101 ESSENTIAL ELEMENTS

in a
Pressure Equipment Integrity Program
For the Hydrocarbon Process Industry

Inspection Summit

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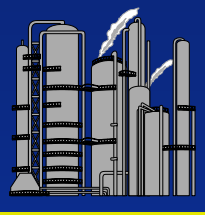
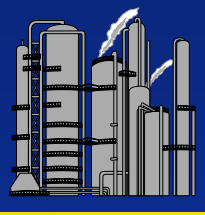


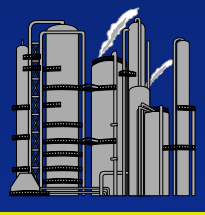
PURPOSE OF PRESENTATION

- **"Pull it all together" - outline the fundamentals of Pressure Equipment Integrity Management (PEIM)**
- **Inform those outside of the mechanical integrity discipline of the scope and magnitude of PEIM efforts that we manage**
- **Improve the effectiveness of PEIM programs within the Industry**
- **Allow companies that apply PEIM effectively, to make maximum use of their physical assets to generate income**
- **Mention a few of the 101 Essential Elements for Pressure Equipment Integrity Management (PEIM)**



PEIM WORK PRIORITY VS. RESOURCE AVAILABILITY

- Need for **prioritization** of PEIM issues is recognized
- Resources are **limited** in a very competitive industry
- Can't do it all at once; may take **5 years** of aggressive effort to reach the top of the **PEIM ladder** (101 steps)
- Must **"shore up"** weakest, higher-risk segments **first**
- **But**, none of the 101 Elements can be neglected, or pressure equipment failures will likely occur

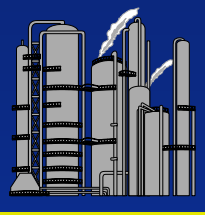


PEIM COMPLIANCE VS. EXCELLENCE

- Compliance is NOT the key to success in PEIM
- Excellence in PEIM is . . .
- Just seeking compliance usually results in mediocre mechanical integrity and process safety
- Climb the ladder of excellence, NOW
- Don't wait until your next fire or explosion or injury to make sure you have an effective PEIM program
- "Excellence" does not mean "overdone or excessive"

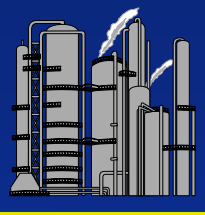
WHOSE JOB IS PRESSURE EQUIPMENT INTEGRITY MANAGEMENT?

- **Management**
- **Operations**
- **Engineering Services**
- **Maintenance / Reliability**
- **Process Engineering**
- **Project Engineering**
- **Corrosion Engineering**
- **Inspection**



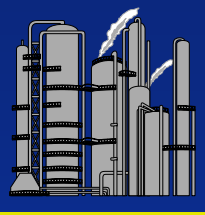
THERE'S NO REAL SECRET TO PEIM!

- It's simply "blocking and tackling"
- It's simply "back to the basics"
- It's simply doing all the right things, right, day after day (perseverance)
- It's not getting distracted by the "hot rocks" of the day
- It's not getting distracted by "the program of the month"



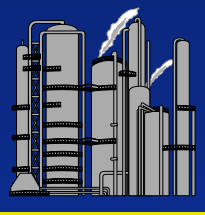
HOW DOES THE USA NAVY DO IT?

- Operates **huge, complex, nuclear aircraft carriers**
- During **war and peace**
- **Very effectively**; usually without incident
- During **high risk periods**, often in darkness
- Landing and launching aircraft **every few minutes**
- Crew of folks with average intelligence and an average age of about **21** years
- How? **Procedures**, **discipline**, **training**, etc., etc., etc.



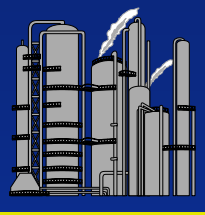
KEY TO SUCCESS IS EFFECTIVENESS

- The most important word I use in describing the 101 Essential Elements of PEIM -> "Effectiveness"
- Dictionary definition: "Producing a decided, decisive, or desired result"
- A lot of time, motion, and money can be, and is wasted on PEIM without really being effective
- Procedures and training are no good without effective implementation and real knowledge transfer to those who need to know about PEIM
- Now let's cover just a few of the 101 Essential Elements



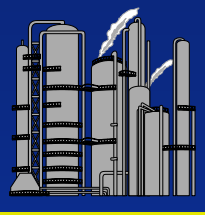
101 ESSENTIAL ELEMENTS OF PEIM

PEIM MOC ☎ Positive Material Identification (PMI) ☎ Temporary Repairs ☎ Temporary Installations ☎ Key and Critical (K/C) Materials Degradation Variables ☎ Materials and Corrosion ☎ Environmental Cracking ☎ Furnace Monitoring ☎ Brittle Fracture ☎ Record Keeping ☎ Flare Systems ☎ Training and Certification ☎ Inspection Procedures ☎ Welding QA/QC ☎ Qualified Suppliers ☎ Fabrication QA/QC ☎ Inspection Scheduling ☎ Remaining Life Calculations ☎ Equipment Overdue ☎ Piping Inspection ☎ Injection Points ☎ Deadlegs ☎ Thickness Measurements ☎ Small Bore Piping Inspection ☎



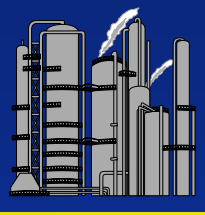
101 ESSENTIAL ELEMENTS OF PEIM

Critical Check Valves ☎ Failure Reporting ☎ Inspection Recommendation Tracking ☎ Risk Management ☎ Corrosion Under Insulation ☎ External Corrosion Prevention ☎ Hot Spots ☎ Bull Plugs ☎ Fatigue Failures ☎ Flange Gaskets ☎ Fitness for Service ☎ Cast Iron ☎ Heat Tracing ☎ Soil-to-Air Interfaces ☎ Bundle Classification ☎ Wire Wrapping/Boxing ☎ Relief Valve Preopping ☎ Hydrotesting Safety ☎ On-Stream Inspection ☎ NDE Specialists ☎ Carbon - 1/2 Molly Equipment ☎ Knowledge Transfer ☎ Localized Corrosion ☎ Hot Tapping ☎ Gray Zone Equipment ☎ Pressure Relief Device Auditing ☎ Tank Bottom Inspection ☎



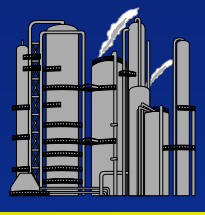
101 ESSENTIAL ELEMENTS OF PEIM

Water Drop Out Points ☎ Inspection Staffing ☎ ERW Pipe and Tubing ☎ Process Contamination ☎ Inspection of Tank Roofs ☎ Inspection of Inaccessible Locations ☎ External Chloride Cracking CUI ☎ Process Creep ☎ Mixed Metallurgy Piping Systems ☎ Third Party Equipment ☎ Corrosive Mix Points ☎ Dummy Leg Corrosion ☎ Corporate Failure Memory ☎ Ammonium Salts ☎ Hydrotest Water Quality ☎ Pipe Rack Inspections ☎ Total Cost of Ownership ☎ Flange Bolting Procedures ☎ Valve Quality ☎ Surface Cleaning ☎ Bad Actor Pumps ☎ Plugged Vents on AST's ☎ PWHT Problems ☎ Risk Based T/A Planning ☎ Failure Analysis



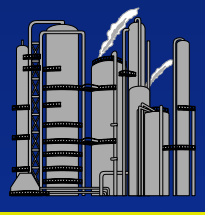
MANAGEMENT OF CHANGE (MOC)

- MOC is one of the most important PEIM issues, as well as important process safety issue
- Inadequate MOC has resulted in numerous PEI incidents
- For example the last major fire at two LA refineries
- Process changes are equally as important as physical changes
- Do you have an effective MOC work process in place that will allow inspectors to know when and if they need to change inspection practices to account for process changes?



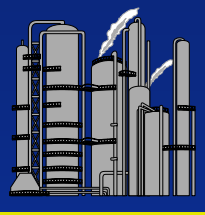
POSITIVE MATERIAL IDENTIFICATION (PMI)

- PMI program needed for **new and existing** equipment
- **API RP 578**, Material Verification for New and Existing Alloy Piping Systems
- Numerous industry incidents traced to **inadvertent material substitutions** in alloy piping systems
- For example a **major fire with three fatalities** in a Baton Rouge, Louisiana Coker in 1993
- **1-3% material errors** in new construction - somewhat normal
- **Maintenance activities** can increase that rate significantly
- **Are you using API 578 effectively to identify rogue materials before you experience surprise failures?**



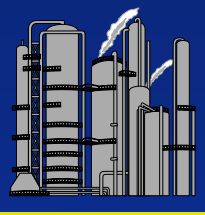
KEY AND CRITICAL (K/C) MATERIALS DEGRADATION VARIABLES

- All K/C variables need to be Identified, documented, and implemented for all known and potential material degradation issues; and then operating windows need to be established and adhered to
- MOC work process for K/C variables must involve PEIM SME's
- Must include effective knowledge transfer to operators
- K/C variables are much more involved than just pressure, temperature, process composition, etc.
- Do you have all the K/C operating variables that can cause material degradation, identified, documented, communicated and understood by operators on the front line?



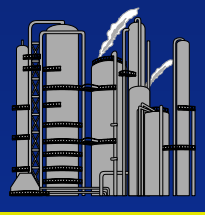
FURNACE MONITORING AND INSPECTION

- Furnace failures are often big contributors to plant reliability problems, but can result in safety problems, as well
- Effective inspection and data analysis (MPC Omega Analysis) are necessary to monitor and evaluate remaining life of tubulars
- Furnaces are a specialized body of knowledge requiring SME's
- Two recent furnace tube failures have resulted in fatalities
- Do all your furnace coils have a reliable structural integrity analysis and remnant life prediction, so that you will not be surprised by predictable failures that could have been avoided by scheduled inspection and maintenance?



BRITTLE FRACTURE PREVENTION

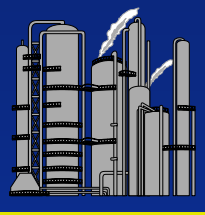
- **Low Probability - High Consequence type failure; but they do happen**
- **In-service brittle fractures must be avoided "at all costs"**
- **API RP 920 and API RP 579 provide good guidance**
- **All potentially susceptible equipment must be identified and handled with extra care and attention for inspection and repairs**
- **Last big brittle fracture disaster happened in Australia, just two years ago with two fatalities and enormous economic impact**
- **Do all the right people in your plant know the MDMT of all your equipment and how to avoid the potential for brittle fracture?**



FLARE SYSTEM INSPECTION

- Flare systems must always be totally reliable - on demand
- Flare systems need inspection for corrosion and fouling
- Density radiography is good for fouling and plugging
- Ultrasonic scanning and radiography for corrosion/cracking
- A major multi-million dollar disaster in Britain when a refinery flare line broke in half and fell to the ground during an emergency venting event

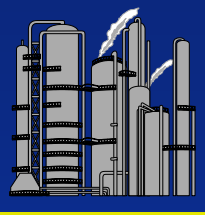
- Are your flare systems "out of sight - out of mind?"



CRITICAL CHECK VALVES

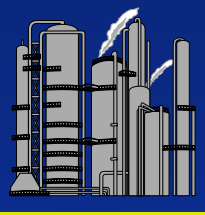
- The operability of some swing check valves is critical to the safety and reliability of process units
- Critical check valves on furnace outlets MUST close off flow when a tube rupture occurs
- A critical check valve failed at a Shell Deer Park ethylene unit in 1997, causing a $300 Million USD loss

- Are all the critical check valves in your plant identified and maintained, so they will operate when necessary?



INJECTION POINT (IP) INSPECTION

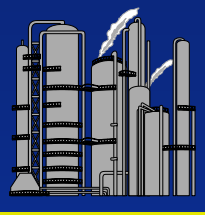
- May 5, 1988 - a day I will never forget - the largest refining disaster in Shell Oil's history; and early this year - another one in Conoco at Humber, UK
- Severe, undetected corrosion downstream of an injection point
- All potentially corrosive IP's must be documented, inspected and tracked like individual pieces of equipment
- Requires quality input and involvement from process engineers and operations in order to identify and track IP's
- Do you know where all your potentially corrosive injection points are; and do you have them documented and scheduled for effective inspection in accordance with API 570?



INSPECTION OF DEADLEGS

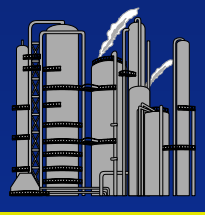
- **April 1, 1996** - a major loss for a California refinery due to undetected corrosion in a hydroprocess deadleg from highly localized ammonium salt corrosion
- Deadlegs often have **different corrosion rates** and thereby require different inspection planning and detection methods
- **Many leaks and fires** originate in small bore piping deadlegs
- **API 570** provides good guidance for inspection of deadlegs

- **Do you have all your process piping deadlegs identified; and do you have an effective program for monitoring or removing them?**



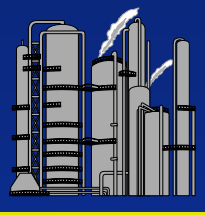
SMALL BORE PIPING (SBP) INSPECTION

- SBP sometimes does not get enough attention
- Under certain circumstances, the failure of SBP can lead to significant PSM incidents
- In the mid-80's, a California refinery experiences a very large HCU fire, including the toppling of a reactor, when a 1 inch hydrogen line fractured
- In March, 2000, a mid-west refinery suffered a major fire in their CFH, when a 3/4 inch stainless steel tubing ruptured
- Do you monitor and inspect your higher risk SBP?



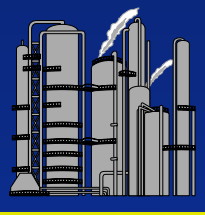
CORROSION UNDER INSULATION (CUI)

- Another potential "out of slight - out of mind", insidious corrosion problem
- A NZ refinery recently experienced an unscheduled outage of a hydrocracker unit due to CUI, soon after a successful T/A, causing a gasoline spray from the top of their fractionator
- CUI rates typically run from 10-40 mpy; leaving susceptible piping fairly thin after 15-25 years of service
- Good guidance on CUI susceptibility and inspection needs included in API 570
- Do you have an effective CUI inspection program: and more importantly a CUI PREVENTION program on equipment and piping susceptible to CUI?



HOT SPOTS

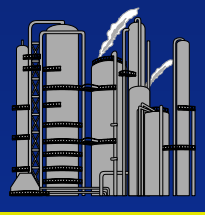
- **Not an infrequent occurrence in furnaces and refractory lined equipment**
- **Led to a fatality recently when a furnace tube ruptured at a Canadian refinery**
- **Another plant recently suffered a fire when a refractory-lined transfer header with a hot spot, resulted in line rupture**
- **Use of temperature sensitive paint and thermography are keys to detection and incident avoidance**
- **Do you have effective hot spot monitoring and evaluation procedures in place to make sure you don't suffer a surprise rupture of equipment with hot spots?**



PIPE (BULL) PLUGS

- Another **often overlooked** source of releases and fires
- A French refinery suffered a **significant fire** when a bull plug (pipe plug) backed out of a pump case, on line
- Another **fire and injury** happened at a mid-west refinery when an inspector stepped on a bull plug, causing it to disengage
- **Vibration, thread corrosion and PMI** are all problems with bull plugs that need to be managed

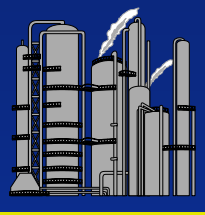
- **Do you have an effective preventive maintenance and control program for bull plugs, to minimize the potential for them blowing out, at your facility?**



FATIGUE FAILURES

- Fatigue failures can lead to **sudden, full bore failures**, especially on small bore piping
- "Almost" an **uninspectible phenomena**; **must** be prevented
- Full line separation of a 2 inch pipe, at a chemical plant released **20,000 pounds** of hydrocarbon in just a few minutes
- A four inch nozzle, with a valve and blind flange on it, fell off a column causing an **immediate fire with major damage**

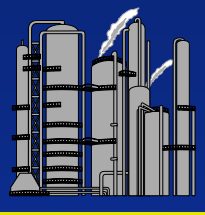
- **Do you train your operators and craftsmen to recognize and report vibration so that preventative measures can be employed before fatigue starts?**



HEAT TRACING FOR SAFETY SYSTEMS

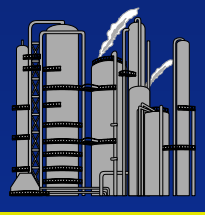
- Heat tracing is often vital for prevention of plugging in safety devices and emergency lines
- Sometimes these systems get inadvertently shut off and plugging occurs from solidification of process material
- Often heat tracing systems fall in the twilight zone of responsibility between functions at the plant

- Do you audit your heat tracing systems at frequent enough intervals to be reasonably assured that you do not have a significant risk of plugging of vital safety systems?



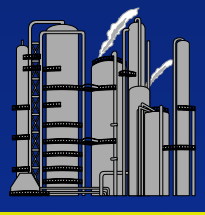
WIRE WRAPPING / BOXING OF FLANGE LEAKS

- Long been a **safe and successful practice** in our industry for stopping leaks on equipment and piping in-service
- Requires the oversight of **knowledgeable** materials engineers
- A California refinery had an **exchanger head blow off** when enclosed bolting suffered caustic cracking from the leaking steam condensate; another company had a valve bonnet blow off
- **Sealant injection** can also **overload** bolted boxes, thin piping being enclosed and flange joints
- **Are you always cautious about what might happen to the bolting material when leak sealant enclosures are installed?**



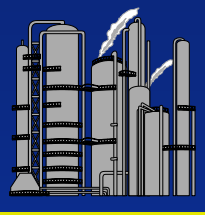
CAST IRON (CI) ISSUES

- Numerous incidents attributed to the **sudden brittle fracture** of cast iron (CI) components
- A CI steam strainer failed suddenly at a mid-west refinery, causing the **death of a pipefitter** in 1969
- A CI pump fractured at a Washington refinery in 1990, **spilling a large amount of crude oil** into the environmentally sensitive Puget Sound
- A CI hot tap valve fractured at a plant on the gulf coast in 1999
- **Does your plant have cast iron components in higher risk services?**



CARBON - 1/2 MOLY EQUIPMENT

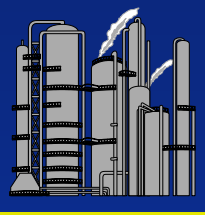
- Well known that some C-1/2 Mo equipment is highly susceptible to High Temperature Hydrogen Attack (HTHA), well below the acceptable "Nelson Curve" in API 941
- HTHA failures have caused a dozen significant incidents in the last 3 decades
- A recent failure and fire at a Texas refinery occurred on an exchanger nozzle operating 75 degrees below the Curve
- Automated Ultrasonic Backscatter Technique (AUBT) can reliably find and measure HTHA damage in early stages
- Do you know where all your C-1/2 Mo equipment is operating relative to the Nelson Curve; and are you monitoring it with AUBT to provide assurance that it is not degrading in service?



FLANGE GASKET SELECTION AND QA

- Another one of the fundamental PEIM building blocks that occasionally causes major losses
- Improper gasket blew out in HCU start up in KSA, causing a fatality
- A spiral wound gasket at gulf coast refinery blew out and caused a major fire when the carbon steel inner ring suffered from creep over time

- How effective is gasket selection and gasket QA/QC at your site?



CONCLUDING REMARKS

- There are many more vital issues in the 101 Essential Elements of a successful Pressure Equipment Integrity Management Program
- PEIM consists of procedures, training, discipline, and effective implementation
- Rarely does our industry experience a failure, explosion or fire because of something that was caused by some phenomena unknown to, or unpredictable by knowledgeable pressure equipment and materials engineers
- Do you have an effective inspection and prevention program in place at your facility for the 101 Essential Elements of PEIM?