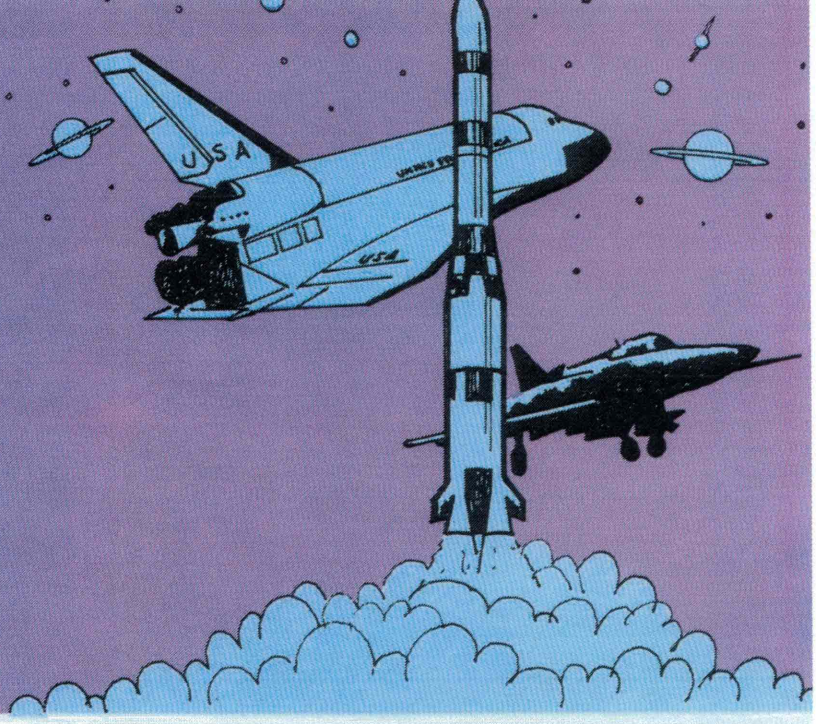
TIOLUBE™ 1175

INORGANIC SOLID FILM LUBRICANT

TIOLUBE 1175 MEETS
AS 1701 CLASS V & VI



INTRODUCTION

What is **TIOLUBE™ 1175?** It's a solid, dry lubricant that is applied in a very thin film to lubricate and prevent galling on very high tolerance surfaces.

What is **TIOLUBE™ 1175F?** It's a solid dry film lubricant that incorporates a sealing agent which enables usage in areas that come in contact with moisture.

What makes them so different from other dry film lubricants? Unlike other products, Tiolube™ 1175 and 1175F are *totally inorganic,* and in addition they do not contain any ceramic, vitreous or sodium silicate materials.

A WORD ABOUT SOLID FILM LUBRICANTS

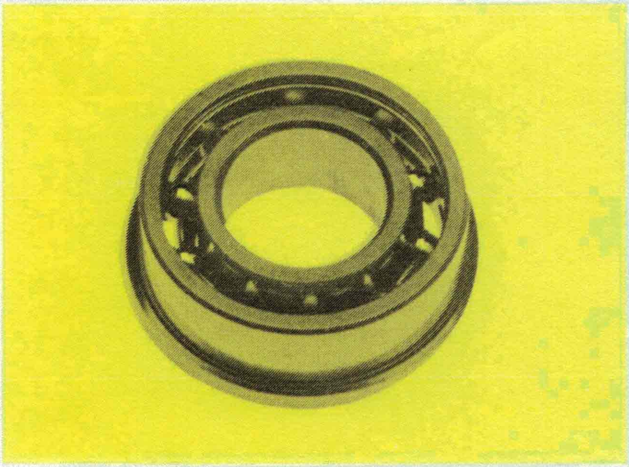
TIOLUBE™ 1175

is unaffected by hostile environments. To function effectively in the aerospace environment, a lubricant must handle extreme, rapid changes in temperature. It must work in vacuum as well as in atmospheric conditions. It has to withstand zero gravity and multiple gravities. The lubricant that does this is TIOLUBE™ 1175, an inorganic bonded dry-film lubricant which utilizes a specially formulated molybdenum disulfide (MoS_2) pigment working in combination with other lubricative pigments. TIOLUBE™ 1175 has been working in the challenging aerospace environment since 1966 and it met all the changing requirements. TIOLUBE™ 1175 prevents galling and increases the wear-life of metal-to-metal surfaces. Because of its low coefficient of friction and its unique binder, it offers a combination of performance not available with other solid film lubricants.

Most lubricants establish their own reputation in industry. No lubricant is a panacea, but TIOLUBE™ 1175 is a unique inorganic solid film lubricant and when used properly will offer a wide range of benefits.

Solid film lubricants are made up of three basic components:

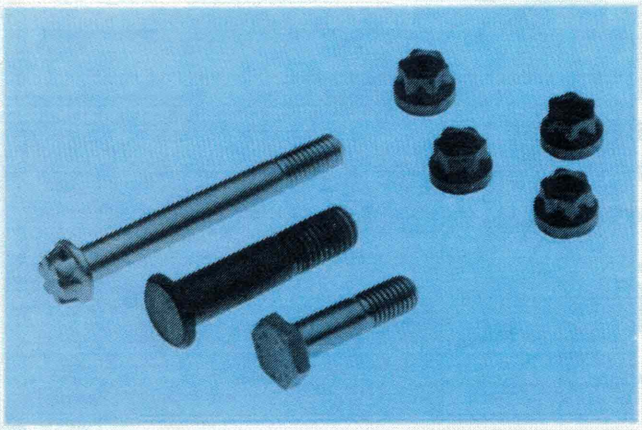
1. Lubricative constituents or pigments to provide low shear strength; i.e., lubrication.
2. A binder system to adhere and to maintain a relatively large quantity of these constituents on the surface.
3. A propellant or carrier—usually consisting of solvent systems, plasticizers, and film formers for controlled application.



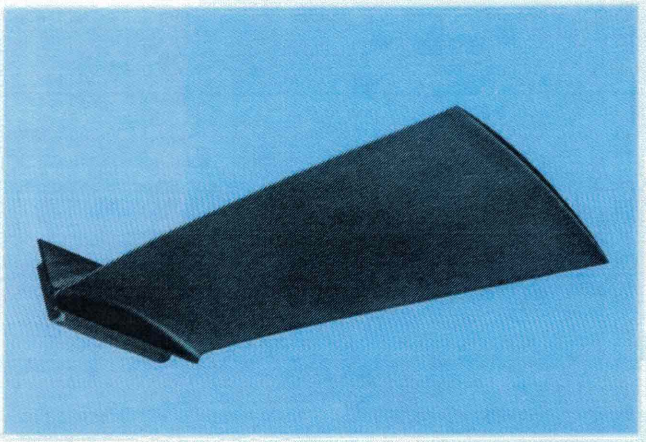
BINDER SYSTEMS, often called "binders," fall in the following categories; thermoplastic vinyl or alkyd resin types, thermosetting phenolic or epoxy resin types (most standard and common), silicone resin binders, sodium silicate binders, phosphoric acid binders, ceramic or vitreous binders, borate-type binders; and a couple of binder systems which require complicated processing, such as a MoS "in situ" film binder and a binder system applied with a high-velocity impingement process. The TIOLUBE™ 1175 solid dry film lubricant is a complete divergence with respect to these conventional binder systems because it forms a direct chemical bond. It is a unique binder system—forming an unusual tenacious bond with all metals, such as stainless steel, aluminum and even titanium.

TIOLUBE™ 1175

has met the test in outer space. Liquid lubricants often cannot be used in aircraft missiles and manned spacecraft. That's where dry-film lubricant TIOLUBE™ 1175 is at its best. TIOLUBE™ 1175 has repeatedly withstood temperatures from +1200°F plunging to minus 420°F. It has voyaged with TRW's Viking probe to the far reaches of the solar system, and flies in the nation's defense aboard such advanced aircraft as the Grumman F-14 and Fairchild-Republic's A-10.
When the Rockwell Space Shuttle boosts into orbit, TIOLUBE™ 1175 will be aboard, for the repeated demands of this multiple re-entry. TIOLUBE™ 1175 is the solution to a wide variety of pistonbore applications in valves, regulators, temperature sensors, as well as engine bleed and airborne environmental control systems.

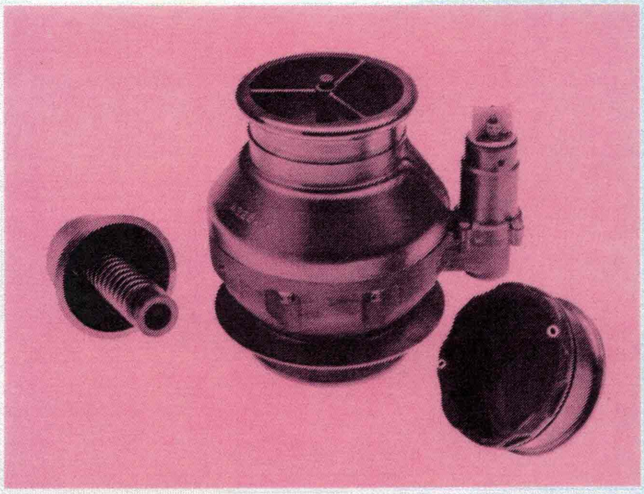


PRODUCT DESCRIPTION
TIOLUBE™ 1175 has been developed after three years of research and supported by more than 20 years of experience in dry lubrication and related fields.



QUALITIES
The complex binder system of TIOLUBE™ 1175 is established by a unique form of electrodeposition based upon a self-induced type of electrophoresis. This relatively slow chemical reaction is accelerated by external thermal stabilizing: 400°F with steel surfaces and only 325°F for aluminum.

COMPATABILITIES
The lubricity of TIOLUBE™ 1175 is provided by a specific combination of friction-and-wear-reducing constituents of controlled particle sizes, such as molybdenum disulfide, graphite and several others. This carefully selected blend of lubricative constituents is completely non-toxic with respect to dermal, as well as respiratory, toxicity. It can therefore be used in breathing oxygen systems, such as a thread lubricant in tubing or fittings; as a valve lubricant; or on other life support system attachments. TIOLUBE™ 1175 inhibits fretting corrosion by separating highly loaded surfaces under extreme vibration conditions.
In addition to its unique tenacity, load-impact resistance and thermal stability, the composition of TIOLUBE™ 1175 is not seriously altered as a result of nuclear radiation. Its wear-life is unaffected after exposure to several levels of gamma or neutron irradiation.



SOME RECOMMENDED USES
TIOLUBE™ 1175 has been successfully used on spherical bearings, ball bearings, sleeve bearings, ball screws, gears, cams, linkages, clamps, clevises, rivets, nuts, bolts, all types of special fasteners, couplings, shafts, journals, chains, and miscellaneous moving parts.

EVALUATION OF TEST METHOD	REQUIREMENTS OF LIMITS	AVERAGE RESULTS & REMARKS
FLUID RESISTANCE After immersion in: Xylene – Dioxane Tricholorethylene (MIL-T-27602) Carbon Tetrachloride Perchlorethylene Toluene – Napthalene Acetone – Hdxane – Skydrol Kerosene – Gasoline Ethyl alcohol – Methyl alcohol Freon TF (trichlorotrifluorethane) Liquid nitrogen – Liquid helium Liquid oxygen (LOX)	No determination of film, swelling, blistering or loss of adhesion for 120 hrs. at room temp. under static conditions.*	Unaffected by exposure to these various fluids. Passes.
After immersion in: MIL-S-3136, hydrocarbon fluid MIL-H-5606B, hydraulic fluid MIL-L-6082, engine oil grade 110 MIL-G-3278, grease MIL-L-5624, jet fuel grade JP-4 MIL-L-7807, oil MIL-G-5572, fuel grade 115-145 MIL-H-8446A, hydraulic fluid MIL-F-5566, anti-icing fluid MIL-G-7118, greese Silicone fluids DC 200 and DC 550 Mineral oil	No determination of film, swelling, blistering or loss of adhesion for 24 hrs. at 72°F under static conditions.*	Unaffected by exposure to these various fluids. Passes.
LOX IMPACT SENSITIVITY ABMA-LOX Test per NASA-MSFC specification STD-106, requiring insensitivity to impact energy levels up to 72.5 ft./lbs.	No detonations, flashes, burning or charring of aluminum and stainless steel test cups after 20 consecutive impacts.	No effects whatsoever after a total of 60 impacts or three qualification test runs. Passes.
VACUUM OF SPACE COMPATABILITY A) After 21-days' exposure to a vacuum of 1.0×10^{-8} Torr or better @ 72°F. Lubricant was applied on both sides of a 1 in. dia. wafer, .0015 in. thick and made of PH15-7 steel. Coating film thickness was .0004 ± .0001".	No deterioration or weight loss of lubricant of less than ½%, after a vacuum of 1.0×10^{-6} Torr has been obtained.	Weight losses observed were less than .001% of the total weight of the original materials. Passes.
B) After 16-day exposure to a vacuum of 1.0×10^{-8} Torr or better @ 350°F.	Total weight loss of less than .02%, after vacuum of 1.0×10^{-6} Torr has been obtained.	Weight losses observed were smaller than .005% of the total weight of the original material. Passes.
ALPHA LFW-1 TEST DEVICE Mild steel test specimens of R_c 58-60 hardness. Timken-type test ring coated with .0004 ± .0001" film thickness. Exposed to 630 lbs. load = approx. 80,000 psi average bearing load. Load was instantaneously applied. Speed 72 rpm or 26 ft./min. with unidirectional motion @ 72°F. No vacuum. Surface finish of unlubricated rider block was in the order of 6-15 microinches rms. Neither specimen was phosphated prior to lubrication.	100,000 cycles wear-life or 23 hrs., 10 min. endurance, which is equivalent to approx. 36,140 linear sliding feet. The kinetic coefficient of friction (Uk) shall have an average of .12 or less.	409,652 cycles, or 147,598 lin. ft. The Uk = .008. 315,107 cycles, or 113,436 lin. ft. The Uk = .025. This is the average of 9 tests. Passes.
TITANIUM FASTENER APPLICATION Locking torque test per MIL-N-25027B on ¼-28 bolt made of 6Al-4V titanium of the NAS 674 type, versus uncoated A-286 nut of the MS21943 type.	In accordance with par. 4.5.3.2.2.1.1. the max. locking torque, installation or removal torque is 300 lbs. The "break-away" to be more than 3.5 inch-lbs.	Max. locking torque range 3.5-20.5 in.-lb. Breakaway range 3.5-18.0 in.-lbs. Passes. (All other inorganic products so tested failed, including nickel and chrome plated bolts.)

*As opposed to dynamic load conditions such as in sliding bearings.

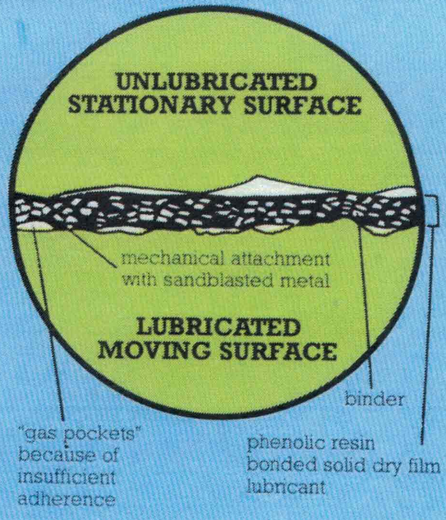


FIGURE 1–Phenolic resin bonded solid dry film lubricant directly attached to a surface of 32 microinches rms.

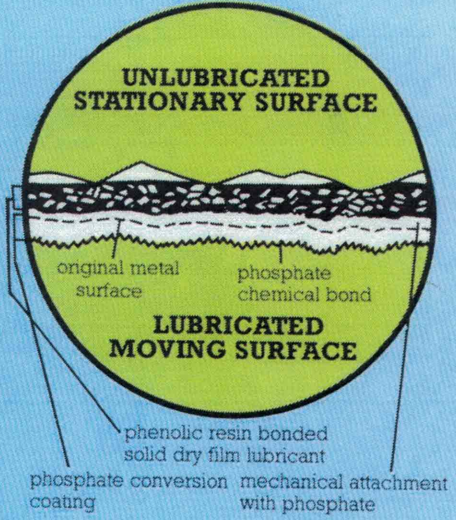


FIGURE 2–Phenolic resin bonded solid dry film lubricant superimposed on a phosphate conversion coating which, in turn, was applied on a metal surface of 32 microinches rms.

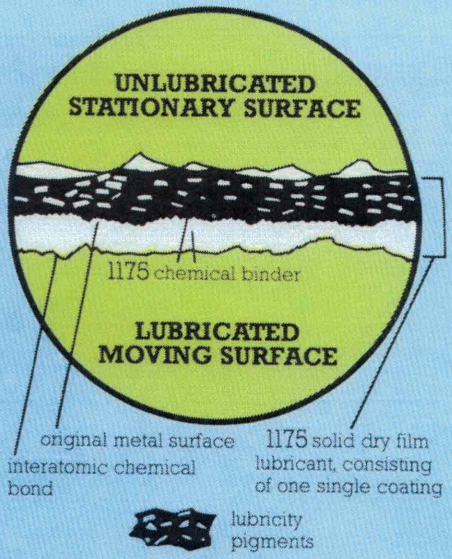


FIGURE 3–1175 solid dry film lubricant with complete inorganic binding on a metal surface of 32 microinches rms.

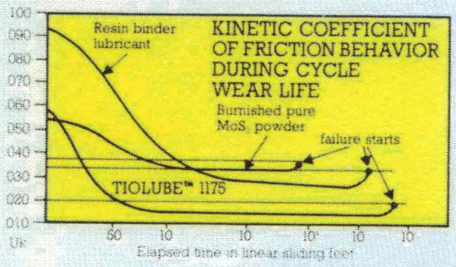
CORROSION PROTECTION GUIDE FOR MOST STEELS WHEN COATED WITH TIOLUBE 1175

Iron-Nickel	Gamma CB	Discalloy	17 W	ATV-3	16 256	S 495	19-9DL	19-9DX
Super Alloys	A-286	CSA	EME	AMS-5700	V 57	25-20-2 Si	CG-27	R-27
High-Nickel	Inconel X750	Inconel 718	Inconel 860	Inconel 600	Rene 41	Hastelloy A	Hastelloy B	Hastelloy C
Super Alloys	Waspalloy	Incolloy 800	Incolloy 901	Udimet 500	Guy	F 342	Hastell. R-235	
High-Cobalt	Vitallium	Stellite 6059	Stellite 30-422	N155 Multimet	Refractolloy	S 590	S 816	M-252
Super Alloys	Mar M302	Mar-M322	HS 31	WI 52	J 1650	L-605 (HS 25)	SM-302	
Austenitic	347	321	317	316	310	309	305	
Chromium-Nickel Steels	304	304L	302	301	303	303Se	329	
Precipitation	17-7PH	Stainless W	17-10P	17-4PH	PH15-7	PH14-8		
Hardenable Steels	17-14 Cu-Mo	HNM	AM 350	AM 355	15-5PH			
High-Manganese	201	202	Mar-aging 12-2	.7C-14Mn-3Ni				
Stainless and Alloy Steels	CMN	G-192	.3C-11Mn 8Ni	1.2C-14Mn-1.5SI	5C-18Mn-4Cr			
Martensitic	AISI 634	AMS 5616	431	440C	440F	H46		
Chromium Steels	420	416	414	410	404	Lapelloy		
High-Strength	18 NI 250	20 NI 250	18 NI 300	VSM	709			
and Mar-aging Steels	430	430F	443	446				
Tool and Die	H-21	H-13	H-12	H-11	D-5	D-3	D-2	
Steels	0-2	0-1	S-1	L-2	W-2	W-1	A-2	
High-Speed	M-35	M-34	M-30	M-10	M-4	M-2	M-1	
Tool Steels	T-8	T-7	T-6	T-4	T-3	T-2	T-1	
Carbon and Low	9440	8640	6150	5140	52100	4640	4340	4140
Alloy Steels	4130	4065	3140	2340	1340	1080	1060	1045

COLOR CODE: (white) = No plating required whatsoever. (yellow) = Plating preferred, especially in cases of **direct exposure** to **severe corrosion-inducing** environments. (blue) = Plating definitely required.

COEFFICIENT OF FRICTION

It is impossible to make a single statement regarding the kinetic or static coefficients of friction of TIOLUBE™ 1175. However, as a general design rule, it is reasonable to incorporate in the stress calculation a Uk=.10 maximum under normal conditions and a Uk=.05 after including a bench cycling or burnishing operation prior to installation. The static coefficient of friction Us plays a role of lesser importance with solid dry film lubricants than the Uk. The Us—usually 20-30% higher then the Uk—shall, therefore, no longer be considered. The Uk is always given as a range, never as an absolute number. This is because the freshly applied 1175 lubricant initially undergoes a so-called period of "run-in" or "burnishing"—approximately the first 25-35 linear sliding feet—like most other products. The relationship between the initial high Uk and its rapid decline to a steady-state value for most of its cyclic wear-life is illustrated in the following diagram:



The coefficient of friction of TIOLUBE™ 1175 comes quite close to that of conventional oils and greases, especially after it is burnished in.

1. The higher the bearing load, the lower the kinetic coefficient of friction. Load increase tends to promote the laminar re-orientation of the 1175 lubricative pigments into an ideal pattern. The re-orientation pattern eliminates interstices, which in turn reduce the internal shear stresses, thereby lowering friction coefficients.

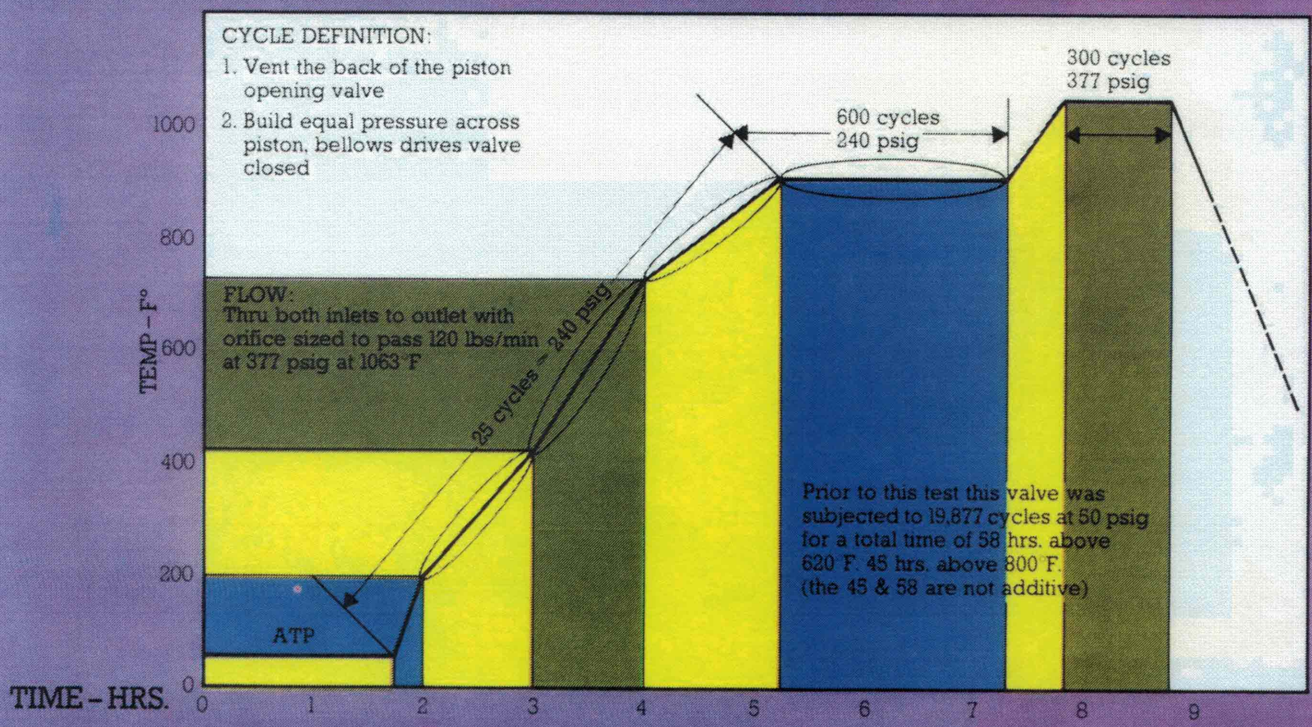
2. Continuous exposure to *light loads,* especially under very *low speeds,* gives substantially *higher kinetic* co-efficient of friction and subsequent *short wear-life.* This can be prevented by initial bench cycling under higher loads or burnishing before the part is installed, since the relatively soft upper strata (layers) of the TIOLUBE™ 1175 are not sufficiently compacted and therefore are rapidly removed by the sloughing-off action of loose surface particles.

3. Increased substrate hardness gives lower coefficients of friction. Mating surfaces of maximum hardnesses result in *less contact area* and causes *less surface deformation* which in turn provides *less surface sliding resistance* for the TIOLUBE™ 1175's low built-in friction coefficient.

4. Coefficient of friction decreases slightly when surface speed increases; but only up to a limit: 40 linear sliding feet per minute. Beyond 40 ft./min., the Uk or wear-life versus surface speed becomes inversely proportional. Solid dry film lubricants are limited in heat dissipation; they cannot carry away frictional heat under increased surface speed conditions.

5. The kinetic coefficient of friction of TIOLUBE™ 1175 with regard to temperature changes can be considered negligible; e.g. from −452°F to +650°F to +1000°F the increase becomes catastrophic. As the temperature rises, the molecular lateral attraction of the 1175's lubricity constituents are weakened and finally overcome by thermal motions. The substrate surface asperities are able to penetrate more easily by the now completely disoriented film, thereby increasing the Uk.

TIODIZE® 1175F VALVE TIME-TEMP. CURVE-HIGH FORCE BELLOWS



TIOLUBE™ 1175F solved one problem for an F-14 assembly.

DRY FILM LUBRICANT TEST EVALUATION OF TIOLUBE™ 1175F

Trouble was encountered with the AV1120-9 isolation, bypass, and shutoff valve used in the environmental control system of the F-14 aircraft. One hundred thousand endurance cycles at temperatures of up to 1100°F and air pressures up to 535 psig were required to qualify this valve. As a result, several dry film lubricants were evaluated. The valve configuration is shown on this page. In addition to the lubricants evaluated, several bore platings and hard coats were evaluated such as Chrome, Triboloy, Stellite, Aluminum Oxide, Boride and Tungsten Carbide. These were not acceptable on a basis of cost, manufacturing techniques or functional testing.

TEST PROCEDURE:

Except for the data enclosed, the piston was cycled to 50 psig at 900°F. A cycle consisted of:

A. Pressurizing the valve

B. Venting the back of the piston opening the valve

C. Equalizing the pressure on both sides of the piston, which allowed the bellows spring to drive the piston to the closed position.

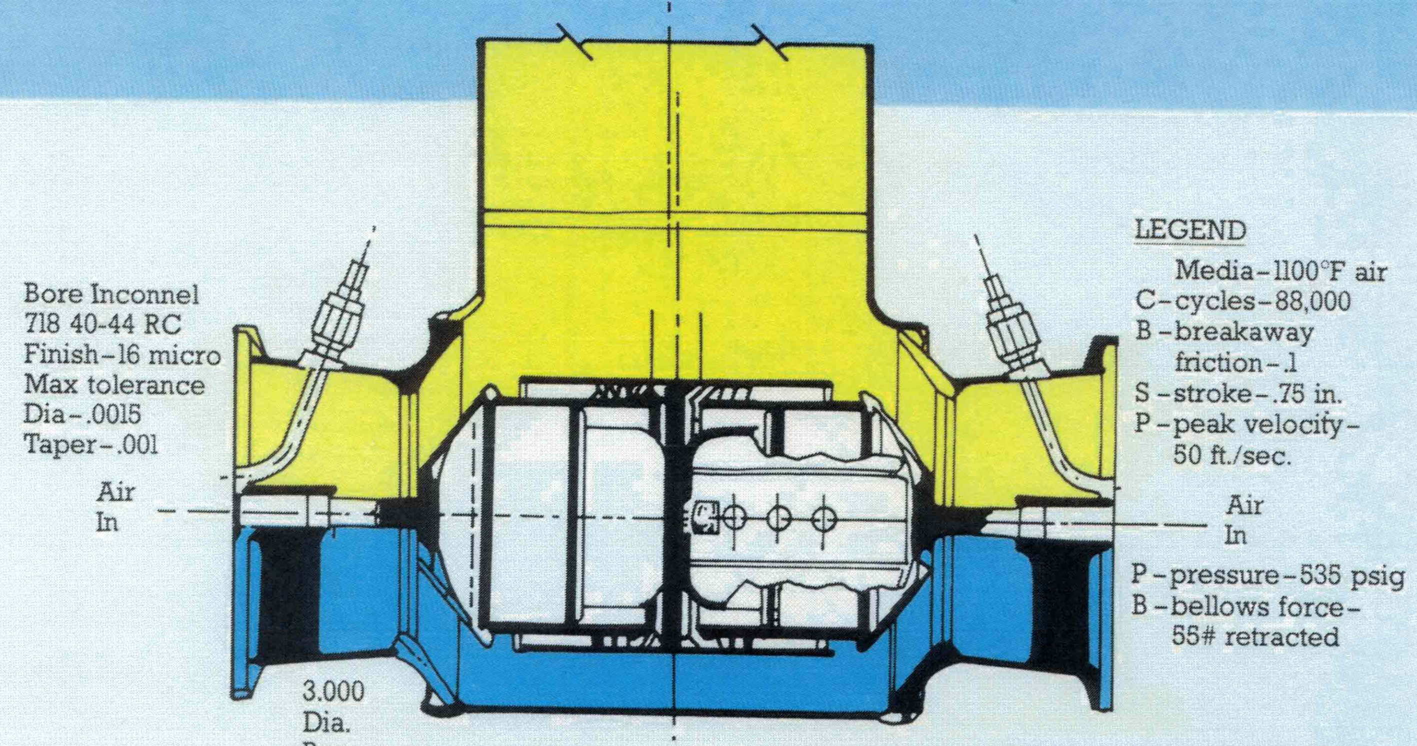
The graph on page 5 shows the valve being evaluated at higher pressures and temperatures with flow through the valve. The test on page 5 was performed at the start of each lubrication evaluation, however, only the "Tiolubed"™ 1175F valve performed satisfactorily after 20,000 cycles. The test described on the graph was also repeated after 50,000 cycles on the "Tiolubed"™ 1175F valve.

SUMMARY:

Before performing the tests on the four dry film lubricants on the piston and bellows bores, several combinations of parts were dry film lubricated, such as piston rings, piston ring grooves, piston ring and not the bore, all moving parts, etc. These approaches were shelved for a variety of reasons too numerous to mention in this report.

TIOLUBE™ 1175F

The valve bore was coated with TIOLUBE™ 1175F. In addition to the cycles reported, 88,000 endurance cycles were performed with little deterioration of performance. The breakaway coefficient of friction (C,) was 0.1 at the start of the tests and was 0.2 after 88,000 cycles. The test was stopped because development was considered completed.



ITT GENERAL CONTROLS
(used on the F-14 ECS system)

TIODIZE CO., INC.

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