
Economic Commission for Europe

Inland Transport Committee

Working Party on the Transport of Dangerous Goods

**Joint Meeting of the RID Committee of Experts and the
Working Party on the Transport of Dangerous Goods**

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Item 6 of the provisional agenda

Reports of informal working groups

Report of the Informal Working Group on the reduction of the risk of a BLEVE

Transmitted by the Government of Spain on behalf of the Informal Working Group

Introduction

1. The Informal Working Group on the reduction of the risk of a BLEVE held its thirteenth session, hosted by the Spanish Ministry of Public Works and Transport on 15 to 17 January 2019 in Madrid, Spain, under the chairmanship of Mr. Claude Pfauvadel (France).
2. The meeting was attended by representatives of contracting parties/member states, ERA, non-governmental organisations and industry as mentioned in the enclosed list of participants.
3. After the approval of the agenda, the meeting began with the discussion of the following topics.

Historical introduction into the working group

4. The Chairman of the working group reminded the working group that the start of the working group was triggered by two events:
 - (a) Norway had in 2000 an accident with LPG transported by rail. BLEVE was avoided, but the firefighters noted problems with the sunshields during their intervention.
 - (b) The Netherlands had concerns with the delivery of autogas LPG in autogas filling stations in urban areas.
5. The works were initiated in the Joint Meeting, and the Working Group looked at different solutions, listing 60 preventive and mitigating measures that would help to prevent or delay a BLEVE in the case when a tank or tank-wagon would be on fire.
6. Testing on two of these measures, Pressure Relief Valve (PRV) and thermal coating, was done at BAM, funded by Germany and France. Findings were that a PRV alone does not prevent a BLEVE, because even if the PRV lowers the internal pressure, it is not able to prevent overheating of the steel of the tank during an engulfing fire. The tank will burst because the metal of which it is constructed becomes too weak under high temperatures. Thermal coating was found to be positive, as it prevented a BLEVE together with a PRV and it retarded the BLEVE to more than 60 minutes without PRV. To be effective, the thermal coating had to be done on the whole surface of the tank.

7. Considering these data at its autumn 2014 session the Joint Meeting did not adopt any new requirements. Especially concerning thermal coating to prevent a BLEVE, it was considered that some factors related to the coating, as proposed, were not known, regarding to its practical implementation, the response of the coating to vibrations, degradation with time, and the protection of the tank when the coating was damaged. It was however decided to continue the work under new terms of reference
8. In the renewed work of the working group (starting in 2017) the case of partial fire engulfment has been analysed. For this case it seems that some preventive and mitigation measures can be combined to avoid a BLEVE.
9. The Joint Meeting has accepted the calculation method provided by the Finite Element Model (FEM) model implemented by INERIS, and the approach followed by the working group.
10. It is anticipated that this working group will propose new provisions that should reduce the likelihood of a BLEVE occurring such as the use of PRVs and other preventive or mitigation measures.
11. It has to be kept in mind that cabin, fuel tank and tyre fires are specific for road transport. For rail transport the case of one tank-wagon affecting a different one has a very low probability of occurrence; general accident prevention has to be linked to the general safety systems, in coordination with the ATMF working group, also considering that the lifespan of a railway vehicle is much longer.
12. Looking to the more distant future, consideration might be given to the development of different designs of tank, such as those that are not 100% metallic, which by the nature of their construction could have fire-resistant properties. Sandwich material, and Fibre-reinforced plastics (FRP) tanks could be analysed, as they could perhaps provide a combination of shock protection and fire protection.

Scope of work

13. The Chairman of the working group summarized the scope of the work agreed on by the working group. Any liquefied substance above its boiling point can be subject to a BLEVE; substances that have undergone a BLEVE are listed in Annex 1 (Abbasi & Abbasi, 2006). (see INF.8/Add.1).
14. Different measures that will be proposed will not only apply to LPG, but also to other substances (in principle other gases, flammable or not, and flammable liquids). Some measures can be interesting for other classes also.
15. Cryogenic gases can also undergo BLEVE phenomena, even if more energy (heat) must be applied than for other gases.
16. Metal tanks can be subject to BLEVE, but probably plastic or fibre reinforced plastic tanks not, because these tanks tend to melt, and the content will be released gradually. It may be interesting to study the possible use of FRP tanks for gases (see Working Group in place in the Sub-Committee of Experts on the Transport of Dangerous Goods).
17. The focus of this Working Group is mainly set on hot BLEVE, caused by fire, but cold BLEVE also can happen (Accident in 1978 in Los Alfaques, Spain).

Presentation on accident in Bologna in August 2018

18. Italy made a presentation on the occurrence of this accident based on the photos included in annex 2 (see INF.8/Add.2) and on a video taken by the surveillance cameras. Additional information on this accident can be found under:

<http://www.unece.org/fileadmin/DAM/trans/doc/2018/dgwp15/ECE-TRANS-WP15-105-GE-inf23e.pdf>

<http://www.unece.org/fileadmin/DAM/trans/doc/2018/dgwp15/ECE-TRANS-WP15-244e.pdf>

19. The following basic data on accident was mentioned:
 - (a) Driver did not brake before impact into preceding truck.
 - (b) Explosion 7 minutes after impact.
 - (c) Windows shattered at 500 m distance.
 - (d) 1 fatality (driver of tank vehicle).
 - (e) Accident was a road accident by vehicles which carried dangerous goods.
 - (f) Some data retained by judge, not available yet.
 - (g) Police arrived early, stopped traffic.
 - (h) Fire fighter arrived just before BLEVE occurred, no measures taken.
20. The following analysis after the accident was made:
 - (a) Accident report: very poor, very little information.
 - (b) Road accident could have been avoided by measures studied by WP.29: autonomous emergency braking, radar, LIDAR, fatigue detection system, adapted cruise control. Technology available.
21. The following points were discussed in the group:
 - (a) 90% of dangerous goods accidents are normal traffic accidents, not motivated by dangerous goods; traffic accident made worse by the transport of dangerous goods.
 - (b) May be easier to avoid collision more than trying to avoid BLEVE after this collision.
 - (c) Typical lifespan of semitrailers 20-30 years; lifespan of tractor units 6-10 years.
 - (d) Autonomous braking system mandatory, according to preliminary information from WP.29, for new trucks of more than 8 t and buses since January 2017 (UN Regulation n°131). First step: collision avoidance against a mobile element and collision mitigation for static obstacles. Second step: full collision avoidance, even for static obstacles. Retrofitting implies software and the installation of sensors.

<https://www.unece.org/fileadmin/DAM/trans/main/wp29/wp29regs/2013/R131e.pdf>
 - (e) It may be interesting to study if the use of autonomous braking system may be made mandatory, starting with transport of some UN numbers. The Problem is that this system cannot be retrofitted, only installed into new vehicles. Other systems, that warn of a possible collision, but do not act to avoid it, may be retrofitted into existing vehicles.
 - (f) Common issues with the working groups on telematics and on accident report are mentioned.

Presentation on accident in filling station in December 2018

22. Italy made a presentation on the occurrence of this accident based on the photos included in annex 3(see INF.8/Add.3).
23. The following basic data on accident was mentioned:
- (a) Delivery of 10.000 l LPG to filling station on road SS4.
 - (b) Start of fire at approx. end of delivery.
 - (c) Start of fire in pipeline connecting tank vehicle to fixed tank or in connection pipe-truck. Fire started at end of the truck and took 25 minutes to engulf whole truck.
 - (d) Escaping vapours from the manhole ignited; explosion; tank was pushed forward and collided with another vehicle; tank detached, with open manhole; acted as a rocket and moved forward 100 m.
 - (e) No emergency call for 10-12 minutes after start of fire, emergency services arrived 20 minutes after start of fire.
 - (f) Driver seems to have been absent during some time.
 - (g) 2 fatalities.
24. The following analysis after the accident was made:
- (a) Part of relevant data not available.
 - (b) Many questions open: Why did the valve not cut the flow? Why was the manual valve not operated? Inspections on tank equipment correctly done?
25. The following points were discussed in the group:
- (a) Obligation to maintain the line of sight have been ignored (existing Italian decree on this subject).
 - (b) Requirements included already in ADR should have avoided the accident. EN standard already covers this, no improvement seems necessary.
 - (c) Two EN standards can be applied:
 - (i) EN 12252 "LPG equipment and accessories - Equipping of LPG road tankers" for road tankers equipment specific for LPG, introduced in 2005, includes all of these requirements. This standard only applies when EN 12493 has been used for the construction of the tank.
 - (ii) EN 14025 for gases is more general, can also be applied, may not include all LPG-relevant details.
 - (d) Difficulties in some countries to obtain the information needed for a good accident analysis.

Presentation on FEM results

26. INERIS presented the new results obtained by the application of the FEM calculation model that has been developed, which is included as annex 4. (see INF.8/Add.4).
27. Since the last meeting of the working group, further calculations have been done, for cases in which no complete fire engulfment takes place. A fluid dynamics model has been

included to simulate the turbulent flow of the air in the exterior of the tank, which now includes both radiation and convection.

28. The characteristics of the vehicle and tank considered are:

- (a) Semitrailer of 31 m³.
- (b) Steel tank with PRV (2'' diameter, and pressure of 16,5 bar).
- (c) No specific isolation nor around tyres nor in other parts of vehicle.
- (d) 50% filling rate.

29. Different cases have been calculated, and the following analysis has been presented to the group:

- (a) Fire start on one tyre, without propagation:
 - (i) No risk of BLEVE for this filling ratio.
 - (ii) The phenomenon of tyre explosion is not correctly modelled here: the explosion or contributes to propagation or extinguishes the flames.
- (b) Fire start on one tyre, with propagation to the rest of the tyres
 - (i) More realistic than case without propagation; with plastic mudguards propagation takes place immediately.
 - (ii) Still far from BLEVE (for this filling ratio) with a big difference in between yield stress and applied stress.
- (c) Fire start on spilled fuel tank content, with propagation to tyres and cabin:
 - (i) Fuel is gasoline as it has a higher energy than diesel.
 - (ii) Surface and form of spillage influences results: more or less time of flames, more or less direct impact of flames.
 - (iii) RISK of BLEVE after 15 minutes, because of contribution of cabin; fuel and tyres only would not BLEVE (but with low safety margin).
 - (iv) Cabin fire impacts on the gas phase of the tank, big impact.
- (d) Fire start on cabin with no propagation:
 - (i) Risk of BLEVE after 18 minutes.
 - (ii) Modelling of cabin has been combustible material heating up to 20 MW; this number has been taken out of studies of fires for the Montblanc tunnel
 - (iii) As the heating is very local, the pressure in the tank does not increase significantly, the PRV does not begin to open.
 - (iv) May be interesting to look on engine fire extinguishing systems and isolation measures of tank from cabins.

30. After the presentation, a general discussion took place. The following points were mentioned:

- (a) Interest in introducing specific protection and isolation measures for tyres, fuel tank and engine.
- (b) Importance of avoiding propagation to/from cabin, perhaps through thermal screen in between cabin and tank or through fire resistant material in the cabin.

- (c) Present regulation on material for cabin: material “not readily flammable”, which means that it takes some time to ignite, but afterwards burns nevertheless. It was noted that UN Regulation No. 118 sets out the uniform technical prescriptions concerning the burning behaviour and/or the capability to repel fuel or lubricant of materials used in the construction of certain categories of motor vehicles. OICA could be consulted for further details on this subject and perhaps more stringent criteria (not flammable?) could be demanded for the cabin materials of new vehicles that will be used to carry certain dangerous goods.
 - (d) Future modelling work needs to be completed, including: pool fire, PRV in liquid phase, and variations of the already existing calculations (other geometries, filling ratios, etc). France highlighted calculations would advance faster if additional funding could be provided by other entities.
 - (e) Modelling for RID: the calculations done by INERIS on the last scenarios are not relevant for rail. PRV operation may interfere with catenary cables. According to a French study for marshalling yards, there BLEVE would be the least probable of all accidents/incidents. Some measures may not be relevant for rail. ERA asked for a balance in between risks and costs.
 - (f) Difficulties to obtain some data are mentioned; the work of the Working Group on accident reporting should be encouraged in order to be able to obtain further data in future.
31. Other sources of relevant information related to this analysis were discussed by the group:
- (a) Liquid Gas Europe would send general characteristics of typical LPG vehicles: axles, sizes, steel thickness, sizes of fuel tanks, general filling ratios (big vehicles normally full/empty, smaller ones for distribution may have different filling ratios) to INERIS in order to take into account a realistic vehicle.
 - (b) The United Kingdom is conducting a test programme to assess the reliability of PRVs. It is anticipated that, once completed, this evaluation will contribute to the evidence base that will allow UK inspection bodies to justify a check of the documentation or the marking of pressure relief valve set pressures rather than physically testing such valves at intermediate inspections. Preliminary findings are reproduced in INF.5, but a more detailed analysis of results will be carried out once more data has been obtained and this will be shared when it becomes available. The evidence base could be improved further with data from other countries and other delegates were asked if they might consider collecting such data.
 - (c) It was noted that Sweden and Portugal may have relevant information on the testing of PRVs.
 - (d) Under a mandate from WP.15 a Working Group is looking to develop the fire protection requirements for EX vehicles. It was thought there may be benefits in collaborating with this group, particularly in relation to the development of requirements for protective shields and the isolation of tyres.
 - (e) Norway is going to do some testing modelling tyre fires for protection of MEMUs; it may be available in spring.
 - (f) It was thought that OICA may be able to provide relevant information on the fire-retardant properties of materials used for the construction of cabins.

Preventive measures in parking areas

32. France presented the preventive measures in parking areas concerning dangerous goods vehicles in France (see annexes 5 and 6 in INF.8/Add.5 and Add.6).

33. Different limitations are introduced in case the vehicle parks more than 2 hours or more than 12 hours.

34. Several accidents have taken place in France in the last years in this kind of parkings, originating BLEVEs/gas cylinder explosions, which seem to be initially caused by robberies in these premises.

35. Before a BLEVE appears, time for detection and for extinction has to be considered. The approximate time of a potential BLEVE can now be calculated accurately by the INERIS model.

36. Surveillance in parking areas is problematic in some cases because security companies do not want to work on these parking places for dangerous goods, as existing automatic detection systems do not work well and cause many false alarms.

37. Work is being done on introducing more efficient systems than thermic cameras, triggering automatic fire fighting systems. IR/UR sensors, thermographic cameras etc are being analyzed, but the installation costs are high (many sensors necessary for early detection of smaller events) and civil works on the site are necessary.

38. On board technology may be interesting: thermal sensors on the tank near to combustible elements, connected to on board processing unit and connected to driver/parking lot owner. Similar technology as the one needed for on board detection is in use for perishable foodstuff and for temperature measurement in explosive transport vehicles.

39. Extinguishing can also be done by on site measures (for example by foam cannons), but similar problems than with detection on site. If extinguishing with on board equipment is implemented, it may be necessary to allow some extra weight to be carried on the trucks.

40. In the discussion it appeared that configuration, size, ownership and operation of parking lots are very different in the different countries represented. In UK vehicles are mainly parked in SEVESO facilities.

41. Spain mentioned that it had a system of recommended parking lots for dangerous good transport, where the parking inter alia had to have surveillance, segregation from non-dangerous goods and be at least 100 m away of a residence or a filling station.

https://www.fomento.gob.es/recursos_mfom/estudiozonasparadahabitual1.pdf

https://www.fomento.gob.es/recursos_mfom/organocolegiado/documentos/folleto_estacionamiento.pdf

42. The group considered that, if France investigated further into on board detection and extinguishing systems for protection of parking lots this could be very interesting for the work of the group itself.

Date of next meeting

43. The date of the next meeting will be fixed after the availability of different additional information is known. The date will be discussed at the Joint Meeting in March 2019.

Annexes

44. The following material has been included as Annexes to this report:
- Annex 1 (INF.8/Add.1): The boiling liquid expanding vapour explosion (BLEVE): Mechanism, consequence assessment, management (Abbasi & Abbasi, 2006)
 - Annex 2 (INF.8/Add.2): Graphic material of the accident in Bologna (Italy)
 - Annex 3 (INF.8/Add.3) Graphic material of the accident in the filling station (Italy)
 - Annex 4 (INF.8/Add.4): Presentation of FEM calculations (INERIS, France)
 - Annex 5 (INF.8/Add.5): Preventive measures in parking areas (France)
 - Annex 6 (INF.8/Add.6): Future developments on preventive measures in parking areas (INERIS, France)
45. For the preliminary results of a PRV reliability test programme (UK) refer to informal document INF.5.

Appendix

List of participants

Informal Working Group on the reduction of the risk of a BLEVE during transport of dangerous goods

Madrid, 15-17 January 2019

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INF.8

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