Estimating Process-Related CO_2 Emissions from Cement Production Using the Clinker-Based Methodology

Handout for Cement Technical Team Discussion: April 11, 2007
California Air Resources Board (ARB): Climate Change Reporting

Summary of Example Calculations

California Air Resources Board (ARB) staff completed a series of example calculations (Attachment 1) that compare CO_2 emissions estimates using two different clinker-based equations. The California Climate Action Registry (Registry) includes Equation 1 in the Cement Reporting Protocol, which is based on the Cement Sustainability Initiative (CSI) Cement Protocol. The Intergovernmental Panel on Climate Change (IPCC) 2006 Guidelines includes Equation 2 in their guidelines for Cement Production.

Equation 1: Registry Cement Reporting Protocol

CO_2 emissions = $[(Cli)\ (EF_{Cli}) + (CKD)\ (EF_{CKD})]$

Where:

Cli	=	Quantity of clinker produced
EF_{Cli}	=	Clinker emission factor
CKD	=	Quantity CKD discarded
EF_{CKD}	=	CKD emission factor

Equation 2: IPCC 2006 Guidelines

CO_2 emissions = $M_{Cl} \bullet EF_{Cli} \bullet CF_{CKD}$

Where:

M_{Cl}	=	Weight (mass) of clinker produced
EF_{Cli}	=	Clinker emission factor
CF_{CKD}	=	Emissions correction factor for CKD

Direct-Process CO_2 Emissions

Table 1 provides a comparison of three scenarios using default values to calculate CO_2 emissions. Table 2 provides a similar comparison using plant-specific data and emission factors. Each scenario assumes that Plant X produces 1.2 MMT clinker per year.

Clinker Emission Factors

Typical clinkers range in lime (CaO) content between 60-67% and magnesium oxide (MgO) content between 1-6%[1]. The calculations in Table 1 use a default clinker emission factor that assumes a CaO content of 64.5% and MgO content of 1%. The plant-specific calculations use a clinker emission factor that assumes a CaO content of 65% and MgO content of 1%.

Cement Kiln Dust (CKD) Values

In the scenarios where it is assumed that 100% cement kiln dust (CKD) is recycled, CKD values are not factored into overall emissions. When a 2% correction factor is applied, CKD emissions represent 2% of clinker CO_2 emissions. When cement Plant X generates a hypothetical 254,504 tons CKD, CO_2 emissions from CKD represent approximately 20% of clinker CO_2 emissions using the Registry equation and 8% of clinker CO_2 emissions using the IPCC 2006 equation.

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[1] Hendrik G. van Oss, "Background Facts and Issues Concerning Cement and Cement Data", *Open-File Report 2005-1152,* U.S. Geological Survey, 2005.

Table 1: CO_2 Emissions Estimated Using Default Values

	EF_{Cli} (CO_2/ton clinker)	Scenario	CKD Assumptions	CKD	EF_{CKD} (CO_2/ton CKD)	CF_{CKD}	CO_2 Emissions (ton CO_2)	
							Registry/CSI	IPCC 2006
Default Values	525 kg = 0.5167 ton	1	100% CKD Recycled	0	499 kg = 0.4911 ton	1.0	620,048	620,048
		2	2% Correction Factor	Clinker CO_2 Emissions	0.02	1.02	632,449	632,449
		3	Plant X Discards CKD	254,504 ton	499 kg = 0.4911 ton	1.08	744,057	669,652

Table 2: CO_2 Emissions Estimated Using Plant-Specific Data

	EF_{Cli} (CO_2/ton clinker)	Scenario	CKD Assumptions	CKD	EF_{CKD} (CO_2/ton CKD)	CF_{CKD}	CO_2 Emissions (ton CO_2)	
							Registry/CSI	IPCC 2006
Plant-Specific Data	530 kg = 0.52117 ton	4	100% CKD Recycled	0	529 kg = 0.5211 ton	1.0	625,404	625,404
		5	2% Correction Factor	Clinker CO_2 Emissions	0.02	1.02	637,912	637,912
		6	Plant X Discards CKD	254,504 ton	529 kg = 0.5211 ton	1.08	756,984	675,436

Conclusions

CO_2 emissions estimates are equal in most scenarios with the exception of scenarios 3 and 6. CO_2 emissions estimates vary between the Registry/CSI and IPCC 2006 equations in the scenarios when Plant X discards a known amount of CKD. The IPCC 2006 CO_2 emissions estimates may be lower due to the fact that the CKD correction factor accounts for 50% calcination of the CKD. The Registry/CSI protocol assumes 100% calcination of CKD, which results in higher CO_2 emissions estimates.

Prepared By: Dana Papke, Air Pollution Specialist