Climax Molybdenum
A Freeport-McMoRan Company

FM AHM **Safety Data Sheet** 17 Feb 2014

Section 1 Substance Identification and Company/Undertaking

(1.1)
Product identifier

Substance name: Hexaammonium heptamolybdate
Chemical formula: $(NH_4)_6Mo_7O_{24} \cdot 4\ H_2O$ or $(NH_4)_6Mo_7O_{24} \cdot x\ H_2O$

(1.2)
Synonyms/trade names: ammonium heptamolybdate; AHM
Index No. (Regulation (EC) No 1272/2008): None, because not currently classified.
CAS Numbers: 12027-67-7 and/or 12054-85-2
EC No.: 234-722-4 and/or 601-720-3 (was 234-320-9)
REACH Registration number: 01-2119498057-28-0000

(1.3)
Product Use: Use by workers in industrial settings: Micronutrient in fertilizers/feed additives; Flame & smoke suppressant; Production of lighting materials; Catalyst Manufacture; Metal Alloy production; Manufacture of ceramics; Manufacture of sintered metal; Industrial detergent for metal surface treatment.

(1.3.1)
Sales restricted to commercial users.

(1.4)
Company/Supplier:
Climax Molybdenum Company
333 North Central Avenue
Phoenix, Arizona 85004, USA

(1.5)
Emergency Information:
Contact: +01-602-366-8100 (U.S. days only)
Chemtrec: +01-800-424-9300 (U.S. 24hr)
+01-703-527-3887 (worldwide)
FAX: +01-602-366-7309
e-mail: robert_stepp@fmi.com

(1.5.1)
REACH Importer:
Climax Molybdenum B.V.
Theemsweg 20
NL-3197 KM Botlek-Rotterdam, Netherlands
Contact: +31-(0)181243737
e-mail: aad_vanmeerkerk@fmi.com

(1.5.2)
Poison Center's - If in Netherlands: National Poison Information center, University Medical Centre, Utrecht – Postbus 85500
Contact #: (P) +31 88 755 85 61; (F) +31 30 254 15 11; (Em) +31 30 274 88 88; nvic@umcutrecht.nl; www.vergiftigingen.info (24 hours) (Note – Not available to public, source WHO.)
Poison Centers provide acute toxicity information and do not provide emergency HazMat, over the road, or hazardous environmental information, please call Chemtrec for all information.

(1.5.1)
Other Emergency numbers – For List of EU Poison Centers see Section 16.7.1, in addition see WHO site - http://www.who.int/gho/phe/chemical_safety/poisons_centres/en/index.html for other country sites.

Section 2 Hazard Identification

(2.1)
EU Regulation (EC) No. 1272/2008 [CLP]

(2.1.1)
Classification according to Regulation (EC) No. 1272/2008 (CLP): Not classified unless local code applies.

(2.1.2)
Classification according to EU Directive 67/548/EEC: Not classified unless local code applies.

UN GHS Classifications:
Acute Toxicity Oral: Category 5
Acute Toxicity Dermal: Category 5
Acute Toxicity Inhalation: Category 5

(2.2)
Label elements

(2.2.1)

Labeling according to Regulation (EC) No. 1272/2008 (CLP): Hexaammonium heptamolybdate is not classified in the CLP regulation and must be self-classified. Local code may apply.

Pictogram(s):	UN GHS CLP – none	EU CLP - None
Signal Word:	UN GHS CLP – Warning	EU CLP - None
Hazard Statement(s):	UN GHS CLP – H303+H313+H333	EU CLP - None
H303+H313+H333	May be harmful if swallowed, in contact with skin or if inhaled.	
Precautionary:	UN GHS CLP – P312	EU CLP – None
P312	Call a POISON CENTER/doctor if you feel unwell.	
Storage:	UN GHS CLP – None	EU CLP – None
Disposal:	UN GHS CLP – None	EU CLP – None

(2.2.2)
Labeling according to EU Directive 67/548/EEC: Hexaammonium heptamolybdate is not classified in the CLP regulations and must be self-classified. Local codes may apply.

Risk phrase(s): **None**

Safety phrase(s): **S 22** Do not breathe dust.
S 46 If swallowed, immediately contact a doctor and show this container or label.

Prevention: Use personal protective equipment as required. Wear respiratory protection. See your supervisor.

Response: If overly exposed or concerned, get medical advice/attention. Immediately call a poison center or doctor/physician. Wash contaminated clothing before reuse.

Storage: Keep container tightly closed.

(2.3)
Other hazards: The substance does not meet the criteria for a PBT or vPvB substance. No environmental, toxicological or physico-chemical hazards identified.

Section 3 Composition/Information on Ingredients

(3.1)

Substance/Chemical	Chemical formula	CAS No	EC No	Content
Hexaammonium heptamolybdate	$(NH_4)_6Mo_7O_{24}{\cdot}4H_2O$	12027-67-7 and/or 12054-85-2	234-722-4 and/or 234-320-9	100%

Section 4 First Aid Measures

Note: The following generic first aid measures should be applied as usual when handling any chemical substance. See Section 8 for normal routine handing.

(4.1)
Description of first aid measures.

(4.1.1)
General Advice: First-aid responders should wear suitable personal protective equipment in case of insufficient ventilation or possible inhalation or eye contact.

(4.1.2)
Following Inhalation: Remove patient from exposure and bring to fresh air. If breathing has stopped, perform artificial respiration and get medical advice/attention immediately.

(4.1.3)
Following skin contact: Wash skin with water and soap, and rinse thoroughly. If skin irritation occurs, get medical advice/attention.

(4.1.4)
Following eye contact: Check for and remove any contact lenses. Immediately flush eyes with plenty of water, occasionally lifting upper and lower eyelids, for several minutes. If irritation occurs, get medical advice/attention.

(4.1.5)
After ingestion: Seek medical advice/attention if feeling unwell.

(4.2)

Most important symptoms and effects, both acute and delayed: Acute or delayed effects are not anticipated for Hexaammonium heptamolybdate.

(4.3)
Indication of any immediate medical attention and special treatment needed: No specific treatment expected to be required.

Notes to Physician: Long term exposure to high dust concentrations may cause changes in lung function (i.e. pneumoconiosis) caused by particles less than 0.5 micron penetrating and remaining in the lung. A prime symptom is breathlessness. Lung shadows show on X-rays. Pre-employment and periodic physical examinations should include irritant effects to eyes or respiratory tract and the general health of the worker.

Section 5 Fire Fighting Measures

Note: Hexaammonium heptamolybdate is not flammable / combustible and it does not support fires (no oxidizing properties). Nevertheless, below are given some general firefighting measures, which should be adjusted to the surroundings (e.g. other, hazardous chemicals involved, packaging materials...).

(5.1)
Extinguishing media

(5.1.1)
Suitable extinguishing media: Standard extinguishing media such as water, sand, foam. Use firefighting measures that suit the location and surroundings. Hexaammonium heptamolybdate is not considered flammable or combustible.

(5.1.2)
Unsuitable extinguishing media: None. Use firefighting measures that suit the location and surroundings.

(5.2)
Special hazards arising from the substance or mixture: None.

(5.3)
Advice for fire fighters: Standard extinguishing media such as water, sand, foam. Use firefighting measures that suit the location and surroundings. Hexaammonium heptamolybdate is not considered flammable or combustible.

Section 6 Accidental Release Measures

Note: As far as it is known, the recommended OELs incorporate a large margin of safety in normal handling and storage. Control work areas to below the recommended OEL. The following generic accidental release measures should be applied as usual when handling any chemical substance.

(6.1)
Personal precautions, protective equipment and emergency procedures

(6.1.1)
For non-emergency personnel: Avoid formation and inhalation of dust. Seek to ensure ventilation that maintains airborne concentrations below Occupational Exposure Limits (OELs). Keep unprotected persons away. Although the substance has no acute toxicity, it is advised to avoid contact with skin, eyes, and clothing – wear suitable protective equipment.

(6.1.2)
For emergency responders: Avoid formation and inhalation of dust. Seek to ensure ventilation that maintains airborne concentrations below OELS. Keep unprotected persons away. Although the substance has no acute toxicity, it is advised to avoid contact with skin, eyes, and clothing – wear suitable protective equipment.

(6.2)
Environmental precautions: Although the substance is not classified as dangerous to the environment, it is advised that in the event of an accidental release the product should be prevented from reaching the sewage system or any water course, and from penetrating the ground/soil. Dispose of spilled material in accordance with the relevant local regulations. See Section 13 for disposal considerations.

(6.3)

Methods and material for containment and cleaning up: Avoid formation and inhalation of dust. Use an appropriate industrial vacuum cleaner, equipped with ULPA or HEPA filters. Collect spilled material in suitable containers or bags for recovery or disposal. In the case of disposal, spilled material or contaminated material should be disposed of as waste as described in Section 13.

(6.4)
Reference to other sections: For more information on exposure controls/personal protection or disposal considerations, check Sections 8 and 13 of this Data Sheet.

Section 7 Handling and Storage

Note: As far as it is known, the recommended OELs incorporate a large margin of safety in normal handling and storage. Control work areas below the recommended OEL. The following generic advice on handling and storage should be followed as for any chemical substance.

(7.1)
Precautions for safe handling

(7.1.1)
Protective measures: Avoid formation of dust, inhalation and ingestion. General occupational hygiene practice should always be followed (see 7.1.2 below).

(7.1.2)
Advice on general occupational hygiene: Avoid formation of dust, inhalation and ingestion. General occupational hygiene measures are required to ensure safe handling of the substance. These measures involve good personal and housekeeping practices (i.e. regular cleaning with suitable cleaning devices), no eating, drinking and smoking at the workplace and wearing standard working clothes and shoes unless otherwise stated. Wash hands after contact with the powder or fume. Remove contaminated clothing and protective equipment before entering eating areas. Shower and change clothes at end of work shift. Do not wear contaminated clothing home. Do not blow dust off with compressed air.

(7.2)
Conditions for safe storage, including any incompatibilities: Store in closed container in a dry area. Do not store in open, inadequate or miss-labeled packaging.

(7.3)
Specific end use(s): See the Identified Uses in Section 1.2 of this Data Sheet.

Section 8 Exposure Controls / Personal Protection

(8.1)
Control parameters

(8.1.1)
US OSHA PEL control parameter for soluble Molybdenum compounds is an 8-hour TWA of 5.0 mg/m³. This is only one of many country control limits that are in use worldwide for soluble molybdenum compounds but not the most restrictive. It's recommended that you consider as a control measure the OEL used in your locality. **Additional country and agency control limits are listed in Section 16.7.2, Other Information.** The appropriate collection method is also country OEL related and you must follow the local country's protocols on collection and analysis which change from time to time and may not be codified.

(8.1.2)
PNECs and DNELs:

Exp. pattern	Route	Descriptor	DNEL / PNEC
Long-term - systemic effects	Inhalation	DNEL (Derived No Effect Level)	20.55 mg/m³ for Hexaammonium heptamolybdate ($(NH_4)_6Mo_7O_{24}$. $4(H_2O)$) (corresponds to 11.17 mg Mo/m³) Note: derived for formal reasons in the REACH registration dossier. This value is usually superseded by lower occupational exposure limits for (soluble) molybdenum compounds or general dust limits.

Long-term - chronic effects	Freshwater	PNEC (Predicted No Effect Concentration)	12.7 mg Mo/L, equivalent to 23.4 mg $(NH_4)_6Mo_7O_{24} \cdot 4\ H_2O$/L
Long-term - chronic effects	Marine	PNEC (Predicted No Effect Concentration)	1.9 mg Mo/L, equivalent to 3.5 mg $(NH_4)_6Mo_7O_{24} \cdot 4\ H_2O$/L
Long-term - chronic effects	Freshwater sediment	PNEC (Predicted No Effect Concentration)	22.6 g Mo/kg dw, equivalent to 41.6 g $(NH_4)_6Mo_7O_{24} \cdot 4\ H_2O$/kg dw
Long-term - chronic effects	Marine sediment	PNEC (Predicted No Effect Concentration)	1.98 g Mo/kg dw, equivalent to 3.64 g $(NH_4)_6Mo_7O_{24} \cdot 4\ H_2O$/kg dw
Long-term - chronic effects	Soil	PNEC (Predicted No Effect Concentration)	11.8-188 mg Mo/kg dw, equivalent to 21.7 - 346 mg $(NH_4)_6Mo_7O_{24} \cdot 4\ H_2O$/ kg dw (dependent upon soil type)
Long-term – chronic effects	STP	PNEC (Predicted No Effect Concentration)	21.7 mg Mo/L, equivalent to 39.9 mg $(NH_4)_6Mo_7O_{24} \cdot 4\ H_2O$/L

Also see GESTIS DNEL Database; http://www.dguv.de/ifa/Gefahrstoffdatenbanken/GESTIS-DNEL-Datenbank/index-2.jsp.

(8.2)

Exposure controls: In some circumstances, high airborne dust concentrations may require local or general ventilation to control worker exposure. Where natural or mechanical ventilation is unable to control the workplace dust levels to below the local or regional OEL, than respirator controls must be used. Exposure controls specific to this substance may not be required, other than good hygiene practice and adherence to national and regional provisions with regards to exposure to dusts in the workplace. National, regional or local provisions or limit values may also apply for emissions to air or water. The generic advice on accidental release measures or handling and storage is given in sections 6 and 7 and should be followed to minimize release/exposure.

(8.2.1)

Engineering Controls: Provide local exhaust ventilation as needed to stay below the OEL. If risk of overexposure exists to excessive dust or fume, then wear a properly fitted approved respirator.

(8.2.2)

PPG/PPE protection and selection)

(8.2.2.1)

Eye and Face: Use safety glasses with side shields; or as required, chemical goggles. Contact lenses may pose a special hazard [(5)]; soft contact lenses may concentrate irritants. A written policy document, describing the wearing of contact lenses or restrictions on use, should be created for each workplace or task. This should include a review of lens absorption and adsorption for the class of chemicals in use and pass injury experience. Medical and first-aid personnel should be trained in their removal and suitable equipment should be readily available. In the event of chemical exposure, begin eye irrigation immediately and remove contact lens as soon as practicable. Lenses should be removed at the first signs of eye redness or irritation - lenses should be removed in a clean environment only after workers have washed hands thoroughly. Where there is a high potential for eye contact, an eyewash station/unit should be readily available within a 10-second walk. To avoid eye and face contact, use a full-face shield (20 cm, 8 in minimum) but never use as primary eye protection. Alternatively, a full-face respirator may replace both eye glasses and face shields. [(4)]

(8.2.2.2)

Skin, Hand and Feet: Material may cause slight skin irritation over a prolonged time. Wear ordinary cloth, leatherwork, latex, PVC or laminate gloves with proper material weight or thickness that is suitable for each task type. Use at a minimum 1.0 mm thickness for glove material. For foot, use good quality safety shoes or boots approved by local code.

Other: Use overalls with cloth apron for light duty. Use a disposable protective suit if there is a high potential for skin contact.

(8.2.2.3)

Respirator: If dust generation is excessive, use an appropriate dust-filtering respirator that is properly fit tested to the user. (4)

Respirator Protection factor up to 50 mg/m^3:

(APF = 25) Any supplied-air respirator operated in a continuous-flow mode.

(APF = 25) Any powered, air-purifying respirator with high-efficiency particulate filter.

(APF = 50) Any respirator with a full face piece and N100, R100, or P100 filters.
(APF = 50) Any air-purifying, full face piece respirator (gas mask) with a chin-style, front- or back mounted canister having an N100, R100, or P100 filter.
(APF = 50) Any self-contained breathing apparatus with a full face piece.
(APF = 50) Any supplied-air respirator with a full face piece

Emergency or planned entry into unknown concentrations or IDLH conditions:

(APF = 10,000) Any self-contained breathing apparatus that has a full face piece and is operated in a pressure-demand or other positive-pressure mode.
(APF = 10,000) Any supplied-air respirator that has a full face piece and is operated in a pressure demand or other positive-pressure mode in combination with an auxiliary self-contained positive-pressure breathing apparatus.

Escape:

(APF = 50) Any air-purifying, full-face piece respirator (gas mask) with a chin-style, front- or back mounted canister having an N100, R100, or P100 filter. Any appropriate escape-type, self-contained breathing apparatus.

Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres; use a supplied air respirator if oxygen-deficient**.**

(8.2.2.4)
Thermal Hazards: None

Section 9 Physical and Chemical Properties

(9.1)
Information about basic physical and chemical properties:

(a) Appearance	Solid, crystalline, white to slightly greenish or yellowish, odorless, inorganic.
(b) Odor	Odorless.
(c) Odor threshold	Not applicable as odorless.
(d) pH	Not applicable.
(e) Melting point	Hexaammonium heptamolybdate decomposes from ca. 90℃.[26]
(f) Initial boiling point and boiling range	Not applicable
(g) Flash point	Not applicable as only relevant for liquids or low melting point solids.
(h) Evaporation rate	Negligible at ambient temperatures.
(i) Flammability (solid, gas)	Not flammable.
(j) Upper/lower flammability or explosive limits	Not flammable or explosive.
(k) Vapor pressure	As an inorganic, crystalline solid, Hexaammonium heptamolybdate does not have a vapor pressure as such. Ammonia evaporates from the substance, specifically if heated (see melting point).
(l) Vapor density	Not applicable (there are no Hexaammonium heptamolybdate vapors).
(m) Relative density	2.86 at 20℃ [27]
(n) Solubility(ies)	206.5 g/L in water at 20℃ [28].
(o) Partition coefficient n-octanol/water	Not applicable for inorganic substances.
(p) Auto-ignition temperature	Not applicable (Hexaammonium heptamolybdate is not combustible/flammable and thus does not auto-ignite).
(q) Decomposition temperature	Hexaammonium heptamolybdate decomposes from ca. 90℃.[26]
(r) Viscosity	Not applicable (solid).
(s) Explosive properties	Non explosive.
(t) Oxidizing properties	Not oxidizing. Read-across from study with pure molybdenum trioxide (MoO_3), which also contains

molybdenum in its highest oxidation state (+VI) [29].

(9.2)
Other information: Not applicable.

Section 10 Stability and Reactivity

(10.1)
Reactivity: Stable under ambient temperatures and pressures.

(10.2)
Chemical stability: Stable under ambient temperatures and pressures.

(10.3)
Possibility of hazardous reactions: According to "Bretherick's Handbook" [40] molybdates react violently or explosively when reduced to molybdenum by heating with zirconium. Other hazardous reactions have not been identified.

(10.4)
Conditions to avoid: No specific conditions to avoid have been identified**.**

(10.5)
Incompatible materials: Hexaammonium heptamolybdate is incompatible with copper and copper-containing materials including bronze and brass.

(10.6)
Hazardous decomposition products: Upon thermal decomposition, gaseous ammonia (NH_3) evolves from hexaammonium heptamolybdate. Ammonia is classified as a hazardous substance according to regulation (EC) No.1272/2008 ("CLP regulation") as follows. There are two entries:

Index No. 007-001-00-5, "ammonia, anhydrous", EC No. 231-635-3, CAS 7664-41-7

Flam. Gas 2,	H221: Flammable Gas
Press. Gas,	H331
Acute Tox 3,	H331: toxic if inhaled
Skin Corr. 1B,	H314: Causes severe skin burns and eye damage
Aquatic Acute 1,	H400: Very toxic to aquatic life

Index No. 007-001-01-2, "ammonia ...%", EC No. 215-647-6, CAS 1336-21-6

Skin Corr. 1B,	H314: Causes severe skin burns and eye damage
Aquatic Acute 1,	H400: Very toxic to aquatic life

Section 11 Toxicological Information

Note: As far as it is known, the recommended OELs incorporate a large margin of safety against potential acute or chronic effects. Maintain work areas below the recommended OEL.

(11.1)
Information on toxicological effects: The information provided in this section is consistent with the information provided in the REACH Chemical Safety Report (CSR) for Hexaammonium heptamolybdate. Further information can be obtained from the REACH Molybdenum Consortium, an initiative of the International Molybdenum Association (IMOA). For contact details, please refer to Section 16.7.4 of this data sheet.

Toxicity endpoints	Description of effects
Toxicokinetics: Absorption, Distribution, Metabolism and Excretion	Molybdenum is an essential element. Up-taken Hexaammonium heptamolybdate dissolves and exists predominantly in the form of the molybdate ion (MoO42-) and ammonium ions. The latter are not to be of any concern regarding toxicological effects and are not explicitly considered further in this section. **Oral absorption**: Rapid and almost complete absorption through GI tract. **Inhalation absorption:** Well absorbed based on animal data. Absorption in humans dependent on particle size, deposition/clearance. **Dermal absorption:** Low to negligible.

	Metabolism: No metabolism. Molybdenum compounds transform quickly to molybdate anions (MoO_4^{2-}) upon dissolution. **Excretion:** Rapidly eliminated from plasma predominantly via renal excretion (>80%), and feces (<10%).
(a) acute toxicity	Low acute toxicity LD50, oral, rat: > 2000 mg/kg bw (male/female) [30] LD50, dermal, rat: > 2000 mg/kg bw (male/female) [31] LC50, inhalation, rat (4h): > 5.0 mg/L (male/female) [32]
(b) skin corrosion/irritation	Not irritating / not corrosive to the skin (read-across from diammonium dimolybdate) [33].
(c) serious eye damage/irritation	Not irritant / not corrosive to the eyes (read-across from diammonium dimolybdate) [34].
(d) respiratory or skin sensitization	Hexaammonium heptamolybdate is not sensitizing to the skin (read-across from several other comparable molybdenum substances [e.g. 35].) There is no data indicating respiratory sensitization.
(e) germ-cell mutagenicity	Not a germ cell mutagen. Negative test results three tests with sodium molybdate for: Bacterial reverse mutation assay [36], in vitro micronucleus assay in human lymphocytes [37], and in vitro gene mutation assay (tk) in mouse lymphoma cells [38]. Unrestricted read-across from sodium molybdate to Hexaammonium heptamolybdate.
(f) carcinogenicity	Not a carcinogen.
(g) reproductive toxicity	There are currently no reliable scientific data available indicating adverse effects on reproduction or fertility.
(h) STOT-single exposure	There are no specific target organ effects after single exposure to Hexaammonium heptamolybdate.
(i) STOT-repeated exposure	No reliable scientific data available indicating adverse systemic effects after repeated exposure to molybdenum substances.
(j) aspiration hazard	Not applicable (not an aerosol/mist).

(11.2)
Other information

Molybdenum is an essential trace element required in nitrogen metabolism in the human body. It enhances cell function and is a component in the metabolic process. It is distributed throughout the body, with the greatest concentration in the liver, where it functions as a facilitator for liver detoxification. It is vital for the function and formation of several (at least 3) enzymes in the body, one of which regulates urinary excretion. Molybdenum contributes to the enzymes which neutralize excess toxic compounds of sulfur in the body; assisting in the production of hemoglobin; and preventing dental caries. It may help to eliminate or neutralize carcinogenic nitrogen compounds, and may play a role in male sexual function. It has been researched for its role in cancer prevention. It also has been associated with a decrease in dental cavities.

Studies report that there is a 30 percent increase in cancer of the esophagus in areas of the United States where there is no molybdenum in the drinking water and also in areas where food is grown in molybdenum-poor soils. Low molybdenum intake has been attributed to the high incidence of esophageal cancer in South Africa among the Bantu of Transkei and in Russia but may be related to a lack of molybdenum in the soil used for farming. Another study of soft and hard drinking water in Taiwan indicated an increased risk of esophageal cancer when drinking soft water. [41] Molybdenum is best known for its role in eradicating esophageal cancer that was prevalent in the Lin Xian region of China for almost 2,000 years [40]. Once the soil was fortified with molybdenum and vitamin C was made available to the population, the occurrence of esophageal cancer has declined dramatically.

Some studies indicate an increased incidence of non-specific symptoms which including headache, weakness, fatigue, anorexia and joint and muscle weakness has been reported to occur in mining and metallurgy workers exposed to 60-600 mg (as Mo). In addition, investigators have attributed gout and elevated uric acid concentration found in some Armenians to result from exposures to Armenian soils rich in molybdenum, and exposure has been implicated as a cause of bone disease amongst Indians. However, US National Research Council believes these reports as being highly speculative. As far as it is known, the recommended OELs incorporate a large margin of safety against potential pulmonary or systemic effects.

The use of vitamin supplements may provide the molybdenum needed to prevent cancer since molybdenum has anti-carcinogenic (anti-cancer) properties in regard to breast cancer in animals, esophageal cancer and stomach cancer in humans, which may be due to the copper-inhibiting effect of molybdenum, or possibility by molybdenum protecting the body from nitrosamine formation as a result of consuming foods high in nitrates or nitrites.

Section 12 Ecological Information

Note: Data in this section is voluntarily in the U.S.A. but may be required in the EU and/or other countries.

(12.1)
Toxicity

(12.1.1)
Reliable acute aquatic toxicity test results: (tests conducted with sodium molybdate; UV-spectra of aqueous solutions of Hexaammonium heptamolybdate demonstrated that the only dissolved molybdenum species, originating directly from Hexaammonium heptamolybdate is molybdate); critical values for classification are also expressed as mg $(NH_4)_6Mo_7O_{24} \cdot 4\ H_2O$)/L.

Test Organisms:	End-point	Range of values	References
Freshwater fish: *Pimephales promelas*	96h-LC50	609 – 681.4 mg Mo/L (1,121-1,254 mg (NH4)6Mo7O24 · 4 H2O /L)	[1]
Freshwater fish: *Oncorhynchus mykiss*	96h-LC50	7600 mg Mo/L	[2]
Freshwater fish: *Oncorhynchus mykiss*	96h-LC50	781 – 1339 mg Mo/L (recalculated – logistic fit)	[3]
Invertebrates: *Daphnia magna*	48h-LC50	1680.4 – 1776.6 mg Mo/L	[1]
Invertebrates: *Daphnia magna*	48h-LC50	2729.4 mg Mo/L	[4]
Invertebrates: *Daphnia magna*	48h-LC50	2847.5 mg Mo/L	[5]
Invertebrates: *Daphnia magna*	48h-LC50	130.9 mg Mo/L (240.9 mg (NH4)6Mo7O24 · 4 H2O/L)	[6]
Invertebrates: *Ceriodaphnia dubia*	48h-LC50	1005.5 – 1024.6 mg Mo/L	[1]
Invertebrate (aq. worm):*Girardia dorotocephala*	96h-LC50	1226 mg Mo/L	[1]
Algae: *Pseudokirchneriella subcapitata*	72h-ErC50 (growth rate)	295.0 – 390.9 mg Mo/L 289.2 – 369.6 mg Mo/L Geom. mean: 333.1 mg Mo/L (613 mg (NH4)6Mo7O24 · 4 H2O/L	[7] [8]

Tests were conducted according to international test guidelines (e.g., OECD) or scientifically acceptable methods.

(12.1.2)
Reliable chronic toxicity test results: (read-across from tests with sodium molybdate; UV-spectra of aqueous solutions of Hexaammonium heptamolybdate demonstrated that the only dissolved molybdenum species, originating directly from Hexaammonium heptamolybdate is molybdate):

Test organisms	Range of values (EC_{10} or NOEC)	References
Aquatic freshwater toxicity data		
Oncorhynchus mykiss, Pimephales promelas, Pseudokirchneriella subcapitata, Ceriodaphnia dubia, Daphnia magna, Chironomus riparius, Brachionus calyciflorus, Lymnaea stagnalis, Xenopus laevis, Lemna minor	43.3–241.5 mg Mo/L	[1], [4], [7], [8], [9], [10], [11]
Most sensitive species were the fish *O. mykiss* (43.3 mg Mo/L) and *P. promelas* (60.2 mg Mo/L). Symptoms of toxicity were effects on biomass growth, reproduction, (population) growth rate and malformation during development.		
Aquatic marine toxicity data		
Mytilus edulis, Acartia tonsa, Phaeodactylus tricornutum, Cyprinodon variegatus, Americamysis bahia, Crassostrea gigas, Dendraster excentricus, Dunaliella tertiolecta, Ceramium tenuicorne, Strongylocentrotus purpuratus,	4.4–1,174 mg Mo/L	[12], [13], [14], [15], [16], [17], [18], [19]
Most sensitive species were the mussel *M. edulis* (4.4 mg Mo/L) and the copepod *A. tonsa* (7.96 mg Mo/L). Symptoms of toxicity		

include effects on biomass growth, growth rate, reproduction and malformation during development		
Chronic sediment toxicity		
No reliable acute/chronic sediment data for molybdenum available. PNEC derivation was based on the equilibrium partitioning method, taking into account the $PNEC_{freshwater}$ and the sediment K_d given in section 12.4.		
Chronic terrestrial toxicity test results (values were determined in different top soils with contrasting properties and spiked with sodium molybdate):		
Annelid worms: *Enchytraeus crypticus, Eisenia Andrei*	7.88 -1661 mg Mo/kg dw (n=11)	[20]
Arthropod: *Folsomia candida*	37.9 – >3395 mg Mo/kg dw	[20]
Plants: *Hordeum vulgare, Brassica napus, Trifolium pratense, Lolium perenne, Lycopersicon esculentum*	4 – 3476 mg Mo/kg dw	[21]
Soil micro-organisms (nitrification, glucose-induced respiration, plant residue mineralization)	10 – 3840 mg Mo/kg dw	[22]
Plants are most sensitive, with reduced shoot yield being the most first symptoms of toxicity, followed by reduced reproduction of invertebrates. Toxicity of sodium molybdate dihydrate in soils is dependent on the soil type. Sandy soils (e.g., 5% clay) with a low organic carbon content (e.g., 1%), a low iron oxide content (e.g., 0.5 g/kg) and high pH (e.g., 7) are most sensitive, while clay soils (e.g., 30% clay) with a high organic carbon content (e.g., 12%), high iron oxide content (e.g., 10 g/kg) and low pH (e.g., 4.5) are least sensitive.		

Tests were conducted according to international test guidelines (e.g., OECD, ASTM, ISO, EPA).

(12.1.3)

Toxicity data for micro-organisms (for STP) (values were determined using molybdenum trioxide unless indicated otherwise; UV-spectra of aqueous solutions of molybdenum trioxide demonstrated that the only dissolved molybdenum species, originating directly from molybdenum trioxide is also the molybdate anion):

Test Organisms:	End-point:	Range of values	References
Domestic activated sludge population	3h-EC_{50} (respiration inhibition)	1926 mg Mo/L	[23]
Domestic activated sludge population	3h-EC_{50} (respiration inhibition)	216.5 mg Mo/L	[23]
Domestic activated sludge population	30 min-NOEC (O_2 utilization)	> 950 mg Mo/L (1)	[24]

Tests were conducted according to international accepted test guidelines or scientifically acceptable methods. (1): test conducted with sodium molybdate

For an overview of PNECs for the different compartments see section 8.1.2.

Conclusion on the environmental classification and labeling: Hexaammonium heptamolybdate is not hazardous to the aquatic environment as:

- The lowest acute reference values for fish, invertebrates and algae are > 100 mg Mo/L
- The lowest aquatic NOEC for these three trophic levels is > 1 mg Mo/L (i.e., 43.2 mg Mo/L for the rainbow trout)
- There is no evidence for bioaccumulation or bio-magnification in the environment

(12.2)

Persistence and degradability: Hexaammonium heptamolybdate – when released into the environment - will rapidly dissolve and will be present as the molybdate species under normal environmental conditions.

(12.3)

Bioaccumulative potential: Available BCF/BAF data for the aquatic environment show a distinct inverse relationship with the exposure concentration. This finding demonstrates that molybdenum is homeostatically controlled by these organisms, and this is so up to the milligram range of exposure. Available information on transfer of molybdenum through the food chain indicates that molybdenum does not bio-magnify in aquatic food chains.

Although not homeostatically controlled in terrestrial plants and invertebrates, molybdenum is not largely concentrated from soil into plants or soil to invertebrates. There is no significant concentration increase from diet to mammals or birds. It is concluded that bio-magnification is not significant in the terrestrial food-chain.

(12.4)

Mobility in soil: Molybdate originating from Hexaammonium heptamolybdate is soluble in water and with its relatively low K_d value, the molybdate ions are leachable through normal soil and are mobile in

sediment. Typical log K_d-values of 3.25 and 2.94 have been determined for sediment and soil, respectively.

(12.5)
Results of PBT and vPvB assessment: The PBT and vPvB criteria of Annex XIII to the REACH Regulation do not apply to inorganic substances, such as hexaammonium heptamolybdate. Therefore a PBT and vPvB assessment is not required.

(12.6)
Other adverse effects: Molybdate originating from hexaammonium heptamolybdate can contribute to the onset of molybdenosis (which is a molybdenum-induced copper deficiency) in ruminants such as cattle, deer, and sheep. The level and bio-availability of copper in the animal diet are critical factors in the onset of molybdenosis. The recommended minimum dietary Cu:Mo mass ratio threshold to prevent molybdenosis is 1.30, i.e. there should be 30% more copper than molybdenum in the diet (note: mass ratio, not molar ratio). Cu & Mo content in the diet can be monitored, and if the ratio is < 1.3 then provide Cu supplements such as copper sulphate enriched feeds or copper sulphate enriched salt blocks for ruminants to use *ad libitum*. If there are ruminants in the vicinity of the plant, identify direct and diffuse air emission sources at the plant and carry out and record emission minimization measures. Have an animal health check program in place (e.g. blood tests for copper) to verify that the measures are effective.

Diammonium dimolybdate is not expected to contribute to ozone depletion, ozone formation, global warming or acidification. Diammonium dimolybdate is considered to be environmentally neutral.

Additional adverse effects: Conversely, a lack of molybdenum in the diet of the human population may increase gastrointestinal and esophageal cancer. [41][42]

Section 13 Disposal Considerations

Note: Data in this section is voluntarily in the U.S.A. but may be required in the EU and/or other countries.

(13.1)
Waste treatment methods: Waste (substance and container material) shall be recycled/recovered or disposed of as applicable and in accordance with community (EU) and local legislation.

Recycle wherever possible. Consult state land waste management authority for disposal. Bury at an approved site. Recycle containers if possible, or dispose of in an authorized landfill.

(13.2)
According to the European Waste Catalogue: Waste Codes are not product specific but application specific. Waste Codes should be assigned by the user based on the application in which the product is used.

(13.3)
For USA Disposal: Waste must be disposed of in accordance with federal, state, and local environmental control regulations.

(13.4)
Other disposal recommendations: No additional data available.

Section 14 Transportation Information

Note: Data in this section is voluntarily in the U.S.A. but may be required in the EU and/or other countries.

Regulation (abbreviation)	Regulation (title)	Transport classification
ADR	European Agreement concerning the International Carriage of Dangerous Goods by **Road**	None
RID	Regulations concerning the International Carriage of Dangerous Goods by **Rail**	None
ADN	European Agreement concerning the International Carriage of Dangerous Goods by **Inland Waterways**	None
IMDG	International **Maritime** Dangerous Goods	None
IATA	Technical Instructions for the Safe Transport of Dangerous Goods by **Air**	None

(14.1)

UN number: None, Not Dangerous for Transport

(14.2)
UN proper shipping name: None, Not Dangerous for Transport

(14.3)
Transport hazard class(es): None, Not Dangerous for Transport

(14.4)
Packing group: None, Not Dangerous for Transport

(14.5)
Environmental hazards: None, Not Dangerous for Transport

(14.6)
Special precautions for user: None, Not Dangerous for Transport

(14.7)
Transport in bulk according to Annex II of MARPOL 73/78 and the IBC Code: None

EU/UK Guidance - Transportation: The product is not individually listed in the United Nations/Economic Commission for Europe (ECE) agreement, ADR [47] 2003, Volume I, Table A or B of Chapter 3.2. The user is advised to consider the physical, chemical and physiological properties of the product in light of the classification criteria set out within ADR to ascertain whether the product is considered to be dangerous for carriage under EU/UK laws.

The user is also advised to refer to the HSE/Department of Transport guide 'Working with ADR: an introduction to the carriage of dangerous good by road' and the HSG guide HSG136 "Workplace Transport Safety: Guidance for Employers." Additional help can be found at the web site – www.unece.org/trans/danger/publi/adr/adr_e.html. [Web link checked 23 July 2013]

US DOT Transportation Data (49 CFR 172.101)

Proper Shipping Name: Metal powders (molybdenum), Flammable, N.O.S.
Non-Hazardous for Transport: No.

Canada - Canadian Transportation of Dangerous Goods: No classification assigned.

Section 15 Regulatory Information

Note: Data in this section is voluntarily in the U.S.A. but may be required in the EU and/or other countries.

(15.1)
Safety, health and environmental regulations/legislation specific for the substance or mixture

(15.1.1)
Worldwide Chemical Inventories: See section 16.7.3 for list of countries where you will find hexaammonium heptamolybdate (CAS 12411-64-2) on chemical inventories and regulatory lists. Hexaammonium heptamolybdate is not a SEVESO substance, not an ozone-depleting substance and not a persistent organic pollutant.

(15.1.2)
Other regulatory information - Refer to any national measures that may be relevant.

Relevant Legislation:

EU Directives: Waste Framework Directive (75/442/EEC)
Hazardous Waste Directive (91/689/EEC)
Council Directive 76/769/EEC
Council Directive 76/464/EEC
Groundwater Directive (80/68/EEC)
Directive 2003/28/EC (transport of dangerous goods by road)
Directive 2003/29/EC (transport of dangerous goods by rail)

Directive 1999/36/EC (transportable pressure equipment)

UK Acts of Parliament:The Environmental Protection Act 1990 (as amended)
Environment Act 1995 (as amended)
The Health and Safety at Work Act 1974 (as amended)

UK Regulations: Control of Substances Hazardous to Health Regulations 2002 (as amended)
Control of Major Accident Hazards Regulations 1999
Groundwater Regulations 1998
Special Waste Regulations 1996
Health and Safety (First-Aid) Regulations 1981
Personal Protective Equipment Regulations 2002
Personal Protective Equipment at Work Regulations 1992
The Carriage of Dangerous Goods and Use of Transportable Pressure Equipment Regulations 2004.

Note - In addition to the principal legislation referred to above the user should also refer to other acts and implementing environmental and health and safety legislation and guidance that are relevant to the intended handling or use of the product.

UK Guidance: HSE Guidance Note "*COSHH Essentials: Easy Steps to Control Chemicals"* HSG193 HSE Books
HSE guide HSG53 "The selection, use and maintenance of respiratory protective equipment: A Practical Guide."
HSE guide HSG136 "Workplace transport safety: Guidance for Employers"
The HSE/Department of Transport Guide "Working with ADR: An introduction to carriage of dangerous goods by road."
First aid at work. The Health and Safety (First-Aid) Regulations 1981. Approved Code of Practice and Guidance L74 HSE Books "Occupational Exposure Limits" EH40 HSE Books 2001.

U.S. Regulations

RCRA: This product does not contain ingredients that could enable it to become a Hazardous Waste, as defined by 40 CFR 260.10, if the product is discarded.

Clean Air Act: This product does not contain ingredients identified as Hazardous Air Pollutants in CAA Section 112(b).

Safe Drinking Water Act: This product does not contain ingredients for which there are secondary Maximum Concentration Limits established. See 40 CFR 141.62.

Clean Water Act: This product does not contain compounds identified in 40 CFR 116.4.

EPCRA, SARA Title III, Section 313 (40 CFR 372): Chemical not subject to reporting requirements.

CERCLA Hazardous Substances: CERCLA reporting for releases of this product into the environment is not required.

DOT: See Section 14 Transport Information

U.S.A. State Right to Know Laws - Molybdenum is found on the following Right-to-Know lists in New Jersey, Florida, Pennsylvania, Minnesota and Massachusetts. Not found on California Proposition 65 list. Does not contain any contaminants or bi-products known to the State of California to cause cancer or reproductive toxicity.

TSCA Inventory Status:	Y
TSCA 12(b) Export Notification:	Not listed
CERCLA Section 103 (40 CFR 302.4):	N
SARA Section 302 (40 CFR 355.30):	N
SARA Section 304 (40 CFR 355.40):	N
SARA Section 313 (40 CFR 372.65):	N
OSHA Process Safety (29 CFR 1910.119):	N

SARA Hazard Categories, SARA Sections 311/312 (40 CFR 370.21)

Acute Hazard:	N
Chronic Hazard:	N
Fire Hazard:	N
Reactivity Hazard:	N
Sudden Release Hazard:	N

Canadian - DSL/NDSL: Listed
WHIS Classification: Not listed
Ingredient Disclosure List: Not Listed

(15.2)
Chemical safety assessment: A Chemical Safety Assessment has been carried out by the Molybdenum Consortium for its members in the context of the REACH registration. For contact details, see Section 16.7.4.

(15.3)
Other Labeling information: This EU Labeling is being replaced and eliminate by June 1, 2015, use the GHS/CLP for labeling.

Risk phrase(s): **None**
Safety phrase(s): **S 22** Do not breathe dust.
S 46 If swallowed, immediately contact a doctor and show this container or label

EU Regulations: This safety data sheet is in compliance with the following EU legislation and its adaptations – as far as applicable - : 67/548/EEC, 1999/45/EC, 76/769/EEC, 98/24/EC, 92/85/EEC, 94/33/EC, 91/689/EEC, 1999/13/EC, (EC) No. 1907/2006 (REACH) as well as the following British legislation: The Control of Substances Hazardous to Health Regulations (COSHH) 2002, COSHH Essentials, and the Management of Health and Safety at Work Regulations 1999.

This material is not subject to the Montreal Protocol, the Stockholm Convention or the Rotterdam Convention.

Germany: Water Hazard class, WGK = 1 (low hazard to water)

Imports to the UK - Listed on the Approved Supply List: No, not listed

Product falls within one of the categories of danger specified in Column 1 of Schedule 1 to the Chemicals (Hazard Information and Packaging for Supply) Regulations 2002: Yes

Section 16 Other Information

(16.1)
Version: 17 Feb 2014 **Creation Date:** 22 August 2011

(16.1.1)
Reason for Change: New Safety Data Sheet for compliance with regulation (EC) No. 1907/2006 (“REACH”). The information provided in this SDS is consistent with the information provided in the REACH chemical safety report (CSR) for Hexaammonium heptamolybdate, submitted to the European Chemicals Agency in September 2010. This SDS replaces an older Climax Molybdenum Company for Hexaammonium heptamolybdate (AHM) MSDS. 15 March 2012, add USA regulatory and Canadian statements. 30 August 2013 – update web link information. Add U.S. OSHA HazCom changes. 17 Feb 2014 – add poison center numbers and change protective clothing.

(16.2)
Abbreviations and acronyms that may have been used in this safety data sheet:

APF	Applied Protection Factor
bw	Body weight
CSA	Chemical Safety Assessment
CSR	Chemical Safety Report
DNEL	Derived No Effect Level
ECHA	European Chemicals Agency
(e-)SDS	(Extended) Safety Data Sheet
i	Inhalable
IARC	International Agency for Research on Cancer
OEL	Occupational Exposure Limit
OELV	Occupational Exposure Limit Value
PBT	persistent, bio-accumulative and toxic
PEL	Permissible Exposure Limit

PNEC	Predicted No Effect Concentration
PPE	Personal Protective Equipment
PPG	Personal Protective Gear
r	Respirable dust method
REACH	Abbreviation for regulation (EC) No. 1907/2006 on the Registration, Evaluation, Authorisation and Restriction of Chemicals.
RTECS	Registry of Toxic Effects Of Chemicals Substances
STEL	Short Term Exposure Limit
STOT	Short Term Organ Toxicity
STP	Sewage Treatment Plant
t	Total dust method
T	Thoracic
TWA	Time Weighted Average
vPvB	very Persistent and very Bio-accumulative
WES	Workplace Exposure Standard
WHO	World Health Organization

(16.3.1)

Literature reference and sources of data: The information provided in this SDS is consistent with the information provided in the REACH chemical safety report (CSR) for hexaammonium heptamolybdate. Non confidential data from the REACH registration dossier is published by the European Chemicals Agency ECHA, see http://apps.echa.europa.eu/registered/registered-sub.aspx [weblink checked 2010-11-23]

The REACH registration, CSA and CSR have been prepared by the REACH Molybdenum Consortium, an initiative of the International Molybdenum Association (IMOA). For further information, please refer to http://www.molybdenumconsortium.org/ and http://www.imoa.info [weblinks checked 2010-12-20].

(16.3.2)

Reference List:

[1] GEI Consultants, Inc (2009). Ambient Water Quality Standards for Molybdenum. Report. Testing laboratory: GEI Consultants, Ecological Division, 5575 South Sycamore Street, Suite 101, Littleton, Colorado (USA). Owner: Chevron Mining Inc, Questa, New Mexico 87556.

[2] Huntingdon Research centre (1994a). The acute toxicity of sodium molybdate dihydrate to rainbow trout (Oncorhynchus mykiss). Testing laboratory: Huntingdon Research Centre ltd. Report no.: IMA 13(b) /920163. Owner: International Molybdenum Association, 280 Earls Court, London, SW5 9AS, England. Report date: 1994-06-09.

[3] McConnell RP (1977). Toxicity of molybdenum to rainbow trout under laboratory conditions. Molybdenum in the environment vol2. The geochemistry, cycling and industrial uses of molybdenum. New York: Marcel Dekker, pp 725-730.

[4] Rodriguez (2007). Sodium Molybdate: Acute and chronic Toxicity to Daphnia magna. Final Report to the International Molybdenum Association. Testing laboratory: Chilean Mining and Metallurgy Research Center. Owner: International Molybdenum Association. Report date: 2007-08-01.

[5] Diamantino TC, Guilhermino L, Almeida E, Soareas AMVM (2000). Toxicity of sodium molybdate and sodium dichromate to Daphnia magna Straus evaluated in acute, chronic and acetylcholinesterase inhibition tests. Ecotoxicology and Environmental Safety, 45, 253-259.

[6] Huntingdon Research Centre (1994b). The acute toxicity of sodium molybdate dihydrate to Daphnia magna. Testing laboratory: Huntingdon Research Centre Ltd, PO box 2, Huntingdon, Cambridgeshire, PE18 6ES England. Report no.: IMA 13(a) /920162. Owner: International Molybdenum Association. Report date: 1994-06-09.

[7] De Schamphelaere KAC, Janssen CR (2008). MOLYTOX - Ecotoxicity of molybdate ion (MoO4(2-)) to the freshwater green alga Pseudokirchneriella subcapitata. Final Report, prepared for the International Molybdenum Association. Testing laboratory: Laboratory of Environmental Toxicology and Aquatic Ecology. Owner: International Molybdenum Association. Report date: 2008-09-01.

[8] Rodriguez PH (2008). Sodium Molybdate: Toxicity to Pseudokirchneriella subcapitata, comparative testing using CIMM and University of Gent Algae and OECD media. Final Report to The International Molybdenum Association. Testing laboratory: Chilean Mining and Metallurgy Reseach Center. Owner: International Molybdenum Association. Report date: 2008-05-01.

[9] Parametrix Environmental Research Lab (2008a). Early Life Stage Toxicity of Molybdenum to the Rainbow Trout (Oncorhynchus mykiss) Under Flow-Through conditions. Final Report prepared for the International Molybdenum Association. Testing laboratory: PERL (Parametrix Environmental Research Laboratory, 33972 Texas St. SW, Albany, Oregon, 97321. Report no.: 598-5541-001. Owner: International Molybdenum Association. Report date: 2008-06-05.

[10] Parametrix Environmental Research Lab (2007). Early Life Stage Toxicity of Molybdenum to the Fathead minnow (Pimephales promelas) Under Flow-Through conditions. Final Report prepared for the International Molybdenum Association. Testing laboratory: PERL (Parametrix Environmental Research Laboratory, 33972 Texas St. SW, Albany, Oregon, 97321. Owner: International Molybdenum Association. Study number: 598-5541-001. Report date: 2007-12-24.

[11] De Schamphelaere KAC, Nguyen LTH, Janssen CR (2008). MOLYTOX - Ecotoxicity of molybdate ion (MoO4(2-)) to eight freshwater species. Final Report, prepared for the International Molybdenum Associaton. Testing laboratory: Laboratory of Environmental Toxicology and Aquatic Ecology, Ghent University, Belgium. Owner: International Molybdenum Association. Report date: 2008-09-03.

[12] Morgan JD, Mitchell DG, Chapman PM (1986). Individual and combined toxicity of manganese and molybdenum to mussel, Mytilus edulis, larvae. Bulletin of Environmental Contamination and Toxicology 37, 303-307.

[13] Grontmij / Aquasense (2009). Tests on toxicity of molybdenum (Mo) to a selection of marine organisms. Final Report, prepared for the International Molybdenum Associaton. Testing laboratory: Grontmij/Aquasense, Colijnsplaat, The Netherlands. Report no.: Project Nr. 274811. Owner: International Molybdenum Association. Report date: 2009-10-26.
[14] Parametrix Environmental Research Lab (2009). Early Life Stage Toxicity of Molybdenum to the Sheepshead Minnow (Cyprinodon variegatus). Final Report prepared for the International Molybdenum Association. Testing laboratory: PERL (Parametrix Environmental Research Laboratory, 33972 Texas St. SW, Albany, Oregon, 97321. Report no.: 598-5541-001. Owner: International Molybdenum Association. Report date: 2008-12-01.
[15] Lehman C (2010). Disodium molybdate: life-cycle toxicity test of the saltwater mysid, Americamysis bahia, conducted under flow-through conditions. Report prepared for the International Molybdenum Association. Testing laboratory: ABC Laboratories, Inc. 7200 E. ABC Lane, Columbia. Report no.: ABC Study No 65760. Report date: 2010-08-01.
[16] Parametrix Environmental Research Laboratory (2008b). Toxicity of Molybdenum to the sand dollar Dendraster excentricus. Final Report, prepared for the International Molybdenum Association. Testing laboratory: Parametrix Environmental Research Laboratory (PERL), Albany, Oregon, USA. Report no.: Test No. 779-1. Owner: International Molybdenum Association. Report date: 2008-12-05.
[17] Parametrix Environmental Research Laboratory (2010). Toxicity of Molybdenum to the purple sea urchin (Strongylocentrotus purpuratus). Final Report, prepared for the International Molybdenum Association. Testing laboratory: Parametrix, Corvallis, Oregon, USA. Report no.: 598-5541-001. Owner: International Molybdenum Association. Report date: 2010-02-01.
[18] Le Page GC, Stewart KM, Vaughan M (2010). Sodium molybdate dihydrate: growth inhibition test with the marine and brackish water macroalgae Ceramium tenuicorne. Final Report, prepared for the International Molybdenum Associaton. Testing laboratory: Brixham Environmental Laboratory, AstraZeneca UK Limited, Brixham, Devon, TQ5 8BA, UK. Report no.: Report No BR0146/B. Owner: International Molybdenum Association. Report date: 2010-03-01.
[19] Le Page GC, Hayfield AJ (2010). Sodium molybdate dihydrate: Determination of the toxicity to the marine alga Dunaliella tertiolecta. Final Report, prepared for the International Molybdenum Association. Testing laboratory: Brixham Environmental Laboratory, AstraZeneca UK Limited, Brixham, Devon, TQ58BA, UK. Owner: International Molybdenum Association. Report date: 2010-02-01.
[20] van Gestel AM, Borgman E, Verweij RA and Diez-Ortiz M (2009). Toxicity and bioavailability of molybdenum in terrestrial environments- soil invertebrates. Final report prepared for the International Molybdenum Association. Testing laboratory: Vrije universiteit. Owner: International Molybdenum Association. Report date: 2009-10-30.
[21] Micò C, Zhao FJ, McGrath SP (2010). Toxicity and Bioavailability of Molybdenum in Terrestrial Environments. Biological endpoint: Plant toxicity. Final report prepared for the International Molybdenum Association. Testing laboratory: Rothamsted Research. Owner: International Molybdenum Association. Report date: 2010-01-01.
[22] Smolders E and Buekers J (2009). Toxicity and bioavailability of molybdenum in terrestrial environments: micro-organisms. Final Report to the International Molybdenum Association. Testing laboratory: University of Leuven, Division of Soil and Water Management. Owner: International Molybdenum Association. Report date: 2009-03-01.
[23] Huntingdon Research Centre (1994c). Assessment of the inhibitory effect of molybdenum oxide (pure) on the respiration of activated sewage sludge. Report to the International Molybdenum Association. Testing laboratory: Huntingdon Research Centre Ltd. Owner: International Molybdenum Association. Study number: IMA 10(c) /920191. Report date: 1994-06-02.
[24] Stearns Catalytic Corp. (1985). Evaluation of acute effects of sodium molybdate on the activated sludge process and on the batch anaerobic sludge digestion process. Laboratory Report for Amax Inc. Testing laboratory: Stearns Catalytic Corp. Report no.: 29225. Owner company: Amax Inc., Report date: 1985-01-01.
[25] ----------
[26] Lide, D.R. (ed.): CRC Handbook of chemistry and physics. Section 4. Properties of the elements and inorganic compounds. 88th Edition (2008), CRC press, New York, 4.1-4.163.
[27] Sodium molybdate dihydrate: relative density (OECD 109). Unpublished study report for the International Molybdenum Association (IMOA). Report No. 20070330.01, Siemens Prozess-Sicherheit, Frankfurt am Main, Germany, 2007
[28] Water solubility of sodium molybdate dihydrate (OECD 105). Unpublished study report for the International Molybdenum Association (IMOA). Report No. 20071507/01-PCSB, Eurofins-GAB GmbH, Pforzheim, Germany, 2008.
[29] Molybdenum trioxide: Oxidising Properties UN Test O.1. Unpublished study report for the International Molybdenum Association (IMOA). Report No. 20090443.01, Siemens AG, Prozess-Sicherheit, Frankfurt am Main, Germany, 2009.
[30] Baldrick, P. & Healing, G. (1990). Acute oral toxicity to rats of sodium molybdate. Testing laboratory: Huntingdon Research Centre Ltd., P. O. Box 2, Huntingdon, Cambridgeshire, PE18 6ES, England. Report no.: 90934D/IMA 1/AC. Owner: International Molybdenum Association, UK. Report date: 1990-11-02
[31] Baldrick, P. & Healing, G. (1990). Acute dermal toxicity to rats of sodium molybdate. Testing laboratory: Huntingdon Research Centre Ltd., P. O. Box 2, Huntingdon, Cambridgeshire, PE18 6ES, England. Report no.: 90800D/IMA 2/AC. Owner: International Molybdenum Association, UK. Report date: 1990-11-06.
[32] Jackson, G.C. et al. (1991). Sodium molybdate acute inhalation toxicity study in rats 4-hour exposure. Testing laboratory: Huntingdon Research Centre Ltd., P. O. Box 2, Huntingdon, Cambridgeshire, PE18 6ES, England. Report no.: IMA 7/901486. Owner: International Molybdenum Association, UK. Report date: 1991-04-08.
[33] Liggett, M. P. & McRae, L. A. (1990). Irritant effects on rabbit skin of sodium molybdate. Testing laboratory: Huntingdon Research Centre Ltd., P. O. Box 2, Huntingdon, Cambridgeshire, PE18 6ES, England. Report no.: 90924D/IMA 3/SE. Owner: International Molybdenum Association, UK. Report date: 1990-11-02.
[34] Liggett, M. P. & McRae, L. A. (1990). Irritant effects on the rabbit eye of sodium molybdate. Testing laboratory: Huntingdon Research Centre Ltd., P. O. Box 2, Huntingdon, Cambridgeshire, PE18 6ES, England. Report no.: 90949D/IMA 4/SE. Owner: International Molybdenum Association, UK. Report date: 1990-11-02.
[35] Allan, S. A. (1996). Sodium molybdate 241/32 - Skin sensitisation in the guinea pig. Testing laboratory: Huntingdon Life Sciences Ltd., P. O. Box 2, Huntingdon, Cambridgeshire, PE18 6ES, England. Report no.: IMA16a/930983/SS. Owner: International Molybdenum Association, UK. Report date: 1996-01-23.
[36] Beevers, C. (2009). Reverse mutation in five histidine-requiring strains of Salmonella typhimurium. Testing laboratory: Covance Laboratories Ltd., Otley Road, Harrogate, North Yorkshire HG3 1PY, ENGLAND. Report no.: 2992/1. Owner: International Molybdenum Association, Belgium. Report date: 2009-01-12.

[37] Taylor, H. (2009). Induction of micronuclei in cultured human peripheral blood lymphocytes. Testing laboratory: Covance Laboratories Ltd., Otley Road, Harrogate, North Yorkshire HG3 1PY, England. Report no.: 2992/2. Owner: International Molybdenum Association, Belgium. Report date: 2009-01-14.
[38] Lloyd, M. (2009). Mutation at the thymidine kinase (tk) locus of mouse lymphoma L5178Y cells (MLA) using the MicrotitreR fluctuation technique. Testing laboratory: Covance Laboratories Ltd., Otley Road, Harrogate, North Yorkshire HG3 1 PY, England. Report no.: 2992/3. Owner: International Molybdenum Association, Belgium. Report date: 2009-01-20
[39] NTP (1997). Toxicology and carcinogenesis studies of molybdenum trioxide (CAS No. 1313-27-5) in F344/N rats and B6C3F1 mice (Inhalation studies). NTP Technical Report 462, NIH Publication No. 97-3378. Testing laboratory: Hazleton Laboratories America, Inc (Vienna, VA) and Bartelle Pacific Northwest Laboratories (Richland, WA).
[40] Bretherick's Handbook of Reactive Chemical Hazards. 7th Edition, Elsevier Academic Press, 2007
[41] Blot WJ, Li JY, Taylor PR, et al. Nutrition intervention trials in Linxian, China: supplementation with specific vitamin/mineral combinations, cancer incidence, and disease-specific mortality in the general population. *J Natl Cancer Inst*. 1993; 85:1483-1492.
[42] Esophageal cancer mortality and total hardness levels in Taiwan's drinking water - Authors CY Yang, HF Chiu, MF Cheng, SS Tsai, CF Hung, MC Lin Full source Environmental Research, 1999, Vol. 81, Issue 4, pp 302-308

(16.4)
Classification procedure for mixtures: Hexaammonium heptamolybdate (12411-64-2) is a pure substance.
(16.5)
R-phrase and/or H-statements: Embedded in document where applicable.

(16.6)
Advice on any training appropriate for workers to ensure protection of human health and the environment: Use this SDS as a Hazard Communication tool and provide training to assist in your risk assessment. Be mindful that many factors determine whether the reported hazards are risks in the workplace or other settings. Before handling Hexaammonium heptamolybdate workers should receive appropriate training about safe handling conditions as described in this Safety Data Sheet.

(16.7)
Other Information

(16.7.1)
List of EU Poison Centres.

Country	Telephone Number	Website	Address
Austria - Vienna Vergiftungsinformationszentrale (Poisons Information Centre)	**+ 43 1 40 406 4343**	http://www.meduniwien.ac.at/viz/	Allgemeines Krankenhaus Waehringer Guertel 18-20, Vienna, Austria
Belgium - Centre Anti-Poisons/ Antigifcentrum	**+ 32 70 245 245**	http://www.poisoncentre.be	Hôpital Militaire Reine Astrid, Rue Bruyn, Brussels, B-1120, Belgium
Germany - Berlin Giftberatung Virchow-Klinikum, Medizinische Fakultät der Humboldt-Universität zu Berlin	**+ 49 30 450 653 565**	http://www.giftnotruf.de	Augustenberger Platz 1 – Berlin 13353, Germany
Italy - Rome Centro Antiveleni (Poisons Centre) Dipartimento di Tossicologia Clinica Universita Cattolica del Sacro Cuore	**+ 39 06 305 4343**	http://www.tox.it	Largo Agostino Gemelli 8 I-00168 Roma
Luxembourg - Uses Belgian service: Centre Anti-Poisons/ Antigifcentrum	**+ 32 70 245 245**	http://www.poisoncentre.be	Hôpital Militaire Reine Astrid, Rue Bruyn, Brussels, B-1120 Belgium
Netherlands - Bilthoven National Poisons Information Centre, National Institute for Public Health & Environment	**+ 31 30 274 88 88**	https://www.vergiftigingen.info https://www.productnotification.nl	3720 BA Bilthoven
Poland - Warsaw (Warszawa) Warsaw Poison Control & Info Centre, Praski Hospital	**+ 48 22 619 66 54 / + 48 22 619 08 97**	No website available.	Al. Solidarnosci 67, P-03 401 Warszawa
Sweden - Stockholm Giftinformationscentralen (Swedish Poisons Info Centre) Karolinska Hospital	**+ 46 8 33 12 31 (International) 112 (National)**	http://www.giftinformationscentralen.se	SE 171 76 Stockholm
United Kingdom - National Poison Information Service Centre	**National: 0844 892 0111**	http://www.npis.org	
The International Programme on Chemical Safety		http://www.who.int/gho/phe/chemical_safety/poiso	

(IPCS) – Directory of EU Poison Centres	ns_centres/en/index.html	

(16.7.2)

Euro Country OEL's

Type of limit value	Limit value [mg Mo/m³]	References, Legislation, ...	Information on recommended monitoring procedures
Austria: Molybdenum compounds (as Mo), **soluble** compounds, **STEL (Peak),** 2 times per shift, 60 minutes:	20 Inhalable dust fraction	GKV_MAK (Austria 9/2007)	Consult the national authorities about which measurement methodology is suitable to demonstrate respective limit values. Applicable standards for monitoring of inhalable and/or respirable dust may include: HSE-MDHS 14: (10/1989) NIOSH 0500 (15/8/1994) NIOSH 0600 (15/1/1998) BS 1/2/92-KB (18/12/91)
Austria: Molybdenum compounds (as Mo), **soluble** compounds, **8-hour TWA** reference period	10 Inhalable dust fraction	GKV_MAK (Austria 9/2007)	
Belgium: molybdenum compounds (as Mo), **soluble**, in the **respirable** fraction, TLV-TWA	0.5 Respirable dust fraction	Belgian Royal Decree of 11/06/2009 (protection of the employee's health and safety against the risk of chemicals).	
Belgium: Mo compounds (as Mo), **soluble**, TLV-TWA	10 Inhalable dust fraction	Belgian Royal Decree of 11/06/2009 (protection of the employee's health and safety against the risk of chemicals).	
Denmark: Molybdenum compounds (as Mo), **soluble**, **8-hour TWA** reference period	5	Arbejdstilsynet (Denmark 3/2008)	
Denmark: Molybdenum compounds (as Mo), **insoluble, 8-hour TWA** reference period	10	Arbejdstilsynet (Denmark 3/2008)	
France: No indicative or mandatory Occupational Exposure Limit (OEL) specifically for molybdenum. **8-hour TWA** reference period to be protective against **long-term** exposure:	10 Total dust 5 Respirable fraction		
Germany: No limit value (MAK-value) is defined for Mo or molybdenum trioxide. In the absence of a MAK-value**,8-hour TWA** limit values for **general dust** should be applied:	10 Inhalable dust fraction 3 Respirable dust fraction	Deutsche Forschungsgemeinschaft: List of MAK and BAT values 2010. Commission for the Investigation of Health Hazards of Chemical Compounds in the Workplace, Report no. 46 WILEY-VCH Verlag GmbH & Co, KGaA, Weinheim, ISBN: 978-3-527-32815-4	Consult the national authorities about which measurement methodology is suitable to demonstrate respective limit values. Applicable standards for monitoring of inhalable and/or respirable dust may include: HSE-MDHS 14: (10/1989) NIOSH 0500 (15/8/1994) NIOSH 0600 (15/1/1998) BS 1/2/92-KB (18/12/91)
Italy: Molybdenum compounds (as Mo), **soluble** compounds**, 8-hour TWA** reference period:	10 Inhalable dust fraction 3 Respirable dust fraction	ACGIH TLV (USA 2/2010)	
Luxembourg: OEL's used in Luxembourg are those used by Germany, unless specific OEL's are provided (none identified for molybdenum)	See Germany		
Netherlands: Employers & employees responsible for setting Occupational Exposure Levels for safe handling since 1-1-2007		http://www.rivm.nl/rvs/normen/werk/grens	
Poland: Molybdenum compounds (as Mo), **soluble** compounds, **STEL/Peak** for 15 minutes:	10		
Poland: Molybdenum compounds (as Mo), **soluble** compounds**, 8-hour TWA** reference period	4		
Sweden: Molybdenum compounds (as Mo), 8-hour	10 Total dust	AFS 2005:17 (Sweden 6/2007)	

TWA reference period:	5 Respirable dust fraction		
United Kingdom: molybdenum compounds (as Mo), **soluble** compounds, **long-term** exposure limit (8-hour TWA reference period)	5 Inhalable dust fraction	UK HSE List of approved workplace exposure limits (WEL), October 2007, (http://www.hse.gov.uk/coshh/table1.pdf)	MDHS: Methods for the Determination of Hazardous Substances (MDHS) guidance http://www.hse.gov.uk/pubns/mdhs/
United Kingdom: molybdenum compounds (as Mo), **soluble** compounds, **short-term** exposure limit (15-minute reference period)	10 Inhalable dust fraction		
United Kingdom: molybdenum compounds (as Mo), **insoluble compounds**, **long-term** exposure limit (8-hour TWA reference period)	10 Inhalable dust fraction		
United Kingdom: molybdenum compounds (as Mo), **insoluble** compounds, **short-term** exposure limit (15-minute reference period)	20 Inhalable dust fraction		
Further source of information: European Agency for Safety & Health at Work:		http://osha.europa.eu/en/topics/ds/oel/members.stm	

Also See the downloadable list on the MoCon SDS webpage for the OEL values in EU countries that MoCon has been able to source. Some of the example data shown above was taken from the GESTIS Database on International Limit Values (http://bgia-online.hvbg.de/LIMITVALUE/WebForm_gw.aspx), accessed 2010-11-10

Another source of available information on Occupational Exposure Limits from Member States is the OSHA (European Agency for Safety and Health at work) website: http://osha.europa.eu/en/topics/ds/oel/index.stm/members.stm

There are also commercial databases where this type of information is available on a subscription or other payment basis. Likewise, Eurometaux is developing an OEL database for several metals. (The MoCon downloadable OEL list includes the Eurometaux data).

Note that as shown in the right-hand column of the UK example above, this section 8.1 must also include the currently recommended monitoring or observation methods for at least the most relevant substances. These monitoring methods can be: personal air monitoring, room air monitoring, biological monitoring etc according to agreed standards. The specific standard should be referenced, for example: "DIN EN 14042:2003 Title Identifier: Workplace atmospheres. Guide for the application and use of procedures for the assessment of exposure to chemical and biological agents." You should consult the national authorities about which measurement methodology is suitable to demonstrate respective limit values.

(16.7.3)
Hexaammonium heptamolybdate is found on the following international regulatory lists;

Australia - Australia New Zealand Food Standards Code - Processing Aids – Permitted catalysts
Australia Exposure Standards
Australia Inventory of Chemical Substances (**AICS**)
Austria Indirect Discharger Ordinance - Annex B: Threshold limit value for daily charges of hazardous waste water constituents
Belgium Occupational Exposure Limits
Bulgaria Limit values for the chemical agents in the air at the working environment
Canada - Alberta Occupational Exposure Limits
Canada - British Columbia Occupational Exposure Limits
Canada - Ontario Occupational Exposure Limits
Canada - Quebec Occupational Exposure Limits
Canada - Saskatchewan Occupational Health and Safety Regulations - Contamination Limits
Canada - Yukon Permissible Concentrations for Airborne Contaminant Substances
Canada Domestic Substances List (**DSL**)
Canada Ingredient Disclosure List (SOR/88-64)
China Inventory of Existing Chemical Substances
China Occupational Exposure Limits for Hazardous Agents in the Workplace
Denmark Limit values for air pollutants
EU Directive 96/61/EC concerning integrated pollution prevention and control, Annex III
European Customs Inventory of Chemical Substances - **ECICS**
European Inventory of Existing Commercial Substances – **EINECS**
France Threshold Limit Values for Occupational Exposure - VLE/VME (French)
Greece Occupational Exposure Limits
India Chemical Accidents Rules - Schedule 1: List of Hazardous Chemicals
India Manufacture, Storage and Import of Hazardous Chemical Rules - Schedule 1: List of Hazardous and Toxic Chemicals
Ireland Occupational Exposure Limits
Ireland Occupational Exposure Limits - Intended Changes
Japan Chemical Substances Control Law - Existing/New Chemical Substances
Japan Industrial Safety and Health Law (ISHL) - Notifiable Substances
Japan PRTR Law
Japan Water Pollution Control Law - National Effluent Standards
Korea (South) Existing Chemicals List (**KECL**)

Malaysia Permissible Exposure Limits
Netherlands Occupational Exposure Limits
New Zealand - Australia New Zealand Food Standards Code - Processing Aids – Permitted catalysts
New Zealand Workplace Exposure Standards (WES)
Philippines Inventory of Chemicals and Chemical Substances (**PICCS**)
Philippines Occupational Exposure Limits
Singapore Permissible Exposure Levels of Toxic Substances
Spain Changes Proposed for Occupational Limit Values
Spain Occupational Exposure Limit for Chemical Agents
Switzerland Occupational Exposure Limits
Taiwan Permissible Concentration of Airborne Harmful Substances
UK Workplace Exposure Limits (WELs)
US - California Environmental Health Standards for the Management of Hazardous Waste -List of Inorganic Persistent and Bioaccumulative Toxic Substances and Their STLC & TTLC Values
US - California Occupational Safety and Health Regulations (CAL/OSHA) – Hazardous Substances List
US - California Permissible Exposure Limits for Chemical Contaminants
US - Connecticut Hazardous Air Pollutants
US - Hawaii Air Contaminant Limits
US - Idaho - Limits for Air Contaminants
US - Minnesota Hazardous Substance List
US - Minnesota Permissible Exposure Limits (PELs)
US - Tennessee Occupational Exposure Limits - Limits for Air Contaminants
US - Vermont Permissible Exposure Limits Table Z-1-A Final Rule Limits for Air Contaminants
US - Vermont Permissible Exposure Limits Table Z-1-A Transitional Limits for Air Contaminants
US - Washington Permissible exposure limits of air contaminants
US - Wisconsin Hazardous Air Contaminants with Acceptable Ambient Concentrations
US ACGIH Carcinogens Listing
US ACGIH Threshold Limit Values (TLV)
US DOE Temporary Emergency Exposure Limits (TEELs)
US OSHA Permissible Exposure Levels (PELs) - Table Z1
US Toxic Substances Control Act (**TSCA**) - Inventory

(16.7.4)

REACH Statement and Point of Contact Information

Climax Molybdenum has pre-registered and registered this substance as required by the European Union's Registration, Evaluation, Authorization, and Restriction of Chemicals regulation, EC 1907/2006 (REACH). Additional registration information is available upon request. Any REACH-related inquiries regarding this substance should be directed to Ir. Aad van Meerkerk, Climax Molybdenum B.V., Rotterdam, The Netherlands, Tel: +31-181-243705; Email: aad_vanmeerkerk@fmi.com.

(16.7.5)

Disclaimer

The information contained herein was obtained from sources we believe to be accurate and is based on the available scientific evidence known to Freeport-McMoRan Corporation. It is provided solely for compliance with the Hazard Communication Standard and is not meant to convey analytical information. This document is intended only as a guide to the appropriate precautionary handling of the material by a properly trained person using this material. Individuals receiving the information must exercise their independent judgment in determining its appropriateness for a particular purpose. This document provides transportation and environmental information, but is not the definitive resource and does not replace required training and knowledge required to address transportation and environmental-related requirements, language, or actions. No representations, guarantees or warranties of any kind are made as to the accuracy of the information contained herein, the suitability of the material or the information contained herein for particular applications, the hazards connected with the use of the material, or the results to be obtained from the use thereof. The user assumes all risks and liability of any use, processing, handling or storage of the material, variations in methods, conditions and equipment used to store, handle or process the material and hazards connected with the use of the material are solely the responsibility of the user and remain at user's sole discretion. Compliance with all applicable federal, state and local laws and regulations remains the responsibility of the user.