WORKSHOP: HYDROGENATION PROCESS

WHAT HAPPENED?

Process B was established under a test authorization—75 batches were successfully produced. Process A was resumed because of a shortage of dechlorination inhibitor B. Additional dechlorination inhibitor B was received and the process switched to B.

An incident occurred because the process was incorrectly switched from A (previous batch) to B (this charge). The autoclave was charged with B ingredients and the process was run erroneously, using A instructions. Reaction temperatures were 10°C lower than specified for process B. When the error was realized, the temperature was increased by 10°C. An uncontrollable pressure increase occurred shortly after the correction was completed.

The autoclave overpressured because the relief system was inadequate, causing the head bolts to stretch. This pressure drove the autoclave through the floor. No serious injuries resulted, but the property damage was $1.7 million.

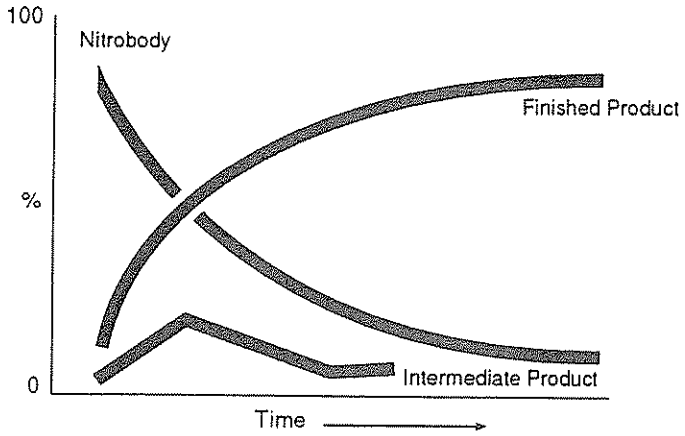
HYDROGENATION PROCESS CHEMISTRY POSSIBLE EXPLANATION

The PSI package was missing the answer to this question: "What happens if process B is run at a temperature lower than normal?" The PSI package should have included:

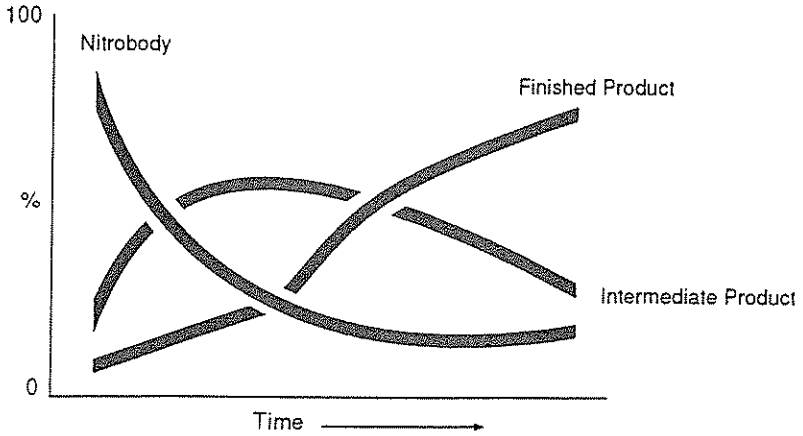
- Hazards of Materials
  - Raw material
  - Hydrogen
  - Dechlorination inhibitor B
- Equipment Design Basis: Autoclave
  - Agitation requirement
  - Heat transfer requirements
  - Relief system design
  - Materials of construction

- Technical Standards
  - Process chemistry
    - — Kinetic data on dechlorination reaction
    - — Kinetic data on intermediate and side reactions
    - — Heats of reaction
  - Limits of each parameter
    - — Temperature (maximum, minimum, and normal)
    - — Pressure (maximum, minimum, and normal)
  - Consequences of deviation above maximum and below minimum for ***each*** parameter

Process A at 100°C **Process B at 110°C**



Process B at 100°C



WORKSHOP: SEALLESS PUMP

WHAT HAPPENED?

Another PHA was performed. The person who questioned the need for a PHA raised a key question during the PHA meeting when he found out that the candidate pump was a diaphragm pump. "What happens if the diaphragm fails?" The answer is that the pump is air driven. Air would leak into the process, which contains isopropyl alcohol, above its flash point (12°C). Now the additional consequence of an explosion is possible, as well as a fire. The same team that did the first PHA might well be assigned to do the second one. It could probably be completed in one to two hours.

RECOMMENDATION

Change the motive force for the test from air to nitrogen to ensure that inert atmosphere will be maintained in the vessel in the event of a diaphragm failure. This action ensures the adequacy of the pressure relief system in scenarios including this failure.

WORKSHOP: NITROBODY DISTILLATION

WHAT HAPPENED?

The test distillation column was destroyed when an explosion occurred during the second campaign of nitrobody distillation.

WHAT WAS NOT CONSIDERED?

The management of change procedure had not been implemented and the individuals involved did not understand the potential for a safety problem when making a change. The differences between stills were not analyzed. The test still system allowed distillation to dryness. The test still supplied 400 psig (superheated) steam versus the existing still's 220 psig (saturated). A TA and a PHA (meeting this course's process safety management requirements) would have prevented the incident.

QUALITY ASSURANCE WORKSHOP

WHAT HAPPENED?

During manufacture of the alloy plate, sulfur content was too high, and the wall was too thin. After rolling the plate, the wall thickness was only 1.225 in. versus the 1.362 in. specified. During welding, there were problems with the "interpasses." The pipe was installed with the longitudinal seam facing the control building. Cracks developed, starting at the internal surface, within months of start-up. Without warning, a 20-foot gash opened in the seam facing the door to the office. The steam knocked the metal door down and filled the building. Of the 12 people in the building at the time, six died (several lingered for days) and another four received serious burns.

(This accident occurred at the Mojave Generating Station of Southern California Edison Co., at Lughlin, Nevada, on June 9, 1985. If all the steps in the recommended quality assurance program had been implemented and qualified inspectors used at all stages, this incident might have been prevented.)

The damaged piping and some similar piping at this location were replaced with seamless extruded pipe. The plant was down for six months.

PRESTART-UP SAFETY REVIEWS WORKSHOP

WHAT HAPPENED?

A prestart-up safety review was made that included the new lo-lo level interlock. Five years later, the pump tank detonated, destroying the sensitizer building. Fortunately, there were no fatalities, although the original studies predicted several fatalities should result from such an explosion.

WHAT WAS MISSED?

While a prestart-up inspection procedure was in place, the implementation of the procedure had not stressed the need to make a final check on the adequacy of all **critical** items.

During the prestart-up inspection, only the presence of the lo-lo level interlock was checked. Measurements were not taken to ensure that the nozzle detecting low level had been placed 3 inches above the pump casing, as specified in the design change. It was found to be at the same level as pump suction.

MECHANICAL INTEGRITY WORKSHOP

WHAT HAPPENED?

The procedure that was prepared stated that liquid level would be dropped until the interlock functioned, then the vaporizer would be restarted. This was a failure to follow the implementation guidelines. No explanation of the hazards of high tube temperatures was given in the procedure, nor had operators been trained in these hazards. As a result, during one of the six-month tests, the operator was called away from the vaporizer for another job just after he began lowering liquid level. When he returned about 20 minutes later, he recognized that the interlock had not functioned, and he proceeded to shut the vaporizer down manually. The interlock was repaired and the vaporizer was restarted. About one month later, one of the tubes that had been unknowingly overheated ruptured, causing 4,000 gallons of Dowtherm to be released into and outside the vaporizer, burning and destroying other equipment. Fortunately there were no injuries.

WHAT SHOULD HAVE BEEN DONE?

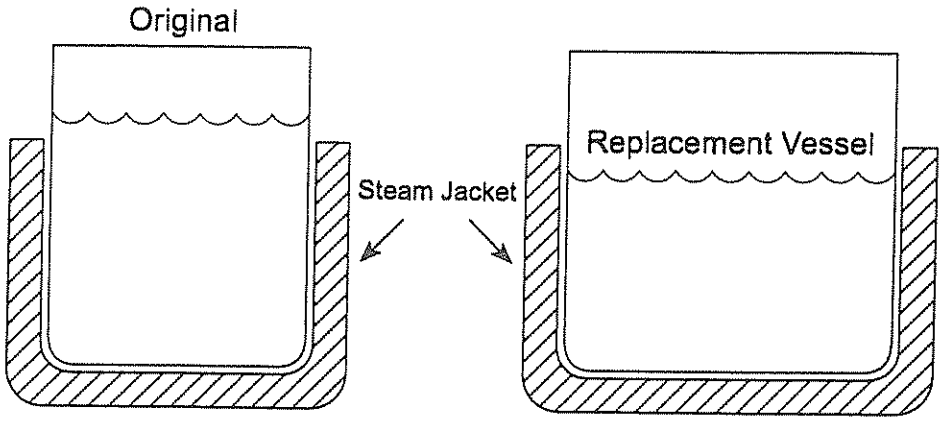
Detailed procedures and training should have covered the following points:

- ❑ Ensure that someone is present to watch the sight glass and other instrumentation during the interlock test at shutdown.
- ❑ In addition, check the interlock when the system is cold during start-up.
- ❑ Provide a low-level alarm at a point just above the interlock setting.
- ❑ Confirm that operators know **why** someone must be present during the low-level test.

WORKSHOP: REPLACEMENT-IN-KIND

WHAT HAPPENED?

The replacement vessel was a 1,000-gallon, glass-lined vessel, but it was not a replacement-in-kind.



The PSI package requires the liquid level to remain above the vessel's exposed heating surface. If this requirement is not met, the product may dry out and ignite if exposed to air.

RECOMMENDATIONS

A test authorization and PHA were in order in this situation. The test authorization and the PHA are the appropriate mechanisms to document that replacement is indeed identical.

A comparison of all the specifications for the two vessels would have shown that the two vessels did not have identical L/D dimensions and that nozzle orientation was different. It must also be ascertained that the two vessels are correctly defined in their respective documentation. Many differences come to the surface when supposedly identical replacements are compared, using the following question raised in a PHA: "What are the differences in the two equipment pieces?" **Note**: A PHA based on P&IDs only would not have revealed the above critical differences.

MANAGEMENT OF PERSONNEL CHANGE WORKSHOP

WHAT HAPPENED?

The seal leg was increased from 12 inches to 72 inches. Two hours later, an explosion and fire occurred in the covered waste stream between the scrubber and the wastewater treatment facility.

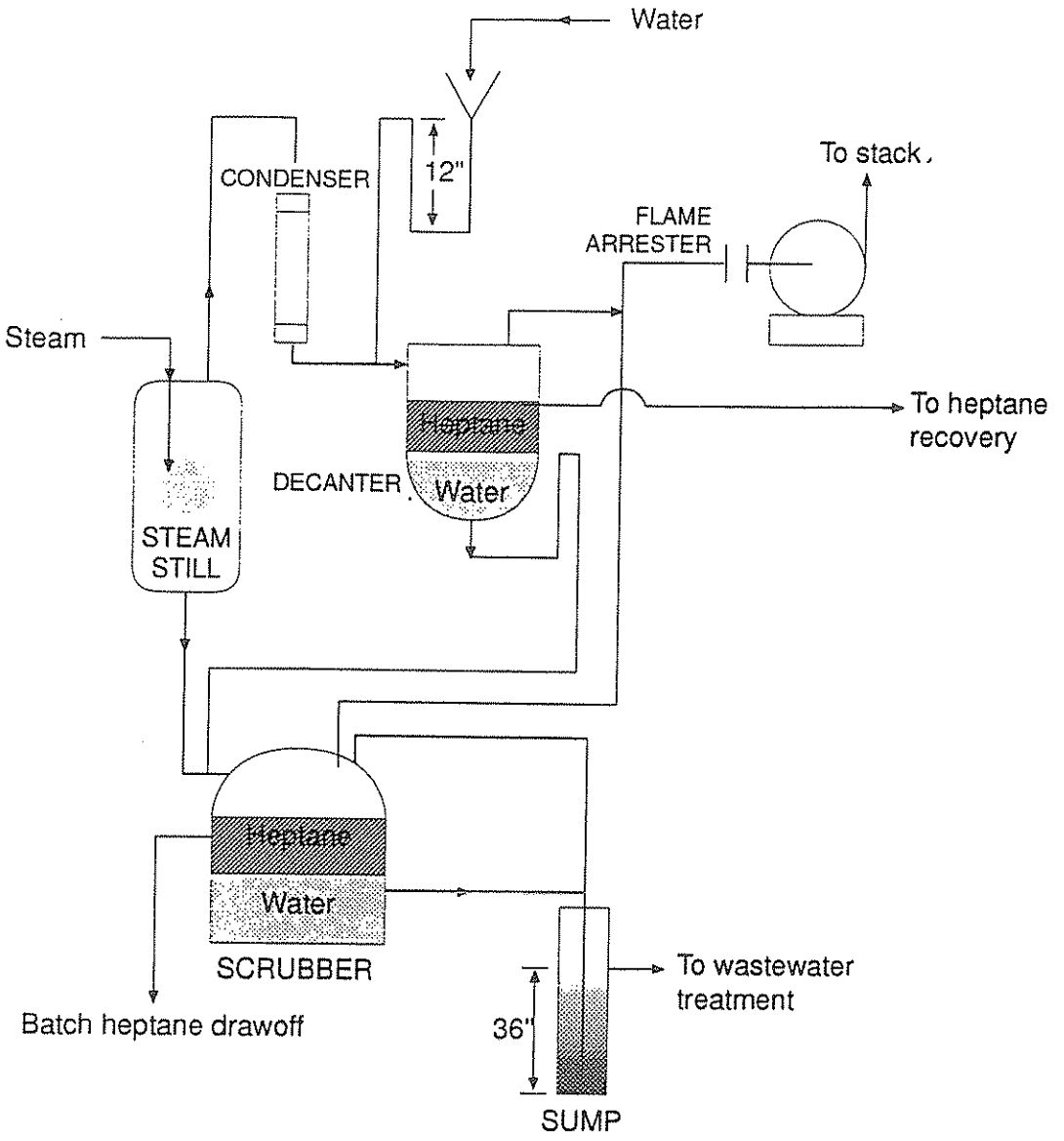
SEQUENCE OF EVENTS

1. The flash screen, installed in the vent six months earlier (a PHR recommendation), became restricted.
2. The resulting increase in pressure caused heptane to vent through the 12-inch seal leg on the decanter.
3. The seal leg was increased to 72 inches.
4. Next, the system began to vent through the path of least resistance—the 36-inch seal leg at the base of the scrubber. Heptane vapors entered the covered aqueous waste stream ditch, forming a flammable gas mixture.
5. Sparks from a welder's torch downstream ignited the vapors.

WHAT SHOULD HAVE BEEN DONE?

1. The flash screen should have been placed on an inspection schedule. Frequent initial inspections are necessary to determine susceptibility to pluggage.
2. The system should have been shut down until the cause of heptane venting was understood.
3. Modifications to the system should not have been made until reviewed via a PHA and a TA.
4. The operations supervisor and his superior had been recently assigned to the area and did not possess adequate knowledge of the process or of PSRM. Management at some level should have recognized the need for additional checks and balances because of so much supervisory inexperience. At a minimum, temporary backup from either higher supervision in the production organization or from technical supervision should have been provided for such process decisions.

HEPTANE RECOVERY



AUDITING WORKSHOP

WHAT HAPPENED?

An annual test of the interlock was done by Maintenance. About six months after the first successful test, the tank overflowed again. This time, the toluene ignited, causing a fire that damaged some equipment. Investigation of the incident revealed that the operator had begun to rely on the interlock as a routine operating control device because of the press of other operating duties. Also, operating procedures and training did not reflect the backup function of the interlock, and no one in the line organization was auditing the reliability of the system.

WHAT SHOULD HAVE BEEN DONE?

Procedures should have been revised and operators trained prior to start-up, as to the proper function of the interlock. In addition, a more frequent (i.e., once a week) full functional test of the interlock by the operator, with follow-up by Maintenance upon test failure, would have significantly improved reliability. Finally, periodic (i.e., once per quarter) auditing by the line organization (i.e., supervisor) would reinforce the importance of the test. This could consist of observing the test, discussions with the operator, and looking at test records.