ASTRON®
ATOMIC FLUORINE GENERATOR
AX7680 SERIES

INSTALLATION AND OPERATIONS MANUAL

Part No. OM86203
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Table of Contents

List of Illustrations

List of Tables

Section 1
Introduction and Specifications

1.1 Introduction

The ASTeX AX7680 Series ASTRON® Fluorine Generator (ASTRON®) is a self-contained atomic fluorine generator. Designed for generating atomic fluorine for chamber cleaning applications, the ASTRON® employs a low field torroidal plasma combined with an integral switching power supply to produce atomic fluorine. Figure 1-1 shows an oblique view of the ASTRON®.

Figure 1-1. ASTRON

1.2 Specifications

Contact ASTeX if operation outside of the specified parameters is contemplated.

TABLE 1-1. AX7680 Series Astron® Fluorine Generator, Technical Specifications	
Item	***Specification***
Electrical Service Requirements	
AC Power Input	187-228 volts (208 nominal), three phase, three-wire plus ground, 50/60 Hz, AX7680 - 50 amps, AX7685 - 60 amps.
Receptacle	ILME bulkhead housing, p/n CH1 16L ILME male insert, p/n CXM 4/0.
Mating Connector	ILME female insert, p/n CXF 4/0 ILME hood, p/n CA016L29 ILME strain relief MCG29
Pin 1, 2, 3	Phases A, B, C respectively
Pin 4	Earth ground.
Cooling Requirements	
Ambient Air Temperature of Operation	5-40°C.
Water Filtration	20 micron.
Water Resistivity	Facility Water
Minimum Water Flow during operation	2.0 gpm
Minimum Water Flow during idle	0.5 gpm
Water Pressure Drop	13 +/- 3 psid at 2.0 gpm
Maximum Water Inlet Temperature	30°C.
Minimum Water Temperature	Ambient dew point or 15°C, which ever is greater
Maximum Water Inlet Pressure	100 psig.
External Water Connections	3/8-in Swagelok®.
Process Compatibility	
Process Gas	100% NF_3
Process Gas Feed	• ISO KF40 (inlet and outlet) connection. • KF40 compatible Chemraz® O-ring and retainer. • External transport tube > 1.3 in. ID recommended (smaller diameter transport tube increases transport loss of atomic fluorine).
Exposed Material Surfaces	• No. 210 Chemraz® SC-513 O-ring. • No. 223 Chemraz® SC-513 O-ring. • No. 325 Chemraz® SC-513 O-ring. • Al_2O_3 (99.5%) • Al_2O_3 (99.99%) • 6061-T6 aluminum • Teflon impregnated, hard coat anodized aluminum.
Operating Performance	
Ignition Gas	Argon (100%), grade 4.4 or better.
Operation Gas	NF_3 97% or better
Ignition Pressure	1-4 torr pre-ignition measured at the exit of ASTRON®.
Operating Pressure	1-10 torr post-ignition pressure measured at exit of ASTRON®.
Operating Gas Flow Rate	AX7680 - 0.5-4 slm NF_3 , AX7685 - 0.5-6 slm NF_3
Reactant Output	≥95% dissociation measured at ASTRON exit @ 5-10 torr post-ignition pressure measured at the exit of ASTRON®.
Physical Characteristics	
Chassis Size	14.53-in. deep by 16.62-in. wide by 10.33-in. high
Weight	Approximately 74 lbs.

1.3 Dimensional Drawings

Dimensional drawings for the ASTRON® are shown in figures 1-2 through 1-4.

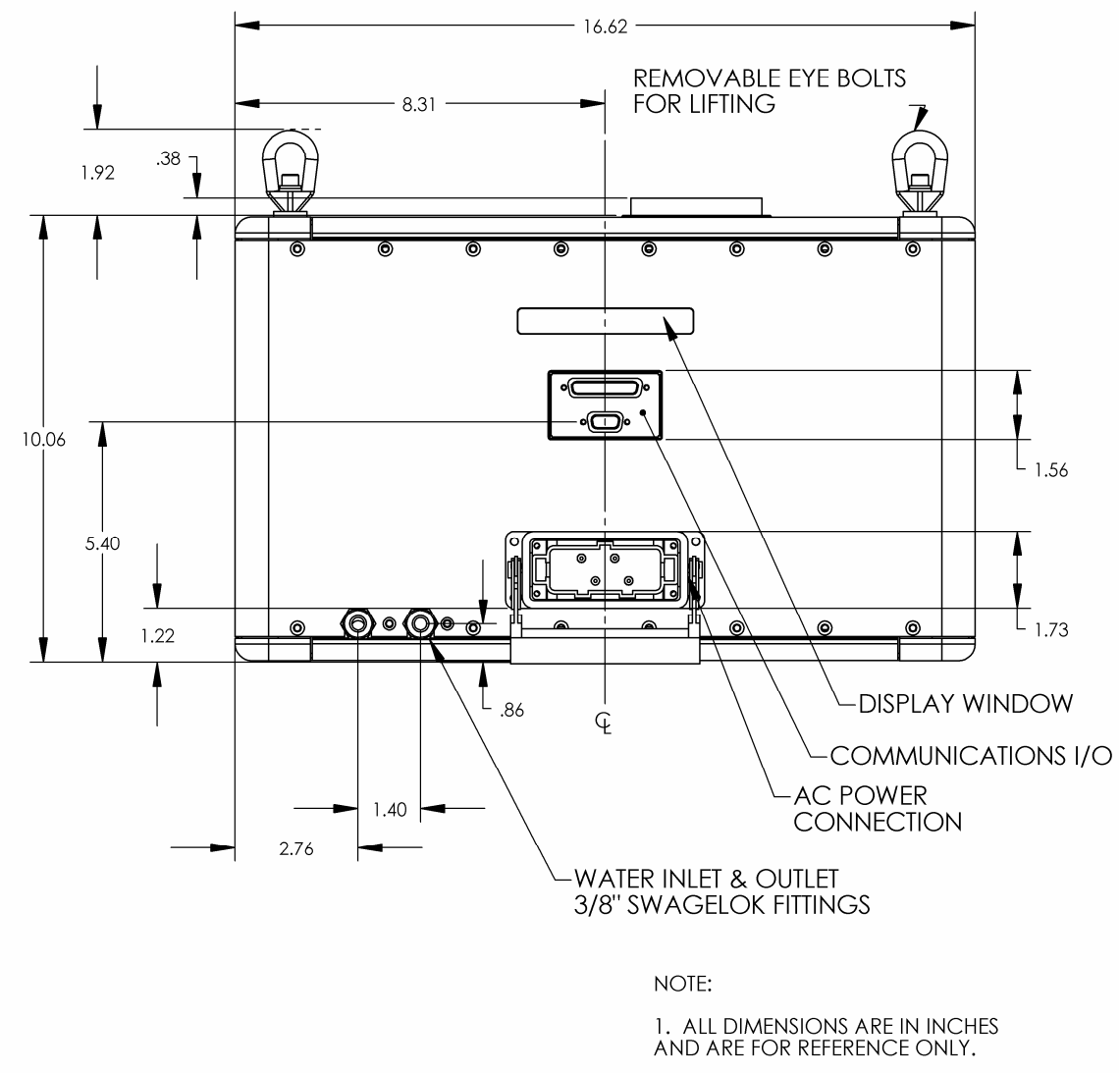

Figure 1-2 Front View

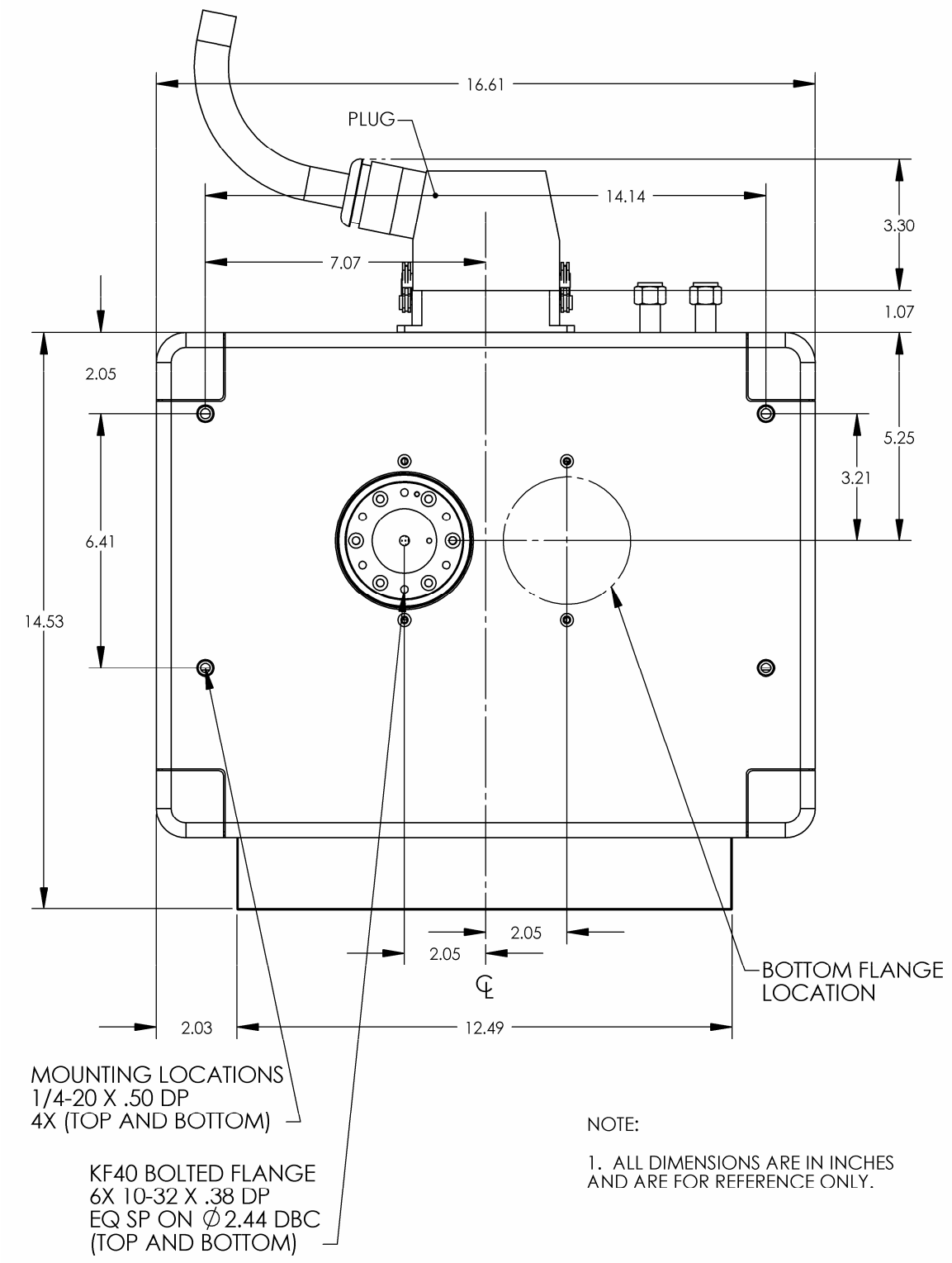

Figure 1-3. Top View

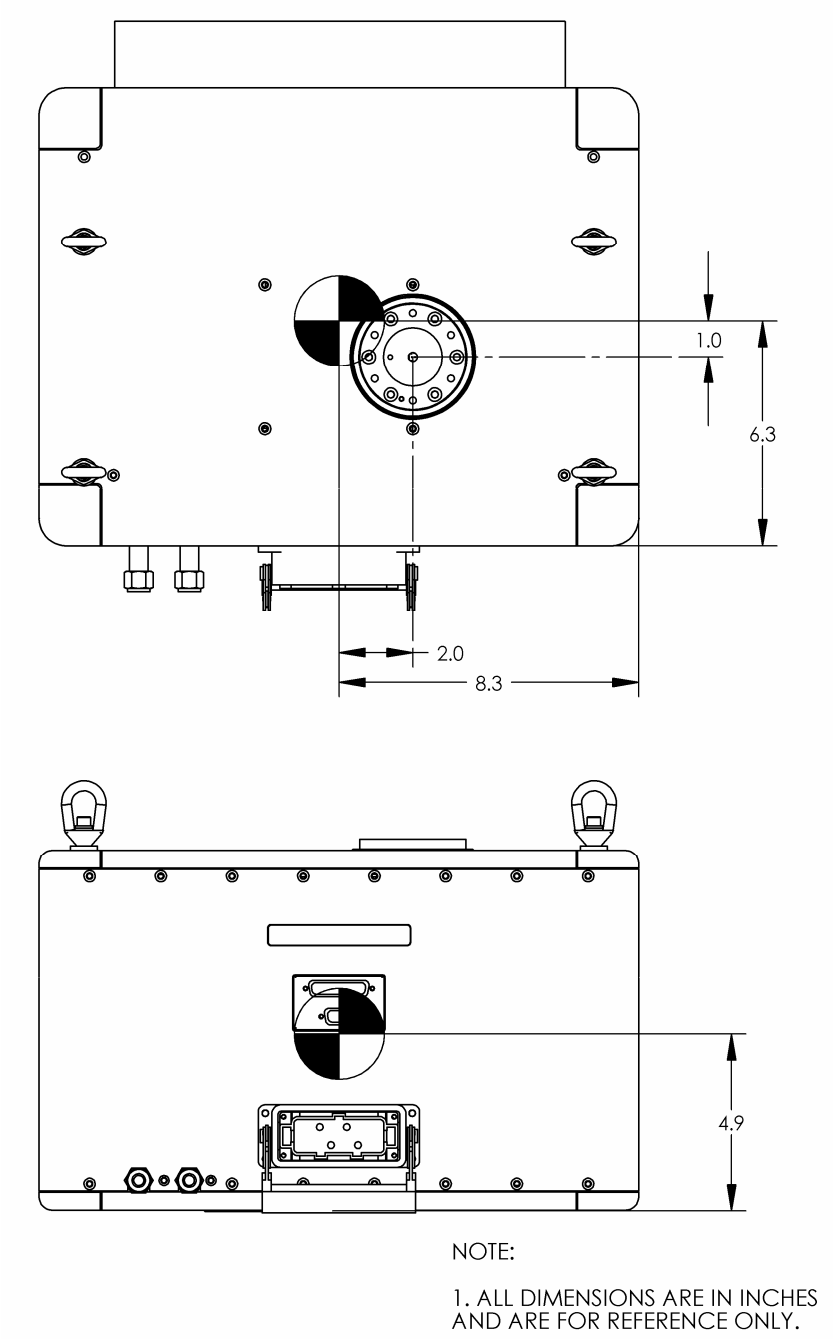

Figure 1-4. Center of Gravity

Section 2
Safety

2.1 Overview

The production of fluorine has the potential for injury to humans and the possibility of damage to equipment and facilities by corrosion or explosion. Argon, a gas used in ASTRON®, can cause asphyxiation. In addition, operation of the ASTRON® involves the use of high voltages within the enclosure that can cause injury or death by electrical shock. Therefore through out this manual there will be text boxes with the titles NOTE, WARNING, or DANGER. DANGER boxes are to alert the user to health hazards, WARNING boxes are to alert the user to equipment hazards, and NOTE boxes are to clarify information to the user. The user shall be made aware that, if the equipment is used in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired.

DANGER

Understand and implement the OSHA and locally-required safety laws involving the use and generation of NF3 and fluorine. MKS ASTeX Products assumes no liability for the user's failure to comply with these requirements.

WARNING

ASTRON®, and the gas-handling components inside ASTRON®, are intended only to be used under vacuum. Subjecting ASTRON® to pressures above atmospheric pressure may permanently damage ASTRON® and/or create a gas leak.

2.2 Nitrogen Trifluoride Safety

Nitrogen trifluoride is a colorless, stable gas with a slightly moldy odor that provides little warning of its presence. In human studies, no odor was detected at less than 500 ppm. The maximum human exposure should be limited to no more than 10 ppm, therefore it is essential that a sensitive nitrogen trifluoride detector be installed together

DANGER

Exposure to nitrogen trifluoride can cause illness and death. Always install a sensitive nitrogen trifluoride detector in the same workspace as the ASTRON®.

with the ASTRON®. It is nonflammable by itself, a strong oxidizer, and reacts explosively with reducing agents. Electrical sparks can cause it to decompose.

Nitrogen trifluoride has a moderate acute inhalation toxicity causing anoxic deaths due to methemoglobinemia. Cyanosis occurs when 15% or greater of the total hemoglobin is converted to methemoglobin. Recommended safety procedures involving fluorine are provided in Appendix A. The material safety data sheets for nitrogen trifluoride are provided in Appendix B.

It is important to have the NF3 supply interlocked such that it is not possible to flow NF3 if one of two events happen:

1) No NF3 should flow if the chamber pressure exceeds ~600 Torr. This will prevent NF3 from flowing into the vacuum system if the system is vented, leaking, or otherwise open to the personnel in the area.
2) The second interlock should be an ambient leak detection system for NF3. Consult the manufacturer of the leak detection for installation information such as proper sensor locations.

2.3 Argon Safety

Argon is a colorless, odorless, tasteless and noncombustible gas used for many purposes including doping semiconductors with controlled amounts of impurities.

Argon is among the number of gases and vapors that, when present in high concentrations in air, act primarily as simple asphyxiates without other significant physiologic effects. A maximum exposure level is not recommended for argon because the limiting factor is the available oxygen. The minimum oxygen content should be 18% by volume under normal atmospheric pressure (equivalent to a partial pressure, pO_2, of 135 torr).Atmospheres deficient in oxygen do not provide adequate warning as most simple asphyxiates are odorless. The material safety data sheets for nitrogen argon are provided in Appendix C.

2.4 Gaseous Byproduct Safety

Common byproducts of fluorine are also hazardous. When fluorine is exposed to moisture in air, gaseous hydrogen fluoride (HF) is commonly formed. HF is very hazardous, is commonly formed during a fluorine leak, and has a TLV of 3 ppm. An MSDS for HF is included in Appendix E.

Tungsten Hexafluoride (WF6) is a byproduct when using atomic fluorine to etch tungsten. Silicon Tetrafluoride (SiF4) is a byproduct when using atomic fluorine to etch silicon. MSDS's for SiF4 and WF6 are included in Appendix F and G, respectively. If Astron is to be used for other applications, understand what the byproducts of the application are, and the safety issues associated with the byproducts.

Verify that the scrubber being used to treat vacuum pump exhaust is effective for the particular byproducts generated. Note that water scrubbers are generally not effective at removing NF3 from the gas stream. It is recommended to only flow NF3 through the system when the plasma is on or when making pre-ignition pressure measurements.

2.5 Environmental

Nitrogen Trifluoride is considered a "greenhouse" or global warming gas. Discharge of NF3 to the atmosphere should be limited. When the plasma is on, the NF3 is almost fully dissociated, and the byproducts can be effectively removed with most scrubbers. If, however, the plasma is not on, NF3 is flowing, and the scrubber being used is not effective with NF3, discharge can be significant. In either case, verify compliance with local regulations regarding allowable discharging and monitoring (if applicable) of NF3 exhaust.

2.6 Safely Venting the Vacuum System

When a vacuum system is at vacuum with fluorine or fluorine containing compounds, a small amount of fluorine will adsorb to the walls of the vacuum chamber. When the system is brought to atmospheric pressure, moisture from room air can hydrolyze the fluorine, forming gaseous HF. For this reason, the following procedure is recommended for venting the vacuum system after running the ASTRON®.

1) Shut off NF3.
2) Shut off plasma.
3) Shut off Argon.
4) Pump system to base pressure for 1 minute.
5) Shut NF3 isolation valves.
6) Remain at base pressure for 1 minute.
7) Backfill the system with Argon until the chamber reaches atmospheric pressure.
8) Pump the system to base pressure to 1 minute.
9) Backfill the system with Argon until the chamber reaches atmospheric pressure.
10) Repeat steps 4 – 9 8 times to complete the purge procedure.

2.7 High Voltage Safety

During operation, the ASTRON® produces voltages up to 10 kV. The ASTRON® is not interlocked so that operation is possible if any covers are removed. *For safety, it is important not to remove the covers for any reason.*

DANGER
Lethal voltages and rf energy are present within the ASTRON®. Do not open the equipment covers.

2.8 Non-Ionizing Radiation

During operation, the ASTRON® produces RF radiation at 400 khz within the enclosure that is in excess of the ACGIH TLV. However, with the covers in place, the RF radiation is minimal outside the enclosure. For this reason, it is important never to remove any covers from ASTRON®.

The plasma generated by ASTRON® produces broadband ultraviolet radiation. ASTRON® itself contains no viewports or windows in the plasma body, but some installations may contain viewports elsewhere in the vacuum system. If an installation does contain viewports, either measure the UV radiation to be below acceptable limits or eliminate the viewports.

NOTE

The ASTRON® contains no user-serviceable parts. Tamper-proof seals and caps are factory installed, and will void the equipment warranty if broken.

2.9 Safety Procedures and Precautions

The following safety precautions must be observed when operating the equipment.

WARNING

Failure to comply with the safety precautions or warnings indicated in this manual violates the safety standards that form a part of the intended use of the equipment. MKS ASTeX Products assumes no liability for the user's failure to comply with these requirements.

- Do not attempt to remove equipment covers or repair or modify the equipment yourself.
- Dangerous RF radiation will occur if the unit is operated without side covers in place.
- Return the equipment to qualified repair personnel or to ASTeX for service and repair to ensure that all safety features are maintained.
- Do not substitute any feedstock gases not specified in this manual without explicit permission of ASTeX.
- Verify that the ASTRON® is not installed where it can cause an unwanted chemical reaction to occur from the mixing of its effluent with incompatible materials downstream or in the process chamber. When using the ASTRON® do allow incompatible gasses and/or materials to mix at any time.
- Do not attempt to operate the equipment in explosive atmospheres.
- Connect all input gas and electrical lines according to the manufacturer's specifications or best commercial practice.
- Always check the fittings of all lines before operating.
- Never allow any foreign material to enter the equipment.

2.10 AX7680 Series Internal Safety Interlock

A thermal switch inside ASTRON® shut off the internal power supply (and therefore the plasma) if the internal heatsink temperature exceeds 65 degrees C. If this interlock trips, a "Overtemperature / Check Water Flow" message is displayed on the LCD display, and the "Ready" signal is removed from the J1 (the 25 pin D connector). In order to reset this interlock, the plasma on request signal must first be removed to clear the error, then activated again to request plasma. This interlock is considered a safety interlock because if this interlock switch did not exist, and the unit was operated without water cooling, outside surfaces of the Astron would exceed 80 degrees C. The installation of an additional, external water flow switch in the cooling water return line is recommended.

2.11 Ergonomic Safety

ASTRON® weighs approximately 74 lbs. Standard lifting equipment is required to lift or lower ASTRON®. Four eye bolts are provided to allow the user to use the standard lifting equipment. See figure 3-2 for the location of the removable eye bolts.

2.12 Symbols

High voltage area. Watch out for voltages as high as 10 kV.

Check the manual before doing any troubleshooting or repair.

Heavy Object. Use appropriate equipment or two people to lift or lower.

Chemical Hazard. Verify leak integrity of system before operating. Purge with inert gas before disconnecting

RF Radiation present within enclosure. Do not remove covers.

2.13 Cleaning

WARNING

Do not clean the equipment with either solvent or water-based cleaners. Wipe the equipment only with cloth damp with water.

2.14 Safety References

Manahan, S.E. “Toxicological Chemistry: A Guide to Toxic Substances in Chemistry”, Lewis Publishers: Chelsea, MI 1994

Armour, M.A. “Hazardous Chemicals: Information and Disposal Guide”, University of Alberta: Alberta, Canada, 1987

Sax, N.I.; Lewis, R.J. “Dangerous Properties of Industrial Materials”, 7th ed., Van Nostrand Reinhold: New York, 1987

Sittig, M. “Handbook of Toxic and Hazardous Chemicals”, Noyes: Park Ridge, NJ, 1981

National Institute for Occupational Health and Safety, “Registry of the Toxic Effects of Chemical Substances”, U.S. Government Printing Office: Washington, D.C.

Matheson Gas Products, Inc. “Guide to Safe Handling of Compressed Gases”, Matheson Gas Products: New York, 1988

Section 3
Installation and Operation

3.1 Installation

3.1.1 Unpacking

Each ASTRON® is packaged in a corrugated cardboard outer container and fitted foam inserts. The ASTRON® itself is encased in clear plastic together with this manual.

Use the following procedure to unpack the equipment:

1. Set corrugated cardboard container on work table and remove ASTRON® equipment together with fitted foam inserts.
2. Put fitted foam inserts aside and rest plastic-covered ASTRON® equipment on work table.
3. Pull away plastic material from around ASTRON® equipment, and remove manual.
4. Write serial number of ASTRON® equipment in this manual in the event that you need the information later.
5. Fill out warranty registration card and return to MKS, ASTeX Products.

Do not discard the packing material. Save it in a cool, dry place in the event you have to return the ASTRON® equipment for service or repair.

3.1.2 Mounting

Eight 1/4-20 threaded holes are available for mechanical support, four on top and four on the bottom. ASTRON® weighs approximately 69 lbs. Standard lifting equipment is required to lift or lower ASTRON®. Four eye bolts are installed in the four top ¼-20 holes to allow the user to use the standard lifting equipment. See figure 3-2 for the location of the removable eye bolts. The ASTRON® equipment is intended to be mounted mechanically only by the use of these eight 1/4-20 threaded holes. The unit should be mounted vertically using short, straight lengths of 1.3-inch diameter transport tubes on the exit. The mechanical constraints provided by the support must not impair a good vacuum seal. The ASTRON® equipment is meant to be installed as part of a system, such as the one shown in figure 3-1.

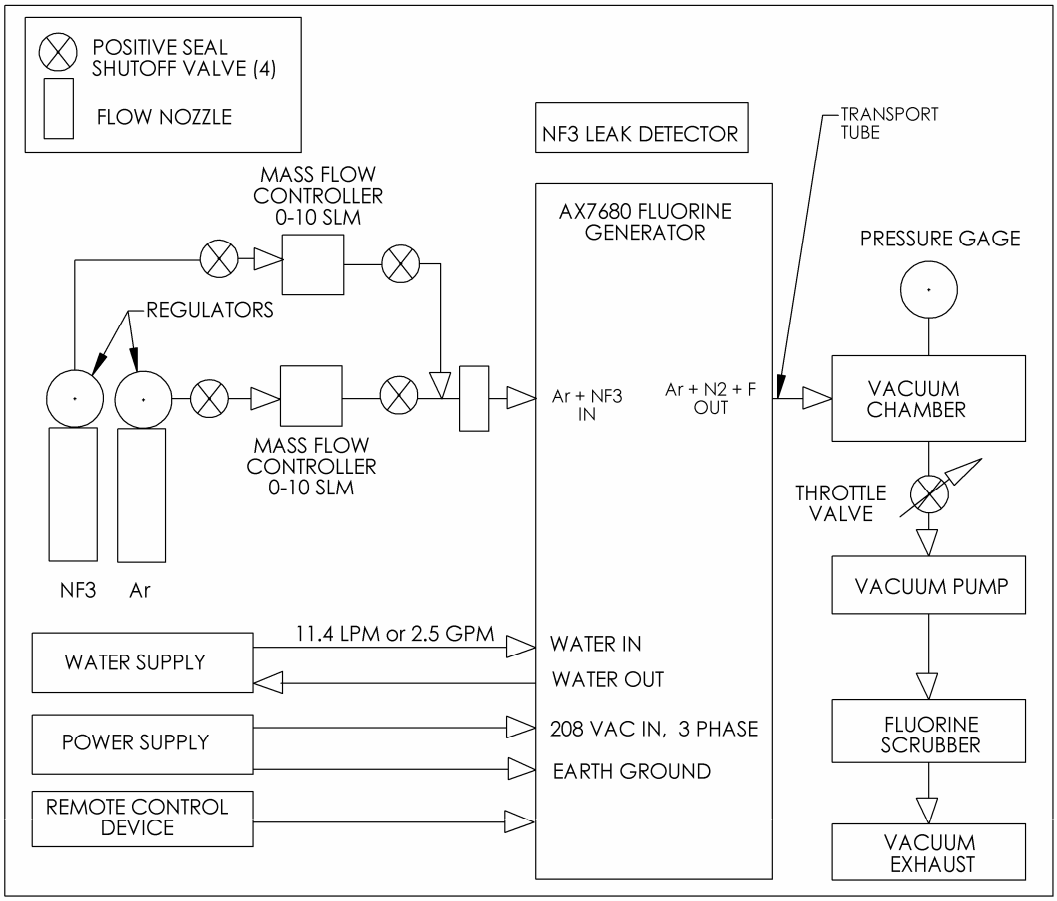

Figure 3-1. Typical System Configuration

3.1.3 System Integration

The ASTRON® equipment is externally connected with power -, water-, remote control-, and feed gas-lines by connectors on the ASTRON® equipment. There must be sufficient access room available to connect these lines to the ASTRON® equipment. The ASTRON® equipment must also be grounded via the power connector.

NOTE

Throughout this section gas flow is shown with the input at the top of the ASTRON® equipment and the exit at the bottom. Gas flow can be either top to bottom or bottom to top.

Because atomic fluorine is extremely reactive there is a potential for significant recombination of the atomic fluorine into F_2 or other molecules during transport from the ASTRON® equipment to the process chamber. The more combination that occurs, the less effective the ASTRON® equipment will be. If the transport tube between ASTRON® and the vacuum chamber has any restrictions, it may be difficult to achieve less than 8 Torr (measured pre-ignition at ASTRON®) with higher flow rates of gas. The ideal transport tube will be short (6 inches or less), made of an inert material (aluminum, anodized aluminum, or Teflon®), and will be of as large a diameter as possible (at least

1.3 inches) to minimize the collisions of molecules with the wall of the transport tube. For example, a long, 1/4-inch diameter stainless steel tube would be ineffective, because the small diameter would generate many wall collisions during transport, and stainless steel will cause a high recombination rate of atomic fluorine. A short 1.3-inch diameter tube made of aluminum, anodized aluminum, or Teflon® would be practical for use with a KF-40 interface.

WARNING

During operation, the temperature of the transport tube can exceed 80 degrees C. The actual temperature will depend on operating conditions and installation. Consider actively cooling the transport tube if appropriate.

It is important that system integration allows ASTRON® to be operated within its post-ignition pressure specification. Post-ignition pressure is defined as the pressure measured directly at the ASTRON® exhaust port with the plasma on. If the pressure in ASTRON® exceeds its maximum specification plasma reliability will decrease. Operating at a pressure above the maximum specification may cause the plasma to extinguish. Operating at a pressure lower than the minimum specification may cause the dissociation fraction of NF3 to fall below 95%.

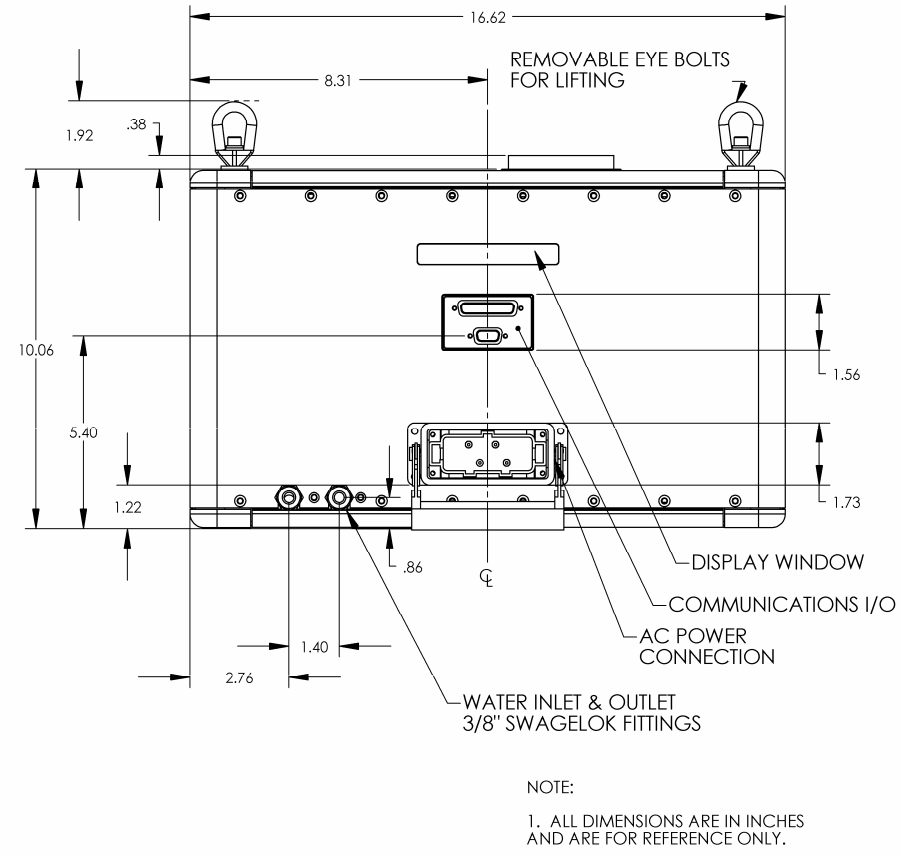

Figure 3-2. ASTRON® Front View, Showing Water, Electrical and Remote-Control Connectors

3.1.3.1 Water Connection

The ASTRON® equipment is cooled by recirculating water according to the specifications provided in table 1-1. Refer to figure 3-2.

- Securely connect a water line to the input 3/8-inch Swagelok® water connector. This water line will carry cooling water to the ASTRON® equipment. Refer to table 1-1 for the cooling water temperature requirements.
- Securely connect a water line to the output 3/8-inch Swagelok® water connector. This water line will carry heated water away from the ASTRON® equipment. The cooling water system must be capable of dissipating the maximum cooling load listed in table 1-1 while provided a maximum inlet temperature of 30°C.

WARNING

To avoid damage to the equipment, it is extremely important that the circulating water is filtered to 20 microns or better.

3.1.3.2 Power Connection

The customer must supply 208 VAC, 3-phase power from an EMO circuit compliant with SEMI requirements. Operation of the EMO circuit should be checked prior to applying power to the ASTRON® equipment. Main power delivered to the ASTRON® equipment must be protected with an approved, customer-provided, power disconnect device rated to 10,000 amps interruptible current (AIC). The customer-provided power disconnect must have OSHA-approved lock-out and tag-out capability. The external disconnect switch should be placed as close as possible to the ASTRON®. Refer to the technical specifications provided in table 1-1 for the power requirements.

Refer to table 3-1 for the required pinouts of the input power cable.

TABLE 3-1. 208 VAC Input Cable Pinouts

Type: ILME Bulkhead Housing P/N CHI16L. Male Insert P/N CXM 4/0

Pin No.	*Name*
1	208 VAC ∅ A
2	208 VAC ∅ B
3	208 VAC ∅ C
4	Power Ground

- Make sure the facility power cable circuit breaker is in the OFF position.
- Securely connect a four-conductor (3-phase and ground) cable or conduit terminating in an ILME Insert p/n CXF 4/0, Hood p/n CA016L29 style connector to the AC power connector. A cable strain relief ILME part number MGC29 is also available. Refer to figure 3-3. The power connection is

designed for make/break with power applied and under load. Follow local guidelines for wire size and type.

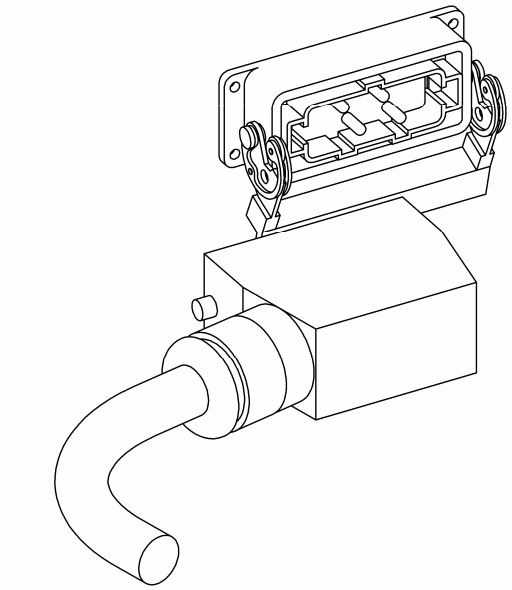

Figure 3-3. Connection Power to ASTRON® Equipment

3.1.3.3 Remote-Control Connection

The ASTRON® equipment is intended to be operated from a remote location by means of a 25-pin cable terminating in a male DB25 connector. The ASTRON® equipment uses 24V logic for inputs and outputs. The inputs and outputs are configured for externally sourced 24V. Refer to figure 3-2 and attach the 25-pin connector to connector J1 on the front of the unit. Table 3-2 provides an explanation of the signals carried by this cable. The active state is defined as a state when current is flowing through the semiconductor (diode for inputs, transistor for outputs) connected to the customer interface. Connector J2 is not used at this time.

The schematic diagram of the interface circuit internal to the ASTRON® equipment is provided in figure 3-4. An example of a remote-control interface is provided in figure 3-5.

TABLE 3-2. Remote-Control Cable Pinouts

*Pin No.**	*Name*	*ASTRON®*	*Active State*	*In-active State*
14	+24 V Return for Outputs			
2	+24 V Return for Inputs			
15	READY	Output	ASTRON® ready	Not ready
16	Plasma OK Output	Output	Plasma OK	Plasma off
4	+24 V In	Input	Plasma on request	Plasma off request/reset
17	AC OK Output	Output	AC supply OK	AC supply malfunction

* All other pins are reserved for future use.

3.1.3.4 Nitrogen Tri-Fluoride Gas Line Connection

DANGER

Read and understand the information provided in Section 2, Safety, as well as the information provided in Appendixes A and B before attempting to connect NF_3 to the ASTRON® equipment. Make sure the gas lines, vacuum pumps, elastomer seals and polymers are designed for use with NF_3.

NOTE

The flow mixing nozzle is mounted in the top KF-40 flange. ***The flow mixing nozzle must be mounted at the intended gas inlet.*** *If you intend to use the bottom inlet as the gas input, move the flow mixing nozzle from the top to the bottom KF-40 flange. The mixing nozzle is secured by six 10-32 screws.*

Refer to figure 3-6. Use the following procedure to connect the nitrogen tri-fluoride gas line to the ASTRON® equipment:

1. Provide an adapter for input nitrogen tri-fluoride and argon feed lines to connect to ISO KF40 connector.
2. Verify flow nozzle is installed at gas inlet.
3. Insert No. 325 Chemraz® O-ring in KF40 connector at top of ASTRON® equipment.
4. Secure gas line and KF40 connectors together by means of six bolts.
5. Install 6-inch KF-40 extension tube or fitting of similar volume between ASTRON® and adapter to VCR fitting.
6. Tighten securely.

3.1.3.5 Vacuum Chamber Connection

Refer to figure 3-6. Use the following procedure to connect the ASTRON® equipment to the vacuum chamber:

1. Insert No. 325 Chemraz® O-ring in KF40 connector at bottom of ASTRON® equipment.
2. Secure KF40 connectors together by means of six bolts.
3. Tighten securely.

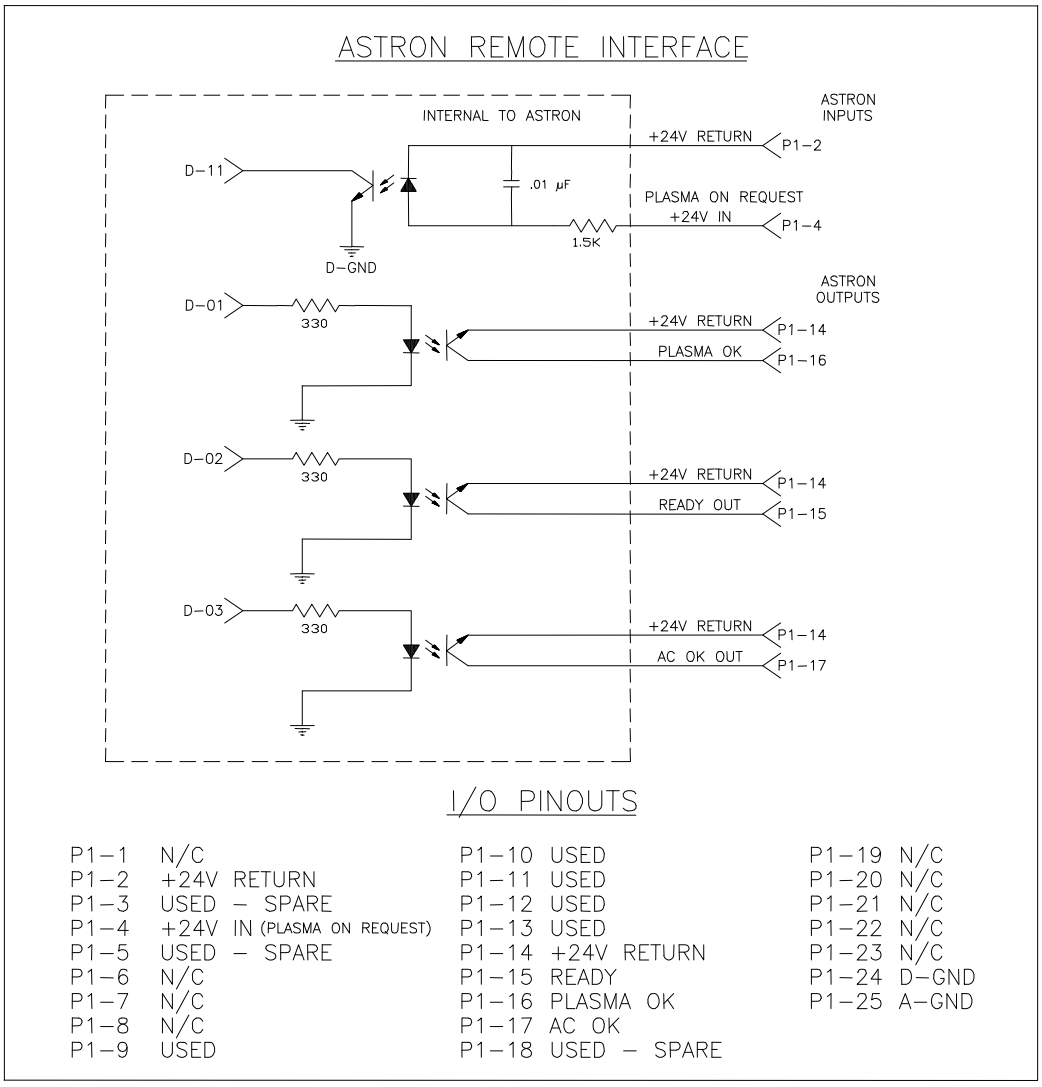

Figure 3-4. Remote Interface Schematic Diagram

NOTE

With respect to figure 3-5, maximum voltage equals 28 volts, which corresponds to a maximum current of 18mA. For output signals, maximum current equals 60 mA continuous with a maximum surge current of 2.5 A.

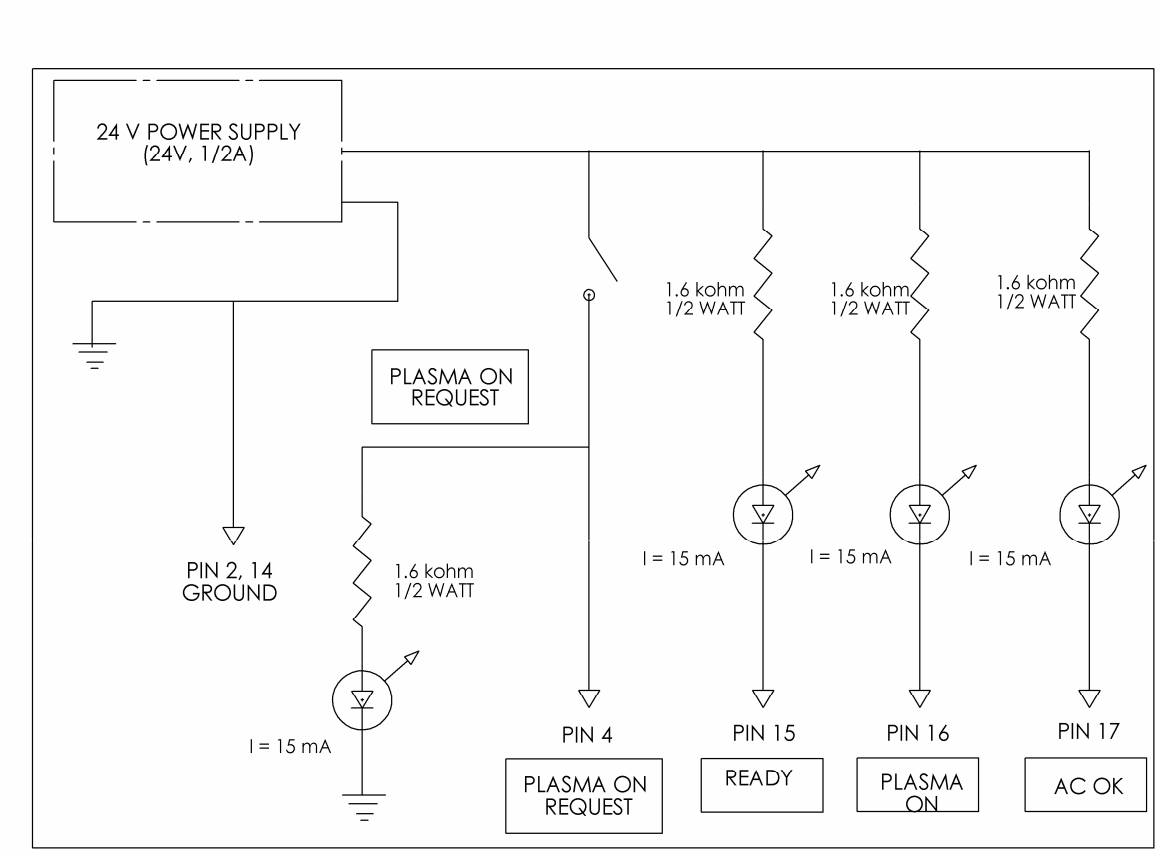

Figure 3-5. Remote-Control Interface, Schematic Diagram

3.2 Operation

3.2.1 Front Panel Indicator

Figure 3-2 shows the front panel liquid crystal display used to record the power-up status of the ASTRON® equipment. It is also used to indicate the status of plasma ignition, and as a troubleshooting device.

3.2.2 Pre-Operational Checkout

Before operating the ASTRON® equipment for the first time, perform the following procedure to assure operational readiness:

1. Perform a leak check using a helium leak detector, or a rate of rise method prior to operation.
2. Turn on facility water supply and allow water to circulate through ASTRON® equipment. Check for any visible leaks. Verify flow is equal to or greater than 2.5 gpm.
3. Check that all electrical and remote-control connector is firmly seated.
4. Place facility dedicated circuit breaker to ON position.
5. Apply facility gas to ASTRON® equipment.

3.2.3 Operational Procedure

Use the following procedure to apply power to the ASTRON® equipment and to produce plasma:

1. Upon power up the front panel indicator should indicate ASTRON by ASTeX, then it should indicate INITIALIZING, then it should indicate READY
2. Pump ASTRON® and feed gas lines to base pressure.
3. Introduce Argon; assure pressure is within the ignition pressure specification listed in table 1-1.
4. Activate remote plasma on request.
5. Front panel indicator should then indicate IGNITING.
6. Front panel indicator should then indicate PLASMA ON.
7. Introduce NF_3 at desired flow rate, assure pressure is within the operating pressure specification listed in table 1-1

Refer to Section 4, Maintenance and Troubleshooting, if these indications are not obtained.

3.2.4 Emergency Shutdown

Use the following procedure to shut down the ASTRON® equipment in an emergency:

1. Place facility circuit breaker to OFF position, or remove the ILME connector from the ASTRON® equipment.
2. Close inlet flow valve to shut off NF_3 and AR gas flow.

3.2.5 Run Time Meter

ASTRON® has a software controlled run time meter to log plasma-on hours. The timer only increments when plasma is on. ASTRON® will only display the run time when in Ready mode (plasma off, AC power applied). When in Ready mode, the LCD display will display the run time for 2 seconds, at 15 second intervals.

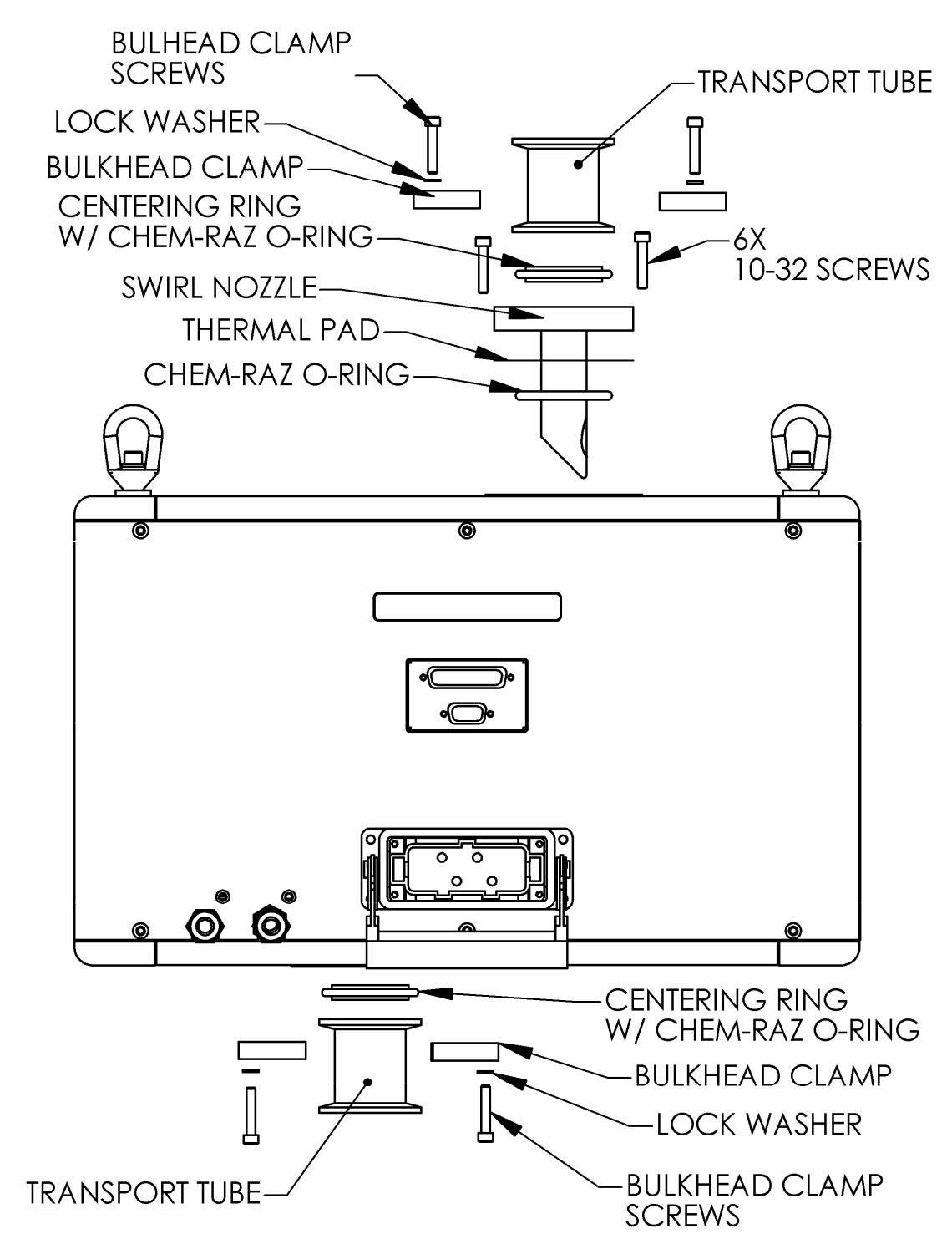

Figure 3-6. Gas Line Connection Details

Section 4
Maintenance and Troubleshooting

4.1 Maintenance

Except for cleaning, no periodic maintenance is required for the ASTRON® equipment.

Clean the exterior of the ASTRON® equipment with a damp cloth, then dry thoroughly.

4.2 Troubleshooting

Troubleshooting is accomplished by means of messages that appear on the liquid crystal display on the front of the ASTRON® equipment. Refer to table 4-1 for troubleshooting information. The notes at the conclusion of Table 4-1 refer to the ASTRON® internal interlock states at the time of the messages. If these troubleshooting techniques do not solve the problems, call ASTeX customer service.

TABLE 4-1. Troubleshooting

Message	*Problem*	*Directions*
LOW PLASMA CURR[2]	• Plasma has extinguished.	• Verify NF_3 flow is within specified limit. • Verify total pressure is 10 Torr (measured at Astron™ post-ignition). • Verify gas purity. • Verify vacuum system is leak-tight.
	• Plasma extinguishes when NF_3 is introduced	• Verify NF_3 flow and pressure is within specifications. • Verify NF_3 delivery system does not overshoot set point.
HI LINE VOLTAGE[2]	Indicates that line voltage has exceeded 228 VAC.	• Shut down ASTRON® equipment. • Check facility power. • Provide substitute power if possible. • Restore power to ASTRON® equipment. • Check that message no longer present.

TABLE 4-1 (Continued). Troubleshooting

Message	*Problem*	*Directions*
LO LINE VOLTAGE[2]	Indicates line voltage has dropped below 187 VAC, or one of the three phases is missing.	• Shut down ASTRON® equipment. • Check facility power. • Provide substitute power if possible. • Restore power to ASTRON® equipment. • Check that message no longer present.
OVERTEMPERATURE CHECK WATER[2]	Indicates that internal power board heat-sink temperature has exceeded 147°F (65°C).	• Shut down ASTRON® equipment. • Check water supply at inlet for proper flow (2.0 gpm). • Check water temperature is <30°C. • Check air temperature is <40°C. • Restore power to ASTRON®. • Check that message no longer present.
OVER PRESS/FLOW[3]	Indicates that the ASTRON outlet pressure or gas flow is over the specification	• Verify NF_3 < max NF3 for the particular model. • Verify post-ignition pressure <10 Torr measured at ASTRON exit. • Check that message no longer present.
IGNITION FAIL[2]	Indicates that plasma has failed to ignite.	• Check argon supply for purity (grade 4.4) and adequate flow (0.5-4 slm). • Check pressure at Astron® to be 1-4 Torr. • Check input AC line voltage to be >187 VAC. • Pump ASTRON® and feed gas lines to base pressure, then restore starting conditions listed above. • Reattempt ignition.
IGNITION RESET..[2]	Indicates that the maximum 40 second ignition sequence was obtained and that a plasma was not ignited. Or indicates that that a plasma request signal prematurely terminated within 40 second ignition window.	• Wait 80 seconds for IGNITION RESET sequence to complete and then re-attempt ignition.
PREVIOUS FAULT alternating with another error message	Indicates that error message occurred momentarily, but ASTRON® equipment ready for operation again.	NOTE *To clear display, turn off PLASMA ON signal, then turn it on again.*
No LCD Display[4]	• Power not correctly installed. • ASTRON® failed.	• Shut down ASTRON® equipment. • Check that proper input power (as specified in table 1-1) is connected to ILME connector (figure 3-4). • Restore power to ASTRON® equipment. • Check that LCD display is active. • Return defective ASTRON® to ASTeX.

RELAY FAULT	Indicates that an internal ignition relay has faulted	• Reattempt ignition • If fault persists, contact MKS customer service.

[1]Warning only. ASTRON® cannot reach current setpoint.
[2]Prevents power supply from operating.
[3]Momentary warning only.
[4]No operation.

4.3 End of product service, re-cycling.

If at any time it is determined that ASTRON® will not longer be put into service it is possible to re-cycle the products components. By removing the printed circuit boards and other electrical components the materials left are copper and aluminum. Therefore after wiping the plasma channel with isopropyl alcohol to remove any contaminates the ASTRON® could be supplied to a recycling center for processing.

Appendix A
Fluorine Handling

NOTE

The information and guidance in this section was prepared by Lawrence Livermore National Laboratory for its own internal use. The requirements and recommendations may not necessarily apply to the operating systems and procedures of a different organization. With permission from Lawrence Livermore National Laboratory, Applied Science and Technology provides this information as a potential aid to its customers, but extends no warranty as to its fitness.

NOTE

This document has been edited to eliminate material pertaining only to Lawrence Livermore National Laboratory.

ASTeX SAFETY PREFACE

After NF_3 is applied to the chamber, the residue in the chamber after cleaning will involve such factors as specific configurations, wetted materials, and etched materials. The substance to be etched may generate a variety of compounds that may be more or less toxic, and may demand more or less rigorous containment and safety systems. At a minimum, molecular fluorine, F_2, is generated.

Appendixes A and B provide information on NF_3 and F_2. If other components are generated during the etching or cleaning process, ASTeX recommends that you obtain safety information on these compounds and follow the recommendations accordingly.

ASTeX makes no claim that following the procedures in Appendix A will prevent personal injury. However, the information presented is considered as being the best commercial practice, and should be followed or adapted for your own purposes.

A.1 Introduction

This supplement describes the common hazards associated with fluorine and details engineering and procedural controls required for its safe use. This supplement is organized according to the process you must go through to safely handle fluorine: (1) educate yourself on the chemical and physical hazards of fluorine, (2) design the fluorine system with appropriate engineering controls, (3) understand the procedure for purchasing fluorine, and understand the administrative controls for the safe use of fluorine and the maintenance of fluorine systems.

Treat mixtures of fluorine and inert gases with the same care as pure fluorine unless otherwise noted in this supplement or unless individual exceptions have been approved.

Although fluorine is extremely hazardous, it can be handled safely if the proper precautions are taken. Only trained and competent personnel are permitted to handle fluorine; therefore, you should be familiar with the contents of this supplement and with such information as the Material Safety Data Sheet available in Appendix B.

A.2 Hazards of Fluorine

A.2.1 Chemical Hazards

Fluorine is a highly toxic and corrosive pale yellow gas whose sharp, penetrating odor is similar to that of a high concentration of ozone. The most powerful oxidizing element known, fluorine (a halogen) reacts readily with practically all organic and inorganic substances except inert gases, metal fluorides in their highest valence state, and a few pure and completely fluorinated organic compounds. However, even these few pure and fluorinated organic compounds may burn in a fluorine atmosphere if they are contaminated with a combustible material or are subjected to high flow rates of fluorine.

Hydrogen and fluorine combine with extreme violence, forming hydrogen fluoride. Fluorine also reacts explosively with most organic compounds. Moreover, it reacts with other halogen gases to form such compounds as ClF, ClF3, BrF3, and IFS. Although oxygen does not ordinarily react with fluorine, two oxygen fluorides, OF2 and O2F2, do react with it. The extreme reactivity of fluorine demands that you properly clean and passivate a fluorine system prior to using fluorine in that system. An explosion and fire may result if proper procedures are not followed.

A.2.2 Health Hazards

Inhalation of fluorine gas can cause nose and throat irritation, respiratory tract and lung injury, unconsciousness, and even death. If fluorine makes contact with your skin or eyes, burns may result. These burns are caused by heat produced when fluorine or hydrogen fluoride (the result of fluorine reacting with moisture in the air) reacts with the

moisture on the skin. Moreover, fluoride ions can penetrate deeply to the bone, replacing the hydroxide ions in the bone to produce injury.
Pain from injuries associated with fluorine exposures is often delayed especially if the fluorine is dilute. Therefore, if you even suspect you may have been exposed, rinse your skin and eyes with large amounts of water; continue rinsing for 20 min. Get immediate medical treatment. Appendix A describes the proper emergency procedures to be followed in the event of exposure to fluorine.

Hygienic Standards. According to the U.S. Department of Labor Occupational Safety and Health Administration,1 the allowable limit for an 8-h time-weighted average exposure to fluorine in a 40-h work week is 0.1 parts per million (ppm). Fluorine gas is so irritating that humans will not tolerate excessive exposures to it. In one incident, brief inhalation of a concentration of 25 ppm caused acute toxic effects in humans.2 In a study on mice, the lethal concentration for 50% of the mice after 60 min of exposure was 150 ppm.3 Direct skin exposure to pure fluorine can cause severe burns in 0.2 s, and an exposure for as long as 0.6 s can result in thermal flash burns comparable to those produced by an oxyacetylene flame.4

A.3 Precautions for the Safe Use of Fluorine

A.3.1 Engineering Controls

You are responsible for establishing the following engineering controls to preclude the release of fluorine into the work area.

Isolation. Closed systems, constructed to prevent the escape of gas into work areas, must be used for all fluorine operations within a building.

Gas Storage Cabinets. All cylinders or containers in use or ready-to-use status need to be kept in ventilated gas storage cabinets. Cylinders must be moved with their caps on until they have been put into and secured in a gas storage cabinet. Gas storage cabinets are commercially available for cylinders in ready-to-use condition. These were developed for the semiconductor industry and can be used without modification for fluorine/inert gas mixtures containing <5% fluorine. (10% fluorine/inert gas mixtures can be used to passivate these systems.) Gas storage cabinets need the following features:

* 18 gauge or thicker steel walls or fluorine/inert-gas mixtures containing <=10% fluorine.

* The smallest doors consistent with safe cylinder handling. The doors must be self-closing and need louvers so the cabinet will be under flowing suction ventilation at all times (see the next item for air flow specifications).

* Self closing and self latching windows to make all routine valve adjustments other than those needed to remove old cylinders and install new ones. Air flow needs to be sufficient to maintain an inflow of air at an average velocity of 200 feet per minute (fpm)

and never less than 150 fpm anywhere in the plane of the fully opened window. Test smoke released in the window plane must never flow outward.

* Toxic gas detectors installed inside the cabinet.

* Cylinders must be rigidly clamped so that opening the supply valve will not cause torque to be transmitted to the regulator manifold (we have found that this can cause a leak). Cabinets used for pure fluorine, inert gas mixtures containing >10% fluorine, other gas mixtures and oxidizing fluorides should have bare-finish stainless steel walls. Such cabinets also need:

* Barricades to protect the operator.

* Valve handles that protrude through the cabinet wall to minimize the times when an operator must open the cabinet door or window and reach inside. Air velocities through the holes must be 500 fpm or more.

Delivery Hardware. Delivery pipes and tubes must be of all-welded construction or be double walled. The outer tubing must be under suction ventilation and be continuously monitored for gas leakage in a double-walled system. Double-walled and all-welded lines are recommended and may become mandatory in the future. All non-welded joints and fittings must be in enclosures that are under suction ventilation and monitored for gas leakage. The materials in all-welded lines and the inner tubes of double-walled lines must be made of compatible materials.

Compatible Materials. Compatible materials must be used. These are summarized in Appendix B for fluorine and fluorine/inert gas mixtures. Contact the material vendor for guidance about compatible materials for the material, temperature and pressure you will use. Additional guidance is available from your Hazards Control Field Team.

At room temperature, fluorine reacts slowly with many metals; this often results in the formation of a metal fluoride film that retards fluorine's effect on brass, iron, aluminum, magnesium, and copper. Hence, these metals are quite satisfactory for handling fluorine at room temperature. However, at higher temperatures, you must consult the manufacturer regarding the adequacy of the material to be used. For example, nickel and Monel are more resistant to corrosion from fIuorine at higher temperatures.

Passivation of Equipment. All equipment used in fluorine operations must be thoroughly cleaned, degreased, dried, and passivated. Never use pure fluorine to passivate fluorine equipment or systems.

All systems must be flow tested ("dry-run") with dry, inert gas before passivation of the assembled system begins if such testing is feasible.

Discharging Fluorine or Fluorine-Like Materials to the Atmosphere. NEPA/CEQA requirements mandate discharging fluorine, any fluorine mixture, or reactive fluoride to the atmosphere in a controlled manner. Possible controls include:
* Rock salt beds. Useful for concentrated streams. The fluorine displaces the chlorine so a chlorine remover is needed just downstream. Chlorine is less reactive and somewhat less toxic.

* Caustic scrubbing followed by precipitation for large gas streams.

* Tall stacks for emergency releases. Tall stacks are used only for discharging unplanned releases or when other controls for planned releases are not practical! Use the cylinder leak time specified by the vendor, if possible, or assume a cylinder filled with liquefied gas voids in 30 min and a cylinder containing gas only will void in 5 min when planning for emergency releases.

* Cylinder size limits. Cylinder size limits can be used to reduce the height of a stack needed for emergency releases.

* Activated carbon was used for removing fluorine gas. This technique is no longer acceptable because it has been found that the fluorine can react explosively with the carbon. Keep any used carbon beds on hand in secure locations away from heat and call Hazards Control for guidance about disposal of them.

Purging. Any equipment that has contained fluorine must be thoroughly purged with dry, inert gas (such as nitrogen) and evacuated at least once before opening or refilling it. Purging by a sequential evacuation and inert gas backfill is preferred; backfill locations need to be as close to the fluorine/fluoride source as possible. Automated purge controllers need to be used whenever possible for sequential evacuation/ backfill purging to reduce the risk of human error during this tedious but critical process.

Gas Monitoring. Gas monitoring is needed where people are or could be present. Contact a vendor that sells approved gas monitoring equipment.

Labels and Signs. Labels should be conspicuously posted near entrances to areas where fluorine is stored or used. In addition to the signs, information concerning the quantity of fluorine in use in the area should be posted at the entrance, along with emergency procedures to be followed in case of an accident. "No smoking" signs should also be posted where fluorine is stored or used. Lines carrying fluorine must be labelled once every 20 ft, at wall penetrations, and in concealed spaces. (It's a good idea never to run fluorine lines through concealed spaces!)

Inactive Gas Storage. Containers that are not in use or ready to be used (i.e., cylinders with valves shut and caps on and thoroughly sealed containers of materials such as XeF6 need to be stored in protected outdoor locations or dedicated-use buildings where they are protected from temperature extremes, contact with rain or condensed moisture, and

direct sunlight. Indoor storage spaces need to be vented at a rate of 1 cfm/ft2 or 10 air changes per hour, whichever is greater. These storage areas must be normally locked and unoccupied and entrances need to be posted with appropriate warning signs. Combustible/flammable materials and reducing agents can not be stored in the same area.

No part of the cylinders should be subjected to temperatures higher than 52deg.C (125deg.F); therefore, place them away from radiators and other heat sources that could cause an excessive rise in temperature. CAUTION: Never allow flame to come in contact with any part of a compressed-gas cylinder.

Additional Design Precautions. Below are additional design precautions that you must take when working with a fluorine system.

Pipes and Fittings. Weld the pipes and fittings of lines that are not to be dismantled. Socket-weld fittings are preferable to butt-weld fittings because they are easier to keep free of slag and foreign matter during joining. However, butt-weld fittings are acceptable if shielded arc techniques are used.

Where welding is impractical, use threaded joints or tube fittings, as long as these fittings are contained in an exhaust ventilation enclosure. Permatex #2, manufactured by Loctite, is recommended as a pipe dope; apply it only after the first few threads of the male fitting are engaged. Parker Aircraft, Swagelok or Cajon fittings (or equivalent) may be used where small connections in the system are broken frequently.

Pressure Regulators. Regulators must be used on a high-pressure fluorine source to facilitate the safe handling of pressure. Using a double-valving system alone to control pressure is not acceptable.

Pressure-Relief Protection. For low-pressure work (3 psi or less), blow-out traps, similar to laboratory test tubes, are recommended to warn of blocked lines or vessels when spring-loaded valves or rupture disks are not available. These traps are filled with chlorotrifluoroethylene (Kel-F) polymer oil. The head of oil should not exceed a nominal 6 in. The trap(s) should be placed in a ventilated enclosure that can exhaust any accidentally vented fluorine. If a blow-out trap is needed, contact the Matheson Company, East Rutherford, NJ.

All components of fluorine systems using pressures above those protected by blow-out traps must have a rated working pressure above the maximum pressure that could accidentally occur in the system. A safety factor of 5 to 8 shall be used in the system design.

When the maximum fluorine pressure could exceed the rated working pressure of any system component because of the pressure supply source or the heat involved in the operation, the system must be protected by a spring-loaded pressure-relief device or a rupture disk. When using a pressure-relief device, ensure that device is acceptable for use in a fluorine system. When using a rupture disk, the discharge from the disk must be directed into a local exhaust ventilation system or extended into an area where it can

discharge safely. You must establish a regular program for replacing rupture disks to prevent corrosion from weakening the disks and causing them to fail prematurely.

Use of a three-disk system is recommended: the inner disk protects the center disk from corrosion by direct contact with gas. The center disk is rated to rupture at a designated pressure, and the outer disk protects the center disk from moisture corrosion.

Valves. All valves for fluorine service must have dissimilar metal-to-metal seating to prevent galling. They shall be provided with packless stem sealing and Monel or stainless-steel bodies. If packed valves are used, tetrafluoroethylene polymer shall be used in the stuffing box.

Gauges. Gauges with Monel or stainless- steel Bourdon tubes passivated for fluorine service shall be used. Gauges should be appropriate for indicating up to two times the pressures expected at the gauged points in the system.

Hydrogen-Fluoride Traps (Optional). Hydrogen-fluoride impurities can be removed from commercial fluorine using a trap containing sodium fluoride.

Flow Meters. Flow meters must be constructed of materials acceptable for use in a fluorine system.

Purge System. A purge system is required for experiments or operations using fluorine. The purge system must include an inert gas supply. This gas supply shall be protected from the fluorine system by use of fluorine-compatible check valves.

It may be desirable to treat the fluorine purged from the system rather than release it to the atmosphere.

Vacuum Pumps. Vacuum pumps compatible with fluorine systems must be used. To protect the pump, a soda-lime tower followed by a drier shall be included in the vacuum line to pick up trace amounts of fluorine. Vacuum pump systems using LN2 traps shall have a relief device vented to a local exhaust ventilation system.

Eyewash and Safety Shower Facilities. You are responsible for ensuring that eyewash and safety shower facilities are located within 10 s travel time or 100 ft walking distance of your fluorine operation.

A3.2 Administrative Controls

The minimum quantity needed to do a job must be used to minimize dangers to safety. The lowest fluorine concentration that will do the job also needs to be used.

Two key administrative controls are OSPs and training.

OSPs. OSPs for fluorine operations need to specify:

* The quantity, concentration and type of material in storage and in use and where it will be stored and used.

* Personal protective equipment (including respirators).

* Passivation and cleaning procedures (also required in the Engineering Safety Note).

* Safety checklist.

* Personnel who transport or handle cylinders of pure fluorine, inert gas mixtures containing >10% fluorine, other fluorine mixtures and oxidizing fluorides need to be warned that dropping, shocking or striking cylinders could cause an incident.

* Cylinders of fluorine, inert gas mixtures containing >10% fluorine, other fluorine mixtures, and oxidizing fluorides need to be transported in the back of an open truck.

Personnel should never work alone when handling fluorine, including fluorine mixtures. Another person should always be within your sight and earshot, although not necessarily in the immediate area.

All components to be used in a fluorine system must be clean and free of organic material and bagged (or otherwise closed off to ensure system cleanliness until final assembly).

All lines and equipment to contain fluorine should be pretested for leaks with dry nitrogen or helium.

Repeated bending or excessive vibration of piping or equipment should be avoided. Either can cause the fluorine film that has developed in the system to flake and corrode valves and other system components. Excessive thermal cycling can also cause this problem.

* Systems containing fluorine under pressure must be inspected for leaks at frequent intervals. If you detect a leak, purge the system immediately and repair the leak. You can detect leaks by purging fluorine from the system and introducing helium.

* The possibility of valves freezing should be minimized by following these rules:

-- Never use a regulator or manual control as the on-off control.

-- When shutting down operations for any extended period, always close the cylinder valve and bleed the pressure in the regulator or manual control to atmospheric pressure.

-- When the regulator or manual control is removed from the cylinder, replace the metal or plastic cylinder valve outlet cap originally provided.

-- Use the proper wrench when opening or closing cylinder valves.

-- Store cylinders in a dry, cool, well-ventilated area.

-- Use traps or check valves to prevent reverse flow.

-- Obtain cylinders of a size that will ensure consumption in a short time. Suppliers usually carry a wide range of sizes to meet this need.

-- Flush the regulator or manual control valve with dry nitrogen or dry air after use.

Personal Protective Equipment

Protective equipment is routinely required; that is:

* Wear clean neoprene gloves when directly handling equipment that contains fluorine or has recently contained fluorine.

* Wear neoprene coats and boots to afford overall body protection for short intervals of contact with low-pressure fluorine. This clothing should be designed and worn so that it can be shed immediately.

* Wear safety glasses at all times. Metal frames are preferable to the customary plastic to eliminate the possibility of the frames catching fire. Never wear contact lenses when working around fluorine.

* Wear face shields made of chemically resistant polymers whenever you change cylinders or manipulate systems containing fluorine under pressure.

* You may also need to wear special respiratory protective equipment. Requirements for this special equipment will depend on the nature of the fluorine system installed and the special circumstances necessitating such equipment.

* Personal protective equipment required for a fluorine operation must be detailed in the OSP. In addition, you must know the location of all personal protective equipment specified for your operation (including respiratory protective equipment) and the proper use and care of that equipment.

References

1. General Industry OSHA Safety and Health Standards (26 CFR 1910), U.S. Department of Labor Occupational Safety and Health Administration, Washington, D.C. OSHA 2206 (1983).

2. Chemical Hazards of the Work Place (J. P. Lippincott Co., Philadelphia, Pa., 1978), p. 271.

3. Chemical Hazards of the Work Place (J. P. Lippincott Co., Philadelphia, Pa., 1978), p. 271.

4. The Matheson Company Gas Data Book, 6th ed. (Matheson Gas Products, Inc., Secaucus, NJ., 1980) p. 331.

Fluorine Emergency Procedures

Calling for Help

In all accidents involving fluorine, notify the fire department using the emergency number for assistance: 911.

Rescuing the Exposed Victim

Do not attempt to rescue a victim unless you are trained in emergency rescue, are adequately protected from any hazard, and have another trained and equipped person standing by. If you enter a heavily contaminated area, you must wear skin protection and use self-contained breathing apparatus or approved air-line equipment.

Treating the Exposed Victim

If That Victim is Someone Else

Skin and Eyes. Remove the victim from the contaminated area as soon as possible. Cleanse the fluorine from skin and eyes by flushing with copious amounts of water. Continue flushing for 20 min. As you flush, remove any contaminated clothing from the victim.

Inhalation. If you suspect a person has inhaled fluorine, move that person into the fresh air. If that person has stopped breathing, apply mouth-to-mouth resuscitation at once. Also treat the victim for eye and skin exposure by flushing the eyes and skin with large

amounts of water. Do not delay emergency treatment; have someone else dial the emergency number.

Refer all affected persons to the nearest hospital, even when the immediate injury seems slight, and give the physician a detailed account of the accident.

If That Victim is You

Skin and Eyes. If your eyes are exposed to fluorine, do not rub them. Flush them with water for at least 20 min, lifting the upper and lower eyelids frequently to ensure complete washing.

If fluorine comes in contact with any part of your body or with your clothing, get into a safety shower immediately and flush your body with large amounts of water for 20 min. Wash thoroughly under your nails. Strip off any contaminated clothing as you wash.

Inhalation. If you have inhaled fluorine, leave the area immediately. Treat yourself for eye and skin exposure by flushing with large amounts of water.

Evacuating the Contaminated Area

In the Event of Leaks

If fluorine cylinders or equipment leak, evacuate the area immediately and dial the emergency number for assistance. Ensure no other personnel enter the area until the Fire Department arrives.

In the Event of Fire

Evacuate the area immediately and call for emergency assistance. Do not attempt to extinguish a fluorine fire. Ensure no other personnel enter the area until emergency response personnel arrive.

Appendix B
Nitrogen Trifluoride MSDS

MATERIAL SAFETY DATA SHEET MAT16650 Page 001 of 010

SECTION 1 CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

MATHESON GAS PRODUCTS
30 SEAVIEW DRIVE
SECAUCUS, NEW JERSEY 07096
(201) 867-4100

EMERGENCY CONTACT:
CHEMTREC 1-800-424-9300

CAS NUMBER: 7783-54-2
RTECS NO: QX1925000

SUBSTANCE: NITROGEN TRIFLUORIDE
TRADE NAMES/SYNONYMS:
NITROGEN FLUORIDE (NF_3); PERFLUOROAMMONIA; TRIFLUOROAMINE; TRIFLUOROAMMONIA; TRIFLUORAMINE; TRIFLUORAMMONIA; UN 2451; STCC 4920524; F_3N; MAT16650
CHEMICAL FAMILY: Halogen
CREATION DATE: 01/24/89 REVISION DATE: 09/29/94

SECTION 2 COMPOSITION, INFORMATION ON INGREDIENTS

COMPONENT : NITROGEN TRIFLUORIDE
CAS NUMBER: 7783-54-2
PERCENTAGE: 100.0
OTHER CONTAMINANTS: None.

SECTION 3 HAZARDS IDENTIFICATION

CERCLA RATINGS (SCALE 0-3): HEALTH=3 FIRE=O REACTIVITY=O PERSISTENCE=3
NFPA RATINGS (SCALE 0-4): HEALTH=L FIRE=O REACTIVITY=O

EMERGENCY OVERVIEW:
Colorless gas with a moldy odor.

May be irritating to the respiratory tract, skin and eyes. May cause blood disorders. May cause convulsions. May affect blood cells. May affect the central nervous system.

Strong oxidizer. Contact with other material may cause fire. Container may rupture in heat of fire.

Keep away from heat and flame. Avoid breathing gas. Avoid contact with eyes, skin and clothing. Keep from contact with clothing and other combustible materials. Store away from combustible materials. Do not puncture container. Keep container tightly closed. Wash thoroughly after handling. Use only with adequate ventilation. Handle with caution.

POTENTIAL HEALTH EFFECTS:
INHALATION:

SHORT TERM EFFECTS: May cause irritation. Additional effects may include burns, coughing, flushing, nausea, vomiting, difficulty breathing, asthma, irregular heartbeat, headache weakness, drowsiness, dizziness, feeling of well-being, confusion, incoordination, bluish skin color, lung congestion, convulsions, unconsciousness and coma.

LONG TERM EFFECTS: In addition to effects from short term exposure, nose bleed and hoarseness may occur.

SKIN CONTACT:

SHORT TERM EFFECTS: May cause irritation. Additional effects may include burns.

LONG TERM EFFECTS: Same effects as short term exposure.

EYE CONTACT:

SHORT TERM EFFECTS: May cause irritation. Additional effects may include burns.

LONG TERM EFFECTS: Same effects as short term exposure.

INGESTION:

SHORT TERM EFFECTS: May cause sores, rash, burns, paleness, thirst, drooling, lack of appetite, weight loss, nausea, diarrhea, stomach pain, bloody vomit, blood in the urine, inability to urinate, difficulty speaking, shortness of breath, irregular heartbeat, low blood pressure, headache, weakness, tingling sensation, twitching, visual disturbances, dilated pupils, bluish skin color, nerve effects, paralysis, convulsions, shock, unconsciousness, coma and heart failure.

LONG TERM EFFECTS: In addition to effects from short term exposure, redness and swelling of the skin, redness and swelling of the mouth, constipation, frequent urination, anemia and bone effects may occur.

CARCINOGEN STATUS:

OSHA: N

NTP: N

IARC: N

SECTION 4 FIRST AID MEASURES

INHALATION:

FIRST AID- Remove from exposure area to fresh air immediately. Perform artificial respiration if necessary. Maintain airway blood pressure and respiration. Keep warm and at rest. Treat symptomatically and supportively. Get medical attention immediately. Qualified medical personnel should consider administering oxygen.

SKIN CONTACT:

FIRST AID- Remove contaminated clothing and shoes immediately. Wash with soap or mild detergent and large amounts of water until no evidence of chemical remains (at least 15-20 minutes). If burns occur, proceed with the following: Cover affected area securely with sterile, dry, loose-fitting dressing. Treat symptomatically and supportively. Get medical attention immediately.

EYE CONTACT:

FIRST AID- Wash eyes immediately with large amounts of water, occasionally lifting upper and lower lids, until no evidence of chemical remains (at least 15-20 minutes). Continue irrigating with normal saline until the pH has returned to normal (30-60 minutes). Cover with sterile bandages. Get medical attention immediately.

INGESTION:

FIRST AID- It is unlikely that emergency treatment will be required. If adverse effects occur, proceed with the following: Treat symptomatically and supportively. Get medical attention.

NOTE TO PHYSICIAN

ANTIDOTE: The following antidote has been recommended. However, the decision as to whether the severity of poisoning requires administration of any antidote and actual dose required should be made by qualified medical personnel.

METHEMOGLOBINEMIA:
(When methemoglobin concentration is over 25-40% or in presence of symptoms.) Give methylene blue, 1% solution, 0.1 mL,/kg intravenously over a 10-minute period. Cyanosis may disappear within minutes or persist longer depending on degree of methemoglobinemia. Intravenous administration of therapeutic doses of methylene blue may cause a rise in blood pressure, nausea, and dizziness. Larger doses (>500 mg) cause vomiting,.diarrhea, chest pain, mental confusion, cyanosis, and sweating. Hemolytic anemia has also occurred several days after administration. These effects are temporary, and fatalities have not been reported. If methylene blue is not available, give ascorbic acid, 1 gram slowly intravenously. Without treatment, methemoglobinemia levels of 20-30% revert to normal within 3 days (Dreisbach, Handbook of Poisoning, 12th Ed.). Antidote should be administered by qualified medical personnel.

SECTION 5 FIREFIGHTING MEASURES

FIRE AND EXPLOSION HAZARD:
Negligible fire hazard when exposed to heat or flame.
Oxidizer: Oxidizers decompose, especially when heated, to yield oxygen or other gases which will increase the burning rate of combustible matter. Contact with easily oxidizable, organic, or other combustible materials may result in ignition, violent combustion or explosion.

EXTINGUISHING MEDIA:
Dry chemical or carbon dioxide
(1993 Emergency Response Guidebook, RSPA P 5800.6).

For larger fires, use water spray, fog or regular foam (1993 Emergency Response Guidebook, RSPA P 5800.6).

FIREFIGHTING:
Do not get water inside container. Move container from fire area if you can do it without risk. Apply cooling water to sides of containers that are exposed to flames until well after fire is out. Stay away from ends of tanks. Isolate area until gas has dispersed (1993 Emergency Response Guidebook, RSPA P 5800.6, Guide Page 15).

Extinguish using agent indicated. Use flooding amounts of water as a fog. Cool cylinders with flooding amounts of water from as far a distance as possible. Avoid breathing vapors; keep downwind. Consider evacuation of downwind area if material is leaking.

FLASH POINT: no data available
LOWER FLAMMABLE LIMIT: no data available
UPPER FLAMMABLE LIMIT: no data available
AUTOIGNITION: no data available
HAZARDOUS COMBUSTION PRODUCTS:
Thermal decomposition may emit toxic fumes of fluorides.

SECTION 6 ACCIDENTAL RELEASE MEASURES

OCCUPATIONAL SPILL:
Stop leak if you can do it without risk. Use water spray to reduce vapors; do not put water directly on leak or spill area. Do not get water inside container. Isolate area until gas has dispersed. For small spills, flush area with flooding amounts of water. For larger spills, dike far ahead of spill for later disposal. Keep unnecessary people away; isolate hazard area and deny entry, Stay upwind, out of low areas, and ventilate closed spaces before entering. Isolate the leak or spill area immediately for at least 150 feet in all directions.

SECTION 7 HANDLING AND STORAGE

Observe all federal, state and local regulations when storing this substance.

Consult NFPA publication 43C, Storage of Gaseous Oxidizing Materials, for Storage Requirements.

Threshold quantity (TQ): 5000 pounds
The Occupational Safety and Health Administration (OSHA) Process Safety Management (PSM) standard requires that facilities utilizing a process which involves a chemical at or above its specified threshold quantity comply with the provisions of 29 CFR 1910.119, Process Safety Management of highly hazardous chemicals.

Store away from incompatible substances.

SECTION 8 EXPOSURE CONTROLS, PERSONAL PROTECTION

EXPOSURE LIMITS:
NITROGEN TRIFLUORIDE:
10 ppm (29 mg/m3) OSHA TWA

10 ppm (29 mg/m3) ACGIH TWA

10 ppm (29 mg/m3) NIOSH recommended 10 hour TWA

5000 pounds OSHA Process Safety Management Threshold Quantity
OSHA revoked the final rule limits of January 19, 1989 in response to the llth Circuit Court of Appeals decision (AFL-CIO v. OSHA) effective June 30, 1993. See 29 CFR 1910.1000 (58 FR 35338)

VENTILATION:
Provide local exhaust ventilation and/or general dilution ventilation to meet published exposure limits.

EYE PROTECTION:
Employee must wear splash-proof or dust-resistant safety goggles and a faceshield to prevent contact with this substance.

Emergency wash facilities:
Where there is any possibility that an employee's eyes and/or skin may be exposed to this substance, the employer should provide an eye wash fountain and quick drench shower within the immediate work area for emergency use.

MAT16650 Page 005 of 010

CLOTHING:
Employee must wear appropriate protective (impervious) clothing and equipment to prevent any possibility of skin contact with this substance.

GLOVES:
Employee must wear appropriate protective gloves to prevent contact with this substance.

RESPIRATOR:
The following respirators and maximum use concentrations are recommendations by the U.S. Department of Health and Human Services, NIOSH Pocket Guide to Chemical Hazards; NIOSH criteria documents or by the U.S. Department of Labor, 29 CFR 1910 Subpart Z.

The specific respirator selected must be based on contamination levels found in the work place, must not exceed the working limits of the respirator and be jointly approved by the National Institute for Occupational Safety and Health and the Mine Safety and Health Administration (NIOSH-MSHA).

NITROGEN TRIFLUORIDE:
100 ppm- Any supplied-air respirator.
Any self-contained breathing apparatus.
Any chemical cartridge respirator with cartridges) providing protection against nitrogen trifluoride.
250 ppm- Any supplied-air respirator operated in a continuous-flow mode.
Any powered, air-purifying respirator with cartridges) providing protection against nitrogen trifluoride.
500 ppm- Any self-contained breathing apparatus with a full facepiece.
Any supplied-air respirator with a full facepiece.
Any chemical cartridge respirator with a full facepiece and cartridges) providing protection against nitrogen trifluoride.
Any air-purifying, full-facepiece chin-style, front or back-mounted canister providing protection against nitrogen trifluoride.
Any supplied-air respirator that has a tight-fitting facepiece and is operated in a continuous-flow mode.
Any powered, air-purifying respirator with a tight-fitting facepiece and cartridges) providing protection against nitrogen trifluoride.
2000 ppm- Any supplied-air respirator that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode.
Escape- Any air-purifying, full-facepiece respirator (gas mask) with a chin-style, front or back-mounted canister providing protection against nitrogen trifluoride.
Any appropriate escape-type, self-contained breathing apparatus.
FOR FIREFIGHTING AND OTHER IMMEDIATELY DANGEROUS TO LIFE OR HEALTH CONDITIONS:
Any self-contained breathing apparatus that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode.
Any supplied-air respirator that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode in combination with an auxiliary self-contained breathing apparatus operated in pressure-demand or other positive-pressure mode.

MAT16650 Page 006 of 010

DESCRIPTION: Colorless gas with a moldy odor.

MOLECULAR WEIGHT: 71.00
MOLECULAR FORMULA: F_3N
BOILING POINT: -200 TO -184°F (-129 TO -120°C)
FREEZING POINT: -359 TO -341°F (-217 TO -207°C)
VAPOR PRESSURE: 1500 mmHg @ -119°C
VAPOR DENSITY: 2.46
SPECIFIC GRAVITY: No data available
WATER SOLUBILITY: Slightly soluble
PH: Not applicable
ODOR THRESHOLD: No data available
EVAPORATION RATE: Not applicable
VISCOSITY: 0.018 cP @ 25°C (gas)
SPECIFIC GRAVITY: 1.537 @ -129°C (liquid)
CRITICAL TEMPERATURE: -39°F (-39°C)
CRITICAL PRESSURE: 4530 kPa

SECTION 10 STABILITY AND REACTIVITY

REACTIVITY: Stable under normal temperatures and pressures.

CONDITIONS TO AVOID: Material is extremely poisonous; avoid inhalation of vapors or contact with skin. Contents may be under pressure; containers may rupture violently and travel a considerable distance.

INCOMPATIBILITIES:
NITROGEN TRIFLUORIDE:
ACTIVATED CHARCOAL: Incompatible.
AMMONIA: Explosive reaction upon ignition.
CARBON MONOXIDE: Explosive reaction upon ignition.
DIBORANE: Violent explosions may occur when handled as liquids at low temperatures.
GREASE: Incompatible.
HYDROGEN: Explosive reaction upon ignition.
HYDROGEN SULFIDE: Explosive reaction upon ignition.
METHANE: Explosive-reation upon ignition.
METALS (ACTIVE): Incompatible.
NATURAL RUBBER: Incompatible.
OIL: Incompatible.
OXIDES: Incompatible.
TETRAFLUOROHYDRAZINE: Mixture may explode when compressed cylinders are opened.
See also oxidizers.

OXIDIZERS:
COMBUSTIBLE MATERIALS: May increase the burning rate or cause ignition on contact; finely divided materials may result in an explosion.
ORGANIC MATERIALS: May increase the burning rate or cause ignition on contact; finely divided materials may result in an explosion.
REDUCING MATERIALS: Fire and explosion hazard.

HAZARDOUS DECOMPOSITION:
Thermal decomposition may emit toxic fumes of fluorides.

OEYE PROTECTION:

POLYMERIZATION:
Hazardous polymerization has not been reported to occur under normal temperatures and pressures.

SECTION 11 TOXICOLOGICAL INFORMATION

NITROGEN TRIFLUORIDE:
TOXICITY DATA: 6700 ppm/i hour inhalation-rat LC50; 2000 ppm/4 hours inhalation-mouse LC50; 7500 ppm/1 hour inhalation-monkey LC50; 9600 ppm/i hour inhalation-dog LC50; 100 ppm/7 hours/19 weeks intermittent inhalation-rat TDLO; 14986 mg/kg intraperitoneal-rat LDLO; 85 cjm/kg/29 days intermittent intraperitoneal-rabbit TDLO.
CARCINOGEN STATUS: None.
ACUTE TOXICITY LEVEL: Moderately toxic by inhalation.
TARGET EFFECTS: Methemoglobin former.

HEALTH EFFECTS
INHALATION:
NITROGEN TRIFLUORIDE:
METHEMOGLOBIN FORMER. 2000 ppm immediately dangerous to life or health. May cause irritation, nausea, and vomiting. Prolonged exposure may cause mottling of the teeth, skeletal changes, slight histologic changes of the liver kidneys, and enlargement and darkening of the spleen. See information on me@hemoglobin formers and inorganic fluorides.

ACUTE EXPOSURE- At about 15% concentration of methemoglobin, observable cyanosis of the lips, nose and earlobes may appear. Symptoms may be absent although euphoria, flushed face and headache are common. At 25-40%, cyanosis is marked, but little disability occurs except on exertion. At 40-60%, symptoms may include weakness, dizziness, lightheartedness, increasingly severe headache, ataxia, rapid, shallow respiration, drowsiness, nausea, vomiting, confusion, lethargy, and stupor. Above 60%, dyspnea, respiratory depression, tachycardia or bradycardia, convulsions, and coma may occur. Levels above 70% may be fatal.

CHRONIC EXPOSURE- Compounds with cumulative properties may produce a persistent, chronic type of methemoglobinemia which is the same as that produced by single large exposures.

INORGANIC FLUORIDES:
500 mg(F)/m3 Immediately Dangerous to Life or Health.

ACUTE EXPOSURE- In the presence of moisture, hydrogen fluoride, a corrosive substance may be formed. Inhalation of dust may cause irritation with coughing and shortness of breath, nausea, and laryngeal and pulmonary edema. May cause or aggravate asthma. systemic poisoning as detailed in acute ingestion may occur.

CHRONIC EXPOSURE- Repeated or prolonged exposure may cause nosebleeds, hoarseness, sore throat, sinus trouble, and asthma. Other effects as detailed in chronic ingestion may also occur.

SKIN CONTACT: SKSCONTACT:
NITROGEN TRIFLUORIDE: See information on inorganic fluorides.

INORGANIC FLUORIDES:

ACUTE EXPOSURE- In the presence of moisture, hydrogen fluoride, a corrosive substance may be formed. Contact may cause irritation with redness, pain and possibly burns. Skin absorption may occur through damaged skin and result in systemic poisoning as detailed in acute ingestion.

CHRONIC EXPOSURE- Repeated or prolonged exposure to dusts or fumes may cause dermatitis.

EYE CONTACT:

NITROGEN TRIFLUORIDE:

See information on inorganic fluorides.

INORGANIC FLUORIDES:

ACUTE EXPOSURE- In the presence of moisture, hydrogen fluoride, a corrosive substance may be formed. Contact with dusts or solutions may cause irritation and possibly burns.

CHRONIC EXPOSURE- Repeated and prolonged exposure may cause conjunctivitis.

INGESTION:

NITROGEN TRIFLUORIDE:

See information on inorganic fluorides.

INORGANIC FLUORIDES:

ACUTE EXPOSURE- In the presence of moisture, corrosive hydrogen fluoride may be formed, especially in the stomach. Symptoms may include a burning sensation in the mouth and abdomen, sore tongue, a salty or soapy taste, nausea, salivation, difficulty speaking, thirst, vomiting, diarrhea, anorexia, and weight loss. Intense epigastric pain, deep ulceration of the esophagus and mucous membranes, hematemesis, and hematuria may also be present. Shock, manifested by symptoms of hypotension, weak pulse, pallor, dilated pupils, cyanosis, and anuria may occur. Muscle weakness, twitching, epileptiform convulsions, paresthesias, paralysis of the muscles of deglutition, carpopedal spasms, and painful spasms of the extremities and facial muscles may result. Other symptoms may include shortness of breath, headache, occasional urticaria, albuminuria, petechial hemorrhages, nystagmus, visual disturbances, optic neuritis, mental deterioration, unconsciousness, and coma. Cardiac arrhythmias, including ventricular fibrillation, leading to cardiac arrest have been reported. Death may also be due to cardiovascular collapse or respiratory failure. In addition to the corrosive effects, symptoms of acute fluoride toxicity may be caused by a variety of metabolic disorders, including hypocalcemia, hypomagnesemia, acidosis, and hyperkalemia. Pathologic findings may include congestion and hemorrhagic infiltration of all organs and degeneration of the kidneys and liver. In non-fatal cases, malaise and epigastric pain may persist for several days.

CHRONIC EXPOSURE- Repeated or prolonged ingestion may cause fluorosis characterized by nausea, vomiting, anorexia, diarrhea or constipation, weight loss, anemia, weakness and general ill health. Excessive calcification of the bones with brittleness, and calcification of the ligaments of the ribs, pelvis and spinal column may occur. Stiffness and limitation of motion may result. Polyuria and polydipsia may occur. A mottled appearance and altered form of the teeth may occur particularly during tooth formation. Exfoliative dermatitis, atopic dermatitis, stomatitis, gastrointestinal and respiratory allergy, and rarely, central nervous system involvement have been reported.

SECTION 12 ECOLOGICAL INFORMATION

ENVIRONMENTAL IMPACT RATING (0-4): No data available '
ACUTE AQUATIC TOXICITY: No data available
DEGRADABILITY: No data available
LOG BIOCONCENTRATION FACTOR (BCF): No data available
LOG OCTANOL/WATER PARTITION COEFFICIENT: No data available

SECTION 13 DISPOSAL CONSIDERATIONS

Observe all federal, state and local regulations when disposing of this substance.
Disposal must be in accordance with standards applicable to generators of hazardous waste, 40 CFR 262. EPA Hazardous Waste Number D001.
100 pound CERCLA Section 103 Reportable Quantity.

SECTION 14 TRANSPORT INFORMATION

U.S. DEPARTMENT OF TRANSPORTATION SHIPPING NAME-ID NUMBER, 49 CFR 172.101: .nitrogen trifluoride-UN 2451

U.S. DEPARTMENT OF TRANSPORTATION HAZARD CLASS OR DIVISION, 49 CFR 172.101: ?2 - Non-flammable compressed gas

U.S. DEPARTMENT OF TRANSPORTATION LABELING REQUIREMENTS, 49 CFR 172.101 AND SUBPART E: Nonflammable gas, oxidizer

U.S. DEPARTMENT OF TRANSPORTATION PACKAGING AUTHORIZATIONS:
EXCEPTIONS: None
NON-BULK PACKAGING: 49 CFR 173.302
BULK PACKAGING: None

U.S. DEPARTMENT OF TRANSPORTATION QUANTITY LIMITATIONS 49 CFR 172.101:
PASSENGER AIRCRAFT OR RAILCAR: Forbidden -
CARGO AIRCRAFT ONLY: 25 kg

SECTION 15 REGULATORY INFORMATION

TSCA STATUS: Y

RCLA SECTION 103 (40CFR302.4):	N
SARA SECTION 302 (40CFR355.30):	N
SARA SECTION 304 (40CFR355.40):	N
SARA SECTION 313 (40CFR372.65):	N
OSHA PROCESS SAFETY (29CFR1910.119):	N
NITROGEN TRIFLUORIDE	5000 pounds TQ
CALIFORNIA PROPOSITION 65:	N

MAT16650Page 010 of 010
HAZARD CATEGORIES, SARA SECTIONS 311/312 (40 CFR 370.21)

ACUTE HAZARD:	Y
CHRONIC HAZARD:	N
FIRE HAZARD:	N
REACTIVITY HAZARD:	N
SUDDEN RELEASE HAZARD:	Y

SECTION 16 OTHER INFORMATION

ADDITIONAL INFORMATION

MATHESON MAKES NO EXPRESS OR IMPLIED WARRANTIES,.GUARANTEES OR REPRESENTATIONS REGARDING THE PRODUCT OR THE INFORMATION HEREIN, INCLUDING BUT NOT LIMITED TO ANY IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS FOR USE. MATHESON SHALL NOT BE LIABLE FOR ANY PERSONAL INJURY, PROPERTY OR OTHER DAMAGES OF ANY NATURE, WHETHER COMPENSATORY, CONSEQUENTIAL, EXEMPLARY, OR OTHERWISE, RESULTING FROM ANY PUBLICATION, USE OR RELIANCE UPON THE INFORMATION HEREIN.

Appendix C
Argon MSDS

MATERIAL SAFETY DATA SHEET

MG Industries
3 Green Valley Parkway
Malvern, Pennsylvania 19355
Phone: 610-695-7400
FAX: 610-695-7596

Emergency Contact:
CHEMTREC
1-800-424-9300

SUBSTANCE IDENTIFICATION

CAS-NUMBER 7440-37-1

Substance: Argon, Compressed
Trade Names/Synonyms: Argon: STCC 4904502; UN 1006; AR; MGI01860
Chemical Family: Non-metallic element
Molecular formula: AR
Molecular Weight: 39.948
CERCLA Ratings (Scale 0-3): Health=U Fire=0 Reactivity=0 Persistence=0
NFPA Ratings (Scale 0-4): Health=U Fire=0 Reactivity=0

COMPONENTS AND CONTAMINANTS

Component: Argon, Compressed Percent: 100.0
Exposure Limits: No occupational exposure limits established by OSHA, ACGIH, or NIOSH.

PHYSICAL DATA

Description: Odorless, tasteless, colorless inert gas.
Boiling Point: -303°F (-186°C) Melting Point: -308°F (-189°C)
Specific Gravity: 1.784 g/l @ 0°C Viscosity: 0.0225 cP @ 25°C
Vapor Pressure: 500 mmHg @ -190°C Solubility in Water: 3.36% @ 20°C
Vapor Density: 1.380
Solvent Solubility: Soluble in organic liquids

FIRE AND EXPLOSION DATA

Fire and Explosion Hazard: Negligible fire hazard when exposed to heat and flame. Container may explode in heat of fire.
Firefighting Media: Dry chemical or carbon dioxide (1993 Emergency Response Guidebook), RSPA P 5800.6).

For larger fires, use water spray, fog, or regular foam (1993 Emergency Response Guidebook..RSP P 5800.6).

Firefighting: Move container from fire, if you can do it without risk. Apply cooling water to sides of containers that are exposed to flames until well after fire is out. Stay away from ends of tanks. Withdraw immediately in case of rising sound from venting safety device or any discoloration of tank due to fire. Some of these materials, if spilled, may evaporate leaving a flammable residue. Isolate for 1/2 mile in all directions if tank, rail car, or tank truck is involved in fire (1993 Emergency Response Guidebook, RSPA P 5800.6, Guide page 12).

Use agent suitable for type of fire. Cool containers with flooding quantities of water; apply from as far a distance as possible. Avoid breathing toxic vapors; keep upwind. Stop leak if possible without hazard.

TRANSPORTATION DATA

U.S. Department of Transportation shipping Name-ID Number, 49 CFR 172.101: Argon, compressed-UN 1006

U.S. Department of Transportation Hazard Class or Division, 49 CFR 172.101: 2.2-Non-flammable compressed gas

U.S. Department of Transportation Labeling Requirements, 49 CFR 172.101 and Subpart E: Non flammable gas

U.S. Department of Transportation Packaging Authorizations:
Exceptions: 49 CFR 173.306
Non-Bulk Packaging: 49 CFR 173.302

U.S. Department of Transportation Quantity Limitations 49 CFR 172.101:
Passenger Aircraft or Railcar: 75 kg
Cargo Aircraft Only: 150 kg

TOXICITY

Argon:
Carcinogen Status: None
Acute Toxicity Level: No data available
Target Effects: Simple asphyxiant.

HEALTH EFFECTS AND FIRST AID

Inhalation:

Simple Asphyxiants. Acute Exposure: The symptoms of asphyxia depend on the rapidity with which the oxygen deficiency develops and how long it continues. In sudden acute asphyxia, unconsciousness may be immediate. With slow development there may be rapid respiration and pulse, air hunger, dizziness, reduced awareness, tightness in the head, tingling sensations, incoordination, faulty judgement, emotional instability, and rapid fatigue. As the asphyxia progresses, nausea, vomiting, collapse, unconsciousness, convulsions, deep coma and death are possible.

Simple Asphyxiants, Chronic Exposure: No data available.

First Aid-Remove from exposure area to fresh air immediately. Perform artificial respiration if necessary. Maintain airway, blood pressure and respiration. Keep warm and at rest. Treat symptomatically and supportively. Get medical attention immediately. Qualified medical personnel should consider administering oxygen.

Skin Contact:

Argon. Acute Exposure: No adverse effects have been reported from the gas. Due to rapid evaporation, the liquid may cause frostbite with redness, tingling, and pain or numbness. In more severe cases, the skin may become hard and white and develop blisters.

Argon. Chronic Exposure: No data available.

First Aid-It is unlikely that emergency treatment will be required. If adverse effects occur, proceed with the following: Get medical attention. If frostbite, freezing, or cryogenic burns occur, proceed with the following: Warm affected areas in warm water at a temperature of 107°F (41.7°C). If this is not available, proceed with the following: Gently wrap affected parts in blankets. Encourage person to exercise affected part while it is being warmed. Allow circulation to return naturally (Braker and Mossman; Matheson Gas Data Book; 6^{th} edition). Get medical attention immediately.

Eye Contact:

Argon. Acute Exposure: No adverse effects have been reported from the gas. Due to evaporation the liquid may cause frostbite with redness, pain and blurred vision.

Argon. Chronic Exposure: No data available.

First Aid: It is unlikely that emergency treatment will be required for contact with the gas form. If contact with liqified or compressed gas occurs, wash with large amounts of water until no evidence of chemical remains (at least 15-20 minutes). Get medical attention immediately.

Ingestion:

Argon. Acute Exposure: Ingestion of a gas is unlikely. If liquid is swallowed, frostbite damage to the lips, mouth and mucous membranes may occur.

Argon. Chronic Exposure: No data available.

First Aid: It is unlikely that emergency treatment will be required. If adverse effects occur, proceed with the following: Treat symptomatically and supportively. Get medical attention.

Antidote: No specific antidote. Treat symptomatically and supportively.

REACTIVITY

Reactivity: Stable under normal temperatures and pressures.

Incompatibilities. Argon: No data available.

Decomposition: None hazardous.

Polymerization: Hazardous polymerization has not been reported to occur under normal temperatures and pressures.

STORAGE AND DISPOSAL

Store in accordance with 29 CFR 1910.101.

Observe all federal, state and local regulations when storing or disposing of this substance.

CONDITIONS TO AVOID

Do not permit physical damage or overheating of containers. Contents are under pressure; containers may violently rupture and travel a considerable distance.

SPILL AND LEAK PROCEDURES

PROTECTIVE EQUIPMENT

•Ventilation: Provide general dilution ventilation.

•Respirator: The following respirators are recommended based on information found in the physical data, toxicity and health effects sections. They are ranked in order from minimum to maximum respiratory protection.

The specific respirator selected must be based on contamination levels found in the work place, must be based on the specific operation, must not exceed the working limits of the respirator and must be jointly approved by the National Institute for Occupational Safety and Health, and the Mine Safety and Health Administration (NIOSH-MSHA).

Any supplied respirator operated in pressure-demand or other positive pressure mode.

Any self-contained breathing apparatus.

For firefighting and other immediately dangerous to life or health conditions:

Any self-contained breathing apparatus that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode.

Any supplied-air respirator that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode in combination with an auxiliary self-contained breathing apparatus operated in pressure-demand or other positive-pressure mode.

•Clothing: For the gas form, protective clothing is not required. If contact with the liquid form is possible, employees must wear appropriate protective clothing and equipment to prevent skin from freezing.

•Gloves: Wear full protective, cold insulating gloves.

•Eye Protection: For the gas form eye protection is not required, but recommended. Where there is any possibility of contact with the liquid form, employees must wear splash-proof safety goggles and a faceshield to prevent contact with this substance. Contact lenses should not be worn.

•Emergency Wash Facilities: Where there is any possibility that an employees eyes and/or skin may be exposed to the liquid form of this substance, the employer should provide an eye-wash fountain and quick-drench shower within the immediate work area for emergency use.

Creation Date: 05/04/90 Revision Date: 09/06/95

Appendix E
Hydrogen Fluoride MSDS

AIR PRODUCTS & CHEMICALS -- HYDROGEN FLUORIDE
MATERIAL SAFETY DATA SHEET
NSN: 913500F029715
Manufacturer's CAGE: 00742
Part No. Indicator: A
Part Number/Trade Name: HYDROGEN FLUORIDE
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General Information
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=
Company's Name: AIR PRODUCTS AND CHEMICALS INC
Company's Street: 7201 HAMILTON BLVD
Company's City: ALLENTOWN
Company's State: PA
Company's Country: US
Company's Zip Code: 18195-1501
Company's Emerg Ph #: 215-481-4911/800-523-9374
Company's Info Ph #: 800-322-9092/800-523-9374
Record No. For Safety Entry: 001
Tot Safety Entries This Stk#: 001
Status: SE
Date MSDS Prepared: 01OCT93
Safety Data Review Date: 06MAR95
Preparer's Company: AIR PRODUCTS AND CHEMICALS INC
Preparer's St Or P. O. Box: 7201 HAMILTON BLVD
Preparer's City: ALLENTOWN
Preparer's State: PA
Preparer's Zip Code: 18195-1501
MSDS Serial Number: BRWYB
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Ingredients/Identity Information
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=
Proprietary: NO
Ingredient: HYDROFLUORIC ACID, HYDROGEN FLUORIDE
Ingredient Sequence Number: 01
Percent: >99
NIOSH (RTECS) Number: MW7875000
CAS Number: 7664-39-3
OSHA PEL: 3 PPM
ACGIH TLV: 3 PPM CEILING
Other Recommended Limit: 2.5 PPM

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Physical/Chemical Characteristics
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Appearance And Odor: COLORLESS GAS THAT FUMES WHITE W/SHARP SUFFOCATING
ACIDIC ODOR.
Boiling Point: 67.14F
Melting Point: -118.43F
Vapor Pressure (MM Hg/70 F): 15.6 PSIA
Specific Gravity: 1.27
Solubility In Water: COMPLETE
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Fire and Explosion Hazard Data
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=
Flash Point: NON-FLAMMABLE
Special Fire Fighting Proc: SAFELY MOVE CYLINDERS AWAY FROM FIRE & KEEP
COOL W/WATER UNTIL FIRE IS OUT.
Unusual Fire And Expl Hazrds: CYLINDERS EXPOSED TO HIGH HEAT/FLAME MAY
RUPTURE VIOLENTLY.
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Reactivity Data
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=
Stability: YES
Cond To Avoid (Stability): HUMIDITY, TEMP >125F, MOISTURE
Materials To Avoid: WATER, ALKALINE SOLUTIONS
Hazardous Decomp Products: HYDROFLUORIC ACID
Hazardous Poly Occur: NO
==========
=
Health Hazard Data
==========
=
Route Of Entry - Inhalation: YES
Route Of Entry - Skin: NO
Route Of Entry - Ingestion: YES
Health Haz Acute And Chronic: HYDROGEN FLUORIDE-INHALATION: CORROSIVE/

IRRITATION OF RESPIRATORY TRACT/MUCOUS MEMBRANES/CHEMICAL PNEUMONITIS/
PULMONARY HEMORRHAGE/EDEMA. EYES: IRRITATION/BURNS. SKIN: BURNS/DEEP TISSUE
DAMAGE. INGESTION: BURNS TO MOUTH/ESOPHAGUS/STOMACH. TOXIC LEVELS CAN CAUSE
HYPOCALCEMIA WHICH MAY BE FATAL.
Carcinogenicity - NTP: NO
Carcinogenicity - IARC: NO
Carcinogenicity - OSHA: NO
Explanation Carcinogenicity: NONE
Signs/Symptoms Of Overexp: HYDROGEN FLUORIDE-IRRITATION, BURNS, VISION
IMPAIRMENT, REDNESS, LESIONS.
Med Cond Aggravated By Exp: ASTHMA, EMPHYSEMA, & OTHER RESPIRATORY DISEASES
Emergency/First Aid Proc: INHALATION: REMOVE TO FRESH AIR. GIVE CPR/ OXYGEN IF NEEDED. GIVE 2.5% CALCIUM GLUCONATE WHILE SITTING UP. EYES: FLUSH
W/WATER FOR 5 MINS. GIVE 1% CALCIUM GLUCONATE SOLUTION BY CONTINUOUS DRIP.
DON'T INDUCE VOMITING. DRINK WATER TO DILUTE ACID FOLLOWED BY SEVERAL
OUNCES OF MILK OF MAGNESIA. (SEE SUPP)
==========

Precautions for Safe Handling and Use

==========
Steps If Matl Released/Spill: EVACUATE AREA. INCREASE VENTILATION TO RELEASE AREA & MONITOR HYDROGEN FLUORIDE LEVELS. USE APPROPRIATE PROTECTIVE
EQUIPMENT. IF LEAK IS IN USERS SYSTEM CLOSE CYLINDER VALVE, VENT PRESSURE &
PURGE W/INERT GAS BEFORE ATTEMPTING REPAIRS.
Waste Disposal Method: RETURN CYLINDER/UNUSED PRODUCT TO SUPPLIER IAW/
FEDERAL, STATE & LOCAL REGULATIONS. DON'T ATTEMPT TO DISPOSE OF UNUSED
PRODUCT. ENSURE CYLINDER VALVE IS PROPERLY CLOSED/VALVE OUTLET CAP HAS BEEN
REINSTALLED/VALVE PROTECTION CAP IS SECURE. UN1052
Precautions-Handling/Storing: STORE <125F/IN WELL VENTILATED AREA/AWAY FROM HIGH TRAFFIC AREAS/EMERGENCY EXITS. SECURE IN UPRIGHT POSITION.

SEPARATE EMPTY CYLINDERS FROM FULL ONES.
Other Precautions: DON'T DRAG/ROLL/SLIDE CYLINDER. USE SUITABLE HANDTRUCK
DESIGNED FOR CYLINDER MOVEMENT. DON'T APPLY FLAME/LOCALIZED HEAT DIRECTLY
TO CYLINDER. USE ADJUSTABLE STRAP WRENCH TO REMOVE OVER-TIGHT/RUSTED CAPS.
KEEP SYSTEM FREE OF MOISTURE.
==========
Control Measures
==========
Respiratory Protection: POSITIVE PRESSURE AIR LINE W/MASK/SELF-CONTAINED
BREATHING APPARATUS SHOULD BE AVAILABLE FOR EMERGENCY USE.
Ventilation: HOOD W/FORCED VENTILATION/LOCAL EXHAUST TO PREVENT ACCUMULATION >3 PPM.
Protective Gloves: ACID-RESISTANT GUANTLET TYPE
Eye Protection: SAFETY GOGGLES/GLASSES & FACE SHIELD
Other Protective Equipment: ACID-RESISTANT JACKET, TROUSERS & BOOTS, SAFETY SHOWER, EYEWASH FOUNTAIN, SELF-CONTAINED ACID SUITS
Work Hygienic Practices: KEEP EQUIPMENT SCRUPULOUSLY DRY. DON'T WEAR
CONTACT LENSES.
Suppl. Safety & Health Data: FIRST AID CONT'D: FLUSH W/WATER FOR 5 MINS. APPLY 2.5% CALCIUM GLUCONATE GEL TO BURN AREA W/GLOVED HAND. OBTAIN MEDICAL
ATTENTION IN ALL CASES. NOTES TO PHYSICIAN: MAY BE NECESSARY TO INJECT 10%
AQUEOUS CALCIUM GLUCONATE BENEATH/AROUND/INTO BURN AREA. OBSERVE PATIENT
FOR CLINICAL SYMPTOMS OF HYPOCALCEMIA.
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Transportation Data
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Disposal Data
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Label Data

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Label Required: YES
Technical Review Date: 16SEP93
Label Date: 02SEP93
Label Status: F
Common Name: HYDROGEN FLUORIDE
Chronic Hazard: YES
Signal Word: DANGER!
Acute Health Hazard-Severe: X
Contact Hazard-Severe: X
Fire Hazard-None: X
Reactivity Hazard-Slight: X
Special Hazard Precautions: CORROSIVE/IRRITATING TO RESPIRATORY TRACT/ SKIN/EYES. EXCESSIVE LUNG IRRITATION CAUSES PNEUMONITIS/PULMONARY EDEMA,
WHICH CAN BE FATAL. CHRONIC TOXICITY DEPLETES CALCIUM, POSSIBLY RESULTING
IN DEATH DUE TO HYPOCALCEMIA. ACID BURNS RESULT IN TISSUE DESTRUCTION &
EVENTUAL SCARRING. ABSORPTION CAUSES FLUOROSIS. TARGET ORGANS: EYES, SKIN,
BONE, RESPIRATORY SYSTEM, LUNGS. TARGET ORGANS: EYES, SKIN, CNS, KIDNEYS.
Protect Eye: Y
Protect Skin: Y
Protect Respiratory: Y
Label Name: AIR PRODUCTS AND CHEMICALS INC
Label Street: 7201 HAMILTON BLVD
Label City: ALLENTOWN
Label State: PA
Label Zip Code: 18195-1501
Label Country: US
Label Emergency Number: 215-481-8257/6311
Year Procured: UNK

Appendix F
Silicon Tetrafluoride MSDS

Section 1: Chemical Product and Company Identification

Material Name:
Silicon tetraflouride
Chemical Formula:
SiF4
Synonyms:
Tetrafluorosilane, silicon fluoride.
Manufacturer:
Voltaix, Inc.:
Post Office Box 5357, North Branch, New Jersey 08876-5357, USA
Voice: 908-231-9060 or 800-VOLTAIX, Facsimile: 908-231-9063

Section 2: Composition/Information on Ingredients

Component	CAS Registry Number	Molar (volume) concentration	Exposure Guidelines
Silicon tetrafluoride	7783-61-1	100%	0.8 ppm TLV-TWA (as SiF4)

Section 3: Hazards Identification

Emergency Overview

Silicon tetrafluoride is a colorless gas with a pungent odor. It fumes to form a dense white cloud in moist air. Silicon tetrafluoride's immediate health hazard is that it is a toxic gas. It reacts with water vapor in the air to form other corrosive, toxic substances. (See Section 4: Note to Physicians.)

NFPA 704 Rating (determined by Voltaix, Inc.): Health 4 Fire 0 Reactivity 1 Special None

Note: NFPA 49-1991 lists "Health 3", "Reactivity 2", and "Special W ", which are not consistent with NFPA 704-1990.

In an emergency, Call CHEMTREC at 800-434-9300 or 703-527-3887.

Potential Health Effects

Routes of Exposure: Inhalation, skin, eye and mucous membrane contact.

Lengths of Exposure: No data are available on exposure to this material.

Severity of Effect: Depends on concentration and duration.

Target Organs: Lungs, kidneys, liver, blood, bones and teeth.

Type of Effect: High concentration exposures may produce pulmonary irritation. Subchronic, low concentration exposures may produce generalized effects of fluorine exposure.

Signs and Symptoms of Exposure: Acute exposure: coughing, shortness of breath, headache, vertigo, chills and nausea. Subchronic: dental fluorosis, increased bone, serum and urinary fluoride levels, hypocalcemia.

Medical Conditions that may be Aggravated by Exposure: None identified.

Reported Carcinogenic and Reproductive Effects: NTP has not reported genetic or long-term toxicology and carcinogenesis effects studies.

Section 4: First Aid Measures

Inhalation

This is the primary route of exposure.

1.Remove the affected person from the gas source or contaminated area. Note: Personal Protective Equipment (PPE), including positive pressure, self contained breathing apparatus, may be required to assure the safety of the rescuer.
2.If the affected person is not breathing spontaneously, administer rescue breathing.
3.If the affected person does not have a pulse, administer CPR.
4.If medical oxygen and appropriately trained personnel are available, administer 100% oxygen to the affected person.
5.Summon an emergency ambulance. If an ambulance is not available, contact a physician, hospital, or poison control center for instruction.
6.Keep the affected person warm, comfortable, and at rest while awaiting professional medical care. Monitor the breathing and pulse continuously. Administer rescue breathing or CPR if necessary.

Skin Contact

Flush with a copious stream of water while removing contaminated clothing. Continue flushing until the professional medical assistance arrives, but for no less than fifteen minutes. Assume that the airway may also have been injured and obtain professional medical assistance immediately. The effects of skin exposure may be delayed.

Eye Contact

Flush continuously with clean water until the professional medical assistance arrives, but for no less than thirty minutes. Continuation of flushing until patient is transferred to an ophthalmologist or emergency physician is recommended. Assume the patient has also been exposed by inhalation and obtain professional medical assistance immediately.

Ingestion

Ingestion is not an observed route of exposure to gaseous hazardous materials.

Chronic Effects

Dental fluorosis, increased bone, serum and urinary fluoride levels, kidney and liver disease, hypocalcemia.

Note to Physicians:

The possible reaction products of silicon tetrafluoride and moist air or water are silicon oxide and hydrofluoric and fluorosilicic acids; the composition of the material to which a patient has been exposed depends on the conditions of the release. Therefore, skin and eye contact should be treated as exposures to acidic fluorine compounds, e.g., hydrofluoric acid. Consider the use of such agents as benzalkonium chloride, magnesium sulfate, and calcium gluconate.

Section 5: Fire Fighting Measures

Flammability and Explosivity

Flash Point: Not applicable, this material is a nonflammable gas.

Flammability Limits in Air: Not applicable, this material is a nonflammable gas.

Autoignition Temperature: Not applicable, this material is a nonflammable gas.

Flammability Classification (per 29 CFR 1910.1200): Nonflammable gas.

Known or Anticipated Hazardous Products of Combustion: Not applicable, this material is a nonflammable gas.

Properties that may Initiate or Intensify Fire: Heating cylinder to the point of activating the pressure relief device.

Reactions that Release Flammable Gases: None.

Extinguishing Media

None.

Fire Fighting Instructions

Cool the cylinder and surroundings with water from a suitable distance. Excessive pressure may develop in gas cylinders exposed to fire, which may result in explosion, regardless of the cylinder's content. Cylinders with pressure relief devices (PRD's) may release their contents through such devices if the cylinder is exposed to fire. Cylinders without PRD's have no provision for controlled release and are therefore more likely to explode if exposed to fire.

Note: If silicon tetrafluoride is released, the water used for fire suppression and cooling may be contaminated with fluorine compounds. The discharge of such compounds to the sewer system or the environment may be restricted, requiring the containment and proper disposal of the water.

Positive pressure, self contained breathing apparatus is required for all fire fighting involving hazardous materials. Full structural fire fighting (bunker) gear is the minimum acceptable attire. The need for proximity, entry, and flashover protection and special protective clothing should be determined for each incident by a competent fire fighting safety professional.

Section 6: Accidental Release Measures

Containment

This material is a gas at atmospheric conditions. The only means of containment is the enclosure of the space into which the material is released. Such containment is described in Section 7.

Clean Up

Clean up consists of passing the entire gas volume of the enclosure through appropriate exhaust gas treatment equipment (EGTE). Purge the enclosure with a

non-reactive gas, such as nitrogen, through the EGTE until an acceptably low level of contamination remains. Equipment contaminated by this material must then be cleaned or decommissioned appropriately.

Evacuation

If the release is not contained in an appropriate device or system, all personnel not appropriately protected (see Section 8) must evacuate the contaminated spaces. Consider evacuation of additional areas, as a precaution against the spread of the release.

Special Instructions

The water used for cleanup may be contaminated with fluorine compounds.The discharge of such compounds to the sewer system or the environment may be restricted, requiring the containment and proper disposal of the water.

Section 7: Handling and Storage

Handling

Handle this material only in sealed, purged systems. The design of handling systems for hazardous materials is beyond the scope of this MSDS, and should be performed by a competent, experienced professional. Consider the use of doubly-contained piping; diaphragm or bellows sealed, soft seat valves; backflow prevention devices; flash arrestors; and flow monitoring or limiting devices. Gas cabinets, with appropriate exhaust treatment, are recommended, as is automatic monitoring of the secondary enclosures and work areas for release.

Handle sealed gas cylinders in accordance with CGA P-1, Safe Handling of Compressed Gases in Containers.

Some material may have accumulated behind the outlet plug. Face the outlet away from you and wear appropriate protective equipment when removing the plug to connect the cylinder to your system.

Never introduce any substance into a gas cylinder. If you believe your cylinder may have been contaminated, notify Voltaix, Inc. immediately. Provide as much information as possible on the nature and quantity of contamination.

Storage

Store cylinders in accordance with CGA P-1, Safe Handling of Compressed Gases in Containers, local building and fire codes and other relevant regulations. Materials should be segregated, by the hazards they comprise, for storage.

Protect the cylinders from direct sunlight, precipitation, mechanical damage, and temperatures above 55 deg.C (130 deg.F).

Ship and store cylinders with the outlet plug and valve protective cap in place.

Section 8: Exposure Control/Personal Protection

Engineering Controls

Local exhaust is required. Secondary containment, with appropriate exhaust gas treatment, is strongly encouraged and is required in some jurisdictions.

Monitor the work area and the secondary containment continuously for release of the material. Automatic alerting of personnel and automatic shutdown of flow are appropriate in most applications and are required in some jurisdictions.

Purge all primary containment systems with a nonreactive gas, such as nitrogen, before introducing silicon tetrafluoride.

Personal Protective Equipment (PPE)

Respiratory Protection: Positive pressure, full face, air supplied breathing apparatus should be used for work within the secondary containment equipment if a leak is suspected or the primary containment is to be opened, e.g., for a cylinder change. Air supplied breathing apparatus is required for response to demonstrated or suspected releases from the primary containment.

Eye/Face Protection: When using respiratory protection as described above, use a face mask that provides splash and impact protection for the face and eyes. For handling sealed cylinders, wear safety glasses.

Skin Protection: Wear appropriate gloves when handling sealed cylinders. Use gloves and other skin protection, as assigned by a competent safety professional, when working within the secondary enclosure with the primary enclosure compromised, e.g., cylinder changing, to protect from exposure to the material. For response to demonstrated or suspected releases from the primary containment, the need for whole-body exposure protection should be determined by a competent safety professional.

Other Protection: Wear appropriate protective footwear when moving cylinders.

Exposure Guidelines

TLV-TWA: 2.5 mg/m3 as F (ACGIH). This is equivalent to 0.8 ppm SiF4 or 3.2 ppm HF.

PEL-TWA: Same as ACGIH (OSHA).

REL-TWA (10 hour): Same as ACGIH (NIOSH).

Section 9: Physical and Chemical Properties

Notes:

1."N/A" means not applicable.
2.Unless otherwise specified, properties are reported at 0 deg. C (32 deg. F) and 1 atmosphere (1.0 bar, 14.7 psia).

Property	Silicon tetrafluoride
Appearance	colorless
Odor	pungent
Physical state at atmospheric conditions	gas
pH	N/A
Vapor Pressure	3.56 bar (51.6 psia) at -79.0 deg. C (-110.2 deg. F)
Vapor Density	4.69 g/L
Subliminal Temperature (at 1 atm)	-95.5 deg. C (-139.9 deg. F)
Melting point	unknown
Solubility in water (v/v)	not applicable, as silicon tetrafluoride reacts with water
Specific gravity of liquid (water = 1)	1.661 at -95 deg. C (-139 deg. F)
Molecular weight	104.08

Section 10: Stability and Reactivity

Chemical Stability: Silicon tetrafluoride is not known to decompose thermally.

Conditions to Avoid: Exposure to air.

Incompatibility with Other Materials: Water, alkali metals, alkaline earth metals, calcium oxide.

Hazardous Decomposition, Reaction and Oxidation (other than burning) Products: Reaction with water, including water vapor in air, produces fluorosilicic acid and hydrofluoric acid.

Hazardous Polymerization: Silicon tetrafluoride is not known to polymerize.

Section 11: Toxicological Information

Acute Data (by route): 3 ppm reportedly produces irritation of the skin, eyes and upper respiratory system. The effects of skin exposure may be delayed; this may make it difficult to associate the injury with the exposure.

Chronic and Subchronic Data: No data for silicon tetrafluoride are available. Silicon tetrafluoride is listed in the Registry of Toxic Effects of Chemical Substances (RTECS), but no information on its carcinogenicity is available.

Special Studies: None known to Voltaix, Inc.

Section 12: Ecological Information

Ecotoxicity: None known to Voltaix, Inc.

Environmental Fate: None known to Voltaix, Inc.

Section 13: Disposal Considerations

Classification under RCRA, 40 CFR 261: This material meets the criteria for an "acute hazardous waste".

US EPA waste number and descriptions: D003 (reactivity characteristic).

Special Instructions and Limitations: Treat process and other exhaust streams appropriately before release to the atmosphere.

Notice: The information above is derived from Voltaix, Inc.'s interpretation of the US federal laws, regulations and policies concerning the material, as shipped by Voltaix, Inc., at the time this MSDS was prepared. Federal controls are subject to change and state and local controls may also apply. Proper waste disposal is the responsibility of the owner of the waste. The user is encouraged to consult with appropriate experts in developing a disposal plan.

Section 14: Transport Information

Basic Description: Silicon Tetrafluoride, Division 2.3 (Poison Gas), UN 1859 Poison - Inhalation Hazard, Inhalation Hazard Zone B.

Note: This material also requires a "Corrosive" label.

Additional Information for shipment by water: IMDG Page Number 2178.

Additional Information for shipment by air: Transportation by air is permitted on Cargo Aircraft Only. A subsidiary Hazard Class of 8 applies, as does a 25 kg/cylinder limit.

Note: As most Poison Gases are excluded from transportation by air, this is not the preferred mode.

Section 15: Regulatory Information

TSCA Status: This material is listed in the index of chemical substances.

CERCLA Reportable Quantity (40CFR302.4): This material is not listed.

SARA Title III Status (Section 302 (40CFR355), Section 311/312, Section 313 (40CFR372)): This material is not listed. The Reportable Quantity (RQ) for " Unlisted Hazardous Wastes Characteristic of Reactivity" (D003) of 45.4 kg (100 lbs.) therefore applies.

Note: State and local requirements may be more stringent.

Section 16: Other Information

References

Book of SEMI Standards, Facilities Standards and Safety Guidelines. Mountain View, CA: Semiconductor Equipment and Materials International, 1993.

Borak, Jonathan, M.D., Michael Callan and William Abbott, Hazardous Materials Exposure: Emergency Response and Patient Care. Englewood Cliffs, NJ: Prentice-Hall, Inc., 1991.

Documentation of TLV's and BEI's. Cincinatti, Ohio: American Conference of Government Industrial Hygienists, 1992.

Effects of Exposure to Toxic Gases: First Aid and Treatment. Lyndhurst, NJ: Matheson Gas Products, 1977.

Fire Protection Guide on Hazardous Materials. Quincy, MA: National Fire Protection Association, 1991.

Safe Handling of Compressed Gases in Containers (Pamphlet P-1). Arlington, VA: Compressed Gas Association, Inc., 1991.

Technical Databook of Silanes (SiH4, Si2H6 and SiF4). Tokyo: Mitsui-Toatsu Chemicals, Inc.

Revision Indication

This MSDS was completely rewritten for this release.

Disclaimer

Voltaix, Inc. cannot guarantee that these are the only hazards that exist. Users are solely responsible for the safe storage, handling, use and disposal of this material, and for compliance with the applicable laws, regulations and accepted practices.

Voltaix, Inc. makes no representations or warranties, either expressed or implied, of merchantability, fitness for a particular purpose, or any other nature.

Appendix G
Tungsten Hexafluoride MSDS

LIQUID AIR -- TUNGSTEN HEXAFLUORIDE
MATERIAL SAFETY DATA SHEET
FSC: 6810
NIIN: 00F002718
Manufacturer's CAGE: 18260
Part No. Indicator: A
Part Number/Trade Name: TUNGSTEN HEXAFLUORIDE

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General Information

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Company's Name: LIQUID AIR CORPORATION
Company's Emerg Ph #: (800) 231-1366
Record No. For Safety Entry: 001
Tot Safety Entries This Stk#: 001
Date MSDS Prepared: 01JAN87
Safety Data Review Date: 13MAR86
MSDS Serial Number: BBLPD

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Ingredients/Identity Information

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Proprietary: YES
Ingredient: PROPRIETARY
Ingredient Sequence Number: 01

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Physical/Chemical Characteristics

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Appearance And Odor: LIQ IS LGT YELLOW; VAPOR IS COLORLESS/ODORLESS.
Boiling Point: 62.71F
Vapor Pressure (MM Hg/70 F): 16.
Vapor Density (Air=1): .793
Specific Gravity: 10.58
Solubility In Water: HYDROLYZES

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Fire and Explosion Hazard Data

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Flash Point: N/A
Lower Explosive Limit: N/A

Upper Explosive Limit: N/A
Extinguishing Media: NONFLAMMABLE
Special Fire Fighting Proc: N/A
Unusual Fire And Expl Hazrds: N/A
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Reactivity Data
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=
Stability: YES
Materials To Avoid: WATER AS VAPOR OR LIQUID
Hazardous Decomp Products: HYDROFLUORIC ACID/TUNGSTEN OXYFLUORIDES WHEN
HYDROLYZED
Hazardous Poly Occur: NO
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Health Hazard Data
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=
Signs/Symptoms Of Overexp: CORROSIVE/IRRITATING TO THE UPPER/LOWER RESPIRATORY TRACTS, SKIN AND EYES.
Emergency/First Aid Proc: INHALATION: UNCONSCIOUS PERSONS SHOULD BE MOVED
TO AN UNCONTAMINATED AREA/BREATHE FRESH AIR/GIVEN OXYGEN. KEEP THE VICTIM
WARM/QUIET. EYES: FLUSH W/WATER FOR 30 MINUTES. SKIN: FLUSH W/WATER. REMOVE
AFFECTED CLOTHING AS RAPIDLY. CALL A PHYSICIAN.
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Precautions for Safe Handling and Use
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Steps If Matl Released/Spill: EVACUATE ALL PERSONNEL FROM AFFECTED AREA.
USE APPROPRIATE PROTECTIVE EQUIPMENT. IF AK IS IN USER'S EQUIPMENT, BE
CERTAIN TO PURGE PIPING WITH IN INERT GAS IOR TO ATTEMPTING REPAIRS.
Waste Disposal Method: DON'T ATTEMPT TO DISPOSE OF RESIDUAL OR UNUSED
QUANTITIES. RETURN IN THE SHIPPING CONTAINER PROPERLY LABELED, WITH ANY

VALVE OUTLET PLUGS OR CAPS SECURED AND VALVE PROTECTION CAP IN PLACE TO
LIQUID AIR CORPORATION FOR PROPER DISPOSAL.
Precautions-Handling/Storing: PROTECT CYLINDERS FROM PHYSICAL DAMAGE. STORE IN COOL, DRY, WELL-VENTILATED AREA AWAY FROM HEALY TRAFFICKED AREAS.
DON'T STORE ABOVE 130F.
Other Precautions: USE ONLY IN WELL-VENTILATED AREAS. VALVE PROTECTION
CAPS MUST REMAIN IN PLACE UNLESS CONTAINER IS SECURED WITH VALVE OUTLET PED
TO USE POINT.
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Control Measures
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Respiratory Protection: POSITIVE PRESSURE AIR LINE WITH MASK/SCBA FOR EMERGENCY USE
Ventilation: HOOD WITH FORCED VENTILATION
Protective Gloves: PLASTIC/RUBBER
Eye Protection: GOGGLES/GLASSES/FACESHIEL
Other Protective Equipment: SAFETY SHOES/SHOWER/EYEWASH. DON'T WEAR CONTACT LENSES.
Suppl. Safety & Health Data: ONE CALIFORNIA PLAZA, SUITE 350/2121 N. CALIFORNIA BLVD/WALNUT CREEK, CALIFORNIA 94596. MOLECULAR WEIGHT: 297.84
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Transportation Data

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Disposal Data
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Disposal Data Review Date: 88320
Rec # For This Disp Entry: 01
Tot Disp Entries Per NSN: 001
Landfill Ban Item: YES
Disposal Supplemental Data: ONE CALIFORNIA PLAZA, SUITE 350/2121 N. CALIFORNIA BLVD/WALNUT CREEK, CALIFORNIA 94596. MOLECULAR WEIGHT: 297.84 IN
CASE OF ACCIDENTAL EXPOSURE OR DISCHARGE, CONSULT HEALTH AND SAFETY FILE
FOR PRECAUTIONS.
1st EPA Haz Wst Name New: NOT REGULATED

1st EPA Haz Wst Char New: NOT REGULATED BY RCRA
1st EPA Acute Hazard New: NO
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Label Data
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=
Label Required: YES
Label Status: G
Common Name: TUNGSTEN HEXAFLUORIDE
Special Hazard Precautions: CORROSIVE/IRRITATING TO THE UPPER/LOWER RESPIRATORY TRACTS, SKIN AND EYES.
Label Name: LIQUID AIR CORPORATION
Label Emergency Number: (800) 231-1366