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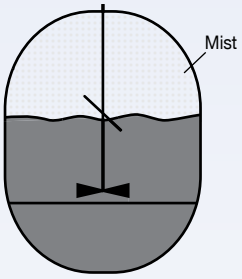
How Could This Happen? The Temperature was Below the Flashpoint!

An oxidation reaction in an atmosphere of pure oxygen at 250 psig (1,825 kPa) was being carried out in a 10-gal (~38-L) agitated vessel at a pilot plant in 1986. It was thought that the vessel atmosphere was safe from ignition because the vessel was operating at 50°C below the flashpoint of the contents in the oxygen atmosphere, and the fuel vapor concentration was below the lower explosive limit (LEL). Processing conditions were stable for 41 min, when suddenly an explosion occurred. The blast ruptured the 750-psig (~5,200-kPa) reactor, significantly damaging the facility (Figure 1) and starting several small fires. Fortunately, no one was injured.

▲ **Figure 1.** The explosion damaged the pilot plant facility, but luckily did not injure anyone.

Because the vessel was operating below the flashpoint of the contents, the concentration of fuel vapor in the vessel atmosphere was too low for ignition, so there should not have been an explosion hazard. However, the investigation determined that the vessel agitator created a fine mist of liquid droplets with an average size of about 1 µm (Figure 2).

Flammability tests demonstrated that the mist could be ignited at room temperature in air, and that the mist could be ignited more easily in a pure oxygen atmosphere. The vessel contained both fuel and oxygen, but what was the ignition source? It is often difficult to identify an ignition source of an explosion, but the investigation concluded that the most likely source was a contaminant that was left over from a previous experiment in the vessel. It was thought that the contaminant decomposed and generated enough heat to ignite the fine mist.



▶ **Figure 2.** An agitator in the tank created a fine mist of combustible liquid droplets.

Reference: Kohlbrand, H. T., "Case History of a Deflagration Involving An Organic Solvent/Oxygen System Below Its Flash Point," *Plant/Operations Progress,* **10** (1), pp. 52–54 (1991).

Did you know?

• A mist of combustible liquid droplets at temperatures below the flashpoint of the liquid can be just as explosive as a mixture of fuel vapor and air. The explosion mechanism is similar to that of a dust explosion, but instead of solid particles, the fuel is present as small drops of liquid.

• Vigorous stirring by an agitator blade near the liquid surface generated the mist present in this incident. Mists can also be created by a liquid leak from a pressurized pipe, vessel, or other equipment.

• A leak from a utility or maintenance system can create an ignitable mist. For example, incidents have occurred where mist ignited from a leak of lubricating, heat-transfer, or fuel oil.

What can you do?

• Be aware of the potential for fire or explosion of a mist of flammable or combustible liquid when responding to a leak or spill. If a mist is present, do not assume there is no hazard because the temperature is below the flashpoint. Take the same precautions that you would take to prevent ignition and protect personnel if the leak had created a flammable vapor cloud.

• If you discover a mist or fog inside any process equipment, inform management so that proper protective measures are put in place.

• Promptly report leaks of flammable or combustible materials, including utility fluids.

Combustible liquid mists can burn or explode!