

CO and The Garage Connection

Stephen Klossner

ACT

s.klossner@att.net

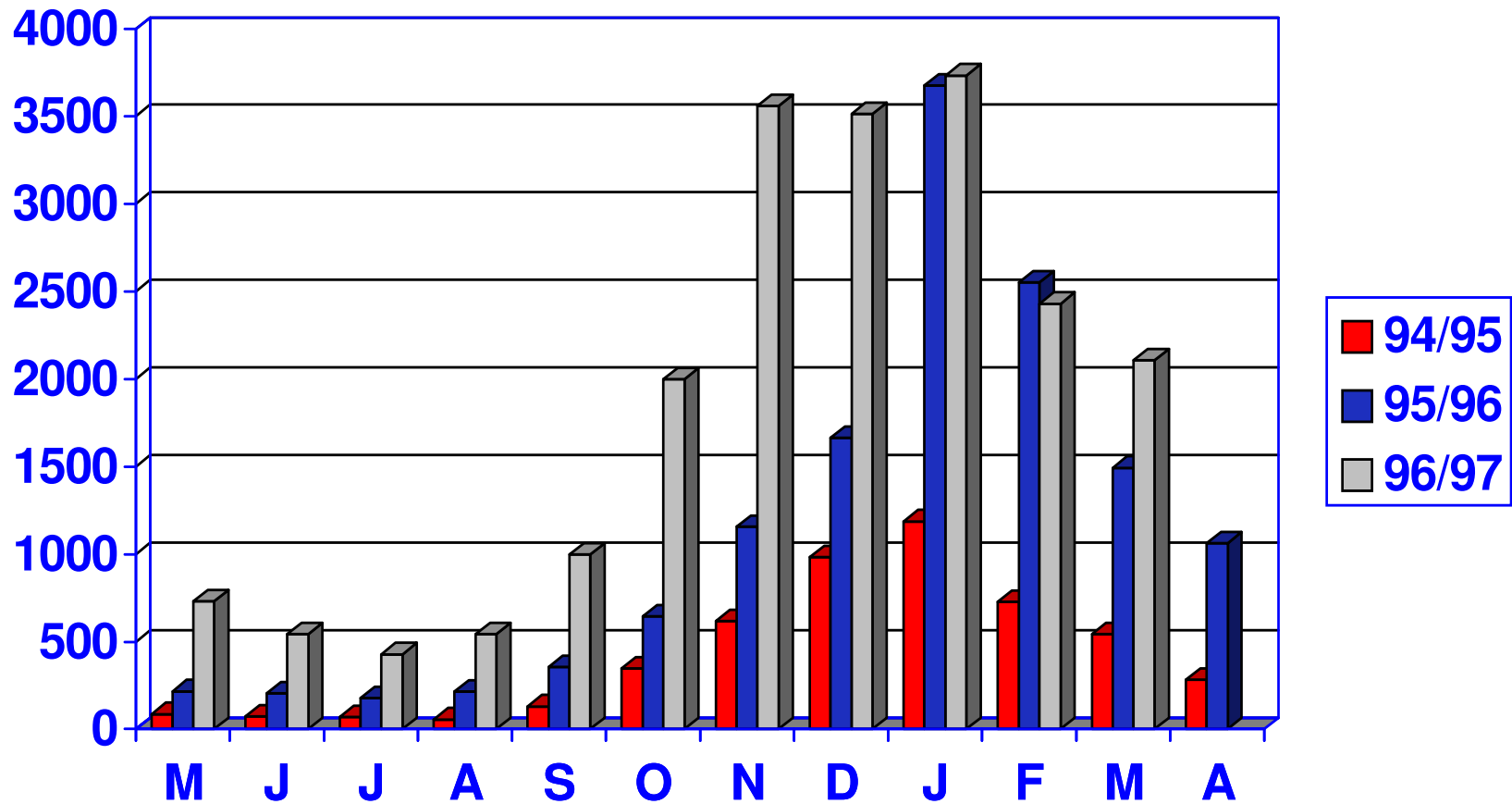
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Attached Garages - IAQ issues

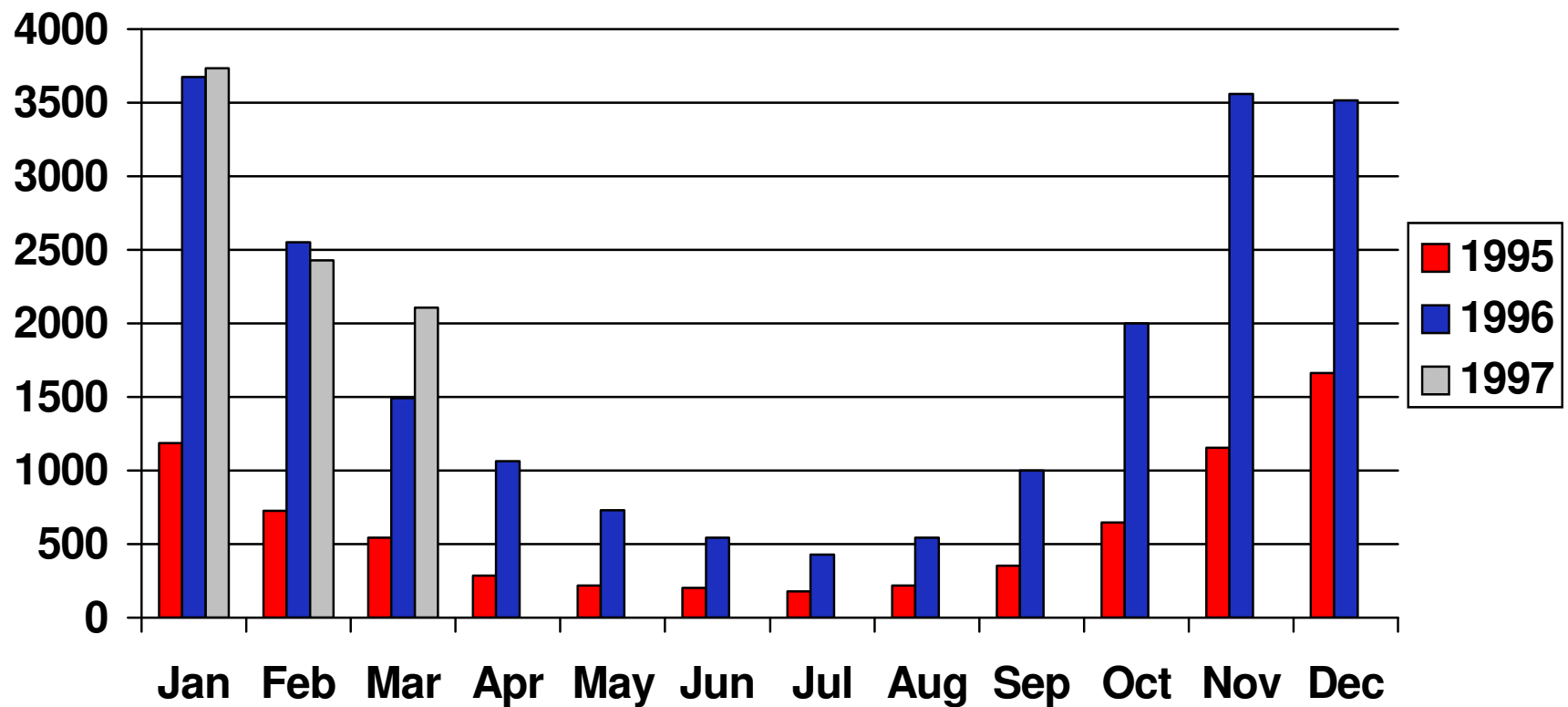
- **CO**
 - Car exhaust
 - Combustion appliances
- **Benzene**
 - Gasoline storage
 - Car start/stops
 - Small engines
- **Other stuff ???**



CO Response May to April



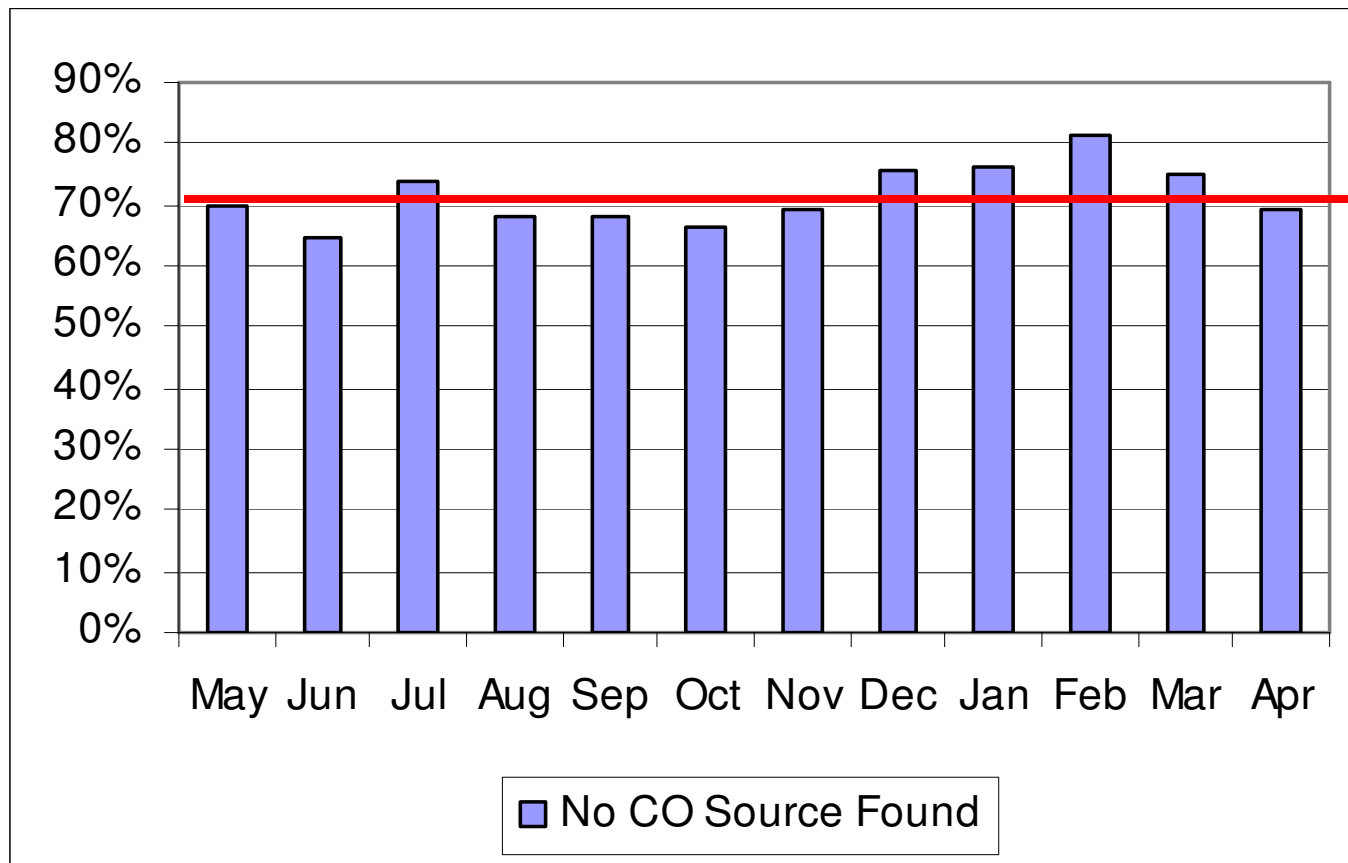
CO Response By Month January to January



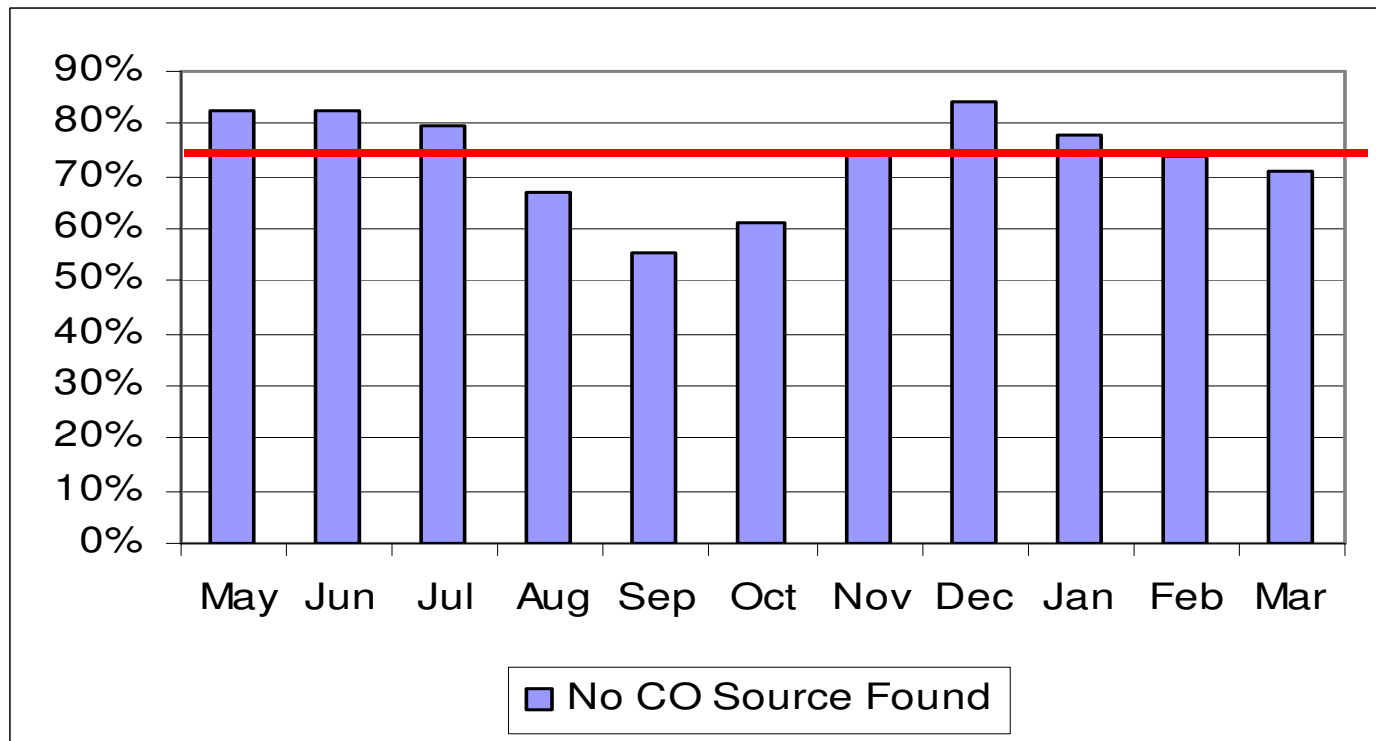
More Detail: Response Data

- Response By Month And Heating Season
- Responses Where No CO Was Found

CO Response May 94 to April 95 Percentages



CO Response May 96 to April 97



Designing A Study

- What Did We Want To Learn?
 - Were these calls false alarms?
 - What were the sources of CO?
 - Why couldn't we find it?

Developing A Protocol

- Carbon Monoxide Investigation Protocol

Carbon Monoxide Investigations

- House Testing to be included;
 - Calibrated blower door test
 - Series leakage, house to garage
 - Pressure measurements in mechanical room
 - Vent pressure measurements under ambient and induced pressures
 - Depressurization from exhaust appliances
 - Depressurization from fireplaces
 - Pressures caused by air handling equipment

Carbon Monoxide Investigations

- Carbon monoxide was tested in the following appliances;
 - Furnaces and boilers (under draft and backdraft)
 - Water heaters (under draft and backdraft)
 - Gas dryers
 - Gas ovens
 - Space heaters
 - Attached garages (if cold vehicle was present)

Carbon Monoxide Investigations

- 50 Homes included in this study
- Homes included in study had 2, or more, carbon monoxide responses from Utility
- Homes were a cross section of ages
- Homes were tested in heating season only
- Carbon monoxide was measured at start of testing

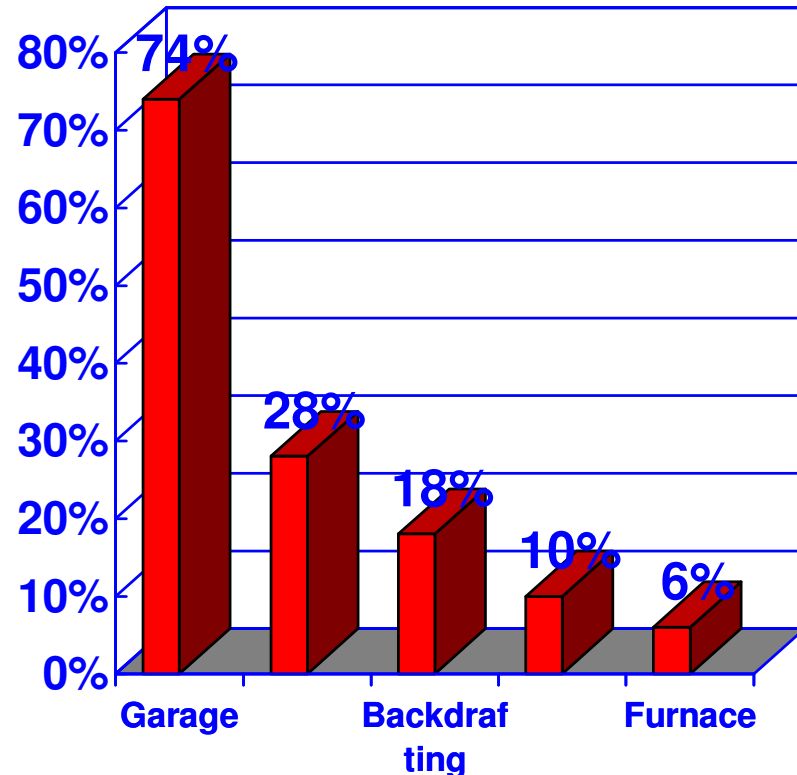
The Top Three

- Automobile Exhaust Infiltration
- Gas Ovens
- Backdrafting

Carbon Monoxide Investigations

Potential source of detector alarm.

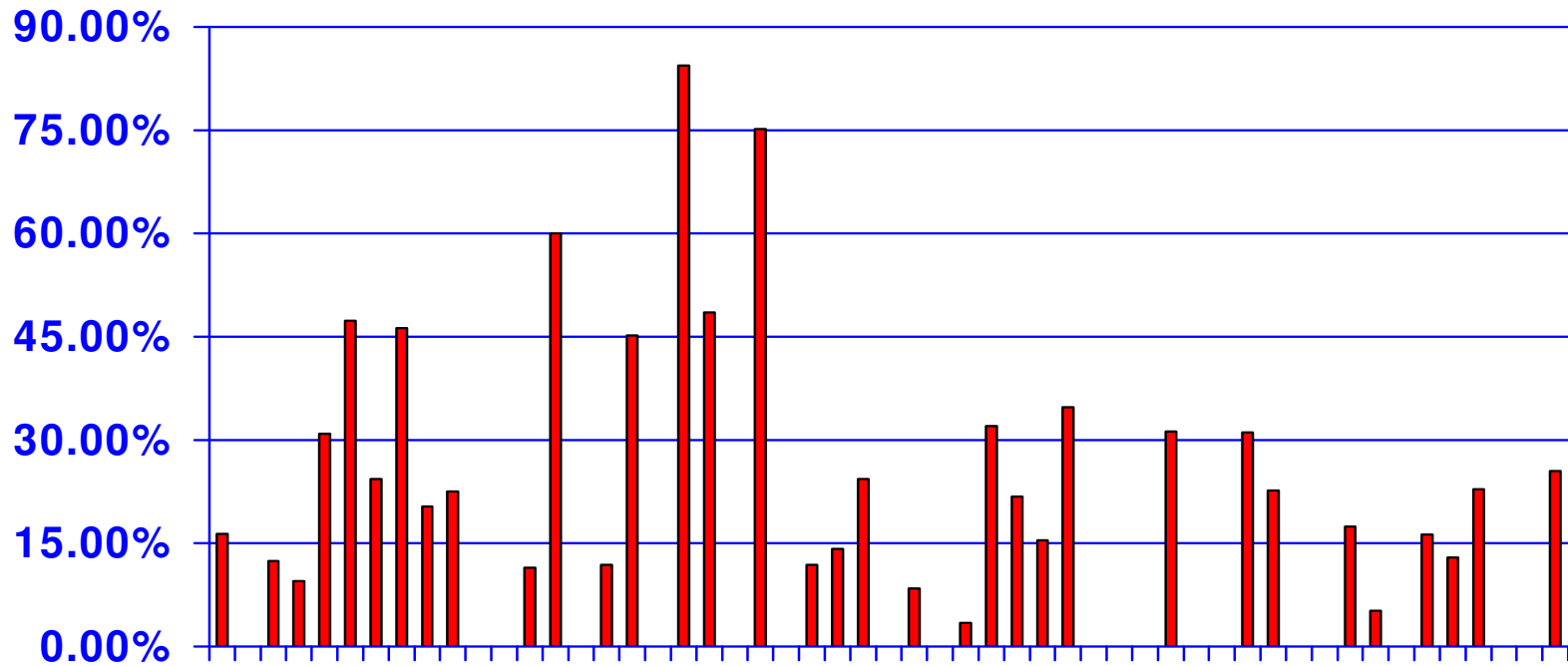
- # 1 is garage (74%)
- # 2 is cooking (28%)
- # 3 is backdrafting (18%)
- # 4 is other sources (6%)
- # 5 is furnaces producing high levels of CO (6%)



The Garage Connection

- Primary Source In 74% Of The Homes
- Large Leakage Rates Documented
 - Garage to house leakage ranged from 124cfm to over 2000cfm
 - Up to 80% of total air leakage into the house (average of 24%)

Measured Leakage from Attached Garages



Attached Garage



Attached Garage



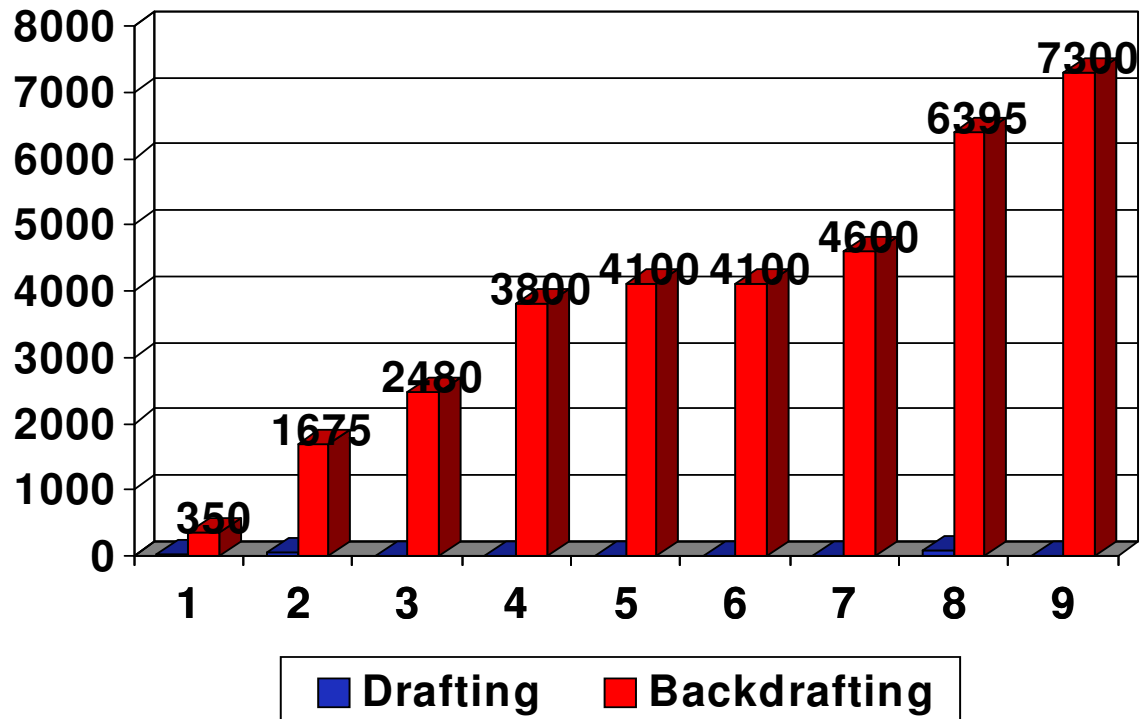
The Garage Connection

- **Remediation Is A Challenge**
- **Sealing the garage wall effectively is difficult**
- **May cause problems in the house due to loss of make-up air????**
- **Ventilation of the garage may work, if done properly**
 - **May cause backdrafting of combustion equipment if done improperly!!**

Backdrafting

- Identified As A Potential Source In 18% Of The Homes
- Induced Mechanically In The Study
- Can Occur Due To A Variety Of Interactions
 - Exhaust equipment
 - Lack of make-up air
- Any Combustion Appliance Should Be Inspected Annually

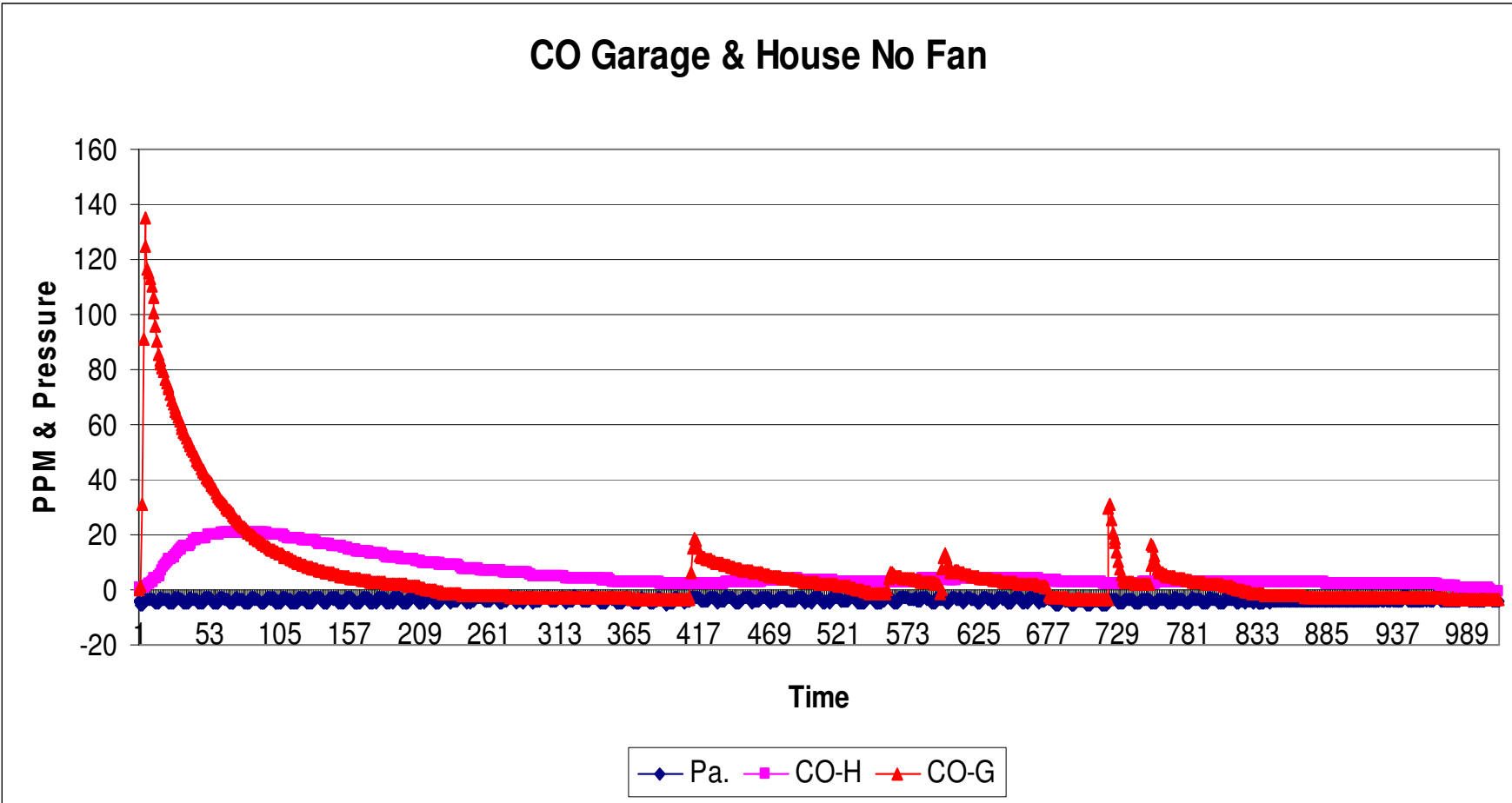
Carbon Monoxide during backdrafting (PPM)



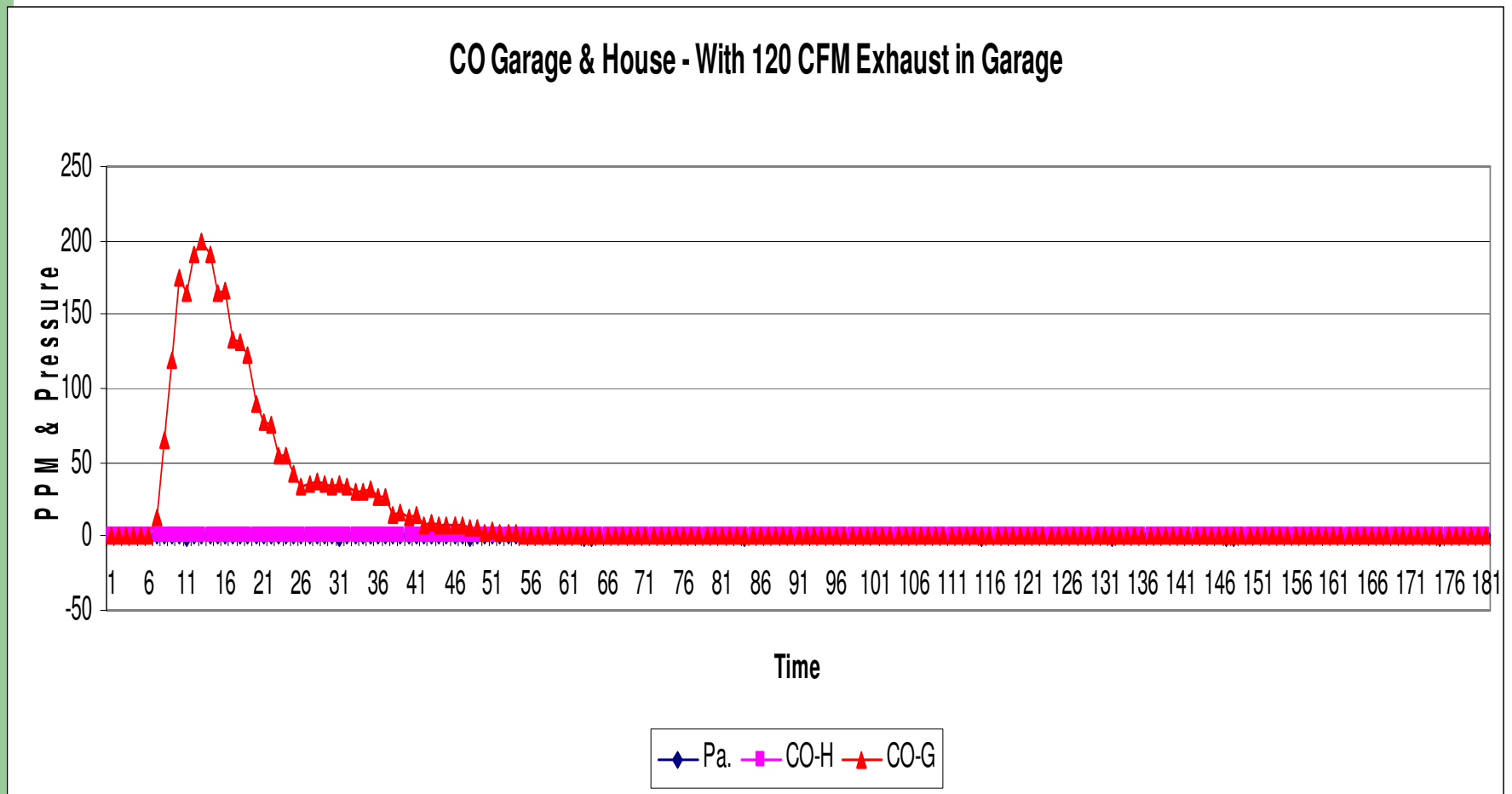
Carbon Monoxide Investigations Data Logging of Homes

- Homes were data logged for:
 - Carbon monoxide (2 locations)
 - Carbon dioxide
 - Temperature
 - Sound
 - Appliance operation (up to 4 appliances)
 - Pressures (2 locations)

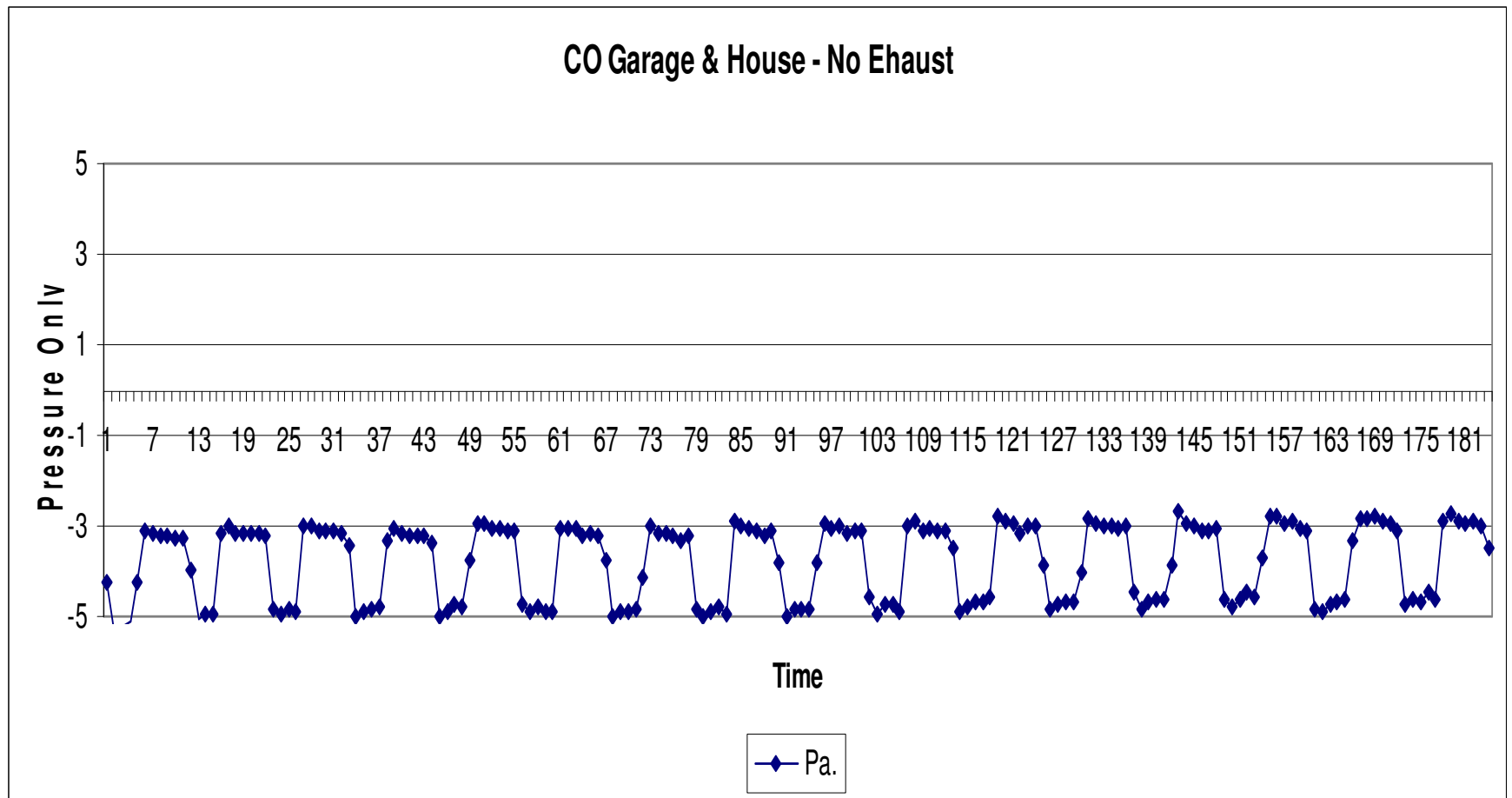
A Typical CO Event



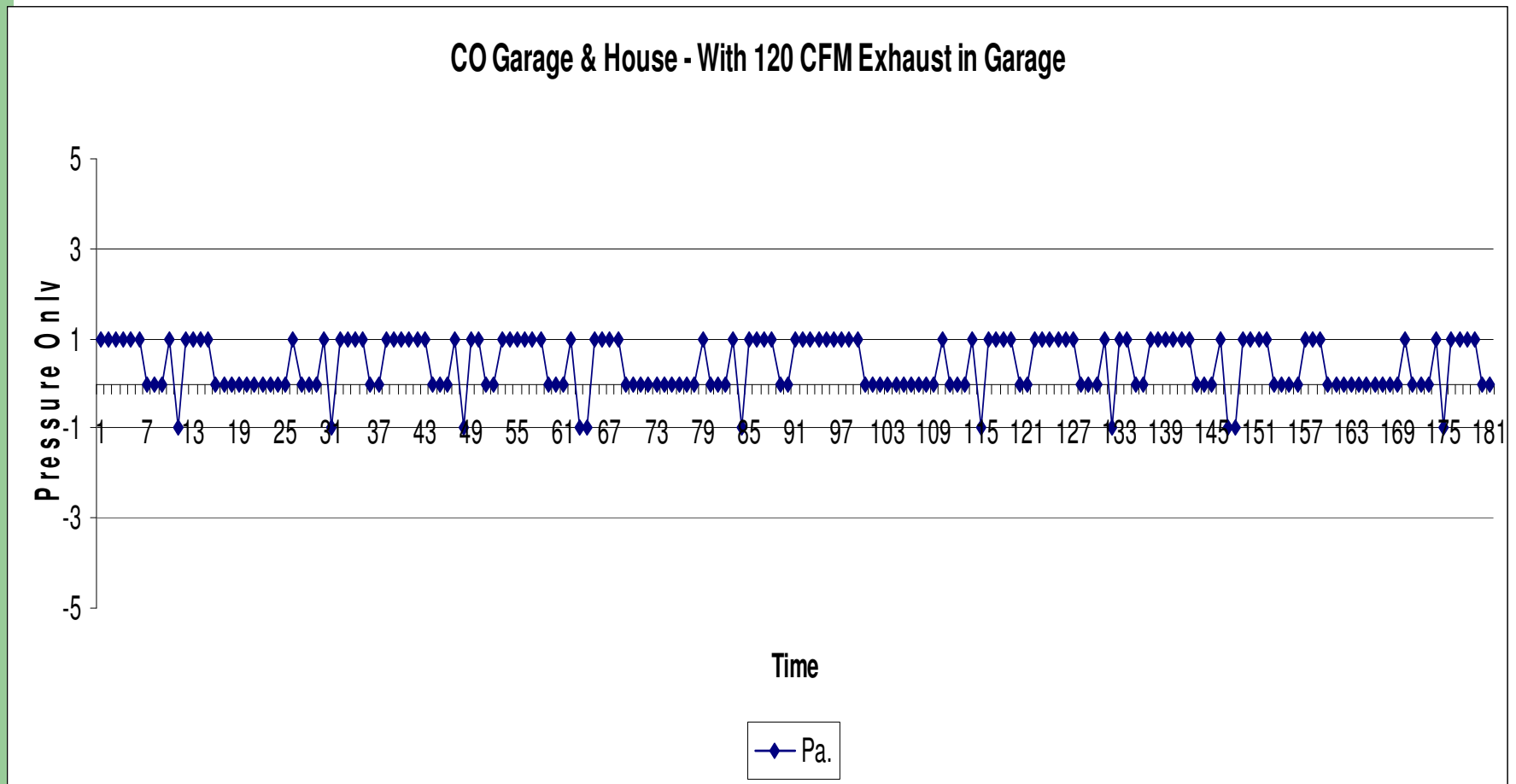
A Typical CO Event “With Exhaust fan”



Closer Look at Pressures



Closer Look at Pressures



Misc. Issues

- Remedial efforts
 - CO during backdrafting
 - Proper adjustment & maintenance
 - **ALL COMBUSTION EQUIPMENT**
 - Building & mechanical code implications
 - make-up air
 - garage wall
 - air handling design
- Central Vacuums
- Townhomes/Twin home

What we do to a house helps/hurts

- Changes to the house influence the garage connection
 - Tightening the house
 - Adding continuous exhaust ventilation
 - Sealing versus pressure reductions
 - Who should test
 - What to test
 - Process and levels of concern

Conclusions

- CO diagnostics are highly complex
- Detectors seem to be reacting to CO
- Other studies indicate 80% of calls undiagnosed
 - Are garages the missing 80%?
- There is a lot left to learn on these issues!

Questions?

- Thanks!