Hydrogen Fuel Cell Engines and Related Technologies

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Jack Dempsey, Director
jdempsey@dccd.cc.ca.us
(760) 773-2596

Course Preparation

Principal Author:

- Andre Lanz, P. Eng., WriteRight Technical Communications, Vancouver, BC, Canada

  Andre Lanz is a mechanical engineer with a specialty in fuel cell systems and the hydrogen economy. He has many years' experience designing and documenting fuel cell systems for Ballard Power Systems, XCELLSiS Fuel Cell Engines and other fuel cell related companies.

Contributing Authors:

- James Heffel, Principal Research Engineer, Advanced Vehicle Engineering, University of California Center for Environmental Research and Technology (CE-CERT), Riverside, CA, USA

  James Heffel is a mechanical engineer and MBA with many years' experience providing testing and engineering support to both the aerospace and alternative energy industries. His interest in hydrogen as a propulsive fuel for surface transportation have led to numerous technical publications and two pending patents.

- Colin Messer, Alternative Fuels Project Instructor, College of the Desert – Energy Technology Training Center, Palm Desert, CA, USA

  Colin Messer has a B.A. in Professional Writing from the University of New Mexico and 18 years of experience working as an instructor and consultant in the gaseous fuels industry. He has served as the principal author for several compressed natural gas manuals published by College of the Desert and the National Alternative Fuels Training Consortium at West Virginia University.

Review Team Members:

- Andre Lanz — WriteRight Technical Communications
- Bill Clapper — SunLine Transit
- Byron Anderson — City College of San Francisco
- Colin Messer — College of the Desert
- Douglas Byrne — A.C. Transit
- Henry Bustillo — A.C. Transit
- Jack Dempsey — Energy Technology
- James Heffel — University of California Riverside CE-CERT
- John Williams — SunLine Transit
- Keith Adams — College of the Desert
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College of the Desert in Palm Desert, CA, is a two-year California State community college with an enrollment of approximately 8,400 students per semester. Associate degrees and certificate programs are offered in over 70 areas of study. The Energy Technology Training Center at College of the Desert was formed in 1993 and is recognized nationally as one of the leading sources of information, training and curriculum development in the area of advanced transportation technologies. ETTC is the lead college in the California Advanced Transportation Technology Initiative and has been designated as National Training Center for alternative fuels/clean energy.

SunLine Transit Agency in Thousand Palms, CA, is an internationally respected leader and advocate of clean fuels and clean energy. In 1994, SunLine became the first public transit agency in the country to park all its diesel buses and switch overnight to a fleet powered 100% by compressed natural gas. The conversion, though extremely successful, was always deemed an interim step toward a zero-emission future powered by hydrogen fuel cells. In April 2000, SunLine opened the world's first hydrogen generation, storage and dispensing facility built by a transit agency where hydrogen is generated from renewable solar power and reformed from natural gas. SunLine has more than a year's experience operating fuel cell and blended fuel vehicles (hydrogen and natural gas) and as an Associate Member of the California Fuel Cell Partnership, looks toward a gradual replacement of its fleet with fuel cell buses.

XCELLSiS Fuel Cell Engines, Inc., in Burnaby, BC, Canada, is a joint venture between Daimler-Chrysler, the Ford Motor Company and Ballard Power Systems that specializes in the design of fuel cell engines for use in heavy, medium and light duty transportation applications. The XCELLSiS Phase 5 fuel cell bus is the first production fuel cell bus in the world.

Ballard Power Systems, Inc., in Burnaby, BC, Canada, is the world leader in proton exchange membrane fuel cell technology. Ballard fuel cells have been used in fuel cell engines, stationary powerplants, submarines, portable power sources, robotics and other applications around the world.

AC Transit in Oakland, CA, is the public bus system serving the thirteen cities and adjacent unincorporated communities in 390 square miles along the eastern shores of San Francisco and San Pablo Bays. AC Transit has 230,000 daily riders and a fleet of 800 buses that run over 25 million annual revenue service miles. In 1999, AC Transit started road testing a hybrid electric bus.

The Santa Clara Valley Transportation Authority (VTA) in San Jose, CA, is an independent special district responsible for bus, light rail and paratransit operations, congestion management, specific highway improvement projects, and countywide transportation planning. The VTA is a member of the California Fuel Cell Partnership (CaFCP), with plans to test zero-emission buses starting in 2003.

WriteRight Technical Communications in Vancouver, BC, Canada, is an independent technical communication business specializing in engineering documentation.

INTRODUCTION

The Advanced Transportation Technology Initiative [ATT], with centers throughout California, provides leadership, guidance and coordination in the development of curricula and technical training programs related to alternative fueled vehicles and other emerging transportation technologies. ATT initiative programs result in consistent, replicable curricula, services and programs tailored to unique regional needs while training technicians to meet the challenges of tomorrow's rapidly developing, technologically driven transportation technologies.

National Automotive Center (NAC), in Detroit, Michigan, is the Nation's unique laboratory for the development and execution of collaborative research to achieve military ground – vehicle superiority for the U.S. Army. The NAC identifies dual needs of the Department of Defense and the commercial automotive sector and then initiates joint government, industry and academic programs to develop and insert new technology into current and future fleets of military vehicles.

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Scope

This course covers hydrogen properties, use and safety, fuel cell technology and its systems, fuel cell engine design and safety, and design and maintenance of a heavy duty fuel cell bus engine. The different types of fuel cells and hybrid electric vehicles are presented, however, the system descriptions and maintenance procedures focus on proton-exchange-membrane (PEM) fuel cells with respect to heavy duty transit applications. The PEM fuel cell engine was chosen as it is the most promising for automotive applications, and its transit application is currently the most advanced.

Specific fuel cell system descriptions and their maintenance is based on the Phase 3 and 4 fuel cell buses designed and built by XCELLSiS Fuel Cell Engines, Inc. This information represents the most complete description of fuel cell bus maintenance currently available, although it cannot cover all hardware configurations and variations or anticipate future developments.

Fuel cell technology is proprietary to those organizations developing it, and subject to patents, confidentiality agreements and copyright. Consequently, the details of fuel cell stack design, their construction methods and fuel cell engine control systems cannot be presented in detail.

The various methods of procuring, storing and transporting hydrogen are presented, but the practical material only covers hydrogen stored on a vehicle as a high-pressure gas. This course does *not* include hydrogen produced by means of an on-board reformer, or stored as a cryogenic liquid on a vehicle.

This course is part of an emerging curriculum under development by the College of the Desert in support of a "Tech Prep Associate Degree" in Advanced Transportation Technologies. This program starts at the high school level with basic automotive technologies and progresses through a rigorous program that includes instruction in electronics, engine performance, alternative fuels and advanced power train technologies. This manual is one of the primary reference books for the study of renewable energies and the use of hydrogen as a fuel for transportation purposes.

Completion of this course does *not* qualify the student for high-pressure cylinder certification or for any other form of high-pressure gas certification. The College of the Desert offers the following related courses pertaining to CNG high-pressure gas training and cylinder safety and certification training:

- CNG Cylinder Safety and Certification Course (12 Hour Course)
- Medium & Heavy-Duty Gaseous Fuel Engines and Fuel Systems (40 Hour Course)

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