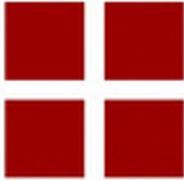


# PRESSURE VESSELS AND CORROSION

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STEVE WALKER, PE

DAKOTA STEARNS, PE

 **WALKER**  
Engineering, P.C.



*Idaho Society of  
Professional Engineers*

2025 Annual Meeting, June 12 & 13

# HISTORY

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**Newcomen Engine 1760**

**Park Bridge  
Ashton Under Lyne  
England**

**This pump was used to  
drain water from the  
Cannel coal pits**

**Henry Ford Museum**



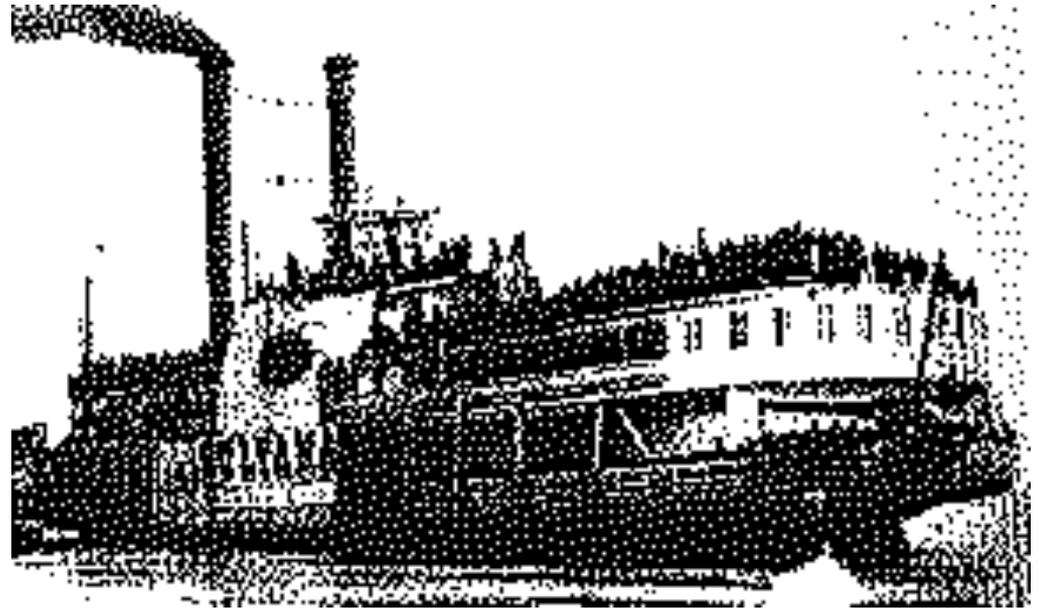


# HISTORY

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## **The Sultana – thousands killed!**

**The steamboat Sultana was a Mississippi River paddle wheeler which was destroyed in an explosion on 27 April 1865, the greatest maritime disaster in United States history. An estimated 1,700 of the Sultana's 2,400 passengers were killed when one of the overcrowded ship's four boilers exploded and the Sultana sank.**

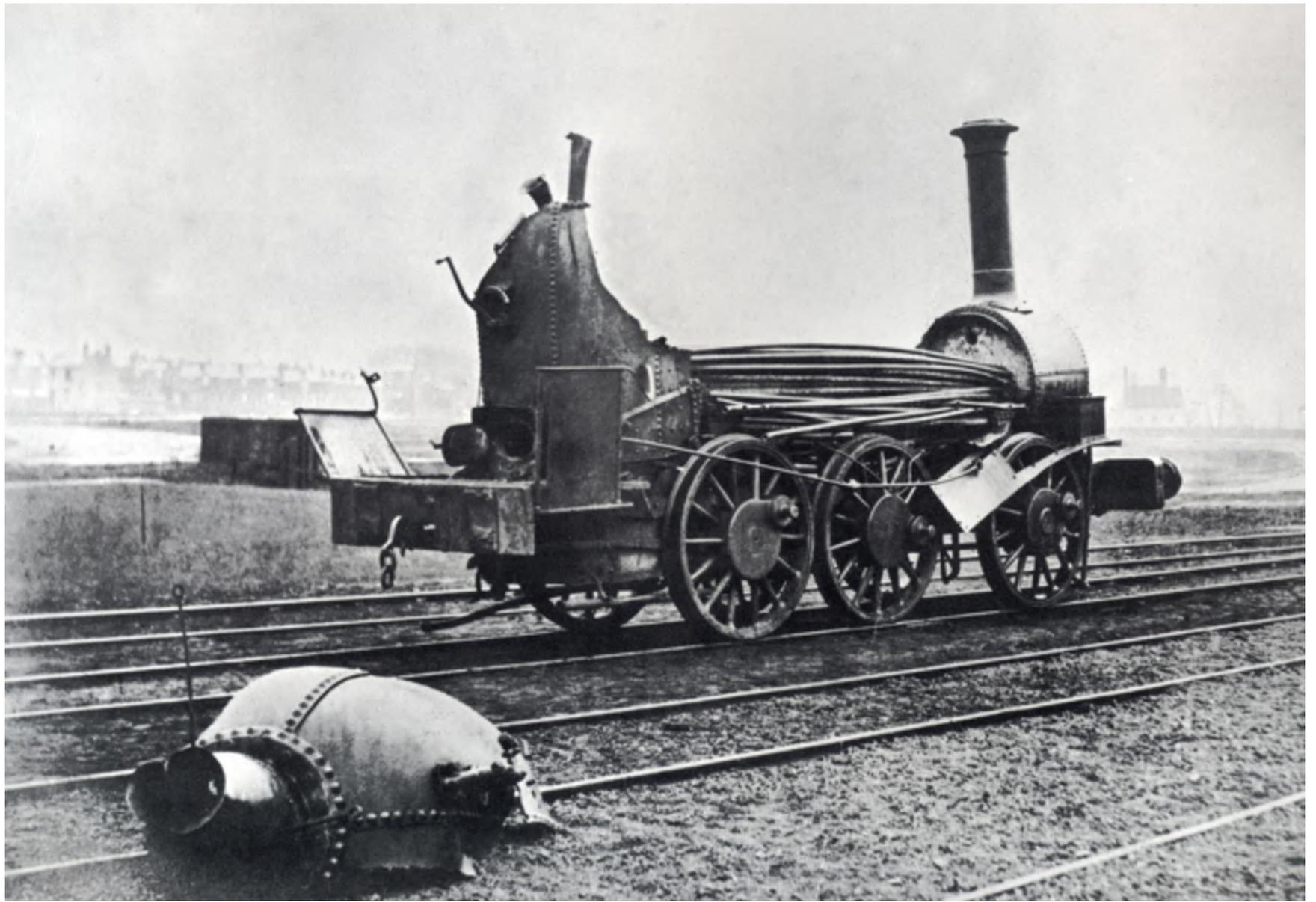


# **PUBLIC OUTCRY AT NUMBER OF EXPLOSIONS**

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**From 1870 to 1910, at least 10,000 boiler explosions were recorded in North America**

**By 1910 the rate of catastrophic boiler failures had jumped to between 1,300 and 1,400 per year**



# BOILER CODE – DEVELOPMENT

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**ASME  
Boiler Code Committee  
formed in 1911**

**Boiler Code  
published 1914-15**



# RECENT EXPLOSIONS

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**The fire that reduced Malden Mills to rubble on the evening of December 11, 1995 was one of the worst in the state's history.**

**Seven hundred people were at work in the factory when, at a little past 8:00 p.m., a boiler exploded in one of the mill buildings.**

**The explosion was so powerful that it ruptured gas mains; fire quickly engulfed the buildings. Employees fled into the streets; 33 were injured, four of them critically.**



# THE CODE

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Or more properly, ASME:

Section I for Power Boilers

Section IV for heating boilers

Section VIII, Division 1 for pressure vessels

Section X for FRP pressure vessels

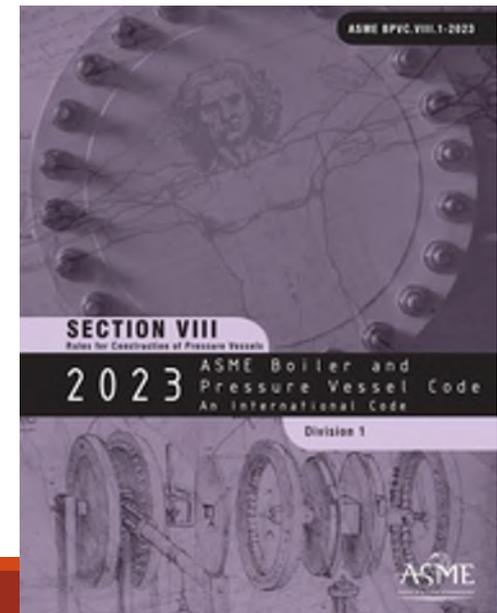
Legal standing – adopted by Idaho (eliminated 2008)

Idaho has no supplemental statutes

United States – adopted by all states  
(except Idaho and Wyoming)

Canada – uses Code, requires a CRN (Canadian  
Registration No.)

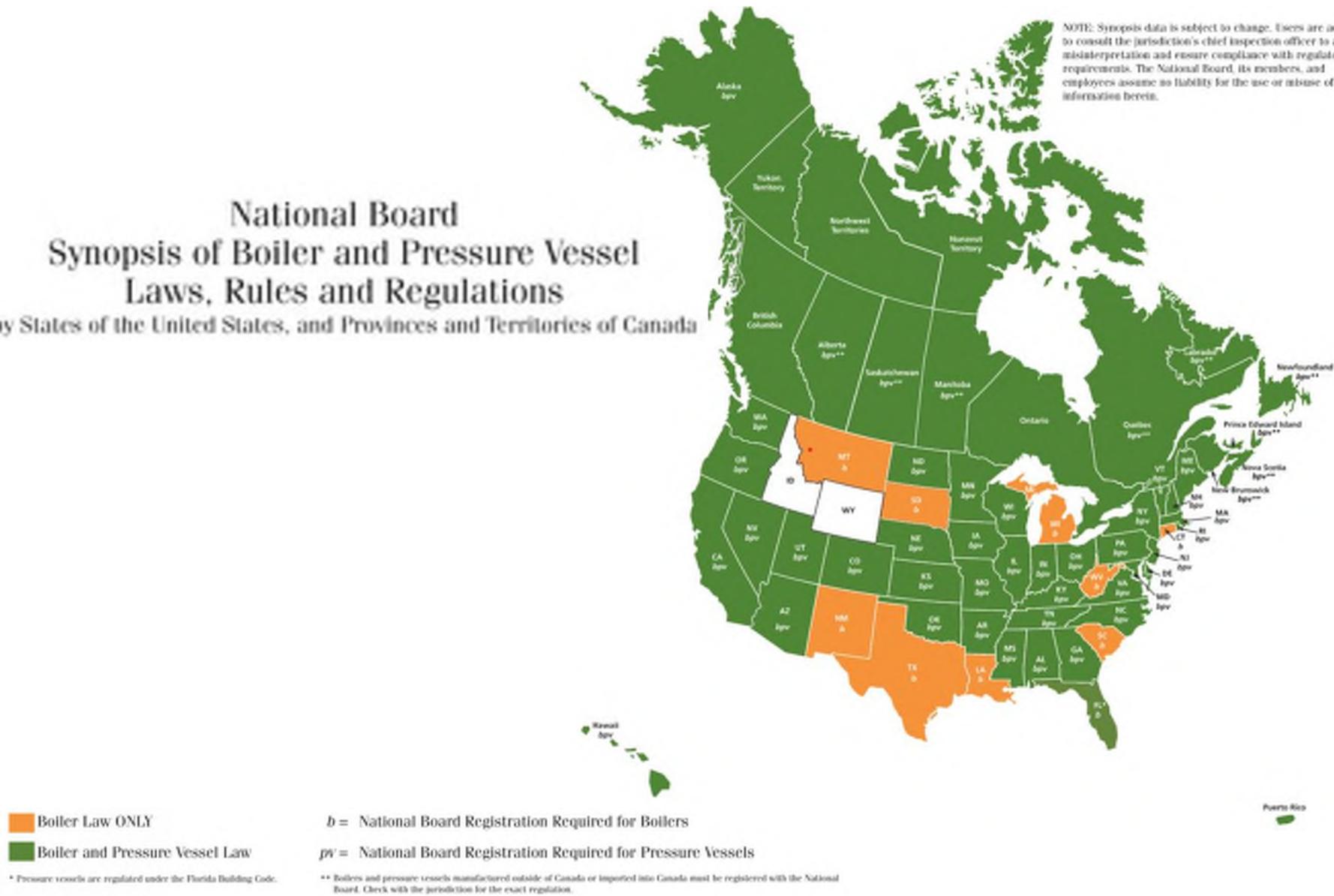
Worldwide – used by most countries except  
European Union



# National Board Synopsis of Boiler and Pressure Vessel Laws, Rules and Regulations

by States of the United States, and Provinces and Territories of Canada

NOTE: Synopsis data is subject to change. Users are advised to consult the jurisdiction's chief inspection officer to avoid misinterpretation and ensure compliance with regulatory requirements. The National Board, its members, and employees assume no liability for the use or misuse of the information herein.



# WHAT THE CODE COVERS

**Pressure design – 15 + PSI and full vacuum**

- **Stress analysis and design criteria**

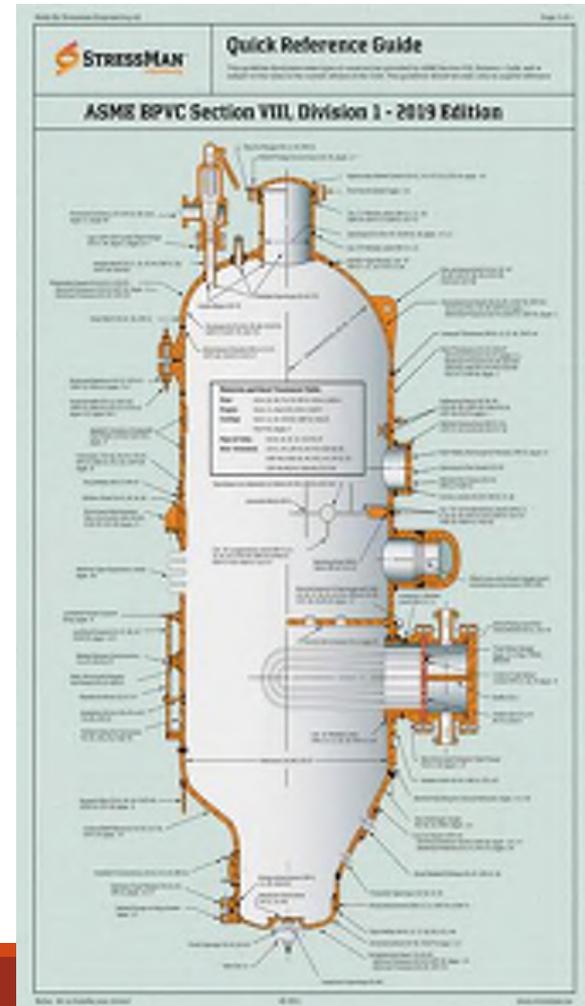
**Materials – steel, alloys and fiberglass**

**Forming processes – cold and hot forming, forging, etc.**

**Fabrication methods – welding and brazing**

**Testing – hydrostatic versus pneumatic**

**Pneumatic testing – blast analysis required**



# WHAT THE CODE DOES NOT COVER

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**Structural loads – ASCE 7**

**Seismic loads – ASCE 7**

**Wind loads – ASCE 7**

**Snow loads – ASCE 7**

**Thermal expansion loads – ASME B31.3 Process Piping**

**Other loads (nozzles, accessories, etc.)**

**Corrosion monitoring and control – corrosion allowance best practice**

**Inspection and maintenance – API 510 widely used**

# WHAT A BUYER OR OWNER SHOULD DO

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## Buying a vessel

**Specify all operating parameters – pressure, temperature, flow, state, etc.**

**Provide fluid properties**

**Consider all other load conditions in addition to pressure (particularly cyclic loads)**

**Specify a corrosion allowance (CA)**

**Consider material selection and fabrication method**

**Provide method for overpressure protection**

**Verify manufacturer is an ASME certified shop**

# RECEIVING A VESSEL

## Obtain ASME Form U-1 (archive)

- Verify filled out correctly, i.e., corrosion allowance, pressure, temperature, etc.

## Verify nameplate on vessel

## Locate vessel so nameplate is visible

FORM U-1 MANUFACTURER'S DATA REPORT FOR PRESSURE VESSELS  
As Required by the Provisions of the ASME Code Rules, Section VIII, Division 1

1. Manufactured and tested by: BARCLAY MECHANICAL SERVICES, INC., 483 W. 100 SOUTH HIGHWAY 25, HAZARD, IN 46027  
(Name and address of Manufacturer)

2. Manufactured for: Continental Sugar Co. 500 W. Park 48347  
(Name and address of Purchaser)

3. Location of installed at: Continental Sugar Co. 500 W. Park 48347  
(Name and address)

4. Size: Vertical SA-240 225'-8 51701 2008  
(Type, with 25 gpm) (Type, diameter, for vessels, diam. and, etc.) (Height, shell H<sub>s</sub>) (CRN) (Design No.) (Mfg. date) (Year built)

5. ASME Code, Section, Div. 1: 2004, 2005  
(Edition and Addenda (date)) (Code Case No.) (Special Allowance per UG-119(c))

6. Shell: (a) No. of welds: 4 (b) Overall length: (ft. in.): 517'-8  
(a) No. 5-11' (to be completed for single wall vessels, jackets of jacketed vessels, shell of shell-in-jacket vessels)

No.	Chord (in.)	Height (ft. in.)	Size, Class or Type	Mat.	Corr.	Type	Full. Shell	Plate	HT	Temp.	Full. Shell	Plate	HT	Temp.
181	28'-5"	50'	SA-240 Ty 204L	509		1	Spw	85		200	85		200	

7. Heads: (a) SA-240 Ty 204L (b) SA-240 Ty 204L  
(Shell Spec. No., Class or Type) (M.T. or T.M.P.) (Shell Spec. No., Class or Type) (M.T. or T.M.P.)

Location (Top)	Thickness	Radius	Material	Corrosion Allowance	Design Pressure	Design Temperature	Full. Shell	Plate	HT	Temp.	Full. Shell	Plate	HT	Temp.
Top	509	192	SA-240	10.5	1	200	Spw	85		200	85		200	
Bot	509	192	SA-240	10.5	1	200	Spw	85		200	85		200	

8. Type of jacket: Jacketed  
(Describe jacket type & wall, etc.)

9. Jacket shell dimensions: Jacketed  
(Describe jacket type & wall, etc.)

10. Jacket design: SA-240 Ty 204L  
(Material, thickness, etc.)

11. Purpose, Storage, Process, Other  
(Describe use or intended use)

12. Temperature: 200  
(Design, shell spec. No.) (Max. in. subject to stress) (CRN) (Design, shell spec. No.) (Max. in. subject to stress)

13. Location: Continental Sugar Co. 500 W. Park 48347  
(Name, address, city, state, zip)

14. Material: SA-240 Ty 204L  
(Material, thickness, etc.)

15. Design: SA-240 Ty 204L  
(Design, shell spec. No.) (Max. in. subject to stress) (CRN) (Design, shell spec. No.) (Max. in. subject to stress)

16. Heads: (a) SA-240 Ty 204L (b) SA-240 Ty 204L  
(Shell Spec. No., Class or Type) (M.T. or T.M.P.) (Shell Spec. No., Class or Type) (M.T. or T.M.P.)

Location (Top)	Thickness	Radius	Material	Corrosion Allowance	Design Pressure	Design Temperature	Full. Shell	Plate	HT	Temp.	Full. Shell	Plate	HT	Temp.
Top	509	192	SA-240	10.5	1	200	Spw	85		200	85		200	
Bot	509	192	SA-240	10.5	1	200	Spw	85		200	85		200	

# OWNING A VESSEL

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**Register with State – a tag is required (not in Idaho)**

**Inspect periodically – inside and outside**

**Test and maintain safety relief valves**

**Inspections may be required/done by the insurance carrier**

**Maintain a file of registration forms and inspections**

**Do not weld on pressure boundary!**

- **This requires an R stamp certified welding shop**

**Recertification is required for operating vessel outside design conditions**

**Do not lose nameplate!**

# INSPECTION AND MAINTENANCE

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**Corrosion – primary reason for most vessel failures**

**Corrosion prevention/reduction**

- **Proper material selection**
- **Post weld heat treatment**
- **Filtration – remove corrosive agent**
- **Chemical treatment of water, etc.**
- **Paint or lining**
- **Chemical treatment of steel**
  - **Passivation**



# INSPECTION AND MAINTANENCE

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## **In-Service Inspection**

- **API 510 certified inspectors**

## **Non-Destructive Testing (NDT)**

- **Liquid Penetrant Testing (PT)**
- **Magnetic Particle Testing (MT)**
- **Ultrasonic Testing (UT)**
- **Radiographic Testing (RT)**

**Destructive testing – obtain a sample**

**Determine corrosion rate inches/year**

**Maintenance plan and life of vessel estimate**

- **Use API 510 for vessel lifespan estimate**
- **Life = Corrosion allowance/corrosion rate**

# CONSEQUENCES

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## Health and safety issues

### Leaking dangerous fluids or gasses:

- High temperature
- High pressure
- Toxic fluids

## Structural failure leading to catastrophic failure

### Legal and compliance issues

- OSHA fines
- Lawsuits
- Increased insurance costs or cancellation

### Downtime and financial loss

- Replacement or repair takes time and resources

# CONSEQUENCES cont.

**Loy-Lange Box Company  
Use of steam for product  
processing.**

**Lack of:**

- 1. Government oversight, i.e., registration, inspection, etc.**
- 2. Operational good practices**
- 3. Corrosion monitoring and prevention**
- 4. Proper code repair weldments**

The image shows the cover of a report from the U.S. Chemical Safety and Hazard Investigation Board (CSB). The title is "Pressure Vessel Explosion at Loy-Lange Box Company" with the location "St. Louis, MO" and incident date "April 3, 2017" (No. 2017-044-MO). The report is titled "Investigation Report" and was published on July 28, 2022. The cover features three photographs: a large pile of debris from a destroyed structure, a close-up of a damaged pipe, and a large pipe being lifted by a crane. A red box on the right lists "KEY ISSUES: Pressure Vessel Corrosion, Pressure Vessel Inspection and Regulation, Pressure Vessel Repair, Process Safety Management Systems".

**CSB**  
U.S. Chemical Safety and  
Hazard Investigation Board

**Pressure Vessel Explosion at  
Loy-Lange Box Company**  
St. Louis, MO | Incident Date: April 3, 2017 | No. 2017-044-MO

**Investigation Report**  
Published: July 28, 2022

**KEY ISSUES:**

- Pressure Vessel Corrosion
- Pressure Vessel Inspection and Regulation
- Pressure Vessel Repair
- Process Safety Management Systems

# Questions?

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■ ■ WALKER  
■ ■ Engineering, P.C.