

#### IV. ENVIRONMENTAL DATA

Environmental levels of boron trifluoride have not been determined with an acceptable degree of accuracy and precision. Although analytical methods for total boron or total fluoride may be accurate and precise, reliable environmental monitoring for boron trifluoride is not possible until a sampling method is developed and validated. This section reviews the sampling and analytical methods which have been tested to date.

##### Sampling Methods

Sampling for boron trifluoride in the workplace environment, in addition to presenting the usual sampling problems, is complicated by the potential presence of both particulate and gaseous forms. The white mist which results from the boron trifluoride reaction with water vapor may contain a variety of compounds. [20,22] Since we do not know the differences between the particulate and gaseous forms of boron trifluoride hydration products, it is important to sample both forms. Filters, absorbers, or combinations of the two have been used. [22,35,36]

Weil et al [30,31,37,38] tested a variety of sampling methods. None of the methods is suitable for personal monitoring, since the equipment was large and up to four impingers were used at the same time. Several absorbents were also tested: 0.4-1.0% potassium hydroxide in absolute alcohol, 4% sodium bisulfite in water, concentrated ammonium hydroxide, 2.5% triethanolamine in alcohol, 10% triethanolamine in water, absolute

alcohol, aqueous silver nitrate, water, and dioxane. Only 0.6% potassium hydroxide in absolute ethyl alcohol showed any promise. These methods are not suitable for personal monitoring, and the sampling efficiencies have not been determined.

Torkelson and coworkers [22] developed a sampling method for boron trifluoride gas and mist in moist air during their inhalation toxicity studies. A single fritted-glass scrubber containing 25 ml of distilled water as the absorbent was used to sample the animal exposure chambers. The authors reported that varying the sampling rate from 0.5 to 3 liters/minute caused no loss of sampling efficiency. The efficiency of a single scrubber was established in a trial with two scrubbers, in which essentially all of the boron was retained by the first. They also tested impingers as an alternate absorber and 1% potassium hydroxide in alcohol as an absorbent, but concluded, without giving details, that a scrubber with water gave the best results. A sample of room air was analyzed to correct for boron that might have leached from the glassware used in the sampling. The method, as described, cannot be recommended for environmental monitoring since no details were reported on the efficiency of collection.

Salyamon and Maslyukova [36] used a series of two aerosol filters and an absorber to sample boron trifluoride gas or mist at a rate of 1-2 liters/minute for 10 minutes. They used both the filters and an absorber since they expected boron trifluoride gas to produce an "aerial emulsion" of "hydrolysates" which would readily pass through absorbers containing water. In the absence of filters, they suggested a flowrate of no greater than 0.5 liters/minute. No data were provided, however, to substantiate this method of sampling.

Allied Chemical Corporation, [28] using an adaption of a NIOSH fluoride sampling method, has reported boron trifluoride environmental data; boron trifluoride was collected with a midget impinger containing 10 ml of 0.1 M sodium hydroxide as the absorbent. The method was not used for personal monitoring, and only area samples were obtained. A sampling rate of 2.5 liters/minute and a volume between 10 and 200 liters were used, based on sampling methods for other fluoride compounds. However, no data on the efficiency of collection were developed.

Kasparov and Kirii [35] reported using a series of two porous-plate absorbers for industrial and animal-chamber sampling of boron trifluoride. Water (10 ml) was chosen as the absorbing medium because boron trifluoride is very soluble in water. The air was sampled at 1 liter/minute for 30-60 minutes. The amount of boron collected in the second absorber was not reported, and the efficiency of air sampling was not stated.

Recently, methods for sampling boron trifluoride in animal exposure chambers have been investigated. [39] Large (300-400 ml) plastic impingers in a series fitted with fritted-glass or plastic dispensers were tested. Several solutions were tried as absorbents: 0.3 M hydrogen fluoride, deionized water, 0.01 N sodium hydroxide, and 0.1 N sodium hydroxide. Hydrogen fluoride produced the most efficient collection. Slow sampling rates (1 liter/minute) were required to prevent the carryover of boron trifluoride into the back-up impinger, resulting in a relatively long sampling time of 7.5 hours. Water and sodium hydroxide, according to the authors, produced variable collection efficiencies, but no absolute values were reported.

Previously, NIOSH has recommended a 0.8- $\mu\text{m}$  cellulose acetate membrane filter impregnated with sodium formate for collecting inorganic fluorides. [34] Theoretically, this method would be satisfactory for sampling boron trifluoride since personal sampling is more readily done with a filter than with an impinger and the sodium formate ensures collection of any gases which may be present. However, the method has not been validated for the collection of the boron trifluoride and thus cannot be recommended at this time.

#### Analytical Methods

Boron trifluoride reacts with the moisture present in air to form hydration products. In dry air, the boron trifluoride gas has been detected by infrared analysis, [22] but the products formed in air of normal humidity were not detected by this method. The hydration products have not been accurately identified but are suspected to be a combination of hydroxyfluoboric acids. [8,20,21] An ideal analytical method, therefore, not only should account for boron trifluoride gas in the environment but also should determine the levels of the hydration products in the mist formed from the release of boron trifluoride gas. Environmental analysis for boron trifluoride has been attempted with surrogate analysis for either the total fluoride or the total boron content in the air. These values are then used to derive the amount of boron trifluoride which would account for the presence of these two elements.

Weil et al [30,31,37,38] investigated analytical methods during their toxicity studies on boron trifluoride, but were unable to develop methods yielding reproducible results for either boron or fluoride. Spectrographic

determinations for boron were inconsistent because variable amounts of boron were eluted from the glassware. Colorimetric titrations for boron were not sufficiently sensitive since too little boron was present for volumetric determination. Attempts to determine the fluoride component in the samples were considered impractical because the results were nonquantitative and because there was a reaction of the fluoride with materials present in the chambers. These authors [31] did develop a semiquantitative spot-test method to approximate the boron trifluoride levels in animal chambers. Air was drawn through a filter which contained paper saturated with alcoholic turmeric solution. When the solution reacted with the boron trapped by the filter, the paper developed a color which then was compared visually to previously prepared standards. Although useful for confirming calculated exposure levels of boron trifluoride, the method has limited application because it is not wholly quantitative and because color development is subject to interference by other compounds.

Torkelson and coworkers [22] used the color-producing reaction of boron with carminic acid reported by Hatcher and Wilcox [40] to determine the boron trifluoride concentration in animal exposure chambers. The reaction of boron with carminic acid in a sulfuric acid solution produced a blue color which was subsequently analyzed spectrophotometrically. Solutions containing less than 0.5 ppm boron were concentrated prior to analysis so that boron concentrations in the air as low as 0.48 ppm could be analyzed. The carmine method of boron analysis has recently been reported to be accurate and precise. [39] Boron, either as boric acid or in the tetrafluoroborate form, was measurable between 0.4 and 5.0  $\mu\text{g}/\text{ml}$ .

Because of sampling difficulties, the precision and accuracy have not been tested in environments containing boron trifluoride.

Kasparov and Kirii [35] have reported the analyses of industrial and chamber atmospheres for boron trifluoride based on boron determination. Samples were collected by an absorber containing water and were distilled in the presence of quartz (silica) to remove the fluoride. The boron content was then determined spectrophotometrically from the color produced by the addition of dianthramide and sulfuric acid. The sensitivity for 1 ml of sample was reported to be 0.2-0.3  $\mu\text{g}$  of boron, which is equivalent to 1.5-2.0  $\mu\text{g}$  boron trifluoride. The error, based on the recovery of boron trifluoride added to water, and not on environmental boron trifluoride, was not more than 5-10% in any trial. Fluoride ion interfered but was quantitatively removed prior to analysis by the distillation. This method, which involves a lengthy distillation, was not validated with boron trifluoride recovery from air and, again, is only as good as the sampling method associated with it.

Other methods potentially useful for determining boron in samples of boron trifluoride and its hydrolysis products include atomic absorption spectrophotometry, [41] curcumin-acetone colorimetric analysis, [42] ignition-electrometric determination, [43,44] and titration for both borates and boric acid. [45,46] None of these methods has been tried with air samples, nor have they been used to measure boron as found in boron trifluoride gas or mist.

The analysis of fluoride in air samples has been studied, [34,47] and analytical methods have been developed. [48] The more recently developed fluoride-ion-specific electrode has been generally accepted as the most

direct method for fluoride determination. [49] The method is suited to both environmental and biologic determinations [49,50] and is recommended by NIOSH [34] for the determination of atmospheric inorganic fluorides. The fluoride-ion-specific electrode has also been used to measure boron trifluoride levels. [28] Although the direct measurement of free fluoride ion is straightforward, the determination of fluorides complexed with other atoms requires the liberation of the fluoride ion, in this case from the boron atom. This has been done by distillation, [28] precipitation with aluminum, [51] or by a similar microdiffusion technique. [34] Data are not available on the recovery of the fluoride ion from boron compounds by any of these methods. Additionally, fluoride from sources other than boron trifluoride, such as hydrogen fluoride used as a cocatalyst, [4] would interfere with the results. For these reasons, fluoride analysis is not recommended for determining environmental boron trifluoride levels.

Tetrafluoborate ion ( $\text{BF}_4^-$ ) reacts with methylene blue to form a complex which can be extracted with an organic solvent such as dichloroethane. Skaar [52] adapted this reaction for determining boron in solution by adding hydrogen fluoride in amounts sufficient to form the tetrafluoborate ion. The methylene blue-boron complex was extracted with dichloroethane and the color measured with a spectrophotometer. Salyamon and Maslyukova [36] extended this method to analyzing boron trifluoride atmospheric samples. Since the hydrolysis products of boron trifluoride exhibited some of the characteristics of the tetrafluoborate ion, these investigators added methylene blue directly to the aqueous contents of absorbers used to sample for boron trifluoride. The resulting complexes were extracted with dichloroethane and analyzed spectrophotometrically.

The lower limit of detection was determined to be 0.3  $\mu\text{g}$  boron or, expressed as boron trifluoride, 2.0  $\mu\text{g}$ . The authors did not ascertain that all the boron present in the hydrolysis products of boron trifluoride was in the form of tetrafluoborate ion; therefore, quantitative analysis was not established.

Carlson and Paul [53] developed a tetrafluoborate-ion-specific electrode using boric acid as a boron source. Boron was concentrated on a boron-specific resin, converted to tetrafluoborate by the addition of hydrogen fluoride, and analyzed directly with the electrode. The investigators, who determined that all the boron from boric acid was changed to the tetrafluoborate ion, analyzed boron at levels as low as 2.6  $\mu\text{g}$ . The presence of hydrogen fluoride required the placement of a protective sleeve around the electrode since this chemical is capable of attacking the reference electrode used in the analysis. In its study of this technique for boron trifluoride analysis in animal toxicity studies, NIOSH [39] found the precision adequate when sampling a known concentration from air bags but the values obtained did not correspond to the nominal values. Field trials have not been attempted. The problem of analysis may be coupled with the pH problems associated with the use of hydrogen fluoride as the sampling medium. If these problems can be overcome, the tetrafluoborate-ion-specific electrode could possibly be used in boron trifluoride analysis. The most serious problem with the available analytical methods are the inadequacy of and lack of information on the sampling procedures, the uncertainty about the actual toxic agent which should be analyzed, and the lack of testing in situations comparable to industrial settings.



The methods presented above describe several potential means whereby boron trifluoride may be sampled and analyzed. Additional testing is needed to resolve the problems described above and confirm their applicability to field and personal monitoring.

#### Environmental Data

Since sampling and analytical methods for boron trifluoride have not been validated, the available environmental data are subject to question. Allied Chemical Corporation [28] reported the results of 10 area samples in its boron trifluoride production plant. The samples were taken in 0.1 M sodium hydroxide, distilled, and analyzed for total fluoride with a fluoride-ion-specific electrode. If it is assumed that boron trifluoride was efficiently collected, that all of the fluoride in the samples originated from boron trifluoride, and that all the fluoride in boron trifluoride was liberated, then the environmental concentration of boron trifluoride ranged from 0.27 to 4.98 mg/cu m. As the production facility is outdoors, there was no local exhaust ventilation in operation at the time of sampling.

Boron trifluoride can be formed during the casting and heat treating of magnesium. Fluoborate salts, which release boron trifluoride gas at high temperatures, [54] are added to the sand molds or placed in the furnace. Upon heating, boron trifluoride is released and effectively prevents magnesium fires and oxidation of the molten metal. [15,55] Reports of the boron trifluoride concentrations in these operations have not been found.

### Control of Exposure

Prevention of occupational diseases resulting from exposure to boron trifluoride requires the protection of employees from the inhalation of boron trifluoride and from eye or skin contact with the gas or mist. The use of a well-maintained closed system, when compatible with the application involved, is the best method of preventing inhalation. In areas where the escape of boron trifluoride into the environment is likely, the use of a properly designed and maintained ventilation system will prevent the accumulation of the hydrolysis products in the workroom atmosphere. Good ventilation practices, such as those outlined in the current edition of Industrial Ventilation--A Manual of Recommended Practice published by the American Conference of Governmental Industrial Hygienists, [56] should be followed. Where exhaust ventilation is required, adequate makeup air, conditioned as needed for worker comfort, should be provided.

Enclosures, exhaust hoods, and ductwork must be kept in good repair so that design airflows are maintained. Airflow should be measured at each hood at least twice a year. Continuous airflow indicators, such as water or oil manometers properly mounted at the juncture of fume hood and duct throat, are recommended. A log showing design airflow and results of periodic inspection should be kept.

Engineering controls have been applied in several boron trifluoride operations. [5 (pp 13,158,206)] As a gas, boron trifluoride is shipped and stored in cylinders or tube trailers. [8,57] Users have constructed closed systems (which are the best engineering control) for introducing boron trifluoride into the operation. Care is taken to prevent the introduction

of moisture into pipelines and storage vessels, as the hydration products are extremely corrosive. Because of its reactivity, boron trifluoride gas introduced below the surface of a liquid may create a hazard from possible back suction into the cylinders. [58] Introducing boron trifluoride below a layer of mercury and the use of traps or check valves are safeguards in this type of system. [2]

Boron trifluoride service lines should be constructed of stainless steel or other corrosion resistant piping and fittings. [8,59] Gaskets made of or containing rubber should not be used but some plastics, such as polytetrafluoroethylene, are corrosion resistant. [59] Pressure fittings are also applicable. The service line should be constructed to withstand pressures of 3,000 psig and should contain a relief valve which is vented in such a way as to prevent worker exposure if it is released. [60]

## V. DEVELOPMENT OF A STANDARD

### Basis for Previous Standards

Consensus standards were not developed for boron trifluoride in the United States until the 1960's. In their absence, the American Petroleum Institute, in 1948, suggested that until such time as a safe limit was established, the "generally accepted limit for hydrogen fluoride of 3 ppm" could be reasonably applied to boron trifluoride. [3] In addition, it was suggested that 24-hour urine samples from boron trifluoride workers be analyzed semiannually for fluoride content and that annual X-rays of the lungs, ribs, spine, and pelvis be examined for evidence of osseous fluorosis. General safety measures, such as those used for all toxic materials, were also recommended.

In 1957, the American Conference of Governmental Industrial Hygienists (ACGIH) [61] promulgated a tentative threshold limit value (TLV) for boron trifluoride of 1 ppm, or approximately 3 mg/cu m. This was a time-weighted average (TWA) concentration from which temporary excursions up to 3 times the TLV were permitted, provided an overall TWA concentration of 1 ppm was maintained. The TLV was adopted in 1960 [62] as the first boron trifluoride limit. The 1962 Documentation of Threshold Limit Values [63] based the TLV of 1 ppm on the toxicity studies reported by Spiegl [29] and the theoretical potential for three molecules of hydrogen fluoride to be formed from each boron trifluoride molecule. Since the 1960 TLV for hydrogen fluoride was 3 ppm, [62] the 1-ppm TLV for boron trifluoride represented a reasonable approach at that time. The Documentation also noted the work of Torkelson et al, [22] who had reported the presence of

respiratory irritation from the inhalation of boron trifluoride at levels as low as 1.5 ppm.

The TLV of 1 ppm was changed to a ceiling value by the ACGIH in 1963. [64] It was recommended that no employee be exposed to boron trifluoride at concentrations greater than 1 ppm, no matter how short the exposure period. No additional documentation was provided. The ACGIH TLV for boron trifluoride has remained a 1-ppm ceiling value since 1963. [65] The 1974 printing of the third edition of the Documentation of Threshold Limit Values [66] incorporates no new data on boron trifluoride.

Few foreign countries have set boron trifluoride standards. The Soviet Union has adopted 1 mg/cu m (0.36 ppm) as a maximum allowable concentration (MAC). [67] The standard of the Federal Republic of Germany is a Maximum Worksite Concentration limit of 3 mg/cu m (1.08 ppm) as a TWA concentration limit. [68] Although the Italian government has not adopted an environmental limit, it recognizes boron trifluoride as a toxic gas and has placed restrictions on its shipment, storage, and use. [69]

The present federal standard (29 CFR 1910.1000) is a ceiling value of 1 ppm (3 mg/cu m), which was based on the 1-ppm ceiling ACGIH TLV for boron trifluoride adopted in 1968.

#### Basis for the Recommended Standard

As discussed in Chapters III and IV, the efficiencies of boron trifluoride monitoring methods are questionable. No reports have demonstrated that boron trifluoride gas and hydrolysis products were efficiently collected, and attempts to recover known concentrations have not succeeded. For this reason, the calculated boron trifluoride

concentrations have been regarded as an upper limit of exposure in animal inhalation studies. It is doubtful, however, that the animals actually received the full nominal concentration and, therefore, where analytical values are given, the effective concentration may be more realistically considered to lie between the analytical and calculated values.

Toxic effects of boron trifluoride on animals exposed at low levels over time periods up to 6 months have been demonstrated. [22,33] Torkelson et al [22] exposed rats and guinea pigs to boron trifluoride at a nominal concentration of 12.9 ppm (35 mg/cu m) for up to 60 exposures. Microscopic examination showed pneumonitis, suggestive of chemical damage, in the hilar and alveolar areas of the lungs. Areas of emphysema were also seen in guinea pig lungs.

Kasparov and Kirii [33] also tested both rats and guinea pigs. A boron trifluoride concentration of 10 mg/cu m was reported in chambers where the animals were exposed for 4 months. Irritation was seen in the upper respiratory pathways, and emphysema, bronchitis, sclerosis, and edema were noted in the lungs. The authors did not specify whether their concentration data was based on analytical or calculated results, nor did they report which effects were noted in which species.

Torkelson et al [22] also tested boron trifluoride at a calculated concentration of 3.0 ppm (8.3 mg/cu m), which analysis showed as only half that amount, 1.5 ppm or 4.2 mg/cu m. Rabbits, rats, and guinea pigs were exposed for 6 months. Upon microscopic examination, the lungs of the rabbits did not differ significantly from those of the controls, but the lungs of the rats had areas of slight pneumonitis, cell infiltration, and congestion. Thirty percent more pneumonitis was seen in the guinea pigs than in the rats.

Rats did not exhibit significant structural changes when exposed to boron trifluoride at 3.0 mg/cu m for 4 months. [33] Guinea pigs developed subacute tracheitis and bronchitis during the same exposure regimen; however, these effects were not noted 30 days after the last test dose.

These animal studies clearly exhibit the potential of boron trifluoride to cause lung irritation at low exposure concentrations over varying exposure periods. Every concentration tested in animals has produced some effect. The concentration inducing a particular effect can not be reliably determined, but the limited analytical and calculated values provide a probable range over which these effects occur: from 35 mg/cu m down to 3 mg/cu m.

Two incomplete but significant reports indicate that boron trifluoride may also affect workers. [27,28] Kirii, in an abstract of an unavailable report from the USSR, reported that workers exposed to boron trifluoride, isobutylene, and ethylene complained of irritability, insomnia, headache, bleeding noses and gums, and increased fragility of tooth enamel to a greater degree than workers exposed only to isobutylene and ethylene. In persons subjected to boron trifluoride exposures, the author described disturbances of vascular permeability, enhanced tendon reflexes, joint disease, and atrophic changes in nasal mucosa. Details permitting an accurate assessment of this report were not given. In an introduction to a paper on animal toxicity by Kasparov and Kirii, [33] the effect of 18-19 mg/cu m of boron trifluoride on workers is described. This description, similar to and possibly from the same report as the abstract above, notes nasal bleeding, dryness of nasal membranes, increased brittleness of teeth, and an increased incidence of upper respiratory tract

disease in workers exposed to boron trifluoride.

Employees in a boron trifluoride production plant have been given physical examinations including X-rays, urinary fluoride determinations, and pulmonary function tests. [28] Boron trifluoride concentrations, the reliability of which are subject to question since they were determined on the basis of an area monitoring method of which details are unavailable, ranged from 0.27 to 0.69 ppm (0.75 to 1.9 mg/cu m) during one 24-hour sampling period and from 0.1 to 1.8 ppm (0.28 to 5.0 mg/cu m) during another. X-ray results were negative. Urinary fluoride levels did not exceed 4 mg/liter in the seven employees currently exposed to boron trifluoride. Pulmonary function tests, however, according to the authors showed lower capacity than that predicted from a normal population. Although, because of the lack of additional medical information, boron trifluoride cannot be labeled as definitely responsible for these effects, it cannot be discounted either.

There is a lack of relevant human toxicity data and of a reliable monitoring method, so accurate correlation of exposure and effect is not possible. Therefore, recommendation of any environmental concentration limit is not justifiable at this time. Nevertheless, based on the evidence of chronic pulmonary effects in animals [22,33] and the available data on pulmonary effects in workers in a boron trifluoride production facility, [28] sufficient information is available to justify concern for worker health in areas where boron trifluoride is manufactured, used, handled or is evolved as a result of chemical processes. It is therefore imperative that workers' exposures be limited by strict adherence to good work practices and the maintenance of adequate engineering controls. Boron



trifluoride should be used only in closed systems where feasible. The potential for respiratory, [22] skin, [21] and eye [33] effects indicates that employees must be fully aware of boron trifluoride hazards. Employees must also be trained in the use of personal protective devices such as respirators, especially if they may be exposed to visible boron trifluoride mist. Because cartridge and canister masks have not been tested for boron trifluoride environments, only supplied-air respirators may be used.

It is recommended that preemployment and periodic medical examinations be particularly directed toward respiratory conditions. Employees with these conditions should be advised of their additional risks from boron trifluoride exposure. In addition, to detect the development of chronic effects, pulmonary function tests should be used to evaluate progressive changes in lung function. Employees trained in first aid, including the treatment of acid burns, must be available during each workshift. Records of medical examinations and of any environmental monitoring should be retained by the employer for 20 years to permit proper evaluation of the effects of boron trifluoride exposures, especially since there is the potential for the development of chronic effects.

Although several sampling and analytical methods appear potentially adaptable to boron trifluoride monitoring, there is not enough information to recommend a reliable method at this time. Urinary fluoride levels are potentially adaptable to employee monitoring, but in the current absence of a suitable monitoring method studies to determine a possible correlation of urine fluoride levels with boron trifluoride environmental concentrations cannot be effectively undertaken.

## VI. WORK PRACTICES

Prevention of occupational diseases resulting from exposure to boron trifluoride requires protection against the inhalation of, and against eye or skin contact with, the hazardous substance. Good work practices, coupled with engineering controls as described in Chapter IV, are important means of limiting exposure to boron trifluoride.

Respirators must be worn during initial charging of the gas into a system and in repairing all leaks. Only air-supplied respirators are recommended for use during work activities, since canister or cartridge masks have not yet been approved for boron trifluoride. A gas mask may be suitable for escape but not for routine use.

Although the animal toxicity studies available for review involved no testing for skin toxicity, irritation of the mucous membranes of the eye was reported in acute inhalation exposures. [33] The limited human data available [21,27] do suggest that prolonged dermal contact can result in burns probably typical of acid burns. Chemical safety goggles and gloves must be worn by workers servicing a boron trifluoride system. [60] Barrier creams should be tested before use to protect against exposure, since they might trap the hydration mist on the skin where, with time, acid products may form. Fountains and safety showers must be provided in areas of potential boron trifluoride exposure, since skin and eye effects can be minimized with immediate, thorough washing of exposed surfaces.

If a leak develops in a boron trifluoride pressurized vessel, water spray can be used to clear the fumes. [70] All leaks must be immediately repaired by trained personnel. Employees involved in this effort must be

provided with personal protective equipment, including respirators and impervious suits.

For entry into a boron trifluoride contaminated area during an emergency situation, especially when entering a visible mist, an impervious suit (many plastics are suitable [59]) and gloves are required in addition to full-face respiratory protection. [60]

Boron trifluoride is commercially available in 60-lb cylinders and in tube trailers containing 5, 6, 7.5, 9, or 10 tons. The gas is shipped at pressures ranging from 1,500 to 1,800 psig. [8]

General guidelines and recommendations for the safe handling of compressed gas cylinders are available in publications of the Compressed Gas Association. [1,71] Current federal standards on the handling of compressed gases have been published in the Federal Register 39:23602-03,23687-92, June 27, 1974 (29 CFR 1910.101,166,167).

Cylinders of boron trifluoride must be secured against dropping, falling, and rupture. Storage areas must be free of excess moisture, and, to minimize corrosion, the cylinders must not be stored on damp ground. [8] No boron trifluoride storage area may contain explosives or flammable materials. [71] Laboratories are advised to store boron trifluoride cylinders in exhaust hoods and to maintain design airflows.

Cylinders must not be exposed to temperatures below -20 F (-29 C) or temperatures exceeding 130 F (54 C). At low temperatures, the steel cylinder walls can become brittle and rupture; at high temperatures, the internal cylinder pressure may trip the relief valve, causing unnecessary exposure. [71]

Permanent storage areas must be equipped with respirators (air-supplied), eyewash fountains, and safety showers. The storage areas must also be well ventilated to prevent the accumulation of boron trifluoride if there is a faulty cylinder. Chances of exposure in such areas can be further reduced if only the quantity of gas necessary for immediate use is stored. [71] Moreover, a first-in, first-out storage system should be developed. Relief valves can be vulnerable to corrosion, which can be minimized by avoiding long periods of storage.

Leaking cylinders which can not be immediately corrected must be removed to a fume hood, a well-ventilated isolated area, or out of doors. If possible, the escaping gas should be trapped, eg, in a mixed solution of caustic soda and slaked lime, and neutralized to prevent the contamination of a wide area. [70]