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# Wetting a rail tanker behind a noise shield

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ABSTRACT

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

To answer this question, a full scale test was conducted on an already constructed part of the Betuweline [N. Rosmuller, D.W.G. Arentsen, (2005). Praktijkproeven Betuweroute: Instantane uitstroming en koeling 24 juni 2005, Nibra, Arnhem, The Netherlands]. Two railcars and a rail tanker were placed behind a 3 m high noise shield. First, it was tested as to whether firemen or water canons should be used to deliver the water. Water canons were best next, four positions of the water canons to wet the rail tanker were tested. Three camera's and three observers recorded the locations and the extent of water that hit the rail tanker.

The results indicate that the noise shield, to a large extent, prevents the water from hitting, and therefore cooling, the rail tanker. The upper parts of the rail tanker were minimally struck 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 wetting 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 possible strategies to deal with these findings.

The results are based upon one single full scale test near a 3 m high noise shield. In addition, it would be valuable to determine what the influence would be of other heights of the noise shields.


## 1. Introduction

In the Netherlands, the Betuweline is a dedicated freight railway that 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 approximately 150 km long. The railway is situated close to, and in some case runs through multiple cities and villages. Because of that, noise shields were designed to protect the inhabitants from high noise levels of passing trains. Alongside the line, for more than 100 km, noise shields have been constructed, varying in height from 1 to 4 m. 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, specifically 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 thus far. As a result, there might be a conflict of environmental interests with safety interests. One of the possible accident scenarios on the Betuweline is a pool fire radiating from a rail tanker filled with a flammable liquid [2]. To prevent the heated rail tanker for exploding, it has to be cooled. Without adequate cooling, a BLEVE (boiling liquid expanding vapor explosion) might occur with 10–25 min after the rail tanker is in the pool fire [3]. Birk et al. [4] concluded, based on casuistic and calculations that a road tanker without being cooled, could result in a BLEVE after being exposed for 25 min to an intensive fire (such as a pool fire of gasoline). 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 wetting of a rail tanker, carrying hazardous flammable liquids or other high risk substances.

## 2. Theory

Several references state that the amount of water to cool a rail tanker should be around 1200–2500 L $min^{-1}$: Germany's VFDB [5]:

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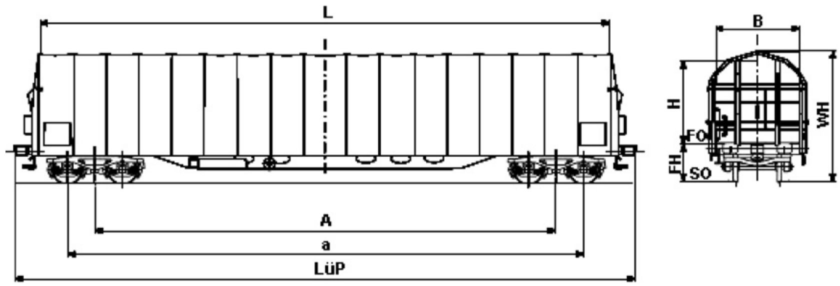


**Fig. 1.** dimensions of Rijmms 660. $L$ = length of cover up roof. $A$ = distance between the front and back wheelbase. $a$ = maximum distance between front and back wheel axis. LüP = maximum length of rail car including armatures.

2500 L min$^{-1}$; America's NSCP [6] 1850 L min$^{-1}$ and Dutch NVBR [7]: 1200 L. In the Netherlands, based on the 1200 L min$^{-1}$ and a rail tanker surface of about 120 m$^2$, about 10 L of water min$^{-1}$ m$^{-2}$ of the rail tanker should be sufficient to cool a rail tanker [2,3]. In order to cool the two direct adjacent (neighbor) rail tankers as well, a total amount of at least 6000 L min$^{-1}$ is advised [2]. Cooling prevents pressure increase in the rail tanker. For example, of a flammable liquid might be limited. 'Sufficient cooling' means that the pressure in the rail tanker does not reach a peak that causes a BLEVE. To this end, the rail tanker should be cooled over its total surface [8]. For a typical rail tanker on the Betuweline, the 10.2 L water min$^{-1}$ m$^{-2}$ implies 6000 L m$^{-1}$ should be used. In addition, this amount of water should be applied during at least 4 h [2]. When formulating these cooling requirements, noise shields were not incorporated in the design and therefore not included 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. If too small a volume of water reaches/hits the rail tanker, heat radiation might cause pressure to increase in the rail tanker and ultimately 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 determine if and to what extent the noise shields influence the cooling opportunities for fire brigades.

The example below of a propane loaded rail tanker accident at Lilleström (April 5th, 2000, Norway) shows the importance of effective cooling [9].

> On the basis of the investigations and analyses that have been carried out, the Commission is in no doubt that a BLEVE would have developed with catastrophic consequences on the night between 4 and 5 April if cooling of the tanks had not been undertaken. In the opinion of the Commission, a catastrophe would have occurred between 3 and 4 a.m. if action had not been taken to start cooling the tanks. At the time the catastrophe would have occurred, evacuation had not been started. It must be assumed that under these circumstances more than hundred people would probably have been killed instantly, and several hundred would have been seriously injured. Many people would perhaps have received life-threatening injuries. It must be assumed that any persons who were outdoors within a radius of 500 m from the tanks would most probably have been killed by thermal radiation. Furthermore, fires in a large number of buildings at the same time at this time of night would probably have meant that many people would have been unable to get out in time.

**Table 1**
Rail tanker and railcar specifications

| Aspect | Rail tanker | Railcar |
|---|---|---|
| Type | Demonstration car | Rijmms 660 |
| Height from rail (WH) | 4.00 m | 4.28 m |
| Height rail to car (FH) | 1.25 m | 1.23 m |
| Width ($B$) | 2.50 m | 2.70 m |
| Length ($L$) | 14.00 m | 14.20 m |

## 3. The rail tanker wetting test

To answer this question, full scale tests were conducted on an already constructed part of the Betuweline [1]. Two railcars and a rail tanker were placed behind a 3 m 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 was positioned in between the two railcars. Table 1 below presents the specifications of both types of containers.

Both types of containers are visualized (Figs. 1 and 2).

The Betuweline noise shield varies in height from 1 to 4 m. We selected a test location where a 3 m high noise shield had already been realized on one side. The test was held near the villages of Leerdam and Vuren, about 25 m away to highway 15, at hectometer 34.7.

Fig. 3 presents a front view of the test arrangement.

The test results were observed in two ways:


**Fig. 2.** Photograph of rail tanker.

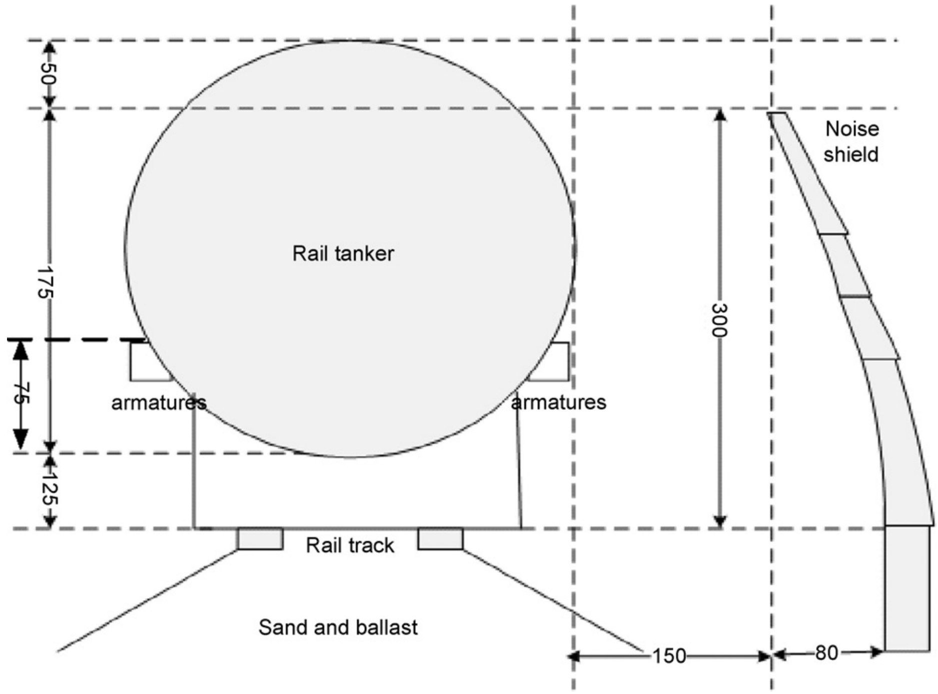


**Fig. 3.** Front view of test arrangement (in centimeters, but not on scale).

- Three police camera's (one helicopter, and two police cars)
- Three observers (one at each side of the rail tanker, and one 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 present 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 wetting activities. Using C2000, 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 off 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 observe.

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

(a) One-sided: two water canons behind the noise shield and rectangular (about 90°) on the rail tanker
(b) Two-sided: two water canons behind the noise shield and two water canons from the south without a noise shield in between, all positioned rectangular (about 90°) on the rail tanker
(c) Two-sided: two water canons behind the noise shield and two water canons from the south without a noise shield in between, both positioned in angle (about 45°) on the railcar
(d) Two-sided: two water canons inside the noise shield (angle about 5–10°) and two water canons from the south without a noise shield in between, the latter positioned in angle (about 45°) on the railcar

Table 2 summarizes the test data. The positions of the water canons are number 1, 2, 3 and 4 in the far left column. The type of water canon is specified in the second column. Each of these produced about 250–400 L water $min^{-1}$. 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

**Table 2**
Test site data: arrangements of water canons (a)–(d)

| No. | Type water- canon | (a) Two canons, 90° and behind noise shield | (b) Four canons, 90° and two behind noise shield | (c) Four canons, 45° and two behind noise shield | (d) Four canons, two canons inside noise shield (5–10°) and two canons 45° |
|---|---|---|---|---|---|
| 1 | Street water-canon: 5–6 bar | North: 25 m<br>East: 10 m | North: 25 m<br>East: 10 m | North: 15 m<br>East: 20 m | North: 1.5 m<br>East: 20 m |
| 2 | Oscillating: 8–10 bar | North: 25 m<br>West: 10 m | North: 25 m<br>West: 10 m | North: 15 m<br>West: 30 m | North: 1.5 m<br>West: 30 m |
| 3 | Oscillating: 8–10 bar | – | South: 25 m<br>East: 10 m | South: 25 m<br>East: 30 m | South: 25 m<br>East: 30 m |
| 4 | Oscillating: 8–10 bar | – | South: 25 m<br>West: 10 m | South: 25 m<br>West: 30 m | South: 25 m<br>West: 30 m |

**Fig. 4.** Tuning water canons for the test.

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 3**
Test site data

| Aspect | Specification |
|---|---|
| Date and time | 24 June 2005, 1.00 p.m. |
| Temperature | 30 °C |
| Weather conditions during test | Dry and sunny, hardly any wind |
| Weather conditions 1 week before test | Heat wave: 5 days, 30 °C |
| Height noise shield | 3.00 m |
| Distance between lower part noise shield and rail tanker | 2.30 m |
| Distance between noise shield and rail tanker at 3 m high | 2.00 m |
| Type pump application | HSP-19B |
| Capacity pump | Covers 15 m height with 2400 L m$^{-1}$ including 1 bar dynamic pressure |

The photograph below shows the beginning 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 direct converged water beams instead of diverged beam. A diverged beam flies 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 stream angle (Fig. 4, Table 3).

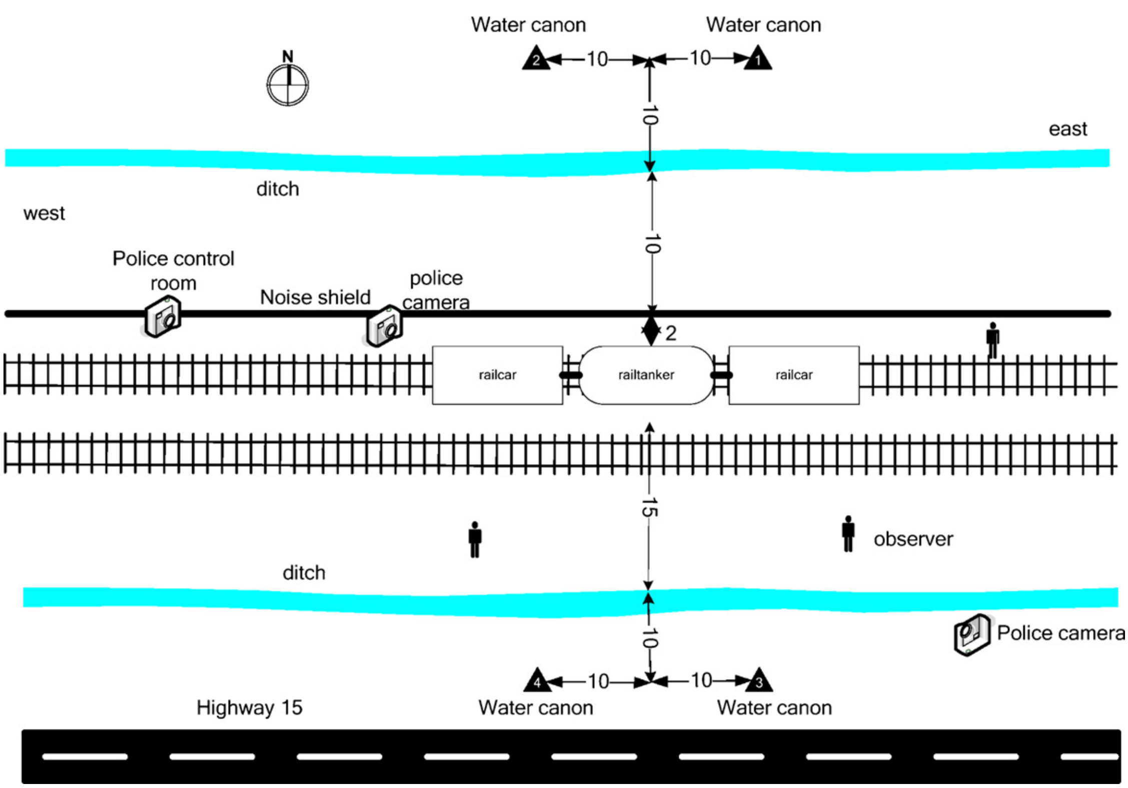


**Fig. 5.** Overview of test location (for illustrative purposes only for test (b)) (in meters but not on scale).

**Table 4**
Test results cooling

| | | (a) | (b) | (c) | (d) |
|---|---|---|---|---|---|
| Railcar: noise shield side (north) | Height (2.75–4 m from rail) | −/+ | −/+ | − | + |
| | Height (1–2.75 m from rail) | -- | -- | -- | −/+ |
| Rail tanker: noise shield side (north) | Height (2.75–4 m from rail) | −/+ | −/+ | − | + |
| | Height (1–2.75 m from rail) | -- | -- | -- | −/+ |

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

The figure below shows the test arrangement (for illustrations purposes, only for test (b) (Fig. 5).

## 4. 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 a noise shield.

Table 4 shows the test results for the rail tanker and railcar streaming converged water beams. For practical reasons, the water canons were operated by firemen[2]. The far left column presents the container (rail tanker or railcar). The second 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. Qualifications are based upon the camera images, completed, out observer formats and interviews with the observers. We emphasize that in this table, water hitting the south side of the containers is not presented: this side was fully hit. In addition, the amount of water that actually hits the rail tanker was not measured.

The results indicate that, to a large extent, prevents the water from hitting, and therefore cooling, the rail tanker. Only the upper 50 cm of the rail tanker were hit directly and the small amount of water flowing down the rail tanker did not reach the lower areas because of the armatures on the rail tanker at 75 cm from the bottom. In the end, 150 cm of the total height of 225 cm of the rail car (2/3) were wetted (directly by the water beam or by flowing down the tank) while total (100%) wetting is required. In addition, 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 trench originates between the track and the noise shield which might cause eventually released liquids (e.g. LPG) to spread along the rail cars and cause fire threats
- Although water runs off the rail tanker, it 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 hit the rail tanker better than oscillating water canons
- Water levels in ditches decreased rapidly causing capacity problems
- Developing new test arrangements took about 10–15 min (included tuning the water canons)

This information regarding the limited possibilities to hit the rail tanker and the limited effective volumes are both relevant to emergency responders for disaster abatement purposes and to water management organizations. For emergency responders, it indicates:

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

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

[2] In reality, during a BLEVE threat, it is advised to keep several hundreds meters distance within seconds, the fire might develop into a deflagrating fire with a radius of 100 m or more and deadly heat radiation at a distance of 300 m.

## 5. Conclusions and recommendations

The following conclusions are drawn:

(1) A converged water beam hits the rail tanker better than a diverged water beam.
(2) Water canons operated by firemen hit the rail tanker better than oscillating water canons.
(3) When water canons are arranged rectangular, they are more effective in wetting the rail tanker than positioned in a 45° angle to the rail tanker.
(4) The 3 m high noise shield prevents that the lower parts of the rail tanker (below the maximum height of the noise shield, e.g. 4 m) from being hit.
(5) The 3 m high noise shield results in the upper parts (50 cm) of the rail tanker being poorly hit.
(6) Water runs down the rail tanker, although it does not reach the lowest points due to the armatures. At 75 cm from the bottom, the water leaves the rail tanker. Hence, only 2/3 of the rail tanker at the noise shield side is wetted.
(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 water volumes used.
(3) If water canons are necessary for providing water, they should be turned 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 in 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) Assess the influence of a 2 m high noise shield.
(8) Consider various extinguish strategies for wetting a rail tanker behind a noise shield. In Duyvis et al. [10], all kinds of BLEVE prevention and suppression measures were analyzed. Regarding the cooling (wetting) of the rail tanker, ideas have been proposed such as a sprinkler integrated the noise shield, elevated water canons, opportunities to attach water canons to the noise shield, and foam forming equipment stored near the noise shields. Most of these would reduce the BLEVE probability and improve the ability to suppress this. However, the maintenance efforts, costs and the lack of support are significant negative side effects.

## 6. Discussion

The results are based upon one single full scale test near a 3 m high noise shield. However, it is anticipated that similar tests would result in similar wetting results. Variables were controlled and unexpected variables, such as weather conditions, would not improve the results. More wind actually would further deteriorate the effectiveness.

In addition, it would be interesting to determine what influence other heights of the noise shields (such as 1.5 and 2.5 m) would have. Because the 3 m high noise shield hampers suppression activities, we argue that the 4 m high noise shield would be as bad as the 3 m high shield. Therefore, a particular test with the 4 m shield would not yield additional insights. 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 additional opportunities when noise shields are present.

## Acknowledgements

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