

8.12 Sodium Carbonate

8.12.1 General¹⁻³

Sodium carbonate (Na_2CO_3), commonly referred to as soda ash, is one of the largest-volume mineral products in the U. S., with 1991 production of over 9 million megagrams (Mg) (10.2 million tons). Over 85 percent of this soda ash originates in Wyoming, with the remainder coming from Searles Valley, California. Soda ash is used mostly in the production of glass, chemicals, soaps, and detergents, and by consumers. Demand depends to great extent upon the price of, and environmental issues surrounding, caustic soda, which is interchangeable with soda ash in many uses and is widely coproduced with chlorine (see Section 8.11, "Chlor-Alkali").

8.12.2 Process Description⁴⁻⁷

Soda ash may be manufactured synthetically or from naturally occurring raw materials such as ore. Only 1 U. S. facility recovers small quantities of Na_2CO_3 synthetically as a byproduct of cresylic acid production. Other synthetic processes include the Solvay process, which involves saturation of brine with ammonia (NH_3) and carbon dioxide (CO_2) gas, and the Japanese ammonium chloride (NH_4Cl) coproduction process. Both of these synthetic processes generate ammonia emissions. Natural processes include the calcination of sodium bicarbonate (NaHCO_3), or nahcolite, a naturally occurring ore found in vast quantities in Colorado.

The 2 processes currently used to produce natural soda ash differ only in the recovery stage in primary treatment of the raw material used. The raw material for Wyoming soda ash is mined trona ore, while California soda ash comes from sodium carbonate-rich brine extracted from Searles Lake.

There are 4 distinct methods used to mine the Wyoming trona ore: (1) solution mining, (2) room-and-pillar, (3) longwall, and (4) shortwall. In solution mining, dilute sodium hydroxide (NaOH), commonly called caustic soda, is injected into the trona to dissolve it. This solution is treated with CO_2 gas in carbonation towers to convert the Na_2CO_3 in solution to NaHCO_3 , which precipitates and is filtered out. The crystals are again dissolved in water, precipitated with carbon dioxide, and filtered. The product is calcined to produce dense soda ash. Brine extracted from below Searles Lake in California is treated similarly.

Blasting is used in the room-and-pillar, longwall, and shortwall methods. The conventional blasting agent is prilled ammonium nitrate (NH_4NO_3) and fuel oil, or ANFO (see Section 13.3, "Explosives Detonation"). Beneficiation is accomplished with either of 2 methods, called the sesquicarbonate and the monohydrate processes. In the sesquicarbonate process, shown schematically in Figure 8.12-1, trona ore is first dissolved in water (H_2O) and then treated as brine. This liquid is filtered to remove insoluble impurities before the sodium sesquicarbonate ($\text{Na}_2\text{CO}_3 \cdot \text{NaHCO}_3 \cdot 2\text{H}_2\text{O}$) is precipitated out using vacuum crystallizers. The result is centrifuged to remove remaining water, and can either be sold as a finished product or further calcined to yield soda ash of light to intermediate density. In the monohydrate process, shown schematically in Figure 8.12-2, crushed trona is calcined in a rotary kiln, yielding dense soda ash and carbon dioxide and water as byproducts. The calcined material is combined with water to allow settling out or filtering of impurities such as shale, and is then concentrated by triple-effect evaporators and/or mechanical vapor recompression crystallizers to precipitate sodium carbonate monohydrate ($\text{Na}_2\text{CO}_3 \cdot \text{H}_2\text{O}$). Impurities

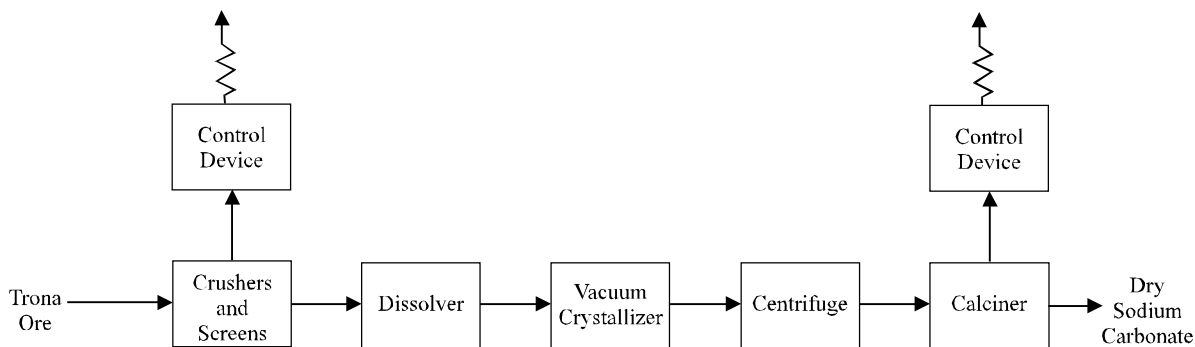


Figure 8.12-1. Flow diagram for sesquicarbonate sodium carbonate processing.

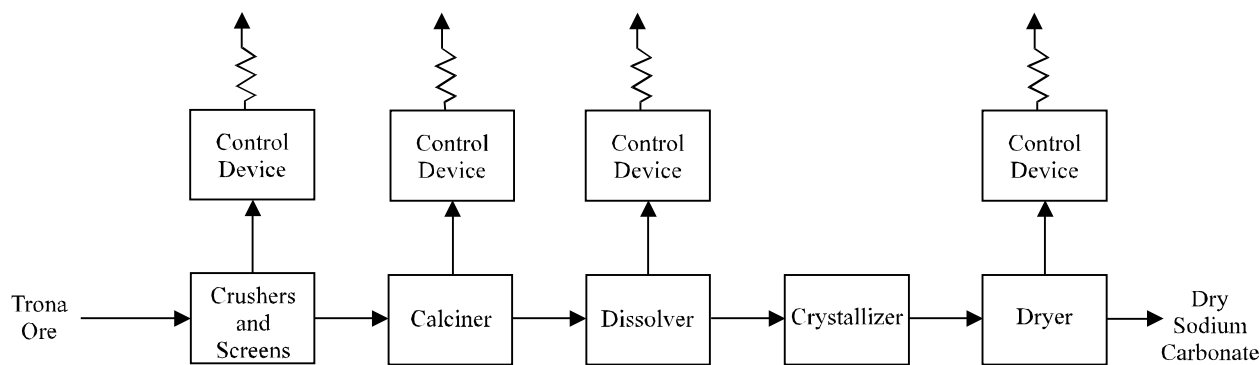


Figure 8.12-2. Flow diagram for monohydrate sodium carbonate processing.

such as sodium chloride (NaCl) and sodium sulfate (Na_2SO_4) remain in solution. The crystals and liquor are centrifuged, and the recovered crystals are calcined again to remove remaining water. The product must then be cooled, screened, and possibly bagged, before shipping.

8.12.3 Emissions And Controls

The principal air emissions from the sodium carbonate production methods now used in the U. S. are particulate emissions from ore calciners; soda ash coolers and dryers; ore crushing, screening, and transporting operations; and product handling and shipping operations. Emissions of products of combustion, such as carbon monoxide, nitrogen oxides, sulfur dioxide, and carbon dioxide, occur from direct-fired process heating units such as ore calcining kilns and soda ash dryers. With the exception of carbon dioxide, which is suspected of contributing to global climate change, insufficient data are available to quantify these emissions with a reasonable level of confidence, but similar processes are addressed in various sections of Chapter 11 of AP-42, "Mineral Products Industry". Controlled emissions of filterable and total particulate matter from individual processes and process components are given in Tables 8.12-1 and 8.12-2. Uncontrolled emissions from these same processes are given in Table 8.12-3. No data quantifying emissions of organic condensable particulate matter from sodium carbonate manufacturing processes are available, but this portion of

Table 8.12-1 (Metric Units). CONTROLLED EMISSION FACTORS FOR PARTICULATE MATTER FROM SODIUM CARBONATE PRODUCTION

Process	Filterable Emissions ^a		Total Emissions ^b	
	kg/Mg Of Product	EMISSION FACTOR RATING	kg/Mg Of Product	EMISSION FACTOR RATING
Ore mining ^c (SCC 3-01-023-99)	0.0016	C	ND	NA
Ore crushing and screening ^c (SCC 3-01-023-99)	0.0010	D	0.0018	C
Ore transfer ^c (SCC 3-01-023-99)	0.00008	E	0.0001	E
Monohydrate process: rotary ore calciner (SCC 3-01-023-04/05)	0.091	A	0.12	B
Sesquicarbonate process: rotary calciner (SCC 3-01-023-99)	0.36	B	0.36	C
Sesquicarbonate process: fluid-bed calciner (SCC 3-01-023-99)	0.021	C	ND	NA
Rotary soda ash dryers (SCC 3-01-023-06)	0.25	C	0.25	D
Fluid-bed soda ash dryers/coolers (SCC 3-01-023-07)	0.015	C	0.019	D
Soda ash screening (SCC 3-01-023-99)	0.0097	E	0.013	E
Soda ash storage/loading and unloading ^c (SCC 3-01-023-99)	0.0021	E	0.0026	E

^a Filterable particulate matter is that material collected in the probe and filter of a Method 5 or Method 17 sampler. SCC = Source Classification Code. ND = no data. NA = not applicable.

^b Total particulate matter includes filterable particulate and inorganic condensable particulate.

^c For ambient temperature processes, all particulate matter emissions can be assumed to be filterable at ambient conditions. However, particulate sampling according to EPA Reference Method 5 involves the heating of the front half of the sampling train to temperatures that may vaporize some portion of this particulate matter, which will then recondense in the back half of the sampling train. For consistency, particulate matter measured as condensable according to Method 5 is reported as such.

the particulate matter can be assumed to be negligible. Emissions of carbon dioxide from selected processes are given in Table 8.12-4. Emissions from combustion sources such as boilers, and from evaporation of hydrocarbon fuels used to fire these combustion sources, are covered in other chapters of AP-42.

Particulate emissions from calciners and dryers are typically controlled by venturi scrubbers, electrostatic precipitators, and/or cyclones. Baghouse filters are not well suited to applications such as these, because of the high moisture content of the effluent gas. Particulate emissions from ore and product handling operations are typically controlled by either venturi scrubbers or baghouse filters. These control devices are an integral part of the manufacturing process, capturing raw materials and

Table 8.12-2 (English Units). CONTROLLED EMISSION FACTORS FOR PARTICULATE MATTER FROM SODIUM CARBONATE PRODUCTION

Process	Filterable Emissions ^a		Total Emissions ^b	
	lb/ton Of Product	EMISSION FACTOR RATING	lb/ton Of Product	EMISSION FACTOR RATING
Ore mining ^c (SCC 3-01-023-99)	0.0033	C	ND	NA
Ore crushing and screening ^c (SCC 3-01-023-99)	0.0021	D	0.0035	C
Ore transfer ^c (SCC 3-01-023-99)	0.0002	E	0.0002	E
Monohydrate process: rotary ore calciner (SCC 3-01-023-04/05)	0.18	A	0.23	B
Sesquicarbonate process: rotary calciner (SCC 3-01-023-99)	0.72	B	0.73	C
Sesquicarbonate process: fluid-bed calciner (SCC 3-01-023-99)	0.043	C	ND	NA
Rotary soda ash dryers (SCC 3-01-023-06)	0.50	C	0.52	D
Fluid-bed soda ash dryers/coolers (SCC 3-01-023-07)	0.030	C	0.39	D
Soda ash screening (SCC 3-01-023-99)	0.019	E	0.026	E
Soda ash storage/loading and unloading ^c (SCC 3-01-023-99)	0.0041	E	0.0051	E

^a Filterable particulate matter is that material collected in the probe and filter of a Method 5 or Method 17 sampler. SCC = Source Classification Code. ND = no data. NA = not applicable.

^b Total particulate matter includes filterable particulate and inorganic condensable particulate.

^c For ambient temperature processes, all particulate matter emissions can be assumed to be filterable at ambient conditions; however, particulate sampling according to EPA Reference Method 5 involves the heating of the front half of the sampling train to temperatures that may vaporize some portion of this particulate matter, which will then recondense in the back half of the sampling train. For consistency, particulate matter measured as condensable according to Method 5 is reported as such.

product for economic reasons. Because of a lack of suitable emissions data for uncontrolled processes, both controlled and uncontrolled emission factors are presented for this industry. The uncontrolled emission factors have been calculated by applying nominal control efficiencies to the controlled emission factors.

Table 8.12-3 (Metric And English Units). UNCONTROLLED EMISSION FACTORS FOR PARTICULATE MATTER FROM SODIUM CARBONATE

Process	Nominal Control Efficiency (%)	Total ^a		
		kg/Mg Of Product	lb/ton Of Product	EMISSION FACTOR RATING
Ore mining (SCC 3-01-023-99)	99.9	1.6	3.3	D
Ore crushing and screening (SCC 3-01-023-99)	99.9	1.7	3.5	E
Ore transfer (SCC 3-01-023-99)	99.9	0.1	0.2	E
Monohydrate process: rotary ore calciner (SCC 3-01-023-04/05)	99.9	90	180	B
Sesquicarbonate process: rotary calciner (SCC 3-01-023-99)	99	36	72	D
Sesquicarbonate process: fluid-bed calciner (SCC 3-01-023-99)	99	2.1	4.3	D
Rotary soda ash dryers (SCC 3-01-023-06)	99	25	50	E
Fluid-bed soda ash dryers/coolers (SCC 3-01-023-07)	99	1.5	3.0	E
Soda ash screening (SCC 3-01-023-99)	99.9	10	19	E
Soda ash storage/loading and unloading (SCC 3-01-023-99)	99.9	2.6	5.2	E

^a Values for uncontrolled total particulate matter can be assumed to include filterable particulate and both organic and inorganic condensable particulate. For processes operating at significantly greater than ambient temperatures, these factors have been calculated by applying the nominal control efficiency to the controlled (as-measured) filterable particulate emission factors above.
SCC = Source Classification Code.

Table 8.12-4 (Metric And English Units). UNCONTROLLED EMISSION FACTORS FOR CARBON DIOXIDE FROM SODIUM CARBONATE PRODUCTION^a

EMISSION FACTOR RATING: E

Process	Emissions	
	kg/Mg Of Product	lb/ton Of Product
Monohydrate process: rotary ore calciner (SCC 3-01-023-04/05)	200	400
Sesquicarbonate process: rotary calciner (SCC 3-01-023-99)	150	310
Sesquicarbonate process: fluid-bed calciner (SCC 3-01-023-99)	90	180
Rotary soda ash dryers (SCC 3-01-023-06)	63	130

^a Factors are derived from analyses during emission tests for criteria pollutants, rather than from fuel analyses and material balances. SCC = Source Classification Code. References 8-26.

References For Section 8.12

1. D. S. Kostick, "Soda Ash", *Mineral Commodity Summaries 1992*, U. S. Department Of The Interior, 1992.
2. D. S. Kostick, "Soda Ash", *Minerals Yearbook 1989, Volume I: Metals And Minerals*, U. S. Department Of The Interior, 1990.
3. *Directory Of Chemical Producers: United States of America, 1990*, SRI International, Menlo Park, CA, 1990.
4. L. Gribovicz, "FY 91 Annual Inspection Report: FMC-Wyoming Corporation, Westvaco Soda Ash Refinery", Wyoming Department Of Environmental Quality, Cheyenne, WY, 11 June 1991.
5. L. Gribovicz, "FY 92 Annual Inspection Report: General Chemical Partners, Green River Works", Wyoming Department Of Environmental Quality, Cheyenne, WY, 16 September 1991.
6. L. Gribovicz, "FY 92 Annual Inspection Report: Rhône-Poulenc Chemical Company, Big Island Mine and Refinery", Wyoming Department Of Environmental Quality, Cheyenne, WY, 17 December 1991.
7. L. Gribovicz, 91 Annual Inspection Report: Texasgulf Chemical Company, Granger Trona Mine & Soda Ash Refinery", Wyoming Department Of Environmental Quality, Cheyenne, WY, 15 July 1991.
8. "Stack Emissions Survey: General Chemical, Soda Ash Plant, Green River, Wyoming", Western Environmental Services And Testing, Inc., Casper, WY, February 1988.
9. "Stack Emissions Survey: General Chemical, Soda Ash Plant, Green River, Wyoming", Western Environmental Services And Testing, Inc., Casper, WY, November 1989.
10. "Rhône-Poulenc Wyoming Co. Particulate Emission Compliance Program", TRC Environmental Measurements Division, Englewood, CO, 21 May 1990.
11. "Rhône-Poulenc Wyoming Co. Particulate Emission Compliance Program", TRC Environmental Measurements Division, Englewood, CO, 6 July 1990.
12. "Stack Emissions Survey: FMC-Wyoming Corporation, Green River, Wyoming", FMC-Wyoming Corporation, Green River, WY, October 1990.
13. "Stack Emissions Survey: FMC-Wyoming Corporation, Green River, Wyoming", FMC-Wyoming Corporation, Green River, WY, February 1991.
14. "Stack Emissions Survey: FMC-Wyoming Corporation, Green River, Wyoming", FMC-Wyoming Corporation, Green River, WY, January 1991.
15. "Stack Emissions Survey: FMC-Wyoming Corporation, Green River, Wyoming", FMC-Wyoming Corporation, Green River, WY, October 1990.

16. "Compliance Test Report: FMC-Wyoming Corporation, Green River, Wyoming", FMC-Wyoming Corporation, Green River, WY, 6 June 1988.
17. "Compliance Test Report: FMC-Wyoming Corporation, Green River, Wyoming", FMC-Wyoming Corporation, Green River, WY, 24 May 1988.
18. "Compliance Test Report: FMC-Wyoming Corporation, Green River, Wyoming", FMC-Wyoming Corporation, Green River, WY, 28 August 1985.
19. "Stack Emissions Survey: FMC-Wyoming Corporation, Green River, Wyoming", FMC-Wyoming Corporation, Green River, WY, December 1990.
20. "Emission Measurement Test Report Of GR3A Crusher", The Emission Measurement People, Inc., Cañon City, CO, 16 October 1990.
21. "Stack Emissions Survey: TG Soda Ash, Inc., Granger, Wyoming", Western Environmental Services And Testing, Inc., Casper, WY, August 1989.
22. "Compliance Test Reports", Tenneco Minerals, Green River, WY, 30 November 1983.
23. "Compliance Test Reports", Tenneco Minerals, Green River, WY, 8 November 1983.
24. "Particulate Stack Sampling Reports", Texasgulf, Inc., Granger, WY, October 1977 — September 1978.
25. "Fluid Bed Dryer Emissions Certification Report", Texasgulf Chemicals Co., Granger, WY, 18 February 1985.
26. "Stack Emissions Survey: General Chemical, Soda Ash Plant, Green River, Wyoming", Western Environmental Services And Testing, Inc., Casper, WY, May 1987.