PREFERRED
RELIABILITY
PRACTICES

FABRICATION OF GASEOUS AND LIQUID FLUORINE SYSTEMS

Practice:

Use established guideline in fabrication and assembly of components for use in gaseous and liquid fluorine systems to eliminate failures and improve reliability of such systems.

Benefit:

This guideline compliments guideline GD-ED-2206, "Selection of Compatible Materials for Use With Gaseous and Liquid Fluorine". The use of these guidelines will benefit a designer in choosing the correct materials, proper fabrication, and assembly of the components for safe and reliable operation.

Center to Contact for More Information:

Lewis Research Center

Implementation Method:

The effect of elemental fluorine and fluorine-oxygen (FLOX) mixtures with most materials is reactive under suitable conditions. As addressed in the guideline GD-ED-2206, "Selection of Compatible Materials for Use With Gaseous and Liquid Fluorine", no organic material is totally resistant to elemental fluorine. Failures in fluorine systems are due to improper fabrication, assembly, and cleaning/removal of contaminants. The major cause of failures in fluorine systems is due to weld defects, trapped moisture, foreign and incompatible materials.
Fabrication

The following conditions should be followed to preclude any failure due to improper fabrication of fluid system components:

Machine parts, castings,and purchased parts. Any parts that contain scales or oxides must be cleaned and passivated. Porous casting must be avoided since foreign material is difficult to remove from the surface of the material.

Soldering and brazing parts. Joints should be free from pits, pockets, and crevices. During soldering and brazing flux should never be used, silver solder

FABRICATION OF GASEOUS AND LIQUID FLUORINE SYSTEMS

or nicro-braze are preferred. If any flux is deposited from the solder it must be completely removed from the system.

Welding or welded component parts. All welds must be free of pinholes, slag, cracks, and crater defects, and have 100% penetration of the welded zones. Welded components with pockets, surface flaking, flux, or slag cannot be permitted. Welded parts and connections must be properly cleaned and passivated prior to service.

Tubing connections and bend radius. The bend radius of tubing should be as large as possible at high flow rate areas. Avoid using sharp angle connections, 90^{o} or 45^{o} pipe fitting connections.

All parts (internal and external surfaces) should be visually inspected for pits, discontinuities, and inclusions. It is also recommended that components be x-rayed to make certain all material discrepancies are found.

Cleaning Procedure

Cleaning of all parts is necessary to remove any possible contaminants that are in the components. A list of common contaminants is shown in Table 1, and the possible reaction occurring under the tested conditions.

Table 1. List of common fluorine contaminants

Contaminants	Gaseous fluorine @ atm. pressure & temperature	Gaseous fluorine @ 1500 psi. & atm. temperature	Liquid fluorine @ -195.5 ºC & atm. pressure	Liquid fluorine @ -195.0 ºC & 1500 psi.
Water	no reaction	reaction	no reaction	reaction
Ice	no reaction	N/A (Not Attempted)	explosive	N/A (Not Attempted)
Fluorolube HO	no reaction	reaction	no reaction	no reaction
Molylube	no reaction	reaction	explosive	N/A (Not Attempted)
Slag on stainless steel joint	no reaction	reaction	no reaction	reaction
Flux on silver-solder stainless steel joint	no reaction	reaction	no reaction	reaction

FABRICATION OF GASEOUS AND LIQUID FLUORINE SYSTEMS

When cleaning components, the proper solvents should be used to prevent ignition from fluorine exposure. A list of recommended cleaning solvents are shown in table 2 (see Reference 1).

Table 2. Recommended Cleaning Solvents

Solvent or Cleaner[1]	Material
West Penetone TPC Solvent	All metals Halon TFE Teflon TFE Teflon FEP Nickel-filled Teflon
Acetone	Kel F-81 Plaskon 2000 Halon TVS

General procedures should be followed when preparing metal parts for cleaning and assembly. The following list, which is detailed in reference 1, shows the recommended procedure for cleaning metallic components.

1. All components (valves, pumps, etc.) should be disassembled, and any parts incompatible with solvents, such as gaskets and O-rings, must be removed.

2. Any amount of scale, slag, flux, etc., must be removed from the surface that will come in contact with the fluorine. The surface can be cleaned with nitric acid or abrasive cleaner. The final result should leave the surface bright and the base metal exposed. Care should be taken to avoid disturbing metal-to-metal sealed joints. There should be no sign of the foreign material on the metal. All solvents must be removed from the cleaned surface such that there is no sign of residue.

3. Piping and components that are visually clean should be dipped into a nitric acid bath solution (10 - 25% nitric acid). Once removed all components should be flushed with deionized water and thoroughly dried.

4. When needed, components may be vapor degreased, solvent bath degreased, and hand wiped. After hand-wiping the component should be immersed in a nitric acid bath or solvent and thoroughly flushed and dried. Vapor degreasing nozzles should be used for components with holes, ports, or complex configurations.

5. To increase drying time and aid in removal of any liquid, helium or dry nitrogen should be used. Valves and complex components can be heated in a vacuum chamber to ensure

[1]Soap and water are preferred for final cleaning of all materials listed, since elastomers absorb solvents. All solvents must be completely removed after cleaning. West Penetone TPC solvent should be used for vapor degreasing of individual parts.

FABRICATION OF GASEOUS AND LIQUID FLUORINE SYSTEMS

all liquid or moisture is removed. Components should be immediately used or packaged to prevent recontamination.

6. Final preparation, after assembly of components, is to passivate the system with a small amount of fluorine gas. Fluorine will react with the metal to form a metal fluoride film. A slight pressure of helium should be maintained in the system to prevent any contamination from moisture. (***Note***: *After final assembly and passivation avoid sharp tapping or rapping of components. The tapping, rapping or movement of passivated components may cause flaking of the fluoride film inside the components which may result in a reaction point.*)

If components are being processed and cleaned, they should be immediately used or packaged in an approved contaminant free plastic bag. Silica gel packets should be contained with the cleaned components to reduce any moisture contamination during storage.

Technical Rationale:

Due to the extreme reactivity of fluorine with certain materials it is necessary that the designer and technicians become knowledgeable with fluorine material compatibility, fabrication, and assembly of components. Carelessness during fabrication or failure to remove contaminants will result in some form of reaction (e.g., fire, explosion). With this understanding of the chemical reactions with fluorine and other materials, system designers will be able to prevent critical failures in the system. This will reduce the unnecessary risks involved in developing fluorine systems.

Impact of Nonpractice:

Failure to use the design data presented in this guideline may result in unsafe systems and failures which are costly and potentially injurious to personnel and environment.

Related Practices:

GD-ED-2206 Selection of Compatible Materials for Use With Gaseous and Liquid Fluorine
PD-ED-1224 Design Considerations for Fluid Tubing Systems

References:

1. Schmidt, H. W., Fluorine and Fluorine-Oxygen Mixtures in Rocket Systems, NASA SP-3037, 1967.
2. Price Jr., H. G. and Douglass, H. W., Nonmetallic Material Compatibility With Liquid Fluorine, NACA RM E57G18, 1957.
3. Slesser, Ph.D. Charles and Schram, Stuart R., Preparation, Properties, and Technology of Fluorine and Organic Fluoro Compounds, McGraw-Hill, New York, 1951.