

# DuPont™ FM-200®

## PHYSICAL PROPERTIES

FM-200® (1,1,1,2,3,3,3-Heptafluoropropane,  $\text{CF}_3\text{CHF}_2\text{CF}_3$ ) is a colorless, non-toxic gas, and a clean and effective fire suppression agent. It is normally shipped and stored as a liquefied compressed gas, and hence is typically handled under saturated conditions, i.e., the liquid and vapor phases coexist in equilibrium. An understanding of the physical properties of FM-200® and the safe and proper techniques for handling liquefied compressed gases allows the agent to be safely transferred from shipping cylinders to the desired end-use container.

Table 1 lists some of the more important physical properties of FM-200®.

**Table 1. Physical properties of FM-200®**

<b>Molecular weight</b>	170.03
<b>Boiling point at 1 bar</b>	-16.36°C
<b>Freezing point</b>	-131°C
<b>Critical temperature</b>	101.7°C
<b>Critical pressure</b>	2.91 Mpa
<b>Critical volume</b>	1.61 L/kg
<b>Critical density</b>	0.621 kg/L
<b>Critical compressibility</b>	0.255
<b>Acentric factor</b>	0.356
<b>Dipole moment</b>	1.4309 Debyes
<b>Specific heat, saturated liquid</b>	1.184 (Cp) at 25°C, kJ/kg K
<b>Specific heat, saturated vapor</b>	0.859 (Cp) at 25°C, kJ/kg K
<b>Specific heat, superheated vapor</b>	0.808 (Cp) at 101.325 kPa, 25°C, kJ/kg K
<b>Heat of Vaporization at boiling point</b>	132.6 kJ/kg
<b>Thermal conductivity, liquid</b>	0.069 W/m K at 25°C
<b>Thermal conductivity, vapor</b>	0.0126 W/m K at 25°C
<b>Viscosity, liquid</b>	0.184 centipoise at 25°C
<b>Viscosity, vapor</b>	0.0127 centipoise at 25°C
<b>Surface tension</b>	7.00 mN/m at 25°C

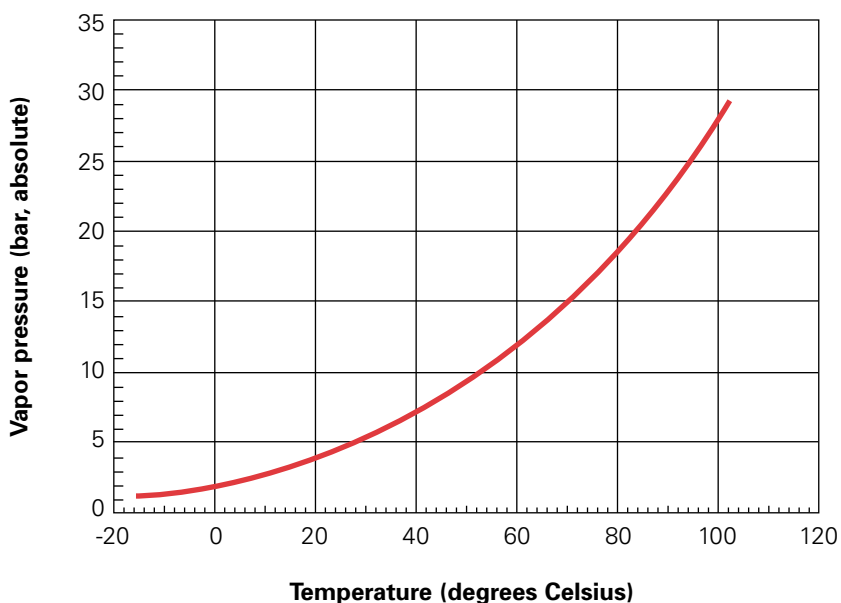


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## Vapor pressure

The physical property of a liquefied compressed gas that is of primary concern during transfer from one container to another is the vapor pressure. At room temperature and atmospheric pressure, FM-200<sup>®</sup> exists as a gas. If this gas is compressed, its pressure will increase; if the pressure is further increased to the vapor pressure of the material, liquefaction will occur. The vapor pressure is the pressure at which liquefaction occurs, and is dependent upon temperature as shown in Figure 1. For a vessel containing liquefied FM-200<sup>®</sup>, the pressure is determined by the vapor pressure as long as the liquid and vapor phases are in equilibrium ("saturation conditions").

**Figure 1. Vapor pressure of FM-200<sup>®</sup>**



## Critical properties

The vapor pressure of FM-200<sup>®</sup> increases with increasing temperature until the critical temperature is reached. At temperatures greater than the critical temperature, FM-200<sup>®</sup> exists only as a vapor, regardless of the pressure. At temperatures above the critical temperature, FM-200<sup>®</sup> cannot be liquefied at any pressure. The vapor pressure at the critical temperature is termed the critical pressure, and the mass per unit volume at the critical temperature is termed the critical density.

## Liquid and Vapor Densities

The saturated (orthobaric) liquid density of FM-200<sup>®</sup> is the density of the liquid under saturated conditions, i.e., the liquid and vapor phases coexisting at equilibrium. The saturated liquid density is temperature dependent. With increasing temperature, a unit mass of FM-200<sup>®</sup> occupies a larger volume (thermal expansion), resulting in a decrease in the saturated liquid density. The saturated vapor density increases with increasing temperature due to the higher vapor pressure of the liquid with which it is in equilibrium. At the critical temperature, the liquid and vapor densities become identical. Above the critical temperature, FM-200<sup>®</sup> exists only as a vapor.



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The saturated liquid and vapor densities of FM-200® as a function of temperature are shown in Table 2. From this table the temperature at which a cylinder becomes liquid-full can be ascertained. For example, consider a container holding 1.3886 kilograms of FM-200® per liter of internal volume. At 25°C, the container will be just liquid-full; any further increase in temperature will result in compression of the liquid and the development of tremendous pressures, potentially exceeding the rating of the cylinder.

For a container holding 1.2674 kilograms of FM-200® per liter of internal volume, the container will become just liquid-full at 55°C; at 25°C, the pressure is the vapor pressure of pure FM-200® at 25°C, i.e., 4.58 bar. Note that these examples are for pure FM-200®; for FM-200® superpressurized with nitrogen, liquid and vapor densities will differ from the values shown in Table 2. For additional thermodynamic property data, please contact your fire protection equipment manufacturer or DuPont.

**Table 2. Vapor pressure and density of FM-200®**

Temperature (°C)	Vapor Pressure (bar)	Density (kg/L)		
		Liquid	Saturated Vapor	Vapor @ 1 bar
-10	1.32	1.5085	0.0109	0.00812
-5	1.62	1.4923	0.0132	0.00795
0	1.96	1.4758	0.0159	0.00778
5	2.35	1.4590	0.0190	0.00762
10	2.81	1.4420	0.0225	0.00747
15	3.33	1.4246	0.0265	0.00733
20	3.91	1.4068	0.0312	0.00719
25	4.58	1.3886	0.0364	0.00705
30	5.32	1.3700	0.0424	0.00693
35	6.15	1.3508	0.0492	0.00680
40	7.08	1.3310	0.0568	0.00668
45	8.10	1.3106	0.0654	0.00657
50	9.23	1.2894	0.0752	0.00646
55	10.47	1.2674	0.0861	0.00635
60	11.83	1.2445	0.0985	0.00625

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