The Importance of Process Safety: A Young Engineer's Perspective

Waheed Wakil and Travis Bruner

1. Introduction

Many young engineers have a point early in his or her career when process safety hits home . Different companies develop their own unique strategies towards safety that they are comfortable with, which results in considerably different safety cultures within industry. Unfortunately, it is all too common for engineers to treat process safety as an afterthought, with priority given to efficiency and profitability. However, as we will see, treating safety with the utmost importance can prevent costly and life-threatening incidents.

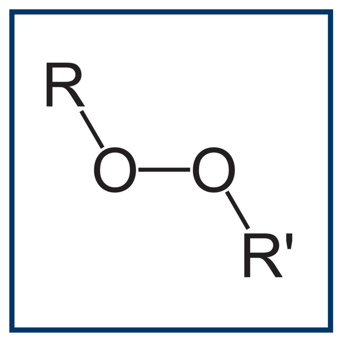
2. First Hand Experiences

Organic Peroxides Plant Background

Two major upsets occurred in one year at a plant that produces organic peroxides. A fellow Process Safety Consultant at Smith & Burgess who was a process engineer at the time was fortunate enough to live through both accidents unscathed. His story is a lesson and reminder that even the most disastrous accidents can be prevented with due diligence, a safety-focused company culture, and proper attention to basic Process Safety Management.

Based on the nature of the chemicals produced, a Process Hazard Analysis for this particular plant would have revealed scenarios with severe consequences.

- Organic peroxides are highly unstable – their O-O bond breaks very easily, and that is why their decomposition properties are so useful in initiating polymerization reactions.
- The rate at which its exothermic decomposition generates heat is likely to be greater than the rate at which the heat can be dissipated to its surrounding environment.

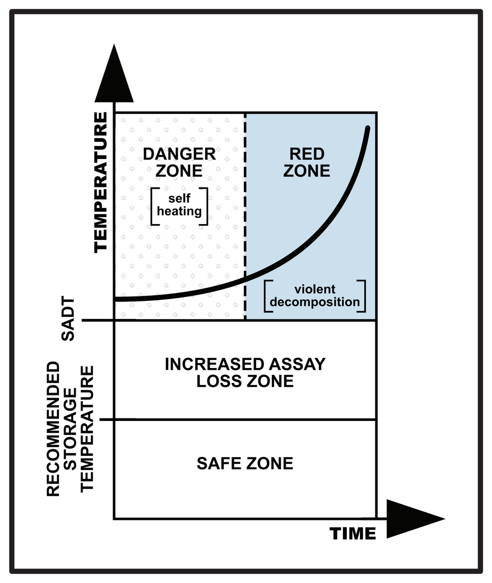


- If proper heat transfer equipment are disabled, organic peroxides can undergo self-accelerating decomposition in which the reaction continues to accelerate due to its own generated heat.

3.1 Organic Peroxides Incident #1:

What Went Wrong?

- An operator was transferring organic peroxides to 55 gallon drums, which are immediately transported by forklift to an icehouse for storage. An incident occurred which caused the operator to abandon the task in the packaging building to provide assistance elsewhere
- While the operator was away, the product remained stagnant in the filter where glycol cooling was inefficient. This caused the material to exceed its Self-Accelerating Decomposition Temperature (SADT). The material began to decompose as temperature continued to increase.



- When the operator returned, the material reacted violently, propelling the head of the drum through the air. The remains of the drum were embedded in the ground. The operator was behind a blast shield, but still suffered severely burnt hands and damage around the ear.

3.2 Organic Peroxides Incident #1:

How Could It Have Been Prevented?

- OSHA 29 CFR 1910.119(f)(1),
  "The employer shall develop and implement written operating procedures that provide clear instructions for safely conducting activities involved in each covered process consistent with the process safety information..."
- OSHA 29 CFR 1910.119(n),
  "The employer shall establish and implement an emergency action plan for the entire plant in accordance with the provisions of 29 CFR 1910.38. In addition, the emergency action plan shall include procedures for handling small releases."

4.1 Organic Peroxides Incident #2:

What Went Wrong?

- The site was hit by a thunderstorm with wind speeds high enough to break a tree branch that would damage a power line, resulting in total loss of electricity to the plant. Electric power was vital to this plant as it kept peroxide flowing through the reactors and piping and it kept glycol flowing through the jacketing to keep the peroxide temperatures down to safe levels. The plant had a backup generator, but only a single operator was aware of the location of its switch. It just so happened that it was this operator's day off.
- Interlocks were in place to purge out residing organic peroxides in the equipment using control valves with actuators regulated by instrument air. Once glycol and peroxide flow was lost in the event of a power failure, the peroxides would rapidly exceed their SADT. The purging action would dump the peroxides into waste water drains that are gravity fed to open tanks, where it is much safer for the peroxides to reach their SADT.
- The instrument air that controlled the valves was supplied from air storage, and during the purging, the instrument air ran out. Nitrogen was used as backup for air during emergency situations, but due to poor inspection and maintenance for cost savings, there was damage to the backup nitrogen header that had gone unnoticed.
- This damage caused a leak in the header when it was exposed to the nitrogen pressure, rendering the header useless as there was not enough pressure to actuate the purge control valves properly. Purging was halted. With stagnant peroxides in piping and equipment, and no jacket cooling, fluid temperatures rapidly sored past the SADTs and eventually resulted in a deflagration. The reactor top heads failed first, and the building in which the reactors were located was designed to fail at the ceiling and the outer wall. The building and its contents were destroyed, and the plant suffered 6 months of downtime.

4.2 Organic Peroxides Incident #2:

How Could It Have Been Prevented?

The number of Independent Protection Layers (IPLs) that were in place at the time of failure, namely the operator's response to activate the backup generator and interlocks that functioned to purge out residing peroxides, were not adequate to prevent a deflagration. Table 1 summarizes the highest possible credits that could be taken for each IPL based on CCPS's LOPA book [1].

Initiating Event	Initiating Event Frequently	Number of IPL Credits Required for Category IV Consequence	Maximum Number of IPL Credits Available
Loss of Cooling	Frequency 1x10	2.0	Operator Response for Backup Generator 0.5
			SIL 1 SIF 1.0
			Total 1.5

The first broken link in the series of events leading up to the accident was the lack of training amongst operators with respect to activating the backup generator in the event of loss of power.

- OSHA 29 CFR 1910.119(n),
  "The employer shall establish and implement an emergency action plan for the entire plant in accordance with the provisions of 29 CFR 1910.38. In addition, the emergency action plan shall include procedures for handling small releases."

This should have been a basic emergency response action that every operator at the plant should have been trained on and been aware of, but unfortunately, no one at the plant at the time of the failure was trained on how to activate the generator. The failures cascaded into the second phase of emergency response when the instrument air was exhausted at exactly the wrong time.

To reduce costs, plant management had increased the length of inspection and maintenance cycles of the backup nitrogen header.

- OSHA 29 CFR 1910.119(j)(2),
  "The employer shall establish and implement written procedures to maintain the on-going integrity of process equipment."

5. Conclusion

A poor safety culture is likely to result in poor preventative inspection and maintenance cycles and lack of clear emergency operating procedures and training. Inadequacies in PSM elements can result in disastrous consequences. For a young engineer, it sometimes takes a real-life experience to change their perspective on PSM from one of passive compliance to one of active responsibility. Each element of PSM is important and critical, from the most obvious and simple to the most expensive and extensive. It makes every detail in every process safety analysis that much more important and that much more rewarding when the benefits are apparent.

6. References

[1] CCPS. Layer of Protection Analysis: Simplified Process Risk Assessment. Center for Chemical Process Safety, American Institute of Chemical Engineers, New York, NY, 2001.

Smith & Burgess
Process Safety Consulting
SmithBurgess.com