CNG Street Sweepers and CNG Fueling Station

FINAL REPORT

Prepared for the Mobile Source Air Pollution Review Committee (MSRC) under the AB 2766 Discretionary Fund Work Program

Prepared by the City of Anaheim

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This report was submitted in fulfillment of ML14016 and CNG Street Sweepers and CNG Fueling Station by City of Anaheim under the partial sponsorship of the Mobile Source Air Pollution Reduction Review Committee (MSRC). Work was completed as of March 31, 2017.

DISCLAIMER

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EXECUTIVE SUMMARY

The City of Anaheim was awarded $380,000 in AB 2766/MSRC Local Government Match Program grant funding by the Mobie Source Air Pollution Reduction Review Committee in April 2015. The City used these grant funds to address its need for additional capacity to supply fuel for its fleet, by upgrading its existing compressed natural gas (CNG) refueling station with fast-fill equipment and purchase of two (2) compressed natural gas-fueled street sweepers.

The station upgrade used the infrastructure already in place, allowing vehicles to connect to an existing underground natural gas line through compressors and connector hoses. The new compressors were placed where the existing compressors were located – between concrete barriers (cinder block walls) as a safety measure – and were secured behind locked gates at the Anaheim City Yard. The City also installed a dual system to allow for redundancy (extremely common with CNG fueling stations and a standard industry operating model) and to meet AM and PM peak fueling times. The project also added capacity for future fuel needs as identified in the City's CNG vehicle fleet expansion plan, which projected continued growth through 2018.

As a result of the station upgrade, the City has increased its ability to efficiently and cost effectively provide fuel for its fleet and now has self-sufficient fueling capability. Previously, the station had a fueling capacity of just 4,620 GGEs (gallon of gas equivalents) per month. As a result of this project, the upgraded CNG station can now provide approximately 31,500 GGEs per month in fuel. This increased capacity allows the City to meet the strategically planned growth of the City's CNG fleet.

During the grant period, the City increased its fleet from 47 CNG vehicles to 60 CNG vehicles. The City anticipates adding another 3 large CNG vehicles over the next 5 years. This MSRC approved Project has allowed the City to expand its fleet in an effort to reduce diesel consumption and carbon dioxide (CO2) and greenhouse gas (GHG) emissions. Natural gas vehicles produce 20-30 percent fewer emissions than diesel vehicles. Finally, the project will have positive fiscal result for the City. Staff time needed for refilling CNG vehicles has been reduced, as have fuel costs as the City is able to utilize more CNG vehicles powered by a less expensive fuel (vs. diesel-fueled equipment), and is able to obtain CNG for refueling as a lower cost. Upon completion of the upgrade, City vehicles no longer have to travel to off-site retail providers for fueling, resulting in a monthly savings of more than $13,000 in fuel costs alone.

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CHAPTER 1:
Project Background and Objectives

1.1 Project Background

The City of Anaheim was awarded $380,000 in AB 2766/MSRC Local Government Match Program grant funding by the Mobile Source Air Pollution Review Committee (MSRC) in April 2015. The City used these grant funds to address its need for additional capacity to supply fuel for its fleet, by upgrading its existing compressed natural gas (CNG) refueling station with fast-fill equipment. The upgrade to the fueling station will allow the City of Anaheim to meet its fleet services fuel demands, prepare for fleet growth, and be in a position to negotiate and offer back-up alternative CNG fueling to other regional fleet services (future plans).

The City of Anaheim is California's tenth largest city with a population of nearly 350,000 and is known worldwide for its entertainment, tourism, sports teams, and convention activities. Under the umbrella of the Department of Public Works, Fleet Services has a 40-member team operating out of a 47,000 square-foot, 30 bay repair facility. Fleet Services is responsible for purchasing and maintaining all of the vehicles and motorized equipment used by the City. Anaheim's fleet consists of over 1,200 pieces of equipment, of which over 780 are on-road vehicles, over 460 are trailers, generators, and other miscellaneous equipment types, and almost 30 are off-road unit engines. At the start of this grant period, the on-road vehicles included 47 natural gas alternative fuel vehicles. Of the 47 compressed natural gas fuel vehicles, 16 were large-capacity, heavy-duty vehicles (e.g., street sweepers, vacuum trucks, trash trucks, broom trucks, etc.) with a fueling capacity of 60 – 70 GGE (gasoline gallon equivalent) and 31 were passenger-size vehicles (e.g., Honda Civic Natural Gas model) with a fueling capacity of approximately 14 GGE.

Prior to this award, the City of Anaheim's fueling station was in dire need of upgrade. The CNG compressors were donated to the City as part of a property acquisition from The Gas Company. The compressors were estimated to be over 40 years old and required continuous maintenance. In addition, they failed approximately 25 percent of the time.

Because of antiquated and faulty equipment, CNG vehicles often had to travel to one of eight other CNG fueling stations in Orange County. These stations were anywhere from 2.5 miles to 23 miles away from the City's fueling station, with an average distance of 12.8 miles. Because of traffic and congestion, City workers often spent up to 30 minutes commuting to even the closest fueling station just 2.5 miles away, and up to 60 minutes reaching the farthest site (22.9 miles away). Traveling offsite to refuel vehicles cost the City notable man hours and wages.
In addition, street sweepers and other large vehicles average three miles per gallon of fuel. Having to travel offsite to fuel was a waste of taxpayers' money given the additional use of fuel to commute to and from offsite stations and the related cost of staff time. The City's goal was to create a facility where all vehicles are filled onsite at the beginning of the day/shift and/or at the

end of the day/shift.

Finally, the City's vehicles, in particular the 16 large fueling capacity vehicles, infringed on the other customers' ability to fuel at these alternative stations in a timely manner due to the length of time it takes to fill a 60 to 70 GGE capacity vehicle (e.g., can take up to 40 minutes).

The City's need for the proposed project was also driven by the anticipated growth of the CNG fleet. At the time of the proposal, the City estimated that its five-year fleet expansion plan would add another 14 vehicles requiring use of the CNG facility. The antiquated fueling system inefficiently provided 8,360 GGE per month (based on an average 19 days / month), while the City's fueling need for its 47 vehicles was 21,500 GGE per month. Figure 1 details the City's CNG vehicle fleet and fueling needs as of 2013, the projected five-year fleet and fueling growth (as of 2013), and the total CNG supply expected following the upgrade of the CNG facility.

Figure 1. Existing and Planned CNG Vehicle Population and Fueling Needs

1	(1) DESCRIPTION	(2) Estimate GGE/day	(3) Operational Days/month	(4) Estimated GGE Monthly (1 x 2 x 3)
1.1	16 large capacity vehicles (street sweepers, vacuum trucks, trash trucks, broom trucks)	60	19	18,240
1.2	31 passenger vehicles (Honda Civic Natural Gas)	10	10	3,100
1.3	***Total Current Monthly Demand (18,240 + 3,100 = 21,500, rounded)**			**21,500**
2	**Proposed Five Year Fleet Plan**			
2.1	5 large capacity vehicles	60	19	5,700
2.2	9 passenger vehicles	11	12	1,188
2.3	**Total Future Demand (5,700 + 1,188, rounded)**			**7,000**
3	TOTAL CITY NEED (21,500 + 7,000)			28,500
4	TOTAL THROUGHPUT AFTER UPGRADE			31,500
5	Current Capacity of Existing Station			8,360

*Calculations are based on quantified data the City has collected and monitored through fuel usage. The calculations are based on average per day fuel usage with each large capacity vehicle being used on average 19 days per month and each passenger vehicle being used on average 10 or 11 days per month.

The City projected that the upgraded facility will provide an estimated 31,500 GGE per month (a 277% percent increase), which would meet the expected growth of the City's CNG fleet (estimated at 28,500 GGE / month) and potentially allow the City to enter into a user agreement(s) with external user(s) to fully utilize the 31,500 GGE projected throughput.

1.2 Objectives

The City established five primary objectives as part of its proposal to upgrade the existing fueling station:

(1) To efficiently and cost effectively provide fuel for the CNG vehicles owned and operated by the City of Anaheim. The existing fueling station, constructed more than five years ago and designed to refuel two to three vehicles per day, did not meet the CNG vehicle fueling needs in 2013. As a result, over 60 percent of fueling occurred offsite.

(2) To provide the City self-sufficient fueling capability. When the City designed and installed its CNG fueling station, self-sufficiency was a solid part of the reasoning behind the fueling station's value. By upgrading the fueling station, the City aimed to return to a model of self-sufficiency, which included:

- Being able to fuel onsite conveniently and timely;
- Not wasting staff time (and, therefore, City/taxpayers' dollars) by driving offsite through traffic and waiting to fuel at an alternative station; and
- Paying retail GGE price per gallon. The savings the City will realize supplying its own CNG fuel versus paying 'retail' cost at alternative sites per GGE is significant. On average, the City paid $2.12 per GGE at offsite fueling stations. With the proposed fueling station upgrade, the City anticipated paying, initially, $1.13 per GGE, which would then drop to $0.63 per GGE due to a $0.50 per GGE tax credit. On average per GGE, the City anticipated saving $1.49 per GGE after installation and full use commenced.

(3) To meet strategically planned growth in the City's CNG fleet. At the time of the grant proposal, the City of Anaheim's fueling need was 21,500 GGE / month (1,132 / day x 19 days / month). At the time, the City's fueling station could only meet 4,620 GGE / month, or 21.5 percent of the fueling needs. The proposed station upgrade was expected to produce a throughput capacity of 31,500 GGE / month, which was anticipated to meet and exceed projected fleet growth needs over the next five years.

(4) To be environmentally responsible. CNG fuel produces far less pollutants than comparable gasoline or diesel type fuel. It also produces less carbon dioxide and other greenhouse gasses. CNG fuel and vehicle usage reduces smog-forming emissions of Carbon Monoxide (CO) (70% per vehicle), Non-Methane Organic Gas (NMOG) (87% per vehicle) and Oxides of Nitrogen (NOx) (87% per vehicle). CNG vehicles typically have 20% fewer greenhouse gas emissions than gasoline-powered cars. In addition, natural gas is not toxic or corrosive and will not contaminate ground water. Orange County's Air Quality Index rated at 4.3 on a scale of 100 (higher being better) in June of 2012, demonstrating that every project supporting air quality improvement is critical and necessary (http://www.bestplaces.net/health/

county/california/orange). Because of the region's population density there is significant traffic congestion and hundreds of thousands of vehicles on the roads. According to the South Coast AQMD, reduction in harmful emissions from vehicles is *the* leading factor in improving air quality in this region. In addition, poor air quality is linked to serious health effects, including respiratory diseases (asthma, bronchitis, infections), lung damage, cancer, and increased and premature death. Air quality also affects the population's outdoor work, exercise and enjoyment opportunities, which are an important part of the southern California lifestyle. Reduction in emissions by use of alternative fuel vehicles directly affects the quality of life in Anaheim and Orange County.

(5) To save staff time and costs. At the time of the proposal, the average time spent offsite fueling 16 large (i.e., street sweepers, trash trucks, broom trucks, garbage trucks) vehicles was 90 minutes with staff members earning an average of $36/hour (full burdened). With approximately 10 staff members who must daily divert their large capacity vehicles for refuel, and using an average 19 working days in a month x 90 minutes x 10 staff members, the total monthly staff time cost for fueling offsite was estimated at $6,840. This is the equivalent of $82,080 per year, or, an entire City mid-level position. With onsite faster-fill fueling, the round-trip transit time and salary waste is eliminated.

CHAPTER 2:
Scope of Work

The City of Anaheim's scope of work under contract ML14016 included:

- the purchase of two heavy-duty vehicles, each with a gross vehicle weight rating greater than 14,000 pounds and equipped with dedicated CNG engines, and

- the upgrade of its existing compressed natural gas (CNG) refueling station with fast-fill equipment.

2.1 Street Sweepers

The natural gas-fueled street sweepers meet criteria specified by the MSRC in that each engine is certified by the California Air Resources Board (CARB) at, or cleaner than, the 2010 heavy-duty engine emission standards of 0.2 g/bhp-hr for oxides of nitrogen and 0.01 g/bhp-hr for particulate matter. As depicted in Figure 2, the vehicles have been entered into service and display the required MSRC decals.

Figure 2. Compressed Natural Gas Street Sweeper Specifications

2015 Freightliner Sweeper

VIN: 1FVAC4DXXFHGD3791

Engine Type: 8.9 Cummins Natural Gas

Engine Family: ECEXH0540LBH

Figure 2. Compressed Natural Gas Street Sweeper Specifications (continued)

2014 Freightliner Sweeper

VIN: 1FVAC4DX9FHGF2073

Engine Type: 8.9 Cummins Natural Gas

Engine Family: ECEXH0540LBH

2.2 CNG Fueling Station

The station upgrade used current infrastructure and allows vehicles to connect from an existing underground natural gas line through compressors and connector hoses. The new compressors were placed where existing compressors were already located – between concrete barriers (cinder block walls) as a safety measure – and are secured behind the locked gates at the Anaheim City Yard. The City also installed a dual system to allow for redundancy and to meet AM and PM peak fueling times. Redundancy is extremely common with CNG fueling stations and is deemed a standard industry operating model.

More specifically, the project included the installation of:

- Natural Gas Dryer (1): A single tower Natural Gas Dryer System with pre-filter, after filter, and block and bypass valves. Dryer includes an effluent gas dew point monitor with digital dew point indication and alarm light, all rated Class 1, Division 2, Group D locations. The dryer was sized to handle the total compressor(s) output.

- Two (2) CNG Compressor Packages (1 skid with 2 compressors each): Two multi-stage, electric motor-driven, Class 1 Division 2, compressor packages. Each compressor package is capable of providing approximately 116 Standard Cubic Feet Per Minute (SCFM) @ 20 pounds per square inch (psi) with a total system output of 232 SCFM or 110 Gas Gallon Equivalent (GGE) / hour. The compressors include inlet and discharge filtration, air blast inter-stage cooler, all necessary pressure and temperature safety devices, automatic condensate drain and blow down system, American Society of Mechanical Engineering (ASME) inter-stage safety relief valves, all interconnecting pipe work, on-skid dual electronic control system Murphy level 2 (UL listed components), on-skid explosion-proof starters, all required valves and associated equipment. The second compressor was installed for redundancy purposes, which is an industry standard.

- Electric motor(s): Four (4) (2 per compressor package) 40 Horsepower (HP) 1800 rpm, totally enclosed, explosion-proof 230/460 volt, 3ph, 60Hz.

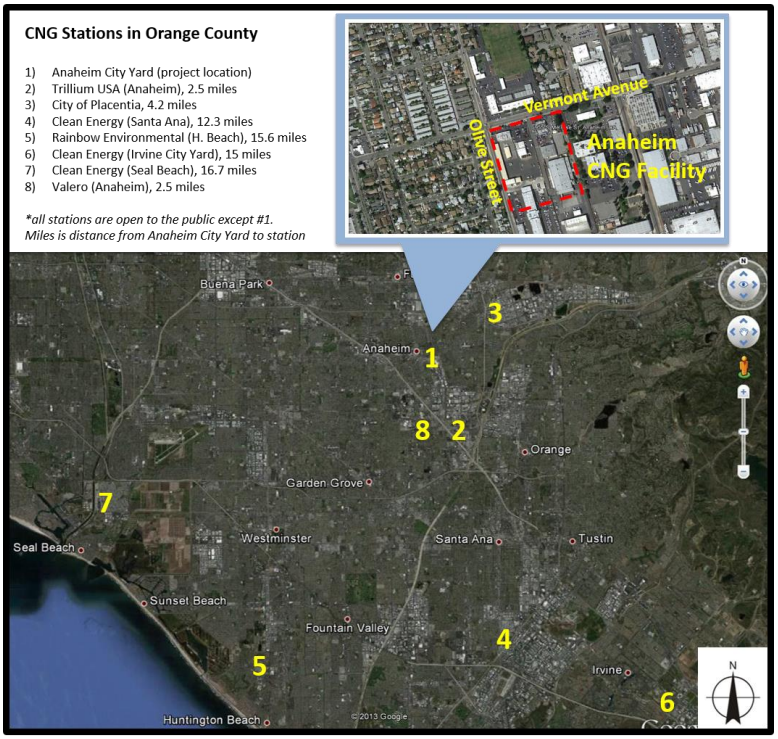
- Two (2) Fast-Fill Dispensers: The fast-fill dispenser are dual hose dispenser with Weh TK17, NGV 1 Type 1 pistol style nozzles and breakaways, and retractors. The hose length is 10 feet. Delivery pressure is set to 3600 psi for each hose. Dispensers utilize a FuelMaster POS interface, which provides the option of fleet card transactions, as well as, external (i.e., non-City) credit-card transactions should the City enter into a contract with other municipalities or organizations negotiating fueling station access. This fast-fill dispenser is be Weights & Measures approved.

In addition to procuring and installing the equipment described above, project work also included minor trenching, backfill, compaction, forming, and concrete, electrical and plumbing work, etc. This work was considered minor because there was already an existing CNG fueling station on site. This project simply upgraded the existing facility to accommodate more vehicles in shorter period of time (i.e. faster fill).

All equipment meets all applicable American Petroleum Institute (API), American Society of Mechanical Engineers (ASME), International Society of Automation (ISA), American Gas Association (AGA), National Electric Code (NEC), and National Fire Protection Association (NFPA) requirements.

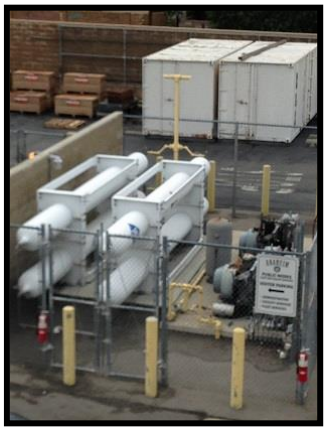
The City's CNG fueling station is located in the City Yard at 955 South Melrose, Anaheim, California, 92805. Figure 3 contains a map of the Anaheim Fueling Station, and an image showing the station in relation to the other 7 refueling stations location in Orange County.

Figure 3. Location of Anaheim CNG Facility and Other CNG Stations in Orange County



As described earlier, the proposed project included the upgrade of existing fueling equipment and utilized the same infrastructure (with minor modifications) already established. Figure 4 contains photos of the CNG fueling stations prior to the upgrade funded through this grant. Photographs of the upgraded station can be found in Chapter 3 of this report.

Figure 4. City of Anaheim's Compressed Natural Gas Fuel Station, Prior to Grant-Funded Upgrades



CHAPTER 3:
Results

Upgrades to the City of Anaheim's CNG fueling station were completed on August 22, 2014. Figure 5 contains photographs of the completed fueling station. Since that time, staff has collected data on fueling capacity, usage, and emissions reductions, among other things. Figure 6 details the quantifiable results of the upgrade project.

Approximately 60 CNG vehicles utilize the upgraded CNG facility in Anaheim. Since the station became operational, fuel usage from August 22, 2014 through January 22, 2015 was approximately 54,000 GGEs. On average, monthly throughput is approximately 9,000 GGEs versus 2,940 GGE previously; this is over a 200 percent increase in CNG usage.

Based on the average throughput of approximately 108,000 GGEs per year, the fuel station upgrade is responsible for a high level of emission reduction benefits. By replacing aging diesel powered vehicles, with newer, post-2012 CNG vehicles, the City's current fleet of 60 CNG vehicles will achieve 80% less NOx, 99% less PM, and 100% less HC than a model year 2000 Diesel Sweeper. Replacing ten (10) older diesel vehicles with new CNG sweepers will reduce annual NOx, PM, and HC emissions by 4,197 kg, 279 kg, and 471 kg respectively. Additionally, the project will conservatively contribute to an over 9 percent reduction of GHG emissions per year.

The project is also achieving a significant economic benefit for the City. In fuel costs alone, by utilizing the City Yard upgraded station instead of paying retail prices at other CNG stations, the City estimates it is saving over $13,000 each month. Eliminating the need for City staff to drive for 60 to 90 minutes to reach an alternative CNG fueling station is also saving the City a substantial sum in staff time costs as well. As promised this project also alleviates pressure from the surrounding CNG Fueiling infrastructure supporting the MSRC grant's intent.

The City completed the project on time and within budget, and encountered no significant problems during construction. The City will continue to monitor the success of this project in order to support the estimated reduction in GHG emissions and its reliance on petroleum, and improve air quality within the state of California.

Figure 5. Photographs of the Upgraded CNG Fueling Station

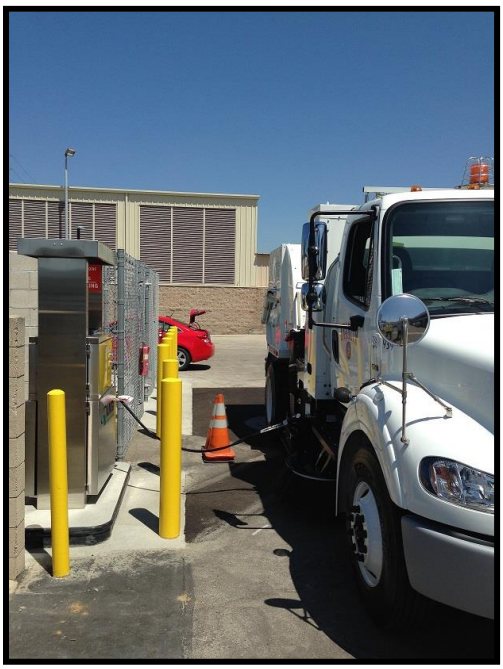


Figure 5 (continued)

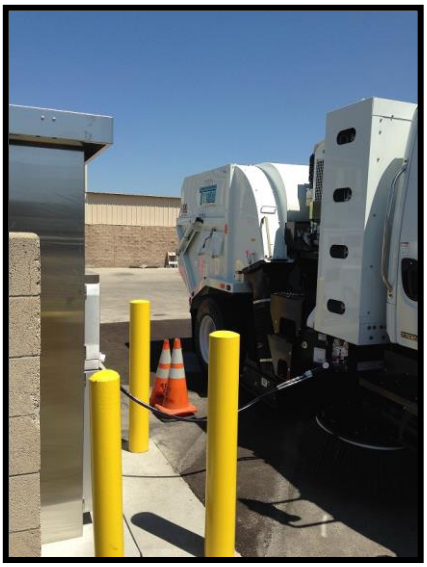


Figure 6. Results of Upgrade to the City of Anaheim's CNG Fueling Station

Average Number of Vehicles Fueled per Day	60 vehicles
Number of Fleet Vehicle Transactions per Day	Currently 27 transactions
Number of Public Vehicle Transactions per day	0 vehicles
Number of Hours that Station was Inoperative (during normal operation hours, since August 2014)	24 hours
Maximum Monthly Capacity of New Fueling Station	31,500 GGE
Electricity Required to Power Compression Equipment	3 phase 480
Gallons of Gasoline or Diesel Fuel Displaced by Using Natural Gas (with Associated Mileage Information)	660 gallons daily 3,360 miles daily
Air Emissions Reductions (Estimated Annual Metric Tons of Emissions Reduced using CNG vs. Diesel)*	
- Carbon Monoxide	1.56
- Oxides of Nitrogen	3.48
- Particulate Matter	0.24
Duty Cycle of Current Fleet	12 Years
Expected Duty Cycle of Future Vehicles	15 Years
Source of the Alternative Fuel	Sempra
Fuel Cost Savings by using City Yard Station over Retail CNG prices (per month)	$13,376
Estimate of the Project's Carbon Intensity Values for Life-Cycle GHG Emissions	>9%

* Source: United States Environmental Protectional Agency, "Average In-Use Emmissions from Heavy Duty Trucks," Office of Transportation and Air Quality, EPA130-F-08-027, October 2008. And, United States Department of Energy, "Natural Gas: Heavy-Duty Emission Testing," National Renewable Enegery laboratory, NREL/FS-540-33280, June 2003.

CHAPTER 4:
Conclusions

The City of Anaheim is dedicated to reducing GHG emissions caused by its fleet and improving air quality throughout Orange County. The completion of the upgrade at the City's existing CNG fueling station ensures that the City has the capacity to meet the needs of its current CNG powered fleet, as well as the projected growth of its fleet over the next five years. The investment of $380,000 by MSRC in this important project provided the City with the capital it needed to complete this critical upgrade. Without it, the City's acquisition of additional CNG vehicles would likely have languished, due to the clear lack of capacity to fuel these vehicles economically. An upgraded CNG station now allows the City of Anaheim to operate its fleet with self-sufficiency, contribute to GHG emission reductions, and realize cost savings for the City and its residents.

APPENDIX A:

Acronyms

Alternative and Renewable Fuels and Vehicle Technology Program (ARFVTP)

American Gas Association (AGA)

American Petroleum Institute (API)

American Society for Mechanical Engineers (ASME)

American Society for Testing and Materials (ASTM)

California Code of Regulations (CCR)

Mobile Source Air Pollution Review Committee (MSRC)

California Environmental Quality Act (CEQA)

Commission Agreement Manager (CAM)

Compressed Natural Gas (CNG)

Gasoline Gallon Equivalent (GGE)

Greenhouse gas (GHG)

Horsepower (HP)

International Society of Automation (ISA)

National Electric Code (NEC)

National Fire Protection Association (NFPA)

Nitrogen Oxides (NOx)

Particulate Matter (PM)

Pounds per Square Inch (psi)

Standard Cubic Feet per Minute (SCFM)

United States Environmental Protection Agency (U.S. EPA)