Environmental
Product
Declaration

NRMCA®
NATIONAL READY MIXED CONCRETE ASSOCIATION

NRMCA MEMBER INDUSTRY-WIDE EPD FOR READY MIXED CONCRETE

National Ready Mixed Concrete Association
Ready Mixed Concrete

According to ISO 14025

NSF International Certified

This industry-wide or sector average environmental product declaration is in accordance with ISO 14025 and describes the environmental characteristics of 72 ready mixed concrete products. It is a certified declaration and all relevant environmental information is disclosed as per the governing product category rules. A list of plants that are eligible to claim participation in this EPD is available at: www.nrmca.org/sustainability/EPDProgram/search

PROGRAM OPERATOR	NSF International 789 N. Dixboro Ann Arbor, MI 48105 www.nsf.org
DECLARATION HOLDER	The National Ready Mixed Concrete Association (NRMCA) 900 Spring Street Silver Spring, MD 20910 www.nrmca.org
DECLARATION NUMBER	EPD 10080
DECLARED PRODUCT	This industry wide EPD covers 72 ready mixed concrete products on a per cubic meter (cubic yard) basis
REFERENCE PCR	Product Category Rules (PCR) for ISO 14025 Type III Environmental Product Declarations (EPDs) for Concrete meeting the requirements of one of the following: ASTM C94, ASTM C90, CSA A23.1/A23.2, UNSPSC code 30111500, Version 1.1 dated December 4, 2013, The Carbon Leadership Forum; www. carbonleadershipforum.org

DATE OF ISSUE	October 20, 2016
PERIOD OF VALIDITY	Until October 20, 2021

CONTENTS OF THE DECLARATION	Declares a cradle-to-gate (A1 to A3) assessment of 72 ready mixed concrete products-capturing a significant spectrum of the industry's production

The PCR review was conducted by: Nicholas Santero, PE International; Holly Lahd, EL Analytics and Medgar Marceau, Morrison Hershfield December 4, 2013	
LCA and EPD Developer: Athena Sustainable Materials Institute	Athena Sustainable Materials Institute
This declaration was independently verified in accordance with ISO 14025 by: Name: Jenny Oorbeck, NSF International	EPD Verifier
This life cycle assessment was independently verified to be in conformance with ISO 14044 and the cited PCR by: Name: Paula Bernstein, PRé North America Inc.	Paula Bernstein LCA Verifier

Certified Environmental Product Declaration
www.nsf.org

Description of Industry and Product

There are approximately 7,000 ready mixed concrete plants across the industry in the U.S. and Canada. NRMCA estimates that their membership represents 30% of all companies and 50% of all plants operating in 2012. A survey of NRMCA members as participating in this project revealed that the majority (>85%) of ready mixed concrete plants are of the truck-mixed type (sometimes called transit-mix) where concrete is batched at a fixed plant location and mixed in truck mixers. Over 95% of plants use supplementary cementitious materials (SCM) to portland cement in their ready mixed concrete products sometimes called mix designs, mixes, mixture compositions or mixture.

Each NRMCA member produces hundreds if not thousands of possible ready mixed concrete (RMC) products (mix designs), which ultimately balance the cost and performance of concrete for a wide variety of applications. For purposes of this NRMCA member Industry-Wide EPD, a conservative approach was taken to arrive at a workable list of 72 RMC products (mix designs) that could pragmatically capture a high proportion of the RMC produced by NRMCA members identified in this EPD.

The typical process for developing mix designs is 1) a design professional or purchaser of concrete states a specified compressive strength and other performance criteria for the concrete in contract documents, and 2) the concrete producer develops a mix design, or proportions, to meet the specified compressive strength and other performance criteria using an accepted mix proportioning methodology such as the American Concrete Institute (ACI) recommended practice 211.1, the most common method used in North America. For this EPD, the NRMCA provided normal weight concrete mixture proportions using the ACI 211.1 process for 6 different specified compressive strengths and 8 different typical mixture compositions. In addition, NRMCA used the same process based on ACI 211.2 for 3 different specified compressive strengths and 8 different typical lightweight mixture compositions.

Declared Product Range Classification

Table 1 lists the 72 ready mixed products considered in the LCA and EPD. They have been purposely enumerated as having a range of mixture components and properties to cover a significant range of possible products and to conservatively estimate life cycle impact indicators; i.e., all product cradle-to-gate life cycle impact indicators and resource use metrics are calculated at the upper bound of the strength class range and lower bound of the indicated SCM percentage and thus, provide a conservative estimate of the life cycle impacts associated with each product. The product name is represented by the specified compressive strength and the quantity (%) of portland cement and SCMs (either fly ash or slag cement or both) used to estimate the life cycle impact indicators and resource use metrics. Of the 72 ready mixed products, 48 are normal weight mixes and 24 are lightweight mixes in which the aggregate input was assumed to be a lightweight manufactured product. These mixes are denoted by the "LW" prefix in the product name.

Table 1: Declared Product Range Classification		
Specified Compressive Strength range (Column 1)	**SCM range (%) (Column 2)**	**Product Name (Column 3)**
0-2500 psi (0-17.24 MPa)	0-19% Fly Ash and/or Slag	2500-00-FA/SL
	20-29% Fly Ash	2500-20-FA
	30-39% Fly Ash	2500-30-FA
	40-49% Fly Ash	2500-40-FA
	30-39% Slag	2500-30-SL
	40-49% Slag	2500-40-SL
	≥ 50% Slag	2500-50-SL
	≥ 20% Fly Ash and ≥ 30% Slag	2500-50-FA/SL
2501-3000 psi (17.25-20.68 MPa)	0-19% Fly Ash and/or Slag	3000-00-FA/SL
	20-29% Fly Ash	3000-20-FA
	30-39% Fly Ash	3000-30-FA
	40-49% Fly Ash	3000-40-FA
	30-39% Slag	3000-30-SL
	40-49% Slag	3000-40-SL
	≥ 50% Slag	3000-50-SL
	≥ 20% Fly Ash and ≥ 30% Slag	3000-50-FA/SL
3001-4000 psi (20.69-27.58 MPa)	0-19% Fly Ash and/or Slag	4000-00-FA/SL
	20-29% Fly Ash	4000-20-FA
	30-39% Fly Ash	4000-30-FA
	40-49% Fly Ash	4000-40-FA
	30-39% Slag	4000-30-SL
	40-49% Slag	4000-40-SL
	≥ 50% Slag	4000-50-SL
	≥ 20% Fly Ash and ≥ 30% Slag	4000-50-FA/SL

How To Use This Table

NRMCA members participating in this project may use Table 1 to claim compliance with this EPD.

Most products proposed for a project will likely not have the precise specified compressive strength and proportions listed in this EPD. One can use Table 1 to classify a proposed product to match one of the products listed in the EPD as follows:

Step 1: Identify the 28-day specified compressive strength of the proposed product and the percentage of fly ash and/or slag cement (e.g. 100 x fly ash quantity / total cementitious materials quantity)

Step 2: In Table 1 identify the specified compressive strength range that captures the specified compressive strength of the proposed product (Column 1).

Step 3: Within that specified compressive strength range row, identify the SCM percentage range that matches the SCM percentage of the proposed product (Column 2). For ternary mixes (mixes containing portland cement, fly ash and slag cement) between 20% and 49% SCM (fly ash plus slag percentage) take the largest percentage of either fly ash or slag cement and use that value to select the SCM range to use. For example, if the proposed mix has 15% fly ash and 40% slag cement, use the 40-49% slag range.

Step 4: In that row, move to Column 3 to identify the product name that can be used to look up the life cycle impacts listed in Tables 6 through 11a for either 1 cubic meter or 1 cubic yard of product. Reference this EPD and the "Product Name" listed in column 3 in any compliance statement/literature (e.g., weigh bill) accompanying the product.

Table 1: Declared Product Range Classification Continued		
4001-5000 psi (27.59-34.47 MPa)	0-19% Fly Ash and/or Slag	5000-00-FA/SL
	20-29% Fly Ash	5000-20-FA
	30-39% Fly Ash	5000-30-FA
	40-49% Fly Ash	5000-40-FA
	30-39% Slag	5000-30-SL
	40-49% Slag	5000-40-SL
	50% Slag	5000-50-SL
	≥ 20% Fly Ash and ≥ 30% Slag	5000-50-FA/SL
5001-6000 psi (34.48-41.37 MPa)	0-19% Fly Ash and/or Slag	6000-00-FA/SL
	20-29% Fly Ash	6000-20-FA
	30-39% Fly Ash	6000-30-FA
	40-49% Fly Ash	6000-40-FA
	30-49% Slag	6000-30-SL
	40-49% Slag	6000-40-SL
	≥ 50% Slag	6000-50-SL
	≥ 20% Fly Ash and ≥ 30% Slag	6000-50-FA/SL
6001-8000 psi (41.38-55.16 MPa)	0-19% Fly Ash and/or Slag	8000-00-FA/SL
	20-29% Fly Ash	8000-20-FA
	30-39% Fly Ash	8000-30-FA
	40-49% Fly Ash	8000-40-FA
	30-49% Slag	8000-30-SL
	40-49% Slag	8000-40-SL
	≥ 50% Slag	8000-50-SL
	≥ 20% Fly Ash and ≥ 30% Slag	8000-50-FA/SL

Product Standard

Products covered by this EPD satisfy general purpose concrete as used in residential, commercial and public works applications in the US and Canada. This EPD reports the impacts for a range of ready mixed concrete products in accordance with the following:

ACI 211.1: Standard Practice for Selecting Proportions for Normal, Heavyweight, and Mass Concrete

ACI 211.2: Standard Practice for Selecting Proportions for Structural Lightweight Concrete

ACI 318: Building Code Requirements for Structural Concrete

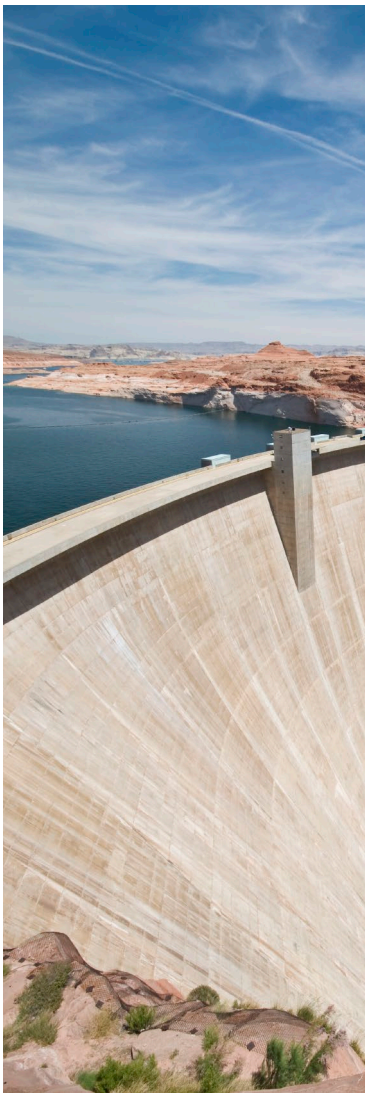
ASTM C94: Standard Specification for Ready Mixed Concrete

CSA A23.1-09/A23.2-09 (R2014): Concrete materials and methods of concrete construction/test methods and standard practices for concrete

CSI MasterFormat Division 03-30-00: Cast-in-Place Concrete

UNSPSC Code 30111500: Ready Mix

Table 1: Declared Product Range Classification Continued		
Lightweight 2501-3000 psi (17.25-20.68 MPa) 112 pcf or heigher (1794 kg/m3 or higher)	0-19% Fly Ash and/or Slag	LW-3000-00-FA/SL
	20-29% Fly Ash	LW-3000-20-FA
	30-39% Fly Ash	LW-3000-30-FA
	40-49% Fly Ash	LW-3000-40-FA
	30-49% Slag	LW-3000-30-SL
	40-49% Slag	LW-3000-40-SL
	≥ 50% Slag	LW-3000-50-SL
	≥ 20% Fly Ash and ≥ 30% Slag	LW-3000-50-FA/SL
Lightweight 3001-4000 psi (20.69-27.58 MPa) 112 pcf or heigher (1794 kg/m3 or higher)	0-19% Fly Ash and/or Slag	LW-4000-00-FA/SL
	20-29% Fly Ash	LW-4000-20-FA
	30-39% Fly Ash	LW-4000-30-FA
	40-49% Fly Ash	LW-4000-40-FA
	30-49% Slag	LW-4000-30-SL
	40-49% Slag	LW-4000-40-SL
	≥ 50% Slag	LW-4000-50-SL
	≥ 20% Fly Ash and ≥ 30% Slag	LW-4000-50-FA/SL
Lightweight 4001-5000 psi (27.59-34.47 MPa) 112 pcf or heigher (1794 kg/m3 or higher)	0-19% Fly Ash and/or Slag	LW-5000-00-FA/SL
	20-29% Fly Ash	LW-5000-20-FA
	30-39% Fly Ash	LW-5000-30-FA
	40-49% Fly Ash	LW-5000-40-FA
	30-49% Slag	LW-5000-30-SL
	40-49% Slag	LW-5000-40-SL
	≥ 50% Slag	LW-5000-50-SL
	≥ 20% Fly Ash and ≥ 30% Slag	LW-5000-50-FA/SL



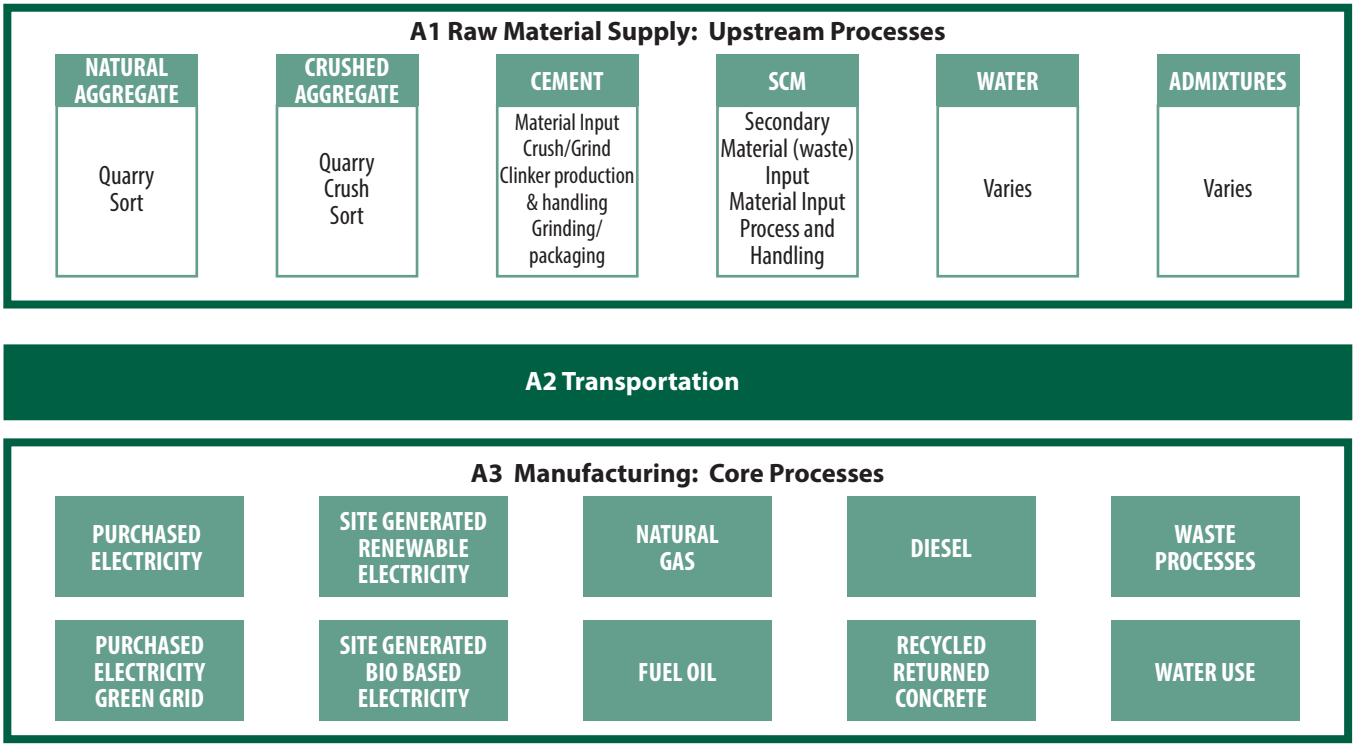
Cradle-to-Gate Life Cycle of Concrete

Business-to-Business EPD and Cradle-to-Gate LCA

This EPD is intended for use in Business to Business (B-to-B) communication. The scope of this EPD is cradle-to-gate and considers the following life cycle stages.

- **A1 - Raw Material Supply (upstream processes):** Extraction, handling and processing of the raw materials used in the production of concrete: cement, supplementary cementitious materials, aggregate (coarse and fine), water, admixtures and other materials or chemicals used in concrete mixtures.
- **A2 - Transportation:** Transportation of these materials from the supplier to the 'gate' of the concrete producer.
- **A3 - Manufacturing (core processes):** The energy used to store, batch, mix and distribute the concrete and operate the facility (concrete plant). A3 also includes the water used in mixing and distributing concrete.

Figure 1: Cradle-to-gate product system for concrete



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Methodology of Underlying LCA

Declared Unit

The declared units are 1 cubic meter and 1 cubic yard for 72 ready mixed concrete products. Key product variables include:

- **Weight of mix:** The normal weight concrete mixes ranged from 3,388 lb/yd3 to 3,678 lb/yd3 (2,011 kg/m3 to 2,184 kg/m3). The lightweight concrete mixes ranged from 2,881 lb/yd3 to 2,924 lb/yd3 (1710 kg/m3 to 1,736 kg/m3).
- **28-day strength**: Six different specified compressive strengths are considered, 2,500 psi (17.3 MPa), 3,000 psi (20.7 MPa), 4,000 psi (27.6 MPa), 5,000 psi (34.5 MPa), 6,000 psi (41.3 MPa) and 8,000 psi (55.1 MPa);
- **Water to cementious materials ratio (w/cm):** Varies, but lower for higher strength concrete mixtures in accordance with ACI 211.1 (normal weight concrete) and ACI 211.2 (lightweight concrete);
- **SCM reactivity:** Assumes 75% reactivity for fly ash (FA) as compared to portland cement and 100% reactivity of slag cement (SL) as compared to portland cement based on NRMCA member feedback;
- **Admixtures use:** Products (mix designs) with specified compressive strengths less than or equal to 5,000 psi (34.5 MPa) included an air entraining admixture since many of these concretes would be exposed to freezing and thawing. Products with specified compressive strengths above 5,000 psi (34.5 MPa) did not include air entraining admixture since these higher strength concretes are rarely exposed to freezing and thawing; water reducing and accelerating admixtures were used across all mixes; high range water reducer admixtures were used in high strength mix designs (5,000psi (34.5 MPa) and above). All lightweight concrete mixes are assumed to have air entraining admixtures to acheive the target weights.

Product (mix design) components include: portland cement, fly ash, slag cement, natural and crushed aggregates, manufactured lightweight aggregate, admixtures and batch water.

Scope of LCA

The life cycle stages included in this EPD are limited to raw materials and component products used in the manufacture of ready mixed concrete (A1), the transportation of these materials and components to the concrete plant (A2) and the manufacture of ready mixed concrete (A3) ready for shipment at the plant gate.

Life cycle stages excluded from this EPD include:

- Transport to the construction site;
- On-site construction processes and components (reinforcement, forms and form work, placing and curing);
- Building (infrastructure) use and maintenance; and
- End of life effects.

In addition, the following cycle processes are excluded from this study:

- Production, manufacture and construction of buildings' capital goods and infrastructure;
- Production and manufacture of concrete production equipment, concrete delivery vehicles, earthmoving equipment, and laboratory equipment;
- Personnel-related activities (travel, furniture, office supplies);
- Energy use related to company management and sales activities.

Note: A significant portion (>85%) of North American concrete plants are truck-mixing plants where the concrete mixing occurs within mixer trucks after they are loaded at the project site; for these operations a portion of the delivery truck's energy use that would typically be captured under "Construction and Process Stage" ***A4-Transportation*** (to site) is allocated to the mixing of concrete for truck-mixing plants and is captured in information module A3. This system boundary refinement addresses the difference between truck-mixing and central-mixing concrete plants where the latter plant type fully mixes the concrete prior to loading the concrete into delivery trucks.

Cut-off Rules

The cut-off criteria for all activity stage flows considered within the system boundary conform with ISO14044:2006 and section 3.3 of the governing PCR. Specifically, the cut-off criteria were applied as follows:

- All inputs and outputs for which data are available are included in the calculated effects and no collected core process data are excluded.
- A one percent cut-off is considered for renewable and non-renewable primary energy consumption and the total mass of inputs within a unit process. The sum of the total neglected flows does not exceed 5% of all energy consumption and mass of inputs.
- All flows known to contribute a significant impact or to uncertainty (e.g., portland cement and admixtures) are included;
- The cut-off rules are not applied to hazardous and toxic material flows – all of which are included in the life cycle flow inventory.

Allocation

The applied allocation procedures conform with ISO14044 clause 4.3.4.

Limitations

The limitations of this EPD include:

- This EPD does not report all of the environmental impacts due to manufacturing of the product, but rather reports the environmental impacts for those categories with established life-cyle assessment based methods to track and report. Unreported environmental impacts include (but are not limited to) factors attributable to human health, land use change, and habitat destruction.
- In order to assess the local impacts of product manufacturing , additional analysis is required.
- This EPD reports the results of an LCA or the 'cradle-to-gate' analysis. Thus, declarations themselves are not comparative assertions, defined as an environmental claim regarding the superiority or equivalence of one product versus a competing product that perfroms the same function. An EPD does not make any statements that the product covered by the EPD is better or worse than any other product.
- NRMCA members participating in the development of this EPD may participate in other sustainability or environmental best practice programs; however, no such additional environmental claim, declaration or claim is conveyed in this EPD.
- EPDs of concrete mixtures may not be comparable if they do not comply with this standard and data from this EPD. The data cannot be used to compare between concrete mixes, construction products or concrete mixtures used in different concrete products unless the data is integrated into a comprehensive LCA. For example, precast concrete, concrete masonry units and site cast concrete all have different manufacturing processes whose impacts are attributed to different LCA stages. This precludes direct comparison between mixtures used in these different products unless all life cycle phases are included.
- Life cycle impact assessment (LCIA) results are relative expressions and do not predict impacts on category endpoints, the exceeding of thresholds, safety margins or risks.
- This EPD does not cover any optional additional information specified in the PCR Section 3.2.
- This EPD is declared as an average environmental performance for a number of products. The range of results (the minimum, maximum, and individual mix results) are provided for each strength class.
- This EPD was created using industry average data for upstream materials. Variation can result from differences in supplier locations, manufacturing processes, manufacturing efficiency and fuel type used.

Data Sources and Data Quality Assessment

This EPD is based on foreground LCI data collected from a representative sample of 494 NRMCA ready mixed concrete production facilities located in the U.S. and Canada. These data, in combination with background datasets, were used to compile this EPD. All upstream material, resource and energy carrier inputs have been sourced from industry-average datasets and literature. Many of these datasets are defaulted to those specified for use in the CLF PCR. Care was taken to fill known data gaps (dummy processes) as recorded in the USLCI database profiles. Tables 2 to 4 describe each LCI data source for raw materials (A1), transportation by mode (A2), the RMC core manufacture process (A3 and A4), and descriptions of data quality for each data source.

Table 2: A1 - Raw Material Supply

Material/Unit	LCI data source [as per CLF PCR: 2013]	Geography	Year	Data Quality Assessment
Cement (lbs)	Portland Cement Association EPD USA Portland Cement, 2016	USA	2014	• Technology: good Process models USA industry average portland cement produciton • Time: Very good Data is within 2 years • Geography: very good • Completeness: good Data is based on an average of national production • Reliability: very good, third party verified EPD
Fly Ash (lbs)	None, no incoming burden, only inbound transport was considered	N/A	N/A	N/A
Silica Fume (lbs)	None, no incoming burden, only inbound transport was considered	N/A	N/A	N/A
Slag cement (lbs)	Slag Cement Association N. America EPD of Slag Cement , 2015	USA	2013-2014	• Technology: good Process models ground granulated blast furnace slag. • Time: good Data is within 3 years. • Geography: very good • Completeness: good • Reliability: very good, third party verified EPD
Crushed Aggregates (lbs) coarse and fine	ecoinvent process: "Gravel, crushed, at mine" ecoinvent 2.02 CLF PCR Default	EU	2004	• Technology: good Processes represent aggregate, with and without crushing. Dust emissions are estimated from limestone mining. • Time: fair Data is within twelve years. • Geography: fair Processes model Swiss production (no U.S. process in USLCI database). • Completeness: very good • Reliability: very good Data is verified by ecoinvent.

Table 2: A1 - Raw Material Supply Continued				
Natural Aggregates (lbs) coarse and fine	ecoinvent process: "Gravel, round, at mine", ecoinvent 2.02 CLF PCR Default	EU	2004	• Technology: good Processes represent aggregate, with and without crushing. Dust emissions are estimated from limestone mining. • Time: fair Data is within twelve years. • Geography: fair Processes model Swiss production (no U.S. process in USLCI database). • Completeness: very good • Reliability: very good Data is verified by ecoinvent.
Manufactured Lightweight Aggregates (lbs)	ecoinvent process: "Expanded clay (USA), production, Alloc Def, U ecoinvent 3.01	USA	2013	• Technology: good • Time: good Data is within three years. • Geography: fair Processes model USA production • Completeness: very good • Reliability: very good Data is verified by ecoinvent.
Admixtures (lbs) *Accelerator* *Air Entrainer* *Retarding* *Waterproofing* *Plasticizer* *Superplasticizer*	EFCA EcoProfiles (300, 301, 302, 303, 324 and 325) http://www.efca.info/publications.html	EU	2005 -2006	• Technology: very good Processes represents admixture production for use in concrete • Time: fair Data is within eleven years • Geography: fair • Completeness: good Data from a federation of European admixture producers • Reliability: good Profiles have undergone an independent review process. Compliance with ISO standards (unknown)

Table 2: A1 - Raw Material Supply Continued				
Concrete Batch and Wash Water (gallons)	Primary (Pre-consumer, burden of crushing is reported and included in module A3)	USA	2013-2015	• Technology: very good Primary data collected via industry survey • Time: very good Data is within three years • Geography: very good • Completeness: very good Primary data from core processes survey • Reliability: very good • Data based on specified use
Crushed Demolition Concrete (lbs)	LCI Slag Cement Manufacturing (crushing data used as proxy)	USA	2003	• Technology: good Process models crushing of blast furnace slag. • Time: fair Data is within thirteen years. • Geography: very good • Completeness: fair • Reliability: fair
Road Dust Control Chemicals (lbs)	ecoinvent 3.01, Calcium chloride used to control dust on gravel roadways CaCl2, 35-38 wt. percent calcium chloride solution to the roadway	Europe	2008	• Technology: good Process models the manufacture of dust control chemical. • Time: good Data is within ten years. • Geography: fair Processes model Swiss production • Completeness: very good • Reliability: very good Data is verified by ecoinvent.

Table 3: A2 - Transportation

Process	LCI Data Source	Geography	Year	Data Quality Assessment
Road (lbs*miles)	USLCI 2014 - single unit transport diesel powered, short haul US avg.;	USA	2014	• Technology: very good Process represents U.S. average transportation profiles • Time: Good Data is within two years • Geography: good • Completeness good (all data place holders filled) • Reliability: good
Rail, ocean freighter and barge (lbs*miles)	USLCI - rail transport, diesel powered; ocean freighter, average fuel mix; barge, average fuel mix	USA	2008	• Technology: very good Process represents U.S. average transportation profiles • Time: good Data is within 10 years • Geography: fair • Completeness good (all data place holders filled) • Reliability: good

Table 4: A3 - Manufacturing

Process	LCI Data Source	Geography	Year	Data Quality Assessment
Electricity (kWh)	NRMCA purchased electricity grid mix-Electricity, medium voltage, at grid, US (ecoinvent v3.01)	USA	2008/2013	• Technology: very good Process represents production of electricity in the appropriate NERC regions. An average NRMCA electricity grid was developed based on total purchased electricity by surveyed plants weighted by RMC production in various NERC regions. • Time: fair/good Electricity production data is within ten years. NERC regional production breakdown from 2013. • Geography: very good • Completeness: good Data is representative of U.S. production • Reliability: good ecoinvent has verified the data

Table 4: A3 - Manufacturing Continued				
Natural Gas (cu. ft.)	USLCI, Natural gas, combusted in industrial boiler/US	USA	2008	• Technology: very good Process represents combustion of natural gas in an industrial boiler. • Time: fair Data is within ten years • Geography: fair • Completeness: good Data is representative of U.S. conditions • Reliability: good Data is from USLCI database
Fuel Oil other than diesel (gallon)	US LCI: Residual fuel oil, combusted in industrial boiler/US	USA	2008	• Technology: very good Process represents combustion of RFO in an industrial boiler. • Time: fair Data is within ten years • Geography: fair • Completeness: good Data is representative of U.S. conditions • Reliability: good • Data is from USLCI database
Diesel (gallon)	US LCI: Diesel, combusted in industrial equipment/US	USA	2008	• Technology: very good Process represents combustion of diesel in industrial equipment. • Time: fair Data is within ten years • Geography: fair • Completeness: good Data is representative of U.S. conditions • Reliability: good Data is from USLCI database
Gasoline (gallon)	US LCI: Gasoline, combusted in equipment/US	USA	2008	• Technology: very good Process represents combustion of gasoline in equipment. • Time: fair Data is within ten years • Geography: fair • Completeness: good Data is representative of U.S. conditions • Reliability: good • Data is from USLCI database

Table 4: A3 - Manufacturing Continued

Liquefied Propane Gas (gallon)	US LCI: Liquefied petroleum gas, combusted in industrial boiler/US	USA	2008	• Technology: very good Process represents combustion of LPG in industrial boiler. • Time: fair Data is within ten years • Geography: fair • Completeness: good Data is representative of U.S. conditions • Reliability: good • Data is from USLCI database
Secondary Fuels, Liquid (waste solvents, etc.) (lbs)	ecoinvent 3.1, 2014 -Spent solvent mixture {US}| treatment of, hazardous waste incineration | Alloc Def, U -Combustion emissions are only included	EU	2008	• Technology: good combustion emissions only • Time: fair Data is within ten years. • Geography: fair Processes model Swiss production (no U.S. process in USLCI database). • Completeness: very good • Reliability: very good Data is verified by ecoinvent.
Secondary Fuels, Solid (tires, etc.) (ton-short)	ecoinvent 3.01: Waste rubber, unspecified {US}| treatment of, municipal incineration | Alloc Def, U	EU	2008	• Technology: good combustion emissions only • Time: fair Data is within ten years. • Geography: fair Processes model Swiss production (no U.S. process in USLCI database). • Completeness: very good • Reliability: very good Data is verified by ecoinvent.
Hazardous Solid Waste (lbs)	ecoinvent 3.1, 2014 -Hazardous waste, for incineration {US}| treatment of hazardous waste, hazardous waste incineration | Alloc Def, U	EU	2008	• Technology: good • Time: fair Data is within ten years. • Geography: fair Processes model Swiss production (no U.S. process in USLCI database). • Completeness: very good • Reliability: very good Data is verified by ecoinvent.

Table 4: A3 - Manufacturing Continued

Non-Hazardous Solid Waste (lbs)	ecoinvent 3.1, 2014 -Waste concrete {US}| treatment of, inert material landfill | Alloc Def, U	EU	2008	• Technology: good • Time: fair Data is within ten years. • Geography: fair Processes model Swiss production (no U.S. process in USLCI database). • Completeness: very good • Reliability: very good Data is verified by ecoinvent.

NRMCA Purchased Electricity source grid mix (as modeled)	**%**
Electricity, medium voltage {FRCC}| market for | Alloc Def, U	6.35%
Electricity, medium voltage {MRO}| market for | Alloc Def, U	6.29%
Electricity, medium voltage {NPCC}| market for | Alloc Def, U	4.15%
Electricity, medium voltage {RFC}| market for | Alloc Def, U	12.95%
Electricity, medium voltage {SERC}| market for | Alloc Def, U	34.10%
Electricity, medium voltage {SPP}| market for | Alloc Def, U	2.96%
Electricity, medium voltage {TRE}| market for | Alloc Def, U	7.79%
Electricity, medium voltage {WECC}| market for | Alloc Def, U	25.41%
Total	**100.00%**

Data Quality

Data quality/variability requirements, as specified in the CLF PCR: 2013 sections 3.5 and 3.6 are applied. This section describes the achieved data quality relative to the ISO 14044:2006 requirements. Data quality is judged on the basis of its representativeness (geographical, temporal, and technological), completeness, and reliability.

Technical representativeness: The degree to which the data reflects the actual technology(ies) used. Core manufacturing process technology is derived from very recent annual data covering a large number of plant sizes and types. These data are deemed to be reflective of typical or average technologies used within the US and Canada in the production of ready-mixed concrete. Some background material and process data are European but deemed to be similar to technologies used in the US and Canada and are often cited as preferred "default data" in the governing CLF PCR.

Overall Data quality: Good to Very Good

Temporal representativeness: The degree to which the data reflects the actual time (e.g. year) or age of the activity. Core manufacturing process data is very recent (2013 and 2015). All significant LCI data sources, those that exercise a large influence over the calculated results, are generally less than 10 years old.

Overall Data quality: Fair to Very Good

Geographical representativeness: The degree to which the data reflects the actual geographic location of the activity (e.g. country or site). Geographical coverage of core manufacturing processes is specific to the US and Canada. All energy profiles reflect US and Canadian conditions. Some material (aggregates and admixtures) and process data are based on European sources. These data have been previously verified or listed in the governing PCR for default use.

Overall Data quality: Fair to Very Good

Completeness: The degree to which the data are statistically representative of the relevant activity. Completeness includes the percentage of locations for which data is available and used out of the total number that relate to a specific activity. Core manufacturing processes are very complete and were derived from a statistical sample with a 95% confidence interval and less than 5% error. These data reflect annual operations inclusive of seasonal and other normal annual fluctuations in operations. All relevant, specific processes, including inputs (raw materials, energy and ancillary materials) and outputs (emissions and production volume) were considered and modeled to represent the specified and declared RMC products. The relevant background materials and processes were taken from the US LCI Database (adjusted for known data placeholders); US system boundary adjusted ecoinvent v 2.2 and v3.0 LCI databases and modeled in SimaPro software v8.1.1. Efforts were made to ensure that all data used was as complete as reasonably possible.

Overall Data quality: Good to Very Good

Reliability: The degree to which the sources, data collection methods and verification procedures used to obtain the data are dependable. For core manufacturing processes the reliability of the information and data is deemed to be very good as these were derived from a large, statistically significant, survey of ready-mixed concrete producers and subsequently reviewed by the NRMCA for plausability. Similarly, the LCI data for portland cement, at plant, reflects a very recent EPD. All missing process data (dummies) associated with the US LCI data have been consistently filled. All other LCI data have been incorporated in accordance with the default PCR requirements or derived from ecoinvent databases, which have been verified by ecoinvent.

Overall Data quality: Fair to Very Good

In addition to the data quality ranking requirements in the CLF PCR: 2013, commentary is provided as to the following data quality characteristics: precision (measured, calculated or estimated), consistency (degree of uniformity of the methodology applied within a study serving as a data source) and reproducibility.

Precision: The NRMCA participating member companies through measurement and calculation collected primary data on their annual production of RMC products. For accuracy the LCA team validated these plant gate-to-gate input and output data. A statistical analysis was completed and documented in a separate report – see Primary Data Sources section.
Consistency: To ensure consistency, the LCI modeling of the production weighted input and output LCI data for the declared products used the same modeling structure across the respective product systems, which consisted of input raw and ancillary material, energy flows, water resource inputs, product and co-products outputs, returned and recovered concrete materials, emissions to air, water and soil, and waste recycling and treatment. The same background LCI datasets from the NRMCA SimaPro LCI database were used across all RMC product systems LCI modeling. Crosschecks concerning the plausibility of mass and energy flows were continuously conducted. The LCA team conducted mass and energy balances at the plant and selected process level to maintain a high level of consistency.

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Reproducibility: Internal reproducibility is possible since the data and the models are stored and available in a database (NRMCA SimaPro LCI database, 2016). A considerable level of transparency is provided throughout the report as the specifications and material quantity make-up for the declared RMC products are presented and key primary and secondary LCI data sources are summarized in Tables 2, 3 and 4. The provision of more detailed data to allow full external reproducibility was not possible due to reasons of confidentiality.

Life Cycle Assessment Results

Environmental indicators and inventory metrics

As specified in the CLF PCR:2013, Section 8, the U.S. EPA Tool for the Reduction and Assessment of Chemical and Other Environmental Impacts (TRACI), version 2.1, 2012 impact categories were used to provide a North American context for the mandatory category indicators included in the EPD. Additionally, the PCR requires a set of inventory metrics to be reported with the LCIA indicators. Table 5 summarizes the 15 life cycle impact assessment indicators and inventory metrics. Tables 6 through 14 then report the LCA results for each product.

Table 5. Life Cycle Category Indicators and Inventory Metrics

#	LCIA Indicators	Abbreviations	Units
1	Global Warming Potential (climate change)	**GWP**	kg CO2-eq
2	Ozone Depletion Potential	**ODP**	kg CFC-11-eq
3	Acidification Potential	**AP**	kg SO2-eq
4	Eutrophication Potential	**EP**	kg N-eq
5	Photochemical Ozone Creation/Smog Potential	**POCP**	kg O3-eq
	Inventory Metrics		
6	Total primary energy consumption	**PEC**	MJ (HHV*)
7	Depletion of non-renewable energy resources	**NRE**	MJ (HHV*)
8	Use of renewable primary energy	**RE**	MJ (HHV*)
9	Depletion of non-renewable material resources	**NRM**	kg
10	Use of renewable material resources	**RM**	kg
11	Concrete batching water consumption	**CBW**	m3
12	Concrete washing water consumption	**CWW**	m3
13	Total water consumption	**TW**	m3
14	Concrete hazardous waste	**CHW**	kg
15	Concrete non-hazardous waste	**CNHW**	kg

*HHV, higher heating value (also called gross calorific value), is the heat of combustion of a given amount of fuel that includes the calorific value of condensing the water content of the fuel (the heat of vaporization). The lower heating value (LHV) excludes the heat of vaporization of the water content and thus the HHV is equal to the LHV plus the heat of vaporization.

Impact Assessment Results

Table 6. Summary Results (A1-A3): 0-2500 psi (0-17.24 MPa) RMC product, per cubic meter															
Indicator/LCI Metric	GWP	ODP	AP	EP	POCP	PEC	NRE	RE	NRM	RM	CBW	CWW	TW	CHW	CNHW
Unit (equivalent)	kg CO2	kg CFC-11	kg SO2	kg N	kg O3	MJ	MJ	MJ	kg	kg	m3	m3	m3	kg	kg
Minimum	185.7	5.40E-6	0.78	0.24	16.57	1491	1463	27	2045	1.49	0.13	0.12	0.29	0.42	3.82
Maximum	300.6	7.60E-6	1.01	0.36	20.92	1994	1956	37	2265	2.22	0.13	0.12	0.29	0.45	4.96
2500-00-FA/SL	300.6	7.60E-6	1.01	0.36	20.92	1994	1956	37	2265	2.22	0.13	0.12	0.29	0.42	4.96
2500-20-FA	258.5	6.50E-6	0.90	0.31	18.86	1758	1726	32	2164	1.91	0.13	0.12	0.29	0.42	4.60
2500-30-FA	235.7	6.00E-6	0.84	0.29	17.74	1632	1602	29	2109	1.74	0.13	0.12	0.29	0.42	4.40
2500-40-FA	211.7	5.40E-6	0.78	0.26	16.57	1499	1473	27	2052	1.56	0.13	0.12	0.29	0.42	4.20
2500-30-SL	231.6	6.90E-6	0.96	0.29	18.92	1738	1704	33	2152	1.82	0.13	0.12	0.29	0.44	4.27
2500-40-SL	208.7	6.70E-6	0.95	0.27	18.26	1653	1621	32	2114	1.69	0.13	0.12	0.29	0.45	4.05
2500-50-SL	185.7	6.40E-6	0.93	0.24	17.60	1568	1538	31	2076	1.56	0.13	0.12	0.29	0.45	3.82
2500-50-FA/SL	186.0	5.80E-6	0.85	0.24	16.76	1491	1463	28	2045	1.49	0.13	0.12	0.29	0.44	3.88

Table 6a. Summary Results (A1-A3): 0-2500 psi (0-17.24 MPa) RMC product, per cubic yard															
Indicator/LCI Metric	GWP	ODP	AP	EP	POCP	PEC	NRE	RE	NRM	RM	CBW	CWW	TW	CHW	CNHW
Unit (equivalent)	kg CO2	kg CFC-11	kg SO2	kg N	kg O3	MJ	MJ	MJ	kg	kg	m3	m3	m3	kg	kg
Minimum	142.0	4.10E-6	0.60	0.18	12.67	1140	1118	20	1563	1.14	0.10	0.09	0.22	0.32	2.92
Maximum	229.8	5.80E-6	0.77	0.28	15.99	1524	1496	29	1732	1.69	0.10	0.09	0.22	0.35	3.79
2500-00-FA/SL	229.8	5.80E-6	0.77	0.28	15.99	1524	1496	29	1732	1.69	0.10	0.09	0.22	0.32	3.79
2500-20-FA	197.6	5.00E-6	0.69	0.24	14.42	1344	1320	25	1654	1.46	0.10	0.09	0.22	0.32	3.51
2500-30-FA	180.2	4.60E-6	0.64	0.22	13.57	1248	1225	23	1613	1.33	0.10	0.09	0.22	0.32	3.37
2500-40-FA	161.9	4.10E-6	0.60	0.20	12.67	1146	1126	20	1569	1.19	0.10	0.09	0.22	0.32	3.21
2500-30-SL	177.1	5.30E-6	0.74	0.22	14.47	1328	1303	26	1645	1.39	0.10	0.09	0.22	0.34	3.27
2500-40-SL	159.6	5.10E-6	0.73	0.20	13.96	1264	1240	25	1616	1.29	0.10	0.09	0.22	0.34	3.09
2500-50-SL	142.0	4.90E-6	0.71	0.19	13.46	1199	1176	24	1587	1.19	0.10	0.09	0.22	0.35	2.92
2500-50-FA/SL	142.2	4.40E-6	0.65	0.18	12.82	1140	1118	22	1563	1.14	0.10	0.09	0.22	0.34	2.96

Table 7. Summary Results (A1-A3): 2501-3000 psi (17.25-20.68 MPa) RMC product, per cubic meter															
Indicator/LCI Metric	GWP	ODP	AP	EP	POCP	PEC	NRE	RE	NRM	RM	CBW	CWW	TW	CHW	CNHW
Unit (equivalent)	kg CO2	kg CFC-11	kg SO2	kg N	kg O3	MJ	MJ	MJ	kg	kg	m3	m3	m3	kg	kg
Minimum	206.0	5.90E-6	0.84	0.26	17.81	1621	1590	29	2034	1.65	0.13	0.12	0.29	0.42	3.97
Maximum	336.2	8.50E-6	1.10	0.41	22.74	2192	2150	42	2284	2.47	0.13	0.12	0.29	0.46	5.26
3000-00-FA/SL	336.2	8.50E-6	1.10	0.41	22.74	2192	2150	42	2284	2.47	0.13	0.12	0.29	0.43	5.26
3000-20-FA	288.4	7.30E-6	0.98	0.35	20.40	1925	1889	36	2169	2.12	0.13	0.12	0.29	0.42	4.85
3000-30-FA	262.6	6.60E-6	0.91	0.32	19.14	1781	1748	33	2107	1.93	0.13	0.12	0.29	0.42	4.63
3000-40-FA	235.4	5.90E-6	0.84	0.29	17.81	1630	1601	29	2042	1.73	0.13	0.12	0.29	0.42	4.40
3000-30-SL	258.0	7.70E-6	1.05	0.32	20.48	1900	1863	37	2156	2.03	0.13	0.12	0.29	0.45	4.49
3000-40-SL	232.0	7.40E-6	1.03	0.30	19.73	1805	1769	36	2113	1.88	0.13	0.12	0.29	0.45	4.23
3000-50-SL	206.0	7.10E-6	1.02	0.27	18.98	1709	1675	34	2070	1.73	0.13	0.12	0.29	0.46	3.97
3000-50-FA/SL	206.2	6.40E-6	0.93	0.26	18.03	1621	1590	31	2034	1.65	0.13	0.12	0.29	0.45	4.04

Table 7a. Summary Results (A1-A3): 2501-3000 psi (17.25-20.68 MPa) RMC product, per cubic yard															
Indicator/LCI Metric	GWP	ODP	AP	EP	POCP	PEC	NRE	RE	NRM	RM	CBW	CWW	TW	CHW	CNHW
Unit (equivalent)	kg CO2	kg CFC-11	kg SO2	kg N	kg O3	MJ	MJ	MJ	kg	kg	m3	m3	m3	kg	kg
Minimum	157.5	4.50E-6	0.65	0.20	13.62	1240	1216	22	1555	1.26	0.10	0.09	0.22	0.32	3.04
Maximum	257.0	6.50E-6	0.84	0.31	17.38	1676	1644	32	1746	1.89	0.10	0.09	0.22	0.35	4.02
3000-00-FA/SL	257.0	6.50E-6	0.84	0.31	17.38	1676	1644	32	1746	1.89	0.10	0.09	0.22	0.33	4.02
3000-20-FA	220.5	5.60E-6	0.75	0.27	15.60	1472	1445	27	1659	1.62	0.10	0.09	0.22	0.32	3.71
3000-30-FA	200.8	5.10E-6	0.70	0.24	14.63	1361	1336	25	1611	1.48	0.10	0.09	0.22	0.32	3.54
3000-40-FA	180.0	4.50E-6	0.65	0.22	13.62	1246	1224	22	1561	1.32	0.10	0.09	0.22	0.32	3.36
3000-30-SL	197.2	5.90E-6	0.80	0.25	15.66	1453	1425	28	1648	1.55	0.10	0.09	0.22	0.34	3.43
3000-40-SL	177.4	5.70E-6	0.79	0.23	15.08	1380	1353	27	1615	1.44	0.10	0.09	0.22	0.35	3.23
3000-50-SL	157.5	5.50E-6	0.78	0.20	14.51	1307	1281	26	1583	1.32	0.10	0.09	0.22	0.35	3.04
3000-50-FA/SL	157.7	4.90E-6	0.71	0.20	13.78	1240	1216	24	1555	1.26	0.10	0.09	0.22	0.34	3.09

Table 8. Summary Results (A1-A3): 3001-4000 psi (20.69-27.58 MPa) RMC product, per cubic meter															
Indicator/LCI Metric	GWP	ODP	AP	EP	POCP	PEC	NRE	RE	NRM	RM	CBW	CWW	TW	CHW	CNHW
Unit (equivalent)	kg CO2	kg CFC-11	kg SO2	kg N	kg O3	MJ	MJ	MJ	kg	kg	m3	m3	m3	kg	kg
Minimum	251.8	7.30E-6	0.99	0.32	20.63	1918	1880	36	2011	2.01	0.13	0.12	0.29	0.42	4.32
Maximum	416.9	1.00E-5	1.31	0.50	26.87	2642	2591	51	2327	3.05	0.13	0.12	0.29	0.47	5.95
4000-00-FA/SL	416.9	1.00E-5	1.31	0.50	26.87	2642	2591	51	2327	3.05	0.13	0.12	0.29	0.43	5.95
4000-20-FA	356.3	8.90E-6	1.15	0.43	23.91	2304	2260	44	2182	2.61	0.13	0.12	0.29	0.43	5.44
4000-30-FA	323.6	8.10E-6	1.07	0.39	22.31	2121	2081	40	2104	2.37	0.13	0.12	0.29	0.43	5.15
4000-40-FA	289.2	7.30E-6	0.99	0.35	20.63	1930	1894	36	2021	2.11	0.13	0.12	0.29	0.42	4.86
4000-30-SL	317.8	9.50E-6	1.24	0.39	24.00	2273	2227	46	2165	2.49	0.13	0.12	0.29	0.46	4.97
4000-40-SL	284.8	9.10E-6	1.22	0.36	23.05	2152	2108	44	2110	2.30	0.13	0.12	0.29	0.47	4.64
4000-50-SL	251.8	8.80E-6	1.20	0.32	22.10	2029	1987	42	2056	2.11	0.13	0.12	0.29	0.47	4.32
4000-50-FA/SL	252.2	7.90E-6	1.09	0.32	20.90	1918	1880	38	2011	2.01	0.13	0.12	0.29	0.46	4.40

Table 8a. Summary Results (A1-A3): 3001-4000 psi (20.69-27.58 MPa) RMC product, per cubic yard															
Indicator/LCI Metric	GWP	ODP	AP	EP	POCP	PEC	NRE	RE	NRM	RM	CBW	CWW	TW	CHW	CNHW
Unit (equivalent)	kg CO2	kg CFC-11	kg SO2	kg N	kg O3	MJ	MJ	MJ	kg	kg	m3	m3	m3	kg	kg
Minimum	192.6	5.50E-6	0.75	0.24	15.77	1466	1437	27	1538	1.54	0.10	0.09	0.22	0.32	3.30
Maximum	318.7	8.00E-6	1.00	0.38	20.54	2020	1981	39	1779	2.33	0.10	0.09	0.22	0.36	4.55
4000-00-FA/SL	318.7	8.00E-6	1.00	0.38	20.54	2020	1981	39	1779	2.33	0.10	0.09	0.22	0.33	4.55
4000-20-FA	272.4	6.80E-6	0.88	0.33	18.28	1762	1728	34	1668	1.99	0.10	0.09	0.22	0.33	4.16
4000-30-FA	247.4	6.20E-6	0.82	0.30	17.06	1622	1591	31	1608	1.81	0.10	0.09	0.22	0.33	3.94
4000-40-FA	221.1	5.50E-6	0.75	0.27	15.77	1476	1448	27	1545	1.61	0.10	0.09	0.22	0.32	3.72
4000-30-SL	243.0	7.20E-6	0.95	0.30	18.35	1738	1703	35	1655	1.90	0.10	0.09	0.22	0.35	3.80
4000-40-SL	217.8	7.00E-6	0.93	0.28	17.63	1645	1611	34	1614	1.76	0.10	0.09	0.22	0.36	3.55
4000-50-SL	192.6	6.70E-6	0.92	0.25	16.90	1551	1519	32	1572	1.62	0.10	0.09	0.22	0.36	3.30
4000-50-FA/SL	192.8	6.00E-6	0.83	0.24	15.98	1466	1437	29	1538	1.54	0.10	0.09	0.22	0.35	3.36

Table 9. Summary Results (A1-A3): 4001-5000 psi (27.59-34.47 MPa) RMC product, per cubic meter															
Indicator/LCI Metric	GWP	ODP	AP	EP	POCP	PEC	NRE	RE	NRM	RM	CBW	CWW	TW	CHW	CNHW
Unit (equivalent)	kg CO2	kg CFC-11	kg SO2	kg N	kg O3	MJ	MJ	MJ	kg	kg	m3	m3	m3	kg	kg
Minimum	305.8	8.80E-6	1.15	0.38	23.97	2268	2222	43	1983	2.44	0.13	0.12	0.28	0.43	4.72
Maximum	511.7	1.30E-5	1.55	0.61	31.75	3173	3110	63	2377	3.73	0.13	0.12	0.29	0.49	6.77
5000-00-FA/SL	511.7	1.30E-5	1.55	0.61	31.75	3173	3110	63	2377	3.73	0.13	0.12	0.29	0.44	6.77
5000-20-FA	436.3	1.10E-5	1.36	0.52	28.07	2752	2699	53	2196	3.18	0.13	0.12	0.28	0.43	6.12
5000-30-FA	395.5	9.90E-6	1.26	0.47	26.07	2525	2476	48	2099	2.88	0.13	0.12	0.28	0.43	5.77
5000-40-FA	352.5	8.80E-6	1.15	0.42	23.97	2285	2241	43	1995	2.56	0.13	0.12	0.28	0.43	5.40
5000-30-SL	388.2	1.20E-5	1.47	0.48	28.18	2714	2658	56	2175	3.03	0.13	0.12	0.29	0.47	5.54
5000-40-SL	347.1	1.10E-5	1.45	0.44	27.00	2561	2508	53	2107	2.79	0.13	0.12	0.29	0.48	5.13
5000-50-SL	305.8	1.10E-5	1.42	0.39	25.80	2407	2356	51	2039	2.56	0.13	0.12	0.29	0.49	4.72
5000-50-FA/SL	306.2	9.60E-6	1.28	0.38	24.31	2268	2222	46	1983	2.44	0.13	0.12	0.29	0.47	4.83

Table 9a. Summary Results (A1-A3): 4001-5000 psi (27.59-34.47 MPa) RMC product, per cubic yard															
Indicator/LCI Metric	GWP	ODP	AP	EP	POCP	PEC	NRE	RE	NRM	RM	CBW	CWW	TW	CHW	CNHW
Unit (equivalent)	kg CO2	kg CFC-11	kg SO2	kg N	kg O3	MJ	MJ	MJ	kg	kg	m3	m3	m3	kg	kg
Minimum	233.8	6.70E-6	0.88	0.29	18.33	1734	1699	33	1516	1.86	0.10	0.09	0.22	0.33	3.61
Maximum	391.2	9.80E-6	1.19	0.47	24.28	2426	2378	48	1818	2.85	0.10	0.09	0.22	0.38	5.17
5000-00-FA/SL	391.2	9.80E-6	1.19	0.47	24.28	2426	2378	48	1818	2.85	0.10	0.09	0.22	0.33	5.17
5000-20-FA	333.6	8.30E-6	1.04	0.40	21.46	2104	2063	41	1679	2.43	0.10	0.09	0.22	0.33	4.68
5000-30-FA	302.4	7.50E-6	0.96	0.36	19.93	1930	1893	37	1604	2.20	0.10	0.09	0.22	0.33	4.41
5000-40-FA	269.5	6.70E-6	0.88	0.32	18.33	1747	1714	33	1526	1.96	0.10	0.09	0.22	0.33	4.13
5000-30-SL	296.8	8.80E-6	1.13	0.37	21.55	2075	2032	43	1663	2.32	0.10	0.09	0.22	0.36	4.24
5000-40-SL	265.3	8.50E-6	1.11	0.33	20.64	1958	1917	41	1611	2.14	0.10	0.09	0.22	0.37	3.92
5000-50-SL	233.8	8.20E-6	1.09	0.30	19.73	1840	1801	39	1559	1.96	0.10	0.09	0.22	0.38	3.61
5000-50-FA/SL	234.1	7.30E-6	0.98	0.29	18.58	1734	1699	35	1516	1.86	0.10	0.09	0.22	0.36	3.69

Table 10. Summary Results (A1-A3): 5001-6000 psi (34.48-41.37 MPa) RMC product, per cubic meter															
Indicator/LCI Metric	GWP	ODP	AP	EP	POCP	PEC	NRE	RE	NRM	RM	CBW	CWW	TW	CHW	CNHW
Unit (equivalent)	kg CO2	kg CFC-11	kg SO2	kg N	kg O3	MJ	MJ	MJ	kg	kg	m3	m3	m3	kg	kg
Minimum	321.7	9.20E-6	1.20	0.40	25.01	2375	2326	45	2020	2.56	0.13	0.12	0.28	0.43	4.84
Maximum	539.1	1.30E-5	1.63	0.64	33.23	3330	3264	66	2437	3.93	0.13	0.12	0.29	0.50	7.00
6000-00-FA/SL	539.1	1.30E-5	1.63	0.64	33.23	3330	3264	66	2437	3.93	0.13	0.12	0.29	0.44	7.00
6000-20-FA	459.4	1.10E-5	1.43	0.55	29.33	2885	2829	56	2246	3.34	0.13	0.12	0.28	0.43	6.31
6000-30-FA	416.3	1.00E-5	1.32	0.50	27.23	2645	2594	51	2142	3.03	0.13	0.12	0.28	0.43	5.94
6000-40-FA	370.9	9.20E-6	1.20	0.44	25.01	2391	2346	45	2033	2.69	0.13	0.12	0.28	0.43	5.55
6000-30-SL	408.6	1.20E-5	1.54	0.50	29.46	2845	2786	59	2223	3.19	0.13	0.12	0.29	0.47	5.70
6000-40-SL	365.2	1.20E-5	1.52	0.46	28.20	2683	2627	56	2151	2.94	0.13	0.12	0.29	0.48	5.27
6000-50-SL	321.7	1.10E-5	1.49	0.41	26.95	2522	2468	54	2080	2.69	0.13	0.12	0.29	0.50	4.84
6000-50-FA/SL	322.1	1.00E-5	1.34	0.40	25.37	2375	2326	48	2020	2.56	0.13	0.12	0.29	0.47	4.95

Table 10a. Summary Results (A1-A3): 5001-6000 psi (34.48-41.37 MPa) RMC product, per cubic yard															
Indicator/LCI Metric	GWP	ODP	AP	EP	POCP	PEC	NRE	RE	NRM	RM	CBW	CWW	TW	CHW	CNHW
Unit (equivalent)	kg CO2	kg CFC-11	kg SO2	kg N	kg O3	MJ	MJ	MJ	kg	kg	m3	m3	m3	kg	kg
Minimum	245.9	7.10E-6	0.92	0.31	19.12	1816	1779	35	1545	1.96	0.10	0.09	0.22	0.33	3.70
Maximum	412.2	1.00E-5	1.24	0.49	25.41	2546	2495	50	1863	3.00	0.10	0.09	0.22	0.38	5.35
6000-00-FA/SL	412.2	1.00E-5	1.24	0.49	25.41	2546	2495	50	1863	3.00	0.10	0.09	0.22	0.33	5.35
6000-20-FA	351.2	8.80E-6	1.09	0.42	22.43	2206	2163	43	1717	2.56	0.10	0.09	0.22	0.33	4.83
6000-30-FA	318.3	7.90E-6	1.01	0.38	20.82	2022	1983	39	1638	2.31	0.10	0.09	0.22	0.33	4.54
6000-40-FA	283.5	7.10E-6	0.92	0.34	19.12	1828	1794	35	1555	2.06	0.10	0.09	0.22	0.33	4.25
6000-30-SL	312.4	9.30E-6	1.18	0.38	22.52	2175	2130	45	1699	2.44	0.10	0.09	0.22	0.36	4.36
6000-40-SL	279.2	8.90E-6	1.16	0.35	21.56	2052	2009	43	1645	2.25	0.10	0.09	0.22	0.37	4.03
6000-50-SL	245.9	8.60E-6	1.14	0.31	20.60	1928	1887	41	1590	2.06	0.10	0.09	0.22	0.38	3.70
6000-50-FA/SL	246.3	7.70E-6	1.02	0.31	19.39	1816	1779	37	1545	1.96	0.10	0.09	0.22	0.36	3.78

Table 11. Summary Results (A1-A3): 6001-8000 psi (41.38-55.16 MPa) RMC product, per cubic meter															
Indicator/LCI Metric	GWP	ODP	AP	EP	POCP	PEC	NRE	RE	NRM	RM	CBW	CWW	TW	CHW	CNHW
Unit (equivalent)	kg CO2	kg CFC-11	kg SO2	kg N	kg O3	MJ	MJ	MJ	kg	kg	m3	m3	m3	kg	kg
Minimum	372.8	1.10E-5	1.36	0.46	28.14	2706	2650	52	1994	2.96	0.13	0.12	0.28	0.43	5.22
Maximum	628.9	1.60E-5	1.86	0.75	37.83	3832	3755	77	2485	4.58	0.13	0.12	0.29	0.51	7.76
8000-00-FA/SL	628.9	1.60E-5	1.86	0.75	37.83	3832	3755	77	2485	4.58	0.13	0.12	0.28	0.44	7.76
8000-20-FA	535.1	1.30E-5	1.62	0.64	33.24	3308	3243	65	2260	3.89	0.13	0.12	0.28	0.44	6.96
8000-30-FA	484.3	1.20E-5	1.49	0.58	30.76	3025	2966	59	2138	3.51	0.13	0.12	0.28	0.43	6.53
8000-40-FA	430.7	1.10E-5	1.36	0.51	28.14	2725	2673	52	2010	3.12	0.13	0.12	0.28	0.43	6.07
8000-30-SL	475.3	1.40E-5	1.76	0.58	33.39	3261	3193	68	2233	3.70	0.13	0.12	0.29	0.48	6.24
8000-40-SL	424.0	1.40E-5	1.73	0.53	31.91	3069	3004	65	2148	3.41	0.13	0.12	0.29	0.50	5.73
8000-50-SL	372.8	1.30E-5	1.69	0.47	30.43	2879	2817	62	2064	3.12	0.13	0.12	0.29	0.51	5.22
8000-50-FA/SL	373.3	1.20E-5	1.52	0.46	28.57	2706	2650	56	1994	2.96	0.13	0.12	0.29	0.48	5.35

Table 11a. Summary Results (A1-A3): 6001-8000 psi (41.38-55.16 MPa) RMC product, per cubic yard															
Indicator/LCI Metric	GWP	ODP	AP	EP	POCP	PEC	NRE	RE	NRM	RM	CBW	CWW	TW	CHW	CNHW
Unit (equivalent)	kg CO2	kg CFC-11	kg SO2	kg N	kg O3	MJ	MJ	MJ	kg	kg	m3	m3	m3	kg	kg
Minimum	285.0	8.20E-6	1.04	0.36	21.52	2069	2026	40	1525	2.27	0.10	0.09	0.22	0.33	3.99
Maximum	480.8	1.20E-5	1.42	0.57	28.92	2930	2871	59	1900	3.50	0.10	0.09	0.22	0.39	5.94
8000-00-FA/SL	480.8	1.20E-5	1.42	0.57	28.92	2930	2871	59	1900	3.50	0.10	0.09	0.22	0.34	5.94
8000-20-FA	409.1	1.00E-5	1.24	0.49	25.41	2529	2480	50	1728	2.97	0.10	0.09	0.22	0.33	5.32
8000-30-FA	370.3	9.20E-6	1.14	0.44	23.52	2313	2268	45	1635	2.68	0.10	0.09	0.22	0.33	4.99
8000-40-FA	329.3	8.20E-6	1.04	0.39	21.52	2084	2044	40	1537	2.38	0.10	0.09	0.22	0.33	4.64
8000-30-SL	363.4	1.10E-5	1.35	0.45	25.53	2493	2441	52	1707	2.83	0.10	0.09	0.22	0.37	4.77
8000-40-SL	324.2	1.00E-5	1.32	0.40	24.39	2347	2297	50	1643	2.61	0.10	0.09	0.22	0.38	4.38
8000-50-SL	285.0	1.00E-5	1.30	0.36	23.26	2201	2153	48	1578	2.38	0.10	0.09	0.22	0.39	3.99
8000-50-FA/SL	285.4	8.90E-6	1.16	0.36	21.84	2069	2026	43	1525	2.27	0.10	0.09	0.22	0.37	4.09

Table 12. Summary Results (A1-A3): Lightweight 2501-3000 psi (17.25-20.68 MPa) RMC product, per cubic meter															
Indicator/LCI Metric	GWP	ODP	AP	EP	POCP	PEC	NRE	RE	NRM	RM	CBW	CWW	TW	CHW	CNHW
Unit (equivalent)	kg CO2	kg CFC-11	kg SO2	kg N	kg O3	MJ	MJ	MJ	kg	kg	m3	m3	m3	kg	kg
Minimum	368.7	1.60E-5	1.71	0.50	26.28	3249	3210	40	1714	8.20	0.13	0.12	0.50	0.42	4.11
Maximum	540.5	2.20E-5	2.28	0.70	34.35	4423	4367	56	1941	11.30	0.13	0.12	0.58	0.47	5.55
LW-3000-00-FA/SL	540.5	2.20E-5	2.28	0.70	34.35	4423	4367	56	1941	11.30	0.13	0.12	0.58	0.43	5.55
LW-3000-20-FA	463.8	1.90E-5	2.00	0.60	30.41	3842	3793	48	1857	9.72	0.13	0.12	0.54	0.42	5.09
LW-3000-30-FA	422.3	1.70E-5	1.84	0.55	28.28	3528	3484	44	1812	8.88	0.13	0.12	0.52	0.42	4.85
LW-3000-40-FA	383.0	1.60E-5	1.71	0.50	26.28	3249	3210	40	1756	8.20	0.13	0.12	0.50	0.42	4.59
LW-3000-30-SL	444.6	2.00E-5	2.17	0.60	31.32	3989	3938	51	1815	10.35	0.13	0.12	0.57	0.45	4.69
LW-3000-40-SL	415.6	2.00E-5	2.15	0.57	30.49	3881	3832	49	1768	10.18	0.13	0.12	0.57	0.46	4.40
LW-3000-50-SL	386.7	2.00E-5	2.13	0.53	29.65	3773	3726	48	1720	10.02	0.13	0.12	0.57	0.47	4.11
LW-3000-50-FA/SL	368.7	1.80E-5	1.92	0.50	27.55	3456	3414	43	1714	9.02	0.13	0.12	0.53	0.45	4.19

Table 12a. Summary Results (A1-A3): Lightweight 2501-3000 psi (17.25-20.68 MPa) RMC product, per cubic yard															
Indicator/LCI Metric	GWP	ODP	AP	EP	POCP	PEC	NRE	RE	NRM	RM	CBW	CWW	TW	CHW	CNHW
Unit (equivalent)	kg CO2	kg CFC-11	kg SO2	kg N	kg O3	MJ	MJ	MJ	kg	kg	m3	m3	m3	kg	kg
Minimum	281.9	1.20E-5	1.31	0.38	20.09	2484	2454	30	1310	6.27	0.10	0.09	0.38	0.32	3.14
Maximum	413.3	1.70E-5	1.75	0.54	26.27	3382	3339	43	1484	8.64	0.10	0.09	0.44	0.36	4.24
LW-3000-00-FA/SL	413.3	1.70E-5	1.75	0.54	26.27	3382	3339	43	1484	8.64	0.10	0.09	0.44	0.33	4.24
LW-3000-20-FA	354.6	1.40E-5	1.53	0.46	23.25	2937	2900	37	1420	7.43	0.10	0.09	0.41	0.32	3.89
LW-3000-30-FA	322.9	1.30E-5	1.41	0.42	21.62	2697	2664	34	1385	6.79	0.10	0.09	0.39	0.32	3.71
LW-3000-40-FA	292.8	1.20E-5	1.31	0.38	20.09	2484	2454	30	1342	6.27	0.10	0.09	0.38	0.32	3.51
LW-3000-30-SL	339.9	1.50E-5	1.66	0.46	23.95	3050	3011	39	1388	7.91	0.10	0.09	0.43	0.34	3.58
LW-3000-40-SL	317.8	1.50E-5	1.64	0.43	23.31	2967	2930	38	1352	7.79	0.10	0.09	0.43	0.35	3.36
LW-3000-50-SL	295.7	1.50E-5	1.63	0.41	22.67	2885	2848	36	1315	7.66	0.10	0.09	0.44	0.36	3.14
LW-3000-50-FA/SL	281.9	1.30E-5	1.46	0.38	21.07	2643	2610	33	1310	6.90	0.10	0.09	0.41	0.34	3.20

Table 13. Summary Results (A1-A3): Lightweight 3001-4000 psi (20.69-27.58 MPa) RMC product, per cubic meter															
Indicator/LCI Metric	GWP	ODP	AP	EP	POCP	PEC	NRE	RE	NRM	RM	CBW	CWW	TW	CHW	CNHW
Unit (equivalent)	kg CO2	kg CFC-11	kg SO2	kg N	kg O3	MJ	MJ	MJ	kg	kg	m3	m3	m3	kg	kg
Minimum	425.3	1.70E-5	1.88	0.57	29.51	3605	3558	47	1678	8.71	0.13	0.12	0.50	0.42	4.50
Maximum	633.7	2.40E-5	2.54	0.81	39.15	4967	4900	67	1982	12.12	0.13	0.12	0.59	0.48	6.31
LW-4000-00-FA/SL	633.7	2.40E-5	2.54	0.81	39.15	4967	4900	67	1982	12.12	0.13	0.12	0.59	0.43	6.31
LW-4000-20-FA	544.6	2.10E-5	2.23	0.70	34.61	4329	4271	58	1861	10.54	0.13	0.12	0.55	0.43	5.74
LW-4000-30-FA	493.7	1.90E-5	2.04	0.63	32.00	3951	3899	52	1801	9.54	0.13	0.12	0.52	0.43	5.43
LW-4000-40-FA	444.5	1.70E-5	1.88	0.57	29.51	3605	3558	47	1729	8.71	0.13	0.12	0.50	0.42	5.10
LW-4000-30-SL	520.1	2.30E-5	2.44	0.69	35.76	4513	4452	61	1809	11.32	0.13	0.12	0.58	0.46	5.22
LW-4000-40-SL	483.5	2.30E-5	2.42	0.65	34.70	4376	4317	59	1749	11.11	0.13	0.12	0.58	0.47	4.86
LW-4000-50-SL	443.2	2.20E-5	2.37	0.61	33.43	4195	4139	56	1695	10.72	0.13	0.12	0.58	0.48	4.50
LW-4000-50-FA/SL	425.3	2.00E-5	2.13	0.57	31.06	3853	3802	51	1678	9.70	0.13	0.12	0.54	0.46	4.59

Table 13a. Summary Results (A1-A3): Lightweight 3001-4000 psi (20.69-27.58 MPa) RMC product, per cubic yard															
Indicator/LCI Metric	GWP	ODP	AP	EP	POCP	PEC	NRE	RE	NRM	RM	CBW	CWW	TW	CHW	CNHW
Unit (equivalent)	kg CO2	kg CFC-11	kg SO2	kg N	kg O3	MJ	MJ	MJ	kg	kg	m3	m3	m3	kg	kg
Minimum	325.1	1.30E-5	1.43	0.44	22.56	2756	2720	36	1283	6.66	0.10	0.09	0.38	0.32	3.44
Maximum	484.5	1.90E-5	1.94	0.62	29.93	3798	3746	51	1515	9.27	0.10	0.09	0.45	0.37	4.83
LW-4000-00-FA/SL	484.5	1.90E-5	1.94	0.62	29.93	3798	3746	51	1515	9.27	0.10	0.09	0.45	0.33	4.83
LW-4000-20-FA	416.4	1.60E-5	1.70	0.53	26.46	3310	3266	44	1423	8.06	0.10	0.09	0.42	0.33	4.39
LW-4000-30-FA	377.5	1.50E-5	1.56	0.48	24.47	3021	2981	40	1377	7.30	0.10	0.09	0.40	0.33	4.15
LW-4000-40-FA	339.8	1.30E-5	1.43	0.44	22.56	2756	2720	36	1322	6.66	0.10	0.09	0.38	0.32	3.90
LW-4000-30-SL	397.6	1.70E-5	1.87	0.53	27.34	3450	3404	47	1383	8.65	0.10	0.09	0.45	0.35	3.99
LW-4000-40-SL	369.6	1.70E-5	1.85	0.50	26.53	3346	3301	45	1337	8.49	0.10	0.09	0.45	0.36	3.71
LW-4000-50-SL	338.8	1.70E-5	1.81	0.46	25.56	3208	3164	43	1296	8.19	0.10	0.09	0.44	0.37	3.44
LW-4000-50-FA/SL	325.1	1.50E-5	1.63	0.44	23.75	2946	2907	39	1283	7.41	0.10	0.09	0.42	0.35	3.51

Table 14. Summary Results (A1-A3): Lightweight 4001-5000 psi (27.59-34.47 MPa) RMC product, per cubic meter															
Indicator/LCI Metric	GWP	ODP	AP	EP	POCP	PEC	NRE	RE	NRM	RM	CBW	CWW	TW	CHW	CNHW
Unit (equivalent)	kg CO2	kg CFC-11	kg SO2	kg N	kg O3	MJ	MJ	MJ	kg	kg	m3	m3	m3	kg	kg
Minimum	465.9	1.90E-5	2.01	0.62	31.92	3883	3831	52	1675	9.19	0.13	0.12	0.51	0.43	4.76
Maximum	709.7	2.70E-5	2.79	0.91	43.18	5491	5415	76	2013	13.29	0.13	0.12	0.61	0.49	6.83
LW-5000-00-FA/SL	709.7	2.70E-5	2.79	0.91	43.18	5491	5415	76	2013	13.29	0.13	0.12	0.61	0.44	6.83
LW-5000-20-FA	605.5	2.30E-5	2.42	0.77	37.86	4733	4668	64	1879	11.36	0.13	0.12	0.56	0.43	6.18
LW-5000-30-FA	545.8	2.10E-5	2.20	0.70	34.79	4282	4224	58	1812	10.15	0.13	0.12	0.53	0.43	5.82
LW-5000-40-FA	489.2	1.90E-5	2.01	0.63	31.92	3883	3831	52	1731	9.19	0.13	0.12	0.51	0.43	5.45
LW-5000-30-SL	574.9	2.50E-5	2.65	0.76	39.02	4912	4844	68	1823	12.12	0.13	0.12	0.60	0.47	5.59
LW-5000-40-SL	533.0	2.40E-5	2.63	0.71	37.81	4755	4690	66	1755	11.89	0.13	0.12	0.60	0.48	5.17
LW-5000-50-SL	485.6	2.40E-5	2.56	0.66	36.28	4533	4470	63	1696	11.37	0.13	0.12	0.59	0.49	4.76
LW-5000-50-FA/SL	465.9	2.10E-5	2.29	0.62	33.62	4151	4095	56	1675	10.25	0.13	0.12	0.55	0.47	4.86

Table 14a. Summary Results (A1-A3): Lightweight 4001-5000 psi (27.59-34.47 MPa) RMC product, per cubic yard															
Indicator/LCI Metric	GWP	ODP	AP	EP	POCP	PEC	NRE	RE	NRM	RM	CBW	CWW	TW	CHW	CNHW
Unit (equivalent)	kg CO2	kg CFC-11	kg SO2	kg N	kg O3	MJ	MJ	MJ	kg	kg	m3	m3	m3	kg	kg
Minimum	356.2	1.40E-5	1.54	0.48	24.40	2969	2929	40	1281	7.02	0.10	0.09	0.39	0.33	3.64
Maximum	542.6	2.10E-5	2.14	0.69	33.01	4198	4140	58	1539	10.16	0.10	0.09	0.47	0.38	5.22
LW-5000-00-FA/SL	542.6	2.10E-5	2.14	0.69	33.01	4198	4140	58	1539	10.16	0.10	0.09	0.47	0.33	5.22
LW-5000-20-FA	463.0	1.80E-5	1.85	0.59	28.95	3618	3569	49	1436	8.69	0.10	0.09	0.43	0.33	4.72
LW-5000-30-FA	417.3	1.60E-5	1.68	0.53	26.60	3274	3229	44	1386	7.76	0.10	0.09	0.40	0.33	4.45
LW-5000-40-FA	374.0	1.40E-5	1.54	0.48	24.40	2969	2929	40	1323	7.02	0.10	0.09	0.39	0.33	4.16
LW-5000-30-SL	439.5	1.90E-5	2.03	0.58	29.83	3755	3703	52	1394	9.27	0.10	0.09	0.46	0.36	4.27
LW-5000-40-SL	407.5	1.90E-5	2.01	0.55	28.91	3636	3586	50	1342	9.09	0.10	0.09	0.46	0.37	3.95
LW-5000-50-SL	371.3	1.80E-5	1.96	0.51	27.74	3466	3418	48	1297	8.70	0.10	0.09	0.45	0.38	3.64
LW-5000-50-FA/SL	356.2	1.60E-5	1.75	0.48	25.70	3174	3131	43	1281	7.83	0.10	0.09	0.42	0.36	3.72

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