

U.S. Chemical Safety and Hazard Investigation Board



CSB Presentation

CSB Investigation of the Tesoro Anacortes Refinery Heat Exchanger Rupture and Fire

Anacortes, Washington

January 30, 2014



U.S. CHEMICAL SAFETY AND HAZARD INVESTIGATION BOARD

INVESTIGATION REPORT

CATASTROPHIC RUPTURE OF HEAT EXCHANGER (SEVEN FATALITIES)



TESORO ANACORTES REFINERY

ANACORTES, WASHINGTON

APRIL 2, 2010

KEY ISSUES

- INHERENTLY SAFER DESIGN
- TESORO PROCESS SAFETY CULTURE
- CONTROL OF NONROUTINE WORK
- MECHANICAL INTEGRITY INDUSTRY STANDARD DEFICIENCIES
- REGULATORY OVERSIGHT OF PETROLEUM REFINERIES

REPORT 2010-08-I-WA

JANUARY 2014



Tesoro Anacortes Refinery Investigation

Speakers:

Dan Tillema – Lead Investigator

Don Holmstrom – Director – Western Regional Office



Tesoro Investigation Presentation Proceedings

- **Video Animation of April 2, 2010 Incident**
- **Key Investigation Findings**
 - **Technical Findings**
 - **Organizational Findings**
 - **Regulatory Findings**
- **Proposed Recommendations**
- **Public Comment Period**



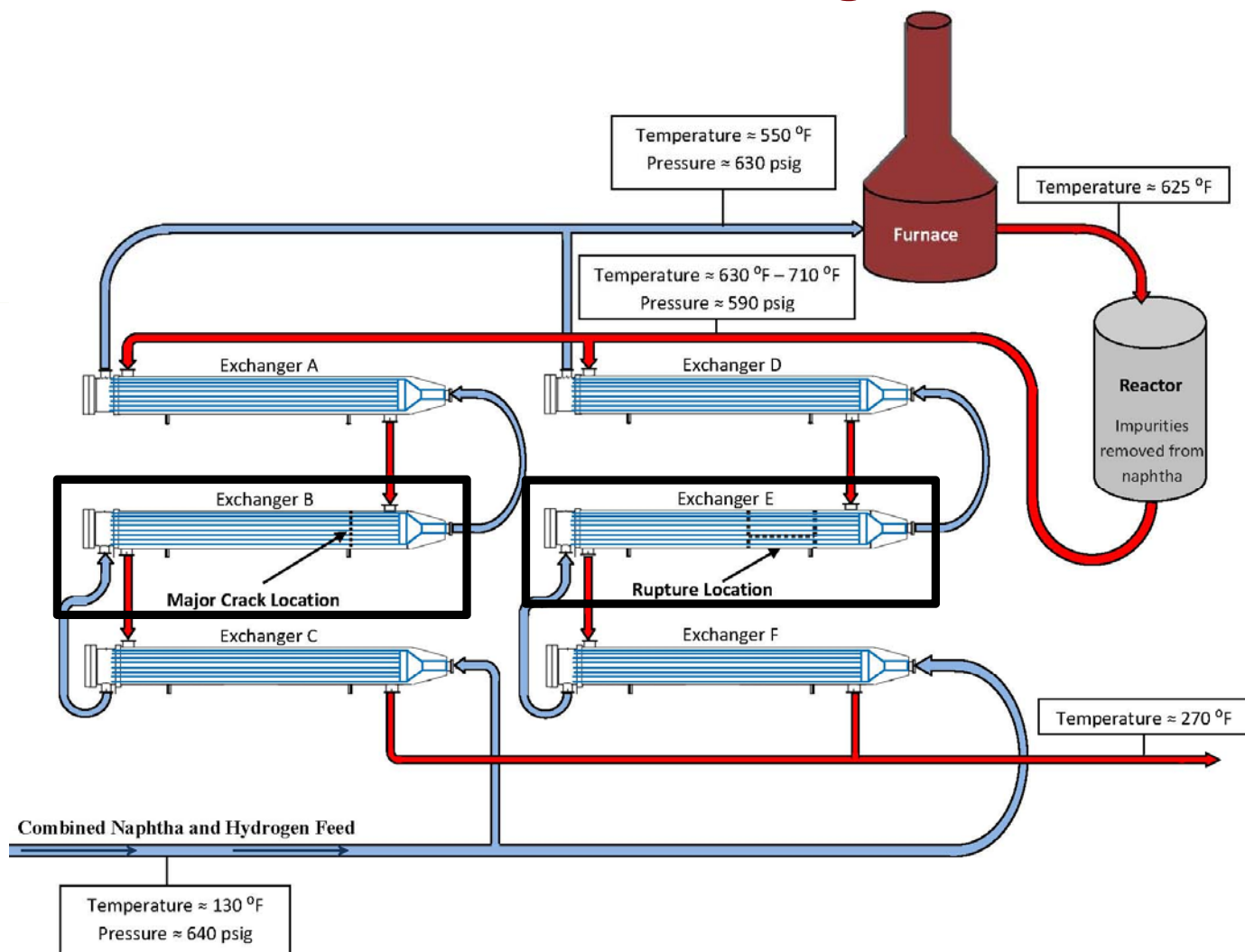
Video Animation of Incident



Technical Findings

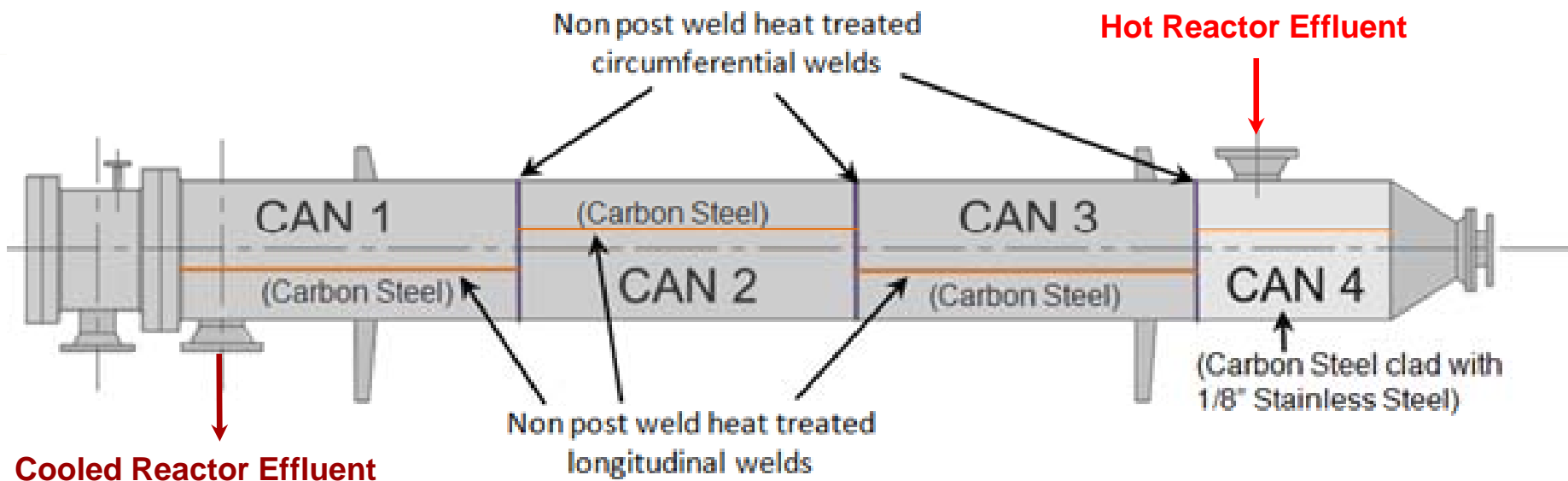


NHT Heat Exchangers



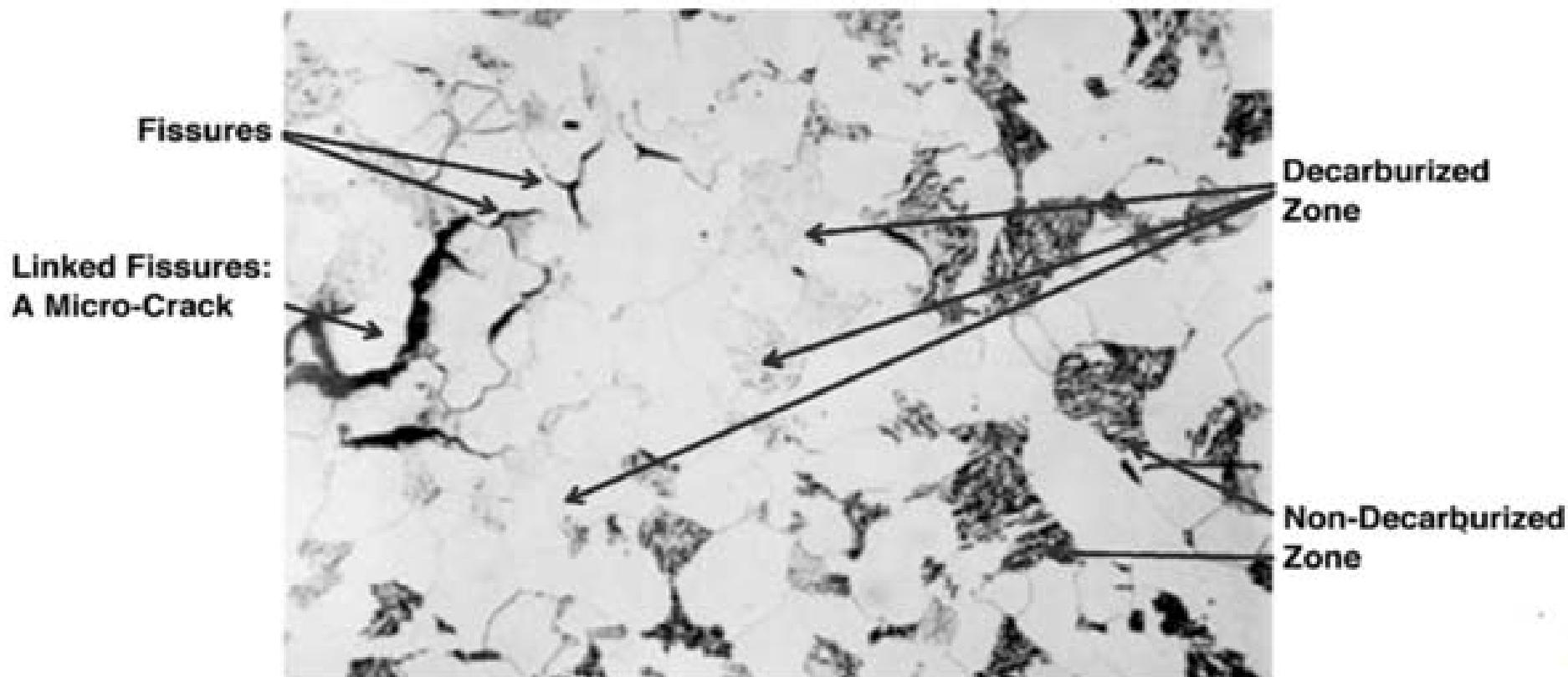


Construction Details of the Failed “E” and Exemplar “B” Exchangers



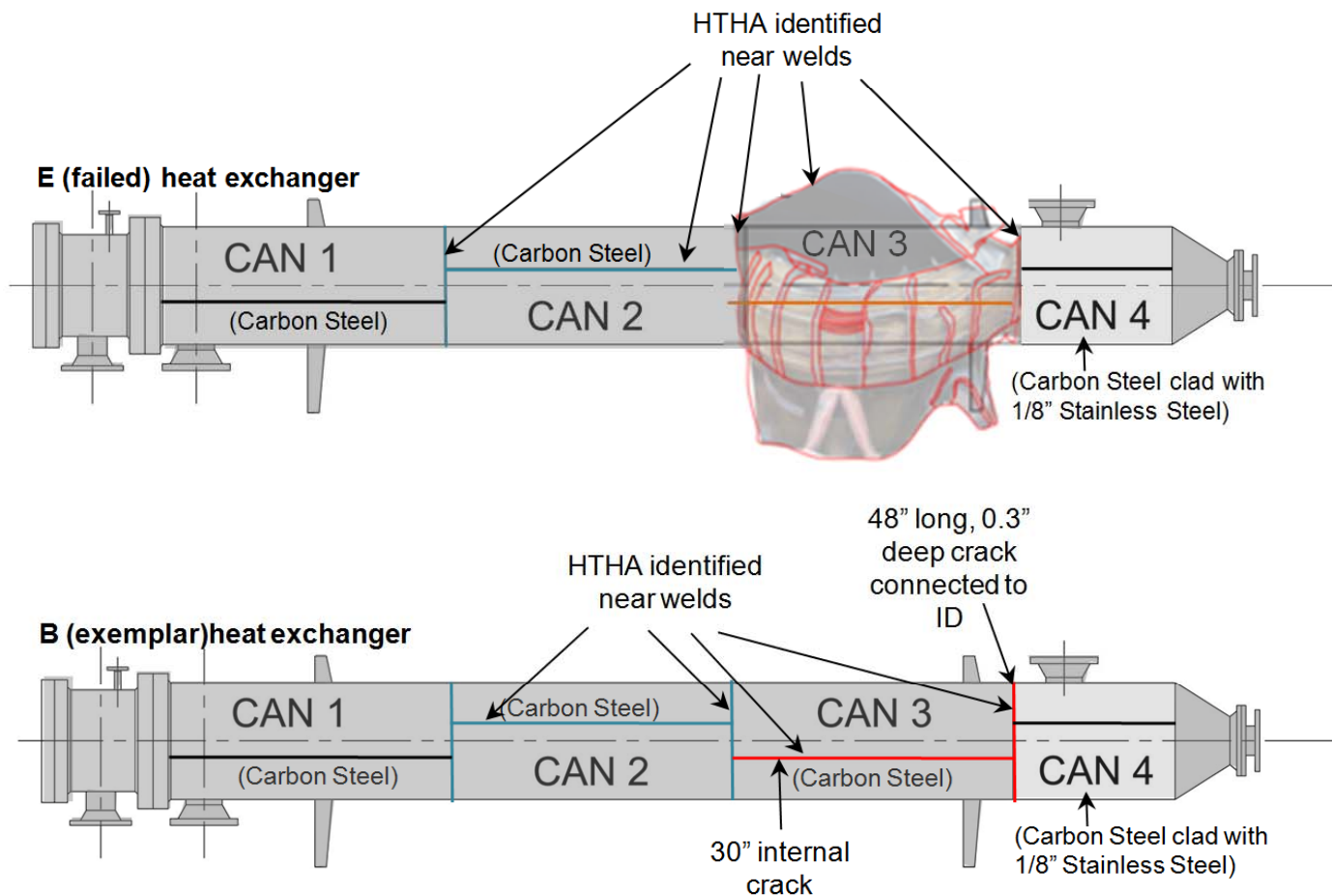


Magnified sample of steel containing HTHA





Locations of HTHA in B and E Heat Exchangers





Tesoro Did Not Identify the Potential for HTHA Damage



Industry's HTHA Resource: API RP 941

- API RP 941 used by refiners worldwide for management of HTHA
- A graph within the standard, the Nelson Curves, is used to predict HTHA
- Location of Nelson curves is based upon industry experience

Steels for Hydrogen Service at Elevated Temperatures and Pressures in Petroleum Refineries and Petrochemical Plants

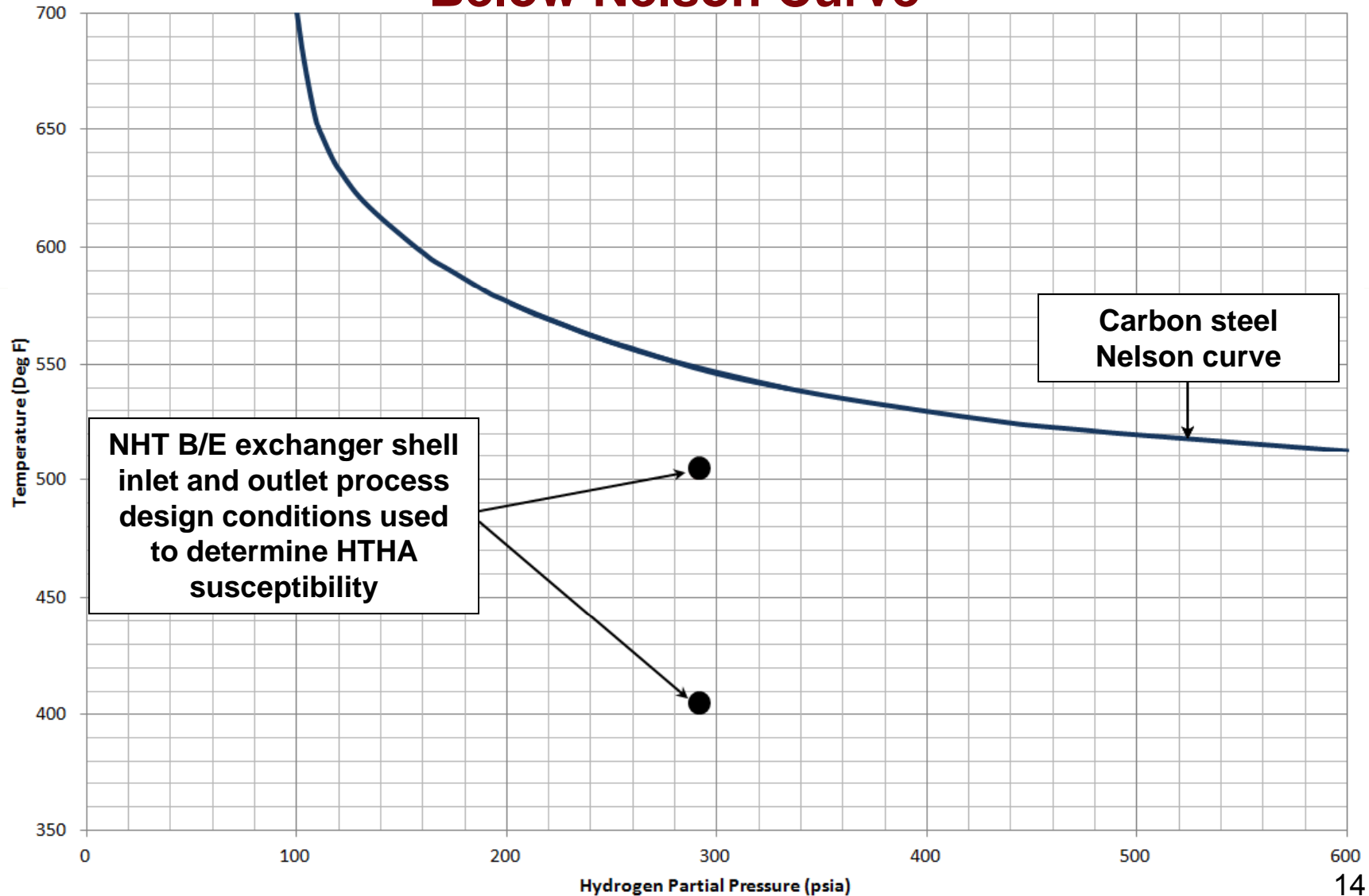
Downstream Segment

API RECOMMENDED PRACTICE 941
SEVENTH EDITION, AUGUST 2008



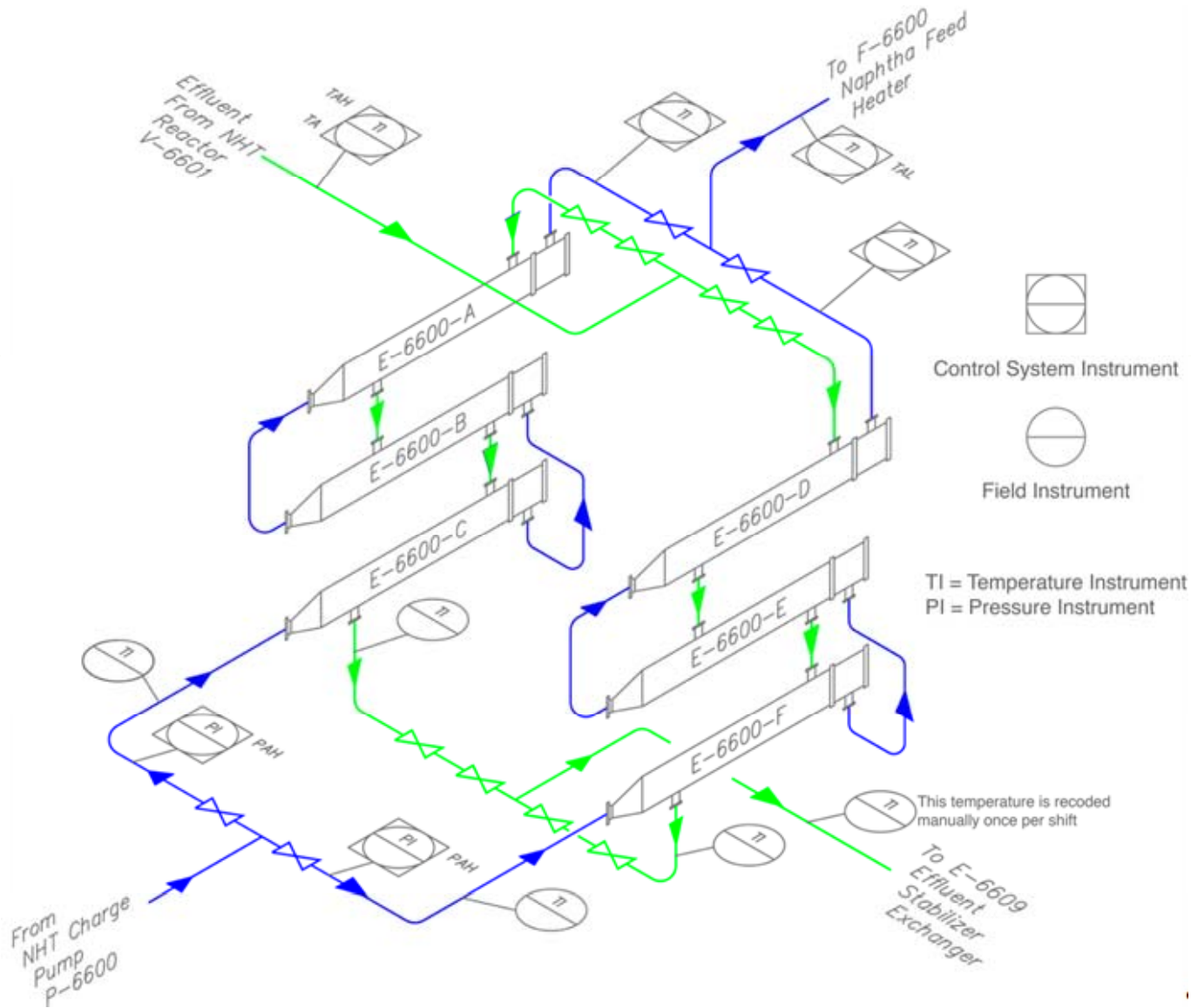


B/E Heat Exchanger Shell Design Process Conditions Were Below Nelson Curve



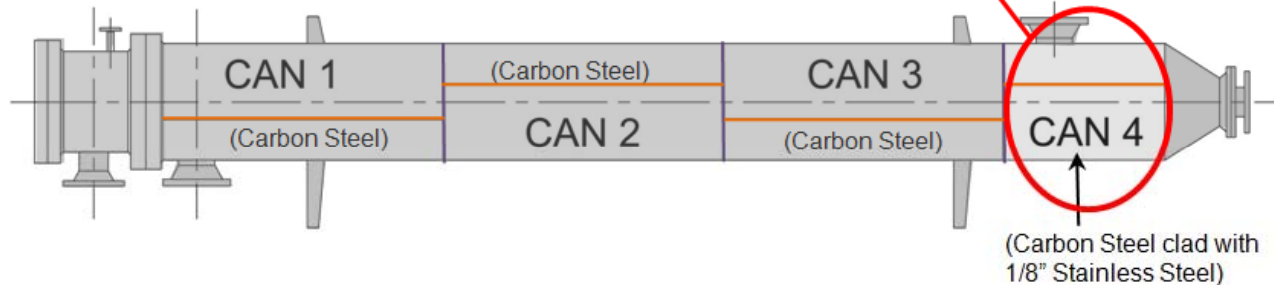
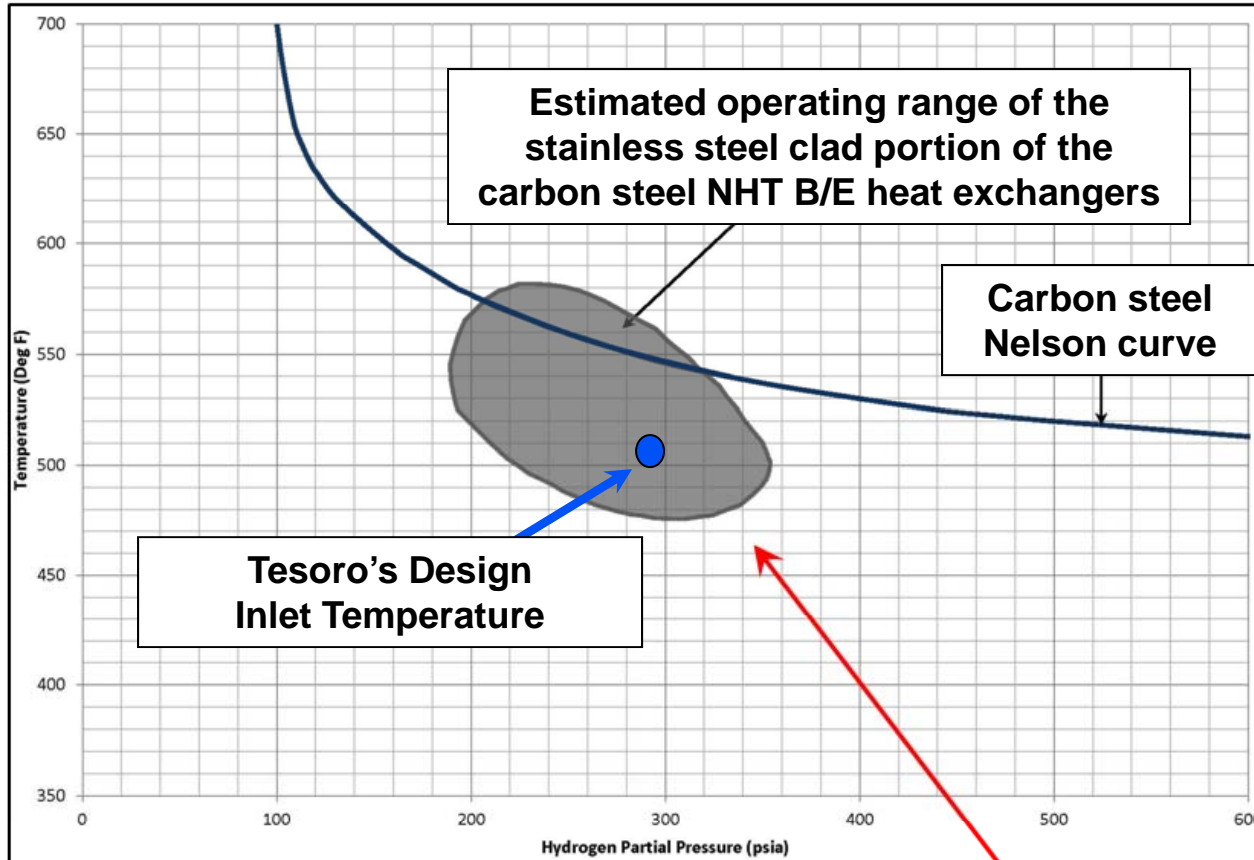


No Temperature Measurement Between Exchangers



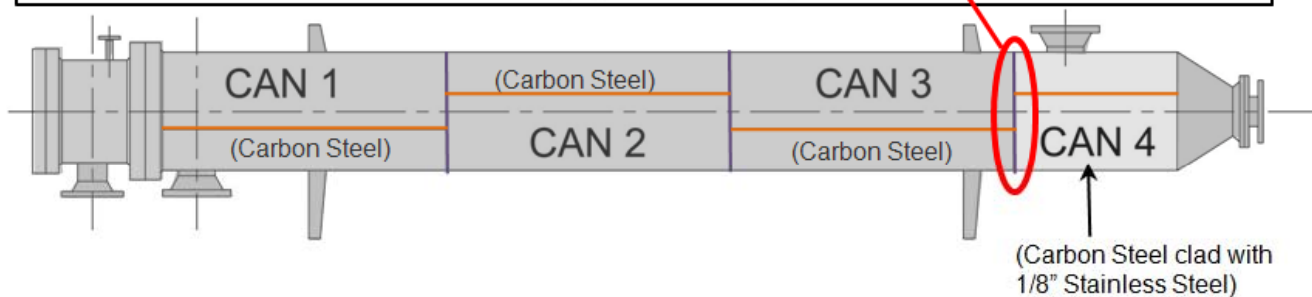
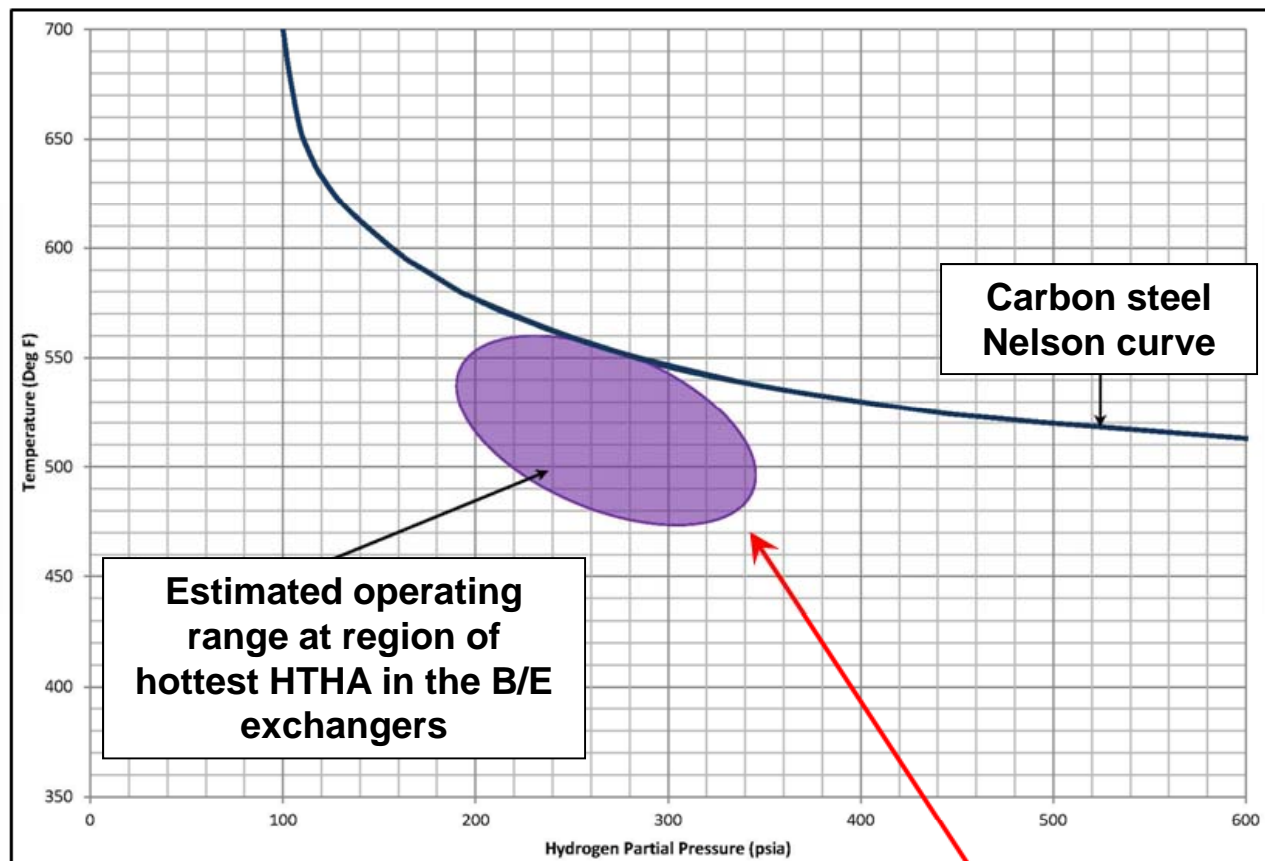


B/E Heat Exchanger “Can 4” Operating Region



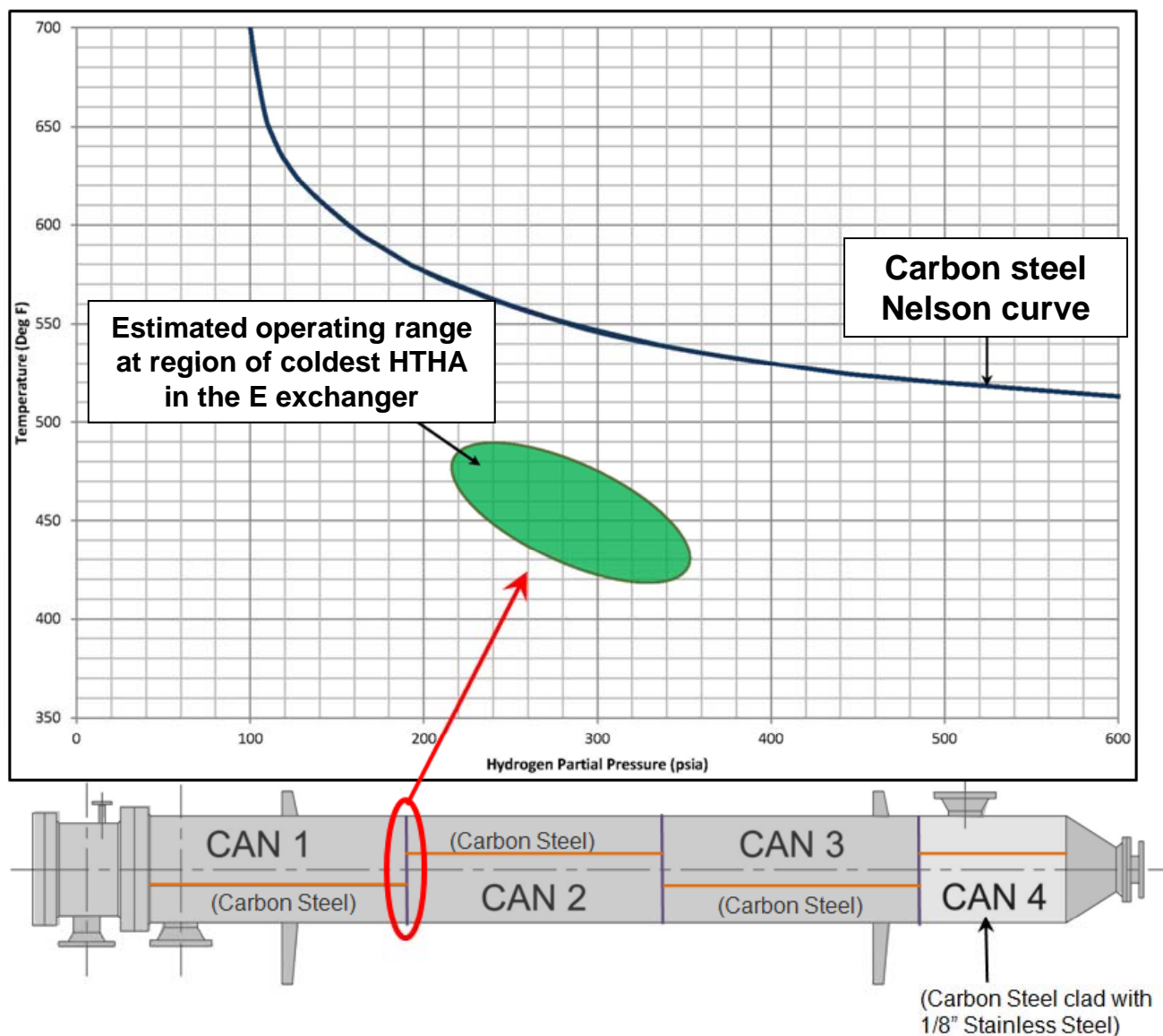


HTHA Occurred Below the Carbon Steel Nelson Curve





HTHA Occurred Below the Carbon Steel Nelson Curve





The current carbon steel Nelson curve is not reliable



Tesoro Organizational Deficiencies



Tesoro Accepted and Normalized Exchanger Leaks

- NHT heat exchangers typically leaked during startup
 - Attempts to fix leaks were unsuccessful
 - Operation techniques developed to minimize leak time
 - Steam lances often used to disperse flammable vapors



Tesoro Failed to Control Exchanger Startup Hazards

- Tesoro relied on additional staffing for heat exchanger startup, and:
 - Did not assess risks associated with the additional personnel
 - Did not conduct MOC to consider risks of organizational changes
-
- PHAs, NHT unit procedure reviews, and organizational MOOCs did not identify increased risk to workers





Tesoro's PHAs Failed to Reduce Consequences of Incident

**PHA cited unidentifiable administrative controls
to reduce personnel hazards during startup**

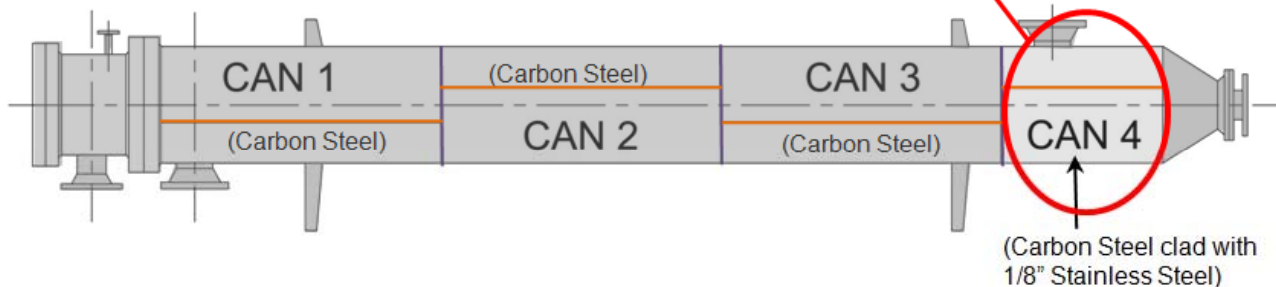
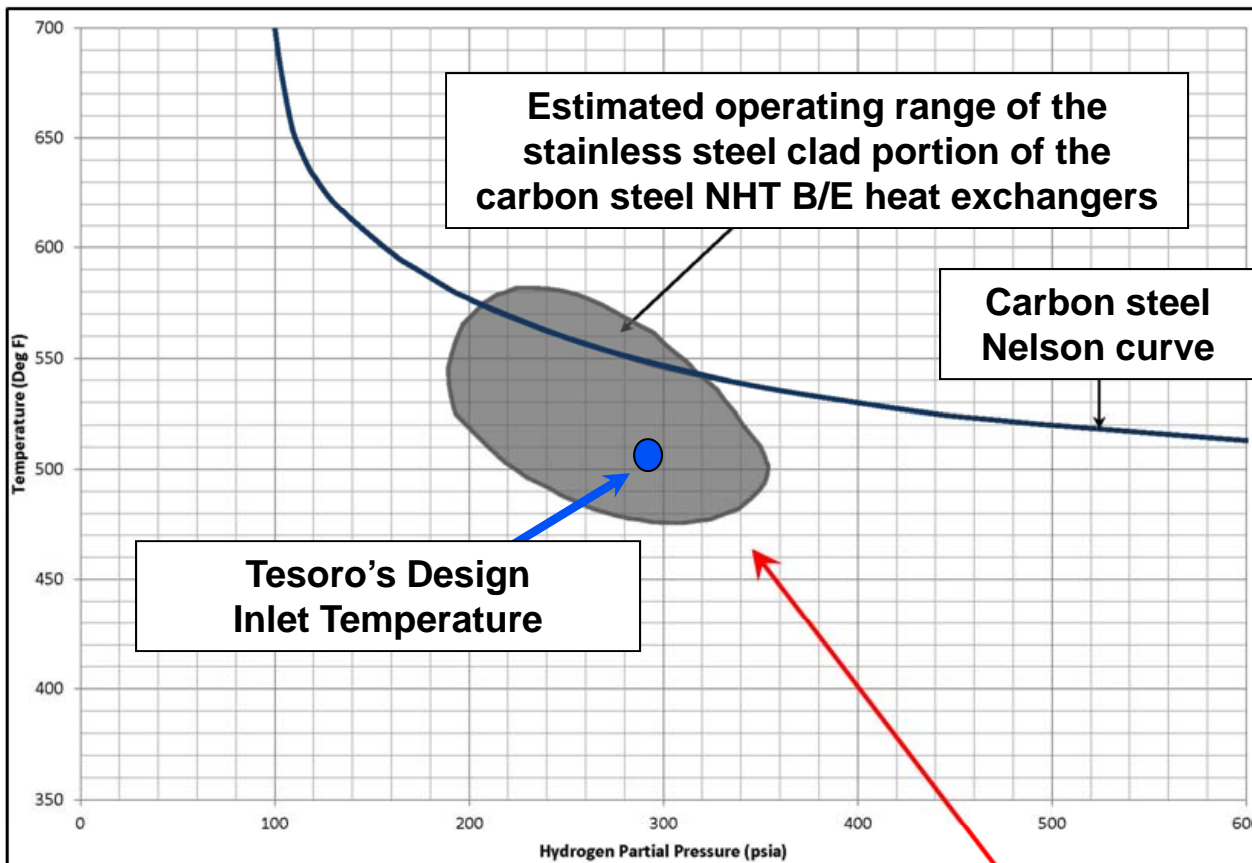


Tesoro's PHAs Failed to Prevent Incident

**Damage Mechanism Hazard Reviews used
inaccurate data**



B/E Heat Exchanger "Can 4" Operating Region





Industry Codes and Standards Deficiencies



API 941 – Industry's HTHA Resource

- Contains no minimum requirements to prevent HTHA
- Does not require inherently safer design where feasible
- Does not require verification of operating conditions
- API 941 relies on voluntary submittals
 - Difficult to verify quality of submissions
 - Not all incidents are reported (Tesoro did not report failure to API)

Steels for Hydrogen Service at Elevated Temperatures and Pressures in Petroleum Refineries and Petrochemical Plants

Downstream Segment

API RECOMMENDED PRACTICE 941
SEVENTH EDITION, AUGUST 2008



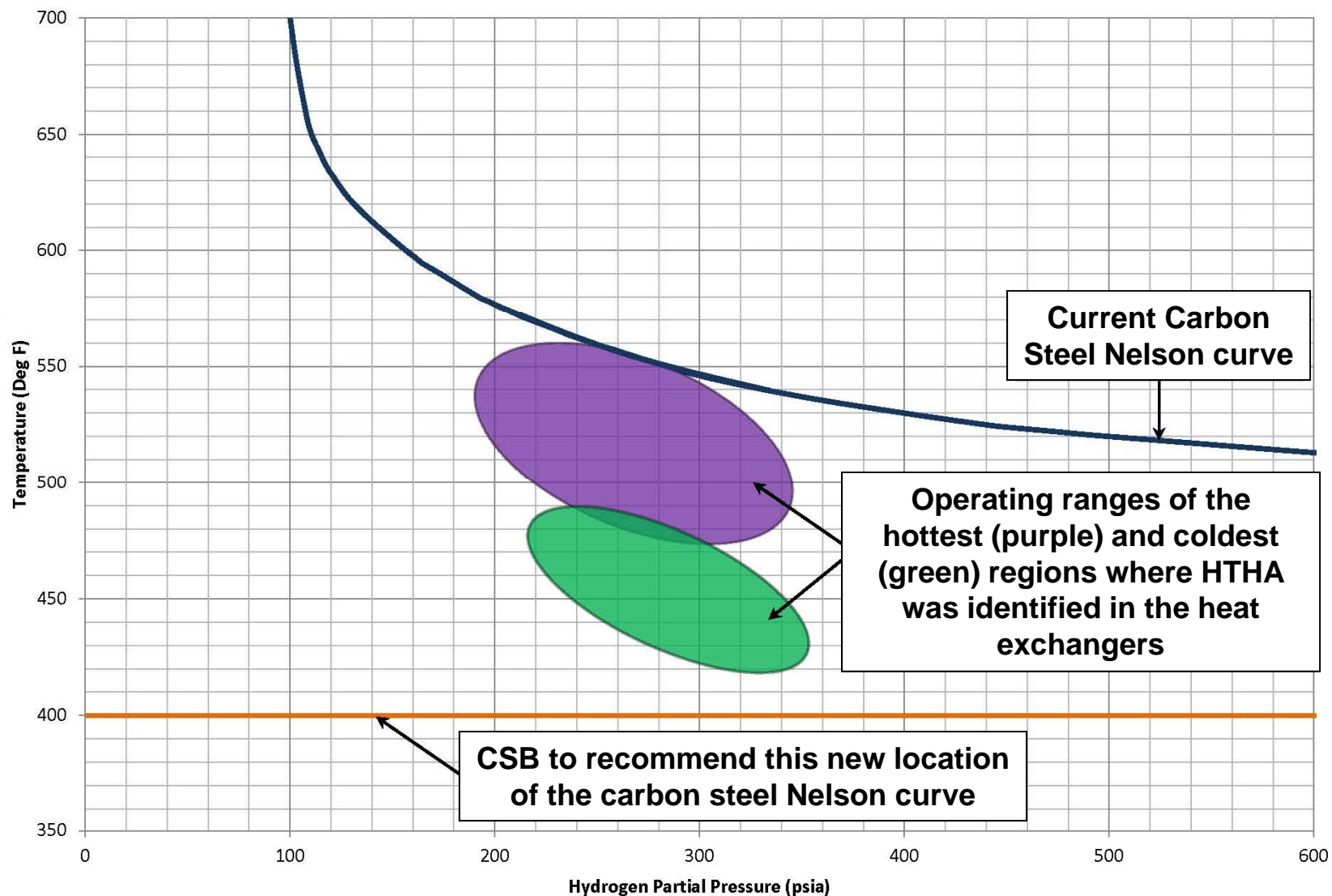


API 941 – Industry’s HTHA Resource

HTHA has been found to have occurred below the carbon steel Nelson curve **in at least 8** other refinery incidents



CSB Proposes New Location for Carbon Steel Nelson Curve





Regulatory System Deficiencies



Washington's PSM Program

- **Washington regulatory regime:**
 - relies on a framework that is primarily activity-based without a risk reduction target;
 - does not effectively involve the workforce in hazard analysis and prevention of major accidents; and
 - does not employ a sufficient number of staff members with the technical expertise needed to provide sufficient oversight of petroleum refineries.



Safety Case Regulatory Regime





EPA Risk Management Program

Inherently Safer Design is essential for ensuring chemical process safety is achieved.

EPA has the authority to require facilities to use inherently safer design where feasible, but currently does not do so.



Delivery of Proposed Recommendations



Proposed Recommendations

To the U.S. Environmental Protection Agency:

Revise the Chemical Accident Prevention Provisions under 40 CFR Part 68 to require the documented use of inherently safer systems analysis and the hierarchy of controls to the greatest extent feasible in establishing safeguards for identified process hazards. Until this revision is in effect, develop guidance and enforce the use of inherently safer systems analysis and the hierarchy of controls to the greatest extent feasible in establishing safeguards for identified process hazards through the Clean Air Act's General Duty Clause.



Proposed Recommendations

To the Washington State Legislature, Governor of Washington:

Develop and implement a step-by-step plan to supplement the existing process safety management regulatory framework with the more rigorous safety management principles of the “safety case” for petroleum refineries in the state of Washington.



Proposed Recommendations

To the Washington State Division of Occupational Safety and Health – Labor and Industries:

Perform verifications at all Washington petroleum refineries to ensure prevention of equipment failure because of HTHA and that effective programs are in place to manage hazardous nonroutine work. In addition, provide oversight of the process safety culture program at the Tesoro Anacortes Refinery.



Proposed Recommendations

To the American Petroleum Institute

Revise API RP 941 and API RP 581 to prohibit the use of carbon steel equipment in HTHA-susceptible service and require verification of actual operating conditions. Make additional revisions to API RP 941 to establish minimum requirements to prevent HTHA failures and to require the use of inherently safer design.



Proposed Recommendations

To the Tesoro Refining & Marketing Company LLC:

Participate with API in the API RP 941 revisions to establish minimum requirements to prevent HTHA failures and to require the use of inherently safer design. Following the API RP 941 revisions, develop and implement a plan to meet the new API RP 941 requirements. Improve process safety management programs for damage mechanism hazards to require the hierarchy of controls and the use of inherently safer design.



Proposed Recommendations

To the Tesoro Anacortes Refinery:

Implement a process safety culture program that will assess and continually improve any identified process safety culture issues at the Tesoro Anacortes Refinery.

U.S. Chemical Safety and Hazard Investigation Board



CSB Presentation

CSB Investigation of the Tesoro Anacortes Refinery Heat Exchanger Rupture and Fire

Anacortes, Washington

January 30, 2014