

Overview of Work Performed
by
PIARC Technical Committee C3.3 Working Group 6
on
Ventilation and Fire Control

Ventilación y control de incendios en túneles carreteros: Revisión de las actividades desarrolladas por el Grupo de Trabajo N° 6, Comisión Técnica C 3.3. de la AIPCR

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ABSTRACT

The World Road Association (PIARC) has long included the subject of road tunnel fire life safety and ventilation as part of its quadrennial activities. The subject of fire life safety and ventilation is addressed by its Technical Committee C3.3 "Road Tunnel Operation", and now in turn by its Working Group 6 "Ventilation and Fire Control". This paper provides a brief overview of the activities of PIARC Working Group 6 principally during the most recent four year PIARC cycles.

RESUMEN

La Asociación Mundial de Carreteras (AIPCR) ha incorporado la temática de seguridad contra incendios y ventilación en túneles carreteros como partes de sus actividades cuatrienales. Este tema es abordado por el Grupo de Trabajo N° 6, "Ventilación y Control de Incendios", que forma parte del Comité Técnico C3.3 de la AIPCR, "Operación de Túneles Carreteros". Este artículo presenta una breve síntesis de las actividades realizadas por dicho Grupo de Trabajo N° 6, especialmente durante los últimos cuatro años.

INTRODUCTION

There are more road tunnels being built to provide access routes under waterways, through mountains or to simply to avoid urban environmental and construction difficulties.

As a result of the significant road tunnel fires occurring during recent years in Europe tunnels worldwide interest in road tunnel fire life safety has intensified. Vehicle fires give rise to particular concern because their consequences can be far greater in a road tunnel than on the open road if appropriate mitigation measures are not taken.

While there is a continuing decrease in road vehicle pollutant emissions such that the capacity of today's ventilation systems and equipment is usually determined by fire and smoke control considerations there continues to be a strong interest in the impact of vehicle emissions on the environment within the road tunnel and on the environment surrounding the tunnel portals during normal tunnel operations. This makes the planning and design decisions regarding both the fire emergency and the normal environment extremely critical to the road tunnel construction process.

TECHNICAL COMMITTEE

Since it was created in 1957, the PIARC Committee on Road Tunnels (more recently known as the PIARC Technical Committee on Road Tunnel Operation) has been engaged in the consideration of fire life safety, emergency ventilation (related to fire smoke control) and normal ventilation systems and equipment. Information and recommendations in these fields have appeared in the reports this committee has produced for most of the recent PIARC World Road Congresses. A list of recent World Road Congress reports of the Road Tunnel Committee is at Appendix A.

Until the Marrakech Congress in 1991 the subject of fire and smoke control had been addressed by various working groups within the technical committee, especially those devoted to Operation-Maintenance-Management and to Pollution-Environment-Ventilation.

The PIARC Cycle

The PIARC operational cycle is four years in length. Therefore, all committees and working groups have a life of four years. It then follows that all work programmes also have a life of four years. Each cycle ends with a World Road Congress which is held every four (4) years. The most recent was held in Durban, South Africa in October 2003. The next World Road Congress will be held in Paris, France in September 2007. After each World Road Congress PIARC leadership determines which committees and which working groups will be reconstituted for the next cycle based on the PIARC conceptual themes for the upcoming cycle. As a part of the current cycle 2003-2007 the activities of Work Group 2 "Pollution, Ventilation, Environment" was folded into Working Group 6 "Fire and Smoke Control" thus creating a new name, "Ventilation and Fire Control" and a new mission for Working Group 6.

Working Group

In 1992 the Committee on Road Tunnels determined that the importance of the subject of fire and smoke control justified the establishment of a specific working group devoted to fire and smoke control to work with the existing working group related to emission and the tunnel environment. This new Working Group 6, has, since starting operation, participated in the Congress Reports for the World Road Congresses in Montreal (1995), Kuala Lumpur (1999) and Durban (2003).

The total Working Group 6 membership during this current cycle is 34 members representing 23 countries. The meetings have been attended by an average of 17 out of 23 countries. A list of the current member countries is at Appendix B.

This working group has met twice a year since its formation in 1992. The working group meetings have been held in Austria, Finland, France, Germany, Italy, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, the United Kingdom and the United States. The working group may be holding meetings in the Czech Republic, Belgium and Croatia in the next eighteen months.

During its initial meetings the working group deemed it necessary to draw up a "state-of-the-art" summary of the primary subjects connected to fire and smoke control in road tunnels. The results of much research, experiences, reflections and even regulatory documents had been published worldwide, but a synthesis was lacking. Early results were published in the report prepared by the Committee on Road Tunnels for the XXth World Road Congress in Montreal in 1995. [1]

An inter-congress technical report, entitled "Fire and Smoke Control in Road Tunnels" was published in 1999 in conjunction with the XXIst World Road Congress in Kuala Lumpur [2]. This 1999 report provided the "state-of-the-art" assessment prepared by the working group. It was intended for all those who are interested in road tunnel planning, design, construction, operation or safety: owners, consultants, operators, researchers, regulators, fire brigades, etc. It provides an overview and recommendations, as well as the background on the way to provide reasonably efficient and cost-effective systems to protect against fire and smoke in road tunnels. It also provides references that are useful to obtain further details.

However, despite the enormous amount of data and information contained in this book experience and research are still needed because the field is quite large and the issues extremely complex: fires in tunnels involve numerous varying and interacting physical phenomena, which have been particularly difficult to investigate.

We do not yet have a complete understanding of the behaviour of a fire in a tunnel, even though our knowledge is quickly improving through numerous research projects. As a consequence further effort will be needed to achieve complete, well-founded and universally accepted guidelines. The PIARC Technical Committee C3.3 (formerly C-5) on Road Tunnel Operation has continued its efforts towards this goal.

The fire incidents in road tunnels during recent years have led to a situation where safety in transport tunnels, particularly evacuation, rescue and suppression concepts are being scrutinised both in the affected countries as well as worldwide.

CURRENT WORK PLAN

At the beginning of each PIARC cycle each working group must, in conjunction with its respective technical committee, develop a work plan to be approved by the respective managing committee.

The approved work plan for Working Group 6 for the 2003-2007 PIARC cycle contained the following major work tasks:

- Task 1. Investigate Pollution Inside Tunnels and at Portals
- Task 2. Study Operation Strategies for Tunnel Ventilation
- Task 3. Assess Fixed Fire Fighting Systems
- Task 4. Review of Vehicle Fire Size
- Task 5. Review of the Impact of Pavement on Tunnel Fires

Each of these work plan tasks is briefly described below:

Task 1. Investigate Pollution Inside Tunnels and at Portals

The scope of this task is to conduct an investigation of the management of vehicle emissions from an environmental perspective and to collect information and conduct comparisons on “new” pollutants, policies, methods to reduce pollution.

The task includes identification of known pollutants in both current regulations and anticipated future regulations. It also includes the identification of vehicle emission trends.

This task will also provide identification of exposure management options to include ventilation design/options, ventilation design/operation, demand management, fleet management and air “cleaning” options.

The results of the task efforts will be the development of guidelines to the design and management of tunnels from a vehicle emissions exposure perspective.

These task efforts will result in a technical report titled “*Road Tunnels: A Guide to Optimising the Air Quality Impact upon the Environment*”.

Task 2. Study Operation Strategies for Tunnel Ventilation

This task is to provide recommendations for ventilation control during normal operation and during emergency operation (fire). It was considered appropriate to consider the following topics:

- Discussion of simulation techniques; updating previous reports of PIARC and adding new developments, information and cautions
- Fire suppression methods
- Backlayering – degree to which this can be allowed
- Active /passive ventilation control and control procedures adopted internationally
- Influences of regulation/European Directive

The task will conclude with the development of recommendations regarding ventilation control during normal operation and during emergency operation (fire).

A technical report will be produced titled “*Road Tunnels: Operation Strategies for Tunnel Ventilation*”.

Task 3. Assess Fixed Fire Fighting Systems

The main objectives of this task are to define relevant fire and ventilation scenarios, collect and review results and national regulations, collect and review practical experience from various countries worldwide and assess the efficiency of fixed fire fighting systems.

It is planned to include and evaluate tests recently conducted in France, Japan, The Netherlands and Switzerland and other countries. Furthermore the various technical options for automatic or manually operated fixed fire fighting systems will be considered.

The task will also deal with the question of when, where, by whom and how the system should be activated.

Another very important element of the task scope will be the reliability of the entire system including the detection, measuring technologies (temperature, visibility), activation, water delivery and general control.

In addition a further very important question contained in this scope is evaluation of the reliability of the systems versus cost effectiveness (installation, operation, regular inspection, maintenance).

This task will also address the question of false alarms. Practical applications have proved in the past that quite often false alarms are hard to avoid.

Another aspect to be investigated is related to the question whether to consider fire hardening of the tunnel structure itself or in contrary the vehicles especially the trucks, HGV's and busses.

The conclusions will include recommendations on the suitability of fixed fire fighting systems in road tunnels.

The task efforts will result in a technical report titled "*Road Tunnels: An Assessment of Fixed Fire Fighting Systems*".

Task 4. Review of Vehicle Fire Size

The primary mission of the task is to review the design fire size data published in earlier PIARC publications such as "*Fire and Smoke Control in Road Tunnels*", 1999 [2] and "*Systems and Equipment for Fire and Smoke Control in Road Tunnels*", 2005 [5].

The result of this task will be recommendations on Design Fire Size and what specific data PIARC should include in its future technical publications and whether there is any need to revise existing published data.

A technical report titled: "*Road Tunnels: Update of Design Fire Size*" will record the results of this task.

Task 5. Review of the Impact of Pavement on Tunnel Fires

The scope of this task includes the examination of new information available on the subject of the impact of pavement on tunnel fires to enable review of the PIARC position as espoused in the 1999 technical report titled “*Fire and Smoke Control in Road Tunnels*” [2].

This task will produce recommendations on the PIARC position on the impact of pavement on tunnel fires.

Publication of the task results will be in a Route/Roads article titled “*Impact of Pavement on Road Tunnel Fires*”

PIARC PUBLICATIONS

Developing PIARC Publications

In conjunction with the approved 2003-2007 work plan, outlined above, the following PIARC documents will be published:

Technical Reports

- *Road Tunnels: A Guide to Optimising the Air Quality Impact upon The Environment*
- *Road Tunnels: Operation Strategies for Tunnel Ventilation*
- *Road Tunnels: An Assessment of Fixed Fire Fighting Systems*
- *Road Tunnels: Update of Design Fire Size*

Route/Roads Article

- *Impact of Pavement on Road Tunnel Fires*

All of these publications should be published in conjunction with the Paris World Road Congress before the end of 2007.

Historical PIARC Publications

There are a series of historic PIARC publications pertinent to the subjects of both ventilation and fire control in road tunnels. In addition there are several other PIARC reports that are useful references for those interested in road tunnel ventilation and fire safety. All of these publications are listed and categorised below:

Pertinent Publications

- Technical Reports
 - *Road Tunnels: Emissions, Ventilation, Environment* [3]
 - *Fire and Smoke Control in Road Tunnels* [2]
 - *Road Tunnels: Vehicle Emissions and Air Demand for Ventilation* [4]
 - *Road Tunnels: Systems and Equipment for Fire and Smoke Control* [5]
- Route-Roads Articles
 - *PIARC Proposal on Design Criteria for Resistance to Fire for Road Tunnel Structures* [6]
 - *A Comparative Analysis Of The Mont Blanc, The Tauern And The Gotthard Tunnel Fires* [7]

Reference Publications

- Technical Reports
 - *Tunnel Classification* [8]
 - *Road Safety in Tunnels* [9]
 - *Good Practice for the Operation and Maintenance of Road Tunnels* [10]
 - *Traffic Incident Management Systems used in Road Tunnels* [11]

Pertinent Technical Report Details

This section addresses, in general, the contents of the pertinent and developing technical reports as listed above.

Fire and Smoke Control in Road Tunnels [2]

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INTRODUCTION

- I OBJECTIVES OF FIRE AND SMOKE CONTROL**
- II FIRE RISK AND DESIGN FIRES**
- III SMOKE BEHAVIOUR**
- IV STUDY METHODS**
- V VENTILATION FOR FIRE AND SMOKE CONTROL**
- VI EXITS AND OTHER SAFETY FACILITIES**
- VII TUNNEL REACTION AND RESISTANCE TO FIRE**
- VIII FIRE RESPONSE MANAGEMENT**
- IX REFERENCES**

Systems and Equipment for Fire and Smoke Control in Road Tunnels [5]

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- 1. SMOKE PROGRESS AT THE BEGINNING OF A FIRE**
- 2. SAFETY CONCEPT FOR ROAD TUNNELS**
- 3. LESSONS LEARNED**
- 4. VENTILATION**
- 5. EMERGENCY EXITS**
- 6. FIRE SPECIFIC EQUIPMENT**
- 7. STRUCTURE RESISTANCE TO FIRE**
- 8. OPERATIONAL RESPONSIBILITIES FOR EMERGENCIES**
- 9. SUMMARY**
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- 12. APPENDICES**

This technical report is composed of eight (8) key technical sections as described below:

- Section 1 presents an introduction to the effects of smoke propagation at the beginning of a road tunnel fire.
- Section 2 develops some sound safety concepts for the road tunnel.
- Section 3 addresses the most severe of the recent tunnel fires. These fires are examined and a set of lessons that the industry should learn from these unfortunate incidents are included.
- Section 4 covers aspects of both transverse and longitudinal ventilation along with some of the equipment required for the ventilation system to function properly.
- Section 5 addresses the issue of emergency exits for evacuation, escape and rescue.
- Section 6 contains discussion of the latest technological advancements in fire detection and suppression.
- Section 7 contains the written material that PIARC Working Group 6 provided to ITA as a part of the collaboration agreement noted above related to the criteria to be applied in the development of methods to furnish structural resistance to fire.
- Section 8 includes a discussion of the objectives for smoke control and how these objectives can be achieved by the designers and operators, the factors affecting emergency response teams, the requirement for an Emergency Response Plan, and the importance of maintenance and testing of equipment.

- Section 9 contains a list of suggested subjects to be considered for future research and study. This final section contains a comprehensive list of suggested issues for further study and research.

Road Tunnels: A Guide to Optimising the Air Quality Impact upon the Environment

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- 5. STRATEGIC PLANNING**
- 6. TUNNEL AIR DISPERSION TECHNOLOGIES**
- 7. REGULATION OF TRAFFIC USE**
- 8. OPERATIONAL ASPECTS**
- 9. LESSONS LEARNED**
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- 6. RECOMMENDATIONS**
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- 8. BIBLIOGRAPHY**

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Road Tunnels: An Assessment of Fixed Fire Fighting Systems

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- 1. BACKGROUND**
- 2. FIXED FIRE FIGHTING SYSTEMS IN AN INTEGRATED SAFETY SYSTEM**
- 3. TECHNICAL PRINCIPLES**
- 4. APPLICATION EXAMPLES**
- 5. PRACTICAL EXPERIENCE**
- 6. POSSIBLE SYSTEMATIC FOR CONTROLLING AND ACTIVATING OF THE SYSTEMS**
- 7. INTERACTION BETWEEN THE FIXED FIRE FIGHTING SYSTEMS AND OTHER SAFETY SYSTEMS**
- 8. REQUIREMENTS FOR FIXED FIRE FIGHTING SYSTEMS**
- 9. RECOMMENDATIONS**
- 10. REFERENCES**
- 11. BIBLIOGRAPHY**

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Road Tunnels: Update of Design Fire Size

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2. DEFINITIONS
3. DESIGN FIRES – PRINCIPLES AND FIRE CHARACTERISTICS
4. DEFINITION OF SAFETY GOALS
5. RECENTLY EXECUTED FIRE TEST IN FULL SCALE AND IN LABORATORY
6. EXPERIENCE RELATED TO THEORY AND FIRES OCCURRED IN REALITY
7. TUNNEL CHARACTERISTICS THAT HAVE GREAT IMPACT ON FIRE DEVELOPMENT
8. SAFETY DESIGN OF PROPERTY
9. FIRE GROWTH CHARACTERISTICS
10. SAFETY DESIGN WITH RESPECT TO THE SAFETY FOR PEOPLE
11. SAFETY DESIGN WITH RESPECT TO ADEQUATE SAFETY CONDITIONS DURING THE FIRE FIGHTING PHASE
12. INFLUENCE OF PAVEMENT ON FIRES
13. CONCLUSIONS
14. REFERENCES
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COLLABORATIVE EFFORTS

Collaboration has been one of the key themes of the Working Group 6 approved work plans over the recent PIARC cycles. The purpose was to interact with organizations, both internal and external, from whom the working group could obtain the best input

The collaboration with ITA and its Working Group 6 resulted in the publication by ITA of the document “*Guidelines for Structural Fire Resistance for Road Tunnels*” [12].

The recent collaboration with the National Fire Protection Association (NFPA) resulted in the joint sponsorship of a two-day workshop on fixed fire suppression systems in tunnels. The workshop was held at the NFPA annual meeting in Las Vegas in June 2005.

Collaboration within the PIARC organisation included working with fellow working groups. The collaboration with Working Group 2 during the last cycle included on the subjects of smoke dampers, jet fans, maintenance and testing and ventilation control resulted in jointly written material in Sections 4 & 8 and the Appendices of the PIARC technical report titled “*Systems and Equipment for Fire and Smoke Control in Road Tunnels*” [5].

CONCLUSION

The primary purpose of this paper is to briefly present the results of the activities of the PIARC Working Group 6 “Ventilation and Fire Control in Road Tunnels” during the recent PIARC cycles. The paper has shown the work performed and the resulting publications produced by this working group. It is clear that the resulting efforts of the working group are a key element in the continuing battle against the impact of emission

pollutants and fires on the operation of road tunnels. This was the result of the over 30 members from 23 countries working together toward a common goal “to improve the environment and fire life safety in and around the world’s road tunnels”. The strong participation by all representatives made the working group’s efforts extremely productive and will result in excellent documentation of the goals achieved.

REFERENCES

- [1] PIARC Committee on Road Tunnels (C-5), “*Report to the XXth World Road Congress*”, Montreal, Canada, September 1995, [20.05.B].
- [2] PIARC Committee on Road Tunnels (C-5), “*Fire and Smoke Control in Road Tunnels*”, 1999, [05.05.B].
- [3] PIARC Committee on Road Tunnel Operation (C-5), “*Road Tunnels: Emissions, Ventilation Environment*”, 1995, [05.02.B].
- [4] PIARC Committee on Road Tunnel Operation (C-5), “*Road Tunnels: Vehicle Emissions and Air Demand for Ventilation*” 2004, [05.14.B].
- [5] PIARC Committee on Road Tunnel Operation (C-5), “*Systems and Equipment for Fire and Smoke Control in Road Tunnels*”.
- [6] PIARC Committee on Road Tunnel Operation (C-5), Route/Roads, “*A Comparative Analysis of the Mont Blanc, the Tauern and the Gotthard Tunnel Fires*”, 2004.
- [7] PIARC Committee on Road Tunnel Operation (C-5), Route/Roads, “*PIARC Proposal on Design Criteria for Resistance to Fire for Road Tunnel Structures*” 2003.
- [8] PIARC Committee on Road Tunnel Operation (C-5), “*Tunnel Classification*”, 1995, [05.03.B].
- [9] PIARC Committee on Road Tunnel Operation (C-5), “*Road Safety in Tunnels*”, 1995, [05.04.B].
- [10] PIARC Committee on Road Tunnel Operation (C-5), “*Good Practice for the Operation and Maintenance of Road Tunnels*”, 2005, [05.13.B].
- [11] PIARC Committee on Road Tunnel Operation (C-5), “*Traffic Incident Management Systems used in Road Tunnels*”, 2004, [05.15.B].
- [12] International Tunnelling Association (ITA), Working Group No. 6, “*Guidelines for Structural Fire Resistance for Road Tunnels*”, 2003.

APPENDICES

Appendix A

World Road Association (PIARC) World Congress Reports on Ventilation

- Report to the XVth World Road Congress, Mexico City, Mexico, 1975
- Report to the XVIth World Road Congress, Vienna, Austria, 1979
- Report to the XVIIth World Road Congress, Sydney, Australia, 1983
- Report to the XVIIIth World Road Congress, Brussels, Belgium, 1987
- Report to the XIXth World Road Congress, Marrakech, Morocco, 1991, [19.05.B]
- Report to the XXth World Road Congress, Montreal, Canada, 1995, [20.05.B]
- Report to the XXIst World Road Congress, Kuala Lumpur, Malaysia, 1999, [21.05.B]
- Report to the XXIInd World Road Congress, Durban, South Africa, 2003, [22.05.B]

Appendix B

Member Countries of PIARC Working Group 6 during the 2003-2007 Cycle

- Australia
- Austria
- Belgium
- Canada
- China
- Croatia
- Czech Republic
- Denmark
- Finland
- France
- Germany
- Iraq
- Italy
- Japan
- the Netherlands
- Norway
- Portugal
- Slovenia
- Spain
- Sweden
- Switzerland
- United Kingdom
- United States of America