HALON 1301 AND GASEOUS DETONATIONS

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ABSTRACT

Halon 1301 has been used as a fire extinguisher for many years.However,its role on gaseous detonations has been less considered although detonations induce important damages for people and properties when such events occur.

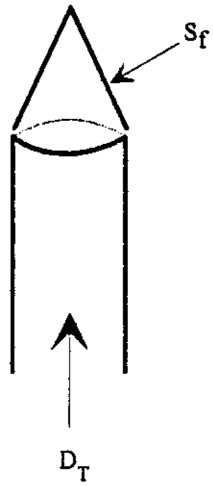
It has been established that the influence of flame inhibitors is also visible on gaseous detonations.The action of those compounds on detonation velocity is quite small, but their presence in the original mixture modify to a large extent the stucture of the detonation waves and play an important role on their behavior at the Limits, allowing to stop the propagation of those phenomena

The actual action of the inhibitor is depending on the nature of the fuel (hydrogen,carbon monoxide,methane,acetylene,...) as well as the chemical composition of the additive.

The value of some fluorocarbon compounds and halon 1301 will be compared and discussed.

INHIBITION PARAMETER ϕ FOR PREMIXED LAMINAR FLAMES

] Velocity



$$V_o = \frac{D_T}{S_f}$$

D_T : Total flow
S_f : Flame Surface

$$\phi = \frac{V_o - V_i}{V_o} \cdot \frac{[O_2]}{[I_n]}$$

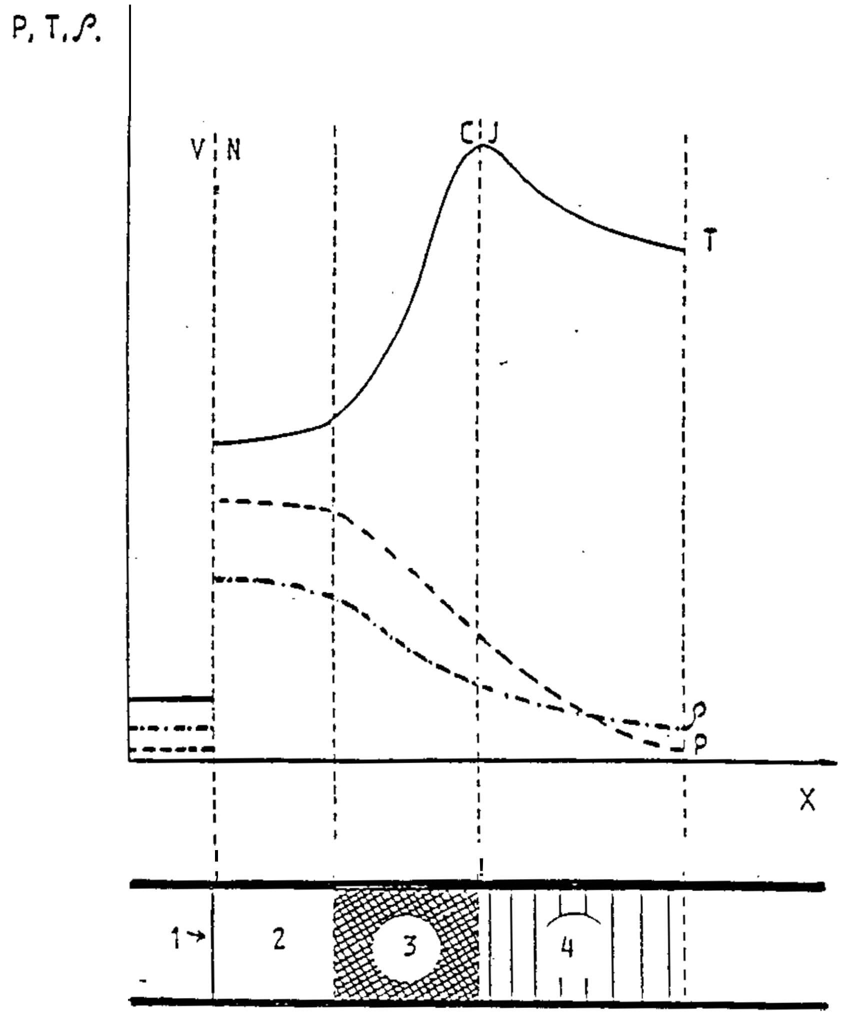
with V_o burning velocity of the uninhibited flame

V_i burning velocity of the inhibited flame

$[O_2]$, $[I_n]$ concentration of oxygen and inhibitor in fresh gases mixture.

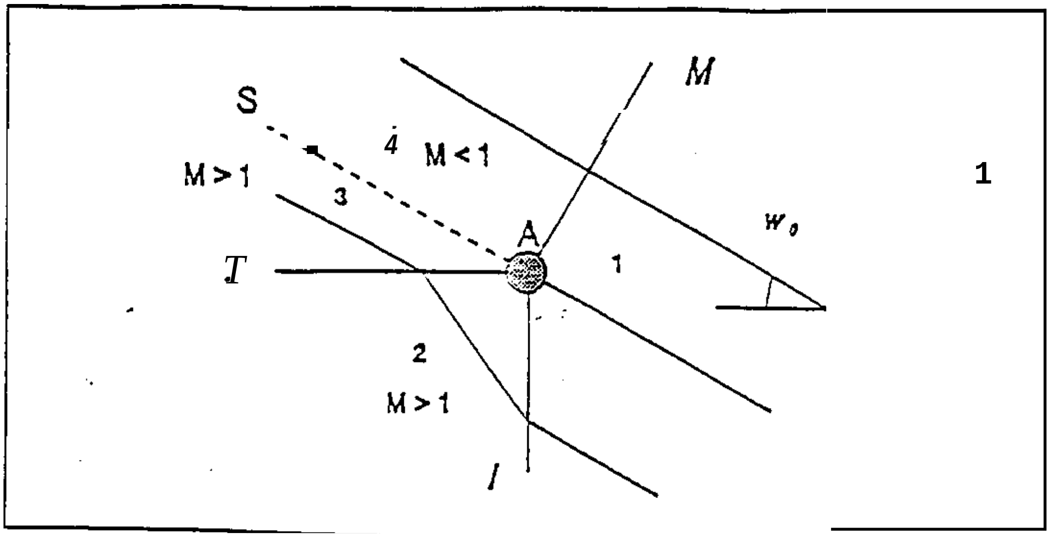
Inhibitor efficiency

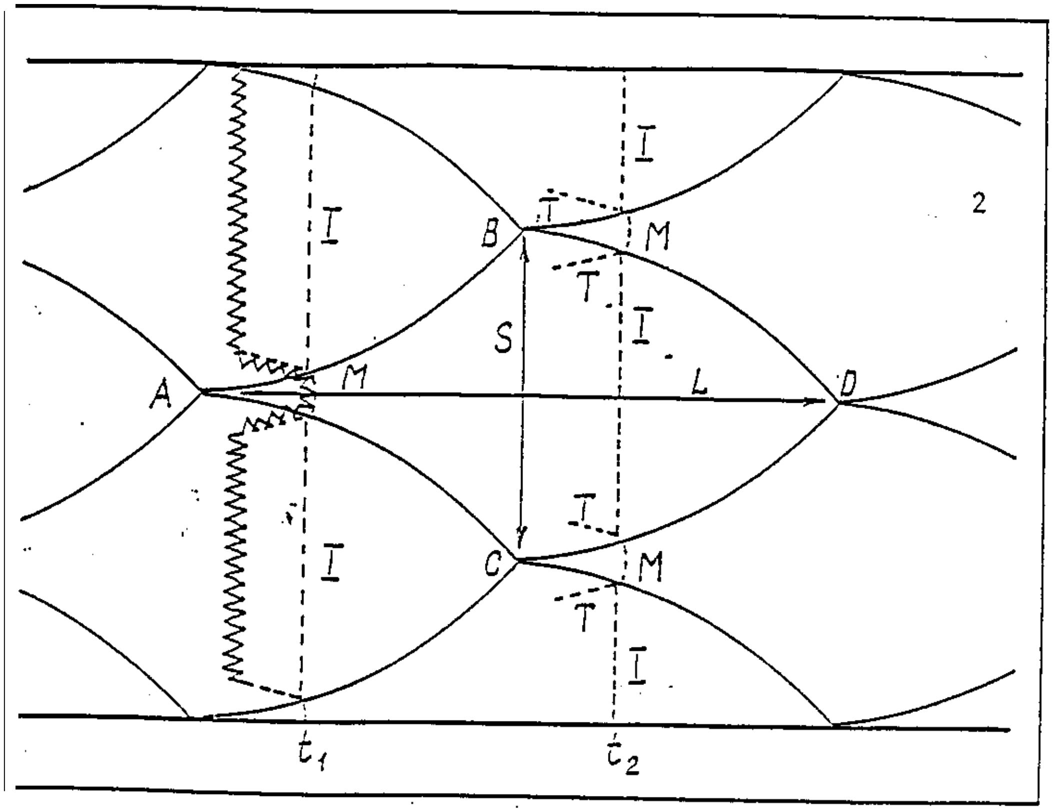
$CF_3Br > CFCl_3 > CF_2Cl_2 > CF_3Cl > CF_3H > CF_4$



1. Shock Wave
2. Ignition Zone
3. Reaction Zone
4. Expansion Wave

One-dimensional steady detonation
Z.N.D. Model
Pressure- Temperature- and Density profiles behind the leading shock
V.N. von Neuman spike C.J. **Chapman-Jouguet plane**





Multidimensional detonation

1. Interaction of triple shock configurations

A Triple point ; **T** : Reflected shock; **M** : Mach stem shock ;
S : Slipstream line; **I** : Incident shock

2. Triple point trajectories in a detonation wave

t_1, t_2 : detonation **wave** at ***two*** **time** intervals
ABCD detonation cell
L cell length and **S** cell **width**
I, **M** and **T** : incident, Mach **and** reflected shocks
Broken line **is the** reaction (hex release) **zone.**

- Experimental Conditions

Cross-section of Detonation Tube : **3.2** cm x 9.2 cm.

Detonation initiated by a shock through a diaphragm

Detonation Tube length : 11 m.

Variable Mixture Composition.

- Measured quantities

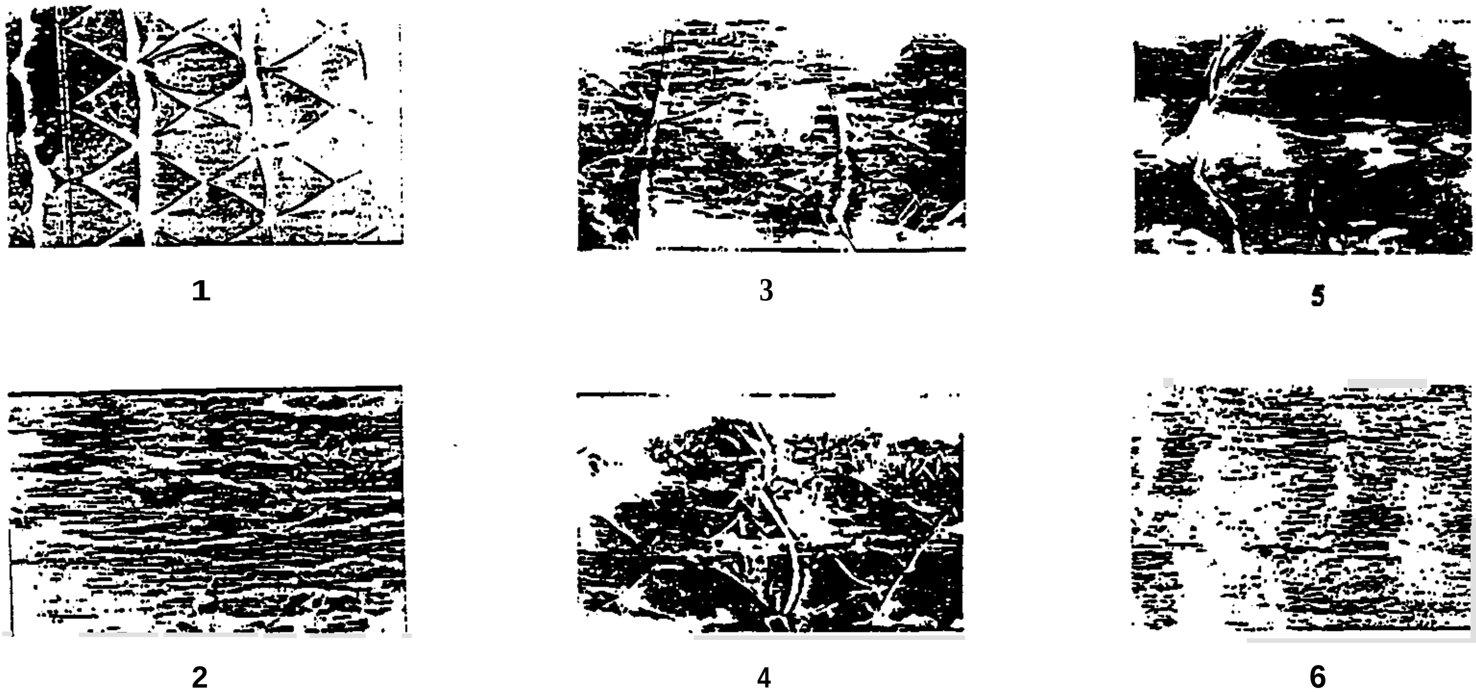
D = Detonation velocity (m/s)

L = Cell length (cm)

- Deduced Parameters

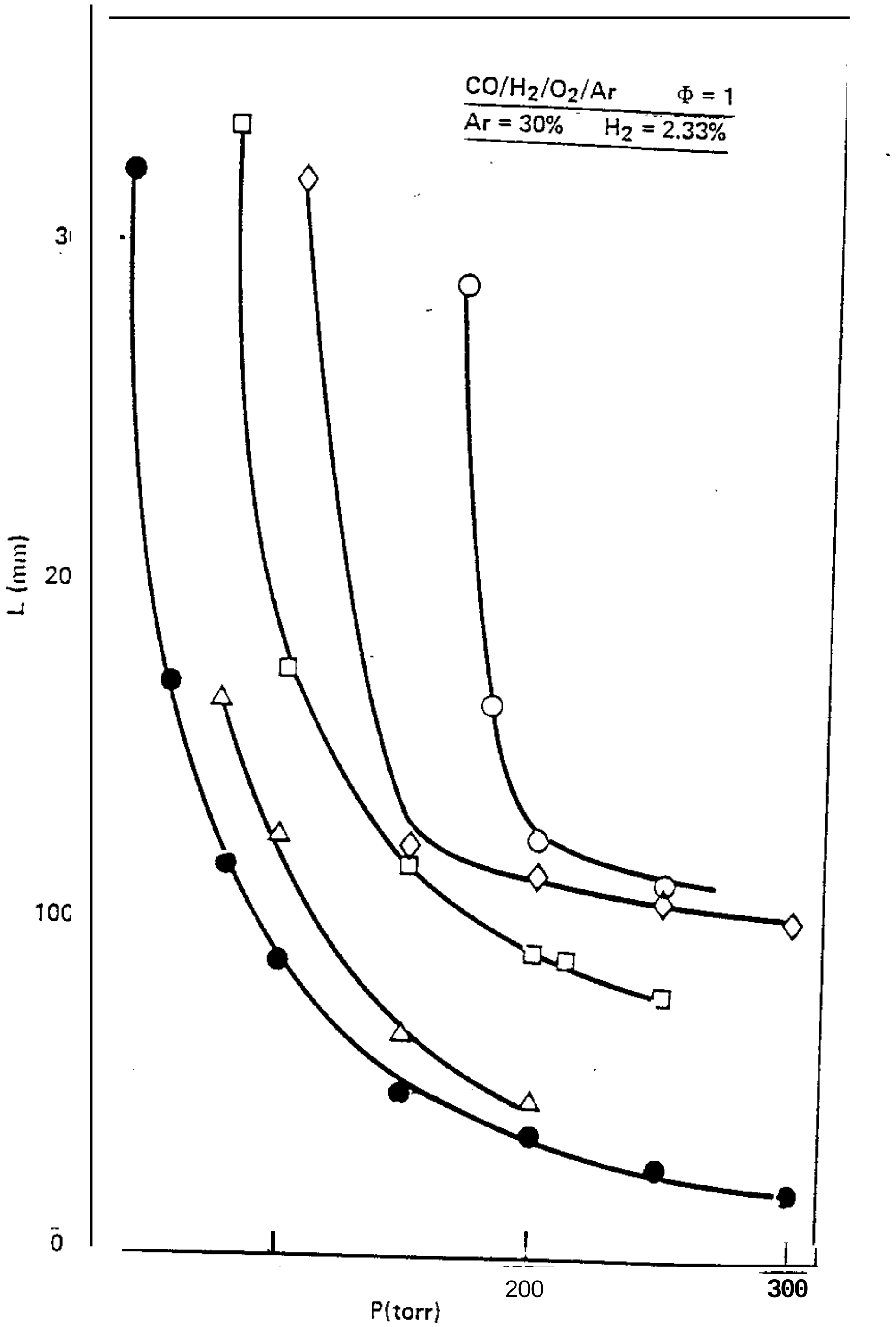
$$t_{car} = \frac{L}{D} \text{ and } t_{car} = cst.\, t_{ind}$$

t_{car} : characteristic time; t_{ind} : induction time



Experimental soot records
for **a** 44.3 CO/2.3 H_2/23.3 O_2/30.0 Ar mixture
at initial pressure 150 Torr

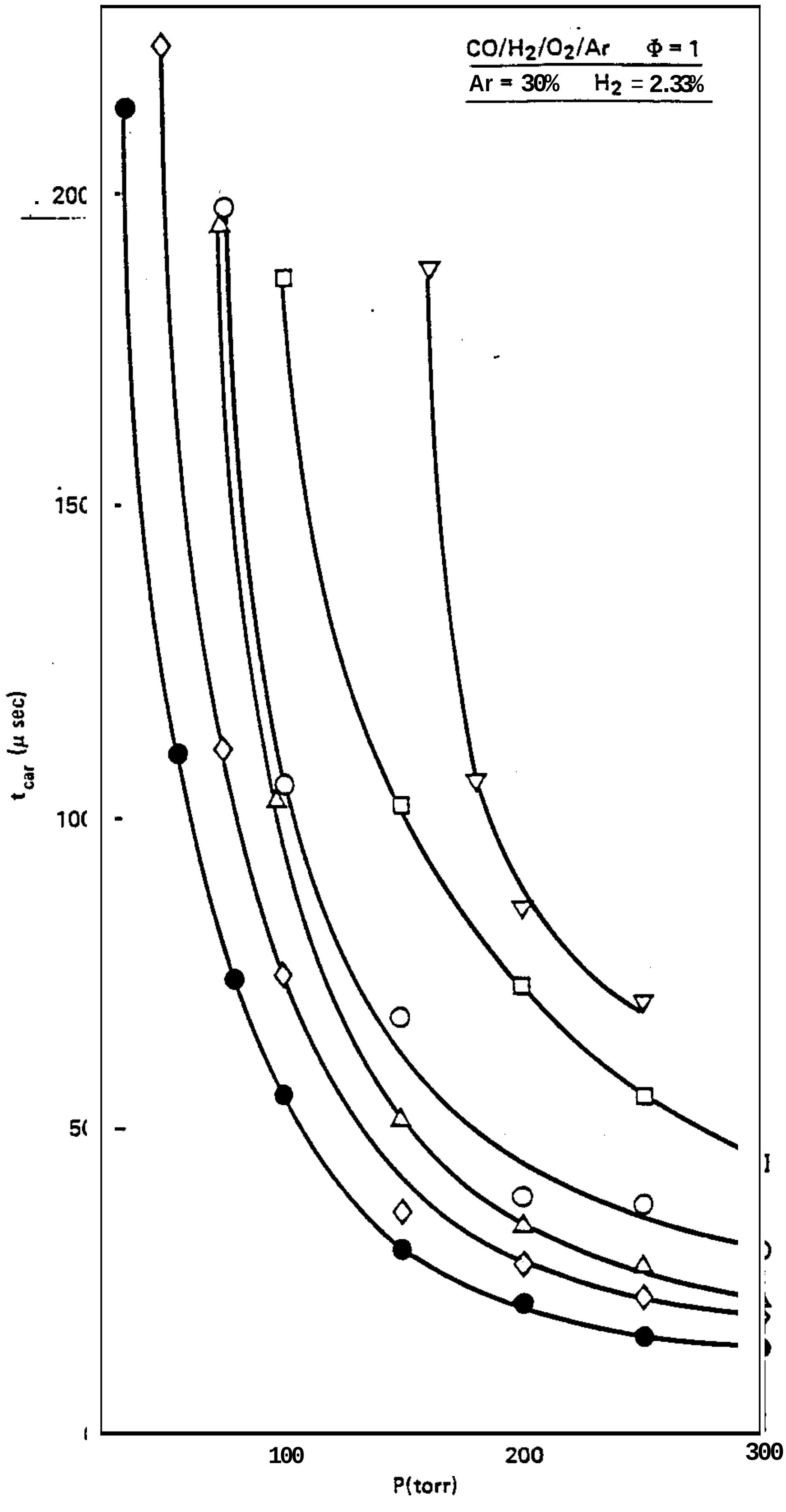
PHOTO	% CF_3Br	Mode
1	0.00	7
2	0.47	5
43.	0.93	4
	1.40	3
5	1.87	2
6	2.33	shock



Detonation Cell Length vs. Pressure

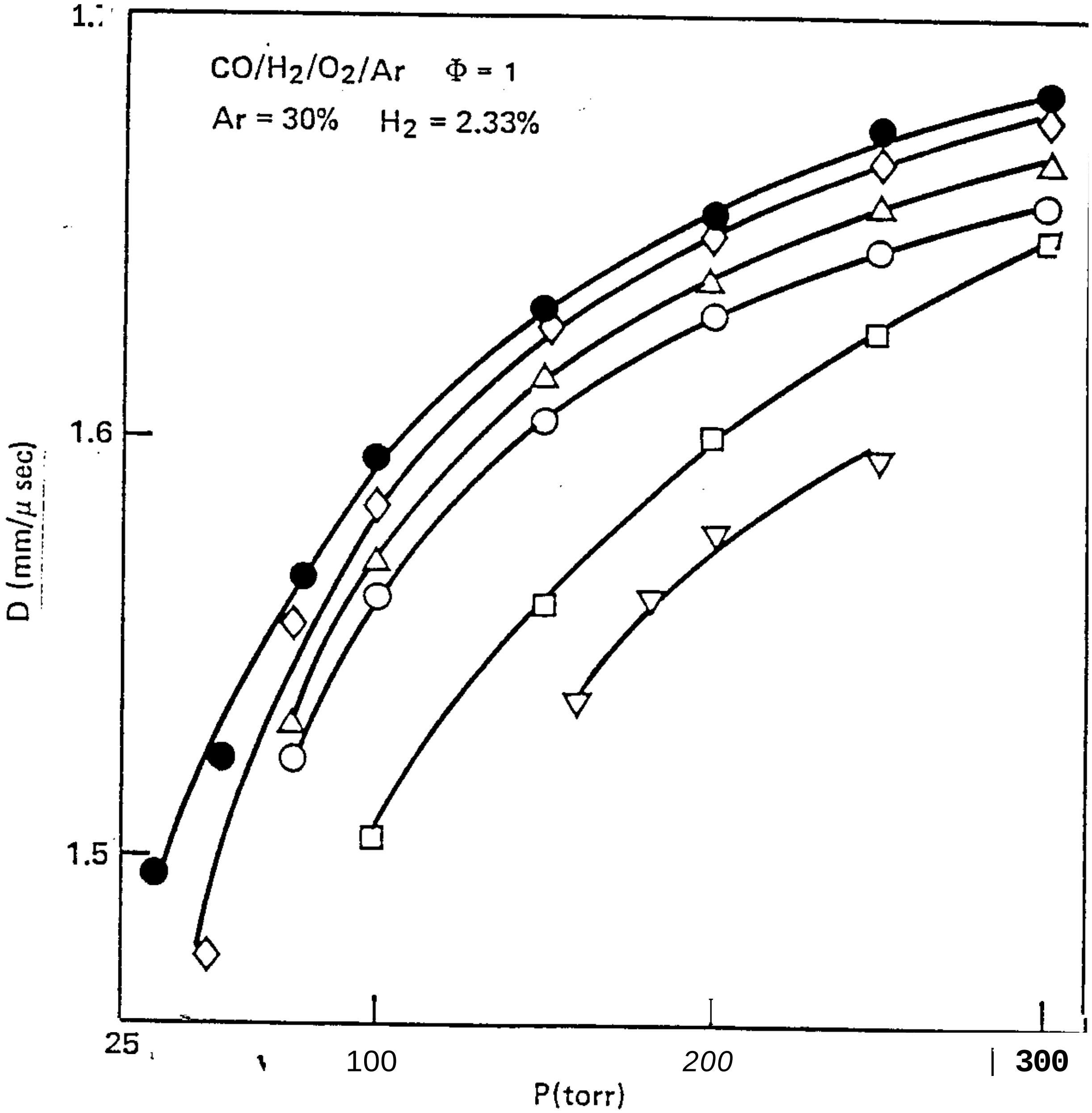
● no inhibitor; A CF_3Cl

☐ CF_2Cl_2; ◊ $CFCl_3$; O CF_3Br



Characteristic Time vs. Pressure
at variable CF_3Br percentage

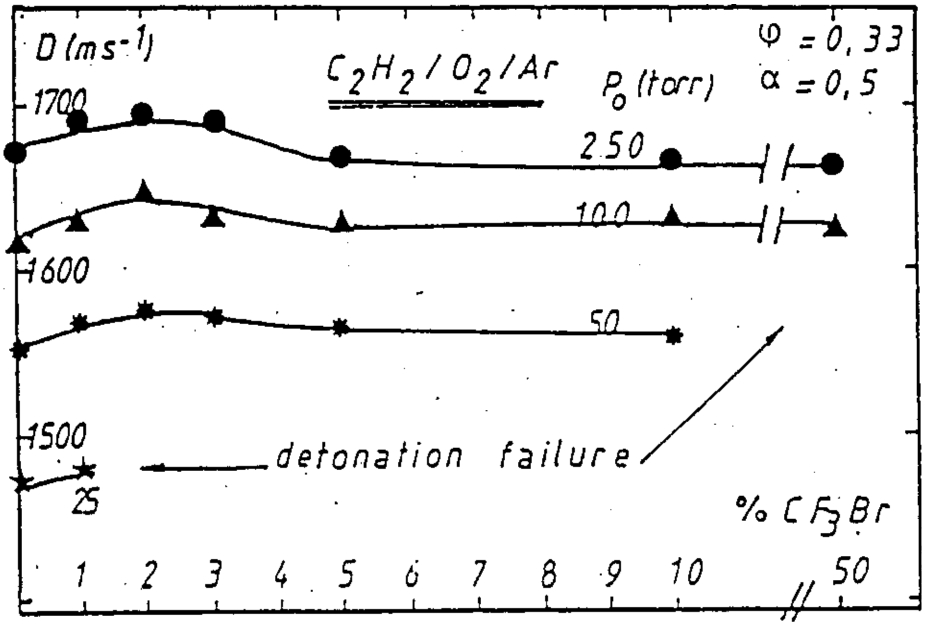
• no CF_3Br; 0 0.47; **A** 0.93
O 1.40; □ 1.87; V 2.33



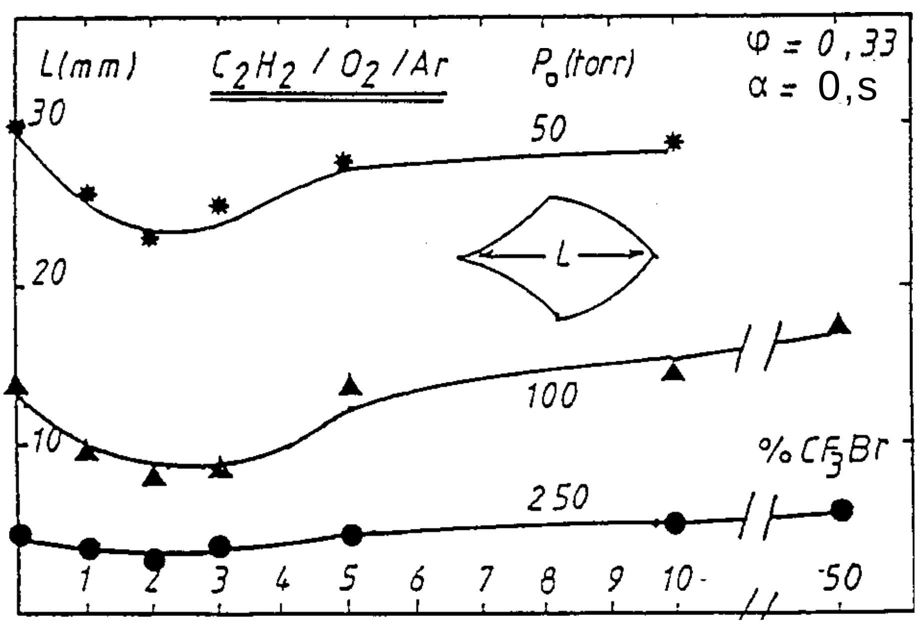
Detonation Velocity vs. Pressure
at variable CF_3Br percentage

• no CF_3Br; ◊ 0.47; **A** 0.93;
O 1.40; □ 1.87; V2.33

a



b



CF3Br-Inhibition in Acetylen-Oxygen Detonations

a. Detonation velocity (D) **vs.** CF_3Br percentage w.r.t. Fuel
b. Cell lenght (L) vs. CF_3Br percentage w.r.t. Fuel
Curves at variable **initial** pressure P_0

Induction time

Induction time is the time required to reach a critical concentration in radical intermediates. It is related to the chemical kinetics of chain branched mechanism for oxidation.

a. with chain branching reaction:

$$\dot{H} + O_2 \rightarrow \dot{O}H + \ddot{O} \qquad (1)$$

$$[\text{Radical}], r \approx cst \,.\, e^{k_1[O_2]t_{ind}}$$

or

$$k_1[O_2]t_{ind} \approx cst$$

b. with chain terminating processes:

$$\dot{H} + CF_3Br \rightarrow \dot{C}F_3 + HBr \qquad (2)$$

$$H + HBr \rightarrow Br + H_2 \qquad (3)$$

$$\{k_1[O_2] - k_2[CF_3Br]\}t_{ind} = cst$$

CONCLUSIONS

The inhibitors increase t_{ind} , t_{car} , L delaying the reaction zone from the leading shock(s). They interfere thus with the sustainance mechanism of a detonation wave. Halon 1301 is the most efficient of the fluorocarbons.