

## Questions

1. In one slide it is mentioned as inhibitor can lessens chances of polymerization but can't eliminate completely, in what type of conditions inhibitor can't eliminate polymerization?

Answer: Inhibitors can lessen unwarranted polymerization. Styrene and other auto polymerization compounds react at ambient condition in the absence of catalyst. T Butyl Catechol is a typical inhibitor used for styrene and its effectiveness is a function of dissolved oxygen, temperature, and inhibitor concentration.

2. Suppose, let's say if the recirculation line was not modified (by Vizag) and remains in the top, auto-polymerization started in the top-layer of liquid styrene would have been detected by TBC check concentration low though drawn from bottom?

Best practice recommends a suction float system along with an educator in the return line to promote mixing in the tank. This can aid in the mixing of inhibitor and maintain a uniform bulk temperature in the tank. Thermal stratification is less likely for a properly designed tank. On 28<sup>th</sup> April 2020, 7 days before the incident, a high polymer content (10 times normal value) was observed. This was noted as a quality problem, not as a precursor for runaway reaction.

3. What is reason for delta T of around 20 deg C between top and bottom in M5? what is the circulation philosophy for M5? is the recirculation frequency is same as M6 or recirculation/cooling is permanent?

Best practice recommends a suction float system along with an educator in the return line to promote mixing in the tank. This can aid in the mixing of inhibitor and maintain a uniform bulk temperature in the tank. Thermal stratification is less likely for a properly designed tank. Continuous cooling is recommended for styrene storage tanks located in India.

4. What is TBC?

T Butyl Catechol. One of the recommended inhibitors to lessen unwarranted polymerization.

5. How to monitor dissolved oxygen in monomer?

Dissolved oxygen in the tank can be monitored by sampling.

6. do you think TBC periodical monitoring and subsequent action (if concentration low) is 'absolutely necessary' even-though the site has reliable temperature management + adequate cooling capacity? if so, why?

TBC Monitoring and sampling is considered as a best practice to improve the reliability of the system. Kindly refer to session handouts for more information, specifically Section 4.1.4 of the LyondellBasell storage guide. The refrigeration system was not utilized throughout the day and the reliability strategy for the storage tank could not resolve the plugging issues that resulted in removing of the suction float system.

7. How moisture can effect monomer?

Published literature do not show correlation between moisture content and bulk storage of styrene

8. Why daily sampling required?

TBC Monitoring and sampling is considered as a best practice to improve the reliability of the system. Kindly refer to session handouts for more information, specifically Section 4.1.4 of the LyondellBasell storage guide.

9. What is standard method of analysis for polymer content & TBC concentration?

Kindly refer to the handout provided during the session, specifically refer to Appendix 2 of the LyondellBasell Storage Handling guide. ASTM D2121 Standard test methods for polymer content of styrene monomer.

10. On Lab measurements: What is the Analytical method used to measure Polymer content? Is it rapid enough to rely on it for Real Time decisions?

Kindly refer to ASTM D2121 Standard test methods for polymer content of styrene monomer.

11. PSM is not mandatory in India as in USA. Why can this be brought in by regulation? Under which rule / act HAZOP is mandatory with reference of Notification Sir in INDIA?

A PSM framework is not mandated in India. Preliminary Hazard Analysis is part of Schedule 8 of MSIHC rules under the Environment Protection Act (and) Schedule 8 of MAH rules under the Factories Act

12. There was 12 minutes gap between start of leak and Alarm sensing the leak. What is the remedy advised on it? and what must be ideal setting of alarm?

Fire and gas mapping can provide insight. Commercially available software can perform this task.

13. What will the scenario if explosion occurs instead of release of vapours? Meaning what consequence expected in explosion scenario?

The High Power Committee recognized the tank explosion scenario as the worst case, however, a consequence model and impact study were not conducted.

14. Have insurance claims be settled? Not conducting HAZOP and with so many discrepancies will bring in willful negligence and insurance companies may not consider the claim viable

No comment

15. How they controlled the styrene gas leakage?

Refer to Section 3 of the summary of the High Power Committee report attached to the session handouts.

16. Role of TBC, Reason for not adding from last 10 years.

Weak understanding of Process Safety Information and little to no Process Safety training to staff.

17. Can we consider this incident not adopting highly technical devices for safety??

One of the major causes of the accident was removal of tank internals that promote mixing. Industry best practices recommend appropriate tank internals to promote and aid mixing. Compliance to standard (industry standard) and best practices is termed as Recognized and Generally Accepted Good Engineering Practice, a.k.a RAGAGEP. It is a legal term in the United States and OSHA has published a memo on interpretation of RAGAGEP. Kindly refer to the following section:

<https://www.osha.gov/laws-regs/standardinterpretations/2016-05-11-0>

Adopting globally recognized PSM Framework and standards is necessary to prevent catastrophic incidents.

18. Can we use any cooling systems to prevent polymerization?

A well-designed system that promotes mixing and maintains the bulk average temperature must be validated.

19. LG is a big company globally. Why such lapse. Is the lapse only in Indian plant or LG Globally has such casual approach?

No comment

20. Is this scenario being worst credible or more worst credible scenario needs to be considered during risk studies?

A Process Hazard Analysis is forward-looking and we typically estimate the worst-case scenario without safeguards.

21. Can Periodic PSSR as part of required tackle to eliminate such kind critical polymer?

A comprehensive PSM framework is necessary to prevent catastrophic incidents. A significant increase in polymer content should trigger operator response to take preventive and/or mitigative actions

22. Proper vent or flare requirement is not specified by the applicable standards?

Styrene storage tanks must be designed, maintained, and operated to ensure no Styrene vapor release occur at the top of the tank.

23. IS PSM is mandatory? Under which rule?

PSM framework is not mandatory in India

24. What action need to take if you see styrene vapour leak?

Refer to session handout, Styrene Chemical Response Guide drafted by CEDRE

25. Why runaway started after resuming from lock down not during lock down

Styrene can auto-polymerize and can run away without effective inhibitor control. The tank design and ineffective operation of the refrigeration system resulted in a runaway reaction.