PRAXAIR

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MATERIALS COMPATIBILITY CONSIDERATIONS FOR SPECIALTY PRODUCTS AND PACKAGED GAS COMPONENTS AND SYSTEMS

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NOTE: ITALIC PORTIONS OF THIS TEXT ARE DESIGN SAFETY RELATED IN ACCORDANCE WITH PRAXAIR STANDARD SA-5.

8.0 COMPATIBILITY DATA

8.1 General

The Compatibility Data Tables in Appendices A, Metals, B, Plastics, and C, Elastomers and Lubricants, assist in evaluating the appropriate materials to use in handling various gases. *It is extremely important that all gas control equipment be compatible with the gas being passed through it.* The use of a device that is not compatible with the gas being used may damage the unit and cause a leak that could result in property damage or personal injury. *To reduce potentially dangerous situations, always check for compatibility of materials before using any gases in your gas control equipment.*

Combinations of gases are virtually unlimited, mixtures (except for Oxyfume and Carboxide sterilizing gas mixtures) are not listed in the Compatibility Data Tables. *Before using a gas mixture or any gas not listed in the chart, contact the Praxair Specialty Products and Packaged Gases Operations Technology Department, Tonawanda, NY.*

These tables have been prepared for use with dry (anhydrous) gases at normal operating temperature of 21°C. Information may vary if different operating conditions exist. Systems used in oxidizer gas service (oxygen or nitrous oxide) shall be cleaned for oxidizer service.

8.2 Directions for Use

- *Select table for either Metals, Plastics, or Elastomers and Lubricants.*
- *Locate the gas of interest in the first column.*
- *Find the symbol shown on the table under the material of interest for that gas.*
- *Determine compatibility using the appropriate Keys to Material Compatibility.*

8.3 Keys to Material Compatibility

The symbols used in the material Compatibility Data Tables indicate whether a material is satisfactory (S), unsatisfactory (U), or conditionally acceptable for use with the intended gas (various symbols).

Two keys to the material compatibility symbols exist. One key is for metals. The other key is for nonmetallics and applies to both of the other tables.

8.3.1 Key to Materials Compatibility Data for Metals

- Basic

Symbol	Meaning
I	Insufficient information.

Symbol	Meaning
S	Satisfactory for use with the intended gas.
U	Unsatisfactory for use with the intended gas.

• Conditional

Symbol	Meaning
C	The sustained load cracking behavior of certain aluminum cylinder alloys may limit their use in certain corrosive, flammable and toxic services.
C1	Satisfactory with brass having a low (65-70% maximum) copper content. Brass with higher copper is unacceptable due to potential formation of acetylides.
C2	Ammonia may promote stress corrosion cracking if contaminated with air. Certain ammonia grades may have water additions of up to 0.2% to inhibit stress corrosion cracking.
C3	Generally unsatisfactory, except where specific use conditions have proven acceptable.
C4	Due to hydrogen embrittlement concerns, the ultimate tensile strength shall not exceed 950 MPa. A maximum tensile strength in the range of 862 to 897 MPa is strongly recommended.
C5	Aluminum-halocarbon reactions have been known to occur. Approach on a case-by-case basis.
C6	Gas mixtures containing both CO and CO_2 may cause stress corrosion cracking when condensed water is present. Recommend maximum water content of 5-20 ppm. COS mixtures containing CO_2 may cause stress corrosion cracking.
C7	Satisfactory with brass except where acetylene or acetylides are present.
C8	Nickel and certain nickel alloys may be subject to hydrogen embrittlement. Approach on a case by case basis.
C9	Special bronze alloys such as aluminum bronzes have been used in valve applications.

Symbol	Meaning
C10	May require limitations on materials depending upon impurity level of natural gas, specifically H_2S level. See NACE guidelines.
C11	Satisfactory below 6.9 MPa.
C12	These materials may be ignitable in oxygen enriched environments. Successful usage upon considerations such as oxygen purity, pressure, velocity, temperature, system cleanliness and presence of potential ignition mechanisms. See relevant Praxair Standards.
C13	Generally satisfactory; however certain aluminum brasses or bronzes may be flammable in high-pressure oxygen. See EN-6.
C14	Nickel carbonyl formation may occur. Metal loss noted in CO-H_2 mixture under certain conditions.
C15	System must be thoroughly cleaned, degreased, dried and passivated before being put into fluorine or highly reactive fluorine bearing gases (ClF_3, NF_3, WF_6). Materials must be compatible with fluorine. See fluorine compatibility listings.

8.3.2 Key to Material Compatibility Data for Nonmetallics (Plastics and/or Elastomers and Lubricants)

• Basic

Symbol	Meaning
S	Satisfactory for use with intended gas.
U	Unsatisfactory for use with intended gas.
I	Insufficient data available to determine compatibility with the intended gas.
O	All nonmetallics, even those though considered compatible, may be ignitable in oxygen enriched environments or in other oxidizing gases. Successful use depends upon oxygen purity, pressure, temperature, cleanliness and elimination of ignition mechanisms. System design is important. See ASTM G63 and relevant Praxair Standards.

• Conditional/supplemental

Symbol	Meaning
F	Compatibility risk due to explosion or fire hazard.
W	Compatibility risk due to weight loss.
D	Compatibility risk due to dimensional change, swelling enlargement.
M	Compatibility risk due to change in mechanical properties.
N	Compatibility risk due to normal impurities in gas.
C	Compatibility risk due to contamination of material by gas.
D/P	Compatibility risk due to release of dangerous products.
G	Compatibility risk due to gradual change in mechanical and physical properties of material in environment (aging).
P	Compatibility risk due to permeation.
E	Compatibility risk due to low temperature embrittlement.
X	Compatibility varies depending upon specific compound used. Consult vendor for information on specific applications.
Z	System shall be thoroughly cleaned, degreased, dried and passivated before being put into fluorine or highly reactive fluorine bearing gases. (ClF_3, NF_3, WF_6). Materials shall be generally compatible with fluorine. See fluorine compatibility listings.

8.4 Special Notes on Oxygen

As a consequence of its long term and widespread use, the compatibility of both metallic and nonmetallic materials with oxygen and oxygen enriched atmospheres in both direct and indirect service has been studied more thoroughly than other gases encountered in the packaged gas business. A substantial data base therefore exists for this key industrial gas.

While criteria and compatibility information cited in Sections 7.0 and 8.0 and Appendices A, B and C are very useful as brief summaries, the performance of materials in oxygen and oxygen enriched environments may well depend upon the presence of various ignition mechanisms and key oxygen parameters such as purity, pressure, temperature and diluent species. Qualified technical personnel are, therefore, advised to review the supplemental references for more in-depth information on oxygen compatibility issues if more in-depth knowledge is required.

9.0 UTILIZATION AND FUTURE DEVELOPMENT OF COMPATIBILITY GUIDE

9.1 Implementation

The compatibility data summarized in this guide shall be utilized on a worldwide basis in all Praxair International Regions that are involved in the packaged gas business. Each organization should appoint at least one individual who shall be responsible for inputs to this Standard.

9.2 Exceptions

Perusal of this guide will show situations where there are multiple choices, an absence of data, and in many cases warnings about potential or real material compatibility issues. *Exceptions to the guide shall be approved through use of the deviation form in PO-1. The results shall be forwarded to the Specialty Products and Packaged Gases Operations Technology Manager at the Praxair Technology Center, Tonawanda, New York.*

9.3 Integration of New Data

There are numerous situations in the tables where insufficient data are noted. However, this does not mean that somewhere in the world compatibility studies were not conducted or successful applications exist of various material-environmental combinations which are not reflected in this Standard. *Information which should be incorporated in this guide to correct current insufficient data listings should be forwarded to the Specialty Products and Packaged Gases Operations Technology Manager at Tonawanda, New York.*

Of particular concern is information regarding new material-environment incompatibility data which could prevent serious incidents or material misapplication. Analysis of service failures to identify or clarify potential material-environment incompatibility is encouraged.

9.4 Compatibility Guide Task Force

To provide for continuous development of this guide, a permanent Task Force with the following membership has been established:

- Specialty Products and Packaged Gases Operations Technology, Manager.
- Specialty Products and Packaged Gases Operations Technology, designated representative.
- Materials Engineering Laboratory Manager.
- Assigned delegates from all parts of Praxair.

Praxair International Regions should identify their delegates by letter to the Specialty Products and Packaged Gases Operations Technology Manager at the Praxair Technology Center, Tonawanda, New York.

APPENDIX A

COMPATIBILITY DATA TABLE FOR METALS

DOT/UN (Common) Name	Chemical Formula	Metals													
		Alum-inum	Car-bon Steel	Low Alloy Steel	Ferritic/ Marten-sitic Stn. Steel	303, 304, 304L Auste-nitic SS	316, 316L Auste-nitic SS	Copper Cupro-nickel	Brass	Bronze	Monel	Nickel (99 + % NI)	Nickel Alloys	Sol-der	Zinc
Acetylene	C2H2	C	S	S	S	S	S	U	C1	U	S	S	S	I	U
Air	—	S	S	S	S	S	S	S	S	S	S	S	S	S	S
Ammonia	NH3	C	C2	C2	S	S	S	U	U	U	S	S	S	I	U
Argon	Ar	S	S	S	S	S	S	S	S	S	S	S	S	S	S
Arsine	AsH3	C/C 3	C4	C4	C4	S	S	S	S	S	S	S	S	I	I
Boron Trichloride	BCl3	U	S	S	S	S	S	S	U	S	S	S	S	I	I
Boron Trifluoride	BF3	C3	S	S	S	S	S	S	S	S	S	S	S	I	I
Bromotrifluoromethane	C2BrF3 (R13B1)	C5	S	S	S	S	S	S	S	S	S	S	S	S	I
1,2-Butadiene	C4H6	C	S	S	S	S	S	S	S	S	S	S	S	S	S
1,3-Butadiene	C4H6	C	S	S	S	S	S	S	S	S	S	S	S	S	S
Butane	C4H10	C	S	S	S	S	S	S	S	S	S	S	S	S	S
1-Butene	C4H8	C	S	S	S	S	S	S	S	S	S	S	S	S	S
Trans-2-Butene	C4H8	C	S	S	S	S	S	S	S	S	S	S	S	S	S
Carbon Dioxide	CO2	S	C6	C6	S	S	S	S	S	S	S	S	S	S	S
Carbon Monoxide	CO	C	C6	C6	S	S	S	S	S	S	S	C14	C14	S	S
Carbon Tetrafluoride	CF4 (R-14)	C5	S	S	S	S	S	S	S	S	S	S	I	S	I
Carbonyl Sulfide	COS	C	C6	C6	S	S	S	S	S	S	S	S	S	S	I
(Carboxide) – 10% ETO, 90% CO_2	—	I	S	S	S	S	S	U	C7	I	I	I	I	I	I
Chlorine	Cl2	U	S	S	S	S	S	U	U	S	S	S	S	C3	U
Chlorodifluorobromotyethane	CBrClF2 (R13B1)	C5	S	S	S	S	S	S	S	S	S	S	S	S	I
Chlorine Trifluoride	ClF3	U	C15	C15	C15	C15	C15	C15	I	I	C15	C15	C15	U	U
1-Chloro-1,1-Difluoroethane	C2H3ClF2 (R142-B)	C5	S	S	S	S	S	S	S	S	S	S	S	S	I
Chlorodifluoromethane	CHClF2 (R-22)	C5	S	S	S	S	S	S	S	S	S	S	S	S	I
Chloropentafluoroethane	C2ClF5 (R-115)	C5	S	S	S	S	S	S	S	S	S	S	S	S	I
Chlorotetrafluoroethane	C2HClF4 (R-124)	C5	S	S	S	S	S	S	S	S	S	S	S	S	I
Chlorotrifluoroethane	C2H2ClF3 (R-133a)	C5	S	S	S	S	S	S	S	S	S	S	S	S	I