Risk-based

Get it right and the savings can be huge, but get it wrong and the cost is unimaginable. Brian Tinham talks to John Wintle about changing best practice for hazardous plant inspections

How frequently would you expect the inside of your car petrol tank to require inspection? Clearly, not often. That's partly because the greatest risk of internal corrosion damage, leading to containment being compromised, is not from the petrol, but from any water ingress. Modern petrol tanks are well sealed against the elements – collisions notwithstanding – and there is plenty of historical evidence to suggest that occasional external inspection is perfectly adequate to ensure safety.

Much the same might also be true of storage tanks and even pressure vessels containing hazardous materials on a wide range of process plant types. Common sense tells us that a judgement about the need for internal examination would probably depend on the fluids being stored or processed, the vessel construction, its age, duty, service conditions, reliability and inspection history to date. If all is well, it might, for example, be enough periodically to monitor the contained product for the presence of water or other corrosives. And if none is found and the tank is effectively sealed to atmosphere, then plant engineers may have good reason to be confident that external thickness checks, and physical inspection of corners and welds should suffice for integrity checking.

PSSR revisited

So, essentially, goes the argument for considering a change of inspection practice on plants. It's all about improving the effectiveness of money spent ensuring plant safety by designing an alternative to today's largely routine, but very expensive, mandatory schedule of internal inspections for high hazard plant under PSSR (Pressure Systems Safety Regulations 2000) regulations.

The goal is a risk-based approach, where information about the plant helps frame a less prescriptive, potentially less costly, but still safe programme of inspection. But how generally

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Bigger picture inspections

The principles and practice of risk-based inspection may also be applicable to other safety-related structures, such as lifting equipment. And they might also be harnessed in other industries entirely – for example, in the offshore sector, where plant ageing is an issue.

"We're working at two levels – the technical level, involving degradation mechanisms and how fast they are occurring, and the management level," says TWI technology fellow John Wintle. "I've been focusing on the managerial level, considering how companies are organising themselves to ensure that managing ageing is someone's responsibility, so that plant remains safe. Items ageing at different rates need different management approaches and you can't just leave all this to maintenance to sort out reactively. Plant managers need an holistic view, so they can take strategic investment decisions."

If you believe your plant may benefit from going the risk-based inspection route, HSE research report 729 contains a six-step, risk-based inspection process for establishing a less invasive inspection regime for high-hazard process plant. It has been developed partly through consultation with leading user inspectorates and inspection bodies operating in the UK, and builds on earlier UK work, covering plant integrity management.

applicable is this concept?

John Wintle, a TWI (formerly the Welding Institute) technology fellow, is among leading authorities in the UK on this subject, having jointly produced the HSE's research report 363 'Best practice for risk-based inspection as a part of plant integrity management', with Glyn Amphlett of RSA (then Royal and SunAlliance Engineering) and others, back in 2001.

COMAH inspections

That report was published after the PSSR regulations came into force and, in the spirit of this goal-setting legislation, was deemed potentially applicable even to process equipment containing high hazard materials, subject to mandatory inspection under the COMAH (Control of Major Accident Hazards) regulations.

changes

"This was the first ever detailed analysis in the UK of risk-based inspection – what it was, where it might be appropriate and how to go about it," explains Wintle. "We followed that with 'Plant ageing: management of equipment containing hazardous fluids or pressure' [HSE research report 509], in 2006, and 'Establishing the requirements for internal examination of high hazard process plant' [HSE Research Report 729], in 2009."

So there's a considerable history of work in the area, predicated on the fact that there are downsides, as well as benefits, to opening up vessels for inspection. And the point is, there is now the potential for alternative options for duty holders [plant owners and operators] to determine different plant integrity inspection regimes by first assessing the risk of failure.

Inevitably, there's a balance to be struck. Wintle points out that technicians moving around inside vessels opened up for inspection can inadvertently cause damage, both to internal surfaces, particularly lining materials, and to internal equipment, such as agitators. There are also inherent risks for plant engineers themselves in such procedures – although these can be, and are, mitigated. On the other hand, it may be too difficult, even with current non-invasive technologies, such as radiography, ultrasonic testing, shearography and thermography, to detect and quantify active internal degradation reliably from the outside, particularly where welds are concerned and access is limited.

"Plainly, there is also equipment where the consequences of failure are so great that duty holders are bound to maximise assurance of plant integrity and, if that means going inside, then that's what they have to do – even if they can't foresee any degradation," agrees Wintle. "So the consequences side is also important, in terms of deciding which inspection approach is appropriate. But so is the age of the plant, and understanding the relevant deterioration mechanisms and rates. Equally, so is the overall information, or lack of it, about the plant, as well as the quality of that information, in terms of design, operational experience and historical inspection records."

And therein lies the rub for plant managers liking the sound of moving to risk-based inspection practices and hence, at the very least, extending intervals between internal inspections. So far, it is mostly refineries and large chemical facilities that have successfully adopted the approach.

Such plants are almost always governed by user inspectorates, who are frequent visitors to site, have access to detailed plant information, including history and operating experience, and have been able to invest in understanding the relevant plant ageing mechanisms, because it makes business sense.

Clearly, such organisations are in a better

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Entering vessels to effect mandatory inspections is not without its risks

Risk-based inspection pitfalls?

Although risk-based inspection is now well established with some of the big boys, there remain pitfalls that can compromise initial assessment and potentially leave plant open to risk.

The first pitfall is inconsistency, in that different teams, even from the same organisation, can end up with very different assessments, due primarily to different levels of experience and rigour. Secondly, however, when teams lack sufficient independence from management and operations, corporate pressures may skew the results.

Thirdly, and perhaps surprisingly, lack of imagination can be a problem, with some plant teams failing to recognise all the potential damage mechanisms and risk factors – and instead only assessing what they expect to find. The fourth pitfall concerns third party inspectorates, who may not be given information on previous operations or inspection history.

The fifth materialises when inspectors are chosen by a company's non-engineering accountants, on the basis of cost alone, or when the third party used changes frequently, so preventing continuity. And the sixth occurs when safeguards are not implemented to check conformance to good practice. That is a particular worry where there are extended intervals between internal inspections. Safeguards need to continue throughout the duration.

position to demonstrate an absence or a possibility of internal degradation, even where plant containing hazardous products under pressure is concerned. The challenge for small to mid-scale plants is to be able to achieve a similar body of knowledge from which to infer plant condition, ageing rates and mechanisms, and the rest. So, how can you step up to the plate and make a case for reducing or cutting out internal plant inspections?

Wintle talks of three primary 'legs' upon which to stand any justification for performing less invasive plant inspections. "First, plant managers need to be clear that they can demonstrate an absence of predictable internal degradation, taking into account the chemistry between the vessel material, the contained product and any contamination during service, considering foreseeable fault conditions.

Unforeseeable events

"Secondly, they need to define safeguards – such as periodic reviews and non-invasive inspections that can take account of potential changes and any unforeseeable conditions. Plant operators need to have control over the numbers of cycles, the product constituents and how the process is doing, in terms of pressure and temperature – and we need to be sure that, for example, water isn't somehow getting into the system.

"Then the third leg concerns proactive management, with respect to plant ageing, and planned and unplanned changes or plant excursions. For example, where operational process limits are exceeded, such as a change in the composition of products or the process, those events need to be flagged up and the impact on vessels checked, so that decisions can be taken on whether to open them up for additional inspections or not. Think about the quality of crude oil: higher sulphur content crude may be much more damaging than other crudes – but detecting that and understanding the significance requires access to scientific competence."

For Wintle, if these three legs can all be satisfied, there's no good reason why risk-based inspection procedures cannot be adopted on a wide range of plant types. "This can filter down through industry to the smaller operators. Any plant operating a system that is capturing good operational experience and history is equally well able to do this, as long as it also has a good relationship with its competent person and that continuity has been there for many years."

But that's easier said than done. Wintle suggests that plant managers need to think very carefully before they decide they can meet the criteria. "[Risk-based inspections] can be harder for third party organisations than for user inspectorates, simply because of the lack of continuity where medium-sized plant owners and small operators are concerned. The inspection and competent person services market is competitive, so operators change suppliers relatively frequently. That makes it difficult to build up the history of reliable plant operations and equipment. Also, small companies don't have the level of monitoring and control over their processes that some of the big boys do – although there are exceptions both ways. Equally important, though, they're unlikely to have the internal resources. All of that prompts a more cautious approach."

Incidentally, Wintle also suggests that it may be in the commercial interests of third party inspectorates, too, to invest the time and effort required for the risk-based inspection route. "A good risk assessment with an appropriate inspection regime, with or without internal examination as appropriate, can be to everyone's benefit. I am sure that SAFed, for example, would agree." PE

Eligible plant equipment

Equipment most eligible for extensions of internal examination intervals is that best described as 'clean non-corrosive service' – meaning that the plant is not expected to suffer from active internal degradation mechanisms, either in normal service or from transient events within the plant design tolerance.

Such equipment should also be: continuously sealed, so that ingress of water and other impurities is not possible; subject only to stresses below code fatigue thresholds; and be the subject of high quality and documented welding.

This can also apply to corrosive products stored in 'non-corrosive systems' (such as pure chemicals in vessels having suitable containment materials), where there are no expected degradation mechanisms. However, the threat of corrosion from even minor contamination may be significantly higher, so such products need careful consideration when risk-based inspection is being considered.

Providing practical safeguards

Aside from non-invasive testing for wall thicknesses and internal equipment conditions, other safeguards include in-service process and product monitoring – aimed at maintaining confidence that clean, non-corrosive conditions are being maintained.

Deviations in concentrations or chemistry can help to show when process upsets have happened, or detect the by-products of corrosion. It is important to recognise, however, that sensors intended for process regulation and product quality may not be suitable.

As for other practicalities, it is worth remembering that, regardless of inspection intervals, safety devices need to be inspected and re-calibrated in accordance with their own technical requirements. That may mean installing additional protective devices, so that removal and testing can be performed without process disruption. Similarly, it is also important to ensure that bolts, seals and other ancillary components can still be inspected, tightened and overhauled as necessary during the extended inspection interval.

And, finally, mitigating hazards arising from worst-case failures provides the ultimate safeguard. Best examples include leak-before-break arrangements and secondary containment.