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COOLING A RAILTANKER BEHIND A NOISE SHIELD

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Abstract

Introduction

In the Netherlands, the Betuweline, a dedicated freight railway, will among other things, be used for transportation of all kind of hazardous materials from the Port of Rotterdam to the German Hinterland and vice versa. The line is about 150 kilometers long. Alongside the line, over more than 100 kilometers noise shields are apparent. The question is to what extent this noise shield hinders the cooling of a rail tanker, carrying for example a flammable liquid, such as LPG?

Theory and method

To answer this question, a full scale test was conducted on an already constructed part of the Betuweline. Two railcars and a rail tanker were placed behind a three meters high noise shield. First, it was tested whether firemen or water canon be used to squirt the water. The water canons prevailed. Next, four positions of the water canons to cool the rail tanker were tested. Three camera's and three observers recorded the spots and the extent of water that hit the rail tanker.

Results

The results indicate that the noise shield to large extent prevents the water from hitting, and therefore cooling, the rail tanker. The upper parts of the rail tanker were hardly hit by the water canons and the small amount of water flowing down the rail tanker did not reach the lower parts of it because of the armatures at the rail tanker. Also the amount of water in the ditches to be used for cooling was too small. The ditch nearby ran empty. These insights are both relevant to emergency responders for disaster abatement purposes and to water management organizations. The ministry of Transport is examining the possibilities to deal with these results.

Discussion

The results are based upon one single full scale test near a three meter high noise shield. In addition, it is interesting to find out what the influence would be in case of other heights of the noise shields.

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Introduction

In the Netherlands, the Betuweline, a dedicated freight railway, will among other things, be used for transportation of all kind of hazardous materials from the Port of Rotterdam to the German Hinterland and vice versa. The line is about 150 kilometers long. The railway is aligned closely to multiple cities and villages. Because of that, noise shields were designed to protect the inhabitants for too high noise levels of passing trains. Alongside the line, over more than 100 kilometers noise shields have been constructed, varying in height from 1 tot 4 meters. Legal criteria are absent in the Netherlands for designing noise shields along railways. Two main aspects are taken into account in designing such noise shields including the noise reduction and the way the noise shield fits in the environment. However, the effect of noise shields on emergency response activities is not a part of the deliberations so far. One of the possible accident scenarios on the Betuweline is a pool fire radiating a rail tanker filled with a flammable liquid (Werkgroep Betuweroute Regionale Brandweren, 1994). To prevent the heated rail tanker for exploding, it has to be cooled. The cooling can be performed by squirting large amounts of water on the rail tanker. The question is to what extent this noise shield hinders the cooling of a rail tanker, carrying for example a flammable liquid?

Theory

In theory, 10,2 liters of water per minute per square meter of the rail tanker is sufficient to cool a rail tanker. Cooling prevents the pressure increase in the rail tanker: the temperature increase of for example a flammable liquid is limited. 'Sufficient cooling' means that the pressure in the rail tanker does not reach a peak that causes a Boiling Liquid Expanded Vapor Explosion (BLEVE). To this end, the rail tanker should be cooled over its total surface, so 360 degrees (NVBR, 2005). For a typical rail tanker on the Betuweline, the 10,2 liters water per minute per square meter implies 6000 liters per minute. In addition, this amount of water should be applied during at least 4 hours (Werkgroep Betuweroute Regionale Brandweren, 1994). When formulating these cooling requirements, noise shields were not incorporated in the design and therefore not reckoned for in the cooling strategy. However, now that the noise shields appear along the Betuweline, fire brigades are aware of the reduced possibilities to get the water on the rail tanker. In case of too small volumes of water reaching/hitting the rail tanker, heat radiation might cause pressure increasing in the rail tanker and in the end an explosion endangering inhabitants along the line and emergency responders. In addition, fires might expand to adjacent rail cars causing domino effects such as releases of hazardous materials or additional explosions. To protect both inhabitants and emergency responders, it is important to find out if and to what extent the noise shields influence the cooling opportunities for fire brigades.

The rail tanker cooling test

To answer this question, full scale tests were conducted on an already constructed part of the Betuweline (Nibra, 2005). Two railcars and a rail tanker were placed behind a three meters high noise shield. Because of safety and financial reasons, we did not position the rail tanker above a real life pool fire. Hence, the test was developed to hit the rail tanker with the water canons and to observe the water volumes that reached the rail tanker. We made use of one rail tanker and two railcars. The rail tanker is position in between the two railcars. The table below presents the specifications of both types of containers.

Table 1: Rail tanker and railcar specifications.

Aspect	Rail tanker	Railcar
Type	Demonstration car	Rijmms 660
Height from rail (WH)	4,00 meter	4,28 meter
Height rail to car (FH)	1,25 meter	1,23 meter

Width (B)	2,50 meter	2,70 meter
Length (L)	14,00 meter	14,20 meter

Both types of containers are visualized below.

Figure 1: dimensions of Rijmms 660.

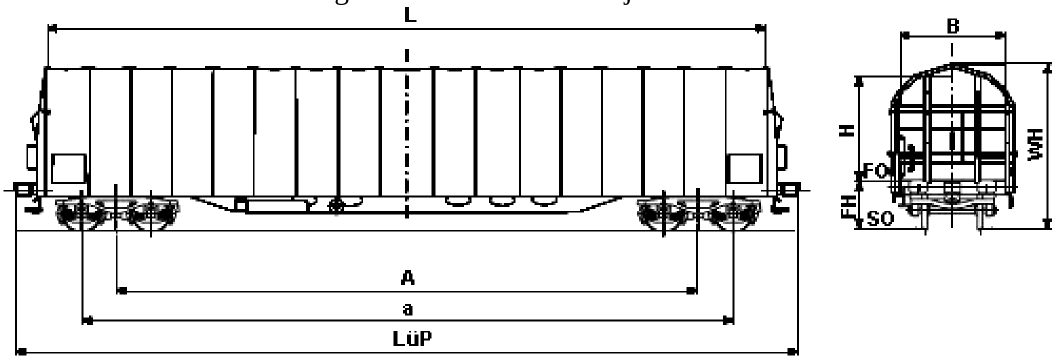
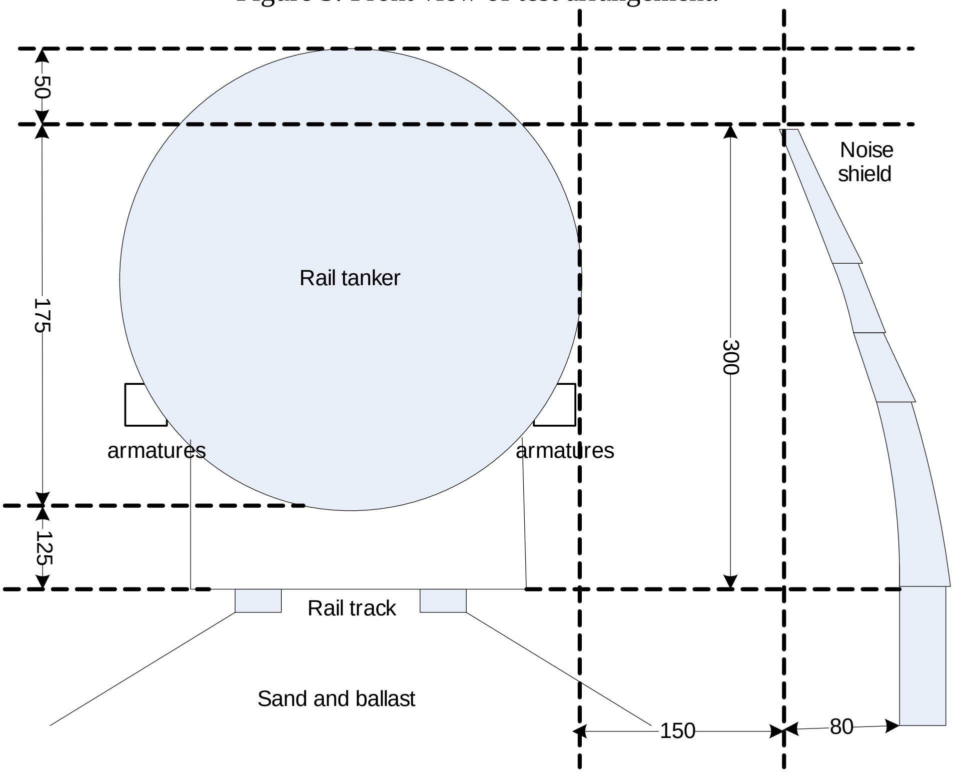


Figure 2: Photograph of rail tanker.

The Betuweline noise shield varies in height from 1 to 4 meters. We selected a test location where a 3-meter high noise shield has already been realized on one side. The test was held near the villages of Leerdam and Vuren very close to highway 15, hectometer 34,7.

Figure 3 presents a front view of the test arrangement.

Figure 3: Front view of test arrangement.



The tests were realized with the cooperation of many stakeholders: ProRail (providing the rail track), fire region Zuid-Holland Zuid (preparation and logistics), fire brigades of Lingewaal/Lingewaal Zuid, Sliedrecht, Lingewaal/ Asperen en Papendrecht (operating the water canons and hoses), NedTrain (providing the rail tanker), the national police ((KLPD) for photography and video observations), Ministry of Transport (traffic management at highway 15) and the dike reeve Vierstromengebied (ditches).

The test results were observed in two ways:

- Three police camera's (1 helicopter, and 2 police cars)
- Three observers (2 at each side of the rail tanker, and 1 behind the noise shield)

An observation protocol was developed. The three police cameras were coordinated by the police control room near the test site. One liaison of the test team was apparent in the police control room. The test leader was in contact with the liaison and the observers. The observers were in contact using the Dutch new emergency response communications system C2000. The test leader coordinated the observations by indicating the start and the end of the cooling activities. UsingC2000, the test leader requested the observers to indicate the place where the rail tanker was directly hit by the water and the amount of water that flew of from the rail tanker. Each of the observers had his own observation map. The observers were asked to indicate those parts of the rail tanker that where directly hit (high/low and left/right) on the papers by marking these parts on a pre specified raster on the rail tanker. The amount of water hitting the rail tanker was qualified in terms of a lot or scarce and in terms of continuous or incidental.

Both observers and policemen were instructed before the test. This instruction was meant to clarify the goal of the test and the aspects the observers should take notice of.

In particular, the rail tanker should be hit with the water canons. Four different water canon positions were tested:

a) 1-sided: 2 water canons behind the noise shield and rectangular (about 90 degrees) on the rail tanker
b) 2-sided: 2 water canons behind the noise shield and 2 water canons from the south without a noise shield in between, both positioned rectangular (about 90 degrees) on the rail tanker
c) 2-sided: 2 water canons behind the noise shield and 2 water canons from the south without a noise shield in between, both positioned in angle (about 45 degrees) on the railcar
d) 2-sided: 2 water canons inside the noise shield (angle about 5 to 10 degrees) and 2 water canons from the south without a noise shield in between, the latter positioned in angle (about 45 degrees) on the railcar

The table below summarizes the test data. The positions of the water canons are number 1, 2, 3 and 4 (most left column). The type of water canon is specified in the one but most left column. The upper row presents the various tests a), b), c) and d). The cells contain the water canon positions per test regarding the centre of the rail tanker. The water canon locations are labeled using the direction from the rail tanker (north, east, south and west). The distances are measured in meters from the centre of the rail tanker. The cells contain information about the direction and distance per canon per test.

Table 2: Test site data: arrangements of water canons a) to d).

nr	Type water-canon	a) 2 canons, 90 degrees and behind noise shield	b) 4 canons, 90 degrees and 2 behind noise shield	c) 4 canons, 45 degrees and 2 behind noise shield	d) 4 canons, 2 canons inside noise shield (5-10 degrees) and 2 canons 45 degrees
1	Street water-canon: 5 to 6 bar	North: 25 m. East: 10 m.	North: 25 m. East: 10 m.	North: 15 m. East: 20 m.	North: 1,5 m. East: 20 m.
2	Oscillating: 8 to 10 bar	North: 25 m. West: 10 m.	North: 25 m. West: 10 m.	North: 15 m. West: 30 m.	North: 1,5 m. West: 30 m.
3	Oscillating: 8 to 10 bar	-	South: 25 m. East: 10 m.	South: 25 m. East: 30 m.	South: 25 m. East: 30 m.
4	Oscillating: 8 to 10 bar	-	South: 25 m. West: 10 m.	South: 25 m. West: 30 m.	South: 25 m. West: 30 m.

The photograph below shows the beginnings of the test where water canons behind the noise shield are installed. From this photograph it is clear that the rail tanker is only slightly higher than the noise shield, and therefore difficult to hit with the water canon.

The water canons were tuned. Tests made clear that water canons should squirt converged water beams instead of diverged beam. A diverged beam flights away even when there is hardly any wind. To hit the rail tanker, a converged water beam is used. The converged water beams could be aimed at the rail tanker by varying the pressure of the pumps and the sprout angle.

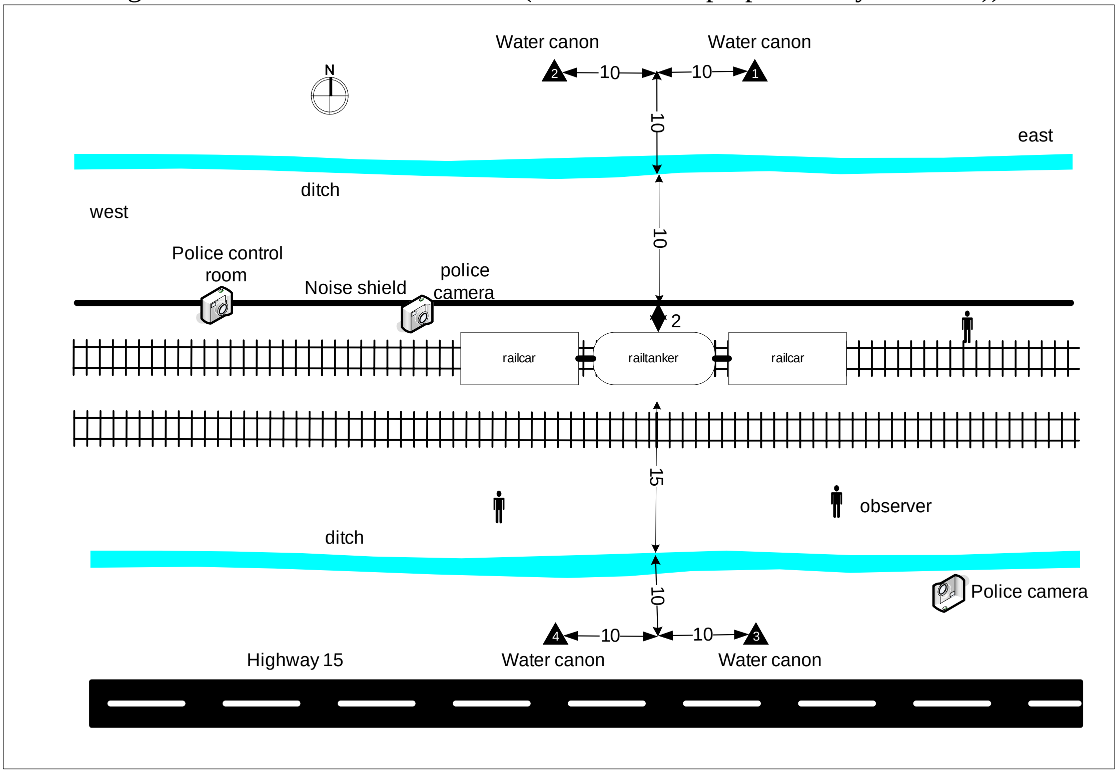
Figure 4: Tuning water canons for the test.

Table 2: Test site data.

Aspect	Specification
Date and time	24 June 2005, 1.00 pm
Temperature	30 degrees Celsius
Weather conditions during test	Dry and sunny, hardly any wind
Weather conditions 1 week before test	Heat wave: 5 days, 30 degrees Celsius
Height railcar (Rijmms 660)	4,20 meter
Height rail tanker (demo car) armatures included	4,00 meter
Height noise shield	3,00 meter
Distance between lower part noise shield and rail tanker	2,30 meter
Distance between noise shield and rail tanker at 3 meters high	2,00 meter
Type pump application	HSP-19B
capacity pump	Covers 15 meter height with 2400 liters/min including 1 bar dynamic pressure

The figure below shows the test arrangement (for illustrations purposes, only for test b).

Figure 5: Overview of test location (for illustrative purposes only for test b)).



Results

We did not observe any differences in hitting the railcar left from the rail tanker or the railcar at the right. This is understandable because neither the containers nor the arrangement of the water canons differed. There was no problem hitting the rail tanker from the side where there was not noise shield.

The table below shows the test results for the rail tanker and railcar squirting converged water beams. The water canons were operated by firemen. The most left column presents the container (rail tanker or railcar). The one but most left column presents the position at the container that is hit. The upper row presents the four different tests. The cells contain the qualifications by the observers. The qualifications are based upon the camera images, filled out observer formats and interviews with the observers. We emphasize that in this table, the amount of water hitting the south side of the containers is not presented: this side was fully hit.

Table 3: Test results cooling.

		a)	b)	c)	d)
railcar: noise shield side (north)	Height (2,75-4 meter from rail)	-/+	-/+	-	+
	Height (1-2,75 meter from rail)	--	--	--	-/+
Rail tanker: noise shield side (north)	Height (2,75-4 meter from rail)	-/+	-/+	-	+
	Height (1-2,75 meter from rail)	--	--	--	-/+

-- = no hit; - = hardly any hit; -/+ = partial hit; += moderate hit; ++ = fully hit

The results indicate that the noise shield to large an extent prevents the water from hitting, and therefore cooling, the rail tanker. The upper parts of the rail tanker were hardly hit by the water canons and the small amount of water flowing down the rail tanker did not reach the lower parts of it because of the armatures at the rail tanker. Also the amount of water in the ditches to be used for cooling was too small. The ditch nearby ran empty.

In addition, the following aspects were observed during the test:

- After a period of squirting water, a pool originates between the track and the noise shield
- Water runs of the rail tanker, however, does not reach the lowest point of the rail tanker because of its armatures
- Water canons inside the noise shield pretty much hit the upper side of the rail tanker
- Canons operated by firemen better hit the rail tanker than oscillating water canons
- Water levels is ditches decreased rapidly causing capacity problems
- Developing new test arrangements took about 10 to 15 minutes (included tuning the water canons)

These insights regarding the possibilities to hit the rail tanker and the limited volumes are both relevant to emergency responders for disaster abatement purposes and to water management organizations. For emergency responders because it determines:

- The lack cooling capacity and hence the risk of explosions
- The primary direction for repressing accidents

For emergency responders and water management organizations because the water canons require large amounts of water that cause ditch to run empty. This shortage disables the cooling opportunities.

Conclusions and recommendations

The following conclusions are drawn:

1. A converged water beam better hits the rail tanker than a diverged water beam
2. Firemen operating the water canons better hit the rail tanker than oscillating water canons
3. There is hardly any difference in effectiveness when water canons are arranged rectangular or 45 degrees regarding the rail tanker
4. The 3-meter high noise shield causes that the upper parts of the rail tanker are hardly hit
5. The 3-meter high noise shields cause that the lower parts of the rail tanker are not hit at all
6. Water runs down the rail tanker, however it does not reach the lowest points
7. In absence of the noise shield, water canons fully hit the rail tanker
8. A water pool develops between the noise shield and the track

The following recommendations were made:

1. Take noise shields into account when preparing for incident management at the Betuweline
2. When preparing for incident management, take into account the development of a pool between the noise shield and the track, due to the squirted water volumes
3. If water canons are necessary for squirting water, then it should be tuned into a converged beam and positioned rectangular regarding the rail tanker
4. Assess the cooling capacity of the water running down the rail tanker
5. Invest the opportunities for replacing/relocating armatures on the rail tanker
6. Reconsider the primary direction for repression activities with respect to the noise shield presence

7. Asses the influence of a 2 meters high noise shield
8. Consider various extinguish strategies for cooling a rail tanker behind a noise shield

Discussion

The results are based upon one single full scale test near a three meter high noise shield. Still, we argue that similar tests would result in similar cooling results. The reason therefore is that variables were controlled and that unexpected variables, such as weather conditions, hardly improve the results. More wind actually would further deteriorate the effectiveness.

In addition, it is interesting to find out what the influence would be in case of other heights of the noise shields. In particular heights in the range of 1,5 and 2,5 meters.

In addition, other types of incident management might be necessary, such as providing a foam blanket. Such strategies have not been tested, but might be useful to give an idea of the opportunities when noise shields are present.

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Author Biography

Nils Rosmuller has a PhD in transport safety at Delft University of Technology. Since 2001, he is working at the Netherlands Institute for Fire Service and Disaster Management, at the research department. His main fields of interests are transport safety, tunnel safety and the safety of fire fighters.