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Webinar

Small bore…still a big problem?

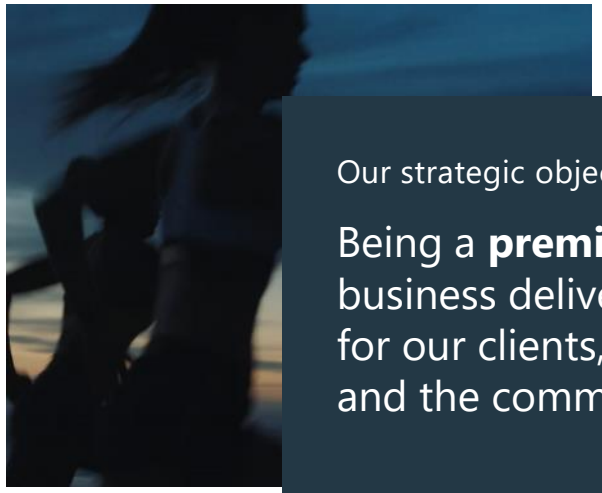
New methods to find and track vibration threats in small-bore piping and tubing

Dr Raj Singh, Bruce Loneragan, Paul Crowther

May 2021

Agenda

- Introduction and safety moment
- What's the problem with small-bore piping and tubing?
- Approaches to manage vibration-related tubing failures
- Managing small-bore anomalies with digital tools
- Conclusions
- Polls and Q&A



Our strategic objective

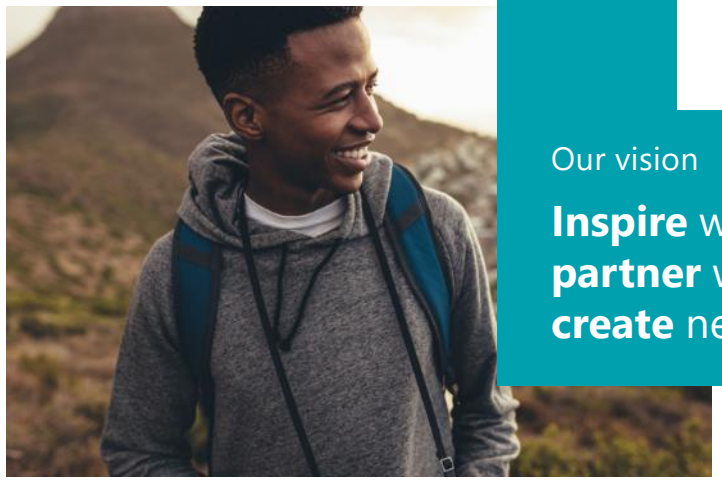
Being a **premium**, **differentiated** business delivering **exceptional** returns for our clients, our team, our investors, and the communities in which we work.

What we do

World leading consulting and engineering company across **energy** and the **built environment**

Our purpose

Unlocking **solutions** to the world's most critical **challenges.**

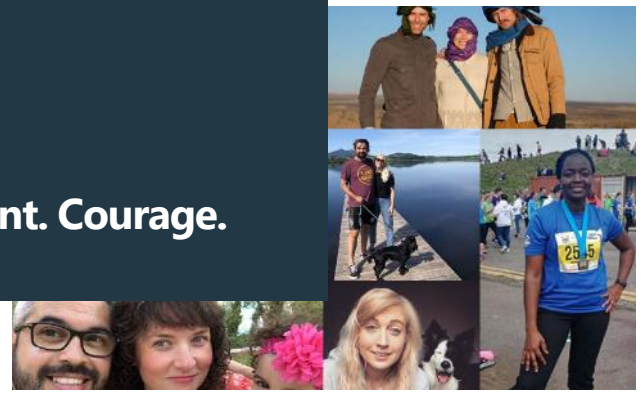


Our vision

Inspire with ingenuity,
partner with agility,
create new possibilities.

Our values

Care. Commitment. Courage.



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Our sectors

Infrastructure

Transportation
Water
Built environment

Industrial & manufacturing

Pulp and paper
Aerospace
Automotive
Food and beverage
Life sciences

Government

Defence
Marine
Government agencies

Mining

Base metals
Precious metals
Industrial minerals
Other minerals

Power

Conventional
Nuclear
Renewables
Transmission and distribution

Oil & Gas

Upstream
Midstream
Downstream
Chemicals

Asset performance optimisation

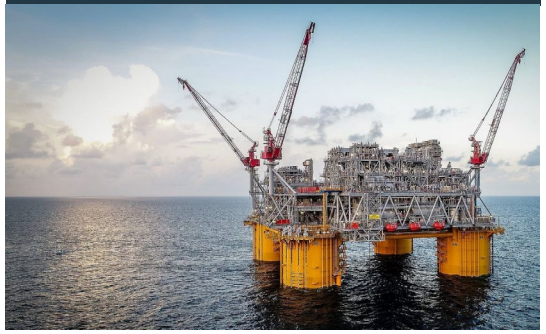
Integrity management

- Integrity assurance and management
- Corrosion modelling, assessments and mitigation
- Materials engineering, welding, fabrication
- Shutdown / turnaround management and support
- RAM – Reliability, availability and maintainability modelling
- RBI – Risk-based inspection and reliability
- Expert witness and due diligence services
- Integrity database development and management

Operational management solutions

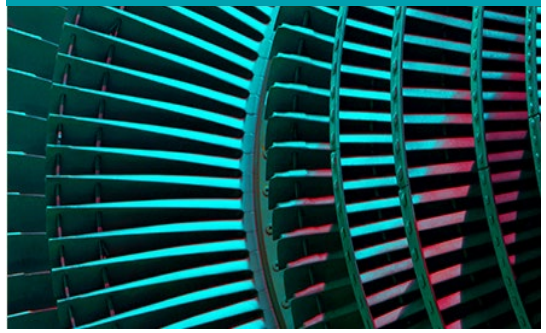
- Operations readiness program management
- Intelligent Information and data management
- Maintenance management consultancy, strategy development
- Asset Performance Management (APM) systems and support services
- Maintenance database development and optimisation
- Bespoke training and competency
- Technical documentation creation, optimisation, management

Commissioning and start-up



- Commissioning consulting
- Detailed planning, certification and schedule
- GoCompletions® Completion Management System (CMS)
- Preservation planning and execution
- Static and dynamic commissioning execution
- 3rd party sub-contract and vendor coordination
- Systems based integrated schedule and project controls
- Facility certification and handover to commercial operations

Vibration, dynamics and noise



- Condition monitoring and rotating equipment analysis
- Digital reliability; IoT and maint.ai
- **Piping fatigue and structural dynamics**
- **Veridian vibration screening and anomaly management software**
- **Field engineering and troubleshooting**
- Anti-vibration solutions
- Noise management
- Customised vibration and reliability training

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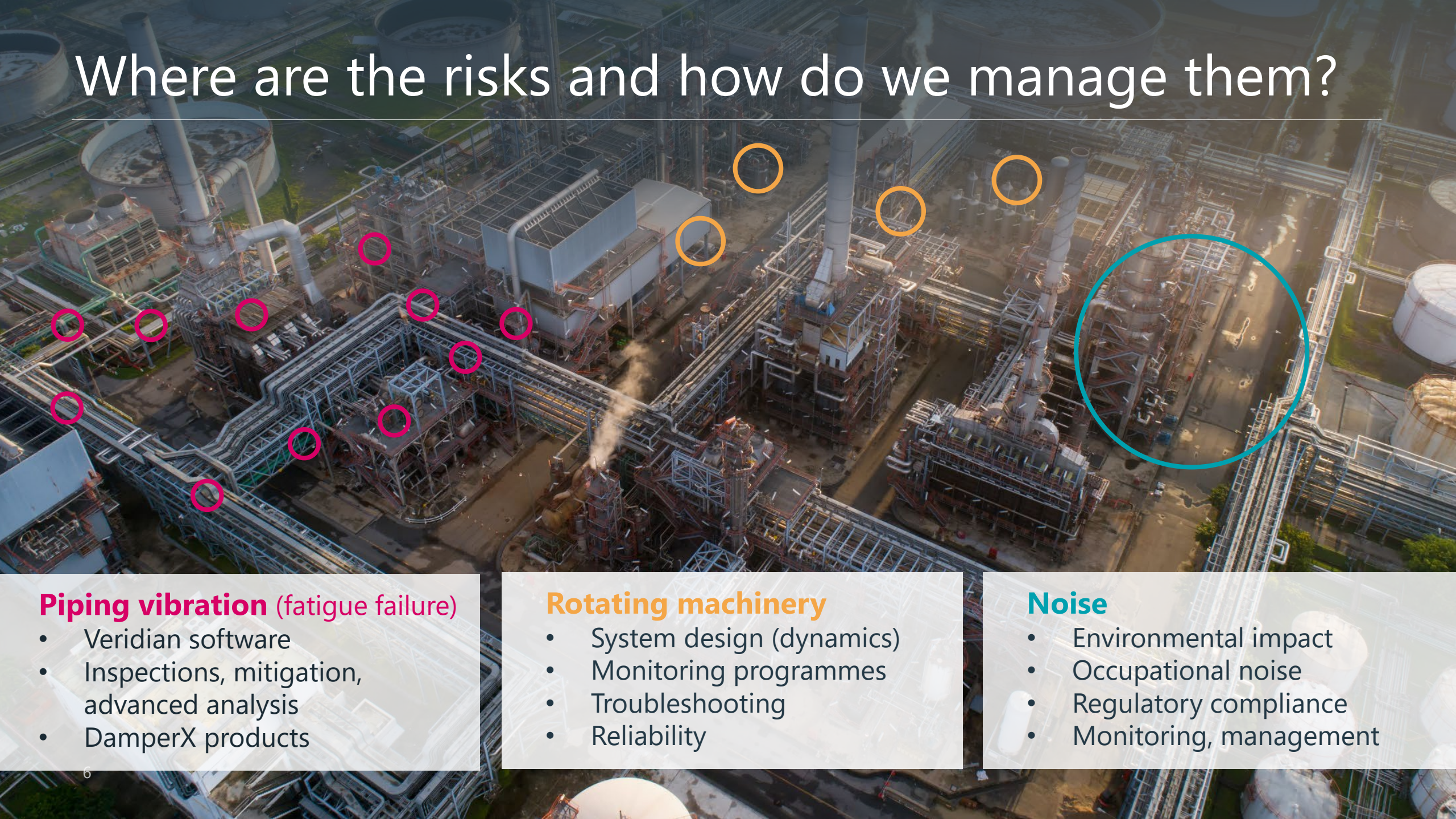
Where are the risks and how do we manage them?



Piping vibration (fatigue failure)

- Veridian software
- Inspections, mitigation, advanced analysis
- DamperX products

Rotating machinery

- System design (dynamics)
- Monitoring programmes
- Troubleshooting
- Reliability

Noise

- Environmental impact
- Occupational noise
- Regulatory compliance
- Monitoring, management

Safety moment



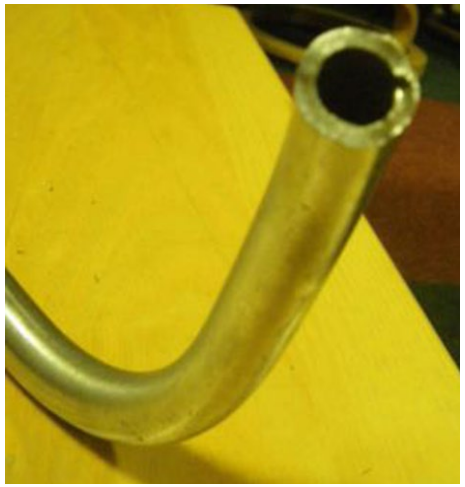


Image source: stepchangeinsafety.net

Fatigue failure of instrument tubing

- Following maintenance work, tubing was left with a pre-load stress and tool marks, suggesting it was re-fitted using force
- Vibration from the compressor led to fatigue cracks and failure; **1.67 Tonnes of gas released**
- Leak not detected by fixed sensors but manually through routine inspection; no ignition occurred

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Speakers

Bruce Loneragan, MSc

Perth, Australia

- Service Line Manager, APAC
- 30+ years' project implementation and management
- Projects and dynamic studies for the oil & gas and mining industries

Paul Crowther, CEng

Calgary, Canada

- Service Line Manager – Americas
- 18 years' experience in issues related to vibration-induced fatigue on piping, pressure equipment and structures

Dr Raj Singh, PhD

Brisbane, Australia

- Senior Consultant – Vibration, Dynamics and Noise
- 13 years' flow and structural dynamics experience
- Specialises in vibration-induced fatigue on piping and tubing

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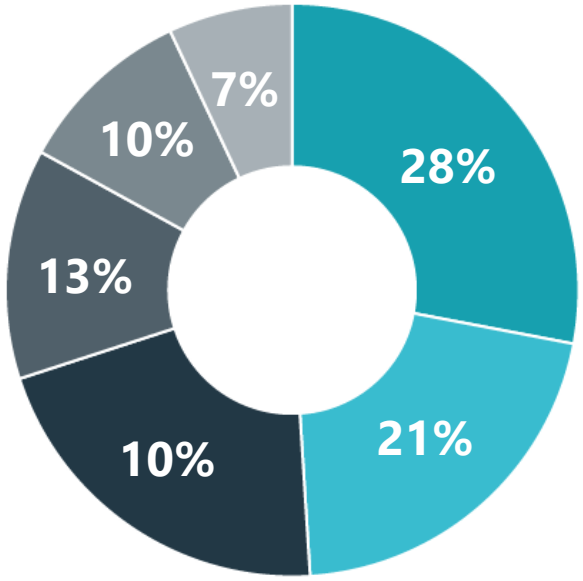
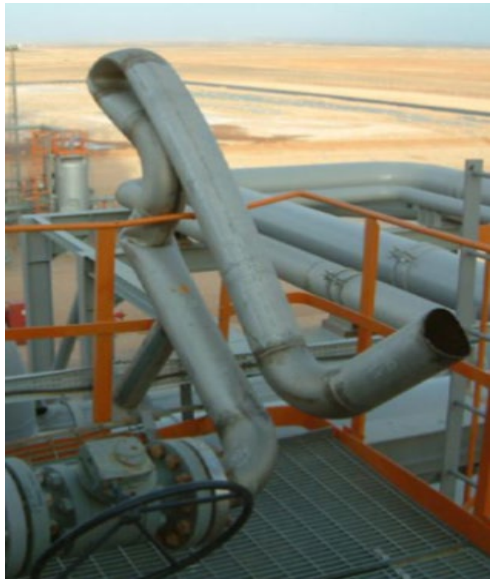
What's the problem with small-bore piping and tubing?

Piping vibration failure → integrity risk



- Degradation of material properties
- Fatigue or vibration
- Incorrect installation
- Corrosion or erosion
- Procedural
- Other



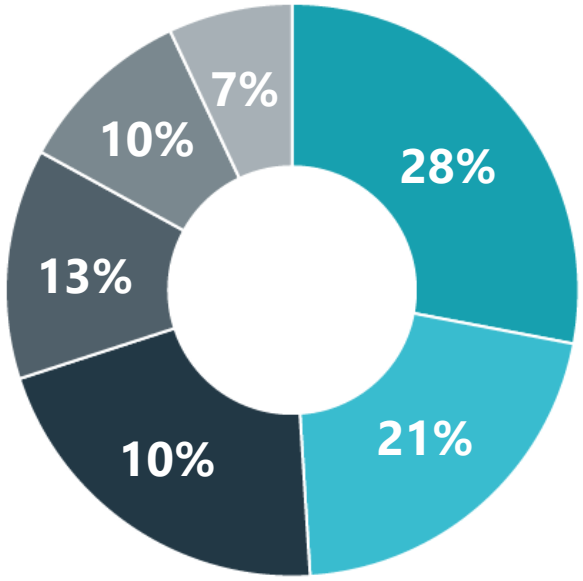
***21%** of hydrocarbon releases are due to **fatigue and vibration**

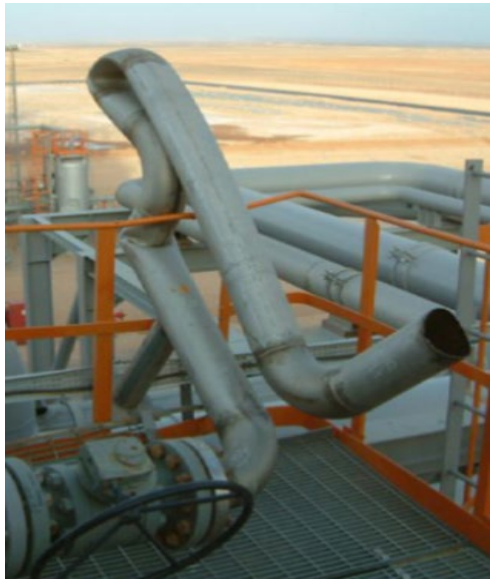
High-impact consequences

- Safety risks
- Environmental consequences
- Corporate liability
- Extended downtime
- Significant financial costs

**Source: UK regulator (HSE)*

Piping vibration failure → integrity risk





***21%** of hydrocarbon releases are due to **fatigue and vibration**

Small-bore tubing

- **20.4%** of all reported H/C leaks related to instruments
- **Two thirds (68%)** of these were gas leaks classified as significant (> 1kg)

**Source: UK regulator (HSE)*

What can be done for piping in *vibratory service*?

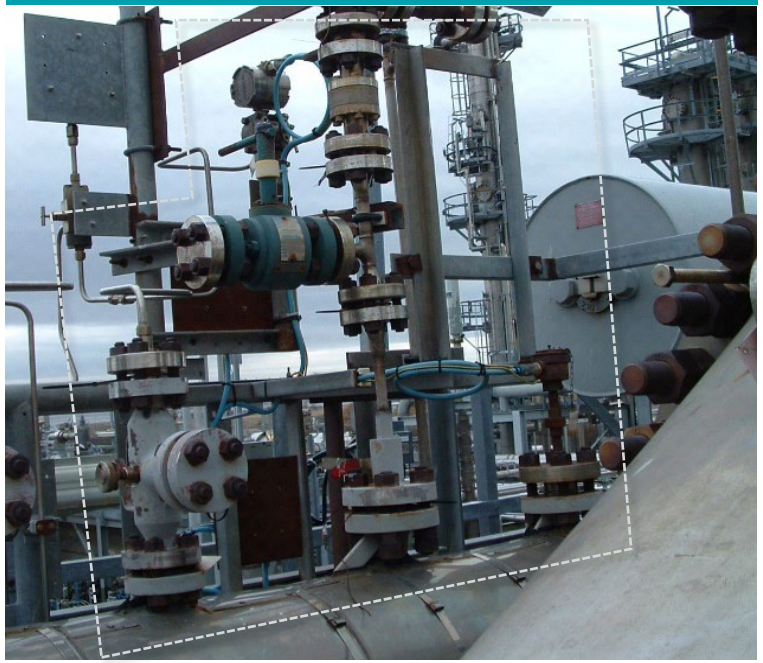
Many options to address vibratory service, including:

- Reducing energy in the system (AIV, FIT)
- Controlling root causes (pulsation, resonance, unbalance)
- Reducing turbulence
- Improving mechanical support
- **Today's focus: managing piping and tubing anomalies in the field**

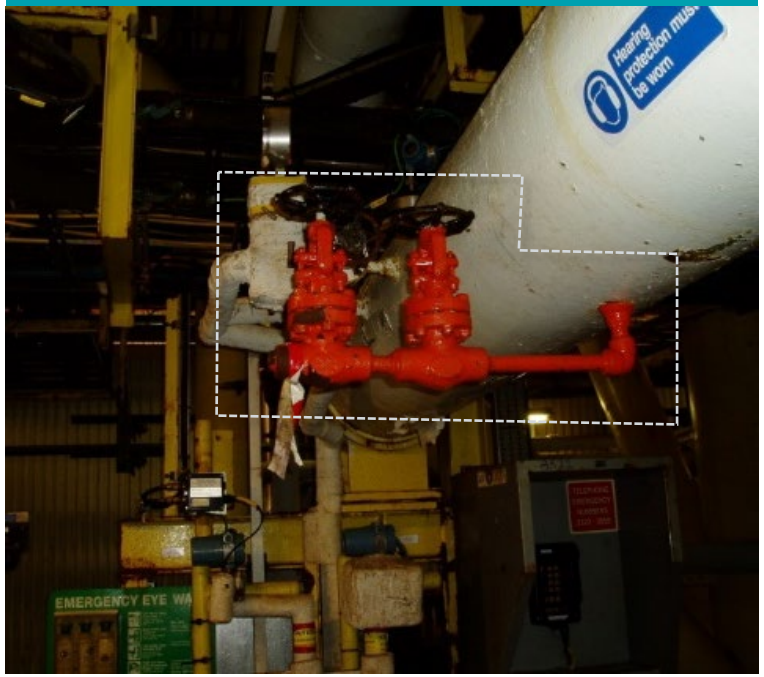
Visit woodplc.com/vdn to watch more.

Why do we need small-bore piping and tubing?

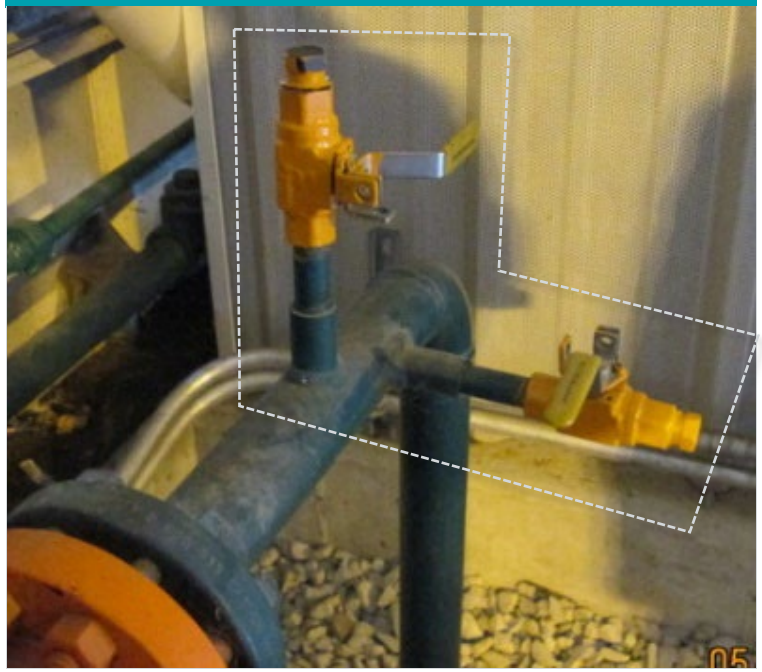
Regulatory



Accessibility



Redundancy



- To **test, monitor, drain, vent, recycle, bypass, inject, and inspect** the product and piping
- Because SBC locations and designs are **driven by process and operator convenience**, their **integrity risk** is sometimes overlooked

The failure chain

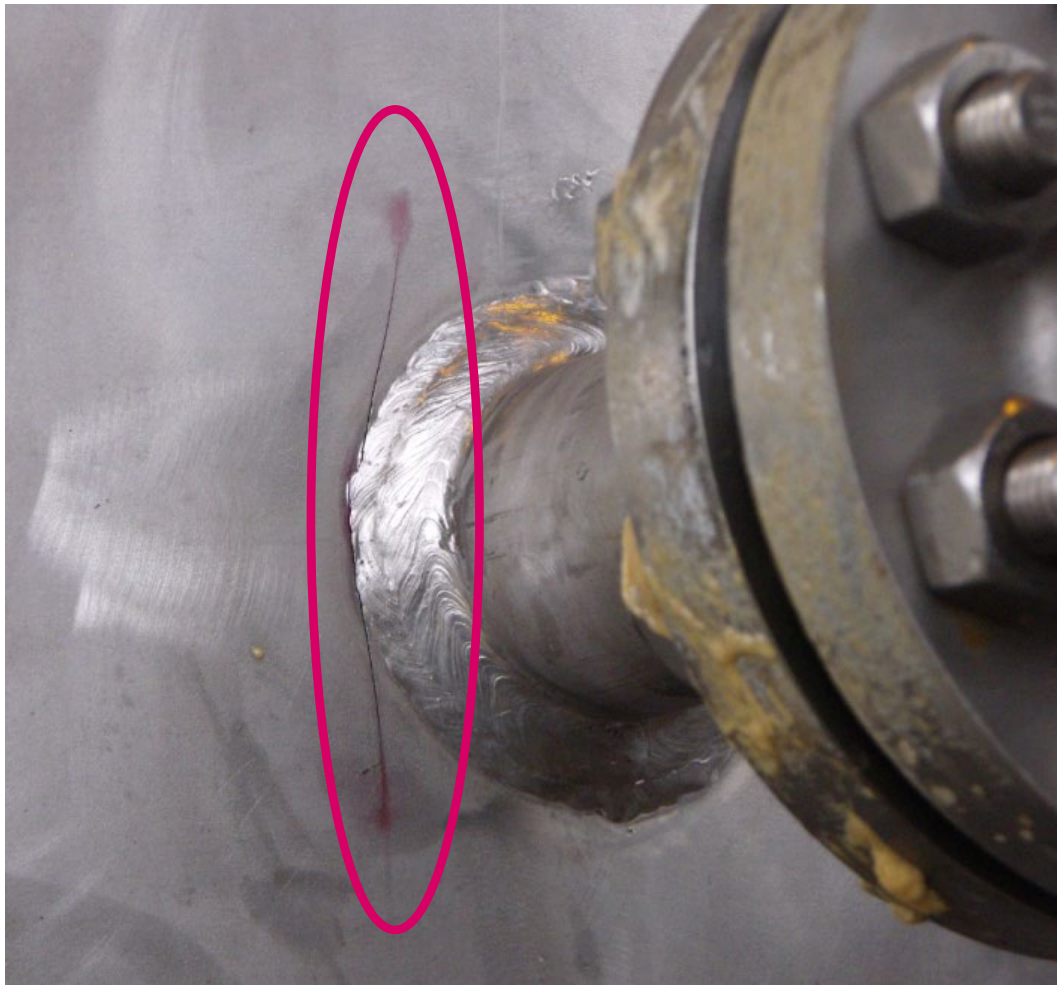
Excitation → Main line vibration → Small-bore connection vibration

- Flow-induced
- Mechanical
- Acoustic

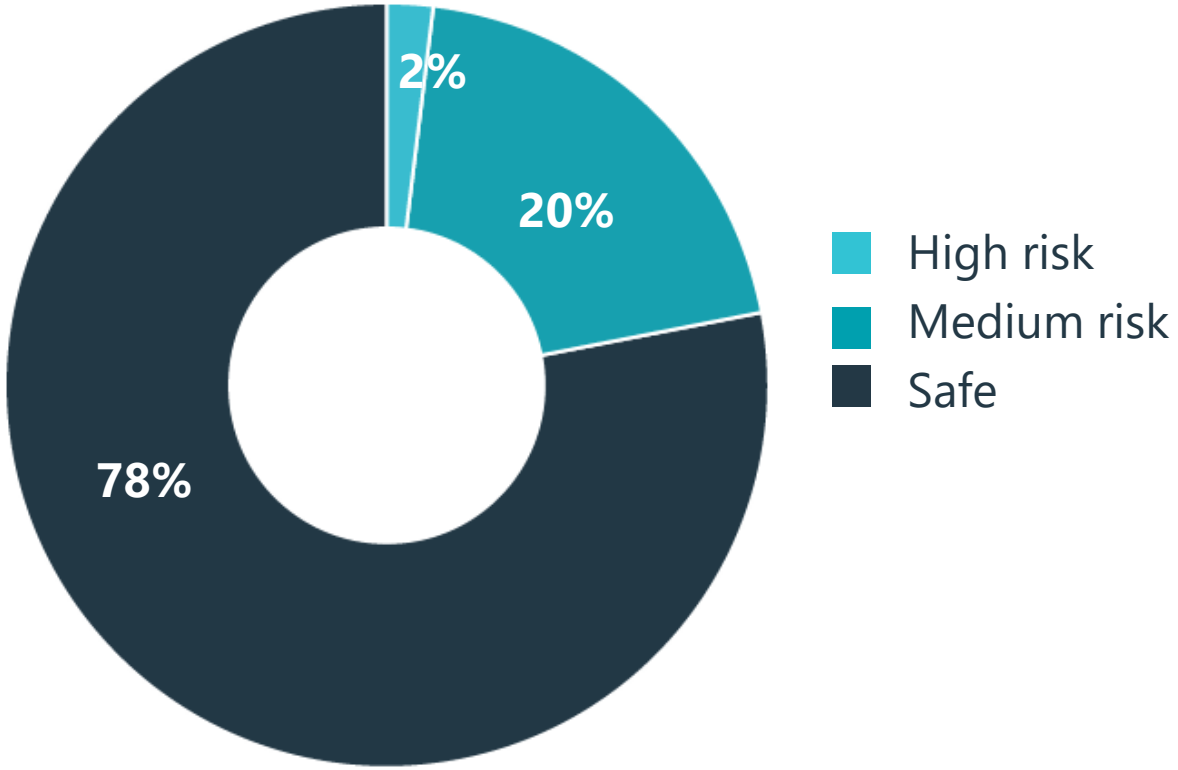
Main line failure

Small-bore connection failure

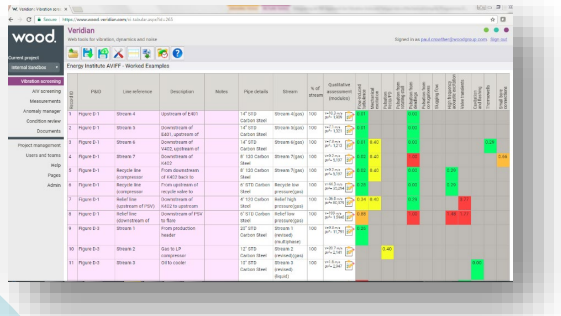
The challenge



The challenge



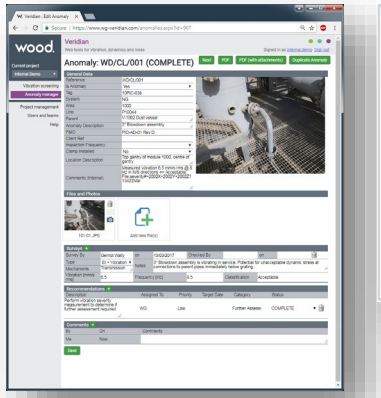
SMART predictive piping fatigue program

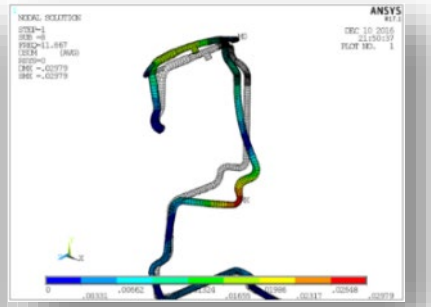


1. **S**creen and identify

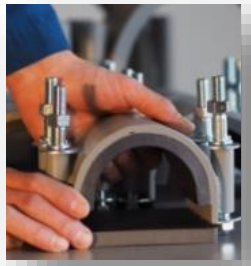
2. **M**easure and inspect

3. **A**nomaly registered





4. **R**ectify and improve



5. **T**rack

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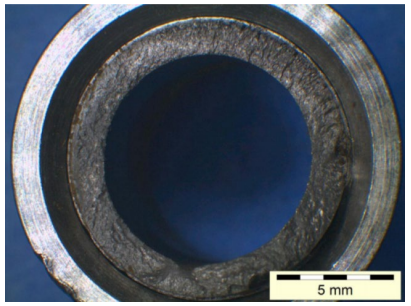
Contributing factors to small-bore and tubing failure

- **Poor installation practice** – tubing is generally field run (not engineered) and vibration (fatigue loading) risk is generally neglected
- **No** existing **method** for inspecting logging, fixing, tracking, and improving vibration risk – fail then fix
- **Lack of documentation** for existing facilities – what is there?
- Piping vibration **surveys fail** to capture tubing failure risks
- Small-bore and tubing **risks are** frequently **hidden** (invisible)
- Lack of acceptance criteria for tubing – **no vibration guidelines**, no common method for measurement
- **Inconsistent approaches** and quality from different contractors
- Requirement for **compliance** of new/replaced tubing with guidelines is **not documented** in IMPs, drawings, project scope requirements, etc
- Tubing is **replaced 'like-for-like'** or worse, and failure recurs
- Several hundred to thousands of SBT assemblies already installed in any plant. **Where to focus** inspection and remediation?
- Difficult to **communicate to higher management** or maintenance/operations personnel



Managing tubing vibration

Industry guidance (Energy Institute -EI)

1. Guidelines for the Avoidance of Vibration Induced Fatigue Failure in Process Pipework (AVIFF) 2nd Edition in 2008.

- Screen for Piping Vibration Risks (LOF and Field Measurement Criteria)
- **TM-06** provides Checklist **for 'quick first-pass' walkdown inspection of tubing in existing installations.**
- Operations personnel can conduct checks as the **'first line of defence' using Visual, Audible, Tactile (touch) means only**
- Wood SMEs are co-authors – 3rd Ed planned for 2022

T6 – VISUAL INSPECTON - TUBING

No.	Consideration	Response "Yes" - Action
1	Is the main line subject to vibration?	Review the design to ensure it is suitable.
2	Are there insufficient bends or pigtails, making the tubing inflexible and unable to accommodate the main line movement?	Consider replacing the tubing with a more suitable design. Check the connector interface for signs of weeping/leaking/ damage.
3	Is there evidence of damage at the point where the tubing enters a connector?	Replace the existing tubing and/or connection and if appropriate, alter the design taking into account the good practice guidelines.
4	Any there any signs of weeping/leaking?	Replace the existing tubing and/or connection and if appropriate, alter the design taking into account the good practice guidelines.
5	Is there any evidence of damage at the tubing supports?	Replace the tubing and consider alternative support arrangements, taking into account the good practice guidelines
6	Are the supports ineffective or loose?	Replace the tubing if there are any signs of damage. Install effective supports.
7	Is there any contact with other structures along its span?	Replace the tubing if there are any signs of damage. Reroute the tubing to avoid contacts.
8	Are any of the masses unsupported?	Install additional supports.
9	Is any disconnected tubing un-supported?	Remove, support or minimise the tubing length.
10	Does the tubing involve long unsupported runs, leading to excessive vibration?	Install additional supports.

Table T6-1 Considerations During Visual Inspection

2. Guidelines for the Design, Installation and Management of Small Bore Tubing Assemblies (2nd Edition, 2013)

- **'Best practice' guideline for tubing management**
- **Should be considered for new tubing or when replacing tubing assemblies**
- 2nd Edition published in 2013 by the Energy Institute (EI) with technical support and background R&D by Wood specialists
- Several industry sponsors; major O&G operators from around the world

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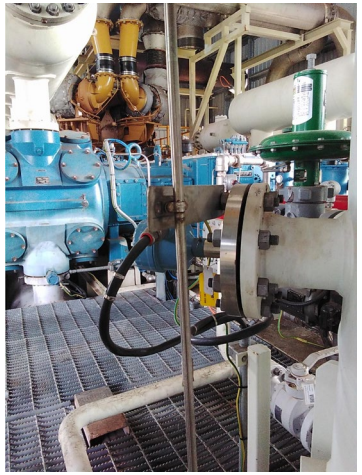
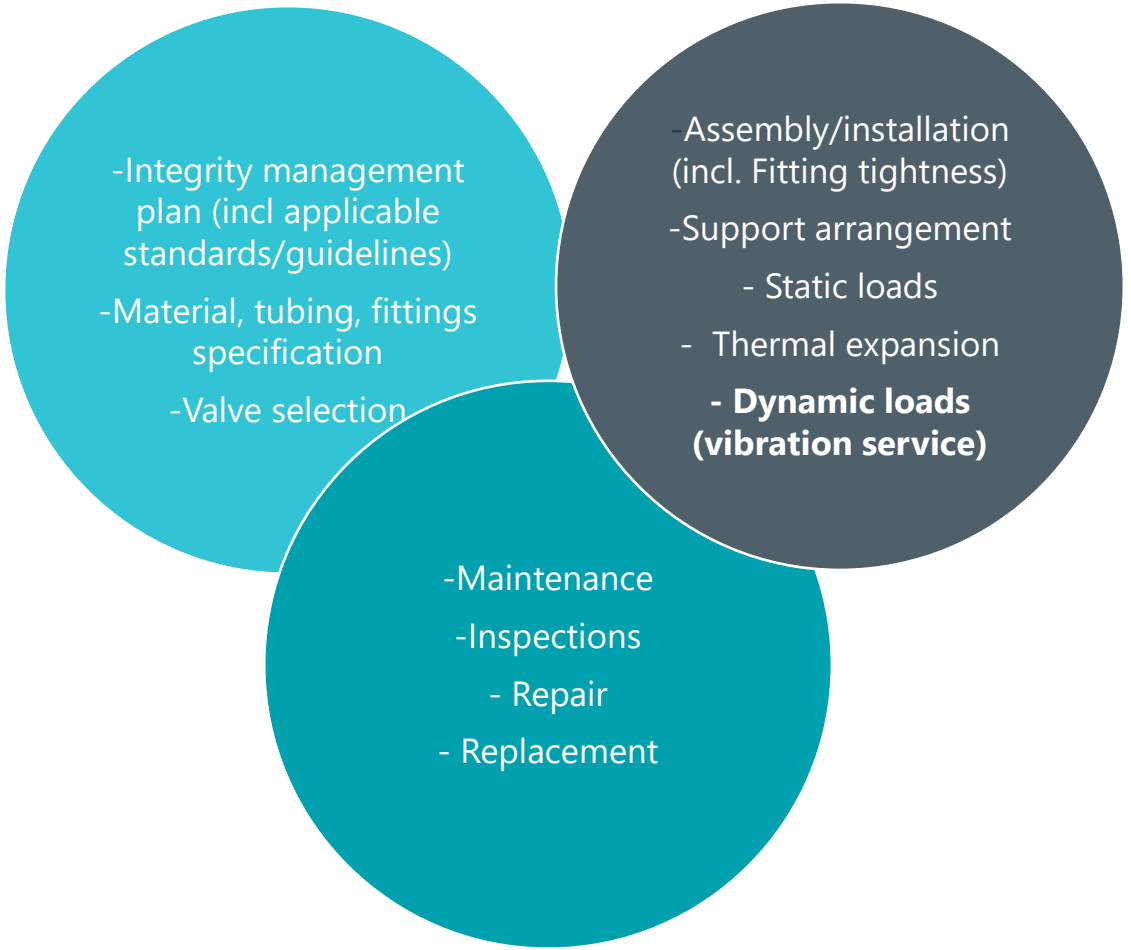
Vibration and tubing failures

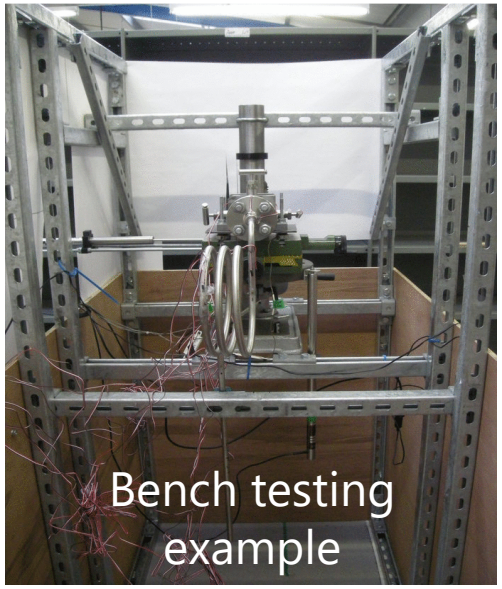
- Several considerations when implementing SBT assemblies to avoid failures
- One of the most common failure causes:
  Excessive dynamic loading (vibration)
  - Vibration will exacerbate other issues and accelerate time to failure
  - **Identifying vibration risks avoids premature tubing failures**

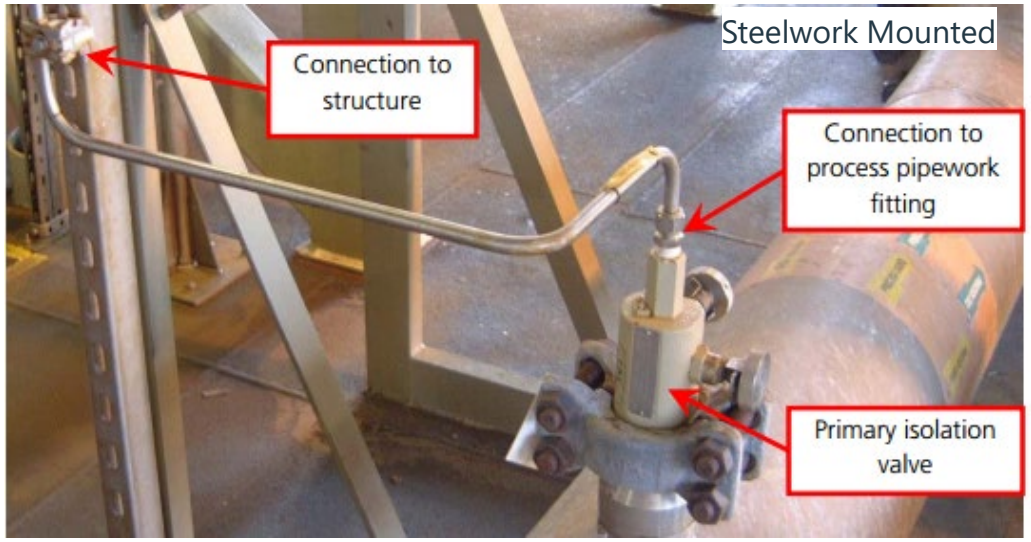




EI SBT guideline – background (dynamics annex)

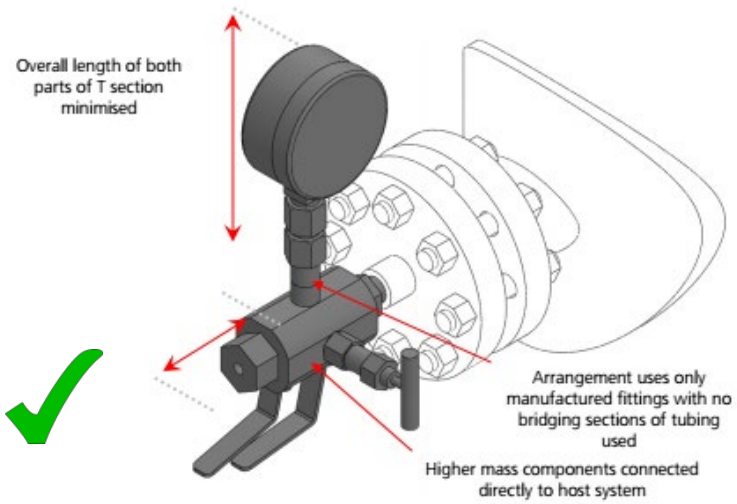
- Provides design steps for fabricating tubing assemblies in vibration applications
- Two basic configurations apply:
  1. **Close-coupled configurations** for vibration service
  2. **Steelwork mounted configurations** for vibration service
- Based on physical test work to determine stress distributions and fatigue limits of compression fittings and tubing supports

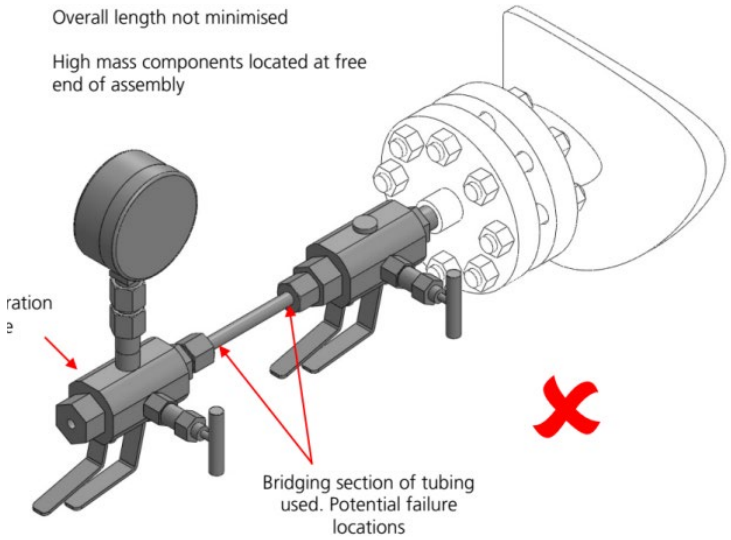


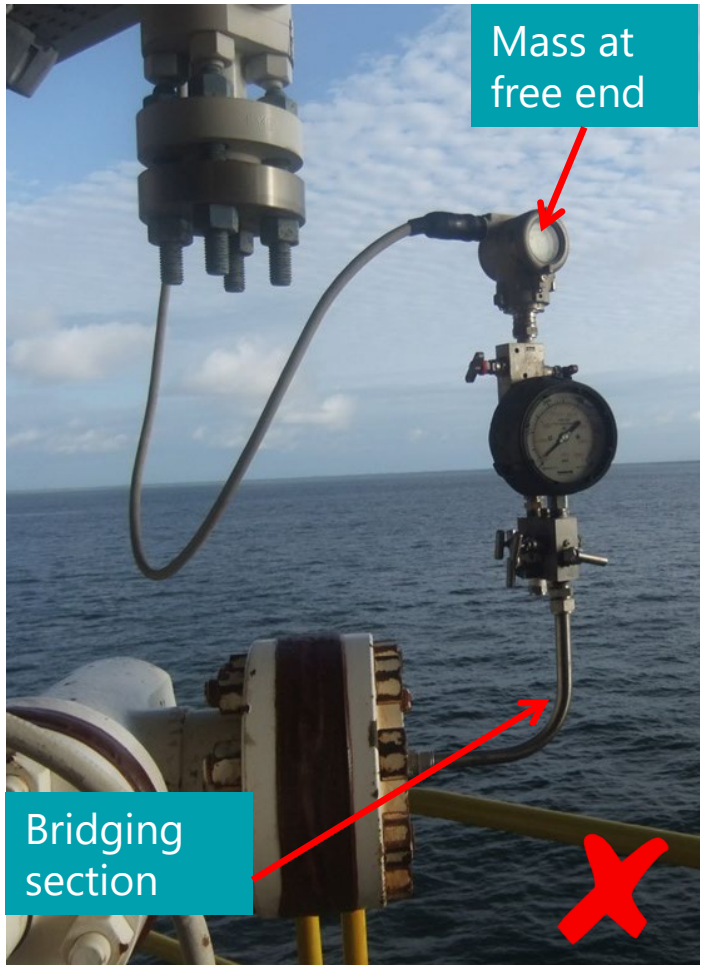


Close coupled – for vibration service

- General guidance for arrangements of close coupled configurations
- List of design principles and good/bad example figures







Steelwork mounted – for vibration service

- Guidance for tubing arrangements with one fixed and one moving (vibrating) end – relative movement between points
- General premise: multi-plane, 3 elbow design protects the vulnerable compression fitting
- Set of standard geometries (3 off) and leg length look up tables

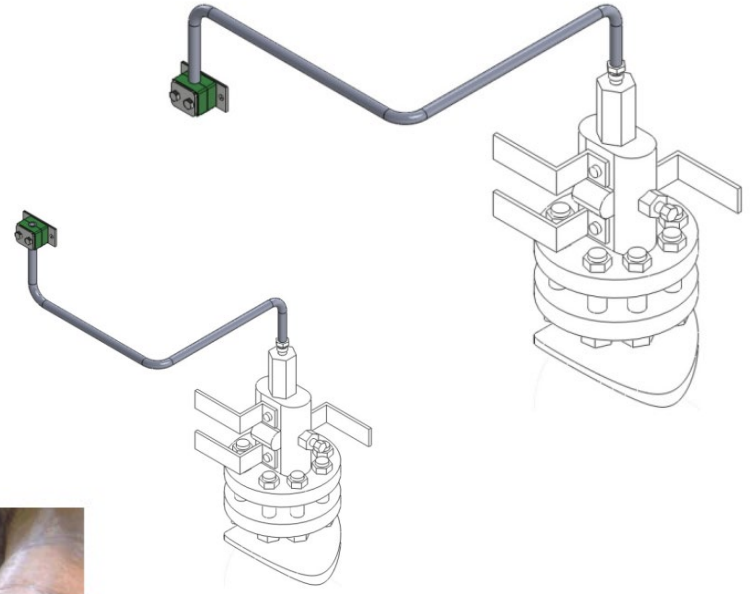
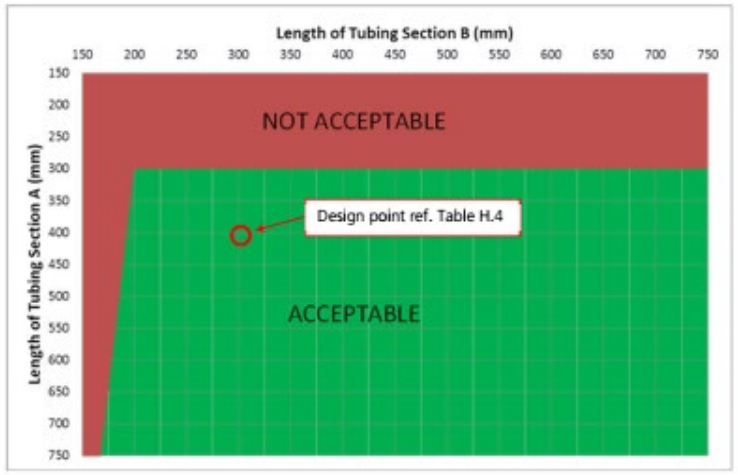
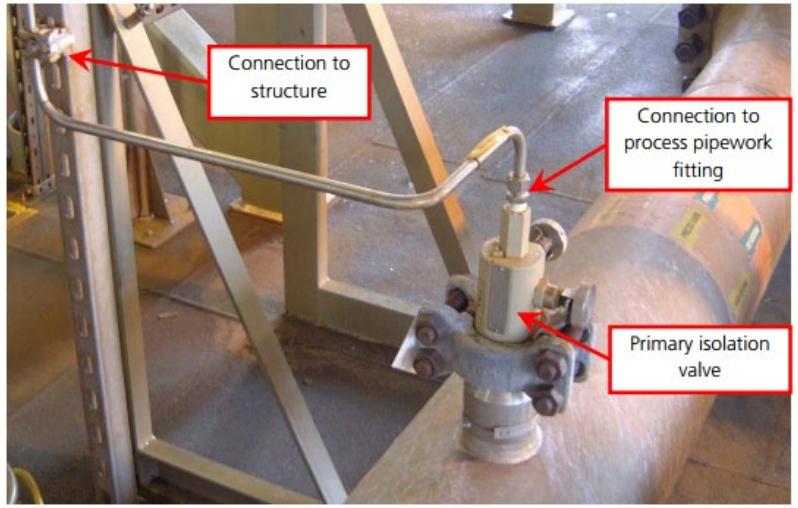
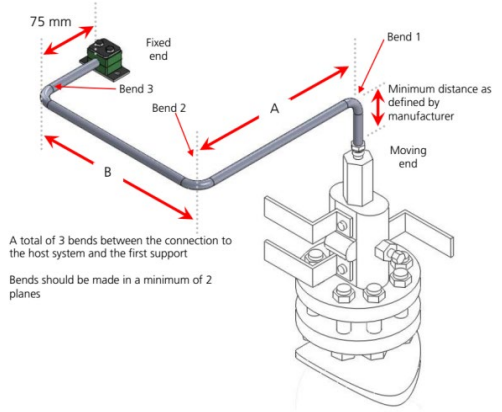


Table H.5 (b) Acceptable length variations for sections A and B in Figure H.11 - 10 mm and 3/8" diameter tubing







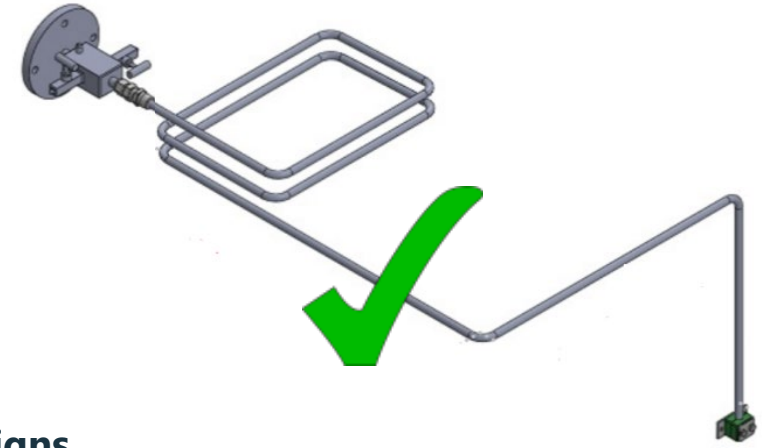
Accommodation of expansion – to coil or to ‘rectoil’

Common misconception: ‘Helix’ coil (or pigtail) behaves like a bellows and can accommodate large scale deformation.

- Intended to add a stiff element local to the vulnerable compression fitting:
- Must be very close to the fitting to achieve this: in many cases the helix is found to be remote from the connection which negates any benefit and can create other issues (lumped mass!)

Detailed investigation shows rectangular coil or ‘rectoil’ is optimal because:

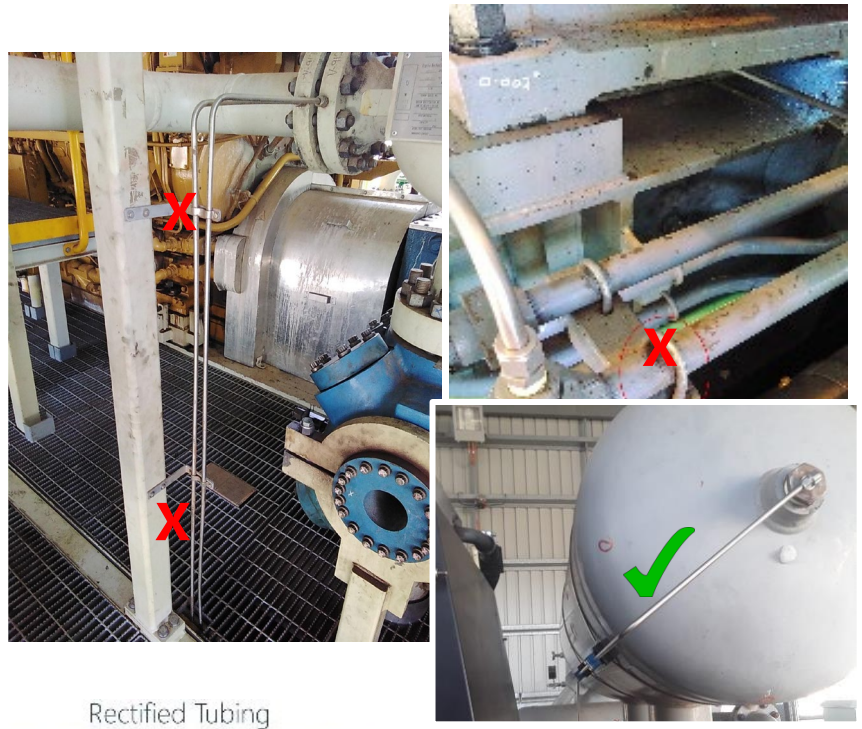
- Long linear length of tubing can fit into small footprint
- **Effect of deferring maximum stresses away from the fitting to fixed end**
- Easier to manufacture on offshore sites (limited working space)



Helix-based designs are not automatically bad designs.

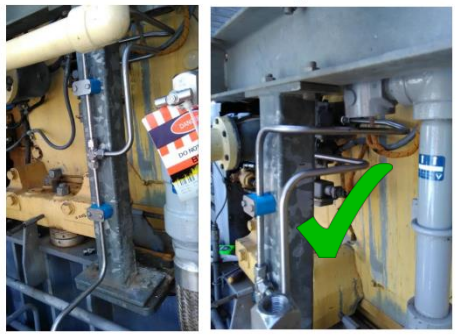
Good practice…

- ✓ Follow *Good Design and Installation Practice* as per *Energy Institute Guidelines* ***when installing new tubing or replacements***
- ✓ Use EI optimum vibration-tolerant routing where practicable
- ✓ Reduce mass loading on connections, avoid bridging sections (points of failure)
- ✓ Support tubing components and masses (unions, elbows, tees, valves, sensors) independently
- ✓ Use mechanically attached supports (eg, Swagelok bolted clamps) – avoid metal clamps and adhesive based attachments
- ✓ Reduce parent structure vibration (eg, piping, supports, etc) – avoid attachments to vibrating structures such as floor plate



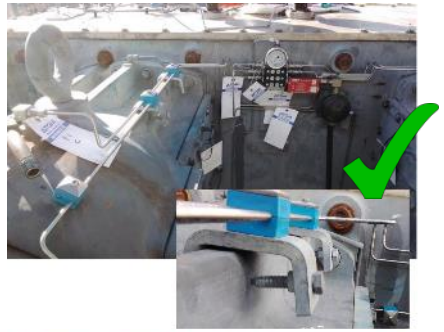
Original Tubing

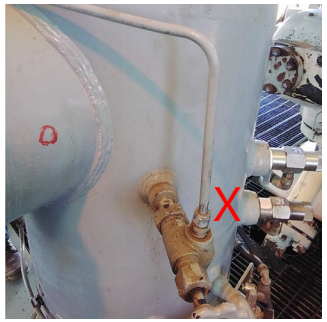
Rectified Tubing

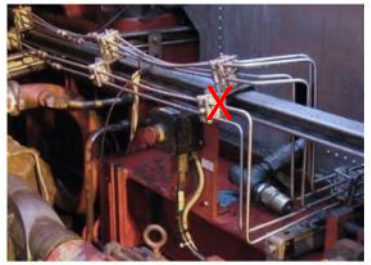


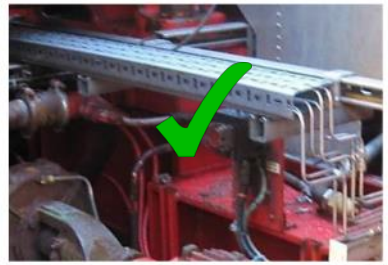
…can go a long way to avoid vibration-induced tubing failures

- ✓ Avoid metal-metal contact with tubing (fretting damage)
- ✓ Ensure proper installation/assembly practice is utlised (no static strain, tool damage, appropriate fitting tightening, etc) and check for manufacturer guidelines
- ✓ Smaller diameter tubing is more susceptible
- ✓ Protect tubing runs (avoid trip hazards, damage due to stepping etc)
- ✓ Standardise assemblies with good practice
- ✓ Inspect and maintain regularly – establish a *tubing vibration condition monitoring* program and track anomalies to pro-actively reduce risk









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Case study

Managing and reducing small-bore anomalies with digital tools

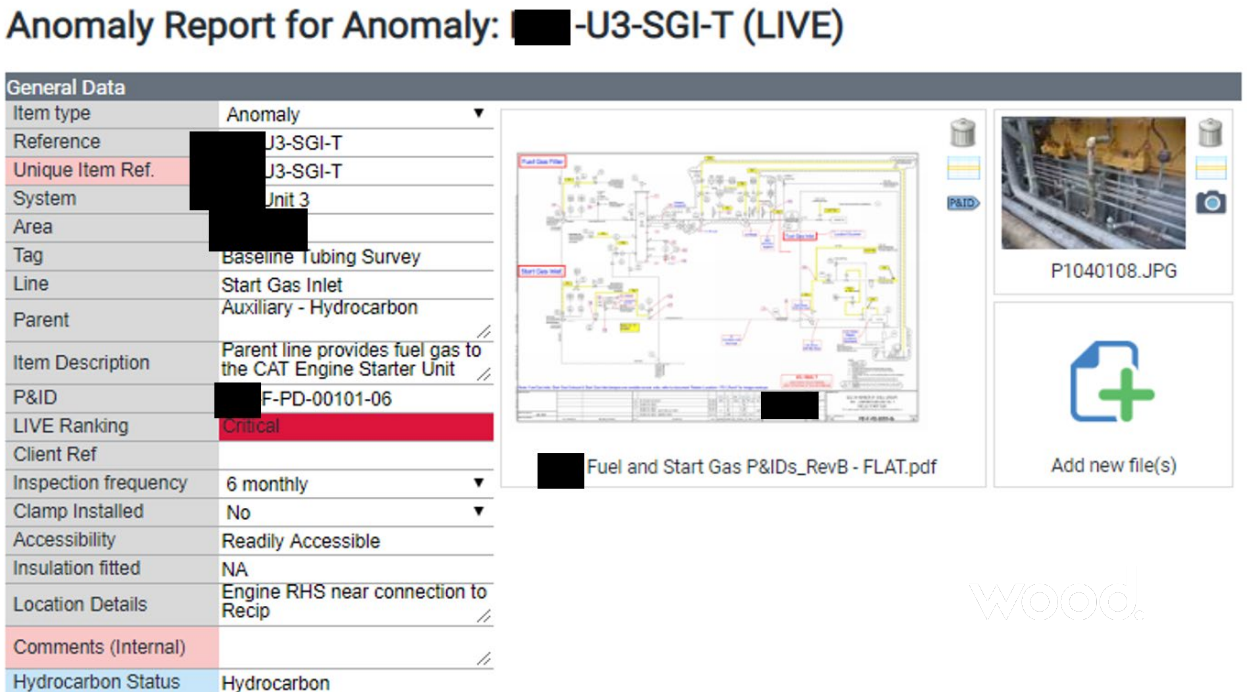
Case study

Problem:

- Several small-bore (SB) piping and tubing vibration failures
- Large number of gas engine-driven reciprocating and screw compressor packages
- Process safety hazards
- Significant impact to production- ad-hoc shutdowns and extended periods of downtime.

Challenges/constraints:

- Large inventory of SBFs and tubing to manage across several facilities – lots of data!
- Information challenges eg, missing information on P&IDs, functionality information, etc
- What to rectify, when, where? (what is 'critical' vs 'improvement opportunity')



Case study

Client feedback:

Successfully reducing failures allowed a shift to 'Preventative Maintenance' – SBP and tubing condition monitoring program to proactively identify and manage anomalies.

The numbers

92%
Average reduction in compressor small-bore tubing and piping failure incidence rate (since 2019)

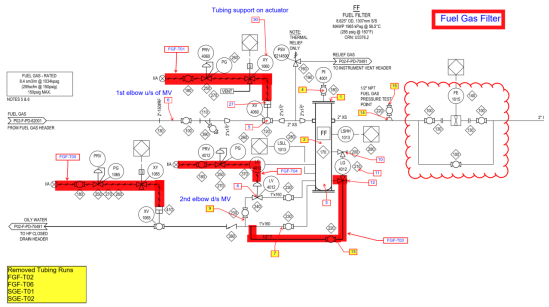
Zero
Tier 1 and tier 2 hydrocarbon leaks in the past 12 months

60
Compressors surveyed (Recip and Screw)

3300+
Compressor tubing runs inspected

1400+
Individual piping and small-bore fitting locations measured for vibration

SMART anomaly risk management



Screen and identify

Measure and inspect

Key expertise

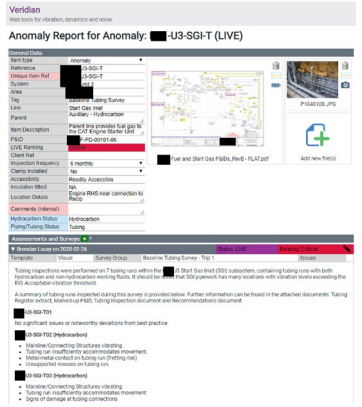
- Field inspection/survey/ troubleshooting support (Field Tubing Inspections)
- SME input to risk assessment, recommendations, and rectification actions (industry-tested solutions)

Anomaly registered

Survey uploaded to Veridian Anomaly Manager (AM)

Risk-based assessment and workpacks

WorkPack



Rectify and improve

Permanent

Temporary

Track: visualise progress, act, and reduce

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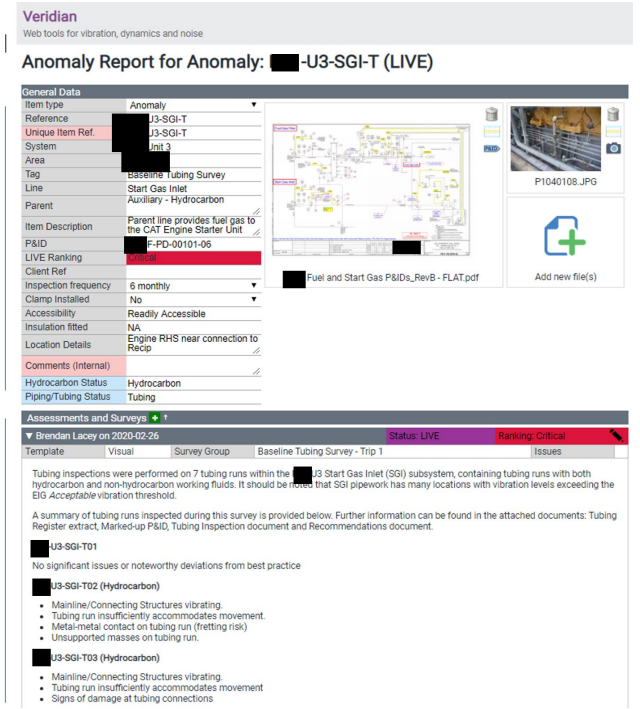
Digital enablers

- **Digital anomaly database and dashboarding enable holistic approach**
  - Cloud-based **Veridian Anomaly Manager (AM)** tool to register, prioritise, track all small-bore fitting and tubing anomalies and rectifications
  - **Custom dashboard** developed to make anomalies 'visible' to all levels of organisation and gain quick insights on plant health, risk progression, and status of actions
- Two-way flow of information between client and Wood



Conclusions

- Small-bore fitting and tubing vibration failures are a **frequent source of leaks and emissions**, but risks are **often neglected**
- You can **improve safety and reliability, and reduce emissions** in your facility by employing a **holistic approach** for continuous risk reduction (SMART)
- **Digital tools** can help you **track anomalies and reduce failures** across large or multiple facilities

Get a free demo or speak to a specialist



Contact us for questions or to get expert support

Request a free demo of Veridian AM

Watch related webinars

Vibration, dynamics and noise

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What can be done for piping in *vibratory service*?

Many options to address vibratory service, including:

- Reducing energy in the system (AIV, FIT)
- Controlling root causes (pulsation, resonance, unbalance)
- Reducing turbulence
- Improving mechanical support
- **This webinar: managing piping and tubing anomalies in the field**

Visit woodplc.com/vdn to watch more.

Wood's vibration and noise expertise

- **Piping and structural vibration**
- Compressor and pump pulsation/dynamics
- Machinery monitoring and reliability
- Damping and clamping solutions
- Noise management
- Field troubleshooting

Piping and small-bore vibration:

- Transients, water hammer
- Flow- and acoustic-induced vibration
- Piping stress and fatigue failure
- Veridian vibration screening and anomaly management software
- Field engineering and troubleshooting

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