

CSB'S DRIVERS OF CRITICAL CHEMICAL SAFETY CHANGE



U.S. Chemical Safety and Hazard Investigation Board

Preventive Maintenance

Mechanical integrity is a primary category of OSHA's Process Safety Management (PSM) regulation. CSB investigations affirm its importance. Inadequate mechanical integrity and preventive maintenance programs, and aging infrastructure and equipment are a recurring root cause of incidents. CSB recommendations have addressed gaps in facility, corporate, regulatory, and industry programs and standards to prevent the failure of equipment involved in highly hazard processes. Damage mechanisms must be promptly identified and mitigated; equipment must not be operated beyond its life cycle expectancy; and upgrades and replacements must not be delayed.

Several of the CSB's investigations involving preventive maintenance issues have occurred at refineries. In 2010, the Tesoro refinery in Anacortes, Washington experienced a catastrophic heat exchanger rupture due to undetected High Temperature Hydrogen Attack (HTHA), localized microscopic cracks that are difficult to identify. The refinery's inspection strategy proved unreliable, because it was based on design rather than actual operating conditions. At design conditions,

The U.S. Chemical Safety and Hazard Investigation Board identified inadequate mechanical integrity and preventive maintenance programs, and the aging infrastructure and equipment as recurring root causes of chemical incidents.

the carbon steel exchanger's resistance to HTHA would have been acceptable. At actual temperatures and hydrogen partial pressure, HTHA occurred, resulting in a catastrophic failure. Given a reliable inspection strategy, a replacement high-chromium steel exchanger, which is more resistant to HTHA, should have been installed.

In 2012, the Chevron U.S.A. Inc. Refinery in Richmond, California, experienced a catastrophic pipe failure in the #4 Crude Unit. The incident occurred in an isolated segment of carbon steel pipe that, due to low silicon content, was especially susceptible to thinning caused by sulfidation corrosion, a common damage mechanism in refineries. The pipe ruptured, releasing flammable, hydrocarbon process fluid which partially vaporized and ignited. Inspection for carbon steel components containing low silicon concentrations is challenging. Each pipe component, from one weld to the next, must be individually inspected. Chevron's inspection program examined just a few locations, all of which turned out to be high-silicone. Based on this incomplete inspection data, Chevron rejected several internal recommendations to replace the carbon steel pipe with a higher chromium steel pipe that would be less susceptible to sulfidation corrosion.



CSB Tesoro Refinery Fire Investigation, 2010

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In the absence of adequate industry guidance that incorporated findings from the Tesoro Anacortes failure, the CSB issued a [Safety Alert](#) to provide the following additional direction for industry.



CSB Chevron Richmond Refinery Fire Investigation, 2012

1. Identify all carbon steel equipment in hydrogen service that has the potential to harm workers or communities due to catastrophic failure;
2. Verify actual operating conditions (hydrogen partial pressure and temperature) for the identified carbon steel equipment;
3. Replace carbon steel process equipment that operates above 400°F and greater than 50 psia hydrogen partial pressure; and
4. Use inherently safer materials, such as steels with higher chromium and molybdenum content.

Year	Investigation/Deployment
2015	ExxonMobil Refinery (Torrance, CA)
2012	Chevron Refinery (Richmond, CA)
2011	Carbide Industries (Louisville, KY)
2011	Hoeganaes Corporation (Gallatin, TN)
2010	NDK Crystal Inc. (Belvidere, IL)
2010	Tesoro Refinery (Anacortes, WA)
2009	Silver Eagle Refinery (Salt Lake City, UT)
2008	Allied Terminals (Chesapeake, VA)
2008	DuPont (Belle, WV)
2007	Valero Refinery (Sunray, TX)
2005	BP America Refinery (Texas City, TX)
2003	Technic Inc. (Cranston, RI)
2002	DPC Enterprises (Festus, MO)
2001	Marcus Oil and Chemical (Houston, TX)
2001	Motiva Enterprises (Delaware City, DE)
1999	Tosco Avon Refinery (Martinez, CA)

VISION: A nation safe from chemical disasters.

MISSION: Drive chemical safety change through independent investigations to protect people and the environment.

The CSB is an independent, non-regulatory Federal agency charged with investigating serious chemical incidents. The agency's board members are appointed by the president and confirmed by the Senate. CSB investigations look into all aspects of chemical incidents, including physical causes such as equipment failure as well as inadequacies in regulations, industry standards, and safety management systems.

The Board does not issue citations or fines but does make safety recommendations to facility management, industry organizations, labor groups, and regulatory agencies such as OSHA and EPA.

U.S. Chemical Safety Board
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