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**Item:** **Report on experience with extra-large tank-containers used by BASF SE**

**Information from CEFIC**

**SUMMARY**

***Executive summary:***

– Extra-large tank-containers have been used in single wagon traffic in all kinds of hump-shunting yards since 2018.
– In Germany, hump-shunting yards with sliding shoe braking only exist with impact speeds of higher than 2 m/s in 1/200 cases.
– Extra-large tank-containers have passed over such humps many times.
– No damage to extra-large tank-containers was detected during periodic inspections.
– Tank-containers approved in accordance with RID intended for the transport of dangerous goods are dimensioned for 3g.

1. BASF Class Tank-Containers (B-TC) have been used by BASF for the transport and storage of dangerous goods since 2015. With a total of around 1,400 units, the tank-containers that have been acquired replaced a significant proportion of BASF's tank-wagon and intermodal tank-container fleet. As they are more flexible and perform better, the new system has enabled more efficient intermodal logistics for bulk chemicals.

2. BASF operates almost 1,400 extra-large tank-containers, with lengths ranging from 40 ft. to 52 ft. and volumes of 40 m³ to 73.5 m³, approved in accordance with RID Chapter 6.8 and falling under the definition of "extra-large tank-container" that is to be introduced. In addition to the extra-large tank-container fleet, BASF uses a fleet of roughly 500 specifically designed innovative container carrying wagons (iCTW) for the transport of extra-large tank-containers. The wagons are equipped with reinforced spigots and long-stroke buffers (150 mm) to be approved for hump shunting without restrictions by fulfilling the requirements of standard DIN EN 12663-2, 8.2.5.1 in conjunction with TSI WAG 321/2013, Annex C, 3. Accordingly, the system is used without restrictions in common railway operations, such as single wagon traffic, all over Europe.

3. As the new system replaced conventional tank-wagons and intermodal tank-containers, BASF's use of the system in its supply chains can be distinguished in different areas and different intermodal transport modes. The tank-containers and wagons are used as block trains between the companies' sites, for internal rail and road transport on the sites or between (neighbouring) intermodal terminals to the sites, or for transport from suppliers or to customers in conventional single wagon traffic. The train composition for all areas is carried out internally with shunting locomotives (i.e. Antwerp), or via an automated shunting hump in Ludwigshafen, or with cranes (in terminals).

4. Since January 2020, the tank-containers have passed the shunting hump at BASF's Ludwigshafen site more than 100,000 times (77.6 times on average per tank-container). 45 B-TC have passed it more than 200 times, of which 10% have already been subject to the 5-year and CSC test. At BASF's fully automated hump-shunting yard, running wagons are slowed down to an impact velocity of max 7 km/h using retarders.

5. More than 4,500 external transport operations (B-TC plus iCTW) have been performed by different railway undertakings all over Europe since the beginning of 2022. Location data shows that on the German railway infrastructure, different shunting yards were passed up to several thousand times. Shunting yards in Germany are classified into fully automated hump-shunting yards (e.g. Mannheim), half automated hump-shunting yards (e.g. Kornwestheim), yards with shunting humps without any kind of automation (e.g. Mainz-Bischofsheim) and shunting yards without humps (e.g. Karlsruhe). Generally, for all types of yards with hump-shunting, an impact velocity of 1.25 m/s is projected. For fully automated yards, the wagons are slowed down using retarders only, half-automated yards use retarders and sliding-shoes, and non-automated yards use sliding-shoes only. According to information provided by DB Netze AG, an impact velocity of 1.5 m/s is reached for 99.0% of all shunted wagons, whilst for 99.5% of all wagons, an impact velocity of 2.0 m/s is reached. However, 1 in 200 shunted wagons reaches an impact velocity higher than 2.0 m/s. Especially for shunting humps without any automation, impact velocities vary between 0 and sometimes up to 4 m/s, depending on the skills and experience of the brakeman. Since January 2022, 834 location marks on hump-shunting yards where sliding shoes are used have been counted.

6. The available location data also indicate that shunting yards have been passed all over Europe. Unlike in Germany, where the maximum hump speed is limited to 15 km/h, other nations limit this velocity to a maximum of 6 km/h (Switzerland). However, impact speeds are related to the height and length of the humps, and ultimately to the braking system used. Projected impact velocities are e.g. 1.5 m/s in Switzerland and Austria. No other information on other hump-shunting yards is available. Therefore, it must be assumed that hump-shunting yards with sliding shoe braking have been passed where the B-TC could have experienced high accelerations on such impacts.

7. First built in 2015, the oldest tank-containers are already seven years old, whereas the average age of all tank-containers is about 2.75 years. Most tank-containers have already been inspected in accordance with RID 6.8.2.4.3 (2.5-year-test). Based on the given age, 3% of the tank-containers had to be inspected in accordance with RID 6.8.2.4.2 (5-year inspection). However, in order to optimize operations, more than 15% were inspected, including the first periodic inspection according to the Convention for Safe Containers (CSC).

8. For the 5-year and CSC inspections, particular attention is given to structural flaws which might have occurred as a result of shunting impacts. Therefore, the tank-container frames and lower corner-castings were visually checked for cracks and dents. The connecting area between frame and tank was similarly checked. In addition, the interior of the shell is specifically checked in the connection area, focusing on welds and other areas where there might be abnormalities. Moreover, the ITCO Manual on "Acceptable Container Condition" is used as additional guidance.

9. Following external and internal inspections, a leakproofness test and a hydraulic pressure test, all the tank-containers inspected passed the inspections successfully, with no structural damage from normal railway operations, including shunting on differently operated humps. Only a few instances of impairments were detected and repaired, such as leaking valves, leaking fittings, malfunctioning hydraulics, or worn-out gaskets. These types of flaws are also common on tank-wagons.

10. In addition to the tank-containers, the innovative container carrying wagons have also been subject to periodic inspections already. About 50 wagons were inspected in accordance with the VPI Guidelines G4.2 inspection programme. In addition, the spigots themselves, as well as their lateral, longitudinal and diagonal distances were measured to detect deviations from given nominal dimensions. No damage or divergences could be detected.

11. Tank-containers approved in accordance with RID 6.8.2.1.2 need to be able to absorb forces exerted by twice the total mass (i.e. 2g) in the direction of travel. In addition, RID 6.8.2.1.13 specifies a safety factor of 1.5, resulting in a dimensioning of 3g. Furthermore, RID 7.1.13 stipulates that tank-containers must comply with UIC Leaflet 592, which requires a dynamic test of 3g for tank-containers intended for the transport of dangerous goods. Accordingly, tank-containers transporting dangerous goods are able to absorb forces of at least 3g in relation to their maximum gross mass.

12. Mandatory approval testing in accordance with RID and other relevant standards and regulations, including ISO 1496-3, ISO 668, CSA B625-13 and IRS 50592, has been carried out. In June 2017, a B-TC with a gross mass of 45.35 t was tested (category A buffers). Based on the required 3g, impact tests were conducted until an equivalent acceleration of 4.96g was reached (45.35 t x 4.95g = 226.75 = 75t x 3g), deploying a 16 Hz low pass filter. For an impact velocity of 12.7 km/h (3.5 m/s), 5.4g were measured, which is equivalent to 3.5g for 75 t. If a 32 Hz low pass filter as required in standard EN 12663-2 is deployed, the acceleration is measured at 7.3g, which equates to 4.7g for 75 tons. Accordingly, the required accelerations would be reached at lower impact velocities, which makes the tank-container approval tests stricter than those required for tank-wagons. The tank-container tested withstands the impacts without any deformation and experienced higher accelerations, as required in the current regulations. Furthermore, B-TC prototypes have been successfully tested in accordance with ISO 1496-3, where a Minimum Shock Response Spectrum Curve is applied. The SRS Curved was developed by Transport Canada and is based on acceleration data measured and experienced in worldwide railway operations.

13. To reach an equal acceleration of 4g for 75 tons with a 16 Hz low pass filter, the impact velocity would need to be further increased above 12.7 km/h/3.52 m/s. In contrast, tests for tank-wagons are limited to 12 km/h/3.33 m/s as higher impact velocities are usually regarded as accidents.

14. The results of shunting tests conducted in 2019 (CSM Risk Assessment) showed that for impact velocities of up to 2 m/s for fully loaded systems (88 t gross weight, category L buffer, 16 Hz), accelerations above 2g were not reached. For fully loaded systems, accelerations up to 2.4g were reached with velocities up to 3.3 m/s, but accelerations never reached 3g. 3g was only reached, but never exceeded, for partially loaded systems (50 t gross weight) for velocities up to 3.33 m/s. It must be borne in mind that for the same forces, a lighter wagon will be affected by higher accelerations than a heavier wagon (i.e. F = 8g x 20 t = 2g x 80 t).

15. Apparently, accelerations exceeding 3g (16 Hz, maximum gross weight) are only detected for impact velocities higher 12 km/h/3.3 m/s. However, even at higher velocities, current B-TC are rigid enough and damage from shunting impacts has not been detected.

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