From: mark curran
To: <gpscno2@parliament.nsw.gov.au>
Date: 4/09/2006 3:38 pm
Subject: Answers to Questions att RachelCallinan

Attached are answers to questions from the inquiry into the health aspects of air pollution in the Sydney basin

Mark Curran

Answers to Questions on Notice

Mark Curran

GASP (Groups Against Stack Pollution)

1. Can you advise the Committee generally of the air quality issues that have arisen in connection with the various tunnels constructed in Sydney in recent times, including the M5 motorway, the Cross City Tunnel and the Lane Cove Tunnel

In this response I am assuming that the members of the inquiry are interested in issues such as adverse health outcomes which are likely to be associated with degraded air quality rather than specific questions relating to the recording and interpretation of air quality monitoring results or to the inappropriate use of NEPM guidelines for the regulation of point source emissions.

My experience has been directly with the M5 tunnel however I have , in the past, been contacted by residents living close to the Eastern Distributor tunnel with reports relating to problems they claimed to have with pollution (mainly dust and smells) relating to this tunnel. More recently they reported increased problems which they related to increased traffic congestion resulting from road changes relating to the Cross City tunnel.

In relation to the M5 tunnel, the problems commenced soon after the tunnel opened, with multiple reports of tunnel smells and exacerbation of asthma conditions from people living close to the stack.

This led RAPS to start collecting these reports in a systematic way by means of 'smell diaries'. After several months RAPS commissioned a professional air quality expert (Dr Peter Best, then of Katestone Environmental in Brisbane) to analyse the results. The cost of this analysis was borne by RAPS members.

He reported that his initial investigation showed a strong temporal and spatial relationship between reports, suggesting a common cause and he suggested that, in his opinion, the evidence was so strong that RAPS faced an ethical dilemma, either continue the study to obtain even stronger evidence or pass the information on the NSW Health to alert them to what appeared to be a significant health problem.

The later option was followed and it was this evidence which prompted NSW Health to commence its residents' health study.

As I pointed out in my evidence to the inquiry, this study was inconclusive but was so poorly conceived and carried out that no credence could be given to its 'non-finding':

"We found no evidence of an association between prevalence of reported symptoms and modeled emissions from the M5 East stack. The methodology used represents the best feasible epidemiological approach to determining if there are population health effects from the M5 East stack emissions.

On the basis of these findings we believe that there is no scientific justification to conduct further epidemiological studies into the reported health effects on the community surrounding the M5 East stack."

We are at a loss to understand why neither the 'smell diary' process, which had proved successful, was not carried on as part of the study, nor why the community's urgings to involve local doctors and schools to gather relevant data were not heeded.

The revision of the study, which was promised by NSW Health in February 2005 as a result of the identified deficiencies, has not been completed and released to the public. Over 1500 people were directly involved in the study and are concerned about the outcome, along with many others in the community. Understandably, as a result of this inaction, many have largely lost faith in NSW Health as a promoter and protector of their health.

There have been numerous reports in the press and on radio about ill-effects suffered by motorists in the tunnel. Although there is supposed to be a 'complaints line' for air quality issues, it has not been promoted and motorists who attempt to report incidents and ill effects report difficulty in getting someone to listen and no feedback or confirmation that their complaints have been recorded.

More recently there have been repeated reports of ill health and irritation from traffic fumes around the tunnel portals. Numbers of residents are attempting to sell their houses and some report moving their asthmatic children out of the area.

This is the basis of the community concern about the current proposals to allow systematic unfiltered portal emissions for operational (rather than emergency) reasons, and the claim that they have been demonstrated to be safe.

The argument about warning signs for asthma sufferers, as suggested by NSW Health as a result of their investigation into in-tunnel conditions, is probably too well known to require canvassing.

2. What special issues are involved in promoting air quality in respect of privately financed projects, such as the Cross-City Tunnel

There appear to be no special issues which would relate to privately financed projects which do not relate to Government funded projects such as the M5 East tunnel.

The conditions under which tunnels are designed and built are the responsibility of the Department of Planning, with advice from the Department of Environment and Conservation and NSW Health.

Those constructing and operating the tunnels have no option but to comply with these conditions so, if these conditions are adequate and provide proper direction, appropriate environmental conditions will be maintained inside and outside tunnels.

<u>The failure of the M5 tunnel, at least, to meet with community approval, and the compelling evidence emerging about the adverse effects would suggest that these conditions are inadequate.</u>

As outlined in the GASP submission, the standards used apply only to some pollutants, and the measuring methodologies tend to systematically underestimate the proven health impacts.

For example, there is only one operational stage condition relating to in-tunnel air quality in the M5 tunnel (condition 70). This limits the carbon monoxide levels in the tunnel but makes no reference to either particulate matter (smoke or haze) or nitrogen dioxide. Interestingly the condition includes the proviso: *. The Proponent must implement any reasonable requirements of the EPA which aim to improve in-tunnel air quality, as requested by the EPA*. The EPA have chosen not to interpret this as giving them the power to demand upgrading of the ventilation system or to mandate the installation of filtration systems.

In the Cross City tunnel , again it is only carbon monoxide which is limited, (conditions 256-260) although in-stack limits for PM10 are also applied (condition 271)

In the Lane Cove tunnel, only carbon monoxide is limited but in addition to the 15 minute exposure limit in the Cross City tunnel, a 30 minute exposure and an instantaneous limit is applied. (conditions 160-162). In-stack PM10 limits are also applied of 1.2mg/m^3 for the western stack and 1.6mg/m^3 for the eastern stack averaged over 30 minutes. (condition 173).

As a comparison, the M5 stack using a one hour averaging period appears never to have reached the level permitted for the LCT eastern stack. Of serious concern to the community is the fact that this limit effectively validates the conditions currently experienced in the M5 tunnel, which are the cause of so much distress on the part of tunnel users.

3. Are current arrangements for enforcing compliance with Conditions Of Approval by operators of privately financed projects adequate.

The M5 East is not privately financed but is operated under contract to the RTA.

The history of this tunnel's operation demonstrates little will on the part of the RTA to enforce compliance by the operator with the operational conditions of approval, nor on the behalf of the regulator (Department of Planning) to enforce the conditions of approval.

Minutes exist of at least 4 meetings between the RTA tunnel management and the tunnel operators BHEgis (3/3/04 to 5/5/04) at which an incident response plan (IRP 7 - response to pm traffic) is actively discussed without apparent objection by the RTA management. The plan is described as *being 'currently updated to provide for trigger of ventilation plan at 80ppm CO (5 min TWA) and if cause determined by operator to be traffic volume (i.e. traffic > 5500 veh/hr, 3 min. rolling volume), the plan to remain in place until 1900 hrs'.* This provision of continuation until 7pm, without reference to actual pollution levels, a situation which can be demonstrated to have occurred, is clearly inconsistent with the prohibition of portal emissions for other than emergency and maintenance reasons.

There is no independent monitoring of compliance, rather, Planning relies on the RTA to self-report breaches. Most of the breaches or problems identified with the M5 East were brought to public attention only as a result of documents released to Parliament, or leaks to the media.

It was only after a Parliamentary Inquiry that Department of Planning decided to undertake a compliance audit, and this has taken over three years so far, with still no conclusive outcomes.

This audit found a number of failures to comply, relating to portal emissions and air quality monitoring. In addition, it noted a number of 'Inconsistencies' and 'Observations', many of which would be regarded as non compliances on a 'plain English' reading of the conditions of approval, but which were excluded for a variety of technical reasons.

The members of the inquiry are referred to the audit report dated September 2005 and especially to the letter reprinted on page 105 from Les Wielinga , as Director of Motorways to Sam Haddad as Deputy Director General of DIPNR, in which Wielinga claims that DIPNR, the author of the conditions of approval , do not understand them.

Such a hectoring approach between two government departments gives the community no confidence that authorities such as the RTA will act with due regard for the public good rather than their own internal concerns.

Many of the issues raised by the audit are still unresolved.

For the M5 tunnel, there are no sanctions against breaches of conditions and there seems to be a reluctance for government departments to act against other government departments, even when private contractors are also involved.

The public good is seriously disadvantaged by a system that relies on self-regulation and has no effective sanctions or penalties for even repeated breaches of conditions of approval.

4. Is the use of air filtration technology in the Sydney tunnels likely to be effective, and affordable~ Can you refer to any scientific studies to support your argument.

The fundamental issues here are:

- what is meant by effective?
- affordable in relation to what criteria?

Filtration could be regarded as just another element of tunnel infrastructure like lighting. No one would question the provision of lighting in the tunnel although the provision of lighting in tunnels is by no means universal, nor is it always provided on the level which it is provided in Sydney's tunnels. After all, every vehicle on the road has to have an effective set of head lights. Specific provision is made in the tunnel to allow for the reception of radio broadcasts and mobile telephone reception, neither of which is essential to the safety and wellbeing of the motorists using the tunnel. Why not filtration to protect against the very real risk posed to some by the excessively polluted atmosphere inside some tunnels?

Is the air filtration technology effective?

All available evidence says it is. Japan, with the longest experience in the use of the technology and with about 50 filtered tunnels , continues to use it when needed. This was made clear to the RTA during their recent visit to Japan. There have been a number of cases where the technology has been installed but is no longer maintained, however there is no evidence that this is because it was ineffective. The lack of use is more probably related to changes in need and improvements in vehicle technology.

Only in the HaiVan tunnel in Vietnam has there been a significant failure in the technology. This failure relates to an underestimation of the quantity of diesel smoke generated by poorly maintained vehicles and the layout of the tunnel, which is being temporally used as a two way tunnel but was designed as one tube in a two tube tunnel system. It is expected that these problems will be resolved by the construction of the second tube of the tunnel (which will also be filtered).

As mentioned previously, the city of Madrid has recently committed to a tunnel system involving 55 km of filtered tunnels and construction of a major (15km) filtered tunnel system in Copenhagen is expected to commence in 2007.

The Child Report , prepared for the RTA and available on the RTA web site concludes, in part:

(h) The balance of these factors indicate that progress has been made in the field of emission treatment technology, and that viable technologies are now available to remove suspended particles, nitrogen dioxide, some portion of

other oxides of nitrogen, and hydrocarbon vapours from road tunnel exhaust air.

In summary, all major manufacturers can supply electrostatic precipitator equipment which can remove PM10 particles with efficiencies between 90 and 98%. The best of this equipment can remove particles down to 0.1 microns in diameter with efficiencies around 90%, thus demonstrating an ability to remove those particles most implicated in the causation of harm. Three credible technologies are available to remove nitrogen dioxide from tunnel atmospheres or from tunnel exhausts. All are capable of reducing nitrogen dioxide levels by 90%, however it is not yet clear which of these technologies will be shown to be the most reliable and economical in use.

The effectiveness the equipment is undoubted, the effectiveness of the individual installations depends on the quality of the ventilation system design, of which the cleaning equipment forms an integral part.

Are air filtration technologies affordable?

In October 1999 at the PIARC conference at Kuala Lumpur Iwasaki *et al* of the Japanese Highway Public Corporation presented a paper "Operational cost comparison between different ventilation systems based on actual cost data"

In this report they demonstrate whole of life cost savings of approximately 30% resulting from the use of ventilation systems based on electrostatic precipitators rather than traditional ventilation systems. It should be noted that this is based on systems designed to make use of the capacities of the EP systems rather than systems added on later to solve problems.

Although the RTA report of their visit to Japan (presumably authored by RTA Public Relations) makes no mention of cost factors as an issue with Japanese installations, the hand written notes of the only engineer on the trip (Garry Humphrey) show that the delegation was told a number of times that a major motivation for the use of electrostatic precipitator equipment was to reduce ventilation costs.

Some examples of the exchanges (transcribed from Humphrey's hand written notes) are included (emphasis added):

In a discussion with Hideto Mashimo, and Mr Mizatani, of PWRI, (presumably Public Works Research Institute)

History?

Beginning '70's research work- pump? System for tunnel dust CO Nox

After 5-10 years dev new EP systems for tunnel

First ? for environmental protection from tunnel exhaust

Karasuyama – used for purification of exh gas from tunnel portal   viaduct – residential areas

-- to capture exhaust smoke

- found to be very cheap – cost saving

--found that if we use EP then cheaper

In a discussion with. Mr Shinoda   JH (Japan Highways)

Sydney tunnels urban – concerned about air outside tunnel.

Aust don't understand about visibility in tunnels – trying to compare what we are doing re in – tunnel AQ in Sydney and Japan

EP and cost of ventilation? One factor visibility

is another cost of ventilation?

Purpose to exchange secondary air to waste.   dust – best but depth of shaft is expensive

Construction or op cost ?   Both

For urban long tunnels - used to be transverse → longitudinal system with EP save maintenance cost.

.Don't need jet fans ? generally do

-- solely rely on cars (short)

-- longer – jet fans

<u>Cost less to recycle than exchange? Problem with jet fans or concerned about speed.</u>

In relation to Norwegian systems, RAPS contacted Sigurd Wiljugrein, a Norwegian consultant engineer who had been involved with the construction of a number of filtered tunnels in Norway, in the hope that he would provide some independent assessment of the claims which were being made by CTA International, the Norwegian manufacturer of electrostatic precipitator equipment.

He was able to confirm that the proper use of electrostatic precipitator equipment could both reduce the cost of tunnel operation and lead to better outcomes. Part of our correspondence with him is provided together with his CV.

The general conclusions about the economic viability of the use of tunnel filtration are supported in the recent report prepared by Child and associates for the RTA and available on the RTA web site.

Child notes:

Previous reviews undertaken in relation to emission treatment technology have not been able to identify a positive balance of potential benefits. In terms of established or demonstrated road tunnel applications, this review has identified further developments and enhancements in particle removal technology, coupled with the demonstration and acceptance of technology capable of removing nitrogen dioxide, volatile hydrocarbons, and some proportion of nitric oxide.

It is the conclusion of this review that this expansion in the range and availability of demonstrated and established tunnel emission treatment systems has shifted the balance to the extent that the cost effectiveness of these technologies might now apply in relevant circumstances.

Those relevant circumstances would need to involve the identification or confirmation of an air quality or ventilation system constraint or limitation that could be resolved by, or reduced by, the application of the types of emission treatment technology described above.

and then concludes:

(j) A potential basis for the cost-effective use of emission treatment technology in road tunnels has been identified. Confirmation of this potential will require a more detailed consideration of the specific circumstances associated with individual tunnels.

It is important to note that these economic benefits are established WITHOUT factoring in potential savings in health costs resulting from reduced exposure to pollutants, or the significant savings in energy and associated green house gas emissions. The savings are in strictly identifiable capital, operational and maintenance costs.

5. What are the likely health impacts on residents and motorists of air pollution from tunnels? Are there any studies to verify these impacts.

The impacts on residents by tunnel emissions are the same as those experienced from vehicle emissions generally but of a different and higher order of magnitude.

A network search by Google using the search term 'emissions from tunnels and health effects" produces a number of useful recent articles directly related to the health impacts of tunnel emissions. Although some relate to occupational exposure by workers, many relate directly to the sorts of exposure experienced by motorists.

The WHO publication 'Health Effects of transport related air pollution ' http://www.euro.who.int/document/e86650sum.pdf summarises impacts as follows (in part):

Studies on health effects
The epidemiological and toxicological evidence on the effects of transport-related air pollution on health has increased substantially in recent decades. Although this includes epidemiological and toxicological evidence, it is only a fraction of the total evidence on the effects on health of urban air pollution.
A review of this evidence indicates that transport-related air pollution contributes to an increased risk of death, particularly from cardiopulmonary causes. It increases the risk of respiratory symptoms and diseases that are not related to allergies. Experimental research indicates that the effects are linked to changes in the formation of reactive oxygen species, changes in antioxidant defense, and increased inflammation, thus providing some indication of mechanisms of susceptibility. Laboratory studies indicate that transport-related air pollution may increase the risk of developing an allergy and can exacerbate symptoms, particularly in susceptible subgroups. The evidence from

population studies, however, does not consistently support this notion. While only a few studies have been conducted on the effects of transport-related air pollution on cardiovascular morbidity, they report a significant increase in the risk of myocardial infarction following exposure. Other studies and the experimental evidence indicate that exposure results in changes in autonomic nervous system regulation and increased inflammatory responses. A few studies suggest an increased incidence of lung cancer in people with long-term exposure to transport-related air pollution. Some studies suggest that it also causes adverse outcomes in pregnancy, such as premature birth and low birth weight, but the available evidence is inconsistent.

Our reactions to in-tunnel exposure effects have been guided and informed by the PIARC (World Road Association) publication "Pollution by nitrogen dioxide in road tunnels" (AIPCR 05.09 B 2000) which contains reports of a number of experiments on exposure in tunnels and exposure chambers.

The study by the Swedish National Road Administration, Vagverket, entitled "*Air Quality in Road Tunnels – Health effects of nitrogen dioxide and aspects on co-pollutants 2003-5"* provides a detailed discussion of the health effects of pollutants in road tunnels and the potential impacts of a variety of regulatory regimes. Many of the proposed pollutant level regulations could not be met in most Sydney tunnels.

The sorts of health impacts include those examined by the NSW Health study on residents health, which included eye, nose, throat and skin irritation, headaches and asthma and other short term respiratory symptoms. Long term effects include COPD and various cancers, including lung cancer.

To these organic adverse health outcomes should be added the psychological and wellbeing impacts of a degraded physical environment with visible dust fallout and regular smell annoyance, experienced in the knowledge that by in large, they are avoidable by the use of relatively simple and economical engineering solutions.

Mark Curran for GASP

2nd September 2006

Attachments:

JapEPcost.doc (includes transcript from RTA Japan trip and summary of Japanese EP cost report)

SigletF.doc and Cvengelsk.doc are the Wiljurein documents from Norway

CURRICULUM VITAE

Name:	Sigurd Wiljugrein
Address:	
Personal:	
Languages:	Norwegian, English, some German.
Current occupation:	Manager and owner of Xenolith AS
Education:	B.Sc. in Civil Engineering, University of Strathclyde, Glasgow 1969 Degree in Business Administration, Bedriftsøkonomisk Institutt, Oslo 1972

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Experience:

1992 - date	Manager of **Xenolith AS**, a consulting company specialising in project management and project assistance in planning and installing technical installations in tunnels.
1988 - 92	Project manager in the consulting company **Grøner AS**.
1987 - 88	Project manager in the real estate company **Byggutvikling AS**.
1984 - 87	Senior engineer and head of the construction department in the building and construction company **Ragnar Evensen AS**.
1981 - 84	Section Manager in the construction company **Veidekke AS**.
1973 - 81	Project Manager/Construction Manager/District Manager of the construction department of **Statens vegvesen Akershus (**Regional Roads Administration in Akershus county).
1970 - 73	Staff Engineer on the Maintenance Division of **Vegdirektoratet** (Norwegian Roads Administration).
1969 - 70	Staff Engineer in **Patentstyret** (Styret for Det Industrielle Rettsvern) (The Norwegian Patent Office).

CURRICULUM VITAE
Sigurd Wiljugrein
May 2002

Projects:

2002 - **E39 Trondheim**
Hired by the Swedish/Norwgian construction company Selmer-Skanska to assist in the planning process of the "design, construct and operate" project on the new E39 south of Trondheim, Norway. The project includes some 22 km of new highway, of which 10 km in tunnels.

1996 – 2001 **Ring Road in Drammen**
Consisting og the Strømsås tunnel and the Bragernes tunnel, both approximately 4 km. Assistance to the management in preparing tender documents for the project contracts and especially the technical contracts. Preparation of tender documents and specifications for electrostatic precipitators in both the Strømsås and the Bragernes tunnels. Monitoring the construction process and technical and control installations.
Project cost: Strømsås tunnel with connecting roads,
NOK 990 mill, Bragernes project, NOK 750 mill.

1995 – 96 **The Oslofjord Connection**
7 300 m long subsea tunnel under the Oslofjord.
Assistance in planning and preparation of tender documents.
Project cost: approx. NOK 1.200 mill.

1993 – 95 **The Ekeberg Tunnel in Oslo**
Responsible for preparation of tender documents for the technical installations. Assistance to the management concerning installation of technical equipment and co-ordinating the technical installations with the construction work on the tunnel.
Responsible for the preparation of the technical specifications for the electrostatic precipitator plants and the constructional design of the purifying plants.

Project cost: approx. NOK 800 mill.

1991 – 93 **The Granfoss Tunnel in Oslo**
Site manager for the technical installations on the project. Responsible for the preparation of the tender documents for the technical installations and for the their execution.
Responsible for the preparation of the technical specifications for the electrostatic precipitator.

Project cost: NOK 640 mill.

1988 – 91 **The Oslo Tunnel and Vestbanen Underground Intersection**
Site manager for the technical installations on the project. Responsible for preparing the tender documents for the technical installations and the execution of these works. Responsible for co-ordinating the technical installations with the construction work.

Project cost: approx. NOK 1.200 mill.

Consultant work

1994 – 95 and 99 **The Stockholm Ring Road**
Special consultant on ventilation and air purifying systems to the Stockholm Region of the Swedish Roads Administration during the planning of the Stockholm ring road.

1995 **RN6 Geneva**
Special consultant to the Ministry of Transport in Geneva, Switzerland for cost estimates for the technical installations in the tunnels of the new ring road RN6.

1993 – 95 **The Norwegian Public Roads Administration**
Special consultant for the Norwegian Public Roads Administration on safety and technical installations in road tunnels.

Miscellaneous

1973 – 88 Site manager/project manager for highways, bridges, housing estate development, petrol stations, district heating plant, office and industrial buildings.

Kuala Lumpur Oct 99
World Road Congress

OPERATION COST COMPARISON BETWEEN DIFFERENT VENTILATION SYSTEMS BASED ON ACTUAL COST DATA

T. IWASAKI, H. YAGI, Y. ERA
Japan Highway Public Corporation, Tokyo, Japan
T. KONDA
Tokyo Metropolitan University, Japan

Summary

The operation cost of road tunnel ventilation will differ significantly according to the system employed. Since the ventilation costs account for ther largest part of total tunnel operation costs, it is important to review the costs for different ventilation systems in order to reduce tunnel operation costs.

The basic ventilation systems for highway tunnels are full transverse, semitransverse and longitudinal ventilation systems. Transverse ventilation has been widely adopted because it is applicable in long tunnels as long as shafts can be installed. From an economical viewpoint, however, transverse ventilation systems have been deemed unacceptable because of the increased tunnel cross-section and large electric power requirement.

Longitudinal ventilation systems, which require no ducts and can make an effective use of traffic-induced piston effects in unidirectional tunnels, provide an economic advantage. Moreover, the longitudinal ventilation system has rapidly increased ventilated length with the development of electrostatic precipitators, and increased cost effectiveness. As a result, longitudinal ventilation system with electrostatic precipitators was adopted in the Kan-etsu Tunnel, the longest highway tunnel of Japan in 1985.

This report provides an operational cost comparison between transverse system, longitudinal system with electrostatic precipitators, and longitudinal system with intermediate shafts and electrostatic precipitators, based on actual cost data obtained 1996. The operational cost includes energy, equipment maintenance and replacement.

The result confirmed that the longitudinal ventilation system with electrostatic precipitators is very energy saving and economical system. Since the cost is greatly and sensitively influenced by various factors, cost evaluation should be done very carefully considering the local conditions of each tunnel.

Transcribed from notes taken in Japan by Garry Humphrey, RTA, General Manager, Motorway Services

In a discussion with Hideto Mashimo, and Mr Mizatani, of PWRI, (presumably Public Works Research Institute)

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Beginning ‘70’s research work- pump? System for tunnel dust CO Nox
After 5-10 years dev new EP systems for tunnel
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-- solely rely on cars (short)
-- longer – jet fans
Cost less to recycle than exchange? Problem with jet fans or concerned about speed.

XENOLITH AS

XENOLITH AS

Sigurd Wiljugrein
Daglig leder

Kringsjå 9
1825 Tomter

Mark Curran

Tomter 17.04.2002

Subject: The Drammen Tunnel

Dear Sir,

Xenolith AS is an independent consultant company which has specialized in site management of technical installations in tunnels, and the coordination of these works with the civil engineering works.

Xenolith, represented by Sigurd Wijiugrein, has in the last 10-12 years been engaged by the Norwegian Roads Administration to act as site manager or to assist the project manager in the specification and the installation of the technical installations in most of the major tunnels in the Oslo area, including tunnels in Drammen. In all of these tunnels there are one or more EP-installations.

In thc period 1996-2001 Mr. Wijiugrein was mainly occupied with the Stroemsas tunnel in Drammen (hereafter called the Drammen Tunnel).

The Drammen tunnel is a two way road tunnel on a main highway(E134) between Oslo and the west of Norway. It was opened to traffic in October 2001. Eventually it is intended that the tunnel will be duplicated and then the existing tunnel will carry one way traffic. The tunnel is 4 km in length and rises some 56 m along its length. The traffic load is currently 15000 vehicles per day of which 15% are diesel trucks.

The ventilation system.

The ventilation system is longitudinal with portal emissions at the west end of the tunnel. This portal is an elevated and relatively isolated area, without residents or industries who might be affected by the emissions. The longitudinal ventilation system consists of 4 ceiling mounted electrostatic precipitators. each capable of treating 160 m^3 /sec tunnel air, together with jet fans according to normal practice. In general, the aim of the system is to prevent the escape of any polluted air from the lower(east) end of the tunnel which is in the city of Drammen.

Dust conditions in the tunnel.

Tunnel particle emissions come from two sources;

1. road dust, especially that generated by studded tyres and
2. vehicle exhaust especially from diesel engines.

Although road dust used to predominate in Norwegian tunnel systems, especially in winter, the proportion of fine mineral dust is now decreasing due to the frequent use of road sweeping to remove the coarse dust before it can be ground fine enough to become an air-borne problem. At most times the major source of airborne dust and particles is vehicle exhaust. The intent of the precipitator installations is to prevent the escape of particulate pollution from the tunnel while reducing dust and smoke inside the tunnel in a cost effective way. When in operation, the precipitators have the capacity to reduce the total air flow required by jet fans by up to 50%. Although jet fans arc also installed in the tunnel, the fans installed in the precipitators(when combined with vehicle induced air flow) have the capacity to fully ventilate the tunnel under maximum traffic conditions.

Equipment cost

The electrostatic precipitators were built, installed and commissioned by CTA International ASA. The cost of the equipment, installed and commissioned (but not including the civil works) was NOK 23.685.000 (US$ 2.725.000).

The installation of precipitators could have reduced the number of jet fans significantly but, as the tunnel will be used initially for two way traffic, the fire department required that a sufficient number of jet fans be installed so as to permit the reversal of the ventilation direction while the tunnel remains a two way tunnel.

Control

The tunnel equipment is controlled by a newly developed web-based surveillance and monitoring system. It was intended that the precipitators would be activated by measurements of carbon monoxide levels. This indirect system was chosen because problems which had arisen in the past with the various opacity measurements systems available. The carbon monoxide based system has proven to be unsatisfactory and the precipitators have been operating on a time clock/manual switch on system since shortly after the opening of the tunnel.

When activated this way, the precipitator operation clears visible pollution from the tunnel within 15 minutes.

Maintenance

Maintenance procedures involve routine washing of precipitator plates using the integral wash system, and the regular checking of plate voltage and high voltage current flow.

After about 3 months operation, there was a plate voltage power failure to 2 of the units. This failure was traced to the incorrect placing of cable runs carried out by the electrical contractor(not CTA). Contrary to specification, the high voltage cables were laid very close to reinforcement bars in a wall penetration. This led to induced eddy currents which caused localised heating and failure of cable insulation. By the use of the remaining precipitators in conjunction with increased ventilation speeds, it was possible to replace the cables without interfering with traffic usage. The affected power units and precipitators were undamaged.

Outcomes

The improvement of visibility in the tunnel has led to a high degree of driver satisfaction. Complaints about smoke and poor visibility are regular during low traffic times when the precipitators are not activated. The efficiency of the ventilation system in achieving its design goals and in removing other pollutants is shown by the experience obtained during the partial shut down of the precipitators, when only jet fans were in use. During this period the tunnel was severely polluted with significant reduction in visibility and unpleasant driving conditions. The efficiency of dust removal under operational conditions is greater than 90% on a number basis as well as on a mass basis for all classes of particles down to 0.3 microns in diameter. For particles greater than 1 micron, the efficiency obtained is more than 95%. This is thought to be better than has ever been obtained in any tunnel worldwide. It should be realised that these results were achieved in a tunnel design which is less than optimal, as it is actually designed for one way traffic.

Cost and economic implications

The partial inactivation of the precipitator system due to the cable failure also enabled a comparison to be made of the relative costs of ventilation using jet fans alone or with partial or complete precipitator use. Ventilation by jet fans alone caused a rise in electrical consumption. During normal, full load operation the total ventilation system, including precipitator fans, consumes 1040 kW. In the absence of operational precipitators, jet fan operation to maintain a much lower level of visibility consumes 680 kW. It is not possible to maintain the same level of visibility which is achievable using the precipitators alone by use of jet fans.

The experience gained from the Drammen tunnel clearly shows that the use of electrostatic precipitators as an integral part of a tunnel ventilation system, (as opposed to their use as a stopping filter at tunnel ends), can provide both economic advantage and cost reductions and is also effective in reducing pollution emitted from the tunnel.

Increasing evidence of the harmful impacts of particle pollution makes control of this insidious form of pollution essential. It is no longer possible to use an argument of additional cost against the use of precipitators, at least in urban areas, as the experience of the Drammen tunnel shows these costs to be, at the most, marginal. With careful design, it should be possible to use precipitator installation to reduce running and, in some cases, capital costs, while at the same time providing a superior in tunnel environment.

Yours faithfully

XENOLITH AS

Sigurd Wiljugrein