RUTHENIUM (-98, -99, -100, -101, -102, -104)

Chemwatch: **17206-1**
Version No: **4.1.1.1**
Safety Data Sheet according to OSHA HazCom Standard (2012) requirements

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Initial Date: **Not Available**
S.GHS.USA.EN

SECTION 1 IDENTIFICATION

Product Identifier

Product name	RUTHENIUM
Chemical Name	Ruthenium
Synonyms	Ruthenium
Proper shipping name	Metal powder, flammable, n.o.s.
Chemical formula	Ru
Other means of identification	Not Available
CAS number	7440-18-8

Relevant identified uses of the substance

	Medical and research applications

Details of the manufacturer

Registered company name	Oak Ridge National Laboratory
Address	P.O. Box 2008 37831, Oak Ridge, Tennessee 37831-6158
Telephone	(865) 574-6984
Fax	(865) 574-6986
Website	http://isotopes.gov/
Email	isotopes@ornl.gov

Emergency telephone number

Association / Organization	Oak Ridge National Laboratory
Emergency telephone numbers	(865) 574-6606
Other emergency telephone numbers	CHEMTREC: 1-800-424-9300

SECTION 2 HAZARDS IDENTIFICATION

Classification of the substance or mixture

CHEMWATCH HAZARD RATINGS

		Min	Max
Flammability	3		
Toxicity	2		
Body Contact	2		
Reactivity	2		
Chronic	2		

0 = Minimum
1 = Low
2 = Moderate
3 = High
4 = Extreme

	Flammable Solid Category 1

Label elements

	

Continued...

Hazard statement(s)

	Flammable solid

Precautionary statement(s): Prevention

P210	Keep away from heat, hot surfaces, sparks, open flames and other ignition sources. No smoking.
P240	Ground/bond container and receiving equipment.
P241	Use explosion-proof electrical/ventilating/lighting/intrinsically safe equipment.
P280	Wear protective gloves/protective clothing/eye protection/face protection.

Precautionary statement(s): Response

	In case of fire: Use media suitable for surrounding materials.

Precautionary statement(s): Storage

Not Applicable

Precautionary statement(s): Disposal

Not Applicable

SECTION 3 COMPOSITION / INFORMATION ON INGREDIENTS

Substances

CAS No	%[weight]	Name
7440-18-8	100	ruthenium

Mixtures

See section above for composition of Substances

SECTION 4 FIRST AID MEASURES

Description of first aid measures

Eye Contact	If this product comes in contact with the eyes: ▪ Wash out immediately with fresh running water. ▪ Ensure complete irrigation of the eye by keeping eyelids apart and away from eye and moving the eyelids by occasionally lifting the upper and lower lids. ▪ Seek medical attention without delay; if pain persists or recurs seek medical attention. ▪ Removal of contact lenses after an eye injury should only be undertaken by skilled personnel. ▪ **DO NOT** attempt to remove particles attached to or embedded in eye. ▪ Lay victim down, on stretcher if available and pad both eyes, make sure dressing does not press on the injured eye by placing thick pads under dressing, above and below the eye. ▪ Seek urgent medical assistance, or transport to hospital.
Skin Contact	If skin or hair contact occurs: ▪ Flush skin and hair with running water (and soap if available). ▪ Seek medical attention in event of irritation.
Inhalation	▪ If fumes or combustion products are inhaled remove from contaminated area. ▪ Lay patient down. Keep warm and rested. ▪ Prostheses such as false teeth, which may block airway, should be removed, where possible, prior to initiating first aid procedures. ▪ Apply artificial respiration if not breathing, preferably with a demand valve resuscitator, bag-valve mask device, or pocket mask as trained. Perform CPR if necessary. ▪ Transport to hospital, or doctor.
Ingestion	▪ Immediately give a glass of water. ▪ First aid is not generally required. If in doubt, contact a Poisons Information Centre or a doctor.

Indication of any immediate medical attention and special treatment needed

Treat symptomatically.

Copper, magnesium, aluminum, antimony, iron, manganese, nickel, zinc (and their compounds) in welding, brazing, galvanizing or smelting operations all give rise to thermally produced particulates of smaller dimension than may be produced if the metals are divided mechanically. Where insufficient ventilation or respiratory protection is available these particulates may produce "metal fume fever" in workers from an acute or long term exposure.

- Onset occurs in 4-6 hours generally on the evening following exposure. Tolerance develops in workers but may be lost over the weekend. (Monday Morning Fever)
- Pulmonary function tests may indicate reduced lung volumes, small airway obstruction and decreased carbon monoxide diffusing capacity but these abnormalities resolve after several months.
- Although mildly elevated urinary levels of heavy metal may occur they do not correlate with clinical effects.
- The general approach to treatment is recognition of the disease, supportive care and prevention of exposure.
- Seriously symptomatic patients should receive chest x-rays, have arterial blood gases determined and be observed for the development of tracheobronchitis and pulmonary edema.

[Ellenhorn and Barceloux: Medical Toxicology]

SECTION 5 FIREFIGHTING MEASURES

Extinguishing media

	Metal dust fires need to be smothered with sand, inert dry powders. **DO NOT** USE WATER, CO2 or FOAM. ▪ Use DRY sand, graphite powder, dry sodium chloride based extinguishers, G-1 or Met L-X to smother fire. ▪ Confining or smothering material is preferable to applying water as chemical reaction may produce flammable and explosive hydrogen gas.

Special hazards arising from the substrate or mixture

	▪ Reacts with acids producing flammable / explosive hydrogen (H2) gas

	▪ Keep dry ▪ **NOTE:** May develop pressure in containers; open carefully. Vent periodically. None known.

Advice for firefighters

Fire Fighting	▪ Alert Fire Brigade and tell them location and nature of hazard. ▪ Wear breathing apparatus plus protective gloves. ▪ Prevent, by any means available, spillage from entering drains or water course. ▪ Fight fire from a safe distance, with adequate cover.
Fire/Explosion Hazard	Decomposition may produce toxic fumes of:, metal oxides ▪ **DO NOT** disturb burning dust. Explosion may result if dust is stirred into a cloud, by providing oxygen to a large surface of hot metal. ▪ **DO NOT** use water or foam as generation of explosive hydrogen may result. With the exception of the metals that burn in contact with air or water (for example, sodium), masses of combustible metals do not represent unusual fire risks because they have the ability to conduct heat away from hot spots so efficiently that the heat of combustion cannot be maintained - this means that it will require a lot of heat to ignite a mass of combustible metal.

SECTION 6 ACCIDENTAL RELEASE MEASURES

Personal precautions, protective equipment and emergency procedures

Minor Spills	▪ Remove all ignition sources. ▪ **DO NOT** touch or walk through spilled material. ▪ Clean up all spills immediately. ▪ Avoid contact with skin and eyes.
Major Spills	▪ Clear area of personnel and move upwind. ▪ Alert Fire Brigade and tell them location and nature of hazard. ▪ **DO NOT** touch or walk through spilled material. ▪ Control personal contact with the substance, by using protective equipment.

	Personal Protective Equipment advice is contained in Section 8 of the SDS.

SECTION 7 HANDLING AND STORAGE

Precautions for safe handling

Safe handling	▪ Avoid all personal contact, including inhalation. ▪ Wear protective clothing when risk of overexposure occurs. ▪ Use in a well-ventilated area. ▪ Prevent concentration in hollows and sumps.
Other information	**FOR MINOR QUANTITIES:** ▪ Store in an indoor fireproof cabinet or in a room of noncombustible construction. ▪ Provide adequate portable fire-extinguishers in or near the storage area. **FOR PACKAGE STORAGE:** ▪ Store in original containers in approved flame-proof area. ▪ No smoking, naked lights, heat or ignition sources.

Conditions for safe storage, including any incompatibilities

Suitable container	▪ **CARE**: Packing of high density product in light weight metal or plastic packages may result in container collapse with product release ▪ Heavy gauge metal packages / Heavy gauge metal drums For low viscosity materials and solids: Drums and jerricans must be of the non-removable head type. Where a can is to be used as an inner package, the can must have a screwed enclosure. For materials with a viscosity of at least 2680 cSt. (23 deg. C): ▪ Removable head packaging and ▪ cans with friction closures may be used.
Storage incompatibility	▪ Metals and their oxides or salts may react violently with chlorine trifluoride and bromine trifluoride. ▪ These trifluorides are hypergolic oxidizers. They ignite on contact (without external source of heat or ignition) with recognized fuels - contact with these materials, following an ambient or slightly elevated temperature, is often violent and may produce ignition. ▪ The state of subdivision may affect the results.

PACKAGE MATERIAL INCOMPATIBILITIES

Not Available

SECTION 8 EXPOSURE CONTROLS / PERSONAL PROTECTION

Control parameters

OCCUPATIONAL EXPOSURE LIMITS (OEL)

INGREDIENT DATA

Source	Ingredient	Material name	TWA	STEL	Peak	Notes
US OSHA Permissible Exposure Levels (PELs) - Table Z3	ruthenium	Inert or Nuisance Dust	5 mg/m3 / 15 mg/m3 / 15 mppcf / 50 mppcf	Not Available	Not Available	Respirable fraction;All inert or nuisance dusts, whether mineral, inorganic, or organic, not listed specifically by substance name are covered by this limit, which is the same as the Particulates Not Otherwise Regulated (PNOR) limit in Table Z-1. / Total dust;All inert or nuisance dusts, whether mineral, inorganic, or organic, not listed specifically by substance name are covered by this limit, which is the same as the Particulates Not Otherwise Regulated (PNOR) limit in Table Z-1.

EMERGENCY LIMITS

Ingredient	TEEL-0	TEEL-1	TEEL-2	TEEL-3
RUTHENIUM	Not Available	Not Available	Not Available	Not Available

Ingredient	Original IDLH	Revised IDLH
ruthenium	Not Available	Not Available

Exposure controls

Appropriate engineering controls	For large scale or continuous use: ▪ Spark-free, earthed ventilation system, venting directly to the outside and separate from usual ventilation systems ▪ Provide dust collectors with explosion vents Metal dusts must be collected at the source of generation as they are potentially explosive. ▪ Avoid ignition sources. ▪ Good housekeeping practices must be maintained. ▪ Dust accumulation on the floor, ledges and beams can present a risk of ignition, flame propagation and secondary explosions.
Personal protection	
Eye and face protection	▪ Safety glasses with side shields. ▪ Chemical goggles. ▪ Contact lenses may pose a special hazard; soft contact lenses may absorb and concentrate irritants. A written policy document, describing the wearing of lenses or restrictions on use, should be created for each workplace or task.
Skin protection	See Hand protection below
Hands/feet protection	The selection of suitable gloves does not only depend on the material, but also on further marks of quality which vary from manufacturer to manufacturer. Where the chemical is a preparation of several substances, the resistance of the glove material can not be calculated in advance and has therefore to be checked prior to the application. The exact break through time for substances has to be obtained from the manufacturer of the protective gloves and.has to be observed when making a final choice. Suitability and durability of glove type is dependent on usage.
Body protection	See Other protection below
Other protection	▪ Overalls. ▪ Eyewash unit. ▪ Barrier cream. ▪ Skin cleansing cream.
Thermal hazards	Not Available

Recommended material(s)

GLOVE SELECTION INDEX

Glove selection is based on a modified presentation of the:
"Forsberg Clothing Performance Index".
The effect(s) of the following substance(s) are taken into account in the computer generated selection:
RUTHENIUM Not Available

Material	CPI

* CPI - Chemwatch Performance Index
A: Best Selection
B: Satisfactory; may degrade after 4 hours continuous immersion
C: Poor to Dangerous Choice for other than short term immersion
NOTE: As a series of factors will influence the actual performance of the glove, a final selection must be based on detailed observation. -
* Where the glove is to be used on a short term, casual or infrequent basis, factors such as "feel" or convenience (e.g. disposability), may dictate a choice of gloves which might otherwise be unsuitable following long-term or frequent use. A qualified practitioner should be consulted.

Respiratory protection

Required Minimum Protection Factor	Half-Face Respirator	Full-Face Respirator	Powered Air Respirator
up to 10 x ES	P1 Air-line*	- -	PAPR-P1 -
up to 50 x ES	Air-line**	P2	PAPR-P2
up to 100 x ES	-	P3	-
		Air-line*	-
100+ x ES	-	Air-line**	PAPR-P3

* - Negative pressure demand ** - Continuous flow
A(All classes) = Organic vapors, B AUS or B1 = Acid gasses, B2 = Acid gas or hydrogen cyanide(HCN), B3 = Acid gas or hydrogen cyanide(HCN), E = Sulfur dioxide(SO2), G = Agricultural chemicals, K = Ammonia(NH3), Hg = Mercury, NO = Oxides of nitrogen, MB = Methyl bromide, AX = Low boiling point organic compounds(below 65 degC)

SECTION 9 PHYSICAL AND CHEMICAL PROPERTIES

Information on basic physical and chemical properties

	Lustrous hard metal; does not react with acids including aqua regia.

Physical state	Divided Solid	**Relative density (Water = 1)**	12.45
Odor	Not Available	**Partition coefficient n-octanol / water**	Not Available
Odor threshold	Not Available	**Auto-ignition temperature (°C)**	Not Applicable
pH (as supplied)	Not Applicable	**Decomposition temperature**	Not Applicable
Melting point / freezing point (°C)	2450	**Viscosity (cSt)**	Not Applicable
Initial boiling point and boiling range (°C)	4150	**Molecular weight (g/mol)**	101.07

Flash point (°C)	Not Available	**Taste**	Not Available
Evaporation rate	Not Applicable	**Explosive properties**	Not Available
Flammability	Not Available	**Oxidising properties**	Not Available
Upper Explosive Limit (%)	Not Applicable	**Surface Tension (dyn/cm or mN/m)**	Not Applicable
Lower Explosive Limit (%)	Not Applicable	**Volatile Component (%vol)**	Negligible
Vapor pressure (kPa)	Negligible	**Gas group**	Not Available
Solubility in water (g/L)	Immiscible	**pH as a solution(1%)**	Not Applicable
Vapor density (Air = 1)	Not Applicable	**VOC g/L**	Not Available

SECTION 10 STABILITY AND REACTIVITY

Reactivity	See section 7
Chemical stability	▪ Unstable in the presence of incompatible materials. ▪ Product is considered stable. ▪ Hazardous polymerization will not occur.
Possibility of hazardous reactions	See section 7
Conditions to avoid	See section 7
Incompatible materials	See section 7
Hazardous decomposition products	See section 5

SECTION 11 TOXICOLOGICAL INFORMATION

Information on toxicological effects

Inhaled	The material is not thought to produce respiratory irritation (as classified by EC Directives using animal models). Nevertheless inhalation of dusts, or fumes, especially for prolonged periods, may produce respiratory discomfort and occasionally, distress. Inhalation of dusts, generated by the material during the course of normal handling, may be damaging to the health of the individual. Persons with impaired respiratory function, airway diseases and conditions such as emphysema or chronic bronchitis, may incur further disability if excessive concentrations of particulate are inhaled.
Ingestion	The material has **NOT** been classified by EC Directives or other classification systems as "harmful by ingestion". This is because of the lack of corroborating animal or human evidence. The material may still be damaging to the health of the individual, following ingestion, especially where pre-existing organ (e.g liver, kidney) damage is evident. Present definitions of harmful or toxic substances are generally based on doses producing mortality rather than those producing morbidity (disease, ill-health).
Skin Contact	The material is not thought to produce adverse health effects or skin irritation following contact (as classified by EC Directives using animal models). Nevertheless, good hygiene practice requires that exposure be kept to a minimum and that suitable gloves be used in an occupational setting. Open cuts, abraded or irritated skin should not be exposed to this material Entry into the blood-stream through, for example, cuts, abrasions, puncture wounds or lesions, may produce systemic injury with harmful effects. Examine the skin prior to the use of the material and ensure that any external damage is suitably protected.
Eye	Limited evidence exists, or practical experience suggests, that the material may cause eye irritation in a substantial number of individuals and/or is expected to produce significant ocular lesions which are present twenty-four hours or more after instillation into the eye(s) of experimental animals. Repeated or prolonged eye contact may cause inflammation characterized by temporary redness (similar to windburn) of the conjunctiva (conjunctivitis); temporary impairment of vision and/or other transient eye damage/ulceration may occur. Contact with the eye, by metal dusts, may produce mechanical abrasion or foreign body penetration of the eyeball.
Chronic	Limited evidence suggests that repeated or long-term occupational exposure may produce cumulative health effects involving organs or biochemical systems. Metallic dusts generated by the industrial process give rise to a number of potential health problems. The larger particles, above 5 micron, are nose and throat irritants. Smaller particles however, may cause lung deterioration.

	Not Available	Not Available

** Value obtained from manufacturer's msds*
unless otherwise specified data extracted from RTECS - Register of Toxic Effects of Chemical Substances

	No significant acute toxicological data identified in literature search.

Acute Toxicity	⊘	**Carcinogenicity**	⊘
Skin Irritation/Corrosion	⊘	**Reproductivity**	⊘
Serious Eye Damage/Irritation	⊘	**STOT - Single Exposure**	⊘
Respiratory or Skin sensitization	⊘	**STOT - Repeated Exposure**	⊘
Mutagenicity	⊘	**Aspiration Hazard**	⊘

Legend: ✔ *– Data required to make classification available*
✖ *– Data available but does not fill the criteria for classification*
⊘ *– Data Not Available to make classification*

CMR STATUS

	ruthenium	US Environmental Defense Scorecard Suspected Carcinogens	P65-MC

SECTION 12 ECOLOGICAL INFORMATION

Toxicity

Metal-containing inorganic substances generally have negligible vapor pressure and are not expected to partition to air. Once released to surface waters and moist soils their fate depends on solubility and dissociation in water. Environmental processes (such as oxidation and the presence of acids or bases) may transform insoluble metals to more soluble ionic forms. Microbiological processes may also transform insoluble metals to more soluble forms.

Persistence and degradability

Ingredient	Persistence: Water/Soil	Persistence: Air
	No Data available for all ingredients	No Data available for all ingredients

Bioaccumulative potential

Ingredient	Bioaccumulation
	No Data available for all ingredients

Mobility in soil

Ingredient	Mobility
	No Data available for all ingredients

SECTION 13 DISPOSAL CONSIDERATIONS

Waste treatment methods

Legislation addressing waste disposal requirements may differ by country, state and/ or territory. Each user must refer to laws operating in their area. In some areas, certain wastes must be tracked.
A Hierarchy of Controls seems to be common - the user should investigate:

- Reduction
- Reuse
- Recycling
- Disposal (if all else fails)

This material may be recycled if unused, or if it has not been contaminated so as to make it unsuitable for its intended use.

SECTION 14 TRANSPORT INFORMATION

Labels Required

Marine Pollutant	NO

Land transport (DOT)

UN number	3089
Packing group	II
UN proper shipping name	Metal powder, flammable, n.o.s.
Environmental hazard	No relevant data
Transport hazard class(es)	Class: 4.1
Special precautions for user	Special provisions: IB8, IP2, IP4, T3, TP33

Air transport (ICAO-IATA / DGR)

UN number	3089
Packing group	II
UN proper shipping name	Metal powder, flammable, n.o.s.
Environmental hazard	No relevant data
Transport hazard class(es)	ICAO/IATA Class: 4.1 ICAO / IATA Subrisk: Not Applicable ERG Code: 3L
Special precautions for user	Special provisions: A3 Cargo Only Packing Instructions: 448 Cargo Only Maximum Qty / Pack: 50 kg Passenger and Cargo Packing Instructions: 445 Passenger and Cargo Maximum Qty / Pack: 15 kg Passenger and Cargo Limited Quantity Packing Instructions: Y441

	Passenger and Cargo Limited Maximum Qty / Pack	5 kg

Sea transport (IMDG-Code / GGVSee)

UN number	3089
Packing group	II
UN proper shipping name	METAL POWDER, FLAMMABLE, N.O.S.
Environmental hazard	No relevant data
Transport hazard class(es)	IMDG Class: 4.1 IMDG Subrisk: Not Applicable
Special precautions for user	EMS Number: F-G , S-G Special provisions: Not Applicable Limited Quantities: 1 kg

SECTION 15 REGULATORY INFORMATION

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

"US - Tennessee Occupational Exposure Limits - Limits For Air Contaminants","US - Hawaii Air Contaminant Limits","US - California Permissible Exposure Limits for Chemical Contaminants","International Agency for Research on Cancer (IARC) - Agents Classified by the IARC Monographs","US - Michigan Exposure Limits for Air Contaminants","US - Oregon Permissible Exposure Limits (Z-1)","US OSHA Permissible Exposure Levels (PELs) - Table Z3","US - Washington Permissible exposure limits of air contaminants","US - California OEHHA/ARB - Chronic Reference Exposure Levels and Target Organs (CRELs)","US - Wyoming Toxic and Hazardous Substances Table Z1 Limits for Air Contaminants","US Toxic Substances Control Act (TSCA) - Chemical Substance Inventory"

SECTION 16 OTHER INFORMATION

Other information

Classification of the preparation and its individual components has drawn on official and authoritative sources as well as independent review by the Chemwatch Classification committee using available literature references.
A list of reference resources used to assist the committee may be found at:
www.chemwatch.net/references

The SDS is a Hazard Communication tool and should be used to assist in the Risk Assessment. Many factors determine whether the reported Hazards are Risks in the workplace or other settings. Risks may be determined by reference to Exposures Scenarios. Scale of use, frequency of use and current or available engineering controls must be considered.