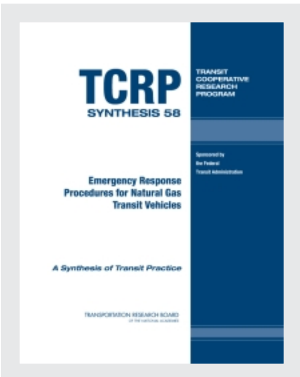


Emergency Response Procedures for Natural Gas Transit Vehicles

DETAILS

53 pages | | PAPERBACK
ISBN 978-0-309-42669-5 | DOI 10.17226/23328

AUTHORS

TRANSIT COOPERATIVE RESEARCH PROGRAM

TCRP SYNTHESIS 58

Emergency Response Procedures for Natural Gas Transit Vehicles

A Synthesis of Transit Practice

CONSULTANT

MICHAEL J. MURPHY

Battelle

Columbus, Ohio

TOPIC PANEL

JOHN CARNEY, *Paul Revere Transportation LLC*

ROBERT COLTON, *Centre Area Transportation Authority*

PETER G. DRAKE, *Peter G. Drake Consulting*

GEORGE FOYT, *Connecticut Academy of Science and Engineering*

BARRY J. GOLDMAN, *Washington Metropolitan Area Transit Authority*

JEFFREY G. MORA, *Jeff G. Mora Consulting*

PETER SHAW, *Transportation Research Board*

STEPHEN M. STARK, *New York City Transit Authority*

GENE WALKER, *Golden Gate Transit*

LURAE STUART, *Federal Transit Administration* (Liaison)

SUBJECT AREAS

Public Transit

Research Sponsored by the Federal Transit Administration in Cooperation with the Transit Development Corporation

TRANSPORTATION RESEARCH BOARD

WASHINGTON, D.C.

2005

www.TRB.org

The nation's growth and the need to meet mobility, environmental, and energy objectives place demands on public transit systems. Current systems, some of which are old and in need of upgrading, must expand service area, increase service frequency, and improve efficiency to serve these demands. Research is necessary to solve operating problems, to adapt appropriate new technologies from other industries, and to introduce innovations into the transit industry. The Transit Cooperative Research Program (TCRP) serves as one of the principal means by which the transit industry can develop innovative near-term solutions to meet demands placed on it.

The need for TCRP was originally identified in *TRB Special Report 213—Research for Public Transit: New Directions,* published in 1987 and based on a study sponsored by the Federal Transit Administration (FTA). A report by the American Public Transportation Association (APTA), *Transportation 2000*, also recognized the need for local, problem-solving research. TCRP, modeled after the longstanding and successful National Cooperative Highway Research Program, undertakes research and other technical activities in response to the needs of transit service providers. The scope of TCRP includes a variety of transit research fields including planning, service configuration, equipment, facilities, operations, human resources, maintenance, policy, and administrative practices.

TCRP was established under FTA sponsorship in July 1992. Proposed by the U.S. Department of Transportation, TCRP was authorized as part of the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA). On May 13, 1992, a memorandum agreement outlining TCRP operating procedures was executed by the three cooperating organizations: FTA, the National Academy of Sciences, acting through the Transportation Research Board (TRB); and the Transit Development Corporation, Inc. (TDC), a nonprofit educational and research organization established by APTA. TDC is responsible for forming the independent governing board, designated as the TCRP Oversight and Project Selection (TOPS) Committee.

Research problem statements for TCRP are solicited periodically but may be submitted to TRB by anyone at any time. It is the responsibility of the TOPS Committee to formulate the research program by identifying the highest priority projects. As part of the evaluation, the TOPS Committee defines funding levels and expected products.

Once selected, each project is assigned to an expert panel, appointed by TRB. The panels prepare project statements (requests for proposals), select contractors, and provide technical guidance and counsel throughout the life of the project. The process for developing research problem statements and selecting research agencies has been used by TRB in managing cooperative research programs since 1962. As in other TRB activities, TCRP project panels serve voluntarily without compensation.

Because research cannot have the desired impact if products fail to reach the intended audience, special emphasis is placed on disseminating TCRP results to the intended end users of the research: transit agencies, service providers, and suppliers. TRB provides a series of research reports, syntheses of transit practice, and other supporting material developed by TCRP research. APTA will arrange for workshops, training aids, field visits, and other activities to ensure that results are implemented by urban and rural transit industry practitioners.

The TCRP provides a forum where transit agencies can cooperatively address common operational problems. The TCRP results support and complement other ongoing transit research and training programs.

TCRP SYNTHESIS 58

Project J-7, Topic SC-07
ISSN 1073-4880
ISBN 0-309-07024-2
Library of Congress Control Number 20045920331

Price $15.00

NOTICE

The project that is the subject of this report was a part of the Transit Cooperative Research Program conducted by the Transportation Research Board with the approval of the Governing Board of the National Research Council. Such approval reflects the Governing Board's judgment that the project concerned is appropriate with respect to both the purposes and resources of the National Research Council.

The members of the technical advisory panel selected to monitor this project and to review this report were chosen for recognized scholarly competence and with due consideration for the balance of disciplines appropriate to the project. The opinions and conclusions expressed or implied are those of the research agency that performed the research, and while they have been accepted as appropriate by the technical panel, they are not necessarily those of the Transportation Research Board, the Transit Development Corporation, the National Research Council, or the Federal Transit Administration of the U.S. Department of Transportation.

Each report is reviewed and accepted for publication by the technical panel according to procedures established and monitored by the Transportation Research Board Executive Committee and the Governing Board of the National Research Council.

Special Notice

The Transportation Research Board of The National Academies, the Transit Development Corporation, the National Research Council, and the Federal Transit Administration (sponsor of the Transit Cooperative Research Program) do not endorse products or manufacturers. Trade or manufacturers' names appear herein solely because they are considered essential to the clarity and completeness of the project reporting.

Published reports of the

TRANSIT COOPERATIVE RESEARCH PROGRAM

are available from:

Transportation Research Board
Business Office
500 Fifth Street, NW
Washington, DC 20001

and can be ordered through the Internet at
http://www.national-academies.org/trb/bookstore

Printed in the United States of America

THE NATIONAL ACADEMIES

Advisers to the Nation on Science, Engineering, and Medicine

The **National Academy of Sciences** is a private, nonprofit, self-perpetuating society of distinguished scholars engaged in scientific and engineering research, dedicated to the furtherance of science and technology and to their use for the general welfare. On the authority of the charter granted to it by the Congress in 1863, the Academy has a mandate that requires it to advise the federal government on scientific and technical matters. Dr. Bruce M. Alberts is president of the National Academy of Sciences.

The **National Academy of Engineering** was established in 1964, under the charter of the National Academy of Sciences, as a parallel organization of outstanding engineers. It is autonomous in its administration and in the selection of its members, sharing with the National Academy of Sciences the responsibility for advising the federal government. The National Academy of Engineering also sponsors engineering programs aimed at meeting national needs, encourages education and research, and recognizes the superior achievements of engineers. Dr. William A. Wulf is president of the National Academy of Engineering.

The **Institute of Medicine** was established in 1970 by the National Academy of Sciences to secure the services of eminent members of appropriate professions in the examination of policy matters pertaining to the health of the public. The Institute acts under the responsibility given to the National Academy of Sciences by its congressional charter to be an adviser to the federal government and, on its own initiative, to identify issues of medical care, research, and education. Dr. Harvey V. Fineberg is president of the Institute of Medicine.

The **National Research Council** was organized by the National Academy of Sciences in 1916 to associate the broad community of science and technology with the Academy's purposes of furthering knowledge and advising the federal government. Functioning in accordance with general policies determined by the Academy, the Council has become the principal operating agency of both the National Academy of Sciences and the National Academy of Engineering in providing services to the government, the public, and the scientific and engineering communities. The Council is administered jointly by both the Academies and the Institute of Medicine. Dr. Bruce M. Alberts and Dr. William A. Wulf are chair and vice chair, respectively, of the National Research Council.

The **Transportation Research Board** is a division of the National Research Council, which serves the National Academy of Sciences and the National Academy of Engineering. The Board's mission is to promote innovation and progress in transportation through research. In an objective and interdisciplinary setting, the Board facilitates the sharing of information on transportation practice and policy by researchers and practitioners; stimulates research and offers research management services that promote technical excellence; provides expert advice on transportation policy and programs; and disseminates research results broadly and encourages their implementation. The Board's varied activities annually engage more than 5,000 engineers, scientists, and other transportation researchers and practitioners from the public and private sectors and academia, all of whom contribute their expertise in the public interest. The program is supported by state transportation departments, federal agencies including the component administrations of the U.S. Department of Transportation, and other organizations and individuals interested in the development of transportation. **www.TRB.org**

www.national-academies.org

TCRP COMMITTEE FOR PROJECT J-7

CHAIR
FRANK T. MARTIN
PBS&J, Tallahassee, FL

MEMBERS
DEBRA W. ALEXANDER
Capital Area Transportation Authority, Lansing, MI
DWIGHT FERRELL
The Ferrell Group, Richardson, TX
MARK W. FURHMANN
Metro Transit, Minneapolis, MN
ROBERT H. IRWIN
British Columbia Transit, Victoria, BC, Canada
PAUL J. LARROUSSE
National Transit Institute, New Brunswick, NJ
WADE LAWSON
South Jersey Transportation Authority, Atlantic City, NJ
DAVID A. LEE
Connecticut Transit, Hartford, CT
DAVID PHELPS
Consultant, Moneta, VA
HAYWARD M. SEYMORE, III
Laidlaw Transit Services, Inc., University Place, WA
PAM WARD
Ottumwa Transit Authority, Ottumwa, IA
JOEL R. WASHINGTON
Washington Metropolitan Area Transit Authority, Washington, DC

FTA LIAISON
KAREN FACEN
Federal Highway Administration

TRB LIAISON
PETER SHAW
Transportation Research Board

COOPERATIVE RESEARCH PROGRAMS STAFF
ROBERT J. REILLY, *Director, Cooperative Research Programs*
CHRISTOPHER W. JENKS, *Manager, TCRP*
EILEEN P. DELANEY, *Director of Publications*

TCRP SYNTHESIS STAFF
STEPHEN R. GODWIN, *Director for Studies and Information Services*
JON WILLIAMS, *Manager, Synthesis Studies*
DONNA L. VLASAK, *Senior Program Officer*
DON TIPPMAN, *Editor*
CHERYL Y. KEITH, *Senior Secretary*

FOREWORD

By Staff
Transportation
Research Board

Transit administrators, engineers, and researchers often face problems for which information already exists, either in documented form or as undocumented experience and practice. This information may be fragmented, scattered, and unevaluated. As a consequence, full knowledge of what has been learned about a problem may not be brought to bear on its solution. Costly research findings may go unused, valuable experience may be overlooked, and due consideration may not be given to recommended practices for solving or alleviating the problem.

There is information on nearly every subject of concern to the transit industry. Much of it derives from research or from the work of practitioners faced with problems in their day-to-day work. To provide a systematic means for assembling and evaluating such useful information and to make it available to the entire transit community, the Transit Cooperative Research Program Oversight and Project Selection (TOPS) Committee authorized the Transportation Research Board to undertake a continuing study. This study, TCRP Project J-7, "Synthesis of Information Related to Transit Problems," searches out and synthesizes useful knowledge from all available sources and prepares concise, documented reports on specific topics. Reports from this endeavor constitute a TCRP report series, *Synthesis of Transit Practice*.

This synthesis series reports on current knowledge and practice, in a compact format, without the detailed directions usually found in handbooks or design manuals. Each report in the series provides a compendium of the best knowledge available on those measures found to be the most successful in resolving specific problems.

PREFACE

This synthesis provides information for transit and transportation professionals who seek to address safety concerns and various educational issues. It is intended for first responders to natural gas incidents—emergency response professionals such as police officers and firefighters; transit agency operations and maintenance employees, police, and security guards; and certain members of the general public. The report offers insight into current practices determined by a combination of agency surveys and an examination of actual procedures provided by several transit agencies.

This report from the Transportation Research Board includes survey responses from 19 transit agencies operating 3,130 natural gas buses in the United States. The report presents a review of relevant literature, as well as anecdotal information. Also included are case studies illustrating current response situations and examples of adopted procedures used for handling both facility and vehicle emergencies.

A panel of experts in the subject area guided the work of organizing and evaluating the collected data and reviewed the final synthesis report. A consultant was engaged to collect and synthesize the information and to write the report. Both the consultant and members of the oversight panel are acknowledged on the title page. This synthesis is an immediately useful document that records the practices that were acceptable within the limitations of the knowledge available at the time of its preparation. As progress in research and practice continues, new knowledge will be added to that now at hand.

CONTENTS

EMERGENCY RESPONSE PROCEDURES FOR NATURAL GAS TRANSIT VEHICLES

SUMMARY

Natural gas is now widely used as a fuel for transit buses. It has properties that are different from those of diesel fuel, resulting in a different set of potential hazards. Transit agencies that use natural gas require emergency procedures that address and mitigate those hazards. These procedures must take into consideration the different groups that may respond to a transit emergency, including firefighters and other emergency responders, transit employees, and even the general public. In most respects, transit experience with natural gas has been successful, but there are some situations for which improved emergency procedures have been needed. Some procedures need to be more fully developed; in several cases, additional information is needed to facilitate such development. Moreover, communication of the procedures to emergency responders represents a continuing challenge. The use of the Incident Command System is now widespread in the fire service, and additional effort is needed to integrate transit emergency response procedures into that system. This synthesis was undertaken to identify and document the state of the practice about emergency response protocols to incidents involving natural gas-filled transit buses.

Typical incidents that required or received an emergency response where the natural gas fuel was an issue were

- Natural gas releases;
- Bus fires; and
- Some traffic accidents, such as collisions of buses having roof-mounted tanks with low bridges.

Emergency procedures must be consistent with the basic objectives of emergency response: assess the situation, assist those in need, prevent further injuries and property damage, and secure the scene and preserve evidence.

To further define the current situation with regard to natural gas-powered bus incidents and the procedure development, a questionnaire was sent to 52 transit agencies that use natural gas fuel. There were 19 responses to the questionnaire that covered 3,130 natural gas buses and showed a reported fuel-related incident rate on the order of 1 incident per 100 natural gas buses per year. Transit mechanics were the most frequent responders to these incidents, responding 92% of the time; fire departments responded 69% of the time. Many of the incidents involved gas releases. However, not all gas releases represent failures: a fuel storage cylinder for liquefied natural gas may release gas as a result of excess pressure developed during a period of non-use or from overfilling.

Overall, the survey found that more than 50% of the responding transit agencies have not prepared emergency procedures for both facility and vehicle emergencies and 40% have not communicated any emergency procedures to local fire or police departments.

Firefighters tend to have their own perspective on responding to incidents involving natural gas transit buses. Many firefighters find it hazardous to fight vehicle fires aggressively, and if a fire involving a natural gas bus does occur, the natural gas fuel may cause additional

concerns for firefighters because they have little experience with natural gas vehicles. Therefore, firefighters may take a defensive approach to a natural gas bus fire. Furthermore, although natural gas buses contain numerous safety features, such as robust fuel tank construction, pressure relief devices, shutoff valves, combustible gas detectors, and on-board extinguishing systems, firefighters have identified additional safety features that they believe would facilitate their emergency response.

Although in many localities significant effort has gone into information transfer from transit agencies with natural gas vehicles to local fire departments, the experience of transit agencies with subsequent fire department response to incidents involving natural gas transit buses caused them to conclude that current efforts in information transfer are insufficient and ineffective. Additional study is needed to define the information that fire departments need and to determine the most effective way to communicate that information.

Emergency procedures for incidents involving natural gas facilities generally emphasize the use of combustible gas alarms and ventilation to mitigate hazards from the accumulation of flammable gas. Such procedures can often be improved by maintaining a clear focus on the actions needed to respond to the emergency.

With respect to natural gas security procedures, some are directed toward protecting essential transit functions. Other security issues connected with the use of natural gas as a fuel for transit vehicles require additional study to define the degree of fuel-related risk.

CHAPTER ONE

INTRODUCTION

BACKGROUND

Natural gas, either in compressed form (CNG) or in liquefied form (LNG), is now used by many transit agencies to fuel their buses. However, natural gas sees only limited use as a vehicle fuel outside of transit and gas utility fleets. One motor vehicle manufacturer is reported to be ending the production of natural gas vehicles in favor of hybrid vehicles (*1*). Thus, emergency responders are often unfamiliar with how to respond to incidents involving vehicles fueled with CNG. Because each transit agency and emergency response authority tends to develop its own response protocol, there can be a wide variety in the quality of information on and even in the basic response strategy to natural gas incidents.

SYNTHESIS OBJECTIVES

The objectives of this synthesis report are to

- Document current practice for emergency response to incidents involving natural gas transit buses,
- Provide information about emergency response to incidents involving natural gas transit buses,
- Document lessons learned from those incidents, and
- Identify issues that need to be addressed in the development of improved and more consistent emergency response protocols for natural gas transit buses.

SYNTHESIS SCOPE

The scope of this synthesis document is limited to a review of emergency response protocols for responding to incidents involving natural gas-fueled transit buses. It also reports observations about deficiencies in those protocols. However, it is not intended to provide recommendations or guidelines for emergency response to incidents involving transit buses fueled by natural gas. Nor is it a general guide to operations for natural gas transit vehicles. Because the use of LNG by transit is small compared with the use of CNG and because there is only limited information on LNG procedures, this document is primarily concerned with CNG.

CHAPTER TWO

CONSIDERATIONS RELATED TO USE OF NATURAL GAS AS A TRANSIT FUEL

PROPERTIES OF NATURAL GAS FUEL

Table 1 lists the key properties of natural gas. Clearly, many of these properties, particularly those related to the physical state of natural gas, differ considerably from those of diesel fuel.

A number of existing resources provide more comprehensive descriptions of the properties of natural gas (both CNG and LNG). Those resources also provide detailed comparisons between the properties of natural gas and those of other conventional and alternative fuels and information on engineering considerations related to the use of natural gas use as a vehicle fuel. The following list cites some of these resources. (References that are primarily of a scholarly nature or that mainly list benefits of natural gas or alternative fuels have been omitted.)

2004 Emergency Response Guidebook, U.S. Department of Transportation, Washington, D.C., 374 pp.

Chernicoff, W.P., T. Balon, and P. Raj, *Design Guidelines for Bus Transit Systems Using Electric and Hybrid Electric Propulsion as an Alternative Fuel*, Report FTA-MA-26-7071-03-1, Federal Transit Administration, Washington, D.C., 2003, 43 pp.

Compressed Natural Gas: A Collection of Resources, DOE/GO-102003-1776, Freedom Car and Vehicle Technologies Program, U.S. Department of Energy, Washington, D.C.

DOE Alternative Fuel Data Center (maintains a list of resources and documents that may be found at www.eere.energy.gov/afdc/index.html) [Nov. 2004].

Hemsley, G.V., *TCRP Synthesis of Transit Practice 1: Safe Operating Procedures for Alternative Fuel Buses,* Transportation Research Board, Natural Research Council, Washington, D.C., 1993, 48 pp.

Fire Protection Handbook, 19th Ed., A.E. Cote, ed., National Fire Protection Association, Quincy, Mass., 2003. (Section 14, Chapter 2, "Alternative Fuels for Vehicles," contains a discussion on the fire implications of alternative fuel vehicles.)

Murphy, M.J., H.N. Ketola, and P.K. Raj, *Summary Assessment of the Safety, Health, Environment, and System Risks of Alternative Fuel*: *Clean Air Program*, Report FTA-MA-90-7007-95-1, Federal Transit Administration, Washington, D.C., 1995, 144 pp.

NFPA 52: Compressed Natural Gas (*CNG*) *Vehicular Fuel Systems*, National Fire Protection Association, Quincy, Mass., 2002.

NFPA 57: Liquefied Natural Gas (*LNG*) *Vehicular Fuel Systems*, National Fire Protection Association, Quincy, Mass., 2002.

Raj, P.K., W.T. Hathaway, and R. Kangas, *Design Guidelines for Bus Transit Systems Using Compressed Natural Gas as an Alternative Fuel*: *Clean Air Program,* Report FTA-MA-26-7021-96-1, Federal Transit Administration, Washington, D.C., 1996, 94 pp.

Raj, P.K., W.T. Hathaway, and R. Kangas, *Design Guidelines for Bus Transit Systems Using Liquefied Natural Gas* (*LNG*) *as an Alternative Fuel*, DOT-FTA-MA-26-7021-97-1, Federal Transit Administration, Washington, D.C., 1997, 84 pp.

Reference Guide for Integration of Natural Gas Fuel Systems, Report GRI-02/0013, Gas Research Institute, Park Ridge, Ill., 2002.

SAFETY ISSUES

Natural gas has a different hazard profile than traditional liquid fuels such as gasoline and diesel fuel. Two properties that affect its hazard profile and consequent emergency response are its gaseous state and its storage at high pressure or low temperature. In normal transit operations, the risks from these hazardous properties have been mitigated through effective design.

Gaseous State

The physical state of a fuel has significant implications for the degree of its fire hazard. Only gases burn; therefore, liquid or solid fuels must first either vaporize or decompose, respectively, before burning. These are relatively slow processes whose rate tends to limit the rate of heat release. However, in the case of a gaseous fuel, the fuel is already in a form suitable for burning, and the rate of heat release is limited only by the rate of release of the gas. Owing to the high pressure of CNG and the high volatility of LNG, both can be released very quickly.

Should a fire occur, the significance for emergency response is threefold. First, fires fed by natural gas may attain large heat release rates quickly. Second, unlike with fires fed by solid and liquid fuels, the size of the fire is generally not reduced by cooling the fuel supply with water. Third, if a fire

TABLE 1
PROPERTIES OF NATURAL GAS AND DIESEL FUEL

Property	Value for Natural Gas	Comparable Value for Diesel Fuel
Nominal chemical formula	CH_4 [a]	$C_{14}H_{25}$
Typical molecular weight	17	~200
Boiling point, °C	−162	200–350
Density, at 20°C, 1 atm, kg/m^3	0.70	850
Density, at 20°C, 25 MPa, kg/m^3	217	
Density, liquid at −162°C	424	
Fuel energy value, mJ/kg	47–50	43
Flammability limits of vapor, vol. %	5–15	No flammable vapors exist below 50°C
Minimum ignition energy, mJ	0.28	0.24
Autoignition temperature, °C	450 [b]	230
Adiabatic flame temperature, K	2157	2275
Odor threshold, ppm	10,000 [c]	~0.5
Occupational exposure limit, ppm	~15,000 [d]	14 [e]

[a]Formula is for methane. Natural gas is typically 85% to 99% methane.
[b]Value includes the effect of higher hydrocarbons present in natural gas. The autoignition temperature of pure methane is higher.
[c]Natural gas itself has essentially no odor. In commerce, natural gas is required to be odorized with sulfur compounds so the odor is detectable at 20% of the lower flammability limit.
[d]Methane is considered nontoxic and a simple asphyxiant, but higher hydrocarbons are considered more toxic. Value is for natural gas assuming a reasonable level of higher hydrocarbons.
[e]No value has been established for diesel fuel. Shown is the National Institute for Occupational Safety and Health recommended value for kerosene.

fed by a natural gas leak is extinguished, but the gas is still escaping, the gas can re-ignite and, because unburned gas has accumulated, lead to an even larger rate of heat release.

Storage Conditions

Compressed Natural Gas

CNG is stored under high pressure, generally at 25 MPa (3,600 psig). Gases at this pressure contain a considerable amount of stored energy.

The significance for emergency response is that under accident conditions hazards related to high-pressure are potentially present. Such hazards include the following:

- Rapid venting of fuel cylinder contents. Cylinders are designed to vent under conditions of excessive temperature, but the resulting release of fuel can present a fire hazard.
- Mechanical forces resulting from the action of high-pressure gas jets.
- Pressure vessel rupture. Because cylinders are well protected from rupture by numerous design features and extensive testing, cylinder rupture would be an extremely rare occurrence.
- A rapid release of gas during fueling, resulting from a failure in a hose or fitting, or for some other reason.

Liquefied Natural Gas

LNG is stored under moderate pressure at a temperature of about −162°C. The hazard implications are:

- LNG can vaporize quickly in contact with a warm surface, leading to a very rapid release of natural gas.
- Odorants are solid at these (–160°C) temperatures, so LNG cannot be odorized effectively.
- Many materials become brittle at cryogenic temperatures and lose their structural strength.
- LNG tanks are designed to vent under conditions of excessive pressure caused by overfilling or overheating, but the resulting release of fuel can present a fire hazard.
- If LNG warms up while being confined, very high internal pressures will be generated that can cause a rupture or explosion.

SECURITY ISSUES

To identify security issues related to the use of natural gas as a transit fuel, it is useful to examine the FTA Top 20 Security Program Action Items for Transit Agencies. Of these action items, those most relevant to the use of natural gas as a transit fuel are listed in Table 2.

Consideration of these action items leads to the identification of any issues that are specific to natural gas. For exam-

TABLE 2
RELATION OF NATURAL GAS TO FTA TOP 20 SECURITY ISSUES

FTA Top 20 Goal	Questions for Natural Gas
No. 8—Threat and vulnerability assessment	Is the threat and vulnerability assessment any different for natural gas vehicles and facilities?
No. 13—Ongoing training programs on safety, security, and emergency procedures	Do these training programs cover natural gas vehicles and facilities?
Nos. 15 and 16—Audits and drills	Do these audits and drills include natural gas vehicles and facilities, if appropriate?
No. 20—Protocols to respond to Office of Homeland Security Threat Advisory Levels	Do these protocols include appropriate responses for natural gas vehicles and facilities?

Source: Adapted from "FTA Top Security Program Action Items for Transit Agencies" [Online]. Available: http://www.transit-safety.volpe.dot.gov/Security/SecurityIniatives/Top20/ [Nov. 2004] (*2*).

ple, with respect to fueling infrastructure availability, if a transit fleet is fueled by natural gas, then without the availability of natural gas in compressed or liquefied form, there can be no transit operations. Inasmuch as there may not be nontransit sources of CNG or LNG available (or at least no other source that can dispense fuel to transit buses), a disruption to or destruction of the natural gas fueling facilities would render the fleet inoperative. Another issue is whether or not the use of natural gas as a transit fuel presents a security hazard. Because the properties of natural gas and the design of equipment for natural gas use do differ in several ways from those for diesel fuel, the question about a security hazard is multidimensional, and additional research is needed to define the outcomes.

CHAPTER THREE

GENERAL CONSIDERATIONS FOR EMERGENCY RESPONSE

TYPES OF EMERGENCY RESPONDERS

Although it is common and often accurate to think of municipal fire and police departments as the only emergency responders, the first responders to a natural gas incident may extend beyond emergency response professionals, such as police officers and firefighters, to include

- Transit operating employees, such as drivers and supervisors;
- Transit maintenance employees, such as vehicle fuelers and mechanics;
- Transit police and security guards; and
- Members of the public.

As emergency responders, fire and police personnel have a great deal of training and experience in handling emergency situations, and they have access to emergency equipment and resources. However, they may have limited experience with transit buses and facilities, because there are relatively few critical incidents involving transit.

In many cases, transit employees are the first responders. Because transit employees are knowledgeable about transit vehicles and facilities, they may be the most likely to recognize abnormal conditions and be the most familiar with facilities, vehicles, controls, and valves.

The initial response may also be provided by someone among the public who happens to be in the vicinity. Although the competence of the general public is often denigrated, analysis of actual incidents shows that such individuals have often provided valuable initial responses. Although some individuals may be uninformed and untrained, the general public may also include off-duty or former transit employees, police officers and firefighters, and medical and military personnel, as well as people with a variety of industrial training and experience. The issue here is how to guide the response of the general public in those circumstances where immediate action is necessary, while to the degree possible protecting them from harm.

USE OF INCIDENT COMMAND SYSTEM FOR MANAGEMENT OF PROFESSIONAL EMERGENCY RESPONSE

Incident Command System

The Incident Command System (ICS) is a management tool for the command, control, and coordination of resources at the scene of an emergency. The use of the ICS has recently become common in firefighting, but the principles are consistent with classic management practices.

The ICS recognizes that if an emergency response is to be effective, there must be an immediate response from those on the scene. Harm and damage can result if nothing is done during the wait for experts or resources, no matter how great their value. Nevertheless, as experts and resources become available, they must be used. The ICS also recognizes that any response must be organized and that expertise and resources may derive from different organizations and agencies.

The functions of the incident commander include planning, operations, logistics, and finance. At the start, the senior responder on the scene becomes the incident commander. As higher ranking people arrive, who presumably have more expertise and additional resources, there is an orderly hand-off of control and a logical division of labor.

The ICS recognizes that for large, complex, or multi-jurisdictional incidents, a formal command structure must be developed for each function. This command structure recognizes that the span of control must be limited, common terminology must be developed, communications must be integrated, and the use of resources must be coordinated. Additional information on the ICS is found in Appendix A.

Incident Command System and Natural Gas Transit Incidents

The initial responders to an incident involving natural gas vehicles or facilities are often transit personnel, and the transit central dispatcher may be the first party to be notified of an incident. In the case of a bus incident, the first person on the scene is probably the driver. In the case of a facility incident, the first person is probably a vehicle fueler or mechanic. Whoever it is, that person is the incident commander until relieved by a supervisor or emergency response forces. For natural gas incidents this means that

- People who work with natural gas every day should be familiar with the first stages of the ICS.
- People who are emergency responders should be aware of proper hand-off procedures and of the need to obtain status and other information from the initial responder.

Futhermore, the initial responder should be aware of the need to brief the subsequent responders.

- The ICS structure has a place for resource management. Transit personnel with knowledge of CNG or LNG should be considered as resources for incidents involving those fuels. Emergency responders should know who those people are, what their expertise is, and how to contact them.

OBJECTIVES OF EMERGENCY RESPONSE

The five basic objectives of emergency response are these:

1. Assess the situation.
2. Assist those involved and treat the injured.
3. Prevent further injuries and property damage.
4. Secure the scene and preserve evidence that could be lost. This evidence could be needed for an engineering investigation to establish a cause or for a criminal investigation to fix blame.
5. Document what happened.

Although the objectives are listed separately and sequentially, it is often the case that actions to achieve these objectives are taken simultaneously.

All aspects of these basic objectives apply to the response to transit emergencies involving natural gas vehicles or facilities. However, for the purpose of this synthesis document, only the natural gas-related aspects of these response objectives will be considered. Those parts of the emergency response that are common to all types of emergencies, such as first aid, traffic control, or property damage procedures, will not be discussed here.

Assess the Situation

The first challenge of an emergency responder is to assess what has happened, what is happening, and what needs to be done in the midst of crowds, traffic, confusion, injuries, smoke, fire, or damage.

Natural gas has characteristics that are different from those of diesel fuel and a different set of hazards. Implications for emergency response include the need to

- Determine whether or not natural gas is being used through observing the blue CNG diamond identification on the rear of the vehicle or the presence of roof-mounted fuel tanks; and
- Recognize the presence of and potential for natural gas leaks and releases, through odor, sound, or, in the case of LNG, visible vapor.

A basic requirement is to recognize the use of natural gas as a vehicle fuel. In this regard, there have been instances of responders and others confusing CNG or LNG with liquefied petroleum gas (LPG). LPG (commercial propane) is a common gaseous fuel frequently used commercially for portable heating and by consumers for barbeque grills and other applications. Anecdotal information shows that education continues to be needed on the differences between CNG, LNG, and LPG.

The fuel tanks for CNG buses have pressure relief devices (PRDs) as a safety feature to vent excess pressure. If excessive heat or mechanical failure causes the operation of a PRD, there may be a torch-like flame. In such a case, the role of the natural gas fuel in feeding a fire is clear. However, in other cases, it may not be clear whether the intensity of other fires is being increased by burning natural gas. Experience suggests that in most cases of natural gas bus fires, the use of natural gas as a fuel does increase the severity of the fire. Moreover, mere visual observation of a CNG bus is not sufficient to determine if the natural gas fuel tanks are full (and have the potential to vent) or have already vented and are empty.

CNG vehicles are identified by the aforementioned blue CNG diamond on the rear of the bus (see Figure 1).

Although the use of the blue CNG diamond on CNG buses has become universal, there is no uniform requirement for marking the exteriors of facilities where CNG or LNG is in use. In some jurisdictions, the appropriate National Fire Protection Association (NFPA) hazard diamond is used on the outside of buildings containing hazardous materials, as described in NFPA Standard 704, System for Identification of

FIGURE 1 Rear of natural gas bus; blue CNG diamond is shown at the lower right.

the Hazards of Materials for Emergency Response. Figure 2 shows an NFPA diamond for natural gas.

Assist Those Involved and Treat the Injured

Large numbers of people may be involved in a transit-related emergency situation. The immediate response to an emergency requires that assistance be provided to the people involved and that those who are injured be identified and treated.

Although providing assistance for people and medical treatment of injuries is important, the procedures and treatment are not specific to incidents involving natural gas. Thus, such procedural information is not included in the scope of this document, which is focused on natural gas-related issues.

With respect to human exposure to natural gas, it should be noted that natural gas is widely used for home cooking and the toxicity of natural gas is very low, unless there is enough gas to displace the oxygen in the air. Therefore, no particular toxic effects are expected from occasional exposures to natural gas.

Prevent Further Injuries and Property Damage

In some cases, an emergency response can be effective in limiting further damage and harm. For example, extinguishing a fire before it spreads can prevent injuries to people and limit property damage. Moreover, prompt treatment can greatly assist an injured person toward a successful recovery. Further injuries are prevented by either moving people from harm's way or ending the conditions that cause injury.

However, in other cases, there is little that can be done to prevent further harm. For example, after a vehicle or structure is totally engulfed in flames, it cannot be saved from further damage. If an explosion has occurred, it may be that all one can do is to survey the damage; if a fatality has occurred, no treatment can reverse the result. The actions necessary to prevent additional damage depend on the situation.

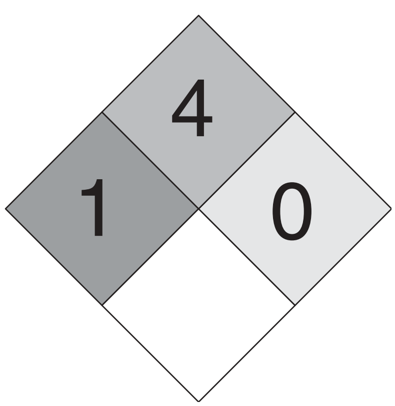


FIGURE 2 NFPA fire diamond for natural gas.

From the perspective of an emergency responder to natural gas leaks and releases, several actions can be taken to prevent further damage or harm:

- Verify the origin of the gas release and stop the release.
- Remove people and property from the vicinity of the release or move the equipment with the release away from people and property. People should be moved upwind from any actual or suspected gas leaks or gas releases.
- Prevent ignition. If natural gas is or has been released, the scene should be surveyed for ignition sources. Ignition sources should be removed or prevented. For example, if a bus with a gas leak or gas release is under a bridge or overpass, vehicles should be prevented from passing overhead. The ignition possibilities of emergency equipment must also be recognized, including abrasive cutting saws and engine-driven rescue tools.
- Be wary of static electricity. For a flammable gas, such as natural gas, static electricity is always a potential ignition source. This is especially true if the relative humidity of the air is low. In rapidly flowing gases, the motion of entrained particles can cause the buildup of static charges.
- Ventilate enclosed areas, considering that natural gas is lighter than air. LNG fuel vapors may be heavier than air until they warm.

Note that once the gas is gone, there are no more hazards. A meter to measure combustible gas can be used to determine that all gas has dissipated. Some locations use non-odorized natural gas. In such cases, combustible gas meters are the only way to detect the presence of natural gas, so they should be widely available and routinely used.

For incidents involving natural gas releases, assistance required from emergency responders will normally include recognizing areas where there could be imminent harm and moving people from these areas to a safe place. Because some of the properties of natural gas may be unfamiliar, expert guidance may be necessary in identifying areas that are or are not danger zones. However, there is anecdotal evidence that the extent of the flammable zone associated with a natural gas release is sometimes greatly overestimated and additional study is needed to develop appropriate evacuation guidelines.

As for the implications pertaining to natural gas-related fires, CNG fuel tanks are pressure vessels that require protection from excessive pressure and are equipped with PRDs. LNG fuel tanks also have pressure relief valves, which are designed to reclose after the pressure falls.

A PRD is designed to fully vent the contents of a compressed gas cylinder that has been exposed to excessive temperatures. Once activated, the PRD will not reclose, and safety codes (for good reason) prohibit any valve in a PRD vent line. If there is a fire nearby to provide an ignition source, it is likely that the natural gas will ignite as well. Therefore, if possible, fire control efforts should be directed toward keeping a fire from approaching fuel containers.

If a fire from a PRD release does occur, it is not possible to cut off the gas supply. Thus, the response to a fire fed by a PRD release may need to be limited to protecting nearby property from exposure to heat from the fire.

In general, large natural gas flames fed by high-pressure supplies are difficult to extinguish. In addition, it may be dangerous to do so, because of the risk of gas accumulation and subsequent explosion unless the supply of natural gas can be cut off.

Secure the Scene and Preserve Evidence

Although determining the cause of an incident is mostly the responsibility of others, emergency responders do have a responsibility to collect information on the incident, particularly information that cannot be observed by investigators at a later time. For example, in the case of a traffic accident, police personnel must note the locations of other vehicles, pavement conditions, and other factors.

In the case of natural gas incidents, there are aspects of the situation that should be recorded to facilitate a subsequent investigation. Some of these are related to the ability of natural gas to dissipate. Thus, for subsequent investigation, it is generally desirable to know about and to document the following:

- Was there an odor of natural gas?
- Was there a sound of escaping gas?
- What was the status of combustible gas alarm systems?
- Were readings taken with a combustible gas meter? What were the readings and where were they taken?
- Was there venting of gas? If so, when and where did the venting occur?
- Was there a fire? If so, where was the fire most intense?

In many cases, someone who is knowledgeable about natural gas fuel systems and who can recognize important evidence should be called to the scene.

Document What Happened

For both investigative and legal purposes, it is essential to document the incident and the emergency responders who are called to record what they observe.

The requirements for natural gas incidents are basically the same as for any other incident. However, given that natural gas incidents are relatively rare, it is important to have a debriefing to review what happened, evaluate the response procedures, and determine if improvements in the emergency response procedures are required.

CHAPTER FOUR

TRANSIT EXPERIENCE WITH NATURAL GAS

ANECDOTAL INFORMATION ON TRANSIT INCIDENTS INVOLVING NATURAL GAS

Anecdotal information available on incidents with natural gas-fueled transit buses is shared at periodic meetings of the Transit User's Group, which operates under the auspices of the U.S. Department of Energy and the Clean Vehicle Education Foundation (formerly part of the Natural Gas Vehicle Coalition).

There is no requirement that incidents involving natural gas transit vehicles be reported to a central authority or clearinghouse. Nor is there a robust definition of what constitutes an incident. Therefore, there are no official statistics on the number of natural gas-related incidents or on incident rates.

General Causes of Natural Gas Fuel Releases

The most common cause of large fuel releases from a CNG bus has been the operation of a PRD on the fuel tanks. Natural gas releases have also occurred from failures in fueling connections and fueling station equipment. In the case of LNG, smaller gas releases may occur owing to the effect of large temperature changes on the tightness of fuel system fittings and connections.

General Causes of Bus Fires

Although exact fire statistics for U.S. transit fleets are not available, it is believed that most bus fires are caused by the following:

- Oil leakage on hot engine parts—for example, turbocharger or exhaust manifold;
- Electrical system short circuits;
- Turbocharger failures;
- Bearing failures;
- Brake problems; and
- Overheated catalytic converters or exhaust stacks.

These factors are consistent with a recent detailed study of transit and other bus fires in Finland (*3*).

SURVEY ON TRANSIT INCIDENTS INVOLVING NATURAL GAS AND ON EMERGENCY RESPONSE PROCEDURES

Many individual transit agencies track natural gas-related incidents or have information on the number of fuel-related incidents of a given type—for example, fuel releases, vehicle fires, or other fuel-related problems.

Scope and Objective

A survey was conducted to gather information on natural gas-related incidents and to determine the status of emergency response procedures for responding to transit emergencies involving the use of natural gas. The objective of the survey was to identify current practices for emergency responder procedures and the experiences of transit agencies with implementing those procedures. FTA's 2002 National Transit Database was used to identify those transit agencies that use natural gas as a fuel, and the survey questionnaire was sent to those 52 agencies. The questionnaire is reproduced in Appendix B.

Results

A total of 19 replies were received, a 37% response rate. All of the respondents were transit agencies that are now operating natural gas buses. The responses covered a total of 3,130 natural gas buses, of which 2,163 were operated by three transit agencies serving communities in Southern California. A detailed summary of the responses to the questionnaire may be found in Appendix C. Some comments on the responses follow.

The most frequent responders to these incidents were transit mechanics (92%); the fire department responded to more than half of the incidents.

More than half of the responding transit agencies reported that they had distributed emergency procedures to local fire departments and less than one-quarter to local police departments. The most common method of transferring information about natural gas to local fire departments was through visits to facilities (67%) or some type of joint training (72%). Less than one-quarter reported that they had prepared a notebook of procedures and information to which emergency responders could refer.

In regard to specific emergency procedures, 84% of the transit agencies had procedures for gas leaks within a storage or maintenance facility, 58% had procedures for a fire involving a natural gas-fueled bus, and 47% had procedures for gas leak or release on a natural gas-fueled bus in service. Approximately 75% of these procedures were developed by the transit agencies themselves; about 25% were developed by consultants, vendors, or other transit agencies; and 50% were developed by fire departments.

Only 4% of the respondents had established security procedures specific to natural gas. The comments on the questionnaires did not identify security as an issue. Generally, the use of natural gas as a fuel was not reported to result in the development of security-related procedures that were specific to natural gas.

Overall, the survey found that fewer than 50% of the responding transit agencies have prepared emergency procedures for the both facility and vehicle emergencies and that 40% have not communicated emergency procedures to local fire or police departments.

Discussion of Findings

Typical incidents that required or received an emergency response were natural gas releases or bus fires. With the exception of some PRD releases where the vented gas ignited and produced a torch-like flame, the survey did not identify any fires where natural gas from the fuel system was the first material ignited. The results of the questionnaire showed the incident rate for CNG buses to be on the order of 1 incident per 100 buses per year.

As mentioned, transit mechanics were the most frequent responders to natural gas incidents. The high response rate of 92% indicates the importance of incorporating transit mechanics into the ICS as equipment experts.

CHAPTER FIVE

CASE STUDIES

The following three case studies serve to illustrate the current emergency response situation at transit agencies.

CASE STUDY I

This transit agency serves a major city and has hundreds of CNG buses in its fleet. As with many other transit agencies, when CNG buses were first introduced there was extensive training of all staff at the facility where the CNG buses were located. Furthermore, like many transit agencies with CNG buses, this one invited the fire department to its site and those personnel were briefed. The briefings included information about the following:

- Properties of CNG and its relative safety;
- A description of the CNG buses, including the locations of fuel tanks, PRDs, and fuel system shutoff valves; and
- Instructions for access to various vehicle compartments.

When several fires occurred that involved CNG buses (the fires did not originate in the CNG fuel system), the response from the emergency responders was not what the transit agency anticipated. The fire department let the buses burn and did not mount an aggressive attack on the fires, while the police response was to cordon off a large area.

This transit agency believes that communications between the fire officials who came to visit the transit facility for an inspection and briefing and the crew of firefighters who actually responded were not effective. Those firefighters were from the principal jurisdiction (the jurisdiction that was briefed by the transit agency) in the metropolitan area.

However, the agency also noted, on reflection, that no written materials had been given to responders describing the desired procedures. The agency believes that written materials might have improved the communications process. Moreover, it realized that a half-dozen other fire jurisdictions are served by CNG buses, but that their fire departments were not involved in the on-site briefings.

CASE STUDY II

This transit agency has approximately 150 CNG buses. As with other transit agencies, this agency met with local fire officials on multiple occasions to educate them on the safety properties of CNG and the type of CNG equipment in use by the agency and to provide information about transit vehicles and equipment.

The agency also prepared a binder that it sent to 31 government agencies that provide emergency response in its service area. This binder was intended to be a "guide for first responders." It contained these items:

- A list of emergency telephone numbers.
- A list of hazards associated with CNG buses.
- A list of switches, valves, and actuators.
- A photograph of the access key needed to open bus compartment doors.
- A series of color photographs of each type of bus, which had callouts that show the locations of the master switch, the battery disconnect switch, the fuel shutoff valve, the PRD vent outlets, and other safety features.

Subsequently, two CNG bus fires occurred. When the firefighters who responded saw that CNG was on board, they did not extinguish the fire, but only protected adjacent property from exposure to the fire. In one case, the bus was only a few months old, so the economic loss was relatively severe. The causes of the two fires were unrelated to the use of CNG.

The CNG buses had functioning fire suppression systems. Although these systems did suppress the fire for a time, they did not extinguish it, and damage continued to occur. Agency staff believes that this is probably a result of the large amount of heat in the engine compartment.

CASE STUDY III—FIREFIGHTER PERSPECTIVE ON RESPONDING TO A BUS FIRE

The following description of the firefighter's perspective on responding to a bus fire is based mainly on discussions with staff at a training academy for firefighters. The academy staff emphasized that firefighter response is highly variable and depends on the experience, philosophy, and personal preference of the fire commander, as well as on the particular circumstances. Lessons learned for transit agencies are featured here.

When an incident requiring fire department response is reported, an alarm is communicated to the dispatcher. The dispatcher not only assigns crews and equipment but also informs the responders about the nature of the incident and about any special hazards the crew may encounter. In regard to buildings, particularly commercial or industrial properties, this information is generally organized by street address and may be quite detailed, based on previous fire inspections.

In the case of a bus fire, the information communicated to the responding crew may be brief and sketchy. The crew will know that there is a bus at a certain intersection. However, those respondents may not know the type of fuel used by the bus and they may not even know whether the bus is a transit bus or a school bus until they arrive on the scene.

Lessons learned are:

- The transit dispatcher should inform the fire department dispatcher about the type of equipment involved.
- The fire department dispatcher should have information on transit equipment and transit bus-related procedures, because if the database of briefing information is street-address oriented, it is easy for mobile equipment, such as transit buses, to "fall through the cracks."
- Because the call for help may be vague or because the public is not considered a reliable source of information concerning the type of equipment involved, the firefighters may arrive on the scene without any briefing.

When the responders arrive, they need to size up the situation. (See Figure 3 for an example of what responders might see. Note the vertical flame from venting PRD.) Evaluating the situation means answering questions such as:

- What is the nature of the emergency?
- Is there a gas release?
- Is there a fire?
- What is on fire?
- Are there any casualties or people in need of rescue?
- What is the size of the fire?
- Where is the nearest supply of water and is it functional?
- Is there a need for traffic control?
- Is there anything unusual about the situation; for example, the use of CNG as fuel?

Lessons learned are:

- Firefighters have many items to address when they first arrive at a fire.
- Seeking detailed information on vehicle construction, from a reference binder, may have to wait until other, more immediate, goals are addressed.
- Firefighters may not immediately notice that the vehicle is a CNG bus. However, many firefighters are familiar with the distinctive roof-mounted fuel tank enclosure used on many CNG buses.

FIGURE 3 What firefighters might observe upon arriving on the scene of a natural gas bus fire. (Used with permission from Peter Jensen 2003.)

As firefighters arrive and size up a situation, they recognize that this is a vehicle fire, that no buildings are involved, and determine whether the occupants of the vehicle have been evacuated. Most commonly, vehicle fires involve automobiles. The firefighters have been trained to fight automobile fires and are aware that:

- Gasoline fuel tanks can explode.
- Air bags can explode.
- Various piston-operated hardware, such as the struts that hold a hood or a hatch cover open, can become lethal missiles when hot.
- Modern automobiles contain a lot of plastics and polymers, and the combustion products from these materials can be extremely toxic. Thus, it is now common for firefighters to wear breathing apparatus even outdoors when in the vicinity of a burning vehicle.
- Opening the hood on a burning car is difficult. Getting inside the vehicle to operate the hood release is dangerous; so is manually unhooking the front hood latch. Even if one uses heavy tools, prying a hood open by brute force is often frustratingly difficult.

- If it is possible to get the hood open, the fire will get a fresh supply of air and is very likely to flare up in the faces of the firefighters. Also, fluid-filled containers may explode in their faces.

Given the latter potential hazard, a penetrating nozzle is sometimes used on vehicle fires. This is a water nozzle that is hammered through the sheet metal that covers the engine or passenger compartment. For example, a penetrating nozzle might be used on a school bus fire to get water inside the passenger compartment without opening up the vehicle. In any case, an automobile becomes a total loss so quickly that little reduction in property damage is gained by trying to extinguish the fire aggressively.

In addition, some fire crews may have experience with truck fires. They are aware that trucks often carry hazardous materials. This is true not only for placarded cargo trucks, but also for smaller vehicles. For example, a plumber's van may carry acidic drain cleaner or a cylinder with welding gas. Thus, truck fires are also problematical for an aggressive, close attack.

All these considerations make firefighters reluctant to mount an aggressive attack on a burning vehicle. The risk–benefit ratio is not very favorable: an aggressive attack on the fire involves risk of injury to the firefighters and does not offer much potential for a reduction in property damage.

The responding crew may find that the vehicle on fire is a transit bus, and that it is a CNG bus. That crew must then decide on a plan of attack. Given the number of transit bus fires compared with the number of fire stations and fire crews in the city, it is likely that this crew has never seen a transit bus fire before. A CNG bus fire can be a once-in-a-career fire for most fire crews. However, as noted, the crew may have experience with automobile and truck fires, as well as with fires involving propane and with natural gas leaks and fires in buildings. The responding crew's perspective may include the following:

- From their experience with gas leaks in buildings, the responders are aware that natural gas that ignites in a confined space can explode.
- From their experience with propane, they know that propane fuel tanks can explode. Also, if they are acquainted with CNG tanks, they know that PRDs can release without warning, and that if the gas jet ignites, a large jet flame with a significant radiant exposure will result. They may know that PRDs are present, but do not know the number, location, and direction in which the devices are pointed.
- They do not know that CNG transit buses are expensive and may cost from one-third to one-half million dollars. However, if they did know, that amount of money would be considered insignificant compared with any risk of firefighter injury.
- They do not realize that even badly damaged transit buses are routinely rebuilt and put back on the road.

Implications for transit are:

- It is unlikely that the responding crew will have previously fought a transit bus fire. Furthermore, the crew may not have received needed information from the dispatcher while responding.
- Without specific training, the responding crew will likely base its response on the situation that most closely approximates what it has been trained for and has experience with—namely, automobile and/or truck fires.

Accordingly, the responding crew decides on a strategy. It protects adjacent property from exposure to the fire. It cools the bus with streams of water from a distance. It does not approach the vehicle closely. (However, if it did approach the bus closely, the crew would consider an approach from the front to be the safest.) The crew does not open hatches or compartments until the fire is extinguished. Then the crew opens up the vehicle to look for hot spots that require further attention. The vehicle suffers extensive damage, but there are no injuries to the general public, no firefighter injuries, and no damage to adjacent property. The operation is therefore considered a success.

CHAPTER SIX

EXAMPLES OF EMERGENCY RESPONSE PROCEDURES

This chapter features several examples of emergency response procedures used by various transit agencies. To convey the format and graphical content of the procedures, scanned images are used. Because the original documents contained color and photographs, the scanned quality may not fully reflect the quality of the original.

In reproducing the emergency response procedures, the following guidelines were followed:

- Only material relevant to the use of natural gas was reproduced. Many notebooks of procedures contained information on other types of equipment, such as conventional diesel buses or light rail, and on other topics, such as routine maintenance, traffic accident response, or non-fuel-related emergencies. Such material is not reproduced here.
- In some cases, similar material was furnished for several fleets of buses. In those cases, only one fleet has been selected.
- All material reproduced has been "sanitized" by removing names and phone numbers specific to the operation, which in many cases were contact names, home telephone numbers, or similar information intended for use only by emergency responders.

TRANSIT AGENCY 1—COMPRESSED NATURAL GAS AND LIQUEFIED COMPRESSED NATURAL GAS FIELD SERVICE GUIDE FOR FIRST RESPONDERS

Preface

It is the intention of ______ to furnish all emergency first response entities within the agency's operating area with training and information resources pertaining to emergency procedures when dealing with natural gas engine fuel. ______currently deploys alternative fuel powered vehicles that use **unodorized** liquefied compressed natural gas (LCNG) as engine fuel. Prior to using LNG as its fuel supply, ______ used pipe-transported natural gas to fuel its vehicles. The gas is compressed to a high pressure (~4000 PSI) and dispensed to vehicles and stored as a high-pressure gas. Today, LNG is stored on ______ properties processed so that it has completely vaporized prior to reaching the main storage vessels. Like CNG, vaporized LNG is compressed to a high pressure and dispensed to vehicles as a high-pressure gas. ______ has coined the term "liquefied compressed natural gas (LCNG)." An important point to remember is that pure uncompressed (= atmospheric pressure) natural gas is lighter than air and is unodorized.

The CNG Field Service Guide for First Responders is meant to be a guideline to familiarize first response personnel with the equipment and conditions ______ deploys and experiences. This document is not intended to replace formal training and education related to compressed natural gas, liquefied natural gas, or liquefied compressed natural gas properties, equipment and facilities, emergencies, or the Incident Command System (ICS). This document does not provide a comprehensive or exhaustive list of all responsibilities assigned to any first responders, nor does it take the place of locally established guidelines for emergency management.

______, Director of Maintenance

Emergency Phone Numbers

Sunday 3:00 AM–11:30 PM

Vehicle Dispatch East	
Vehicle Dispatch West	

Monday–Friday 24 Hours

Saturday and Sunday 4:30 AM–1:00 AM

Monday–Sunday 4:30 AM–1:00 AM

Vehicle Maintenance East	
Vehicle Maintenance West	

Vehicle Manufacturers

New Flyer Industries	
Orion Bus Industries	
Neoplan USA Corporation	

Hazard Assessment

Introduction

Transit vehicles that are powered by natural gas fuel are subject to hazards similar to all other types of transit vehicles. For instance, traffic collisions, system malfunctions, and other undesirable conditions are experienced by all transit vehicles including those powered by natural gas fuels. Vehicles powered by natural gas fuel, specifically those [where] the gas is stored on the vehicle under high pressure, possess unique dangers if an undesirable condition or conditions exist. Dangers include unscheduled release of gas to the atmosphere, sudden release (explosion) of high-pressure gas to the atmosphere, freezing of the skin or eyes, and asphyxiation. Each brand and each model and model year of those brands of transit vehicles that are powered by natural gas fuel have unique configurations, but safety procedures when responding to incidences involving the unique dangers associated with vehicles powered by natural gas fuel are standard.

Standard Guidelines

- Use extreme caution. Be aware of sights and sounds. Identify any confined spaces near the incident, and ventilate as necessary.
- Eliminate ALL possible sources of ignition. No smoking or road flares near the incident. Check for downed utility wires.
- Establish a controlled area with a radius of no less than 50 feet.
- Include in all preliminary investigations information gathering from all involved employees. Utilize Field and Maintenance Supervisors as liaisons.
- Be aware that natural gas displaces oxygen and may cause asphyxiation.
- ______ utilizes natural gas fuel that is unodorized. Use proper equipment/instruments to determine concentration of gas.
- Both slow leaks and sudden gas releases can cause frosting. Do not touch frosted areas or components.
- Engine compartment fires will cause the release of fire suppressant at a very high rate. Use caution when dowsing fires in the engine compartment.
- Identify the vehicle model and model year. Vehicles can be identified by unit number. Use the guides within this document to assist in the identification of the vehicle type.
- If there is no apparent hazard, request ______ transit personnel to determine if the vehicle is safe to operate.
- If a leak is accompanied by fire or explosion, the lead fire agency must activate appropriate resources.

Mechanical Device Operating Procedures

<table>
<tr><td>1. Master Rotary Control Switch</td><td>Effect: Stops engine</td></tr>
<tr><td colspan="2">Rotate the switch counterclockwise to off position. The engine should shut down, interior and exterior lighting should shut off, and all other electrically operated equipment should cease to operate. The switch is located in the driver’s cab, on the left switch panel, next to the driver’s seat.</td></tr>
<tr><td>2. Engine Compartment Control Switch</td><td>Effect: Stops engine</td></tr>
<tr><td colspan="2">Toggle the rear engine control switch to the off position. The off position is the center toggled position. The rear engine control switch is located in the engine compartment and can be accessed when the rear engine compartment door is open.</td></tr>
<tr><td>3. Manual Fuel Shut-Off Valve</td><td>Effect: Stops fuel flow to the engine</td></tr>
<tr><td colspan="2">Rotate the handle ¼ turn. This stops fuel flow from the storage cylinders to the engine. The engine will not immediately shut off. Despite closing the valve, treat all fuel lines as filled with high-pressure gas.</td></tr>
<tr><td>4. Battery Disconnect Switch</td><td>Effect: De-energizes battery power to the vehicle</td></tr>
<tr><td colspan="2">Move the battery disconnect switch to the “OFF” position. The engine will shut down and wires and devices after the disconnect switch will be de-energized. The fuel solenoid valves will be closed, but treat fuel lines as filled with high-pressure gas.</td></tr>
</table>

5. Pressure Relief Device Vent Outlets and Pressure Relief Devices	**Effect: Allows "normal" depressurization of fuel storage cylinders**
The pressure relief devices (PRD) allow the AUTOMATIC "unscheduled" release of gas due to excessive heat. The PRDs are SAFETY devices and are there to prevent a sudden explosion associated with the fuel storage cylinders. DO NOT attempt to block the PRDs or PRD vents from discharging gas.	
6. Fire Suppression System Manual Actuator	**Effect: Extinguishes or assists in extinguishing fires in the engine compartment**
Located in the driver compartment next to the driver seat. Remove the retaining pin and depress the red FIRE button. The fire suppression system will discharge the dry chemical agent (PKP) in the engine compartment only.	

Access keys may be needed to open certain compartment doors.

1996 Orion Bus Industries
Specifications

Orion Bus Industries	
Model Year	1996
Model Number	Orion V
Identifiers	Bus Numbers 700-723
High Passenger Cabin Floor, Low Vehicle Profile	
Fuel Capacity (Scf)	18250@3600 PSI
Number of Fuel Cylinders	10
Service Pressure	3600 PSI@70°F
Maximum Pressure	4500PSI@130°F
Cylinder Location	Roof Mounted

Fuel storage cylinders are type 4 and meet the NGV-2 standard.

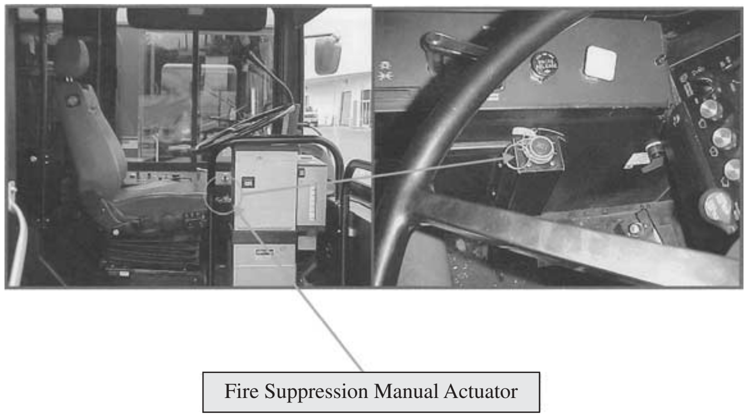
Fuel storage cylinders are composite wrapped plastic membranes.

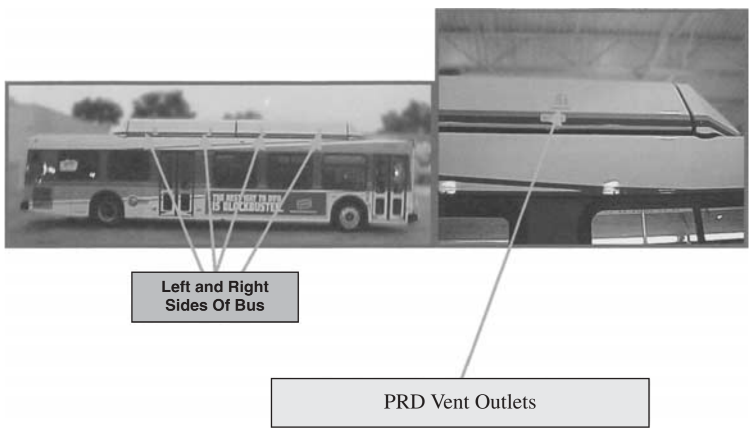
The fuel system is protected by pressure relief devices that open under excessive heat and/or high system pressure conditions. The devices may also open when the fuel storage cylinders encounter extreem impact.

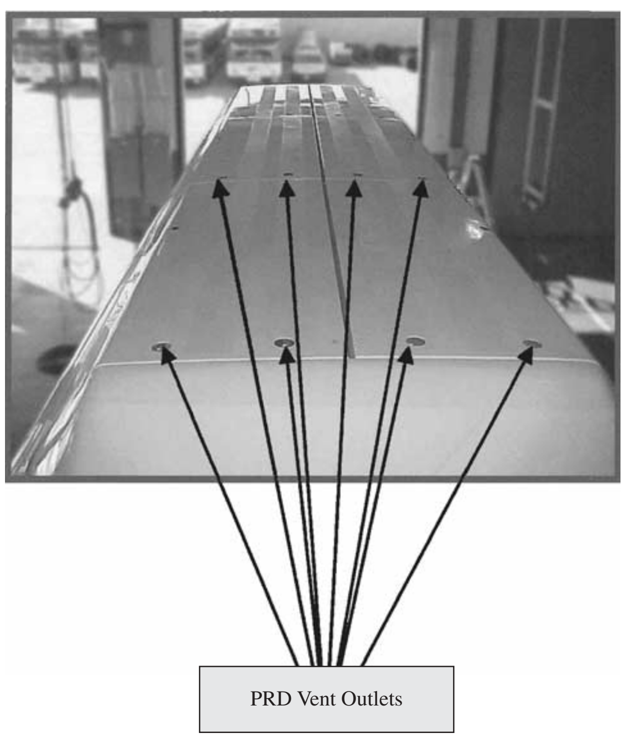
January 31, 2002

Left Side
Of Bus

Battery Disconnect Switch


Fire Suppression Manual Actuator


Left and Right
Sides Of Bus
PRD Vent Outlets


PRD Vent Outlets

BUS EMERGENCY RESPONSE

GENERAL SAFEGUARDS ✓ AND PRECAUTIONS ⃠

✓ **Always** secure the area: position response vehicles so approaching motorists have good site distance and time to react.

✓ **Always** approach the bus from the side until the bus is secure and will not move.

✓ **Always** secure the bus first: check to make sure the PARKING BRAKE is applied.
check to make sure the gear selector is in NEUTRAL
(service brake may have to be applied to move gear selector).

✓ **Always** use self-contained breathing apparatus (SCBA) if the bus is on fire. Toxic smoke and gases will be emitted.

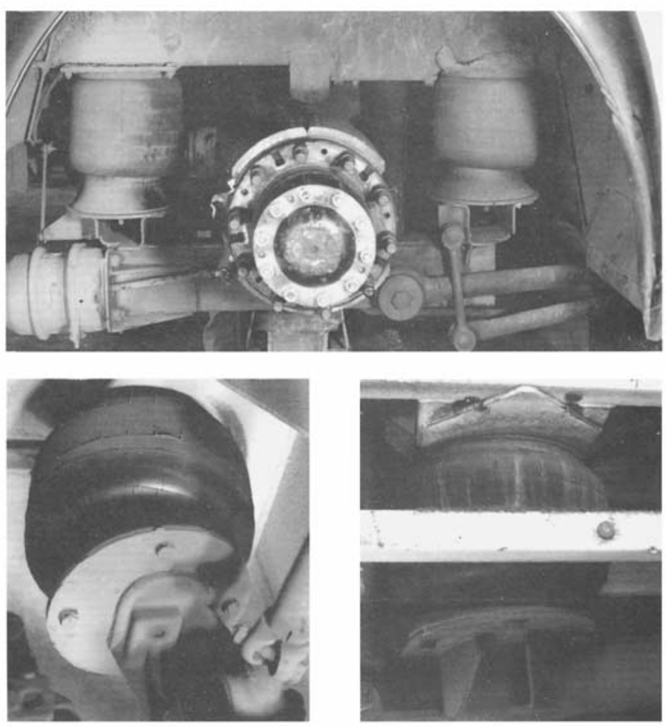
✓ **Always** chock the bus wheels.

✓ **Always** park emergency units upwind of CNG buses.

⃠ **Never** use flares near a CNG bus. Two-way radios and standard flashlights can be potential ignition sources.

⃠ **Never** position equipment or personnel directly in front of or behind a bus that is on a slope or grade.

⃠ **Never** crawl under a bus not secured and supported; the air suspension may fail and **ground clearance is zero**.

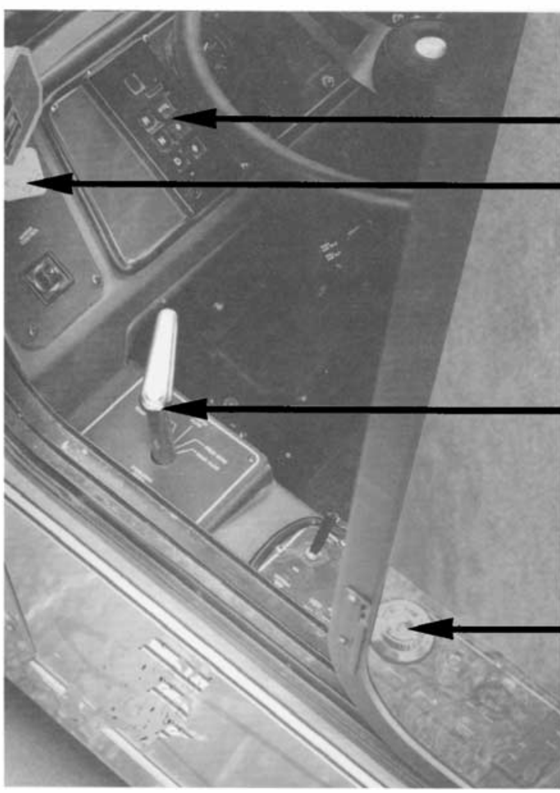


AIR SUSPENSION SYSTEMS

EMERGENCY ROOF HATCH
Shown from inside the bus.
PUSH black tab in direction shown
PULL handle out.

EMERGENCY ROOF HATCH OPENED
Hatches can be completely removed, if necessary.
2' by 2' opening

WHEELCHAIR SECURING DEVICES AND INSTRUCTIONS FOR USE
Side-facing seats fold up to make access for a wheelchair. Wheel latches and seat-belts are available.



DRIVER'S SIDE WINDOW

TRANSMISSION SELECTOR
PUSH "N" for Neutral position.
(may have to have service brake applied)

PARKING BRAKE CONTROL
PULL UP to apply the parking brake.

DOOR CONTROL KNOB
TURN it full clockwise or full counterclockwise to open doors.

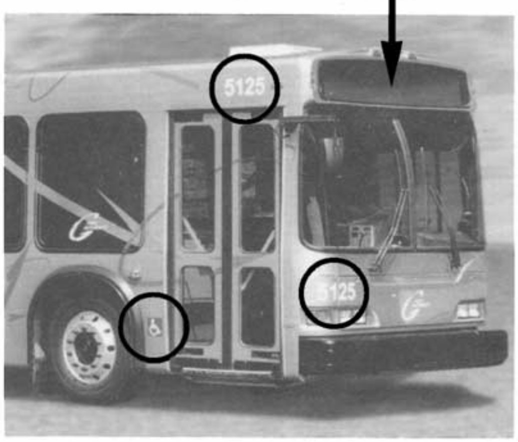
MASTER SWITCH
TURN to STOP position (Full counterclockwise) to shut off engine.

PARKING BRAKE KNOB AND TRANSMISSION SELECTOR

BEWARE: If Operator is incapacitated or unconscious, the only thing that might be keeping the bus from moving is the Operator's foot resting on the service brake pedal. Secure the bus BEFORE moving the Operator.
PULL UP on knob to apply the parking brake and
PUSH "N" to select NEUTRAL.

BUS IDENTIFICATION NUMBERS AND DECALS

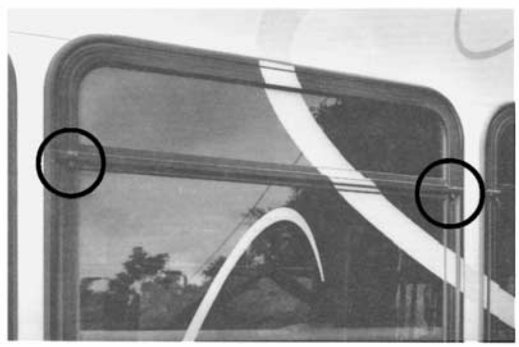
The route number is displayed on the head sign.



The bus number is displayed on the right front and above the front doors. A handicapped accessible decal displayed between the front doors and the right front tire indicates the bus is wheelchair accessible and passengers with a disability may be on board.

EMERGENCY WINDOW EXITS

Windows can be propped open. **DANGER:** If prop is dislodged, window will slam down and cause serious injury. (Window weight is approximately 60 lbs.)



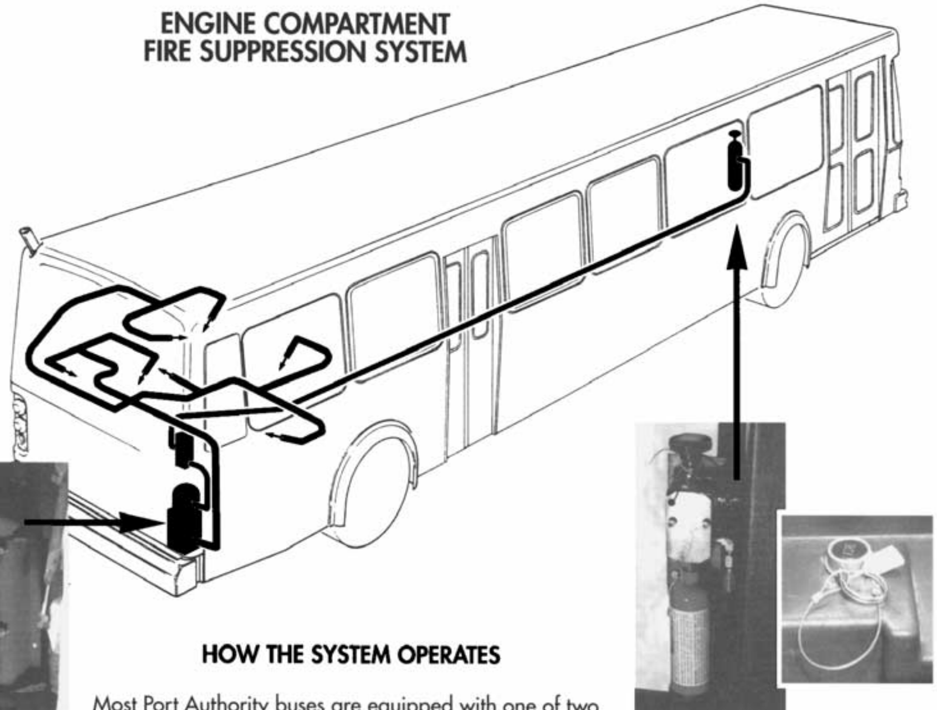
EMERGENCY WINDOW EXITS

Two grommets can be axed off and the whole window removed. Window is hung on a "J" hook hinge.
BEWARE: Window weight is approximately 60 lbs.
Use two people to swing out and lift up off channel.

WINDSHIELDS

Can be removed if absolutely necessary. Windshield wipers can be pulled away and off.
PRY UP rubber seal with screwdriver or other tool,
PEEL AWAY and
KICK OUT glass.

ENGINE COMPARTMENT FIRE SUPPRESSION SYSTEM



Extinguishing Agent Tank (Dry Chemical)

Manual Actuators

HOW THE SYSTEM OPERATES

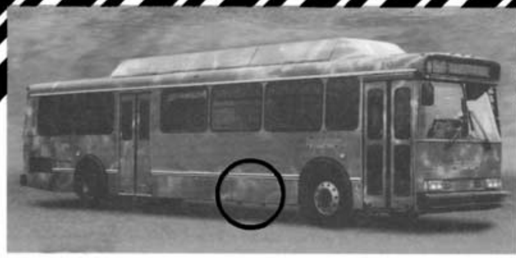
Most Port Authority buses are equipped with one of two different types of fire suppression systems. One has a extinguishing agent tank that is under constant pressure. The other has a tank that is pressurized by a nitrogen cylinder upon activation. Discharge of the fire suppression system is actuated automatically from the fire control module or manually from an actuator.

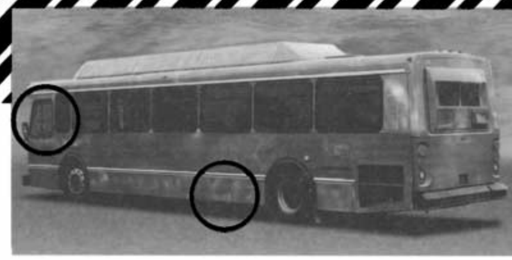
MANUAL ACTUATION

PULL pin. DEPRESS the actuator (red plunger knob or red button) to activate the system and discharge the fire extinguishing agent. You may have to strike down hard on the plunger. Manual actuators are located alongside or behind the Operator's seat.

AUTOMATIC ACTUATION

Two heat detectors monitor the temperature in the engine compartment. If a fire starts in the engine compartment or the temperature rises above 325 °F (162°C), the detectors notify the fire control module. The fire control module activates the fire suppression system and the extinguishing agent is discharged through nozzles located in the engine compartment. The module will also activate the system alarm box which gives the Operator a visual and an audible indication of a fire condition and shuts down the engine. **BEWARE:** Wear Self-Contained Breathing Apparatus (SCBA) or keep away from engine compartment when system discharges 25 lbs. of dry chemical extinguishing agent.





ORION: COMPRESSED NATURAL GAS

(Refer to **ORION Sheet** for standard features)

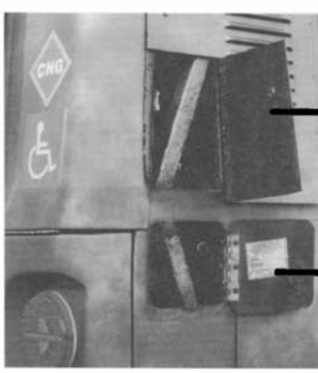
RIGHT SIDE OF BUS
Manual wheelchair lift control access panel

NOTE: "POWERED BY CLEAN NATURAL GAS" decal.
Bus is powered by Compressed Natural Gas only.
DANGER: DO NOT use flares near this bus.
ALWAYS park emergency vehicles UPWIND of bus.

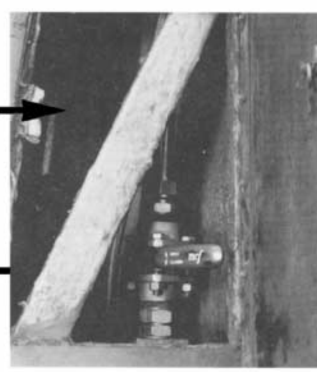
LEFT SIDE OF BUS
Operator's sliding window
Battery compartment access panel

RIGHT REAR OF BUS
CNG and Handicapped accessible decals required by federal regulations are located on the right rear corner of bus.

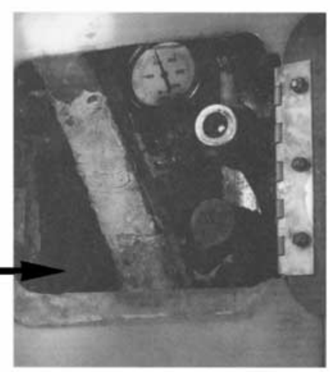
RIGHT REAR CORNER OF THE BUS
Fuel shut-off decal on door indicates location of the CNG fuel shut-off valve.
Fueling port access door indicates location of fuel gauge.



CNG SHUT OFF AND FUELING PORT ACCESS DOORS OPENED



CNG SHUT OFF VALVE
$^{1}/_{4}$ turn shut off valve in the closed (off) position. Shuts off the flow of gas from the storage tanks to the engine. NOTE: **Engine will not shut off immediately.** Bus will run until the gas in the lines is used.



CNG FUEL GAUGE
3000 psi is a full load of fuel.

TRANSIT AGENCY 3—PROCEDURES AND INSPECTION MANUAL FOR COMPRESSED NATURAL GAS PROGRAM AND FACILITY

CNG FUEL LEAK PROCEDURE FOR BUS OPERATORS

In the event of a CNG fuel leak while you are driving the bus you should follow these procedures:

- Pull the bus over as soon as possible in a safe and open location.
- Secure the vehicle by putting the bus in neutral, setting the parking brake, and shutting the engine off.
- Instruct the passengers to get off the bus and guide them to a safe location (100 yards if possible) up-wind of the bus.
- Contact the dispatch office as soon as possible via a land line and provide your exact location so we may respond to the scene promptly.
- Each CNG bus is equipped with a fire suppression system that will automatically activate in the event of extreme heat or fire.

It is of utmost importance that you remain calm and follow the proper procedures, because the passengers will be looking to you for guidance in this situation.

Updated—April 5, 2000

PROCEDURES FOR RESPONSE TO FIRE ALARM ACTIVATION FOR OPERATIONS, MAINTENANCE AND SECURITY PERSONNEL

I. Description of Alarm System

A. The fire alarms in the _____ Facility are designed to be activated by heat, smoke, manual pull station, water flow in sprinkler piping, or a release of natural gas in the fueling station.

B. The three fire alarm panels in the Facility are divided into zones which identify the location of the alarm origin. Each panel has a zone labeled <u>Gas Alarm Panel,</u> which will illuminate when a concentration of natural gas accumulates in the new fueling station which is 40% of the Lower Explosive Level (LEL) of a natural gas and air mixture.

C. In the event of a fire alarm activation within this Facility, the majority of occupants are required to exit the building in adherence to ______ Emergency Evacuation Plan. Part of this plan, however, requires the dispatcher and key maintenance or security personnel to remain and investigate the cause of the alarm unless doing so obviously exposes them to a hazardous situation.

II. Outside Monitoring of ______ RTA Fire Alarm

A. A fire alarm activation in this Facility does not automatically ring into the City Fire Department. It does, however, ring into ______ Security Service who will call the ______ Dispatcher's Office and allow up to 5 minutes for an inspection to be performed of the Facility to determine if an emergency situation exists or if a false alarm has occurred.

B. ______ Security will send the ______ City Fire Department to our Facility if any of the following occur:

1. ______ RTA dispatcher informs ______ that fire or smoke is present in the Facility.
2. ______ RTA dispatcher informs ______ that the doors and exhaust fans are not cycling properly to exhaust the fueling station in the event of a natural gas release.
3. ______ RTA dispatcher fails to communicate the findings of Facility inspection to within 5 minutes.
4. ______Security is unable to contact RTA.

III. Response by Key Maintenance and/or Weekend Security Personnel to Fire Alarm Activation (Security Personnel are present in the Facility from Friday 5:00 pm through Monday 4:00 am)

A. Maintenance and/or security personnel are to establish communications with dispatcher using one of the following:

1. Obtain portable radio from Maintenance or Dispatch Office. Use Channel 2/Channel 3 as backup.
2. Call Dispatch Office using ______ RTA phone system or cellular phone. Call ext. ______ or use ext. ______ as backup. Note: Portable radio or cellular phones are preferable since communications with dispatcher can be maintained while Facility inspection is performed.
3. In the event of a natural gas release in the fueling station, the dispatcher can be contacted using the dedicated "Direct Line to Dispatch" phone located just outside main door to fueling station. Two additional "Direct Line to Dispatch" phones are available for use in the bus storage area, one at the front of row 7 and the other at the back of row 19. These phones will automatically ring in on ext. ______ in the Dispatch Office when the handset is lifted.

B. Maintenance and/or security personnel need to identify location or zone indicated on alarm panels where alarm originated so they know where to inspect.

1. Dispatcher can identify location by phone or radio or any one of the three alarm panels can be viewed directly.
2. To ensure employee evacuation, ***do not silence alarms*** until after building has been inspected and no trouble found.

C. Maintenance and/or security personnel are now to inspect the portion of the building where the alarm originated.

1. Inspect for fire and smoke.
2. If the alarm activation was caused by a natural gas release, inspect the fueling station for proper door and fan cycling and make sure that the source of the release has been valved off or removed from the Facility.

D. Report findings of inspection to dispatcher:
   1. Remember that this inspection and communication with dispatcher must be performed in under 5 minutes from time of alarm activation or the ______ City Fire Department will be sent.

IV. Response by Dispatcher to Fire Alarm Activation

A. Terminate non-emergency phone calls from ext. ______, ______, and ______.
B. Receive incoming call from ______ Security Service.
   1. ______ will call on ext. ______ or ______.
   2. ______ will remain on the phone for up to 5 minutes while cause of alarm is investigated.
C. Receive incoming call from maintenance and/or security personnel using Channels 2 or 3 of radio system or ext. ______ or ______ of phone system.
   1. Weekday second and third shift supervisors carry a cellular phone. Phone: ______.
   2. Weekend security service carries a portable radio.
D. At no time is the dispatcher to leave the Dispatch Office in order to inspect any part of the Facility for fire, smoke, or a natural gas release.
E. Report findings of building inspection performed by key maintenance and/or security personnel to ______Security Service.
   1. If fire, smoke, or other hazardous situation is found, then identify situation and location in Facility to______ Security and request them to send ______City Fire Department then terminate call.
   2. Call 911 (9911 on our system) before evacuating building.
   3. If no hazardous situation [is] found, inform ______ Security that a false alarm has occurred and terminate call.

V. Dispatcher or Maintenance Employee Can Silence Alarms and Reset System

A. Alarm can be reset by using key labeled “Fire Alarm Control Key” hanging next to fire alarm panel in Dispatch Office. Use key in key switch labeled “Alarm Reset.” Additional key set is in Dispatch Office key box.
B. After alarm is reset, announce over outside PA system that alarm activation was a false alarm and that employees may reenter the building.
C. If fire alarm system will not reset and goes back into alarm, ______ Security Service will call back and maintenance and/or security personnel will perform a more thorough inspection; i.e., inspect manual pull stations for having been tripped.
D. If still no apparent reason for continued alarm activation, attempt to reset again this time with ______ Security Service remaining on the phone.
E. If fire alarm system still will not reset:
   1. Inform ______ Security of the problem. **1-800-**______.
   2. Silence the alarms by pushing the black button labeled “Alarm Silence” on Dispatch Office fire alarm panel.
   3. Inform Facilities Maintenance of the problem.
      ______ Work
      ______ Home
      ______ Cellular
      ______ Home
      ______ Cellular
      ______ Home
      ______ Home
      ______ Home

Automatic Sequence of Operations

In the event of a natural gas leak, the natural gas detectors will operate the ventilation fans automatically. Upon detection of natural gas at a level of approximately 1% of the air in the zone [10% of the Lower Explosive Limit (LEL) for a mixture of a natural gas and air], the exhaust air fan(s) for the zone will be engaged by the controls and the gas heaters in the zone will be shut off. The fans are designed to rapidly reduce the concentration of gas in each zone in the building. ***Operation of the fans is indicated by a yellow status light*** on the main panel in the Maintenance Office and by a similar status light on the dispatcher's panel.

In normal operation, the natural gas ventilation system will operate the zone fan(s) to reduce gas concentration below 1% of the air in the zone and then shut down the fan. However, because of fluctuations in the mixture of natural gas and air in a zone, concentrations of natural gas may reach 2% of the air in the zone (20% LEL). Should this level of gas/air mixture be reached, the odor of natural gas would be heavy and noticeable in the area of release. In this event, ***an alarm condition will be indicated by a red status light*** on the main panel in the Maintenance Office and by a similar status light on the dispatcher's panel. In addition, the audible alarm in the zone will operate.

Zones 6, 8, 12, 13, and 14 (Running Repair; Body Shop; Air Conditioning Repair Bays; Preventative Maintenance Bays; and Steam, Tire, and Dynamometer Rooms) are the zones in which major maintenance activities occur. Each of these zones is equipped with a manual switch which allows the zone exhaust fans to be manually operated for a limited period of time in the event that maintenance personnel working in the area detect natural gas by sense of smell.

Alarm Response

In the event of an alarm (20% LEL):

1. *Clear the building until the condition has been corrected.*
2. *Report the cause of the gas release (if known) to the supervisor in charge in the Maintenance Office.*
3. *Leave the bus in the area where it is located.*

The Natural Gas Ventilation System will ventilate the zone and shut down the gas heaters until the gas has been ventilated from the zone as described in "Automatic Sequence of Operations" above.

The supervisor will direct maintenance personnel to react to the gas detection with one or more of the following responses:

1. *Activate additional ventilation if needed.*
2. *Identify the source of the gas release.*
3. *Shut down the source of the gas release.*
4. *Drive the bus with the gas release out of the building.*
5. *Evacuate the building.*
6. *Call the ______ City Fire Department.*
7. *Block access to vehicles entering the garage.*
8. *Document the quality of the vehicle for repair by Engine Shop.*

ALARM SEQUENCE FOR COMBUSTIBLE GAS DETECTION IN NATURAL GAS FUELING STATION

Detection can occur at any one of six sensors; four sensors are located in the fueling bays and two are in the compressor room.

- **10% Lower Explosive Level (LEL) Detection of Natural Gas**
  The following responses occur automatically:
  - ✓ Shutdown of natural gas compressors, fuel dispensers, and all fueling system gas valves.
  - ✓ Startup of exhaust fans 3–10 (small displacement fans).
  - ✓ Opening of outside overhead doors.
  - ✓ Activation of yellow warning lights adjacent to inside overhead doors. Inside overhead doors will close approximately 20 seconds later.
  - ✓ Activation of yellow warning light and bell sound at fueling bays and in Operations Department.
  - ✓ Opening of small and large louvers on north and east walls of compressor room.

- **20% LEL Detection**
  In addition to the above, the following responses occur automatically:
  ✓ Startup of exhaust fans 11–14 (large displacement fans).
  ✓ Previously activated yellow warning light and bell sound at fueling bays and in Operations Department upgrade to red alarm light and horn sound.
  ✓ Activation of horn on Mine Safety Appliance (MSA) Combustible Gas Monitoring Panel located in the Maintenance Office.

- **40% LEL Detection**
  ✓ In addition to all of the above, the building fire alarm will be activated.

RESET PROCEDURE FOR NATURAL GAS FUELING STATION

This procedure is to be performed only after stopping the release of natural gas inside the facility.

1. Determine remaining concentration of gas in fueling station by viewing display on monitoring panel in Maintenance Office.
2. If at any time the concentration of gas exceeded 20% LEL, then horn on front of monitoring panel will be sounding. Push back button located on the front of the monitoring panel to silence.
3. Open door on front of monitoring panel. When concentration of gas has dropped below 10% LEL on all 6 displays, gas detection system can be reset by pushing red button labeled, “Alarm Acknowledge.”
4. If gas concentration never exceeded 20% LEL, Maintenance Office horn would not have sounded and the red “Alarm Acknowledge” button does not have to be pushed. This detection system will automatically reset after any detection of less than 20% LEL.
5. If at any time the concentration of gas exceeded 40% LEL and the fire alarms were activated, the fire alarm system can now be reset. The fire alarm system is only to be reset after all procedural steps described in “RTA Procedures for Response to Fire Alarm Activation for Operations, Maintenance and Security Personnel” document dated March 16, 1998, have been followed.
6. Reset door and fan operation using computer terminal on filing cabinet in Maintenance Office using keystroke directions displayed over terminal. Resetting the doors from the computer terminal releases the control of the doors to the push button controllers located at the doors. In order to continue fueling, the doors have to be properly positioned using these push button controllers.
7. Reset natural gas compressors, fuel dispensers, and all flow control valves by turning key switch in the Fuel Station Electrical Control Room. Key switch is labeled Reset and is located on panel labeled “ESD Relay Panel.” Key is to be turned clockwise to stop, then released. When red light next to key switch goes out, reset of compressors, dispensers, and flow control valves is complete.

Natural Gas Fueling Station is once again ready for use!

February 2001

DESCRIPTION OF SAFETY INSPECTIONS FOR RTA FACILITY COMBUSTIBLE GAS DETECTION AND EXHAUSTING EQUIPMENT

- **The Facilities Maintenance Superintendent will perform the following tasks daily:**
  - ✓ Review Siemens System 24-hour history report which prints automatically each morning at 5:00 AM. This report shows activity of air handlers, exhaust fans, and alarms. In addition, it gives all combustible gas sensor readings at the time the report was generated.
  - ✓ After verifying that all equipment functioned properly, report is signed and filed.
  - ✓ Any sensors whose readings are approaching 5% Lower Explosive Level (LEL) are investigated and recalibrated if needed.

- **The Daytime Public Fueling Attendant will perform the following task at the beginning of their shift:**
  - ✓ Verify that yellow light at Public Fueling Station is illuminated. This light verifies fire suppression system at island is ready to operate.

- **The Fueling Shift Supervisor will perform the following task at the beginning of their shift:**
  - ✓ Verify operation of 2 air handlers and 4 ventilation fans before fueling procedure begins.

- **The Facilities Maintenance Department will perform the following tasks monthly:**
  - ✓ Cycle and visually inspect air handlers and exhaust fans which serve building. Check belt tensions and listen for abnormal noise.
  - ✓ Release test gas at a random combustible gas detector in the original facility. Verify facility operation of exhaust fans, activation of alarms, and shutdown of radiant heaters.
  - ✓ Release test gas at a random combustible gas detector in the fueling station. Verify operation of exhaust fans, doors, Emergency Shutdown System (ESD), and activation of alarms.
  - ✓ Test the ESD by pushing one of the red slap switches located on each of the fuel dispensers and the compressor skids. Verify that the skids will not run and that the pneumatic powered isolation valves installed throughout the system shutdown.
  - ✓ Verify that fuel cannot be dispensed in the fuel island without the air handlers' small displacement fans being turned on and the doors cycled to the correct positions.
  - ✓ Verify operation of the safety eyes located on the inside doors of the fueling station.

TRANSIT AGENCY 4—COMPRESSED NATURAL GAS FIELD SERVICE GUIDE FOR FIRST RESPONDERS

Scene Assessment

Introduction

Like other transit vehicles, Compressed Natural Gas (CNG) buses are exposed to a variety of hazards and risks—equipment malfunctions, traffic collisions, road conditions, or activities requiring law enforcement involvement. Any one of these hazards may create public safety or environmental concerns as well as cause a disruption in service to ______ patrons. First responders may face CNG bus incidents where the possibility of an unscheduled release of gas, a gas leak with fire, or an explosion can occur. Though there are various types of CNG vehicles, there are standardized safety operating procedures for the evaluation of vehicle damage and control of the incident.

General Guidelines

- Approach scene with caution, recon area as necessary;
- Ensure that all sources of ignition are eliminated—NO TRAFFIC FLARES;
- Establish a safe zone at 50 feet minimum, more expansive as incident dictates;
- Conduct a preliminary evaluation by interviewing the bus operator or ______ field supervisor on-scene and/or perform a visual inspection.

NOTE: Though CNG is considered to be nontoxic, large volumes of the gas in a confined space can displace oxygen and cause asphyxiation.

Unscheduled Release of Gas (Gas Leak)

- Determine if gas leak [is] present by odor detection, sharp hissing sound, icing on fuel components, or use a hand-held gas detection device;
- If a leak is present:
  - ✓ Identify type of CNG bus involved;
  - ✓ Follow Emergency Operating Procedures within this guide for bus specific type (indexed by series number);
  - ✓ Protect against body or eye injury due to release of gas under high pressure;
- If no leak is present, initiate public safety duties and request ______ equipment maintenance personnel to determine if bus is to continue in-service operations or is in need of towing.

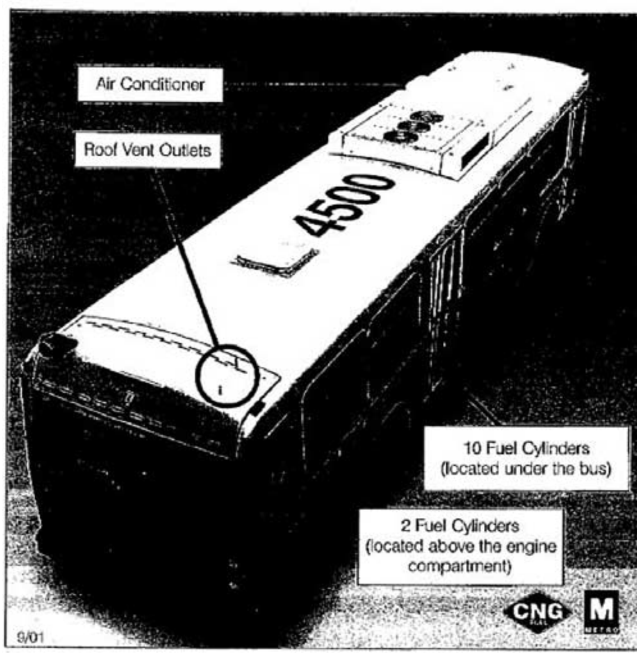
Gas Leak with Fire or Explosion

- Lead fire agency to activate Incident Command Structure, Rescue, and Mass Casualty Incident protocols as needed;
- Utilize ______ field supervisor/on-scene coordinator as a resource/liaison.

Activities Requiring Law Enforcement Involvement

- Lead law enforcement agency to activate Incident Command Structure, Hostage, or other incident specific protocols as needed;
- Utilize ______ field supervisor/on-scene coordinator as a resource/liaison.

CNG Field Service Guide for First Responders



Bus Specifications	
Model	AN440
Fuel Cylinders	12 Total
[illegible]	16,000 cu.ft.
[illegible]	3,600 psi
Fuel Cylinders location	10 under the bus / 2 above the engine compartment
[illegible]	• High Floor, identified by entrance and exit door steps • Roof mounted air conditioner
[illegible]	Neoplan USA

Fuel System

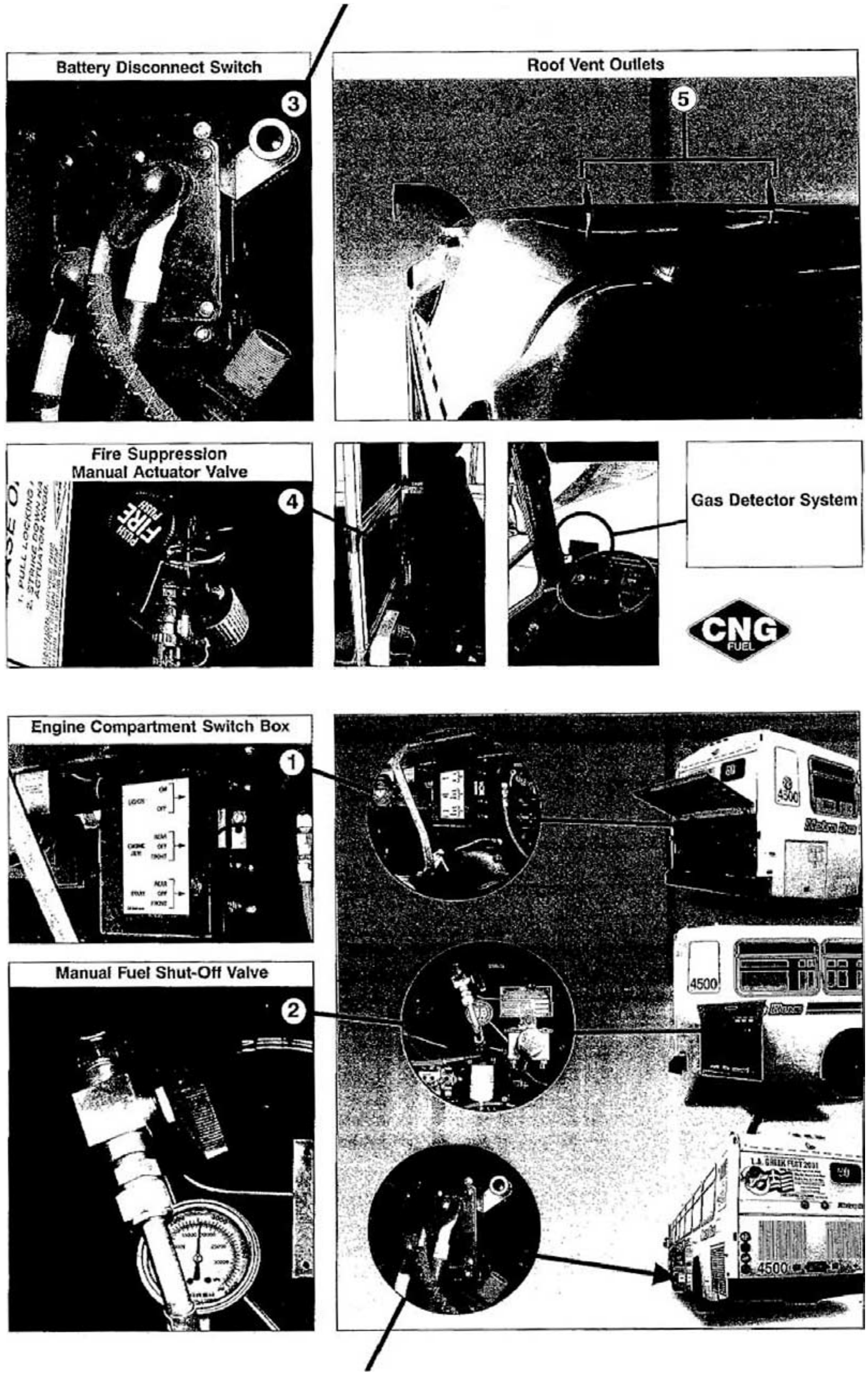
This bus has composite cylinders mounted under the bus which are covered by aluminum shield panels.

These cylinders meet all Natural Gas Vehicle requirements. Cylinder integrity may be compromised by armor piercing bullets, significant impact and/or fire. Exercise caution when working around or on CNG gas systems.

This vehicle is equipped with Pressure Relief Devices (PRDs) throughout the fuel system that will automatically open. They will vent fuel into the atmosphere in the event system design pressure or temperature is exceeded.

MTA Series Number

4500 – 4695


Battery Disconnect Switch
3
Roof Vent Outlets
5
Fire Suppression Manual Actuator Valve
4
Gas Detector System
CNG FUEL
Engine Compartment Switch Box
1
Manual Fuel Shut-Off Valve
2
4500

EMERGENCY OPERATING PROCEDURES

<table>
<tr><td>1. Engine Compartment Switch Box</td><td>Action: Stops engine</td></tr>
<tr><td colspan="2">Position the “Rear Engine Run” toggle switch to the center or “OFF” position to shut down the engine. The engine Switch Box assembly is located in the engine compartment and is visible immediately upon opening the engine door.</td></tr>
<tr><td>2. Manual Fuel Shutoff Valve</td><td>Action: Stops fuel flow to engine</td></tr>
<tr><td colspan="2">Turn the BLACK handle ¼ turn to stop fuel flow to the engine.
Caution: Although the shut-off valve is closed, the fuel tanks, distribution lines, the vent lines, and the main supply line above the shutoff valve are still under high pressure.</td></tr>
<tr><td>3. Battery Disconnect Switch</td><td>Action: Disables main electrical power and shuts off all fuel solenoid valves</td></tr>
<tr><td colspan="2">Slide both battery disconnect switches to the “OFF” position to disable 12 and 24 volt electrical power to all bus components. Disconnecting the battery power will also de-energize (close) the fuel system’s solenoid valves.</td></tr>
<tr><td>4. Manual Fire Suppression Actuator Valve</td><td>Action: Extinguishes fire in engine compartment</td></tr>
<tr><td colspan="2">Pull the safety ring from manual actuator and press the red “FIRE” button down to initiate the discharge of the fire extinguishing agent in the engine compartment.</td></tr>
<tr><td>5. Roof Vent Outlets</td><td>Action: Depletes gas from fuel system</td></tr>
<tr><td colspan="2">These outlets, located on the right rear roof area, are where unscheduled release of gas occurs. Internal Pressure Relief Devices (PRD) allow for discharge of the gas into the atmosphere when either over-pressurization or excessive heat occurs. DO NOT ATTEMPT TO STOP THIS GAS FROM VENTING.</td></tr>
</table>

CHAPTER SEVEN

OBSERVATIONS ON IMPROVED EMERGENCY PROCEDURES

VEHICLES

Transit Bus Design for Emergency Response

The firefighter's perspective provides insight into the perceived hazards of dealing with vehicle fires and their comfort level in responding to a fire involving a natural gas-fueled bus. A consideration of these hazards leads to the following comments on aspects of bus design that some firefighters believe could make an aggressive response to fires more feasible.

- Many buses have one or more combustible gas sensors; however, often the sensor alarm indicator is visible only from inside the bus. Arriving firefighters have a concern that the interior of a bus could contain toxic or flammable gases, and therefore they may be reluctant to enter. An external indicator of the status of the methane detection system gas sensors would be useful to them.
- PRD release points are not always easy to locate, even by someone familiar with transit equipment. A distinctive marking on the outside of the bus would help responders and others to locate them. In some cases, although the location of vents is clear, it is not clear in which direction they point.
- Documentation (notebooks) showing the locations of important shutoff valves and switches are useful. However, a symbol or legend on the vehicle itself would be quicker to use than notebooks. Figure 4 shows a bus with marked shutoff locations. If bus markings are used, the labeling should match that in printed documentation and/or training materials.

Although the electrical and fuel supply shutoffs on buses are relatively accessible (though some are covered by access doors that require the use of special keys), operating these shutoffs still requires a close approach to the bus. From a firefighting perspective, ease of operation is important, especially if a fire is already present. At the same time, the importance of such manual fuel system shutoffs must be placed in perspective. On the one hand, internal electric tank valves are more effective because they are located closer to the fuel source; on the other hand, if there is a PRD release (which cannot be reset) then a fuel shutoff valve is of little use. In any case, if the natural gas fuel is not feeding the fire (and experience shows that natural gas fuel system fires are uncommon), there will not be a benefit from shutting off the fuel. Paragraph numbers are keyed to Figure 5.

(3) Normally closed, electric shutoff valves that are internal to the fuel tanks are useful for limiting the ability of the on-board fuel supply to feed a fire. However, currently, a responding fire crew cannot determine from visual observation whether these internal tank valves are open or closed. A visible indicator of the status of those valves is required if firefighters are to depend on the valves being closed.

(5) Fires often originate in the engine compartment. If there is a fire in the engine compartment, the rate of burning is likely to be limited by the lack of fresh air in the compartment. If the compartment door is opened, the fire is likely to flare up in the face of the person opening the compartment, due to the renewed oxygen supply. A better plan would be to have a small hole in the engine compartment door into which a fire extinguisher nozzle could be inserted to get an extinguishing agent (perhaps a dry chemical) into the engine compartment.

(6) Also, from a firefighting perspective, it was suggested that there be a standpipe on the front of the bus onto which a firefighter could hook a 1½-in. hose to get water inside the engine compartment or the passenger compartment, should that be necessary.

FACILITIES

Emergency procedures for transit agency facilities typically cover points such as response to alarms from combustible gas sensors, operation of ventilation fans, control of ignition sources, response to buses with fuel leaks, and fueling island failures. However, some issues remain.

Topics Covered

The focus of emergency procedures for facilities should be on informing the people who work in those facilities what to do in case of an emergency. Often, procedures contain information on topics such as the advantages of natural gas, the history of the natural gas fleet at that location, the cost of the equipment, the model numbers and engineering specifications of the compressor or fueling equipment, wiring diagrams, and other information that is of a background or engineering nature. The result is both to submerge the key points in a surfeit of nonessential information and to discourage employees

FIGURE 4 Bus with marked shutoff locations.

with limited technical education from reading and understanding the procedures.

Shut-Down Procedures

Many of the emergency procedures may be characterized as shut-down procedures. Attention needs to be given as well to start-up procedures, particularly if suspected or actual trouble was the reason for the shut-down or if repairs have been made. Experience with similar types of fuels and equipment in the chemical process industry shows that a disproportionate number of accidents have occurred during start-up. Thus, procedures for transit fueling facilities should cover start-up procedures as well as shut-down procedures.

OPERATIONS

Driver Training

There have been incidents in which the driver could have noticed that there was a vehicle malfunction that had the potential to cause a fire. For example, a substantial change in vehicle handling could be an indication of a brake malfunction. Increased driver training can be of use in addressing such situations, thus reducing the number of overall incidents that have the potential to cause vehicle fires.

On-Board Extinguishers

In general, the first responsibilities of the driver in case of a fire incident are to park the bus safely, remove the passengers from the bus safely, and notify the appropriate authorities. In some cases, a driver or supervisor may choose to use an on-board fire extinguisher.

The use of on-board extinguishers by transit agency personnel raises procedural questions. If extinguishers are provided, they should be of adequate size, and the driver should be trained how to use them. A recent analysis of bus fires concluded that if an on-board handheld fire extinguisher is available for the driver's use, it must be of adequate size to be effective (*2*). According to that study, 2-kg (4.4-lb) capacity extinguishers were not adequate, and a 6-kg (13-lb) capacity was the minimum useful size.

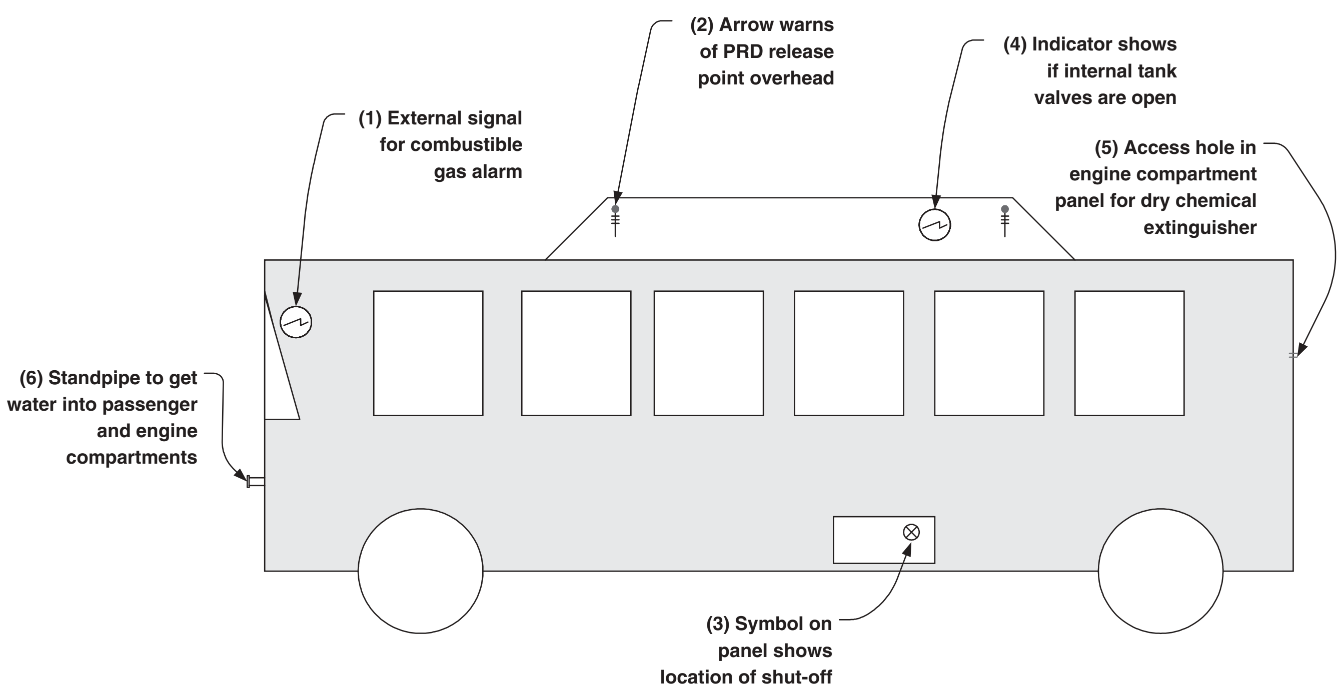


FIGURE 5 Features of CNG bus to facilitate firefighting.

INCIDENT RESPONSE

Possibility of PRD Release

Although procedures generally call for responders to check for a gas release, the procedures do not adequately describe or illustrate the direction and extent of the gas jet or torch flame that may result from a PRD release. A video could be particularly useful for training firefighters in what to expect.

Control of Ignition Sources

For a fire to occur, several conditions must be met simultaneously, including the presence of a fuel–air mixture within the flammable range and the presence of a suitable ignition source.

Guidelines are needed on the distance from a CNG bus that flares and other strong ignition sources can be used. It is suspected that the safe distance is less than generally assumed, perhaps as little as 10 to 20 m (35 to 75 ft). More information on transit situations is needed to set reasonable procedures.

Some safety instructions forbid the use of flashlights and cellular phones near a CNG bus. Cellular phones are very weak ignition sources, and a recent analysis by the Institute of Electronic and Electrical Engineers has indicated that cellular phones can be discounted as ignition sources for hydrocarbon vapors (*4*). Given the importance of cellular phones in emergency communications, additional tests that can further quantify this hazard under transit conditions would be desirable.

INFORMATION MANAGEMENT

Fire Department Information Notebooks

Although much work and effort have gone into the preparation of information guides or notebooks for fire departments and other emergency responders, such guides could be improved. Following are several suggestions:

- Guides should have a quick key that matches bus numbers with appropriate procedures. It should not be necessary to first look at sections for each bus fleet and then at a list of bus numbers for that bus fleet to find the appropriate procedure.
- Firefighters are interested in hazard information, such as what can explode, where there are fluids, circumstances that can lead to tank rupture, or what happens when there is a PRD release. Generally, this type of information is not available.
- Although many guides contain phone numbers of various transit personnel, more specific types of information could be supplied by those transit experts, if they were contacted.
- The information in the notebooks should coordinate with information in the U.S. Department of Transportation's *2004 Emergency Response Guidebook* (*5*). That document is frequently used by responders when developing a response to a hazardous material.

Fire Training Academies

Firefighters are often trained at a state or regional fire academy. Working with the instructors at those academies could be a fruitful (and necessary) way to communicate transit response procedures. Firefighters may not consider transit staff alone to be a credible source of information on fire safety and emergency response. In this respect, it may be better to prepare responder guides jointly with someone having a fire department or fire academy affiliation.

National Standard for Emergency Responders

There is a perceived need for a national standard for emergency procedures to use in responding to natural gas bus incidents, to distribute to fire responders. The rationale is that the national standard would then flow down to all fire jurisdictions in a service area. The presumption is that with a national standard, the firefighter response to transit bus fires would be more consistent with a transit agency's expectations.

However, it is not clear what such a standard would contain. Information on transit equipment tends to be specific to the transit agency involved, and it changes as new equipment is acquired and old equipment is retired. Moreover, the strategy used by firefighters when they arrive on the scene of a bus fire depends greatly on the response time (which affects the extent of the fire), the resources available (e.g., size of the crew and the number of pieces of fire apparatus available on the scene), the local situation (e.g., distance to an adequate water supply or distance to nearby structures), and the personal preferences of the fire commander. Thus, the content of such a standard might be too general for specific application.

KNOWLEDGE GAPS

This study identified numerous areas where additional information and resources could benefit the transit community. Many of these areas are interrelated and are discussed here.

Transit Experience with Natural Gas Buses

Incident Reporting

Standardized reporting of incidents involving natural gas buses and facilities would be valuable in defining problem areas and involving resources.

Procedures Development

Overall, the survey found that more than 50% of the responding transit agencies have not prepared emergency procedures for the both facility and vehicle emergencies, and 40% have not communicated any emergency procedures to local fire or police departments.

Fire Department Issues

Much more attention should be given to surveying fire departments and firefighters about their concerns and their experiences.

Fire Department Involvement

Fire department involvement in the preparation of emergency procedures was found to be minimal or nonexistent. To gain the insights and experiences of firefighters and to increase the credibility of procedures and recommendations with emergency responders, there is a strong need for fire department involvement in the procedure development process.

Information Transfer

A fire department briefing package should be developed. Before such development, fire departments should be approached to determine (1) their concerns, (2) their experiences with natural gas vehicles and facilities, and (3) the format that they find most effective.

Vehicle Fires

In regard to vehicle fires, more information is needed to prepare a decision tree to help fire fighters determine whether or not a natural gas bus fire can be safely extinguished and the most effective strategy to use. Clearly, such a resource must be prepared jointly by the transit community and fire department experts.

Debriefings

There is a strong need for debriefings from firefighters who have responded to incidents involving natural gas buses fires. For firefighters, as for many professionals, the experiences of colleagues are often the most credible sources of information. Collecting this information and distilling it into lessons learned is important.

Training Presentation

Information resources for firefighters could include the production of a training video or slide presentation showing what to expect, what can happen, and what techniques work. Such a presentation would not show such sales-oriented topics as the advantages of alternative fuels, why natural gas is good for the environment, or how safe natural gas is compared with gasoline. It would show fire department responses to actual natural gas bus emergencies and would focus on specific emergency response techniques, potential hazards to firefighters, and methods of fire attack that minimize damage to the bus.

Technical Information

Ignition Sources

Some statements and procedures for avoiding possible ignition sources, though well intentioned, appear to lack a technical foundation of experimental measurements or detailed calculations. For example, as mentioned, recent statements by the IEEE have cast doubt on the need to consider cellular phones to be ignition sources (*4*). Moreover, there is anecdotal evidence that the extent of the flammable zone associated with a natural gas release is sometimes greatly overestimated by emergency responders. However, without actual measurements it is difficult to suggest a different approach.

Hazards from Small Gas Leaks and Releases

Small leaks are often associated with fittings that are improperly tightened, insufficient use of pipe thread sealant, defective O-rings, or foreign matter on mating surfaces. Although small leaks present only a minor fire hazard, they result in an odor of gas and can trigger methane detection systems; both are situations that can generate an emergency response. More information is needed to determine the degree to which small leaks can support a flame under practical conditions of ventilation and gas dispersion.

Procedures for Nonodorized Gas

Some transit agencies use nonodorized natural gas. LNG cannot be odorized because the odorant is a solid at cryogenic temperatures, and CNG derived from LNG will not be odorized unless it is added by the transit agency. The use of nonodorized fuels requires a particular awareness of the need to depend on instruments for sensing the existence and extent of any natural gas releases.

Bus and Facility Design

Standard signage should be developed for transit buses and facilities that shows the locations of shutoffs and vents, the status of combustible gas detectors, and extinguishing points.

CHAPTER EIGHT

CONCLUSIONS

The hazards associated with the use of natural gas-fueled buses differ from those associated with diesel buses. Emergency response procedures that respond to and mitigate these hazards are required.

For this synthesis report, insight into current practices was determined by a combination of a survey of agencies using natural gas as an alternative fuel and an examination of actual procedures provided by several of those agencies. The survey covered transit experience with 3,130 natural gas buses.

Key findings were:

- One fuel-related incident per 100 buses per year was experienced by the agencies that responded to the survey.
- Transit mechanics were more likely to be the first responders to a compressed natural gas (CNG) incident than were fire department personnel.
- Of those agencies that had emergency procedures, the majority were developed in-house, whereas the rest were developed by vendors, consultants, or other transit agencies.
- Overall, the survey found that although 84% of transit agencies responding have developed some natural gas-related emergency procedures, more than 50% have not prepared emergency procedures that cover both facility and vehicle emergencies, and 40% have not communicated emergency procedures to local fire or police departments.
- In regard to security, because natural gas differs from diesel fuel in several ways, additional study is needed to define any security issues.

There is a general reluctance among transit agencies to share information on existing procedures. Multiple requests were made for practices to obtain the examples used for this synthesis. Survey results indicated that many transit agencies lacked emergency procedures for scenarios such as a fuel leak on a vehicle in service. Forty percent of the transit agencies had not shared procedures, for any type of emergency, with the fire department.

Two case studies illustrate deficiencies in existing procedures, whereas a third focuses on a firefighter's perspective. In the first two cases, the agencies had written procedures and had shared them with their local fire departments. Subsequent on-board fires were allowed to burn, resulting in a total loss of the vehicle. Whether there are written procedures or not, fire departments may respond to CNG bus fires with the same approach as for an automobile fire—where a total loss is almost a given.

Two lessons learned from actual incidents are of particular interest. First, better information would help firefighters become more proactive in responding to incidents involving CNG vehicles. Second, despite the existence of procedures, there appears to be a significant disconnect in the expectations of agencies that operate CNG-fueled buses and the fire departments that respond to incidents involving these vehicles.

This synthesis illustrates that there are significant knowledge gaps in protocols followed in response to fires, as well as gas releases involving CNG-fueled transit buses. The question remains of whether or not there is value in developing a standard set of protocols that can be used by agencies operating a CNG fleet. However, because much of what is known is based on anecdotal information, there is need for the following issues to be addressed:

- There is an immediate need for
  - A repository and standard reporting format for incidents involving natural gas-fueled transit vehicles,
  - A robust definition of the term "incident,"
  - An incentive for agencies to report their experiences, and
  - A mechanism for the dissemination of lessons learned.
- Improvements in vehicle design could help firefighters change their perspective on responding to fires involving natural gas-fueled transit buses.
- The development of natural gas vehicle emergency response protocols needs to occur within the context of the Incident Command System.
- Differences in knowledge, training, and perspective between various stakeholders—including fire departments, police departments, transit agencies, and vehicle manufacturers—indicate that a collaborative effort will be required to develop an effective set of emergency response protocols. Regional fire academies and the International Association of Fire Fighters should also be involved.
- There have already been incidents that highlighted the need for improved emergency response protocols. Clearly, some procedures need to be more fully developed, and additional study is needed to further define the type of information that fire departments need, as

well as to determine the most effective way to communicate that information. For example, firefighters could be helped to recognize areas where there may be imminent harm during emergency response operations and to determine the extent of the area to be cordoned off during an incident involving a natural gas-fueled bus.

- Overall, improved emergency response protocols are needed, along with training programs and materials for firefighters. The cost of developing response protocols could be recovered if the cost of even one transit bus can be saved through better response to fires or other emergencies.

REFERENCES

1. *Inside Fuels and Vehicles,* Feb. 12, 2004, p. 10.
2. "FTA Top Security Program Action Items for Transit Agencies," Federal Transit Administration, Washington, D.C. [Online]. Available: http://www.transit-safety.volpe.dot.gov/Security/SecurityIniatives/Top20 [Nov. 2004].
3. "Bus Fires in Finland During 2000," Accident Investigation Board, Helsinki, Finland, 2001.
4. "Cell Phones Pose No Gas Station Hazard," *Spectrum,* Apr. 2004, p. 6.
5. *2004 Emergency Response Guidebook*, U.S. Department of Transportation, Washington, D.C., 2004, 374 pp.

APPENDIX A

Description of the Incident Command System

This description is drawn mainly from training information available from the Federal Emergency Management Administration on its website at http://training.fema.gov/EMIWeb/IS/is195.asp. This training is directed toward introducing emergency responders to the Incident Command System (ICS).

ICS is the model tool for *command, control,* and *coordination* of a response and provides a means to coordinate the efforts of individual agencies as they work toward the common goal of stabilizing the incident and protecting life, property, and the environment. ICS uses principles that have been proven to improve efficiency and effectiveness in a business setting and applies the principles to emergency response.

We live in a complex world in which responding to emergencies, from single-car accidents to large-scale disasters, often requires cooperation among several agencies. Given the current movement toward using an ICS structure for emergency response, it is likely, therefore, that one will function in an ICS environment. In an emergency, an individual may not be working for one's day-to-day supervisor or may be working in a different location. Thus, emergency response operations are *not* "business as usual."

This unit will provide the rationale for using ICS and show how ICS can be used to manage all types of incidents. It also will describe the basic ICS organization, how ICS can form the basis for an effective emergency management system, and how ICS can enhance Emergency Operations Center (EOC) operations.

WHEN IS ICS USED?

ICS has been proven effective for responding to all types of incidents, including:

- Hazardous materials (hazmat) incidents;
- Planned events (e.g., celebrations, parades, concerts, and official visits);
- Natural hazards;
- Single agency and multiagency law enforcement incidents;
- Inadequate comprehensive ***resource management*** strategy;
- Incidents involving multiple casualties;
- Multijurisdictional and multiagency incidents;
- Air, rail, water, or ground transportation accidents;
- Wide-area search and rescue missions;
- Pest eradication programs; and
- Private-sector emergency management programs.

Federal law requires the use of ICS for response to hazmat incidents. Many states are adopting ICS as their standard for responding to all types of incidents. ICS has been endorsed by the American Public Works Association and the International Association of Chiefs of Police and has been adopted by the National Fire Academy as its standard for incident response. ICS is included in the National Fire Protection Association (NFPA) "Recommended Practice for Disaster Management" (NFPA1600). ICS is also part of the National Interagency Incident Management System (NIIMS).

ICS HISTORY

ICS was developed in the 1970s in response to a series of major wildfires in southern California. At that time, municipal, county, state, and federal fire authorities collaborated to form the Firefighting Resources of California Organized for Potential Emergencies (FIRESCOPE). FIRESCOPE identified several recurring problems involving multiagency responses, such as

- Nonstandard terminology among responding agencies,
- Inadequate capability to ***expand and contract*** as required by the situation,
- Nonstandard and nonintegrated communications,
- A lack of consolidated action plans, and
- A lack of designated facilities.

Efforts to address these difficulties resulted in the development of the original ICS model for effective incident management. Although originally developed in response to wildfires, ICS has evolved into an all-risk system that is appropriate for all types of fire and non-fire emergencies. Much of the success of ICS has resulted directly from applying

- A common organizational structure and
- Key management principles in a standardized way.

ICS ORGANIZATION

Many incidents—whether major accidents (such as hazmat spills), minor incidents (such as house fires and utility outages), or emergencies and major disasters (such as tornadoes, hurricanes, and earthquakes)—require a response from a number of different agencies. Regardless of the size of the incident or the number of agencies involved in the response, all incidents require a coordinated effort to ensure an effective response and the efficient, safe use of resources.

No single agency or department can handle an emergency situation of any scale alone. All parties must work together to manage the emergency. To coordinate the effective use of all of the available resources, agencies need a formalized management structure that lends consistency, fosters efficiency, and provides direction during a response. The ICS organization is built around five major components:

- Command
- Planning
- Operations
- Logistics
- Finance/Administration.

The relationship among these components is shown in Figure A1. These five major components are the foundation on which the ICS organization develops. They apply during a routine emergency, when preparing for a major event, or when managing a response to a major disaster. In small-scale incidents, all of the components may be managed by one person, the *Incident Commander.* Large-scale incidents usually require that each component, or *section,* is set up separately. Each of the primary ICS sections may be divided into smaller functions as needed. The ICS organization has the capability to expand or contract to meet the needs of the incident, but **all incidents, regardless of size or complexity, will have an Incident Commander.** A basic ICS operating guideline is that the Incident Commander is responsible for on-scene management until command authority is transferred to another person, who then becomes the Incident Commander. Each of the major components of the ICS organization is described in the sections that follow.

Command Function

The command function is directed by the Incident Commander, who is the person in charge at the incident, and who must be fully qualified to manage the response. Major responsibilities for the Incident Commander include

- Performing command activities, such as establishing command and establishing the Incident Command Post (ICP);
- Protecting life and property;
- Controlling personnel and equipment resources;
- Maintaining accountability for responder and public safety, as well as for task accomplishment; and
- Establishing and maintaining an effective liaison with outside agencies and organizations, including the EOC, when it is activated.

Incident management encompasses

- Establishing command,
- Ensuring responder safety,
- Assessing incident priorities,
- Determining operational objectives,
- Developing and implementing the Incident Action Plan (IAP),
- Developing an appropriate organizational structure,
- Maintaining a manageable span of control,
- Managing incident resources,
- Coordinating overall emergency activities,
- Coordinating the activities of outside agencies,
- Authorizing the release of information to the media, and
- Keeping track of costs.

An effective Incident Commander must be assertive, decisive, objective, calm, and a quick thinker. To handle all of the responsibilities of this role, the Incident Commander also needs to be adaptable, flexible, and realistic about his or her limitations. The Incident Commander also needs to have the capability to delegate positions appropriately as needed for an incident. **Initially, the Incident Commander will be the senior responder to arrive at the scene.** As additional responders arrive, command will transfer on the basis of who has primary authority for overall control of the incident. As incidents grow in size or become more complex, the responsible jurisdiction or agency may assign a more highly qualified Incident Commander. At transfer of command, the outgoing Incident Commander must give the incoming Incident Commander a full briefing and notify all staff of the change in command.

As incidents grow, the Incident Commander may delegate authority for performing certain activities to others, as required. When expansion is required, the Incident Commander will establish the other *Command Staff* positions shown in Figure A2.

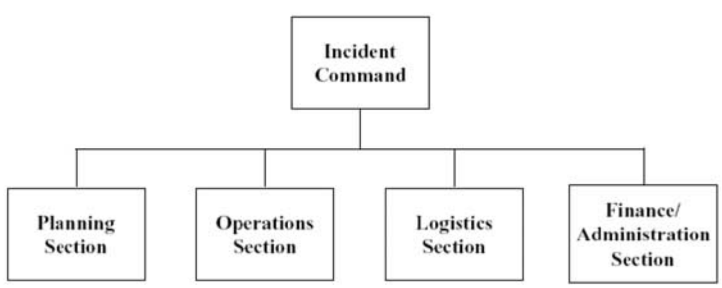


FIGURE A1 Relationships among the five major components of the ICS organization.

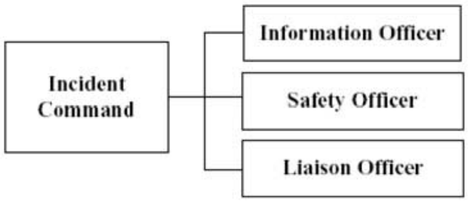


FIGURE A2 Command staff positions.

- The *Information Officer* handles all media inquiries and coordinates the release of information to the media with the Public Affairs Officer at the EOC.
- The *Safety Officer* monitors safety conditions and develops measures for ensuring the safety of all assigned personnel.
- The *Liaison Officer* is the on-scene contact for other agencies assigned to the incident.

The Incident Commander will base the decision to expand (or contract) the ICS organization on three major incident priorities:

- *Life safety*—The Incident Commander's first priority is always the life safety of the emergency responders and the public.
- *Incident stability*—The Incident Commander is responsible for determining the strategy that will
  - Minimize the effect that the incident may have on the surrounding area.
  - Maximize the response effort while using resources efficiently. The size and complexity of the command system that the Incident Commander develops should be in keeping with the *complexity* (i.e., level of difficulty in the response) of the incident, not the size (which is based on geographic area or number of resources).
- *Property conservation*—The Incident Commander is responsible for minimizing damage to property while achieving the incident objectives.

As incidents become more involved, the Incident Commander can activate additional *General Staff* sections (i.e., Planning, Operations, Logistics, and/or Finance/Administration), as necessary. Each *Section Chief*, in turn, has the authority to expand internally to meet the needs of the situation.

Planning Section

In smaller events, the Incident Commander is responsible for planning, but when the incident is of larger scale, the Incident Commander establishes the *Planning Section.* The Planning Section's function includes the collection, evaluation, dissemination, and use of information about the development of the incident and status of resources. This section's responsibilities can also include creation of the IAP, which defines the response activities and resource utilization for a specified time period.

Operations Section

The *Operations Section* is responsible for carrying out the response activities described in the IAP. The Operations Section Chief coordinates Operations Section activities and has primary responsibility for receiving and implementing the IAP. The Operations Section Chief reports to the Incident Commander and determines the required resources and organizational structure within the Operations Section. The Operations Section Chief's main responsibilities are to

- Direct and coordinate all operations, ensuring the safety of Operations Section personnel;
- Assist the Incident Commander in developing response goals and objectives for the incident;
- Implement the IAP by requesting (or releasing) resources through the Incident Commander; and
- Keep the Incident Commander informed of situation and resource status within operations.

Logistics Section

The *Logistics Section* is responsible for providing facilities, services, and materials, including personnel to operate the equipment requested for the incident. This section takes on great significance in long-term or extended operations. It is important to note that the Logistics Section functions are geared to support the incident responders. For example, the Medical Unit in the Logistics Section provides care for the incident responders, not civilian victims.

Finance/Administration Section

Though sometimes overlooked, the *Finance/Administration Section* is critical for tracking incident costs and reimbursement accounting. Unless costs and financial operations are carefully recorded and justified, reimbursement of costs is difficult, if not impossible. The Finance/Administration Section is especially important when the incident is of a magnitude that may result in a Presidential Declaration. Each of these functional areas can be expanded into additional organizational units with further delegation of authority. They also may be contracted as the incident deescalates.

ICS CONCEPTS AND PRINCIPLES

The adaptable ICS structure is composed of major components to ensure quick and effective resource commitment and to minimize disruption to the normal operating policies and procedures of responding organizations. Remember that ICS concepts and principles have been tested and proven over time—in business and industry and by response agencies at all governmental levels. ICS training is required to ensure that all who may become involved in an incident are familiar with ICS principles. This section reports on how the application of these concepts and principles makes ICS work. An ICS structure should include

- Common terminology,
- A modular organization,
- Integrated communications,
- Unity of command,
- A unified command structure,
- Consolidated IAPs,
- A manageable span of control,
- Designated incident facilities, and
- Comprehensive resource management.

Common terminology is essential in any emergency management system, especially when diverse or other than first-response agencies are involved. When agencies have even slightly different meanings for terms, confusion and inefficiency can result. Do you know what a staging area is? Will all responders understand what a staging area is? In ICS, major organizational functions, facilities, and units are predesignated and given titles. ICS terminology is standard and consistent among all of the agencies involved.

To prevent confusion when multiple incidents occur simultaneously within the same jurisdiction, or when the same radio frequency must be used for multiple incidents, the Incident Commander will specifically name his or her incident. For example, an incident that occurs at 14th and Flower might be called "Flower Street Command." One that occurs at 14th and Penn could be called "Penn Street Command." Other guidelines for establishing common terminology include

- Response personnel should use common names for all personnel and equipment resources, as well as for all facilities in and around the incident area.
- Radio transmissions should use clear text (i.e., plain English, without "ten" codes or agency-specific codes).

All common terminology applies to all organizational elements, position titles, and resources.

A *modular organization* develops from the top-down organizational structure at any incident. "Top-down" means that, at the very least, the command function is established by the first arriving officer who becomes the Incident Commander. As the incident warrants, the Incident Commander activates other functional areas (i.e., sections). In approximately 95% of all incidents, the organizational structure for operations consists of command and single resources (e.g., one fire truck, an ambulance, or a tow truck). If needed, however, the ICS structure can consist of several layers. In this unit, we have described the two top layers: command and general staff. Other layers may be activated as warranted.

Integrated communications is a system that uses a common communications plan, standard operating procedures, clear text, common frequencies, and common terminology. Several communication networks may be established, depending on the size and complexity of the incident.

Unity of command is the concept by which each person within an organization reports to only one designated person.

A *unified command* structure allows all agencies with responsibility for the incident, either geographic or functional, to manage an incident by establishing a common set of incident objectives and strategies. Unified command does not mean losing or giving up agency authority, responsibility, or accountability. The concept of unified command means that all involved agencies contribute to the command process by

- Determining overall objectives,
- Planning jointly for operational activities while conducting integrated operations, and
- Maximizing the use of all assigned resources.

Under unified command, the following always apply:

- The incident functions under a single coordinated IAP,
- One Operations Section Chief has responsibility for implementing the IAP, and
- One ICP is established.

Consolidated IAPs describe response goals, operational objectives, and support activities. The decision to have a written IAP is made by the Incident Commander. ICS requires written plans whenever

- Resources from multiple agencies are used,
- Several jurisdictions are involved, and
- The incident is complex (e.g., changes in shifts of personnel or equipment are required).

IAPs should cover all objectives and support activities that are needed during the entire operational period. A written plan is preferable to an oral plan because it clearly demonstrates responsibility, helps protect the community from liability, and provides documentation when requesting state and federal assistance. IAPs that include the measurable goals and objectives to be achieved are always prepared around a time frame called an *operational period.* Operational periods can be of various lengths, but should be no longer than 24 hours. Twelve-hour operational periods are common for large-scale incidents. The Incident Commander determines the length of the operational period based on the complexity and size of the incident.

A *manageable span of control* is defined as the number of individuals one supervisor can manage effectively. In ICS, the span of control for any supervisor falls within a range of three to seven resources, with five being the optimum. If those numbers increase or decrease the Incident Commander should reexamine the organizational structure.

Designated incident facilities include

- An ICP at which the Incident Commander, the Command Staff, and the General Staff oversee all incident operations.
- Staging areas at which resources are kept while awaiting incident assignment. Other incident facilities may be designated for incidents that are geographically dispersed, require large numbers of resources, or require highly specialized resources.

Comprehensive resource management

- Maximizes resource use,
- Consolidates control of single resources,
- Reduces the communications load,
- Provides accountability,
- Reduces freelancing, and
- Ensures personnel safety.

All resources are assigned to a status condition:

- *Assigned* resources are performing active functions.
- *Available* resources are ready for assignment.
- *Out-of-service* resources are not ready for assigned or available status.

Any changes in resource location and status must be reported promptly to the Resource Unit by the person making the change. Personnel accountability is provided throughout all of ICS. All personnel must check in as soon as they arrive at an incident. Resource units, assignment lists, and unit logs are all ways for personnel to be accounted for. When personnel are no longer required for the response, they must check out so that they can be removed from the resource lists.

The ICS principles can and should be used for all types of incidents, both small and large—from a warrant execution to a hostage situation or a search for a missing child. Because ICS can be used at virtually any type of incident of any size, it is important that all responders use the ICS approach.

ICS AND THE EMERGENCY OPERATIONS CENTER

Most jurisdictions maintain an EOC as part of their community's emergency preparedness program. An EOC is where department heads, government officers and officials, and volunteer agencies gather to coordinate their response to an emergency event. The proper interface between the EOC and the on-scene management should be worked out in advance, if possible.

The Incident Command structure and the EOC function together with the same goals, but function at different levels of responsibility. The Incident Command operation is responsible for on-scene response activities, and the EOC is responsible for the entire community-wide response to the event. (Note that the EOC also can function under an ICS structure.) If the EOC does operate under the ICS structure, it must be careful not to confuse personnel at the EOC with the same personnel on site. Thus, ICS is a management system that works both for the responding agencies and for the community.

SUMMARY

The main components of an ICS structure are

- Command
- Planning
- Operations
- Logistics
- Finance/Administration

The *Incident Commander* has overall control over the incident. In a small incident, he or she may assume the responsibilities of all components. In larger or more complex incidents, the Incident Commander may assign other members of the *Command Staff,* including an *Information Officer,* a *Safety Officer,* and/or a *Liaison Officer.* The Incident Commander also may assign *General Staff,* who serve as *Section Chiefs* for the Planning, Operations, Logistics, and Finance/Administration Sections. The Section Chiefs have the authority to expand or contract their operations as the demands of the incident increase or decrease.

ICS operates according to basic principles to ensure quick and effective resource commitment and to minimize disruption of usual operating policies and procedures of responding organizations. These principles include

- *Common terminology,* which ensures that all responders use terms that are standard and consistent.
- A *modular organization,* which enables the ICS structure to expand or contract to meet the needs of the incident.
- *Integrated communications,* which establishes a common communications plan, standard operating procedures, clear text, common frequencies, and common terminology.
- *Unity of command,* where each person within an organization reports to only one designated person.
- *A unified command structure,* which allows all agencies with responsibility for the incident, either geographic or

functional, to manage an incident by establishing a common set of incident objectives and strategies.

- *Consolidated IAPs,* which describe response goals, operational objectives, and support activities.
- *A manageable span of control,* which limits the number of resources that any supervisor may control to between three and seven, with five being optimal.
- *Designated incident facilities,* which include an ICP and may include staging areas. Other incident facilities may be designated, depending on the requirements of the incident.
- *Comprehensive resource management,* which maximizes resource use, consolidates control of single resources, reduces the communications load, provides accountability, reduces freelancing, and ensures personnel safety.

These principles should be used for all types of incidents, both small and large. At larger or more complex incidents, the ICS structure in the field will work with personnel in the EOC (which also may be organized under ICS principles). The Incident Command and the EOC function together and work toward the same goals, but their responsibilities are at different levels. The Incident Command operation is responsible for on-scene response activities and the EOC is responsible for community-wide resource management.

APPENDIX B

Questionnaire

Emergency Procedures for Use of Natural Gas in Transit
TCRP Synthesis SC-07

Please answer the following 12 questions. You may choose to send a separate, more detailed response to any of the questions.

Please send the completed questionnaire and any additional responses to:
Battelle, 505 King Avenue, Columbus, OH 43201.

1. How many natural gas vehicles do you have on the property? ______

2. How many centers of operation (bases) have natural gas vehicles? ______

3. Have *emergency* procedures been established that are *specific to natural gas* transit vehicles or facilities? These might include procedures for the following:

   ______ natural gas leak/release in storage or maintenance buildings

   ______ natural gas/leak/release in fueling facilities

   ______ natural gas leak/release on vehicles in service

   ______ natural gas release during vehicle maintenance

   ______ natural gas leak/release due to vehicle collision or traffic accident

   ______ fire in building or facility with natural gas vehicles

   ______ fire involving a natural gas vehicle

   ______ security emergency; e.g., bomb threat involving natural gas vehicle or facility

4. If such procedures have been developed, were they developed by:

   ______ your own organization

   ______ a consultant

   ______ a gas supplier or distributor

   ______ the local fire department

   ______ used procedures of another transit agency,

   other, please specify ________________________

5. Are emergency procedures distributed outside your organization; e.g., to local fire or police departments? No ___ Yes ___ If yes, to whom?
   ____

6. How are local emergency responders informed about natural gas transit vehicles and facilities?
   ____ notebooks ____facility visits ____train together ____ joint drills

7. Have you established security procedures that are specific to the use of natural gas, or made security-related modifications to natural gas vehicles, equipment, or facilities?
   No ___ Yes ___ If yes, please describe briefly:
   ____

8. How many incidents or emergencies involving natural gas transit vehicles or facilities has your organization experienced? Past year ______ Past 5 years ______

9. Who responded to the natural gas incidents/emergencies?

   ______ transit mechanic

   ______ transit police

   ______ municipal police

   ______ fire department

   ______ Other; e.g., air pollution control district, state or federal agency

10. What were the most significant incidents?

    ____

    ____

11. What issues, problems, and lessons learned have there been with the response?
    ____

    ____

12. What suggestions would you have for other transit properties for developing emergency response procedures for natural gas transit vehicles/facilities?

    ____

    ____

My contact information is:

Transit agency: ____

Name: ______________________________________ Phone: ______ ______ ________

E-mail: ______________________________________

A better person to contact for further information is: ______________________________

APPENDIX C
Summary of Questionnaire Responses

Emergency Procedures for Use of Natural Gas in Transit
TCRP Synthesis SC-07

Please answer the following 12 questions. You may choose to send a separate, more detailed response to any of the questions.

Please send the completed questionnaire and any additional responses to:

Battelle, 505 King Avenue, Columbus, OH 43201.

The following are the responses to the survey questionnaire. All percentages are based on the 19 responding transit agencies, except as noted.

1. How many natural gas vehicles do you have on the property? 3,130 total

2. How many centers of operation (bases) have natural gas vehicles? 32 total

3. Have *emergency* procedures been established that are *specific to natural gas* transit vehicles or facilities? These might include procedures for the following:

   84% natural gas leak/release in storage or maintenance buildings

   68% natural gas/leak/release in fueling facilities

   47% natural gas leak/release on vehicles in service

   68% natural gas release during vehicle maintenance

   37% natural gas leak/release due to vehicle collision or traffic accident

   58% fire in building or facility with natural gas vehicles

   58% fire involving a natural gas vehicle

   21% security emergency; e.g., bomb threat involving natural gas vehicle or facility

4. If such procedures have been developed, were they developed by:

   72% your own organization

   33% a consultant

   28% a gas supplier or distributor

   50% the local fire department

   22% used procedures of another transit agency

   other, please specify: CNG station contractor (1)

5. Are emergency procedures distributed outside your organization; e.g., to local fire or police departments? No Yes If yes, to whom? 61% with fire department, 22% with police or sheriff's department as well [of 18 respondents]

6. How are local emergency responders informed about natural gas transit vehicles and facilities?
17% notebooks 67% facility visits 72% train together 22% joint drills [of 18 respondents]

7. Have you established security procedures that are specific to the use of natural gas, or made security-related modifications to natural gas vehicles, equipment, or facilities?
No Yes If yes, please describe briefly: 4% (locked/secured compressor facility)

8. How many incidents or emergencies involving natural gas transit vehicles or facilities has your organization experienced? Past year 31 Past 5 years 24 (5-year data did not include Los Angeles)

9. Who responded to the natural gas incidents/emergencies?

   92% transit mechanic

   8% transit police

   31% municipal police

   69% fire department

   23% Other; e.g., air pollution control district, state or federal agency

10. What were the most significant incidents?

    Bus fires due to turbocharger failures, brake problems, electrical shorts, oil leaks onto hot turbocharger or manifold, PRD releases, safety valve on cascade

11. What issues, problems, and lessons learned have there been with the response?

    Need to familiarize fire department with CNG; fire department did not attempt to control fire on bus, leading to heavy damage to bus; need to have and practice procedures; get worker input to procedures; get fire department inputs to procedures

12. What suggestions would you have for other transit properties for developing emergency response procedures for natural gas transit vehicles/facilities?

    Need to keep reinforcing procedures and training

APPENDIX D

Transit Agencies That Responded to the Questionnaire

Metropolitan Atlanta Rapid Transit Authority, Atlanta, GA
Niagara Frontier Transportation Authority, Buffalo, NY
Unitrans, Davis, CA
Kenosha Department of Transportation, Kenosha, WI
Los Angeles County Metropolitan Transit Authority, Los Angeles, CA
Monterey–Salinas Transit, Monterey, CA
Muskingum Area Transit System, Muskingum, MI
North County Transit District, Oceanside, CA
South Coast Area Transit, Oxnard, CA
Port Authority of Allegheny County, Pittsburgh, PA
Sacramento Regional Transit District, Sacramento, CA
Bi-State Development Agency, St. Louis, MO
Salem Area Mass Transit District, Salem, OR
Omnitrans, San Bernardino, CA
Santa Fe Trails, Santa Fe, NM
Simi Valley Transit, Simi Valley, CA
Springfield Mass Transit District, Springfield, IL
CNY Centro, Syracuse, NY
Transit Service, Tucson, AZ

Abbreviations used without definitions in TRB publications:

AASHO	American Association of State Highway Officials
AASHTO	American Association of State Highway and Transportation Officials
APTA	American Public Transportation Association
ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
ATA	American Trucking Associations
CTAA	Community Transportation Association of America
CTBSSP	Commercial Truck and Bus Safety Synthesis Program
DHS	Department of Homeland Security
FAA	Federal Aviation Administration
FHWA	Federal Highway Administration
FMCSA	Federal Motor Carrier Safety Administration
FRA	Federal Railroad Administration
FTA	Federal Transit Administration
IEEE	Institute of Electrical and Electronics Engineers
ITE	Institute of Transportation Engineers
NCHRP	National Cooperative Highway Research Program
NCTRP	National Cooperative Transit Research and Development Program
NHTSA	National Highway Traffic Safety Administration
NTSB	National Transportation Safety Board
SAE	Society of Automotive Engineers
TCRP	Transit Cooperative Research Program
TRB	Transportation Research Board
TSA	Transportation Security Administration
U.S.DOT	United States Department of Transportation