

PM Speciation Profiles for Running Exhaust from Compressed Natural Gas Transit Buses Equipped with Three-Way Catalyst

—PM4004 & PM4005

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April 8, 2021

Introduction

Compressed natural gas (CNG) engines have been used in urban transit buses as an alternative to diesel engines. Studies show that the 2010 emission compliant stoichiometric heavy-duty CNG engines are able of meeting the stringent particulate matter (PM) and nitrogen oxides (NO_x) standards with only a three-way oxidation catalyst (TWC) equipped as the after-treatment system [1, 2].

To complement the current CARB speciation profile database, two PM speciation profiles were developed for CNG transit buses equipped with TWC. These new profiles are based on emission source tests from advanced technology natural gas vehicles conducted by West Virginia University in 2010 [1-4]:

- PM4004: Running exhaust from CNG-TWC on steady state (SS) cruise driving cycle
- PM4005: Running exhaust from CNG-TWC on Urban Dynamometer Driving Schedule (UDDS) cycle

A new set of CARB Emission Inventory Codes (EICs) were recently created for CNG trucks and buses equipped with catalytic converters. Profiles PM4004 and PM4005 will be used to characterize the PM emissions of these EICs.

Methodology

In the study of emissions from advanced technology natural gas vehicles [3], two CNG transit buses equipped with stoichiometric engines and TWCs were tested and the PM emissions were characterized. The source tests were performed in 2010 using the West Virginia University (WVU) Transportable Emission Measurement System (TEMS) set up at the CARB's Stockton laboratory [1-4]. The WUV TEMS is equipped with a chassis dynamometer and an

emission measurement system which includes two constant-volume sampling (CVS) dilution tunnels [3]. The two test buses had 2007 Cummins-Westport ISLG 280 8.9-L stoichiometric engines and equipped with OEM TWCs. The buses were tested over a high speed SS cruise driving cycle and the UDDS cycle. Commercially available CNG fuel was used for all the tests.

Samples for elemental carbon/organic carbon (EC/OC) analysis were collected on 47 mm pre-fired Quartz filters and analyzed using the IMPROVE thermal-optical method [1]. Samples for trace element analysis were collected on 47 mm Teflon filters and analyzed with an inductively coupled plasma mass spectrometer (ICP-MS) that quantifies a suite of 50 trace elements [1]. Samples for water-soluble ions were collected on Teflon filters and analyzed by utilizing an Ion Chromatography (IC) [3]. With the emission data of EC/OC, metals, and ions, the following steps were carried out to develop the PM speciation profiles for CNG-TWC running exhausts:

- NCOM (non-carbon organic matter): a factor of 1.25 was used to convert OC to OM (organic matter) for motor vehicle exhaust sources [5]. NCOM is calculated by subtracting OC from OM, i.e.,

$$[\text{NCOM}] = [\text{OM}] - [\text{OC}] = 1.25 \times [\text{OC}] - [\text{OC}] = 0.25 \times [\text{OC}].$$

- 'others': this species group is created to capture the metal-bound oxygen by multiplying the five geological elements (i.e., Al, Si, Ca, Fe and Ti) by their oxygen-to-metal ratios. These ratios were based on the expected oxidation state of the metals in the atmosphere (i.e., Al_2O_3 , SiO_2 , CaO , Fe_2O_3 and TiO_2). The following equation is used to calculate "others" [6]:

$$[\text{others}] = 0.89 \times [\text{Al}] + 1.14 \times [\text{Si}] + 0.40 \times [\text{Ca}] + 0.43 \times [\text{Fe}] + 0.67 \times [\text{Ti}]$$

- Double-counting species: because different analytical methods are performed on PM samples to determine more complete speciation information for multiple purposes, some species are often reported twice in the speciation profiles, such as, total sulfur and sulfate and total phosphorus and phosphate. To avoid double counting in profiles, the overlap portion has to be eliminated. In this work, sulfate instead of total sulfur and phosphate instead of total phosphorus are included in the profiles because calculations indicate that the reported sulfur and phosphorus are covered by sulfate and phosphate, respectively.
- Normalization: the emissions of all the chemical species, including EC/OC, metals, ions, NCOM and 'others', are added up to get an emission total for the profile species; and then the emission of each species is divided by the total emission to get its weight percentage in the new profile.

Results and discussion

I. Chemical Speciation

The details of the new profiles PM4004 (SS) and PM4005 (UDDS) are listed in Appendix Table 1 and Table 2, respectively. Since particle-size-specific chemical composition data are not available, a homogeneous chemical composition is assumed for all PM size ranges. That is, the chemical speciation profiles of TPM (total particulate matter), PM₁₀ and PM_{2.5} are assumed to be the same.

Two metal species in the newly developed profiles are not in the existing CARB CEIDARS (California Emission Inventory Development and Reporting System) Pollutant table. Their names, CAS numbers, and assigned ARB-SAROAD codes are listed in Table 1 and the two species will be added to the CEIDARS database.

Table 1. New ARB-SAROAD codes to be added to CEIDARS POLLUTANT table

<i>ARB- SAROAD</i>	<i>CAS</i>	<i>Chemical Name</i>	<i>Formula</i>	<i>Molecular Weight</i>
12129	7440-60-0	holmium	Ho	164.93
12139	7439-94-3	lutetium	Lu	174.97

Major components of profiles PM4004 (SS) and PM4005 (UDDS) are plotted in Figure 1. In PM4004 (SS), nitrate (is the most abundant species, followed by OC, and these two species account for over 76% of the PM mass. However, OC is the most abundant species in PM4005 (UDDS), followed by nitrate and EC, and the three species contribute almost 80% of the PM mass. It is worth noting that EC is about 20% of the PM emitted from UDDS cycle (PM4005) but it was not detected in the SS cruise exhaust (PM4004). The change of EC content shows the biggest difference between the two profiles PM4004 and PM4005.

Except for NCOM, the remaining 20% of the PM mass for both profiles is mainly composed of sulfate, chloride, phosphate and metals. The weight percentage of sulfate is close to 5% in PM4004 (SS) and a little more than 2% in PM4005 (UDDS); the percentage of phosphate is less than 5% of the PM mass. The content of detected metals is very low, all accounting for only 3 to 4% of the total PM emissions in both profiles. The ionic species and metals are all produced in the combustion chamber as a result of additives in the engine lubricating oil. Among the almost 50 detected metals, calcium was the dominant species and it accounts for over 2% of the PM mass over both driving cycles.

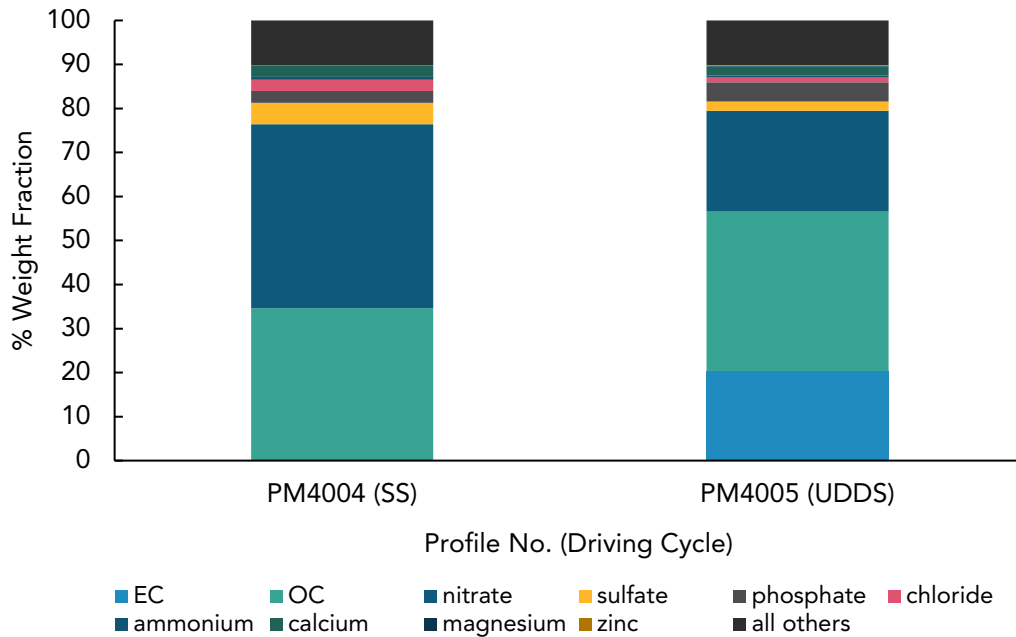


Figure 1. Major species in CNG-TWC PM profiles

II. Size Distribution

Because size distribution data are not available for the CNG PM profiles, the size fractions of PM emitted from gasoline vehicles equipped with catalytic converter (PM4001) [7] are used for PM4004 (SS) and PM4005 (UDDS) as shown in Table 2.

Table 2. PM profile size fractions

Profile No.	PM_{10}/TPM	$PM_{2.5}/TPM$
PM4004	0.894	0.822
PM4005	0.894	0.822

III. Profile Assignment

The newly created CNG EICs include 30 EICSUBs (emission inventory code—subcategories). The EICSUBs are classified into cruise-type group and transient-type group based on their related driving characteristics [8, 9]. PM4004 (SS) is assigned to the cruise-type group EICs including the long-haul trucks that travel mostly on highways; and PM4005 (UDDS) is assigned to the transient-type group EICs including the vehicles that are typically driven locally, such as, utility trucks, public trucks, and solid waste collection vehicles. All the buses are classified into the transient-type group. The mapping of the new CNG-TWC PM profiles to their associated EICs is listed in Appendix Table 3.

References:

1. Yoon, S., et al., *Chemical and toxicological properties of emissions from CNG transit buses equipped with three-way catalysts compared to lean-burn engines and oxidation catalyst technologies*. *Atmospheric Environment*, 2014. **83**: p. 220-228.
2. Yoon, S., et al., *Criteria pollutant and greenhouse gas emissions from CNG transit buses equipped with three-way catalysts compared to lean-burn engines and oxidation catalyst technologies*. *Journal of the Air & Waste Management Association*, 2013. **63**(8): p. 926-933.
3. Gautam, M., et al., *Testing of Volatile and Nonvolatile Emissions from Advanced Technology Natural Gas Vehicles*, 2011, West Virginia University.
4. Thiruvengadam, A., et al., *Characterization of Particulate Matter Emissions from a Current Technology Natural Gas Engine*. *Environmental Science & Technology*, 2014. **48**(14): p. 8235-8242.
5. Reff, A., et al., *Emissions Inventory of PM_{2.5} Trace Elements across the United States*. *Environmental Science & Technology*, 2009. **43**(15): p. 5790-5796.
6. Allen, P., *Developing PM Species Profiles for Emission Inventory*, 2008.
7. *California Air Resources Board Main Speciation Profiles, 2021*, California Air Resources Board, Accessed: March 15, 2021.
8. Yang, W., *Heavy Duty Diesel Vehicle Exhaust PM Speciation Profiles*, 2011, California Air Resources Board: Sacramento, CA.
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Appendix

Table 1. Profile PM4004: CNG-TWC (SS)

<i>Species Name</i>	<i>ARB-SAROAD</i>	<i>TPM Weight Percentage (%)</i>	<i>PM₁₀ Weight Percentage (%)</i>	<i>PM_{2.5} Weight Percentage (%)</i>
organic carbon (OC)	11102	34.607865	34.607865	34.607865
non-carbon organic matter (NCOM)	11103	8.651966	8.651966	8.651966
chloride	12203	2.484438	2.484438	2.484438
nitrate	12306	41.798195	41.798195	41.798195
phosphate	12153	2.716224	2.716224	2.716224
sulfate	12403	4.895455	4.895455	4.895455
ammonium	12301	0.677355	0.677355	0.677355
aluminum	12101	0.037393	0.037393	0.037393
antimony	12102	0.000377	0.000377	0.000377
arsenic	12103	0.000270	0.000270	0.000270
barium	12107	0.003183	0.003183	0.003183
boron	12108	0.011770	0.011770	0.011770
cadmium	12110	0.000170	0.000170	0.000170
calcium	12111	2.455195	2.455195	2.455195
cerium	71111	0.000045	0.000045	0.000045
cesium	12118	0.000009	0.000009	0.000009
chromium	12112	0.012783	0.012783	0.012783
cobalt	12113	0.001276	0.001276	0.001276
copper	12114	0.004238	0.004238	0.004238
dysprosium	12121	0.000003	0.000003	0.000003
europium	12192	0.000005	0.000005	0.000005
holmium	12129	0.000001	0.000001	0.000001
iron	12126	0.086636	0.086636	0.086636
lanthanum	12146	0.000025	0.000025	0.000025
lead	12128	0.000725	0.000725	0.000725
lithium	12138	0.000197	0.000197	0.000197
lutetium	12139	0.000001	0.000001	0.000001
magnesium	12140	0.186179	0.186179	0.186179
manganese	12132	0.003308	0.003308	0.003308
molybdenum	12134	0.000770	0.000770	0.000770
neodymium	12144	0.000014	0.000014	0.000014
nickel	12136	0.006999	0.006999	0.006999
niobium	12147	0.000061	0.000061	0.000061

<i>Species Name</i>	<i>ARB-SAROAD</i>	<i>TPM Weight Percentage (%)</i>	<i>PM₁₀ Weight Percentage (%)</i>	<i>PM_{2.5} Weight Percentage (%)</i>
palladium	12151	0.000029	0.000029	0.000029
platinum	12178	0.000003	0.000003	0.000003
potassium	12180	0.209308	0.209308	0.209308
praseodymium	12155	0.000004	0.000004	0.000004
rhodium	12177	0.000003	0.000003	0.000003
rubidium	12176	0.000109	0.000109	0.000109
samarium	12190	0.000005	0.000005	0.000005
scandium	12104	0.000013	0.000013	0.000013
selenium	12154	0.002965	0.002965	0.002965
silver	12166	0.000047	0.000047	0.000047
strontium	12168	0.004745	0.004745	0.004745
thallium	12173	0.000005	0.000005	0.000005
thorium	12174	0.000006	0.000006	0.000006
tin	12160	0.034872	0.034872	0.034872
titanium	12161	0.000525	0.000525	0.000525
tungsten	12119	0.000430	0.000430	0.000430
uranium	12179	0.000006	0.000006	0.000006
vanadium	12164	0.000235	0.000235	0.000235
ytterbium	12122	0.000002	0.000002	0.000002
yttrium	12183	0.000014	0.000014	0.000014
zinc	12167	0.050579	0.050579	0.050579
others	12999	1.052964	1.052964	1.052964
<i>Total</i>		<i>100.000000</i>	<i>100.000000</i>	<i>100.000000</i>

Table 2. Profile PM4005: CNG-TWC (UDDS)

<i>Species Name</i>	<i>ARB-SAROAD</i>	<i>TPM Weight Percentage (%)</i>	<i>PM₁₀ Weight Percentage (%)</i>	<i>PM_{2.5} Weight Percentage (%)</i>
elemental carbon (EC)	12116	20.338314	20.338314	20.338314
organic carbon (OC)	11102	36.229200	36.229200	36.229200
non-carbon organic matter (NCOM)	11103	9.057300	9.057300	9.057300
chloride	12203	1.050374	1.050374	1.050374
nitrate	12306	22.916216	22.916216	22.916216
phosphate	12153	4.362307	4.362307	4.362307
sulfate	12403	2.130902	2.130902	2.130902
ammonium	12301	0.431178	0.431178	0.431178
aluminum	12101	0.022658	0.022658	0.022658
antimony	12102	0.000216	0.000216	0.000216
arsenic	12103	0.000104	0.000104	0.000104
barium	12107	0.007276	0.007276	0.007276
boron	12108	0.006407	0.006407	0.006407
cadmium	12110	0.000080	0.000080	0.000080
calcium	12111	2.139185	2.139185	2.139185
cerium	71111	0.000039	0.000039	0.000039
cesium	12118	0.000013	0.000013	0.000013
chromium	12112	0.001603	0.001603	0.001603
cobalt	12113	0.003938	0.003938	0.003938
copper	12114	0.006423	0.006423	0.006423
dysprosium	12121	0.000004	0.000004	0.000004
europium	12192	0.000008	0.000008	0.000008
iron	12126	0.016074	0.016074	0.016074
lanthanum	12146	0.000019	0.000019	0.000019
lead	12128	0.000545	0.000545	0.000545
lithium	12138	0.000683	0.000683	0.000683
lutetium	12139	0.000001	0.000001	0.000001
magnesium	12140	0.147480	0.147480	0.147480
manganese	12132	0.008462	0.008462	0.008462
molybdenum	12134	0.000742	0.000742	0.000742
neodymium	12144	0.000013	0.000013	0.000013
nickel	12136	0.003451	0.003451	0.003451
niobium	12147	0.000011	0.000011	0.000011
palladium	12151	0.000025	0.000025	0.000025
platinum	12178	0.000001	0.000001	0.000001

<i>Species Name</i>	<i>ARB-SAROAD</i>	<i>TPM Weight Percentage (%)</i>	<i>PM₁₀ Weight Percentage (%)</i>	<i>PM_{2.5} Weight Percentage (%)</i>
potassium	12180	0.105548	0.105548	0.105548
praseodymium	12155	0.000005	0.000005	0.000005
rhodium	12177	0.000001	0.000001	0.000001
rubidium	12176	0.000098	0.000098	0.000098
samarium	12190	0.000004	0.000004	0.000004
scandium	12104	0.000005	0.000005	0.000005
selenium	12154	0.001427	0.001427	0.001427
silver	12166	0.000032	0.000032	0.000032
strontium	12168	0.003493	0.003493	0.003493
thallium	12173	0.000004	0.000004	0.000004
thorium	12174	0.000013	0.000013	0.000013
tin	12160	0.015957	0.015957	0.015957
titanium	12161	0.000274	0.000274	0.000274
tungsten	12119	0.000667	0.000667	0.000667
uranium	12179	0.000003	0.000003	0.000003
vanadium	12164	0.000105	0.000105	0.000105
ytterbium	12122	0.000001	0.000001	0.000001
yttrium	12183	0.000012	0.000012	0.000012
zinc	12167	0.108161	0.108161	0.108161
others	12999	0.882938	0.882938	0.882938
<i>Total</i>		<i>100.000000</i>	<i>100.000000</i>	<i>100.000000</i>

Table 3. Mapping of CNG-TWC PM profiles to new CNG EICs

<i>EIC</i>	<i>EIC Name</i>	<i>PM Profile No.</i>
72773101107044	MHDT-Catalyst Starts-Natural Gas-T6 CAIRP Class 7	PM4004
72773101107045	MHDT-Catalyst Starts-Natural Gas-T6 Instate Delivery Class 4	PM4004
72773101107046	MHDT-Catalyst Starts-Natural Gas-T6 Instate Delivery Class 5	PM4004
72773101107047	MHDT-Catalyst Starts-Natural Gas-T6 Instate Delivery Class 6	PM4004
72773101107048	MHDT-Catalyst Starts-Natural Gas-T6 Instate Delivery Class 7	PM4004
72773101107049	MHDT-Catalyst Starts-Natural Gas-T6 Instate Other Class 4	PM4004
72773101107050	MHDT-Catalyst Starts-Natural Gas-T6 Instate Other Class 5	PM4004
72773101107051	MHDT-Catalyst Starts-Natural Gas-T6 Instate Other Class 6	PM4004
72773101107052	MHDT-Catalyst Starts-Natural Gas-T6 Instate Other Class 7	PM4004
72773101107053	MHDT-Catalyst Starts-Natural Gas-T6 Instate Tractor Class 6	PM4004
72773101107054	MHDT-Catalyst Starts-Natural Gas-T6 Instate Tractor Class 7	PM4004
72773101107059	MHDT-Catalyst Starts-Natural Gas-T6 Public Class 4	PM4005
72773101107060	MHDT-Catalyst Starts-Natural Gas-T6 Public Class 5	PM4005
72773101107061	MHDT-Catalyst Starts-Natural Gas-T6 Public Class 6	PM4005
72773101107062	MHDT-Catalyst Starts-Natural Gas-T6 Public Class 7	PM4005
72773101107063	MHDT-Catalyst Starts-Natural Gas-T6 Utility Class 5	PM4005
72773101107064	MHDT-Catalyst Starts-Natural Gas-T6 Utility Class 6	PM4005
72773101107065	MHDT-Catalyst Starts-Natural Gas-T6 Utility Class 7	PM4005
72773401107044	MHDT-Catalyst Hot Stabilized Exhaust-Natural Gas-T6 CAIRP Class 7	PM4004
72773401107045	MHDT-Catalyst Hot Stabilized Exhaust-Natural Gas-T6 Instate Delivery Class 4	PM4004
72773401107046	MHDT-Catalyst Hot Stabilized Exhaust-Natural Gas-T6 Instate Delivery Class 5	PM4004
72773401107047	MHDT-Catalyst Hot Stabilized Exhaust-Natural Gas-T6 Instate Delivery Class 6	PM4004
72773401107048	MHDT-Catalyst Hot Stabilized Exhaust-Natural Gas-T6 Instate Delivery Class 7	PM4004
72773401107049	MHDT-Catalyst Hot Stabilized Exhaust-Natural Gas-T6 Instate Other Class 4	PM4004
72773401107050	MHDT-Catalyst Hot Stabilized Exhaust-Natural Gas-T6 Instate Other Class 5	PM4004
72773401107051	MHDT-Catalyst Hot Stabilized Exhaust-Natural Gas-T6 Instate Other Class 6	PM4004
72773401107052	MHDT-Catalyst Hot Stabilized Exhaust-Natural Gas-T6 Instate Other Class 7	PM4004

<i>EIC</i>	<i>EIC Name</i>	<i>PM Profile No.</i>
72773401107053	MHDT-Catalyst Hot Stabilized Exhaust-Natural Gas-T6 Instate Tractor Class 6	PM4004
72773401107054	MHDT-Catalyst Hot Stabilized Exhaust-Natural Gas-T6 Instate Tractor Class 7	PM4004
72773401107059	MHDT-Catalyst Hot Stabilized Exhaust-Natural Gas-T6 Public Class 4	PM4005
72773401107060	MHDT-Catalyst Hot Stabilized Exhaust-Natural Gas-T6 Public Class 5	PM4005
72773401107061	MHDT-Catalyst Hot Stabilized Exhaust-Natural Gas-T6 Public Class 6	PM4005
72773401107062	MHDT-Catalyst Hot Stabilized Exhaust-Natural Gas-T6 Public Class 7	PM4005
72773401107063	MHDT-Catalyst Hot Stabilized Exhaust-Natural Gas-T6 Utility Class 5	PM4005
72773401107064	MHDT-Catalyst Hot Stabilized Exhaust-Natural Gas-T6 Utility Class 6	PM4005
72773401107065	MHDT-Catalyst Hot Stabilized Exhaust-Natural Gas-T6 Utility Class 7	PM4005
72773501107044	MHDT-Catalyst Idle Exhaust-Natural Gas-T6 CAIRP Class 7	PM4004
72773501107045	MHDT-Catalyst Idle Exhaust-Natural Gas-T6 Instate Delivery Class 4	PM4004
72773501107046	MHDT-Catalyst Idle Exhaust-Natural Gas-T6 Instate Delivery Class 5	PM4004
72773501107047	MHDT-Catalyst Idle Exhaust-Natural Gas-T6 Instate Delivery Class 6	PM4004
72773501107048	MHDT-Catalyst Idle Exhaust-Natural Gas-T6 Instate Delivery Class 7	PM4004
72773501107049	MHDT-Catalyst Idle Exhaust-Natural Gas-T6 Instate Other Class 4	PM4004
72773501107050	MHDT-Catalyst Idle Exhaust-Natural Gas-T6 Instate Other Class 5	PM4004
72773501107051	MHDT-Catalyst Idle Exhaust-Natural Gas-T6 Instate Other Class 6	PM4004
72773501107052	MHDT-Catalyst Idle Exhaust-Natural Gas-T6 Instate Other Class 7	PM4004
72773501107053	MHDT-Catalyst Idle Exhaust-Natural Gas-T6 Instate Tractor Class 6	PM4004
72773501107054	MHDT-Catalyst Idle Exhaust-Natural Gas-T6 Instate Tractor Class 7	PM4004
72773501107059	MHDT-Catalyst Idle Exhaust-Natural Gas-T6 Public Class 4	PM4005
72773501107060	MHDT-Catalyst Idle Exhaust-Natural Gas-T6 Public Class 5	PM4005
72773501107061	MHDT-Catalyst Idle Exhaust-Natural Gas-T6 Public Class 6	PM4005
72773501107062	MHDT-Catalyst Idle Exhaust-Natural Gas-T6 Public Class 7	PM4005
72773501107063	MHDT-Catalyst Idle Exhaust-Natural Gas-T6 Utility Class 5	PM4005
72773501107064	MHDT-Catalyst Idle Exhaust-Natural Gas-T6 Utility Class 6	PM4005
72773501107065	MHDT-Catalyst Idle Exhaust-Natural Gas-T6 Utility Class 7	PM4005

<i>EIC</i>	<i>EIC Name</i>	<i>PM Profile No.</i>
72873101107067	HHDT-Catalyst Starts-Natural Gas-T7 CAIRP Class 8	PM4004
72873101107071	HHDT-Catalyst Starts-Natural Gas-T7 POAK Class 8	PM4004
72873101107072	HHDT-Catalyst Starts-Natural Gas-T7 POLA Class 8	PM4004
72873101107073	HHDT-Catalyst Starts-Natural Gas-T7 Public Class 8	PM4005
72873101107074	HHDT-Catalyst Starts-Natural Gas-T7 Single Concrete/Transit Mix Class 8	PM4005
72873101107075	HHDT-Catalyst Starts-Natural Gas-T7 Single Dump Class 8	PM4005
72873101107076	HHDT-Catalyst Starts-Natural Gas-T7 Single Other Class 8	PM4005
72873101107077	HHDT-Catalyst Starts-Natural Gas-T7 SWCV Class 8	PM4005
72873101107078	HHDT-Catalyst Starts-Natural Gas-T7 Tractor Class 8	PM4004
72873401107067	HHDT-Catalyst Hot Stabilized Exhaust-Natural Gas-T7 CAIRP Class 8	PM4004
72873401107071	HHDT-Catalyst Hot Stabilized Exhaust-Natural Gas-T7 POAK Class 8	PM4004
72873401107072	HHDT-Catalyst Hot Stabilized Exhaust-Natural Gas-T7 POAK Class 8	PM4004
72873401107073	HHDT-Catalyst Hot Stabilized Exhaust-Natural Gas-T7 Public Class 8	PM4005
72873401107074	HHDT-Catalyst Hot Stabilized Exhaust-Natural Gas-T7 Single Concrete/Transit Mix Class 8	PM4005
72873401107075	HHDT-Catalyst Hot Stabilized Exhaust-Natural Gas-T7 Single Dump Class 8	PM4005
72873401107076	HHDT-Catalyst Hot Stabilized Exhaust-Natural Gas-T7 Single Other Class 8	PM4005
72873401107077	HHDT-Catalyst Hot Stabilized Exhaust-Natural Gas-T7 SWCV Class 8	PM4005
72873401107078	HHDT-Catalyst Hot Stabilized Exhaust-Natural Gas-T7 Tractor Class 8	PM4004
72873501107067	HHDT-Catalyst Idle Exhaust-Natural Gas-T7 CAIRP Class 8	PM4004
72873501107071	HHDT-Catalyst Idle Exhaust-Natural Gas-T7 POAK Class 8	PM4004
72873501107072	HHDT-Catalyst Idle Exhaust-Natural Gas-T7 POLA Class 8	PM4004
72873501107073	HHDT-Catalyst Idle Exhaust-Natural Gas-T7 Public Class 8	PM4005
72873501107074	HHDT-Catalyst Idle Exhaust-Natural Gas-T7 Single Concrete/Transit Mix Class 8	PM4005
72873501107075	HHDT-Catalyst Idle Exhaust-Natural Gas-T7 Single Dump Class 8	PM4005
72873501107076	HHDT-Catalyst Idle Exhaust-Natural Gas-T7 Single Other Class 8	PM4005
72873501107077	HHDT-Catalyst Idle Exhaust-Natural Gas-T7 SWCV Class 8	PM4005
72873501107078	HHDT-Catalyst Idle Exhaust-Natural Gas-T7 Tractor Class 8	PM4004

<i>EIC</i>	<i>EIC Name</i>	<i>PM Profile No.</i>
77573101107202	Buses-Catalyst Starts-Natural Gas-All Other Buses	PM4005
77573101107203	Buses-Catalyst Starts-Natural Gas-School Buses (SB)	PM4005
77573401107202	Buses-Catalyst Hot Stabilized Exhaust-Natural Gas-All Other Buses	PM4005
77573401107203	Buses-Catalyst Hot Stabilized Exhaust-Natural Gas-School Buses (SB)	PM4005
77573401107204	Buses-Catalyst Hot Stabilized Exhaust-Natural Gas-Heavy Duty Urban Buses (UB)	PM4005
77573501107202	Buses-Catalyst Idle Exhaust-Natural Gas-All Other Buses	PM4005
77573501107203	Buses-Catalyst Idle Exhaust-Natural Gas-School Buses (SB)	PM4005