CALIFORNIA ENERGY COMMISSION

California Energy Commission

Clean Transportation Program

FINAL PROJECT REPORT

Exeter Unified School District Compressed Natural Gas Filling System

Prepared for: California Energy Commission

Prepared by: Exeter Unified School District

Gavin Newsom, Governor

January 2020 | CEC-600-2020-026

California Energy Commission

Tim A. Hire
George Eddy
Primary Authors

Exeter Unified School District
215 N. Crespi Avenue
Exeter, California 93221
(559) 592-9421
Exeter Unified School District Website www.exeter.k12.ca.us

Agreement Number: ARV-16-009

Eric VanWinkle
Project Manager

Elizabeth John
Office Manager
ADVANCED FUELS AND VEHICLE TECHNOLOGIES OFFICE

Kevin Barker
Deputy Director
FUELS AND TRANSPORTATION

Drew Bohan
Executive Director

ACKNOWLEDGEMENTS

Special thank you to:

- SIM/PBK, Architect
- Micham Inc., Contractor
- Revolution CNG, Contractor
- A/C Electric, Contractor
- So Cal Gas
- Gabe Espinola – Exeter Unified School District Project Manager
- Exeter Unified School District Support Staff

PREFACE

Assembly Bill 118 (Núñez, Chapter 750, Statutes of 2007) created the Clean Transportation Program, formerly known as the Alternative and Renewable Fuel and Vehicle Technology Program. The statute authorizes the California Energy Commission (CEC) to develop and deploy alternative and renewable fuels and advanced transportation technologies to help attain the state's climate change policies. Assembly Bill 8 (Perea, Chapter 401, Statutes of 2013) reauthorizes the Clean Transportation Program through January 1, 2024, and specifies that the CEC allocate up to $20 million per year (or up to 20 percent of each fiscal year's funds) in funding for hydrogen station development until at least 100 stations are operational.

The Clean Transportation Program has an annual budget of about $100 million and provides financial support for projects that:

- Reduce California's use and dependence on petroleum transportation fuels and increase the use of alternative and renewable fuels and advanced vehicle technologies.
- Produce sustainable alternative and renewable low-carbon fuels in California.
- Expand alternative fueling infrastructure and fueling stations.
- Improve the efficiency, performance and market viability of alternative light-, medium-, and heavy-duty vehicle technologies.
- Retrofit medium- and heavy-duty on-road and nonroad vehicle fleets to alternative technologies or fuel use.
- Expand the alternative fueling infrastructure available to existing fleets, public transit, and transportation corridors.
- Establish workforce-training programs and conduct public outreach on the benefits of alternative transportation fuels and vehicle technologies.

To be eligible for funding under the Clean Transportation Program, a project must be consistent with the CEC's annual Clean Transportation Program Investment Plan Update. The CEC issued GFO-16-602 to establish or expand infrastructure necessary to store, distribute and dispense compressed natural gas for use in natural gas vehicle. In response to GFO-16-602, the recipient submitted an application which was proposed for funding in the CEC's Notice of Proposed Awards posted December 20, 2016 and the agreement was executed as ARV-16-009 on February 28, 2017.

ABSTRACT

This paper describes the process for design and construction of a compressed natural gas filling system for the Exeter Unified School District. It further details the resulting use of compressed natural gas buses as a way to reduce cost and provide better air quality in the Central San Joaquin Valley.

Keywords: California Energy Commission, Exeter Unified School District, Alternative and Renewable Fuel and Vehicle Technologies Program, Clean Transportation Program, natural gas fueling station, compressed natural gas

Please use the following citation for this report:

Author(s) Hire, Tim A., George Eddy, SIM/PBK, Architect, Micham Inc., Revolution CNG, A/C Electric, Southern CA Gas. 2020. *Exeter Unified School District Compressed Natural Gas Filling System*. California Energy Commission. Publication Number: CEC-600-2020-026.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

Page

EXECUTIVE SUMMARY

The Exeter Unified School District was fueling its existing fleet of five compressed natural gas buses at either the City of Exeter's compressed natural gas filling station or a compressed natural gas fueling station in a neighboring community. Both stations utilized had limited time availability and fueling capacity that allowed only a 40 percent to 60 percent of capacity fill, and required considerable Exeter Unified School District staff resources and time to daily refuel at these off-site locations. This arrangement was inefficient and prevented maximum use of the compressed natural gas powered buses.

To remedy this inefficient arrangement, Exeter Unified School District applied for and was awarded an CEC grant to supplement district funds to build an on-site (within the Transportation Department yard) compressed natural gas refueling station consisting of eight slow-fill stations and two fast-fill stations and all necessary equipment for operating and maintaining the new facility. The new facility design accommodates projected future compressed natural gas refueling capacity needs as the compressed natural gas bus fleet expands when replacing current diesel fuel powered buses.

The completed project has accomplished the goals outlined in the original grant proposal of providing the most efficient, effective use of the compressed natural gas bus fleet, and minimizing harmful emissions through reduced use of diesel fuel powered buses. Data collected during the initial three months of operation showed the miles driven by the five compressed natural gas buses was reduced by 7,500 miles due to having a compressed natural gas fueling station on-site at Exeter Unified School District's transportation yard versus driving off-site to fuel the buses at stations located in Exeter and/or neighboring towns. Overnight slow-fill refueling of the buses resulted in near full capacity fills, and combined with on-site fast-fill capabilities to top-off quickly when necessary during daytime usage, permitted increased and more efficient use of the compressed natural gas bus fleet and less use of Exeter Unified School District diesel fuel powered buses. This resulted in approximately $44,900 savings in just the initial three months of operation as well as additional staff time redirected to provide needed services to district students and to further district goals.

CHAPTER 1:
Objective and Goal of this Project

Objective

The objective of this grant was to assist Exeter Unified School District (EUSD) in the design, acquisition and installation of a Compressed Natural Gas (CNG) fueling facility to efficiently operate the current fleet of five CNG powered buses and provide fuel for a future expanded CNG bus fleet as EUSD replaces current diesel-powered buses.

Goal

The goal of this project was to construct a CNG fueling facility as seen in Figure 1, consisting of eight slow-fill stations and two fast-fill stations. Located within EUSD's transportation yard, the new CNG fueling facility would enable reliable and timely CNG fueling for the current fleet of five CNG powered buses that need daily refueling to provide transportation for students, and reduce EUSD's staff resources/time currently required for off-site fueling in Exeter or a neighboring community.

Figure 1: Construction of Fueling Stations

Source: EUSD

The fueling facility also has the ability to expand as the CNG bus fleet grows as EUSD replaces current diesel-powered buses, resulting in increased efficiency of staff time, better use of district resources, increased CNG bus use, and reduced harmful emissions by reducing/eliminating the use of diesel engine buses.

Chapter 2:
Project Summary

Project Summary

EUSD partnered with SIM/PBK Architect, and Lozano-Smith, Attorneys at Law, to solicit proposals for the CNG filling system as part of a larger project to replace the asphalt transportation yard with concrete as shown during construction in Figure 2; upgrade the overall electrical service to the yard; and construct a shade structure for bus parking including a solar power generation system as shown in Figure 3.

Figure 2: Concrete Upgrade

Source: EUSD

Figure 3: Upgraded Shade and Electrical

Source: EUSD

Due to the anticipated energy savings from the solar power generation system, EUSD was able to use Government Code Section 4217 for the Request for Proposal process. This code allowed

a faster and more streamlined approach to develop the end contract with the contractors who ultimately would perform the work. The process was shortened from nearly a four-month to a two-month process because it eliminated the lengthy formal bid process and allowed qualified contractors to provide a proposal that could then be negotiated by EUSD.

Specifically addressing the CNG portion of the project, EUSD found that the most important portion of the design phase was sizing and designing the system to meet current needs and anticipated future needs. Other issues that affected this included utilization of space and constructability within the scope of the larger project. CNG equipment and system operations were at the heart of the project team's most intense conversations. EUSD's proposal, the engineer, and the CNG contractor had differing opinions about the overall design of the system as specified in the grant application. The engineer designed the plans to meet the grant proposal while the CNG contractor felt the system was significantly over-designed. After several reviews and consultation with the CEC Project Manager, the project team was able to agree on the design and move forward with project.

The first phase of the project was to order the CNG equipment and upgrade the electrical and gas service to the facility as shown in Figure 4. There was significant lead-time to acquire the equipment from A-C Electric, located in Fresno, CA, because manufacturing initiated only after the purchase order was generated and submitted. The lead-time for the major equipment was approximately twelve weeks. In the meantime, EUSD worked with Southern California Edison to upgrade the main electrical service to the transportation yard from 3-phase 120/240 volts to 3-phase 480 volts to accommodate the increase in electrical use and to provide a more efficient power source to operate the motors in the CNG system. Southern California Gas Company has requirements - as explained below - and was integral in setting up the correct gas service.

Figure 4: Upgraded Electrical Service

Source: EUSD

Southern California Gas Company required the installation of a new gas meter and upgraded main line to match the increased volume and to separate the CNG for fueling purposes from other uses within the Transportation Department facility.

The second phase of the project was construction of the walls surrounding the equipment and CNG storage vessels as shown in Figure 5; the installation of two new gas meters and the required manifold system including protective bollards; and placement of the appropriate conduits, pipes and wiring for the electrical, gas and data systems. These items were completed while another crew poured concrete and constructed the parking structure.

Figure 5: Concrete Wall Surrounding Equipment

Source: EUSD

As the equipment arrived and was put in place, connections were made and the system began to take shape but one significant final design error quickly became apparent - the filling hoses were too short to reach the filling locations on the buses. This caused the engineer and the CNG Contractor to revise the delivery system and reroute the service overhead by attaching the CNG pipe to the main beams of the parking structure. The filling hoses then were attached to a pulley and stored via a bracket mounted on a free-standing pole or to the pillars of the structure as shown in Figure 6. In all actuality, the delivery of the CNG via an overhead system was EUSD's preferred method during the design phase but that idea was not recommended by the engineer due to the proximity of the electricity for the lights.

Figure 6: Filling Hose Attached to Pillar

Source: EUSD

The final phase of construction included connecting the electricity, double-checking all the fittings and connections, performing a test run of the mechanical portion of the system, conducting an extensive system pressure test, and comprehensive staff training for safe operation of the fueling system. The system is pressurized to 4000 psi and could cause significant damage and loss if the system were to fail or be operated in an unsafe manner. Therefore, staff training was essential. As a result of a few small adjustments to the overall system, it is now filling busses to maximum capacity overnight as shown in Figure 7 and the

fast fill is meeting CNG refueling needs for buses used for extracurricular activities and events on busy days.

Figure 7: Bus Connected to Slow Fill Station

Source: EUSD

Chapter 3:
Project Results

Results

EUSD's opinion, based on the completed station installation as shown in Figure 8, and the data already collected, is that this project was a total success. EUSD now has an on-site, reliably functioning CNG filling system that has the capacity to fuel eight busses at once using the slow-fill portion. It has two fully functioning fast-fill hoses that are topping off EUSD's buses when the need arises. During the last quarter of the year, October – November 2018, which was also when the system became fully functional, EUSD saw a decrease in the number of miles driven in the five CNG buses by over 7,400 miles due to fueling in EUSD's own transportation yard versus driving to the neighboring town to fuel the CNG busses (see Appendix A, tables A-1 through A-3 for CNG dispensed data). At a cost of approximately $6.00 per mile, this reduction has resulted in an approximate savings of $44,900 in just three months. The additional time and money saved by the installation of this system has increased the time staff has available to provide EUSD other needed services to EUSD's students and additional revenue that can be used to further EUSD's goals.

Figure 8: Completed Overhang Project

Source: EUSD

EUSD will monitor the usage of the CNG busses beyond the three-month data collection requirement. Because of the convenience and reliability of the on-site fueling facility, EUSD is increasing opportunities for student participation in off-site events that require bus transportation; and is using CNG buses instead of diesel fuel powered buses whenever possible. As CNG bus fleet use increases, replacing EUSD's older diesel fuel powered buses, a larger longitudinal database of CNG bus usage (miles driven, fuel consumed, diesel fuel avoided, etc.) will be analyzed to provide a clear determination of the reduced degree of environmental impact this system has made in Exeter and the surrounding area.

Chapter 4:
Lessons Learned

Key Points to Consider

Work with an engineering firm that has prior experience designing an efficient and effective CNG system. The sizing and design of the system is key to use resources effectively and avoid overbuilding.

Working with the electricity and gas providers is essential. These entities need to be involved early because of the lead-time to provide the service that meets the project and utility company's requirements.

CNG contractors are limited. It is imperative that the general contractor or construction manager be diligent about deadlines, inspections, and meeting the owner's expectations for the project. Discuss ongoing maintenance and periodical checks of the system as part of the initial agreement.

GLOSSARY

CALIFORNIA ENERGY COMMISSION (CEC) - The state agency established by the Warren-Alquist State Energy Resources Conservation and Development Act in 1974 (Public Resources Code, Sections 25000 et seq.) responsible for energy policy. The Energy Commission's five major areas of responsibilities are:

- Forecasting future statewide energy needs
- Licensing power plants sufficient to meet those needs
- Promoting energy conservation and efficiency measures
- Developing renewable and alternative energy resources, including providing assistance to develop clean transportation fuels
- Planning for and directing state response to energy emergencies.

COMPRESSED NATURAL GAS (CNG) - Natural gas that has been compressed under high pressure, typically between 2,000 and 3,600 pounds per square inch, held in a container. The gas expands when released for use as a fuel.

EXETER UNIFIED SCHOOL DISTRICT (EUSD) - Exeter Unified School District serves students in grades K-12 in Tulare County.[1]

1 Exeter Unified School District Website https://www.exeter.k12.ca.us/

Appendix A:
District CNG Dispensed 2017 vs. 2018

Daily bus CNG usage during fourth quarter 2017

Table A-1: Fourth Quarter 2017 Raw CNG Fill Data for Each Bus

Bus 13	Bus 13	Bus 13	Bus 14	Bus 14	Bus 14	Bus 15	Bus 15	Bus 15	Bus 16	Bus 16	Bus 16	Bus 20	Bus 20	Bus 20
Oct	Nov	Dec	Oct	Nov	Dec	Oct	Nov	Dec	Oct	Nov	Dec	Oct	Nov	Dec
13.756	17.967	21.395	42.323	40.932	17.032	29.876	19.143	22.414	22.876	16.99	45.22	21.31		20.954
17.146	22.896	29.186	23.606	21.097	40.316	18.711	20.795	17.004	18.201	12.953	32.36	20.634		14.114
40.506	14.42	25.861	25.941	12.322	17.968	17.044	16.685	17.44	15.526	11.294	17.461	16.232		17.895
33.852	16.614	8.494	17.992	11.24	20.174	19.953	16.716	23.224	17.264	25.701	22.707	17.428		16.253
11.84	15.393	24.837	13.888	9.725	38.609	25.91	25.48	25.164	11.78	23.102	27.979	30.41		23.252
16.47	18.428	39.152	20.934	24.759	15.618	18.543	26.969	18.033	15.644	26.096	20.268	8.926		18.218
18.423	16.113	11.768	11.794	17.698	19.465	16.134	20.573	28.461	16.626	17.828	23.692	11.08		17.038
10.167	12.43	18.103	11.336	27.388	33.691	19.382	26.788	16.898	15.961	18.331	25.299	11.664		14.884
14.501	13.21	17.193	20.96	16.232	25.385	19.735	17.742	16.113	14.352	10.584	32.487	11.862		18.625
19.573	11.355	25.627	15.912	14.643	19.297	15.376	18.247		10.568	25.159	31.082	9.13		
17.326	24.552	20.378	16.563	17.845	21.936	19.33	21.913		5.184	12.439		19.485		
19.75	13.389	10.498	19.362	30.155	14.285	13.707	18.612		14.113	24.108		6.747		
11.718	14.666	17.395	17.176	15.004	21.956	21.024	20.945		18.694					
14.999	20.691	9.766	32.922	19.856	14.333	12.457			21.089					
19.232	19.886		22.385	20.613		16.432			21.118					
18.732	6.93		23.499	38.148		13.482								
17.433	12.941		22.52	16.707		19.438								
	21.184			20.727										
				27.774										
376.826	366.08	349.33	448.58	503.236	399.81	395.395	338.03	230.78	298.54	280.538	347.96	230.976		201.403

Source: EUSD

Note: Table A-1 shows 4th Quarter 2017 daily bus CNG fill data from refueling each bus individually at various nearby CNG fueling stations. After installation of the new station in the EUSD Transportation Department yard, where one gas meter was installed for the entire station, EUSD receives one monthly bill from Southern California Gas Company for all CNG dispensed (in therms) for all buses which cannot be broken down daily or by individual bus. Tables A-2 and A-3 show summaries of monthly CNG dispensed in therms and converted to gasoline gallon equivalents.

Fuel usage summary of Exeter Buses before and after CNG Station Installation

Table A-2: Fourth Quarter 2017 Fuel Dispensed

					Therms	GGE
GRAND	TOTAL	OCT			1750.3	1381.78
GRAND	TOTAL	NOV			1487.9	1174.63
GRAND	TOTAL	DEC			1529.3	1207.31
TOTAL	**4th**	**QTR**	**2017**	GGE Dispensed		**3763.7**

Source: EUSD

Table A-3: Fourth Quarter 2018 Fuel Dispensed

					Therms	GGE
GRAND	TOTAL	OCT			1641	1295.5
GRAND	TOTAL	NOV			858	677.35
GRAND	TOTAL	DEC			1028	811.56
TOTAL	**4th**	**QTR**	**2018**	GGE Dispensed		**2784.4**

Source: EUSD

Appendix B:
Photographs of Major Equipment

Figure B-1: Bauer CNG Compressor Package and CP Industries CNG Storage Vessels

Source: EUSD

Figure B-2: Bauer CNG Compressor

Source: EUSD

Figure B-3: Bauer CNG Compressor Package Serial Number 204526

Source: EUSD

Figure B-4: Bauer CNG Compressor Package

Source: EUSD

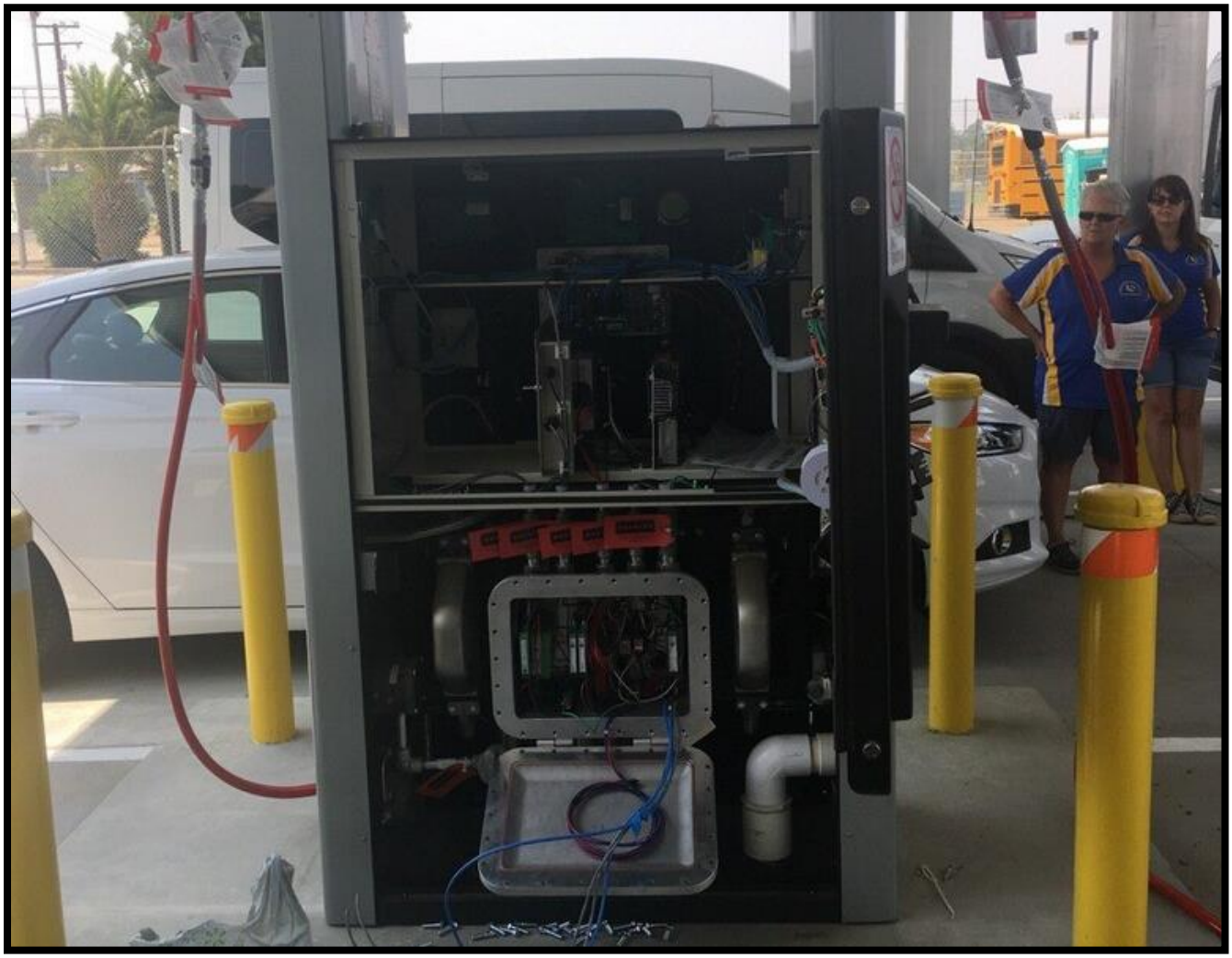
Figure B-5: CP Industries CNG Storage Vessels

Source: EUSD

Figure B-6: Krauss Fast Fill Dispenser

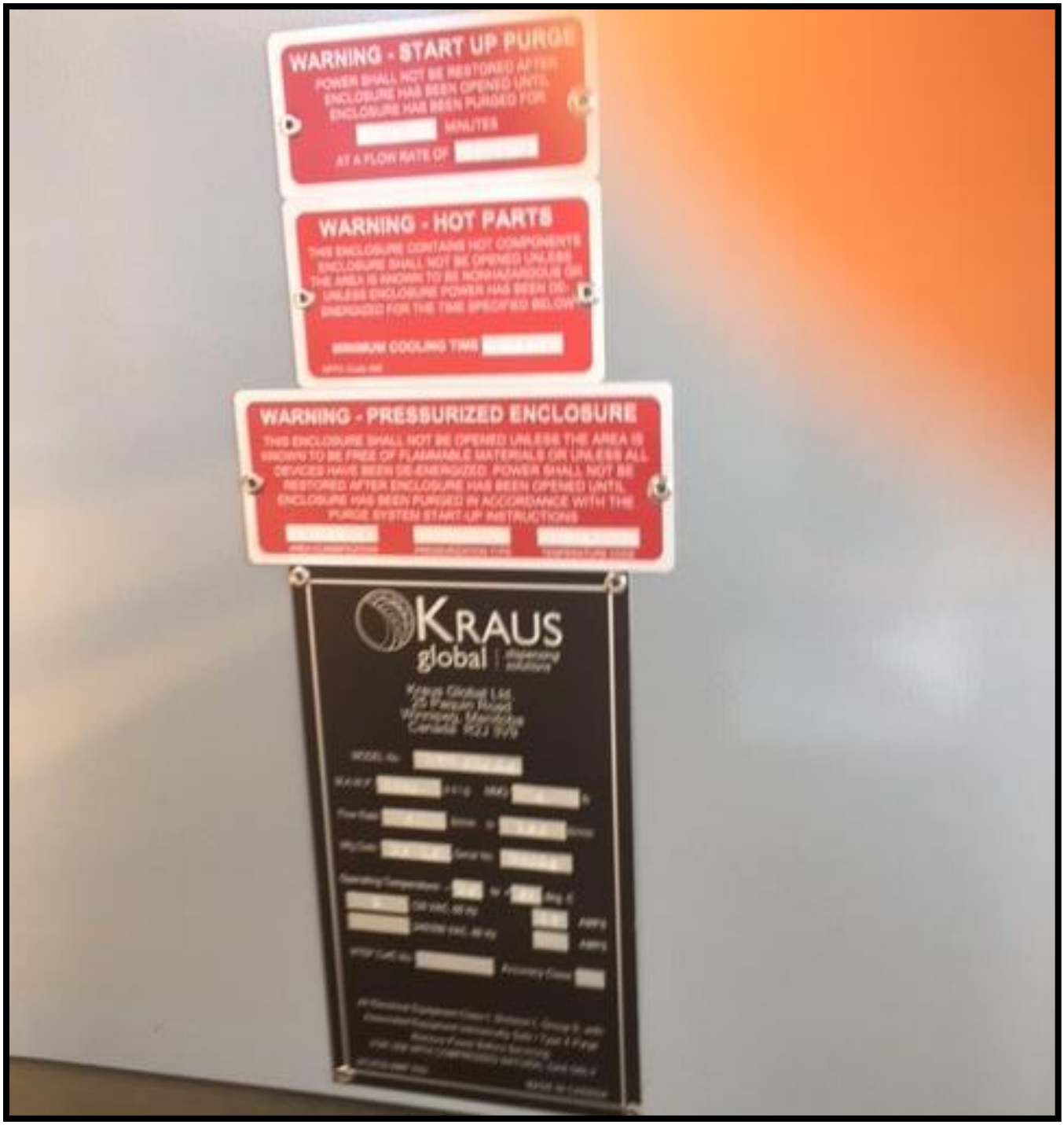
Source: EUSD

Figure B-7: Krauss Fast Fill Dispenser



Source: EUSD

Figure B-8: Krauss Fast Fill Dispenser Serial Number R0008



Source: EUSD

Figure B-9: Krauss Fast Fill Dispenser

Source: EUSD

Figure B-10: Broadlux/Com Data Fuel Management System

Source: EUSD

Figure B-11: Broadlux/Com Data Fuel Management System

Source: EUSD