

# Workshop

# Safety in Boilers & Fired Systems

# Program

## Part 1

- Fundamental Concepts of Safety in Boiler & Fired Systems (30 minutes)
- Safety Risks & Recommendations of Prevention Measures (30 minutes)

Break: 10 minutes

## Part 2

- Safety Instrumented Systems applications in Boilers and Fired equipment (30 minutes)
- Hazard Assessment and Controls (40 Minutes)

Break: 10 minutes

## Part 3

- Guidelines for a Safety Management Plan applied Boilers & Fired Systems (30 minutes)
- Basic Financial Evaluation and Benefits for improving, safety and efficiency (40 minutes)

## Workshop Objective

To transfer



Fundamental concepts of Safety Risks

To promote



Safety Risk Prevention

The integration/interface  
of OHS System & Process Safety  
Management System

To create



Safety Awareness

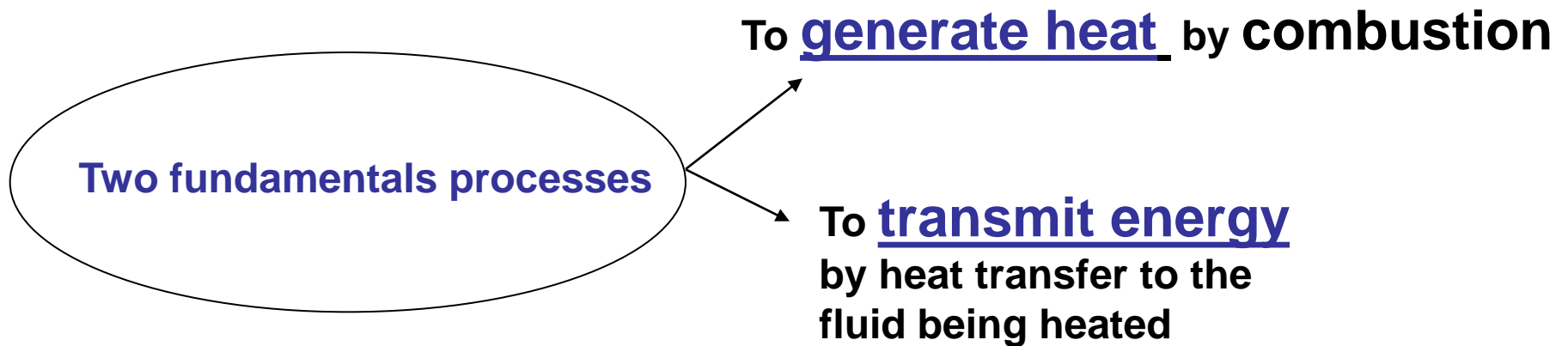
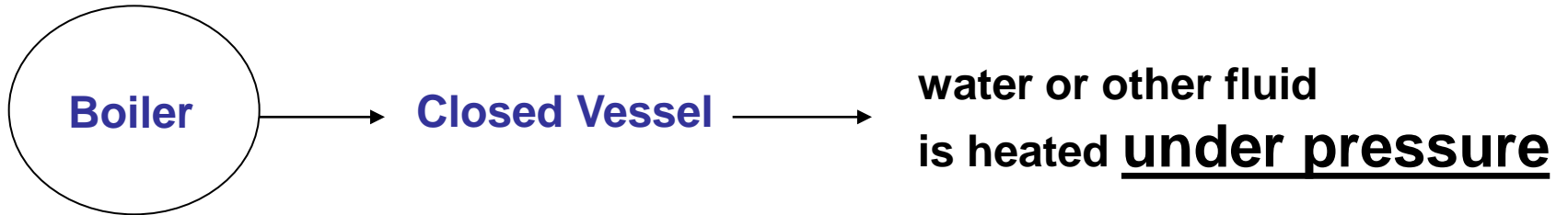
To promote



The economical benefits obtained  
by improving safety and efficiency

**Part 1**

# Fundamental Concepts of Safety in Boilers & Fired Systems



# Classification

## ASME Boiler and Pressure Vessel Code

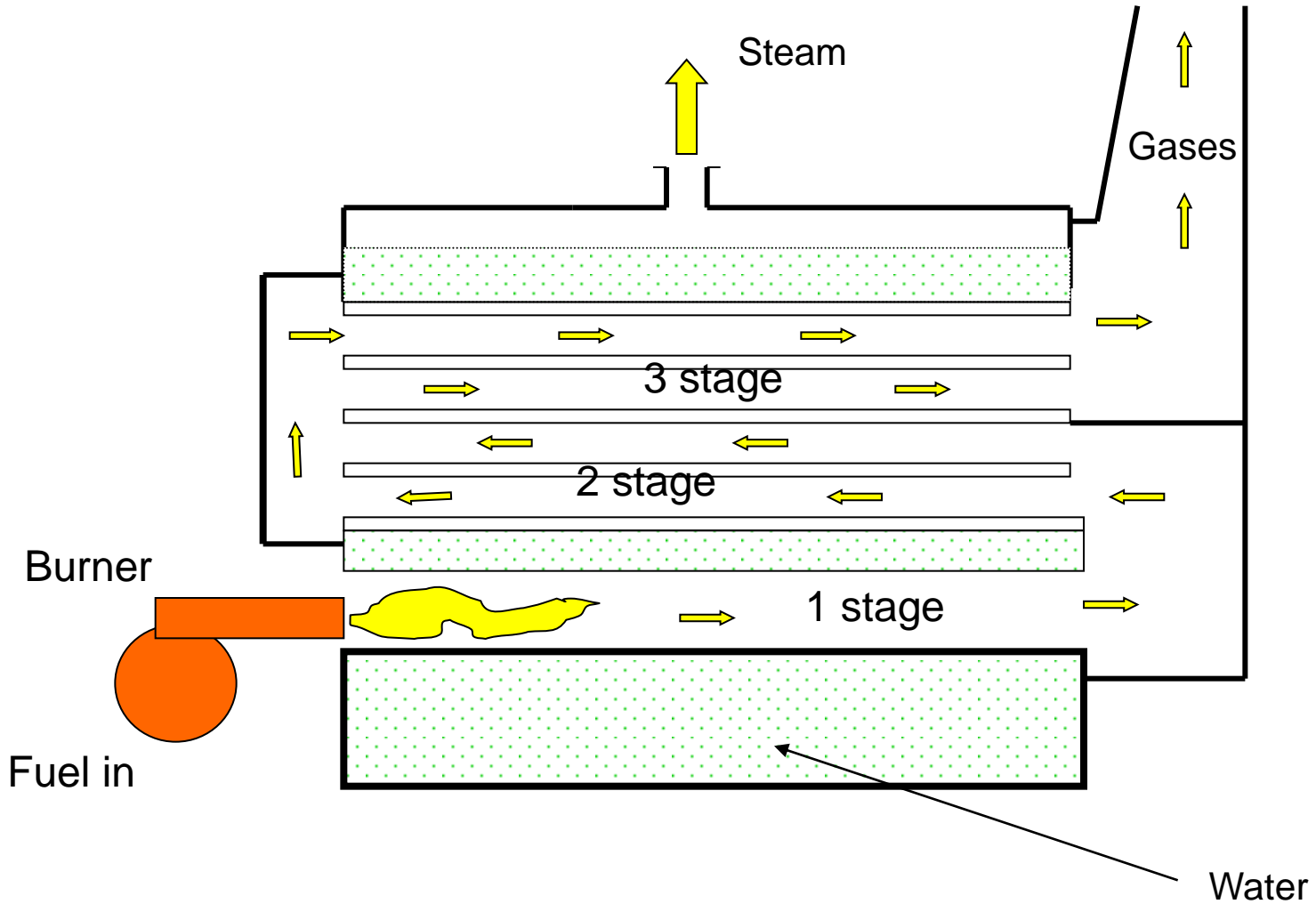
### Section I Power Boilers – process boilers, power boilers and high-pressure boilers

- Steam at a pressures exceeding *15 psig*
- High temperature water at pressures exceeding *160 psig* and or temperatures exceeding *250 degrees F*

### Section IV Heating Boilers - commercial boilers, industrial boilers, heating boilers, low pressure boilers

- Steam at a pressures not exceeding *15 psig*
- High temperature water boilers at pressures not exceeding *160 psig* and or temperatures exceeding *250 degrees F*

# Fire Tube Boilers



# Fire Tube Boilers

## Advantages

- Easy to install and operate
- Simple construction
- Less rigid water treatment requirements

## Disadvantages

- Risk of catastrophic failure due to the high stresses
- Inability to respond quickly

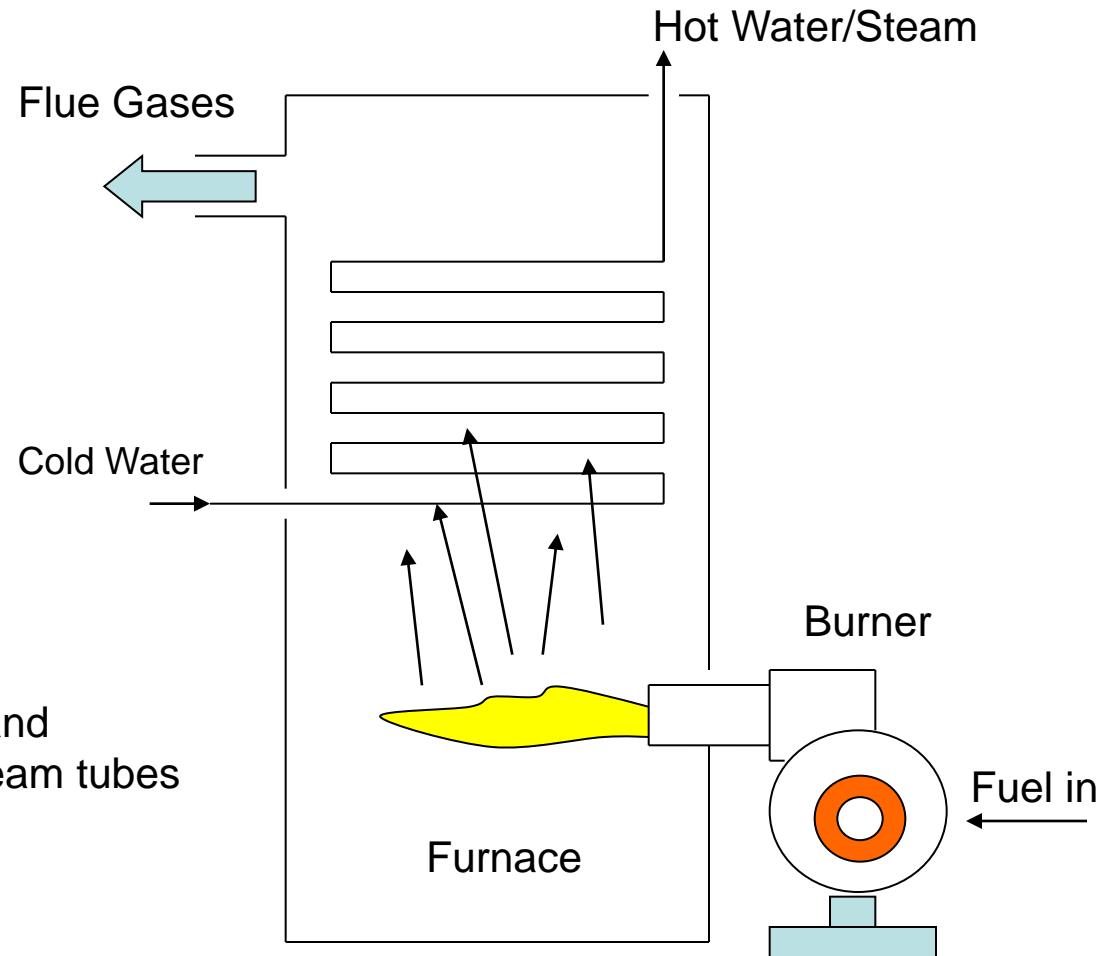
# Water Tube Boilers

## Advantages:

- **Low risk** of disastrous explosion compared to fire box boiler
- A greater flexibility for responding to load changes
- Higher Efficiencies than Fire Tube Boilers

## Disadvantages:

- The supply water has to be pure and specially treated to protect the steam tubes
- Water tube boiler systems are often complicated require special maintenance procedures



## Incidents in Boilers & Pressure Vessels (2001)

	Accidents	Injuries	Fatalities
Power Boilers	296	56	7
Heating Boilers: Steam	<b>1091</b>	0	1
Heating Boilers: Water (includes hot water supply)	<b>631</b>	10	0
Unfired Pressure Vessels	201	18	<b>4</b>
Total	2219	84	12

The U.S. National Board of Boiler and Pressure Vessel Inspectors report  
Source : [http://www.steamcycle.com/safety\\_issues.pdf](http://www.steamcycle.com/safety_issues.pdf)  
<http://www.steamcycle.com/>

## Incidents occurring in power boilers in 2001

Cause of Incident	Accidents	Injuries	Deaths
Safety Valve	4	0	0
<b>Low-Water Condition</b>	<b>161</b>	3	0
Limit Controls	8	0	0
Improper Installation	2	0	0
Improper Repair	1	0	0
Faulty Design or Fabrication	2	0	0
<b>Operator Error or Poor Maintenance</b>	<b>82</b>	<b>50</b>	<b>7</b>
Burner Failure	29	2	0
Unknown/Under Investigation	7	1	0
Subtotal	296	56	7

The U.S. National Board of Boiler and Pressure Vessel Inspectors report

Source : [http://www.steamcycle.com/safety\\_issues.pdf](http://www.steamcycle.com/safety_issues.pdf)

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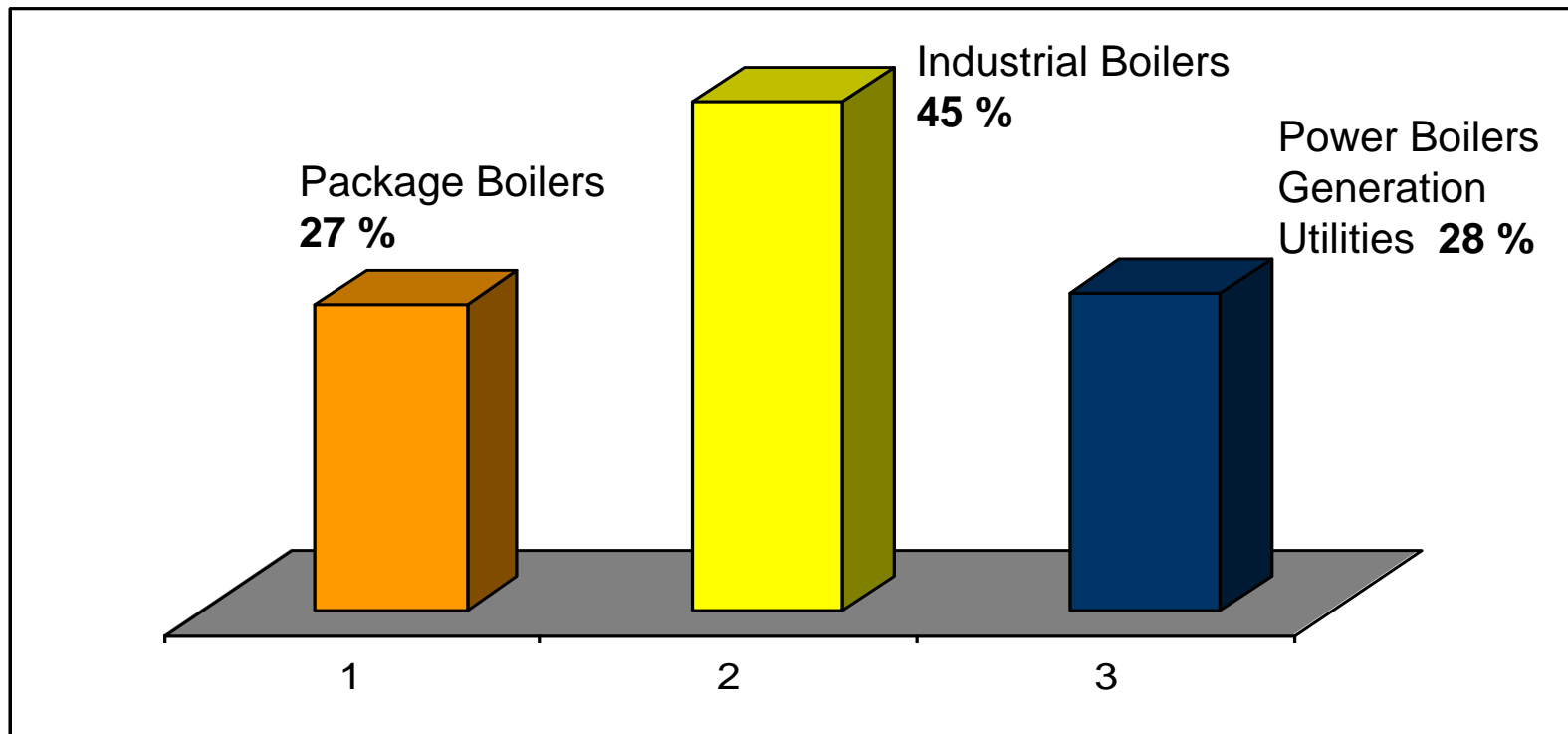
## Boiler Incidents

Incident	Quantity	%
Low level of water	359	49
Poor operation and maintenance	262	35.7
Poor design	54	7.3
Poor controls	17	2.3
Failure in Burners	16	2.2
Unknown problems	16	2.2
Not adequate installation	5	0.6
Safety valves	2	0.35
Poor repairs	2	0.35
<b>TOTALS</b>	<b>733</b>	<b>100</b>

*National Board of Boiler and Pressure Vessel Inspectors USA. 2002*

Source: <http://www.thermal.cl/>

# Explosions in Boilers



Data provide by an International Boiler Manufacturer

Source: [www.dacs.com.ar](http://www.dacs.com.ar)

# Explosions in Boilers

<b>Causes of Explosions</b>			
<b>Type of Boilers</b>	<b>Operation Failure</b>	<b>Equipment Failure</b>	<b>Both Failures (Operation + Equipment)</b>
<b>Package</b>	<b>44%</b>	<b>49%</b>	<b>7%</b>
<b>Industrial</b>	<b>71%</b>	<b>22%</b>	<b>7%</b>
<b>Power (Utilities)</b>	<b>74%</b>	<b>21%</b>	<b>5%</b>

Data provide by an International Boiler Manufacturer

Source: [www.dacs.com.ar](http://www.dacs.com.ar)

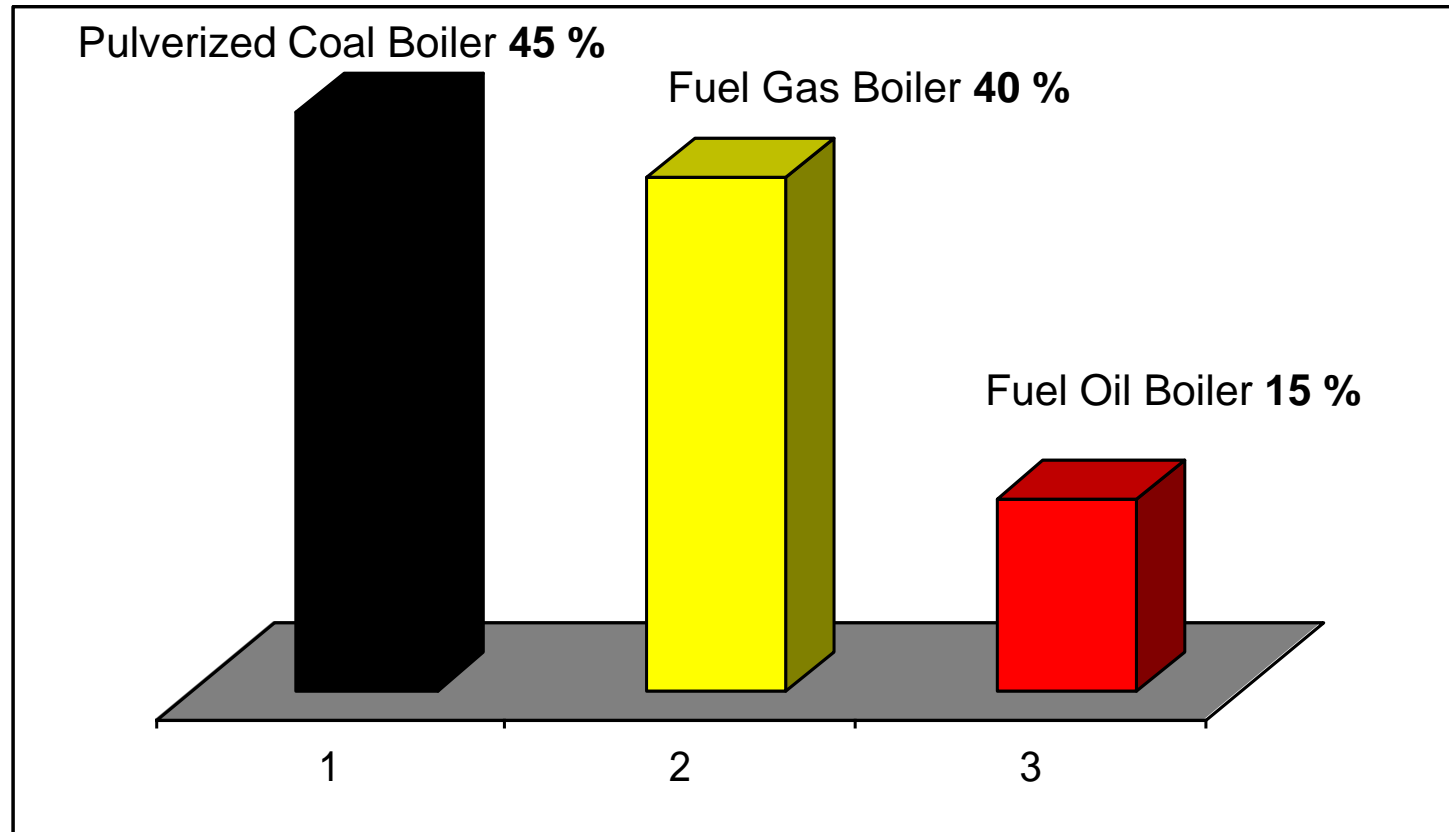
## Explosions in Boilers

Type of Boilers	% of Explosions during Start Up	% of Explosions at Low Load	% of Explosions Start Up or Low Load
Package	63 %	32%	95%
Industrial	47%	45%	92%
Power (Utilities)	60%	32%	92%

Data provide by an International Boiler Manufacturer

Source: [www.dacs.com.ar](http://www.dacs.com.ar)

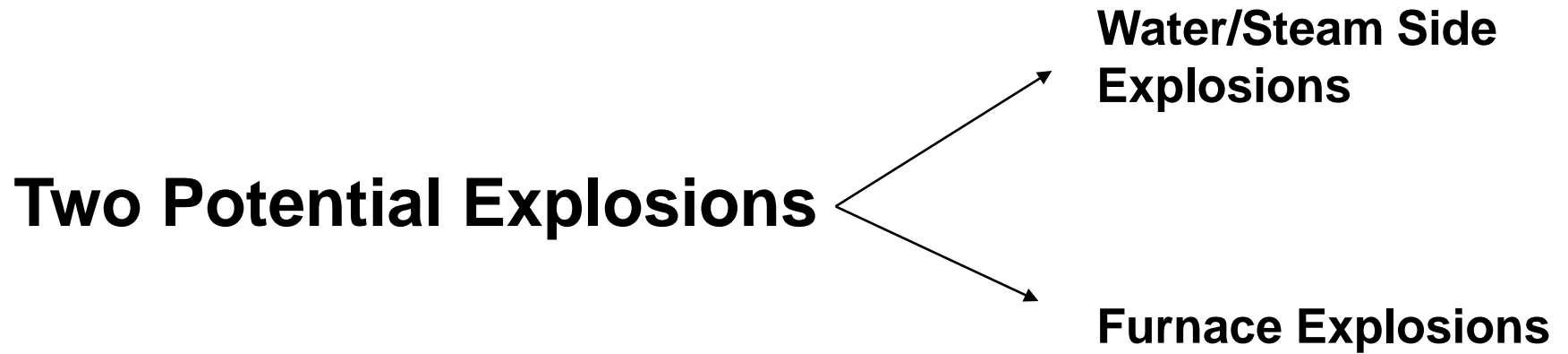
# Explosions in Boilers



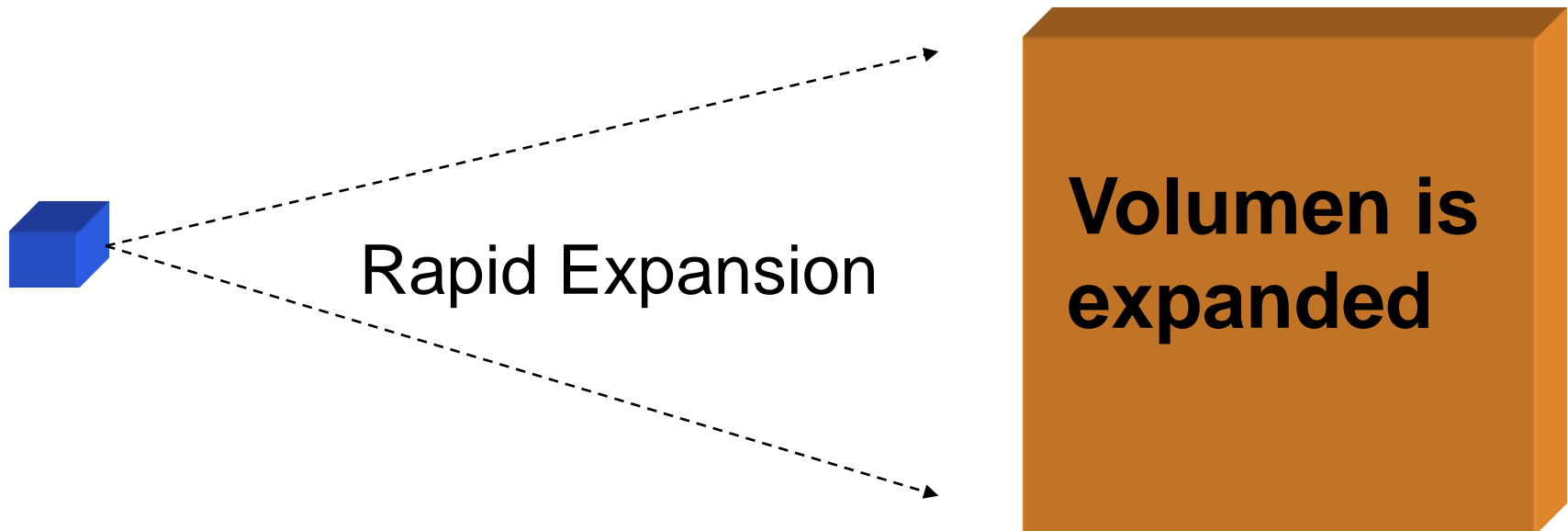
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# Boiler Room



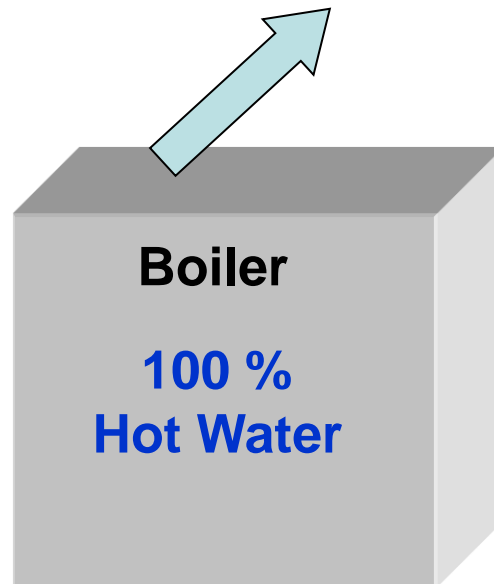
# Water/Steam Side Explosions



Water flashing to Steam expands **1700 (approx)** times its original volume within a few microseconds

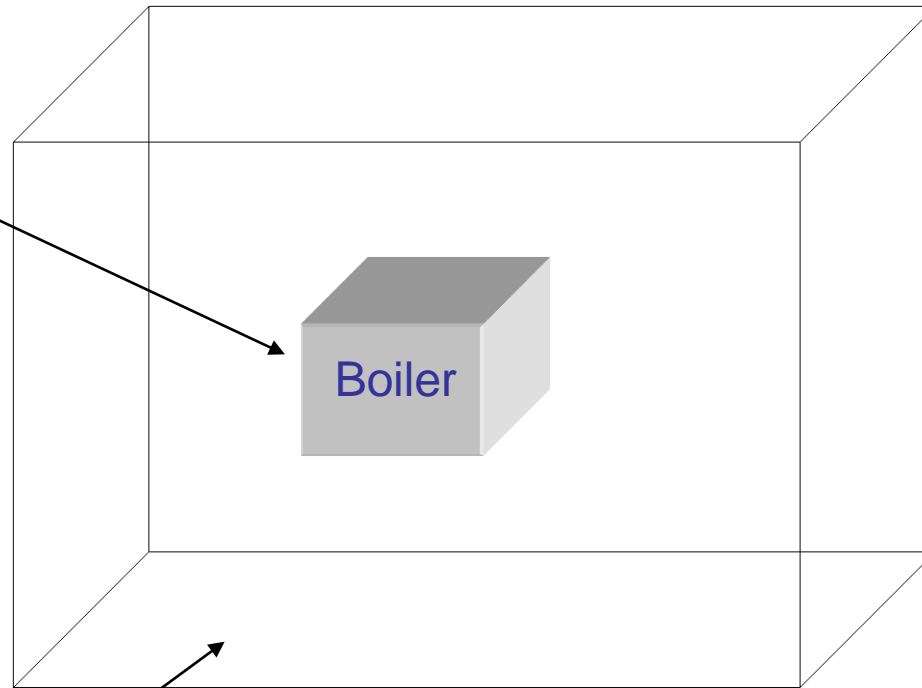
## At the Steam Explosion

**15-20 % of water will  
Instantaneously Flash to Steam**



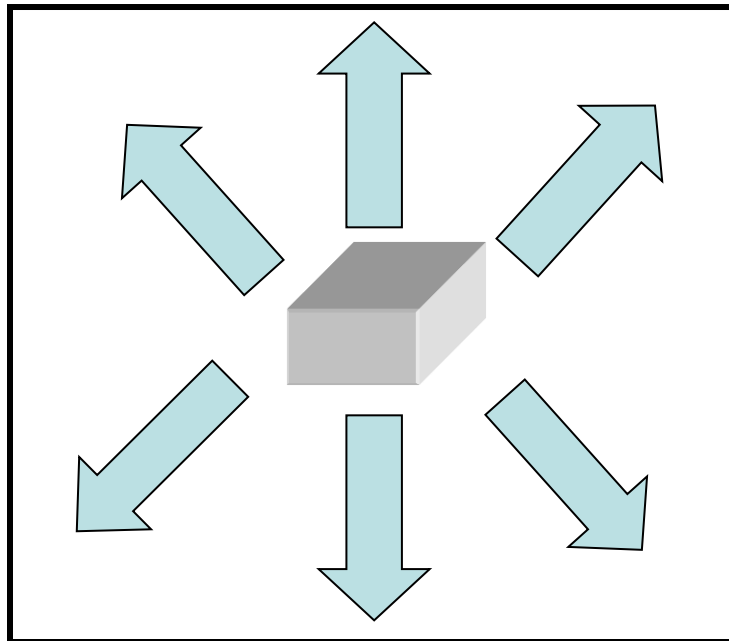
## Example: Before Steam Explosion

Boiler contains  
**2000** Gallons  
of water at  
120 psi  
350 F



**Volumen of Boiler Room :  $10 \times 20 \times 20 = 4,000$  cubic feet**

## Example: At the Steam Explosion



Boiler Room

Suddenly hot water turns into  
Steam producing  
**64,000** cubic feet of steam  
expanding inside of Boiler Room

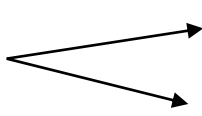
16 times its original volume

Over pressure of the structure

# Case Study # 1

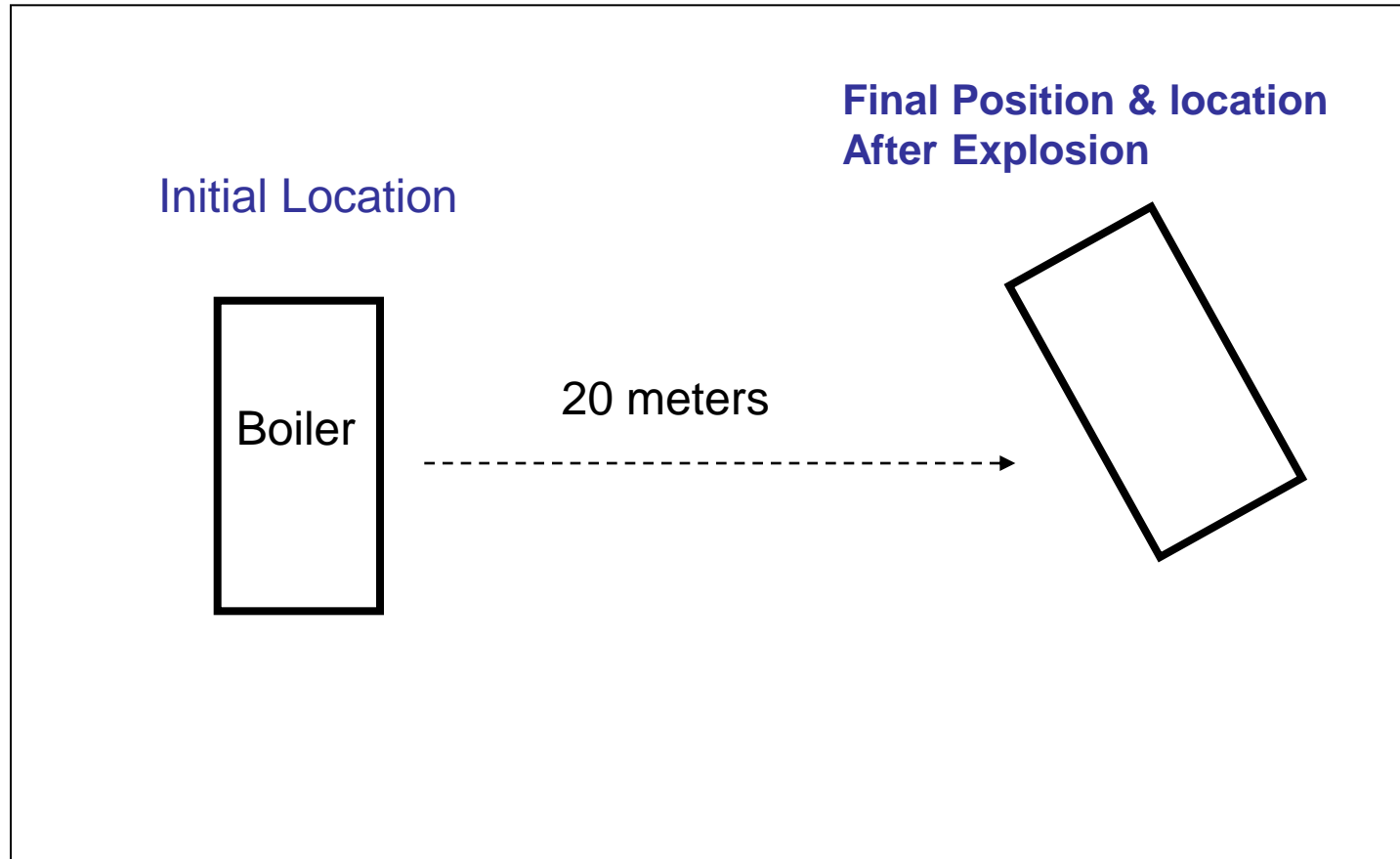
## Boiler Water/Steam Side Explosion

**Activity: Rubber products manufacturer for the automotive industry**  
200 employees

**Boiler # 2 exploded**  Extensive damage  
Time: 2:00 PM (3) Employees serious injuries

The high-pressure fire tube boiler was operating concurrently with a second high-pressure boiler (boiler #1).

Both boilers were online to handle the steam demand of plant operations.



**1 million dollars** in property damage + others costs **\$\$\$\$\$**

## The Investigation Committee considered the following factors

- The operation of the boilers at the time of the explosion,
- Past and current maintenance,
- Boiler attendance and operation logs, audible and visual alarms,
- Past inspections and findings,
- Installation and condition of controls and safety devices,
- Witnesses

## Causes of the Accident

**cause**



Sudden introduction of feed water to the boiler

- At the time of the explosion the boiler was operating in a dry-fired state

**Before the explosion**



inoperative controls and safety devices  
allowed boiler #2 to continue to fire

# Factors contributing to the Accident

- Lack of Standard Operating Training
- Inadequate boiler operating procedures (SOP)
- Inadequate boiler attendance  
The maintenance man (boiler operator) visits the boiler room each two (2) hours rather than 30 minutes required by the provincial authority of Boiler
- Improper boiler maintenance
- Inoperative boiler controls and safety devices

## Date Inspections recorded by the company

September 15, 2003 Internal

June 18, 2004 Internal

September 17, 2004 External

October 6, 2005 Internal

October 5, 2006 Internal

October 2, 2007 Internal

January 6, 2008 External

The required external inspections  
**were not performed** between  
September 17, 2004 and January 6, 2008

All controls and safety devices would have been tested during that inspection

# Furnace Explosions

It is usually the result of ignition and instantaneous combustion of highly flammable gas, vapor, or dust that has accumulated in a boiler.

## Important

Before to attempting to light any gas, fuel oil or pulverized coal boiler, **the furnace must be purged** of any ignitable vapor or dust by operating the combustion air fan (s) for specific period of time

# Case Study # 2

# Boiler Furnace Explosion

XXXX Electrical Power generation Company

**Dec 8 , 2007, 07:50 AM**

## At the Furnace Explosion:

Two (2) operators were working directly below the furnace on a pulverizer seal air fan when the explosion occurred

When the tubes failed , the vestibule was instantly pressurized, causing a secondary rupture of the boiler casing around the bottom of the furnace.

Ash and 550 F steam was then released into the area where the three workers were located

# Boiler Furnace Explosion

The boiler was operating at 1,800 psi at the time of the failure.

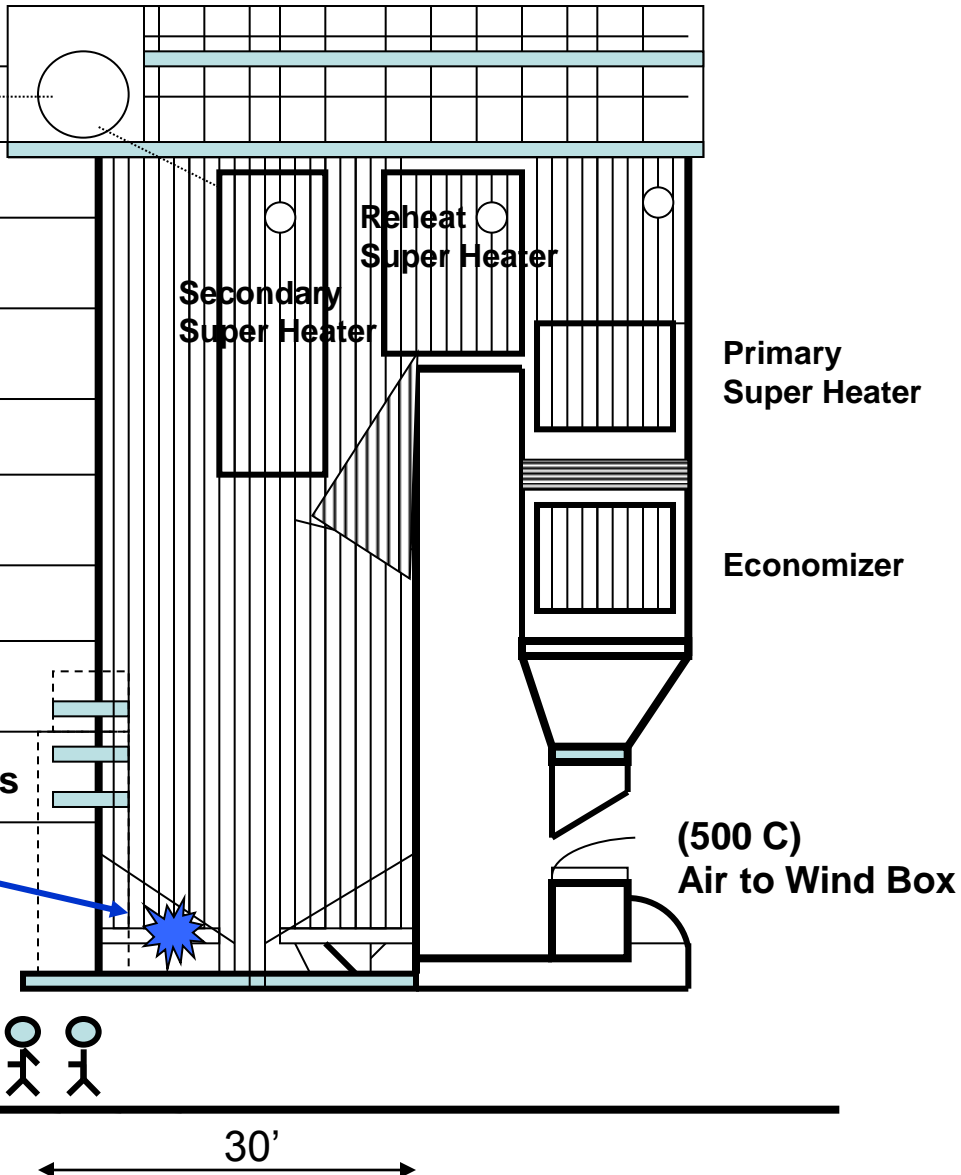
Number of fatalities : 2

130'

Location of Failure

Burners

Location of victims  
at times at time of accident



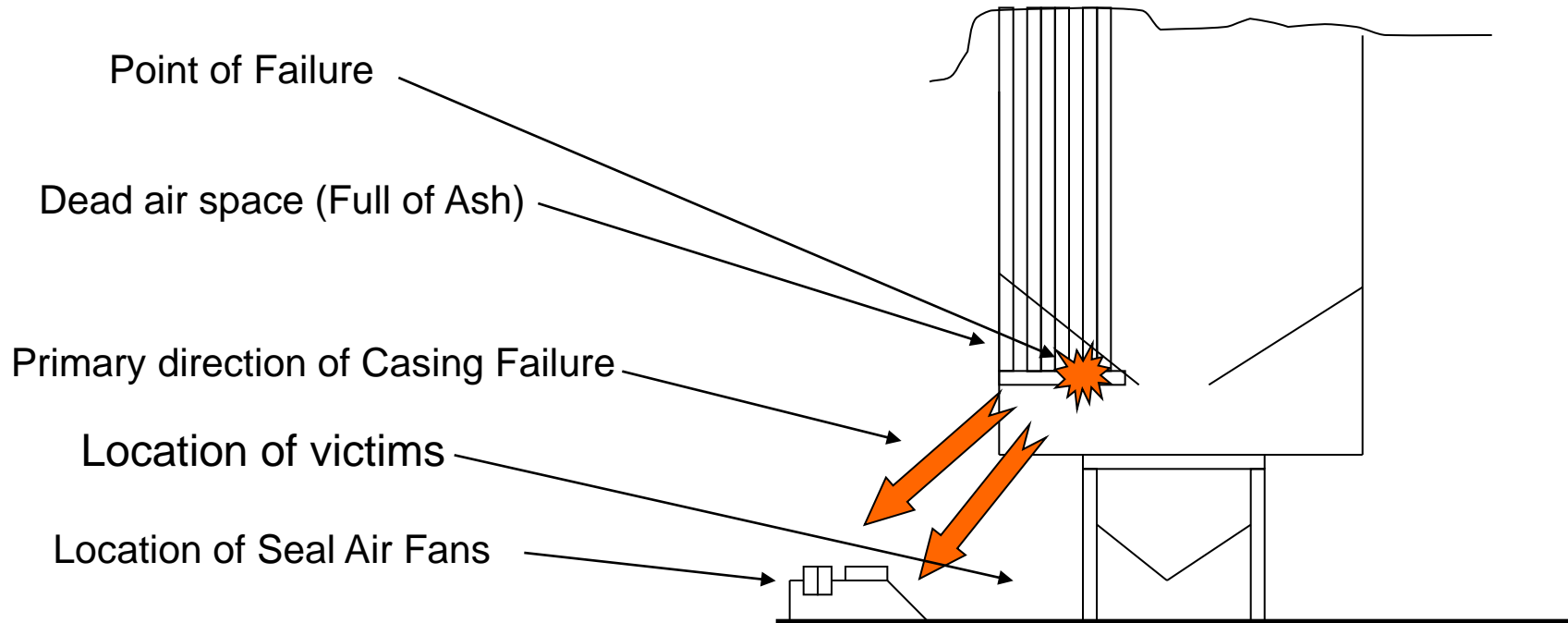
# Boiler Furnace Explosion

**The primary cause  
of explosion**

**Extensive corrosion of boiler tubes  
in the division wall at the  
East Furnace Lower Slope Dead Air Space**

**Consequence**

**A tube rupture caused a furnace explosion  
that killed three men.**

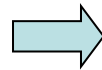


## Final Accident Report of Boiler Furnace Explosion

- The Final Accident Report found that extensive corrosion of the boiler tubes, caused by ash captured in the lower slope air space that had mixed with water introduced by furnace washes, was the cause of the explosion
- For the past 10 years or so, planned maintenance tasks were reduced
- At the time of the accident, approximately 2,000 work orders were pending.
- The report also noted that the dead air space had not been opened or inspected in at least 10 years and was full of ash at the time of the explosion

## Final Accident Report of Boiler Furnace Explosion

The Power Chief Engineer and  
the outside boiler inspector



Directly responsible for the explosion  
Because they failed to perform a  
comprehensive inspection as required  
by provincial law.

The catastrophe could have been prevented if proper inspections had been made of the entire furnace and more than visual inspection techniques had been used.

The Occupational Safety and Health Investigation Committee has found 12 serious safety violations at the plant, including failure to enter and inspect the area where the tube rupture occurred.

# Recommendations for Safety Professionals

- **Procedures**

For the training and certification of all boiler operators.  
Standard Operation (SOP) & Maintenance Procedures

- **All maintenance to the boiler associated equipment's controls and safety devices**

Must be performed by experienced, certified and qualified professionals

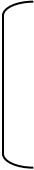
- **Boilers and associated equipment's controls and safety devices**

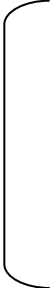
Must be tested in accordance with Standard /Codes by an experienced, certified and qualified professional


- **Steam Pressure Relief Valves**

Must be removed, inspected, and tested In accordance with standard/codes to ensure proper set pressure and operation.

# Recommendations for Safety Professionals

- **Audible and Visual Alarm System** 

Should be kept in excellent condition to ensure notification throughout the plant
- **Emergency and Evacuation procedures** 

Should be developed in case of a boiler incident, or accident.  
All employees should be made aware of these procedures.
- **Any type of incident, near miss or accident** involving a boiler, pressure vessel and associated equipment 

Should be reported immediately and recorded

# Recommendations for Safety Professionals

**When the company  
purchased an Used Boiler**

To obtain all historic information since its Construction Operation and Repairs , and then make all Inspections and tests in accordance with Local legislation

**Lack of training of operators**

Principal cause of accidents

**Remote monitoring system**

**Regular Checklist**

All mandatory inspections to the boilers must be performed in accordance with the requirement of the province Laws, Codes, Rules and Regulations by a certified boiler inspector.