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Classification of vapour spaces for storage of flammable substances

Within the vapour space of a chemical tank, there is a possibility of a flammable substance to be present within its explosive limits. This necessitates the consideration of the vapour space within the tank for hazardous area classification. The incorrect classification of a vapour space of a tank can result in explosions that can be fatal.

For an explosion to occur there must be three components present which are oxygen, ignition source and a flammable substance within its explosive limits. The LEL (lower explosive limit) is the minimum concentration of a substance, when mixed with air that will cause a flammable mixture. Below this concentration, the mixture will be too lean to ignite. The UEL (upper explosive limit) is the maximum concentration of a substance, when mixed with air that will cause a flammable mixture. Above this concentration, the mixture will be too rich to ignite.

Various codes that are used for area classification indicate that the vapour space of rail, road and storage tanks are to be classified. The classifications are done according to direct example which can give rise to Zone 0, Zone 1 or Zone 2 in the vapour space.

With all the variables the above classifications are very generalised, and it can be further refined by considering if the criteria for explosions are met. This would result in the mitigation of the classification of the inside and/or the outside of a storage or transport vessel.

Table 1 represents the classification of a vessel. The table is broken down into 14 regions that define the requirement for classification on the vapour space and outside of a tank.

T_{LEL} is the temperature at which the concentration of flammable vapour is equal to the temperature required to reach the lower explosive limit (LEL).

T_{UEL} is the temperature at which the concentration of flammable vapour is equal to the temperature required for the upper explosive limit (UEL) for that product.

Table 1 takes the substance that is present in the tank into consideration which allows for a more accurate classification. If the LEL of the substance will not be met, then the vapour space of the tank will not require classification.

The graph shown in Figure 1 demonstrates the breakdown of the three columns by using the ratios of partial pressures to atmospheric pressure. The oxygen availability is also considered,

About the author

Miriam Gani is a Senior Explosion Prevention Technician at Sasol's Hazardous Location Centre (HLC). After obtaining her degree in chemical engineering from the University of the Witwatersrand, she got an opportunity to enter the hazardous area classification field. Going as far back as 2008, Miriam has been focusing on cultivating her career by being part of a team that refines hazardous area classification methodologies. In 2021, she joined Sasol where she services various Sasol plants across regions.

if there is no oxygen within the tank and ingress is not possible then the vapour space will not require classification.

From the table, the vapour space of a tank will be classified only when it is stores a substance between T_{LEL} and T_{UEL} and there is a potential for oxygen to be present within the vapour space of the tank. The generalised approach being used in industry currently does not take these factors into account.

Consideration of these factors will allow for a less conservative approach into classification of vapour spaces. This has the potential of cost saving in terms of instrumentation and equipment without compromising on safety.

The classification methodologies used are constantly being refined to ensure that the most accurate and applicable classification can be determined for a given process. ■

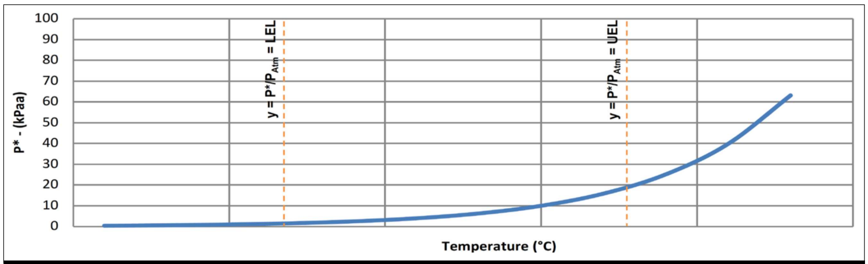

Figure 1

(green)	Do not require classification, flammable mixture not possible.
(pink)	Require classification, flammable mixture possible.
(yellow)	Do not require classification, flammable mixture not possible. Mists or aerosols require special consideration.

		$T < T_{LEL}$	$T_{LEL} < T < T_{UEL}$	$T > T_{UEL}$
Inside Vessel	Pvessel > Patm	**Inside of Vessel do not require classification** 1) Vessel pressure under normal operating conditions is above atmospheric pressure and therefore any release will always be to atmosphere, air cannot enter vessel. 2) Even if oxygen was available flammable mixture cannot form since T < TLEL 1	**Inside of Vessel do not require classification, no oxygen from upstream process is possible.** 1) Vessel pressure is above atmospheric pressure, any release will always be to atmosphere, air cannot enter vessel. **Note:** Liquid comes from equipment where it was at boiling point or under Nitrogen blanket. 2 **Inside of Vessel require classification, oxygen can enter vessel from upstream process.** 1) Although vessel pressure is above atmospheric pressure and air cannot enter vessel, dissolved oxygen can be boiled off or there is an air supply to vessel. 3	**Inside of Vessel do not require classification.** 1) Vessel pressure is above atmospheric pressure, any release will always be to atmosphere, air cannot enter vessel. 2) Even if air could enter vessel, the mixture will be too rich (above UEL) to form flammable mixture. 4
Inside Vessel	Pvessel < Patm	Inside of Vessel do not require classification. 1) If air enters vessel, the mixture will be too lean (below LEL) to form flammable mixture. 5	**Inside of Vessel require classification, oxygen can enter vessel from atmosphere.** 1) Vessel pressure is below atmospheric pressure and air will enter vessel if there is a leak. 2) If oxygen enters vessel a flammable mixture will form, TLEL < T < TUEL. 6	**Inside of Vessel do not require classification.** 1) If air enters vessel, the mixture will be too rich (above UEL) to form flammable mixture. 7
Outside Vessel	Pvessel > Patm	**Outside of vessel don not require classification.** 1) If there is a release a flammable mixture cannot form, T < TLEL. **Note:** Pvessel >> Patm - Mists or Aerosols could form if there is a release. 8 **Outside of Vessel do not require classification.** 1) If there is a release the mixture will be too lean (below LEL) to form flammable mixture. 9	**Outside of Vessel require classification, any release will form a flammable mixture.** 1) Vessel pressure is above atmospheric pressure and will release to atmosphere if there is a leak. 2) A release will form a flammable mixture since, TLEL < T < TUEL. 10	**Outside of Vessel require classification, any release will form a flammable mixture.** 1) Vessel pressure is above atmospheric pressure and will release to atmosphere if there is a leak. 2) A release will form a flammable mixture since, although T > TUEL, the released mixture will dilute with increasing radius to eventually drop below UEL. 11
Outside Vessel	Pvessel < Patm	**Outside of Vessel do not require classification.** 1) If there is a leak, air will leak into vessel and product will not be released to atmosphere. 2) Even if there is a release the mixture will be too lean (below LEL) to form flammable mixture. 12	**Outside of Vessel do not require classification.** 1) If there is a leak, air will leak into vessel and product will not be released to atmosphere. 13	**Outside of Vessel do not require classification.** 1) If there is a leak, air will leak into vessel and product will not be released to atmosphere. 14

Table 1 – Hazardous area classification of a vessel