Technical Information

P-MP/409A

DuPont™ Suva®
refrigerants

DuPont™ Suva® MP and 409A Refrigerant Blends

Properties, Uses, Storage, and Handling

DuPont™ Suva® MP39 (R-401A) refrigerant

DuPont™ Suva® MP66 (R-401B) refrigerant

DuPont™ Suva® 409A (R-409A) refrigerant

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DuPont™ Suva® MP and 409A Refrigerant Blends

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Introduction

Background

Chlorofluorocarbons (CFCs), which were developed over 60 years ago, have many unique properties. They are low in toxicity, nonflammable, noncorrosive, and compatible with other materials. In addition, they offer the thermodynamic and physical properties that make them ideal for a variety of uses. CFCs have been used as refrigerants; as blowing agents in the manufacture of insulation, packaging, and cushioning foams; as cleaning agents for metal and electronic components; and in many other applications.

However, the stability of these compounds, coupled with their chlorine content, has linked them to depletion of the earth's protective ozone layer. As a result, DuPont has stopped production of CFCs and is offering environmentally acceptable alternatives, such as the family of DuPont™ Suva® refrigerant blends.

Suva® Refrigerant Blends to Replace R-12

DuPont has developed Suva® refrigerants as alternatives for CFC-12 in refrigeration and air conditioning applications. These refrigerants are intended to replace CFC-12 in existing refrigeration equipment. Suva® MP66 is also an excellent replacement for R-500 applications.

Suva® MP39 and MP66 products contain three components: HCFC-22, HFC-152a, and HCFC-124. **Table 1A** shows their compositions.

Table 1A
Composition of DuPont™ Suva® MP Refrigerant Blends, wt%

	HCFC-22	HFC-152a	HCFC-124
Suva® MP39 (R-401A)	53	13	34
Suva® MP66 (R-401B)	61	11	28

Suva® 409A contains three components, as shown in **Table 1B**.

Table 1B
Composition of DuPont™ Suva® 409A, wt%

	HCFC-22	HCFC-142b	HCFC-124
Suva® 409A (R-409A)	60	15	25

Table 2 shows the chemical names and formulae of the refrigerants above.

Uses

Suva® MP39, MP66, and 409A are mixtures designed to replace CFC-12 in existing refrigeration systems.

Some applications for these refrigerants are: home refrigerators and freezers, reciprocating chillers, retail food refrigeration, refrigerated transportation equipment, dehumidifiers, ice machines, beverage vending machines, and water fountains.

Suva® MP39 (R-401A) and Suva® 409A (R-409A) are alternatives for use in most CFC-12 systems. Comparable capacities and efficiencies to CFC-12 are expected in systems operating in such applications as walk-in coolers, food and dairy display cases, beverage dispensers and vending machines, and domestic refrigerators.

Suva® MP66 (R-401B) provides comparable capacity to CFC-12 in retrofit CFC-12 systems operating at low evaporator temperatures, making it suitable for use in transport refrigeration equipment and domestic and commercial freezers. Suva® MP66 can also be used to replace R-500 in existing equipment.

The thermodynamic and physical properties of these Suva® refrigerants make them very efficient and safe replacement refrigerants for CFC-12.

Table 2
Refrigerant Information

Refrigerant	Chemical Name	Formula	CAS No.*	Molecular Wt.
HCFC-22	Chlorodifluoromethane	$CHClF_2$	75-45-6	86.47
HFC-152a	1,1-Difluoroethane	CH_3CHF_2	75-37-6	66.00
HCFC-124	2-Chloro-1,1,1,2-Tetrafluoroethane	$CHClFCF_3$	2837-89-0	136.50
HCFC-142b	1-Chloro-1,1-Difluoroethane	CH_3CClF_2	75-68-3	100.47

*Chemical Abstract Service Registry Number (American Chemical Society)

Table 3 summarizes the theoretical performance characteristics of Suva® MP39, Suva® MP66, and Suva® 409A at given evaporator conditions. All exhibit a slightly higher refrigeration capacity and equivalent coefficient of performance to CFC-12.

Effect of Leakage on Performance

Although any leak in a refrigeration system should be repaired as soon as possible, it is advantageous that a refrigerant maintain its performance characteristics throughout a series of leaks and recharges. Theoretical calculations were made to simulate a realistic scenario in which a refrigeration system goes through a series of five vapor leaks and subsequent recharges with Suva® MP39. Vapor leaks were induced in a static system (compressor not running). Each leak was 20% by weight of the original charge, and each recharge was made liquid phase. **Table 4** shows the performance characteristics of the refrigeration system after each recharge. Although the composition of the system refrigerant changes, its performance remains comparable to that of CFC-12, leveling off just below the capacity of CFC-12.

In field tests with continuously operating equipment (such as found in a supermarket), vapor leaks have been found to cause little change in refrigerant composition. The continuous operation keeps the refrigerant well mixed, resulting in a leakage of vapor with entrained liquid rather than exclusively vapor in the event of a leak in the two-phase region of the refrigeration system.

Physical Properties

General physical properties of the Suva® refrigerant blends are shown in **Table 5**.

Additional physical property data may be found in other DuPont publications. Bulletin ART-10 contains viscosity, thermal conductivity, and heat capacity data for saturated liquid and vapor, in addition to heat capacity data and heat capacity ratios for both saturated and superheated vapors. Thermodynamic tables in English and SI units are available for Suva® MP39 in Bulletins T-MP39-ENG and T-MP39-SI and for Suva® MP66 in Bulletins T-MP66-ENG and T-MP66-SI.

Table 3
Theoretical Cycle Comparison* of CFC-12, DuPont™ Suva® MP39, Suva® MP66, and Suva® 409A

	CFC-12	Suva® MP39 (R-401A)	Suva® MP66 (R-401B)	Suva® 409A (R-409A)
Refrigeration Capacity (Relative to CFC-12)	1.00	1.09	1.09	1.13
Coefficient of Performance	1.72	1.58	1.58	1.52
Compression Ratio	10.19	13.03	12.67	13.97
Compressor				
Discharge Temperature, °C	130	149	152	154
°F	266	300	306	310
Discharge Pressure, kPa (abs)	1344	1662	1744	1689
psia	195	241	253	245

*–23°C (–10°F) evaporator; 54°C (130°F) condenser; subcool to 43°C (110°F); suction temperature 10°C (50°F).

Table 4
Theoretical Effect of Leakage on DuPont™ Suva® MP39 Performance

Leak No.	Discharge Pressure, kPa (psia)	Discharge Temperature, °C (°F)	COP	Capacity, W (Btu/min)
Initial	990 (144)	95.3 (204)	3.29	2619 (149)
1	967 (140)	94.9 (203)	3.28	2537 (144)
2	944 (137)	93.9 (201)	3.30	2491 (142)
3	928 (135)	93.5 (200)	3.30	2445 (139)
4	916 (133)	93.5 (200)	3.30	2409 (137)
5	905 (131)	92.9 (199)	3.30	2372 (135)
CFC-12	908 (132)	85.8 (186)	3.25	2391 (136)

Assumptions: –6.7°C (20°F) evaporator/37.8°C (100°F) condenser/18.3°C (65°F) suction gas/5.6°C (10°F) of subcooling.

Table 5
General Property Information

Physical Property	Unit	Suva® MP39 (R-401A)	Suva® MP66 (R-401B)	Suva® 409A (R-409A)
Composition (wt%) (HCFC-22/HFC-152a/HCFC-124)	—	53/13/34	61/11/28	60/15/25 (HCFCs 22, 142b, 124)
Molecular Weight	g/mol (avg.)	94.4	92.8	97.45
Boiling Point (1 atm)	°C °F	–33.0 –27.3	–34.7 –30.4	–35 –31
Critical Temperature	°C °F	108 226	106 223	107 225
Critical Pressure	kPa (abs) psia	4604 668	4682 679	4599 667
Critical Volume	m^3/kg ft^3/lb	0.00196 0.0314	0.00195 0.0312	N/A
Critical Density	kg/m^3 lb/ft^3	510.6 31.9	512.7 32.0	N/A
Liquid Density at 25°C (77°F)	kg/m^3 lb/ft^3	1194 74.5	1193 74.4	1219 76
Density, Saturated Vapor at 25°C (77°F)	kg/m^3 lb/ft^3	29.0 1.81	30.7 1.92	29.6 1.85
Specific Heat Liquid at 25°C (77°F)	kJ/kg·K Btu/lb·°F	1.300 0.310	1.300 0.310	1.29 0.293
Specific Heat Vapor, 25°C (77°F) at 1 atm pressure	kJ/kg·K Btu/lb·°F 807	0.734 0.176	0.724 0.173	0.83 0.199
Vapor Pressure of Saturated Liquid at 25°C (77°F)	kPa (abs) psia	772.9 112.1	819.2 118.8	807 117
Heat of Vaporization at Normal Boiling Point	kJ/kg Btu/lb	227.3 97.8	229.4 98.7	220.6 94.9
Thermal Conductivity at 25°C (77°F)				
Liquid	W/m·K Btu/hr·ft·°F	0.0900 0.0517	0.0900 0.0517	N/A
Vapor (1 atm)	W/m·K Btu/hr·ft·°F	0.0119 0.00688	0.0119 0.00688	0.0097 0.0056
Viscosity at 25°C (77°F)				
Liquid	mPa·s (cP)	0.194	0.190	0.184
Vapor (1 atm)	μP	121	121	120
Solubility of Water in Refrigerant at 25°C (77°F)	wt%	0.10	0.10	N/A
Flammability Limit in Air (1 atm)	vol%	none	none	none
Ozone Depletion Potential))	CFC-12 = 1	0.03	0.035	0.05
Global Warming Potential	CO_2 = 1	973	1,062	1,288
TSCA Inventory Status* Reported/Included	—	yes	yes	yes
Inhalation Exposure Limit	AEL** ppm (v/v)	1,000	1,000	1,000

* U.S. Toxic Substance Control Act (TSCA)

** Acceptable exposure limit , established by DuPont.

Note: kPa is absolute pressure.

Pressure–enthalpy relationships for Suva® MP39, Suva® MP66, and Suva® 409A refrigerants are shown in **Figures 1** through **6**.

Note: Like R-500 and R-502, these Suva® refrigerants exhibit temperature glide in both the evaporator and the condenser. Isotherms shown within the two-phase region slope due to this temperature glide. For a more detailed explanation of temperature glide, see Bulletin ART-7.

Chemical/Thermal Stability

Thermal Decomposition

Suva® refrigerant blends, as with all fluorocarbons, will decompose when exposed to high temperatures from sources such as open flames or electric resistance heaters. Decomposition may produce toxic and irritating compounds such as hydrogen chloride and hydrogen fluoride. The pungent odors released will irritate the nose and throat and generally force people to evacuate the area. Therefore, it is important to prevent decomposition by following DuPont recommendations for handling and use.

Stability with Metals and Refrigeration Lubricants

Thermal stability tests for refrigerants with metals are typically performed in the presence of refrigeration oils. The results of sealed tube stability tests are available for CFC-12/mineral oil combinations, which have shown long-term stability in contact with copper, steel, and aluminum in actual refrigeration systems. Alkylbenzene (AB), polyol ester (POE), and mixtures of AB/mineral oil or mixtures of POE/mineral oil are all possible candidates for use with Suva® refrigerant blends. Also, in some hermetic systems where oil return is not a problem, experience has shown that Suva® MP39 and 409A will operate with mineral oil. A summary of thermal stability tests performed with both AB and POE lubricants with Suva® refrigerant blends is shown in **Table 6. It should be noted that in all cases both AB and POE lubricants with these Suva® refrigerants performed better than mineral oil with CFC-12. Although not tested by DuPont, similar performance is expected with Suva® 409A.**

The sealed tube test method used for stability testing was based on ASHRAE 97 methods. A 3-mL volume of refrigerant/lubricant solution was heated in the presence of copper, steel, and aluminum strips in an oven for 14 days at 175°C (347°F). Both the neat lubricant and a mixture of lubricant and refrigerant (50/50 volume ratio) were tested. Visual ratings were obtained on both the liquid solutions and the metal coupons after the designated exposure time. The visual ratings range from 0 to 5, with 0 being best and 5 being worst.

After the visual ratings were obtained, sample tubes were opened, and the lubricant and refrigerant (if present) were analyzed. The lubricant was typically checked for halide content and viscosity, while the refrigerant was examined for the presence of decomposition products. **Table 6** summarizes typical viscosity, miscibility, and stability data for both CFC-12 and Suva® refrigerant blends. The lubricant miscibility range, shown in **Table 6**, indicates the temperature range in which the refrigerant and lubricant mix to form a single liquid phase. Stability data for a specific Suva® refrigerant/lubricant combination (i.e., Suva® MP39 with Zerol* 150DL) should apply to both Suva® MP39 and Suva® MP66, because they represent different compositions of the same three components (HCFC-22, HFC-152a, HCFC-124). Laboratory tests and field experience show similar behavior for Suva® 409A. Ratings are listed in **Table 6** for the neat lubricant, the lubricant/refrigerant solution, and the three metals that were present in the lubricant/refrigerant solutions. Viscosity was determined on the unused lubricant and the tested neat lubricant. Decomposition products (fluoride and chloride) were determined.

Note: Lubricant/refrigerant combinations shown throughout this report are for the purposes of comparing the effects of different lubricants on the Suva® refrigerants. No recommendation is made or implied that these combinations will operate successfully in refrigeration systems.

Materials Compatibility

It is important to review materials of construction for compatibility when designing new equipment, retrofitting existing equipment, or preparing storage and handling facilities. Because the Suva® blends have been designed as refrigerants, the compatibility data in **Table 7** will include materials commonly used in refrigeration applications.

*Zerol is a trademark of Shrieve Chemical Co.

Elastomers

Note: The data in **Tables 7** and **8** reflect compatibility in sealed tube tests. Actual refrigerant compatibility in real systems can be influenced by the operating conditions, the nature of the polymers used, compounding formulations of the polymers, and the curing or vulcanization processes used to create the polymer. Polymers should always be tested under actual operating conditions before reaching final conclusions about their suitability.

Sealed tube compatibility results for a representative Suva® refrigerant blend (36% HCFC-22, 24% HFC-152a, 40% HCFC-124) were developed with eleven different polymers and Zerol 500 alkylbenzene lubricant (with additives). Suva® MP39 and Suva® MP66 compatibilities are similar to the blend shown in **Table 7**, because the formulations are based on the same components. **Table 7** is a summary of these tests. **Table 8** shows a glossary of common elastomers.

Motor Materials

Compatibility tests were performed on a representative Suva® refrigerant blend with naphthenic and alkylbenzene lubricants in contact with a typical polyester insulation material used in hermetic motors. In this test, the polyester insulation was flexed and examined for cracks and splits to evaluate the level of embrittlement. The samples were rated according to a comparative scale, with zero as the best rating (indicating no change). The results shown in **Figure 7** show that this blend and alkylbenzene lubricant combination is very compatible, with no polyester embrittlement. In general, most modern (10–15 yr old) compressor motors used in CFC-12 compressors are compatible with HCFC-22. Based on this, the Suva® refrigerant blends should not have any gross effects on modern CFC-12 compressor motors.

Desiccants

In refrigeration systems, keeping the refrigerant and lubricant free of moisture is very important. Dryers filled with moisture-absorbing desiccant are typically used to prevent moisture accumulation. For R-12, the 4A-XH-5 or 4A-XH-6 desiccant produced by UOP (a U.S. company—formerly Union Carbide Molecular Sieve) can be used for both loose-filled and solid core dryers. For Suva® blends, a new desiccant is needed for loose-filled dryers, because components of the blends may be incompatible with loose-fill 4A-XH-5. UOP's XH-9 desiccant or equivalent (such as MS594 from Grace) is compatible with the Suva® MP and 409A refrigerant blends and is recommended for loose-filled dryers. For solid core dryers, some existing dryer models may be compatible. Consult dryer manufacturer or equipment manufacturer to determine a suitable dryer.

Refrigeration Lubricants

Most compressors require a lubricant to protect internal moving parts. The compressor manufacturer usually recommends the type of lubricant(s) and proper viscosity that should be used to ensure acceptable operation and equipment durability. Recommendations are based on several criteria, which can include:

- lubricity
- lubricant/refrigerant solubility
- compatibility with materials of construction
- thermal stability and compatibility with other lubricants

It is important to follow the manufacturers' recommendations for lubricants to be used with their equipment.

Lubricant return to the compressor is very important. One factor that affects this is the liquid-phase lubricant/refrigerant solubility, particularly at evaporator temperatures. Ideally the lubricant/refrigerant pair are completely soluble in each other (miscible, one phase forms), which allows the lubricant to flow with the liquid refrigerant and return to the compressor. Even if the lubricant/refrigerant pair are not miscible (two phases form) in the evaporator, they may still have some degree of solubility. Solubility of refrigerant in lubricant lowers lubricant viscosity, which helps it flow through the evaporator and return to the compressor. This is why many refrigeration systems can operate properly, even though the lubricant and refrigerant are immiscible (yet partially soluble) in the evaporator. Other factors, such as refrigerant vapor velocity, play a key role in lubricant return. Overall, it is important to note that lubricant/refrigerant miscibility is helpful, but not necessarily essential, for proper system operation.

Naphthenic and paraffinic lubricants (mineral oils) are miscible (fully soluble) with CFC-12 over the range of expected operating conditions, which helps lubricant return to the compressor and helps maintain efficient heat transfer. Suva® refrigerant blends are not fully miscible with mineral oils. However, experience has shown that Suva® MP39 and 409A can be operated with mineral oils in many hermetic systems where oil return is not a problem. For systems that require miscibility to aid in oil return, alkylbenzene offers excellent miscibility with Suva® MP and 409A refrigerants.

Figure 1. DuPont™ Suva® MP39 (R-401A) Pressure vs. Enthalpy (SI Units)

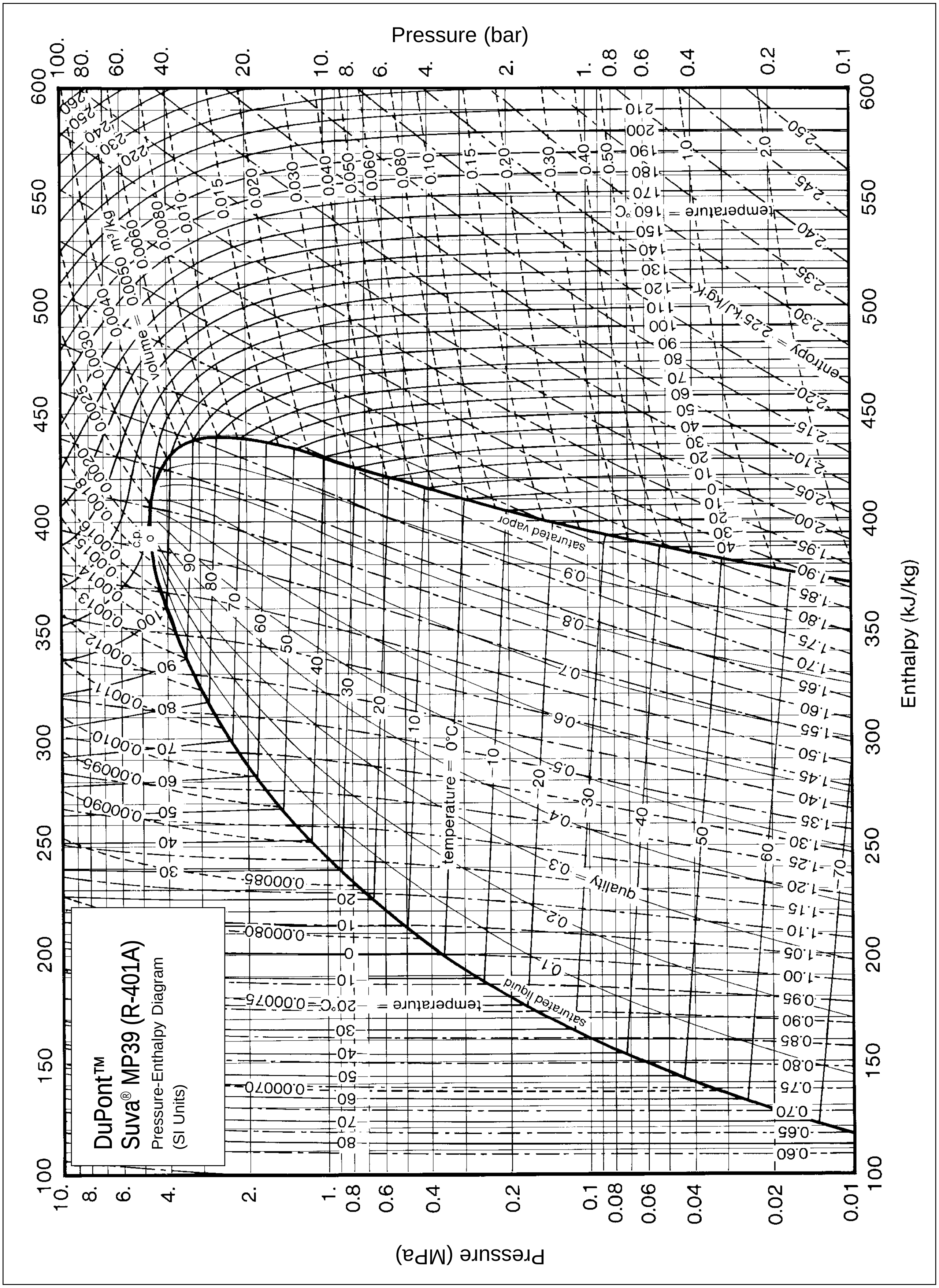

Figure 2. DuPont™ Suva® MP39 (R-401A) Pressure vs. Enthalpy (English Units)

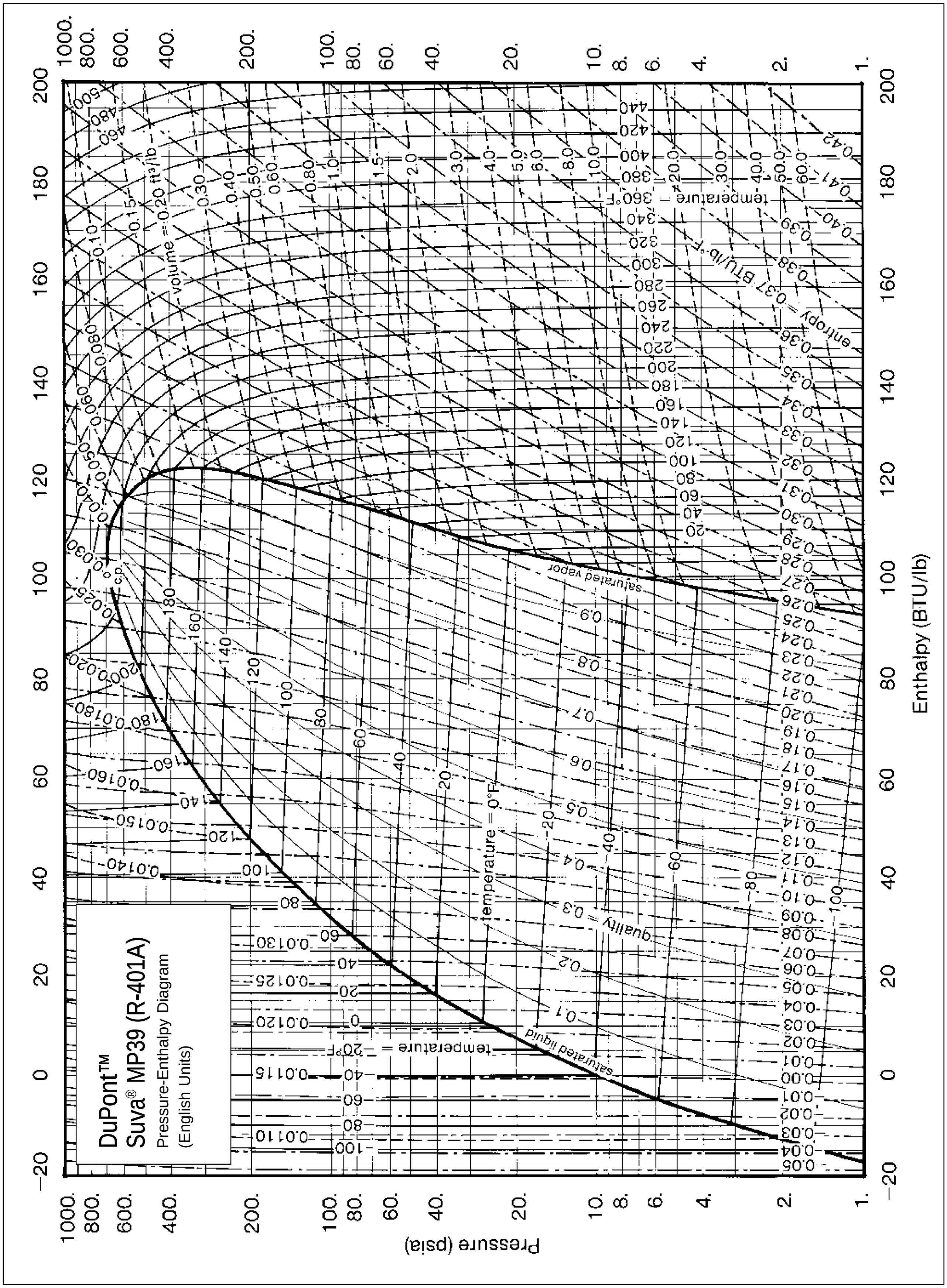

Figure 3. DuPont™ Suva® MP66 (R-401B) Pressure vs. Enthalpy (SI Units)

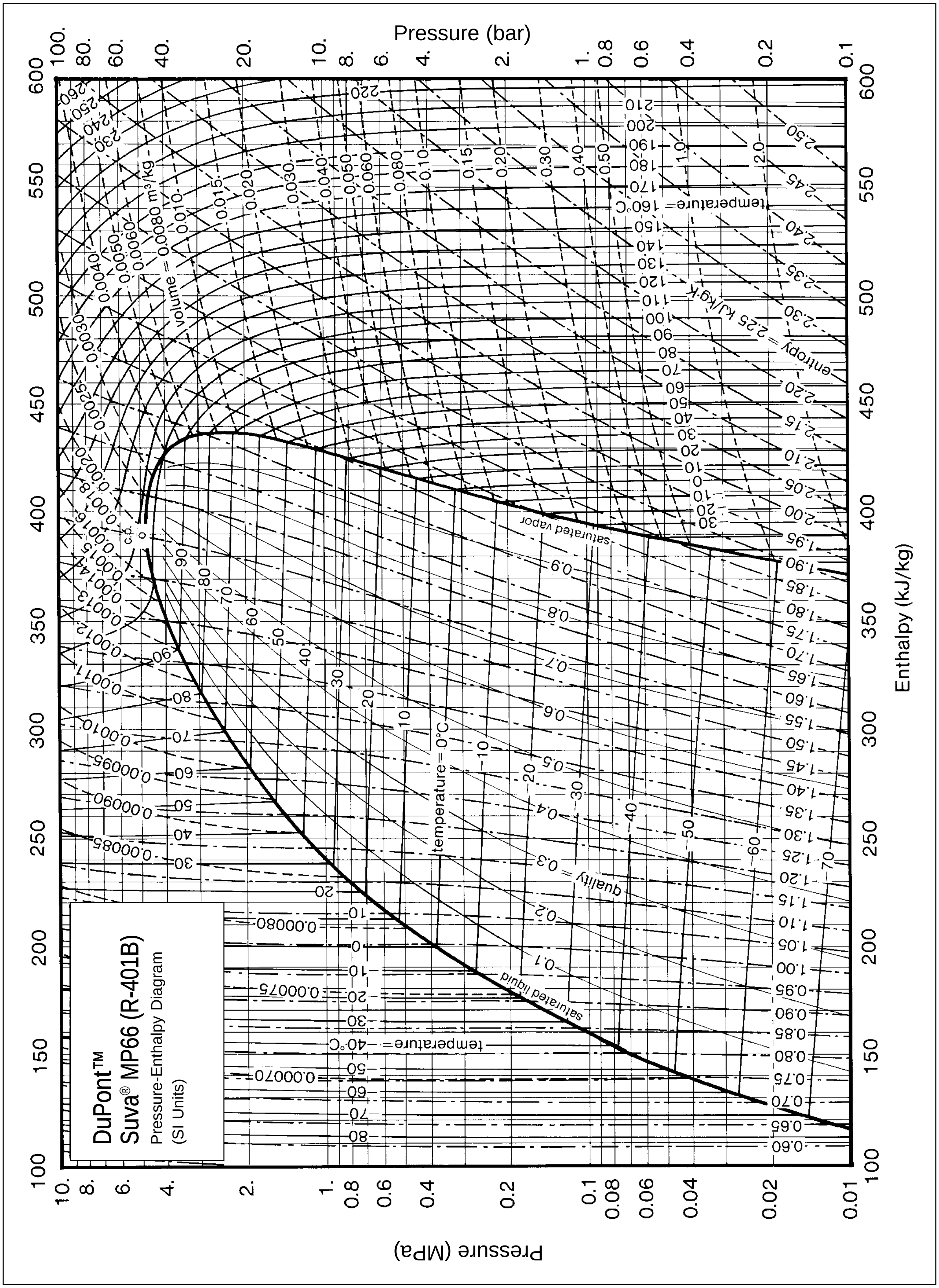

Figure 4. DuPont™ Suva® MP66 (R-401B) Pressure vs. Enthalpy (English Units)

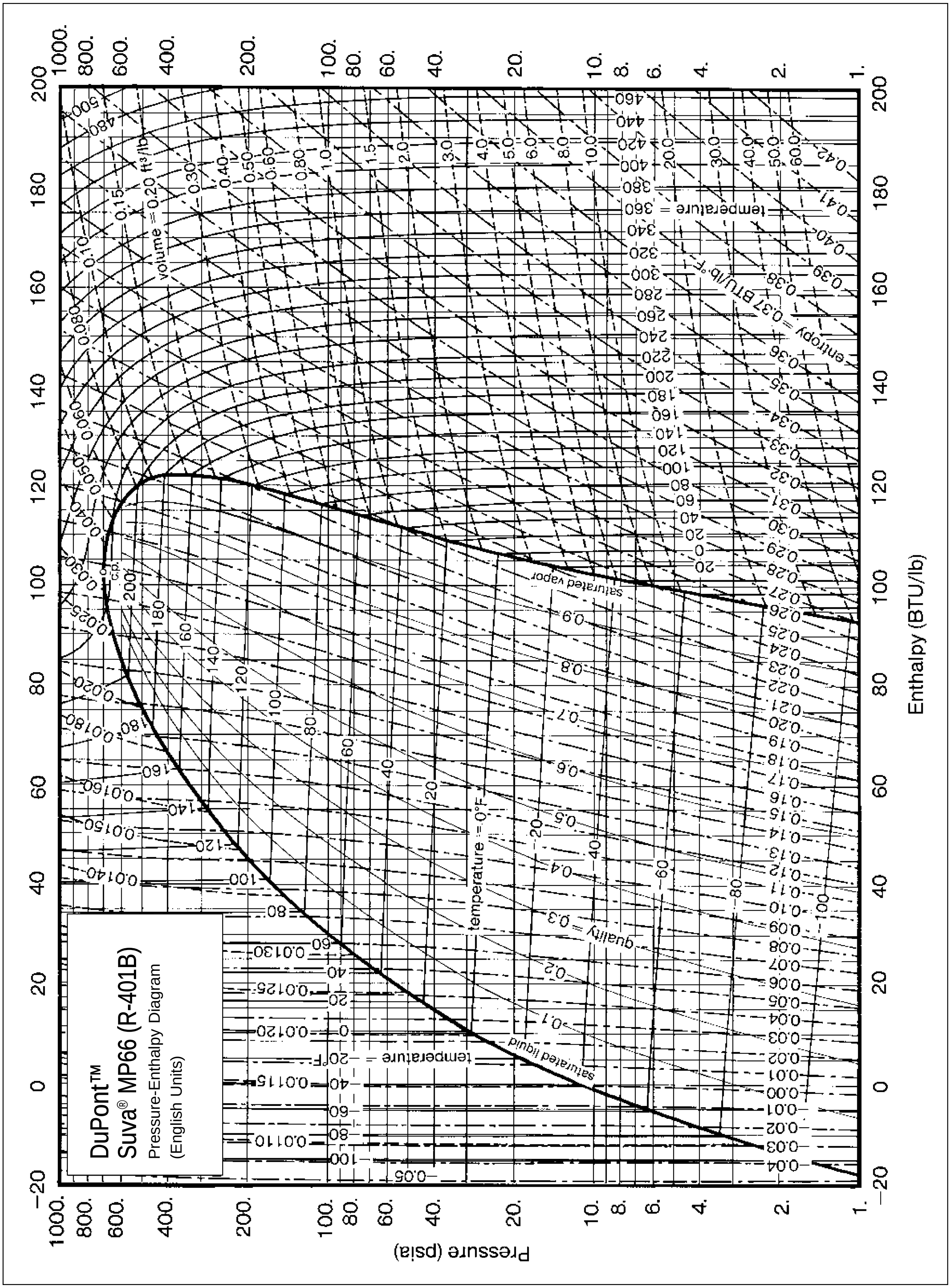

Figure 5. DuPont™ Suva® 409A (R-409A) Pressure vs. Enthalpy (SI Units)
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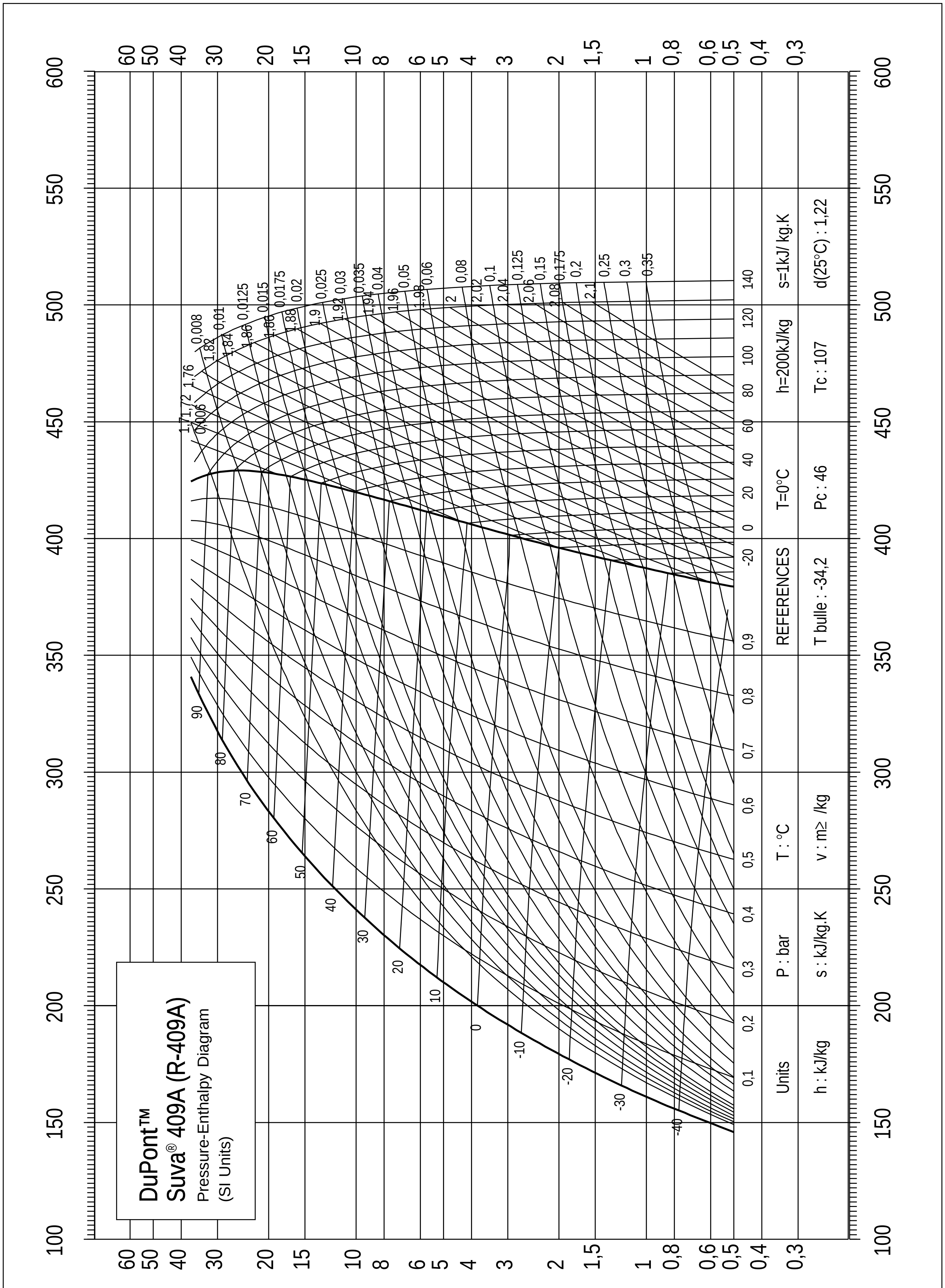

Figure 6. Suva® 409A (R-409A) Pressure vs. Enthalpy (English Units)
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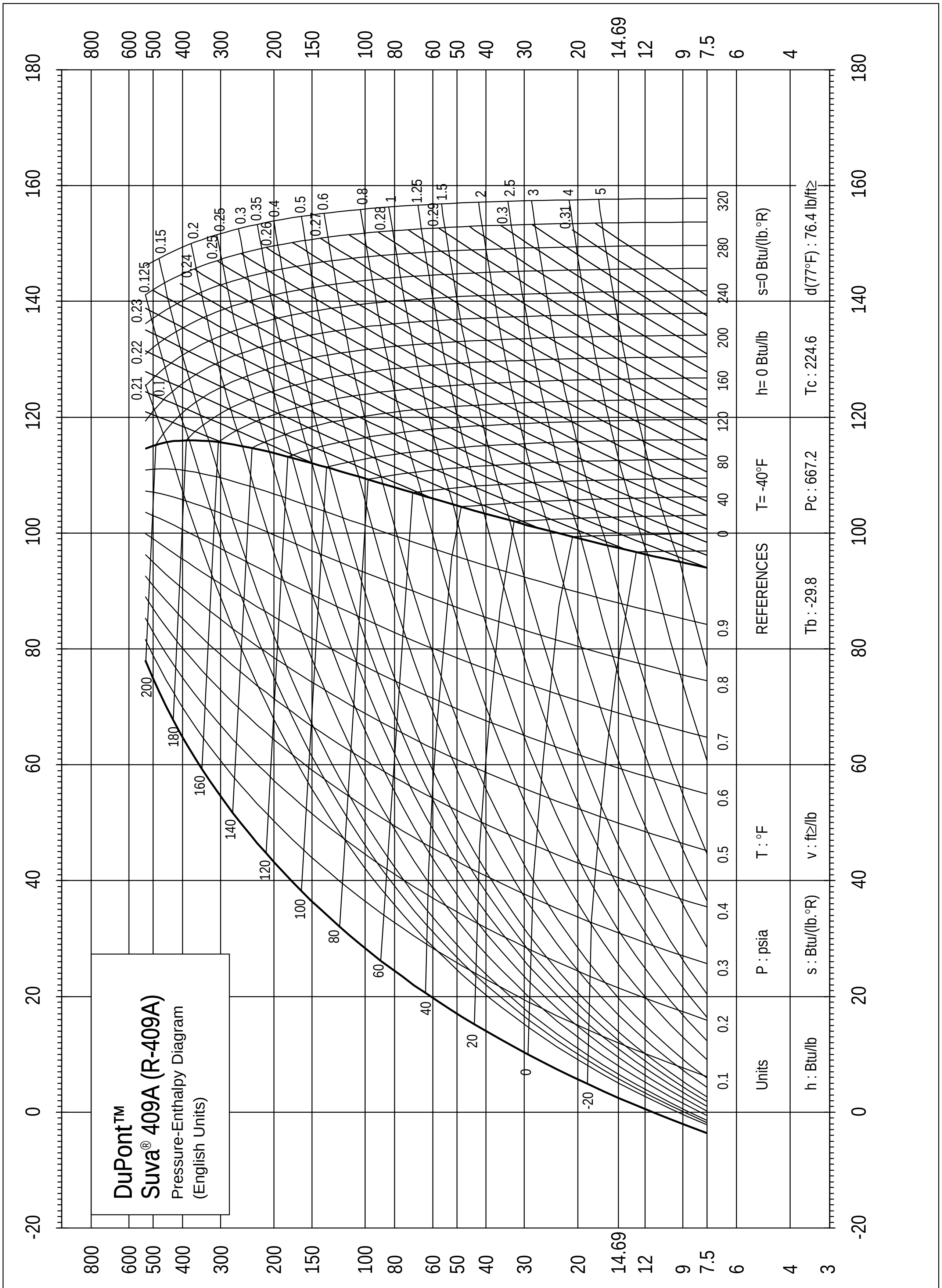


Table 6
Stability of DuPont™ Suva® Refrigerant Blends with Metals and Lubricants

Lubricant	Mineral Oil	Mineral Oil	Zerol 150DL	Zerol 300	Zerol 500T	Castrol Icematic SW22	Castrol Icematic SW32	Castrol Icematic SW68	Castrol Icematic SW100	Mobil EAL Arctic 68	Emery ISO10 Refrigeration Lubricant	Emery ISO100 Refrigeration Lubricant	Lubrizol ISO 150
Lubricant Viscosity, cSt at 40°C (104°F)	31	125	35	ND	94	22	32	68	100	62	10	100	140
Refrigerant	CFC-12	CFC-12	MP39	Blend[a]	Blend[a]	Blend[b]	Blend[b]	Blend[b]	Blend[b]	Blend[b]	Blend[b]	Blend[b]	Blend[b]
Lubricant Miscibility Range[c] 90% Refrigerant/10% Lubricant	–50 to 93°C (–58 to 199°F)	–50 to 93°C (–58 to 199°F)	–40 to 85°C (–40 to 185°F)	ND	–10 to 93°C (14 to 199°F)	–50 to 93°C (–58 to 199°F)	–50 to 93°C (–58 to 199°F)	–50 to 93°C (–58 to 199°F)	–50 to 93°C (–58 to 199°F)	–50 to 93°C (–58 to 199°F)	ND	–50 to 93°C (–58 to 199°F)	ND
Thermal Stability Ratings													
Neat Lubricant	ND	ND	2, P	0	0	0	0	0	0	0	0	0	0
Lubricant/Refrigerant[d]	—	—	2, P	0	0	0	0	0	0	2	0	0	1, D
Copper	—	—	2, T	0	0	0	1	0	0	0	0	0	1, D
Iron	—	—	0, T	0	0	3	3	0	0	2, T, CP	3, T, CP	1, T	1, D, CP
Aluminum	—	—	0	0	0	0	2	0	0	0	0	0	0
% Viscosity Change of Neat Lubricant	ND	ND	ND	ND	ND	2.3	5.0	0.8	4.4	–2.0	1.3	0.1	ND
Decomposition Analysis													
Fluoride, ppm	ND	420	ND	10	10	80	60	<7	<7	113	ND	13	57
Chloride, ppm	ND	ND	ND	<10	<10	286	286	<7	<7	340	ND	7	57

ND = Not determined

[a]Representative refrigerant blend of HCFC-22/HFC-152a/HCFC-124 (36/24/40).

[b]Representative refrigerant blend of HCFC-22/HFC-152a/HCFC-124 (33/15/52).

[c]Miscibility was tested in a sealed glass tube in the temperature range of –50 to 93°C (–58 to 199°F).

[d]Lubricant/refrigerant mixtures were all 50/50 ratios for sealed tube testing.

Field experience shows similar compatibility for Suva® 409A.

Stability Ratings
0 = Best
5 = Worst

Visual Ratings Key
P = Precipitate present
CP = Copper plating
T = Tarnish
D = Dark-colored liquid

Table 7
Compatibility of DuPont™ Suva® MP39 and DuPont™ Suva® MP66 with Selected Elastomers

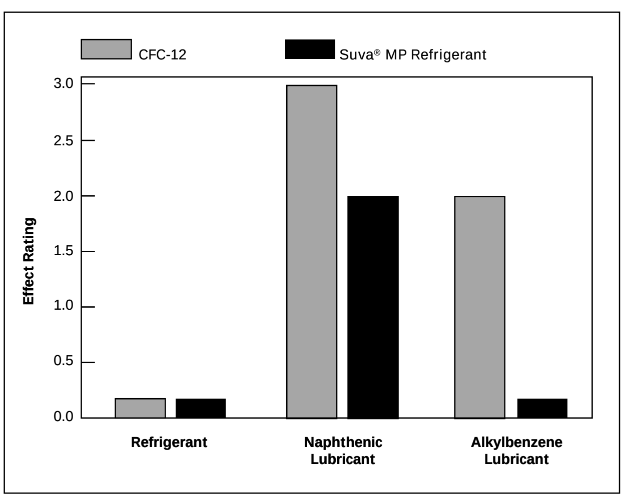
	Refrigerant/Lubricant (50/50%)			Refrigerant Only			Lubricant Only		
	Rating	Linear Swell, %	Δ Shore A Hardness	Ratinga	Linear Swell, %	Δ Shore A Hardness	Rating	Linear Swell, %	Δ Shore A Hardness
Natural Rubber	2	+48	–28	0 (2)	+5	–8	2	+56	–34[b]
Butyl Rubber	2	+20	–30	0 (0)	+1	–2	2	+30	–40
Nordel® EPDM	2	+19	–19	0 (0)	<–1	–6	2	+31	–19
Neoprene W	0	+7	–3	1 (0)	<+1	–14	0	+7	–9
SBR	2	+22	–55[b]	1 (1)	+2	–15	2	+26	–46[b]
NBR Nitrile	1	+9	–15	2 (0)	+16	–6[c]	0	<–1	0
Hypalon® 48	0	+3	–6	0 (0)	<+1	–1	0	+3	–1
Viton®	2	+12	–11	2 (1)	+17	–33	0	–1	1
Silicone	2	+48	–27	2 (2)	+31	–14	2	+27	–29
Adiprene® Urethane	1	+11	–5	2 (2)	+29	–24	0	<+1	1
Polysulfide Rubber	2	+12	–21	0 (0)	+2	–7	2	+13	–12

[a] Ratings in ( ) are those of CFC-12; for comparisons.
[b] Gross loss of tensile strength (elastomer broke when stretched).
[c] Rating reflects Ð Shore A hardness of –21 (at 25°C [77°F]) and –11 (at 140°C [284°F]).

Notes:
Refrigerant Composition: 22/152a/124 (36/24/40%)
Lubricant: Zerol 500 (an alkyl benzene lubricant)
Ratings based on sealed tube tests at 80°C (176°F) for 4 weeks.

		Linear Swell, %		Δ Shore A Hardness
Ratings:	0 = Compatible	-10	and	-10
	1 = Borderline	>10	or	>10
	2 = Incompatible	>10	and	>10

Figure 7. Hermetic Motor Insulation Compatibility Test Conducted at 121°C (250°F) for 30 Days



Note: Suva® Refrigerant Composition: 22/152a/124 (36/24/40 wt%)

Table 8
Glossary of Elastomers

Common Name	Chemical Description	Supplier Company Trade Name
Natural Rubber	Polyisoprene	
Butyl Rubber	Isobutylene/isoprene copolymer	
EPDM	Ethylene/propylene/side-chain diene monomer terpolymer	DuPont Dow Elastomers Nordel®
Neoprene; Chloroprene	Polychloroprene	DuPont Dow Elastomers
Buna-S (Styrene) Rubber	Styrene (25%)/butadiene copolymer	
Buna-N (Nitrile) Rubber	Acrylonitrile/butadiene copolymer	Polysar Krynac®
HNBR	Hydrogenated Nitrile-butadiene rubber	Polysar Tornac®
Hypalon®	Chlorosulfonated polyethylene	DuPont Dow Elastomers Hypalon®
Viton®	Vinylidene fluoride/hexafluoropropylene copolymer	DuPont Dow Elastomers Viton®
Silicone	Poly(dimethyl siloxane)	Dow Corning Silastic®
Epichlorohydrin Homopolymer	Polyepichlorohydrin	B. F. Goodrich Hydrin®
Epichlorohydrin Copolymer	Epichlorohydrin/ethylene oxide copolymer	B. F. Goodrich Hydrin®
Urethane	Reaction product of diisocyanates and polyalkylene ether glycols	DuPont Company Adiprene®
Polysulfide Rubber	Organic polysulfide	Thiokol FA®

Hose Permeation

Tests have been run comparing hose permeation rates of CFC-12, HFC-134a, and a Suva® refrigerant blend through both nylon-lined and nitrile (all rubber) hoses, as shown in **Table 9**. Permeation rates of a Suva® MP blend are much higher than those of CFC-12 or HFC-134a. More importantly, the permeation rates of the Suva® blend through nylon-lined hose are reduced by a factor of 8. For this reason, nylon-lined hose is recommended for use with Suva® blends.

Table 9
Permeation Rates of CFC-12, HFC-134a, and DuPont™ Suva® Blend Through Nylon-Lined and Nitrile Hoses (at 80°C [176°F])*

	Permeation Rates, g/cm2·y (lb/ft2·y) Nylon-Lined	Nitrile
CFC-12	0.7 (1.5)	3.7 (7.5)
HFC-134a	0.8 (1.6)	6.8 (14.0)
Suva® MP Blend	4.3 (8.7)	24.4 (50.0)

*Data supplied by Goodyear

Note: These tests are for comparison purposes only. Actual permeation will be less. Suva® refrigerant blend is HCFC-22/HFC-152a/HCFC-124 (33/15/52).

Safety

Users must have and understand the applicable Material Data Safety Sheets (MSDSs).

Inhalation Toxicity

The Suva® refrigerant blends pose no acute or chronic hazard when they are handled in accordance with DuPont recommendations and when exposures are maintained at or below recommended exposure limits, such as the DuPont Acceptable Exposure Limit (AEL) of 1,000 ppm for Suva® MP39, MP66, and 409A.

An AEL is an acceptable exposure limit established by DuPont. AELs specify a time-weighted average (TWA) airborne concentration for which nearly all workers may be repeatedly exposed without adverse effects during an 8- or 12-hour day or 40-hour work week. In practice, short-term exposures should not exceed three times the established exposure limit (AEL, PEL, TLV, or other index) published by the manufacturer, or 1,250 ppm, **whichever is lower**. Repeated exposure to refrigerant vapors at levels above manufacturers' recommended limits can cause adverse health effects, and must be avoided.

Inhaling high concentrations of Suva® refrigerant vapor may cause temporary central nervous system depression with narcosis, lethargy, and anesthetic effects. Other effects that may occur include dizziness, a feeling of intoxication, and a loss of coordination. Continued breathing of high concentrations of Suva® refrigerant vapors may produce cardiac irregularities (cardiac sensitization), unconsciousness, and with gross overexposure, death. If you experience any of the initial symptoms, move to fresh air and seek medical attention.

Cardiac Sensitization

An effect that occurs with most hydrocarbons and halocarbons at high concentrations is that the human heart can become sensitized to adrenalin, leading to cardiac irregularities and even cardiac arrest. The likelihood of these cardiac problems increases if you are under physical or emotional stress. Suva® refrigerants can cause these responses well above the AEL, but the effect level varies with people and has not been fully determined.

If you are exposed to very high concentrations of Suva® refrigerants, move immediately from the area and seek medical attention as a precaution. DO NOT attempt to remain in the area to fix a leak or perform other duties—the effects of overexposure can be very sudden.

Medical attention must be given immediately if someone is having symptoms of overexposure to any refrigerant. DO NOT treat the patient with drugs such as epinephrine, because these drugs could increase the risk of cardiac problems. If the person is having trouble breathing, administer oxygen. If breathing has stopped, give artificial respiration immediately.

Spills or Leaks

If a large release of vapor occurs, such as from a large spill or leak, the vapors may concentrate near the floor or low spots and displace the oxygen available for breathing, causing suffocation. When a large spill or leak occurs, always wear appropriate respiratory and other personal protective equipment. Evacuate *everyone* until the area has been ventilated. Use blowers or fans to circulate the air at floor level. Do not reenter the affected area, unless you are equipped with a self-contained breathing apparatus.

Always use a supplied air mask when entering tanks or other areas where vapor concentration might exist. Use the buddy system *and* a lifeline. Refer to the Suva® refrigerant MSDS for more information.

Some Suva® refrigerants have a slightly sweet odor that can be difficult to detect. Therefore, frequent leak checks and the installation of permanent leak detectors may be necessary for enclosed areas used by personnel.

To ensure safety when working with Suva® refrigerants, first, route relief and purge vent piping outdoors, away from air intakes. Second, make certain the area is well ventilated, using auxiliary ventilation if necessary to move refrigerant vapors. Third, make sure the area is clear of vapors prior to beginning work. And, finally, install air monitoring equipment to detect leaks.

Skin and Eye Contact

Always wear protective clothing when there is a risk of exposure to liquid refrigerants. Where splashing is possible, *always* wear eye protection and a face shield. If your eyes are splashed, flush them with plenty of water (see the MSDS). In liquid form, Suva® refrigerants can freeze skin on contact, causing frostbite.

Following contact, soak the exposed area in *lukewarm* water, *not* cold or hot.

If treatment cannot begin immediately, apply a light coat of a nonmedicated ointment, such as petroleum jelly. If the exposed area is in a location where the presence of the ointment would be awkward, such as on the eye, apply a light bandage.

In *all* cases of frostbite, seek medical attention as soon as possible.

Nonflammability of Suva® Refrigerants

Nonflammability is an essential requirement for refrigeration and air conditioning applications. The Suva® refrigerant blends are formulated so that they are nonflammable and will not reach a flammable composition during leakage from equipment. In addition, these Suva® refrigerants have been extensively tested for flammability by Underwriters Laboratories, Inc. (USA), and have been added to their list of recognized refrigerants with a "practically nonflammable" rating (same as HCFC-22).

Combustibility of Suva® MP39, MP66 and 409A

Suva® MP39, MP66 and 409A are not flammable in air at temperatures up to 100°C (212°F) at atmospheric pressure. However, mixtures of MP39, MP66 or 409A with high concentrations of air at elevated pressure and/or temperature can become combustible in the presence of an ignition source. MP39, MP66 or 409A can also become combustible in an oxygen enriched environment (oxygen concentrations greater than that in air). Whether a mixture containing MP39, MP66 or 409A and air, or MP39, MP66 or 409A in an oxygen enriched atmosphere becomes combustible depends on the inter-relationship of 1) the temperature 2) the pressure, and 3) the proportion of oxygen in the mixture. In general, MP39, MP66 or 409A should not be allowed to exist with air above atmospheric pressure or at high temperatures; or in an oxygen enriched environment. **For example: MP39, MP66 or 409A should NOT be mixed with air under pressure for leak testing or other purposes.**

Refrigerants should not be exposed to open flames or electrical heating elements. High temperatures and flames can cause the refrigerants to decompose, releasing toxic and irritating fumes. In addition, a torch flame can become dramatically larger or change color if used in high concentrations of many refrigerants including R-500 or R-22, as well as many alternative refrigerants. This flame enhancement can cause surprise or even injury. Always recover refrigerants, evacuate equipment, and ventilate work areas properly before using any open flames.

Based on the above information, the following operating practices are recommended.

- **Do Not Mix With Air For Leak Testing**
  - Equipment should **never** be leak tested with a pressurized mixture of MP39, MP66 or 409A and air. Pressurized mixtures of dry nitrogen and MP39, MP66 or 409A can be used for leak testing.
- **Filling and Charging Operations**
  - Before evacuating cylinders or refrigeration equipment, any remaining refrigerant should be removed by a recovery system.
  - Vacuum pump discharge lines should be free of restrictions that could increase discharge pressures and result in the formation of combustible mixtures.
  - Cylinders or refrigeration equipment should be evacuated at the start of filling, and should never be filled while under positive air pressure.
  - Filled cylinders should periodically be analyzed for air (nonabsorbable gas or NAG).
- **Refrigerant Recovery Systems**

  Efficient recovery of refrigerant from equipment or containers requires evacuation at the end of the recovery cycle. Suction lines to a recovery compressor should be periodically checked for leaks to prevent compressing air into the recovery cylinder during evacuation. In addition, the recovery cylinder pressure should be monitored, and evacuation stopped in the event of a rapid pressure rise indicating the presence of air. The recovery cylinder contents should then be analyzed for NAG, and the recovery system leak checked if air is present. Do not continue to evacuate a refrigeration system that has a major leak.
- **Combustibility With Chlorine**

  Experimental data have also been reported which indicate combustibility of HCFC-22 (a component of these blends) in the presence of chlorine.

Monitors and Leak Detection

Service personnel have used leak detection equipment for years when servicing equipment. Leak detectors exist not only for pinpointing specific leaks, but also for monitoring an entire room on a continual basis. There are several reasons for leak pinpointing or area monitoring, including: conservation of refrigerants, protection of valuable equipment, reduction of fugitive emissions, and protection of employees. American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE) Standard 15 requires air monitors in refrigeration machinery rooms as defined in the Standard. In conformance with the Standard, an air monitor capable of measuring 0–1500 ppm of the refrigerant *may* be required for indoor installations. The user should check ASHRAE Standard 15 to determine what is required for the particular application.

Leak detectors can be placed into two broad categories: leak pinpointers and area monitors. Before purchasing a monitor or pinpointer, several instrumental criteria should be considered, including: sensitivity, detection limits, and selectivity.

Types of Detectors

Using selectivity as a criteria, leak detectors can be placed into one of three categories: nonselective, halogen-selective, or compound-specific. In general, as the specificity of the monitor increases, so does the complexity and cost. Another method used to find leaks is to add fluorescent additives to the system.

A detailed discussion of leak detection, along with a list of manufacturers of leak detection equipment, is given in Bulletin ARTD-27.

Nonselective Detectors

Nonselective detectors are those that will detect any type of emission or vapor present, regardless of its chemical composition. These detectors are typically quite simple to use, very durable, inexpensive, and almost always portable. However, their inability to be calibrated, long-term drift, lack of selectivity, and lack of sensitivity limit their use for area monitoring. Some detectors currently available on the market are not sensitive enough for use with Suva® blend compositions.

Halogen-Selective Detectors

Halogen-selective detectors use a specialized sensor that allows the monitor to detect compounds containing fluorine, chlorine, bromine, and iodine without interference from other species. The major advantage of such a detector is a reduction in the number of "nuisance alarms"—false alarms caused by the presence of some compound in the area other than the target compound.

These detectors are typically easy to use, feature higher sensitivity than the nonselective detectors (detection limits are typically <5 ppm when used as an area monitor and <0.05 oz/yr when used as a leak pinpointer), and are very durable. In addition, due to the partial specificity of the detector, these instruments can be calibrated easily. Contact the manufacturers of leak detectors for their current models.

Compound-Specific Detectors

The most complex detectors, which are also the most expensive, are compound-specific detectors. These units are typically capable of detecting the presence of a single species, without interference from other compounds.

Fluoroescent Dyes

Fluorescent dyes have been used in refrigeration systems for several years. These dyes, invisible under ordinary lighting but visible under ultraviolet (UV) light, are used to pinpoint leaks in systems. The dyes are typically placed into the refrigeration lubricant when the system is serviced. Leaks are detected by using a UV light to search for dye that has escaped from the system.

Recent innovations in dye technology have allowed fluorescent dyes to be used with some fluorocarbon refrigerants. However, before adding dyes to a system, the compatibility of the specific dye with the lubricant and refrigerant should be tested.

Storage and Handling

Shipping Containers in U.S.

Suva® refrigerant blends are liquefied compressed gases. According to the U.S. Department of Transportation (DOT), a nonflammable compressed gas is defined as a nonflammable material having an absolute pressure greater than 40 psi at 21°C (70°F) and/or an absolute pressure greater than 104 psi at 54°C (130°F).

The appropriate DOT designations are as follows:

Proper shipping name: Liquefied Gas, N.O.S. (contains chlorodifluoromethane and chlorotetrafluoroethane)

Hazard class: 2.2

UN no.: 3163

Three different types of containers can be used to ship Suva® refrigerants; their water capacity, dimensions, and DOT specifications are provided in **Table 10**. All pressure relief devices used on the containers must be in compliance with the corresponding Compressed Gas Association (CGA) Standards for compressed gas cylinders, cargo, and portable tanks.

Table 10
Specifications of Shipping Containers for DuPont™ Suva® Refrigerants

Water Capacity	Dimensions	DOT Specification
30 lb Dispos-A-Can®	10 x 10 x 17 in (box)	39
125 lb	55 in H x 10 in OD	4BA300
1700 lb ton	82 in L x 30 in OD	110A500W

Table 11
Color Codes and Fill Weights for DuPont™ Suva® Refrigerant Blends

Refrigerant	Color	PMS No.	Net Weight (lb) Refrigerant 30-lb Water Capacity	125-lb Water Capacity	Ton Cylinder
Suva® MP39 (R-401A)	Coral Red	177	30	125	1700
Suva® MP66 (R-401B)	Yellow Brown (Mustard)	124	30	125	1700
Suva® 409A (R-409A)	Tan	465	30	125	1700

The 30-lb cylinder, known as a Dispos-A-Can® (DAC), fits into a box that measures 10 x 10 x 17 in. Review information on box to determine the proper orientation of the cylinder to remove liquid or vapor. Dispos-A-Can® is DuPont's registered trademark for this type of single-use container.

The 125-lb cylinders are equipped with a nonrefillable liquid vapor CGA-660 valve. With this two-way valve, Suva® refrigerant blends can be removed from the cylinder as either a vapor or as a liquid, without inverting the cylinder. The vapor handwheel is located on the top. The liquid wheel is on the side of the valve and attached to a dip tube extending to the bottom of the cylinder. Each is clearly identified as vapor or liquid.

The 30- and 125-lb cylinders designed for Suva® blends use have the colors and weight/container as provided in **Table 11**.

The general construction of a one-ton returnable container is shown in **Figure 8.** Notice that one end of the container is fitted with two valves. When the container is turned so that the valves are lined up vertically, the top valve will discharge vapor and the bottom valve will discharge liquid. The valves are protected by a dome cover.

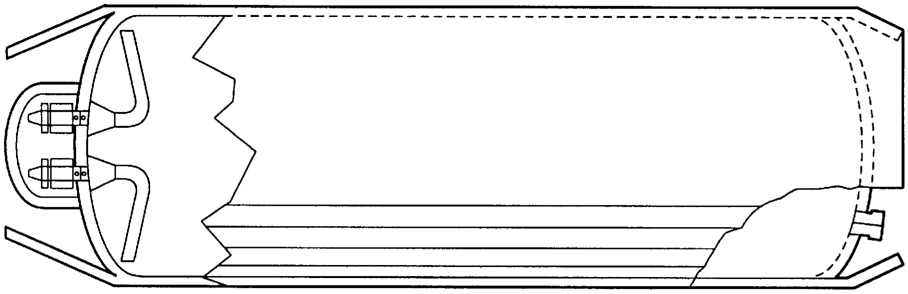
Ton containers are equipped with two fusible plugs in each end. The fusible metal in the plugs is designed to start melting at 69°C (157°F) and completely melt at 74°C (165°F). Containers should never be heated to temperatures higher than 52°C (125°F). One spring-loaded pressure relief valve is also located in each end of the ton container.

Handling Precautions for Suva® Refrigerants Shipping Containers

The following rules for handling Suva® refrigerants containers are strongly recommended:

- Use personal protective equipment, such as side shield glasses, gloves, and safety shoes when handling containers.
- Avoid skin contact with refrigerant liquid or vapor, because it may cause frostbite.
- Never heat a container to a temperature higher than 52°C (125°F).
- Never apply direct flame or live steam to a container or valve.
- Never refill disposable cylinders with anything. The shipment of refilled disposable cylinders is prohibited by DOT regulations.
- Never refill returnable cylinders without DuPont consent. DOT regulations forbid transportation of returnable cylinders refilled without DuPont's authorization.
- Never use a lifting magnet or sling (rope or chain) when handling containers. A crane may be used when a safe cradle or platform is used to hold the container.
- Never use containers for rollers, supports, or any purpose other than to carry refrigerant.
- Protect containers from any object that will result in a cut or other abrasion in the surface of the metal.
- Never tamper with the safety devices in the valves or containers.
- Never attempt to repair or alter containers or valves.
- Never force connections that do not fit. Make sure the threads on the regulators or other auxiliary equipment are the same as those on the container valve outlet.
- Keep valves tightly closed and valve caps and hoods in place when the containers are not in use.
- Store containers under a roof to protect them from weather extremes.
- Use a vapor recovery system to collect refrigerant vapors from lines after unloading a container.

Figure 8. One-Ton Returnable Container



Responsible Use

Responsible use of Suva® refrigerants requires that the product be recovered for reuse or disposal whenever possible. DuPont purchases used refrigerants for reclamation through its distributor networks in the United States, Canada, and Europe. In the United States, used Suva® refrigerants are accepted as part of this program. Recovery and reuse of Suva® refrigerants makes sense from an environmental and economic standpoint. In addition, the U.S. Clean Air Act prohibits known venting of CFC, HCFC, and HFC refrigerants during the maintenance, servicing, or disposal of refrigeration equipment.

Recovery

Recovery refers to the removal of Suva® refrigerants from equipment and collection in an approved recovery cylinder. As defined by the Air Conditioning and Refrigeration Institute (ARI), a U.S. organization, recovery does not involve processing or analytical testing. Suva® refrigerants may be recovered from refrigeration equipment using permanent on-site equipment or one of the portable recovery devices now on the market. The portable devices contain a small compressor and an air cooled condenser and may be used for vapor or liquid recovery. At the end of the recovery cycle, the system is evacuated to remove vapors. In the United States, the Environmental Protection Agency (EPA) sets standards for recovery equipment. Before purchasing a specific recovery unit, check with the manufacturer to be sure that it contains elastomeric seals and a compressor oil compatible with the refrigerants you are recovering.

Reclamation

Reclamation refers to the reprocessing of used Suva® refrigerants to new product specifications. Quality of reclaimed product is verified by chemical analysis. Contact DuPont or one of its authorized distributors for further information.

Reclamation offers advantages over on-site refrigerant recycling procedures, because these systems cannot guarantee complete removal of contaminants. Putting refrigerants that do not meet new product specifications back into expensive equipment may cause damage.

Recycle

Refrigerant recycle refers to the reduction of used refrigerant contaminants using devices that reduce oil, water, acidity, and particulates. Recycle is usually a field or shop procedure with no analytical testing of refrigerant. Suva® refrigerants may be recycled using many of the devices now available, providing that the entire charge is removed from the refrigeration equipment and recycled. If you routinely recycle Suva® refrigerants through several cycles, we recommend that you have the composition of the refrigerant checked periodically. This will prevent loss of performance, in the unlikely event that the composition has shifted.

In the United States, the EPA sets standards for recycle equipment. Consult with the manufacturer before specifying a recycle device for any refrigerant.

Disposal

Disposal refers to the destruction of used Suva® refrigerants. Disposal may be necessary when Suva® refrigerants have become badly contaminated with other products and no longer meet the accept-ance specifications of DuPont or other reclaimers. Although DuPont does not presently accept severely contaminated refrigerants for disposal, licensed waste disposal firms are available. Be sure to check the qualifications of any firm before sending them used Suva® refrigerants.

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