



Statens vegvesen
Norwegian Public Roads
Administration

Vehicle Fires in Norwegian Road Tunnels 2008–2015

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Background:

- Norway is one of the countries that constructs the most road tunnels.
- Over 1,100 in the country, comprising a total of 1,134 tunnel kilometres.
- Road tunnels are usually at least as safe as or safer than similar roads in the open air without junctions, exits, pedestrians and bicyclists.
- Road tunnels do nevertheless deserve attention from a traffic safety perspective, because of their disaster potential related to vehicle fires.



Study mapping vehicle fires in tunnels:

- Study commissioned by the Norwegian Public Roads Administration.
- Aim: to collect data on fires in Norwegian road tunnels 2008–2015.
- The study was conducted by the Institute of Transport Economics (Nævestad, Ranestad, Elvebakk & Meyer 2016; TØI-report 1542–2016).



Five data sources:

- Incident data from “Vegloggen”, which is the five Norwegian road traffic centrals’ (RTC) systems for recording road traffic-related events.
- Additional information from road traffic central staff.
- Additional information from employees of the Public Roads Administration working on tunnel safety.
- Incident data from fire services.
- Additional data from news archives.



The study includes information on (1):

- Time of the fires
- Location of the fires (road, tunnel, where in the tunnel)
- Involved vehicles, type of vehicle, injuries to people and damage to vehicles
- Damage to tunnels
- Efforts at the scene of the emergency from emergency services and other road users

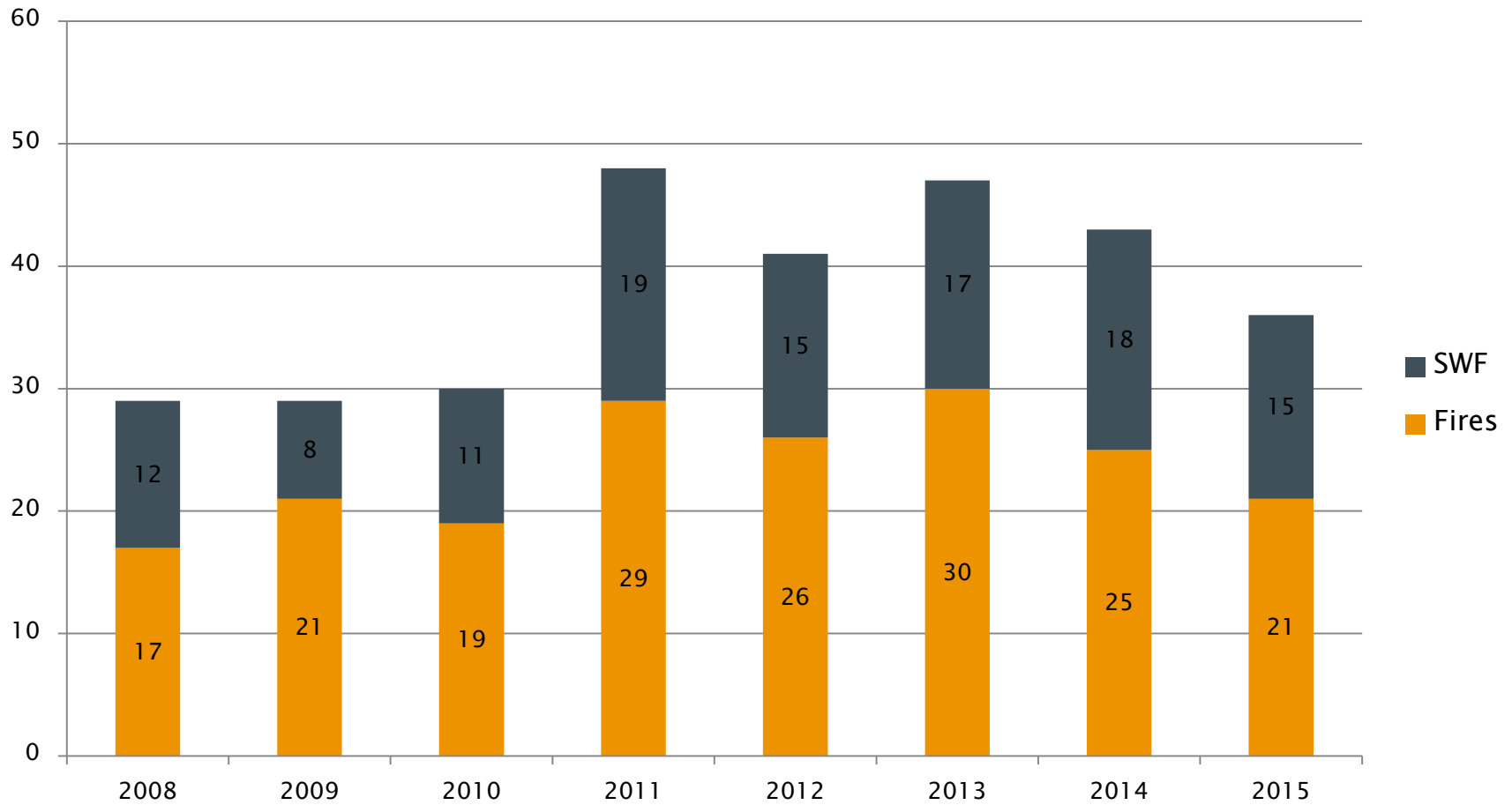


The study includes information on (2):

- How was the fire extinguished?
- For how long was the tunnel closed?
- How was the RTCs notified of the fire?
- Cause of the fire
- Subsea tunnels and tunnels with high gradient
- Fire ventilation
- Estimated fire load in megawatts (MW)

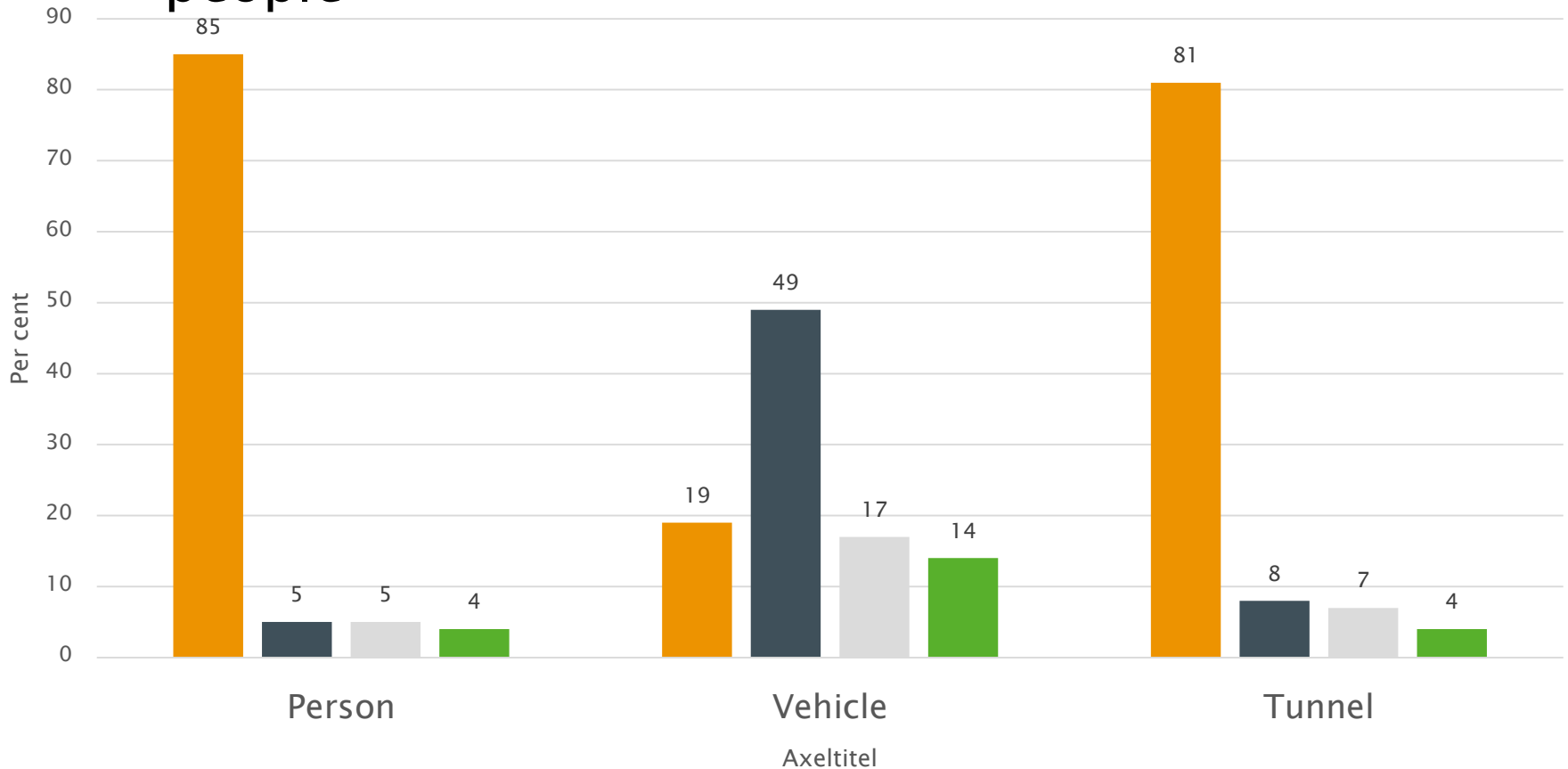


Fires and SWFs per year





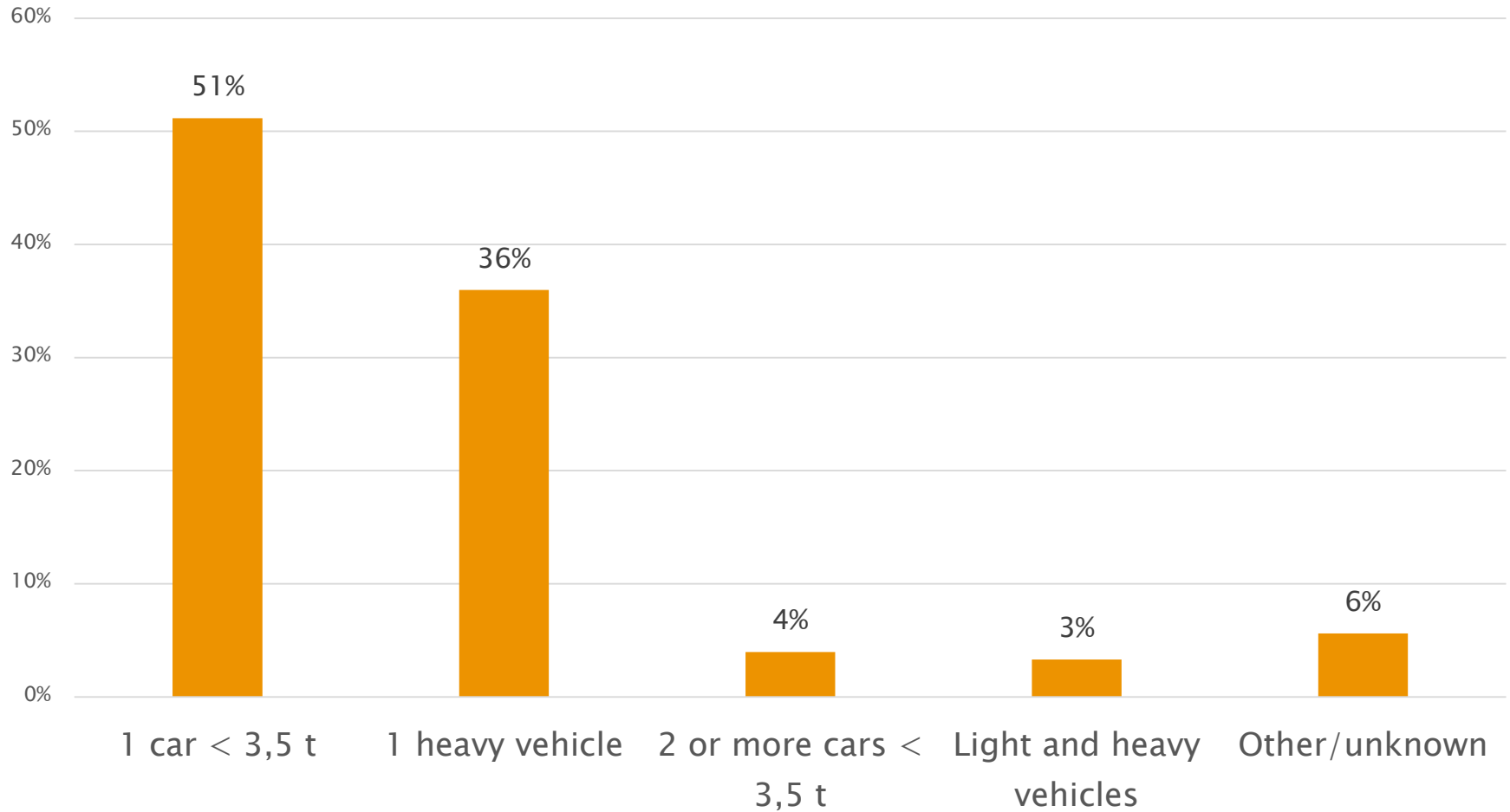
1) The fires generally did not involve harm to people



■ No/not relevant ■ Unclear ■ Some/light injury ■ Serious injury/great damages



2) Heavy vehicles are overrepresented





3) Different causes of fires involving heavy and light vehicles

Causes	Vehicles <3,5 t	Vehicles >3,5 t	Number of incidents:
Unclear	61 %	41 %	154
Technical problems	20 %	52 %	95
Single accidents	8 %	1 %	15
Head on accident	11 %	7 %	27
Number of incidents	175	116	291

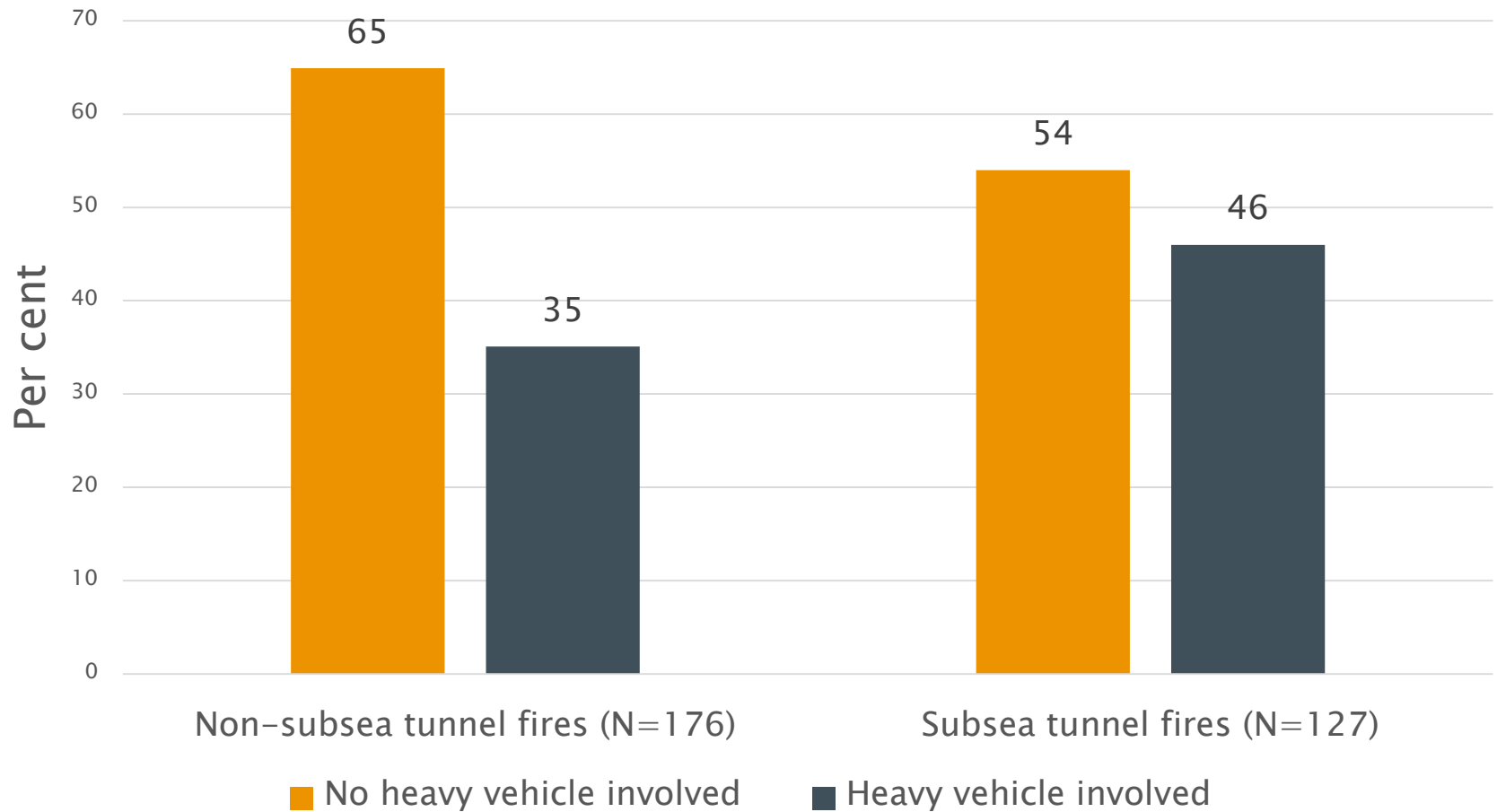


4) Subsea road tunnels are over represented

- There are at least 57 road tunnels in Norway with high gradient ($> 5\%$): 33 subsea road tunnels and 24 that are not subsea.
- These represent approximately 5 % of the road tunnels in Norway, and 14.5 % of the tunnel kilometres in Norway (165/1134).
- These tunnels had 42 % of the fires in the period 2008–2015.
- This gives 0.1 fires and SWFs per year per tunnel km with high gradient (15.9/165) versus 0.02 fires and SWFs per year per tunnel km without high gradient (22/969).
- Tunnels with high gradient are, in other words 5 times more exposed to fires.

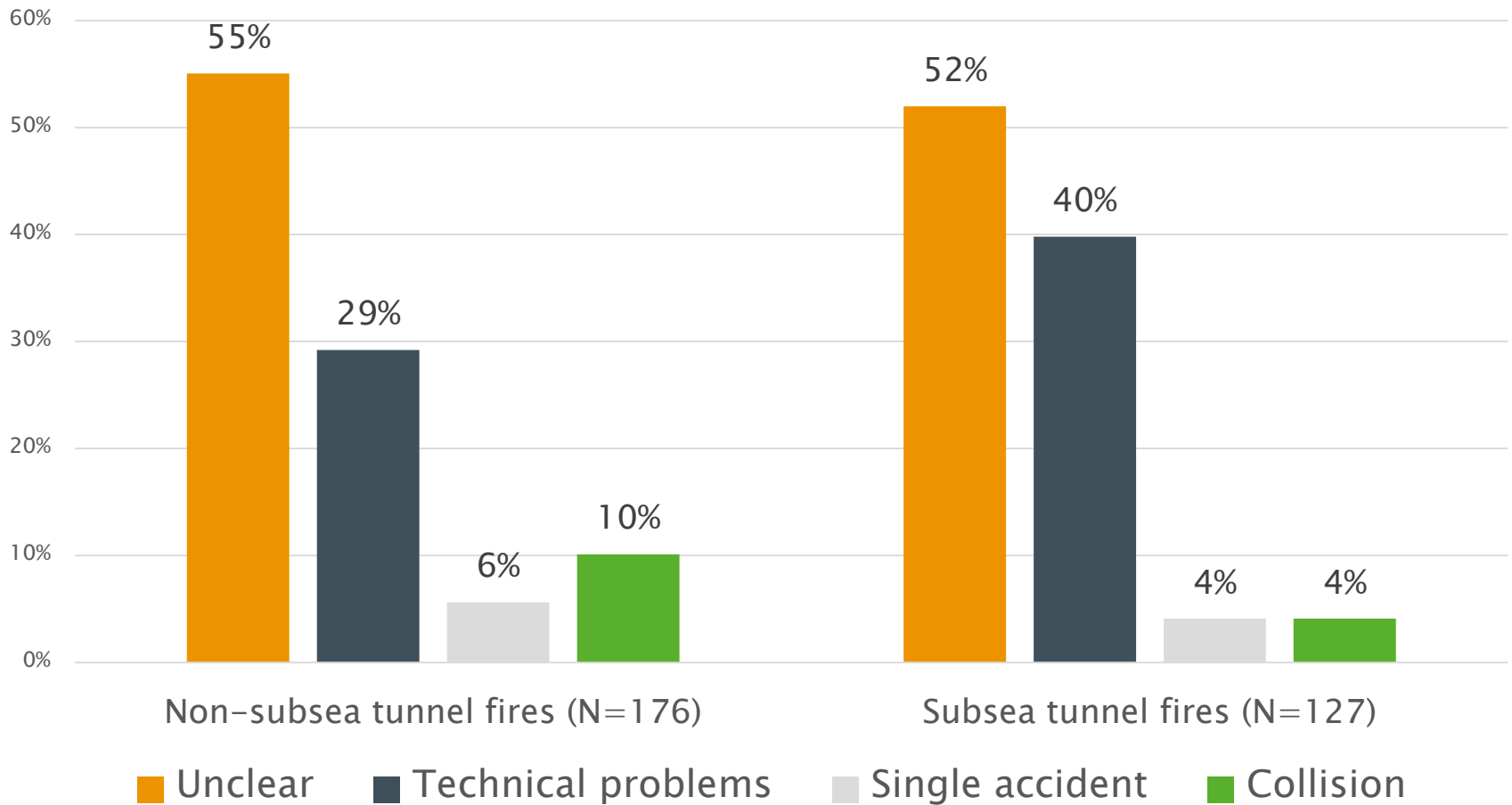


Heavy vehicles in subsea tunnel fires





Causes of vehicle fires in tunnels





Potential causal mechanisms behind vehicle fires in subsea tunnels

1. High gradient
2. Heavy vehicles' brakes or engines?
3. Tunnel length
4. Distance with high gradient
5. Traffic volume and share of heavy vehicles
6. Vehicle type, age and standard
7. Heavy vehicle drivers' experience and competence.



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Directorate of Public Roads
Traffic Safety, Environmental Technology Department
Traffic Safety
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The 5 major tunnel fires in Norway

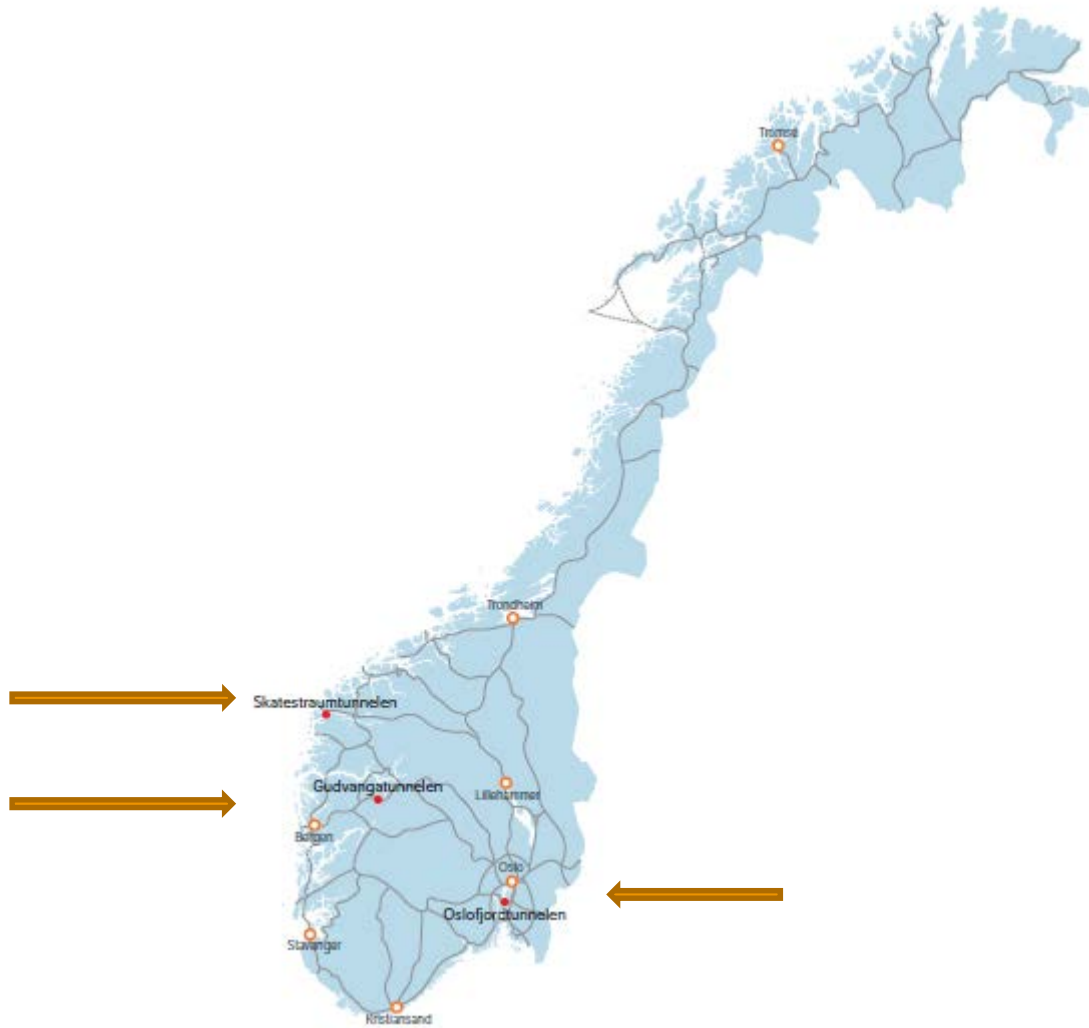
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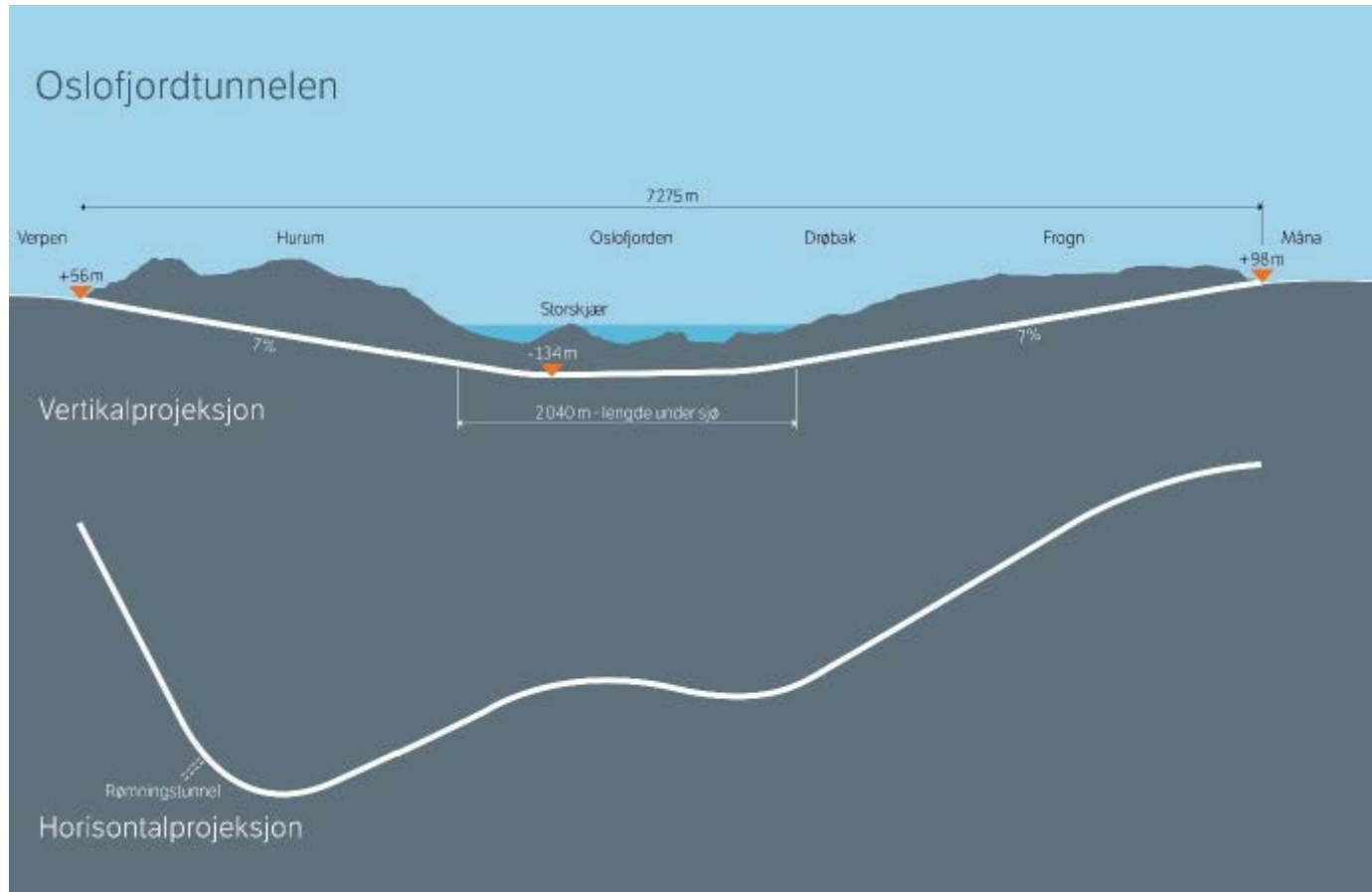
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- Oslofjordtunnelen ble åpnet for trafikk 29 juni 2000. Den forbinder Måna i Akershus fylke med Verpen i Buskerud fylke. Rv 23 er en TEN-T veg.
- Tunnelen er 7250 m lang. Laveste punkt i tunnelen ligger 2700 m fra Buskerud og er 130 m under havet.
- Årsdøgnetrafikken var i år 2010 7100 kjt/døgn.
- Tungtrafikkandelen var i samme år 15 %.





Oslofjordtunnelen(1) 29.mars 2011

- Vogntog med 30 tonn papir tok fyr pga. varmgang i bremses og brannutvikling som følge
- Branneffekten ikke kjent
- 4 personer skadet/røykpåvirket
- Ukjent antall kjøretøyer involvert/skadet



Oslofjordtunnelen(2) 23.juni 2011

- Vogntog med 22 tonn papir tok fyr pga. motorhavari med varmgang og brannutvikling som følge
- Branneffekten estimert til 70 – 90 MW
- 32 personer ble skadet/røykpåvirket
- 7 kjøretøyer involvert/skadet

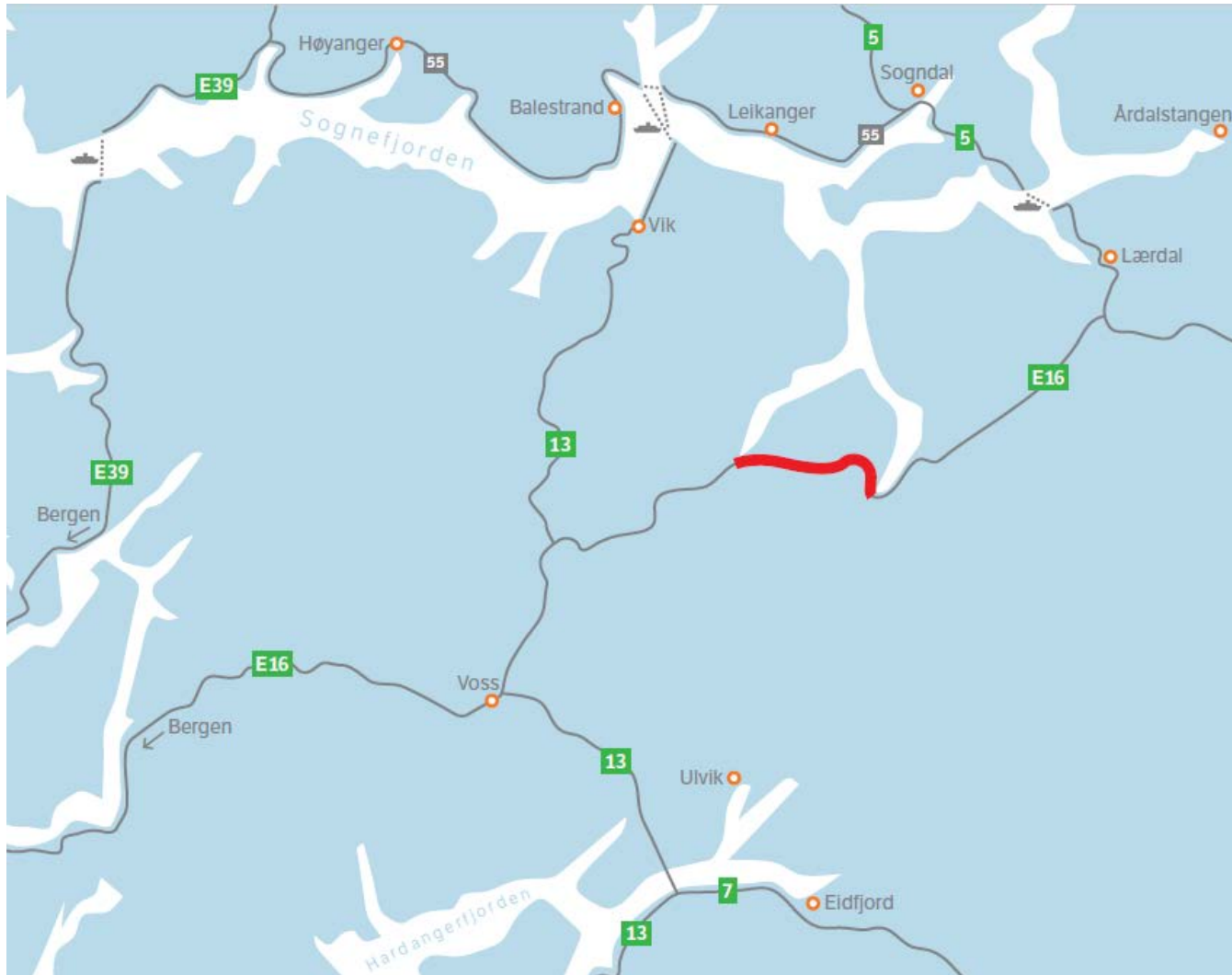


Safety recommendations from AIBN

1. AIBN recommends that NPRA, together with DSB and the fire service, should review and update the emergency response plans for long single bore tunnels, including VTS's procedures in the event of a fire so that the criteria for the self rescue principle are met
2. AIBN recommends that NPRA and DSB should establish systems for recording fires and fire situations in road tunnels for use in systematic safety work
3. AIBN recommends that NPRA should further develop its safety management system in accordance with risk-based and proactive principles in order to guarantee a satisfactory level of safety for the Oslofjord tunnel and corresponding road tunnels.
4. AIBN recommends that NPRA, together with DSB and the fire service, should follow up and dimension rescue and fire extinguishing efforts according to actual fire energy and the design of the specific tunnel.



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- Gudvangatunnelen er en ettløpstunnel som ligger på E16, som er en TEN-T veg, mellom Flåm og Gudvangen i Aurland kommune i Sogn og Fjordane. Tunnelen er 11 428 m lang og ble åpnet i 1991 (offisiell åpning 27 mai 1992).
- Tunnelen har en stigning på 3,5% fra Gudvangen mot Aurland. Den har således en høydeforskjell på ca. 300 m og høyeste punkt ligger ca. 300 m vest for tunnelåpningen ved Flåm (Langhuso).





Gudvanga tunnel(1) 5.august 2013

- Vogntog uten last tok fyr pga. motorhavari med varmgang og brannutvikling som følge
- Branneffekten estimert til 25 MW
- 28 personer ble registrert skadet/røykpåvirket
 - 5 klassifisert meget alvorlig
 - 23 klassifisert alvorlig
- 15 kjøretøy involvert/skadet



Gudvanga tunnel(2) 11.august 2015

- Turistbuss tok fyr pga. motorhavari med varmgang og brannutvikling som følge
- Branneffekten estimert til 30 MW
- 5 personer ble skadet/røykpåvirket
- 6 kjøretøy involvert/skadet



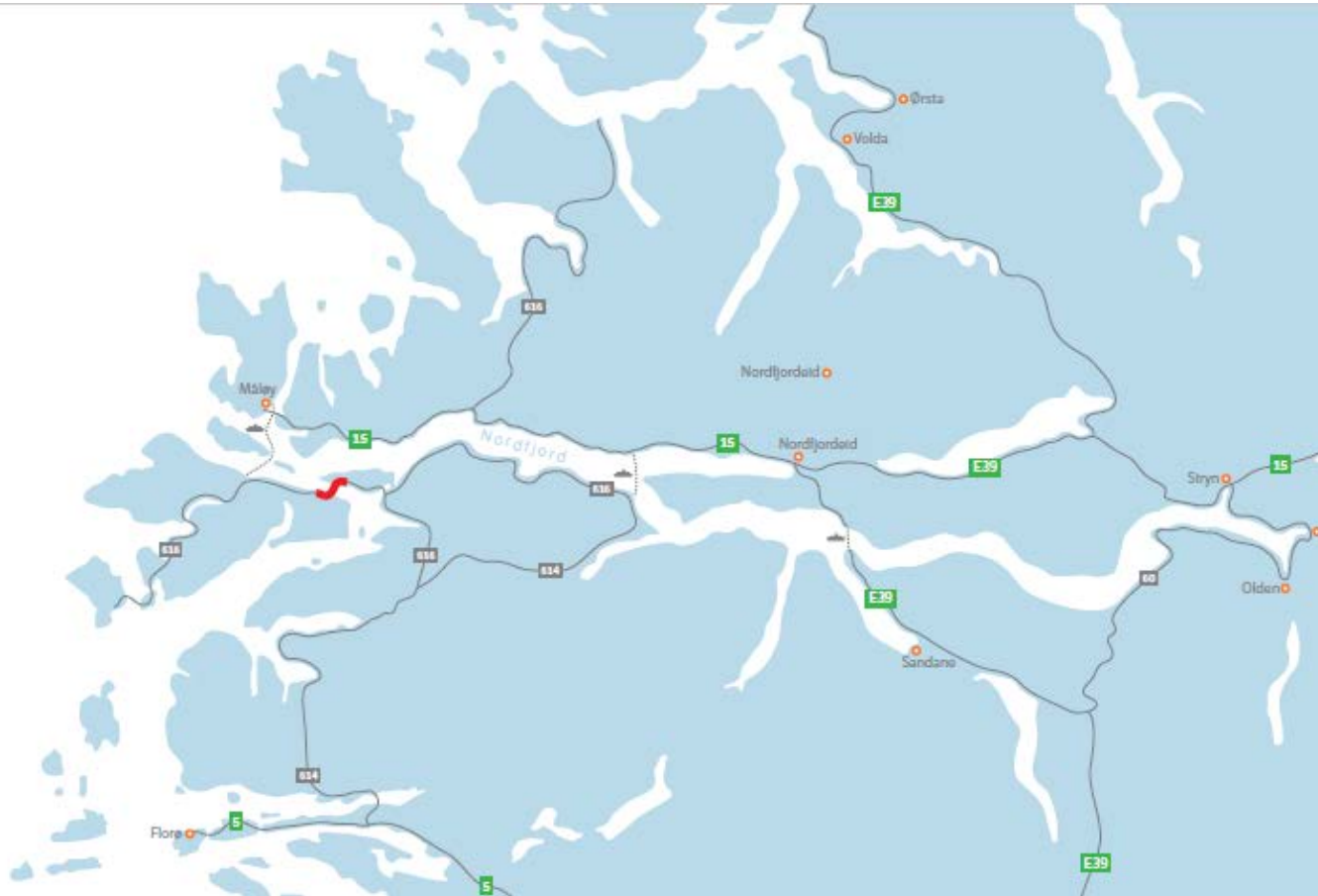
Safety recommendations from AIBN (1)

1. AIBN recommends that NPRA should improve the safety equipment in the Gudvanga tunnel in order to safeguard robustness and self-rescue conditions
2. AIBN recommends that NPRA and the relevant fire services should improve information to road users in the event of a fire in the Gudvanga tunnel. Signposting, radio announcements and text message notification should all be assessed.
3. AIBN recommends that NPRA should work to ensure that the Nation center for statistics (SSB) and/or the Directorate of Health includes injuries resulting from smoke inhalation in connection with tunnel fires in relevant accident statistics.



Safety recommendations from AIBN (2)

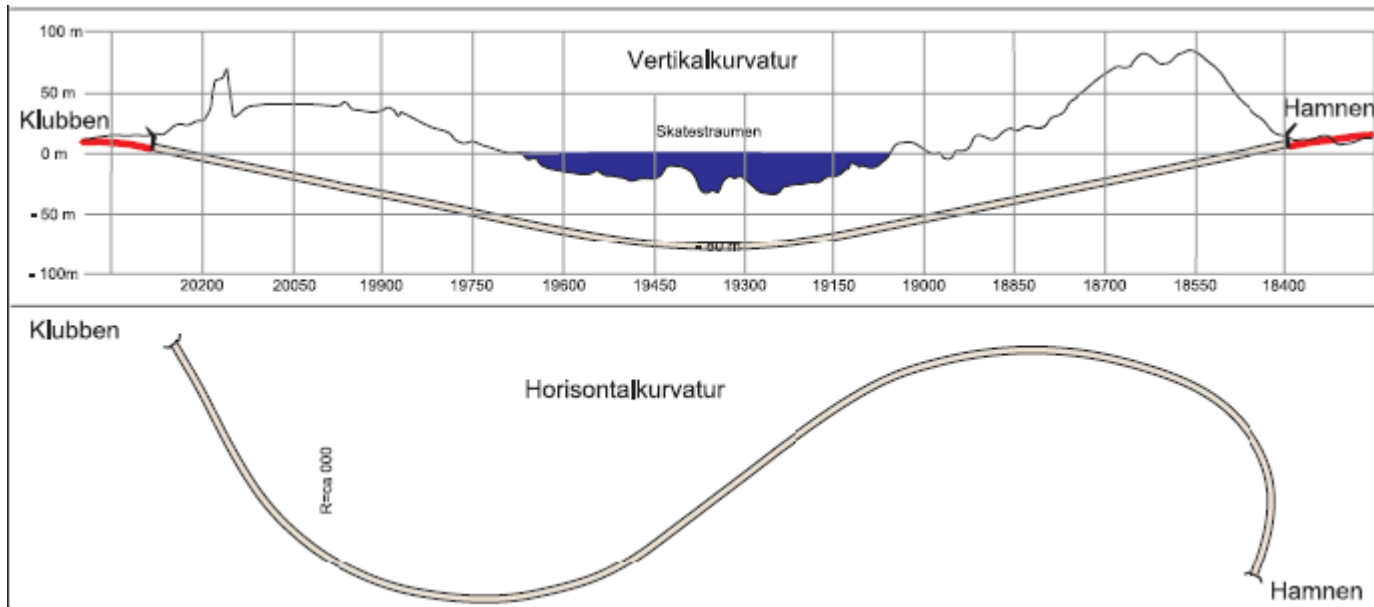
4. AIBN recommends that DSB and the fire service, in consultation with NPRA, should revise their strategy for fire extinguishing, rescue and smoke control in long single bore tunnels so that fire ventilation systems conflict with road users' options for self-rescue to as small an extent as possible.
5. AIBN recommends that in the event of a fire in the Gudvanga tunnel, the emergency services involved (the fire service, health service, police) should coordinate their planning in order to ensure notification, management of the scene, sharing of information and sufficient resources.
6. AIBN recommends that NPRA Region West and Aurland Fire Service should work together to update and coordinate emergency response plans and other response plans for the Gudvanga tunnel in order to give tunnel users more opportunities for self-rescue, and to carry out inspections and scenario-based exercises in the Gudvanga tunnel.





- Skatestraumtunnelen ble åpnet for trafikk 12. juli 2002. Den er en undersjøisk tunnel mellom Hamnen på Rugsundøy og Klubben på Bremangerlandet som er en øy. Tunnelen er 1902 m. lang
- Maksimal stigning på vegen er 10 %.







Skatestraumen tunnel 15.juli 2015

- Tilhengeren til tankbil løsnet pga. korrosjon i draget og havnet i fjellveggen. Lekkasje fra 16500 l bensin medførte brannutvikling
- Branneffekten estimert til >200 MW
- 5 personer ble skadet/røykpåvirket
- 6 kjøretøyer involvert/skadet



Recommendations from AIBN

1. AIBN recommends that the Norwegian Public Roads Administration should revise the requirements for drainage systems in tunnels, allowing them to be dimensioned to deal with large quantities of hazardous liquids escaping from vehicles.
2. AIBN recommends that Sogn og Fjordane County Council and the Norwegian Public Roads Administration, when carrying out risk analyses, should describe and follow up measures in connection with described scenarios/incidents.
3. AIBN recommends that DSB, in consultation with the relevant road authorities in consultation with DSB, should introduce restrictions on the transportation of hazardous goods in tunnels, based on risk assessments of the individual tunnels.
4. AIBN recommends that Sogn og Fjordane County Council should carry out and reinforce its safety follow-up of the Skatestraumen tunnel and other tunnels on the county roads.



Læringspunkter – Lessons learned (1)

- Selvberging og/eller assistert redning
 - (Self-rescue and/or assisted rescue?)
- Brannventilasjon – forhåndsbestemt eller etter vurdering
 - (Fire ventilation – predetermined or following assessment)
- Kommunikasjon mellom nødetatene
 - (Communication between the emergency services)
- Registrering og læring av hendelser
 - (Recording and learning from events)
- Oppfølging av røykskadde personer over tid
 - (Following up on people suffering from smoke inhalation)



Læringspunkter – Lessons learned (2)

- Dynamiske beredskaps- og innsatsplaner
 - (Dynamic emergency response and other response plans)
- Beredskapsanalyse
 - (Emergency response analysis)
- Sanntidsinformasjon og bruk av sosiale media
 - (Real-time information and the use of social media)
- Bygging av evakueringsrom i lange ettløps tunneler
 - (Construction of evacuation facilities in long, single bore tunnels)
- Risikoanalyser, risikoaksept og valg av effektive tiltak
 - (Risk analyses, risk acceptance and selection of effective measures)