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Messages for Manufacturing Personnel

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Accumulation of small changes leads to an explosion

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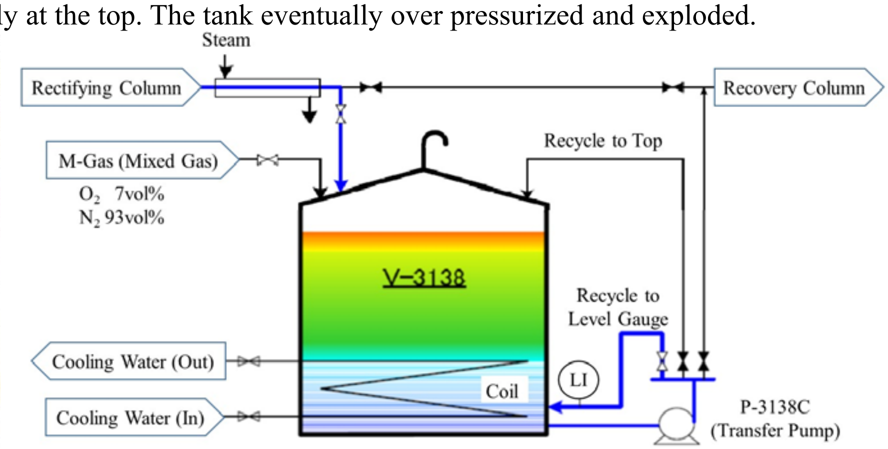
In September 2012, at an industrial site in Himeji, Japan, a 70 cu m (18,500 US gal) fixed roof acrylic acid (AA) tank exploded, and a fire followed. There was one fatality, a fire-fighter. 36 people were injured – 2 policemen, 24 fire-fighters, and 10 plant workers. The tank was destroyed and nearby facilities were significantly damaged (Photo 1). There were no major impacts to the neighborhood and environment.

The tank provided intermediate storage between two distillation columns for purifying AA. Originally the tank had been used at full capacity. The contents were cooled and mixed by pumping from the bottom of the tank to the top. Later, the normal operating level was reduced to a level below the cooling coil. The contents were no longer recirculated to the top of the tank, but instead to a nozzle near the bottom that was also used to connect a level gauge (Drawing 2).

At the time of explosion, the plant was conducting a test of the downstream distillation column, which required stopping feed from this tank. The level of the tank gradually increased to its original operating level. Without recycle to the top of the tank, the AA above the cooling coils was not mixed and cooled. The temperature of the incoming AA was believed to be below the onset temperature for polymerization, and the AA contained polymerization inhibitor. However, the temperature in the tank increased, especially at the top. The tank eventually over pressurized and exploded.

Courtesy of Nippon Shokubai

Photo 1: Destroyed AA Tank



Drawing 2: Only the bottom of the tank was cooled, the liquid above became hot

Reference: Nippon Shokubai Co., Ltd. Himeji Plant Explosion and Fire at Acrylic Acid Production Facility Investigation Report March 2013.

What happened?

- Originally the pipe feeding the tank was hot water jacketed to provide freeze protection, but this was changed to steam.
- Removal of a steam trap made temperature control unreliable.
- The top layer was no longer mixed with cooler AA, and stayed warm from incoming AA.
- There are two exothermic AA self-reactions – dimerization and polymerization. Polymerization inhibitor does not stop the dimerization reaction. Experiments showed that heat from dimerization raised the temperature sufficiently to start a runaway polymerization reaction.
- The hazard of heat from dimerization was not recognized, so recirculation to the top of tank was not resumed.
- The tank had no temperature indicator. The first indication of a problem was observation of AA vapors escaping from the top vent on the tank.

What can you do?

- Never make any changes to your plant, even changes you think are small, without following your plant Management of Change (MOC) procedures.
- When you see any change in your plant, ask if there has been an MOC review. If there has been, and you were not informed of the change, tell your supervisor. You should always be informed of changes in your plant that impact your job.
- If something is different from normal operation, confirm operating procedures or ask your supervisor what to do.
- Accumulation of small changes can cause an incident with a big consequence. All small changes must be identified and the risk to the total system analyzed and adequately managed.

Small changes can cause a big consequence!

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Questions:

Students may find helpful the full incident report.

1. **(10 min)** Discuss at least three measures which should have been taken after the previous hose leakage. Consider List and describe at least three errors which led to the incident. Reference mistakes made by the operators and ways in which the machinery was inadequate.

2. **(10 min)** *What did you learn?*
   What lessons have you learned from this article? What procedures should have been in place to prevent this from occurring? What design or controls changes would you implement to this acrylic acid process unit? Your response should comprise 6-8 sentences.