Regulation Update – 1,3-Butadiene

Occupational Health and Environmental Safety Division

Number 19, January 1997

OSHA Regulation: 29 CFR 1910.1051

On November 4, 1996, The Occupational Safety and Health Administration (OSHA) issued a final rule for occupational exposure to 1,3-butadiene (BD). The standard was published in the *Federal Register*, 61 *Fed. Reg*. 56746.

This summary of the BD standard was prepared by 3M OH&ESD and focuses primarily on the respiratory protection aspects of the standard. It does not represent an official nor legal nor necessarily complete interpretation of the standard. If specific questions arise, the standard itself should be reviewed and relied on, rather than this summary.

I. 1,3-Butadiene

The chemical 1,3-butadiene (BD) is a colorless, noncorrosive, flammable gas with a mild aromatic odor at standard ambient temperature and pressure. It is highly reactive and polymerizes readily. BD is a major commodity product of the petrochemical industry. It is used as a building block for many other products. Over 60% of the BD consumed in the United States is used in the manufacture of rubber. Other uses include manufacture of a component for nylon and acrylonitrile-butadiene-styrene (ABS) resins.

A. Physical Data: 1,3-Butadiene CAS # 106-99-0

Molecular weight: 54.1Appearance: Colorless gasBoiling point: -4.41 deg.C (760 mm Hg)Vapor pressure: 2 atm @ 15.3 deg.C; 5 atm @ 47 deg.CExplosive limits: 2 to 11.5% (by volume in air)Odor threshold: 0.45 ppm

Synonyms: BD; biethylene; bivinyl; butadiene; divinyl; buta-1,3- diene; alpha-gamma-butadiene; erythrene; NCI- C50602; pyrrolylene; vinylethylene.

B. Potential Health Effects

Breathing very high levels of BD for a short time can cause central nervous system irregularities, blurred vision, nausea, fatigue, headache and unconsciousness. Breathing lower levels of BD may cause irritation of the eyes, nose and throat. Skin contact with liquefied BD may cause irritation and frostbite.

BD has been found to be a potent carcinogen in rats. A recent study of BD-exposed workers showed they have an increased risk of developing leukemia. OSHA has concluded that there is strong evidence that workplace exposures to BD poses an increased risk of death from cancers of the lymphohematopoetic (lymph and blood forming) system.

II. Dates

Effective Date: February 3, 1997.
Start-up dates:

- engineering controls November 4, 1998
- exposure goal program November 4, 1999.
- initial monitoring April 4, 1997
- all other requirements August 4, 1997

III. Scope and Application

This standard applies to all occupational exposures to 1,3-Butadiene (BD) with three (3) exemptions for those situations where OSHA concluded the likelihood of significant exposure is quite low.

IV. Definitions

The following is a partial list of definitions used in the BD standard. These definitions were included because the terms are used in this document.

- Action level means a concentration of airborne BD of 0.5 ppm calculated as an eight (8)-hour time-weighted average.
- Day means any part of a calendar day.
- Employee exposure means exposure of a worker to airborne concentrations of BD which would occur if the employee were not using respiratory protective equipment.
- Objective data means monitoring data, or mathematical modeling or calculations based on composition, chemical and physical properties of a material, stream or product.
- Permissible Exposure Limits, PELs means either the 8 hour Time Weighted Average (8-hr TWA) exposure or the Short-Term Exposure Limit (STEL).

V. Permissible Exposure Limits (PELs)

Time-weighted average (TWA) limit. The employer shall ensure that no employee is exposed to an airborne concentration of BD in excess of one (1) part BD per million parts of air (1 ppm) measured as an eight (8)-hour time-weighted average.

Short-term exposure limit (STEL). The employer shall ensure that no employee is exposed to an airborne concentration of BD in excess of five (5) parts of BD per million parts of air (5 ppm) as determined over a sampling period of fifteen (15) minutes.

VI. Exposure Monitoring

A. General

Determinations of employee exposure shall be made from breathing zone samples that are representative of the 8-hour TWA and 15-minute short-term exposures of each employee.

1. 8-hr TWA exposure evaluation: Representative 8-hour TWA employee exposure shall be determined on the basis of one or more samples representing full-shift exposure for each shift and for each job classification in each work area.
2. STEL exposure evaluation: Representative 15-minute short-term employee exposure shall be determined on the basis of one or more samples representing 15-minute exposures associated with operations that are most likely to produce exposures above the STEL for each shift and each job classification in each work area.

B. Initial Monitoring

Each employer who has a workplace or work operation covered by this section, shall perform initial monitoring to determine accurately the airborne concentrations of BD to which employees may be exposed, or shall rely on objective data to fulfill this requirement.

C. Periodic Monitoring

Periodic monitoring frequency is determined by the results of the initial monitoring. Table 1 gives various exposure scenarios and their required monitoring frequencies, as required by the final standard for occupational exposure to BD.

Table 1.--Five Exposure Scenarios and Their Associated Monitoring Frequencies

Action level	8-hr TWA	STEL	Required monitoring activity
-*	-	-	**No 8-hr TWA or STEL monitoring required.**
+*	-	-	**No STEL monitoring required. Monitor 8-hr TWA annually.**
+	+	-	**No STEL monitoring required. Quarterly monitoring for 8-hr TWA.****
+	+	+	**Quarterly monitoring for 8-hr TWA and STEL.****
+	-	+	**Quarterly monitoring for STEL.** Monitor 8-hr TWA, annually.**

* Exposure Scenario, Limit Exceeded: + = Yes, -= No.** The employer may decrease the frequency of exposure monitoring to annually when at least 2 consecutive measurements taken at least 7 days apart show exposures to be below the 8 hr TWA, but at or above the action level.

D. Monitoring Techniques

Appendix D of the BD standard describes the validated method of sampling and analysis which has been tested by OSHA for use with BD. The employer has the obligation of selecting a monitoring method which meets the accuracy and precision requirements of the standard under his or her unique field conditions. The standard requires that the method of monitoring must be accurate, to a 95 percent confidence level, to plus or minus 25 percent for concentrations of BD at or above 1 ppm, and to plus or minus 35 percent for concentrations below 1 ppm.

VII. Regulated Areas

The employer shall establish a regulated area wherever occupational exposures to airborne concentrations of BD exceed or can reasonably be expected to exceed the permissible exposure limits.

VIII. Methods of Compliance

Wherever the feasible engineering controls and work practices which can be instituted are not sufficient to reduce employee exposure to or below the PELs, the employer shall use them to reduce employee exposure to the lowest level achievable by these controls and shall supplement them by the use of respiratory protection.

Compliance plan Where any exposures are above the PELs, the employer shall establish and implement a written plan to reduce employee exposure to or below the PELs primarily by means of engineering and work practice controls and by the use of respiratory protection where required or permitted under the BD standard. No compliance plan is required if all exposures are under the PELs. Such plans shall be reviewed at least every 12 months, and shall be updated as necessary to reflect significant changes in the status of the employer's compliance program.

IX. Exposure Goal Program

[This requirement is unique to the BD standard.] For those operations and job classifications where employee exposures are greater than the action level, in addition to compliance with the PELs, the employer shall have an exposure goal program that is intended to limit employee exposure to below the action level during normal operations. Respirator use is not required in the exposure goal program.

X. Respiratory Protection

A. General

The employer shall provide respirators that comply with the requirements listed below, at no cost to each affected employee, and ensure that each affected employee uses such respirator where required by this standard.

Respirators shall be used in the following circumstances:

1. During the time interval necessary to install or implement feasible engineering and work practice controls;
2. In non-routine work operations which are performed infrequently and in which exposures are limited in duration;
3. In work situations where feasible engineering controls and work practice controls are not yet sufficient to reduce exposures to or below the PELs;
4. In emergencies.

B. Respirator Selection

1. Where respirators are required, the employer shall select and provide the appropriate respirator as specified in Table 2 and ensure its use.
2. The employer shall select respirators from among those approved by the National Institute for Occupational Safety and Health (NIOSH) under the provisions of 42 CFR Part 84, ``Respiratory Protective Devices.'' Air purifying respirators shall have filter element(s) approved by NIOSH for organic vapors or BD.
3. If an employee whose job requires the use of a respirator cannot use a negative pressure respirator, the employee must be provided with a respirator having less breathing resistance, such as a powered air-purifying respirator or supplied air respirator, if the employee is able to use it and if it will provide adequate protection.

C. Respirator Program

Where respiratory protection is required, the employer shall institute a respirator program in accordance with 29 CFR 1910.134.

D. Respirator Use

1. Where air-purifying respirators are used, the employer shall replace the air purifying filter element(s) according to the replacement life interval set for the class of respirator listed in Table 2 and at the beginning of each work shift.

2. In lieu of the replacement intervals listed in Table 2, the employer may replace cartridges or canisters at 90% of the expiration of service life, provided the employer can demonstrate that employees will be adequately protected. BD breakthrough data relied upon by the employer must derive from tests conducted under worst case conditions of humidity, temperature, and air flow rate through the filter element (85%, 25 ^{o}C, 64 Lpm, respectively). The employer shall describe the data supporting the cartridge/canister change schedule and the basis for reliance on the data in the employer's respirator program.
3. A label shall be attached to the filter element(s) to indicate the date and time it is first installed on the respirator. If an employee detects the odor of BD, the employer shall replace the air-purifying element(s) immediately.
4. If a NIOSH-approved end of service life indicator (ESLI) for BD becomes available for an air-purifying filter element, the element may be used until such time as the indicator shows no further useful service life or until replaced at the beginning of the next work shift, whichever comes first. If an employee detects the odor of BD, the employer shall replace the air-purifying element(s) immediately.
5. The employer shall permit employees who wear respirators to leave the regulated area to wash their faces and respirator facepieces as necessary in order to prevent skin irritation associated with respirator use or to change the filter elements of air-purifying respirators whenever they detect a change in breathing resistance or whenever the odor of BD is detected.

Table 2.--Minimum Requirements for Respiratory Protection for Airborne 1,3-Butadiene

Concentration of airborne BD (ppm) or condition of use	Minimum required respirator	3M suggested respirator
≤ 5 ppm (5 times PEL).	a) Air-purifying half mask or full facepiece respirator equipped with approved BD or organic vapor cartridges or canisters. **Cartridges or canisters shall be replaced every 4 hours.**	(a) 6000 or 700X Series Half Facepiece Respirators with 6001 organic vapor cartridges; 7X00 Series Half Facepiece Respirators with 7251 organic vapor cartridges; 5X01 Organic Vapor Respirator.
≤ 10 ppm (10 times PEL).	a) Air-purifying half mask or full facepiece respirator equipped with approved BD or organic vapor cartridges or canisters. **Cartridges or canisters shall be replaced every 3 hours.**	(a) 6000 or 700X Series Half Facepiece Respirators with 6001 organic vapor cartridges; 7X00 Series Half Facepiece Respirators with 7251 organic vapor cartridges; 5X01 Organic Vapor Respirator.
≤ 25 ppm (25 times PEL).	(a) Air-purifying full facepiece respirator equipped with approved BD or organic vapor cartridges or canisters. **Cartridges or canisters shall be replaced every 2 hours.**(b) Any powered air-purifying respirator equipped with approved BD or organic vapor cartridges. **PAPR cartridges shall be replaced every 2 hours.**(c) Continuous flow supplied air respirator equipped with a hood or helmet.	(a) 6000 Series Full Facepiece with 6001 organic vapor cartridge; 7800 Series Full Facepiece with 7251 organic vapor cartridges. (b) Any 3M Belt-Mounted PAPR with GVP-401 organic vapor cartridge. (c) Whitecap II Series, Snapcap Series, Hardcap and Airhat continuous flow airline respirators.

Concentration of airborne BD (ppm) or condition of use (cont'd)	Minimum required respirator (cont'd)	3M suggested respirator(cont'd)
≤ 50 ppm (50 times PEL).	(a) Air-purifying full facepiece respirator equipped with approved BD or organic vapor cartridges or canisters. **Cartridges or canisters shall be replaced every (1) hour.** (b) Powered air-purifying respirator equipped with a tight-fitting facepiece and an approved BD or organic vapor cartridges. **PAPR cartridges shall be replaced every (1) hour.**	(a) 6000 Series Full Facepiece with 6001 organic vapor cartridges; 7800 Series Full Facepiece with 7251 organic vapor cartridges. (b) GVP-4 PAPR with GVP-401 organic vapor cartridge.
≤ 1,000 ppm (1,000 times PEL).	(a) Supplied air respirator equipped with a half mask or full facepiece and operated in a pressure demand or other positive pressure mode	(a) 6000 or 7000 Series Half Mask Airline; 6000 or 7800 Series Full Facepiece continuous flow; 7800 Full Facepiece-pressure demand Airline Respirators
> 1000 ppm, unknown concentration or firefighting.	(a) Self-contained breathing apparatus equipped with a full facepiece and operated in a pressure demand or other positive pressure mode. (b) Any supplied air respirator equipped with a full facepiece and operated in a pressure demand or other positive pressure mode in combination with an auxiliary self-contained breathing apparatus operated in a pressure demand or other positive pressure mode.	(a) None available from 3M (b) 3M 7800 Full Facepiece Pressure Demand Combination Airline/5-Minute Escape SCBA (a.k.a. 5 Minute Escape System)
Escape from IDLH conditions	(a) Any positive pressure self-contained breathing apparatus with an appropriate service life. (b) A air-purifying full facepiece respirator equipped with a front or back mounted BD or organic vapor canister.	(a) None available from 3M (b) None available from 3M

Notes: Respirators approved for use in higher concentrations are permitted to be used in lower concentrations. Full facepiece is required whenever eye irritation is anticipated.

[**Note**: The BD standard is the first OSHA standard to contain a chemical cartridge change-out schedule in the selection table that varies with the airborne concentration. For example, a half facepiece organic vapor respirator can be used up to 10 times the PEL (10 ppm), but the cartridge must be changed more frequently when used for airborne BD concentrations of 10 ppm (every 3 hours) than when used for airborne BD concentrations of 5 ppm (every 4 hours). Full facepiece organic vapor respirators can be used in airborne BD concentrations up to 50 ppm, but the chemical cartridge change-out schedule is more frequent.]

E. Respirator Fit Testing

1. The employer shall perform either qualitative fit testing (QLFT) or quantitative fit testing (QNFT), as required in Appendix E to this standard, at the time of initial fitting and at least annually thereafter for employees who wear tight-fitting negative pressure respirators. Fit testing shall be used to select a respirator facepiece which exhibits minimum acceptable leakage and provides the required protection as prescribed in Table 2.
2. For each employee wearing a tight-fitting full facepiece negative pressure respirator who is exposed to airborne concentrations of BD that exceed 10 times the TWA PEL (10 ppm), the employer shall perform quantitative fit testing as required in Appendix E to this standard, at the time of initial fitting and at least annually thereafter.
3. The employer shall ensure that employees wearing tight fitting respirators perform a facepiece seal fit check to ensure that a proper facepiece seal is obtained prior to each entry into a BD atmosphere. The recommended positive or negative pressure fit check procedures listed in Appendix E to this standard or the respirator manufacturer's recommended fit check procedure shall be used.

XI. Medical Screening and Surveillance

For each employee who must wear a respirator, physical ability to perform work and use the respirator must be determined as required by 29 CFR 1910.134.

XII. Communication of BD hazards to employees

The training program shall be conducted in a manner that the employee is able to understand. The employer shall ensure that each employee exposed to BD over the action level or STEL is informed of, among other things, the protective equipment.

XIII. Recordkeeping

Two records that relate to respiratory protection programs are required by this standard:

Exposure Monitoring: The BD standard requires the employer to establish and maintain an accurate record of all measurements taken to monitor employee exposure to BD as prescribed by the BD standard. Specific details to include in the record are listed.

Respirator Fit Test: The employer shall establish a record of the fit tests administered to an employee including:

- The name of the employee,
- Type of respirator,
- Brand and size of respirator,
- Date of test, and
- Where QNFT is used, the fit factor, strip chart recording or other recording of the results of the test.

Fit test records shall be maintained for respirator users until the next fit test is administered.

XIV. Appendices

Six appendices are included with the standard. Appendix E of the BD standard on fit testing is mandatory. Appendices A, B, C, D, and F of the BD standard are informational and are not intended to create any additional obligations not otherwise imposed or detract from any existing obligations.

XV. Appendix E: Respirator Fit Testing Procedures (Mandatory)

Only those items unique to the BD standard are included here. Those items identical to fit testing requirements in other OSHA substance specific standards are not included.

A. These provisions apply to both QLFT and QNFT

1. The test subject shall be allowed to pick the most comfortable respirator from a selection of respirators of various sizes and models [No number is given].
2. The test subject shall conduct the negative and positive pressure fit checks using procedures in Appendix A [Contrary to what OSHA states in the BD standard, fit check procedures are not included in either Appendix A or E of this standard] or those recommended by the respirator manufacturer.
3. Exercise regimen. The respirator to be tested shall be worn for at least 5 minutes before the start of the fit test.4. Test Exercises. The test subject shall perform the following exercises: normal breathing, deep breathing, turning head side to side, moving head up and down, talking (The subject can read from a prepared text such as the Rainbow Passage, count backward from 100, or recite a memorized poem or song), grimace (Only for QNFT testing, not performed for QLFT), bending over, (Jogging in place shall be substituted for this exercise in those test environments such as shroud type QNFT units which prohibit bending at the waist), normal breathing. Each test exercise shall be performed for one minute except for the grimace exercise which shall be performed for 15 seconds.

B. Qualitative Fit Test (QLFT) Protocols

1. General

   The BD standard published three QLFT protocols: Isoamyl Acetate Protocol, Saccharin Solution Aerosol Protocol and Irritant Fume Protocol. While the fit test protocol using Bitrex™ was not published, OSHA has written a letter of interpretation (3/6/96) stating that OSHA will accept "the common Bitrex™ aerosol QLFT procedure ... as a valid alternative to the other QLFT protocols." In the isoamyl acetate protocol each respirator used for the fitting and fit testing shall be equipped with organic vapor cartridges or offer protection against organic vapors. In the saccharin solution aerosol protocol the respirator shall be properly adjusted and equipped with a particulate filter(s). In the irritant fume protocol the respirator to be tested shall be equipped with high-efficiency particulate air (HEPA) filters.

2. Irritant Fume Protocol [OSHA made some changes to the irritant fume protocol compared to other versions. OSHA no longer recommends the MSA smoke tube and does not require the use of a low flow pump calibrated at 200 cc/min.] The standard states "Break both ends of a ventilation smoke tube containing stannic chloride. Attach one end of the smoke tube to an aspirator squeeze bulb and cover the other end with a short piece of tubing to prevent potential injury from the jagged end of the smoke tube."

C. Quantitative Fit Test (QNFT) Protocols The following quantitative fit testing procedures have been demonstrated to be acceptable:

1. Quantitative fit testing using a non-hazardous challenge aerosol (such as corn oil or sodium chloride) generated in a test chamber, and employing instrumentation to quantify the fit of the respirator. (Protocol provided)
2. Quantitative fit testing using ambient aerosol as the challenge agent and appropriate instrumentation (condensation nuclei counter) to quantify the respirator fit. (Protocol provided)
3. Quantitative fit testing using controlled negative pressure and appropriate instrumentation to measure the volumetric leak rate of a facepiece to quantify the respirator fit. (No protocol provided)

C1. Generated aerosol quantitative fit testing protocol

Some key points of the protocol are listed below. It is worth noting that OSHA addressed the issue of probing respirators.

1. When testing air-purifying respirators, the normal filter or cartridge element shall be replaced with a high-efficiency particulate air (HEPA) filter supplied by the same manufacturer in the case of particulate QNFT aerosols.
2. The sampling port on the test specimen respirator shall be placed and constructed so that no leakage occurs around the port (e.g. where the respirator is probed), a free air flow is allowed into the sampling line at all times so that there is no interference with the fit or performance of the respirator. The in-mask sampling device (probe) shall be designed and used so that the air sample is drawn from the breathing zone of the test subject, midway between the nose and mouth and with the probe extending into the facepiece cavity at least 1/4 inch.

Calculation of fit factors

1. The fit factor shall be determined for the quantitative fit test by taking the ratio of the average chamber concentration to the concentration measured inside the respirator for each test exercise *except the grimace exercise*.
2. The test subject shall not be permitted to wear a half mask or quarter facepiece respirator unless a minimum fit factor of 100 is obtained, or a full facepiece respirator unless a minimum fit factor of 500 is obtained.

C2. Ambient aerosol condensation nuclei counter (CNC) quantitative fit testing protocol

[This is the first OSHA standard to contain a protocol for QNFT with the CNC method.]

The ambient aerosol condensation nuclei counter (CNC) quantitative fit testing (Portacount™) protocol quantitatively fit tests respirators with the use of a probe. The probed respirator is only used for quantitative fit tests. A probed respirator has a special sampling device, installed on the respirator, that allows the probe to sample the air from inside the mask. A probed respirator is required for each make, model, and size which your company requires and can be obtained from the respirator manufacturer or distributor. The CNC instrument manufacturer Dynatech Nevada also provides probe attachments (TSI sampling adapters) that permits fit testing in an employee's own respirator **[Dynatech Nevada does not manufacture CNC instrumentation and its adapters cannot be used with the Portacount.]**. A fit factor pass level of 100 is necessary for a half-mask respirator and a fit factor of at least 10 times greater than the assigned protection factor for any other negative pressure respirator. The Agency [OSHA] does not recommend the use of homemade sampling adapters. The entire screening and testing procedure shall be explained to the test subject prior to the conduct of the screening test.

Portacount Fit Test Requirements.

1. Check the respirator to make sure the respirator is fitted with a high efficiency filter and that the sampling probe and line are properly attached to the facepiece.
2. Instruct the person to be tested to don the respirator several minutes before the fit test starts. This purges the particles inside the respirator and permits the wearer to make certain the respirator is comfortable. This individual should have already been trained on how to wear the respirator properly.

3. Check the following conditions for the adequacy of the respirator fit:

    - chin properly placed;
    - adequate strap tension, not overly tightened;
    - fit across nose bridge;
    - respirator of proper size to span distance from nose to chin;
    - tendency for the respirator to slip,
    - self-observation in a mirror to evaluate fit and respirator position.

4. Have the person wearing the respirator do a fit check. If leakage is detected, determine the cause. If leakage is from a poorly fitting facepiece, try another size of the same type of respirator.
5. Follow the instructions for operating the Portacount and proceed with the test.

Portacount Test Exercises.

The test exercises are the same as those identified under the procedures that apply to both QLFT and QNFT.

Portacount Test Instrument.

1. The Portacount will automatically stop and calculate the overall fit factor for the entire set of exercises. The overall fit factor is what counts. The Pass or Fail message will indicate whether or not the test was successful. If the test was a Pass, the fit test is over. [It may be necessary to consult TSI to determine how to calculate the overall fit factor without the results of the grimace exercise per the BD standard requirements.]