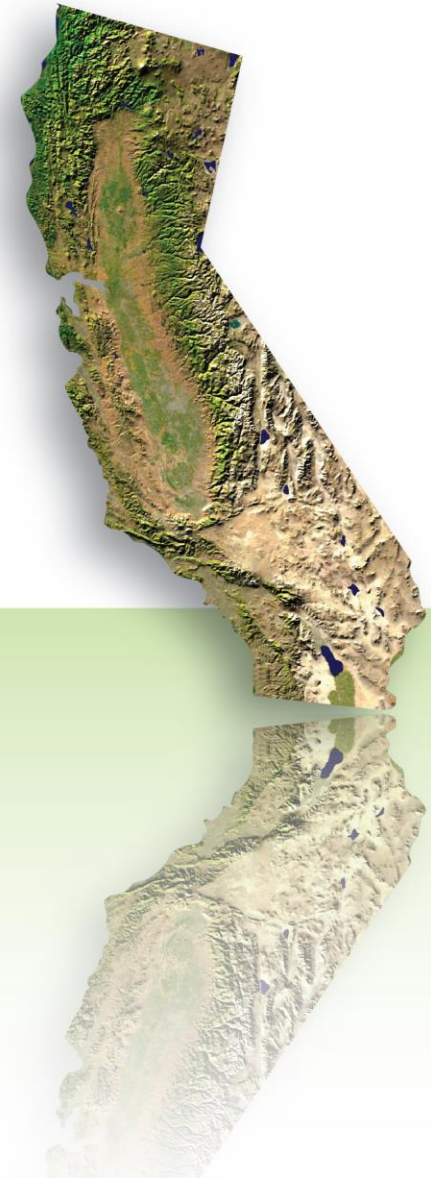
Verifier Accreditation Training for Mandatory Greenhouse Gas Reporting



Process Emissions Specialty
Course 4.2: Lime Manufacturing

California Environmental Protection Agency
Air Resources Board

Verifier Accreditation Training for Mandatory Greenhouse Gas Reporting

Course 4: Process Emissions Specialty

4.1 Cement Production

4.2 Lime Manufacturing

4.3 Glass Manufacturing

4.4 Nitric Acid Production

4.5 Iron and Steel Production

4.6 Pulp and Paper Manufacturing

4.7 Lead Production

California Environmental Protection Agency

Air Resources Board

Course 4.2 Handouts

See 4.1.1 Cement and Lime Mass Balance Calculation Workbook from Course 4.1

Course 4.2 Lime Manufacturing

1. Overview
2. Emissions Data and Calculation Methods
3. Verifying Emissions
4. Missing Emissions Data Substitutions
5. Product Data
6. Group Participation Exercise

Lime Production Plant

§95117 Lime Manufacturing (1 of 2)

- Refers to Subpart S for reporting process emissions
- Applies to lime manufacturing plants (LMPs) that manufacture lime products by calcination of limestone*, dolomite**, shells, or other calcareous substances (aragonite, chalk, coral, marble)
  - Calcium oxide
  - High-calcium quicklime
  - Calcium hydroxide
  - Hydrated lime
  - Dolomitic quicklime
  - Dolomitic hydrate

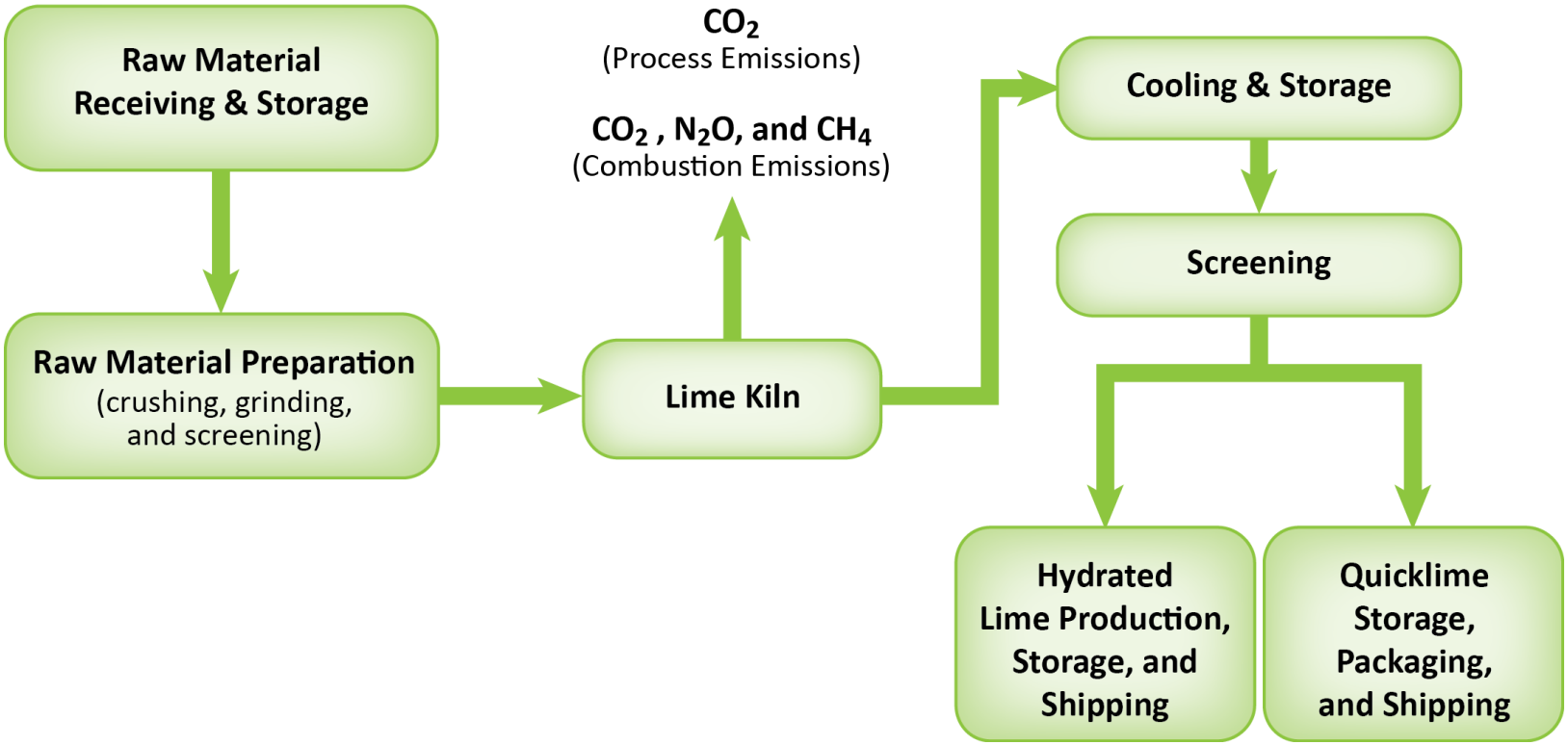
**Rock must contain at least 50% calcium carbonate to be classified as limestone*

***Rock that contains 30 to 45% magnesium carbonate is referred to as dolomite or dolomitic limestone*

§95117 Lime Manufacturing (2 of 2)

- Includes marketed and non-marketed lime manufacturing facilities
- Lime production facilities are “all in”
- Excluded from § 95117 (but none in California)
  - LMPs located at a Kraft pulp mill, soda pulp mill, and sulfite pulp mill (report under 40 CFR Part 98, Subpart AA)
  - LMPs that process only sludge containing calcium carbonate from water softening processes

Processes and Emissions Generation in a Lime Plant



Rule of Thumb Values

Production Ratios (Approximate)

- 0.5 Ton Lime / Ton Limestone (wet)
- 0.44 Ton CO_2 / Ton Limestone (dry)
- 0.1 - 0.15 Ton Fuel / Ton Lime
- 0.1 Ton Lime Kiln Dust (LKD) / Ton Lime

Basic Reactions (Process Emissions)

- Limestone $CaCO_3$ is heated to release CO_2 giving lime product (CaO)
  - $CaCO_3$ + Heat => CaO + CO_2
  - 1 metric ton of pure, dry limestone gives 440 kg of CO_2
- Dolime (calcined dolomite) $CaMg(CO_3)_2$ is heated to release CO_2 giving lime product (CaO) and MgO
  - $CaMg(CO_3)_2$ + Heat => CaO + MgO + $2CO_2$
  - 1 metric ton of pure, dry dolomite gives 477 kg of CO_2

Loss on Ignition (LOI)

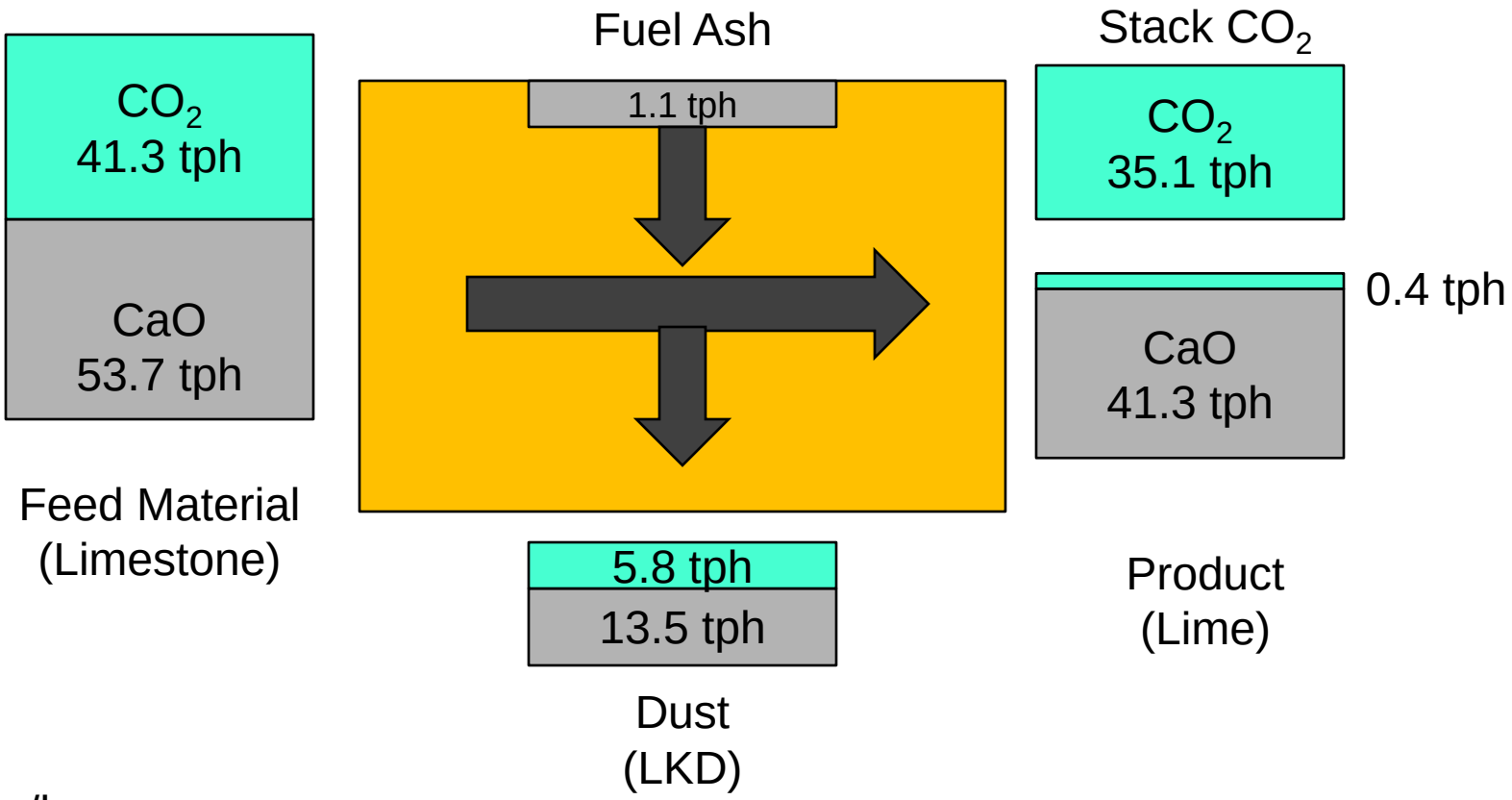
- The purity of limestone is measured by the lime (CaO) and/or magnesium oxide (MgO) content
- One common measure used in the industry is the Loss on Ignition (LOI) or Ignition Loss
- This is the loss of weight of a dried sample of limestone or dolomite when heated above the calcination temperature and generally represents the amount of CO_2 in the sample
- LOI is important for mass balances

Example Mass Balance (LOI Basis)

Limestone Feed Rate	100	TPH	Plant Data
H2O %	5%	Percent	Plant Data
Dry Limestone	95	TPH	Limestone * (1 - H2O%)
Limestone LOI %	43.5%	Percent	Plant Data Lab Test
Inerts in Limestone	53.68	TPH	Dry Limestone * (1 - LOI%)
CO2 in Limestone	41.33	TPH	Dry Limestone - Lime in
Fuel Feed Rate	10.00	TPH	Plant Data
Fuel H2O %	10%	Percent	Plant Data
Fuel Ash %	12%	Percent	Plant Data
Fuel Ash	1.08	TPH	Fuel Rate * (1 - H20%) * Ash%
Daily Lime Production Rate	1000	TPD	Plant Data
Hourly Product Out	41.67	TPH	Daily Production / 24 Hours
Product LOI %	1.0%	Percent	Plant Data Lab Test
Lime Out (excl. CO2)	41.25	TPH	Product * (1 - LOI%)
CO2 in Product	0.42	TPH	Product Out - Lime Out
LKD excluding CO2	13.51	TPH	Lime in + ash in - Lime Out
LKD LOI %	30%	Percent	Plant Data Lab Test
LKD Out (incl CO2)	19.29	TPH	LKD Lime / (1 - LOI%)
CO2 in LKD	5.79	TPH	LKD Out - LKD excluding CO2
Process CO2 Emitted	35.12	TPH	CO2 LS - CO2 Prod - CO2 LKD
Hours of Operation	7500	Hours	Plant Data
Total CO2 Tons per Year	263404	Tons	CO2 TPH * Hours
*Loss on Ignition (LOI) - lab test determined loss upon combustion (in % as CO2)			

Process Emissions Lime Kiln

CO_2 in stack = CO_2 in Raw Material – CO_2 in Product – CO_2 in Dust



tph = tons/hr

Emissions Data Reported for Lime Manufacturing Facilities (1 of 2)

These emissions must be reported:

- CO_2 process emissions from lime kilns (§95117)
- CO_2, CH_4, and N_2O emissions from stationary combustion of fuels (§95115)
- CO_2 captured for use on-site (40 CFR 98.196(b)(17))

Emissions Data Reported for Lime Manufacturing Facilities (2 of 2)

All process emissions assumed to occur in kiln; no process emissions are assumed to occur from

- Raw material handling
  - Receiving, crushing, grinding, and screening, & transportation
- LKD handling
  - Treatment, transportation, and disposal / disposition
- Lime screening and grinding
- Lime storage and shipping
- Hydrated lime production (when sole LMP process)

§95117 Relation to Subpart S

§95117 refers to subpart S for all requirements except

- Stationary fuel combustion emissions - Tiers 1 through 4 methodologies as specified by fuel type in § 95115
- More conservative missing emissions data substitution procedures
- Additional product data reported
  - Dolime produced (covered product data)
  - Lime produced (not a covered product)

Calculation Methods for CO_2 Process Emissions from Lime Kilns

- Reporters must use either of the methods specified in Subpart S:
  - **Mass balance calculation** based on quantity and composition analysis of lime product, LKD, and calcined byproducts/wastes
    - Report CO_2 from combustion and process separately
  - **CEMS (California facilities do not have CEMS)**
    - Report CO_2 from both combustion and process combined
- When verifying produced CO_2 used onsite
  - New requirement – discuss with ARB during verification
  - No covered product data reported

Verifying CO_2 Emissions from Lime Kilns (1 of 2)

For mass balance method

- Obtain and review documentation describing how facility derived its lime and calcined lime byproduct/waste production and sales numbers including measurement data
- Verify appropriate measurement methods were used to determine
  - Monthly lime/lime byproduct (40 CFR 98.194(b))
  - Total CaO and MgO weight fractions in each product/byproduct (40 CFR.194(c))

Verifying CO_2 Emissions from Lime Kilns (2 of 2)

Reproduce CO_2 emission calculations using Eq. S-1 through S-4 to calculate CO_2 emissions

S-1 - Calculate monthly emission factor for lime

S-2 - Calculate monthly emission factor for LKD sold

S-3 - Calculate CO_2 emissions from waste not sold

S-4 - Sum of emissions from lime, LKD sold, and waste not sold

$$E_{CO_2} = \sum_{i=1}^{t}\sum_{n=1}^{12}(EF_{LIME,i,n} * M_{LIME,i,n}) + \sum_{i=1}^{b}\sum_{n=1}^{12} EF_{LKD,i,n} * M_{LKD,i,n}) + \sum_{i=1}^{z} E_{waste,i}$$

Verifying Missing Emissions Data Substitution (1 of 2)

- § 95117 refers to § 95129 for missing SFC data

- For mass balance method
  - Missing CaO or MgO composition data § 95117(c)(2)
    - If ≤ 10% missing, use best available data for reporting year
    - If >10 and ≤20% missing, use highest quality assured value recorded for the missing parameter during the given year, as well as the two previous years
    - If >20% missing, use highest quality assured value recorded for the parameter in all records kept

Verifying Missing Emissions Data Substitution (2 of 2)

For emissions data reporting using mass balance method

- Missing monthly amounts of lime production and byproduct/waste produced and sold (and used to report emissions) § 95117(c)(3)
  - If ≤20% missing , use best available estimate based on all available process data or data used for accounting purposes
  - If >20% missing , use the maximum capacity of the lime kiln

Data Elements Reported for Lime Manufacturing Facilities under Subpart S

- Monthly quantities of each lime product
- Monthly quantities of calcined lime byproduct/waste sold
- Annual quantities of calcined lime byproduct/waste not sold
- Beginning and end of year inventories of each lime product
- Beginning and end of year inventories of each calcined byproduct/waste sold
- Annual quantity of CO_2 captured for onsite production process, if applicable (quantity that is used, not sold)

Product Data Reported for Lime Manufacturing Facilities under § 95117(d)

- Annual quantity of dolime produced
  (Covered, short tons)
- Annual quantity of lime produced
  (Not covered, short tons)
- Missing data procedures not allowed for product data reporting

Verifying Product Data for Lime Manufacturing Facilities

- Evidence to request
  - Documentation describing how the facility determined its production data (for emissions and covered product data)
  - Direct measurement records from product measurement
  - Product sales invoices/delivery receipts
  - Beginning and end of year product inventory records
- How to evaluate evidence
  - Confirm records are complete
  - Confirm that monthly data are summed correctly
  - Compare summed monthly data with reported production data

Verifying Other Production-Related Data for Lime Manufacturing Facilities

- "Other production-related" data
  - 40 CFR 98 subpart S requires other production-related data to be reported to U.S. EPA: annual quantity of lime sold, amount of calcined lime/byproduct waste sold/not sold, monthly weights and mass of each lime product sold, annual production capacity per facility
  - Production-related data ≠ Covered product data
- *Other production-related data are not subject to the same requirements as covered product data required under the MRR and listed in Table 9-1 of the Cap-and-Trade Regulation. However, the 40 CFR 98 production-related data elements must be verified for conformance.*
- If production-related data are used to estimate emissions, then they must be accurate and errors could influence the evaluation of material misstatement for emissions data.

Questions and ARB Comments

1. Overview
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6. **Group Participation Exercise**

Group Participation Exercise 4.2.1
LMP Missing Data Substitution (1 of 2)

- A lime plant operates a single kiln that produces 1,000 tons of dolime per day. During the site visit, the plant manager indicated that some construction at the plant resulted in a plant shutdown beginning September 30, 2014. The plant started back up on October 21, 2014 and operated at its normal production level, but the data was not recorded and is "missing" for 11 days after the plant restarted. The plant provided the dolime production data shown in the next slide.
- What value should be substituted for the missing dolime production data (for the purposes of calculating emissions and for reporting covered product data) for October?
  - A. 7,100
  - B. 17,000
  - C. 20,000
  - D. 20,583

Group Participation Exercise 4.2.1
LMP Missing Data Substitution (2 of 2)

	Monthly Dolime Production (Based on Plant logs) (tons)	
	2013	2014
January	20,000	20,000
February	22,000	22,000
March	20,000	20,000
April	20,000	20,000
May	25,000	20,000
June	20,000	20,000
July	21,000	21,000
August	21,000	21,000
September	20,000	15,000
October	18,000	missing
November	20,000	20,000
December	20,000	20,000
Total Production for the year	247,000	
Annual Average (based on available data)	20,583	19,909

Group Participation Exercise 4.2.1
LMP Missing Data Substitution - Solution

- For emissions, as missing data is less than 20%, can use best estimate based on available data
- Answer **A** is the most reasonable (7,100 tons or 11/31*20,000 which is the average output for 11 days in October where there is missing data), but other answers are possible
- For covered product data, missing data substitution is not allowed; so October dolime production would have to be reported as excluded

Questions and ARB Comments

Course 4: Process Emissions Specialty

Complete:

4.1 Cement Production

4.2 Lime Manufacturing

Next:

4.3 Glass Manufacturing

4.4 Nitric Acid Production

4.5 Iron and Steel Production

4.6 Pulp and Paper Manufacturing

4.7 Lead Production