



URGENT RECOMMENDATIONS:

Tesoro Refinery Hydrocarbon Release and Fire

Whereas:

1. On April 2, 2010, a heat exchanger in the Naphtha Hydrotreater Unit (NHT) at the Tesoro Refining and Marketing Company (Tesoro) refinery in Anacortes, Washington catastrophically ruptured releasing high temperature naphtha and hydrogen. The naphtha and hydrogen quickly ignited.
2. The release and fire killed six operators and a shift supervisor all working near, but not on or directly with the failed heat exchanger.
3. Metallurgical testing identified High Temperature Hydrogen Attack (HTHA) as the immediate cause of the heat exchanger rupture.
4. A nondestructive examination performed after the incident on an identically designed heat exchanger in the same service in the NHT showed defects (cracks and indications in the welds) that are consistent with the defects found on the failed heat exchanger. Metallurgical examination of this heat exchanger is ongoing.
5. HTHA occurs when hydrogen at high pressure and temperature diffuses into steel and reacts with the carbon in the steel to form methane. The methane molecule, being too large to diffuse out of the steel, creates high-pressure gas pockets that form microfissures in the steel. The microfissures coalesce into cracks. When a critical crack size is reached, the steel can catastrophically fail.
6. The occurrence of HTHA is dependent on the steel composition, temperature, hydrogen partial pressure, time, and material stress. HTHA damage is cumulative and dependent on the operating history of the equipment.
7. API Recommended Practice 941, "Steels for Hydrogen Service at Elevated Temperatures and Pressures in Petroleum Refineries and Petrochemical Plants," Seventh Edition, August 2008, graphically presents the combined temperatures and hydrogen partial pressures shown to cause HTHA in various types of steel. These graphs are commonly known as the Nelson curves. The Nelson curves are a best fit of actual failure data and do not include any safety factors.
8. API Recommended Practice 571, "Damage Mechanisms Affecting Fixed Equipment in the Refining Industry," recommends ultrasonic testing for HTHA inspection when equipment is operated within 25°F to 50°F of the Nelson curves.
9. The actual operating temperatures of the failed heat exchanger are not measured by the installed process instrumentation. Measured temperatures from the inlet and outlet suggest that the middle heat exchanger likely operated at temperatures greater than the original calculated process

U.S. Chemical Safety and Hazard Investigation Board

Document no. 2010-08-I-WA-UR
Board Approved: Month Day, Year

parameters and at times, operated near or above a combined temperature and hydrogen partial pressure shown to cause HTHA.

10. Tesoro's Mechanical Integrity (MI) program followed API RP 941 and 571 and included an ultrasonic inspection program for equipment Tesoro determined to be susceptible to HTHA. Tesoro implemented their MI program as required by Occupational Safety and Health Administration standard 1910.119 Process Safety Management of Highly Hazardous Chemicals (PSM).
11. An October 8, 2008 corrosion study for the Naphtha Hydrotreater and Catalytic Reformer Units conducted by Lloyd's Register Capstone, Inc. concluded that the subject heat exchanger was not susceptible to HTHA, because the temperature was below the Nelson curve. The study relied upon calculated process parameters from the original design in the early 1970's and did not consider actual conditions, operational history, or process changes from original design.
12. On June 3, 2009, Tesoro evaluated the subject heat exchanger and concluded that the subject heat exchanger was not susceptible to HTHA, because the design temperature was more than 25°F below the Nelson curve. This evaluation also relied upon calculated process parameters from the original design in the early 1970's and did not consider actual conditions, operational history, or process changes from original design.
13. The subject heat exchanger was never inspected for HTHA.
14. The Tesoro corporate MI program document (TRS-520, Rev.) applicable to all seven Tesoro refineries requires inspections and tests be performed in accordance with appropriate consensus and Tesoro codes and standards and does not specifically address equipment inspection selection and use of actual process parameters.
15. Current Occupational Safety and Health Administration, US Department of Labor (OSHA) dynamic question sets for the refinery and chemical plant NEPs do not include any questions related to using actual process conditions in the selection of equipment inspections for known degradation mechanisms.
16. Under 42 U.S.C. §7412(r)(6)(C)(ii), the Board is charged with "recommending measures to reduce the likelihood or the consequences of accidental releases and proposing corrective steps to make chemical production, processing, handling and storage as safe and free from risk of injury as is possible"
17. Board procedures authorize the development of an urgent safety recommendation "if an issue is identified during the course of an investigation that is considered to be an imminent hazard and has the potential to cause serious harm unless it is rectified in a short timeframe, or a hazard is identified that is likely to exist in a large segment of industry such that the probability of an incident is significant."

U.S. Chemical Safety and Hazard Investigation Board

Document no. 2010-08-I-WA-UR
Board Approved: Month Day, Year

Accordingly:

Pursuant to its authority under 42 U.S.C. §7412(r)(6)(C)(i) and (ii), and in the interest of promoting safer operations at U.S. facilities handling chemicals and protecting workers and communities from future accidents, the Board makes the following urgent safety recommendations:

To Tesoro Refining and Marketing Company, Anacortes, WA

2010-08-I-WA-UR1

Revise company procedures and policies for establishing mechanical integrity inspections to require use of actual process parameters (pressure, temperature, flow, and chemical composition) in determining the susceptibility of equipment to all degradation mechanisms described in API Recommended Practice 571 “Damage Mechanisms Affecting Fixed Equipment in the Refining Industry.” Where sufficient process instrumentation does not exist, require field measurements and process modeling to supplement process instrumentation measurements.

2010-08-I-WA-UR2

Review all equipment in each of the four hydrotreater units at the Anacortes refinery for susceptibility to High Temperature Hydrogen Attack (HTHA). The review should verify the use of actual process parameters in the determination of susceptibility and the inclusion of all susceptible equipment in the HTHA inspection program. Inspect all equipment susceptible to HTHA for HTHA. Share the results of this review and inspections with the all operators in each of these units.

To Tesoro Companies, Inc.

2010-08-I-WA-UR3

Within six months, conduct comprehensive audits of the Mechanical Integrity programs at Tesoro’s six other refineries with an emphasis on the use of actual process parameters (pressure, temperature, flow, and chemical composition) to determine the susceptibility of equipment to all degradation mechanisms described in API Recommended Practice 571 “Damage Mechanisms Affecting Fixed Equipment in the Refining Industry.” Implement audit recommendations and revise company procedures and policies as necessary.

National Petrochemical & Refiners Association

2010-08-I-WA-UR4

Include in your upcoming 2011 Reliability and Maintenance Conference and Exhibition, a breakout session, workshop, or panel discussion on using field measurements and process modeling to supplement process instrumentation measurements in selecting inspections for known degradation mechanisms in chemical plants and refineries. At a minimum include the degradation mechanisms described in API Recommended Practice 571 “Damage Mechanisms Affecting Fixed Equipment in the Refining Industry.”

U.S. Chemical Safety and Hazard Investigation Board

Document no. 2010-08-I-WA-UR
Board Approved: Month Day, Year

Occupational Safety and Health Administration, US Department of Labor

2010-08-I-WA-UR5

Include in your dynamic question sets for the refinery and chemical plant NEPs and in your inspection guidance requirements to check how equipment inspections are selected for known degradation mechanisms and that actual process conditions and equipment history is used in the selection process.

DRAFT