



U.S. Chemical Safety and Hazard Investigation Board

Investigation Presentation

July 28, 2022

Pressure Vessel Steam Explosion at The Loy-Lange Box Company

St. Louis, Missouri

April 3, 2017

Drew Sahli
Investigator-In-Charge



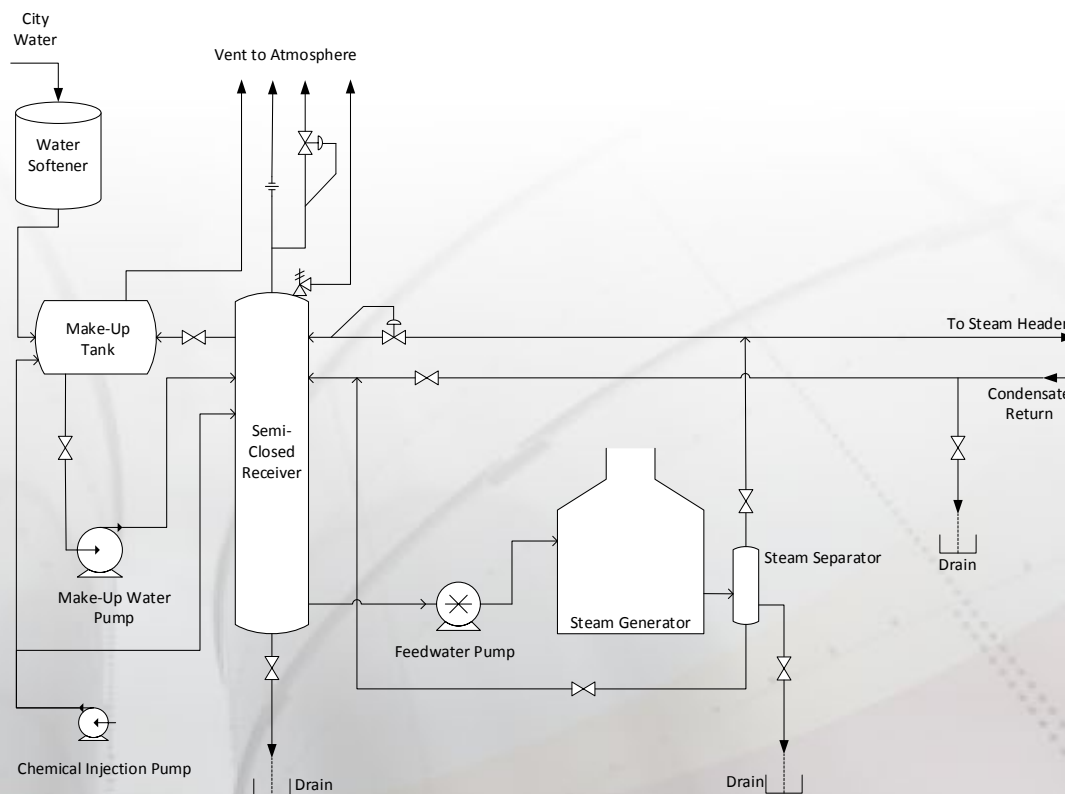
Incident Overview

- **Location:** St. Louis, MO
- **Incident Date:** April 3, 2017
- **Consequences:**
 - 4 fatalities – one employee, 3 public at large
 - Severe property damage to Loy-Lange and Faultless Healthcare Linen



Loy-Lange Steam System

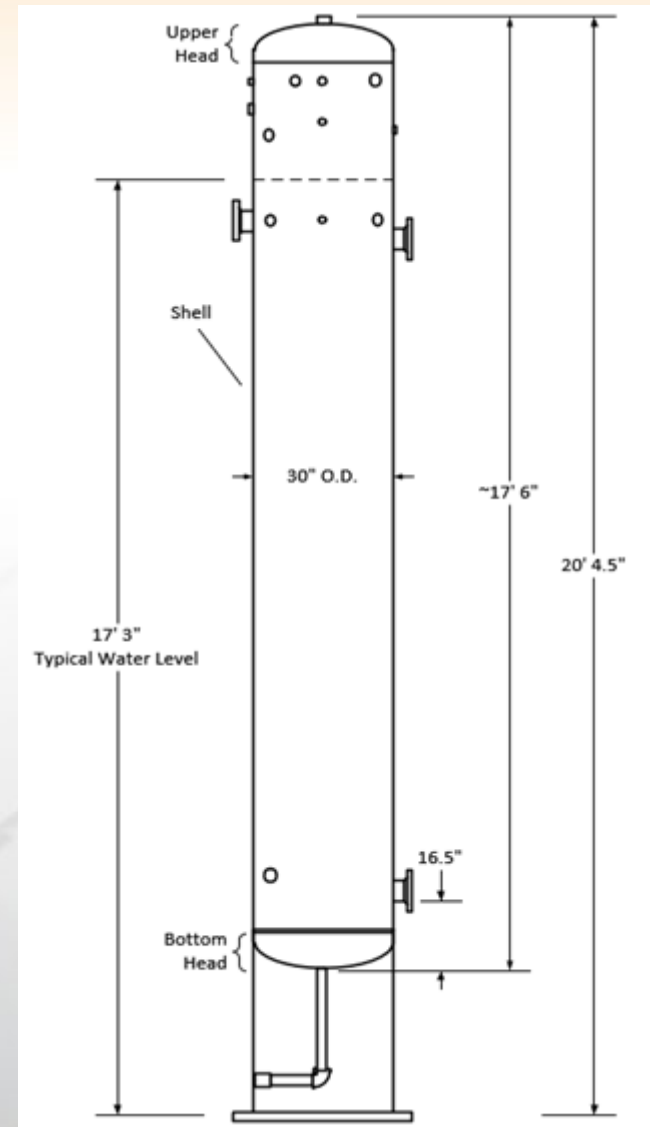
- Municipal water fed through water softener and into make-up tank
- Water in make-up tank heated with steam to drive off dissolved oxygen
- Chemically treated with oxygen scavengers
- Deaerated water flowed to pressure vessel - “Semi-Closed Receiver” or “SCR”
- From SCR, water flowed to the steam generators
- Steam flowed to corrugation process
- Condensed, fed back to SCR





SCR Background

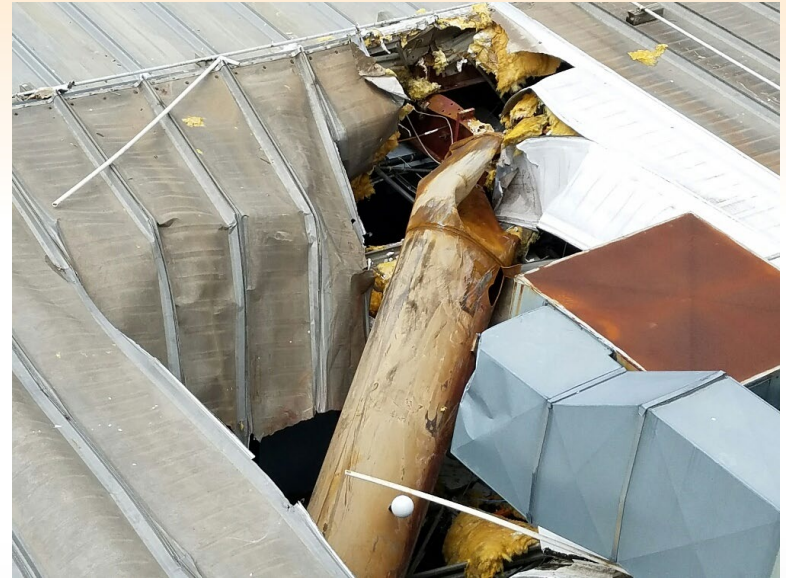
- Semi-Closed Receiver
- Vertical, cylindrical pressure vessel
- Designed for max pressure of 150 psi
- Receives incoming make-up water and returning condensate
- Supplies feedwater to steam generators





Incident Description

- Steam generation system only operated on weekday shifts, shut off for nights and weekends
- Friday March 31, 2017
 - Operators notice a leak from bottom of SCR
 - Contact local welding company
 - Company unavailable until Monday, April 3
- Continued operating steam system Friday 3/31
- Shut system down as normal Friday evening
- Monday April 3, 2017
 - Operator begins normal startup routine, ~6am
 - At around 7:20am, SCR explodes





Safety Issues

- Pressure Vessel Corrosion
- Pressure Vessel Inspection
- Pressure Vessel Repair
- Safety Management Systems



Pressure Vessel Corrosion

- Excessive thinning found in SCR bottom head
- Thinning caused by oxygen corrosion
- Oxygen Corrosion in steam systems results from dissolved oxygen in boiler feedwater
- Loy-Lange had chronic corrosion failures in its steam system
- Oxygen likely entered steam system during routine startup
- Loy-Lange and its contractors did not adequately remove oxygen from the steam system water (deaeration and chemical treatment)



Pressure Vessel Inspection

- SCR never inspected while in service, by any party
- Loy-Lange had no in-house inspection program
- Loy-Lange knew about the corrosion, contractors recommended inspection
- SCR never inspected by City of St. Louis (jurisdictional authority)



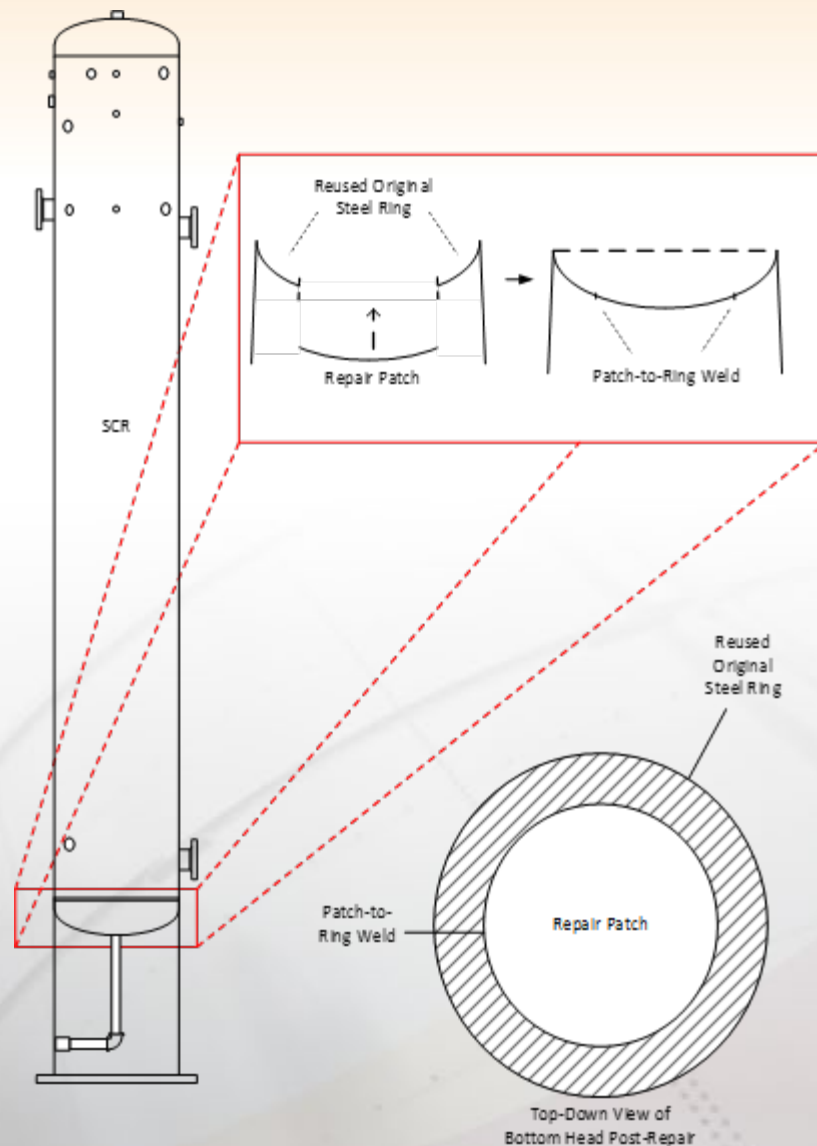
Pressure Vessel Repair

- In 2012, Loy-Lange hired Kickham Boiler and Engineering to repair the SCR – leaking
- Repair left unacceptably thin material in place
- Repair did not conform to National Board code
- Material left in place continued corroding until failure in 2017
- Repair Inspector did not detect non-conforming repair



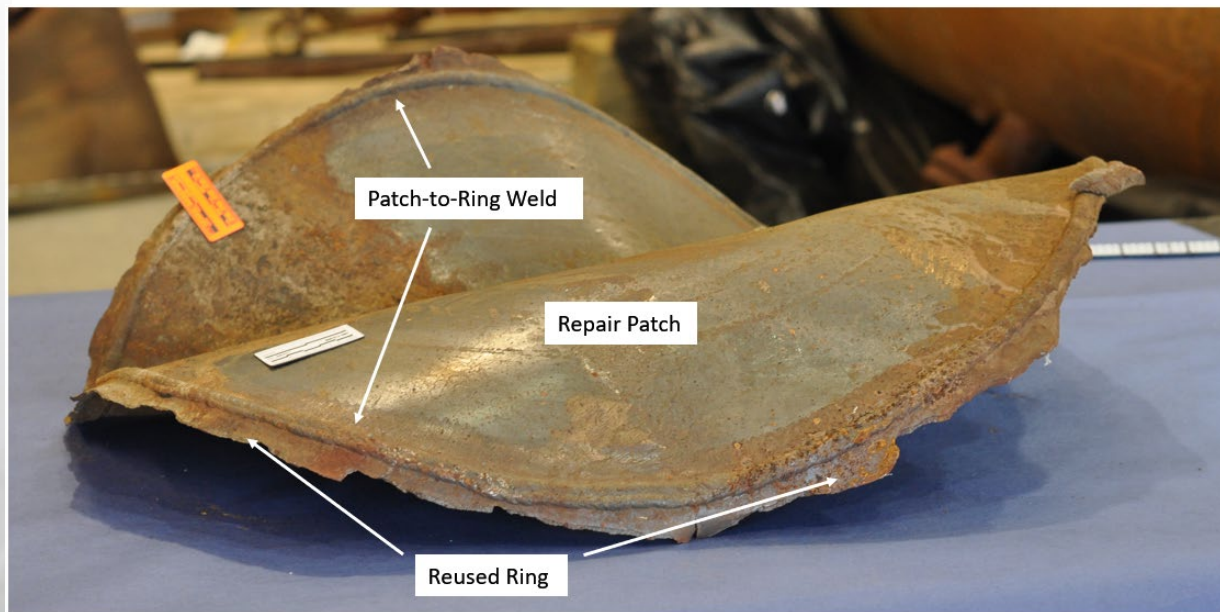
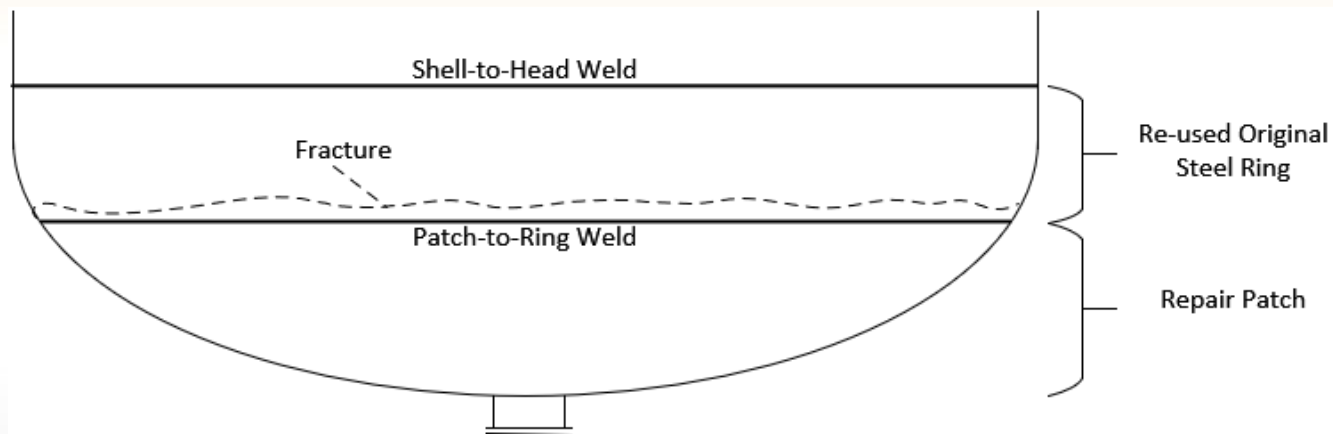
Repair Highlights

- Kickham removes lower head and skirt from shell
- Cut out center portion of bottom head
 - Left in place a ring of original steel
- Re-welded lower head and skirt assembly back onto shell





Repair Highlights





Safety Management Systems

- Loy-Lange had inadequate safety management systems:
 - No corrosion management program
 - No incident investigation
 - No mechanical integrity or inspection programs
 - Inadequate operating procedures
 - Insufficient hazard awareness



Recommendations

- Loy-Lange: 3
 - Centered around improving safety management systems
- The City of St. Louis: 3
 - Focused on closing gaps in pressure vessel regulation
- Arise: 1
 - Close gaps in company repair and alteration inspection and acceptance process
- National Board of Boiler and Pressure Vessel Inspectors (NBBI): 1
 - Close gaps in NBBI repair and alteration inspection and acceptance process



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