Simulation of Dry Bay Discharge of Alternative Agents[1]

J.C. Yang[2], T.G. Cleary, and **W.L.** Grosshandler

Building and Fire Research Laboratory
National Institute of Standards and Technology
Gairhersburg, MD 20899 U.S.A.

ABSTRACT

As a continuation of the USAF/Navy/Army/FAA sponsored halon replacement project, the discharge characteristics of the three selected alternative agents (CF_3I, FC-218, and HFC-125) for dry bay applications will be further evaluated. Halon **1301** will also be included in the study for the purpose of comparison.

The experimental set-up involves a pressure vessel in which a fixed amount of agent is placed. The vessel is pressurized with nitrogen to a specified charge pressure. To simulate dry bay applications, discharge of the agent from the vessel into an unconfined space is initiated by a quick-action solenoid valve or a squib. The shape of the vessel is either cylindrical or spherical. To monitor the behavior of the agent inside the vessel during discharge, internal pressure and temperature changes are measured. A cylindrical pressure vessel with sight glasses is used for visual observations of the internal processes during discharge. The external behavior of the discharge is evaluated using a laser-light attenuation technique which has been used in the previous agent screening project and high speed photography. Parameters to be studied include: (1) nitrogen charge pressure, (2) initial amount of agent, (3) discharge temperature, (4) discharge orientation, and (5) discharge orifice size.

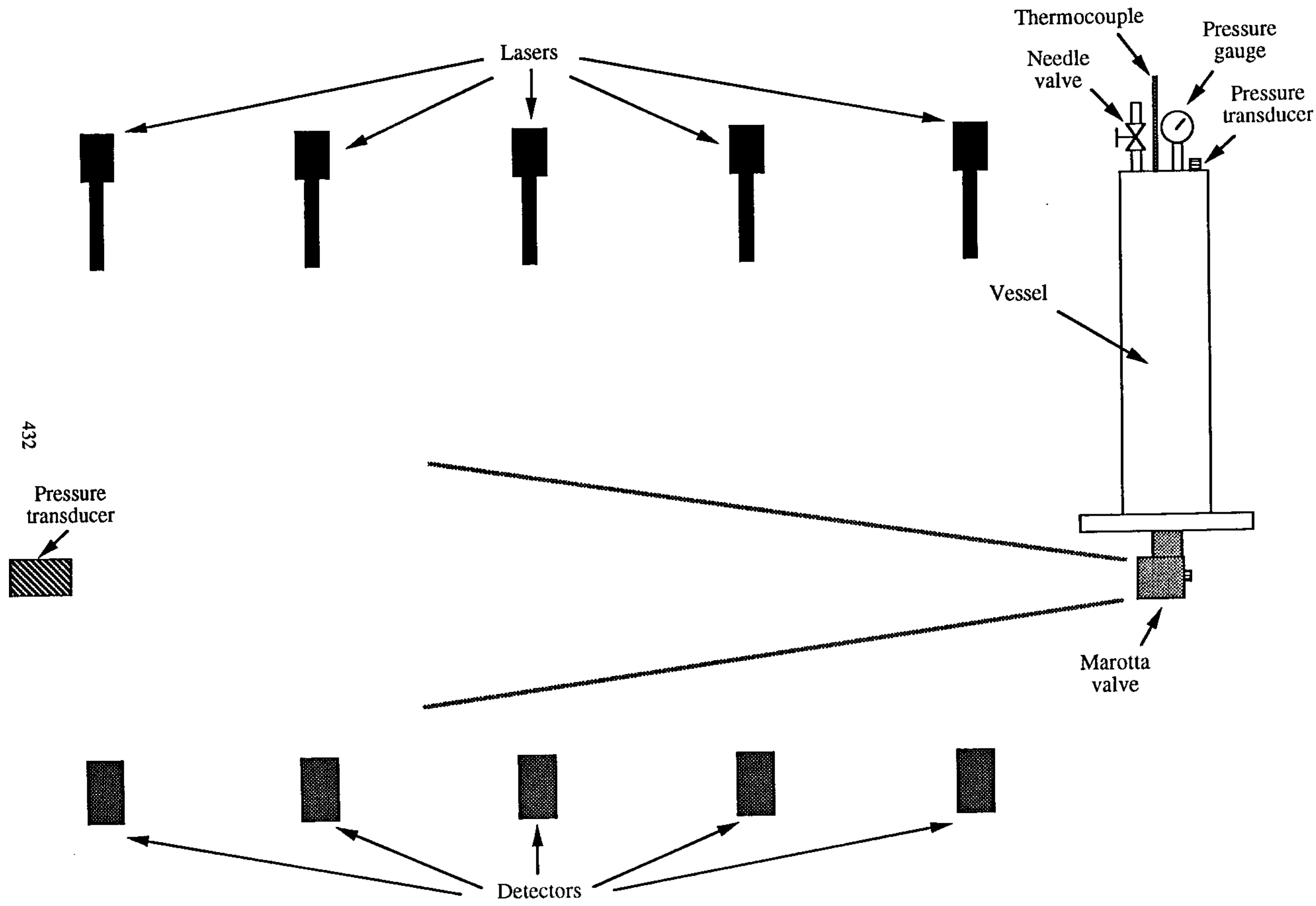
Since the work is still in progress, only the data from FC-218 discharges will be presented. The results were obtained using a cylindrical vessel (with sight glasses and equipped with a **Marotta** valve) at room temperature and 2/3 fill (by volume) condition. Nitrogen charged pressures varied from about 2.75 to 4.12 MPa.

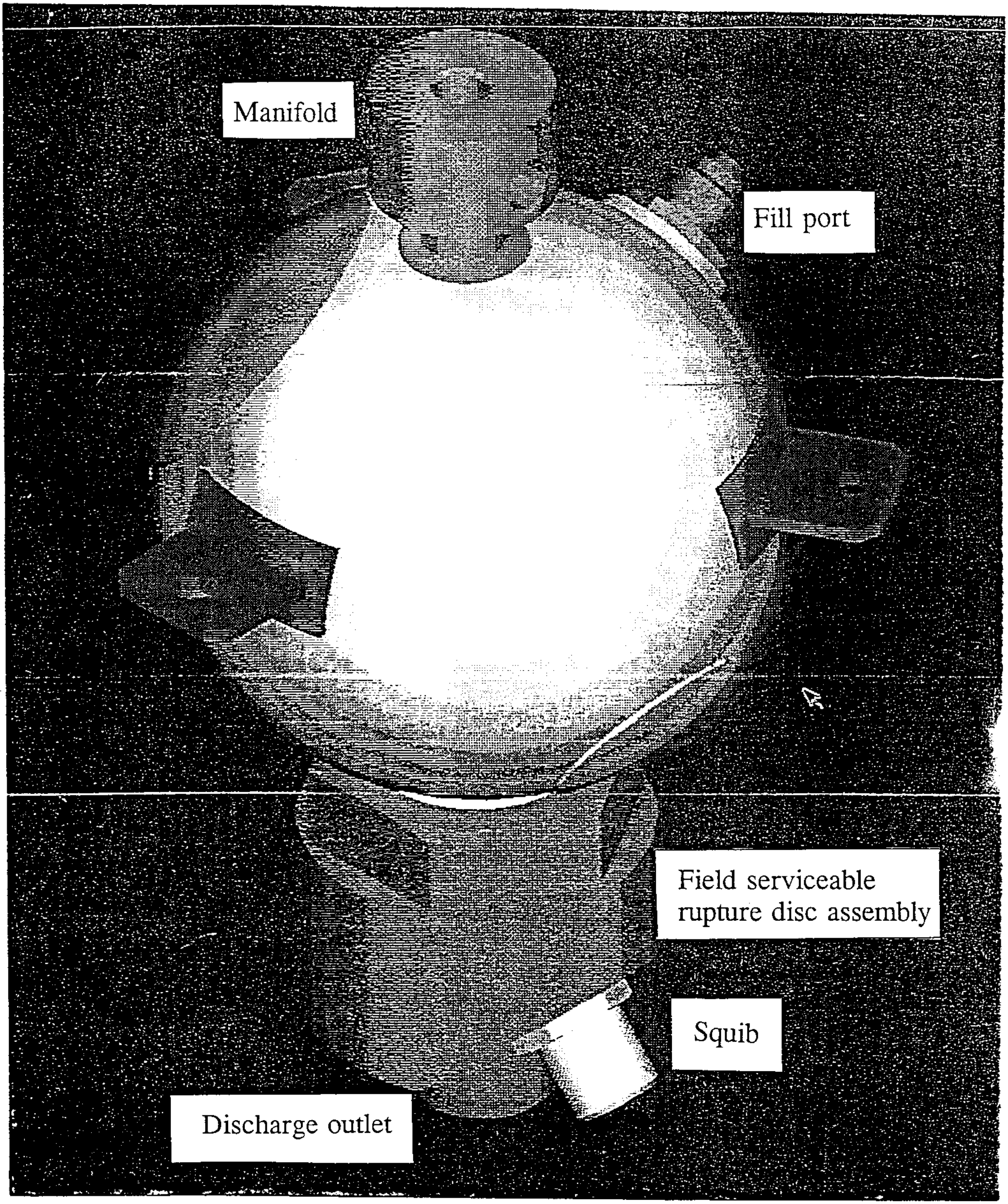
---

[1]*sponsored by USAF Wright Patterson Laboratory*

[2]*corresponding author Tel: (301) 975-6662, Fax: (301) 975-4052*

EXPERIMENTAL APPARATUS





Spherical Vessel

Experimental Conditions

Agents

- HFC-125, FC-218, & CF_3I

Initial conditions

- Different fill densities
- Different nitrogen charge pressures

Test conditions

- High & low temperatures
- Different release mechanisms
- Different bottle shapes (cylindrical *vs.* spherical)

Parameters to be measured

- Temporal variations of internal pressure and temperature

- Documentation of discharge by high speed photography

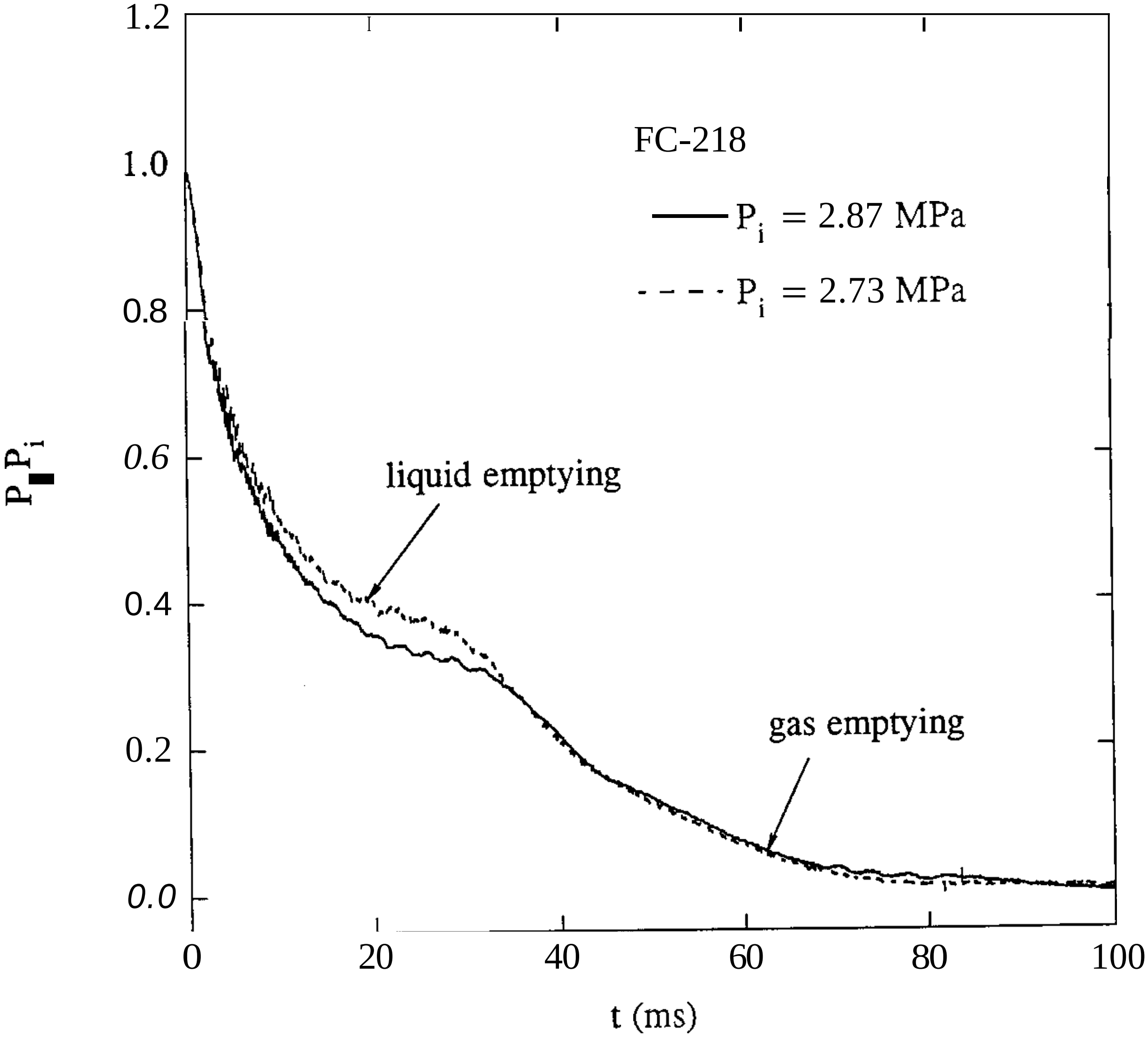
- Documentation of depressurization processes inside the vessel (using a vessel with sight glasses)

- Average velocities using laser attenuation technique

$$average\ velocity = \frac{(X)_{laser\,a} - (X)_{laser\,b}}{t_{extinction,\,a} - t_{extinction,\,b}}$$

- Downstream dynamic pressures

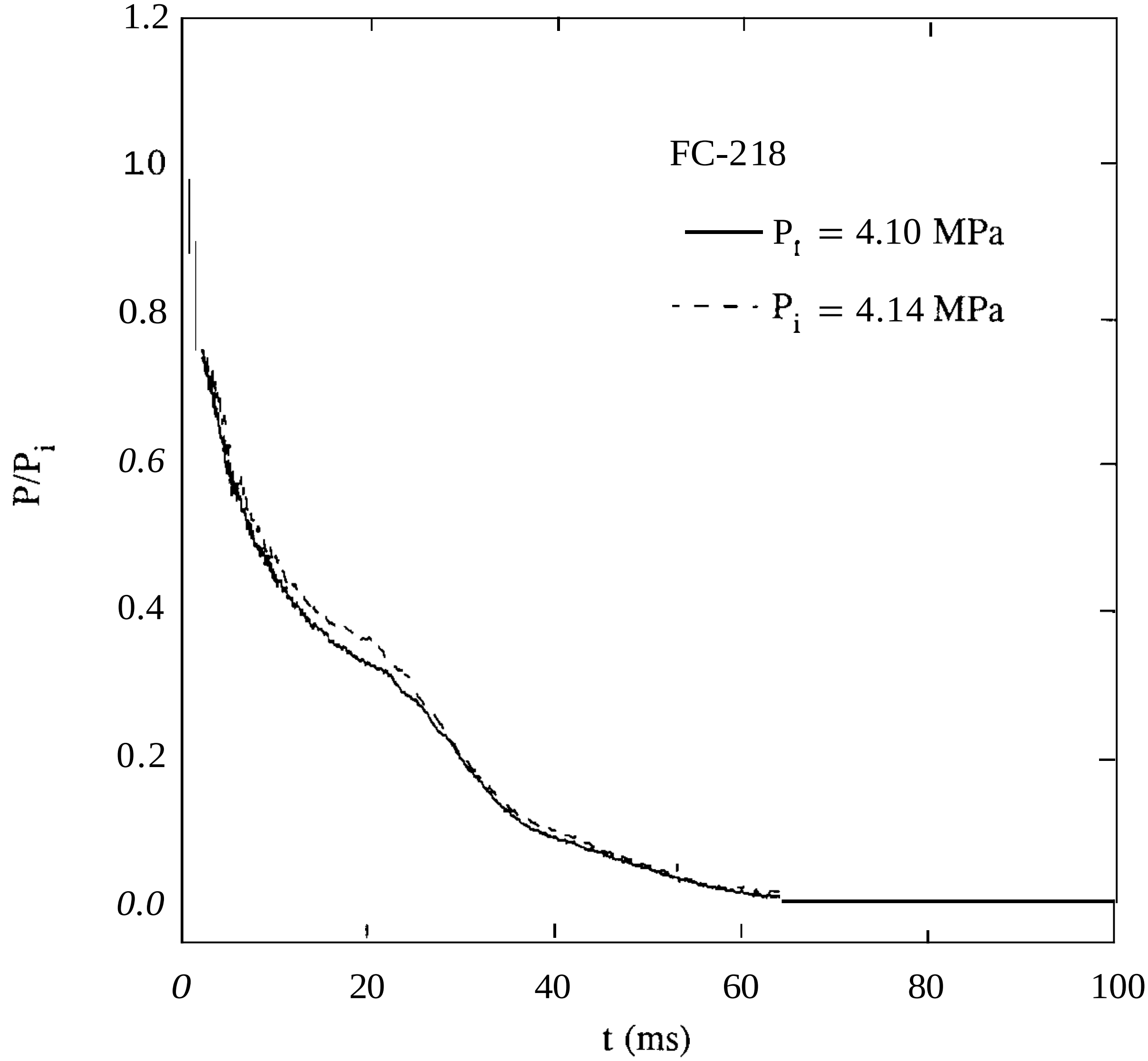
Temporal variations of pressure inside the vessel during discharge at room temperature

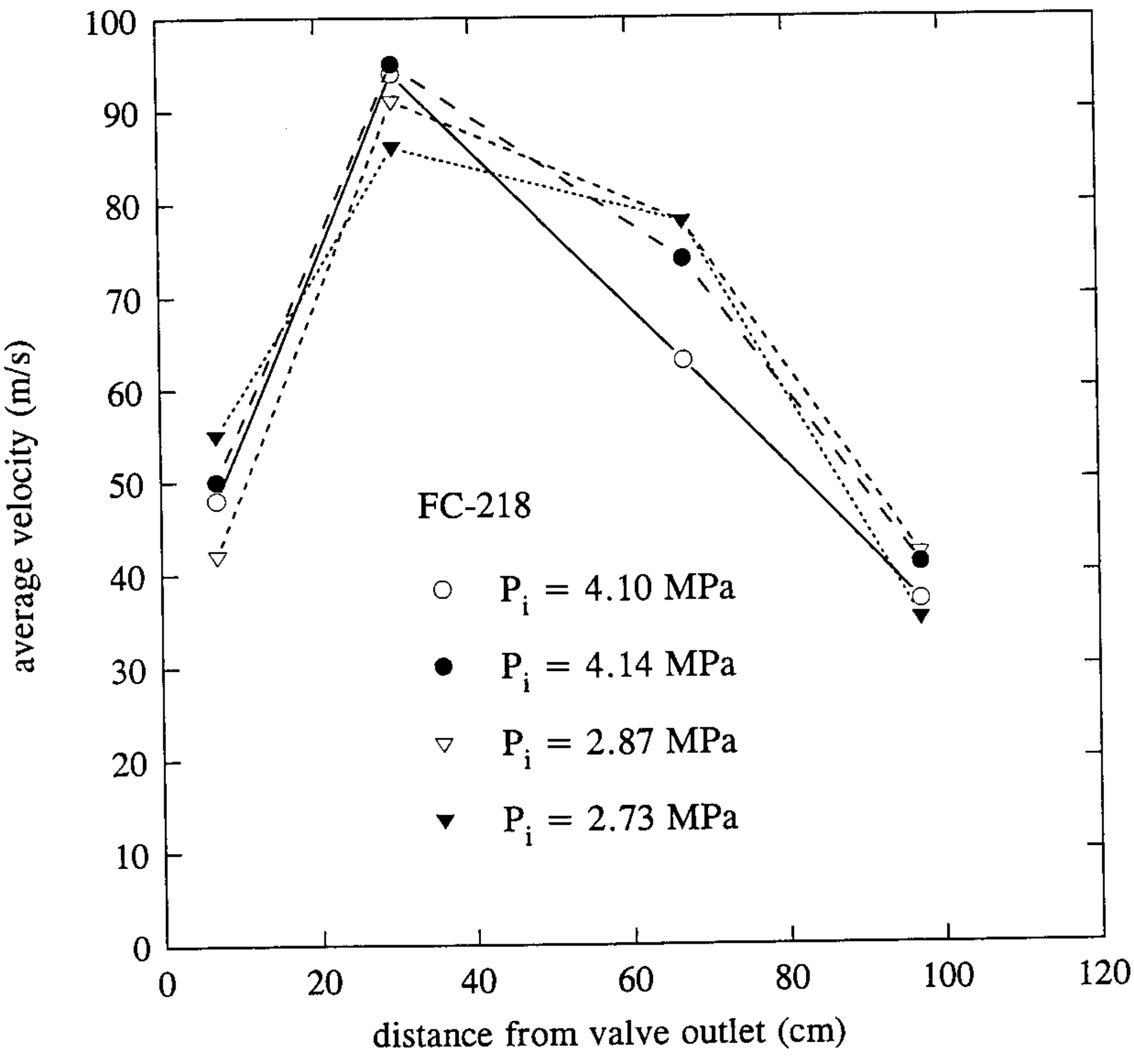


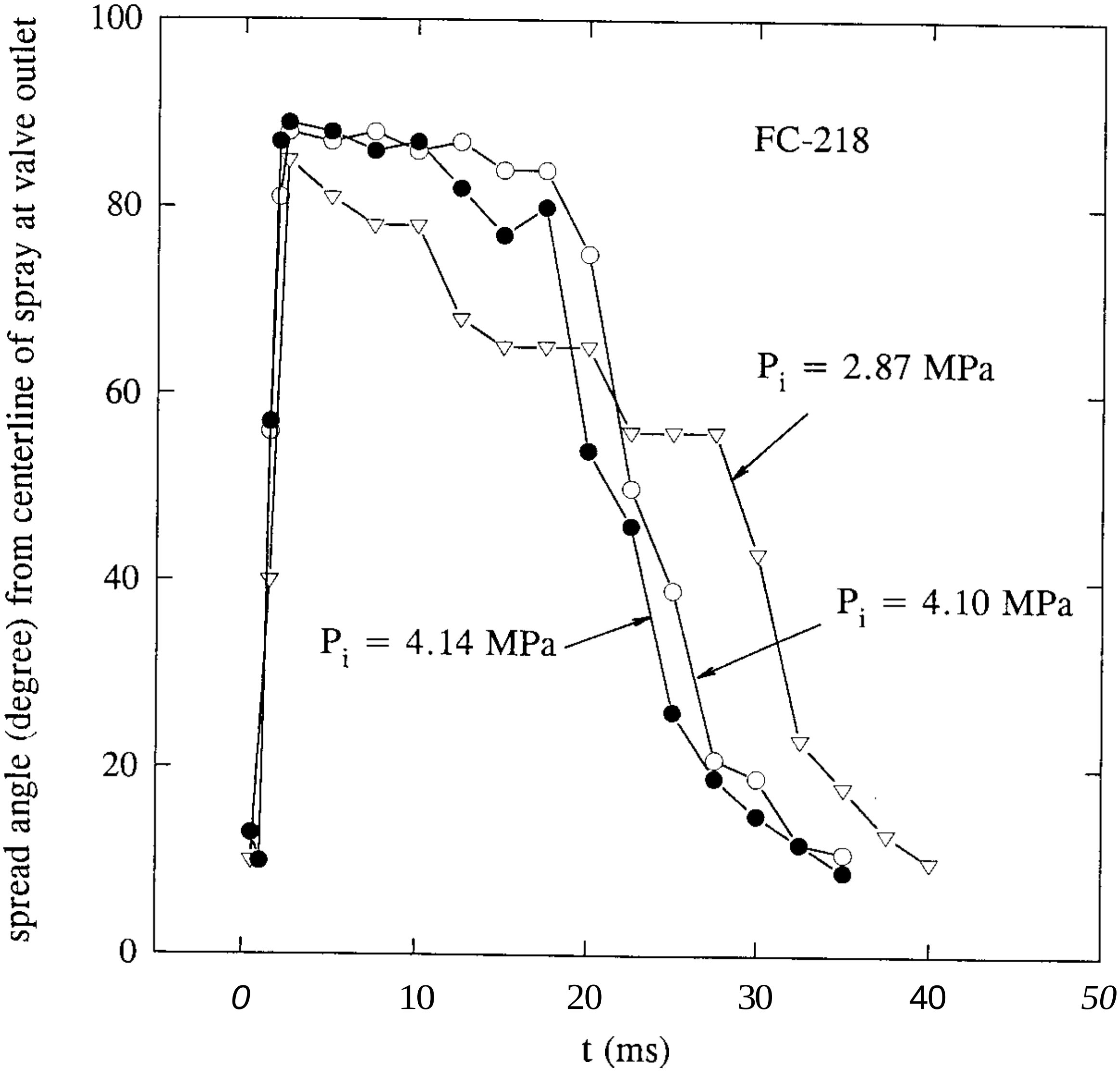
Note that degassing of nitrogen was not observed inside the vessel. In our case,

$$t_{discharge} << t_{degas}$$

Temporal variations of pressure inside the vessel during discharge at room temperature




FC-218
P_i = 4.10 MPa
P_i = 4.14 MPa
P_i = 2.87 MPa
P_i = 2.73 MPa
average velocity (m/s)
distance from valve outlet (cm)
0
10
20
30
40
50
60
70
80
90
100
0
20
40
60
80
100
120



100
80
60
40
20
0
spread angle (degree) from centerline of spray at valve outlet
FC-218
P_i = 2.87 MPa
P_i = 4.10 MPa
P_i = 4.14 MPa
0
10
20
30
40
50
t (ms)

Information from the downstream pressure transducer can be used to obtain some qualitative two-phase behavior of the flashing spray

If one assumes the two-phase flow to be homogeneous, then

$$M \ (momentum\ flux) = \frac{G^2}{\rho_h} = \rho_h u^2$$

with

$$\rho_h = \rho_g \alpha + (1 - \alpha)\rho_l$$

where G is the mass flux, u is the average velocity, α is the void fraction, ρ_h is the homogeneous mixture density, and ρ_g and ρ_l are the saturated vapor and liquid densities

Solve for α, then

$$a = \frac{\rho_l}{\rho_l - \rho_g} (1 - \frac{M}{\rho_l u^2})$$

If M (measured from the downstream transducer) and u (measured from laser extinction) are known, one could obtain an estimate of α by assuming the spray is at the boiling point of the agent.