

CGA G-15—2018

**FLUORINE AND FLUORINE
MIXTURES WITH INERT GASES**

SECOND EDITION
(Corrected 2/13/2020)

PREFACE

As part of a program of harmonization of industry standards, the Compressed Gas Association (CGA) has issued CGA G-15, *Fluorine and Fluorine Mixtures with Inert Gases*, jointly produced by members of the International Harmonization Council and originally published by the European Industrial Gases Association (EIGA) as EIGA Doc 140, *Fluorine and Fluorine Mixtures with Inert Gases*.

This publication is intended as an international harmonized standard for the worldwide use and application of all members of the Asia Industrial Gases Association (AIGA), Compressed Gas Association (CGA), European Industrial Gases Association (EIGA), and Japan Industrial and Medical Gases Association (JIMGA). Each association's technical content is identical, except for regional regulatory requirements and minor changes in formatting and spelling.

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NOTE—Technical changes from the previous edition are underlined.

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1 Introduction

Fluorine is a highly toxic and oxidizing gas that presents health risks such as poisoning by inhalation and safety risks such as combustion.

Fluorine and fluorine mixtures can be safely handled if equipment is properly designed and maintained, handling precautions are taken, and employees are trained. As a minimum, all personnel shall have access to the safety data sheet (SDS) and be trained in the use of the SDS and other reference material.

2 Scope and purpose

This publication is for suppliers, distributors, and users of gaseous fluorine and mixtures of fluorine with inert gases and handling equipment. This publication is intended for fluorine and mixtures where the resulting fluorine concentrations greater than or equal to 0.5% fluorine are considered to present a risk of reaction due to the oxidizing potential.

This publication provides a good understanding of the potential hazards involved in storage, use, and transportation of compressed fluorine and its mixtures with inert gases and approaches to be taken to minimize the risk of incidents.

The manufacture, purification, liquefaction, and analysis of fluorine or its mixtures with inert gases are beyond the scope of this publication, although the general guidance given is also relevant to these processes.

An audit checklist is located in Appendix A of this publication.

3 Definitions

For the purpose of this publication, the following definitions apply.

3.1 Publication terminology

3.1.1 **Shall**

Indicates that the procedure is mandatory. It is used wherever the criterion for conformance to specific recommendations allows no deviation.

3.1.2 **Should**

Indicates that a procedure is recommended.

3.1.3 **May**

Indicates that the procedure is optional.

3.1.4 **Will**

Is used only to indicate the future, not a degree of requirement.

3.1.5 **Can**

Indicates a possibility or ability.

3.2 Technical definitions

3.2.1 **Auto-ignition temperature**

Temperature at which a substance will spontaneously ignite in a specified oxidant at a given pressure.

3.2.2 **Bundle (of cylinders)**

Assembly of cylinders that are fastened together and interconnected by a manifold and carried as a unit.

3.2.3 **Cylinder**

Transportable pressure receptacle having a water capacity that does not exceed 150 L and can be filled with gas under pressure.

3.2.4 Cylinder recovery vessel

Pressure receptacle with a water capacity not exceeding 3000 L into which damaged, defective, leaking or non-conforming pressure receptacle(s) are placed for the purpose of transport (for example, for recovery or disposal).

NOTE—A cylinder recovery vessel is often fitted with a gauge to indicate internal pressure and with valves to enable purging. Referred to in the UN Recommendations on the Transport of Dangerous Goods – Model Regulations (UN Model Regulations) as a salvage pressure receptacle and also known as a salvage cylinder [1].

NOTE—Due to the strong oxidizing potential of fluorine, the use of a cylinder recovery vessel for pure fluorine or high concentrations of mixtures may not be appropriate. Refer to Section 12 for details.

3.2.5 Gas cabinet

Locally ventilated enclosure designed to contain a gas supply cylinder and, where appropriate, an associated purge gas supply cylinder. The gas cabinet also encloses the gas supply handling equipment such as purge manifolds, process gas pressure reducing regulators, and control systems. The gas cabinet can be quite complex in design, often being equipped with automatic microprocessor control.

3.2.6 Immediately Dangerous to Life or Health (IDLH)

Concentration value from which one could escape without loss of life or immediate or delayed irreversible health effects (30 minutes is considered the maximum time for escape so as to provide a margin of safety) [2].

3.2.7 Impingement site

Impingement occurs when the flow stream changes direction abruptly, or when the presence of eddies leads to the impact of particles with the system walls [3].

3.2.8 Lethal concentration 50 (LC₅₀)

Concentration of a substance in air, exposure to which for a specified length of time is expected to cause the death of 50% of the entire defined experimental animal population. Usually measured in ppm or mg/m³.

3.2.9 Occupational exposure limit (OEL)

Values set by competent national authorities or other relevant national institutions as limits for concentrations of hazardous compounds in workplace air.

3.2.10 Monel®

U.S. registered trademark for an alloy of copper and nickel, UNS N04400.

3.2.11 Oxipotential

Oxidizing power of a gas compared to that of oxygen, given as a dimensionless number, where oxygen = 1 [4].

3.2.12 Passivation

Pre-treatment method to allow the formation of a self-limiting protective fluoride film on the surface of the material in a controlled manner, which limits any additional fluorine reaction.

3.2.13 Permissible Exposure Limit (PEL)

Eight (8) hour time-weighted average occupational exposure limit set by the U.S. Occupational Safety and Health Administration (OSHA).

3.2.14 Pressure

Bar shall indicate gauge pressure unless otherwise noted (bara for absolute pressure).

3.2.15 Risk assessment

Documented assessment of the risks of a specific operation to personnel and the environment. This process usually takes into account safety controls inherent in equipment, operating procedures, and the personal protective equipment (PPE) provided. Sometimes, it may be deemed appropriate to improve operational safety controls after undertaking a risk assessment.

3.2.16 Short-Term Exposure Limit (STEL)

Time-weighted average concentration, usually averaged over 15 min, aimed at avoiding acute effects.

3.2.17 Threshold Limit Value–Time-Weighted Average (TLV[®]-TWA)

Time-weighted average concentration for a normal 8-hour work day or 40-hour work week to which nearly all workers may be exposed, day after day, without adverse effect [5].

3.2.18 Tube

Transportable pressure receptacle of seamless or composite construction having a water capacity exceeding 150 L but not more than 3000 L.

NOTE—Tubes are often connected together in a manner similar to that for bundles and mounted on a vehicle trailer for transport, storage, and use. In Europe, these are defined as battery vehicles or multiple element gas containers (MEGCs).

NOTE—Also known as tube trailers, ISO tube modules, or ISO containers.

4 Properties of fluorine

Fluorine is a gas at normal pressure and temperature with a very pungent odor. It is heavier than air and is highly oxidizing and highly toxic. When exposed to moisture, it can become corrosive to materials. See Tables 1, 2, and 3.

In Europe, fluorine is classified as Comp.Gas, H280; Ox. Gas 1, H270; Acute Tox.1, H330; Skin Corr.1A, H314; Eye Dam.1, H318; EUH071, see EIGA Doc 169, *Classification, and Labelling Guide in accordance with EC Regulation 1272/2008 (CLP Regulation)* [6]. For classification of fluorine in the United States, refer to CGA C-7, *Guide to Classification and Labelling of Compressed Gases* [7]. In Japan, fluorine is classified as Oxidizing gases 1, H270; Gases under pressure, Compressed gas, H280; Serious eye damage/eye irritation 2A, H319; Acute toxicity, inhalation 1, H330; Reproductive toxicity 2, H361; Specified target organ toxicity, single exposure 1, H370; Specified target organ toxicity, repeated exposure 1, H372.

4.1 Fluorine identification

Chemical formula:	F ₂
CAS No.:	7782-41-4
EC No.:	231-954-8
UN No.:	<u>UN</u> 1045

4.2 Physical properties of pure fluorine

Table 1—Physical properties of pure fluorine

Property	SI Units	U.S. Units
Chemical formula	F ₂	F ₂
Molar mass	37.977 g/mol	0.0418 lb/mol
Melting point	−219.6 °C	−363.3 °F
Boiling point	−188.1 °C	−306.6 °F
Latent heat of fusion at melting point	13.4 kJ/kg	5.8 Btu/lb
Gas density at 32 °F (0 °C), 1.01 bara	1.696 kg/m ³	0.106 lb/ft ³
Gas density at 59 °F (15 °C), 1.01 bara	1.608 kg/m ³	0.100 lb/ft ³
Gas density at 70 °F (21.1 °C), 1 atm	1.57 kg/m ³	0.098 lb/ft ³
Relative gas density (air = 1)	1.312	1.312
Density of the liquid at −306.8 °F (−188.2 °C)	1509 kg/m	94.21 lb/ft ³
Density of the liquid at −320.4 °F (−195.8 °C)	1568 kg/m	97.91 lb/ft ³
Latent heat of vaporization at boiling point	173 kJ/kg	74.8 Btu/lb
Critical temperature	−129.0 °C	−200.2 °F
Critical pressure	52.2 bara (757.1 psia)	5220 kPa, abs
Critical density	570 kg/m ³	35.6 lb/ft ³
Heat capacity at 77 °F (25 °C)	0.82 J/g*K	0.1966 Btu/(lb _m *°R)
Entropy at 77 °F (25 °C), 1.01 bara	3.65J/(g*K)	0.7322 Btu/(lb _m *°R)
Specific volume of the gas at 70 °F (21.1 °C), 1 atm	0.635 l/g	10.17 ft ³ /lb
Triple point	−219.7 °C at 0.223 kPa, abs	−363.4 °F at 0.324 psia
Weight of liquid per gallon at: −306.8 °F (−188.2 °C) −320.4 °F (−195.8 °C)	1509.8 kg/m ³ 1569.7 kg/m ³	12.6 lb/gal 13.1 lb/gal
Heat capacity of the gas (C _p) at: 32 °F (0 °C) 70 °F (21.1 °C)	0.828 kJ/(kg)(°C) 0.825 kJ/(kg)(°C)	0.198 Btu/(lb)(°F) 0.197 Btu/(lb)(°F)
Heat capacity of the gas (C _v) at 70 °F (21.1 °C)	0.610 kJ/(kg)(°C)	0.146 Btu/(lb)(°F)
Ratio of specific heats, C _p /C _v , at 70 °F (21.1 °C)	1.353	1.353

Table 2—Physical properties of fluorine/nitrogen mixtures (10/90 mol %)—ideal mixture

Property	SI Units	U.S. Units
Molar mass (mean value)	29.012 g/mol	0.0319 lb/mol
Gas density @ 0 °C, 1.01 bara	1.295 kg/m ³	0.0818 lb/ft ³
Relative gas density (air = 1)	1.002	1.002

Table 3—Physical properties of fluorine/nitrogen mixtures (20/80 mol %)—ideal mixture

Property	SI Units	U.S. Units
Molar mass	30.010 g/mol	0.0330 lb/mol
Gas density @ 0 °C, 1.01 bara	1.340 kg/m ³	0.0836 lb/ft ³
Relative gas density (air = 1)	1.036	1.036

4.3 Chemical reactivity

As one of the most reactive of all the elements and one of the most powerful known oxidizing agents, fluorine is able to react with almost all elements and compounds depending on pressure and temperature, with the exception of lighter noble gases (for example, helium, argon), inorganic fluorides of the highest valence, and perfluorinated organic compounds.

Fluorine reacts with many organic substances even at room temperatures and is often accompanied by combustion and possible explosion.

The reactivity of fluorine is dependent on the pressure and temperature of the system. Dilution with inert gas has shown to reduce the oxidizing potential.

4.3.1 Reaction with flammable gases

Fluorine will react with all flammable gases. As an example, fluorine and hydrogen react with extreme violence, thus producing a highly exothermic reaction [$\Delta H_{f(g)}(25\text{ }^{\circ}\text{C}) = -271.7\text{ kJ/mol}$]. Even at very low temperatures (solid fluorine, liquid hydrogen), a violent reaction is produced.

4.3.2 Reaction with water

Fluorine reacts with water to form oxygen, oxygen difluoride, and hydrogen fluoride. Small quantities of ozone and hydrogen peroxide can also be formed. Oxygen difluoride is much more toxic than fluorine.

4.3.3 Reaction with halogens

If fluorine is combined with any of the other elements in Group VII/17 of the periodic table, it produces a highly exothermic reaction, from which a series of interhalogen compounds are formed (such as chlorine trifluoride, chlorine pentafluoride, bromine trifluoride, and iodine pentafluoride). Halogen fluorides are also widely used as fluorinating agents.

4.3.4 Reaction with carbon

Carbon can react differently with fluorine depending on the carbon structure and surface configuration. Activated carbon can ignite at room temperature in presence of fluorine but it may also absorb fluorine until it is saturated and then detonate.

4.3.5 Reaction with other nonmetals

Boron, silicon, phosphorus, sulfur, selenium, and tellurium all react with fluorine to cause combustion and the formation of fluorides of the highest valence. Under normal conditions, oxygen and nitrogen do not react with fluorine, but reactions can occur under special conditions. Of the noble gases, radon and xenon react readily with fluorine while krypton reacts only under special conditions.

4.3.6 Reaction with hydrocarbons and other organic compounds

All organic compounds, including hydrocarbons, react with fluorine. Ignition usually occurs and under certain circumstances the reaction can be explosive. The end product of the reaction is invariably carbon tetrafluoride. Under suitable reaction conditions, organic compounds can be partially or completely fluorinated with elemental fluorine, without causing destruction of the molecule.

With the exception of carbon tetrafluoride, all fully halogenated carbon compounds also react with fluorine. In many cases, however, this reaction proceeds so slowly that some of these materials such as polytetrafluoroethylene (PTFE), can be used as construction materials or sealants, provided reaction conditions (purity of the materials, pressure/temperature, and concentration of fluorine) are controlled.

4.3.7 Reaction with metals

Fluorine reacts with many metals and alloys at room temperature, but it shall be understood that any metal can ignite in fluorine under specific conditions. Passivation of metals is used to protect them from additional fluorine attack.

4.4 Toxicity

Pure fluorine is a highly toxic gas. Established levels of exposure for fluorine vary between countries and agencies. Refer to the governing agency in the country where the fluorine is being used. See Table 4 for examples of established maximum limits of fluorine exposure to personnel used in the industrial gas industry and Table 5 for established LC₅₀ values.

For more information, refer to the most recent SDS of the fluorine supplier.

Table 4—Regulatory exposure limits for fluorine

	Value	Value	Reference
OSHA PEL TLV–TWA	0.1 ppm	0.2 mg/m ³	[8]
American Conference of Governmental Industrial Hygienists (ACGIH) TLV–TWA	1 ppm	1.6 mg/m ³	[5]
ACGIH TLV–STEL	2 ppm	3.1 mg/m ³	[5]
National Institute for Occupational Safety and Health (NIOSH) IDLH	25 ppm		[2]
Acute Exposure Guideline Levels (AEGLs)			
AEGL-1 (30 minutes)	1.7 ppm	2.6 mg/m ³	[9]
AEGL-2 (30 minutes)	11 ppm	17 mg/m ³	
AEGL-3 (30 minutes)	19 ppm	29 mg/m ³	
NOTES			
1 OSHA limits are the legal exposure limits allowed by U.S. law and are enforceable.			
2 ACGIH limits are recommended values and are not enforceable by law.			
3 NIOSH limits are recommended values and are not enforceable by law.			
4 AEGL-1 is the airborne concentration (expressed as ppm or milligrams per cubic meter [mg/m3] of a substance above which it is predicted that the general population, including susceptible individual, could experience notable discomfort, irritation, or certain asymptomatic, non-sensory effects. However, the effects are not disabling and are transient and reversible upon cessation of exposure.			
5 AEGL-2 is the airborne concentration (expressed as ppm or mg/m ³) of a substance above which it is predicted that the general population, including susceptible individual, could experience irreversible or other serious, long-lasting adverse health effects or an impaired ability to escape.			
6 AEGL-3 is the airborne concentration (expressed as ppm or mg/m ³) of a substance above which it is predicted that the general population, including susceptible individuals, could experience life threatening health effects or death.			
7 In Europe, the SDS of the supplier shall be consulted to find the applicable regulatory exposure limits where determined in the different countries.			

Table 5—Established LC₅₀ values

	Value	Reference
LC ₅₀ (1h rat) (pure fluorine)	185 ppm	[10]
LC ₅₀ (1h rat) (for 20% fluorine in nitrogen)	925 ppm	calculated per [10]
LC ₅₀ (1h rat) (for 10% fluorine in nitrogen)	1850 ppm	calculated per [10]

4.5 Routes of exposure

There are two main routes of exposure for fluorine:

- inhalation; and
- eye and skin contact.

Exposure to fluorine shall be treated as an exposure to hydrofluoric acid. Hydrofluoric acid is one of the most hazardous chemicals used in industry. It is unlike other acids because it cannot be rapidly neutralized and can continue to destroy tissue for several days after exposure to skin. The fluoride ion readily penetrates the skin, causing destruction of deep tissue layers including bone.

One of the most serious consequences of severe exposure to hydrogen fluoride by any route is the marked lowering of serum calcium (hypocalcemia) and other metabolic changes, which can result in a fatal outcome if not recognized and treated. Hypocalcemia should be considered a potential risk in all instances of inhalation and whenever skin exposure exceeds 25 in² (160 cm²) [11].

4.5.1 Inhalation

Fluorine has a pungent, irritating odor. Harmful concentrations of this gas in the air can be reached very quickly on loss of containment. Inhalation produces hydrogen fluoride as the fluorine reacts with moisture in the lungs and respiratory tract. The principal effect of exposure to fluorine is pulmonary irritation, which can begin at concentrations as low as 2 ppm, up to severe pulmonary edema, which can lead to death. Some subacute exposure at 0.5 ppm can result in no significant pathology, but there is some retention of fluorine, primarily in the bones and teeth.

Other symptoms include:

- irritation of the nose and/or throat;
- coughing;
- choking;
- swelling of the throat;
- chest tightness;
- chills;
- fever;
- cyanosis; and
- severe pulmonary edema [11].

4.5.2 Eye and skin contact

Fluorine is extremely corrosive to the eyes and skin. However, the effects may be delayed.

Skin burns are of two types:

- caused by hydrogen fluoride formed by fluorine in moist conditions; and
- caused by fluorine in dry conditions (similar to a second degree thermal burn).

Exposure to fluorine shall be treated as an exposure to hydrofluoric acid, which can cause serious, painful burns of the skin, eyes, and mucous membranes. Hydrofluoric acid burns can be more severe and are slower to heal than fluorine burns.

Symptoms can include:

- redness of the skin;
- severe, burning, or throbbing pain;
- whitish discoloration of the skin;
- blisters; and
- edema.

Contact between the skin and high concentrations of fluorine gas under pressure will produce burns comparable to thermal burns along with chemical burn effects. Contact with lower concentrations results in a chemical type of burn resembling those caused by acid [11].

4.6 Environmental issues

Fluorine is not categorized as a Class I or Class II ozone depleting substance and it does not have properties that contribute to global warming. However, fluorine is highly toxic and reactive on environmental release. Because of its toxic properties, fluorine and/or fluorine mixtures shall not be vented directly to the atmosphere and shall be treated through a designed abatement system.

Contact with water will form hydrofluoric acid, which creates aquatic toxicity concerns at very low concentrations (for example, 50 ppm to 60 ppm).

5 Oxidizing/reactivity hazards

The information presented in this section is for components in direct flow path of the fluorine. Components used for static seals, gaskets, etc., are chosen based on compatibility relative to the fluorine concentration and pressure.

5.1 Introduction to fire and explosion hazards

Figure 1 illustrates that combustion requires the simultaneous occurrence of the following elements:

- the presence of an oxidizer (fluorine);
- a combustible material in contact with the oxidizer (fluorine handling equipment); and
- a source of ignition energy.

Because of its very high oxidizing ability, the fluorine molecule can spontaneously react with most combustible substances, without any external ignition source. This behavior is different from the properties of air/combustible or oxygen/combustible systems and therefore mixtures of fluorine and combustible substances can be regarded as self-ignitable or hypergolic. Several factors influencing the combustion are considered in the following paragraphs.

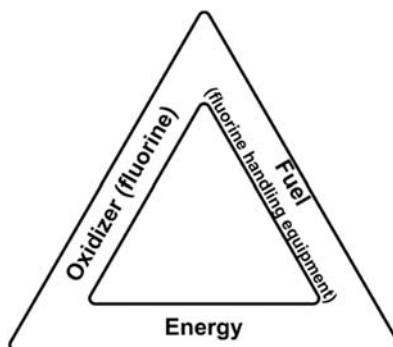


Figure 1—Fire triangle

5.2 Factors influencing reaction, ignition, and combustion

Fluorine reactions are influenced by numerous factors. The majority of reported fluorine ignitions have been attributed to improper cleaning or use of a less resistant material in the system.

Reactivity of materials in fluorine systems is somewhat peculiar in that ignitions have occurred after years of service with no apparent change in operating conditions. Even under controlled test conditions, the ignition of some materials is not able to be repeated to a high degree of confidence. Therefore, the possibility of an ignition/fire shall be considered by the system designer when locating equipment especially in close proximity to personnel. Refer to Section 7 for additional details.

The primary factors that influence ignition in fluorine systems are:

- resistance of the material to fluorine (see 5.2.1);
- size and configuration of equipment (see 5.2.2);
- cleanliness of equipment and passivation with fluorine (see 5.2.3);
- fluorine pressure (see 5.2.4);
- concentration of fluorine in inert gas (see 5.2.5);
- gas temperature (see 5.2.6); and
- dynamic exposure of materials to fluorine (see 5.2.7).

5.2.1 Resistance of the material to fluorine

Most metals offer far better resistance to fluorine ignition than nonmetals or polymeric materials. Metal composition, mass, and heat conductivity (ability to dissipate heat) are some factors that influence the potential for ignition. The use of polymeric materials in a fluorine system significantly increases the risk of fluorine ignition and their use is limited to specific applications. Ignition of even the most resistant metals with fluorine can occur if a less resistant material (for example, polymers, lubricants) ignites in the system. This mechanism of ignition is commonly known as the kindling effect.

5.2.1.1 Auto-ignition temperature

The auto-ignition temperature is an important factor that needs to be considered when choosing materials to resist combustion in fluorine. The risk of combustion is higher when the auto-ignition temperature is low since the energy required to reach this temperature is lower.

Unlike oxygen, where standardized tests exist to determine the auto-ignition temperatures of materials such as described in ISO 11114-3, *Gas cylinders—Compatibility of cylinder and valve materials with gas contents—Part 3: Autogenous ignition test for nonmetallic materials in oxygen atmosphere*, the testing for fluorine ignition and combustion is not standardized and in many cases is based on testing performed many years ago [12]. It is clearly recognized that the relative auto-ignition temperatures in fluorine are much lower than for ignition in oxygen systems [13].

The auto-ignition temperature in fluorine service is affected by pressure, the fluorine concentration, and the system operating temperature.

5.2.1.1.1 Auto-ignition temperature of metals

Temperature effects on common metals used for fluorine systems are shown in Table 6.

Any metal can ignite in fluorine under specific conditions.

Table 6—Temperature effects on common metals used for fluorine service

Metal	Recommended temperature limits for 100% fluorine service based on industry practice (°C) ¹⁾	Test data from published literature			
		Average ignition temperature (°C) ²⁾	Threshold temperature for low probability of failure (°C) ³⁾	Threshold temperature for high probability of failure (°C) ⁴⁾	Temperature where metal-fluoride film can vaporize causing accelerated corrosion (°C) [14]
Copper	150	692	588	863	No data
Carbon steel	150	672 (iron)	No data	No data	No data
Stainless steel	150 (300 series)	681 (302 grade)	696 (304L grade)	1054 (304L grade)	⁵⁾
Monel®	400 (UNS N04400)	⁶⁾	924 (UNS N05500)	1041 (UNS N05500)	648
Nickel (UNS N02200)	600	1162	> 957 At sonic velocity	> 957 At sonic velocity	648
NOTES ¹⁾ Temperatures approaching the listed temperature can result in rapid corrosion to the metal even with only short-term exposure. It is imperative that the user fully analyze (possible corrosion testing) the operating conditions (temperature, pressure, flow) and consequences of failure from corrosion prior to using a fluorine system at or higher than the listed temperatures. ²⁾ Tests were with thin wire (0.25 mm to 0.50 mm [0.010 in to 0.020 in] diameter) in static fluorine at atmospheric pressure [14]. ³⁾ Tests were with 100 psia (6.9 bara) fluorine in static condition. Failure is defined as the temperature at which the onset of a discernible but relatively minor material response was observed in a few seconds [15]. ⁴⁾ Tests were with fluorine in static condition. Temperature at which the onset of a major material response was observed in a period of a few seconds or less [15]. ⁵⁾ Chromium in the stainless steel can form four types of fluorides. Below 150 °C, a protective chromium fluoride scale forms but this can be converted to a more volatile form above 150 °C, which can compromise the protective ability of the film. ⁶⁾ The published ignition temperature for Monel from the reference paper is listed as 396 °C but accuracy of the measurement has been questioned in additional papers possibly because of temperature measurement technique [14]. Additionally, the ignition temperature could have been affected by the possible presence of detrimental minor alloying elements [15]. Industry experience suggests Monel (UNS N04400) auto-ignition temperature is greater than that of stainless steel, but precise measurements are not available.					

5.2.1.1.2 Auto-ignition temperature of nonmetals

Ignition tests on polymeric materials and lubricants in static and dynamic conditions have shown that the ignition risk increases with pressure and temperature. Most polymeric materials will spontaneously react upon exposure to fluorine. While some historical test results indicate little or no reaction under a given condition, there is a high degree of uncertainty of fluorine ignition/reaction especially with nonmetals. Small amounts of contaminants or a slight change in operating conditions (velocity, pressure) can be enough to initiate ignition even after an extended time in fluorine service.

Highly fluorinated polymers such as polychlorotrifluoroethylene (PCTFE), PTFE, Perfluoro (alkoxy alkane) (PFA), including metal-filled (for example, bronze) types, exhibit the best resistance to ignition in fluorine systems, but even their use shall be carefully reviewed and exposure minimized. Refer to 7.2.2 for additional details of nonmetal use in fluorine service.

5.2.1.2 Propagation of metal fires

The propagation of metal fires ignited in fluorine is also an important factor that needs to be considered when selecting metal equipment components, in particular if there are components with low auto-ignition temperatures (for example, polymeric materials). The consequences of the auto ignition of sensitive materials (polymeric materials) are aggravated when a metal propagates from ignition under fluorine pressure. The degree of propagation of a fluorine-metal fire is a function of the fluorine pressure and material. Nickel, copper, and Monel are the best metals for limiting the propagation if ignited.