MATERIAL SELECTION LIST FOR OXYGEN SERVICE

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1. FOREWORD

Materials selection requirements for oxygen service have changed significantly since the last revision of this document. Historically, flammability and mechanical impact ratings were the main criteria for materials selection for oxygen service. Materials used in liquid oxygen (LO_2) or gaseous oxygen (GO_2) environments must be evaluated as described in NASA-STD-6001B, section 6.3. Materials selection for LO_2 and GO_2 environments in accordance with NASA-STD-6001B begins with pre-selection of materials based on flammability and combustion test data, followed by flammability assessment of materials in the worst-case configuration and environment. Material flammability ratings based on NASA-STD-6001B test results for many materials, including those identified in this document, are found in the Materials and Processes Technical Information System (MAPTIS) database and ASTM G63 and ASTM G94. If test results are not available through ASTM, NASA, or other sources, materials should be submitted to NASA/NE-L2-T for testing. Requests for flammability testing should be addressed to NASA/MC: NE-L2-T, Kennedy Space Center, FL 32899. The test results will be electronically archived locally at KSC by NASA/NE-L and submitted for inclusion in MAPTIS II. If the materials are determined to be nonflammable in their use configuration and environment, and no additional material control is required, the materials may be used.

If the materials are determined to be flammable, an oxygen compatibility assessment[1] (OCA) must be performed on the components and systems in accordance with NASA/TM-2007-213740, which provides an overview of oxygen fire hazards and procedures which are consistent with the latest versions of ASTM G63, ASTM G94, and ASTM MNL 36. The OCA is used to determine whether the material may be used, or whether there is a need to perform supplemental material, configuration, or component testing. Requests for oxygen compatibility testing of materials should be addressed to NASA/MC: NE-L2-T, Kennedy Space Center, FL 32899. Oxygen compatibility test results will be transmitted to the customer by NASA/NE-L. The test results will be electronically archived locally at KSC by NASA/NE-L and submitted for inclusion in MAPTIS II. Contact NASA M&P for further information on configuration or component testing.

[1] Oxygen Compatibility Assessment (OCA) is the terminology used by NASA to describe the process formerly known as Oxygen Hazard Analysis (OHA). The terminology was changed to avoid confusion between OHA and the non-oxygen-related Hazard Analysis performed by Safety. The OHA terminology is still used outside of NASA and is considered to be synonymous with OCA.

Materials used in oxygen systems for the Shuttle program were typically been tested for flammability and mechanical impact, which have been the basic criteria for materials selection for oxygen service for more than 20 years. Materials selection for post-Shuttle programs will be in accordance with the materials selection and OCA requirements called out in NASA-STD-6016 for flight and NASA-STD-5005C for GSE. Materials used in existing oxygen system designs with a history of safe use are considered acceptable for continued use; however, changes to materials used in such systems must be assessed on an individual basis. Contact NASA M&P for further information on materials with a history of safe use in oxygen systems and assessment criteria for new or untested materials.

When a material has been determined to be flammable by the NASA-STD-6001B Test 1, for nonmetals or Test 17 for metals, but has been determined suitable for use by an OCA, then a system/component safety rationale must be documented and must be approved by NASA M&P, either through a Material Usage Agreement (MUA) for existing drawings or NASA M&P signature on new or revised drawings. NASA Design Engineering and NASA M&P Engineering, through the signature of the cognizant organization, are responsible for ensuring that materials used in oxygen system designs have been assessed and determined acceptable for use. All new and modified oxygen system designs are required to be routed to NASA M&P Engineering for evaluation.

2. SCOPE

This document is intended as a resource for materials selection for design of oxygen systems for KSC ground support equipment (GSE) and ground support systems (GSS). Flammability and combustion data extracted from NASA, ASTM, and industry documents for materials commonly used in KSC oxygen systems are summarized in Table 1 (Nonmetallic [Soft Good] Materials) and Table 2 (Metals), in order to facilitate selection of materials for oxygen service. Autogenous Ignition Temperature, Heat of Combustion, and Oxygen Index data are presented for nonmetallic materials; Promoted Ignition (NASA-STD-6001B, Test 17) data are presented for metallic materials. Codes are assigned to each material per KTI-5209, Material Usage Code.

The nonmetallic materials listed in Table 1 were also tested per NASA-STD-6001B supplemental tests for mechanical impact in ambient pressure LO_2 (Test 13A) and variable pressure GO_2 and LO_2 (Test 13B). The materials listed in Table 1 are rated A[2] for mechanical impact up to the operating pressures listed in the table. Mechanical impact is only considered a credible ignition mechanism in certain components; mechanical impact test results can be utilized as an aid to the OCA process when mechanical impact is identified as a credible ignition mechanism. Batch/lot testing for mechanical impact is no longer required for all soft goods used in oxygen service in the 1,650 - 6,700 psi range. NASA Design Engineering or NASA M&P may still require mechanical impact testing for operating pressures higher than the pressures at which the materials are rated A, in cases where mechanical impact is a credible ignition mechanism. In these cases the mechanical impact testing requirement will be stated on the drawing.

[2] Meets the measurements/test condition requirements of NASA-STD-(I)-6001B Appendix A.5, **Mechanical Impact for Materials in Ambient Pressure LOX (Test 13A) and Mechanical Impact for Materials in Variable Pressure GOX and LOX (Test 13B),** and does not require batch testing; number of tests = 20 and the number of reactions = 0 (zero), or number of tests = 60 and the number of reactions = 1 (one). Standard impact energy is 72 ft-lb, but may vary. Consult MAPTIS for actual test conditions.

The vendors and applicable specifications for the materials listed in this KTI have been updated from the previous revision. These listings do not take into account the effects of unknown formulation and/or process changes that could be performed by a manufacturer, which could result in a material performing differently than these test results would indicate. Materials requiring initial testing, revalidation testing, or mechanical impact testing in accordance with NASA-STD-6001B may be submitted to the KSC Materials Science Laboratory.

3. GUIDELINES FOR MATERIALS SELECTION FOR OXYGEN SYSTEM DESIGN

The list is new to this revision and is intended as a starting point for materials selection in the preliminary design phase. This list is to be utilized only as reference prior to evaluation of the system for oxygen service.

3.1 Nonmetallic Materials (Soft Good Materials and Lubricants)

Nearly all soft goods and lubricants are flammable in oxygen at ambient pressure. Selection of soft goods is based on their relative performance in various oxygen compatibility studies (autogenous ignition, heat of combustion, oxygen index, mechanical impact, and gaseous impact tests) and histories of use within NASA and other institutions. In addition to material compatibility, mechanical properties of soft goods and lubricants must be considered, e.g., cold flow of PTFE. Information on material trade names within the chemical classes is found in Table 1. Consult ASTM G63 for further information on selection of nonmetallic materials for oxygen service. The following nonmetallic materials are recommended for consideration for oxygen service:

<u>Plastics</u>

Polytetrafluoroethylene (PTFE)
Fluorinated ethylene propylene (FEP)
Perfluoroalkoxy (PFA)
Polychlorotrifluoroethylene (PCTFE)
Polyimide (PI)
Amorphous fluoropolymers

<u>Elastomers</u>

Fluorocarbonelastomer (FKM)
Perfluoroelastomer (FFKM)
Fluorosilicone elastomer (MVQ)

Lubricants

Perfluoropolyether (PFPE)
Chlorotrifluoroethylene (CTFE) oligomers
Molybdenum disulfide (MoS_2) dry lubricants

3.2 Ceramics

All ceramics without organic fillers or binders may be used in oxygen service; however, due to the brittleness of many ceramics, consideration of the effects of failure, including the functionality of components within the system, is recommended. Contact NASA M&P for further information on use of ceramics in oxygen service.

3.3 Metals

Metals that burn in oxygen at 14.7 psia or less, or pose a toxicity hazard, are to be avoided in direct oxygen service. When selecting a metal for oxygen service, situational flammability must be considered. In general, metals, including those that normally exhibit high resistance to ignition, are more flammable in oxygen when they have thin cross-sections, such as thin-walled tubing, or when they are finely divided, such as in wire mesh or sintered filters. If a metal is found to be situationally flammable, special care should be taken to avoid ignition sources. Consult ASTM G94 for further information on selection of metals for oxygen systems. The following metals are recommended for oxygen service:

Commercially Pure Nickel
Monel K-500 UNS
Monel 400
Inconel MA754

Commercially Pure Copper
Tin Bronze
Yellow Brass
Red Brass

Stainless steel is frequently used in high-pressure oxygen systems, even though it is flammable in certain configurations, such as meshes and thin sections. The use of stainless steels in high-pressure oxygen systems is possible, as long as the severity of the environment is controlled in order to minimize the probability of ignition and minimize the risk if ignition occurs. The following controls should be implemented when using stainless steels in high-pressure oxygen systems:

- Systems are initially clean, to KSC-C-123 level 300A or better.
- Proper system assembly practices are followed, in order to avoid contamination.
- Inert gas blow-downs are performed, in order to reduce contamination.
- System designs eliminate the use of tubing with a 90-degree bend radius wherever possible.
- Valves are designed to reduce generation of contaminates, e.g. non-rotating stems.
- Valve soft goods are surrounded by metal with low Heat of Combustion, such as Monel.
- Remote or limited operations are employed, in order to minimize personnel exposure.
- Gas velocities in lines are low (< 100 ft/s).
- Kindling chain is taken into consideration.

4. APPLICABLE DOCUMENTATION

NASA-STD-5005	Standard for the Design and Fabrication of Ground Support Equipment
NASA-STD-6001B	Flammability, Offgassing, and Compatibility Requirements and Test Procedures
NASA-STD-6016	Standard Materials and Processes Requirements for Spacecraft
MAPTIS-II	MSFC/Materials and Processes Technical Information System (http://maptis.nasa.gov/index.asp)
KTI-5209	Material Usage Code
NASA/TM-2007-213740	Guide for Oxygen Compatibility Assessments on Oxygen Components and Systems
ASTM MANUAL 36	Safe Use of Oxygen and Oxygen Systems
ASTM G63	Standard Guide for Evaluating Non-metallic Materials for Oxygen Service
ASTM G94	Standard Guide for Evaluating Metals for Oxygen Service
KSC-C-123	Surface Cleanliness of Ground Support Equipment Fluid Systems, Specification for
79K19956	Batch Test Requirements for Oxygen Compatibility

Table 1: Nonmetallic Materials

CODE	GENERIC NAME	CHEMICAL CLASS	FORMULATION NAME	AIT (°C)	AIT TEST PRESSURE (psia)	ΔHc (kJ/g)	MECHANICAL IMPACT	OI (%)	SPECIFICATION/CERTS/NOTES	LAST LISTED OWNER
	ELASTOMERS									
E01	Fluoroelastomer copolymer	FKM (copolymer of VF2 and HFP)	Viton A	239-322[2]	1500	12.64-16.71[2]	A (1650)	31.5-57.5[2]	SAE-AMS-7276; SAE-AMS-7259; SAE-AMS-3216; SAE-AMS-3218	DuPont, North America (800) 222-8377
E01	Fluoroelastomer copolymer	FKM (copolymer of VF2 and HFP)	Dyneon FKM Fluoroelastomer (Formerly Fluorel)	297-302[2]	1500	16.71[2]	A (1650)	73.9-93.5[2]	SAE-AMS-7276; SAE-AMS-7259; SAE-AMS-3216; SAE-AMS-3218 Dyneon FKM Replaces Fluorel. Values listed are for Fluorel.	3M (888) 364-3577
E01	Fluoroelastomer copolymer	FKM (copolymer of VF2 and HFP)	Fluorel E2160	297-328[2]	1500	11.51-14.24[2]	NT	None[2]	SAE-AMS-7276; SAE-AMS-7259: SAE-AMS-3216; SAE-AMS-3218	3M (888) 364-3577
E08	Perfluoroelastomer	FFKM (terpolymer of TFE, PMVE and cure site monomer)	Kalrez	355[2]	1500	6.55-8.75[2]	A (1650)	100[2]	SAE-AMS-7257	DuPont, North America (800) 222-8377
E08	Perfluoroelastomer	FFKM (terpolymer of TFE, PMVE and cure site monomer)	Chemraz 570	NT	NT	NT	A (1650)	NT	SAE-AMS-7257	Greene, Tweed, Kulpsville, PA (215) 256-9521
	LUBRICANTS									
L01	Perfluoroalkylpolyether Grease (PFPE Base Oil Plus PTFE Telomer)	PFPE	Christo-Lube-MCG-111	>400		12.78[4]	A (6700)	NT	MIL-PRF-27617	Lubrication Technology, Inc., Franklin Furnace, OH (800) 477-8704
L01	Perfluoroalkylpolyether Grease (PFPE Base Oil Plus PTFE Telomer)	PFPE	Braycote 600EF	NT		NT	A (6700)	NT	NONE; Replaces Braycote 600 with environment friendly formula. May require re-test.	Castrol Industrial North America, Inc. Naperville, IL (800) 621-2661
L01	Perfluoroalkylpolyether Grease (PFPE Base Oil Plus PTFE Telomer)	PFPE	Braycote 806	NT		NT	A (1650)	NT	MIL-PRF-27617	Castrol Industrial North America, Inc. Naperville, IL (800) 621-2661
L01	Perfluoroalkylpolyether Grease	PFPE	NYE UniFlor 8531R (Formerly Fluoroether)	NT		NT	A (1650)	NT	NONE: Replaces Fluoroether with environment friendly formula. May require re-test	NYE Lubricants, Inc., Fairhaven, MA (508) 996-6721
L01	Polychlorotrifluoroethylene Jelled Oil with Polytetrafluoroethylene Particles)	PCTFE & PTFE	LOX-8 Grease	447[4]	1500	NT	A (1650)	NT	NONE	Fluoramics, Inc., Mahwah, NJ (800) 922-0075
L01	Perfluoroalkylpolyether Grease (PFPE Base Oil plus PTFE Thickener	PFPE	Demnum L200	NT		NT	A (1650)	NT	NONE	Daikin America, Inc., Orangeburg, NY (800) 365-9570

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L01	Perfluoroalkylpolyether Grease (PFPE Base Oil plus PTFE Thickener)	PFPE	Demnum L200	NT		NT	A (1650)	NT	NONE	Daikin America, Inc., Orangeburg, NY (800) 365-9570
L05	Polychlorotrifluoroethylene Oil	CTFE oil	LOX Pump Oil	NT		NT	A (1650)	NT	79K22280	KSC Laboratory-Manufactured, using Halocarbon Oil No. 27 as base
L06	Perfluoroalkylpolyether Oil	PFPE oil	Krytox 143AC	427[1]	1500	NT	A (6700)	NT	NONE	DuPont, North America (800) 222-8377
L06	Perfluoroalkylpolyether Oil	PFPE oil	Fomblin Y-LVAC 06/6	427+[1]	1500	NT	A (6700)	NT	NONE	Solvay Solexis, Inc. Thorofare, NJ (800) 554-2874
L06	Perfluoroalkylpolyether Oil	PFPE oil	Fomblin Y-LVAC 16/6	427+[1]	1500	NT	A (6700)	NT	NONE	Solvay Solexis, Inc. Thorofare, NJ (800) 554-2874
L09	Polychlorotrifluoroethylene Oil	CTFE oil	Halocarbon Oil	>500[3]	1500	4.19[3]	A (1650)	NT	NONE	Halocarbon Products Corp. Riveredge, NJ (201) 262-8899
L08	Polychlorotrifluoroethylene Grease (Polymer Thickened)	PCTFE grease	Halocarbon 25-5S Grease	427+[1]	1500	5.02 - 5.44[3]	A (1650)	NT	NONE	Halocarbon Products Corp. Riveredge, NJ (201) 262-8899
L08	Polychlorotrifluoroethylene Grease	CTFE grease	Fluorolube GR-362 Grease	>427[1]	1500	4.99[1]	A (1650)	67 +/- 4[1]	NONE	Gabriel Performance Products Ashtabula, OH (866) 800-2436
L09	Polychlorotrifluoroethylene Oil	CTFE grease	Fluorolube LG160 Grease	382[1]	1500	2.52[1]	A (1650)	NT	NONE	Gabriel Performance Products Ashtabula, OH (866) 800-2436
L10	Solid Dry-Film Lubricant	MoS2 Base	Dri-Lube 703	NT		NT	A (1650)	NT	NONE	Drilube/All Metals Processing Stanton, CA (714) 828-8238
L10	Solid Dry-Film Lubricant	MoS2 Base	Dri-Lube 831	NT		NT	A (1650)	NT	NONE	Everlube Products Peachtree City, GA (800) 428-7802
L10	Solid Dry-Film Lubricant	MoS2 Base	Dri-Lube 842	205[3]		9.63[3]	A (1650)	NT	NONE	
L11	Solid Dry-Film Lubricant (Sodium Silicate Binder)	MoS2 Base	Everlube 812	NT		NT	A (6700)	NT	SAE-AMS-3084	
L11	Solid Dry-Film Lubricant (Sodium Silicate Binder)	MoS2 & Graphite Base	Everlube 811	271[2]	1500	11.27[3]	A (6700)	NT	MIL-PRF-81329D	Everlube Products Peachtree City, GA (800) 428-7802
L12	Solid Dry-Film Lubricant (Proprietary Binder)	MoS2 Base	Tiolube 1175	NT		NT	A (1650)	NT	SAE-AS-1701, Class VI	Tiodize Company, Inc. Huntington Beach, CA (714) 898-4377

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L13	Solid Dry-Film Lubricant (Inorganic Binder)	MoS2 & Graphite Base	DC-321 (LOX only)	NT		NT	A (1500)	NT	NONE	Dow Corning Corp. Midland, MI (800) 248-2481
L14	Perfluoroalkylpolyether Grease (PFPE oil with PTFE thickener)	PFPE	Krytox 240AC	427+[3]	1500	3.77 - 4.19[3]	A (6700)	NT	MIL-PRF-27617	DuPont, North America (800) 222-8377
L14	Perfluoroalkylpolyether Grease (PFPE oil with PTFE Dispersion Particles)	PFPE	Braycote 640AC	NT		NT	A (6700)	NT	Reformulated with environment-friendly ingredients - may need retest.	Castrol Industrial North America, Inc. Naperville, IL (800) 621-2661
L15	Perfluoroalkylpolyether Grease (PFPE oil with PTFE Dispersion Particles)	PFPE	Braycote 601EF	NT		NT	A (6700)	NT	NONE	Castrol Industrial North America, Inc. Naperville, IL (800) 621-2661
L16	Perfluoroalkylpolyether Oil	PFPE	Braycote 815Z	NT		NT	A (6700)	NT	Production facility relocated in February, 2005; first batch produced in March, 2005. Mechanical impact testing was for material produced prior to March 2005.	Castrol Industrial North America, Inc. Naperville, IL (800) 621-2661
	MISCELLANEOUS									
M25	Polytetrafluoroethylene Submicronic Spheres Embedded Within Electroless Nickel Coating	PTFE	Niflor	NT		NT	A (1650)	NT	NONE	Norman Hay/Surface Technology plc, Coventry, UK; Fothergill & Harvey, Manchester, England, UK
M31	Leak Detector Fluid		Sherlock	190-210[3]	2000	28.47[3]	A (1650)	NT	MIL-PRF-25567	Winton Products Co., Inc., Charlotte, NC
	Silica Aerogel Thermal Blanket	Silica Aerogel	Spaceloft, 10 mm	NT		2.22-2.484	A	25.6-26.94		Aspen Aerogels Northborough, MA

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	PLASTICS									
P01	Polytetrafluoroethylene	PTFE	PTFE; Teflon TFE	434-526[2]	1500	4.78-7.12[2]	A (6700)	95-100[2]	The Following Specifications are Applicable for Code PO1 Materials: A-A-58092 (PTFE Tape, Anti-Seize); SAE-AMS-3668 (PTFE Moldings, Premium Grade); SAE-AMS-3669 (PTFE Sheet, Molded, Premium Grade); SAE-AMS-3657 (PTFE Extrusions, Premium Strength); SAE AMS-3658 (PTFE Extrusions, Premium Strength, Stress-Relieved, Radiographically Inspected); SAE-AMS-3659 (PTFE Extrusions, Premium Strength, Stress-Relieved); ASTM-D3294 (PTFE Resin Molded Sheet and Molded Basic Shapes); ASTM-D3308 (PTFE Resin Skived Tape); ASTM-D3369 (PTFE Resin Cast Film); SAE-AS-8791 (PTFE Retainers); ASTM-D1710 (Extrusion and Compression Molded PTFE Rod and Tubing); SAE-AMS-3652 (PTFE Film, Non-Critical Grade); SAE-AMS-3656 (PTFE Extrusions, Normal Strength); SAE-AMS-3660 (PTFE Moldings, General Purpose Grade), SAE-AMS-3667 (PTFE Sheet, Molded, General Purpose Grade); ASTM-D4894 (PTFE Granular Molding and Ram Extrusion Matls.); ASTM-D4895 (PTFE Resin Produced from Dispersion)	DuPont, North America (800) 222-8377
P01	Polytetrafluoroethylene	PTFE	Algoflon F7, Algoflon F2	NT		NT	A (6700)	>95 %[4]		Solvay Solexis, Inc. Thorofare, NJ (800) 554-2874
P02	Perfluoro(ethylene-propylene) Copolymer	FEP	Teflon FEP	378[2]	1500	10.47[2]	A (6700)	77-95[2]	ASTM-D2116 (FEP-Fluorocarbon Molding and Extrusion Matls.); ASTM-D3368 (FEP-Fluorocarbon Sheet and Film); ASTM-D3296 (FEP-Fluorocarbon Tube); SAE-AMS-3647 (FEP Film and Sheet)	DuPont, North America(800) 222-8377
P03	Glass-Filled Polytetrafluoroethylene	PTFE	Fluorogold	484[2]	500	7.12[2]	A (6700)	None [2]	ASTM-D4894, Type II; ASTM-D4745, Type I, Grade 2	St. Gobain Performance Plastics (800) 544-0080
P04	Glass-Filled Polytetrafluoroethylene	PTFE	Fluorogreen E-600	479[2]	500	10.05[2]	A (6700)	None [2]	ASTM-D4894, Type II; ASTM-D4745, Type I, Grade 2	UFC Fluorogreen Co. Houston, TX (713) 460-2500
P06	Glass-Filled Polytetrafluoroethylene	PTFE	RT/Duroid 5870	NT		NT	A (1650)	NT	ASTM-D4894; ASTM-D4745	Rogers Corp. Chandler, AZ (480) 961-1382

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P07	Perfluoroalkoxy perfluoropolymer	PFA	Teflon PFA	424[1]	1500	5.23[1]	A (1650)	NT	ASTM-D3307 (PFA-Fluorocarbon Resin Molding and Extrusion Materials)	DuPont, North America (800) 222-8377
P09	Polychlorotrifluoroethylene	PCTFE	Neoflon CTFE	377-382[2]		5.12 - 5.15[2]	A (1650)	NT	ASTM-D7194 (Aerospace Parts Machined from PCTFE) Note: ASTM-D7194 replaces ASTM-D1430, SAE-AMS-3645, 3646, and 2650 for purposes of new and direct procurement of moldings. ASTM-D1430 is still valid for classification purposes.	Daikin America, Inc. Orangeburg, NY (845) 365-9500
TBD	Polychlorotrifluoroethylene (PCTFE-Film Grade)	PCTFE	Aclar 22A	390[1]	1500	NT	A (1650)	NT	ASTM-D3595; SAE-AMS-3649	Honeywell International Specialty Films Morristown, NJ (800) 934-5679
P12	Polytetrafluoroethylene Compound (Filled, Reinforced)	PTFE	Rulon A	484[2]	NR	5.86[2]	A (6700)	None[2]	NONE	St. Gobain Performance Plastics (800) 544-0080
P14	Polyimide Resin (15% Graphite Fill)	PI	Vespel SP-21	343-562[2]	1500	25.54-31.81[2]	A (1650)	53[2]	ASTM-D6456	DuPont, North America (800) 222-8377
P32	Silica-Filled Polytetrafluoroethylene	PTFE	Garlock 3502 (Fawn Gylon)	NT		6.28-7.12[3]	A (1650)	NT	ASTM-D4895	Garlock Sealing Technologies Palmyra, NY (800) 448-6688
P33	Polytetrafluoroethylene Form-In-Place Gasketing	PTFE	Gore-Tex Joint Sealant	150-470[3]	2000	5.99[1]	A (1650)	NT	NONE	W.L. Gore and Associates, Inc. Newark, DE (410) 392-3200
P36	Glass-Filled Polytetrafluoroethylene	PTFE	Fluoroloy 36	NT		NT	A (1650)	NT	NONE	St. Gobain Performance Plastics (800) 544-0080

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PH1, PH3, PH5	Polytetrafluoroethylene Flexible Hose Liner	PTFE	Teflon (PTFE) Liner	NT		NT	A (1650)	NT	NONE	Trademark: DuPont, North America(800) 222-8377Distributors: Crane-Resistoflex, Marion, NC; Smiths Tubular Systems-Laconia, Inc./Titeflex /Lewis & Saunders, Inc., Laconia, NH; Parker-Hannifin Corporation, Stratoflex Products Division, Ft. Worth, TX
PH2, PH4, PH6, PH7	Polytetrafluoroethylene Flexible Hose Liner With Carbon Additive	PTFE	Teflon (PTFE) Liner	NT		NT	A (1650)	NT	NONE	

1 - ASTM G63
2 - ASTM Manual 36
3 - Wendell Hull & Associates Oxygen Compatibility Material Database
4 - Other
NT = Not Tested

Table 2: Metals

MATERIAL	NUMBER	PROMOTED IGNITION LOWEST BURN PRESSURE (psia)	BURN LENGTH (in.)	PROMOTED IGNITION HIGHEST NO-BURN PRESSURE (psia)	# OF TESTS (><10)	# OF TESTS (ACTUAL)	BURN LENGTH (in.)	ΔHc (kJ/g)
Aluminum	VARIOUS	12.4	2.93	NT	NT	NT	NT	31.07
Aluminum-Bronze	C61300	250	0 - 6	200	<10	1	0	4.605 - 5.862
Aluminum (commercially pure)		12.4	2.93	NT	NT	NT	NT	31.087
Aluminum 1100	A91100	100	0 - 5	50	<10	3	0 - 0.9	NT
Aluminum 2219	A92219	25	0 - 1.9	15	<10	1	0.2	NT
Copper	VARIOUS	NT	NT	>10,000	2	2	0 - 0.6	2.45
Zirconium Copper	C15000	NT	NT	>480	>10	40	0.3	NT
Copper Beryllium	C81400	NT	NT	>10 000	<10	3	0-0.125	NT
Copper 102	C10200	NT	NT	>8000	<10	2	0	NT
Tin (commercially pure)		500	0 - 6	200	<10	6	0	4.895
Bronze	C93600	NT	NT	>10 000	<10	3	0.3-0.4	NT
Tin Bronze	C90700	NT	NT	>7,000	<10	5	0.1	NT
Yellow Brass	C36000	NT	NT	>7,000	<10	5	0.2	3.45
Red Brass	C23000	NT	NT	>7,000	<10	5	0.2	2.89
Brass 360 CDA	C36000	NT	NT	>10 000	<10	1	0.25	NT
Stellite 6	R30006	1400	0.5 - 1.4	1200	10	10	0.1 - 0.7	NT
Stellite 6-B	R30006	2,500	1.2 - 5.0	1,000	<10	4	0.3	NT
Invar 36	K9360X	≤1,000	3	NT	NT	NT	NT	NT
Inconel 600	N06600	2,500	0.4 - 5.0	2,000	>10	11	0.1 - 0.4	5.44
Inconel 625	N06625	≤1,000	0.4 - 2.1	NT	NT	NT	NT	6.048
Inconel 718	N07718	≤500	0.5 - 4.3	NT	NT	NT	NT	6.804
Inconel 750X	N07750	NT	NT	NT	NT	NT	NT	NT
Inconel 800 HT	N08811	200	0.2 - 1.8	35	<10	5	0.2 - 0.5	NT
Inconel MA754	N07754	NT	NT	>10 000	>10	10	0.3-0.4	NT
Monel 400	N04400	NT	NT	>10 000	>10	13	0-0.4	3.643
Monel K-500	N05500	NT	NT	>10 000	>10	15	0.25-0.4	NT
Hastelloy C-22	N06022	≤2,500	0.4 - 5.8	NT	NT	NT	NT	6.027
Hastelloy C-276	N10276	1750	>1.16	1500	<10	6	<1.16	6.258
Hastelloy G-30	N06030	1,000	0 - 5	500	<10	2	0.25 - 0.5	6.006
Hastelloy C-4	N06455	NT	NT	NT	NT	NT	NT	6.905

MATERIAL	NUMBER	PROMOTED IGNITION LOWEST BURN PRESSURE (psia)	BURN LENGTH (in.)	PROMOTED IGNITION HIGHEST NO-BURN PRESSURE (psia)	# OF TESTS (><10)	# OF TESTS (ACTUAL)	BURN LENGTH (in.)	ΔHc (kJ/g)
9% Nickel Steel		≤500	5	NT	NT	NT	NT	NT
Nitronic 60	S21800	300	1.2	200	>10	25	0 - 1.1	NT
Type 304 Stainless Steel	S30400	NT	NT	NT	NT	NT	NT	NT
Type 304L Stainless Steel	S30403	NT	NT	NT	NT	NT	NT	NT
Type 316 Stainless Steel	S31600	400	4.4	350	10	10	0.4 - 1.0	5.80
Type 316L Stainless Steel	S31603	200	0.1 - 1.3	111	>10	20	0.1 - 0.9	NT
Type 321 Stainless Steel	S32100	NT	NT	NT	NT	NT	NT	NT
Type 347 Stainless Steel	S34700	NT	NT	NT	NT	NT	NT	NT
Type 400 Series Stainless Steel	VARIOUS	≤500	0 - 1.1	NT	NT	NT	NT	NT
420 Stainless Steel	S42000	≤500	0 - 1.3	NT	NT	NT	NT	NT
422 Stainless Steel	S42200	≤500	0 - 1.3	NT	NT	NT	NT	NT
430 Stainless Steel	S43000	≤500	0 - 1.3	NT	NT	NT	NT	NT
440A Stainless Steel	S44002	≤500	0 - 1.1	NT	NT	NT	NT	NT
440C Stainless Steel	S44004	≤500	0 - 1.1	NT	NT	NT	NT	NT
A-286	S66286	NT	NT	NT	NT	NT	NT	NT
15-7 PH	S15700	NT	NT	NT	NT	NT	NT	NT
17-4 PH	S17400	200	≥ 1.16	150	<10	3	<1.16	NT
17-7 PH	S17700	NT	NT	NT	NT	NT	NT	NT
Carbon Steel	VARIOUS	≤100	>1.16	NT	NT	NT	NT	7.38-7.53
A516 (70)	K02700	NT	NT	NT	NT	NT	NT	NT
A537	K12437	NT	NT	NT	NT	NT	NT	NT
A737	K12202	NT	NT	NT	NT	NT	NT	NT
AL6XN (6% Mo)	N08367	NT	NT	NT	NT	NT	NT	7.74
254 SMO	S31254	NT	NT	NT	NT	NT	NT	NT
Elgiloy	R30003	≤1,500	0.1 - 4.0	NT	NT	NT	NT	NT
Silicon (commercially pure)		3800	1.25	3000	<10	1	0.75	NT
Haynes 188	R30188	≤3000	0.94 - 3.38	NT	NT	NT	NT	NT
Haynes 214	N07214	≤1000	0.1 - 2.2	NT	NT	NT	NT	NT
Haynes 242		≤3000	2.5 - 5.25	NT	NT	NT	NT	NT
MP 35N	R30035	≤1500	0.3 - 3.0	NT	NT	NT	NT	NT
Incoloy 800	N08800	1000	1.1 - 5.0	500	<10	5	0.4	NT
Waspaloy	N07001	1000	0.8 - 5.8	500	<10	3	0.8	NT
Colmonoy	N996XX	1000	2.4	500	<10	5	0.25	NT

MATERIAL	NUMBER	PROMOTED IGNITION LOWEST BURN PRESSURE (psia)	BURN LENGTH (in.)	PROMOTED IGNITION HIGHEST NO-BURN PRESSURE (psia)	# OF TESTS (><10)	# OF TESTS (ACTUAL)	BURN LENGTH (in.)	ΔHc (kJ/g)
Inco X-750	N07750	≤1000	0.1 - 2.2	NT	NT	NT	NT	NT
Udimet 700		≤400	0 - 1.75	NT	NT	NT	NT	NT
Udimet 720		≤250	0.8 - 2.4	NT	NT	NT	NT	NT
AMS 6278		200	0 - 5.5	100	<10	5	0	NT
Welda-lite 049		80	0.59 - 1.46	30	<10	1	0.86	NT
Welda-lite 2195		≤125	0.2 - 5.1	NT	NT	NT	NT	NT
AISI 9310	H93100	100	0 - 5.5	50	<10	3	0	NT
Molybdenum (commercially pure)	R03XXX	100	5.5	50	<10	3	0	NT
Zinc (commercially pure)		300	1.6	200	<10	1	0.5	5.314
Chromium (commercially pure)		600	0 - 5	500	<10	3	0	NT
Lead (comercially pure)		500	0 - 1	400	<10	1	0.5	1.05
Antimony (commercially pure)		500	0.5 - 2	400	<10	1	0.25	NT
Beryllium (commercially pure)		≤500	0 - 1.25	NT	NT	NT	NT	66.42
Iron (commercially pure)		≤75	5	NT	NT	NT	NT	7.39
Ductile Cast Iron		≤500	5	NT	NT	NT	NT	NT
Tungsten (commercially pure)		25	2.2	12.4	<10	1	0	NT
Vanadium (commercially pure)		≤25	2.6	NT	NT	NT	NT	NT
Indium (commercially pure)		20	0 - 5	12.3	<10	4	0 - 0.5	NT
Titanium (commercially pure)		≤1	3.0-6.0	NT	NT	NT	NT	19.72
Ti-6A1-4V		≤1	NT	NT	NT	NT	NT	NT
Tantalum (commercially pure)		>12.4	0	NT	NT	NT	NT	NT
Magnesium (commercially pure)		≤12.4	0-2.6	NT	NT	NT	NT	24.702
Ytterbium (commercially pure)		12	5	NT	NT	NT	NT	NT
Hafnium (commercially pure)		≤8	5	NT	NT	NT	NT	NT
Zirconium (commercially pure)		≤8	NT	NT	NT	NT	NT	NT
Strontium (commercially pure)		≤Ambient Air	NT	NT	NT	NT	NT	NT
Lithium (commercially pure)		≤Ambient Air	NT	NT	NT	NT	NT	NT
Platinum (commercially pure)		NT	NT	>10 000	<10	3	0.3	NT
Gold (commercially pure)		NT	NT	>10 000	<10	3	0	NT
Silver (commercially pure)		NT	NT	>10 000	<10	3	0	0.147

NT = Not Tested