

Health and Safety Guide No. 46

# BARIUM

## HEALTH AND SAFETY GUIDE



UNITED NATIONS  
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Health and Safety Guide No. 46

**BARIUM  
HEALTH AND  
SAFETY GUIDE**

This is a companion volume to  
Environmental Health Criteria 107: Barium

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Programme on Chemical Safety  
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## INTRODUCTION

The Environmental Health Criteria (EHC) documents produced by the International Programme on Chemical Safety include an assessment of the effects on the environment and on human health of exposure to a chemical or combination of chemicals, or physical or biological agents. They also provide guidelines for setting exposure limits.

The purpose of a Health and Safety Guide is to facilitate the application of these guidelines in national chemical safety programmes. The first three sections of a Health and Safety Guide highlight the relevant technical information in the corresponding EHC. Section 4 includes advice on preventive and protective measures and emergency action; health workers should be thoroughly familiar with the medical information to ensure that they can act efficiently in an emergency. Within the Guide is a Summary of Chemical Safety Information which should be readily available, and should be clearly explained, to all who could come into contact with the chemical. The section on regulatory information has been extracted from the legal file of the International Register of Potentially Toxic Chemicals (IRPTC) and from other United Nations sources.

The target readership includes occupational health services, those in ministries, governmental agencies, industry, and trade unions who are involved in the safe use of chemicals and the avoidance of environmental health hazards, and those wanting more information on this topic. An attempt has been made to use only terms that will be familiar to the intended user. However, sections 1 and 2 inevitably contain some technical terms. A bibliography has been included for readers who require further background information.

Revision of the information in this Guide will take place in due course, and the eventual aim is to use standardized terminology. Comments on any difficulties encountered in using the Guide would be very helpful and should be addressed to:

The Manager  
International Programme on Chemical Safety  
Division of Environmental Health  
World Health Organization  
1211 Geneva 27  
Switzerland

**THE INFORMATION IN THIS GUIDE  
SHOULD BE CONSIDERED AS A  
STARTING POINT TO A COMPREHENSIVE  
HEALTH AND SAFETY PROGRAMME**



# 1. PRODUCT IDENTITY AND USES

## 1.1 Identity

Symbol:	Ba
CAS registry number:	7440-39-3

## 1.2 Physical and Chemical Properties

Some physical and chemical properties of barium are given in the Summary of Chemical Safety Information (section 6).

## 1.3 Occurrence

Barium is an alkaline earth metal that occurs in nature in a combined form. It is present in rocks, minerals, soils, air, natural waters, and fossil fuels. Some barium salts (e.g., acetate, nitrate, and chloride) are quite soluble in water, whereas others (e.g., arsenate, carbonate, oxalate, chromate, fluoride, sulfate, and phosphate) are very poorly soluble. The water solubility of barium salts, except for barium sulfate, increases with decreasing pH.

## 1.4 Analytical Methods

Sampling and handling procedures for barium are those used in general analytical practice. Three atomic absorption spectrophotometry (AAS) methods, recommended for the determination of barium, include: the direct aspiration method, the furnace technique, and emission spectrometry, using an inductively coupled plasma (ICP) source. Mass spectrometry, X-ray fluorescence, and neutron activation analysis are used for special applications.

## PRODUCT IDENTITY AND USES

### 1.5 Production and Uses

The major raw materials from which barium compounds are obtained are barite (barium sulfate) and witherite (barium carbonate). The barite and witherite are converted to metallic barium and other barium compounds, including barium oxide, hydroxide, peroxide, and a variety of salts.

Metallic barium is used in the manufacture of alloys. Barium compounds are used: as loaders for paper, soap, rubber, and linoleum; in the manufacture of valves, and in the production of lights and green flares. They are also used: as pigments in the manufacture of paints; in cement where concrete is exposed to salt-water; in the radio industry to capture the last traces of gases in vacuum tubes; in the ceramic and glass industries; as insecticides and rodenticides; as extinguishers for radium, uranium, and plutonium; and as contrast material in X-ray medical examination.

## 2. SUMMARY AND EVALUATION

### 2.1 Human Exposure

The general population is exposed to barium through air, drinking-water, and food.

The concentration in air has been estimated to be  $\leq 0.05 \mu\text{g}/\text{m}^3$  and, assuming an average ventilatory rate of  $20 \text{ m}^3/\text{day}$ , a daily inhalation intake of barium of approximately  $1.0 \mu\text{g}$  can be derived. Occupational exposure to barium has been found to range from  $0.02$  to  $6.1 \text{ mg}/\text{m}^3$ .

Recent studies from the USA showed exposure levels in drinking-water ranging from  $1$  to  $20 \mu\text{g}/\text{litre}$ . On the basis of this range, and assuming a daily consumption of  $2$  litres of drinking-water, the daily intake of barium would be  $2$ – $40 \mu\text{g}$ . However, in certain regions of the USA, barium concentrations of up to  $10\,000 \mu\text{g}/\text{litre}$  have been reported. In the United Kingdom (Wales), the average daily intake of barium from drinking-water has been estimated to be approximately  $86 \mu\text{g}$ .

The major route of barium exposure is through the diet. On the basis of data from the USA, the dietary intake of barium ranges from  $300$  to  $1700 \mu\text{g}/\text{day}$ , with an average concentration ranging from  $600$ – $900 \mu\text{g}/\text{day}$ . In the United Kingdom (Wales), the average intake has been estimated to be  $1240 \mu\text{g}/\text{day}$ .

### 2.2 Uptake, Metabolism, and Excretion

In human beings, the absorption of barium from the gastrointestinal tract largely depends on age and the solubility of the compound. Less than  $10\%$  of an ingested quantity is believed to be absorbed in adults; however, absorption may be significantly higher in children. Inhaled barium compounds are absorbed through the lungs or directly from the basal membrane. Poorly soluble compounds may accumulate in the lungs and removal is slow. Absorbed barium enters the bloodstream and various soft tissues, and is deposited in the bone. A barium level of about  $20 \text{ mg}$  has been found in the average-sized person ( $70 \text{ kg}$ ),  $93\%$  of which is localized in the bone.

## SUMMARY AND EVALUATION

The metabolism of barium is similar to that of calcium; however, unlike calcium, barium has no known biological function.

Barium is eliminated in both the faeces and the urine, elimination varying according to the route of administration and the solubility of the compound. Barium, which had been absorbed and transported by the plasma, was found to be almost entirely eliminated from the body within 24 h.

### 2.3 Effects on Experimental Animals

Barium compounds, particularly soluble compounds, are toxic in animals. Oral LD<sub>50</sub>s in the rat for barium chloride, fluoride, and nitrate were reported to be 118, 250, and 335 mg/kg body weight, respectively. Acute effects of barium ingestion include salivation, nausea, diarrhoea, tachycardia, hypokalaemia, twitching, flaccid paralysis of skeletal muscle, respiratory muscle paralysis, and ventricular fibrillation. Respiratory muscle paralysis and ventricular fibrillation may lead to death. Studies on dogs showed that acute effects were due to the rapid onset of substantial hypokalaemia (abnormally low potassium levels in the blood) and could be prevented or reversed by potassium administration.

No clinical signs of toxicity or microscopic alterations were seen in rats given tap water containing  $\leq 250$  mg barium/litre for periods of up to 13 weeks.

Lethal concentrations following acute inhalation exposure have not been reported. However, at concentrations higher than 5.2 mg barium/m<sup>3</sup>, rats exhibited decreases in body weight, blood glucose, and haemoglobin, and an increase in leukocytes.

In rabbits, topical administration of barium resulted in mild skin irritation and severe eye irritation.

The results of one study on mice and rats did not reveal any evidence of carcinogenicity for barium.

Both oral and inhalation exposure to barium carbonate induced adverse reproductive effects in male and female rats.

There is limited evidence of the teratogenic potential of barium.

## SUMMARY AND EVALUATION

### 2.4 Effects on Human Beings

Barium doses as low as 0.2–0.5 g (3–7 mg/kg body weight), generally resulting from the ingestion of barium chloride or carbonate, have been found to lead to toxic effects in adult human beings. In untreated cases, doses of 3–5 g (40–70 mg/kg body weight) were lethal. Clinical features of barium poisoning include: acute gastroenteritis, loss of deep reflexes with onset of muscular paralysis, and progressive muscular paralysis. The muscular paralysis appears to be related to severe hypokalaemia. In most reported cases, rapid and uneventful recovery occurred after treatment with infused potassium salts (carbonate or lactate) and/or oral administration of sodium sulfate.

Adverse health effects have been observed in sensitive individuals (e.g., diuresis patients) following exposure to barium as a medical X-ray contrast medium.

In the workplace, inhaled barium has resulted in baritosis. A significantly higher prevalence of hypertension was observed in workers exposed to high levels of airborne barium than in unexposed workers.

The results of early, limited, epidemiological studies, relating exposure to low levels of barium with cardiovascular disease and mortality, were inconsistent and inconclusive. In a later epidemiological study, no conclusive evidence of barium-induced effects on blood pressure was revealed. No effects on blood pressure were identified in a short-term study in which volunteers consumed increasing levels of barium up to 10 mg/litre in drinking-water.

There is no conclusive evidence that barium compounds induce reproductive, teratogenic, or carcinogenic effects in human beings.

### 2.5 Effects on the Environment

Barium has been reported to inhibit growth and cellular processes in microorganisms, and to affect the development of germinating spores.

No information was obtained on the adverse effects of barium on terrestrial plants or wildlife. No toxic effects have been reported in aquatic plants due to barium at the usual concentrations found in water. Reported LC<sub>50</sub>

## SUMMARY AND EVALUATION

values for fish in fresh water range from 46 to 78 mg/litre. Reproduction and growth in *Daphnia* spp. were impaired by barium concentrations of 5.8 mg/litre.

### 3. CONCLUSIONS AND RECOMMENDATIONS

Barium, at concentrations normally found in the environment, does not pose any significant risk for the general population. However, for specific subpopulations, and under conditions of high barium exposure, the potential for adverse health effects should be taken into account.

Few data are available to evaluate the risk to the environment posed by barium. On the basis of the available information on the toxic effects of barium in *Daphnia* spp., it appears that high concentrations may represent a risk to populations of some aquatic organisms.

In order to adopt adequate preventive measures in the workplace, more data on exposure levels should be obtained, including human monitoring data.

## **4. HUMAN HEALTH HAZARDS, PREVENTION AND PROTECTION, EMERGENCY ACTION**

### **4.1 Main Human Health Hazards, Prevention and Protection, First Aid**

The three stages of poisoning from soluble barium compounds are acute gastroenteritis, loss of reflexes with the onset of muscular paralysis, and progressive muscular paralysis. When ingested, barium compounds exert profound effects on all muscles, especially the heart. In addition, exposure to metallic barium may result in severe burns, through explosion and fire. The human health hazards associated with certain types of exposure to metallic barium, together with preventive and protective measures and first-aid recommendations, are listed in the Summary of Chemical Safety Information (section 6).

#### *4.1.1 Advice to physicians*

Immediate care should consist of the administration of 30 g sodium sulfate in 250 ml of water (a glass of water), repeated in one hour. In the case of very severe symptoms, intravenous administration of potassium bicarbonate or lactate, to overcome hypokalaemia, is necessary, and should be carried out, under controlled medical conditions, only by qualified medical personnel.

#### *4.1.2 Health surveillance advice*

Persons handling barium and its compounds should undergo periodic medical examination. Special consideration should be given to the skin, eyes, heart, and lungs, and serum potassium levels should be measured at each examination.

### **4.2 Explosion and Fire Hazards, Storage, Transport, Spillage, and Disposal**

Barium metals and barium compounds have been described separately; section 4.2.1 refers to barium as a metal, while section 4.2.2 refers to barium compounds.



## HUMAN HEALTH HAZARDS, PREVENTION AND PROTECTION, EMERGENCY ACTION

### 4.2.1 *Barium metal*

#### 4.2.1.1 *Explosion hazards*

Metallic barium reacts exothermically on contact with water, releasing flammable hydrogen gas, which may be ignited by the heat of the reaction. Fine powders or dusts of barium can explode when heated. Barium runoff to sewer water may create an explosion or fire.

#### 4.2.1.2 *Fire hazards*

Barium in the form of finely ground powder or fumes is flammable or explosive, when exposed to heat or flames.

#### 4.2.1.3 *Prevention*

Keep barium away from water, heat, sparks, and open flames.

#### 4.2.1.4 *Extinguishing agents*

Move barium containers from fire area, if possible. Do not use water, carbon dioxide, or foam. In case of small fires, use dry chemical powder, soda ash, or lime. In case of large fires, withdraw from area and let fire burn.

#### 4.2.1.5 *Storage*

Store barium under inert gas, petroleum, argon, or oxygen-free liquid. Store away from the following: water, most acids, ammonia, halogens, and oxidizers.

#### 4.2.1.6 *Transport*

Package barium in sealed containers. Pack glass bottles together with cushioning material in a wooden box; pack cans together in a wooden box. Label metal drums with the warning "Dangerous When Wet". Limit transportation of barium to cargo ships or passenger ships carrying not more than 25 passengers; on ships, limit stowage to above the deck or under

## HUMAN HEALTH HAZARDS, PREVENTION AND PROTECTION, EMERGENCY ACTION

the deck, preferably the latter. During transportation by air (single or combination packagings), steel drums, aluminum drums, plastic drums, or plastic jerricans are required as the inner shell, and wooden, plywood, or fibreboard boxes are required as the outer shell.

### 4.2.1.7 Spillage

In case of spillage, shut off ignition sources. Do not touch spilled material. Stop leak, if possible to do so without risk. Water should not come into contact with spilled material or the inside of the container. For small dry spills, use a clean shovel to place material into a clean, dry container and cover; move containers from area of spillage. Cover dry powder spills with plastic sheet or tarp to minimize spreading. Keep unnecessary persons away. Isolate area and prevent anyone from entering.

### 4.2.1.8 Disposal

Material in the elemental state should be recovered for re-use or recycling. Recovered metal should be stored under a layer of kerosene and kept dry.

## 4.2.2 Barium compounds

### 4.2.2.1 Explosion and fire hazards

Specific soluble barium compounds, such as barium oxide, peroxide, and nitrate, can cause an explosion or fire, when in contact with water, carbon dioxide, or hydrogen sulfide.

### 4.2.2.2 Prevention

Handle with care, avoid inhalation and contact with skin. Do not eat, drink, or smoke in the workplace.

### 4.2.2.3 Extinguishing agents

Move containers from the fire area, if possible. In case of small fires, use dry chemical powder, soda, or lime. In case of large fires, withdraw from the area and let the fire burn.

## HUMAN HEALTH HAZARDS, PREVENTION AND PROTECTION, EMERGENCY ACTION

### 4.2.2.4 *Storage*

Store in closed labelled containers.

### 4.2.2.5 *Transport*

Package barium compounds in sealed containers. Pack glass bottles, together with cushioning material, in a wooden box; pack cans together in a wooden box. Label metal drums with the warning "Dangerous When Wet". Limit transportation of barium compounds to cargo ships or passenger ships carrying not more than 25 passengers; on ships, limit stowage to above the deck or under the deck, preferably the latter. During transportation by air (single or combination packagings), steel drums, aluminum drums, plastic drums, or plastic jerricans are required as the inner shell, and wooden, plywood, or fibreboard boxes, as the outer shell.

### 4.2.2.6 *Spillage*

In case of spillage, shut off ignition sources. Do not touch spilled material. Stop leak, if possible to do so without risk. Water should not come into contact with the spilled material or the inside of the container. For small dry spills, use a clean shovel to place in clean, dry container and cover; move containers from area of spillage. Take up liquid spills with sand or absorbent material and place in containers for later disposal. Larger spills should be contained with a barrier for later disposal. Cover dry powder spills with plastic sheet or tarpaulin, to minimize spreading. Keep unnecessary persons away. Isolate area, and prevent anyone from entering.

### 4.2.2.7 *Disposal*

Soluble barium compounds can be removed from water by the addition of controlled amounts of sulfuric acid or acidified sulfate salts, to form insoluble barium sulfate.

## 5. HAZARDS FOR THE ENVIRONMENT AND THEIR PREVENTION

As barium at a concentration of 5.8 mg/litre has been observed to impair reproduction and growth in *Daphnia* spp., similar concentrations may present a risk for other aquatic organisms.

Avoid contamination of soil, water, and the atmosphere by using proper methods of processing, transport, and waste disposal.

## 6. SUMMARY OF CHEMICAL SAFETY INFORMATION

*This summary should be easily available to all health workers concerned with, and users of, barium. It should be displayed at, or near, entrances to areas where there is potential exposure to barium, and on processing equipment and containers. The summary should be translated into the appropriate language(s). All persons potentially exposed to the chemical should also have the instructions in the summary clearly explained.*

*Space is available for insertion of the National Occupational Exposure Limit, the address and telephone number of the National Poison Control Centre, and local trade names.*

## SUMMARY OF CHEMICAL SAFETY INFORMATION

Barium (Ba)

### PHYSICAL PROPERTIES

Relative molecular mass 56  
 Appearance yellowish-white solid  
 Melting point (°C) 725  
 Boiling point (°C) 1640  
 Solubility in water (20 °C) reacts with release of H<sub>2</sub>  
 Density (20 °C) 3.51  
 Vapour pressure (20 °C) 2  
 Electronegativity 1.02  
 Flame coloration test green

### OTHER CHARACTERISTICS

Extremely reactive with water, ammonia, halogens, oxygen and most acids

### HAZARD/SYMPTOM

SKIN: Irritation

Avoid exposure; wear protective clothing and gloves

Remove contaminated clothing; wash skin with plenty of water and soap

EYE: Irritation; redness; pain

Wear safety goggles if there is a possibility of eye contact

Flush eyes with plenty of water for 15 minutes

**INHALATION (metallic powder):**  
Sore throat, coughing, shortness of breath, trembling, vomiting

Avoid exposure by using ventilation, local exhaust, or breathing protection by a suitable respirator

Fresh air, administer oxygen, if required

**INGESTION:** Salivation, vomiting, abdominal pain; gastroenteritis; giddiness; stimulation of all muscle types; hypokalaemia; delayed kidney damage; vasoconstriction, irregular heartbeat; death may occur from cardiac or respiratory failure

Do not eat, drink, or smoke when handling the material

Rinse mouth; induce vomiting in conscious patients; administer sodium sulfate (30 g in 250 ml water); if swallowed, begin gastric lavage (stomach wash) followed by saline catharsis, seek medical attention immediately

#### SPILLAGE

Do not touch spilled material; do not get water on the spillage; for dry spills, use a clean shovel to place material in clean, dry container

#### STORAGE

Store under inert gas, petroleum, argon, or oxygen-free liquid

#### FIRE AND EXPLOSION

Finely ground particle or fumes are flammable or explosive

#### WASTE DISPOSAL

Recover elemental barium for re-use or recycling; store under a layer of kerosene and keep it dry  
National Occupational Exposure Limit:  
National Poison Control Centre:

## **7. CURRENT REGULATIONS, GUIDELINES AND STANDARDS**

The information given in this section has been extracted from the International Register of Potentially Toxic Chemicals (IRPTC) legal file. A full reference to the original national document from which the information was extracted can be obtained from IRPTC. When no effective date appears in the IRPTC legal file, the year of the reference from which the data are taken is indicated by (r).

The reader should be aware that regulatory decisions about chemicals taken in a certain country can only be fully understood in the framework of the legislation of that country. Furthermore, the regulations and guidelines of all countries are subject to change and should always be verified with appropriate regulatory authorities before application.

### **7.1 Previous Evaluations by International Bodies**

The International Agency for Research on Cancer (IARC) evaluated the carcinogenicity of barium chromate (VI) and concluded that there was sufficient evidence for carcinogenicity in human beings (positive carcinogen) and insufficient evidence in animals. However, the carcinogenic properties of barium chromate are related to the presence of chromium (VI) and not barium.

### **7.2 Exposure Limit Values**

See table on pages 24-25.

### **7.3 Specific Restrictions**

No specific restrictions were found.

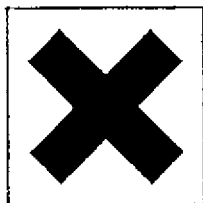


## CURRENT REGULATIONS, GUIDELINES AND STANDARDS

### 7.4 Labelling, Packaging, and Transport

European Economic Community legislation requires labelling as a dangerous substance using the symbol:

Xn



- \* ES: Nocivo
- DA: Sundhedsskadelig
- DE: Mindergiftig  
(Gesundheitsschädlich)
- EL: Επιβλαβές
- EN: Harmful
- FR: Nocif
- IT: Nocivo
- NL: Schadelijk
- \* PT: Nocivo

The label must read:

*Harmful by inhalation – avoid contact with skin.*

The European Economic Community legislation on labelling classifies barium as a poisonous substance for the purpose of determining the label on preparations containing this substance.

The United Kingdom legislation on regulations requires that all general requirements concerning labelling, containers, storage, and transport are laid down; this applies to all barium salts except barium sulfate.

The label that both recommend is:



## CURRENT REGULATION, GUIDELINES, AND STANDARDS

### EXPOSURE LIMIT VALUES

Medium	Specification	Country/ organization	Exposure limit description	Value	Effective date
AIR	Occupational	Argentina	Maximum allowable concentration (MAC) - Time-weighted average (TWA) Short-term exposure limit (STEL)	0.5 mg/m <sup>3</sup> 0.5 mg/m <sup>3</sup>	1979 1979
		Australia	Threshold limit value (TLV) - Time-weighted average (TWA)	0.5 mg/m <sup>3</sup>	1985(r)
		Belgium	Threshold limit value (TLV) - Time-weighted average (TWA)	0.5 mg/m <sup>3</sup>	1980(r)
		Canada	Maximum allowable concentration (MAC) - Time-weighted average (TWA)	0.5 mg/m <sup>3</sup>	1985(r)
		Finland	Maximum allowable concentration (MAC) - Time-weighted average (TWA)	0.5 mg/m <sup>3</sup>	1985(r)
		Germany, Federal Republic of	Maximum at work-site concentration (MAK) - 8 h time-weighted average Short-term exposure limit (STEL) - 30 minutes	0.5 mg/m <sup>3</sup> 1.0 mg/m <sup>3</sup>	1987(r) 1987(r)
		United Kingdom	Recommended limits (RECL) - Time-weighted average	0.5 mg/m <sup>3</sup>	1987(r)

	USA (ACGIH)	Threshold limit value (TLV) - Time weighted average	0.5 mg/m <sup>3</sup>	1986(r)
	USA (OSHA)	Threshold limit value (TLV) - Time weighted average	0.5 mg/m <sup>3</sup>	1985(r)
WATER	Canada	Maximum allowable concentration (MAC) - Guideline level for water quality	1.0 mg/litre	1987
	European Economic Community	Maximum allowable concentration (MAC) - Guideline level requirements	0.1 mg/litre	1982
	USA	Reported quantity requirement (RQR) - Bottled water	1.0 mg/litre	1981(r)
		Maximum allowable concentration (MAC) - Public water systems	1.0 mg/litre	1986(r)
FOOD	European Economic Community	Reported quantity requirement (RQR) - intended for the abstraction of drinking water; simple water treatment methods - for normal and intensive methods	0.1 mg/litre	1977
	USA	Maximum permissible concentration (MPC) - for colours that may be used in food, drugs, and/or cosmetics	0.5 g/kg	1986 (r)

TWA = Time-weighted average over one working day (usually 8 h).

## CURRENT REGULATIONS, GUIDELINES AND STANDARDS

### 7.5 Other Measures

United Kingdom legislation classifies barium as a poisonous substance that is not to be sold except by a person lawfully conducting a retail pharmacy business, and requires that proper records be kept of the sales.

Under the Hazardous Products Act, Canadian legislation prohibits the advertising, sale, or import of toys, equipment, or other products, for use by children in learning or play, which have a decorative or protective coating that contains 0.1% barium.

### 7.6 Waste Disposal

European Economic Community legislation on waste disposal requires that Member States should take the necessary steps to limit the introduction of barium and its compounds into ground water, by subjecting to prior investigation and authorization all direct discharges, and disposal or tipping that might lead to indirect discharges, and all indirect discharges.

United Kingdom legislation classifies barium as a "special waste" that requires completion of a consignment note for the disposal authorities. This applies to controlled waste containing, or consisting of, barium compounds.

United States legislation requires an owner or operator of a certain type of hazardous waste storage, treatment, or disposal facility to install a ground water monitoring system and to periodically report on the concentrations of this substance. In addition, permits are required for the discharge of any pollutant from any point source into US waters. Quantitative data must be reported in the application. The level applies to total barium. Waste regulations also require that the analytical method(s) used in determining the presence of barium in solid waste be specified.

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