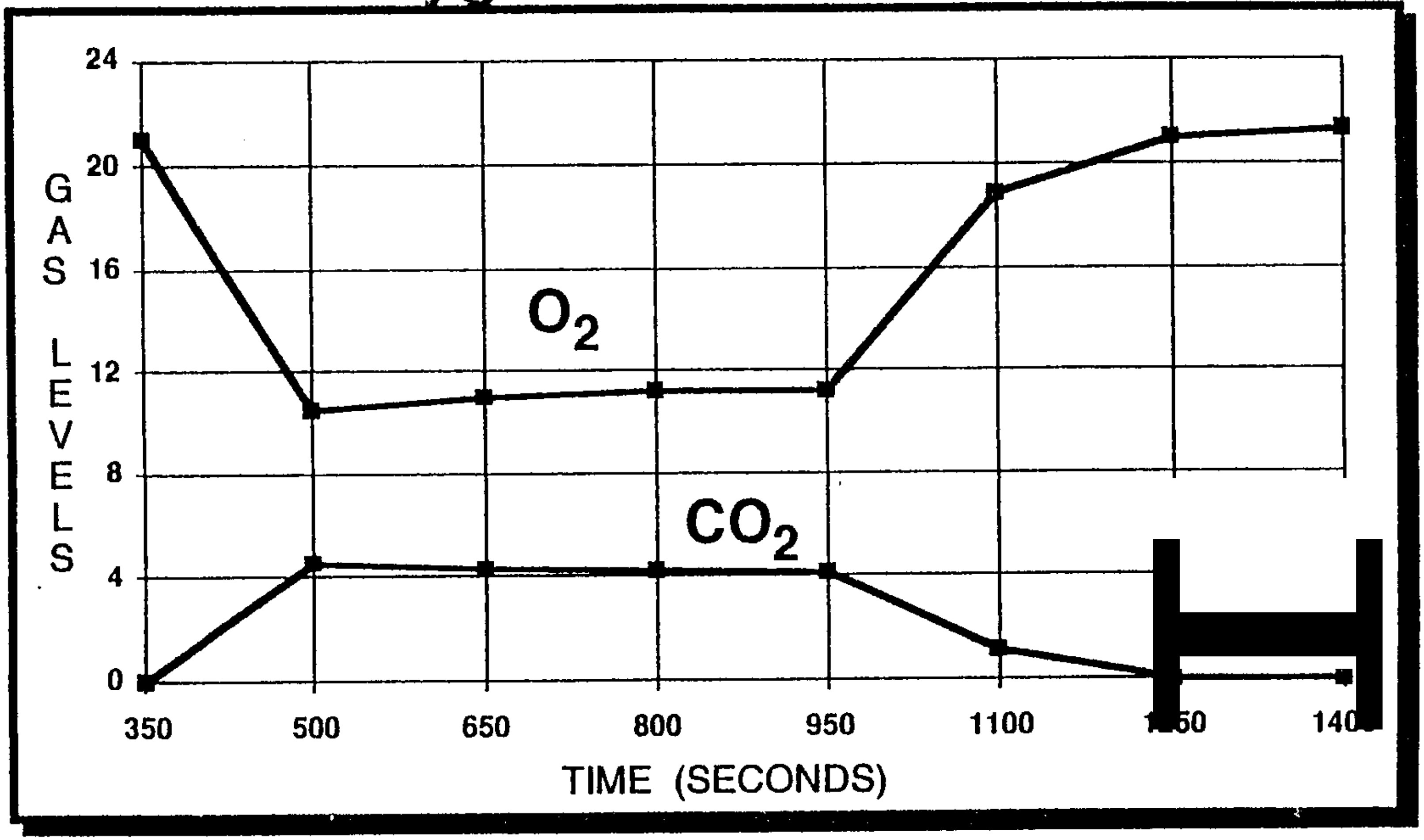
Class 'A' Fire Results

Weight Loss Profile



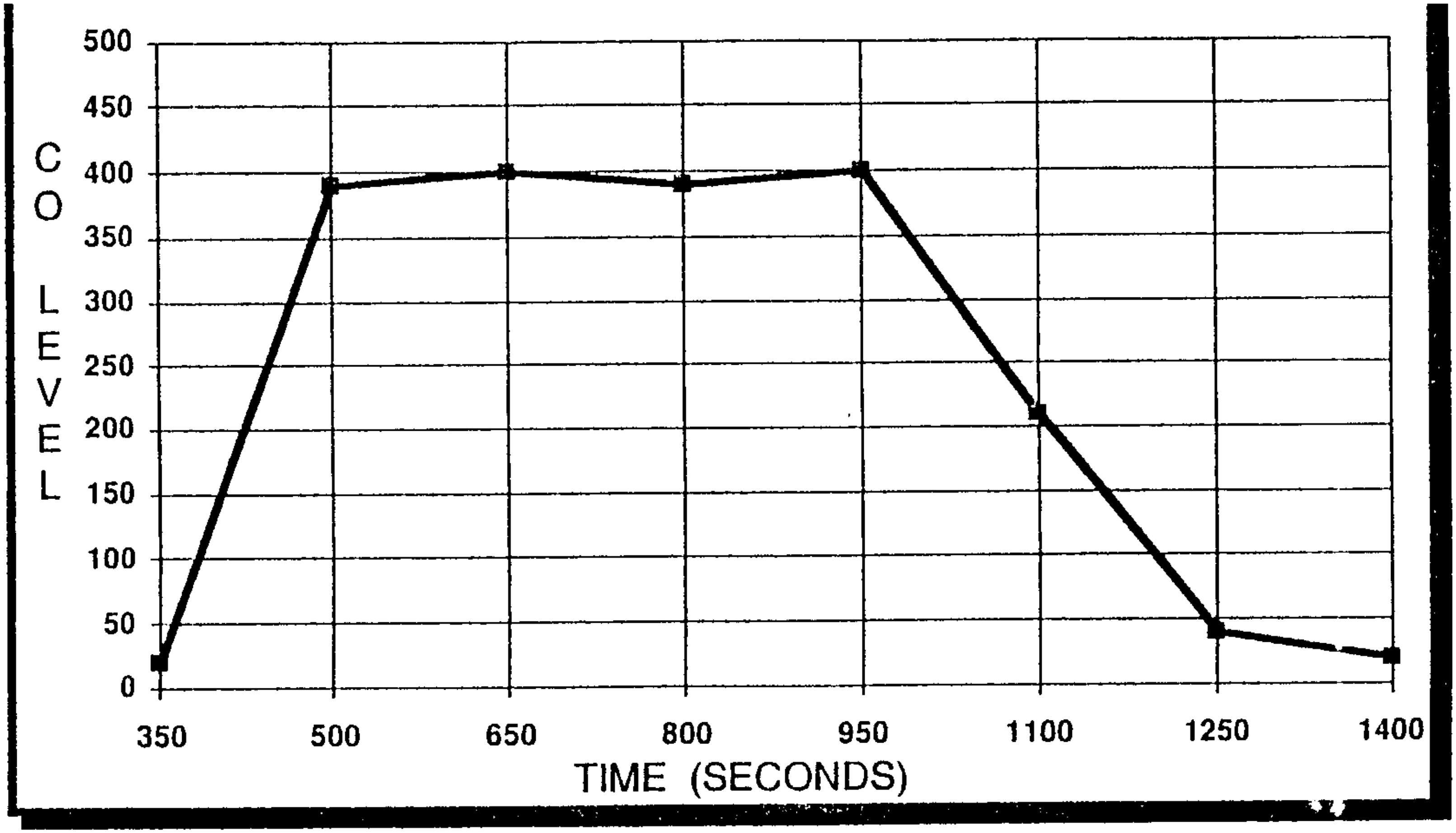
34% INERGEN™ - 30% BURN - 8 INCH CRIB

Class 'A' Fire Results
Oxygen & Carbon Dioxide Levels



34% INERGEN™ - 30% BURN - 8 INCH CRIB

Class 'A' Fire Results
Carbon Monoxide Profile



34% INERGEN™ - 30% BURN - 8 INCH CRIB

The results demonstrate that INERGEN is capable of extinguishing class A crib fires at an injected concentration of 34%, equivalent to a received concentration of 28-29%. In testing to this protocol, extinguishment has been achieved on average within 90 seconds of the start of discharge with a total discharge occurring over two minutes. The concentration of carbon dioxide increased to 4.5% with the oxygen concentration stabilizing at 11%. Carbon monoxide reached an average maximum of 380 ppm.

By setting the preburn time a5 a function of weight loss, a more controlled experiment was established for evaluating class A effectiveness. The burning rate over twenty-five to thirty-five percent weight loss was found to be linear and very reproducible during this testing. The results of this testing indicate that INERGEN demonstrates good class A fire extinguishing capacity for normal class A loading, at a concentration of 29%, equivalent to a design concentration of 34%.

INERGEN CLASS B FIRE CAPABILITY

The extinguishing concentration of INERGEN can be determined using the Cup-Burner method as developed by Imperial Chemical Industries in the mid 70's. Cup-burner evaluations have been used since that time for the purpose of establishing extinction concentrations for Halon fire extinguishing agents. With the banning of Halons because of their contribution to ozone depletion, the use of the cup-burner has again been employed to evaluate alternative clean agents. National Fire Protection Association proposed standard 2001, Clean Agent Fire Extinguishing Systems, expressly calls out the use of the cup-burner for demonstrating the class B effectiveness of candidate agents and for establishing minimum extinguishing concentrations.

Class ‘A’ Fire - Summary

Crib Fire Test Results

Extinguishment Concentration 29.0%

Design Concentration 34.0%

Final Carbon Dioxide
Concentration 4.5%

Final Oxygen Concentration 11.0%

Final Carbon Monoxide
Concentration .... 380 ppm

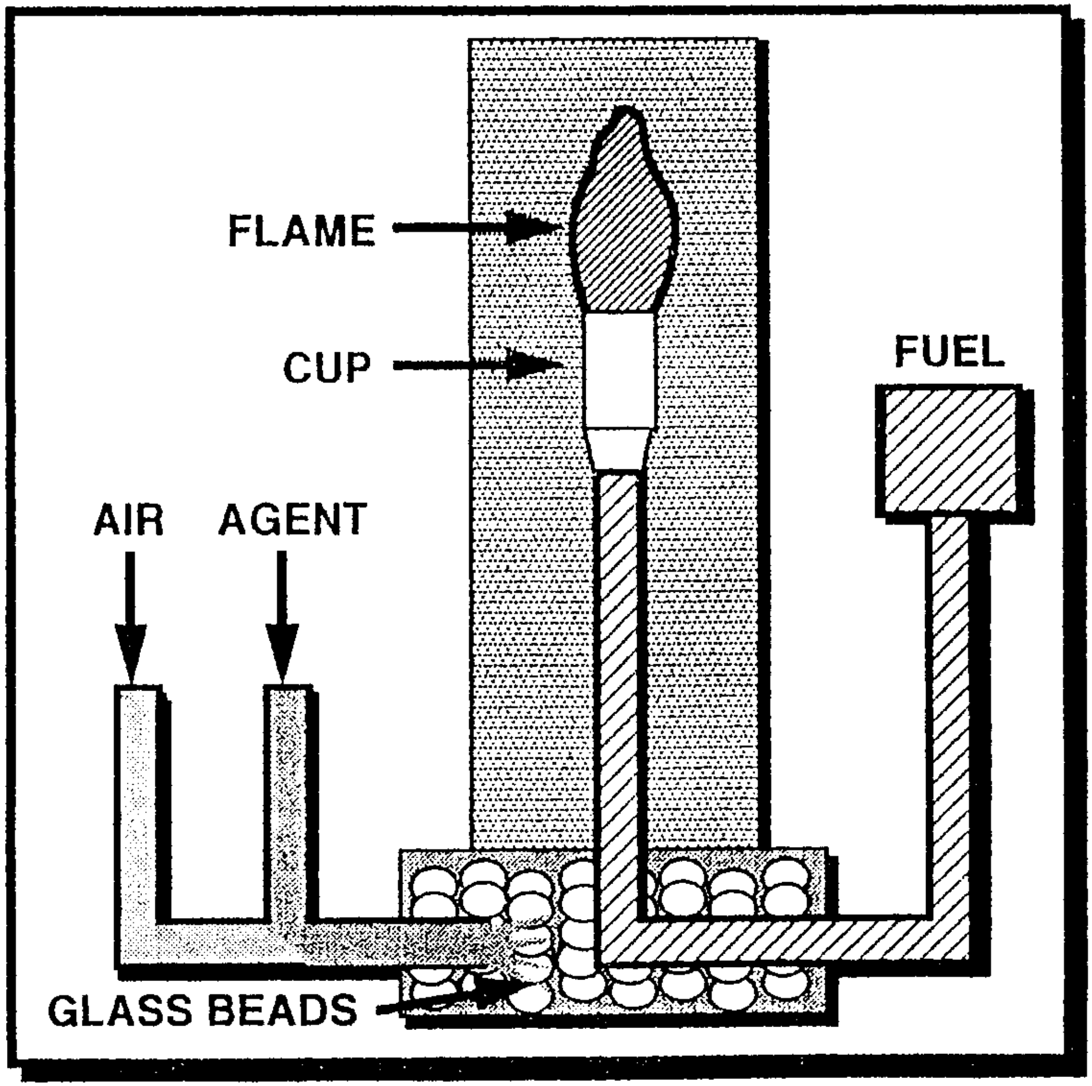
The basic components to the cup-burner consist of the cup, burner support block, chimney, and flov meters. The apparatus vas set-up as described in Appendix A Section 3-4.2.2 of draft NFPA standard 2001. To the inlet of the cup-burner is attached Tygon tubing of sufficient length and diameter to allow convenient location of a 500 ml separatory funnel. This funnel is used as the fuel reservoir and fuel leveling mechanism. The funnel is fixed with a side-mounted-teflon-micrometer valve for fuel flow adjustment. The funnel sits in an adjustable ring stand for ease in maintaining a constant fuel level.

Brooks flow meters were used to measure the flov of air and INERGEN. Line regulators were used to reduce the house pressure of air and tank pressure of INERGEN. Air flov vas measured at 10-12 psi while INERGEN pressure vas regulated at 40 psi. A volumetric flov curve for air vas developed using the bubble burette technique. A similar curve for INERGEN vas developed. Volumetric gas flovs for test purposes are then set using the flov cur-res.

Reagent grade heptane vas used as the fuel source. INERGEN vas supplied to the manufacturing specification of 52% N_2±4%; 40% Ar±4%; 8% CO_2+½%-0%.

The test for extinguishing concentration is as follows. After assembling the burner apparatus, charge fuel to the reservoir. Set the rotameter to a flow of 30 l/min. Center the cup-burner in the block and allow fuel to fill the cup to within 3 mm of the lip. Avoid spillage of fuel as any spillage will contaminate the air flow. Light the fuel in the cup-burner and place the chimney on the apparatus. Begin to increase the flov of the extinguishing agent to the point of extinguishment. Allow ten seconds between each successive flow increase. Back the extinguishing concentration down and repeat the test three times. Record the extinguishing concentration.

Class ‘ B’ Fires - Cup Burner



The determination of extinguishing concentration is computed as follows:

$$\% \text{ Conc.} = \frac{F_1}{F_1 + F_2} \times 100$$

where:

F_1 is the agent flow rate in L/min; F_2 is the air flov rate in L/min. Because the inerting volume of INERGEN is higher than that of alternative agents the total flow through the cup-burner vas balanced **so** that *40* L/min vas maintained. As an example, if the INERGEN flow for an extinguishing Concentration vas determined to be **11.5** L/min, the air flow vas reduced to **28.5** L/min thus maintaining a total flow of *40* L/min through the system. It was the opinion of those skilled in the use of the cup-burner that flows exceeding 40 L/min could result in blow-out of the cup-burner rather than extinguishment. However, tests up to **a** total flow rate of 50 L/min gave similar results. All other aspects of the cup-burner test remained consistent with earlier work.

The cup-burner results for the extinguishing capacity of INERGEN, **for** heptane at **25°C,** vas found to be **29.1** Vol.%. Extinguishment occurred within **5** seconds of exposure to this atmosphere.

THE INERGEN SYSTEM

The efficacy of the agent can be demonstrated within the laboratory through Class **A** and Class B fire testing. **As** vith all new clean agents the question of application must then be addressed. The INERGEN fire supptession system is an engineered system utilizing a fixed nozzle distribution network. Standard DOT cylinders and a special version **of** Ansul's **CV-90** valve are used. The **flow** is single phase and typically lasts **1-3** minutes.

Class 'B' Fires

Cup Burner Calculation

$$\text{EXTINGUISHING CONCENTRATIONS} = \frac{F_1}{F_1 + F_2} \times 100$$

F_1 = agent Flow Rate

F_2 = air Flow Rate

Class ' B' Fires

Cup Burner Results

Fuel .... Heptane

Temperature .... 25 °C

Time to Extinguish .... 5 Sec. Max.

INERGEN™
Concentration 29.1%

The system can be actuated by detection and control equipment for automatic system operation along with providing local and remote manual operation as needed. Accessories are used to provide alarms, ventilation control, door closures or other auxiliary shutdown or functions.

The basic system consists of extinguishing agent stored in high strength steel alloy cylinders. Various types of actuators, either manual or automatic, are available for release of the agent into the hazard area. Both pilot and slave valves are available. The agent is distributed and discharged into the hazard area through a network of piping and nozzles. The piping is schedule 80 for the manifold and schedule 40 for distribution. Typical pressure drops are as shown. The cylinders are connected to the distribution piping or the manifold by means of a flexible discharge bend and check valve assembly. Each nozzle is drilled vith a fixed orifice designed to deliver a uniform discharge to the protected area.

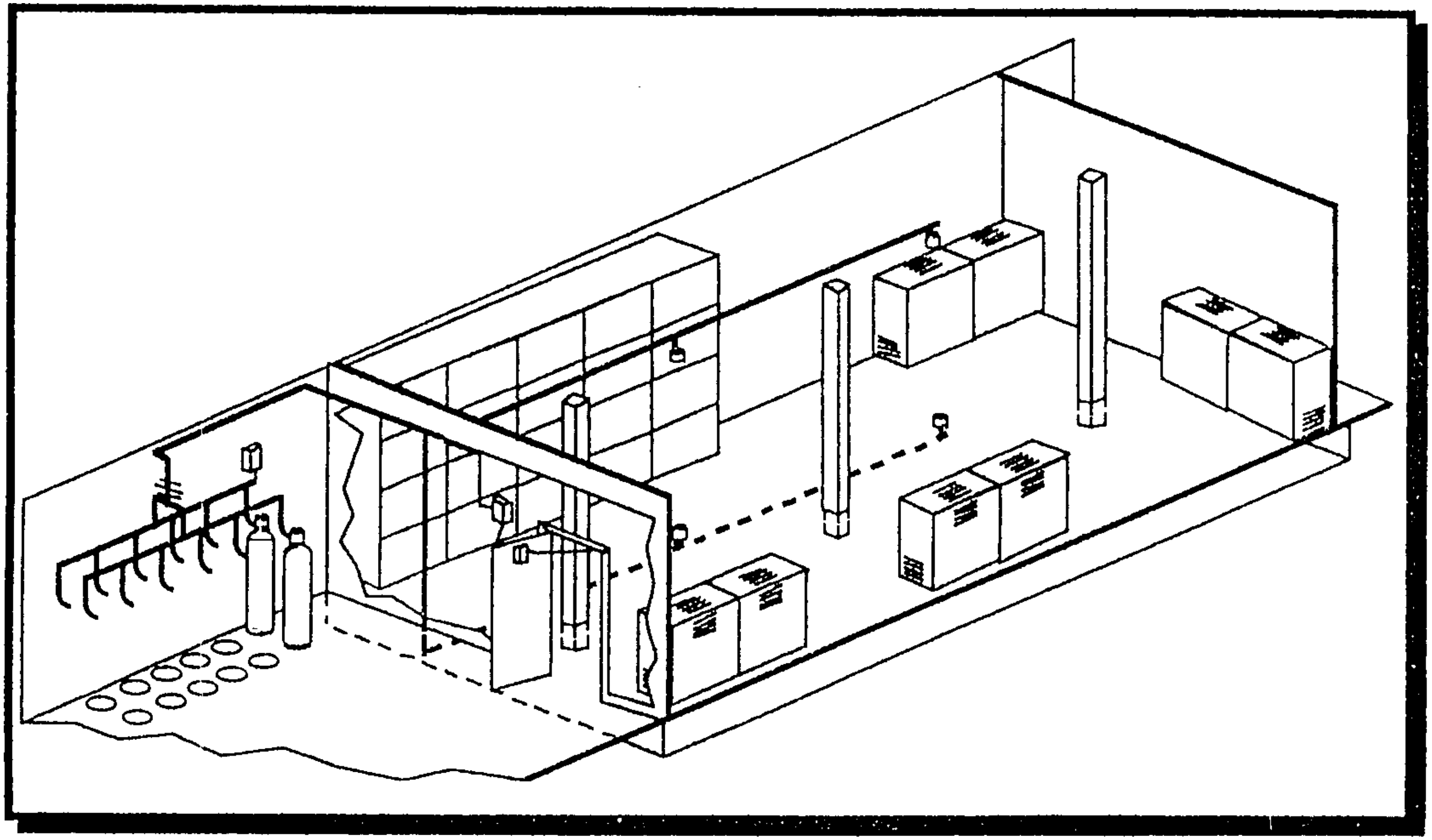
A hydraulic flow program has been written to calculate system design parameters. Single phase flow provides a relatively straight-forward basis for this program. A system installation and maintenance manual is available containing information on system components and procedures concerning design, operation, inspection, maintenance and recharge. The system is installed and serviced by authorized distributors that are trained by the manufacturer.

The **INERGEN** system is particularly useful for suppressing fires in hazards where an electrically non-conductive medium is essential *or* desirable; where clean-up of other agents presents a problem; *or* where the hazard is normally occupied and requires a non-toxic agent.

INERGEN™ Systems

Design Type:	Modular / Engineered
Cylinder Assembly:	3A/3AA DOT 2015+ Minimum
Cylinder Valves:	ANSUL CV90 (With Gauge)
Discharge Nozzles:	New, Similar To Halon Types
Distribution Piping:	Schedule 80-Manifold, Union Orifice Plate
	Schedule 40-Branch Pipe Network
Detection / Control:	Standard Detection / AutoPulse™
Flow Calculation:	Single Phase Flow
Discharge Time:	1 - 3 Minutes

Engineered Systems Design



APPLICATIONS

The following are typical hazards protected by INERGEN systems:

Computer Rooms

Subfloors

Tape Storage

Telecommunication/Switchgear

Essential Electronics

Banks/Vaults

Oil/Gas Facilities

Process Equipment

Total flooding is currently the only recommended application method for INERGEN systems. The design flooding concentration of an INERGEN system will typically be from 44-50%. This will result in a room concentration falling within the design window of 11% to 14% oxygen and 2.5% to 4.5% CO_2. A typical set of curves for oxygen and CO_2 concentrations and the pressure drop for a typical system discharge is as shown.

NOISE

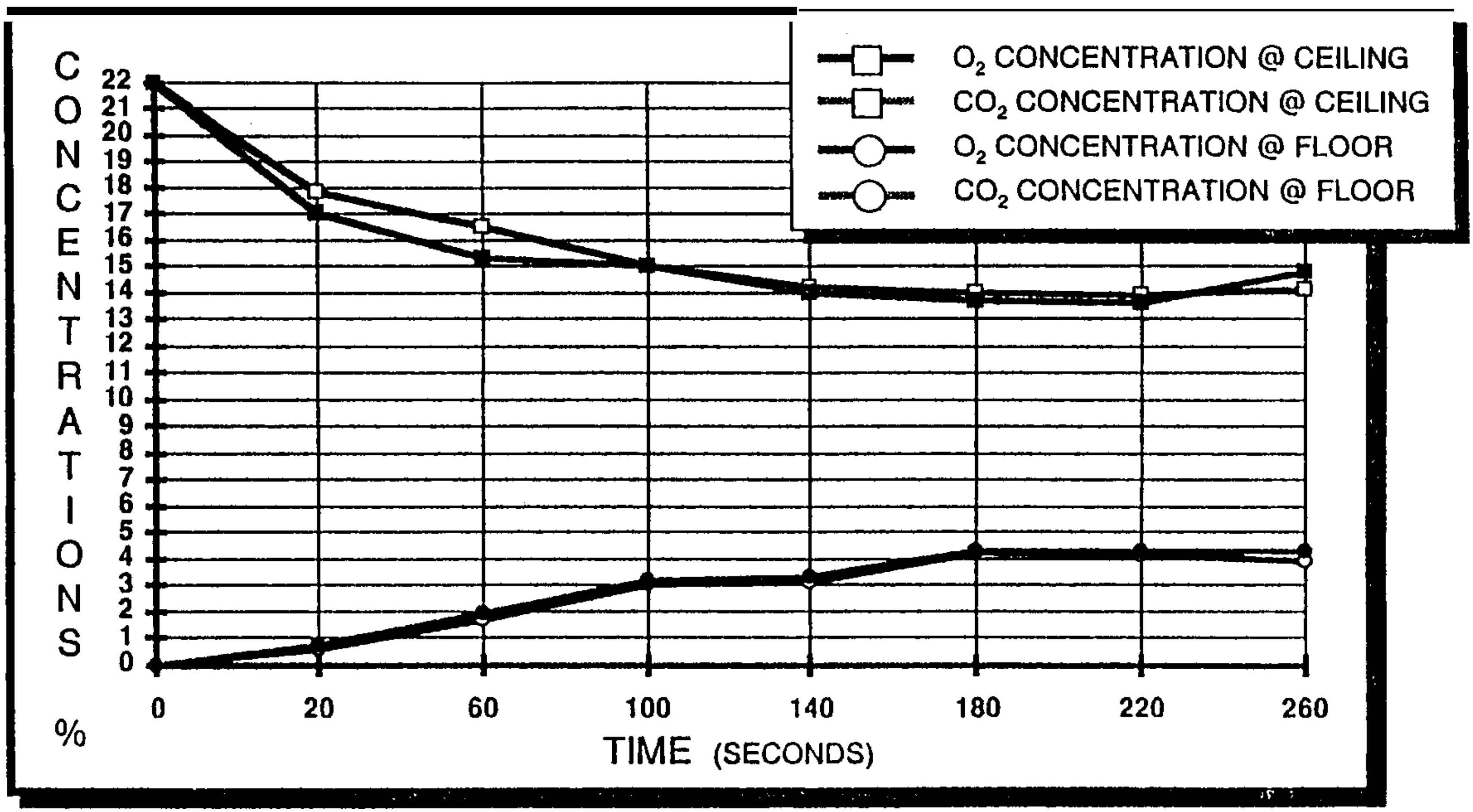
During the initial testing of INERGEN systems in August 1992, it was thought that the relative noise level of the INERGEN discharge was louder than that for Halon 1301. This led Ansul to investigate ways of reducing the sound pressure associated with the system design. Initial pressure waves were recorded in the range of 122 dB to 126 dB using the A scale of measurement. Subsequent design changes have reduced the noise level significantly.

A typical noise level curve for an INERGEN discharge is as shown, dropping quickly, from a peak of 117 dB to levels below 90 dB.

Where Will INERGEN™ Be Used

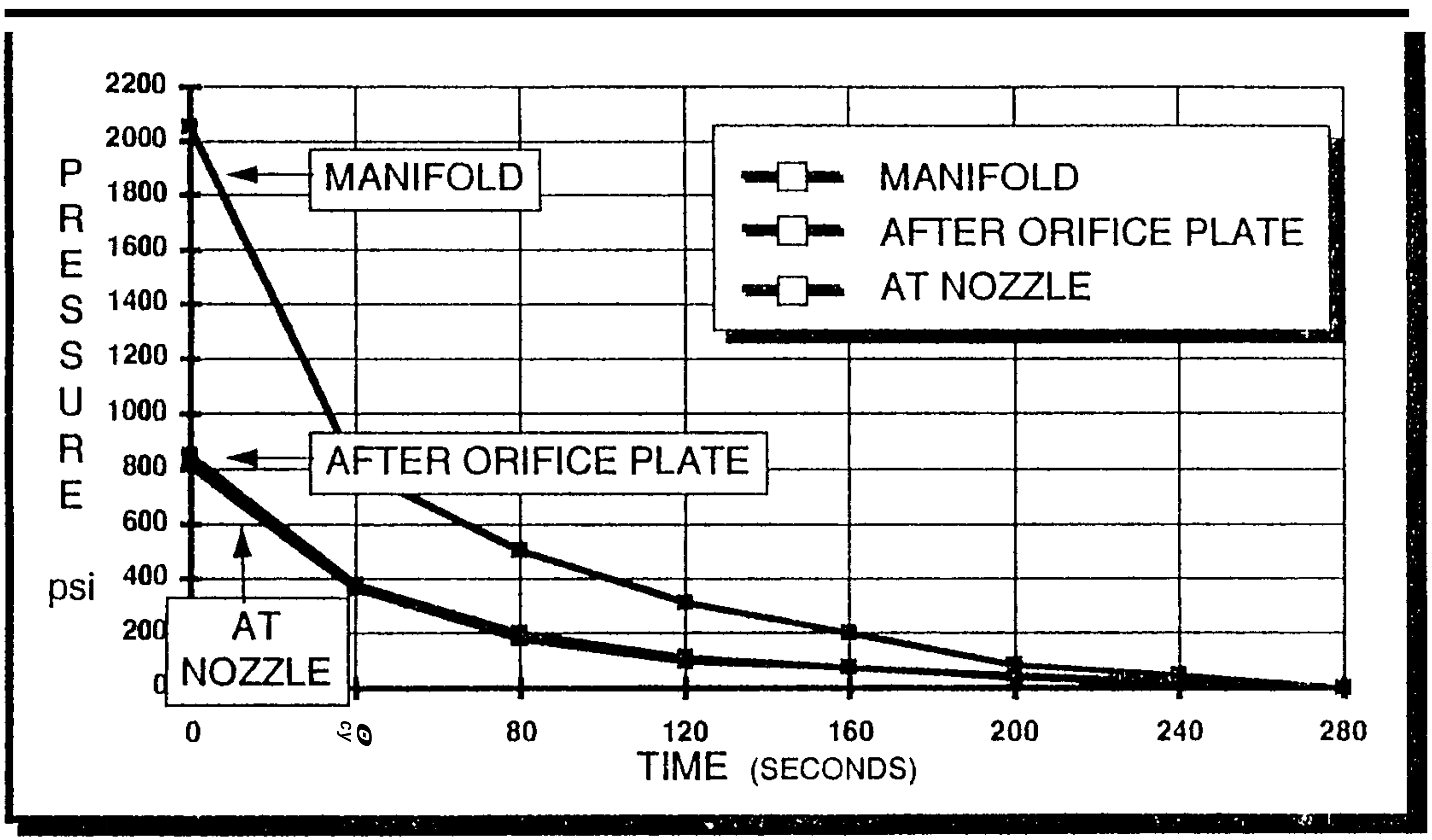
- EDP / Computer Facilities
- Telecommunications
- Essential Electronics
- Oil / Gas Facilities
- Banks / Records Storage
- Historical Sites

Room Concentrations % of Oxygen and Carbon Dioxide



INERGEN™ Discharge .

Manifold, After Orifice Plate, Nozzle..



For a comparison to Halon, refer to the following:

Noise Monitoring of INERGEN Discharge (dB)

	INERGEN Discharge	Halon 1301 Discharge
PK L	117.9	130.0
Max L	103.4	113.4
Min L	46.7	46.8
LAvg	90.0	101.4

The discharge of INERGEN developed a peak sound pressure of 117.9 dB while the Halon test developed a peak of 130 dB. The INERGEN discharge noise level decrease quickly, while a Halon discharge is relatively unchanged throughout.

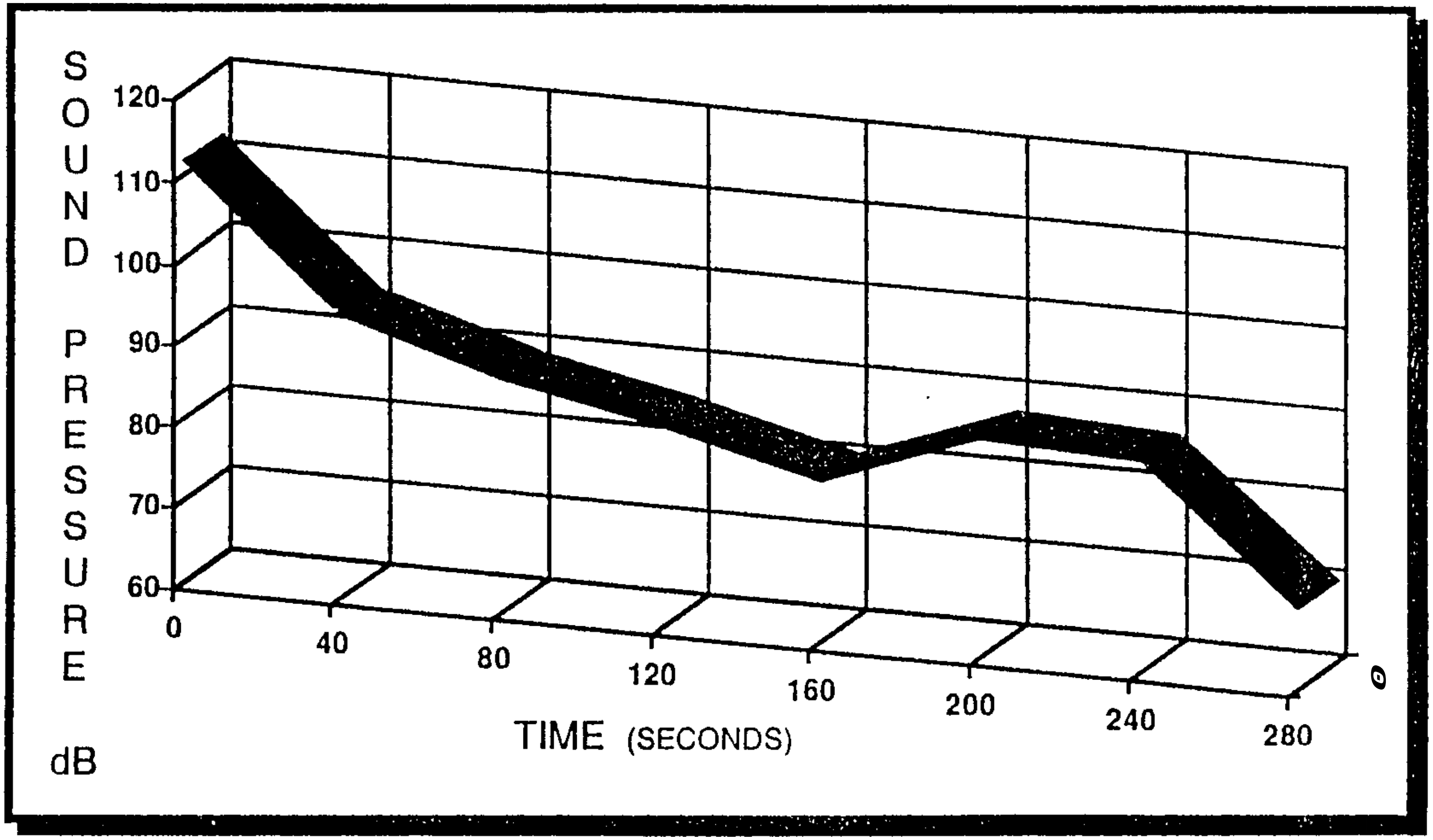
The Occupational Safety and Health Standard for Occupational Noise Exposure, 1910.59, defines permissible noise exposure for the workplace. The allowable limits can be found in Table G-16 and G-16A of the standard. OSHA recommends a 90 dB TWA with a peak dB of 140.

Although both INERGEN and Halon would comply with this requirement, comparatively halon displays a peak sound pressure 24 times the intensity of INERGEN for a period seven times longer.

PHYSIOLOGY SUMMARY OF INERGEN

As with all total flooding fire extinguishing agents, it is recommended that personnel evacuate the space as soon as a fire is detected. In addition rapid response detectors, warning alarms, sirens, and horns are used to prompt rapid evacuation, and a short time delay prior to system release provides sufficient evacuation time. With these standard precautions, exposure to the hypoxic atmosphere created by INERGEN will not normally occur. Hov ver, consideration must be given to situations in vhich an individual cannot or chooses not to evacuate.

INERGEN™ Discharge - Sound Pressure Level



Noise Comparison

	Inergen™	HALON
Peak Level (db)	117.9	130.0
Allowable Exp (Hrs.)	0 19	0 031
Peak Sound Pressure Duration (Seconds)	3.0	21 0
Peak Sound Pressure As % of Discharge Time	1.1%	100.0%

The components of INERGEX are non-toxic. The carbon dioxide content of the atmosphere created by INERGEN has a well documented beneficial physiological effect, stimulating respiration and enhancing the efficiency of oxygen transfer from the atmosphere to the blood stream ana to the brain. Nitrogen and argon are physiologically inert at normal atmospheric pressures. The sustained breathability of the extinguishing atmosphere created by INERGEN is directly related to the degree of hypoxia (decreased oxygen) and hypercapnia (increased carbon dioxide).

A distinction should be made between the physiologic effects of INERGEN use and the effects of fire, heat, or toxins in smoke produced by combustion. The duration of safe tolerance to the toxic products of combustion will be much less than the physiologic tolerance to the non-toxic component gases of INERGEN. In the event of unavoidable delay in evacuation, the physiologic tolerance to INERGEN extinguishing atmospheres greatly enhances the prcspects of human survival without residual effect.

With this background, it is appropriate to examine the following:

+ The physiologic effect of the INERGEN extinguishing atmosphere on "normal" individuals.
+ The physiologic effect of the INERGEN extinguishing atmosphere on individuals with cardiovascular or pulmonary impairments.

- H po͏xia -

  Low Oxygen

- Hypercapnia -

  High CO_2

Effects On
"Normal" Individuals

Effects On
"Impaired" Individuals

TEE INERGEN EXTINGUISHING ATMOSPHERE

The concentration of oxygen necessary to support combustion is dependent on the fuel. Data is available on a wide range of Class B fuels. With the exception of those fuels which provide their own oxygen, extinguishment typically occurs below 14-15): oxygen. This has been the basis for the successful use of carbon dioxide systems for many years. Class A and Class B testing vith INERGEN has shown the typical INERGEN design extinguishing atmosphere to be 12.5-14.0% oxygen and corresponding carbon dioxide levels of 3.5-4.0%.

PHYSIOLOGIC EFFECT ON "NORMAL" INDIVIDUALS

A significant body of scientific study exists concerning the concurrent exposure to lowered inspired levels of oxygen and increased inspired levels of carbon dioxide. All of the referenced data is based on direct measurements in human subjects.

Small degrees of hypoxia (low oxygen) and hypercapnia (high carbon dioxide) can be tolerated for several days without detectable adverse effect. Extremely lov levels of oxygen or extremely high levels of carbon dioxide can be tolerated for less than a minute. In betveen these extremes are degrees of combined hypoxia and hypercapnia which are advantageous to the safety of occupants for durations necessary in fire protection applications.

INERGEN™ *Atmosphere*

Oxygen .... 12.5 - 14.0%

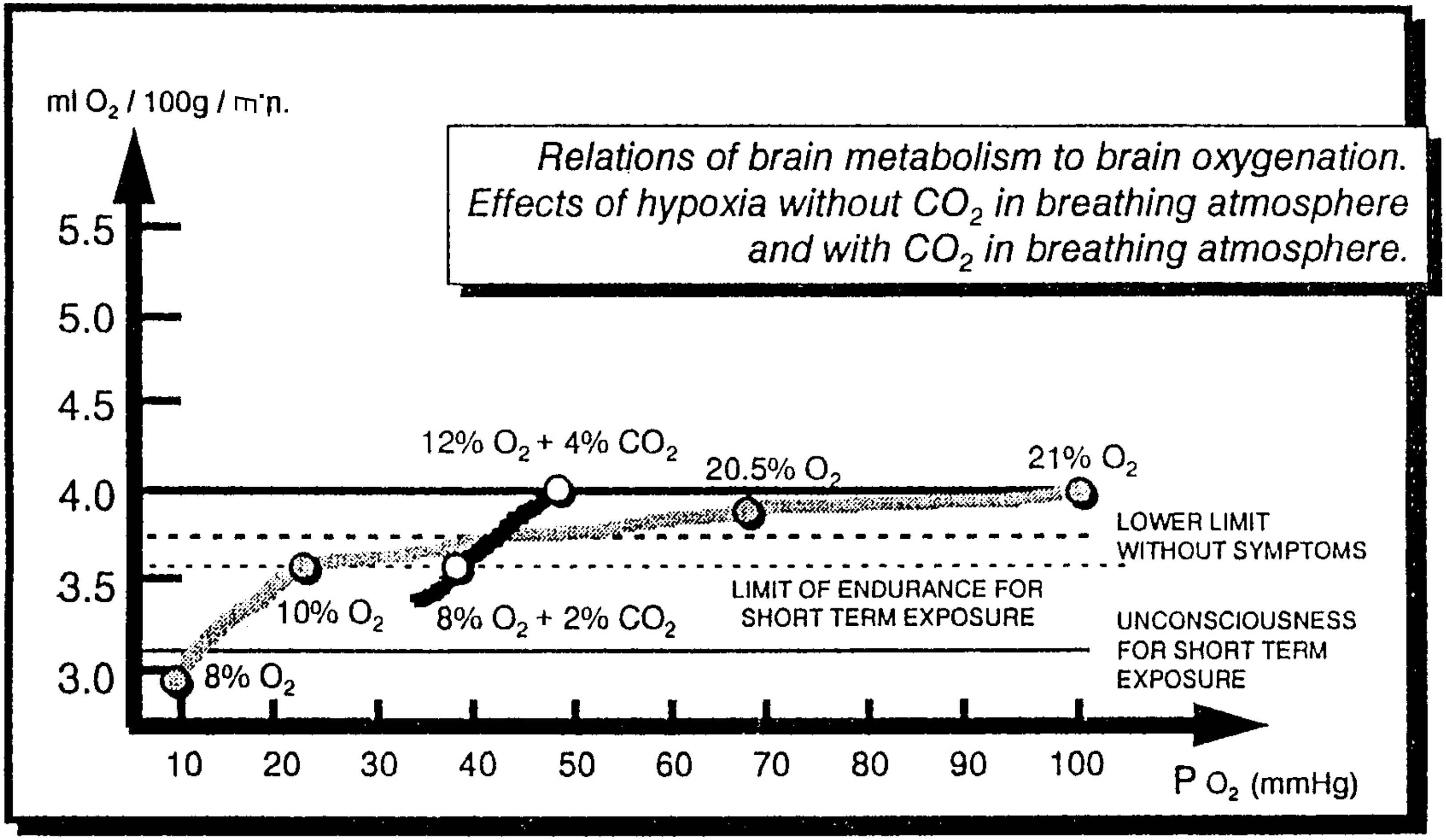
Carbon Dioxide ..... 3.5 - 4.0%

Over the range of oxygen reduction to be encountered in fire extinguishment the tolerance of normal individuals to hypoxia is improved by simultaneous exposure to increased carbon dioxide levels. Carbon dioxide increases brain blood flow and oxygenation at all levels of inspired oxygen. The rate of oxygen consumption by the brain at 12% oxygen and 4% carbon dioxide is the same as the consumption in normal air containing 21% oxygen. Because of the constant ratio of carbon dioxide to inert gases in INERGEN, there tends to be an automatic adjustment toward increased levels of carbon dioxide as oxygen levels are reduced through the application of increasing amounts of INERGEN. This is clearly physiologically appropriate.

PEXSIOLOGIC EFFECTS ON INDIVIDUALS VITH IHPAIRHENTS

Specific experiments have not been conducted concerning tolerance of individuals having heart or lung abnormalities to INERGEN or to any other extinguishing agent, nor are they likely to be performed. It is therefore necessary to obtain practical clinical judgement concerning situations of risk for such impaired individuals in the workplace. Such an evaluation has been conducted by clinical and research specialists at the University of Pennsylvania Hedical Center, and has been peer reviewed for the EPA by specialists at the University of Rochester Hedical Center, the National Institute of Health, and Temple University Hedical Center. All of the reviews have been favorable.

INERGEN™ Health Effects



For individuals with abnormalities of heart, circulation or lung, only their prompt exit from space involved in fire and extinguishment is considered rational. If assistance is not normally required, it is unlikely to be needed as a specific consequence of INERGEN flooding . The time course for changes of oxygen and carbon dioxide levels within the individual are in the order of several minutes. The full degree and effect of long duration exposure to hypoxia will not occur vithin the first several minutes after the first breath of a low oxygen atmosphere. Therefore, physiologic changes should not interfere with an exit procedure, even for an individual with circulatory or pulmonary impairment.

Specific relevant clinical abnormalities considered include:

- Coronary vascular disease.
- Cardiac decompensation.
- Cardiac arrhythmia.
- Prior stroke.
- Pulmonary emphysema.

For the above conditions, review by scientists of the Environmental Biomedical Research Data Center at the University of Pennsylvania concludes that persons handicapped by degrees of cardiac or pulmonary abnormality not limiting capability for normal entry and exit should be able to exit during INERGEN flooding, with any transient exposure completely reversing itself on exposure to the external atmosphere.

U.S. EPA SNAPS PROGRAM

Based on the physiologic dara presented for INERGEN and the resulting peer review, EPA has accepted INERGEN for use in occupied and non-occupied spaces, and for inerting.

CONCLUSION

INERGEN is a unique extinguishing agent that is completely environmentally friendly. It has effectiveness on both Class A and Class B fires, it does not form toxic or corrosive decomposition products, it does not create obscuration and it leaves no residue. INERGEN can be used in an engineered system with readily available equipment, and is accepted for occupied spaces by the U.S. EPA.