



U. S. Chemical Safety and Hazard Investigation Board

RECOMMENDATIONS STATUS CHANGE

SUMMARY

Report:	Tesoro Refinery Fatal Explosion Fire
Recommendation Numbers:	2010-8-I-WA-R10
Date Issued:	May 1, 2014
Recipient:	American Petroleum Institute
New Status:	Closed – Unacceptable Action/No Response Received
Date of Status Change:	July 13, 2016

Recommendation Text:

CSB Recommendation No. 2010-8-I-WA-R10:

Revise American Petroleum Institute API RP 941: *Steels for Hydrogen Service at Elevated Temperatures and Pressures in Petroleum Refineries and Petrochemical Plants* to:

- Clearly establish the minimum necessary “shall” requirements to prevent HTHA equipment failures using a format such as that used in ANSI/AIHA Z10-2012, *Occupational Health and Safety Management Systems*;
- Require the use of inherently safer materials to the greatest extent feasible;
- Require verification of actual operating conditions to confirm that material of construction selection prevents HTHA equipment failure; and
- Prohibit the use of carbon steel in processes that operate above 400 °F and greater than 50 psia hydrogen partial pressure.

Board Status Change Decision:

A. Rationale for Recommendation

On May 1, 2014, the U.S. Chemical Safety Board (CSB) released its report on the April 2, 2010 catastrophic heat exchanger rupture at the Tesoro Anacortes refinery which fatally injured seven workers. The CSB found that management at the refinery failed to effectively evaluate the potential for high temperature hydrogen attack (HTHA), the damage mechanism which caused the heat exchanger rupture. HTHA occurs in process plants in steel equipment exposed to hydrogen and high temperatures. HTHA causes cracking that weakens vessels, which can lead to sudden and devastating failures, such as that which occurred at Tesoro Anacortes.

Part of the CSB’s investigation reviewed the American Petroleum Institute’s (API’s) Recommended Practice (RP) 941, *Steels for Hydrogen Service at Elevated Temperatures and Pressures in Petroleum Refineries and Petrochemical Plants*, which is the industry guidance document on ways to predict and manage HTHA. The CSB found in its investigation that RP 941 does not contain any minimum requirements to prevent HTHA, does not require the use of inherently safer design where feasible, and does not require verification of operating conditions. As a result, CSB made a recommendation to API to further prevent the occurrence of HTHA by revising RP 941 to: verify operating conditions to confirm appropriate materials of construction selection; establish minimum requirements to prevent HTHA; require the use of inherently safer materials; and prohibit the use of carbon steel in processes that operate above 400 °F and greater than 50 psia hydrogen partial pressure.

B. Response to the Recommendations

API revised RP 941 and published the 8th edition of the RP in February 2016. API's actions for each subpart of the recommendation are listed below:

Regarding subpart (a) of the recommendation, API did not change the format of this recommended practice, citing that they are following their internal style guide. In addition, API did not establish minimum requirements to prevent HTHA and is still a permissive document. Two "shall" requirements were added, but they apply to methods used in steel heat treatment, not in prevention of HTHA.

Regarding subpart (b) of the recommendation, RP 941 did add a new carbon steel Nelson curve for non-post-weld-heat-treated (non-PWHT) carbon steel, RP 941 does not require the use of inherently safer materials. Although API states that there is a 50 °F design margin for their Nelson curves, no quantified safety or design margin is specified in the standard.

Regarding subpart (c) of the recommendation, API states that the existing Nelson curve graph conveys the safe operating limits for various materials of construction. However, RP 941 did not add any guidance or requirements for methods to verify actual operating conditions. API's states a requirement for proper temperature measurement, but only for measurement of temperature during steel heat treatment, not for measurement of process conditions.

Regarding subpart (d) of the recommendation, API created a new non-PWHT carbon steel curve. This new curve takes into account newly reported failures in non-PWHT carbon steel, but it ignores the process conditions identified in the CSB report where HTHA occurred in Tesoro heat exchangers. While the CSB does not take issue with having separate PWHT and non-PWHT carbon steel lines, as all recent failures below the carbon steel Nelson curve were in non-PWHT carbon steel, the CSB is concerned with the new non-PWHT carbon steel line placement. This new line does not take into account all operating conditions where HTHA and severe cracking from HTHA was identified in the Tesoro heat exchangers. HTHA occurred below this new Nelson curve line at the Tesoro Anacortes Refinery.

API states that industry uses a 50 °F design margin as a safety factor below the applicable Nelson curve, meaning that equipment should be designed to not operate this close to the Nelson curve, however; "design margins" are for the design of *new* equipment. Existing equipment that operates near the Nelson curves do not require an *operating* margin safety factor. HTHA is a damage mechanism that takes years to form cracks that severely weakens vessels. This is a major ageing equipment issue, as older equipment is much more susceptible to catastrophic failure from HTHA than the new equipment to which this design margin would apply. While RP 941 communicates it is desirable to generically establish a safety margin below the relevant curve, this safety margin is not quantified as 50 °F within the RP 941 standard. All existing equipment is not required to incorporate a 50 °F safety margin.

C. Board Analysis and Decision

Based on the above analysis, CSB concluded that API took insufficient action on all parts of the recommendation. The new line placement for non-PWHT carbon steel Nelson curve is not safe and will not prevent future HTHA failures and worker deaths. As the API's 8th edition on RP 941 does not meet the intent of the CSB's recommendation, the Board voted to designate Recommendation **No. 2010-8-I-WA-R10** as "**Closed – Unacceptable Action.**"