APPENDIX A

Checklist of Problems with Centrifugal Pumps and their Causes

Centrifugal pumps are one of the world's most commonly used devices. Moreover, their field of application is continuously expanding. However, new applications often bring about new problems. Consequently, it is impossible to foresee the problems that may turn up in the future. The only alternative is an indepth knowledge and understanding of how different factors may affect pump performance.

However, even with this knowledge, it is not easy to determine which of the over 120 known causes of trouble with centrifugal pumps is the most likely source of a given malfunction. Unique cases may also occur. Therefore, one of the first steps in diagnosing the source or sources of a given problem is to reduce the number of factors to be checked. This can be best accomplished by studying ready-made checklists that enumerate the most probable causes of a given problem.

The following is a list of problems that I have encountered during my practice. Following this list are checklists of causes that might have generated the given problems.

LIST OF PROBLEMS WITH CENTRIFUGAL PUMPS

1. Pump does not develop any head, nor does it deliver liquid
2. Pump develops some pressure, but delivers no liquid
3. Pump delivers less liquid than expected
4. Pump does not develop enough pressure
5. Shape of head-capacity curve differs from rated curve
6. Pump consumes too much power
7. Pump does not perform satisfactorily, although nothing appears to be wrong with pumping unit or system
8. Pump operates satisfactorily during start, but performance deteriorates in a relatively short time
9. Pump is operating with noise, vibrations, or both

10. Stuffing box leaks excessively
11. Packing has short life
12. Mechanical seal has short life
13. Mechanical seal leaks excessively
14. Bearings have short life
15. Bearings overheat
16. Bearings operate with noise
17. Pump overheats, seizes, or both
18. Impeller or casing, or both, has short life
19. Loud blow is heard each time pump is started or stopped
20. Casing bursts each time pump is started or stopped
21. Gaskets leak during pump operation
22. Flow-rate periodically decreases, or stops completely, then returns to normal
23. Pump develops cavitation when the available NPSH is increased

CHECKLISTS OF CAUSES OF PROBLEMS

1 Pump does not develop any head, nor does it deliver liquid

Possible Causes	See Also
1. Pump not primed (not full of liquid)	Chapter 1
2. Shaft is broken	Chapters 18, 22
3. Broken or disengaged connection between driver and pump	
4. Impeller key broken or missing	
5. No impeller in pump	

2 Pump develops some pressure but delivers no liquid

Possible Causes	See Also
1. Air pockets in pump or pipelines	Chapters 1, 4, 15
2. Suction line clogged	Chapters 5, 18, 23
3. Foot valve stuck to seat or clogged	Chapters 5, 18, 23
4. Strainer covered with solid, usually stringy, matter	Chapters 5, 18, 23
5. Strainer filled with solid matter such as sand	Chapters 5, 18, 23
6. Discharge pressure required by system is higher than maximum pressure developed by pump	Chapters 1, 23
7. Operating speed too low	Chapters 1, 6, 25
8. Wrong direction of operation	Chapters 19, 23
9. Available NPSH inadequate	Chapters 1, 5, 6
10. Excessive amounts of gas or air entrained in pumped liquid	Chapters 4, 13
11. Outer diameter of impeller machined to a too small diameter	Chapter 25

3 Pump delivers less liquid than expected

Possible Causes	See Also
1. Air enters pump during operation, or pumping system not deaerated before starting	Chapters 12, 15, Figs. 12-5, 12-6, 12-15, 12-17, 15-1, 15-7
2. Insufficient speed	Chapter 25
3. Wrong direction of rotation	Chapters 19, 23
4. System requires higher pressure than that developed by pump	Chapters 1, 23
5. Measuring instruments not properly calibrated or incorrectly installed	Chapter 12
6. Available NPSH too low	Chapters 1, 5, 6
7. Excessive amount of air or gas entrained in pumped liquid	Chapters 1, 12, 15
8. Excessive leakage through wearing rings or other sealing faces	Chapter 7, Figs. 7-7–7-12
9. Viscosity of liquid higher than that for which pump has been designated	Chapter 8
10. Impeller or casing partially clogged with solid matter	Chapters 12, 15
11. Fins, burrs, or sharp edges in path of liquid	Chapter 15, Figs. 12-2, 12-15
12. Impeller damaged	Chapter 15, 26
13. Outer diameter of impeller machined to a smaller dimension than specified	Chapter 25
14. Faulty casting of impeller or casing	Chapter 15, 19
15. Impeller incorrectly installed	Chapters 15, 19, Fig. 15-17
16. Pump operating too far out of the head-capacity curve	Chapters 6, 20, Figs. 6-10, 20-2
17. Obstruction to flow in suction or discharge piping	Chapters 5, 18, 23
18. Foot valve clogged or jammed	Chapters 5, 18, 23
19. Suction strainer filled with solid matter	Chapters 5, 18, 23
20. Suction strainer covered with fibrous matter	Chapters 5, 18, 23
21. Incorrect layout of suction or discharge piping	Chapter 14
22. Incorrect layout of suction sump	Chapter 14
23. Excessive leakage through stuffing box or seal	Chapter 7, Figs. 7-7–7-12
24. Excessive amount of liquid recirculated internally to stuffing box lantern or seal	
25. Excessive leakage through hydraulic balancing device	Chapter 19, Figs. 10-4, 10-5, 10-7, 10-8
26. Liquid level in suction tank or sump lower than originally specified	Chapters 5, 23
27. In a system with more than one pump, operation of one pump may affect operation of others	Chapters 14, 23

4 Pump does not develop enough pressure

See checklist 3.

5 Shape of head-capacity curve differs from rated curve

See checklist 3.

6 Pump consumes too much power

Possible Causes	See Also
1. Speed too high	Chapter 25
2. Pumped liquid of higher specific gravity than originally quoted	
3. Pumped liquid of higher viscosity than originally quoted	Chapter 8
4. Oversized impeller	Chapter 25
5. Total head of system either higher or lower than anticipated	Chapter 23
6. Misalignment between pump and driver	Chapters 15
7. Rotating parts rubbing against stationary parts	Chapters 15, 16
8. Worn or damaged bearings	Chapter 16
9. Packing improperly installed	Chapter 17, Fig. 12-21
10. Incorrect type of packing	Chapter 17, Appendix B-3
11. Mechanical seal exerts excessive pressure on seat	Chapter 17
12. Gland too tight	Chapter 17
13. Improper lubrication of bearings	Chapter 16
14. Too much lubricant in bearings	Chapter 16
15. Bent shaft	Chapter 16, Fig. 15-16
16. Uneven thermal expansion of different parts of pumping unit	Chapter 8
17. Faulty power-measuring instruments	Chapter 12
18. Power-measuring instruments incorrectly mounted or connected	Chapter 12
19. Wrong direction of rotation	Chapters 19, 23
20. Liquid not preheated to keep viscosity below specified limits	Chapter 8
21. Impeller or casing partially clogged with solid matter	Chapters 5, 15
22. Wetted surfaces of impeller or casing very rough	Chapter 7
23. Damaged impeller	Chapter 15
24. Faulty casting of impeller or casing	Chapter 15
25. Impeller incorrectly located in casing	Chapter 19, Fig. 15-17
26. Impeller inversely mounted on shaft	Chapter 19, Fig. 10-6
27. Pump operating too far out on head-capacity curve	Chapter 6, 20, Figs. 6-10, 20-2
28. Incorrect layout of suction sump	Chapter 14
29. Breakdown of discharge line	

7 Pump does not perform satisfactorily, although nothing appears to be wrong with pumping system

Possible Causes	See Also
This is usually due to incorrect testing. The reasons for this may be as follows:	
1. Incorrect measuring instruments	Chapter 12
2. Measuring instruments damaged during installation	Chapter 12
3. Measuring instruments mounted in wrong locations	Chapter 12
4. Tubing that leads from pipelines to measuring instruments clogged	Chapter 12
5. Instrument-connecting tubing that should be full of liquid not deaerated completely	Chapter 12
6. Instrument-connecting tubing that should be full of air contains some liquid	Chapter 12

7 (*continued*)

Possible Causes	See Also
7. Leakage in instrument-connecting tubing or in its fittings	Chapter 12
8. Burrs or fins at mouth of connections between tubing and piping	Chapter 12, Fig. 12-7
9. Incorrect connections of wiring to electrical instruments	Chapter 12
10. Connections of wires to terminals too loose	Chapter 12
11. Dirty electrical terminals or connections	Chapter 12
12. Dust or dirt in torque bar	Chapter 12
13. Torque bar incorrectly mounted	Chapter 12
14. In a dynamometer, misalignment or dirt in bearings produces false readings	Chapter 12
15. In a dynamometer, excessive friction in pivots or pulleys that guides the levers and cables produces false readings	Chapter 12
16. In a dynamometer, weight and stiffness of the electrical cables affect torque readings	Chapter 12
17. Cavitation in measuring instruments	Chapter 12
18. Cavitation in pipelines where instruments are hooked up	Chapter 12
19. Actual inner diameter of piping different from nominal diameter	Chapter 12

8 Pump operates satisfactorily during start, but performance deteriorates in a relatively short time

Possible Causes	See Also
1. Air leaks into pump	Chapters 4, 15
2. Pumped liquid contains high percentage of entrained air or gas	Chapter 4
3. Waterfall-like supply of liquid into suction sump draws air into pump	Chapter 4, Fig. 14-22
4. Air pocket in suction line has moved into pump	Chapters 4, 14, Figs. 12-5, 12-6, 12-15, 15-1–15-7
5. Air funnels in suction sump	Chapter 14

9 Pump is operating with noise or vibrations, or both (see also checklist 16)

Possible Causes	See Also
1. Misalignment between pump and driver	Chapter 15
2. Rotating parts rubbing against stationary parts	Chapter 15
3. Worn-out bearings	Chapter 16
4. Wrong direction of rotation	Chapters 19, 23
5. Available NPSH too low	Chapters 1, 5, 6
6. Impeller or casing partially filled with solid matter	Chapters 5, 18, 23
7. Fins, burrs, or sharp edges in waterways causing cavitation	Chapter 13
8. Damaged impeller	Chapter 15
9. Impeller incorrectly mounted	Chapters 15, 19, Fig. 15-17
10. System requirements too far out on head-capacity curve	Chapters 6, 20, Figs. 6-10, 20-2
11. Suction strainer filled with solid matter	Chapters 5, 18, 23
12. Strainer covered with fibrous matter	Chapters, 5, 18, 23

9 *(continued)*

Possible Causes	See Also
13. Incorrect layout of suction sump	Chapter 14
14. Air enters pump during operation	Chapters 1, 13
15. Mutual interaction of several pumps within one common system	Chapters 14, 21–23
16. Incorrect layout of suction or discharge piping	Chapter 14
17. Piping imposes strain on pump	Chapters 15, 23
18. Pump operating at critical speed	Chapter 18
19. Rotating elements not balanced	Chapter 15
20. Excessive radial forces on rotating parts	Chapters 10, 17, 27
21. Too small distance between impeller outer diameter and volute tongue	Chapter 27
22. Faulty shape of volute tongue	Chapter 27
23. Undersized suction or discharge piping and fittings causing cavitation somewhere in system	Chapter 13, Fig. 13-11
24. Loose valve disc in system	Chapter 13, Figs. 13-12, 13-14
25. Bent shaft	Chapter 15
26. Impeller bore not concentric with its outer diameter or not square with its face	Chapter 15, Fig. 15-16
27. Misalignment of pump parts	Chapter 15
28. Pump operates at very low flow rates	Chapter 9, Figs. 9-8–9-10
29. Improperly designed base plate or foundations	Chapter 15
30. Resonance between pump speed and natural frequency of base plate or foundations	Chapter 18
31. Resonance between operating speed and natural frequency of piping	Chapter 18
32. Resonance between operating speed and valve discs	Chapter 18
33. Loose bolts	Chapter 15
34. Uneven thermal expansion	Chapter 8
35. Improper installation of bearings	Chapters 15, 16
36. Damaged bearings	Chapters 15, 16
37. Improper lubrication of bearings	Chapter 16
38. Obstruction to flow in suction or discharge piping	Chapters 13, 15, Figs. 12-15–12-17, 15-1
39. Total head of system either higher or lower than expected	Chapter 2, 23
40. Excessive amount of air or gas entrained in liquid	Chapters 4, 15
41. Waterways of impeller or casing badly eroded or rough	Chapter 23
42. Cavitation in pipelines	Chapter 13, Figs. 13-11, 13-12, 13-14

10 Stuffing box leaks excessively

Possible Causes	See Also
1. Worn out bearings	Chapters 14,16
2. Improperly installed packing	Chapter 17, Fig. 12-21
3. Incorrect type of packing	Chapter 17, Appendix B-3

10 (*continued*)

Possible Causes	See Also
4. Rotating element not balanced	Chapter 15
5. Excessive radial forces on rotating parts	Chapters 10, 27
6. Bent shaft	Chapter 15
7. Bore of impeller not concentric with outer diameter, or not square with face	Chapter 15, Fig. 15-16
8. Misalignment of pump parts	Chapter 15
9. Rotating parts running off-center	Chapter 15
10. Water-seal pipe clogged	Chapter 17
11. Seal cage improperly located	Chapter 17, Fig. 12-21
12. Shaft sleeve worn or scorched at packing	Chapter 17
13. Failure to provide cooling liquid to water-cooled stuffing boxes	Chapter 17, Fig. 12-21
14. Excessive clearance at bottom of stuffing box (between shaft and box bottom)	Chapter 17
15. Dirt or grit in sealing liquid	Chapter 17

11 Packing has short life

Possible Causes	See Also
1. Worn bearings	Chapter 16
2. Improperly installed packing	Chapter 16, Fig. 12-21
3. Incorrect type of packing	Chapter 17, Appendix B-3
4. Gland too tight	Chapter 17
5. Rotating element not balanced	Chapter 15
6. Excessive radial forces on rotating parts	Chapters 10, 17, 27
7. Bent shaft	Chapter 15, Fig. 15-16
8. Bore of impeller not concentric with its outer diameter or not square with its face	Chapter 15
9. Misalignment of pump parts	Chapter 15
10. Rotating parts running off-center from damaged bearings or other parts	Chapter 15
11. Water-seal pipe clogged	Chapter 17
12. Seal cage improperly located in stuffing box, preventing sealing fluid from entering	Chapter 17, Fig. 12-21
13. Shaft scorched where it contacts packing	Chapter 17
14. Failure to provide cooling liquid to water-cooled stuffing box	Chapter 17
15. Excessive clearance at bottom of stuffing box, between shaft and stuffing box's bottom	Chapter 17
16. Dirt or grit in sealing liquid	Chapter 17
17. Improper lubrication of packing	Chapter 17
18. Space in stuffing box where packing is located is excentric to the shaft	Chapter 17, Fig. 17-1

12 Mechanical seal has short life

Possible Causes	See Also
1. Worn out bearings	Chapter 16
2. Rotating elements not balanced	Chapter 15
3. Excessive radial forces on rotating parts	Chapters 10, 27
4. Bent shaft	Chapter 15
5. Misalignment of pump parts	Chapter 15
6. Rotating elements running off-center from damage to bearings or other parts	Chapters 15, 16
7. Dirt or grit in seal-flushing liquid	Chapter 17
8. Sealing face not perpendicular to pump axis	Chapter 17
9. Mechanical seal has been run dry	Chapter 17
10. Abrasive particles in liquid coming in contact with seal	Chapter 17
11. Mechanical seal improperly installed	Chapter 17
12. Incorrect type of mechanical seal	Chapter 17
13. Misalignment of internal seal parts preventing proper mating between seal and seat	Chapter 17

13 Mechanical seal leaks excessively

Possible Causes	See Also
The same factors as in checklist 12, plus the following	
1. Leakage between the seal seat and gland from faulty gasket or O-ring	Chapter 17
2. Leakage between seal and shaft from faulty O-ring or lip seal	Chapter 17

14 Bearings have short life

Possible Causes	See Also
1. Damaged impeller	Chapter 15
2. Impeller partially clogged	Chapter 15
3. Rotating elements not balanced	Chapter 15
4. Excessive radial loads on rotating parts	Chapters 10, 27
5. Excessive axial loads	Chapters 10, 27
6. Bent shaft	Chapter 15, Fig. 15-16
7. Bore of impeller not concentric with outer diameter or not square with hub face	Chapter 15
8. Misalignment of pump parts	Chapter 15
9. Misalignment between pump and driver	Chapter 15
10. Pump operates for prolonged time at low flow rate	Chapter 18, Figs. 9-8–9-10
11. Improper base plate or foundations	Chapter 15
12. Rotating parts running off-center from damaged or misaligned parts	Chapter 15, Fig. 15-16

14 (*continued*)

Possible Causes	See Also
13. Improper installation of bearings	Chapter 16, Figs. 15-10, 15-15
14. Bores of bearing housing not concentric with bores in water end	Chapter 15
15. Cracked or damaged bearing housing	Chapter 15
16. Excessive grease in bearings	Chapter 16
17. Faulty lubrication system	Chapter 16
18. Improper workmanship during installation of bearings	Chapter 16, Figs. 16-4, 16-5
19. Bearings improperly lubricated	Chapter 16
20. Dirt finds access to bearings	Chapter 16
21. Water has entered bearing housing	Chapter 16
22. Excessive wear of impeller sealing rings reducing the effects of balancing means	Chapters 7, 19
23. Excessive suction pressure	Chapter 20
24. Too tight fit between line bearing and seat (may prevent it from sliding under axial load, transferring this load to the line bearing)	Chapter 16, Figs. 15-15, 16-10
25. Inadequate cooling of bearings	Chapter 16
26. Inadequate cooling of lubricant	Chapter 16
27. Source of cooling media shut-off from bearing housing	Chapter 16

15 Bearings overheat

See checklist 14.

16 Bearings operate with noise

Possible Causes	See Also
A. Steady high-pitch tone	
1. Excessive radial load	Chapters 10, 27
2. Excessive axial load	Chapter 10
3. Misalignment	Chapter 15
4. Too much clearance between bearing and shaft, and/or housing	Chapter 16
B. Continuous or intermittent low-pitch tone	
1. Bearing brinelled	Chapter 16
2. Pitted raceway, from dirt	Chapter 16
3. Resonance with other structural pump parts	Chapter 17
C. Intermittent rattles, rumbles, and/or clicks	
1. Loose machine pats	Chapter 18
2. Dirt in bearings	Chapter 16
3. Clearance between balls and races too large for given application	Chapter 16
4. Bearings that require preloading not adequately preloaded	Chapter 16

16 (*continued*)

Possible Causes	See Also
D. Intermittent squeal or high-pitch tone	
1. Balls skidding from excessive clearance between balls and races	Chapter 16
2. Balls skidding from insufficient preloading (whenever required)	Chapter 16
3. Shaft rubbing against housing from improper mounting of housing	Chapter 16
4. Shaft rubbing against housing from bent shaft	Chapter 23
5. Shaft rubbing against housing from having been machined excentrically	Chapter 23

17 Pump overheats or seizes, or both

Possible Causes	See Also
1. Pump allowed to run dry	Chapters 1, 15
2. Vapor or air pockets inside pump	Chapter 14, Figs. 15-6–15-9
3. Pump operates near shut-off	Chapter 13, Figs. 9-8–9-10
4. Simultaneous operation of poorly matched pumps	Chapter 14
5. Internal misalignment from too much pipe strain, poor foundations, or faulty repair work	Chapter 15
6. Internal rubbing of rotating parts against stationary parts	Chapter 15
7. Worn or damaged bearings	Chapter 16
8. Poor lubrication	Chapter 16
9. Rotating and stationary wearing rings made of identical, galling-prone materials	Chapter 16, Appendix B-2

18 Impeller or casing, or both, has short life

Possible Causes	See Also
1. Corrosion from chemical interaction with pumped liquid	Chapter 18
2. Electrochemical corrosion from difference of electrochemical potential of different materials of which wetted pump parts are made	Chapter 18
3. Abrasion from solids contained in pumped liquid	Chapter 18
4. Fatigue from thermal shocks	Chapters 15, 18
5. Fatigue from vibrations	Chapter 16
6. Erosion from cavitation	Chapter 18
7. Excessive transient stresses during starting or stopping	Chapter 14
8. Pump used at excessively high temperatures	Chapter 8
9. Excessive stresses imposed on pump by piping	Chapters 15, 18
10. Excessive stresses imposed on casing by foundation bolts	Chapter 15
11. Pump mishandled during installation	Chapter 15

19 Loud blow heard each time pump is started or stopped

Possible Causes	See Also
1. Water hammer	Chapter 14
2. Air or gas entrapped between pump discharge and nonreturn valve	Chapter 14, Figs. 15-10, 15-11
3. Slam pressure	Chapter 14

20 Casing bursts each time pump is started or stopped

Possible Causes	See Also
1. Water hammer	Chapter 14
2. Slam pressure	Chapter 14

21 Gaskets leak during operation

Possible Causes	See Also
1. Uneven thermal expansion of pump parts	Chapter 18
2. Loose bolts	Chapter 15
3. Unevenly tightened bolts	Chapter 15

22 Flow rate periodically decreases, or stops completely, then returns to normal

Possible Causes	See Also
1. Periodic fluctuations of liquid level in suction tank	Chapter 18
2. During operation pump removes more liquid from suction tank than rate at which liquid enters the tank	Chapter 18

23 Pump develops cavitation when the available NPSH is increased

Possible Causes	See Also
This may happen when the increase in the available NPSH has reduced the system resistance so far that the pump operates far out on the *QH* curve. This happens when	
1. Oversized impeller installed in pump	Chapter 20
2. Pump operates at excessive speed	Chapter 20
3. Breakdown or serious leak in discharge line	Chapter 20
4. Open bypass in discharge line	Chapter 20
5. Extremely large clearances between impeller and casing	Chapter 20
6. Hole in casing allowing liquid from pressure side of casing to return to its suction inlet	Chapter 20, Fig. 15-12

APPENDIX B

Tables

Table B-1 Vapor Pressures of Water at Different Temperatures

Temperature		Density at a given temperature	Vapor Pressure		
			Equivalent head of water at a given temperature		Absolute pressure
Degrees (°C)	Degrees (°C)		(m)	(ft)	(kg/cm^2)
0	32	1.000	0.0396	0.13	0.0040
4	39	1.000	0.0823	0.27	0.0083
10	50	1.000	0.125	0.41	0.0125
20	68	0.998	0.238	0.78	0.0237
30	86	0.996	0.426	1.4	0.0424
40	104	0.992	0.762	2.5	0.0755
60	140	0.983	2.012	6.6	0.1977
80	176	0.972	5.000	16.4	0.4860
100	212	0.959	10.775	35.6	1.0333
120	248	0.944	21.275	69.8	2.0083
140	284	0.927	39.624	130	3.6731
160	320	0.909	69.799	229	6.3447
180	356	0.889	114.605	376	10.1884
200	392	0.866	184.992	604	16.0203
220	428	0.841	281.635	924	23.6885
240	464	0.814	420.624	1380	34.2388

Table B-2 Gall Resistance of Material Combinations

	Cast Iron	3% Ni Cast Iron	Ni-Resist (Type 1, 2)	Ductile Iron	Ductile Ni-Resist	Nickel-Copper Alloy K-500	Nickel-Copper Alloy 400	Nickel-Copper Alloy 506	Nickel-Aluminum Alloy 301	Nickel 213[2]	Nickel 305[2]	Nickel-Chromium Alloy 600	Nickel-Chromium Alloy 705[3]	400 Ser. Stainless Steel (Soft)	400 Ser. Stainless Steel (Hard)	300 Series Stainless Steel	SAE 1000 to 6000 Steel (Soft)	SAE 1000 to 6000 Steel (Hard)	Bronze (Leaded)[5]	Ni-Vee Bronze "A"[4]	Ni-Vee Bronze "B"	Ni-Vee Bronze "D"	Ni-Al Bronze[6]	HASTELLOY[1] Alloys A, B	HASTELLOY Alloy C	HASTELLOY Alloy D	Nitrided	Chrome Plate[7]	STELLITE[1]
Cast Iron	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
3% Ni Cast Iron	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
Ni-Resist (Type 1, 2)	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
Ductile Iron	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
Ductile Ni-Resist	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
Nickel–Copper Alloy 505	S	S	S	S	S	F	F	S	S	S	S	F^+	S	F	S	F	F	S	S	F[5]	S	S	F	F^+	S	S	S	S	S
Nickel–Copper Alloy K-500	S	S	S	S	S	F	N	F	F	S	S	N	S	F	F	N	N	F	S	F	S	S	F^-	F	F	S	S	S	S
Nickel–Copper Alloy 400	S	S	S	S	S	N	N	F	N	F	F	N	S	N	F	N	N	F	S	F	S	S	F^-	N	F	S	S	F	S
Nickel–Copper Alloy 506	S	S	S	S	S	F	F	F	F	F	F	N^-	S	N	F	N	N	F	S	F	S	S	F^-	N	F	S	S	S	S
Nickel–Alluminum Alloy 301	S	S	S	S	S	F	N	F	F	S	S	N	S	N	F	N	N	F	S	F	S	S	S^-	F	F	S	S	S	S
Nickel 213[2]	S	S	S	S	S	S	F	F	S	S	F	F	S	F	S	F	F	S	S	S	S	S	S	S^-	S	S	S	S	S
Nickel 305[2]	S	S	S	S	S	F	F	F	S	F	S	F	S	F	S	F	F	S	S	S	S	S	S	S^-	S	S	S	S	S
Nickel–Chromium Alloy 600	S	S	S	S	S	N	N	N	N	F	F	N	F	N	F	N	N	F	S	F	S	S	F^-	N	F	S	S	S	S
Nickel–Chromium Alloy 705[3]	S	S	S	S	S	S	S	S	S	S	S	F	S	F	S	F	F	S	S	S	S	S	S	S	S	S	S	S	S
400 Series Stainless Steel (Soft)	S	S	S	S	S	F	N	N	N	F	F	N	F	N	F	F	N	F	S	F	S	S	F^-	N	F	S	F	F	S
400 Series Stainless Steel (Hard)	S	S	S	S	S	F	F	F	F	S	S	F	S	F	S	F	S	S	S	S	S	S	F^+	F	S	S	S	S	S
300 Series Stainless Steel	S	S	S	S	S	N	N	N	N	F	F	N	F	F	F	N	N	F	S	F	S	S	F^-	N	F	S	S	S	S
SAE 1000 to 6000 Steel (Soft)	S	S	S	S	S	N	N	N	N	F	F	N	F	N	S	N	N	S	S	S	S	S	F^+	N	F	S	S	S	S
SAE 1000 to 6000 Steel (Hard)	S	S	S	S	S	F	F	F	F	S	S	F	S	F	S	F	S	S	S	S	S	S	S	F	S	S	S	S	S
Bronze (Leaded)[5]	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S[5]	S[5]	S	S[5]
Ni-Vee Bronze "A"[4]	S	S	S	S	S	F	F	F	F	S	S	F	S	F	S	F	S	S	S	F	S	S	F	F	S	S	F[5]	S	S
Ni-Vee Bronze "B"	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	F	S	S	F	S	S	S	S	S	S
Ni-Vee Bronze "D"	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
Ni-Al Bronze[6]	S	S	S	S	S	F^-	F^-	F^-	F^-	S	S	F^-	S	F^-	F^+	F^-	F^+	S	S	F	F^+	S	N	F^-	F^+	S	F	S	S
HASTELLOY[1] Alloys A, B	S	S	S	S	S	F	N	N	F	S^-	S^-	N	S	N	F	N	N	F	S	F	S	S	F^-	N	F	S	S	S	S
HASTELLOY Alloy C	S	S	S	S	S	F	F	F	F	S	S	F	S	F	S	F^-	F	S	S	S	S	S	F^+	F	F	S	S	S	S
HASTELLOY Alloy D	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
Nitrided	S	S	S	S	S	S	S	S	S	S	S	S	S	F	S	S	S	S	S	F[5]	S	S	F	S	S	S	S	S	S
Chrome Plate[7]	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	?[7]	S
STELLITE[1]	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S

Degree of Resistance: S=Satisfactory F=Fair N=Little or None Courtesy of Goulds Pumps, Inc.

1 Trademark of Union Carbide Corporation.

2 Nickel 213 and Nickel 305 have better gall resistance than Nickel 210. Both are comparable in gall resistance but Nickel 305 will stand heavier loads.

3 Nickel–chromium alloy 705 is superior to Nickel 305 and nickel–copper alloy 505 in gall resistance.

4 The Ni-Vee bronzes are 5% nickel, 5% tin, cast and heat-treatable, similar in balance of composition to the 88-10–2 Cu Sn Zn type. A, No load. B, 1% load. D, 10% load.

5 Loaded Bronze—85-5-5-5 or 80-10-10. Hard materials might "bite" into softer bronzes.

6 Nickel–aluminum–bronze is generally somewhat inferior to Ni-Vee "A" in gall resistance and coefficient of friction, but will stand heavier loads in slower motion.

7 Chromium plate varies greatly in gall resistance. To be its best it must be backed up by hard material and the plating must bond well to the backing.

Table B-3 Packing Selections

Standard

Style	Description	Maximum Pressure Temperature	Remarks
Garlock 5022 AFP or equal (CO6)	PTFE, Impregnated Copper, Wire Braided Ring (5/16 in. through 2 in. Plungers)	5000 PSI/550°F	Good for most liquids except bromine, chlorine, and oxygen compounds
Garlock 8922 or equal (CO6)	PTFE, Impregnated, Braided Ring, (2½ in. through 4 7/16 in. Plungers)	500 PSI/550°F	

Optional

Style	Description	Maximum Pressure Temperature	Remarks
G8048, G432 or equal	Nitrile/Fabric, V Ring (Neo Duck)	2000 PSI/200°F	Aqueous solutions except aromatics or aqueous solutions of acids or bases
Crane CVH or equal (8764)	PTFE, V Ring with PTFE Adaptors	5000 PSI/500°F	All liquids except flourine and its components
Crane 829 or equal	Nitrile/Fabric with Brass Adaptors (other adaptor material available)	7500 PSI/250°F	Mineral oils, petroleum products, water emulsion solutions

Special Common specials noted below. Contact Application Engineer

Style	Description	Maximum Pressure Temperature	Remarks
Crane C1055 or equal	PTFE Yarn, Braided Ring	2000 PSI/500°F	Food products
Grafoil 235A or equal	Graphite, Comp-Split Ring	4000 PSI/1500°F	Strong corrosive, heat transfer liquids

Courtesy of Milton Roy Company, A Sundstrand Subsidiary.

Notes:

1. Pressures over 2000 psig require hardened plungers and close clearance rings. V-Ring–type packing requires metal adaptors.
2. When flushing is required, use a V-ring–type packing.
3. Use Neo Duck packing for lima and diatomaceous earth slurries with ceramic plungers and flush connections.
4. Milroyal D⅛ in. & ¼ in. plungers are only available with 25% carbon-filled PTFE packing.

Table B-4 Chemical Resistance Guide for Valves and Fittings

Chemicals and Formula	CONCENTRATION	Plastics and Elastomers at Maximum Temperature (°F)											Metals																	
		ABS	CPVC	PP	PVC	PVDF	TEFLON	EPDM	BUNA-N	HYPALON	NEOPRENE	FLUOROCARBON	ALUMINUM	COPPER	BRONZE (85% Cu)	SILCON BRONZE	ALUMINUM BRONZE	BRASS	GRAY IRON	DUCTILE IRON	CARBON STEEL	3% NI/IRON	NI PLATED DUCTILE	400 SERIES S.S.	316 S.S.	17-4 PH	ALLOY 20	MONEL	STELLITE	HASTELLOY C
Acetaldehyde CH_3CHO	Conc.			120	C	C	350	200	C	C	C	C	B	C	C	C	C	C	B	B	A		B	B	A		A	A	A	A
Acetic Acid CH_3COOH	60%		73		73	175	350	140	C		C	C	C	C	C	C	C	C	C	C	C	C	C	A	A	A	A	A		A
Acetic Acid CH_3COOH	85%		C	120	73	150	350	140	C		C	C	C	C	C	C	C	C	C	C	C	C	C	A	A	A	A	A		A
Acetic Acid CH_3COOH	Glacial		C	120	73	120	350	140	C		C	C	C	C	C	C	C	C	C	C	C	C	C	C	A	B	A	A		A
Acetic Anhydride $(CH_3CO)_2O$					C	C	350	C	70	200	B to 70	C	B	C	C	C	C	C	C	C	C	C	C	C	B	B	B	B		A
Acetone Ch_3COCH_3			C	73	C	C	350	130	C	B to 70	C	C	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
Acetylene HC=CH	GAS 100%	70		73	140	250	250	200	140	70	70	200	A	C	C	C	C	C	A	A	A	A	A	A	A	A	A	A	A	A
Acrylonitrile $H_2C:CHCN$			C		C	73	350	C	C	140	C	C	B		A	A	A	A	A	A	A	A	A	A	A	A	A	A		A
Allyl Chloride CH_2CHCH_2Cl					C	212	350	C	C			70	C								C									
Aluminum Hydroxide $AlO_3 \cdot 3H_2O$)	Sat'd		185		140	280	250	210	180		100	200		C	C	C	C	C	B	B	C		B	B	A	A	A	B		
Aluminum Nitrate $Al(NO_3)3 \cdot 9H_20$	Sat'd		185	180	140	280	250	210	180	100	100	100	C	C	C	C	C	C	C	C	C	C	C		A	A	A	C		
Aluminum Sulfate (Alum) $Al_2(SO_4)_3$	Sat'd		185	180	140	280	250	210	200	160	140	185	C	C	C	C	C	C	C	C	C		C	C		B				A
Ammonia Anhydrous NH_3							250	200			100	C		C	C	C	C	C	A		A				A	A	A	A		A
Ammonia Liquid NH_3	100%			73	C	C	400	210	B to 70	70	70	C	A	C	C	C	C	C			A			A	A	A	A	A		A
Ammonium Carbonate $(NH_4)HCO_3 \cdot (NH_4)CO2NH_2$	Sat'd			180	140	280	400	210		140	140	250	B to 212	B to 70	C			C			A to 140	C		B	B	B	B	B		A
Ammonium Chloride NH_4Cl	Sat'd		185	180	140	280	400	210	180	200	160	250	B		C			C	C	C	C	C	C	C	B	C	B	B		B
Ammonium Hydroxide NO_4OH	10%		185	180	140	225	400	210	B to 70	200	70	70	B	C	C	C		C			C			B	A	A	A	B		A

(The information given is indended as a guide only. See page 374 for further information)

Table B-4 Chemical Resistance Guide for Valves and Fittings (*continued*)

Chemicals and Formula		Plastics and Elastomers at Maximum Temperature (°F)											Metals																	
	CONCENTRATION	ABS	CPVC	PP	PVC	PVDF	TEFLON	EPDM	BUNA-N	HYPALON	NEOPRENE	FLUOROCARBON	ALUMINUM	COPPER	BRONZE (85% Cu)	SILCON BRONZE	ALUMINUM BRONZE	BRASS	GRAY IRON	DUCTILE IRON	CARBON STEEL	3% NI/IRON	NI PLATED DUCTILE	400 SERIES S.S.	316 S.S.	17-4 PH	ALLOY 20	MONEL	STELLITE	HASTELLOY C
Ammonium Nitrate NH_4NO_3	Sat'd		185	180	140	280	400	250	180	200	160	100		C	C	C		C								A	A	A		A
Ammonium Sulfate $(NH_4)_2SO_4$			185	180	140	280	400	210	180	200	160	200	C	C	C	C	C	C	B	B	C	B	B	B	B	B	A	B		A
Ammonium Sulfide $(NH_4)_2S$	Dilute					125	350	210	140	200	160		A	C	C	C	C	C	C	C	C		C		B		B	B		
Ammonium Thiocyanate NH_4SCN	50-60%				140	275			70	70	70	185	B	C	C	C	C	C	C	C	C		C		A	A	A	B		A
Amyl Acetate $CH_3COOC_5H_{11}$				C	C	125	100	B to 70	C	C	C	C	A		B	B	B	B	B	B	B	A	B	A	A	A	A	A	A	A
n-Amyl Chloride $CH_3(CH_2)_3CH_2Cl$					C	280	400	C	C	C	C	200	C		A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
Aniline $C_6H_5NH_2$			C	180	C	120	200	140	C	70	C	C	C	C	C	C	C	C	B	B	C	B	B	A	A	A	A	B		A
Arsenic Acid $H_3AsO_4 \cdot \frac{1}{2}H_2O$	80%		185		140	280	400	185	160	200	180	200	C		C	C	C	C	C	C	C		C	B	A	B	A	A		A
Barium Carbonate $BaCO_3$	Sat'd				140	280	400	250	180	200	160	250			A	A	A	A	B	B	B	B	B	A	A	A	A	A		
Barium Chloride $BaCl_2 \cdot 2H_2O$	Sat'd				140	280	400	250	180	200	160	300		A	A	A	A	A	B	B	C	B	B	B	A		A	A		
Barium Hydroxide $Ba(OH)_2$	Sat'd				140	280	400	200	180	200	140	300			C	C	C	C	B	B	C		B	A	A	A	A	A		A
Barium Sulfate $BaSO_4$	Sat'd		185		140	280	400	200	100	200	160	300			B	B	B	B	B	B	A		B	A	A	A	A	A		
Barium Sulfide BaS	Sat'd				140	280	400	140	C	200	160	300		C	C	C	C	C	B	B	C		B	A	A	A	A	A		
Beer		C		180	140	200	300	200	70	200	140	200	A	A	A	A	A	A	C	C	C		C	A	A	A	A	A		
Beet Sugar Liquors				180	140	225		210	100	200	160	185	A				A		B	B	B				A	A	A	A		
Benzene C_6H_6		C	C	C	C	170	250	C	C	C	C	150		A	A	A	A	A	A	A	A	A	A	A	A	A	A	A		
Benzoic Acid C_6H_5COOH	All			73	140	230	350	C	C	200	160	200			C	C	C	C	C	C	C		C	A	A	A	A	A		A
Black Liquor	Sat'd		185		140	175	225	180	180	70	70	200			C	C	C	C	B	B	B		B	B	A	B	A	B		

Table B-4 Chemical Resistance Guide for Valves and Fittings (*continued*)

Chemicals and Formula	CONCENTRATION	Plastics and Elastomers at Maximum Temperature (°F)											Metals																	
		ABS	CPVC	PP	PVC	PVDF	TEFLON	EPDM	BUNA-N	HYPALON	NEOPRENE	FLUOROCARBON	ALUMINUM	COPPER	BRONZE (85% Cu)	SILCON BRONZE	ALUMINUM BRONZE	BRASS	GRAY IRON	DUCTILE IRON	CARBON STEEL	3% NI/IRON	NI PLATED DUCTILE	400 SERIES S.S.	316 S.S.	17-4 PH	ALLOY 20	MONEL	STELLITE	HASTELLOY C
Borax $NA_2B_4O_7 \cdot 10H_2O$	Sat'd			180	140	280		210	140	200	140	185			A	A	A	A	A	A	B	A	A	A	A	A	A	A	A	A
Boric Acid H_3BO_3	Sat'd		185	180	140	280		210	140	200	140	185			B	B	B	B	C	C	B		C	B	A	B	A	A		A
Butane C_4H_{10}	50%			73	140	250	350	C	70	200	70	185	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
Butylene (C) $CH_3CH{:}CHCH_3$	Liquid				140	280	400	C	70	C	C	100			A	A	A	A			A			A	A	A	A	A	A	A
Butyric Acid $CH_3CH_2CH_2COOH$				180	73	230	300	140		C	C	70			A	A	A	A	C	C	C	C	C	B	A	A	A	A		
Calcium Bisulfite $Ca(HSO_3)_2$			185	180	140	280	350	C	70	200	70	185			C	C	C	C	C	C	C		C	B	A		A	C		A
Calcium Carbonate $CaCO_3$			185	180	140	280	350	210	100	70	70	300		A	C	C	C	C	B	B	B		B	A	A	A	A	A		A
Calcium Chlorate $Ca(ClO_3)_2 \cdot 2H_2O$					140	280	350	140	70	70	70	185		C	B	B	B	B	B	B	B	B	B	B	A		A	A		
Calcium Chloride $CaCl_2$		100	185	180	140	280	350	210	100	200	160	250		B	B	B	B	B	A	A	C		C	B	A	B	A	A	B	A
Calcium Hydroxide $Ca(OH)_2$			185	180	140	280	250	210	140	200	70	250	C	C	C	C	C	C	C	C	C		C	A	A	A	A	A		A
Calcium Hypochlorite $Ca(OCl)_2$	30%		185	150	140	200	200	70	C	140		185	C	C	C	C	C	C	C	C	C		C	B	B	B	B	C		B
Calcium Nitrate $Ca(NO_3)_2$				180	140	280	200	210	180	100	100	200		B	B	B	B	B	B	B			B		A		A	A		
Calcium Sulfate $CaSO_4$		100			140	280	200	210	180	200	160	200		A	A	B	B	B	A	A	B	A	A	A	A	A	A	A	A	A
Cane Sugar $C_{12}H_{22}O_{11}$				73	140	275	400	250	180	100	160	200			A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
Carbon Dioxide CO_2	Dry 100%	100	185	150	140	280	400	200	180	200	160	200	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	
Carbon Tetrachloride CCl_4		C	73	C	73	280	350	C	C	C	C	185		B	A	A	A	A	C	C	A		C	A	A	A	A	A		A
Carbonic Acid H_2CO_3	Sat'd		185		140	280	350	210	180	70	70	200			C	C	C	C	B	B	B	B	B	A	A	A	A	A	B	
Cellosolve $ClCH_2COOH$					73	280	200	140	C	70		C			A	A	A	A	A	A	A		A		A		A		A	
Chloral Hydrate $CCl_3CH(OH)_2$	All				140	75				70	B to 70	C																		

Table B-4 Chemical Resistance Guide for Valves and Fittings (*continued*)

Chemicals and Formula		Plastics and Elastomers at Maximum Temperature (°F)											Metals																	
	CONCENTRATION	ABS	CPVC	PP	PVC	PVDF	TEFLON	EPDM	BUNA-N	HYPALON	NEOPRENE	FLUOROCARBON	ALUMINUM	COPPER	BRONZE (85% Cu)	SILCON BRONZE	ALUMINUM BRONZE	BRASS	GRAY IRON	DUCTILE IRON	CARBON STEEL	3% NI/IRON	NI PLATED DUCTILE	400 SERIES S.S.	316 S.S.	17-4 PH	ALLOY 20	MONEL	STELLITE	HASTELLOY C
Chlorobenzene C_6H_5Cl	Dry			73	C	170	200	C	C	C	C	70			A	A	A	A	C	C	B		C	A	A	A	A	A		A
Chloroform $CHCl_3$	Dry		C	C	C	125	200	C	C	C	C	70			A	A	A	A	C	C	C		C	A	A	A	A	A	A	
Chlorosulfonic Acid $ClSO_2OH$				C	73	C	200	C	C	C	C	C	C	C	C	C	C	C	B	B	C	C	B	C	C	C	B	A		A
Chromic Acid H_2CrO_4	10%		210	150	140	175	350	70	C	140		100	C	C	C	C	C	C	C	C	C	C	C	B to 212	A to 70		A to 125	B		A
Chromic Acid H_2CrO_4	50%		210	180	C	125	200	C	C	140		C	C	C	C	C	C	C	C	C	C	C		C	B to 70		B to 212	C		B
Citric Acid $C_6H_8O_7$	Sat'd		185	180	140	275	200	210	70	140	140	200		C	C	C	C	C	C	C	C		C	B	A	A	A	A		A
Coffee								140	100			200		A	A	A	A	A	C	C	C			A	A	A	A		A	
Copper Acetate $Cu(C_2H_3O_2)_2 \cdot H_2O$	Sat'd		73	73	73	250	350	100	180	C	160	140			C	C	C	C	C	C	C		C	B	A		A	B		A
Copper Chloride $CuCl_2$	Sat'd		185		140	280	350	210	180	200	160	200	C	C	C	C	C	C	C	C	C	C	C	B	A		A	B		A
Copper Cyanide $Cu(CN)_2$			185		140	275	350	210	180		160	185		C	C	C	C	C	C	C	C	A	C	B	A		A	B		
Copper Nitrate $Cu(NO_3)_2 \cdot 3H_2O$	30%				140	280		210	B to 70	200	160	200	C	C	C	C	C	C	C	C	C		C	B	A		A	C		
Copper Sulfate $CuSO_4 \cdot 5H_2O$	Sat'd		185	120	140	280		210	180	200	160	200	C	C	C	C	C	C	C	C	C		C	A	A	A	A	C		A
Creosote			73		73		350	C	73	73	C	73		B	B	B	B	B	A	A	A	A	A	A	A	A	A	A	A	A
Cresylic Acid	50%				140	150	200	C	C	C	C	185		A	A	A	A	A	A	A	B	A	A	A	A	A	A	A	A	
Cyclohexane C_6H_{12}		100	C	C	C	280	300	C	C	C	C	185			A	A	A	A	B	B	A		B	A	A	A	A	A	A	A
Detergents (Heavy Duty)			185	150	140			250	180	200	160	210		A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	
Dow Therm A					C		212	C	C	C	C	C			A	A	A	A	B	A	A		A	A	A	A	A	A	A	
Ether ROR			C	73	C	125			C	C	C	C		A	A	A	A		B	B	B	A	A	A	A	A	A	A	A	

Table B-4 Chemical Resistance Guide for Valves and Fittings (*continued*)

Chemicals and Formula		Plastics and Elastomers at Maximum Temperature (°F)											Metals																	
	CONCENTRATION	ABS	CPVC	PP	PVC	PVDF	TEFLON	EPDM	BUNA-N	HYPALON	NEOPRENE	FLUOROCARBON	ALUMINUM	COPPER	BRONZE (85% Cu)	SILCON BRONZE	ALUMINUM BRONZE	BRASS	GRAY IRON	DUCTILE IRON	CARBON STEEL	3% NI/IRON	NI PLATED DUCTILE	400 SERIES S.S.	316 S.S.	17-4 PH	ALLOY 20	MONEL	STELLITE	HASTELLOY C
Ethyl Acetate $CH_3COOC_2H_5$		C		120	C	C	200	70	C	C	C	C			A	A	B		A	A	A			A	A	A	A	A	B	A
Ethyl Alcohol (Ethanol) C_2H_5OH			140	180	140	280	300	170	180	200	70				A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
Ethyl Chloride C_2H_5Cl	Dry			73	C	280	350	B to 70	C	70	B to 70	140			A	A	B		A	A	A	A	A	A	A	A	A	A	B	A
Ethylene Chloride $ClCH_2CH_2Cl$	Dry	C		73	C	280	350		C	C		70													A		A	A		
Ethylene Glycol CH_2OHCH_2OH		73	185	120	140	280		210	180	200	160	250		A	A	A	A	A	A	A	A		A	A	A	A	A	A	A	A
Ethylene Oxide CH_2CH_2O				C	C	C	400	C	C	C	C	C			A	A			B	A	A		A		A		A	B		A
Fatty Acids R-COOH			73	120	140	280	400	C	140	C	140	185	C		C	C	C	C	C	C	C		C		A		A	A		A
Ferric Chloride (Aqueous) $FeCl_3$	Sat'd		185	180	140	280	400	225	180	200	160	200	C	C	C	C	C	C	C	C	C	C		C	C	C	C	C		A to 175
Ferric Nitrate $Fe(NO_3)_3 \cdot 9H_2O$	Sat'd		185	180	140	280	400	210	180	140	160	200		C	C	C	C	C	C	C	C		C	B	A	A	A	C		A
Ferric Sulfate $Fe_2(SO_4)_3$				180	140	280	200	210	140	140	140	185		C	C	C	C	C	C	C	C		C	B	A	A	A	C		
Ferrous Chloride $FeCl_2$	Sat'd		185	180	140	280	400	200	180			200	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C			B
Ferrous Sulfate $FeSO_4$		70	185	180	140	280	400	200	180	140	160	200		B	C	C	B		C	C	C	C	C	A	A	A	A	A		A
Fluosilicic Acid H_2SiF_6	50%		73		140	280	300	140	100	200	100	210	C	C	B	B			C	C	C		C	B	B	B	A	A		A
Formic Acid HCOOH			73	73	73	250	300	200	C	70	140	C			C	C	B		C	C	C	B	C	A	A	A	A	A		A
Freon 11	100%	C	73		140	200	300	C	70	130	C	70		A	A	A	A	A	B	B	B		B	A	A	A	A	A		
Furfural C_4H_3OCHO				C	C	75	300	140	C	70	70	C		A	A	A	A	A	A	A	A		A	A	A	A	A	A		A
Gasoline, Leaded		C		C	140	275	200	C	70	70	70	100	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
Gasoline, Unleaded		C		C	140	280	200	C	70	70		100	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A

Table B-4 Chemical Resistance Guide for Valves and Fittings (*continued*)

Chemicals and Formula		Plastics and Elastomers at Maximum Temperature (°F)											Metals																	
	CONCENTRATION	ABS	CPVC	PP	PVC	PVDF	TEFLON	EPDM	BUNA-N	HYPALON	NEOPRENE	FLUOROCARBON	ALUMINUM	COPPER	BRONZE (85% Cu)	SILCON BRONZE	ALUMINUM BRONZE	BRASS	GRAY IRON	DUCTILE IRON	CARBON STEEL	3% NI/IRON	NI PLATED DUCTILE	400 SERIES S.S.	316 S.S.	17-4 PH	ALLOY 20	MONEL	STELLITE	HASTELLOY C
Glucose $C_6H_{12}O_6 \cdot H_2O$		180	185	180	140	280	400	250	180	200	160	300	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
Heptane C_7H_{16}				C	140	280	300	C	70	70	70	185			A	A	A		A	A	A	A	A	A	A	A	A	A	A	A
Hydrazine H_2NNH_2					C	200	250	70	70	70		C			C	C	C	C	C	C	C		C		A		A	A		
Hydrobromic Acid HBr	20%		73	120	140	280	250	140	C	100	B to 70	185	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	
Hydrochloric Acid HCl	35%	C	210	150	140	280	250	70	C	100		100	C	C	C	C	C	C	C	C	C	C	C	C	B	C	B	C	C	
Hydrocyanic Acid HCN	10%			73	140	280	250	200	70	200		185	C	C	C	C	C	C	C	C	C	C	C	C	A	B	A	A	C	A
Hydrofluoric Acid HF	Dilute		73	180	73	250	300	70	C	150	70	150	C	C	C	C	C	C	C	C	C	C	C	C	C	C	B	A	C	A
Hydrogen Peroxide H_2O_2	50%		185	150	140	150	300	100	C	200	C	185	C	C	C	C	C	C	C	C	B	C	C	A	A	A	A	A		
Hydrogen Sulfide H_2S	Dry		185	150	140	280		100	C	140	C	140	B		B				B		B				A	B	A	A		A
Inks							300		70		70	70			A	A	A		C	C	C		C		A		A	A		
Iodine I_2	10%		73	150		150	200	70	70	70	C	70		C	C	C	C	C	C	C	C		C	C	C	C	B	A		A
Kerosene		B to 70	185	73	140	280	250	C	140	C	70	300	70	A	A	A	A	A	A	A	A	A	A		A	A	A	A	A	A
Lactic Acid $CH_3CHOHCOOH$	25%			150	140	125	300	70		140	140	70			C	C	C	C	C	B	C		B	A	A	A	A	A		
Lactic Acid $CH_3CHOHCOOH$	80%			150	73	125	300	70	C	140		70			C	C	C	C	C	B	C		B	A	A	A	A	A		A
Lead Acetate $Pb(C_2H_3O_2)_2 \cdot 3H_2O$	Sat'd		185	180	140	280	300	210	70	100	160	C			C	C			C	C	C		C		A		A	A		
Lime Slurry								100	100	160	100				A	A					A				A		A	A		
Linseed Oil		100	185	150	140	280	300	B to 70	180	200	70	250	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A		
Magnesium Carbonate $MgCO_2$					140	280	225	170	140	140	140	210			B	B			B	B	B		B	A	A	A	A	A		

Table B-4 Chemical Resistance Guide for Valves and Fittings (*continued*)

Chemicals and Formula		Plastics and Elastomers at Maximum Temperature (°F)											Metals																	
	CONCENTRATION	ABS	CPVC	PP	PVC	PVDF	TEFLON	EPDM	BUNA-N	HYPALON	NEOPRENE	FLUOROCARBON	ALUMINUM	COPPER	BRONZE (85% Cu)	SILCON BRONZE	ALUMINUM BRONZE	BRASS	GRAY IRON	DUCTILE IRON	CARBON STEEL	3% NI/IRON	NI PLATED DUCTILE	400 SERIES S.S.	316 S.S.	17-4 PH	ALLOY 20	MONEL	STELLITE	HASTELLOY C
Magnesium Chloride $MgCl_2$	Sat'd		185	180	140	280	400	170	180	200	160	170		A	A	A	B	B	C	C	C		C	C	C	C	B	A		A
Magnesium Hydroxide $Mg(OH)_2$	Sat'd		185	180	140	280	300	170	180	200	160	225		B	C	C	B	B	A	A	A		A	A	A	A	A	A	A	A
Magnesium Nitrate $Mg(NO_3)_2 \cdot 2H_2O$			185	180	140	280	300	140	70	140	160	225		A	C	C					B			A	A	A	A	B		
Magnesium Sulfate $MgSO_4 \cdot 7H_2O$			185	180	140	280	300	175	180	140	160	200		A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
Malic Acid $COOHCH_2CH(OH)COOH$			185	150	140	250	250	C	100	70	70	200		A	B	B			C	C	C		C	A	A	A	A	A		
Mercuric Chloride $HgCl_2$			140	180	140	250	300	210	140	140	140	185	C	C	C	C	C	C	C	C	C	C	C	C	C	C	B	C		A
Mercuric Cyanide $Hg(CN)_2$	Sat'd				140	250	300	70	70	140	70	70		C	C	C	C	C	C	C	C		C		A		A	C		
Mercury Hg			185	150	140	275	300	210	140	140	140	185		C	C	C	C	C	A	A	A		A	A	A	A	A	B		A
Methyl Acetate $CH_3CO_2CH_3$						100	300	B to 70	C	C	C	C			B	B			B	B	B		B	B	A		A	A		A
Methyl Acetone C_3H_6O						C		70	C	C		C		A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	
Methyl Bromide CH_3Br					C	280	300	C	70	C	C	185			C	C	B		C	C	B				B		B	B		
Methyl Cellosolve $HOCH_2CH_2{}^0CH_3$					C	280		70	C	70	70	C			A	A	B		B	B	B			A	A	A	A	A	A	
Methyl Chloride CH_3Cl	Dry	C			C	280	250	C	C	C	C	70	C		A	A	C	C	A	A	A	A	A	A	A	A	A	A	A	A
Methyl Ethyl Keytone (MEK) $CH_3COC_2H_5$		C	C	C	C	C	200	70	C	C	C	C		A	A	A	A	A	A	A	A		A	A	A	A	A	A	A	A
Methylene Chloride CH_2Cl_2					C	C	250	C	C	C	C	70			B	B	B		B	B	B				A	A	A	A		A
Molasses				73	140	150	300	100	150	150	150	185		A	A	A	A	A	A	A	A		A	A	A	A	A	A		A
Monochloroacetic Acid $CH_7ClCOOH$	50%		73	73	140	150	200	C	70	C	C	70		C	C	C	C	C	C	C	C		C	C	C	C	B	B		
Morpholine C_4H_8ONH						75	200	70	C	C	C	C			B	B			B	B	B		B	B	B	B	B	B		

Table B-4 Chemical Resistance Guide for Valves and Fittings (*continued*)

Chemicals and Formula	CONCENTRATION	Plastics and Elastomers at Maximum Temperature (°F)											Metals																	
		ABS	CPVC	PP	PVC	PVDF	TEFLON	EPDM	BUNA-N	HYPALON	NEOPRENE	FLUOROCARBON	ALUMINUM	COPPER	BRONZE (85% Cu)	SILCON BRONZE	ALUMINUM BRONZE	BRASS	GRAY IRON	DUCTILE IRON	CARBON STEEL	3% NI/IRON	NI PLATED DUCTILE	400 SERIES S.S.	316 S.S.	17-4 PH	ALLOY 20	MONEL	STELLITE	HASTELLOY C
Naphtha		B to 70	73	73	140	280	200	C	140	C	C	150	A		A	A	B		A	A	A	A	A	A	A	A	A	A	A	A
Naphthalene $C_{10}H_8$		B to 70			C	200	250	C	C	C	C	170	A		A	A	B		A	A	A	A		A	A	A	A	A	A	A
Nickel Chloride $NiCl_2$	Sat'd		185	180	140	280	406	210	180	200	160	210			C	C	B		C	C	C				A		A	C		A
Nickel Nitrate $Ni(NO_3)_2 \cdot 6H_2O$	Sat'd				140	280	400	210	180			250	C		C	C			C	C	C			A	A	A	A	C		
Nickel Sulfate $NiSO_4$	Sat'd		185	180	140	280	400	210		200	160	300		A	C	C	B		C	C	C									A
Nicotinic Acid C_5H_4NCOOH					140	250		70			140			A	B	B			C	C	C			B	B	B	B	B		
Nitric Acid HNO_3	30%		180	120	140	125	250	70	C	100	C	185	C	C	C	C	C	C	C	C	C		B	A		A				
Nitric Acid HNO_3	70%		73	C	73	C	250	C	C	C	C	100	B	C	C	C	C	C	C	C	C	C		C	A		A			
Nitric Acid HNO_3	100%			C	C	C	70	C	C	C	C	70	B	C	C	C	C	C	C	C	C	C	C	C	A		A	C		
Nitrobenzene $C_6H_5NO_2$				73	C	73	400	C		C	C	70			B	B			A	A	A				A		A	A		A
Oleic Acid $CH_3(CH_2)_7CH{:}CH(CH_2)_7COOH$			185	150	140	250	250	B to 70	100	70	B to 70	185		A	B	B	A		B	B	C			B	A	A	A	A		A
Oxalic Acid $HOOCCOOH \cdot 2H_2O$	50%		185	180	140	125	300	150	C		100	100	C		C	C	C		C	C	C	C	C	B	A	A	A	A		A
Palmitic Acid $CH_3(CH_2)_{14}COOH$	70%		73	180	73	250	300		100	C	C	185		A	B	B	B	A	B	B	B		B	B	A	A	A	A		
Perchloric Acid $HClO_4$	10%		140	73	73	200	250	70	C	70	70	70							C						A		A	A		
Perchloroethylene $Cl_2C{:}CCl_2$						275	200	C	C	C	C	200			B	B			B	B	B		B	A	A	A	A	A		A
Phenol C_6H_5OH		C	73	73	73	125		70	C	C	C	200			A	A	C		C	C	C		C	A	A	A	A	A		A
Phosphoric Acid H_3PO_4	10%		210	180	140	275	300	140	70	200	140	200	C	C	C	C	C	C	C	C	C	C	C	B	A	A	A	C		

Table B-4 Chemical Resistance Guide for Valves and Fittings (*continued*)

Chemicals and Formula	CONCENTRATION	Plastics and Elastomers at Maximum Temperature (°F)											Metals																	
		ABS	CPVC	PP	PVC	PVDF	TEFLON	EPDM	BUNA-N	HYPALON	NEOPRENE	FLUOROCARBON	ALUMINUM	COPPER	BRONZE (85% Cu)	SILCON BRONZE	ALUMINUM BRONZE	BRASS	GRAY IRON	DUCTILE IRON	CARBON STEEL	3% NI/IRON	NI PLATED DUCTILE	400 SERIES S.S.	316 S.S.	17-4 PH	ALLOY 20	MONEL	STELLITE	HASTELLOY C
Phosphoric Acid H_3PO_4	50%		210	180	140	275	300	70	C	200	70	200	C	C	C	C	C	C	C	C	C	C	C	B	A	A	A	C		
Phosphorus Trichloride PCl_3					C	200	300		C	C	C		C												A		A	A		
Potassium Bicarbonate $KHCO_3$	Sat'd		73	170	140	200	400	170	70	200	160	200	A								A				A		A			
Potassium Bromate $KBrO_3$				180	140	275	400		180	140	140	250							C	A	A		A		A		A			
Potassium Bromide KBr				180	140	280	400	170	180	200	160	200			B	B	B		C	C	C				A		A	A		
Potassium Carbonate K_2CO_3		70		180	140	280	400	170	180	200	160	200		B	B	B	B	B	A	A	A	A	A	A	A	A	A	A	A	
Potassium Chlorate $KClO_3$ (Aqueous)				180	140	200	400	140	B to 70	140	100	140		B	B	B			A	A	A	A		A	A	A	A	A	A	
Potassium Chloride KCl			185	180	140	280	400	210	180	200	160	200		B	A	A	B	B	B	B	C	B	B	B	A	A	A	A		A
Potassium Chromate K_2CrO_4					140	280	400	170	140	70	70	200			A	A	B		B	B	B		B		A	A	A	A		
Potassium Cyanide KCN			185		140	280	400	140	180	200	160	185	C	C	C	C	C	C	B	B	B	B		A	A	A	A	A		A
Potassium Fluoride KF					140	275	400	140	180			250													A		A	A		
Potassium Hydroxide KOH	25%		185	150	140	150	400	210	B to 70	140	160	140	C		C	C	C		B	B	B	B		A	A	A	A	A		
Potassium Nitrate KNO_3					140	280	400	210	180	140	140	250		A	A	A	B	B	B	B	B	B		A	A	A	A	A	A	A
Potassium Permanganate $KMnO_4$	10%			150	140	250	400	210	C	100	100	140			B	B			A	A	A			A	A	A	A	A	A	
Potassium Sulfate K_2SO_4				180	140	280	200	210	140	140	140	250		A	A	A	B	B	A	A	A	A	B	A	A	A	A	A	A	A
Potassium Sulfide K_2S						275	300		100		70	100		C	C	C	C	C	C	C	C	B		B	B	B	B	C		A
Potassium Sulfite $K_2SO_3 \cdot 2H_2O$							300	140	70		70	200			B	B	B		C	C	C				A		A	B		

Table B-4 Chemical Resistance Guide for Valves and Fittings (*continued*)

Plastics and Elastomers at Maximum Temperature (°F)

Chemicals and Formula	CONCENTRATION	ABS	CPVC	PP	PVC	PVDF	TEFLON	EPDM	BUNA-N	HYPALON	NEOPRENE	FLUOROCARBON
Propane C_3H_8			73		140	280	300	C	70	B to 70	70	70
Propyl Alcohol $CH_3CH_2CH_2OH$						150	350	140	140	140	140	250
Rosin							200		70	70	70	100
Silver Nitrate $AgNO_3$		70	185	180	140	280	350	210	140	200	160	250
Soaps		70	185	73	140		400	210	180	140	140	250
Sodium Acetate $NaC_2H_3O_2$	Sat'd		185	180	140	280	400	170	C	70		C
Sodium Aluminate $Na_2Al_2O_3$	Sat'd						300	200	180	140	140	200
Sodium Bicarbonate $NaHCO_3$		70	185	180	140	280	400	250	180	200	160	300
Sodium Bisulfate $NaHSO_4$		70		180	140	280		200	180	100	140	250
Sodium Bisulfite $NaHSO_3$			185	180	140	280	400	200	180	200	140	250
Sodium Borate (Borax) $Na_2B_4O_7 \cdot 10H_2O$	Sat'd			73			300	140	70	100	100	140
Sodium Carbonate Na_2CO_3		70	185	180	140	280	400	140	140	140	140	300
Sodium Chlorate $NaClO_3$	Sat'd			180	73	250	350	B to 140	B to 70		B to 140	100
Sodium Chloride $NaCl$			210	180	140	280	350	140	140	100	160	200
Sodium Chlorite $NaClO_2$	25%		73		C	250	200	C	C	140		C
Sodium Chromate $Na_2CrO_4 \cdot 10H_2O$						200		70	70		70	70
Sodium Cyanide $NaCN$			185	180	140	280	350	140	140	140	140	200
Sodium Fluoride NaF			140	185	140	280	350	140	70	140	70	140

Metals

Chemicals and Formula	ALUMINUM	COPPER	BRONZE (85% Cu)	SILCON BRONZE	ALUMINUM BRONZE	BRASS	GRAY IRON	DUCTILE IRON	CARBON STEEL	3% NI/IRON	NI PLATED DUCTILE	400 SERIES S.S.	316 S.S.	17-4 PH	ALLOY 20	MONEL	STELLITE	HASTELLOY C
Propane C_3H_8	A	A	A	A	A	A	A	A	A	A		A	A	A	A	A	A	A
Propyl Alcohol $CH_3CH_2CH_2OH$	A	A	A	A	A	A	A	A	A	A		A	A	A	A	A	A	A
Rosin			C	C			C	C	C		C	A	A	A	A	A		
Silver Nitrate $AgNO_3$		C	C	C	C	C	C	C	C		C	B	A		A	C		
Soaps			B	B	A		B	B	B		B	A	A	A	A	B		A
Sodium Acetate $NaC_2H_3O_2$			A	A	B		B	B	C		B	B	A		A	A		A
Sodium Aluminate $Na_2Al_2O_3$			C	C	B		B	B	A		B		A		A	A		A
Sodium Bicarbonate $NaHCO_3$		A	A	A	B	B	A	A	C		A	A	A	A	A	A	A	A
Sodium Bisulfate $NaHSO_4$		C	C	C	C	C	C	C	C		C	B	A		A	A		
Sodium Bisulfite $NaHSO_3$			B	B			C	C	C		C		A		A	C		A
Sodium Borate (Borax) $Na_2B_4O_7 \cdot 10H_2O$			A	A			B	B			B	A	A	A	A	A		
Sodium Carbonate Na_2CO_3		C	A	A	B	B	A	A	A	A	A		A	A	A	A	B	A
Sodium Chlorate $NaClO_3$			A	A	C		B	B	B		B	B	A	A	A	C		
Sodium Chloride $NaCl$	B	A	A	A	B	B	B	B	C	A	B	B	B	B	A	A	A	A
Sodium Chlorite $NaClO_2$																		
Sodium Chromate $Na_2CrO_4 \cdot 10H_2O$			A	A			B	B	B		B	A	A	A	A	A		
Sodium Cyanide $NaCN$		C	C	C	C	C	A	A	A	A		A	A	A	A	A		
Sodium Fluoride NaF			A	A	B		C	C	C				A		A	A		

Table B-4 Chemical Resistance Guide for Valves and Fittings (*continued*)

Chemicals and Formula		Plastics and Elastomers at Maximum Temperature (°F)											Metals																	
	CONCENTRATION	ABS	CPVC	PP	PVC	PVDF	TEFLON	EPDM	BUNA-N	HYPALON	NEOPRENE	FLUOROCARBON	ALUMINUM	COPPER	BRONZE (85% Cu)	SILCON BRONZE	ALUMINUM BRONZE	BRASS	GRAY IRON	DUCTILE IRON	CARBON STEEL	3% NI/IRON	NI PLATED DUCTILE	400 SERIES S.S.	316 S.S.	17-4 PH	ALLOY 20	MONEL	STELLITE	HASTELLOY C
Sodium Hydroxide NaOH	15%	70	185	180	140	170	400	210	140	200	160	B to 100	C		A		A			A	A		B	A	A	A	A	A	A	A
Sodium Hydroxide NaOH (Caustic Soda)	30%	70	210	180	140	73	350	210	100	140	160	B to 100	C		A		B			B	B		B	A	A	A	A	A		
Sodium Hydroxide NaOH	50%	70	210	180	100	C	350	180	C	140	160	C	C	B	B	C	C	C	B	B	B	B	B	A	A	A	A	A		
Sodium Hydroxide NaOH	70%	70		180	100	C	350	70	C	100	100	C	C	B	C	C	C	C	B	B	B	B	B	A	A	A	A	A		
Sodium Hypochlorite $NaOCl \cdot 5H_2O$		C	185	120	73	200	350	70	C	150	C	140	C	C	C	C	C	C	C	C	C	C	C	C	A		A	A		A
Sodium Nitrate $NaNO_3$	Sat'd		185	180	140	280	400	210	140	140	140	225		B	A	A	B	B	A	A	A	A	A	A	A	A	A	A	B	A
Sodium Perborate $NaBO_2 \cdot 3H_2O$				73	140		350	70	70	70	70	70			C	C			B	B	B			A	A	A	A	A		A
Sodium Peroxide Na_2O_2					140	200	250	140	B to 70	200	70	185		B	C	C	C	C	C	C	C			A	A	A	A	A		B
Sodium Silicate $2Na_2O \cdot SiO_2$				180		280		200	140	200	140	200			C	C	B		A	A	A		A	A	A	A	A	A	A	A
Sodium Sulfate Na_2SO_4	Sat'd	70	185	150	140	280	400	140	140	140	140	200		A	A	A	B	B	A	A	A	A	A	A	A	A	A	A	A	A
Sodium Sulfide Na_2S		70	185	150	140	280	350	140	180	200	140	200		C	C	C	C	C	B	B	C	B	B	A	A	A	A	A		
Sodium Sulfite Na_2SO_3		70	185	180	140	280	350	140	140	140	140	200			A	A	C		B	B	B		B	B	A	A	A	C		A
Sodium Thiosulphate $Na_2S_2O_3 \cdot 5H_2O$				150	140	280	350	200	140	200	160	200	A		B	B	C		C	C	C		C		A		A	A		
Starch					140	200	300	170	180	200	160	200			B	B	B	B	B	B	B		B	A	A	A	A	A		
Stearic Acid $CH_3(CH_2)_{16}COOH$			185	73	140	275	350	C	140	70	70	100		A	A	A	C	B	C	C	C	B	C	A	A	A	A	A		A
Sugar $C_6H_{12}O_6$						275	350	140	100	140	140	200			C	C				B	C		B	A	A	A	A	A		
Sulfur S				C	140	250	350		C	70	70	250	C	C	C	C	C	C	B	B	C	B	B	B	A		A	A		A

Table B-4 Chemical Resistance Guide for Valves and Fittings (*continued*)

Chemicals and Formula		Plastics and Elastomers at Maximum Temperature (°F)											Metals																	
	CONCENTRATION	ABS	CPVC	PP	PVC	PVDF	TEFLON	EPDM	BUNA-N	HYPALON	NEOPRENE	FLUOROCARBON	ALUMINUM	COPPER	BRONZE (85% Cu)	SILCON BRONZE	ALUMINUM BRONZE	BRASS	GRAY IRON	DUCTILE IRON	CARBON STEEL	3% NI/IRON	NI PLATED DUCTILE	400 SERIES S.S.	316 S.S.	17-4 PH	ALLOY 20	MONEL	STELLITE	HASTELLOY C
Sulfur Chloride S_2Cl_2				C		73	350	C	C	70	C	70	C	C	C	C	C	C	C	C	C	C	C	C	C	C	B	C	C	
Sulfur Dioxide SO_2	Dry		C	73	140	175	350	70	C	200	C	100	A	A	A	B	A	A	A	A	A		A	A	A	A	A	A	A	A
Sulfur Dioxide SO_2	Wet		C	73	73	150		140	C	200		140	B	C	C	B	B	C						C	A	C	A	A		A
Sulfuric Acid H_2SO_4	Up to 30%	B to 100	210	180	140	250	250	140	C	100	100	200		C	C	C	C	C	C	C	C	C	C	C	A	B	A	A	C	A
Sulfuric Acid H_2SO_4	50%	C	210	150	140	250	250	140	140	150	C	200		C	C	C	C	C	C	C	C	C	C	C	A	C	A	A	C	A
Sulfuric Acid H_2SO_4	70%	C	210	120	140	200	200	140	C	150	C	250	C	C	C	C	C	C	C	C	C	C	C	C	B	C	A	C	C	A
Sulfuric Acid H_2SO_4	100%	C	C	C	C	C	B to 200	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	B	C	B	C	C	
Sulfurous Acid H_2SO_3				150	C	230	350	C		150	C	C		C	C	C	C	C	C	C	C	C	C	B	A	A	A	A	C	A
Tannic Acid $C_{76}H_{52}O_{46}$	10%	C	185	180	140	225	250	70	100	100	100	100			A	A			B	B	C	B	B	B	A	A	A	A		A
Tartaric Acid $HOOC(CHOH)_2COOH$				150	140	250	250	C	70	200	70	70		B	A	A	C	C	C	C	C	C	C	A	A	A	A	A		A
Toluene (Toluol) $Ch_3C_6H_5$		C	C	C	C	175	200	C		C	C	70	A	A	A	A	A	A	A	A	A	A		A	A	A	A	A	A	A
Trichloroethylene $CHCl{:}CCl_2$		C	C	C	C	280	200	C	C	C	C	185	A	A	A	A	A	A	B	B	B			A	A	A	A	A	A	A
Turpentine			73	C	140	280		C	70	C	C	150	A	A	A	A	A	A	A	A	A	A		A	A	A	A	A	A	A
Urea $CO(NH_2)_2$			185	180	140	250		210	140	140	140	185		C		B	B			C	C	C				A	A	B	C	
Varnish						250	350	C	70		C	70		A	A	A	B	B	C	C	C			B	A	A	A	A		A
Vegetable Oil			185	73	140	275	300	C	70	70	70	200	A		A	A				A	A			A	A	A	A	A	A	
Vinegar		73	150	140	140	225	300	140	C	200	70	C	C	B	C	C	C	C	C	C	C			A	A	A	A	A		A
Vinyl Acetate $CH_3COOCH{:}CH_2$				C	C	250	350	70	70	C	C	C			B	B			B	B	B				A		A	B		

Table B-4 Chemical Resistance Guide for Valves and Fittings (*continued*)

Chemicals and Formula	CONCENTRATION	Plastics and Elastomers at Maximum Temperature (°F)										
		ABS	CPVC	PP	PVC	PVDF	TEFLON	EPDM	BUNA-N	HYPALON	NEOPRENE	FLUOROCARBON
Water, Deionized H_2O		70	210	180	140	280	400	200	70		160	
Water, Salt H_2O		70	210	180	140	280	400	250	180	200	160	
Water, Sea H_2O		70	210	73	140	280	400	250	180	200	160	
Whiskey			185	150	140	200	350	200	140	140	140	140
Wine			185	150	140	200	350	170	140	140	140	140
Xylene (Xylol) $C_6H_4(CH_3)_2$		C	C	C	C	200	350	C	C	C	C	150
Zinc Chloride $ZnCl_2$			185	180	140	280	400	180	70	200	160	200
Zinc Sulfate $ZnSO_4 \cdot 7H_2O$			185	180	140	280	400	180	140	200	140	200

Chemicals and Formula	Metals																	
	ALUMINUM	COPPER	BRONZE (85% Cu)	SILCON BRONZE	ALUMINUM BRONZE	BRASS	GRAY IRON	DUCTILE IRON	CARBON STEEL	3% NI/IRON	NI PLATED DUCTILE	400 SERIES S.S.	316 S.S.	17-4 PH	ALLOY 20	MONEL	STELLITE	HASTELLOY C
Water, Deionized H_2O	A	A	B	B	C	C	C	C	C		C	B	A	A	A	A		A
Water, Salt H_2O	C	B	B	B	C	C	C	C	C	B	C	B	A	A	A	A	B	A
Water, Sea H_2O	C	B	B	B	C	C	C	C	C	B	C	B	B	A	A	A	C	A
Whiskey		A	C	C	B		C	C	C		C	B	A		A	A		A
Wine			C	C			C	C	C		C	B	A		A	A		
Xylene (Xylol) $C_6H_4(CH_3)_2$	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
Zinc Chloride $ZnCl_2$			C	C	C		C	C	C		C	C	B	B	A	A		
Zinc Sulfate $ZnSO_4 \cdot 7H_2O$		A	C	C	B		C	C	C	B	C	A	A	A	A	A		A

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MATERIAL RATING FOR THERMOPLASTICS & ELASTOMERS

Temp. in °F	=	"A" rating, maximum temperature which material is recommended, resistant under normal conditions
B to Temp. in °F	=	Conditional resistance, consult factory
C	=	Not recommended
Blank	=	No data available

MATERIAL RATINGS FOR METALS

A	=	Recommended, resistant under normal conditions
B	=	Conditional, consult factory
C	=	Not recommended
Blank	=	No data available

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Index

D

E

F

G

H

I

P

R

S

T

U

V

W