

## 4. CHEMICAL, PHYSICAL, and RADIOLOGICAL INFORMATION

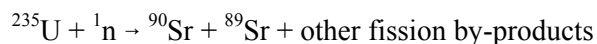
### 4.1 CHEMICAL IDENTITY

Strontium is an alkaline earth element in Group IIA of the periodic table. Because of its high reactivity, elemental (or metallic) strontium is not found in nature; it exists only as molecular compounds with other elements. The chemical information for elemental strontium and some of its compounds is listed in Table 4-1. Radioactive isotopes of strontium (e.g.,  $^{89}\text{Sr}$  and  $^{90}\text{Sr}$ , see Section 4.2) are the primary cause of concern with regard to human health (see Chapter 3).

### 4.2 PHYSICAL, CHEMICAL, AND RADIOLOGICAL PROPERTIES

The physical properties of strontium metal and selected strontium compounds are listed in Table 4-2. The percent occurrence of strontium isotopes and the radiologic properties of strontium isotopes are listed in Table 4-3.


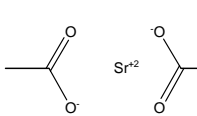
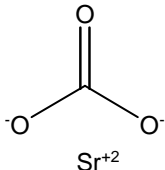
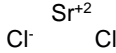
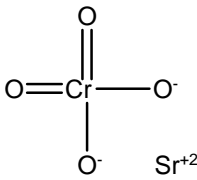
Strontium can exist in two oxidation states: 0 and +2. Under normal environmental conditions, only the +2 oxidation state is stable enough to be of practical importance since it readily reacts with both water and oxygen (Cotton and Wilkenson 1980; Hibbins 1997). There are 26 isotopes of strontium, 4 of which occur naturally. The four stable isotopes,  $^{84}\text{Sr}$ ,  $^{86}\text{Sr}$ ,  $^{87}\text{Sr}$ , and  $^{88}\text{Sr}$ , are sometimes referred to as stable strontium. The most important radioactive isotopes,  $^{89}\text{Sr}$  and  $^{90}\text{Sr}$ , are formed during nuclear reactor operations and during nuclear explosions by the nuclear fission of  $^{235}\text{U}$ ,  $^{238}\text{U}$ , or  $^{239}\text{Pu}$ . For example,  $^{235}\text{U}$  is split into smaller atomic mass fragments such as  $^{90}\text{Sr}$  by a nuclear chain reaction initiated by high energy neutrons of approximately 1 million electron volts (or 1 MeV). These smaller atomic mass fragments are referred to as fission by-products. This process is illustrated below:



$^{90}\text{Sr}$  is the more dangerous of the two isotopes due to its long half-life (29 years).  $^{90}\text{Sr}$  decays by emission of a beta-particle with a maximum energy of 0.546 MeV and the creation of an  $^{90}\text{Y}$  isotope, or progeny product. Unlike other radioactive isotopes that decay by beta-emission,  $^{90}\text{Sr}$  does not directly release high energy photons or gamma-ray radiation ( $\gamma$ ). However, the progeny product of  $^{90}\text{Sr}$ ,  $^{90}\text{Y}$ , is both a beta-particle (2.28 MeV maximum energy) emitter and to a minor degree for 0.02% of all disintegrations, a

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**Table 4-1. Chemical Identity of Strontium and Strontium Compounds**

Property	Strontium (0)	Strontium acetate	Strontium carbonate	Strontium chloride	Strontium chromate
Chemical formula	Sr	C <sub>4</sub> H <sub>6</sub> O <sub>4</sub> Sr	CO <sub>3</sub> Sr	Cl <sub>2</sub> Sr	CrH <sub>2</sub> O <sub>4</sub> Sr
Chemical structure	Sr	Sr(O <sub>2</sub> CCH <sub>3</sub> ) <sub>2</sub>	SrCO <sub>3</sub>	SrCl <sub>2</sub>	SrCrO <sub>4</sub>
					
Synonyms	None	Strontium diacetate	Carbonic acid, strontium salt (1:1); strontianite	Strontium dichloride	Chromic acid, strontium salt
Trade names	No data	No data	No data	No data	No data
Identification numbers					
CAS registry	7440-24-6	543-94-2	1633-05-2	10476-85-4	7789-06-2
NIOSH RTECS	WK7849000	AJ4725000	No data	WK8400000	GB3240000
EPA hazardous waste	No data	No data	No data	No data	D007
OHM/TADS	No data	No data	No data	No data	No data
DOT/UN/NA/IMO shipping	UN 1383/IMO 4.2	No data	No data	No data	9149/NA 9149
HSDB	2545	No data	5845	No data	2545
NCI	No data	75799	112224	No data	No data
STCC	No data	No data	No data	No data	49 633 77

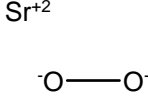
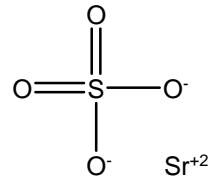
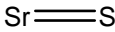
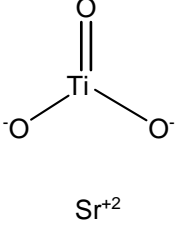
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**Table 4-1. Chemical Identity of Strontium and Strontium Compounds**

Property	Strontium fluoride	Strontium hydroxide	Strontium nitrate	Strontium phosphate	Strontium oxide
Chemical formula	F <sub>2</sub> Sr	H <sub>2</sub> O <sub>2</sub> Sr	N <sub>2</sub> O <sub>6</sub> Sr	O <sub>8</sub> P <sub>2</sub> Sr <sub>3</sub>	OSr
Chemical structure					
Synonyms	Strontium difluoride	Strontium hydrate	Nitrate de strontium (French); Nitric acid, strontium salt; strontium dinitrate; strontium(II) nitrate (1:2)	No data	Strontia, strontium monoxide
Trade names	No data	No data	No data	No data	No data
Identification numbers					
CAS registry	7783-48-4	18480-07-4	10042-76-9	7446-28-8	1314-11-0
NIOSH RTECS	WK8925000	WK9100000	WK9800000	No data	No data
EPA hazardous waste	No data	No data	No data	No data	No data
OHM/TADS	No data	No data	No data	No data	No data
DOT/UN/NA/IMO shipping	No data	No data	UN 1507 Oxidizer IMO 5.1	No data	No data
HSDB	No data	No data	No data	No data	No data
NCI	No data	No data	No data	No data	No data
STCC	No data	No data	49 187 54	No data	No data

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**Table 4-1. Chemical Identity of Strontium and Strontium Compounds**

Property	Strontium peroxide	Strontium sulfate	Strontium sulfide	Strontium titanate
Chemical formula	O <sub>2</sub> Sr	O <sub>4</sub> SSr	SSr	O <sub>3</sub> SrTi
Chemical structure	SrO <sub>2</sub>	SrSO <sub>4</sub>	SrS	SrTiO <sub>3</sub>
				
Synonyms	Strontium dioxide	Celestine, celestite	Strontium monosulfide	No data
Trade names	No data	No data	No data	No data
Identification numbers				
CAS registry	1314-18-7	7759-02-6	1314-96-1	12060-59-2
NIOSH RTECS	WL0100000	No data	WL0400000	No data
EPA hazardous waste	No data	No data	P107/D003	No data
OHM/TADS	No data	No data	No data	No data
DOT/UN/NA/IMO shipping	UN 1509 Oxidizer IMO 5.1	No data	No data	No data
HSDB	788	No data	12	No data
NCI	No data	No data	No data	No data
STCC	49 187 55	No data	No data	No data

CAS = Chemical Abstracts Services; DOT/UN/NA/IMCO = Department of Transportation/United Nations/North America/International Maritime Dangerous Goods Code; EPA = Environmental Protection Agency; HSDB = Hazardous Substances Data Bank; NCI = National Cancer Institute; NIOSH = National Institute for Occupational Safety and Health; OHM/TADS = Oil and Hazardous Materials/Technical Assistance Data System; RTECS = Registry of Toxic Effects of Chemical Substances; STCC = Standard Transportation Commercial Code

Source: ChemFinder 2002; HSDB 2002; Lide 2000

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**Table 4-2. Physical and Chemical Properties of Strontium and Strontium Compounds<sup>a</sup>**

Property	Strontium (0)	Strontium acetate <sup>b,c</sup>	Strontium carbonate <sup>b,c</sup>	Strontium chloride <sup>c</sup>	Strontium chromate
Molecular weight, g/mole	87.62	205.71	147.63	158.53	203.62
Color	Pale yellow	White	White	White	Yellow
Physical state	Solid	Solid	Solid	Solid	Solid
Melting point	777 °C	Decomposes	1,497 °C <sup>d</sup>	875 °C	No data
Boiling point	1,382 °C	Not applicable	Decomposes at 1,100 °C	1,250 °C	No data
Density, g/cm <sup>3</sup>	2.64	2.099	3.5	3.05	3.90
Odor	No data	No data	Odorless	No data	No data
Odor threshold:					
Water	No data	No data	No data	No data	No data
Air	No data	No data	No data	No data	No data
Solubility:					
Water	Decomposes	369 g/L (cold)	0.11 g/L at 18 °C	538 g/L at 20 °C	30 g/L at 100 °C
Organic solvents(s)	Alcohol	Alcohol, slightly	No data	Alcohol, acetone	Acetic acid
Partition coefficients:					
Log K <sub>ow</sub>	No data	No data	No data	No data	No data
Log K <sub>oc</sub>	No data	No data	No data	No data	No data
Vapor pressure	5 mmHg at 847 °C	No data	No data	No data	No data
Henry's Law constant	No data	No data	No data	No data	No data
Autoignition temperature	No data	No data	No data	No data	No data
Flashpoint	No data	No data	No data	No data	No data
Flammability limits	No data	No data	No data	No data	No data
Explosive limits	No data	No data	No data	No data	No data

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**Table 4-2. Physical and Chemical Properties of Strontium and Strontium Compounds<sup>a</sup>**

Property	Strontium fluoride <sup>e,c</sup>	Strontium hydroxide <sup>c</sup>	Strontium nitrate <sup>c</sup>	Strontium phosphate <sup>f</sup>	Strontium oxide <sup>c</sup>
Molecular weight, g/mole	125.62	121.64	211.63	452.80	103.62
Color	White	Colorless	Colorless	White	Yellow
Physical state	Solid	Solid	Solid	Solid	Solid
Melting point	Decomposes >100 °C	375 °C	570 °C	No data	2,430 °C
Boiling point	2,489 °C	No data	645 °C	No data	3,000 °C
Density, g/cm <sup>3</sup>	4.24	3.63	2.98	No data	4.56
Odor	No data	No data	Odorless	No data	No data
Odor threshold:					
Water	No data	No data	No data	No data	No data
Air	No data	No data	No data	No data	No data
Solubility:					
Water	0.12 g/L at 18 °C	470 g/L at 100 °C	790 g/L at 18 °C	Insoluble	229 g/L at 100 °C
Organic solvents(s)	Alcohol, acetone	Alcohol	Slightly in alcohol and acetone	No data	Slightly in alcohol
Partition coefficients:					
Log K <sub>ow</sub>	No data	No data	No data	No data	No data
Log K <sub>oc</sub>	No data	No data	No data	No data	No data
Vapor pressure	1 mmHg at 921 °C	No data	No data	No data	No data
Henry's Law constant	No data	No data	No data	No data	No data
Autoignition temperature	No data	No data	No data	No data	No data
Flashpoint	No data	No data	No data	No data	No data
Flammability limits	No data	No data	No data	No data	No data
Explosive limits	No data	No data	No data	No data	No data

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**Table 4-2. Physical and Chemical Properties of Strontium and Strontium Compounds<sup>a</sup>**

Property	Strontium peroxide	Strontium sulfate	Strontium sulfide	Strontium titanate
Molecular weight, g/mole	119.63	183.68	119.70	183.52
Color	White	Colorless	Gray	White
Physical state	Solid	Solid	Solid	Solid
Melting point	Decomposes at 215 °C	1,605 °C	>2,000 °C	No data
Boiling point	No applicable	No data	No data	No data
Density, g/cm <sup>3</sup>	4.56	3.96	3.70	4.810
Odor	Odorless	No data	Hydrogen sulfide in moist air	No data
Odor threshold:				
Water	Not applicable	No data	No data	No data
Air	Not applicable	No data	No data	No data
Solubility:				
Water	Decomposes	0.14g/L at 30 °C	Decomposes	Insoluble
Organic solvents(s)	Alcohol	Slightly in alcohol	No data	No data
Partition coefficients:				
Log K <sub>ow</sub>	No data	No data	No data	No data
Log K <sub>oc</sub>	No data	No data	No data	No data
Vapor pressure	No data	No data	No data	No data
Henry's Law constant	No data	No data	No data	No data
Autoignition temperature	No data	No data	No data	No data
Flashpoint	No data	No data	No data	No data
Flammability limits	No data	No data	No data	No data
Explosive limits	No data	No data	No data	No data

<sup>a</sup>Source: HSDB 2002, unless otherwise stated<sup>b</sup>Merck 1989<sup>c</sup>Lide 1995<sup>d</sup>At 69 atmospheres pressure<sup>e</sup>Sigma-Aldrich 2000<sup>f</sup>Lide 2000

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**Table 4-3. Percent Natural Occurrence and Radioactive Properties of Isotopes of Strontium**

Isotope	CAS registry number	Natural abundance (by weight %)	Beta energies, MeV	Half-life	Activity, Ci/gram
<sup>84</sup> Sr	15758-49-3	0.56	No data	Stable	No data
<sup>85</sup> Sr	13967-73-2	No data	1.065 <sup>a</sup>	65 days	35,400
<sup>86</sup> Sr	13982-14-4	9.86	No data	Stable	No data
<sup>87</sup> Sr	13982-64-4	7.00	No data	Stable	No data
<sup>88</sup> Sr	14119-10-9	82.58	No data	Stable	No data
<sup>89</sup> Sr	14158-27-1	No data	1.495	51 days	27,800
<sup>90</sup> Sr	10098-97-2	No data	0.546	29 years	143
<sup>91</sup> Sr	14331-91-0	No data	2.707	10 hours	3.4x10 <sup>6</sup>
<sup>92</sup> Sr	14928-29-1	No data	1.911	3 hours	1.1x10 <sup>7</sup>

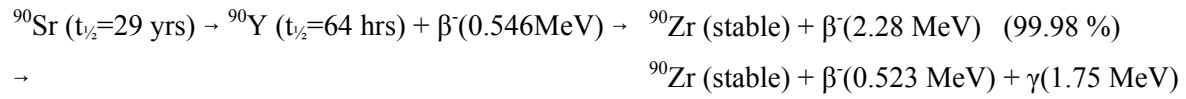
<sup>a</sup>Decay mechanism by electron capture with gamma emission

Source: Lide 1995



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beta-particle and gamma-ray (2.19 keV) emitter. The decay product of  $^{90}\text{Y}$  is  $^{90}\text{Zr}$ , a stable isotope. The reaction is:



$^{89}\text{Sr}$ , like  $^{90}\text{Sr}$ , is a fission product of  $^{235}\text{U}$ ,  $^{238}\text{U}$ , or  $^{239}\text{Pu}$ . It decays to  $^{89}\text{Y}$  by emission of a beta-particle of 1.495 MeV  $^{89}\text{Y}$ .  $^{89}\text{Sr}$  has half-life of 51 days (Lide 1995).