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COMMONALITIES IN TRANSPORTATION FIRE SAFETY: REGULATIONS, RESEARCH AND DEVELOPMENT, AND DATA BASES

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16. Abstract

This report presents a comprehensive review of current modal fire safety efforts within the U.S. Department of Transportation. Common fire safety problems and modal administration response are identified. Work completed includes the following:

1. A review of modal administration fire regulations for extent of coverage and commonalities,

2. A review of modal administration fire research and development projects to determine commonalities of purpose and interest in current projects which either support or suggest revision of existing regulations, or in some instances, suggest promulgation of new regulations, and

3. A survey of statistical fire/accident data bases to determine the availability of transportation fire statistics and the commonalities of these data bases.

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PREFACE

The Office of the Secretary of Transportation (OST) is developing an integrated fire safety program to address national transportation safety.

This report reviews the commonalities which exist among the modal administrations of the U.S. Department of Transportation in the categories of regulations, research and development activities, and statistical data bases. Areas for potential cross-application are analyzed, and further suggestions are made for development work.

The author wishes to thank Mr. Charles W. McGuire of OST, for his sponsorship and helpful comments and guidance on this effort.

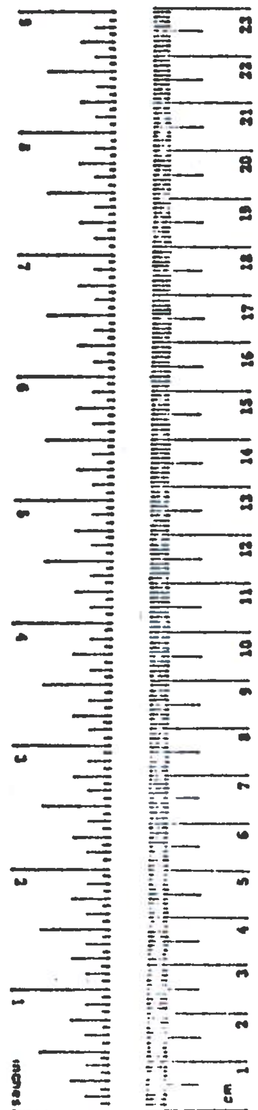
W.T. Hathaway of the Transportation Systems Center (TSC) provided direction and guidance during the preparation of this report. Dr. Herbert L. Bogen of Raytheon Service Company (RSC) provided the framework for the overall analysis and Appendix A. He also prepared Section 4 and Appendix C. Robert P. Anderson, formerly of RSC and presently a member of the TSC staff, prepared Sections 1, 2, 3 and Appendix B. Stephanie H. Markos (RSC), provided research support and prepared the Executive Summary.

METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

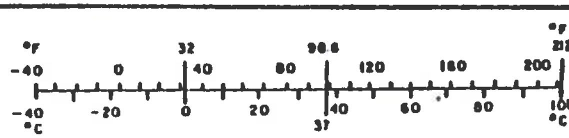
Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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EXECUTIVE SUMMARY

This report presents a comprehensive review of current modal fire safety efforts within the Department of Transportation (DOT) and will serve as the basis for the preparation of an integrated fire safety program plan.

Current modal efforts are reviewed to identify common fire safety problems and the responses of the modes to these problems. This report examines not only deficiencies identified in a previous DOT study* but encompasses a much broader scope as evidenced by the following completed tasks:

1. A review of modal administration fire regulations for extent of coverage and commonalities,
2. A review of modal administration fire research and development projects to determine commonalities of purpose and interest in current projects, which either support or suggest revision of existing regulations, or in some instances, suggest promulgation of new regulations, and
3. A survey of statistical fire/accident data bases to determine the availability of transportation fire statistics and the commonalities of these data bases.

A limited review of other governmental and non-governmental related activities is also included where it has been determined that such efforts could prove useful to the modal administrations.

*McLane, Barbara, "Review of Transportation Fire Safety," Safety Study No. TES 10-77-S, July 1977. Available upon request from the Office of Energy and Environment, U.S. DOT, Washington, DC.

Summaries of the three areas investigated are presented below:

REGULATIONS SUMMARY

An extensive survey of fire safety regulations,* promulgated by the modal administrations, was conducted. This survey was then reviewed and identified two areas for further investigation:

1. The extent to which fire safety regulations, issued by each of the modal administrations, cover potential hazards, and

2. The degree of existing commonality in fire safety problems and fire prevention and control methods.

The Federal Aviation Administration (FAA) and the United States Coast Guard (USCG) have been the most active in issuing fire safety regulations; the other administrations, with one exception, the Urban Mass Transportation Administration (UMTA), have promulgated regulations to varying degrees. A common emphasis exists in the regulation of furnishings and interior materials, fuel system integrity, and the quality of electrical insulation. Moreover, the FAA and USCG regulations extensively address fire protection and control equipment, quality assurance of structural components, and fire safety aspects in transportation buildings and facilities.

UMTA has proposed flammability specification guidelines for interior materials used in transit vehicles but has not, as yet, issued any formal regulations.

It appears that the modal administrations would benefit from technology sharing in the regulatory area. Appendix A addresses regulatory commonalities and provides the basis for such cooperation.

*Hathaway, W.T., Technical Monitor, "Transportation Fire Safety-Summary of Regulations," Staff Study DOT-OST, October, 1978. Available upon request from Mr. William T. Hathaway, Transportation Systems Center, Cambridge, MA.

RESEARCH AND DEVELOPMENT SUMMARY

Many fire safety regulations have resulted from fire related research and development (R&D) programs. Modal administrations sponsoring R&D efforts use the results of such investigations to establish pertinent regulations.

A review of fire R&D project abstracts indicates the specific efforts sponsored by the modal administrations and other groups. As noted in the regulations summary, the majority of R&D projects have been sponsored by the FAA and the Coast Guard, with emphasis on fire prevention and control equipment, interior materials flammability, and fuel system integrity. Analysis of this review reveals many areas of common interest among the modal agencies. A further coordination of R&D activities will minimize the possibility of duplication of effort and will facilitate the distribution of knowledge among the administrations. Highlights of three common interest R&D areas are presented below.

Fire and Smoke Detectors

Fire and smoke detectors play an important role in preventing minor smoke or fire incidents from developing into major conflagrations. Among the modal administrations research efforts, the FAA is sponsoring the simulation and flight testing of overheat detection systems. An evaluation of various types of fire detectors is being conducted by the Coast Guard.

The United States Air Force is attempting to develop the use of ultra-violet and infra-red sensors to reliably detect fires and eliminate false alarms. The results of this effort could be utilized for other transportation vehicles regulated by the modal administrations.

Reliable early warning detection devices may be utilized by the Federal Railroad Administration (FRA) and UMTA, two administrations that do not currently require their use.

Interior Materials

Non-metallic materials (plastics, elastomers) are extensively used in the furnishing of interiors of many transportation vehicles.

Major efforts to explore the flammability and toxicity of these materials have been undertaken by the DOT-Office of the Secretary, the FAA, USCG, National Highway Traffic Safety Administration (NHTSA) and UMTA. One significant effort is the FAA sponsorship of the development of a Combined Hazard Index to assist in determining the potential fire hazard within an entire aircraft cabin by investigating the relationship between combined flammability, smoke, and toxicity hazards. The results of this work may benefit other modes in assessing the fire hazard of light rail and rapid rail transit car interiors.

Fuel Systems

The prevention of fuel system fires centers on research to minimize hazards resulting from the leakage and accidental ignition of fuel. Various approaches to reduce the risk of such hazards, including the investigation of fuel tank integrity, fuel composition, and spontaneous combustion of fuel, have been used by the Coast Guard, the FAA, and NHTSA.

The Coast Guard has studied the use of fiberglass construction to improve fuel tank rupture resistance. NHTSA conducted vehicle tests to determine the amount of fuel spillage under crash conditions. The FAA is examining novel jet fuel that, upon accidental release, will not expand into a highly combustible mist. Another FAA effort involves the nitrogen inerting of fuel tanks to inhibit oxygen build-up and the risk of spontaneous combustion.

The development of improved fuel tank structure, safer fuels, and successful fuel tank inerting could contribute to the increased fire safety of vehicles regulated by all the modal administrations.

The examples cited above illustrate the existing commonalities of interest and potential cross-application among the modal administrations.

The detailed review of R&D activities contained in Section 3 of this report identifies a number of areas in which current research continues and new efforts could be initiated.

An extensive discussion of areas in which further R&D work could result in increased fire safety is presented in Appendix B.

Statistical data concerning transportation fires can also be used to determine areas in which further R&D could reduce or eliminate fire hazards.

DATA BASE SUMMARY

Information concerning transportation fire causes, contributing factors, damage, injuries, etc. is available to a varying degree from statistical data bases. Various types of statistical data bases are maintained by the modal administrations and other groups. The examination of sixteen major data bases* containing transportation fire/accident information identified the following areas for further analysis:

1. Extent of transportation fire-related content and usefulness of data for analytical purposes, and
2. The degree of existing or potential commonalities of the data bases.

With the exception of NHTSA's National Crash Severity Study-Vehicle Fire Supplement, none of the accident data bases was specifically designed for the study of transportation fires. As a result, many of the accident data bases examined contain a minimal amount of vehicle fire data.

Commonalities in the data bases were identified as to their purpose and actual use, data base structures, categories, level of information, and data collection procedures.

A common use for data bases designed for regulatory or administrative purposes is the retrieval of individual case information. Among common uses for data bases designed for research and analysis are the detection of patterns and trends and the measuring of the effects of new regulations, standards and technologies.

*Hathaway, W.T., I.Litant, "Assessment of Current U.S. Department of Transportation Fire Safety Efforts," Transportation Systems Center, Cambridge, MA, Report No. UMTA-MA-06-0051-79-4, July 1979.

The amount and kind of fire data contained in the data bases varies and is, in most cases, quite limited. The data that are mos important and the most difficult to obtain concern the origination and development of vehicle fires.

In this regard, the two most comprehensive data bases, dealing with structure, categories, and level of detail, are the National Fire Protection Association's (NFPA) Fire Incident Data Organizatic (FIDO) and the National Fire Incident Reporting System (NFIRS), established by the U.S. Fire Administration (USFA).

Despite differences in modes and operating environments, a need exists for a common set of categories and items to provide a basis for fire safety analysis. A comprehensive list of categories and items which represent an "ideal" data base is included in Appendix C.

Data fitting into these classifications are obtained from various sources. Some administrations require the submission of reports from transportation companies, carriers, and transit properties, while others conduct their own field investigations. Local fire departments voluntarily file information with the NFPA.

Because under-reporting of fire accidents/incidents is common, whether reporting is mandatory or voluntary, a sampling approach using field investigative teams, would perhaps be a more reliable method of collecting transportation fire statistics.

A summary of statistical data base commonalities is included in Section 4, Table 4-1 of this report.

1. INTRODUCTION

1.1 PURPOSE

This study was conducted to identify commonalities in fire problems experienced by modal administrations and the programs they have developed to deal with these problems. In order to take advantage of cumulative knowledge and to avoid the possibility of duplication of effort, DOT modal administrations should further coordinate their efforts in attacking fire safety problems.

The scope of the study includes a detailed review and evaluation of three major elements of modal fire safety programs: regulations, research and development activities, and statistical data bases. The current status of efforts in these three elements is explored, and commonalities among modal administrations are cited in which the knowledge developed or the experience gained by one administration would be helpful to another administration in dealing with a similar fire safety problem. The conclusions drawn from this study will provide a basis for the preparation of an integrated fire safety program plan for the Department of Transportation.

1.2 CONTENT OF REPORT

Each of the three major elements cited above is described in the following sections:

Section 2, Regulation Coverage and Commonalities, presents an analysis of existing modal fire regulations and their potential for intermodal application.

Section 3, Research and Development Commonalities and Relevance to Regulation Promulgation, analyzes previous and current research and development projects conducted by DOT modal administrations and other groups. The relationship of R&D to regulation promulgation by the sponsor, as well as to other administrations, is also discussed.

Section 4, Statistical Data Base Commonalities, presents an analysis of relevant fire-related data bases applicable to transportation fires. The structure, level of detail, and data collection procedures are among the categories discussed.

Supplemental information is presented in the appendices. Tables indicating regulation coverage and commonalities are provided in Appendix A; suggested areas for further research and development are contained in Appendix B, and Appendix C presents a list of categories that might be included in an "ideal" statistical data base.

2. REGULATION COVERAGE AND COMMONALITIES

2.1 PURPOSE

The purpose of this section is to examine Department of Transportation modal fire safety regulations to assess the degree of coverage provided and to determine commonalities in methods used in dealing with similar problems. Almost every administration has issued fire safety regulations; however, the scope of these regulations varies considerably from one administration to another.

2.2 CATEGORIES USED IN ANALYSIS OF REGULATIONS

The fire safety regulations have been placed in the following seven categories: fire protection and control, interior material flammability, engine components, structural components, procedures, transportation buildings, structures and areas, and miscellaneous regulations. Within each category of regulation there are further subdivisions. For example, the category "Procedures," contains smoking, fueling and safety regulations. The categories and subdivisions of the categories are presented in Table 2-1.

In addition, Appendix A contains tables which show current regulations issued by each modal administration in these categories and subdivisions.

2.3 ANALYSIS OF REGULATIONS

2.3.1 Fire Protection and Control

Regulations concerning fire protection and control have been divided into five categories: portable fire extinguishers, fire extinguishing systems, fire extinguishing agents, fire detectors, and the use and maintenance of fire protection devices. These regulations, summarized below and presented in the tables in Appendix A, offer a large potential for intermodal applicability.

TABLE 2-1. CATEGORIES FOR REGULATION ANALYSIS

<u>Fire Protection and Control</u>
Fire extinguishers, portable
Fire extinguishing systems
Fire extinguishing agents
Fire detectors
Use and maintenance of fire protection devices
<u>Interior Materials Flammability</u>
<u>Engine Components</u>
Fuel tanks
Fuel lines
Oil lines
Electrical equipment
Batteries
Exhaust systems
Air intake
Ventilation systems
General
<u>Structural Components</u>
Firewalls, structural fire protection
Cargo compartments
<u>Procedures</u>
Smoking regulations
Fueling regulatons
Safety regulations
<u>Transportation Buildings, Structures, and Areas</u>
Fire protection regulations
Miscellaneous regulations
<u>Miscellaneous</u>
Heating systems

2.3.1.1. Portable Fire Extinguishers - Within DOT, the United States Coast Guard (USCG) has the most comprehensive set of regulations concerning portable fire extinguishers. Citations specify the type, number and location of extinguishers required, proper training in their use, descriptive numbering to indicate their location, and inspection and testing of equipment with specific tests cited for each type of extinguisher.

Federal Aviation Administration (FAA) regulations specify the type, number, and location of portable fire extinguishers required on airplanes and require that the crew be trained in their operation.

The other modal administrations do not have regulations of this type, although they would appear to be equally applicable. Although the vehicle configuration requirements make regulations for type, number, and location of extinguishers mode specific, other regulations refer mainly to requirements which are intended to increase passenger safety and are not mode dependent. These include the requirements for inspection and testing and those which require the operator or crew member to ensure that the vehicle is properly equipped with a fire extinguisher(s) prior to operation.

2.3.1.2 Fire Extinguishing Systems - As is the case with protable fire extinguishers, many of the regulations for fire extinguishing systems are meant to provide system safety and passenger safety. Presently, only USCG and FAA regulations exist. Since most of the regulations deal with safety, they would be applicable to other modes. These include required inspections, safety of the system components acting alone or with each other, and the descriptive marking of all equipment in a specified manner to indicate the type of agent used in the system.

2.3.1.3 Fire Extinguishing Agents - Citations in this area are taken almost entirely from the FAA or USCG regulations. Both administrations are specific about the chemical agents they will allow. The USCG requires that the agent used in an extinguisher or system be listed on its container. FAA regulations require testing application for toxicity resulting from the use of the extinguisher and from container leakage. In addition, testing is also required to determine if the agent will have any chemical reaction with other members of the extinguishing system. Regulations of this nature and the results of testing of various agents would be useful to all modes.

2.3.1.4 Fire Dectectors - Fire detectors have varying applications in the different modes, making some of the existing regulations rather mode specific. Currently, only the FAA and USCG regulate their use. However, some of the regulations, specificall those which deal with annual inspection and/or testing of detector could be applied to any mode.

2.3.1.5 Use and Maintenance - Regulations in this area are limite almost entirely to the USCG. The Coast Guard requires that anyone wishing to obtain an officer's or motorboat operator's license must be questioned in the use of fire protection devices. They also require yearly inspections and advance notice to the Officer-in-Charge of Marine Inspection for repair to fire protection equipment. Regulations concerning the operating condition of fire protection equipment would apply equally well to any mode. Many of the Coast Guard regulations are intended for the individua who is the owner/operator of the vessel. However, these regulatio could be modified to relate to crew member requirements and apply to all modes.

2.3.2 <u>Interior Materials Flammability</u>

The modal administrations, directly involved with vehicles, viz., the Federal Aviation Administration (FAA), the Federal Highway Administration (FHWA), the Federal Railroad Administration (FRA), the National Highway Traffic Safety Administration (NHTSA), the United States Coast Guard (USCG) and the Urban Mass Transportation Administration (UMTA) are all affected by problems of flammability of interior materials. Although the same types of materials may be used in their vehicles, the vehicle environments may be different in many cases.

The FAA, NHTSA and the USCG regulate the flammability requirements of vehicles in their jurisdictions, while the FRA assisted AMTRAK in establishing flammability specifications. Although UMTA has not issued regulations in this area, they have been active in establishing proposed guideline specifications for flammability and smoke emission characteristics of combustible interior materials used in transit systems. These guidelines require that specific categories of materials be tested using the methods of the American Society of Testing and Materials (ASTM) or other methods as determined. Acceptance criteria for these tests must also be defined. UMTA is in the process of developing materials fire safety standards for transit systems.

Regulations for this category are presented in the tables of Appendix A.

2.3.3. Engine Components

The analysis of engine components was divided into nine categories: fuel tanks, fuel lines, oil lines, electrical equipment, batteries, exhaust systems, air intake, ventilation, and a general category including those regulations which treat the engine as a single unit rather than its individual components. Although the propulsion systems of the various modes can be radically different, there are regulations pertaining to the design specifications and testing of the auxiliary components which do apply to many of the modes. Regulations are summarized below and presented in the tables of Appendix A.

2.3.3.1 Fuel Tanks - There is a great deal of similarity in problems concerning fuel tanks, irrespective of the type of system of which they are a part. Fuel tank rupture and resultant fire can occur in a crash situation. Leaking fuel can be ignited by a heat source, or the fumes can seep into passenger or crew compartments. Regulations designed to deal with problems of this sort can find application in the other modes as well as in those cited.

2.3.3.2 Fuel Lines - Current fuel line regulations are limited almost exclusively to those of the FAA. The problems that they are meant to deal with are very similar to those for fuel tanks: leakage/accidental ignition/seepage of flammable fluids or fumes and quality of the system components. Regulations with the same intent of those of the FAA would have definite intermodal application.

2.3.3.3 Oil Lines - There are currently few regulations concerning oil line problems. They deal mainly with quality control in their manufacture and maintenance to ensure that leakage does not initiate a fire hazard. Maintenance requirements should be considered for all modal regulations.

2.3.3.4 Electrical Equipment - The basic problem associated with electrical equipment is that arcing may occur and cause the ignition of a combustible substance. Regulations deal with the location of components that are likely to arc, the quality, location and inspection of wiring systems, and design and manufacturing specifications for appliances. Faulty wiring is an intermodal problem, and current FAA and USCG regulations would have relevance in many instances.

2.3.3.5 Batteries - Existing regulations deal with the battery as an ignition source and possible source of emission of explosive gases. Methods of dealing with the problem include design and manufacturing specifications to prevent gas emissions and designating specific locations where batteries may not be located. Design and manufacturing standards would have broad application, while location regulations could have some cross application.

2.3.3.6 Exhaust Systems - Exhaust system regulations are concerned with the safe disposal of system gases and/or fluids, the heat from exhaust systems as an ignition source and the combustibility of the exhaust system itself. These regulations are, for the most part, generated by the FAA with a few similar regulations by the Federal Highway Administration (FHWA). Intermodal application is limited due to vehicle configuration, but some similarities do exist.

2.3.3.7 Air Intake - Only the Federal Aviation Administration (FAA) regulates air intake components. These regulations are concerned with the accumulation of flammable fluids in air ducts and the proximity of air ducts to equipment subject to back-fire flame. The air flow could amplify the flame and help ignite a fire. These regulations are very specific to aircraft and would have little or no application to the other modes.

2.3.3.8 Ventilation Systems - These systems are regulated by the USCG and the FAA. Both administrations' regulations deal with the system components as a fire hazard. In addition, the Coast Guard describes the type of system required and specifies that design of ventilation fans must include emergency turn-off switches in case of a fire. These regulations may have some intermodal application but are basically limited to the two administrations by which they are promulgated.

2.3.3.9 General - The regulations in this category are similar to those in the previous categories except that they cover the engine in broader terms. Problems include ignition of engine or vehicle control components and leakage of flammable fluids. In addition, the Coast Guard and Federal Aviation Administration have regulations concerning reporting and inspection of fires caused by failures, malfunctions, or defects. This has very definite intermodal applications. The risk of future problems can be reduced if a record is kept, and inspections reveal the source of the problem.

2.3.4 Structural Components

Two categories were considered in analyzing structural component regulations. They are firewalls and cargo compartments. These regulations are summarized below and presented in the tables in Appendix A.

2.3.4.1 Firewalls, Structural Fire Protection - Only the FAA and USCG have regulations in this area, and each deals with different problems. The FAA regulations require combustion equipment to be separated from other sections of the aircraft by firewalls that do not permit seepage of fluids or fumes to other compartments. The Coast Guard classifies types of bulkheads as to their use and location. There are requirements for testing bulkheads including panel insulation tests.

2.3.4.2 Cargo Compartments - Currently, only the Federal Aviation Administration has regulations concerning cargo compartments. These are meant to deal with the flammability of materials used in the construction of the compartment and with the ease of access to any section of a compartment in case of fire. To a varying degree all of the modes have cargo or baggage compartments. Fire resistance of compartments and ease of access to extinguish fires are problems which apply to all modes and, therefore, would suggest a degree of commonality in regulations.

2.3.5 Procedures

The analysis of procedures was divided into three categories: smoking, fueling, and safety regulations. Many of these regulations have applicability to all modes, especially smoking and fueling regulations. The regulations are summarized below and presented in the tables or Appendix A.

2.3.5.1 Smoking Regulations - The FAA, FHWA and USCG recognize smoking as an ignition source. They attempt to deal with this problem by prohibiting or restricting smoking under a variety of circumstances and by emphasizing the regulations using signs. The Coast Guard regulations are mostly mode specific in that they deal with special types of boats, such as tankers and ferries.

2.3.5.2 Fueling Regulations - The focus of fueling regulations is to prevent accidental ignition of fuel and possible explosion and loss of life and property. Methods of avoiding these problems include specifying where fueling is permitted, maintaining hose assemblies, requiring that the engine of the vehicle be turned off, prohibiting passengers to be on board during fueling, prohibiting smoking, and requiring that the vehicle be attended during fueling. These regulations are promulgated mostly by the FAA and FHWA and would have definite intermodal application.

2.3.5.3 Safety Regulations - These regulations cover general safety requirements such as fire emergency procedures, fire drills, and designation of fire zones. Additional regulations apply to design specifications for ease of passenger and crew access/egress in case of fire, the marking of emergency exits so they can be easily located, provision of emergency lighting, designation of emergency lifesaving equipment, motion picture film flammability specifications, reporting of failures of equipment and fire resistance of flotation devices. Application to other modes is desirable in reference to regulations concerning/access egress specifications, emergency exit marking, emergency lighting, reporting of failures and malfunctions, and flammability of motion picture film permitted.

2.3.6 Transportation Buildings, Structures, and Areas

The intent of this section is to examine regulations concerning vehicle terminals, garages, maintenance facilities, bridges, and tunnels. The analysis is divided into two parts: fire protection regulations and miscellaneous regulations. The regulations are summarized below and presented in the tables of Appendix A.

2.3.6.1 Fire Protection Regulations - The impact of a fire at a terminal, port, or garage could have serious implications. Regulations in this area are promulgated mostly by the United States Coast Guard, with a few by the Federal Aviation Administration. Regulations deal with portable and fixed fire extinguishers, the operating conditions of fire protection equipment, the descriptive markings on extinguishing systems as to type of agent and auxiliary fire equipment. These regulations have a good deal of intermodal applicability in that most of the vehicles enter terminals and are garaged at some time.

2.3.6.2 Miscellaneous Regulations - These regulations deal with flammable materials' handling and storage in buildings, ignition of flammable materials, and ignition sources. Most of the regulations would have a high degree of intermodal commonality.

2.3.7 Miscellaneous Regulations

Only heating systems are included within the category of miscellaneous regulations. There may be some modal application since heaters are used in all modes. However, the regulations basically restrict the auxiliary open flame type of heater since it constitutes a fire hazard. Regulations also describe design and manufacturing specifications for combustion heaters. The regulations are presented in the tables of Appendix A.

3. RESEARCH AND DEVELOPMENT COMMONALITIES AND RELEVANCE TO NEW REGULATIONS

3.1 PURPOSE

This section presents a summary and analysis of previous and current research and development projects sponsored by the modal administrations within the DOT and by other governmental agencies or private research groups. Application of research and development findings of one administration's efforts to another administration's problems is also discussed.

3.2 BACKGROUND

TSC has prepared a report which includes summaries of DOT fire research projects for the Urban Mass Transportation Administration which summarizes current DOT projects.* It identified both ongoing and recently completed modal fire safety projects conducted during the period December 1977 to June 1978. To identify DOT projects conducted prior to this survey and projects conducted by other government agencies and private research groups, a literature search was conducted using the National Technical Information Service (NTIS) and the Smithsonian Science Information Exchange (SSIE). This yielded project abstracts which summarized the scope and results of projects and provided project data such as the contract number, date performed, sponsor, and the funding level.

3.3 CATEGORIES USED IN THE ANALYSIS OF RESEARCH AND DEVELOPMENT PROJECTS

The previous section, Regulation Commonalities, established seven categories of modal fire regulations: Fire Protection and Control, Interior Materials Flammability, Engine Components, Structural Components, Procedures, Transportation Buildings,

*Hathaway W.T., I. Litant, "Assessment of Current U.S. Department of Transportation Fire Safety Efforts," Transportation Systems Center, Cambridge, MA, Report No. UMTA-MA-06-0051-79-4, July 1979.

Structures and Areas, and Miscellaneous. These categories are also used in this analysis to group the research and development projects. Projects which were not applicable to these categories are grouped in a Miscellaneous, General category.

3.4 ANALYSIS OF RESEARCH AND DEVELOPMENT PROJECTS

3.4.1 Fire Protection and Control

The bulk of research and development projects within this category is concerned with the development and testing of fire extinguishants and detection equipment. These and other projects dealing with fire protection and control are discussed below.

3.4.1.1 Portable Fire Extinguishers - Projects pertaining to portable fire extinguishers within the Department of Transportation have been conducted by the United States Coast Guard (USCG). For example, the USCG evaluated portable fire extinguishers for use on Coast Guard cutters.[1*] In this study, dry chemical extinguishers and those using halogenated compounds (described in Fire Extinguishing Agents subcategory, which follows) were tested against CO_2 extinguishers which were commonly in use at the time. Three types of fires were used in the evaluation: bilge, flowing and spray fires. The dry chemical extinguishers proved to be equal to or better than the halogenated compounds (Halons) in all cases. The Halons were found to be much more effective than CO_2 on a weight basis, an important consideration for portable extinguishers since their effectiveness may be dependent on the volume of agent they contain. An interesting secondary output from the study was that the technique of the operator of the extinguisher was more important than the agent used.

The study just mentioned is supportive of USCG regulations. Its purpose was to determine if the extinguishers, in use at the time, were the best available and, if not, to revise the regulations.

The results of this study are relevant for intermodal application. The FAA currently regulates types of fire extinguishers

*References are numbered sequentially throughout this section and are compiled at the end of the section.

permitted on aircraft. Although the fire types used in the project may be dissimilar to those on aircraft, the data collected on characteristics of each extinguishant may be helpful. This may also be the case for the FHWA, FRA and UMTA which have few or no regulations. The finding that operator technique is more important than extinguishing agent is very important and suggests the need for regulations requiring the training of crews in the operation of extinguishers. Such training may be able to help prevent a minor fire within a particular component from spreading and involving the entire vehicle, which was the case in the Rohr Transbus fire in 1974.

3.4.1.2 Fire Extinguishing Systems - Within the Department of Transportation, research and development concerning fire extinguishing systems has been sponsored by the U.S. Coast Guard and the Federal Aviation Administration. Projects initiated by the Coast Guard deal principally with the evaluation of automated deck foam fire extinguishing systems and associated hardware (nozzles, etc.). These systems (AFFF - aqueous film forming foam) have been tested on Coast Guard tank ships.[2] The results showed the system to be unreliable, as it did not concentrate on one area, in some cases wasting as much as 50 percent of the foam due to improper aim.

The Federal Aviation Administration has investigated the use of Halon 1301 dispensing systems for aircraft cabin fire extinguishing systems.[3,4,5] Non-DOT-sponsored projects have been carried out by the National Aeronautics and Space Administration (NASA), U.S. Air Force and U.S. Navy. These projects dealt with fire suppression and control for passenger and vehicle survivability, system requirements and simulated testing for advanced flight vehicles, and design of fire tolerable systems which are activated upon impact in a crash situation.

Modal regulations in this area have been promulgated by the U.S. Coast Guard and the Federal Aviation Administration. Researc and development by these two administrations is basically supporti of their regulations which specify the types of systems allowable. The projects are concerned with improving upon the level of knowledge in an already regulated area. It is likely that there may be scientific and technolgy transfer pertaining to fire extinguishment between the FAA and USCG.

The FHWA, FRA, NHTSA, and UMTA currently have no regulations governing fixed fire extinguishing systems. The feasibility of automobile systems could be studied by NHTSA with consideration given to a study such as the FAA Halon 1301 dispensing system investigation. Although the FRA and UMTA may require different types of installation for a system than those used on aircraft or vessels, it would seem that they could benefit from the knowledge of system agents, hardware and performance criteria developed in the FAA and USCG studies.

A study by the U.S. Air Force has investigated fire tolerable extinguishing systems which engage upon impact in a crash.[6] Further modal research and development in such systems may be beneficial. This might be an excellent safety precaution to be considered by NHTSA for the engine compartments of motor vehicles, since in automotive and truck crashes, fire often results after impact and involves the entire vehicle before passengers can safely escape.

3.4.1.3 Fire Extinguishing Agents (Extinguishants) - The U.S. Coast Guard and the Federal Aviation Administration have investigated various extinguishants. The Coast Guard projects have tested carbon dioxide (CO_2), Halon 1301, Halon 1211 and high expansion foams for their suitability in extinguishing cargo hold fires.[7,8,9,10] Halons, chemically composed of members of the Halogen family (Fluorine, Chlorine and Bromine), are extinguishants which are gaining greater use. The two most common are Halon 1301 and Halon 1211.

Halons are effective for suppressing fires involving ordinary combustibles, such as paper, wood and textiles and gaseous and liquid flammable materials. Since Halons are non-conductive, they are also effective in the extinguishment of electrical fires. The National Fire Protection Association (NFPA) has issued standards for the use of Halon 1301 and Halon 1211.* Although the process by which Halons work to extinguish a fire is not entirely understood, they apparently use a "chain-breaking" process which breaks down the combustion reaction process.

The FAA has also been very active in the testing of extinguishants. Projects have dealt with the evaluation and ranking of all available foam extinguishants,[11] full-scale modeling for aqueous film forming foams (AFFF),[12] comparison of foam and dry chemical extinguishing system agents,[13] and evaluation of a Halon 1301 system for post-crash aircraft internal cabin fire protection.[3]

Research by NASA and the U.S. Air Force involves the development and testing of a wide variety of fire extinguishants including foams and Halons. In these studies, an agent's extinguishing capabilities are investigated as well as its synergistic and/or antagonistic reactions and toxicological impact in a fire environment.[14,15]

The research and development in this area is both extensive and intensive. Studies have been conducted under small- and full-scale conditions. Both the FAA and USCG have conducted R&D for the purpose of examining the validity of their regulations and to determine if revisions are necessary. An example is the set of studies mentioned above in which the Coast Guard investigated extinguishment of cargo hold fires with CO_2, Halon 1301, Halon 1211 and high expansion foams. The carbon dioxide extinguishment study was to determine the adequacy of existing CO_2 system regulations. The study with Halon 1301 was to determine if it could safely extinguish cargo space fires as it had already been shown to be satisfactory for machinery space protection. Halon 1211 was to be tested for its ability to extinguish cargo fires and as a substitute for CO_2 systems as were the high expansion foams.

*NFPA 12-A-1972 and NFPA 12B.

This kind of comparative testing and analysis is not only valuable to the administrations conducting the research but can be beneficial to all other administrations. Through the sharing of Coast Guard and FAA research, the other modal administrations are in a position to learn the state-of-the-art in fire extinguishants. Not only will they be able to promulgate their own regulations more readily, but they will also have a broad base of knowledge on which to initiate their own research and development programs. As an example, the FRA may be able to adapt FAA and USCG cargo R&D findings to problems with train baggage compartment extinguishing systems. Another important point to be considered is that, with new agents and new materials continually being developed, regulations may need to be revised periodically.

Much of the R&D in this area has concentrated more on an agent's ability to extinguish a fire than on other characteristics such as its toxicological impact or its reaction with other agents in a fire situation. The National Research Council has investigated this problem.[16] It is one which is relevant to all passenger carrying modes, as an agent can only be considered as effective for use as it is safe for a human environment. For example, Halon 1301 is safe for use in habitable compartments, but Halon 1211 is not. Regulations must be promulgated which have taken all such factors into account.

3.4.1.4 Fire Detectors - Research has been conducted by the FAA and the USCG among the DOT modal administrations. The projects reviewed include those dealing with smoke, explosion and overheat detectors, as well as fire detectors. FAA sponsored projects include simulation and flight testing of a self-generating overheat detection system[17,18] and testing of fire detectors in a turbo-jet power plant.[19] The investigation of hazard detectors, other than fire detectors, is important because the use of such detectors could enable a crew to correct a dangerous situation before a fire occurs.

The Coast Guard has conducted a project to evaluate the performance of various types of fire detectors when installed at different locations in machinery spaces and when affected by varying environmental/ventilation conditions.[20]

Projects conducted outside of DOT have investigated the development and testing of new types of detectors using laser beams,[21] solid electrolyte oxygen sensors[22] and ultra-violet fiber optics;[23] evaluated the performance of installed detectors[24] (tests show a high false alarm rate for certain types of detectors); and developed test methods and techniques for use in the evaluation of fire detectors.[25]

Current regulations dealing with the type, number and location of detectors permitted; the susceptibility of detectors to fire, and the monitoring of detectors to ensure proper operating condition have been promulgated by the FAA and USCG.

Coast Guard research and development has been conducted with respect to their regulations. The studies have attempted to determine the optimal placement of detectors to assure the earlies possible detection. A similar type of R&D may be considered for other modes such as the FAA and FRA where the vehicles involved have rather inaccessible power plant areas and early detection is crucial to vehicle safety.

The FAA research and development is more explorative in natur and is basically mode oriented, dealing with detection equipment for jet powerplant areas. However, these results may have application for high speed trains or large vessels with similar propulsion systems.

Research projects conducted by the U.S. Air Force dealing with detectors may be useful in the review of existing FAA and USCG regulations or for the promulgation of new regulations. For example, a study by the U.S. Air Force[24] has indicated that direct contact thermal sensor detector systems are unreliable, with 83 percent of all alarms being false. In addition, in cases where the threat (fire, smoke, etc.) actually existed, the detectors failed to operate about one-half of the time. The Air Force, ther fore, developed another approach to the problem[26] using integrated systems of ultraviolet and infrared sensors coupled with a dual-loop overheat sensor under computer control. This system is expected to eliminate the false alarms. For administrations such as the FRA and UMTA, where regulations do not exist, evalution of detector performance may indicate which types of detectors are unacceptable for use or which types require further testing before use in their mode. Similarly, the study which developed test methods and techniques for detector evaluation would be relevant to all modes using or considering the use of detectors. The methods developed in the study may be used by other modal administrations to evaluate their detector regulations or expand upon the study to promulgate inspection criteria and standards.

3.4.1.5 Use and Maintenance of Fire Prevention Devices - The survey of research and development projects indicated that only one was concerned with the use and maintenance of fire extinguishing devices. This project was sponsored by the FAA and developed criteria for aircraft installation and utilization of an extinguishing agent concentration recorder.[27] This device would be capable of determining the concentration of agents stored in an extinguisher or extinguishing system in order to ensure that the concentration is within specified limits required for fire safety.

It is important for the proper utilization of fire protection and control equipment that there be regulations requiring regular inspection and maintenance of equipment. Otherwise, it is possible that when the equipment is needed, it will fail in its intended purpose, causing loss of life and/or property. A device such as the concentration recorder just mentioned, could be useful in all modal fire safety programs to ensure that high levels of safety are achieved and maintained.

3.4.2 Interior Materials Flammability

Combustible non-metallic materials have many uses in the interior compartments of all vehicles (i.e., seat backs, cushions, and wall panels). However, when exposed to fire they may thermally degrade and emit toxic gases and vision-obscuring smoke. Extensive research has been sponsored in the area of flammability and toxicity by the DOT-Office of the Secretary, the Federal Aviation Administration, the United States Coast Guard, the National Highway Traffic Safety Administration, and the Urban Mass Transportation Administration. Projects include the investigation of the toxicity of polymer combustion products, flammability characteristics of interior materials, and the effect of combustion of polymers on compartment visibility. Typical projects are discussed below.

The FAA has sponsored an investigation to develop a mathematical model to compute a Combined Hazards Index (CHI).[28] In this model an entire compartment and its environment is considered rather than individual components. Each material is assigned a weighting factor according to its flammability, smoke and toxicity potential relevant to other factors. Then one index is formulated for the cabin. The objective of this method is to support the regulatory process for improved cabin fire safety. This method, if it is determined to be reliable, will be relevant to every modal administration in assessing flammability criteria for their particular vehicles.

Another FAA study, conducted by the Civil Aeromedical Institute (CAMI), investigated the thermal decomposition products of aircraft interior materials.[29] This study may be helpful to other administrations in developing specifications with respect to toxic combustion products in addition to flammability criteria.

In 1973, NASA and the FAA initiated the FIREMEN Program. The program has been concerned with making aircraft interiors more fire safe. A typical effort involved the development and use of fire-hardened materials in lavatories and cargo compartments.[30]

The Coast Guard has investigated the flammability of carpets, mattresses, drapes, curtains and lighweight wall panels.[31,32,33] Many of these items are also used in other modes. Therefore, findings of these studies would be directly applicable to the regulations development of other modal administrations.

The Urban Mass Transporatation Administration maintains a data base of all materials currently being used in vehicles under their jurisdiction and of the various fire-related characteristics of the materials. In addition, the data base contains materials which may have a potential for use.

UMTA has also investigated transit system fires to determine the extent of damage, materials involved, and degree of fire safety provided by various components such as firewalls.

Present efforts by UMTA include an evaluation of the materials data bank to improve its potential[34] and an investigation of electrical insulation to determine flammability, toxicity and smoke production criteria.[35]

Research and development concerned with interior materials, as with R&D concerned with fire protection and control devices, offers a great deal of intermodal applicability from the findings because of similarities between the modal vehicles.

3.4.3 <u>Engine Components</u>

3.4.3.1 Fuel Tanks and Lines - The major problem with the fire safety of fuel systems is to keep the fuel from leaking and igniting when the vehicle is damaged. When the fuel is effectively contained, the chance of accidental ignition is much lower. A second problem, often the subject of many research and development projects, is the oxygen build-up in the fuel tank ullage, i.e., the vapor space above the fuel line. When the oxygen level in this space becomes too great, combustion and explosion may occur. Federal Aviation Administration research has determined the oxygen level must be less than 10 percent.[36]

There has been a great deal of research and development conducted to address the two problems mentioned above. Principal among the investigators have been the FAA, NHTSA and the USCG. Studies have dealt not only with improving the tank and/or lines to avoid leakage and accidental ignition of the fuel but also with improving the fuel by attempting to reduce its flammability without decreasing its utility.

The FAA has conducted studies on anti-mist fuels,[37] nitrogen inerting of the fuel tank ullage space,[38] and fire resistant fuel lines and coatings.[39,40] Nitrogen inerting is a method by which the ullage space is filled with nitrogen to prevent the build-up of oxygen to a dangerous level. These projects support FAA regulations which deal with fuel tank rupture and fuel/vapor ignition. Findings developed in these studies are potentially useful in regulation development by modes using similar fuel systems, such as NHTSA and USCG.

Other research and development in the area of fuel system safety has been sponsored by the USCG and NHTSA. The Coast Guard investigated the fabrication of fuel tanks from fiberglass[41] and NHTSA crash-tested vehicles to determine fuel spillage characteristics.[42] The design of a fuel tank that would not rupt in a vehicle crash and would not lose fuel when subject to violent motion would have tremendous intermodal application becau of the increased fire protection it would offer.

3.4.3.2 Electrical Equipment - Present research and development projects support or improve upon existing FAA, FHWA and USCG regulations which deal with sparking in the vicinity of flammable fluids/vapors and with the quality of cable insulation and the wiring system.

The Urban Mass Transportation Administration is currently investigating commonly used electrical insulations to determine the fire characteristics associated with these materials, namely flame propagation, smoke and toxic gas emission.[43] The findings will be useful in improving fire safety and in developing regulations not only for UMTA but for other administrations since mos modal vehicles use similar electrical wiring components. Similar studies of electrical cable and insulation have been conducted by NHTSA,[44] the USCG,[45] UMTA, the FRA,[46] the U.S. Navy[47] and the N.Y.C. Transit Authority.[48]

The DOT-Office of the Secretary has also gathered and assessed data from transit authorities and vehicle manufacturers on the problems of electrically caused fires.[49] Such a pooling of data is very helpful in determining problem areas where R&D and/or regulation promulgation is necessary and would be beneficial for use by modal administrations to determine intermodal common problem areas. Once common problems are identified, research and development may be performed on a shared basis.

3.4.3.3 Exhaust Systems - Current regulations pertaining to exhaust systems have been promulgated by the FAA and USCG and deal with two major problem areas: (1) disposal of system gases and fluids, and (2) exhaust system components acting as an ignition source, e.g., hot surface ignition of flammable fluids. In support of the efforts to deal with ignition sources, the Federal Highway Administration (FHWA) has conducted research and development concerning this problem in post-crash fuel spill conditions[50] and has promulgated regulations defining unacceptable locations for vehicle exhaust systems. Other modes with similar problems, such as USCG recreational boats, may be able to adapt the findings of the FHWA study to their own vehicle specifications.

3.4.3.4 Ventilation Systems - Research and development in this area deals principally with the effect a ventilation system may have on fire growth and spread, e.g., ventilation fans or exhaust outlets may help to intensify a fire. A Coast Guard study, in support of their regulations, is investigating the impact of varying ventilation rates in compartment burn out tests.[51] This study may have value for intermodal application since most modal vehicles involve some compartmentation, and the fire testing method may also be adaptable to other types of investigations.

An FAA study of fire suppression in large cargo aircraft investigated the degree of fire suppression attainable by shutting off ventilation and found it to be insignificant.[52] Test methods used and findings obtained from this research and development could be helpful to other modes with similar systems in determining ventilation specifications.

3.4.3.5 General - Regulations and research and development in this area deal with the engine as a unit as opposed to naming separate components. Current regulations deal with the ignition of the engine, the fires caused by failures, malfunctions and defects of the engine, and requirements for emergency shut-off controls.

Research and development in support of these regulations includes projects sponsored by the FAA and the USCG, which have investigated the use of materials and coatings for fire resistance,[53] development of fire and explosion suppression systems for engine compartments[54] and fire testing of emergency shut-off valves.[55] Some of these projects yield information which is mode specific, such as that concerned with aircraft nacelle fire simulations. However, these projects may yield performance standards for various fire resistant materials and coatings and thus be helpful to a modal administration which has no regulations in this area.

3.4.4 Structural Components

3.4.4.1 Firewalls, Structural Fire Protection - Research and development in this area is mode specific since the modal vehicles are structurally different. However, materials and investigation techniques used may be relevant for adaptation by other modes. Projects which illustrate this point have been conducted by the U.S. Coast Guard. One dealt with analyzing structural casualties and developing methods of collecting and assessing the casualty data.[56] This type of R&D is explorative in nature and will enable the Coast Guard to determine the cause of a casualty and also to identify problem areas in which research and development or regulation promulgation is necessary. Other modal administrations could also benefit from the development of such an investigative system.

Another USCG study tested lightweight compartmentation panels for structural durability and fire resistance.[57] The results of the testing offer a basis of development to other modal administrations wishing to determine specifications for panels used in their vehicles.

3.4.4.2 Cargo Compartments - Current regulations of the FAA, dealing with flammability of cargo compartments and access to the compartment in case of fire, have been supported by research and development. Investigations have considered characteristics of fires in large cargo aircraft and the degree of suppression attainable in such fires by shutting off ventilation fans.[53] The study showed that this action had little effect on the fire. The FAA has also investigated fire extinguishing methods for passenger/cargo aircraft.[58]

Similar research and development has been carried out by the United States Coast Guard. Their studies have developed design criteria for flame control devices in cargo venting systems.[59]

It is possible that other modes which need to determine regulations parameters involving cargo compartments may adapt some of the findings from these studies to their own specific situations.

3.4.5 Procedures

3.4.5.1 Safety Regulations - Research and development in this area includes effectiveness evaluations of training methods; development of fire protective garments for crew use; and proceedings from accident investigations and fire prevention seminars.

The FAA has been active in the development of fire protective clothing for crew members.[60] Such garments enable the crew to extinguish fires with a low risk of injury. This R&D may be directly adapted by such agencies as the USCG, UMTA and FRA to protect crew members who are responsible for the safety of a large number of passengers.

In addition, the FAA has investigated locating emergency lighting at armrest height instead of on the ceiling to increase visibility in smoke filled cabins.[61] Similar installations are relevant to the FRA and UMTA since their seating configurations are basically the same.

A study by the Urban Mass Transportation Administration has examined safety priorities in rail rapid transit.[62] Similar studies should be carried out by all the modal administrations.

Knowledge gained from research and development may eventually be incorporated into rulemaking. In addition, the findings of accident investigations and the recommendations developed in fire safety symposiums are essential to the rule-making process. In fire safety forums, problem areas have been identified which require new regulations and/or research and development. For example, accident investigations by the U.S. Coast Guard have indicated that the two major causes of boating accidents are fuel tank problems and lack of extinguishing equipment,[63] clearly identifying specific areas in which R&D and rulemaking should be concentrated.

3.4.6 <u>Transportation Buildings, Structures and Areas</u>

3.4.6.1 Fire Protection - In a vehicle crash and/or fire situati it is necessary to evacuate passengers and extinguish the fire as quickly as possible. The FAA has investigated various extinguish agents and techniques[64] and developed specialized equipment including a fuselage skin penetrator nozzle for quick extinguishi agent access[65] and special ground cover materials.[66] These studi have been related to FAA regulations dealing with portable means of fire extinguishment.

The U.S. Coast Guard has a program for training specialized reservist fire fighting strike teams to be on call for fires in port or at sea. Similar special groups, trained for vehicle terminal area emergencies, may be considered by other transportation modes.

Research and development projects within the Armed Forces include the development of special crash rescue and flight deck firefighting clothing by the U.S. Navy[67,68] and a firefighting training program developed by the U.S. Air Force.[69]

Vehicle configuration constraints make research and development in this area very mode specific. For example, the equipment used at an airport may be impractical to use in a seaport or a tunnel. Nevertheless, the concept which motivates the research and development in one mode may be applicable to another mode and thus lead toward modal research and development and regulatic promulgation.

3.4.6.2 Miscellaneous - The Department of Transportation, Office of the Secretary, has sponsored a research effort which produced design guidelines for intermodal transit stations. Certain specifications contained in the report[70] could be directly applied to fire safety concerns.

Other studies of interest include a report by the National Institute for Occupational Safety and Health (NIOSH) that addresses fire safety in service stations.[71] The NIOSH study, investigating the use of fire extinguishers at gasoline stations, may be adaptable to other modal vehicle fueling areas.

Research and development has also been conducted investigating ventilation in rail rapid transit tunnels. The Subway Environmental Design Handbook, a three and one-half year research project sponsored jointly by UMTA and transit properties in the U.S. and Canada, was published in 1976. It presented criteria for the development of environmental control systems for subways, including the design of cost-effective and reliable ventilation systems. The Subway Environmental Simulation (SES) Program was developed during this project. A current project at the DOT, Transportation Systems Center, Cambridge, MA is investigating modifications to the SES Program which will enable a better analysis of subway fires.[72]

Individual transit properties have also sponsored research in this area by means of fire investigations. The Montreal Urban Community Transit Commission sponsored the Metro Emergency Ventilation Operating Procedure Study in 1975,[73] after a major fire had occurred on a vehicle between two stations. It was intended to develop guidance for operators of ventilation equipment so that the flow of smoke and heat could be controlled while passengers evacuated the train and tunnel.

3.4.7 Miscellaneous, General

The research and development projects grouped in this category did not fit exactly into any one of the categories that had been developed for use during the survey of modal regulations. For example, a Coast Guard study cataloged flammability characteristics of solids and liquids,[74] and a FRA study reviewed AMTRAK materials.[75] Studies such as these have a high potential for transferability between modal administrations for keeping up-to-date on what materials are being used and which ones should be regulated. Other relevant studies are discussed below.

A National Highway Traffic Safety Administration (NHTSA) study investigated possible ignition sources of spilled fuel in motor vehicle crash fires.[76] Friction sparking caused by dragging metal components and fuel coming into contact with the heated exhaust system are common sources.

Studies by the FAA and FHWA investigated the crashworthiness[7] of the vehicles they regulate. Research and development of this type is very useful in determining if vehicle design specification are adequate or if revisions are required.

Appendix B describes areas in which further research and development may be necessary.

REFERENCES FOR SECTION 3
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54. Development of Explosion Suppression System Requirements for Shipboard Pump Rooms, USCG, D0121B4, January 1976.

55. Fire Test of Resiliently Seated Butterfly Valves, USCG, 1974

56. Ship Structural Casualty Data Assessment, USCG, N00024-76-C-4255, July 1977.

57. USCG Cutter Bulkhead Panel Fire Tests, USCG, 3308.5.8.

58. Fire Extinguishing Methods for New Passenger/Cargo Aircraft, FAA-502-201-0X, November 1971.

59. Design Criteria for Flame Control Devices for Cargo Venting Systems, USCG, CG-42357-A, August 1975.

60. Fire Protective Garment for Crew Use During Aircraft Cabin Fire, USDOT-OS, FA58735; FA75WAI-567 FY 76.

61. Improve Transport Aircraft Emergency Lighting, FAA, 181-521-

62. Safety Priorities in Rail Rapid Transit, UMTA-DC-06-0091.

63. Boating Accidents Investigations, 1974, Fire and Explosion, USCG, DOT-CG-23200A.

64. Evaluation of Aircraft Ground Firefighting Agents and Techniques, FAA-910-003-19X, February 1972.

65. Evaluate Aircraft Skin Penetrator Nozzle for Cabin Fire Protection, FAA-NPD-08-472.

66. The Use of Ground Cover Materials to Suppress Fuel Spill Fires, FAA-081-431-030, July 1973.

67. Crash Crew Fire Protective Clothing, US Navy, DN543073, FY 77.

68. Aircraft Carrier Flight Deck Clothing, US Navy, DN043003, FY 76.

69. Firefighter Training Effectiveness, USAF DF 221710 FY 77.

70. Criteria for Evaluating Alternative Transit Station Designs, Office of the Secretary, University of Virgina, DOT-OS-50233.

71. Health and Safety Guide for Service Stations, Department of Health, Education and Welfare, National Institute for Occupational Safety and Health.

72. Fire Emergency Control Techniques, DOT-TSC-1592.

73. Metro Emergency Ventilation Operating Procedure Study, Montreal Urban Community Transit Commission, Report No. 75-81R, 1975.

74. Flammability of Solids and Liquids, USCG CG-74142.

75. Rail Car Material Evaluation (AMTRAK).

76. Ignition Sources of Spilled Fuel in Motor Vehicle Crash Fires, DOT-HS-4-00872, September 1975.

77. A Crashworthiness Analysis with Emphasis on the Fire Hazard, U.S. and Selected Foreign Turbine Aircraft Accidents, 1964-1974, FAA, July 1976.

78. Escape-Worthiness of Vehicles for Occupancy Survivals and Crashes - Autos, DOT-FH-11-7512.

4. STATISTICAL DATA BASE COMMONALITIES

4.1 GENERAL CHARACTERISTICS

This section describes the commonalities of seventeen major statistical data bases containing information on transportation fires. These data bases were described in Section 4.2 of the previously cited TSC report.* With the exception of one data base maintained by a private non-profit organization, the National Fire Protection Association (NFPA), all the data bases discussed here are maintained by Federal agencies; of these, only two, the U.S. Fire Administration (USFA) and the National Transportation Safety Board (NTSB), are not within the Department of Transportation.

With the exception of the National Crash Severity Study (NCSS) Vehicle Fire Supplement, none of the data bases reviewed were designed specifically to study transportation fires. Two of the data bases, those maintained by NFPA and USFA, record statistics for all types of fires. Their data, as a result, are primarily related to fires in buildings rather than to transportation vehicle fires which, on the whole, are a small component of the total data base. This is due partly to the fact that vehicle fires frequently don't involve local fire departments which are the principal source of information for the NFPA and USFA data bases and partly because a large proportion of vehicle fires are not reported to any official agency.

The other fifteen data bases, which are maintained by administrations within the Department of Transportation and the NTSB, are designed to record accident information and are not limited to fire accidents. In these data bases the information dealing specifically with fires tends to be less complete than data concerning other types of accidents.

Commonalities of these statistical data bases may be identified by purpose, structure, categories and items, level

*Hathaway and Litant, "Assessment of Current U.S. Department of Transportation Fire Safety Efforts," July 1979.

of detail, and data collection procedures. Each of these commonalities is discussed, and the data bases are grouped in accordance with the commonalities they exhibit. A summary of the commonalities of all data bases is included at the end of this discussion in Table 4-1.

4.2 COMMONALITIES IN THE PURPOSE AND USE OF STATISTICAL DATA BASES

Transportation fire safety data bases exhibit commonalities in purpose and actual use. In the report* cited earlier, fire safety data bases were grouped into two major types: the case and index type and the analytical type. The case and index type of data base is used for administrative, regulatory, and investigative purposes. It is designed to facilitate retrieval of information pertaining to individual cases. Often the information is in the form of abstacts of accidents and incidents. Files of this type are useful in tracking individual cases, in writing case histories, and in providing examples for general reports. Data may be extracted from the cases and used statistically provided that the selection and data compilation are done systematically.

Data bases in this category include the NFPA Fire Incident Data Organization (FIDO) files, the NTSB-Surface Transportation investigation files, and the NTSB recommendations.

The other type of statistical data base is the analytical type. This data base is specifically designed for research and analysis purposes. It may be used to assess the magnitude of a problem, to identify major causal factors in transportation fires, to detect patterns and trends, and to measure the effects of new regulations, standards and technologies. In addition, it can be used to establish priorities for development of corrective measures, such as changes in vehicle and equipment design, operating and maintenance practices, and training programs.

*Hathaway and Litant, Assessment of Current U.S. Department of Transportation Fire Safety Efforts, July 1979.

Examples of the analytical type of data base are the USFA National Fire Incident Reporting System (NFIRS) files, the NTSB Automated Aircraft Accident/Incident Information System (AAAIIS) file, and the different U.S. Coast Guard (USCG) files.

4.3 COMMONALITIES IN DATA BASE STRUCTURE

Fire safety statistical data bases have commonalities in structure partly because of similar requirements due to the nature of the data and partly because of resemblances in reporting and analytical procedures. For example, the USFA data base, the National Fire Incident Reporting System (NFIRS) was modeled after the NFPA data base using the NFPA 901 Uniform Fire Protection Code as the basis for the USFA fire reporting code. Both of these data bases deal with fire data comprehensively, although the reporting procedures and the purpose of the files are somewhat different. NFPA's file has a different set of inclusion criteria than USFA's and is used more as an index than as an analytical tool. A peculiarity of both the NFPA and the USFA data bases is the hierarchical breakdown of information separating type of material ignited e.g., gasoline, rubber, from the manner in which material is used, e.g., fuel, tires.

As another example, the General Aviation Air Carrier Accident/Incident Data System (GAADS), now being developed for the FAA, has many points of similarity in structure with the NTSB's AAAIIS. This is due to the nature of the data and to data base use. The GAADS system cross-references NTSB's reports pertaining to accidents included in the data base.

The USCG accident data bases maintained by the Office of Merchant Marine Safety and the Office of Boating Safety, although different in content due to modal characteristics and operating environments, do have structural resemblances to the accident data bases maintained for aviation. In each case, it is necessary to provide identifiers, general information as to location, date/time, type of accident, personnel involved, casualties, vehicle information, environmental conditions and accident descriptors, including the human factor aspects.

A noteworthy improvement in accident data base structure, attempting to provide adequate coverage of fire data, is the Vehicle Fire Supplement to the ongoing National Crash Severity Study (NCSS) of NHTSA. The Vehicle Fire Supplement is designed to provide data on highway vehicles involved in both fire and collision. It provides data concerning the origin and development of the vehicle fire, fire fighting, injury and damage. A separate set of data within the supplement relates to fuel system damage and leakage when it is present or when the fuel system has been crash damaged. This is the only example in any of the data bases of a component concerned solely with vehicle fires.

4.4 COMMONALITIES IN CATEGORIES AND ITEMS OF INFORMATION

The categories and items included in a transportation fire safety data base vary in relation to the function of the data base, the specific transportation mode or modes covered, and how the data base is related to the administrative and research functions of the agency or private group responsible for its maintenance.

As has been noted, many of the data bases that have been discussed contain limited information on vehicle fires. The most complete data bases such as the National Fire Incident Reporting System (NFIRS) or the National Crash Severity Study Vehicle Fire Supplement include data in the following categories:

1. Identifying and General Information
2. Vehicle Information
3. Environmental Information
4. Origin and Development of Fire
5. Equipment Involved in Fire
6. Materials Involved in Fire
7. Fire Detection and Warning Systems

8. Firefighting Response
9. Firefighting Characteristics
10. Fire Damage
11. Fire Casualties
12. Information Concerning Crew, Operator, Pilot, etc.
13. Accident Descriptors

The data bases that are less complete, in terms of vehicle fire data such as the FRA, NTSB, FAA, and USCG include only categories 1, 2, 10, 11, 12 and a limited number of descriptors under category 13, as far as vehicle fires are concerned. Despite the differences in modes and operating environments, there is a common set of categories and items that is needed to provide the basis for fire safety analysis. A comprehensive list of categories and items which may be adapted to creating fire safety components for accident data bases is included in Appendix C.

4.5 LEVEL OF DETAIL OF ITEMS OF DATA

There is a wide range in the level of detail and breakdown of information under each of the categories in transportation fire/accident data bases.

All of the data bases that have been reviewed include items such as the location of the fire/accident (in terms of major geographic unit) and the date and time of the fire/accident. Information about environmental conditions is covered less uniformly. NTSB covers these items thoroughly while USFA-NFIRS, the Federal Aviation Administration (FAA), and the Federal Railroad Administration (FRA) cover them to a more limited degree.

Vehicle information ranges from a designation as to the particular type of vehicle (reported by FRA) to complete informatior as to the vehicle make and model, engine make and model, identification numbers, horsepower, and the age of vehicle (AAAIIS).

Areas of origin of the fire and its propagation and development are the most important data and the most difficult to obtain.

Most of the existing data bases do not make provisions for including items relating to the origin of the fire, equipment involved, how the fire was ignited, what kinds of materials were ignited, the rate of propagation, avenue of flame and smoke travel and structural factors which allowed such travel.

The exceptions are the USFA-NFIRS which includes most of the items mentioned above, and the National Highway Traffic Safety Administration (NHTSA) National Crash Severity Study Vehicle Fire Supplement, in its pilot stage, which includes an abbreviated compilation of data on ignition, fire development, and location.

4.6 DATA COLLECTION PROCEDURES

Data for transportation fire safety data bases are obtained from such sources as investigative reports, transportation companies, carriers, and transit properties, local fire departments or, in some cases, police departments, and from sample surveys. In the data bases that have been investigated, the various data sources used are as follows:

DATA SOURCE	AGENCY/DATA BASE
Investigative reports	NTSB, FAA-GAADS, NHTSA-NCSS*
Transportation companies, carriers, transit operators	FRA, USCG: FHWA-BMCS
Local fire/police department	USFA, NFPA; NHTSA-NCSS*, NHTSA-FARS
Individual vehicle operators	NHTSA-NCSS*
Sample surveys	NHTSA-NCSS*

*The data collection program for the NHTSA-NCSS is underway and will extend into 1979. Cases were selected from seven data collection areas that were chosen on the basis of a stratified random sampling plan. Cases are divided into three strata determined by the severity of the accident. The three strata are sampled at the rate of 100%, 25%, and 10%, in the order of severity.

Accident reports are submitted to the FRA, USCG, and FHWA-BMCS by transportation companies, carriers, and properties as required by law. On the other hand, USFA and NFPA must depend upon voluntary reporting by local fire departments. NTSB and FAA carry out investigations of selected accidents. The Coast Guard, through the Marine Board of Investigation, also carries out investigations of major accidents. NHTSA, in the National Crash Severity Study, is sending an investigative team into the field to sample accidents classified into three strata in accordance with the severity of the casualties and injuries. Data collection based on voluntary efforts appears to be the least satisfactory procedure resulting in incompleteness in reporting and a serious lack of representation for some large urban areas. Mandatory reporting by transportation companies and carriers and transit properties provides more complete information than voluntary procedures, but it appears that under-reporting of accidents is common for all modes of commercial transportation. The investigative team approach using sampling methods, as in the NHTSA-NCSS, would appear to be the most reliable procedure for collecting transportation accident statistics. Since it is in its early stages, an evaluation of its success would be premature.

TABLE 4-1. SUMMARY OF DATA BASES

DATA BASE	FORM OF DATA RETRIEVAL		
	Automated	Manual	DETAIL OF FIRE DATA*
Case and Index Type			
NFPA-FIDO	X		Moderate
NTSB-SURFACE (RAIL, MARINE)		X	High
NTSB-PIPELINE		X	High
NTSB-AVIATION RECOMMENDATIONS	X		NA
Analytical Type			
USFA-NFIRS	X		High
FRA	X		Low
NHTSA-FATAL ACCIDENT REPORTING SYSTEM	X		Low
NHTSA-NCSS	X		High
NTSB-AAAIIS	X		High
FHWA-BMCS	X		Low
USCG (All 3)	X		High
FAA-SERVICE DIFFICULTIES	X		High
FAA-GAADS	X		High

*DEFINITION OF LEVEL OF DETAIL OF FIRE DATA

Low: Indicates whether fire occurred. Limited or no information on origin of fire, causes, damages, or casualties.

Moderate: Indicates origin of fire. General classification of causes but no disaggregation. Includes general information on damages and casualties.

High: Provides data on origin and cause of fire. Additional information on severity of casualties and damage. Refers to operation of fire detection devices, extinguishment, emergency medical services unit, and other circumstances of the fire accident.

APPENDIX A

FIRE SAFETY REGULATIONS: COVERAGE AND COMMONALITIES TABLES

APPENDIX A

FIRE SAFETY REGULATIONS: COVERAGE AND COMMONALITIES TABLES

The tables which follow have been prepared for each category and subdivision developed in the analysis of modal fire regulations. The first column of the table shows the problem which was addressed by the regulation. The second column indicates the method of dealing with the problem. The remaining columns identify the administration issuing the regulations and provide the numbers of the Sections under the appropriate Title in the Code of Federal Regulations (CFR) that are directed toward the specific problems.

Each CFR Section number is followed by a symbol: "+" indicates a high potential for intermodal applicability; "/", a medium potential; and "-", a low potential.

In cases where no CFR Section number appears, the designation A indicates that one or more of the regulations of another administration might be applied to the same type of problem. If an NA appears, there is no obvious cross-application.

TABLE A-1. FIRE SAFETY REGULATION COMMONALITIES - Fire Protection and Control: Portable Fire Extinguishers (1 of 6)

PROBLEM	METHOD OF DEALING WITH PROBLEM	MODAL ADMINISTRATIONS					
		FAA TITLE 14	FHWA TITLE 49	NHTSA TITLE 49	UMTA (NONE)	FRA TITLE 49	USCG TITLE 33* TITLE 46
Portable means to extinguish a fire	Specify Type, Number and Location of Portable Fire Extinguishers	25.851+ 25.853+ 25.1307+ 37.129+ 91.193+ 121.309+ 135.161+	393.95+	A	A	A	2.75-25+ 25.30+ 34.01thru 34.60+ 76.01thru 76.60+ 145.10*+ 162.028+ 162.039+ 167.45+ 181.01thru 181.35+ 193.01thru 193.60+
Correct use of fire extinguisher	Operator/Crew Training	121.417+	A	NA	A	A	A
Operating condition of extinguisher	Inspections	A	A	NA	A	A	71.25-20+ 91.25-20+ 189.25-20+
	Testing	A	A	NA	A	A	2.75-25+
	Maintenance	A	A	NA	A	A	78.17-80+ 97.15-60+ 196.15-60+
Provision for extinguisher	Designate Responsibility	A	392.80+	NA	A	A	35.35-1+

* Section numbers so indicated are from Title 33, otherwise Title 46

TABLE A-1. FIRE SAFETY REGULATION COMMONALITIES - Fire Protection and Control: Portable Fire Extinguishers (2 of 6)

PROBLEM	METHOD OF DEALING WITH PROBLEM	MODAL ADMINISTRATIONS					
		FAA TITLE 14	FHWA TITLE 49	NHTSA TITLE 49	UMTA (NONE)	FRA TITLE 49	USCG TITLE 33* TITLE 46
Locating an extinguisher in an emergency	Specify Markings to Indicate Location	25.1561+	A	NA	A	A	2.75-25+ 35.40+ 78.47+ 97.37+ 167.55+ 196.37+

* Section numbers so indicated are from Title 33, otherwise Title 46

TABLE A-1. FIRE SAFETY REGULATION COMMONALITIES - Fire Protection and Control: Fire Extinguishing Systems (3 of 6)

PROBLEM	METHOD OF DEALING WITH PROBLEM	MODAL ADMINISTRATIONS					
		FAA TITLE 14	FHWA TITLE 49	NHTSA TITLE 49	UMTA (NONE)	FRA TITLE 49	USCG TITLE 33* TITLE 46
System requirements	Specifications	25.1195+ 121.263+	A	NA	A	A	25.30+ 34.01thru 34.60/ 71.65-5+ 95.01thru 95.60/ 113.20+ 162.027/ 167.45+ 181.01thru 181.35/ 189.55-5+ 193.01thru 193.60/
	Location	25.1201+ 121.263+	A	NA	A	A	A
Safety of system materials	Design & Manufacturing Specifications	25.1201+ 121.271+	A	NA	A	A	A
	Location	25.851+	A	NA	A	A	A
Identifying the agent contained in a system	Specify Descriptive Markings to be Used	A	A	NA	A	A	35.40+ 78.47+ 97.37+ 167.55+ 196.37+
Operating condition of system	Require Inspections	A	A	NA	A	A	71.25-20+ 91.25-20+ 176.25-25+ 189.25-20+

* Section numbers so indicated are from Title 33, otherwise Title 46

TABLE A-1. FIRE SAFETY REGULATION COMMONALITIES - Fire Protection and Control: Fire Extinguishing Agents (4 of 6)

PROBLEM	METHOD OF DEALING WITH PROBLEM	MODAL ADMINISTRATIONS					
		FAA TITLE 14	FHWA TITLE 49	NHTSA TITLE 49	UMTA (NONE)	FRA TITLE 49	USCG TITLE 33* TITLE 46
Chemical composition of extinguishing agents	Design & Manufacturing Specifications	25.851/ 25.1197/ 37.129/ 121.265/	393.95/	A	A	A	25.30/ 34.01thru 34.60/ 76.01thru 76.60/ 95.01 thru 95.60/ 167.45/
Toxicity of agents	Design & Manufacturing Specifications	25.1197+ 121.265+	A	A	A	A	A
	Testing	121.223+	A	A	A	A	A
Container rupture	Design & Manufacturing Specifications	25.1199+ 121.267+	A	A	A	A	A
	Location	121.269/	A	A	A	A	A
Chemical reaction of agents with system components	Design & Manufacturing Specifications	25.1201+	A	A	A	A	A
Agent identification	Specifications for Container Markings	A	A	A	A	A	35.40+ 167.55+

* Section numbers so indicated are from Title 33, otherwise Title 46

TABLE A-1. FIRE SAFETY REGULATION COMMONALITIES - Fire Protection and Control: Fire Detectors (5 of 6)

PROBLEM	METHOD OF DEALING WITH PROBLEM	MODAL ADMINISTRATIONS					
		FAA TITLE 14	FHWA TITLE 49	NHTSA TITLE 49	UMTA (NONE)	FRA TITLE 49	USCG TITLE 33* TITLE 46
Location, number and type of detectors required	Design & Manufacturing Specifications	25.1203/ 25.1305/ 37.121/ 37.185/ 121.273/ SFAR NO.55+	A	NA	A	A	76.27/ 76.30/ 76.35/ 113.10/ 113.70/ 161.002/
Susceptibility of detectors to fire	Design & Manufacturing Specifications	37.111+ 121.275+ SFAR NO.55+	A	NA	A	A	A
Operating condition of detector	Inspection	37.111+ SFAR NO.55+	A	NA	A	A	71.25-20+ 78.17-65+ 111.05-10+

* Section numbers so indicated are from Title 33, otherwise Title 46
SFAR = Special Federal Aviation Regulation

TABLE A-1. FIRE SAFETY REGULATION COMMONALITIES - Fire Protection and Control: Use and Maintenance of Fire Protection Devices

PROBLEM	METHOD OF DEALING WITH PROBLEM	MODAL ADMINISTRATIONS					
		FAA TITLE 14	FHWA TITLE 49	NHTSA TITLE 49	UMTA (NONE)	FRA TITLE 49	USCG TITLE 33* TITLE 46
Proper utilization fire protection equipment	Operator/Crew Member Training	121.417+	A	NA	A	A	78.13-15+
	Licensing Requirements	NA	A	NA	NA	NA	10.20-5/ 187.20-10/ 187.20-15/ 187.20-17/ 187.25-15/ 187.20-20/ 187.20-21/
Operating condition of equipment	Inspection	SFAR NO.55+	392.80+	NA	A	A	71.25-20+ 78.17-65+ 78.17-80+ 91.25-20+ 97.15-60+ 111.05-10+ 162.028+ 162.039+ 176.25-25+ 189.25-20+ 196.15-60+
System not operating due to repair	Require Advance Notice of Extensive Repairs	NA	NA	NA	NA	NA	35.01-35- 78.33-10- 196.30-10-
Fire protection element in new construction	Require Plans and Specifications for Fire Protection in New Construction	NA	NA	NA	NA	NA	71.65-5- 91.55-5- 189.55-5-

* Section numbers so indicated are from Title 33, otherwise Title 46
SPAR = Special Federal Aviation Regulation

TABLE A-2. FIRE SAFETY REGULATION COMMONALITIES - Interior Materials Flammability

PROBLEM	METHOD OF DEALING WITH PROBLEM	MODAL ADMINISTRATIONS					
		FAA TITLE 14	FHWA TITLE 49	NHTSA TITLE 49	UMTA (NONE)	FRA TITLE 49	USCG TITLE 33* TITLE 46
Combustibility of compartments & Furnishings	Design & Manufacturing Specifications	23.853+ 25.853+ 121.312+	393.84+	A	A	A	72.05-15/ 72.05-45/ 72.05-55+ 164.012/ 190.07-10/
	Testing	25.853+	A	571.302+	A	A	A

* Section numbers so indicated are from Title 33, otherwise Title 46

TABLE A-3. FIRE SAFETY REGULATION COMMONALITIES - Engine Components: Fuel Tanks (1 of 10)

PROBLEM	METHOD OF DEALING WITH PROBLEM	MODAL ADMINISTRATIONS FAA TITLE 14	FHWA TITLE 49	NHTSA TITLE 49	UMTA (NONE)	FRA TITLE 49	USCG TITLE 33* TITLE 46
Fuel tank rupture	Design & Manufacturing Specifications	25.963+ 25.981+	392.51+	A	A	A	58.50-5+ 58.50-10+ 183.512*+ 183.514*+ 183.520*+
	Location	25.1185/	A	A	A	A	A
	Testing	25.965+	A	571.301-75	A	A	A
Fuel/vapor ignition	Design & Manufacturing Specifications	23.853+ 23.954/ 25.954/ 25.975+	A	A	A	230.257+	58.50-1/
	Location	23.954/ 25.954/	A	A	A	A	72.01-10/
	Maintenance	A	A	A	A	230:221+ 230.255+	183.510*+
	Fuel Specifications	A	A	A	A	A	58.01-10/ 58.01-15/ 196.15-55
Seepage of toxic fumes	Design & Manufacturing Specifications	23.853+	A	A	A	A	A
	Location	121.229+	393.76-	A	A	A	A
Fuel spillage	Design & Manufacturing Specifications	23.973+	393.65- 393.67+	A	A	A	183.518*+

* Section numbers so indicated are from Title 33, otherwise Title 46

TABLE A-3. FIRE SAFETY REGULATION COMMONALITIES - Engine Components: Fuel Tanks (2 of 10)

PROBLEM	METHOD OF DEALING WITH PROBLEM	MODAL ADMINISTRATIONS					
		FAA TITLE 14	FHWA TITLE 49	NHTSA TITLE 49	UMTA (NONE)	FRA TITLE 49	USCG TITLE 33* TITLE 46
Liquid petroleum gas (LPG) systems	Restrictions	A	393.69/	A	A	A	25.45/ 58.16/ 184.05-1/
Cutting off gas flow in case of fire	Design & Manufacturing Specifications	23.1189+ 25.1189+ 121.257+	NA	NA	A	230.255+	111.80-13+ 185.30-20+

* Section numbers so indicated are from Title 33, otherwise Title 46

TABLE A-3. FIRE SAFETY REGULATION COMMONALITIES - Engine Components: Fuel Lines (3 of 10)

PROBLEM	METHOD OF DEALING WITH PROBLEM	MODAL ADMINISTRATIONS					
		FAA TITLE 14	FHWA TITLE 49	NHTSA TITLE 49	UMTA (NONE)	FRA TITLE 49	USCG TITLE 33* TITLE 46
Seepage of toxic fumes	Design & Manufacturing Specifications	23.853+ 121.227+	A	A	A	A	A
Ignition of fuel lines	Design & Manufacturing Specifications	23.1183+ 25.1183+ 33.17+ 121.255+ 121.259+	A	A	A	A	A
	Location	23.1183+ 25.1183+ 121.227+ 121.233+ 121.255+ 121.259+	A	A	A	A	A
Leakage of flammable fluids	Design & Manufacturing Specifications	25.863+ SFAR NO.57+	A	A	A	A	A
	Testing	25.863+	A	A	A	A	A
	Crew/Operator Training	25.863+ SFAR NO.57+	A	NA	A	A	A
	Maintenance	A	A	NA	A	230.255+	A
Quality of fuel system hose assemblies	Design & Manufacturing Specifications	37.152+ 121.231+ 121.269+	A	A	A	A	A
	Testing	37.152+	A	A	A	A	A
	Location	37.152+	A	A	A	A	A

* Section numbers so indicated are from Title 33, otherwise Title 46
SFAR = Special Federal Aviation Regulation

TABLE A-3. FIRE SAFETY REGULATION COMMONALITIES - Engine Components: Electrical Lines (4 of 10)

PROBLEM	METHOD OF DEALING WITH PROBLEM	MODAL ADMINISTRATIONS					
		FAA TITLE 14	FHWA TITLE 49	NHTSA TITLE 49	UMTA (NONE)	FRA TITLE 49	USCG TITLE 33* TITLE 46
Foaming of oil breather lines	Design & Manufacturing Specifications	23.1017- 25.1017-	NA	NA	NA	NA	NA
Oil lines as a fire hazard	Design & Manufacturing Specifications	23.1183+ 37.152+	A	A	A	A	A
	Specifications by Location	121.237/	A	A	A	A	A
Fuel oil quality	Testing	A	A	A	A	A	58.01-15/
Oil Leakage	Inspection of Lines	A	A	NA	A	A	91.25-45+

* Section numbers so indicated are from Title 33, otherwise Title 46

TABLE A-3. FIRE SAFETY REGULATION COMMONALITIES - Engine Components: Electrical Equipment (5 of 10)

PROBLEM	METHOD OF DEALING WITH PROBLEM	MODAL ADMINISTRATIONS					
		FAA TITLE 14	FHWA TITLE 49	NHTSA TITLE 49	UMTA (NONE)	FRA TITLE 49	USCG TITLE 33* TITLE 46
Sparking in vicinity of flammable fluids/vapors	Location	23.1157/ 25.1163/	A	A	A	A	35.30-35/ 111.05-15/ 111.80-25+
Quality of cable/insulation	Design & Manufacturing Specifications	23./1351/ 23.1365+ 25.1165+ 25.1351/ 25.1359+	A	A	A	A	183.01thru 183.10/
Wiring system	Location	A	393.28-	A	A	A	111.60-25/ 111.75-1/ 111.80-5/
	Inspection	A	A	A	A	A	111.05-10/ 176.25-25/
Explosion resulting from an ungrounded fuel tank	Design & Manufacturing Specifications	A	A	A	A	230.257/	183.415*/
Emergency fire control	Design & Manufacturing Specifications	NA	NA	NA	NA	NA	111.10-15/ 113.15/ 176.25-15+
Appliance hazards	Design & Manufacturing Specifications	A	NA	NA	A	A	111.80-60+ 111.80-65+ 111.85-90+

* Section numbers so indicated are from Title 33, otherwise Title 46

TABLE A-3. FIRE SAFETY REGULATION COMMONALITIES - Engine Components: Batteries (6 of 10)

PROBLEM	METHOD OF DEALING WITH PROBLEM	MODAL ADMINISTRATIONS					
		FAA TITLE 14	FHWA TITLE 49	NHTSA TITLE 49	UMTA (NONE)	FRA TITLE 49	USCG TITLE 33* TITLE 46
Emission of explosive gases	Design & Manufacturing Specifications	23.1353+ 25.1353+	A	A	A	A	A
Ignition source	Location	A	A	A	A	A	111.85-10/ 183.05/ 183.420*/

* Section numbers so indicated are from Title 33, otherwise Title 46

TABLE A-3. FIRE SAFETY REGULATION COMMONALITIES - Engine Components: Exhaust Systems (7 of 10)

PROBLEM	METHOD OF DEALING WITH PROBLEM	MODAL ADMINISTRATIONS					
		FAA TITLE 14	FHWA TITLE 49	NHTSA TITLE 49	UMTA (NONE)	FRA TITLE 49	USCG TITLE 33* TITLE 46
Disposal of exhaust system gases/ fluids	Location	23.1121/ 25.1121/ 25.1433-	A	A	A	A	A
Exhaust system as an ignition source	Location	23.1121- 23.1192/ 25.1121- 25.1192/ 121.251/	393.65/ 393.83/	A	A	A	A
Combustibil- ity of system	Design & Manufacturing Specifications	23.1123/ 25.1125/	A	A	A	A	A

* Section numbers so indicated are from Title 33, otherwise Title 46

TABLE A-3. FIRE SAFETY REGULATION COMMONALITIES - Engine Components: Air Intake (8 of 10)

PROBLEM	METHOD OF DEALING WITH PROBLEM	MODAL ADMINISTRATIONS					
		FAA TITLE 14	FHWA TITLE 49	NHTSA TITLE 49	UMTA (NONE)	FRA TITLE 49	USCG TITLE 33* TITLE 46
Proximity of air duct to flame caused by backfire	Design & Manufacturing Specifications	23.1061-	NA	NA	NA	NA	A
	Location	23.1091- 25.1091-	NA	NA	NA	NA	A
Accumulation of flammable fluids in ducts	Design & Manufacturing Specifications	23.1103- 25.1103-	NA	NA	NA	NA	A

* Section numbers so indicated are from Title 33, otherwise Title 46

TABLE A-3. FIRE SAFETY REGULATION COMMONALITIES - Engine Components: Ventilation Systems (9 of 10)

PROBLEM	METHOD OF DEALING WITH PROBLEM	MODAL ADMINISTRATIONS					
		FAA TITLE 14	FHWA TITLE 49	NHTSA TITLE 49	UMTA (NONE)	FRA TITLE 49	USCG TITLE 33* TITLE 46
Ventilation fans intensifying a fire	Design & Manufacturing Specifications	A	NA	NA	NA	NA	72.15-15/ 92.15-10/ 111.80-10/ 190.15-10/
System outlets and members as a fire hazard	Location	25.975/ 25.1187/	NA	NA	NA	NA	32.53/ 72.05-50/ 111.05-15/
	Design & Manufacturing Specifications	121.267/	NA	NA	NA	NA	162.017/ 162.018/
Type of system required	Design & Manufacturing Specifications	A	NA	NA	NA	NA	25.40/ 72.15-10/ 92.15-5/ 190.15-5/

* Section numbers so indicated are from Title 33, otherwise Title 46

TABLE A-3. FIRE SAFETY REGULATION COMMONALITIES - Engine Components: General (10 of 10)

PROBLEM	METHOD OF DEALING WITH PROBLEM	MODAL ADMINISTRATIONS					
		FAA TITLE 14	FHWA TITLE 49	NHTSA TITLE 49	UMTA (NONE)	FRA TITLE 49	USCG TITLE 33* TITLE 46
Ignition of powerplant/ vehicle control components	Design & Manufacturing Specifications	23.865/ 23.1141/ 23.1193/ 25.865/ 25.1193/ 25.1337/ 33.17/ 33.73- 33.77- 33.92- 121.249/	A	A	A	230.327-	25.35/ 32.20-10/ 58.10/ 162.016/ 162.041/ 162.042/ 162.043/ 182.15/
	Location	23.903/ 23.1182/ 25.867/ 25.1182/ 37.140/ 121.277/ SFAR NO.56/	A	A	A	A	A
Flammable fluids leakage/ ignition	Design & Manufacturing Specifications	25.863/ 25.929/ 25.1435/ 121.225/	A	A	A	A	58.10/ 58.30-10/
	Inspections	A	A	A	A	A	71.25-45+ 189.25-45+
Emergency powering-off of engine	Design & Manufacturing Specifications	25.903/ 25.1435/	NA	NA	A	A	58.10/
Fires caused by failures, malfunctions or defects	Require Report by Manufacturer	37.17+	A	A	A	A	A
	Inspection	A	A	A	A	A	176.25-10+ 182.15+ 182.20+

* Section numbers so indicated are from Title 33, otherwise Title 46
SFAR = Special Federal Aviation Regulation

TABLE A-4. FIRE SAFETY REGULATION COMMONALITIES - Structural Components: Firewalls, Structural Fire Protection (1 of 2)

PROBLEM	METHOD OF DEALING WITH PROBLEM	MODAL ADMINISTRATIONS					
		FAA TITLE 14	FHWA TITLE 49	NHTSA TITLE 49	UMTA (NONE)	FRA TITLE 49	USCG TITLE 33* TITLE 46
Proximity of combustion equipment to other compartments	Design & Manufacturing Specifications	23.1191/ 23.1192/ 25,1191/ 121.245/	NA	NA	A	A	A
Seepage of fluids or fumes between compartments	Design & Manufacturing Specifications	121.247/	A	A	A	A	A
Bulkhead construction	Design & Manufacturing Specifications	37.127/	NA	NA	A	A	72.05-10- 92.07-10- 164.008- 190.07-10-
	Classification of Types	A	NA	NA	A	A	72.05-10- 92.07-5- 92.07-10- 164.008- 190.07-5-
	Testing	A	NA	NA	A	A	164.009/
	Location	A	NA	NA	A	A	72.05-10/
Insulating materials	Design & Manufacturing Standards	A	A	A	A	A	72.05-40/
	Testing	A	A	A	A	A	164.007+

* Section numbers so indicated are from Title 33, otherwise Title 46

TABLE A-4. FIRE SAFETY REGULATION COMMONALITIES - Structural Components: Cargo Compartments (2 of 2)

PROBLEM	METHOD OF DEALING WITH PROBLEM	MODAL ADMINISTRATIONS					
		FAA TITLE 14	FHWA TITLE 49	NHTSA TITLE 49	UMTA (NONE)	FRA TITLE 49	USCG TITLE 33* TITLE 46
Flammability of compartment	Design & Manufacturing Specifications	23.787+ 25.855+ 25.857/ 121.285/	A	A	A	A	A
Access to fire in compartment	Classification by Ease of Access	121.221/ 121.287/	NA	NA	NA	A	A

* Section numbers so indicated are from Title 33, otherwise Title 46

TABLE A-5. FIRE SAFETY REGULATION COMMONALITIES - Procedures: Smoking Regulations (1 of 5)

PROBLEM	METHOD OF DEALING WITH PROBLEM	MODAL ADMINISTRATIONS					
		FAA TITLE 14	FHWA TITLE 49	NHTSA TITLE 49	UMTA (NONE)	FRA TITLE 49	USCG TITLE 33* TITLE 46
Ignition source	Prohibit or Restrict Smoking	23.853+ 25.853+	392.50+ 397.13+	A	A	A	*35.30-5/ 78.40-10- 185.20-20-
Passenger awareness of restriction	Signing to Emphasize Regulations	25.791+ 91.197+ 121.317+	A	NA	A	A	35.30-1+

* Section numbers so indicated are from Title 33, otherwise Title 46

TABLE A-5. FIRE SAFETY REGULATION COMMONALITIES - Procedures: Fueling Regulations (2 of 5)

PROBLEM	METHOD OF DEALING WITH PROBLEM	MODAL ADMINISTRATIONS					
		FAA TITLE 14	FHWA TITLE 49	NHTSA TITLE 49	UMTA (NONE)	FRA TITLE 49	USCG TITLE 33* TITLE 46
Ignition of fuel/vapor and resultant loss of life and property	Location	159.133+	392.52+	A	A	A	A
	Maintenance of Hoses	159.133+	A	A	A	A	A
	Require Engine to be Off	159.133+	392.50+	A	A	A	A
	Prohibit Refueling With Passengers on Board	159.133+	392.52+	NA	A	A	185.20-25+
	Prohibit Smoking in Area	A	392.50+ 397.15+	A	A	A	A
	Require Vehicle to be Attended During Refueling	A	397.15+	A	A	A	A

* Section numbers so indicated are from Title 33, otherwise Title 46

TABLE A-5. FIRE SAFETY REGULATION COMMONALITIES - Procedures: Safety Regulations (3 of 5)

PROBLEM	METHOD OF DEALING WITH PROBLEM	MODAL ADMINISTRATIONS					
		FAA TITLE 14	FHWA TITLE 49	NHTSA TITLE 49	UMTA (NONE)	FRA TITLE 49	USCG TITLE 33* TITLE 46
Procedures to follow in a fire emergency	Procedure Manual	25.1585+	NA	NA	A	A	185.25+
	Post Procedures	A	NA	NA	A	A	35.10-3+ 78.13-10/ 196.11-30/
	Conduct Fire Drills	A	NA	NA	A	A	35.10-1+ 35.10-5- 78.17-50- 97.15-35- 116.15/ 196.15-35/
Combustibility of movie film	Specify Types Permitted	25.853+	NA	NA	NA	A	35.30-45+ 78.75+ 97.60+ 111.80-30+ 196.60+
Knowledge of mechanical failures, malfunctions etc.	Require Report of Occurence	121.703+	NA	NA	A	A	A
	Require Monthly Report	A	NA	NA	A	225.11+	A
Auxiliary fire equipment	Require Emergency Equipment	A	NA	NA	A	A	35.30-20/ 77.35-10/ 96.35-10/

* Section numbers so indicated are from Title 33, otherwise Title 46

TABLE A-5. FIRE SAFETY REGULATION COMMONALITIES - Procedures: Safety Regulations (4 of 5)

PROBLEM	METHOD OF DEALING WITH PROBLEM	MODAL ADMINISTRATIONS					
		FAA TITLE 14	FHWA TITLE 49	NHTSA TITLE 49	UMTA (NONE)	FRA TITLE 49	USCG TITLE 33* TITLE 46
Fire caused by welding etc. during repairs, alterations	Require Approval Before Commencing Work	NA	NA	NA	NA	NA	35-01-1- 71.60-1-. 91.50-1- 189.50-1-
Suscepti-bility of certain areas to fire	Specify Criteria for Fire Zones	25.1181/ 25.1451- 121.253/	NA	NA	NA	NA	A
Fire resist-ance of flotation devices	Testing	37.178/	NA	NA	NA	NA	A
Ease of access/ egress in case of fire	Specifications for Stairways, Doorways, Exits, Seating Arrangements, etc.	23.783/ 23.803- 23.807+ 25.772/ 25.805- 25.807+ 25.809/ 25.813+ 25.815+ 25.817+ SFAR NO.23+ SFAR NO.32+	393.91+	571.217/	A	A	72.05-20- 72.05-25- 72.05-35- 72.10-. 92.10- 177.15- 177.30-1- 190.10--

* Section numbers so indicated are from Title 33, otherwise Title 46
SPAR = Special Federal Aviation Regulation

TABLE A-5. FIRE SAFETY REGULATION COMMONALITIES - Procedures: Safety Regulations (5 of 5)

PROBLEM	METHOD OF DEALING WITH PROBLEM	MODAL ADMINISTRATIONS					
		FAA TITLE 14	FHWA TITLE 49	NHTSA TITLE 49	UMTA (NONE)	FRA TITLE 49	USCG TITLE 33* TITLE 46
General fire protection	Design & Manufacturing Specifications	A	NA	NA	NA	NA	72.03/ 92.05/ 190.05/
Inability to locate exits	Marking of Exits	23.807+ 25.811+ 25.1557+ 121.310+ 121.1557+	393.91+	NA	A	A	78.37+ 78.40+ 78.47+
Poor visibility	Emergency Lighting	25.812+	A	NA	A	A	112.0+ 184.30-1* 184.30-5*
Emergency lifesaving equipment	Provide First Aid and Survival Kits	25.1561+	393.96+	A	A	A	33.0- 75.0- 94.0- 192.0-

* Section numbers so indicated are from Title 33, otherwise Title 46

TABLE A-6. FIRE SAFETY REGULATION COMMONALITIES - Transportation Buildings, Structures and Areas: Fire Protection Regulations (1 of 2)

PROBLEM	METHOD OF DEALING WITH PROBLEM	MODAL ADMINISTRATIONS					
		FAA TITLE 14	FHWA TITLE 49	NHTSA TITLE 49	UMTA (NONE)	FRA TITLE 49	USCG TITLE 33* TITLE 46
Portable means to extinguish a fire	Specify Location, Type and Number of Extinguishers Required	139.49/ 159.159+	A	NA	A	A	145.10*+ 149.481*+ 149.501*+ 149.503*+
Operating condition of equipment	Require Maintenance	139.89/	A	NA	A	A	145.01*+ 150.505*- 150.507*-
	Require Spare Charges	A	A	NA	A	A	149.505*+
Using the correct extinguisher for a fire	Lable as to Type of Fires Unit Will Extinguish and as to Location	A	A	NA	A	A	145.05*+ 149.507*+
Fixed fire extinguishing system	Specifications for Components	A	A	NA	A	A	149.451thru 149.479*/
	Restrictions	A	A	NA	A	A	150.504*-
Fire in an unmanned area	Require Detectors	A	A	NA	A	A	149.491*+
Auxiliary equipment needed to fight a fire	Require Auxiliary Equipment	A	NA	NA	A	A	149.515*/ 149.517*/

* Section numbers so indicated are from Title 33, otherwise Title 46

TABLE A-6. FIRE SAFETY REGULATION COMMONALITIES - Transportation Buildings, Structures and Areas: Miscellaneous Regulations (2 of 2)

PROBLEM	METHOD OF DEALING WITH PROBLEM	MODAL ADMINISTRATIONS					
		FAA TITLE 14	FHWA TITLE 49	NHTSA TITLE 49	UMTA (NONE)	FRA TITLE 49	USCG TITLE 33* TITLE 46
Handling and storage of fuel and materials	Require Controls, Procedures and Training of Personnel	139.51+ 139.127+	A	A	A	A	A
Ignition of fluids or materials	Specify Standards and Precautions for Use	159.121+ 159.131/	A	A	A	A	A
	Fueling Regulations	159.133+	392.52+	A	A	A	A
	Clean-up	159.129+	A	A	A	A	A
Ignition sources	Restrict Open Flame Operations	159.123+	A	A	A	A	A
	Restrict Smoking	159.125+	A	A	A	A	A
Use of power operated trucks in and around vehicle	Require Approved Type of Vehicle	A	NA	NA	NA	A	78.80-10/ 97.70-10/
	Fueling Regulations	A	NA	NA	NA	A	97.70-20/

* Section numbers so indicated are from Title 33, otherwise Title 46

TABLE A-7. FIRE SAFETY REGULATION COMMONALITIES - Miscellaneous: Heating Systems (1 of 1)

PROBLEM	METHOD OF DEALING WITH PROBLEM	MODAL ADMINISTRATIONS					
		FAA TITLE 14	FHWA TITLE 49	NHTSA TITLE 49	UMTA (NONE)	FRA TITLE 49	USCG TITLE 33* TITLE 46
Fire hazard	Design & Manufacturing Specifications	23.859/ 25.859/ 37.130/	NA	NA	A	A	63.05- 63.10-
	Restrictions	A	392.67/ 393.77/	A	A	A	A

* Section numbers so indicated are from Title 33, otherwise Title 46

APPENDIX B

SUGGESTED AREAS FOR FURTHER RESEARCH AND DEVELOPMENT

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SUGGESTED AREAS FOR FURTHER RESEARCH AND DEVELOPMENT

Fire safety regulations promulgated by the Federal Aviation Administration and the U.S. Coast Guard are extensive and can provide guidance to other modal administrations. Tables were developed (see Appendix A) to show regulation coverage and commonalities, indicating areas where the other modes could bene from regulations similar to those of the FAA or USCG. In some c because of modal similarities, it would be possible to adapt an existing regulation. In other cases, it would be necessary to initiate research and development to determine specific modal applications.

The need for further research and development is apparent when modal research and development efforts are reviewed. Certa areas, such as the flammability of interior materials and the development of more reliable fire detectors, have been the subje of many studies but still require further research. Evaluating materials by toxic and smoke producing characteristics is also a area in which research should continue.

Technological advances have been able to reduce the number of equipment-related fires through improved vehicle design. However, as technology continues to make transportation vehicles more fire-safe, methods of preventing fire due to human factors must also be explored.

Suggested areas for further research and development are as follows:

1. Fire Protection and Control

A method of improving fire safety in transportation vehicles would be to incorporate all presently available knowledge in the design of vehicles and the selection of materials. Similarly, methods of retrofitting existing vehicle fleets should be investigated. It would be useful if modal guidelines for vehicle design and construction were established for new systems.

An important factor in the development of fire-safe vehicles is the use of fire detectors. Experience and testing have indicated that certain types of existing detectors exhibit a high false alarm rate. Further research and development is necessary in the design of a reliable detector. Along with the development of a better detector, installation techniques might be formulated for determining the proper location and the number of detectors for a vehicle. In rail rapid transit vehicles, detectors would be beneficial since there is not usually a crew member in each car of a train.

Training of crews in the use of fire extinguishers may significantly reduce transportation fire losses. Development of easy-to-use equipment and clear, understandable instructions are essential.

Even when an acceptable set of fire-safety specifications exists, it is necessary to maintain the fire protection equipment on a vehicle and to conduct regular inspections to ensure that the equipment is in proper functioning condition. Modal inspection and maintenance criteria should be developed for this purpose.

2. <u>Interior Materials</u>

Extensive research and development has been conducted in the area of interior materials. In many of the abstracts of projects reviewed in the preparation of this report, it was apparent that only flammability characteristics were developed for particular materials, but toxic and smoke producing characteristics were not determined. These two products of combustion must be considered in all studies as they are often the cause of death or injuries in vehicle fires. In addition, the testing of materials for flammability, toxicity and smoke production should be a continual process since new materials are constantly being developed.

In the testing of candidate materials it is not always clear if the fire-related characteristics of the material can be accurately represented from the use of a small-scale test or if full-scale conditions are necessary. Futher R&D could investigate the correlation of small-scale test results with actual full-scale results.

A related question is whether or not use of fire modeling techniques may reduce the number of full-scale tests needed to determine fire, smoke and toxicity characteristics.

3. <u>Engine Components</u>

Further research and development efforts could be directed toward the design of rupture-proof fuel tanks, lines and fittings, fire resistant coatings for engine components, alternative, less flammable fuels, elimination of the problem of hot surface ignition by improved placement, protection and insulation of electrical equipment including batteries, cables, etc.

4. <u>Structural Components</u>

The increasing use of new lightweight structural panels requires that research and development be conducted to ensure that these materials are fire safe and can serve to prevent the spread of fire and fumes between compartments.

The increased use of fire walls between compartments or provision for subdivisions within compartments could also be investigated further. Firewalls may potentially restrict a fir to a small area rather than allowing it to involve the entire vehicle.

In addition, a general overview of modal vehicle structural requirements is suggested to determine the degree of fire safety offered. Factors to consider could include the ability of a wall to both contain flame spread and to limit radiation of heat through to the other side. If, on the other side of the wall, there is located an interior compartment, then radiated heat might cause a fire.

5. Procedures

Two areas in which R&D may lead to improved fueling regulations are:

1) Methods of providing safer fueling connections to avoid exposure to ignition sources, and

2) The development of criteria for passenger safety during fuel operations.

Crew member and passenger instructions of emergency and evacuation procedures should be developed for passenger-carrying vehicles. Effective methods of displaying safety information should be determined.

6. Transportation Buildings, Structures and Areas

One of the most effective ways of providing fire safety is through design. Accordingly, new facilities, such as terminals, garages, remote areas, and tunnels should be designed to provide for the safe movement of passengers and workers in case of a fire. Design criteria for such elements as emergency exits and fire extinguishing systems should be under continued review and evaluation.

It would also be beneficial to develop a program to train local fire fighting companies in the vicinity of airports, terminals, railroads, etc. in the special problems of extinguishing fires involving vehicles and transportation facilities.

APPENDIX C

CATEGORIES AND ITEMS IN TRANSPORTATION FIRE SAFETY STATISTICAL DATA BASES

APPENDIX C

CATEGORIES AND ITEMS IN TRANSPORTATION FIRE SAFETY STATISTICAL DATA BASES

The categories and items included in each statistical data base that have been discussed vary in relation to the function and purpose of the data base, the transportation mode or modes that are covered, and the relative importance of fire safety data to the administrative functions of the agency responsible for the maintenance of the statistical data base.

The compilation, presented below, represents the categories and items that appear in the data bases reviewed. The information, pertaining to fires and other related background information useful in analyzing transportation fire accidents/incidents, has been emphasized in this compilation. In all cases the fire information is part of a larger file dealing with other non-fire related aspects of accidents and incidents. None of the individual data bases include all of the categories and items appearing in this compilation.

The compilation itself indicates the comprehensiveness of an "ideal" data base for investigating transportation fire incidents.

CATEGORIES AND ITEMS IN STATISTICAL DATA BASES OF TRANSPORTATION FIRES

1. <u>Identifying Information and General Information</u>

    1.1 File number, case, serial number

    1.2 Accident/incident classification

        1.2.1 Fire associated with collision or impact

            1.2.1.1 Direct collision

            1.2.1.2 Secondary contact as a result of collision

            1.2.1.3 Induced damage

1.2.1.4 Exterior object penetration

1.2.2 Fire not associated with collision or impact

1.2.3 Fire/explosion (fuel)

1.2.4 Fire/explosion (other)

1.3 Date: day, month, year

1.4 Day of week

1.5 Time of occurrence, incident, accident

1.6 Location/Site

1.6.1 City, county, district, state, territory, jurisdiction, census tract, geocode, highway intersection, airport, etc.

2. <u>Vehicle</u>

2.1 Vehicle make

2.2 Vehicle model

2.3 Engine make

2.4 Engine model

2.5 Manufacturer's identification numbers (engine, hull, etc.)

2.6 Vehicle type

2.7 Material (hull, etc.)

2.8 Engine or type of propulsion

2.9 Horsepower

2.10 Year vehicle built

3. <u>Environment</u>

3.1 Type of environment in which fire/accident occurs: grade crossing, highway, street, airport, wharf, type of body of water, etc.

3.2 Environmental features, problems, or hazards

3.3 Environmental conditions: temperature, wind, etc.

4. <u>Area of Origin of Fire</u>

4.1 Passenger area

4.2 Trunk, load carrying area

4.3 Engine area

4.4 Running gear

4.5 Wheel area

4.6 Fuel tank

4.7 Fuel line

4.8 Operating control area: bridge of ship, cockpit of plan cab of truck, etc.

4.9 Exterior, exposed surface of transportation equipment

4.10 Other transportation vehicle areas not classified

4.11 Other areas of origin, not vehicle or transportation facility

5. <u>Equipment Involved in Ignition</u>

5.1 Engine

5.2 Bearings, brakes

5.3 Electrical equipment

5.4 Wiring

5.5 Rectifier, charger

5.6 Separate motor, generator

5.7 Separate pump, compressor

5.8 Heating system

5.9 Auxiliary equipment

5.10 Vehicle frame or structure

6. <u>Form and Source of Ignition</u>

6.1 Spark flame, or heat from gas fueled equipment

6.2 Heat from liquid fueled equipment

6.3 Heat or arcing from overloaded electrical equipment

6.4 Cigarette, match, or heat from open flame

6.5 Backfire - internal combustion engine

6.6 Heat spark from friction (including overheated tires)

6.7 Other forms of ignition not classified above

7. <u>Type of Material Ignited</u>

7.1 L.P. gas

7.2 Class IB flammable liquid

Flashpoint less than 22.8°C, boiling point at or above 37.8°C

Includes J-4 jet fuel

Excludes gasoline

7.3 Gasoline

7.4 Class IC flammable liquid
Flashpoint at or above 22.8°C and below 37.8°C

7.5 Class II combustible liquid
Flashpoint at or above 37.8°C and below 60°C
Includes kerosene and diesel fuel

7.6 Class IIIB combustible liquid
Flashpoint above 93.4°C
Includes transformer oil and lubricating oil

7.7 Other flammable, combustible liquids

7.8 Grease

7.9 Plastics

7.9.1 Polyurethane
Includes polyisocyanurates

7.9.2 Polystyrene
Includes styrene copolymers such as styrene-acrylonitrile (SAN), styrene-butadiene, and acrylonitrile-butadiene-styrene (ABS)

7.9.3 Polyvinyl
Includes polyvinyl chloride (PVC), polyvinyl fluoride, polyvinylidene chloride, polyvinylidene fluoride, and vinyl-chloride-acrylonitrile

7.9.4 Polyacrylic
Includes polymethyl methacrylate (PMMA)

7.9.5 Polyester
Includes fiberglass reinforced polyester

7.9.6 Polyolefin
Includes polyethylene and polypropylene

7.9.7 Other Plastics

7.10 Rubber and elastomers

7.11 Textiles

8. <u>Fire/Flame Propagation Rate</u>

8.1 Explosive

8.2 Rapid

8.3 Slow

8.4 Smoldering

9. <u>Avenue of Flame Travel</u>

9.1 Interior finish

9.1.1 Combustible ceiling finish, covering (finish is more than 1/32" thick, covering less than 1/32")

9.1.2 Combustible wall finish, covering

9.1.3 Combustible floor finish, covering

9.1.4 Combustible ceiling and wall finish, covering

9.1.5 Combustible ceiling and floor finish, covering

9.1.6 Combustible wall and floor finish

9.1.7 Combustible ceiling, wall, floor finish

9.1.8 Interior finish not classified

9.2 Structural factors allowing vertical flame travel

9.2.1 Inadequate firestopping construction of vehicle Includes insides of walls, around pipes, poke-throughs and the like

9.2.2 Air handling ducts

9.2.3 Utility shaft, pipe shaft

9.2.4 Failure of rated bulkheads, components

9.2.5 Exterior spread

9.2.6 Floor, ceiling

9.2.7 Structural factors not classified above

9.3 Structural factors allowing horizontal flame travel

9.3.1 Air handling duct

9.3.2 Concealed spaces

9.3.3 Door open or burned

9.3.4 Utility opening, pipe opening

9.3.5 Window

9.3.6 Wall or bulkhead

9.3.7 Structural factors not classified above

9.4 Physical transfer of materials ignited

9.4.1 Human being, animal

9.4.2 Conveyer, special materials handling equipment

9.4.3 Gravity
9.4.4 Wind
9.4.5 Pipeline, material transfer system
9.4.6 Other, not classified above

9.5 Contents of vehicle

9.5.1 Seats
9.5.2 Fixtures
9.5.3 Flammable liquids improperly handled or contained
9.5.4 Flammable dust, solid chemical
9.5.5 Flammable gases improperly handled or contained
9.5.6 Explosives
9.5.7 Luggage
9.5.8 Cargo
9.5.9 Other contents

9.6 Other flame travel factors

10. Type of Material Generating Most Smoke

10.1 L.P. gas

10.2 Class IB flammable liquid
Flashpoint less than 22.8°C, Boiling point at or above 37.8°C
Includes J-4 jet fuel
Excludes gasoline

10.3 Gasoline

10.4 Class IC flammable liquid
Flashpoint at or above 22.8°C and below 37.8°C

10.5 Class II combustible liquid
Flashpoint at or above 37.8°C and below 60°C
Includes kerosense and diesel fuel

10.6 Class IIIB combustible liquid
Flashpoint above 93.4°C
Includes transformer oil and lubricating oil

10.7 Other flammable combustible liquids

10.8 Grease

10.9 Plastics

10.9.1 Polyurethane
Includes polyisocyanurates

10.9.2 Polystyrene
Includes styrene copolymers such as styrene-acrylonitrile (SAN), styrene-butadiene, and acrylonitrile-butadiene-styrene (ABS)

10.9.3 Polyvinyl
Includes polyvinyl chloride (PVC), polyvinyl fluoride, polyvinylidene chloride, polyvinylidene fluoride, and vinyl-chloride-acrylonitri

10.9.4 Polyacrylic
Includes polymethyl methacrylate (PMMA)

10.9.5 Polyester
Includes fiberglass reinforced polyester

10.9.6 Polyolefin
Includes polyethylene and polypropylene

10.9.7 Other Plastics

10.10 Rubber and elastomers

10.11 Textiles

11. <u>Avenue of Smoke Travel</u>

11.1 Air handling duct

11.2 Corridor

11.3 Openings resulting from construction, gaps over doors, walls

11.4 Stairwells

11.5 Utility opening in walls and floors

11.6 No significant avenue

11.7 Unknown or not reported

12. <u>Fire Detection, Warning Systems</u>

12.1 Detector installed and operated in vehicle

12.2 Detector installed but did not operate

12.3 Not installed

12.4 Installed but too small a fire to operate

12.5 Not classified

12.6 Unknown or not reported

13. Firefighting Response

13.1 Fire time interval to alarm

- 13.1.1 Immediate
- 13.1.2 1-5 minutes
- 13.1.3 5-30 minutes
- 13.1.4 30-60 minutes
- 13.1.5 More than an hour
- 13.1.6 Fire discovered after self-extinguishment
- 13.1.7 Unknown

13.2 Time interval from alarm to use of extinguishing agent

- 13.2.1 Agent used prior to alarm
- 13.2.2 Immediate-less than a minute
- 13.2.3 1-5 minutes
- 13.2.4 5-30 minutes
- 13.2.5 30-60 minutes
- 13.2.6 More than an hour
- 13.2.7 Self-extinguished prior to alarm
- 13.2.8 Did not use extinguishing agent

14. Method of Extinguishment

14.1 Self-extinguished

14.2 Fuel source removal

14.3 Cooling-Water

- 14.3.1 Preconnected hose line with water carried in apparatus tanks
- 14.3.2 Preconnected hose line with water from hydrant, draft, standpipe
- 14.3.3 Hand-laid hose with water from hydrant, draft, or standpipe
- 14.3.4 Master stream device with/without hand lines
- 14.3.5 Automatic sprinkler system

14.4 Chemical

- 14.4.1 Portable and hand-held extinguishers

14.5 Suffocation - dirt, sand, blankets
14.6 Fire department equipment
14.7 Other, unclassified, unknown
14.8 None

15. <u>Persons Providing Primary Extinguishment</u>

15.1 Occupants of crash vehicle
15.2 Bystander(s)
15.3 Police
15.4 Fire department
15.5 Other
15.6 No one, self-extinguished
15.7 Unknown

16. <u>Operation of Automatic Fire Extinguishment System in Vehicle</u>

16.1 Activated and effective within selected compartment
16.2 Activated, did not operate within selected compartment
16.3 Activated, ineffective within selected compartment
16.4 Not activated
16.5 Not equipped

17. <u>Crashfire Inerting System-Aircraft</u>

17.1 Available, operated effectively
17.2 Available, ineffective
17.3 Not equipped
17.4 Operation not reported

18. <u>Firefighting Equipment Availability</u>

18.1 On-site - Fire department, etc.

18.1.1 Alerted, standing by
18.1.2 Late in arrival
18.1.3 Inadequate equipment
18.1.4 Effectiveness in fighting fire
18.1.5 Not available

18.2 Interior of Vehicle

18.2.1 Installed
18.2.2 Adequate

18.2.3 Effectiveness in extinguishing of fire

18.2.4 Not installed

19. Fire Extinguishing Agents Used, On-Site

19.1 Carbon Dioxide CO_2

19.2 Chlorobromomethane (Halon 1011)

19.3 Foam

19.4 Water

19.5 Dry chemical

19.6 Bromochlorodifluoromethane (Halon 1211)

19.7 Bromotrifluoromethane (Halon 1301)

19.8 Dirt/Sand

19.9 None

19.10 Other

19.11 Unknown/not reported

20. Fire Extinguishing Agents Used in Vehicle

20.1 Portable

20.1.1 Carbon Dioxide CO_2

20.1.2 Chlorobromomethane (Halon 1011)

20.1.3 Bromochlorodifluoromethane (Halon 1211)

20.1.4 Bromotrifluoromethane (Halon 1301)

20.1.5 Dry chemical

20.1.6 Water solutions

20.1.7 None

20.1.8 Other

20.1.9 Unknown/unreported

20.2 Fixed

20.2.1 Carbon Dioxide CO_2

20.2.2 Chlorobromomethane (Halon 1011)

20.2.3 Freon

20.2.3.1 Dibromotrifluoromethane (Halon 1302)

20.2.3.2 Bromotrifluoromethane (Halon 1301)

20.2.4 Methyl Bromide (Halon 1001)
20.2.5 None
20.2.6 Other
20.2.7 Unknown/unreported

21. Vehicle Destruction by Fire

21.1 Percentage of vehicle damaged

21.1.1 None
21.1.2 Up to 10%
21.1.3 10 to 25%
21.1.4 25 to 50%
21.1.5 50 to 75%
21.1.6 75 to 100%
21.1.7 Unknown

21.2 Percentage of vehicle damaged beyond repair

21.2.1 None
21.2.2 Up to 10%
21.2.3 10 to 25%
21.2.4 25 to 50%
21.2.5 50 to 75%
21.2.6 75 to 100%
21.2.7 Unknown

22. Type of Vehicle Destruction

22.1 Flame damage
22.2 Smoke damage
22.3 Water damage

23. Number of Vehicles Involved

24. Fire Control Damage

24.1 Confined to object of origin
24.2 Confined to part of area of origin
24.3 Confined to area of origin
24.4 Confined to fire rated compartment, bulkhead
24.5 Confined to floor of origin
24.6 Confined to vehicle

24.7 Damage extended to beyond vehicle
24.8 No damage of this type
24.9 Unknown/unreported

25. <u>Estimated $ Amount of Vehicle Loss</u>

26. <u>Fire Casualties</u>

26.1 Type of fatal injuries

26.1.1 Immediate death

26.1.1.1 Incineration
26.1.1.2 Inhalation of products of combustion
26.1.1.3 Incineration and inhalation
26.1.1.4 Inhalation of poisonous gases from cargo spillage
26.1.1.5 Unknown

26.1.2 Subsequent death

26.1.2.1 Thermal burns
26.1.2.2 Fire related complications (not crash injuries)
26.1.2.3 Unknown

26.2 Type of non-fatal injuries

26.2.1 Burns (flames)
26.2.2 Burns (heat, hot surface)
26.2.3 Toxic gases, smoke etc.
26.2.4 Extinguishing agents
26.2.5 Extrication
26.2.6 Other
26.2.7 Unknown

27. <u>Means of Extrication from Vehicle</u>

27.1 Self, unassisted
27.2 Assisted by other crash vehicle occupant(s)
27.3 Assisted by bystanders
27.4 Assisted by police or other rescue personnel
27.5 Not extricated
27.6 Extricated or exited prior to fire

27.7 Vehicle not occupied prior to crash event
27.8 Unknown

28. Crew, Operators, Pilot

28.1 Met training requirements for fire safety
28.2 Age
28.3 Operator experience (appropriate mode)

29. Accident Descriptors

29.1 Could not reach fire extinguisher
29.2 Fire extinguisher not serviceable
29.3 Attempted to fight fire
29.4 Extinguisher not adequate
29.5 Hit by lighting or struck power cable
29.6 Contact with power line
29.7 Etc.