



***25 Real Life Hazards.....
& WHAT TO DO ABOUT THEM!
(Boilers, fuels, steam systems)***



**AMERICAN SOCIETY OF
SAFETY PROFESSIONALS**

***ASSP – NEO Chapter Meeting
August, 2018***

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- having or showing knowledge of events before they take place

Who is John Puskar, P.E.?

Licensed Professional Engineer
Practicing over 30 years
Founder – CEC Combustion Services
BSME, Mechanical Engineering,
Youngstown State Univ., 1981
MBA, Weatherhead School of Mgt.
Case Western Reserve Univ., 1985
Former/Member of NFPA 54, 56, 85, 86,
820, ASME CSD-1
Author and presenter of
more than 50 papers .

**Also, had some significant
real life experiences on some
very public
projects and cases in more than a
dozen countries.**



Fuel and Combustion Systems Safety

What you don't know can kill you!



This presentation takes you through FINDING and then FIXING these HAZARDS.

Apollo Arez
Furnace Explosion
10/18/2010

WILEY



**Kleen Energy 2010
Nat.Gas
Explosion, 6 dead**



**ConAgra Garner
2009 Nat.Gas
Explosion, 4 dead**

17 dead in 3 Incidents I have had personal experience with.

We want to remove HAZARD's:

1.

Easy, lots of
People can do this



© Deadline News

*People thing, brutal,
culture change,
someone will pay
an emotional price*

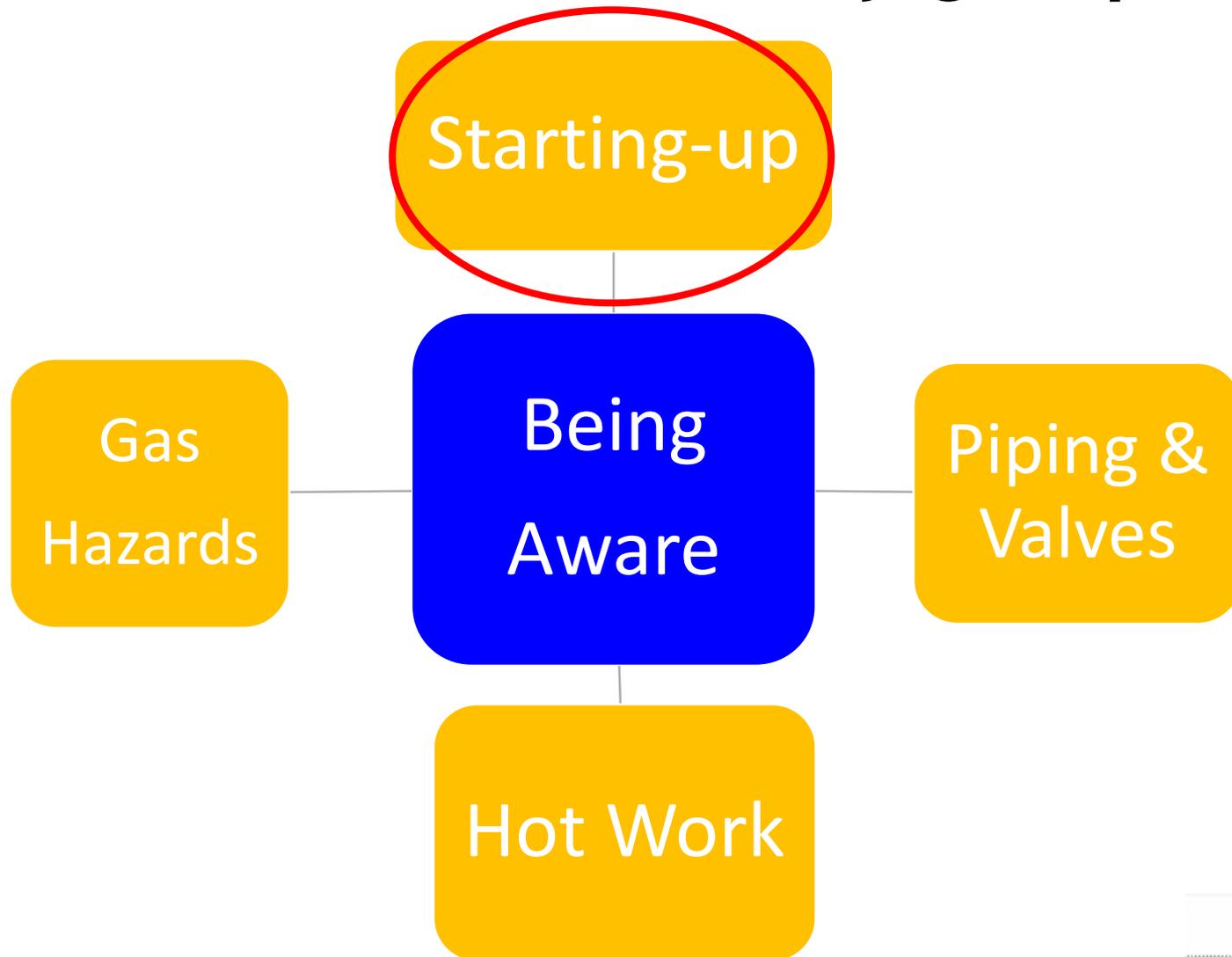
We will find and discuss 25 hazards!



Call this out
If I see it!

People have told us about it our entire
lives and many have experienced it!

25 hazards from 5 key groupings

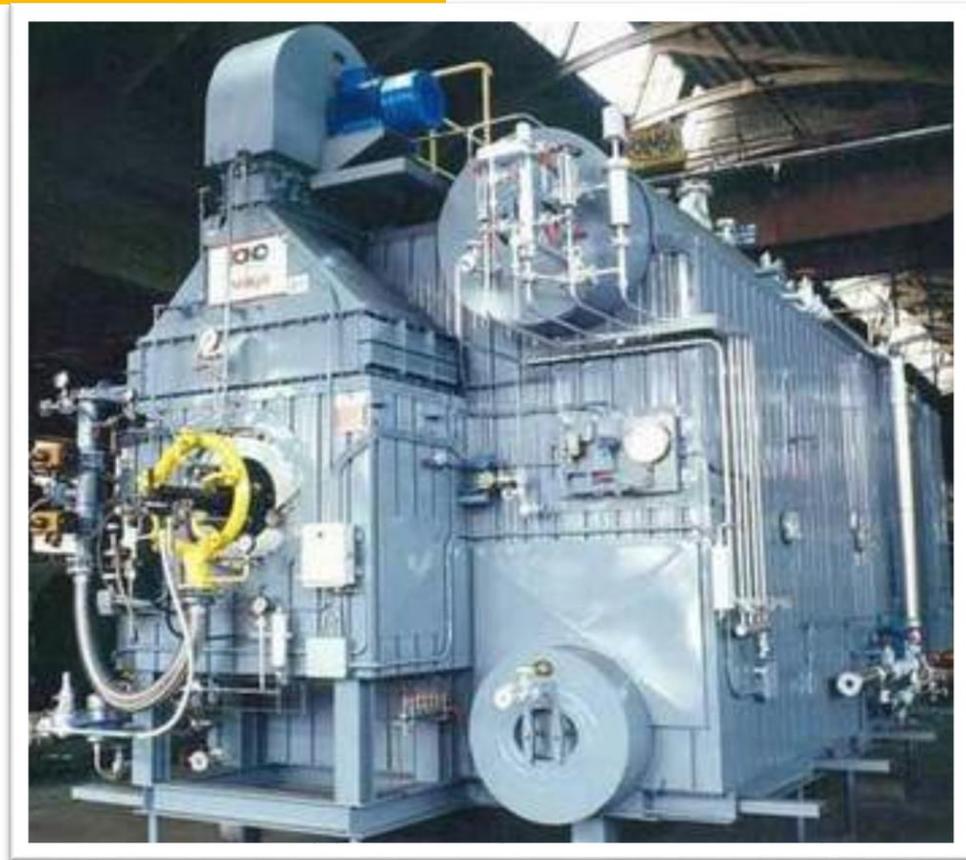


***1. Not more than 2 (two)
start-up attempts!***

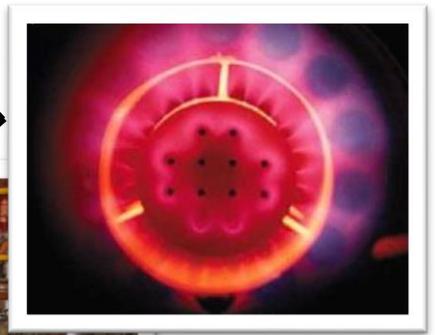
Starting-up



X2



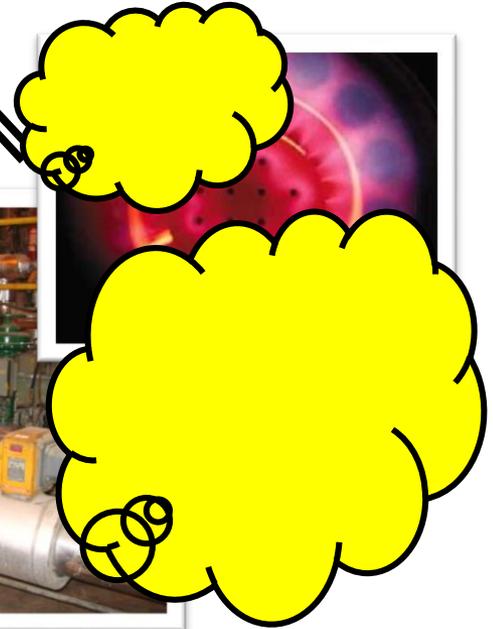
What happens when we hit the start button?



START

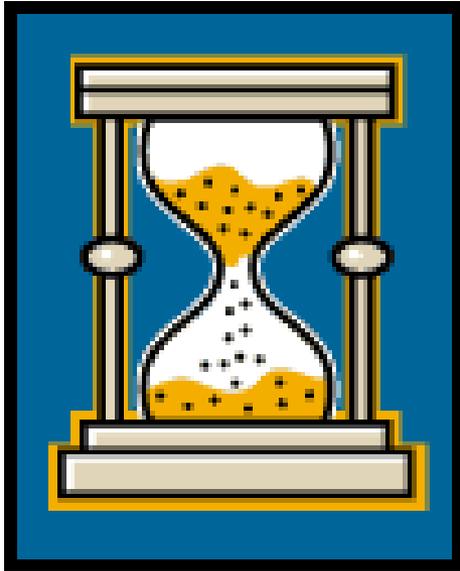
**10 second
gas release
for Pilot**

**10 second
gas release
for Main**

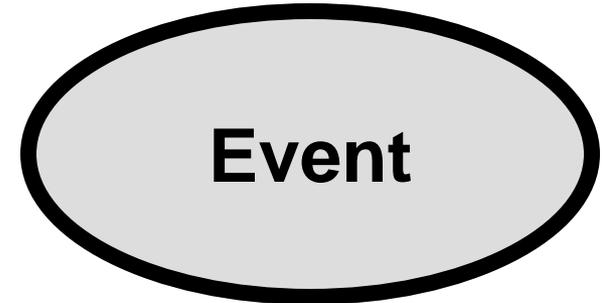


**Gas gets released
into firebox every
time you hit the
button.**

Trials For Ignition – 10 seconds

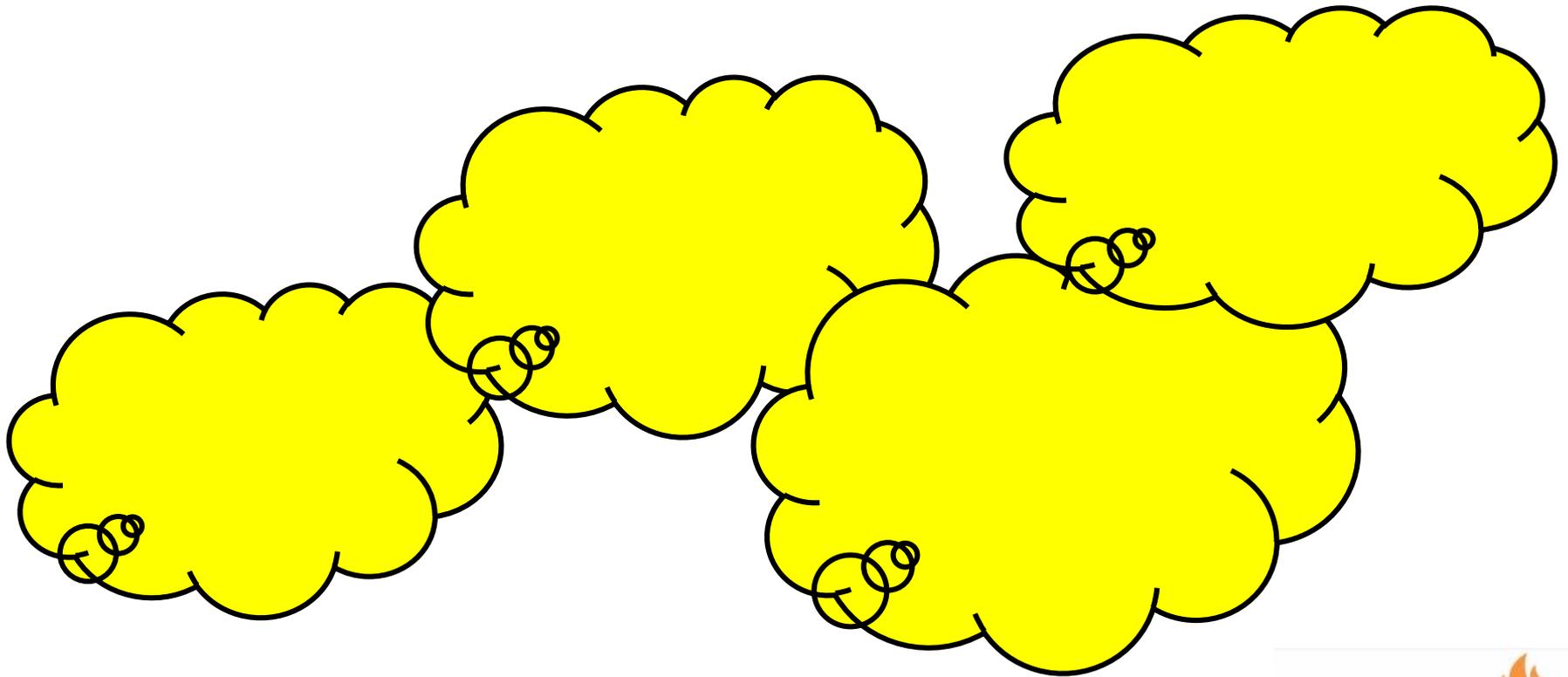


**Gas released for the pilot
and for the main flame**

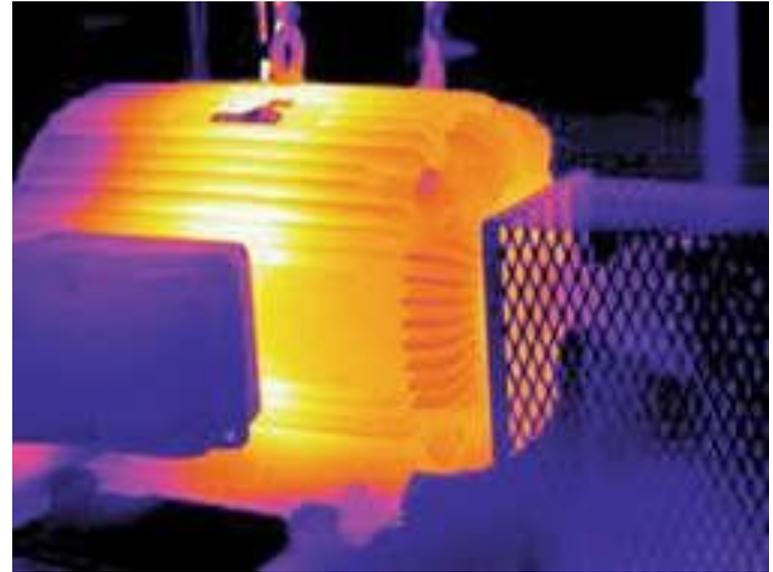


**Ignition should not take
more than 2-3 seconds**

If you did this a bunch of times
and you did not get a good
purge, it would accumulate!



Even with electric motors, starting them generates heat in the windings.



If you don't let them cool after multiple trips the windings get damaged.



Motor Winding Damaged by Excessive Heat

2. Start-up Precautions

Starting-up

Start-up/shut down procedure CAUTIONS

Equipment Pre-Start Walk-Around

It is good practice to perform a walk-around of your equipment prior to start-up. This should especially be done after a unit has been down due to maintenance, repairs, or on extended down time. This walk-around should attempt to identify any deviations from normal operation/condition of the equipment. The following checklist should be used to identify these issues. Note: This checklist is not specific to any particular piece of fuel fired equipment but should be used as a guideline only. Equipment specific walk-around

- A. Review control panel for loose wires, fuses, and relays that may be loose.
- B. Review all safety interlocks (as per marked settings).
- C. Review all valves to ensure they are in the proper position prior to start-up.
- D. Review that all safety devices are connected.
- E. Review all firebox and/or entrance doors to combustion chamber or furnace/oven chamber to make sure all are latched properly.
- F. Review fan dampers so that they are free to move and are not jammed. Check that all filters are unclogged and in place. Check fan blades and general fan condition. See if purge fans are moving air.
- G. Review exhaust system fans, dampers, and related components.
- H. Locate the termination of each vent/bleed line. Review for gas flow and insect/bird nests (or other type of blockage).
- I. Check the time settings on all purge timers.
- J. Do a no fuel ignition sequence if possible to see that BMS sequences properly.

"15 Minutes to walk things down" can SAVE YOUR LIFE!!!

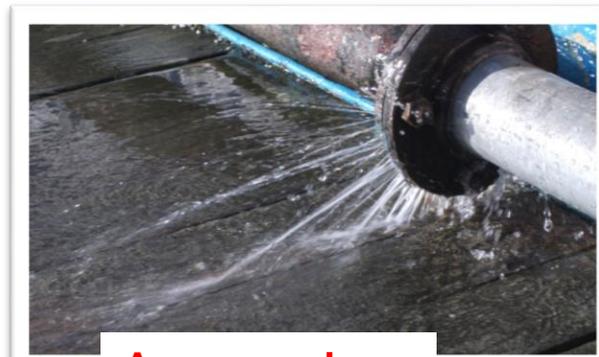
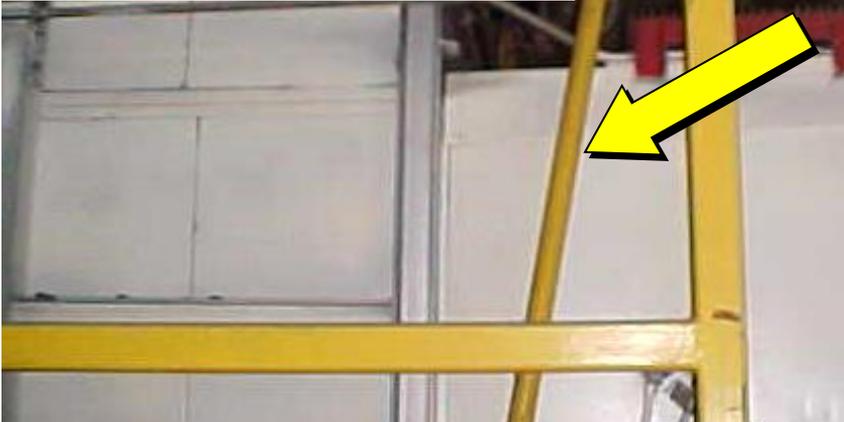


Any evidence of sooting?



**Loose / Disconnected
Instrument Tubing?**

Anything bent or damaged?

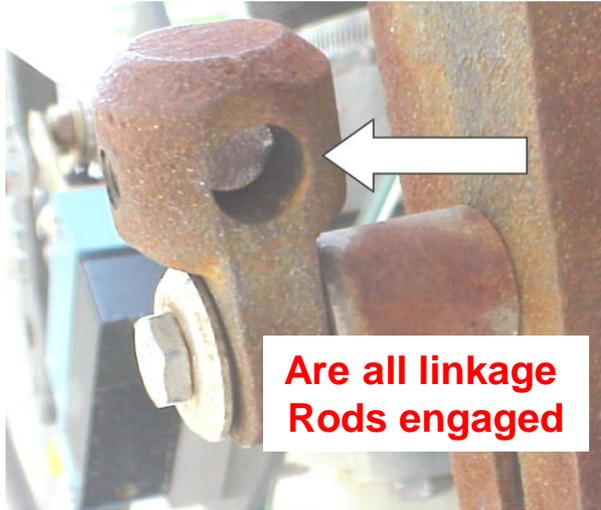


**Any gas, air or
water or leaks?**

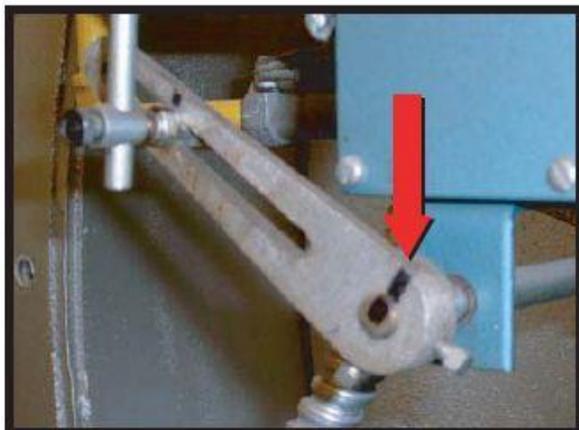
**Create your own specific start-up
and take over shift checklists**



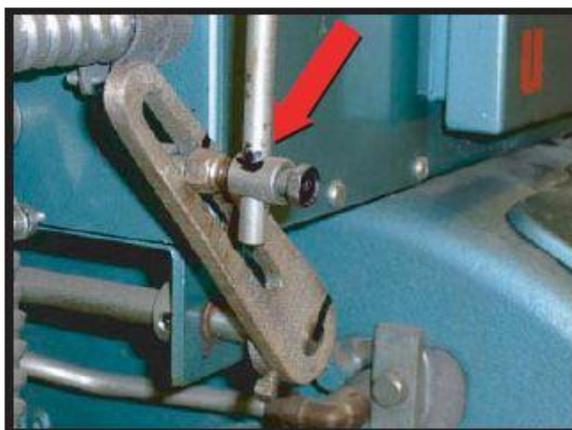
Verify actuator & linkage conditions



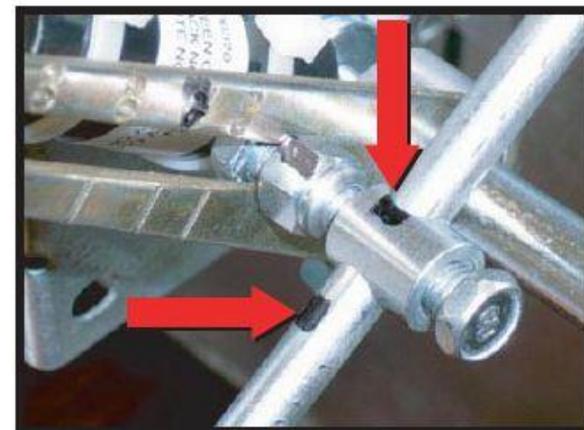
Is every linkage connection in the plant match marked? Go check them!



Shaft Match Mark



Rod Match Mark



Linkage moved from markings

Never stand in front, bolted things fly off if an explosion

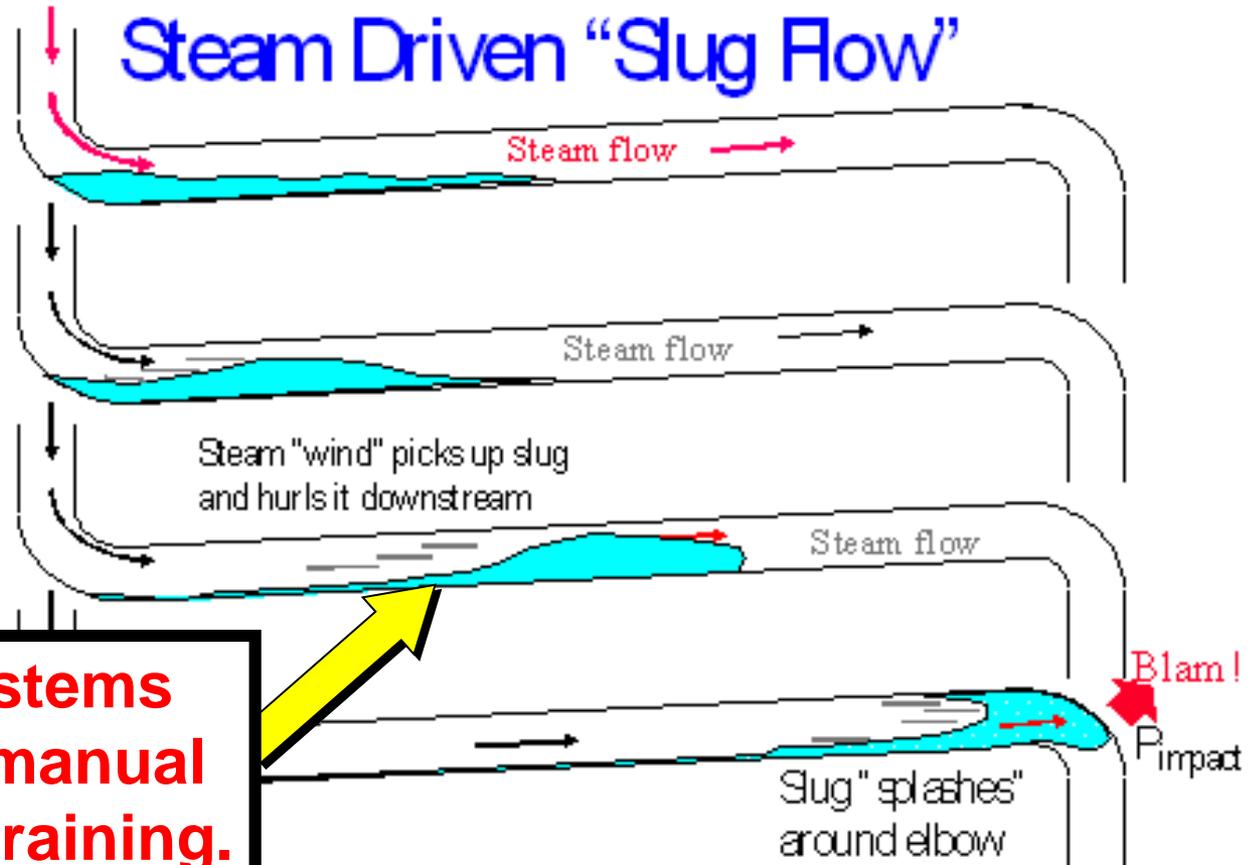


Example of an item on start-up
checklist: Where to stand!

3. Starting up steam lines

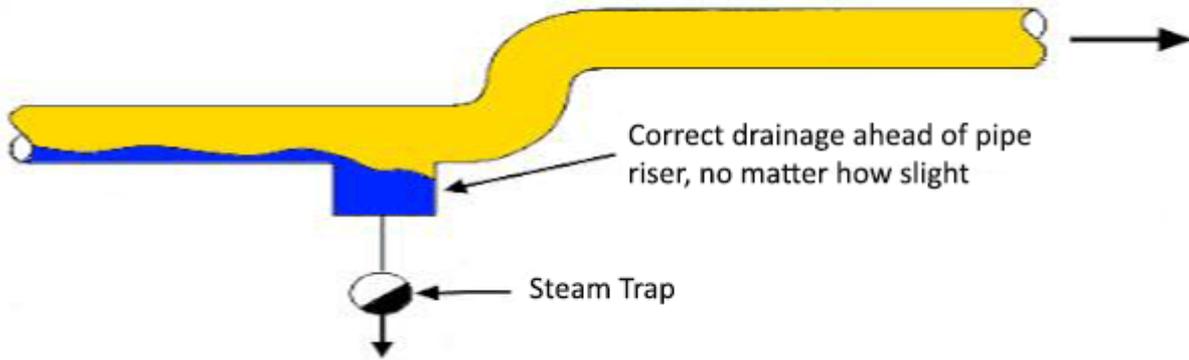
Starting-up

The steam immediately turns to water until the pipes heat up.



Your systems Require manual Start-up draining.

<https://www.youtube.com/watch?v=aGyeLxpX5vs>

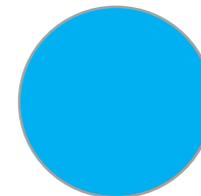


**Steam traps
Are not
usually
designed
for start-up
flow**

**Have to go slow and
keep lines drained!**



**Hammering noise, pipes moving, sometimes
things break and fly off**



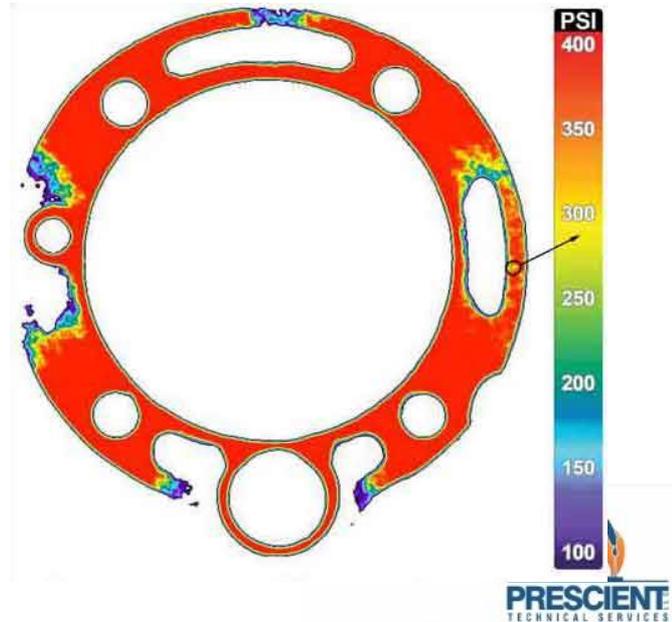
***4. High pressure
steam/water leaks
can be deadly!***

Piping &
Valves

**Over 120F and 12% moisture =
Severe lung burns and death!
(Operators crawling out- hands & knees)**

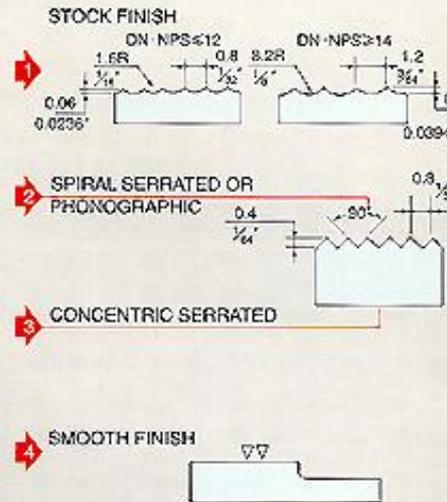
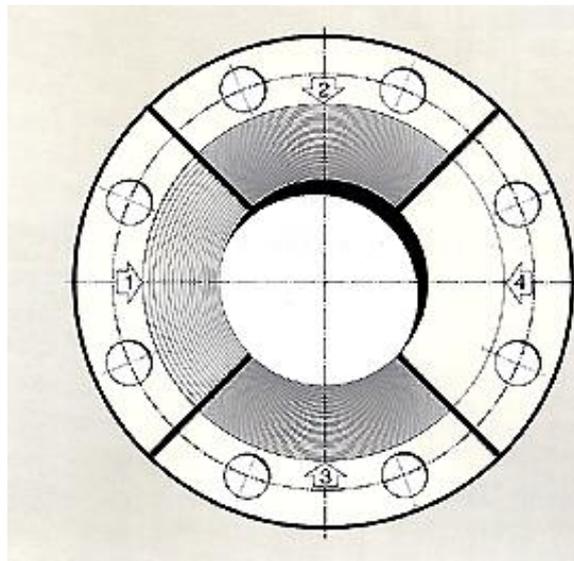
**If tube ruptures or if you had a big
Steam leak, you need to get out fast!**

Report steam or PV leaks right away! Little leaks can turn deadly



Report damaged flanges

Pitting, scratches, or improper cleaning



Improper surface and damaged fasteners or improper torque pattern

Catastrophic Recent Incident



Loy-Lange Box Company
4 dead, one injured
April 19, 2017

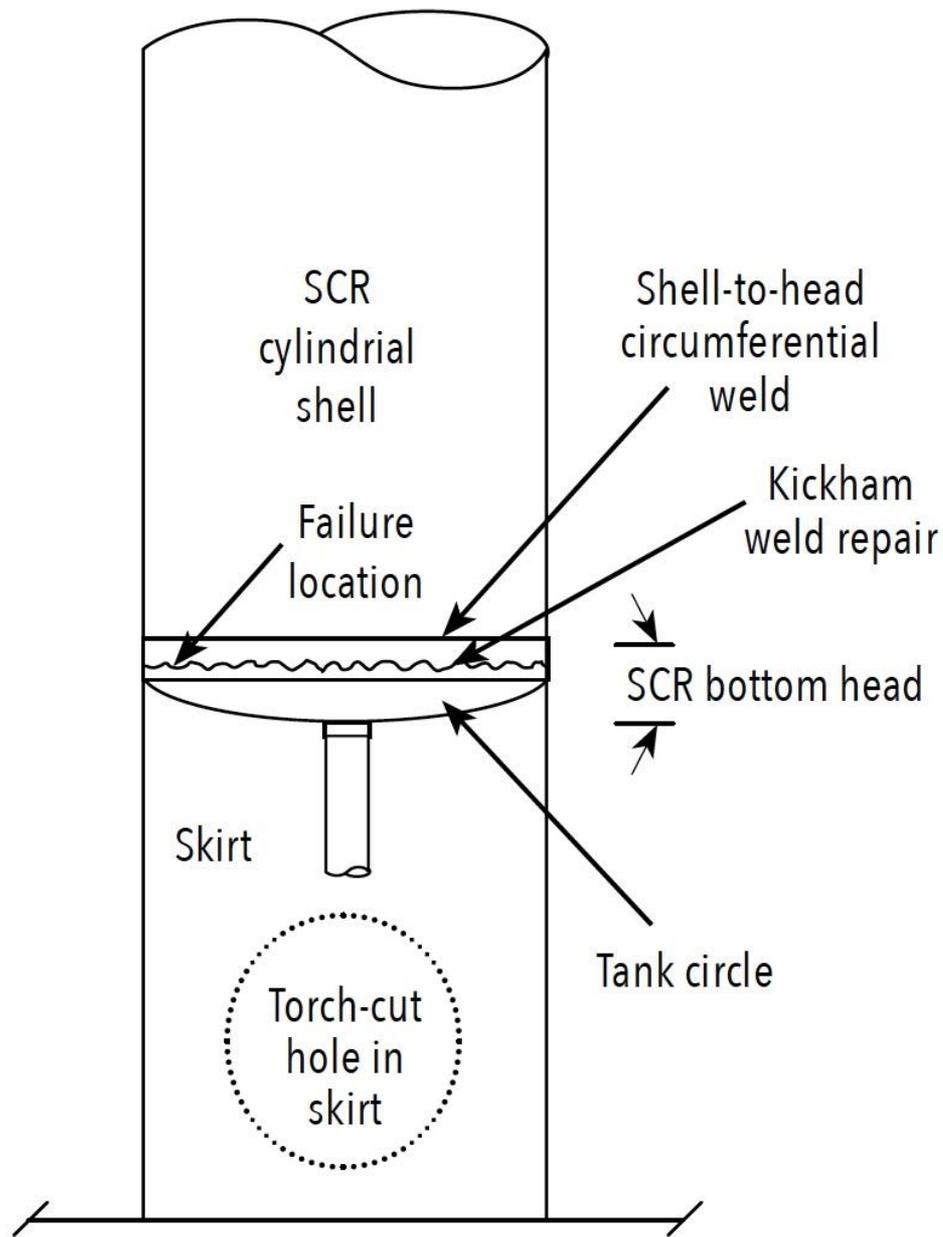


Figure 7. Drawing of various parts of the SCR



patch



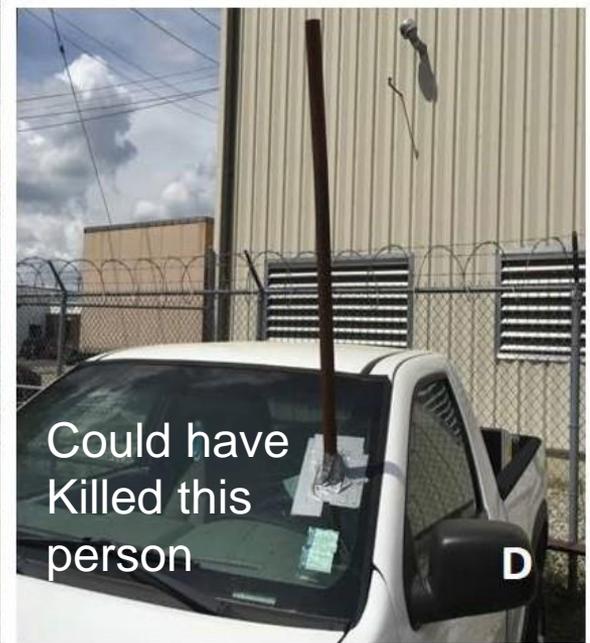
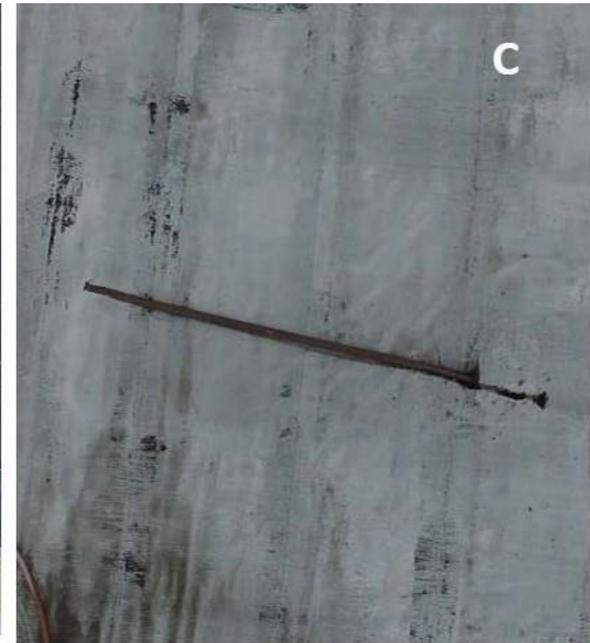
Shell steel - clean and undamaged

Remaining "ring" of bottom head showing significant corrosion damage. Original thickness was 1/4 inch. Current thickness 1/8 inch.

Behind this bar is the shell-to-bottom head weld

Skirt metal





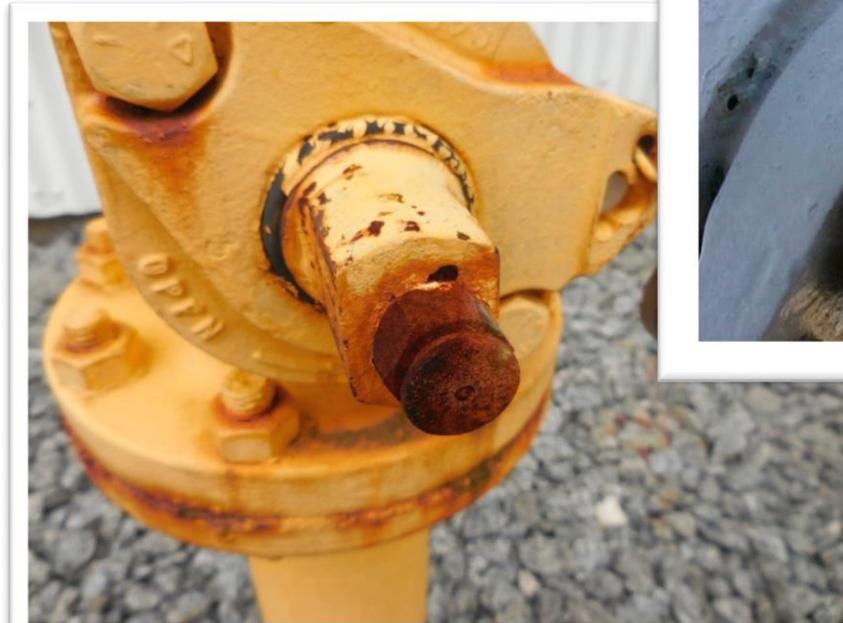
5. Don't force valves open or closed!

Starting-up

Report valves that are seized or difficult to operate



Bent valve handle



6. Operate valves carefully!

Starting-up

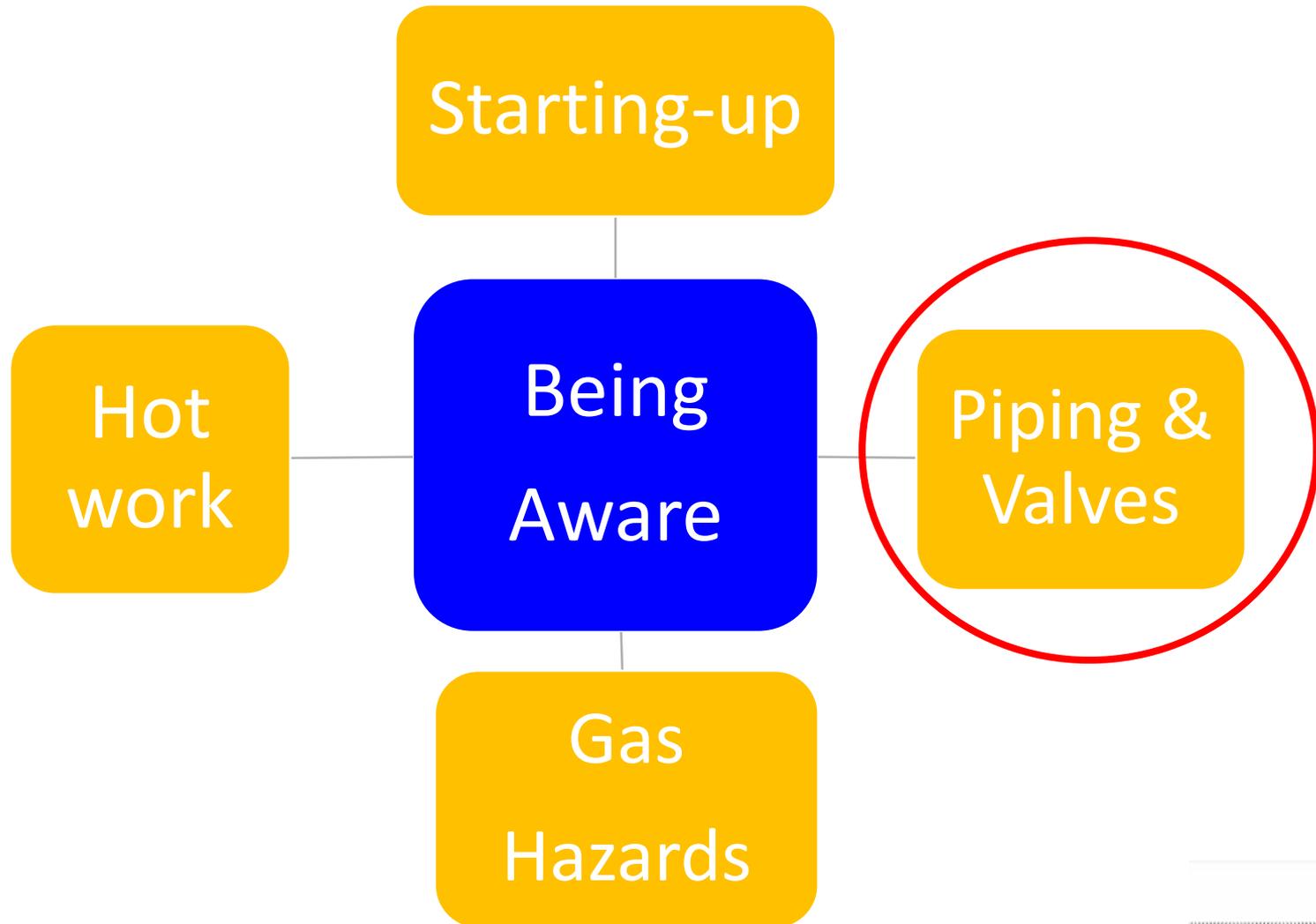
Always open all valves slowly
Use proper PPE



Never Trust Valve Handle Positions



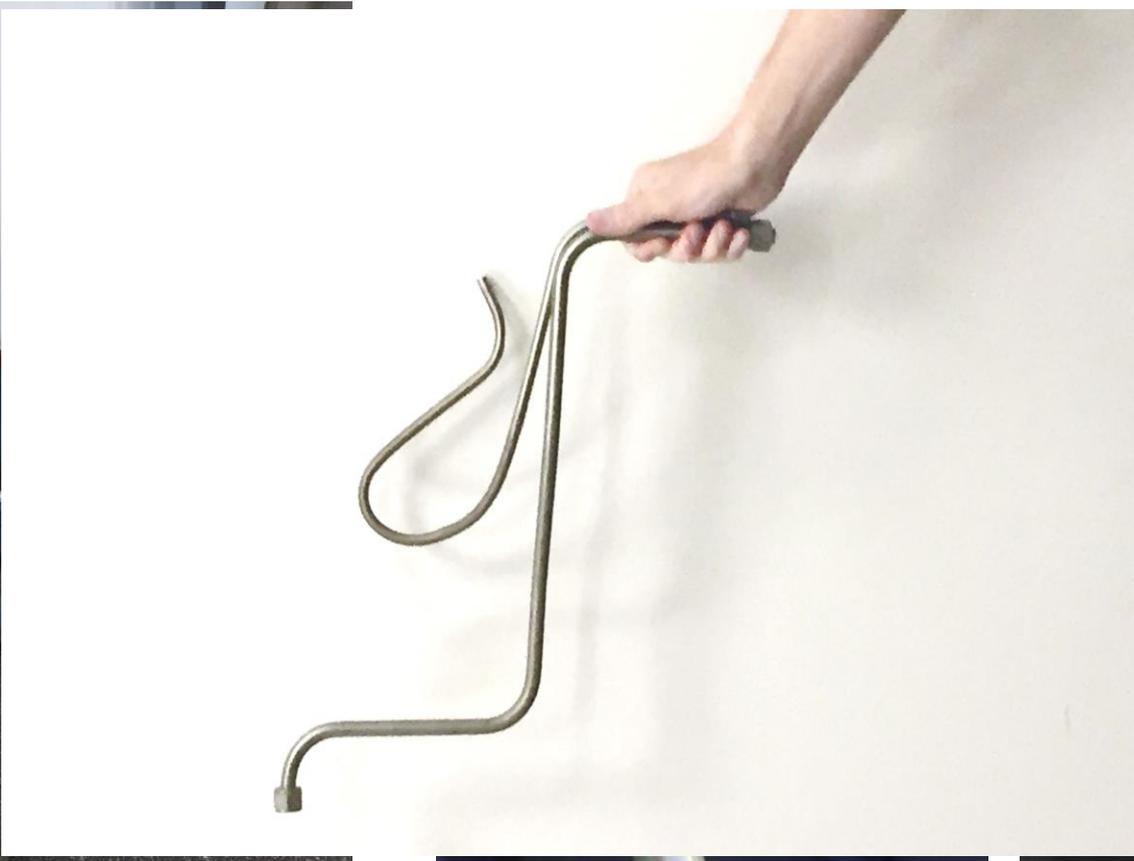
25 hazards from 5 key groupings



7.HP compressed gas tubing can ruin your day!

Piping & Valves

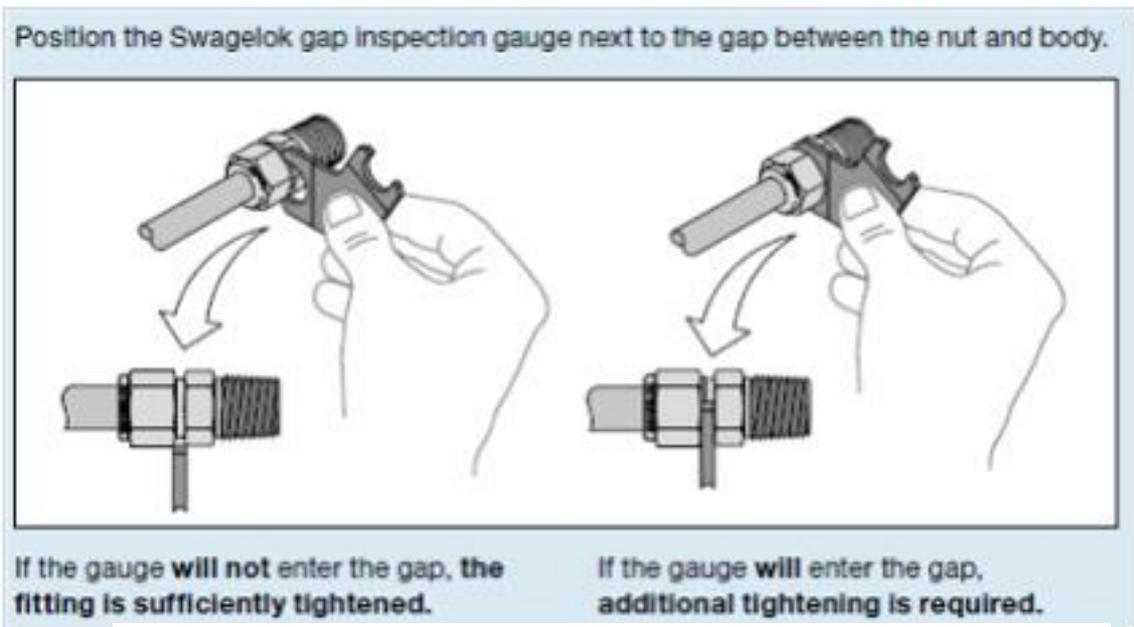
Just touched it and it came apart!



7.HP compressed gas tubing can ruin your day!

Piping & Valves

Swagelok has an installation manual and gauge blocks to do it right!



Consider witnessing and check offs for each fitting installed.

8. Never use damaged fasteners, inspect carefully

Piping &
Valves



Bolts want to be in tension
(thousandths of an inch can change everything)

Verify that threads are not damaged



**Careful
Reusing
fasteners**

9. Always use the right strength fasteners.

Piping & Valves

Bolts & Nut Strength: It's about the markings

Unmarked

The lack of slash marks on a bolt's head indicates that this fastener meets SAE 2 standards, which confirms the fastener is made of low- to medium-carbon steel. Such fasteners deliver a minimum tensile strength of 74,000 psi in sizes ¼ to ¾ inch in diameter and 60,000 psi in sizes ¾ through 1½ inch in diameter. This makes them best suited for general hardware use where high strength is not required.

Six Slash Line

Indicate that a bolt meets SAE 8 standards, confirming the fastener is made of high-carbon steel (both quenched and tempered), zinc plated, and able to deliver a minimum tensile strength of 150,000 psi in sizes ¼ to 1½ inches in diameter. They are ideal for applications where high strength and hardness are required. A stainless steel version of this fastener is identified as 18-8.

Three Slash Line

Indicates that this fastener meets SAE 5 standards, confirming the bolt is made of medium-carbon steel (both quenched and tempered). Such fasteners deliver a minimum tensile strength of 120,000 psi in sizes ¼ to 1 inch diameter and 105,000 psi in sizes 1 to 1½ inches, making them ideal for automotive uses and other areas where higher strength is needed.

Markings (Fasteners may also have manufacturer I.D. markings)	Specification	Material	Nominal Size Range (inches)	Mechanical Properties		
				Proof Load (psi)	Minimum Yield Strength (psi)	Minimum Tensile Strength (psi)
SAE Imperial						
	Grade 2	Low or Medium Carbon Steel	1/8 thru 3/4	55,000	57,000	74,000
No Markings			Over 3/4 thru 1-1/2	33,000	36,000	60,000
	Grade 5	Medium Carbon Steel, Quenched and Tempered	1/4 thru 1-1/2	85,000	92,000	120,000
3 Radial Lines			Over 1 thru 1-1/2	74,000	81,000	105,000
	Grade 8	Medium Carbon Alloy Steel, Quenched and Tempered	1/4 thru 1-1/2	120,000	130,000	150,000
6 Radial Lines						
Stainless markings vary; most stainless steel is non-magnetic	18-8 Stainless and A-2 Metric	Stainless steel with 17-18% Chromium and 8-13% Nickel	1/4 thru 5/8 3/4 thru 1 Above 1		80,000 - 90,000	100,000 - 125,000
ISO / DIN Metric						
	Class 8.8	Medium Carbon Steel, Quenched and Tempered	All Sizes thru 1-1/2	85,000	92,000	120,000
6.8						
	Class 10.9	Alloy Steel, Quenched and Tempered	All Sizes thru 1-1/2	120,000	130,000	150,000
10.9						

Tensile Strength: The maximum load in tension (pulling apart or shearing which a material can withstand before breaking or fracturing).

Yield Strength: The maximum load at which a material exhibits a specific permanent deformation.

Proof Load: An axial tensile load which the product must withstand without evidence of any permanent set.



Report short Studding



Anatomy of a Catastrophic Boiler Piping Accident #1



SS Iwo Jima LPH2
10 dead
October 30, 1990



...having of an... ...its before they take plac



Valve bonnet
and bolts



Grade 8 Nut

Thoughts about why:

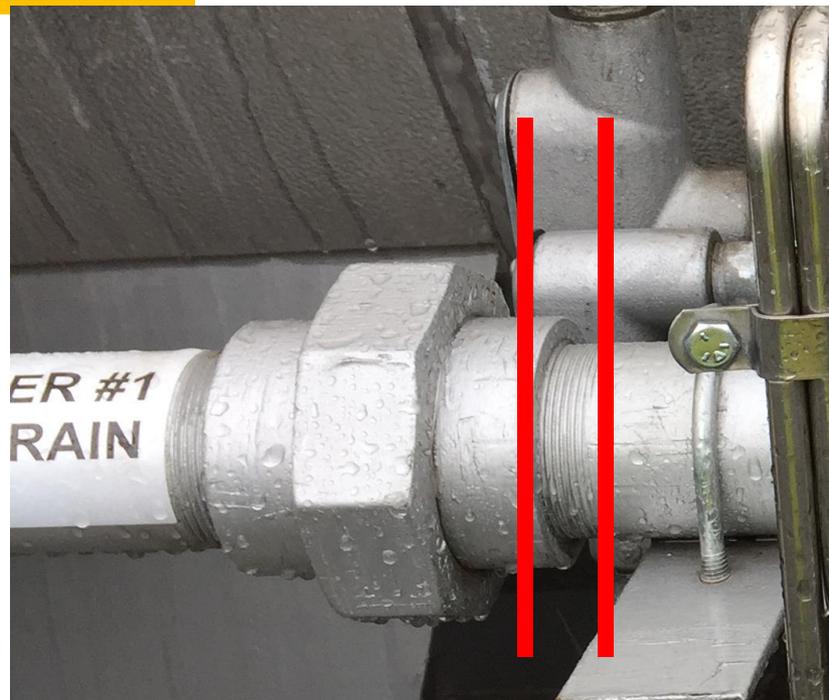
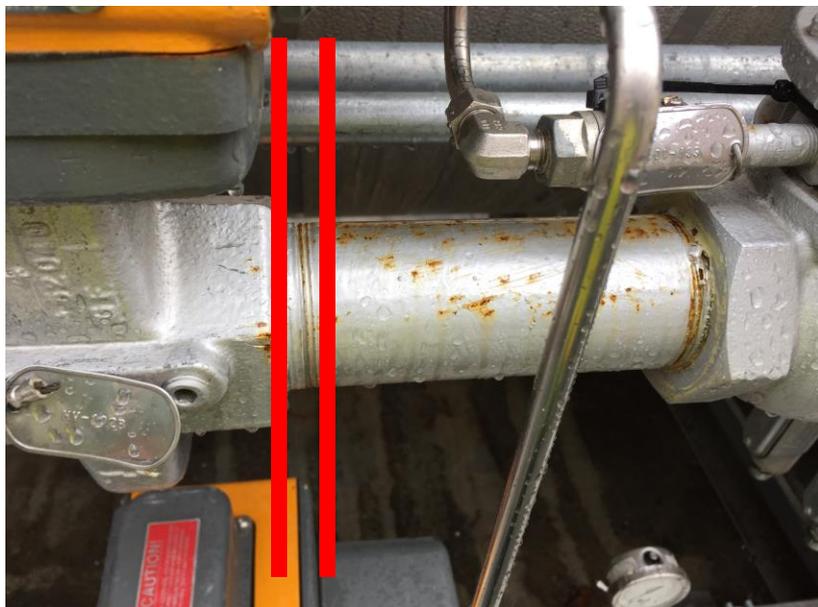
1. Wrong nuts, “Human Factors”
2. Poor QA process, (no pressure test)

Black Oxide
Coated Brass Nuts

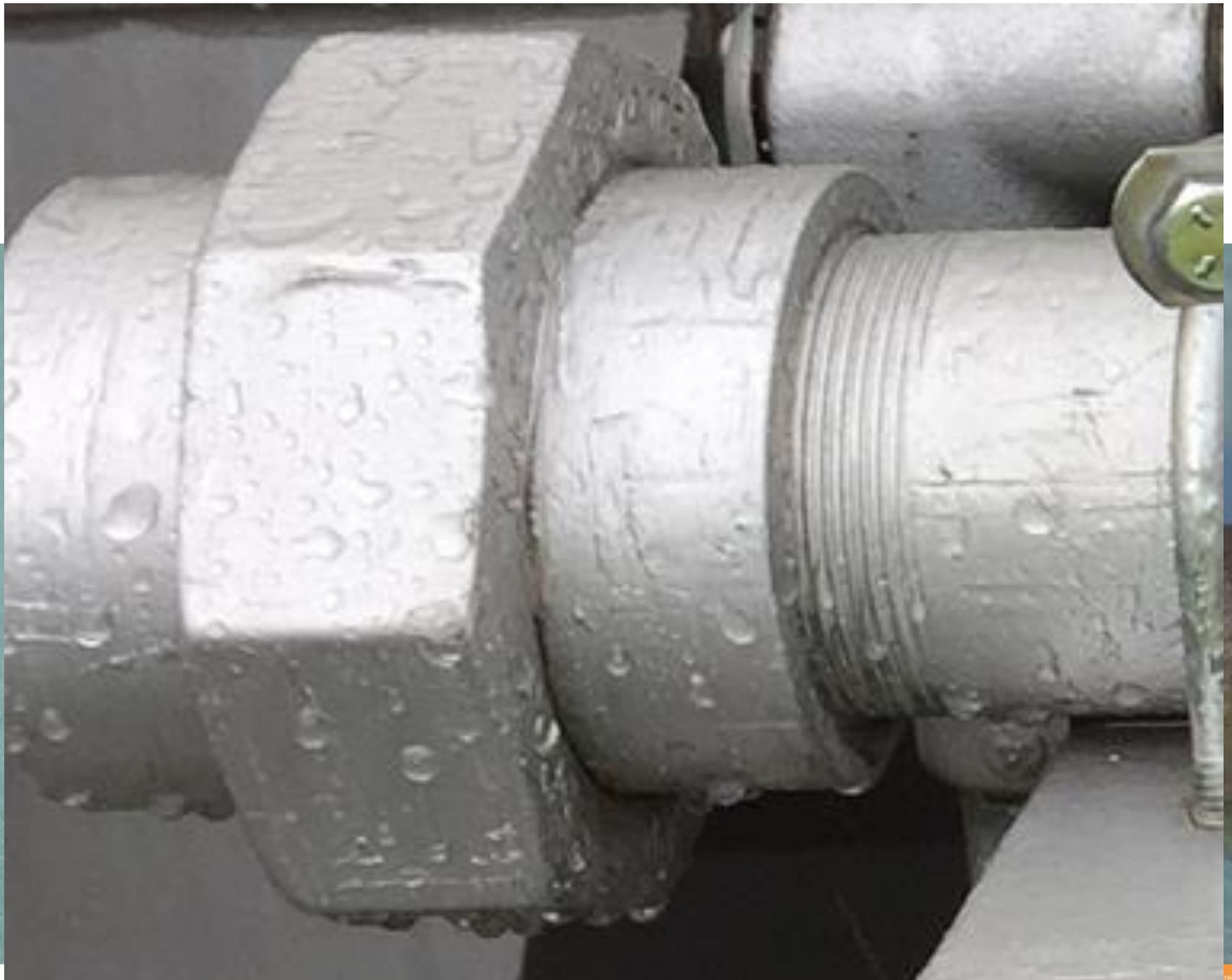


10. Report suspicious threaded piping.

Piping & Valves

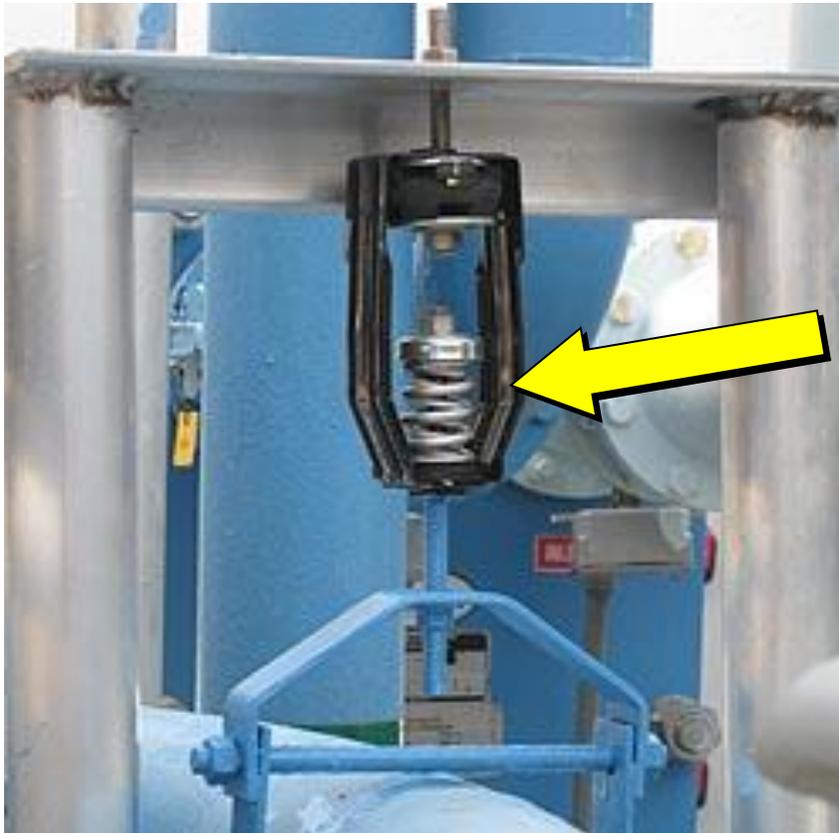


Are enough threads engaged?



11. Has the steam piping moved? Still supported?

Piping &
Valves



**Spring not
Compressed
NO LOAD
on this
Hanger**

**Unloaded hangers means other hangers
are taking load not designed for and
piping is deflected**



This means LEAKS

Report hangers missing, broken, loose

12. Corrosion can be a big killer!

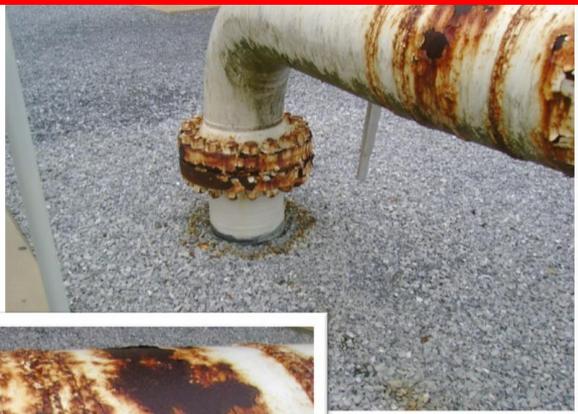
Piping & Valves



Paint thickness
specs, paint gauge
Because, you lose
coating annually



Report pipe exterior corrosion

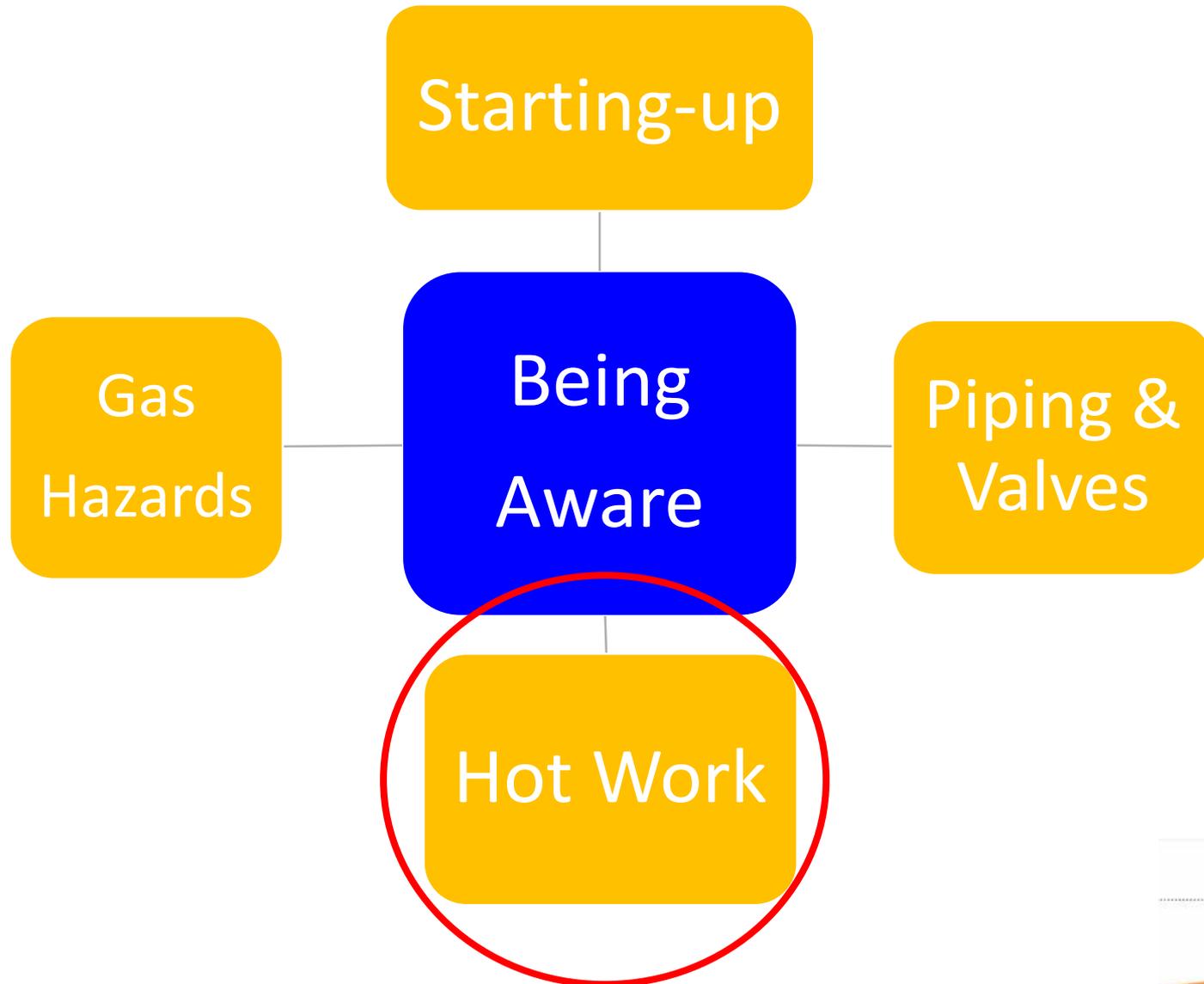


13. Do you have the right parts?

All flanges, fittings, & valves need to be the right material and right temperature pressure rating for the project!



25 hazards from 5 key groupings



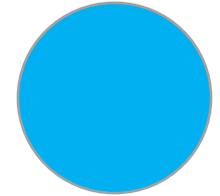
14. Don't work on energized pressurized piping systems!

Hot Work

Don't tighten bolts on any pressurized systems



<https://www.csb.gov/videos/animation-of-fire-at-exxonmobils-baton-rouge-refinery/>



Metallurgy changes over time, high temperature creep failure, erosion or corrosion inside.

Catastrophe working on a live pressurized line!



<http://www.csb.gov/videos/>

1:30 to 4
Fire in Baton Rouge



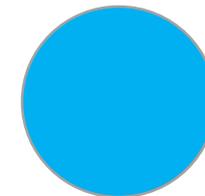
15. Fire resistant clothing ! (pick and wear it right)

Hot Work

What's a Flash Fire?

What makes something officially FRC clothing?

What are some important FRC performance factors?



156 221
645

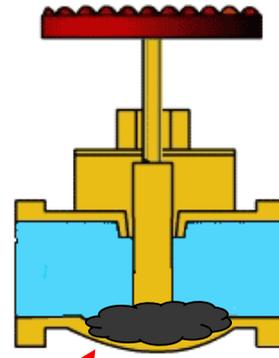


16. Lockout/isolation – more than a closed valve!

Hot Work

**Might not
seal tightly
Because:**

- Wire drawing - erosion of valve disc and seat due to high velocity flow.
- Debris in seat, stem proper location?
- Bushing wear/failure, (sloppy movement)



**Possible
deposits**



Positive Isolation Technique (#1)

Get correct type & thickness!

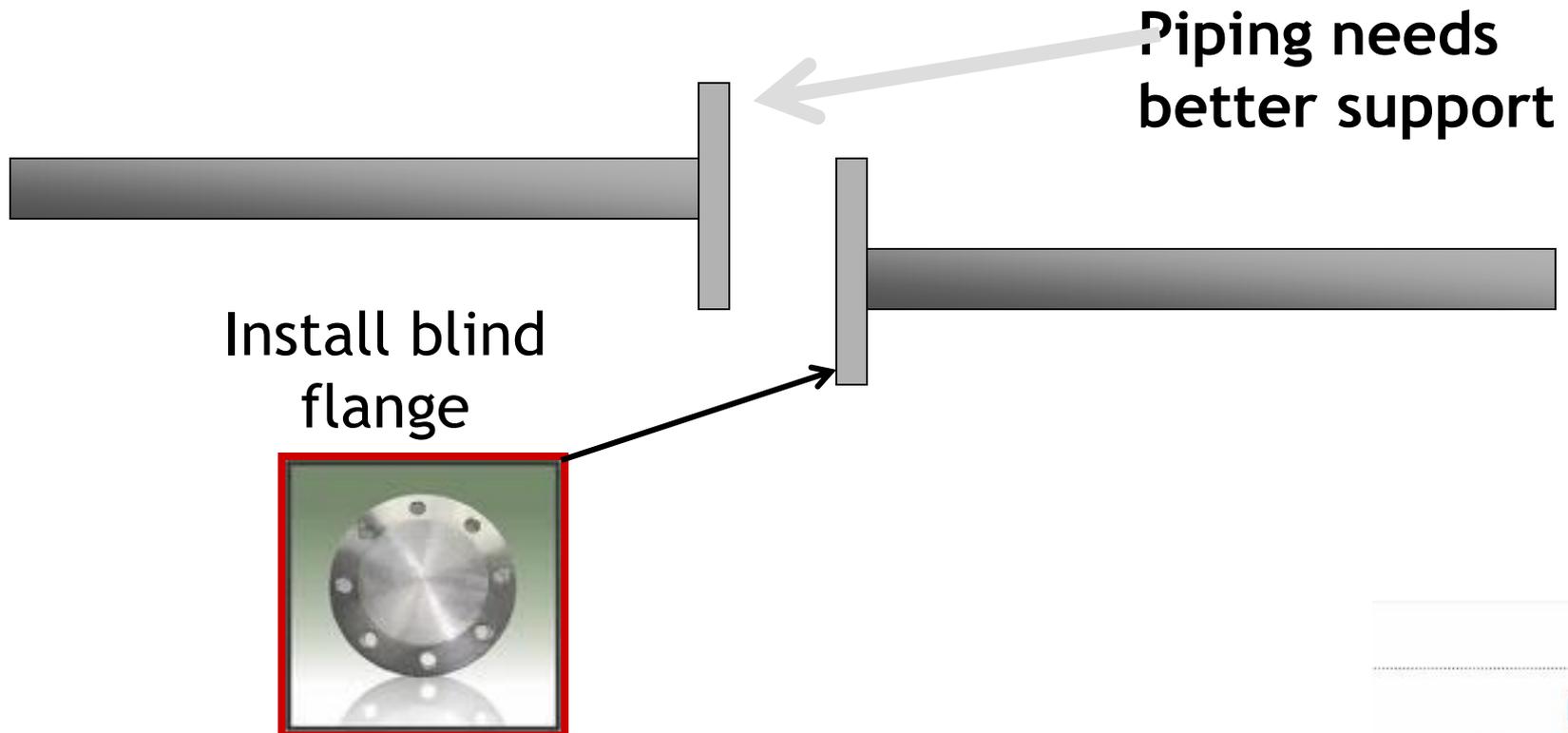


Blinds



Positive Isolation Technique (#2)

Disconnection and Misalignment from Source
(Needs Capping/Sealing)

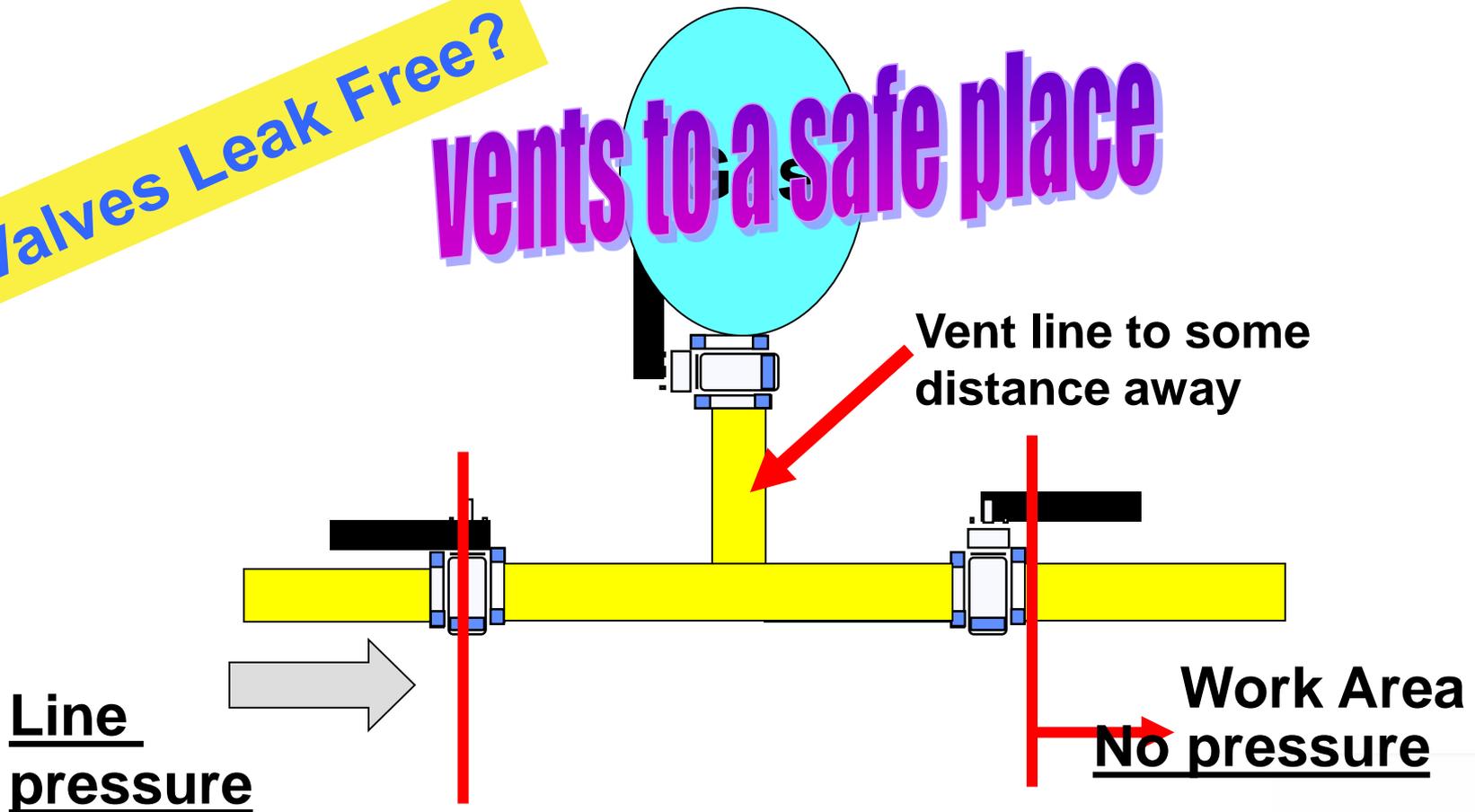


Positive Isolation Technique (#3)

Double Block and Vent

Valves Leak Free?

vents to a safe place

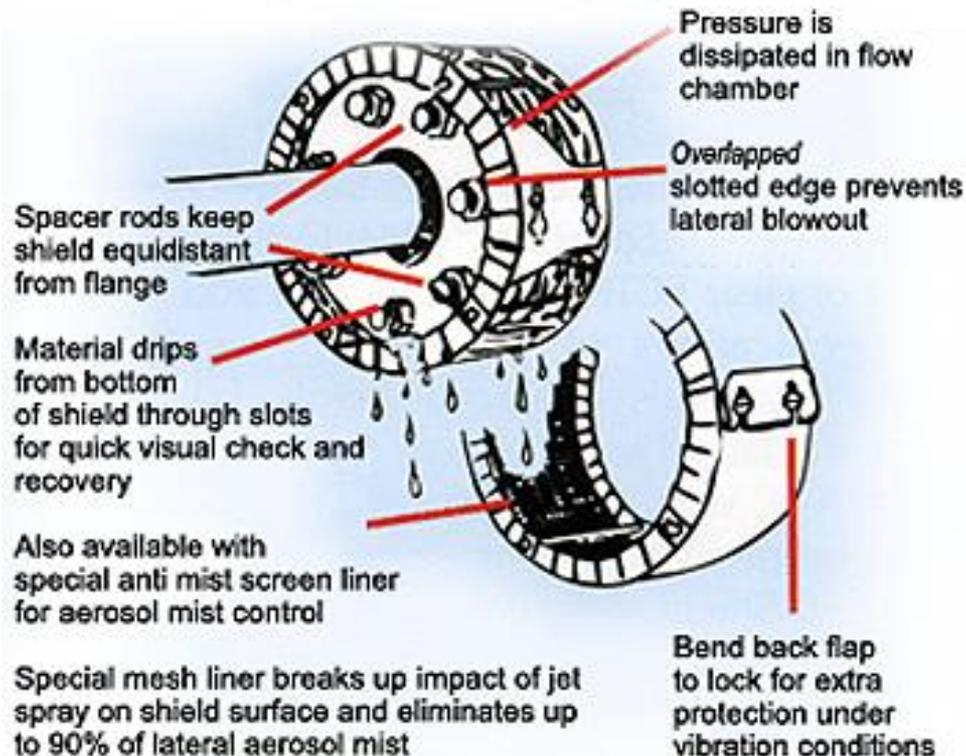


17. Line breaking can be trouble – be prepared!

Hot Work

Line breaking precautions!

How Metal Safety Shields Control Sprayouts

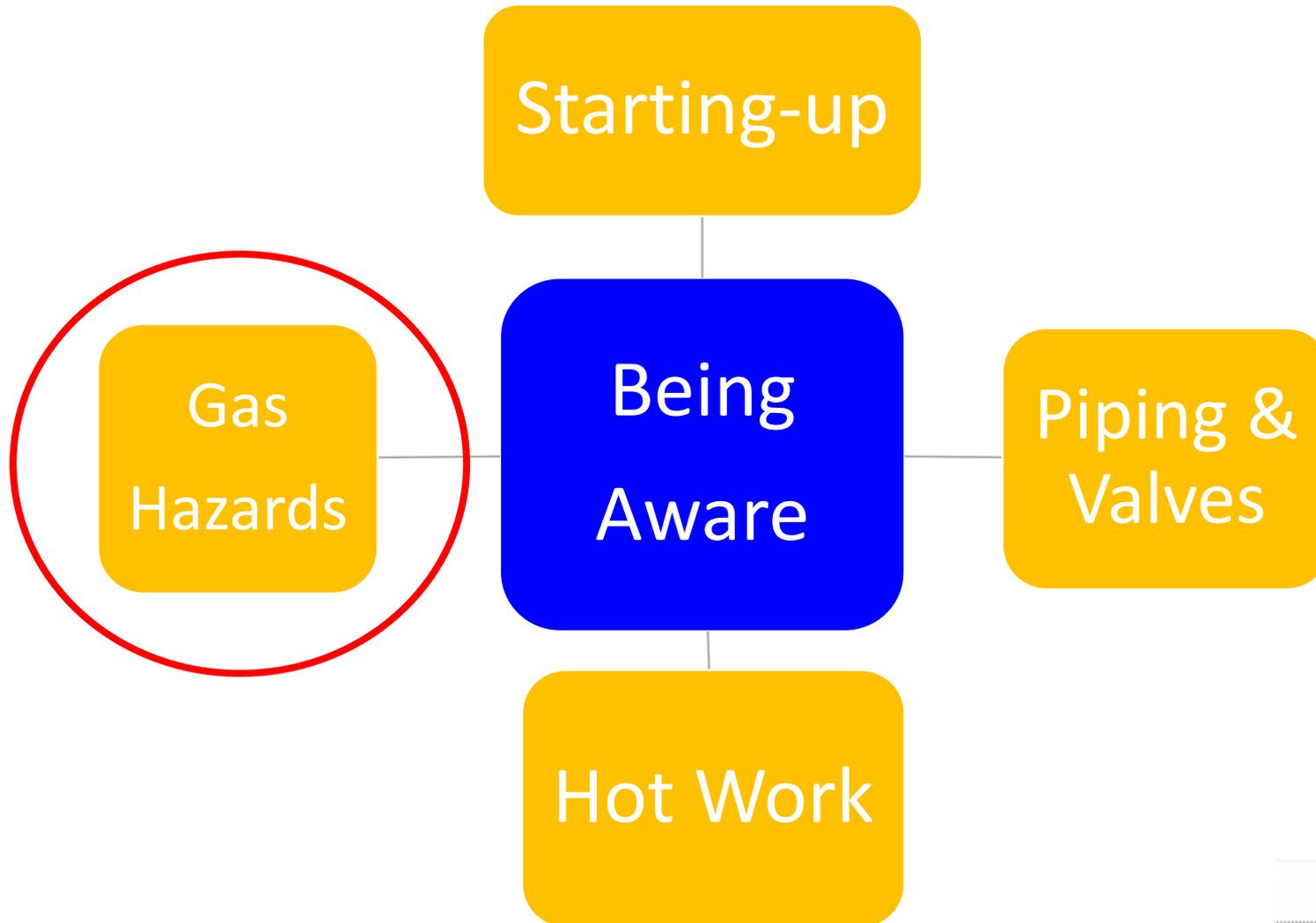


**Loosen Bolts First
Away From Your Face**

Spray shields

Bonding jumpers

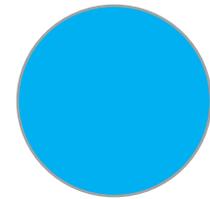
25 hazards from 5 key groupings



18. Purging gasses requires special procedures!

Gas
Hazards

Never release gas into a building!



Deadly practices

243

518

6 Dead, and all of this from a mistake purging a new 4" gas line

Understanding Safe Gas Piping Practices



Any awareness of NFPA 54 purging rules or NFPA 56 Standard at all?

6 steps for safe gas piping work:

1. Shut-offs and isolation
2. Pre-repair purge or venting
3. Make the repair
4. Pressure test/Leak check
5. Post-repair purge
6. Gas re-introduction



19. Even a small natural gas leak can be a BIG PROBLEM!

Gas Hazards

Report all gas leaks immediately!



Odor Fade & Odor Fatigue



You can't trust your nose



Ignition sources are everywhere!

Hot Work

- 1) Dragging your feet with gravel imbedded in your shoes can create a spark.
- 2) Wearing plastic clothing, especially socks, can also build up and discharge a static electricity spark, especially on cold dry days.
- 3) Lighting, Electric motors or controls
- 4) Weld slag coming out of a pipe under pressure
- 5) Cell phones or radios or instruments, even flashlight
- 6) Two metal parts at unequal potential moving apart from each other, (separating flanges), tools.
- 7) Stray currents from electrical equipment.
- 8) Liquids flowing through non-conductors
- 9) Opening a metal door and it separating from the frame, different potentials
- 10) Explosion rated electrical equipment not installed properly or not put back into service properly after maintenance.

Never lacking!

**20. Two (2) gasses that
can kill immediately!**

Gas
Hazards

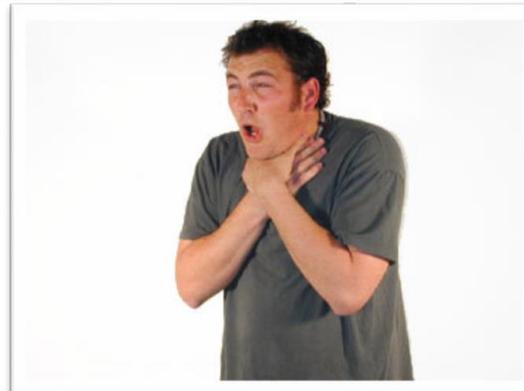
Hydrogen Sulfide & Nitrogen

Toxicity



Rotten egg smell
Very levels are toxic
Can occur in sewers,
Tanks, and process areas
With little ventilation

Nitrogen
Asphyxiation

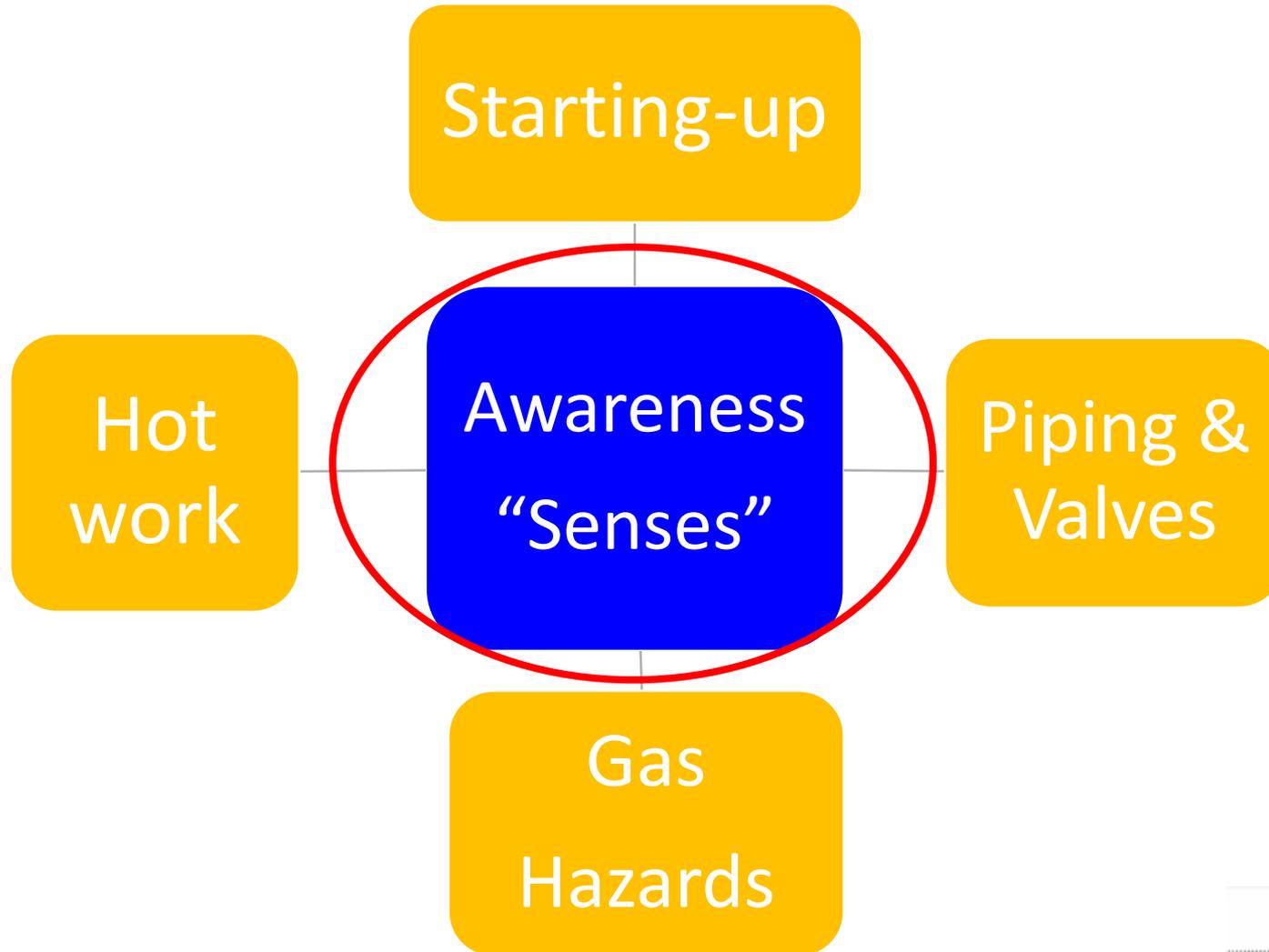


No odor,
used for purging

**Nitrogen, 78% of each breath but
One breath at 100% and you're dead**



25 hazards from 5 key groupings

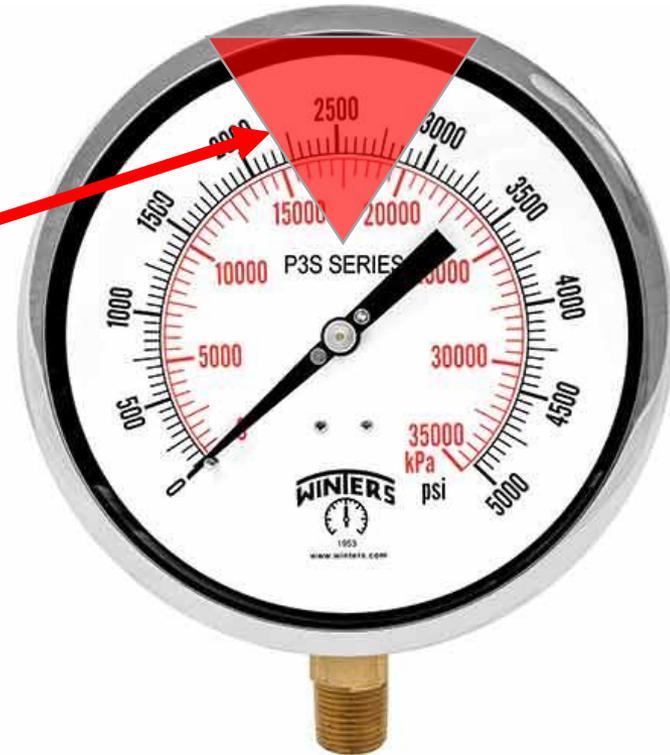


21. Gauges should not be bouncing!

Being Aware

Should be some stable range

No gauges should be bouncing around, shows process instability somewhere.



Processes and pressures should be stable

22. Bad vibrations from boilers and rotating equipment!

Being
Aware



Seeing



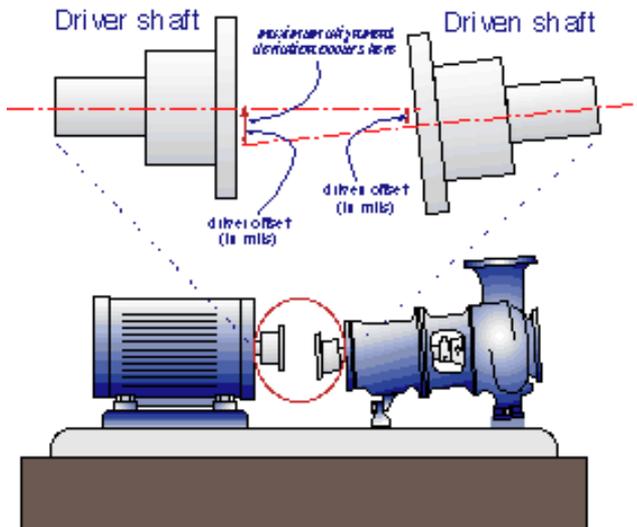
Touching



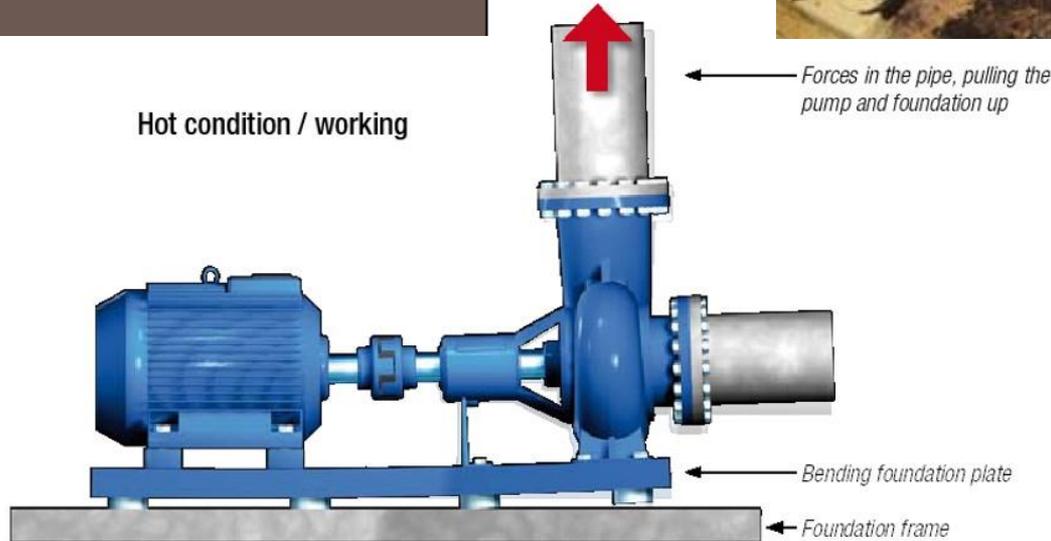
Things to report!

**Combustion rumble, burner problem
Boiler shaking or vibrations?**

Misalignment or failed bearings can make a motor shake



Hot condition / working



23. Boiler flames are trying to tell you something!

Being
Aware



Never watch a light off!

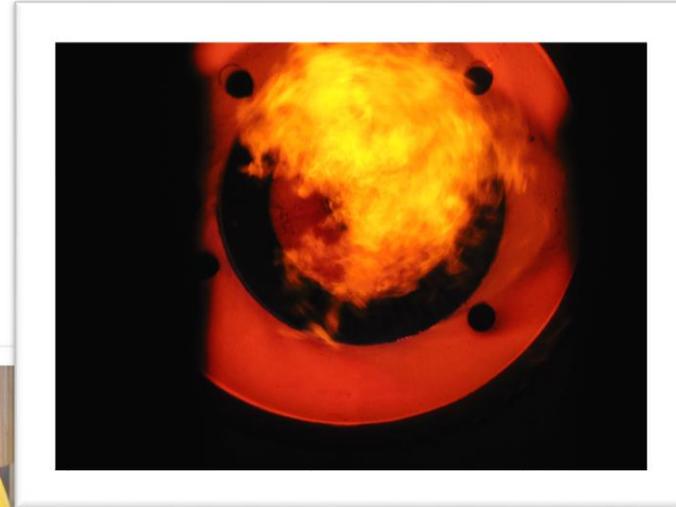
**Things to Look For – COLOR, SHAPE,
MOVEMENT, SYMMETRY, STABILITY
Burner Damage (impingement/lick)**

Knowing about flame color

Things to Look For – COLOR, SHAPE, MOVEMENT, SYMMETRY, STABILITY
Burner Damage (impingement/lick)



**Too Lean, pale,
high energy!**

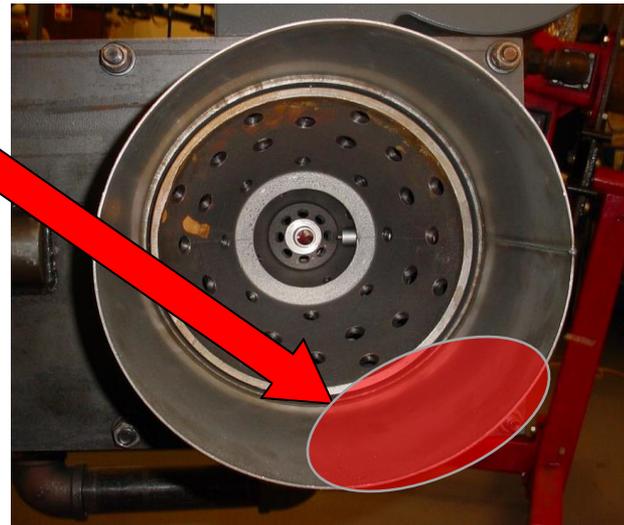


**Too rich, lazy,
smoky!**

23. Report flame impingement

Impingement

Steel changes properties @ about 850F



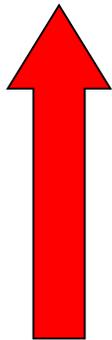
Damaged from impingement

24. Report Fuel/Air Ratio Problems!

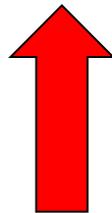
If there's too much or too little
fuel for the air/oxygen

Combustion Products become =

$\text{CO}_2 + \text{CO} + (\text{Other Compounds}) + \text{H}_2\text{O} + \text{Fuel} + \text{Nitrogen}$



Carbon Monoxide



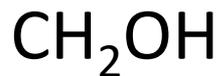
Could be many things

*CO – about the same weight as air
Hangs around the breathing zone*

24. Strange smells/sooting=PROBLEMS!

**Report strange smells
& sooting IMMEDIATELY!**

Don't leave anyone with symptoms alone



Alcohol



Ammonia



Formaldehyde



Carbon (i.e. Black smoke)



Carbon Monoxide

**CO – cumulative effect,
appearance of drunkenness**

**Eyes burn?
Funny smells?**



25. Report Refractory Problems!

Being
Aware



**Things to
Look For**



**Deformation &
Discoloration**

Report these immediately!

25. Report Refractory Problems!

**Steel changes
properties
@ about 850F**

Steel Beam
Furnace support

Refractory

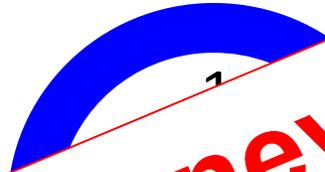
Need to manage start-ups & shut-downs very carefully

Steel expands at different rates than the refractory

Refractory very brittle (except fiber), Can be permanently damaged from improper start-ups/shut-downs.

You now have at least 25 HAZARD's to be aware of:

Technical thing, pretty straight forward

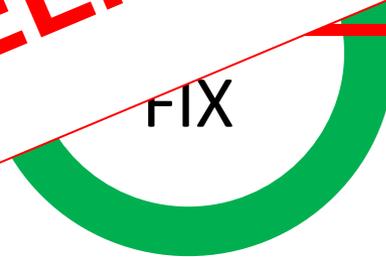


If things never get fixed, we never really HELP anyone!

Time consuming, unpredictable, frustrating

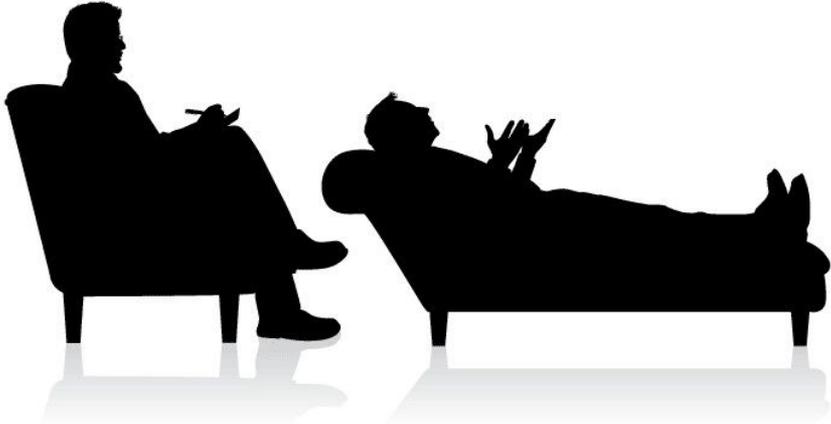
Technical thing, brutal, change, will pay emotional price

Technical thing, pretty straight forward



This is where I change from ENGINEER

Psychologist



Coach & Motivator





Board Room
C- Suite

Safety is our number one thing! It's the only thing, safety



What others say to you the safety professional!

our
ne thing!, but
numbers.

I gotta keep this planning and I have no money to fix anything & Oh Yeah, safety safety safety



Operations & maintenance



EASIEST to Get Things Done, Unlimited authority, BUT PEOPLE USUALLY HAVE TO DIE TO GET PROBLEMS TO THIS LEVEL.



**Board Room
C- Suite**



Middle Management

If a Really Big Problem & Fatalities

**1% OF REAL LIFE
Incidents at this level**

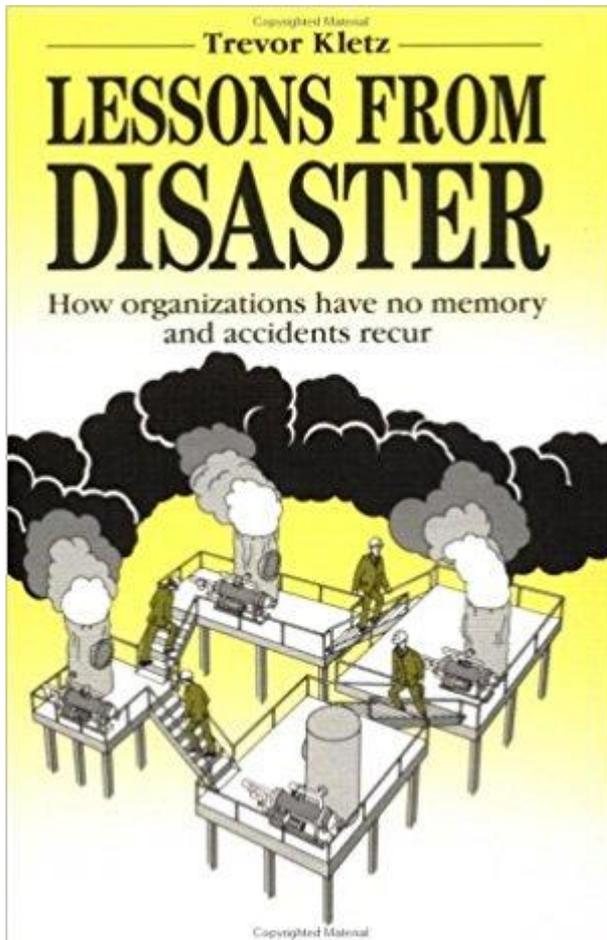


Operations & maintenance



Trevor Kletz

Immediately a lot of attention & funding
**BUT - How Long will
they care?**



**Corporate memory
about terrible tragedies
is only about 10 years.**

**Then BAD BEHAVIORS
OFTEN COME BACK**



Example #1: Ford Motor Company
1999 Rouge Explosion Kills 6, Bill Ford Jr.

20
Years



Some Companies Really Get It!
Programs
going



Example #2: US Steel, 2010 Clairton Plant
Clairton Plant Gas Explosion, John Surma CEO



U. S. Steel

10
Years





**Board Room
C- Suite**

EASIEST to Get Things Done, Unlimited authority, BUT PEOPLE USUALLY HAVE TO DIE TO GET PROBLEMS TO THIS LEVEL.



Middle Management

**99% OF REAL LIFE
HAZARD ABATEMENT**



Operations & maintenance

Show up with your new **25 HAZARDS** & human nature kicks in



Middle Management



Operations & maintenance

- But who says we have to “do that” or “need that”
- It’s been fine for 50 years
- That’s never been a problem before
- We are grandfathered by the code
- That’s wasn’t a near miss!, that was just abnormal operations
- Who’s this “Ass%^&* Puskar”?

The problem is an emotional chasm or gap, can't be filled With facts and figures.



Emotions

Make it an emotional battle

Personal Criminal Liability is more and more of a reality for managers today!



In January 2016, a... Enterprises with nine records, tampering with pending.

Henzerling's supervisor, **reckless homicide**, and to take proper precautions to

Personal Criminal Liability & Gross Negligence & the jail time that goes with them are very emotional.

any manager
e want to
his own
m?

mental
tampering with
e is

er, one count of
ense, including failure
e indictment.

This strategy and that your management team is intelligent and has a shred of morality!

You need to understand:

NEGLIGENCE/GROSS NEGLIGENCE

<https://www.youtube.com/watch?v=NFuyKbFiMv8> (1:06)

2nd Degree Murder vs.

INVOLUNTARY MANSLAUGHTER

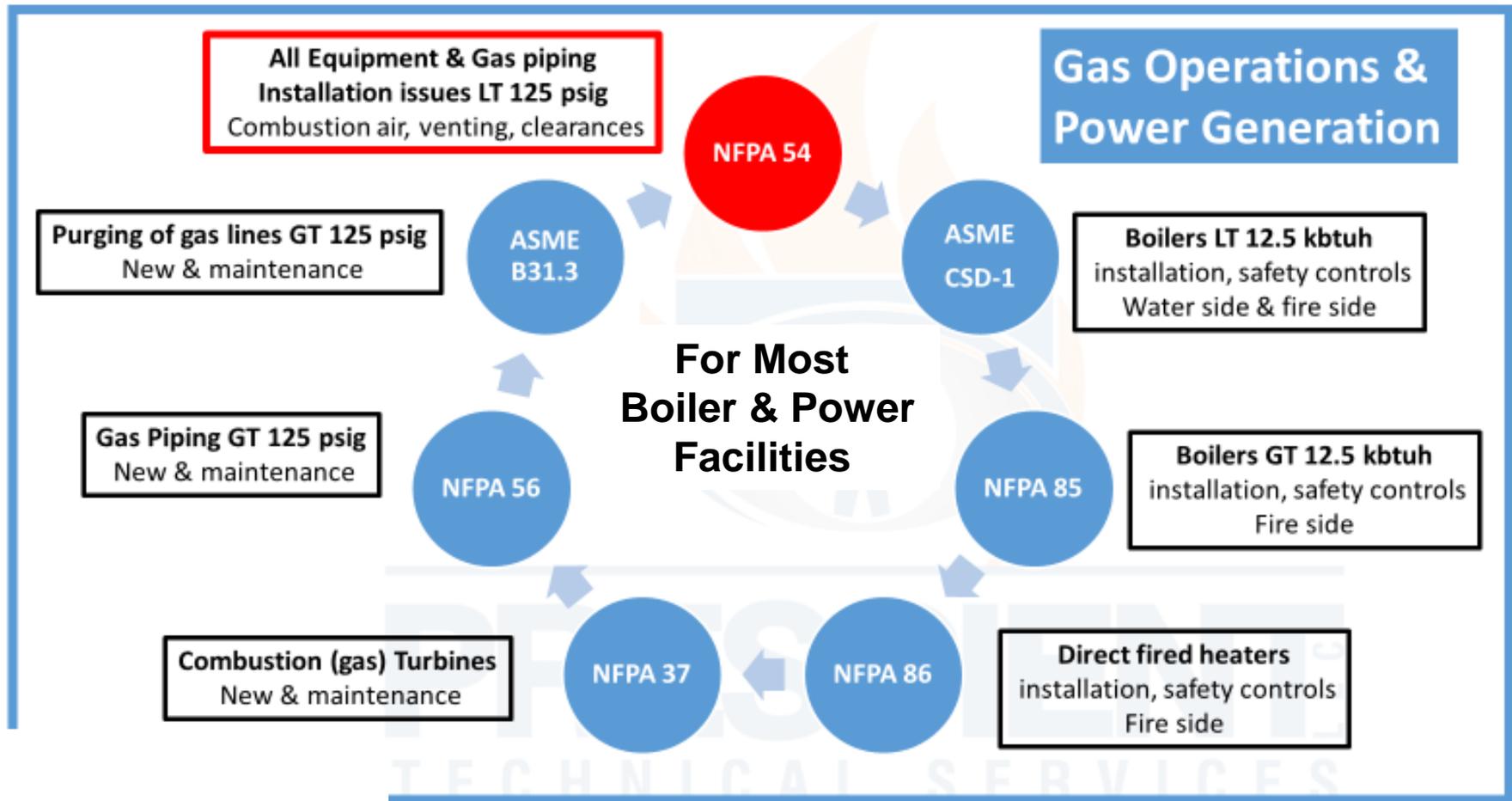
<https://www.youtube.com/watch?v=NuyhxlKdp54> (1:26 – 3:58)

BUILD AN EFFECTIVE PAPER TRAIL

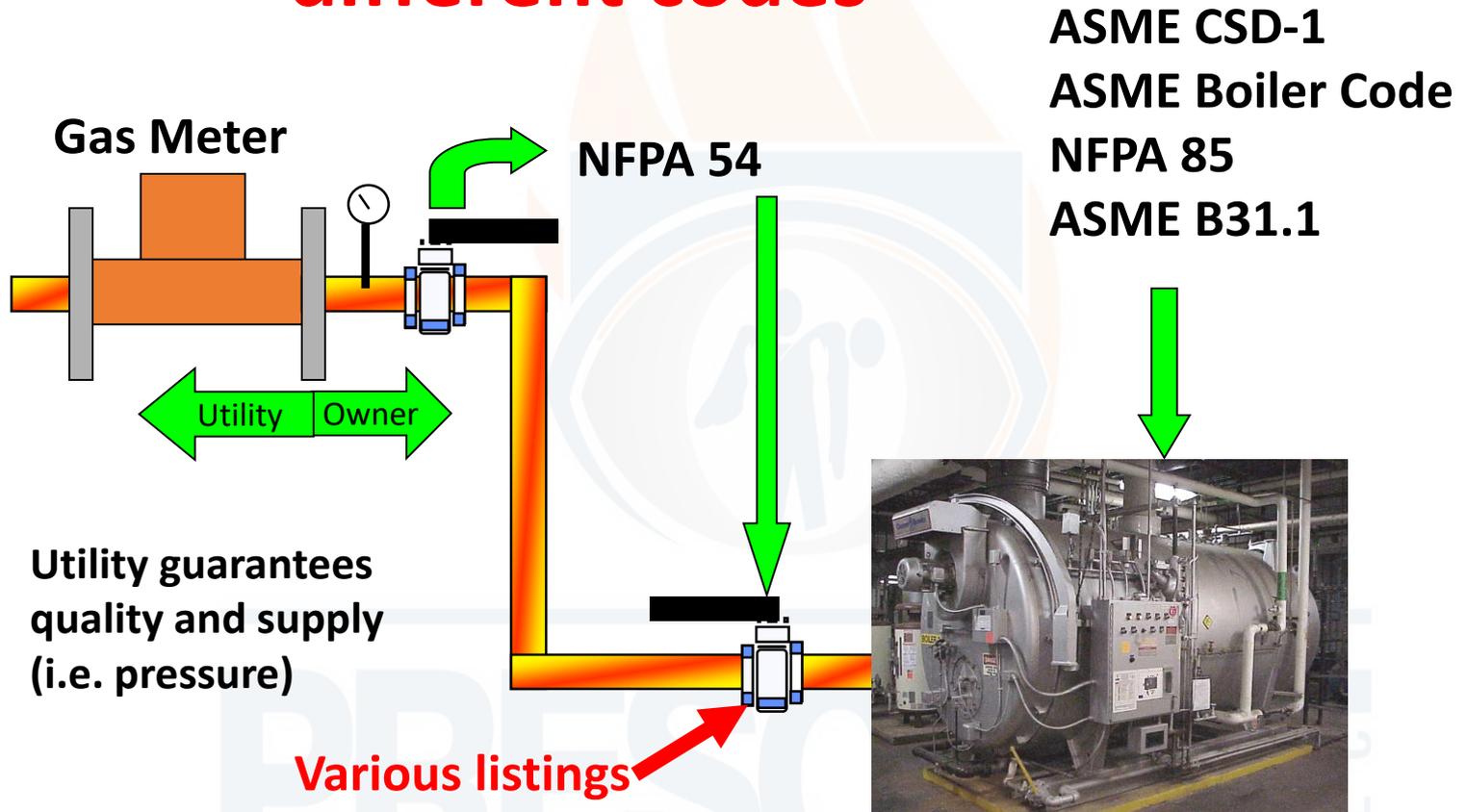
- Document everything and include times, days, temperatures, chemical concentrations, and test statements, prepare like you are going to court because at some point YOU WILL BE.
- Make sure that you identify that the risk for acknowledgment.
- Communicate the possible danger of the hazard: can it result in death or a major injury?
- Provide management with copies of sections of codes or standards that are applicable.

If all else fails, keep yourself out of JAIL!

It will help to know What codes & standards are being VIOLATED?



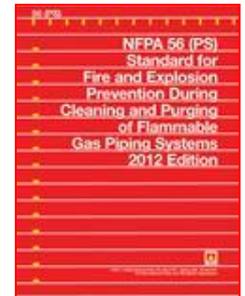
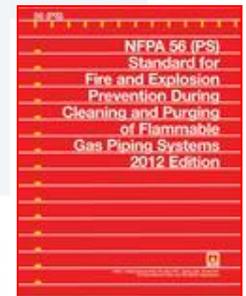
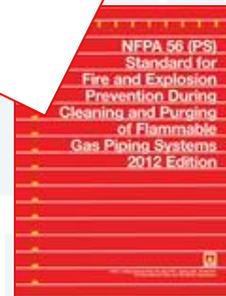
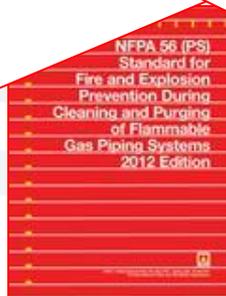
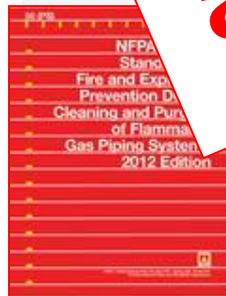
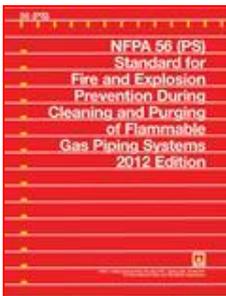
Gas Line & Boiler might involve 5 different codes



Current or former members of 7 different
code committees including NFPA 54, 56, 85,
86, and 88, as well as NFPA 1 and API - 54



Call me, I'm
retired, I don't
charge like a
lawyer.
and



Any Questions?



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- having or showing knowledge of events before they take place