Materials of Compatibility

A. Introduction

Chlorine dioxide is quite corrosive under high concentrations, as are some of the chemicals used to produce ClO_2. A number of companies which manufacture various types of equipment have published compatibility charts for their equipment with various chemicals. For many of the compatibility charts, ClO_2 and its precursor, aqueous sodium chlorite, are not listed. When ClO_2 compatibility is listed, neither the tested concentration nor the conditions under which the testing was done are generally given. In addition, some of this compatibility information is conflicting. Therefore, the compatibility information that follows is from personal experience, eiher that of the author's or that of others intimately involved with the construction and maintenance of ClO_2 generation equipment. This list is not meant to be comprehensive, but it is meant to provide useful information about materials that are in current use as well as those that have held up under actual long-term use.

In determining the compatibility of ClO_2 with various materials, the concentration of the ClO_2 solution, the temperature at the interface, the pH of the solution, and the generation chemistry used to produce ClO_2 all need to be considered. In general, lower pH and higher temperatures typically result in substantially reduced compatibility with all materials.

B. Elastomers

NBR - Nitrile rubber, also called Buna-N, is a copolymer of butadiene and acrylonitrile.

EPDM, EPM - Ethylenepropylene rubber is an elastomer prepared from ethylene and propylene monomers. EPM is a copolymer of ethylene and propylene, while EPDM contains a small amount of a third monomer (a diene) to aid in the curing process.

FKM - FKM is a fluoroelastomer of the polymethylene type having substituent fluoro and perfluoroalkyl or perfluoroalkoxy groups on the polymer chain.

CR - CR is chloroprene, commonly know as neoprene, which is a homopolymer of chloroprene (chlorobutadiene).

NR - NR is natural rubber which is a natural polyisoprene, primarily from the tree, Hevea Brasiliensis.

FFKM - FFKM is generally a perfluoroelastomer. Perfluoro rubbers of the polymethylene type all have substituent groups on the polymer chain of fluoro, perfluoroalkyl, or perfluoroalkoxy groups. The resulting polymer has superior chemical and heat temperature resistance.

FVMQ - FVMQ is fluorosilicone rubber which should only be used for static seals because it has poor mechanical properties.

VMQ - VMQ is silicone rubber. Silicone rubber can be designated MQ, PMQ, and PVMQ. The Q designates any rubber with silicon and oxygen in the polymer chain, and the M, P, and V represent methyl, phenyl, and vinyl substituent groups on the polymer chain. This elastomer is used only for static seals due to its poor mechanical properties.

PTFE – PTFE is polytetrafluoroethylene. Known by its trade name, TEFLON®, it is unaffected by nearly all chemicals.

PVDF – PVDF is polyvinylidene fluoride, a high molecular weight thermoplastic polymer with excellent chemical inertness. It is highly resistant to oxidizing agents and halogens and is almost completely resistant to aliphatic, aromatics, alcohols, and chlorinated solvents as well as to most acids and bases.

FRP – FRP is a fiberglass-reinforced plastic. For the purposes of this text, the FRP mentioned here should include Hetron 22 or equivalent (Food grade additives are available.), natural color, and UV protection.

Table 11-1. Common Elastomers

Abbreviation	Chemical Designation or Trade Name
FKM	Fluorelastomer (VITON®)
FFKM	Perfluoroelastomer (KALREZ®)
FFKM	Perfluoroelastomer (CHEMRAZ®)
EPDM	Ethylene Propylene (NORDEL®)
CSM	HYPALON® (Synthetic Rubber)
CR	Neoprene
VMQ	Silicone
NBR	Buna N (NITRILE)
NR	Natural Rubber
PTFE	Polytetrafluoroethylene (TEFLON®)

Table 11-2. Elastomer Compatibility with Various Chemicals

Chemical Elastomer	NaOCl	$NaClO_2$	HCl	H_2SO_4	Citric Acid	ClO_2
VITON® (FKM)*	1	3	3	0	4	2
KALREZ® (FFKM)	4	4	4	4	4	4
CHEMRAZ® (FFKM)	4	4	4	4	4	4
NORDEL® (EPDM)	1	2	2	0	4	1
HYPALON® (CSM)	4	2	1	0	4	1
TEFLON® (PTFE)	**	**	**	**	**	**
Neoprene (CR)	1	1	1	0	3	1
Silicone (VMQ)	1	1	1	0	4	3
Nitrile (NBR)	2	1	1	1	4	1
Natural Rubber (NR)	1	1	1	0	4	1

Key

0 No Data
1 Poor
2 Sometimes acceptable for use as static seals; unacceptable for use as dynamic seals
3 Fair, usually acceptable for use as static seals
4 Good for use as both static and dynamic seals

* There appears to be significant variability in the chemical resistance of FKM elastomers, as FKM "O"-rings from some suppliers is more chemical resistant than others [Martens 2005]. In addition, some FKM elastomers contain varying amounts of carbon, which make the seal black. In general, the greater the amount of carbon (i.e., the darker the color), the lower the compatibility with various chemicals.

** TEFLON®, though very good from a chemical compatibility standpoint, has some physical properties that must be taken into account when considering this material for use as a seal. The actual application should be discussed with a seal expert prior to its selection.

C. Piping and Tubing

CPVC - Chlorinated polyvinylchloride is a thermoplastic pipe and fitting material that is exceptionally chemically inert and is compatible with most acids, bases, and oxidants.

PP - Polypropylene is a thermoplastic polymer used in a wide variety of applications. Polypropylene is unusually resistant to many chemical solvents, bases, and acids.

PVC - Polyvinyl chloride is either a flexible or rigid material that is chemically nonreactive. There are three broad classifications for rigid PVC compounds: Type I, Type II, and CPVC. Type II varies from Type I due to greater impact values but lower chemical resistance. CPVC has greater high-temperature resistance. These materials are considered "unplasticized" because they are less flexible than the plasticized formulations. Schedule 80 PVC has a thicker wall than schedule 40 and therefore has a higher pressure limit.

Table 11-3. Common Plastics

Abbreviation	Chemical Designation
PVC	Polyvinyl chloride
CPVC	Chlorinated polyvinyl chloride
PP	Polypropylene
PVDF	Polyvinylidene fluoride
PTFE	Polytetrafluoroethylene

Table 11-4. Piping Materials Compatibility with Various Chemicals

Chemical Material	NaOCl	$NaClO_2$	HCl	H_2SO_4	Citric Acid	ClO_2
CPVC	3	3	3	3	3	3
PP (Polypropylene)	1	2	2	2	2	2
Sch 80 PVC Type I	2	2	2	2	2	2
KYNAR® (PVDF)	3	3	3	3	3	3
TEFLON® (PTFE)	3	3	3	3	3	3

Key

0	No Data
1	Not Recommended
2	Acceptable
3	Recommended

D. Metals

Stainless 304 - 304 stainless is the most versatile and most widely used stainless steel. Grade 304 has the composition shown in Table 11-5. Grade 304L is the low-carbon (0.03%) version of 304. Grade 304H has higher carbon content (0.10 wt% max) and can be used at elevated temperatures.

Stainless 316 - Grade 316 differs from 304 in that it contains molybdenum, which gives 316 higher resistance to pitting and crevice corrosion in chloride environments. 316L is the low-carbon version (0.03 wt% max), and 316H is the higher carbon version (0.10 wt% max).

Hastelloy – Hastelloy is a nickel alloy containing large amounts of chromium, molybdenum, and tungsten and has good resistance to both uniform and localized corrosion as well as to a variety of mixed industrial chemicals.

Titanium - Titanium minerals are quite common. The metal is easily fabricated has low density, good strength, and excellent corrosion resistance.

Table 11-5. Composition for Stainless

Grade		C	Mn	Si	P	S	Cr	Mo	Ni	N
304	min.	-	-	-	-	-	18.0	-	8.0	-
	max.	0.08	2.0	0.75	0.045	0.030	20.0	-	10.5	0.10
316	min.	-	-	-	-	-	18.0	2.00	8.0	-
	max.	0.08	2.0	0.75	0.045	0.030	20.0	3.00	10.5	0.10

Table 11-6. Typical Composition for Hastelloy

Grade	W	C	Mn	Si	Fe	Co	Cr	Mo	Ni	V
Hastelloy	3 4.5	0.01	1.0	0.08	4–7	2.5	14.5 16.5	15 17	bal.	0.35

Table 11-7. Metals Compatibility

Chemical Material	NaOCl	$NaClO_2$	HCl	H_2SO_4	Citric Acid	ClO_2
Stainless 304	1	1	1	1	2	1
Stainless 316	1	1	1	1	2	1
Titanium	3	3	3	3	3	2
Hastelloy	3	3	3	3	3	2

Key

0 No Data
1 Not Recommended
2 Acceptable
3 Recommended

E. Tank Specifications

Table 11-8. Tank Specifications

Chemical Material	NaOCl	$NaClO_2$	HCl	H_2SO_4	Citric	ClO_2
Stainless 316	1	1	1	1	3	1
Polypropylene	1	1	2	2	3	1
HDPE (crosslinked)	3	3	3	3	3	1
FRP	0	3	0	0	0	3
Titanium	3	3	3	3	3	3

Key

0 No Data
1 Not Recommended
2 Acceptable
3 Recommended

F. Pump Specifications – Wetted Parts

Table 11-9. Pump Specifications – Wetted Parts						
Chemical Material	**NaOCl**	**$NaClO_2$**	**HCl**	**H_2SO_4**	**Citric**	**ClO_2**
Stainless 316	1	1	1	1	3	1
Titanium	3	3	3	3	3	3
PVDF	3	3	3	3	3	3
PTFE	3	3	3	3	3	3
PP (glass filled)	2	2	1	?	3	2

Key

0	No Data
1	Not Recommended
2	Acceptable
3	Recommended

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