Why maintenance systems fail

Investigation of rolling bearing lubrication condition

Confronting the challenges of failing to follow procedures

Crystal ball gazing

6 Emerging Solutions for Industrial Noise Control

The Factories of the Future

Parry and Thrust

Emerging Solutions for Industrial Noise Control

The Factories of the Future

Parry and Thrust
The IIMS proudly presents a brand new standalone Professional Qualification in Marine Corrosion, a new standard by which those who inspect corrosion can be judged against.

Marine corrosion and prevention in small vessels, ships and offshore structures

Download the detailed Prospectus at https://bit.ly/3az430w
The objects of the Institution are:

- To promote the education and training of persons whether resident in the United Kingdom or worldwide in all matters relating to diagnostic engineering and allied technologies.

- To establish and maintain contacts with persons and/or organisations concerned with the employment of diagnostic engineers and consultants.

- To develop and promote the science, practice and business of diagnostic engineering and allied technologies.

- To encourage and improve the technical, financial, business, managerial and general knowledge of all persons engaged in the practice of fault and failure diagnosis, condition monitoring, post-mortem examination, accident investigation and allied activities.

- To compile and classify information and particulars relating to the expert services rendered by members of the Institution.

- To disseminate information and particulars relating to the expert services rendered by members of the Institution.

- To stimulate efficiency in diagnosis and to elevate the position of those connected therewith in skilled practical employment.

- To foster intelligent appreciation of the facilities existing for the provision of education and research.

- To facilitate the exchange of information, ideas and practice by the publishing of such information as shall be of interest to diagnostic engineers.

- To render advice and aid in the exploitation of inventions and to make known their nature and merits.

- To assist in obtaining employment and to help engineers and others to find competent staff.

Definition:
A ‘Diagnostic Engineer’ shall be any person capable of contribution to the art or science of determining the existence of a problem in a machine, plant, system or structure and/or appraising the cause(s) of a failure which may have taken place and/or assessing the condition or vulnerability of such machine, plant, system or structure either during use or while under development.

Interpretation:
It is accepted that through a diagnostic capability or a special knowledge of a failure and deterioration modes, reliabilities and hazards a person will be able to contribute to a satisfactory assessment of the causes of a defect and able to contribute to the identification of remedial action to cure the defect and prevent failure.

Motivation:
Employers are invited to recognise that persons who have joined have shown distinguished interest in developing and extending their technical skill.

Activities:
The Institution shall arrange periodically:
- Local, national and international events of benefit to members either face to face or online
- Occasional publication of newsletters for subscribers
- Occasional publication of the DIAGS magazine, Diagnostic Engineering
Editor’s Welcome

Dear Colleagues

Those who have been following the fortunes of DIAGS over the years, before it was reborn at the start of this year under new management, will know of Jeffrey Casciani-Wood’s reputation and fine work. Not only was he a consummate Marine Surveyor and Diagnostic Engineer, but he was also President of this Institution for many years. His death in recent weeks following a short illness, has left a big hole in the organization. Jeffrey was a one off and is sorely missed by those who knew him. His obituary appears on page 17.

Compiling this edition of Diagnostic Engineering has reminded me of the breadth of the profession which touches so many industry sectors. Diagnostic engineers are invaluable and are involved in every sector imaginable. Editing a publication such as this and making it appeal to the majority of readers is a challenge. If you would like to see something in a future edition, or want to suggest, or submit some content for publication, please do make contact with the office.

It seems there is something of a shortage of talented engineers and still not enough women entering the profession, although the gap has narrowed. You will surely have seen this issue widely reported in the national press and trade media? The role of the diagnostic engineer is pivotal to the successful functioning of so many businesses in the UK and further afield. So how does industry attract and train new talent? What’s the answer?

The Institution of Engineering & Technology Industry proposes that educators and the government must work closely to improve the engineering skills pipeline. They suggest that half of engineering employers feel new recruits lack crucial technical and soft skills. A survey conducted by the Institution showed that 49% of engineering companies are currently experiencing difficulties with a lack of skills available in the external labour market, and 45% face skills gaps or limitations within their internal workforce. Clearly this is not sustainable, but all I can do is bring it to your attention, for I have no solution to propose, other than to engage children and promote engineering to them at a young age.

Is it me, or do I sense that technological developments seem to be advancing at a faster rate than ever? One of the joys of editing this publication is that I get a bird’s eye view as to what is going on across industry. There are cracking initiatives under way everywhere, but the area that is most interesting and impressive to watch right now, in my opinion, is the work and rapid development going on with battery technologies to power electric vehicles (EVs). The time taken to charge EVs has been one of the reasons holding back people like me who have steadfastly resisted swapping fuel guzzling cars for one of the many fancy EVs on the market. But it is abundantly clear now that several companies are grappling with this challenge and a resolution seems close that will transform things.

Letters to the editor are always welcome and I am keen to hear from you on any topic. Feel free to email me at info@institutiondiagnosticengineers.org any time.

Diagnose well and safely!

Mike Schwarz
Chief Executive Officer
How to subscribe to DIAGS and which grade is right for you

Applications are invited from suitably qualified diagnostic engineers, or those wishing to enter the engineering profession, in any industry sector for any of the following subscription grades listed below. Only fully paid-up subscribers may use the designated postnominal letters as indicated.

To subscribe please use the secure online subscription application form at https://bit.ly/3ngCQY9. You will be asked to make payment using either your credit or debit card as you complete the form. Alternatively call us on +44 23 9238 5223.

## Subscription Criteria & Fees

### Student Subscription Criteria
1. age up to 20 and
2. is engaged in an appropriate occupation or is studying
A STUDENT may use the POSTNOMINAL LETTERS – SIDiagE.
Student subscription is FREE

### Associate Subscription Criteria
1. aged 20 and above and
2. is engaged in an appropriate occupation or is studying
or is awaiting fresh employment or is undertaking research
An ASSOCIATE may use the POSTNOMINAL LETTERS – AMiDiagE.
Associate subscription is £90 per annum

### Member Subscription Criteria
1. aged 25 and above and
2. is engaged in an appropriate occupation or is studying
or is awaiting fresh employment or is undertaking research and
3. occupies (or has occupied) a responsible position
or has made a written contribution to advance the knowledge of diagnostics or has attended at least TWO acceptable post-experience courses
A MEMBER may use the POSTNOMINAL LETTERS – MIdiagE.
Member subscription is £150 per annum

### Fellow Subscription Criteria
1. has been a Member of the Institution (MIdiagE) for 2 years and
2. aged 30 and above and
3. is engaged in an appropriate occupation or is studying
or is awaiting fresh employment or is undertaking research and
4. occupies (or has occupied) a responsible position
or has made a written contribution to advance the knowledge of diagnostics or has attended at least TWO acceptable post-experience courses and
5. has made a significant contribution to the technology of diagnostic engineering or by participation as an active technical correspondent or has made a significant contribution to the objectives of the Institution
A FELLOW may use the POSTNOMINAL LETTERS – FIdiagE.
Fellow subscription is £190 per annum

### Corporate Subscription
Any company or organisation that employs diagnostic engineers or uses their services, or that simply supports the aim of the Institution is welcome to subscribe.
Corporate subscription is £150 per annum

### Retired Subscription
The retired subscription fee for all grades is £35 per annum

### Other Subscription
Examples of those organisations that fall into this category are libraries, research establishments, universities, and education establishments
Subscription is £67 per annum

That link again to the secure online application form is https://bit.ly/3ngCQY9

DIAGS subscribers are invoiced annually on the anniversary of their original subscription date.

You may cancel your subscription at any time, but no refund will be payable if it is part way through the year.
Engineering skills crisis requires collaborative action

Photograph courtesy of BP

Industry, educators and the government must work closely to improve the engineering skills pipeline according to the Institution of Engineering & Technology, which reported that half of engineering employers feel new recruits lack crucial technical and soft skills.

A survey conducted by the Institution showed that 49% of engineering companies currently experience difficulties with a lack of skills available in the external labour market, and 45% face skills gaps or limitations within their internal workforce.

The most common concern cited by respondents was missing engineering or technical skills, with significant gaps reported across all levels of the profession from technician or skilled craft level down to operative or semi-skilled levels.

“Workers are in high demand, but we don’t have readily available recruits with the right skills to fill the labour market – something we have been reporting via the skills survey for the last 15 years,” said IET director of governance and external management Simon Edwards. “Frustratingly nothing has changed.”

The impact of skills gaps means 45% of companies who see a skills shortage within young people provide additional training for apprentices and graduates who are new to the industry. However, 25% said they recruit fewer apprentices and graduates as a result.

When asked what support businesses need from government to improve skills nationally, more funding for apprenticeships came out on top (54%), with greater support to train or reskill in priority areas (51%) and better careers advice and guidance in schools and colleges (49%) also coming out as popular asks.

IET’s report says there continues to be a mismatch between employers’ desire for new entrants to the workforce to have experience and the proportion engaging with educators to offer this experience. Employers who engage with educators have the opportunity to shape the skills pipeline for the industry, it says.
UK engineering community urged to “Think ethics before action” in new engineering ethics report

A new report, Engineering Ethics: maintaining society’s trust in the engineering profession, has been published to ensure that ethical culture and practice become embedded in the engineering profession in the same way as health and safety considerations. The report has been produced by the joint Engineering Ethics Reference Group, established in 2019 by the Royal Academy of Engineering and the Engineering Council, and includes a roadmap of short, medium and long-term actions to embed ethical best practice. At the heart of the report is the need to retain public confidence in the ethical behaviour of engineers.

Download the report in full at https://bit.ly/357PPER.

Kalitta Air deploys 3D scanner tool to improve maintenance routines

US cargo airline Kalitta Air has begun using a handheld and completely wireless 3D scanner tool with integrated AR to improve its maintenance operations. The ‘dentCHECK’ tool has been created by 8tree and is purpose-built for the aviation maintenance industry.

Kalitta Air said 8tree’s dentCHECK would enhance the efficiency and quality of its dent mapping activities. The tool delivers real-time ‘go/no-go’ answers at the push of a single-button, 8tree said, and “significantly reduces” damage mapping and reporting times compared to traditional manual methods that use depth-gauges and straight-edges.

“With the implementation of 8tree’s dentCHECK technology, Kalitta Air’s dent mapping programme will be elevated to the next level,” said Kalitta Air’s vice president of maintenance, engineering and procurement Zoltan Kocis. “We look forward to working with 8tree in implementing this state-of-the-art technology.”

The dentCHECK tool is approved and recognised by aerospace OEMs such as Airbus, Boeing, Bombardier and Embraer and used for fast and accurate damage mapping and SRM-compliant multi-dent reporting, 8tree noted. The company said that when compared to traditional inspection methods, “dentCHECK delivers a 90 per cent gain in efficiency and 37x better measurement consistency”.

Fronius has the solution for complex welding challenges

Fronius is supporting industrial and commercial enterprises at its prototyping centre in Wels, Austria, to develop individual solutions for challenging welding tasks. Whether the focus is on feasibility studies, welding prototypes, pre-production series or contract manufacturing for small series, the customer benefits from the Fronius experts’ comprehensive welding knowledge and their deadline pressure and investment risk are reduced.

Companies that want to take advantage of new trends or tap into fresh market segments are forced to leave their comfort zone because they need innovative materials and components, and set new challenges for themselves in production. A big issue here is the development and construction of prototypes. This can involve large investments, including in systems, software and staff, which come with a certain level of uncertainty. To reduce risks and costs, Fronius provides companies with the option to permanently outsource the welding-relevant parts of their prototype construction. In the Fronius prototyping centre, which covers a total area of more than 900 square metres, specialists from Fronius develop customised solutions to tackle every welding challenge.

“Since we put the Fronius prototyping centre into operation in early 2021, we have developed solutions to meet a wide range of requirements for customers from various sectors,” emphasises Wolfgang Scherleitner, head of the prototyping centre. “However, we don’t just offer technical support. Instead, we have expanded our range of services to include a number of high-tech analyses and simulations. This enables us to guarantee high quality as well as seamless welding data documentation.”
Veolia announces its first electric vehicle battery recycling plant in UK

Gavin Graveson, Senior Executive Vice-President, Northern Europe Zone

Veolia, the UK’s leading resource management company, has announced its first electric vehicle battery recycling facility in the UK, which will have the capacity to process 20% of the UK’s end of life electric vehicle batteries by 2024.

Many of the materials required for battery manufacturing rely on traditional water and energy intensive processes. It is estimated that 500,000 gallons of water is required to extract one tonne of lithium using this type of mining. Urban mining or the use of recycled materials could reduce water consumption as well as cutting greenhouse gas emissions from battery production by up to 50%.

Veolia’s new facility in Minworth, West Midlands marks the first step in developing its recycling technology and treatment capacity within the UK, with an anticipated 350,000 tonnes of end of life electric vehicle batteries predicted to be in the country by 2040.

Gavin Graveson, Senior Executive Vice-President, Northern Europe Zone, said, “This is an important first step on the UK’s journey to create an ethical and sustainable supply chain for batteries that will be increasingly necessary as we transition to a greener economy. We will not reach carbon neutrality without increasing our investment and development of new technologies and recycling opportunities. As the demand for electric vehicles increases, we will need this facility - and more like it in the UK - to ensure we don’t hit a resource crisis in the next decade.”

Bentley set to build its first electric vehicle in the UK

Luxury car maker Bentley Motors has announced that the company’s first ever battery electric vehicle will be developed and built in the UK. The first in this new generation of electric Bentleys is scheduled to roll off the firm’s Crewe production line in 2025 and the company is aiming to focus exclusively on electric vehicles by 2030.

Bentley, which is owned by Volkswagen Group, is committing to investing £2.5 billion in sustainability over the next ten years. Alongside the introduction of the firm’s first electric vehicle this will be used to transform operations at the historic Cheshire site which currently employs around 4000 people.
The climate crisis requires ramping up usage of renewable energy sources like solar and wind, but with intermittent availability, scalable energy storage is a challenge.

Hydrogen, especially carbon-free green hydrogen, has emerged as a promising clean energy carrier and storage option for renewable energy such as solar and wind. It adds no carbon emissions to the atmosphere, but currently is costly and complex to create. One way to produce green hydrogen is electrochemical water splitting. This process involves running electricity through water in the presence of catalysts (reaction-enhancing substances) to yield hydrogen and oxygen.

Researchers at Georgia Institute of Technology and Georgia Tech Research Institute (GTRI) have developed a new water-splitting process and material that maximize the efficiency of producing green hydrogen, making it an affordable and accessible option for industrial partners that want to convert to green hydrogen for renewable energy storage instead of conventional, carbon-emitting hydrogen production from natural gas.

Scientists hope to replace natural gas and coal, currently used today for storing extra electric energy at the grid level, with green hydrogen because it doesn’t contribute to carbon emissions, making it a more environmentally friendly means for storing renewable electricity. The focus of their research is electrolysis, or the process of using electricity to split water into hydrogen and oxygen.

**A catalyst for more efficient green hydrogen production**

**It’s official: Rolls-Royce’s all-electric aircraft becomes the world’s fastest**

Rolls Royce has announced that its all-electric ‘Spirit of Innovation’ aircraft officially became the world’s fastest all-electric aircraft. Two new world records set by the aircraft on 16 November 2021 have been officially verified by the World Air Sports Federation (FAI), which controls and certifies world aeronautical and astronomical records.

Back in November, the aircraft reached a top speed of 555.9 km/h (345.4 mph) over 3 kilometers, smashing the existing record by 213.04 km/h (132 mph). In further runs at the UK Ministry of Defence’s Boscombe Down experimental aircraft testing site, the aircraft achieved 532.1 km/h (330 mph) over 15 kilometers – 292.8 km/h (182 mph) faster than the previous record. During its record-breaking run, the aircraft also clocked up a maximum top speed of 623 km/h (387.4 mph), making it the world’s fastest all-electric vehicle.

During the successful world-record runs, the company gathered important data for its future electric power and propulsion systems for all-electric urban air mobility (UAM) and hybrid-electric commuter aircraft. The company says the characteristics that air taxis require – such as the batteries – are very similar to what was developed for the ‘Spirit of Innovation.’

“Rolls-Royce’s revolutionary Spirit of Innovation aircraft is yet more proof of the UK’s enviable credentials when it comes to innovation,” said Business Secretary Kwasi Kwarteng. “This record will show the potential of electric flight and help to unlock the technologies that could make it part of everyday life. The government is proud to back projects like this to leverage the private investment necessary to unlock cleaner, greener aircraft which will allow people to fly as they do now, but in a way that cuts emissions.”
**Atom augmented reality brings construction sites to life**

The company that developed the first engineering-grade augmented reality platform is going global with the worldwide launch of Atom.

XYZ Reality’s Holosite – an AR hardhat solution that lets construction teams view and position holograms of design models ‘to millimetre accuracy’ – has spent the past two years being deployed on projects valued at over £1.5bn, which has helped to refine the technology and position XYZ as a leading construction technology provider.

The Atom is XYZ’s next-generation AR headset, which combines a safety-certified hardhat, augmented reality displays and in-built computing capabilities of HoloSite. In use, the AR tool allows the wearer to see full holographic BIM (Building Information Modelling) models of structures that are superimposed on work already underway to identify errors before they become too costly to rectify.

David Mitchell, founder and CEO, XYZ Reality explained that the building/project data is uploaded into the HoloSite platform which the Atom headset plugs into.

“Atom positions 3D design models to construction tolerances with its laser-based tracking technology. The models are positioned by tapping into the site coordinate system”, Mitchell said.

**Figures reveal sales of used EVs surged last year**

Motorway.co.uk has revealed figures on the most popular EV used cars in 2021, as the latest SMMT data shows more EVs were sold in the past 12 months than over the previous five years combined.

Alex Buttle, co-founder of Motorway.co.uk, commented: “The future has never felt more electric. On the back of the SMMT revealing that more EVs were sold in the past 12 months than over the previous five years combined, EVs are clearly taking over. We expect to see new EV sales growth accelerate in 2022 as manufacturers expand their electric car ranges and more car owners have the confidence to switch to electric.

“Unsurprisingly, the growth in the EV market has had a knock-on effect for the used car market. Early adopters who went electric back in 2018 and 2019 are now upscaling their older models for the newest EVs hitting the market which means we have seen an unprecedented surge in the sale of used EVs too. This has culminated in a +256% increase in sales of used EVs on Motorway in the past 12 months, and the numbers keep climbing.”

Tyre manufacturer, Bridgestone, has opened its new Wet Handling Track, located at its European Proving Ground near Rome in Italy.

Sir Robert McAlpine has begun work on a ‘world first’ airport for drones and vertical take-off vehicles in Coventry. The project has been developed by Urban-Air Port (UAP), a start-up that plans to build hubs for drones.

The Rinsdorf viaduct on Germany’s A45 autobahn near Wilnsdorf in the state of North Rhine-Westphalia was destroyed by demolition crews who used around 120 kilograms of explosives.

A German consortium is working on hydrogen tank system for future fuel-cell cars.

The UK and Japan have signed a deal to jointly conduct research on sensor technology to help fighter jets detect lethal threats.

Addionics, the Israeli rechargeable battery startup, has raised $27 million in venture funding in support of efforts to redesign battery architectures around its electrode technology.
A chip shortage sends European car sales plunging to a new low

EU car sales fell to a new low last year as the auto sector was hobbled by the Covid pandemic and a shortage of computer chips, industry figures have shown.

Registrations of new passenger cars in the EU slid by 2.4 percent in 2021, to 9.7 million vehicles, the worst performance since statistics began in 1990, according to data from the European Automobile Manufacturers Association (ACEA).

That follows the historic fall of nearly 24 percent suffered in 2020 due to pandemic restrictions, and brought new car registrations in the EU to 3.3 million below the pre-crisis sales of 2019.

The lack of semiconductors, the computer chips used in a multitude of car systems in both traditional and electric vehicles, was the main reason holding the industry back.

“This fall was the result of the semiconductor shortage that negatively impacted car production throughout the year, but especially during the second half of 2021,” said the ACEA.

EU car sales did rebound strongly in the second quarter, but for most of the second half they were down by around 20 percent.

The short-term perspectives for supplies are not good.

Torque sensor can reach hidden depths

Sensor Technology has extended its new range of torque sensors with a model that has the sensing head and electronics in separate housings. This has two advantages: the sensing head can fit into very confined spaces, and the electronics can be located in a position where they are protected from physical damage, dust, dirt, moisture, electromagnetic forces, etc.

The new TorqSense SGR530/540 series operates on the same principle as all the other SGR510/520 units, namely a full four element strain gauge bridge. This uses four individual stain gauges affixed to the drive shaft; each measures the deflection of the shaft in a different direction as it rotates under load. The electronics collects readings from all four gauges and calculates the torque value.

Website: [https://www.sensors.co.uk](https://www.sensors.co.uk)

Production line with intelligent process control

For continuous production data acquisition, Losyco equipped all stations with networked operator terminals and implemented a central control and evaluation unit with visualisation and an MES interface. Events triggered at the stations by pushbutton input are registered and evaluated – cycle prompts, help requests in the event of material shortage or assembly requirements, and emergency stops.

Based on these comprehensive data, the construction machinery manufacturer can optimise the performance of the entire line through targeted process control by efficiently coordinating start, cycle and break times, and organising the station-related tasks according to how much time each takes. Problems and interruptions of the process flow can be identified early on and corrected, for example, by reassigning tasks or readjusting the quality of components and manufacturing and logistics processes.

Designed with 12 workstations on a total length of 165m, the line can be expanded to up to 17 cycles. It has a maximum towing capacity of 170 tons. Assemblies weighing several tons are placed on special transport platforms running on floor-level rails. A special drag system consisting of tie rods and a chain conveyor moves the transport platforms from station to station. A chain conveyor with a cycle length of 10.15m is installed at the end of the line.
Brick-laying robot gets NHBC accreditation

The Automatic Brick Laying Robot (ABLR) builds external walls, laying bricks, blocks and mortar, while running on a track around the foundations of the building.

NHBC Accepts accreditation means that the leading warrant provider for new build housing accepts that the robot delivers work to the same standard that it expects from skilled human bricklayers.

Having been under assessment by warranty provider NHBC for more than a year, the ABLR can now be used in the construction of new homes covered by all NHBC warranty products – subject to appropriate design and installation.

NHBC innovation manager Richard Lankshear said: “It has been an intensive, year-long endeavour both for our team and Construction Automation and involved an extremely rigorous process.”

Virtual reality deployed to optimise production processes

Virtual reality and simulation technology has been deployed in a novel way to help design the physical layout of a new nickel plating facility in Chesterfield and optimise complex production processes at the site.

NiTEC UK – a division of CBE+ – embraced the technology to aid the design of its Electroless Nickel Plating facility with digital support from engineers at the University of Sheffield Advanced Manufacturing Research Centre (AMRC).

Electroless nickel plating is a chemical process that deposits an even layer of nickel-phosphorus alloy on the surface of a solid substrate. The process is typically used to improve corrosion protection, hardness or wear resistance for an array of applications, from subsea to space and medical to defence.

Insights gained from the use of virtual reality simulation informed a decision by the company to invest in robotics systems.
“WHAT A MARINE SURVEYOR NEEDS TO KNOW ABOUT...”

The growing series of IIMS self help handy guides

BUY ONLINE AT: https://bit.ly/2KIN5WM

or call +44(0)23 9238 5223 and pay by credit/debit card
Plummer block housings for conveyors and turbines

Motion and mobility solutions firm to the automotive and industrial sectors, Schaeffler, has launched its new generation of FAG plummer block housings which replace its existing SNV and SNG portfolio.

Suitable for rolling bearings of various diameters and widths, and for shafts from 20mm-160mm, Schaeffler’s SES plummer block housings are made of flake graphite cast iron. They can be used in conveyor systems, crushers and mills, drive drums, fans and turbines across a multitude of industries. For particularly demanding applications they can also be supplied in spheroidal graphite cast iron.

Seal options include double lip, felt, V-ring, Taconite and labyrinth variants, which are complemented by a choice of plastic or steel covers. Schaeffler also offers a standard range of split spherical roller bearings for use with the SES plummer block housing range, providing a complete solution for quick replacement of both bearings and housings. Unlike previous generations of product, they are compatible with all established solutions available on the market and the housing dimensions adhere to common standards, so it is easy to replace competitor products with these new newly created products, the company has said.

Johnson Matthey to utilize new reverse water gas shift technology

Johnson Matthey has launched a new reverse water gas shift technology called HyCOgen to produce chemical feedstocks for aviation fuel from captured CO2. Unveiling the technology, the company said it wants its catalysed process to be used in the production of greener aviation fuel. To this end, HyCOgen would use captured CO2 and react it with hydrogen from renewable sources to produce carbon monoxide. Then by integrating the process with the FT CANS Fischer-Tropsch technology that it developed with BP, the carbon monoxide would be combined with more hydrogen to produce synthetic crude and upgraded into a range of products including aviation fuel, diesel and naphtha.

Johnson Matthey said the integrated technology is cost-effective across a wide range of project sizes and can help the aviation industry reduce emissions as it works to develop non-fossil fuel propulsion systems, including battery powered planes.

In 2020 there were 11,300 tool thefts reported in the UK, with drills being the most common tool stolen - Toolstation reports.

Nearly one in three respondents to a UK health and safety survey say they have received no workplace training.

A team of researchers at MIT and in China has developed a new solar-powered desalination system that is both more efficient and less expensive than previous solar desalination methods.

The British Aggregate Association has issued a safety alert to raise awareness of dangers involving concrete skips.

Scientists in the UK have set a new record for energy generated by nuclear fusion, an achievement heralded as a significant step toward conquering one of the biggest scientific and engineering challenges.

Bentley has invested £3m to double its additive manufacturing (AM) capacity at its headquarters in Crewe. An AM facility has been applied to a wide range of uses, producing more than 15,000 components in 2021 alone.

Photo by Géraud Gordias on Unsplash
Three Asian firms to build world’s first sea to air integrated drone

QYSEA, a China-based manufacturer of undersea robots has teamed up with KDDI, a Japanese telecommunications provider to develop the world’s first integrated drone that can fly in the air and perform operations underwater, a company press release said.

The drone was showcased recently at the Hakkeijima Sea Paradise in Yokohama, Japan.

The breakthrough was made possible with inputs from commercial drone manufacturer PRODRONE who supplied the airborne vehicle. Connected to the electric winch on this drone is QYSEA’s underwater drone that is ferried through the air in a quick release cage. Once the aerial drone managed a water landing, the underwater drone is released and begins to perform its assigned task.

The flight over water as well as the underwater dive can both be managed by an operator sitting far away on land. Making this possible is KDDI’s advanced mobile communication network that works across extended distances between the drones and the operator.

Protecting EV charging stations from cyberattacks

As the number of electric cars on the road grows, so does the need for their electric vehicle (EV) charging stations and the Internet-based managing systems within those stations. However, these managing systems face their own issues: cybersecurity attacks.

Elias Bou-Harb, director of the UTSA Cyber Center for Security and Analytics, and his colleagues Claud Fachkha of the University of Dubai and Tony Nasr, Sadegh Torabi and Chadi Assim of Concordia University in Montreal are shedding light on the vulnerabilities of these cyber systems. The researchers are also recommending measures that would protect them from harm.

The systems built into electric cars perform critical duties over the Internet, including remote monitoring and customer billing, as do a growing number of internet-enabled EV charging stations.

Bou-Harb and his fellow researchers wanted to explore the real-life implications of cyber-attacks against EV charging systems and how to utilize cybersecurity countermeasures to mitigate them. His team also assessed how exploited systems can attack critical infrastructure such as the power grid.

“Electrical vehicles are the norm nowadays. However, their management stations are susceptible to security exploitations,” said Bou-Harb, who is an associate professor in the Carlos Alvarez College of Business’ Department of Information Systems and Cyber Security. “In this work, we endeavored to uncover their related security weaknesses and understand their consequences on electrical vehicles and the smart grid while providing recommendations and sharing our findings with relevant industry for proactive security remediation.”

During this project, the team developed several security measures, guidelines and best practices for developers to mitigate cyber-attacks. They also created countermeasures to patch each individual vulnerability they found.

To prevent a mass attack on the power grid, the researchers are recommending that the developers patch existing vulnerabilities but also incorporate initial security measures during the manufacturing of the charging stations.

“Many industry members have already acknowledged the vulnerabilities that we uncovered,” Bou-Harb said. “This information will help immunize these charging stations to protect the public and provide recommendations for future security solutions in the context of EVs and the smart grid.”
DIAGS Honorary Life President Jeffrey Casciani-Wood has passed away

By Mike Schwarz

News reached me late in the evening on 16th February to say that the Institution of Diagnostic Engineers’ Honorary Life President and Director of the former limited company, Eur.Ing Jeffrey Casciani-Wood CEng, FRINA, HonFIIMS, FLLA, FiDiagE (aka Mog), had passed away peacefully following a short illness.

Known to many in both the marine surveying and diagnostic engineering fields, Jeffrey’s passing leaves a huge hole in the industry. His longevity and desire to continue to contribute to both the Institution of Diagnostic Engineers and the International Institute of Marine Surveying Institute (IIMS) life into his 90s marks him out as a unique and inspirational character. There are many superlative adjectives and words that could be used to describe Mog, and all would be appropriate. Words and phrases such as a heavyweight, a legend, a giant, a humourist, consummate author, ‘good bloke’ and gentleman all fit. But he was those things and more.

Jeffrey Casciani-Wood was a long standing member of DIAGS and became President in 2010. I know how proud he was to have served the Institution. I also know by chatting with him personally how distressed he was on the one hand to witness the liquidation of DIAGS late in 2021, yet how delighted he was knowing that IIMS (and the Marine Surveying Academy Ltd) would become the new guardians of the brand.

I recall on my first day in post as IIMS CEO back in 2014 when he rang to introduce himself. I had been sitting in the hot seat for less than 30 minutes. He introduced himself simply as Mog. I replied that’s an unusual name. He responded by telling me with gusto that it stood for Moaning Old Git and informed me how much he enjoyed making a nuisance of himself wherever and whenever he could and how proud he was of doing so. Our exchange of banter left a mark on me. We became good friends over the years and developed a healthy professional respect for each other, although both from very different backgrounds.

Jeffrey Casciani-Wood devoted so much of his professional life to the art of marine surveying, (an industry that he cared passionately about), even well after he stopped working. Jeffrey’s legacy will live on for many years to come through the numerous articles and papers he wrote for both the Diagnostic Engineering and Report magazines, from his videos stored on YouTube and via the handy guides written by him. Indeed he told me that his Small Craft, Ship & Boatbuilding Terminology handy guide, still a steady seller, was the culmination of 50 years work.

Mog was a devoted family man and used to tease me saying he had lost count of the number of grand and great grandchildren he had and would say, “Oh by the way another is on the way.” My thoughts are with his family at this time as they mourn his passing.

Jeffrey Casciani-Wood was ‘old school’ and truly a one off who will be sorely missed by all who knew him. I doubt we will see his like again and in that sense, he is irreplaceable.

Rest in Peace Jeffrey Casciani-Wood.
As announced in mid-February, you will be aware that DIAGS lost its Honorary President, Jeffery Casciani-Wood. This was both a huge personal loss to myself and many others too, but it has also left a huge void in the fields of both Diagnostics and Marine Surveying.

Jeff was a long-standing member of DIAGS and became President in 2010. He quickly encouraged me to join and eventually led to me becoming Chairman of the Council.

I have had the benefit of having the last 25 years with Jeff as initially my teacher, then as an employer, a colleague, and an employee - but more importantly as a great friend.

Jeff taught me everything I know about boats, ships and marine surveying as well as how to navigate the country by cafes, teashops and Little Chefs! He also taught me early on that for safety and sanity reasons it was best that I took responsibility for driving us to and from jobs and Council meetings. I have little doubt that his family would agree with this.

Jeff was an incredibly clever and knowledgeable man with a voracious appetite for learning new skills, even into his 90s.

His career began on 1st January 1945 when he started pre apprenticeship training at the London graving dock, leading into a five-year Apprenticeship as a shipwright.

In 1951 Jeff went to sea in general cargo vessels, tankers and trawlers whilst also attending college to obtain formal qualifications.

Upon his return from sea in 1957, he secured employment at Messrs. Green and Silley Weir Ltd as a Junior Draughtsman rising to Assistant Manager. During this period Jeff was also a Part Time Lecturer in naval architecture and ship construction at Poplar Technical College in London teaching these subjects to students at ONC level.

In 1964, Jeff joined Hart Fenton & Co. Ltd. as Superintendent Engineer until 1970 when he formed his own company as an independent marine surveyor.

Jeff considered the field of diagnostic engineering to have a huge part in a vast array of different fields and was extremely proud that the Institution was so inclusive. The number of different professions within the Institution is frankly staggering.

Some of you may have known Jeff personally and others will have known him purely in a professional capacity, but Jeff always left an impression and leaves an extraordinary legacy behind him.

Many years ago his daughter Marilyn gave the nickname MOG (Miserable Old Git). He loved it and often used it to introduce himself.

The last 25 years have absolutely flown by and every one of them has been a joy. I have Jeff to thank for that. I will miss him terribly as both a friend, colleague and mentor.
How many ‘thinkers’ did you find on the last page of issue #200?

There were nine in total.

Here they are shown in red. If you missed it last time, go to the last page of this issue and see how many you can spot this time.

When Diagnostic Engineering was repurposed at the start of 2022, it was pleasing to see many of the ‘original gang’ who were delighted that it is back with a bang! We received many goodwill gesture from well-wishers verbally, but here are a few of the written comments.

**Thanks. I have been a member of DIAGSS for some 30 years. First Institution I ever joined. I saw the email saying that DIAGS had closed and reopened, and I still wanted to be a part of it, as I consider a part of my job is ‘diagnosing’ issues and solving them.**

**Great to be back with you.**

**I have read the email concerning the new DIAGS and applaud the action taken.**

**I would like to wish you tremendous success in taking the rebranded institution forward and would like to continue with my long-standing membership. Best wishes for what I am sure will be a challenging 2022.**

**I had a quick look at the new magazine format; it’s a vast improvement.**

**Thank you, making contact regarding the re-forming of the institution, I had thought it had curled up under a log somewhere! I look forward to a new and rejuvenated DIAGS and hope you are successful in securing subscribers.**

**It takes a lot to impress me these days, but this magazine is SUPERB in content and quality. I will take a few days to read right through, ideal for my coffee stops! The print quality is also superb.... way to go.**

**I get various magazines each month; for example, RSGB sends their members a radio amateur monthly magazine, usually I just skim it, but this DIAGS mag makes you sit up and pay attention.**
Here is a selection of upcoming events that will be of interest to members of the Institution. Most (if not all) will offer an online joining option.

<table>
<thead>
<tr>
<th>APRIL 2022</th>
</tr>
</thead>
<tbody>
<tr>
<td>24/28 April 2022</td>
</tr>
<tr>
<td>Building and Facilities Maintenance Management</td>
</tr>
<tr>
<td>Location: London, UK</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>MAY 2022</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 May 2022</td>
</tr>
<tr>
<td>International Conference on Wireless Sensor Networks, Ubiquitous Computing and Applications</td>
</tr>
<tr>
<td>Location: Dublin, Ireland</td>
</tr>
<tr>
<td>1/5 May 2022</td>
</tr>
<tr>
<td>Assessment Of Defects In Concrete Structures and Evaluation Of Safety Of Concrete Infrastructure</td>
</tr>
<tr>
<td>Location: London, UK</td>
</tr>
<tr>
<td>5/6 May 2022</td>
</tr>
<tr>
<td>Conference on Aviation and Aircraft Maintenance Engineering</td>
</tr>
<tr>
<td>Location: Dubai, UAE</td>
</tr>
<tr>
<td>5/6 May 2022</td>
</tr>
<tr>
<td>Conference on Transportation Engineering and Traffic Planning</td>
</tr>
<tr>
<td>Location: Rome, Italy</td>
</tr>
<tr>
<td>5/6 May 2022</td>
</tr>
<tr>
<td>Advances in Automated Software Engineering</td>
</tr>
<tr>
<td>Location: Singapore</td>
</tr>
<tr>
<td>More info: <a href="https://bit.ly/3Hg4aNz">https://bit.ly/3Hg4aNz</a></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>5/6 May 2022</th>
</tr>
</thead>
<tbody>
<tr>
<td>International Conference on Mechanical and Mechatronics Engineering</td>
</tr>
<tr>
<td>Location: Rome, Italy</td>
</tr>
<tr>
<td>5/6 May 2022</td>
</tr>
<tr>
<td>International Conference on Electrical Engineering and Green Energy</td>
</tr>
<tr>
<td>Location: Singapore</td>
</tr>
<tr>
<td>More info: <a href="https://bit.ly/3g8CmPm">https://bit.ly/3g8CmPm</a></td>
</tr>
<tr>
<td>16/17 May 2022</td>
</tr>
<tr>
<td>International Conference on Agricultural Engineering and Automation</td>
</tr>
<tr>
<td>Location: Amsterdam, The Netherlands</td>
</tr>
<tr>
<td>16/17 May 2022</td>
</tr>
<tr>
<td>International Conference on Internal Combustion Engines and Automotive Engineering</td>
</tr>
<tr>
<td>Location: Amsterdam, The Netherlands</td>
</tr>
<tr>
<td>16/17 May 2022</td>
</tr>
<tr>
<td>Conference on Heating System Engineering</td>
</tr>
<tr>
<td>Location: Sydney, Australia</td>
</tr>
<tr>
<td>16/17 May 2022</td>
</tr>
<tr>
<td>Conference on Earthquake Engineering, Seismic Design and Seismology</td>
</tr>
<tr>
<td>Location: Paris, France</td>
</tr>
<tr>
<td>16/17 May 2022</td>
</tr>
<tr>
<td>Conference on Advances in Metal Engineering</td>
</tr>
<tr>
<td>Location: Sydney, Australia</td>
</tr>
</tbody>
</table>
Forthcoming international events calendar

**JUNE 2022**

- **2/3 June 2022**
  - Conference on Asphalt Science, Engineering and Technology
  - Location: New York, USA

- **2/3 June 2022**
  - Conference on Production and Industrial Engineering
  - Location: Rome, Italy

- **2/3 June 2022**
  - Conference on Offshore Engineering and Technology
  - Location: Rome, Italy

- **2/3 June 2022**
  - Conference on Industrial Engineering, Decision Analysis and Utility Theory
  - Location: San Francisco, USA

- **9/10 June 2022**
  - Conference on Flight Test Engineering
  - Location: Barcelona, Spain

- **10/11 June 2022**
  - Conference on Security Engineering, Processes and Procedures
  - Location: Copenhagen, Denmark

- **12/16 June 2022**
  - Risk Based Inspection and Maintenance For Reinforced Concrete Structure
  - Location: London, UK

**JULY 2022**

- **28/29 July 2022**
  - Conference on Aerospace, Mechanical, Automotive and Materials Engineering
  - Location: London, UK

Keep an eye on the Institution’s website at https://bit.ly/2FxH4Yb which will be updated often with other relevant conferences, events and symposiums.
Professional Qualifications in Marine Surveying

awarded by the International Institute of Marine Surveying

Study online at home and at sea
- IIMS Student Membership included
- Courses start every three months

IIMS is dedicated to developing the next generation of marine surveyors by offering quality qualifications that are recognised throughout the maritime world. Both IIMS professional qualifications are equivalent to a level 4/5 education qualification and can be studied on a distance learning basis. All you need is access to the internet.

For more info email education@iims.org.uk, tel. +44 (0) 23 9238 5223
How maintenance underpins the science of the future

**ABSTRACT**
At a world leading Oxfordshire research facility maintenance of a particle accelerator that makes neutrons and muons occurs against a radioactive background, so must be an organised and optimised affair.

Maintenance is a crucial part of the unique research effort involving thousands of research scientists and engineers that aims to produce the materials of the future and deliver wide ranging benefits such as a potentially net-zero National Grid.

The engineers involved are at the cusp of the next generation of computer aided maintenance, explain Accelerator Design Group Leader Galen Aymar and Mike Glover, Electrical Systems Division Head, ISIS Neutron and Muon Source at the STFC Rutherford Appleton Laboratory.
Introduction

Society’s biggest challenges can be hard to predict, but when they do arise, expert analysis is crucial to getting the upper hand. Just like a better telescope enables you to see in more detail, we not only need to develop, but also maintain the equipment that will help to find the answers to new questions we’ve not faced before. Those at the ISIS Neutron and Muon Source confront this very challenge – and it’s a particularly exciting and complex endeavour because of the unique research that takes place at the facility.

A world-leading facility for research

The ISIS Neutron and Muon Source, based at the STFC Rutherford Appleton Laboratory in Oxfordshire, is a world-leading facility defining the materials that will shape our society and economy for decades to come. It supports a national and international community of more than 4000 scientists who use the facility’s particle accelerator for research in physics, chemistry, materials science, geology, engineering and biology.

At the facility, beams of neutrons and muons created using the accelerator are fed into a suite of cutting-edge instruments. In a similar way to how we can see things through a microscope because of how light interacts with it, our researchers observe how neutrons and muons interact with materials. This provides them with important information about processes that occur at the atomic level.

As the complexities of human society and human science become more and more intertwined it is important that the UK has the tools to stay ahead. We support researchers from both industry and academia, who come to the facility to employ a range of techniques to explore the materials of batteries for electric cars, chemicals for detergents and shampoos, and even the inner workings of a virus, to name but a few.

Time is invaluable at such a facility like ours; we are active 24/7, continually providing the tools for investigation. As a result, we are constantly working against the clock. Like any large research facility, thousands of researchers apply for time to use our beamlines annually, some of whom have even planned their experiments years ahead. Our role in maintenance is to ensure that their experiments can run smoothly and successfully, so they get the most out of their time at the facility.

With this in mind, most of our maintenance must be completed while parts of the facility are still in operation, and any downtime must be minimised wherever possible. In the unlikely event of the full stoppage of a particle beamline, it could take up to five days to get back up and running. This not only means lost time for experiments, but also wasted energy. Maintenance must be an optimised and organised affair.

Maintaining a machine that makes neutrons and muons

There are three main parts of the facility that must be taken into account when considering maintenance at the ISIS Neutron and Muon Source: the particle accelerator, the targets that particles hit to create the neutrons and muons, and the instruments used for research.

To create neutrons, high energy protons, accelerated by the particle accelerator, are aimed at a tungsten target to generate an intense beam of neutrons. These neutrons are slowed to optimal speeds using a series of moderators, and then directed to a suite of neutron instruments, each optimised to explore the different properties of those materials. A small

Preparation of the old tank IV for removal.
This is an engineering challenge as the geometry to bring out the old tank in one piece was only just feasible, and the weight of the tank was close to the limit of the current crane.
fraction of these protons also interact with a carbon target, creating pions which decay into muons and are likewise directed to a suite of muon instruments.

These conditions are therefore naturally radioactive, producing an added layer of risk management to the maintenance work we would look to conduct. It means that in many cases we are focused on reducing the amount of time a repair takes to reduce human exposure to radiation. Or we ensure we can do it while the facility is not running during a period of 'shut down'. As a result, we need clear programmes for preventative or predictive maintenance in order to stop issues from developing before they reach the point of severe loss of function.

The process used to generate particles creates a large amount of heat, and cooling is an essential part of the particle acceleration process. Many parts are surrounded by watercooling systems for instance. At the same time, such a high throughput of water means that the erosion of parts is commonplace, and clogs caused by impurities reacting with water can also easily occur. These extremes are necessary to the continued function of the particle accelerators, but bring with them complicated maintenance issues that the engineers here tackle on a daily basis.

Access is an even greater challenge in many cases. Certain parts have short lifetimes that need replacing or maintaining often, and others can operate for decades before needing service. But those that are in hard-to-reach places can cause disruption to research. The muon collimator, for example, is fitted in a part of the beamline that is highly radioactive and incredibly small, smaller than the average width of a human arm.

Therefore, repairing a water leak that may occur from the cooling system is made doubly difficult and often requires a total shutdown of the system. Fortunately for the muon collimator, this has only happened once after almost 30 years of use!

One method that helps us to maintain the facility, and prevent a full shut down, is to use our beamlines as diagnostic tools. In the accelerator we have the proton beam which goes to several target locations every 20 milliseconds. Our diagnostics tools monitor changes to the characteristics of the proton beam, alerting our engineers as to when a part might need investigation and maintenance.

This could include the detection of a change in the current, or increased radiation in certain areas – a sign that part or all of the proton beam has been disturbed. A change in the intensity or shape of the beam implies that we need to revisit the positioning of the magnets, which impacts on how they focus the beam.

Similarly, trips in our neutron beamlines can be easily identified by the extremely precise instruments on the end, which are carefully monitored by scientists as they conduct their work. We also use systems that monitor the vibration of a
particular instrument using the neutrons and confirm that it is performing within the expected parameters.

These measures for preventative maintenance are effective at a facility like ours because making small changes without the need for a total shutdown is core to our ongoing operations. We have to prioritise tasks and do what we can with what we can access safely.

Meeting the needs of science and the environment

The facility’s priority is to serve researchers who come to explore the inner workings of materials at an atomic scale so they can be better used by society. Keeping the neutrons and muons running requires a perpetual programme of maintenance with this aim front and centre.

So far, we have achieved a continuous function 92% of the time, which is extremely good relative to other similar scientific facilities around the world, however, there is always room for improvement, and even a small increase in this number would have wide-ranging benefits for carbon emissions, water usage and costs.

It is not easy or efficient to shut down every part of the facility when any single thing needs maintaining, but occasionally it is necessary. Typically, the facility is shut down once every six years, for a rigorous programme of maintenance, repairs, replacements and updates. This is done to achieve high levels of reliability, and during this period the facility closes for at least three months for major repairs.

We also plan a mid-cycle shutdown as part of every operational cycle, which lasts for two to six weeks. Occasionally, a one day maintenance shut down will occur to repair equipment that will not make it to the end of an operational cycle. Only equipment undergoing maintenance is switched off to allow for a quick start up, as restarting the whole facility can take up to five days and is generally avoided.

Currently, as we write this article, the facility is undergoing a long shutdown. The accelerator has been turned off and we have made progress on a range of large engineering projects, for example:

- The replacement of Tank IV, which was originally installed in 1976 and accelerates the particles in the linear accelerator while also maintaining a vacuum necessary for the particle accelerator’s normal function. Leaks in this tank had naturally weakened the vacuum, but it is inaccessible and therefore irreparable without a complete shutdown of the facility.
The only temporary fix to this problem is to increase the vacuum pumping capacity which cannot be done indefinitely. With the long shutdown, this tank could be removed and a new one installed.

The replacement of the target in Target Station One (TS1), which had been operational for over 35 years without significant maintenance or development work. As parts of its components were radioactive, they had to be disassembled and sealed into shielded flasks before removal. The new design of the target includes improvements to its cooling systems, moderators, reflectors, and monitoring instrumentation.

Sustainability is also another focus of our maintenance plans. Electricity used by the facility generates 22,000 tonnes of CO2 equivalent per year. Particle acceleration also involves a high demand of electricity and water consumption. Reducing our carbon footprint is a goal of ours, and there is still some way to go with these aspirations.

However, thanks in part to the research conducted at this very facility, there are opportunities to be more sustainable in the future. In fact, it is estimated that while our current energy consumption from non-renewable sources is high, the output from the science uncovered could be key to a net-zero National Grid, through finding the materials that will help us to store and create energy much more sustainably.

**Maintenance is nothing without the human touch**

Whilst the highly technical machinery at the ISIS Neutron and Muon Source is a crucial part of the research we are able to support, the facility would be nothing without its 400-strong community of engineers and technicians on site. The broad skillset required to run such a site is vast with people ranging from craft technicians to fully qualified chartered engineers.

Maintenance conducted at the site can be general in nature, or highly specialist, involving mechanical, electrical or even cryogenic systems that keep the facility running. Research is also undertaken at some of the highest pressures and temperatures seen on Earth, so specialists in high-energy furnaces and pressure systems hold a visible presence here.

Many of our engineers joined us at early stages in their careers, as part of degree programmes, apprenticeships or other formal schemes. They now play a crucial role in the evolution of our engineering projects, some of which span decades, nurturing them through their development into the fully-fledged research programmes we see today. We are also constantly recruiting engineers who are passionate about the work we do.

Not everyone will have the specialism required to spot an area that needs attention, or to even provide a solution, but ensuring a team of engineers with a coherent communication strategy is always on-call to assess any new issue is what makes our facility a world-leading particle accelerator.

The unique ecosystem here provides a space for engineers to solve exciting problems whilst working with hundreds of other specialists every day. While maintenance is a big part of our work here, engineers also spend their days feeding back and communicating their insights into each intimate detail of the accelerator’s inner workings. One day you might be repairing a magnet on a beamline, the next designing and building a new one to replace the older model.

**Evolving to a new era of maintenance**

As ISIS Neutron and Muon Source has been running for decades, the processes we have used for maintenance have evolved significantly, as you would expect. We’ve transitioned from solely working with paper, to recording on computers, and now we are at the cusp of the next generation of computer aided maintenance.

Looking to the future, we’re exploring machine learning software to monitor the lifetime of certain instruments and estimate when they will need replacing or cleaning. This has been used already in our methane moderator, a key piece of kit used to slow down the neutrons to the correct energy needed.

However, as neutrons are passed through methane, it has the side-effect of producing a substance similar to sludge, which build-ups up and eventually hinders the function of the whole beamline.

Currently, cleaning this methane moderator requires a stop to the beamline while it is warmed up, cleared, and then cooled down again. With machine learning, we can instead develop an accurate prediction of when that sludge is going to build and add foresight into our operations and ensure that all of this equipment can be cleaned with as little disruption to the facility as possible.
Looking forward to ISIS-II

Our experience of maintaining the current facility over its more than 30-year history has been leading towards ISIS-II, the next generation facility that will build upon the lessons of the original ISIS Neutron and Muon Source. The specifications are still being finalised, but this new facility is looking to secure higher powers, higher energies and not only maintain reliability but increase it.

Even at these beginning stages of design, our engineers are constantly thinking about how to take maintenance into account. We are in a unique position to apply the learnings we have taken with the current accelerator and apply them to our design of ISIS-II, for example, through better access and a need to reduce radiation risks in areas that need regular maintenance.

One design option that is being explored is a vertical Fixed Field Alternating (FFA) Gradient accelerator – where the particle beam spirals vertically as it accelerates. Only a handful of similar accelerators have been built over the last 30 years, but no vertical FFA has ever been fully designed and this would be the world’s first.

Although we are still undergoing feasibility studies for accelerator possibilities, it is exciting to be investigating how maintenance considerations will play out in these unique concepts, and how engineers more than 20 years down the line when ISIS-II becomes a reality will have to adapt and learn when it comes to repairing the facility.

We are also focused on how we can monitor the timelines of components in the accelerator and really consider the lifetimes, not just based on their specification, but how they will be used. For example, we may want to remove and test pieces of equipment earlier because we know that they have been fitted with insulation or sealant that could impact on performance. These are points we can pick up now, rather than wait for later.

Another exciting update we are looking to explore with ISIS-II is a digital twin system, using a virtual copy of the facility’s blueprints to help assess and plan maintenance operations before they are done in the real world.

This allows engineers to practice in a safe environment before being exposed to radiation, and therefore limit this exposure. State-of-the-art technologies such as this will ensure ISIS Neutron and Muon Source continues to be one of the most advanced facilities in the world, and experience of these new technologies is an unmissable opportunity for any trainee engineer.

The success and discovery of our search for answers to underpin what matters in the future hinges on the maintenance of our tools. At the ISIS Neutron and Muon Source, we are fortunate enough to have a dedicated and skilled team of engineers and technicians spotting problems, finding solutions, and preventing and reducing system downtime.

At the same time, we’re in the unique position to ensure maintenance is considered at every step in the plan for the next iteration of our facility. It is at the heart of the operation, and we are excited to see how developments of technology and science – from the facility or beyond – will build upon the work we have done here.

This feature article was published online at Maintenance & Engineering https://www.maintenanceandengineering.com and is reprinted here with our thanks.
INVESTIGATION OF ROLLING BEARING LUBRICATION CONDITION

By Andrzej JAŁOWIECKI, Marek FIDALI and Adrian KROL
Silesian University of Technology, Faculty of Mechanical Engineering, Department of Fundamentals of Machinery Design, Poland
andrzej.jalowiecki@polsl.pl                   marek.fidali@polsl.pl                   adrian.krol@polsl.pl

ABSTRACT

The research aimed to assess the lubrication condition of rolling bearings dismounted from previously operated passenger car alternators. The tests measured the vibrations and evaluated the technical condition of the bearings based on selected estimators of the vibration acceleration signal subjected to earlier band-pass filtration in the high-frequency range of 8-10kHz. Next, the bearings have been disassembled, allowing inspection of the lubricant condition for each measured bearings and the visual assessment of individual components. Based on the test results, it was observed that the mean value and standard deviation of considered features of vibration acceleration signals in the 8-10kHz band might be helpful in the classification of the lubrication condition.
1. INTRODUCTION

One of the essential maintenance activities during the machine operation is to provide proper lubrication of different machine parts, including rolling bearings. Improper lubrication of the rolling bearing leads to premature bearing degradation, which can cause unexpected machine failure.

According to research published in [1], [2], and [3], 80% of bearing faults is caused by improper lubrication conditions. The leading cause of poor lubrication conditions is over- or under-lubrication and change of physical and chemical properties of the grease, e.g., by overheating or moisture. There are many in-field testing techniques to control and monitor bearing lubrication conditions. Very often a portable mini-labs [4] ultrasonic equipment, infrared cameras [5] as well as vibration measurements [6] are applied. Many of the machine bearings are under continuous vibration monitoring. It makes possibilities for constant assessment of machine condition including bearings lubrication one. According to some publications [7] [8] [9], poor lubrication condition affects the increase of the level of vibration acceleration signal, usually in high-frequency bands. As stated in [10], lack of lubrication influences acceleration RMS values differently in frequency bands 1Hz-2 kHz, 2-4 kHz, 4-6 kHz, 6-8 kHz and 8-12 kHz. They concluded that the RMS of vibration acceleration signal at the frequency band of 8-12 kHz was the most sensitive for detecting poor lubrication conditions in the test arrangement and bearing type used. Depending on the grease film thickness, the vibration level increases when thinner [9]. This phenomenon can be explained by the rising of the grease viscosity [11]. Based on the research presented in [12], the relation between the roughness and the oil film thickness, marked as λ, can be related to the higher vibration level value. The crucial λ value is estimated at around 1.6, and this is a point when the vibration level starts to rise [13] [14] [15].

In this paper, the authors focused on assessing the lubrication condition of deep groove rolling bearings based on statistical parameters of vibration signal estimators. To do that, authors have tested a series of ball-bearing, first measuring the vibration signals and then disassembling the bearings, performing few grease condition tests, and visually inspect bearings rolling elements. A detailed discussion on the assessment of the tested bearings’ condition based on the vibration signal features has been described in another article [19].

2. RESEARCH

The research has been performed on a set of 19 ball bearings type 6303 dismantled from car alternators. Bearings were different manufacturers, and their conditions were unknown. Before estimation of bearing grease conditions, a vibration test was performed.

2.1. The vibration measurement and signal analysis

All vibration measurements have been carried out on a test bench designed and manufactured by scientists from the Department of Fundamentals of Machinery Design at the Silesian University of Technology. The stand was controlled by an industrial PLC – Siemens S7-1200. Vibration signals were acquired and processed by measurement setups (Fig 1) consisted of an industrial accelerometer (SLC144TB-M8; 2 Hz-10 000 Hz and 100 mV/g) connected to a conditioning module (SPM Intelinova) and then to NI data acquisition card NI-USB-4432. Digital signal from DAQ module was processed by software developed in NI LabView environment.

The tested bearing was mounted on the test bench shaft, blocked by the specially designed holder, and fixed on the horizontal electric actuator’s rod. The accelerometer was installed on a platform that allows vertical movement, ensuring constant and controlled, by actuator controller, bearing load of 60N in a radial direction, and good contact between the sensor probe and an outer bearing ring. Each bearing was measured in four positions, as shown in Fig. 2. The shaft speed during the test was 3000 RPM, and each measurement took 10 seconds.

The collected signals have been proceeded to extract the following commonly known [20] acceleration signal estimators:
- RMS;
- Peak;
- Crest Factor (CF);
- Kurtosis (KF);
- Clearance factor (CLF);
- Impulse factor (PF).

All that estimators have been evaluated in the following frequency bands:
- 0.5 - 10 kHz;
- 1 - 10 kHz;
- 2 - 10 kHz;
- 5 - 10 kHz;
- 8 - 10 kHz.

Fig. 1. Test stand.
After all measurements, plots for all estimators have been made. Fig 3 presents an example of elaborated plots for selected bearing. The given case is the plot of the mean Peak value in the band from 8 kHz to 10 kHz.

More detailed discussion devoted to vibration analysis results of tested bearings can be found in [19]. The obtained values are placed in increasing order. What can be seen in the presented plot is that increasing the standard deviation is related to increasing the mean of the feature’s value. The further considerations focused on using the mean and the standard deviation of selected signal features to assess bearings grease condition.

In Table 1 are aggregated average values of vibration signal features, for investigated bearings, in ascending order, the highest value of the parameter, the worst bearing condition. And for example, bearings marked as U028, U043, U084, U184, and U204 are among the worst conditions. The bearings’ ID listed in Table 1 are authors’ identification and are irrelevant in distinguishing new and used bearings.

### 2.2. The grease condition evaluation

The next step of investigations was the determination of the grease condition of the tested bearings. Bearings’ grease was subjected to a series of tests using an SKF grease test kit (TKGT1) [4], presented in Fig 4. The following tests were carried out:

- Test No. 1 – Visual assessment of a grease sample;
- Test No. 2 – Consistency test;
- Test No. 3 – Oil leakage test;
- Test No. 4 – Contamination test.

Additionally, one new bearing was also tested as a source of reference results for the grease parameters comparison. This bearing is marked as N00. We did not perform a vibration test for this bearing. During the visual assessment, the following grease features were examined:

- a) colour of the grease,
- b) consistency,
- c) shine,
- d) visible contamination, discolouration, and any anomalies [16].

Fig 5 presents exemplary sealing rings with bearing grease for bearings with the highest vibration values.

The consistency test lied to determine the NLGI consistency number for each sample and determine how the wearing process affects the grease consistency properties [17]. The analysis was based on putting a specific load on a prepared sample for 15 seconds. The level of flattening is a factor allowing to assign the NLGI number. The test results are presented in Table 2 and are shown a description of correspondent NLGI numbers according to ISO 6743-9 standard [18].

### Table 1. Average values of acceleration signal’s features in 8 - 10 kHz band

<table>
<thead>
<tr>
<th>ID</th>
<th>Peak m/s²</th>
<th>Rms m/s²</th>
<th>CF</th>
<th>KF</th>
<th>PF</th>
<th>CLF</th>
</tr>
</thead>
<tbody>
<tr>
<td>L01</td>
<td>0.76</td>
<td>0.10</td>
<td>7.35</td>
<td>3.30</td>
<td>9.28</td>
<td>10.98</td>
</tr>
<tr>
<td>L02</td>
<td>1.29</td>
<td>0.11</td>
<td>11.74</td>
<td>4.91</td>
<td>15.18</td>
<td>18.13</td>
</tr>
<tr>
<td>U002</td>
<td>0.45</td>
<td>0.07</td>
<td>6.49</td>
<td>3.15</td>
<td>8.15</td>
<td>9.61</td>
</tr>
<tr>
<td>U022</td>
<td>0.48</td>
<td>0.07</td>
<td>7.05</td>
<td>3.01</td>
<td>8.76</td>
<td>10.27</td>
</tr>
<tr>
<td>U028</td>
<td>4.07</td>
<td>0.16</td>
<td>26.37</td>
<td>44.55</td>
<td>39.95</td>
<td>49.43</td>
</tr>
<tr>
<td>U029</td>
<td>1.17</td>
<td>0.09</td>
<td>12.40</td>
<td>4.49</td>
<td>15.99</td>
<td>19.10</td>
</tr>
<tr>
<td>U033</td>
<td>0.86</td>
<td>0.13</td>
<td>6.81</td>
<td>3.83</td>
<td>8.78</td>
<td>10.50</td>
</tr>
<tr>
<td>U043</td>
<td>14.57</td>
<td>0.82</td>
<td>17.71</td>
<td>14.42</td>
<td>27.12</td>
<td>34.93</td>
</tr>
<tr>
<td>U070</td>
<td>1.29</td>
<td>0.12</td>
<td>10.72</td>
<td>5.18</td>
<td>14.00</td>
<td>16.79</td>
</tr>
<tr>
<td>U071</td>
<td>0.58</td>
<td>0.08</td>
<td>7.65</td>
<td>3.45</td>
<td>9.69</td>
<td>11.48</td>
</tr>
<tr>
<td>U084</td>
<td>2.28</td>
<td>0.15</td>
<td>15.00</td>
<td>11.82</td>
<td>21.14</td>
<td>25.98</td>
</tr>
<tr>
<td>U112</td>
<td>4.15</td>
<td>0.35</td>
<td>11.63</td>
<td>4.97</td>
<td>15.13</td>
<td>18.12</td>
</tr>
<tr>
<td>U119</td>
<td>0.94</td>
<td>0.12</td>
<td>7.82</td>
<td>3.40</td>
<td>9.85</td>
<td>11.63</td>
</tr>
<tr>
<td>U142</td>
<td>1.28</td>
<td>0.10</td>
<td>12.21</td>
<td>4.23</td>
<td>15.62</td>
<td>18.58</td>
</tr>
<tr>
<td>U149</td>
<td>0.62</td>
<td>0.08</td>
<td>8.06</td>
<td>4.59</td>
<td>10.51</td>
<td>12.60</td>
</tr>
<tr>
<td>U180</td>
<td>0.73</td>
<td>0.08</td>
<td>9.00</td>
<td>4.26</td>
<td>11.56</td>
<td>13.76</td>
</tr>
<tr>
<td>U184</td>
<td>9.48</td>
<td>0.41</td>
<td>22.63</td>
<td>28.13</td>
<td>38.39</td>
<td>51.81</td>
</tr>
<tr>
<td>U185</td>
<td>2.27</td>
<td>0.16</td>
<td>13.99</td>
<td>6.13</td>
<td>18.63</td>
<td>22.55</td>
</tr>
<tr>
<td>U204</td>
<td>6.11</td>
<td>0.25</td>
<td>25.07</td>
<td>27.10</td>
<td>38.00</td>
<td>47.97</td>
</tr>
</tbody>
</table>
The oil leakage test consisted of heating the grease sample at a temperature of 60°C, in a time of 2 hours, on a special absorbent pad. After the heating process, the diameter of the circular mark created by leaked oil was measured. The lower mean value of measured diameter refers to the more reduced lubrication properties of the grease. Table 3 presents the results of the measurements. Due to insufficient grease in bearings U112 and U184, it was impossible to make an oil leakage test. We decide not to consider those bearing in further considerations.

The last performed test consisted of an assessment of contaminations in the grease. The test was carried out using an optical microscope. The main goal of the test was to find out any marks of the wearing process in grease, such as small metallic particles, dirt nuggets, and so ones. Microscopic images presented the three most contaminated grease samples are shown in Fig 6. On those images, we can see many intrusions in grease in the form of different-sized forging particles.

The results of the performed tests were ranked using grades from 1 to 5, where one means terrible and five

**Table 2. The consistency test results**

<table>
<thead>
<tr>
<th>Bearing ID</th>
<th>NLGI number</th>
</tr>
</thead>
<tbody>
<tr>
<td>N00</td>
<td>2</td>
</tr>
<tr>
<td>L01</td>
<td>1</td>
</tr>
<tr>
<td>L02</td>
<td>4</td>
</tr>
<tr>
<td>U002</td>
<td>4</td>
</tr>
<tr>
<td>U022</td>
<td>4</td>
</tr>
<tr>
<td>U149</td>
<td>4</td>
</tr>
<tr>
<td>U071</td>
<td>4</td>
</tr>
<tr>
<td>U142</td>
<td>5</td>
</tr>
<tr>
<td>U180</td>
<td>4</td>
</tr>
<tr>
<td>U029</td>
<td>4</td>
</tr>
<tr>
<td>U119</td>
<td>4</td>
</tr>
<tr>
<td>U033</td>
<td>4</td>
</tr>
<tr>
<td>U070</td>
<td>5</td>
</tr>
<tr>
<td>U185</td>
<td>5</td>
</tr>
<tr>
<td>U028</td>
<td>5</td>
</tr>
<tr>
<td>U084</td>
<td>4</td>
</tr>
<tr>
<td>U204</td>
<td>4</td>
</tr>
<tr>
<td>U112</td>
<td>1</td>
</tr>
<tr>
<td>U184</td>
<td>1</td>
</tr>
<tr>
<td>U043</td>
<td>3</td>
</tr>
</tbody>
</table>

**Table 3. The oil leakage test results**

<table>
<thead>
<tr>
<th>Bearing ID</th>
<th>Mean of measured diameter [mm]</th>
<th>The difference to a new bearing</th>
</tr>
</thead>
<tbody>
<tr>
<td>N00</td>
<td>26.25</td>
<td>0%</td>
</tr>
<tr>
<td>L01</td>
<td>23.00</td>
<td>12.38%</td>
</tr>
<tr>
<td>L02</td>
<td>20.50</td>
<td>21.90%</td>
</tr>
<tr>
<td>U002</td>
<td>25.25</td>
<td>3.81%</td>
</tr>
<tr>
<td>U022</td>
<td>19.50</td>
<td>25.71%</td>
</tr>
<tr>
<td>U149</td>
<td>20.50</td>
<td>21.90%</td>
</tr>
<tr>
<td>U071</td>
<td>19.75</td>
<td>24.76%</td>
</tr>
<tr>
<td>U142</td>
<td>20.50</td>
<td>21.90%</td>
</tr>
<tr>
<td>U180</td>
<td>22.75</td>
<td>13.33%</td>
</tr>
<tr>
<td>U029</td>
<td>24.25</td>
<td>7.62%</td>
</tr>
<tr>
<td>U119</td>
<td>19.25</td>
<td>26.67%</td>
</tr>
<tr>
<td>U033</td>
<td>24.75</td>
<td>5.71%</td>
</tr>
<tr>
<td>U070</td>
<td>19.75</td>
<td>25.76%</td>
</tr>
<tr>
<td>U185</td>
<td>15.75</td>
<td>40.00%</td>
</tr>
<tr>
<td>U028</td>
<td>19.50</td>
<td>25.71%</td>
</tr>
<tr>
<td>U084</td>
<td>17.00</td>
<td>35.24%</td>
</tr>
<tr>
<td>U204</td>
<td>19.50</td>
<td>25.71%</td>
</tr>
<tr>
<td>U112</td>
<td>Not enough grease to create a standard sample</td>
<td></td>
</tr>
<tr>
<td>U184</td>
<td>Not enough grease to create a standard sample</td>
<td></td>
</tr>
<tr>
<td>U043</td>
<td>23.75</td>
<td>9.52%</td>
</tr>
</tbody>
</table>

**Fig. 4. The SKF grease condition test set. Sampling accessories (A), Consistency test accessories (B), Oil leakage test accessories (C), Contamination test accessories (D), Manual (E). [4]**

**Fig. 5. The examples of grease samples**
means excellent. It allows us to indicate bearing in good and bad conditions. Quantitative results of bearing grease condition evaluations are presented in Table 4.

Quantitative parameters like the NGLI number and mean measured diameter of oil mark (from test 3) were compared in Fig 7. Comparison of the two reliable quantitative parameters indicates that the grease condition of bearings U185 and U084 (dotted line ellipse) are not satisfactory due to dry grease. For comparison in Fig 8 presented the result of SPM HD vibration measurements where parameter HDc confirms the worst lubrication conditions of those bearings.

Table 4.
The summary of grease condition investigation results

<table>
<thead>
<tr>
<th>Bearing ID</th>
<th>Visual assessment</th>
<th>Consistency</th>
<th>Oil leakage</th>
<th>Contamination</th>
<th>Overall score</th>
</tr>
</thead>
<tbody>
<tr>
<td>U070</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2.0</td>
</tr>
<tr>
<td>U185</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>2.3</td>
</tr>
<tr>
<td>L01</td>
<td>1</td>
<td>4</td>
<td>3</td>
<td>1</td>
<td>2.3</td>
</tr>
<tr>
<td>U112</td>
<td>3</td>
<td>2</td>
<td>-</td>
<td>3</td>
<td>-</td>
</tr>
<tr>
<td>U184</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2.5</td>
</tr>
<tr>
<td>L02</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>2.5</td>
</tr>
<tr>
<td>U180</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>2.5</td>
</tr>
<tr>
<td>U028</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>5</td>
<td>2.5</td>
</tr>
<tr>
<td>U142</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>2.8</td>
</tr>
<tr>
<td>U149</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>3.0</td>
</tr>
<tr>
<td>U204</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>5</td>
<td>3.0</td>
</tr>
<tr>
<td>U002</td>
<td>4</td>
<td>3</td>
<td>4</td>
<td>2</td>
<td>3.3</td>
</tr>
<tr>
<td>U029</td>
<td>1</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>3.3</td>
</tr>
<tr>
<td>U084</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>4</td>
<td>3.3</td>
</tr>
<tr>
<td>U071</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>5</td>
<td>3.5</td>
</tr>
<tr>
<td>U119</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>5</td>
<td>3.5</td>
</tr>
<tr>
<td>U033</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>3.5</td>
</tr>
<tr>
<td>U043</td>
<td>3</td>
<td>4</td>
<td>3</td>
<td>5</td>
<td>3.8</td>
</tr>
<tr>
<td>U022</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>4.0</td>
</tr>
<tr>
<td>N00</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5.0</td>
</tr>
</tbody>
</table>

2.3. Visual inspection

After vibration analysis and grease condition evaluation, all tested bearing has been disassembled and cleaned for visual inspection. All signs of wearing, such as pitting, overheating, cracks, and others, have been noticed during the examination. All spotted defects are photographed and described. In Table 5, the authors arbitrary summarised the visual inspection results, where the overall condition is graded on a 1 to 5 scale, where 1 means a poor condition, and 5 means excellent condition.

Fig. 9. are shown examples of found defect.
3. ANALYSIS OF STATISTICAL PARAMETERS OF VIBRATION SIGNAL FEATURES

After collecting all data related to the bearings grease and mechanical condition and vibration signals, authors put their effort to observe a relationship between the mean and standard deviation values of signal features and the result of grease condition evaluation.

Based on the research, one can assume that vibration parameters’ statistical parameters could be helpful to classify bearings grease conditions. But it must be considered that the vibration signal cares about the grease condition and mechanical damages. Some mechanical defects can be caused by insufficient lubrication, and inadequate lubrication can accelerate some damages. Bearings marked as U084 and U185 have been selected as references for comparisons. The reason for that is that their grease differs the most from the other bearings, as shown in Fig. 7.

The following research step was essential to answer the vibration signal that allows for the lubrication condition identification. To find such a relationship, the authors have prepared a series of graphs showing the relationship between the mean value of the considered signal features and standard deviation calculated on four measurements - Fig. 10 to Fig. 14 present examples of obtained plots.

The plots’ axes are in logarithmic scale for better distribution analysis of mean value and standard deviation of considered signal features. The first step of the research has been looking for frequency band influences on the value distribution. The best separation and bearings identification is seen in a band between 8 kHz and 10 kHz. In the presented plots, it is also clear which bearings have some mechanical damage or poor grease condition. The best separation of defected bearings is observed for Peak (Fig 10) and Clearance (Fig 13) features. A hypothesis can be made that in the case of the investigated bearings before mechanical damage occurs, gradual deterioration of the grease condition and mechanical wear of the bearing occurs. It leads to fatigue damage. Such a process can be associated with the distribution of Peak and Clearance values visible in the plots. It has been observed that Kurtosis (Fig 14) is a feature that mainly identifies mechanical damage of the bearings.

Table 5.

<table>
<thead>
<tr>
<th>Bearing ID</th>
<th>Outer ring</th>
<th>Inner ring</th>
<th>Balls</th>
<th>Cage</th>
<th>Overall condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>L01</td>
<td>OK</td>
<td>OK</td>
<td>OK</td>
<td>OK</td>
<td>5</td>
</tr>
<tr>
<td>L02</td>
<td>OK</td>
<td>OK</td>
<td>OK</td>
<td>OK</td>
<td>5</td>
</tr>
<tr>
<td>U002</td>
<td>OK</td>
<td>DC</td>
<td>OK</td>
<td>OK</td>
<td>4,5</td>
</tr>
<tr>
<td>U022</td>
<td>W</td>
<td>OK</td>
<td>OK</td>
<td>OK</td>
<td>3</td>
</tr>
<tr>
<td>U028</td>
<td>AB</td>
<td>DC</td>
<td>OK</td>
<td>OK</td>
<td>2</td>
</tr>
<tr>
<td>U029</td>
<td>OK</td>
<td>OK</td>
<td>OK</td>
<td>OK</td>
<td>5</td>
</tr>
<tr>
<td>U033</td>
<td>DC</td>
<td>DC</td>
<td>PT</td>
<td>OK</td>
<td>1</td>
</tr>
<tr>
<td>U043</td>
<td>PT</td>
<td>PT</td>
<td>OK</td>
<td>OK</td>
<td>1</td>
</tr>
<tr>
<td>U070</td>
<td>OK</td>
<td>DC</td>
<td>OK</td>
<td>OK</td>
<td>4,5</td>
</tr>
<tr>
<td>U071</td>
<td>OK</td>
<td>OK</td>
<td>OK</td>
<td>OK</td>
<td>5</td>
</tr>
<tr>
<td>U084</td>
<td>SC</td>
<td>OK</td>
<td>OK</td>
<td>OK</td>
<td>3</td>
</tr>
<tr>
<td>U112</td>
<td>OK</td>
<td>AB</td>
<td>OK</td>
<td>OK</td>
<td>3</td>
</tr>
<tr>
<td>U119</td>
<td>OK</td>
<td>OK</td>
<td>OK</td>
<td>OK</td>
<td>5</td>
</tr>
<tr>
<td>U142</td>
<td>OK</td>
<td>OK</td>
<td>OK</td>
<td>OK</td>
<td>5</td>
</tr>
<tr>
<td>U149</td>
<td>W</td>
<td>AB</td>
<td>AB</td>
<td>OK</td>
<td>2</td>
</tr>
<tr>
<td>U180</td>
<td>OK</td>
<td>OK</td>
<td>OK</td>
<td>OK</td>
<td>5</td>
</tr>
<tr>
<td>U184</td>
<td>IM</td>
<td>IM</td>
<td>IM</td>
<td>OK</td>
<td>1</td>
</tr>
<tr>
<td>U185</td>
<td>OK</td>
<td>OK</td>
<td>OK</td>
<td>OK</td>
<td>5</td>
</tr>
<tr>
<td>U204</td>
<td>IM</td>
<td>IM</td>
<td>OK</td>
<td>OK</td>
<td>2</td>
</tr>
</tbody>
</table>

Fig. 9. Images of defects of specific bearings: a) discolouring on the inner ring of U028. b) scratch on the outer ring of U028. c), d), e) pitting of U043 bearing’s elements. f) pitting of U084 bearing’s outer ring
Fig. 10. Plot of mean and standard deviation values of Peak accelerations of investigated bearings in band 8000 Hz to 10000Hz

Fig. 11. Plot of mean and standard deviation values of RMS accelerations of investigated bearings in band 8000 Hz to 10000Hz

Fig. 12. Plot of mean and standard deviation values of Crest factor of accelerations of investigated bearings in band 8000 Hz to 10000 Hz

REFERENCES


2. FAG. Rolling bearing damage: Recognition of damage and bearing inspection. Publication no. WL 82 1022 ED. 1996.


Mechanical damage of the bearings. It leads to fatigue damage. Such a process can be associated with mechanical wear of the bearing occurs. It leads to gradual deterioration of the grease condition. Further research considered the larger dimension of the mean and standard deviation of signal estimators such as, e.g. Peak and Clearance factor. The best classification of bearings grease condition based on vibration parameters is obtained for the band between 8 kHz to 10 kHz. In the presented research results, we can quite reasonably say that not only the lubrication condition based on the vibration signal. According to the research authors try to answer whether it is possible to define the lubrication condition based on the vibration signal. According to the research results, we can quite reasonably say that not only acceleration RMS could be helpful in lubrication diagnostic [4][5][6]. It is possible to define the grease condition of the roller bearing using mean and standard deviation values of standard signal estimators such as, e.g. Peak and Clearance factor. The best classification of bearings grease condition based on vibration parameters is obtained for the band between 8 kHz to 10 kHz. According to the results, the signal feature’s mean value and standard deviation allow for grouping features belonging to different bearing conditions.

For detection and classification of different bearing conditions, a two-dimensional diagram of the mean and standard deviation of signal estimators could be used. This type of diagram can show the trend of bearing condition deterioration. Further research considered the larger population of bearings must be conducted to support the obtained results fully.

4. CONCLUSIONS

In this paper, the authors try to answer whether it is possible to define the lubrication condition based on the vibration signal. According to the research results, we can quite reasonably say that not only acceleration RMS could be helpful in lubrication diagnostic [4][5][6]. It is possible to define the grease condition of the roller bearing using mean and standard deviation values of standard signal estimators such as, e.g. Peak and Clearance factor. The best classification of bearings grease condition based on vibration parameters is obtained for the band between 8 kHz to 10 kHz. According to the results, the signal feature’s mean value and standard deviation allow for grouping features belonging to different bearing conditions.

For detection and classification of different bearing conditions, a two-dimensional diagram of the mean and standard deviation of signal estimators could be used. This type of diagram can show the trend of bearing condition deterioration. Further research considered the larger population of bearings must be conducted to support the obtained results fully.
Confronting the challenges of failing to follow procedures

By James T McKenna

More than three decades after a 737 ripped open over Hawaii and stunned the flying public with the dangers of human error in aircraft maintenance, the aviation industry is still challenged to contain that risk and keep crews and passengers safe in the air.

The toughest hurdle is persuading aircraft operators, manufacturers, vendors and their maintenance technicians to comply with procedures.

The industry has made great progress since April 28, 1988, when the top of an Aloha Airlines Boeing 737’s fuselage tore free at 24,000 feet. A flight attendant vanished and 94 others on board were terrified, with 65 injured. Images of them surrounded in the landed jet’s front cabin by little more than moist island air and shredded metal shocked much of the world. It was vivid proof of the hazards in pushing aircraft beyond the eye’s and brain’s abilities to keep them flying safely.

The fuselage blew because a lap joint failed, then a lot of minor cracks around rivet heads opened up like a zipper. The NTSB said Aloha Airlines maintenance program failed to detect significant disboding and fatigue damage that led to that. It found “difficult and tedious” 737 inspection procedures had “physical, physiological and psychological limitations.”
The Threat Persists

Spurred by the flying public and the U.S. Congress, regulators and the industry launched an effort to identify maintenance-error hazards, research their causes, find ways to reduce risks and field effective mitigation measures. Over three decades, inspection procedures and techniques were improved, and maintenance standards made stricter. Yet incidents and accidents show repeatedly that the threat persists, particularly the biggest one: failure to follow procedures.

Most maintenance tasks have written procedures that they say must be followed and are intended to produce the same result every time. “However, the incidence of failure-to-follow-procedures events continues to be a major issue in aviation maintenance,” three researchers reported in 2017.

Colin G. Drury and Catherine Drury Barnes of Applied Ergonomics Group and Michelle R. Bryant of the FAA’s Civil Aerospace Medical Institute had been tasked in 2015 with examining primary and contributing factors of failing to follow procedures and then developing mitigation strategies. Despite 30 years of research into procedural compliance, their report noted, “these challenges and recommendations have not changed a great deal in that time period.”

In 2019, FAA chief maintenance human factors advisor Bill Johnson spoke with executives of large U.S. airlines. “Without exception,” Johnson, said, they told him “procedural non-compliance is the unanimous No. 1 contributing factor” for maintenance-error events.” (Now retired from the FAA, Johnson is principal scientist at drbillj.com.)

“Even as we speak, there are hundreds of mechanics probably deviating from procedures,” said Robert Baron, president and chief consultant of The Aviation Consulting Group. He specializes in human factors and other safety training and issues, working with hundreds of aviation organizations around the world. “Fortunately, it’s a safe system. There are backups, redundancy, cross-checking and different types of oversight. But when something slips through, that could be potentially catastrophic.”

Consequences of Rule-Breaking

Baron’s comment pointed toward an underlying reason for persistent procedural non-compliance, which Gordon Dupont explains with an everyday analogy. As a Transport Canada safety officer in the 1990s, Dupont crafted the noteworthy “Dirty Dozen” list of 12 human factors that can degrade your ability to perform effectively and safely and lead to maintenance errors. He is the retired CEO of System Safety Services in Richmond, British Columbia.

“What’s the most common rule broken every day all around the world? The speed limit,” Dupont has said. “The average driver will go between 5 and 10 mph over the speed limit unless the weather is bad, there is a police officer close by” or some other condition slows the driver down. “So why do we do it? The answer is very simple. We foresee no negative consequences in breaking the speed limit and the positive consequence of getting to our destination sooner serves to justify the rule-breaking. Rule-breaking at work goes along the same lines.”

Procedural non-compliance is the unanimous No. 1 contributing factor” for maintenance-error events.”

Overall, maintenance errors can appear to be a small problem. Boeing’s analysis has long put maintenance as a primary cause of just 3 to 4 percent of hull-loss accidents and a contributing cause of about 10 percent. By comparison, flight crew actions are cited as a primary cause in more than 60 percent.

Analysis by the International Air Transport Association (IATA) found that “maintenance operations” were a latent condition in 21 percent of 2020’s airline accidents and “maintenance operations: SOPs and checking” was a latent condition in 13 percent. IATA’s safety analysts define a latent condition as one that is present in the system before an accident that is made evident by triggering factors (which often relate to deficiencies in organizational processes and procedures).

In 2020’s accidents, IATA said, maintenance was a threat in 21 percent. It defines a threat as an event or error that occurs outside the pilots’ influence but requires their attention and management to maintain safety margins.

From 2016 to 2020, IATA found, maintenance operations were a latent condition in 12 percent of accidents. For maintenance operations: SOPs and checking, the number was 11 percent. Maintenance was a threat in 14 percent over that time. From 2011 to 2015, maintenance operations and maintenance operations: SOPs and checking each were latent conditions in 7 percent of accidents and maintenance was a threat in 10 percent.

“We’re stalled,” said John Goglia, a retired airline mechanic and former U.S. National Transportation Safety Board (NTSB) member who has been a driving force in addressing maintenance human factors issues. “We need to look at our history and do something different.”
A Problem Lies in Wait

One recent incident illustrates how the failure to follow procedures can create a problem that lies in wait.

An on-wing borescope inspection of this Jetstar Airways Airbus A320 found out-of-limit damage to the right engine’s high-pressure compressor (HPC) consistent with foreign object strikes. A teardown inspection confirmed substantial HPC damage, including a broken stage 5 blade and one stage 6 vane, four stage 7 blades and one stage 8 blade that were missing. A screwdriver tip was found between the combustion liner and engine case, burnt, discolored and eroded. ATSB image.

BA 787-8 Case Study

Another recent maintenance error made itself known much faster.

On June 21, 2021, a British Airways Boeing 787-8 was being loaded at London’s Heathrow Airport for a cargo flight. Three mechanics were tasked with clearing status messages about a nose landing gear solenoid valve. The procedure required cycling the landing gear with hydraulic power applied to the aircraft. To prevent the gear from retracting, the procedure required pins to be inserted in the main and nose gear downlocks.

The lead mechanic, in the cockpit captain’s seat preparing for the job, told the other mechanics to place pins in the downlocks and ensure the four people loading cargo were clear of the aircraft. At the nose gear, the first mechanic could not reach the locking pin hole. He pointed to the hole’s location and the second mechanic fitted the pin, which like the others had red and yellow flags attached. At the right main gear, the first mechanic used portable steps to fit the pin. He repeated that on the left gear.

The first mechanic returned to the cockpit to tell the lead the pins had been fitted. The two mechanics then returned to the nose gear and plugged a communications headset into the nose gear bay port. The lead requested confirmation again that the pins were in place. The first mechanic said they were.

The lead mechanic applied hydraulic power. Before moving the gear lever, he requested final confirmation from the first mechanic that the pins were in place and the cargo team was clear. This mechanic visually checked that he could see the warning flags for each gear pin. He also checked that no feet were visible to indicate the load team was clear. He then confirmed this to the lead.

In the cockpit, the lead selected the gear lever to up. The nose gear retracted, and the nose fell to the ground.

The worker on the pallet loader under the starboard forward cargo door was slightly injured as that door moved down when the fuselage dropped. The co-pilot, sitting in the cockpit, received a minor injury.

The nose crushed a ground power unit’s articulated cable arm. The lower forward fuselage and nose gear doors were damaged, as were both engine cowlings (which also struck the ground). Door 2L struck the stairs positioned at its opening when the nose fell and was severely damaged.

When the recovery operation lifted the nose, the nose gear was examined and the downlock pin was found fitted not in its hole but in the apex pin bore next to it.

On Oct. 23, 2020, a Jetstar Airways Airbus A320-232 was taking off from Brisbane, Australia. As the IAE V2527-A5 engines spooled up, the pilots noticed a vibration and “popping” noise that rapidly increased in frequency and volume. They rejected the takeoff at 30 knots. Stall and temperature-exceedance warnings appeared for the No. 2 engine. They learned that passengers had reported flames coming from the right engine, as had the tower controller and a following flight crew. Recorded data indicated it had surged.

The aircraft had been parked for four months. The return-to-service work included lubrication of the low-pressure compressor bleed valve mechanism. Procedures “contained specific highlighted caution notes regarding the loss of any screws or other loose objects down the bleed duct,” the Australian Transport Safety Bureau said in its Aug. 16, 2021 incident report. “The notes highlighted that lost articles would progress to the HPC and break valves and vanes.”

The bleed valve was lubricated 112 flight cycles prior to the Oct. 23 engine surge, the ATSB said.
Helicopter Crew Gets Lucky

Sometimes negative consequences of procedural non-compliance are quickly apparent.

On June 1, 2020, the crew of a Northern HeliCopter AS365-N3 were alerted for a rescue mission from their St. Peter-Ording Airfield base, about 85 miles (138 kilometers) northwest of Hamburg on Germany’s North Sea coast. It would be the day’s second flight. The pilots used an approved “scramble” takeoff procedure that did not include a flight control hydraulic check.

The co-pilot increased thrust. The helicopter lifted to a hover, then immediately pitched up. The co-pilot lowered the collective. The tail struck the ground and the main landing gear touched down hard. No one was injured. The helicopter was slightly damaged.

The pilots determined that forward and backward cyclic inputs had no effect on the rotor disk. They shut down on the runway. Back in the hangar, they found that the left actuator was not connected to the swashplate that redirects the main rotor blades. Its fastener was missing. They found the bolt, two washers and one Nylon stop crown nut on the gear box compartment below. They did not find a loose cotter pin or parts of one.

Through mid-May, a contractor had performed substantial maintenance on the helicopter, including a main gearbox leak repair that required the left actuator’s removal. A post-maintenance check flight was done. The repair was assigned to experienced mechanics and was checked by an experienced inspector. “However, that check had been signed a few days after the occurrence,” said the Federal Bureau of Aircraft Accident Investigation (with the German acronym BFU), which investigated. The mechanics, inspector and maintenance pilot told the BFU in written statements that the actuator’s screw fitting was properly installed and the cotter pin was positioned and visually checked several times before the helicopter was returned to the operator.

Those maintenance personnel “were certainly aware of the importance of the flight controls and were certainly familiar with different types of screw lockings,” the BFU said in its report.

The BFU concluded the incident was most likely caused by mechanics using a worn Nylon stop crown nut on the actuator-to-swashplate bolt, applying insufficient torque to that nut and not installing a cotter pin on it.

The BFU also concluded the inspector did not sufficiently check the mechanics’ work and that two other mechanics failed to check the actuator connection as required by a 10-flight-hour/seven-day-inspection performed the day before the incident.

“It was just luck that during the occurrence — total loss of control — only the tail skid of the helicopter was damaged and more severe damage or even injuries to persons did not occur,” the BFU report observed. Between its return from maintenance and the loss of control, the helicopter flew for a total of 8:46 flight hours.
No Silver Bullet

Researchers talk of errors of omission (such as failing to install O-ring seals on turbine engine chip detectors) and of commission (such as using incorrect fasteners to install a cockpit windshield). There are timing errors (performing a task at the wrong time or in the wrong order) and precision errors (such as using the wrong setting on a torque wrench).

They also talk of perception errors ("I didn’t see that") and slips ("I didn’t mean to do that"), as well as wrong assumptions ("I assumed we returned to Stand 513, where the aircraft’s integrated drive generator oil levels had to be checked, but we went to Stand 517"). There is technical misunderstanding ("I tried to replace the landing gear hydraulic-retract actuator, but I didn’t understand what I had to do").

One of the most common maintenance errors involves a mechanic forgetting to do a task planned for completion before a job is closed out, such as removing an engine thrust-reverser lockout pin after investigating an engine bleed-air issue.

All of the above can involve failure to follow procedures, since many procedures are aimed at heading off such errors. Dupont classifies violations in three main ways.

In a situational violation, he says, a mechanic concludes a job can’t be completed without violating a procedure. This is often related to time pressures. It may not be repeated. The situation seems to justify the violation.

An exceptional violation occurs when there appears to be no other way to accomplish the task. Dupont offers the example of a manual calling for three people to be used at all times when moving an aircraft. If a mechanic is out sick, crewmates may decide to push the aircraft carefully using the only two people available.

A routine violation happens when a mechanic believes there is a better way to complete a task and sees no negative consequences to the ad hoc procedure, Dupont explains. It may start as a situational violation, but over time the informal procedure may become a norm.

If the mechanic’s organization condones or tolerates the violation, it can move into a fourth class: the organizational violation. A classic example, Dupont says, is May 25, 1979’s crash of American Airlines Flight 191. The links leading to the accident, which killed all 271 on the plane and two on the ground, included failures by the jet’s manufacturer, the FAA and the airline’s management, engineering and maintenance departments, as well as the mechanics.

Safety proponents are refining efforts to reduce procedural non-compliance. The FAA has fielded a free, 45-minute training course, “The Buck Stops with Me,” aimed at “creating champions for rules-following,” Johnson said. Several researchers are pursuing efforts to apply the safety gains of line-oriented safety audits on the flight deck to maintenance operations. Expanding requirements for operators to set up safety management systems may aid the effort by promoting the acceptance and use of human factors analysis to maintenance.

“There is no silver bullet for any of this,” Baron said. “It’s all about awareness.”

When the recovery operation lifted the nose of this British Airways 787, the downlock pin was found fitted not in its hole but in the apex pin bore next to it. This occurred after multiple checks to ensure the downlock pins were in place.
Here are a few recommendations of suggested reading for diagnostic engineers. All the books featured on this page can be found (and are available for online purchase) on the Amazon web site.

The Science of Structures and Materials

Covers form, tensile strength, tensile failure, metals, animal soft tissues, stiff biological materials, and new artificial materials.

More details at https://amzn.to/3gi5pQp

High Performance Fasteners & Plumbing

This user-friendly guide explains high-performance fasteners, plumbing, and all the other hardware used by racers, rodders, restorers and all other auto enthusiasts. Subjects include hose sizes, fittings, materials, routing and installation tips, heat shielding, brake, fuel, coolant, and oil lines, as well as fastener technology such as thread sizing, clamping loads, bolt stretch, and fastener styles.

More details at https://amzn.to/3ocYwo3

Complete Guide to Preventive and Predictive Maintenance

This book shares the best practices, mistakes, victories, and essential steps for success which the author has gleaned from working with countless organizations. Unlike other books that only focus on the engineering issues (task lists) or management issues (CMMS), this in-depth resource is the first to give true emphasize to the four aspects of success in preventive maintenance systems - engineering, management, economic and psychological.

More details at https://amzn.to/3rYY6CO

Introduction to Engineering Heat Transfer

This new text integrates fundamental theory with modern computational tools such as EES, MATLAB®, and FEHT to equip students with the essential tools for designing and optimizing real-world systems and the skills needed to become effective practicing engineers.

More details at https://amzn.to/3g7lJZn

Probability, Statistics, and Decision for Civil Engineers

This text covers the development of decision theory and related applications of probability. Extensive examples and illustrations cultivate students’ appreciation for applications, including strength of materials, soil mechanics, construction planning, and water-resource design.

More details at https://amzn.to/3ISaiw4

Welding made easy

Welding is an important skill which is on high demand. Having the basic information needed for development in welding is an advantage. You need this this book to gain more knowledge in welding.

More details at https://amzn.to/3ocwF7D

Marks’ Standard Handbook for Mechanical Engineers

This thoroughly revised, industry-standard resource provides you with all the information you need to solve engineering problems on the job. Now celebrating its 100th anniversary, Mark’s Standard Handbook for Mechanical Engineers, 12th Edition, offers up-to-date, accurate data and calculations along with clear and concise explanations of theory and applications.

More details at https://amzn.to/3HnBC56

Electrical and Electronic Principles and Technology

This practical resource introduces electrical and electronic principles and technology covering theory through detailed examples, enabling students to develop a sound understanding of the knowledge required by technicians in fields such as electrical engineering, electronics and telecommunications.

More details at https://amzn.to/3HhyU0Q
The Bilstein group outlines the correct replacement procedure.

The Volvo V50 estate and the S40 saloon models were introduced in 2004 and were manufactured with several different engine and transmission options, until 2012.

This Volvo model shared its platform with many other Volvo, Ford and Mazda models, making mechanical repairs on this vehicle seem familiar, even if this model is not an everyday visitor to an independent workshop.

The vehicle featured in this article, is a 2011 model, fitted with the 1.6 litre diesel PSA group engine and a six-speed GETRAG manual transmission, and has stop/start, as it is a DRIVEe model.

The owner of the vehicle had reported some difficulty with the clutch operation, which was suspected to be a hydraulic fault, due to the loss of fluid. However, there were no obvious external fluid leaks from the clutch master cylinder or associated pipes, hoses or connections. Therefore, the fault was suspected to be a leaking clutch concentric slave cylinder (CSC), which required the removal of the transmission for inspection and diagnosis.

The vehicle was brought into the workshop, the bonnet was opened and the engine cover along with the battery cover, battery, battery tray and air cleaner assembly were removed, as well as the DPF pressure sensor, which is attached to the battery tray. This was to provide access to the top of the engine and transmission.

All cables associated with the battery were unclipped and secured until reassembly.

With the top of the transmission visible, the two gear selector cables were unclipped from their mounting points and were secured out of the way.

The reverse lamp switch and the neutral switch wiring harness connectors were unclipped, along with the CSC hydraulic pipe connection. The open end of the connector was sealed with a plastic cap to stop any excess fluid from leaking out.

The main wiring harness that goes across the top of the transmission was eased back to reveal the top bell housing bolts, these were removed with two of the starter motor bolts that were accessible from the top of the transmission.
The vehicle was raised to a suitable height and the front wheels were then removed, this gave access to the hub retaining bolts, which were also removed. Then, the left front wheel arch liner was also removed, to improve clearance ready for the removal of the transmission.

The vehicle was raised again, and the transmission oil was drained, followed by the removal of both front lower arm ball joints, from the hub assembly.

This was followed by the removal of the left driveshaft from the transmission.

A supporting centre bearing retains the right driveshaft; this needs to be unbolted before the driveshaft can be removed.

Working from under the vehicle, the last starter motor bolt was located and removed. The starter motor was supported and left in place because it does not need to be removed completely for the removal of this transmission.

Next, was the removal of the gearbox torque mounting, followed by the gear selector cable bracket.

The diesel particulate filter (DPF), fitted to this engine needs to be lowered to gain access to one of the front bell housing bolts.

The temperature and lambda sensor wiring harness were disconnected and the differential pressure sensor pipes. The air intake pipe, heat shield and retaining clamp were removed, and then the DPF can be eased down to give clearance for the removal of the bell-housing bolt.

This was to give extra clearance, to help when removing the transmission.
The engine was supported, the top transmission mount was released, and then the last of the bell housing bolts were removed, before separating the transmission from the engine.

The transmission was lowered to the floor and inspected. Upon inspection of the bell housing, it became obvious that the CSC had been leaking, which was the cause of the loss of fluid in the clutch system and the poor pedal performance.

The leaking CSC was removed.

Then, the bell housing and the input shaft were thoroughly cleaned of all grease, dirt and old friction fibres, from the previous clutch and the input shaft seal was inspected before fitting the new CSC (ADM53635).

The clutch pressure plate and friction disc were removed and inspected, along with the condition of the dual mass flywheel (DMF). The friction disc was very close to being worn out and there was a lot of bluing on the friction surface of both the pressure plate and flywheel. Therefore, all parts required replacing. Clutch kit (ADF123081) and DMF (ADBP350003) were selected for this repair, the original flywheel was removed from the engine and the rear main oil seal was inspected for any oil leaks before fitting the new flywheel. The new flywheel is an updated design and is supplied complete with new bolts. It is essential that the new bolts supplied be used, because they are of a different length to the original bolts. The new flywheel bolts were tightened to the recommended settings and the clutch kit was aligned and fitted to the flywheel. The transmission input shaft splines were lightly greased in preparation before installation.

The transmission was aligned to the engine and secured in place with a few of the bell housing bolts.

This was followed by refitting all of the parts to the transmission, and all of the other parts that were removed in the process of the removal of the transmission. Then all the bolts and fixings were tightened accordingly.

The transmission was filled with fresh oil through the level plug located on the front of the transmission, until the level was reached and then the plug was refitted. Following this, the brake/clutch fluid reservoir was topped-up with fresh fluid, and then the new CSC was bled of any excess air.

Finally, the battery tray along with all the associated wiring were refitted, and then the battery and all the other covers were refitted.

This was followed, by resetting the clock and a check of the clutch pedal operation, before a road test was carried out to check that the clutch was back to full operational order.

**About the bilstein group:** The bilstein group is one of the world’s leading specialists for aftermarket spare parts and offers repair solutions for all popular vehicle types in the passenger car and commercial vehicle sector. The family-run, independent corporate group unites the leading traditional brands febi, SWAG and Blue Print under one strong umbrella. The three brands are inherently synonymous for high-quality precision spare parts in OEM quality. Further information can be found at: www.bilsteingroup.com
Imagine the following scenario: a vehicle has arrived at your workshop and you need to start the diagnostic or programming process. You start where you normally would by running a diagnostic test. You run a pre-scan of the vehicle to identify all of the DTCs – Diagnostic Trouble Codes; this is great. You now have a starting point for the repairs. However, a vehicle’s condition can often affect the vehicle’s battery displaying a low voltage. This condition may not allow all of the modules to be read, affecting the quality of the scan and the accuracy of the report.

For this reason, 3D Group suggests the use of battery support when scanning a vehicle. During diagnostic or programming operations, the vehicle’s systems are operated solely from the battery.

Battery support units provide a continual voltage to prevent data loss and possible damage to control units during diagnostic processes, software updates and module reprogramming.

Before running tests
The first and most crucial step is to provide adequate battery support to the vehicle before beginning any diagnostic and vehicle scans. Battery chargers or jump cables are not recommended as they cannot provide the proper battery support. It is also good to bear in mind that battery chargers can overcharge and damage a battery.

Voltage
If the battery voltage drops below a certain level, the battery will start to shut down nonessential modules, allowing the vehicle to preserve the ability to start. Low voltage can create a situation where the scan tool might not be able to read all of the available modules. Connecting an appropriate battery support tool to the vehicle battery will ensure that the battery will provide consistent voltage, which will allow you to provide the highest quality report and information to undertake the repairs or reprogramming.

Advantages
A quality battery voltage maintainer provides stable voltage to the vehicle for more extended periods than an unsupported battery. The bottom line is to ensure that the vehicle has proper battery support before you begin any diagnostic or reprogramming tasks to provide the best possible outcomes.

When vehicle voltage levels fall below the normal levels, diagnostic results are no longer accurate – fluctuations in battery voltage can also cause additional codes to appear. If this does occur, it can cause the programming to fail, incurring extensive costs.

Additional uses
Not to forget there are additional uses for battery support units such as:
- Charging: battery support units such as the 30A GYSFLASH 30.12 PL can charge vehicle batteries (12 V Lead or Lithium (LFP)) from 5 to 1500 Ah
- Showroom: battery support units provide power compensation when using the electrical accessories of a demonstration vehicle. It also manages the optimal charging of the battery
- Tester: battery support units also allow technicians to check the battery voltage, evaluate the starting system (starter + battery) and the condition of the vehicle’s alternator

To recap, you can perform the relevant diagnostic and vehicle electronic scans only when the vehicle has proper battery support. A stable battery voltage ensures that you can generate the quality scan results and corresponding reporting necessary to provide the information needed to produce an accurate, efficient, and safe repair.

At the post-scan stage, battery support is required to ensure that all codes can be cleared, and additional codes aren’t introduced due to voltage fluctuations.
Assuming the chain is of good quality, it could be easily argued that the most important factors in chain performance are cleanliness and lubrication. If chains are not properly maintained, they can wear (stretch), resulting in gear-tooth wear, ultimately degrading overall conveying-system speed and performance, and eventually leading to extensive and costly repair.

To prevent added expense and unscheduled downtime due to unexpected equipment failure, consider these tips, which will not only keep conveyor chains in tip-top shape, but also help avert accidents caused by broken or poorly maintained equipment.

METAL ON METAL REQUIRES TLC

Whether it’s roller chains, cardan chains, or trolley forged chains, metal on metal should be the subject of focused attention when it comes to lubrication and cleaning. A good general rule is, if it’s moving, then it needs to be lubricated. If a chain also intersects with other materials such as plastic, polymer, rubber, or composite parts, it’s important to choose a lubricant that’s safe for use on multiple surfaces. Check the fine print on labels to make sure lubricants are safe for metal and non-metal parts.

CONSIDER THE ENVIRONMENT

The environment in which a business operates plays a big role in which lubricant is used. In general, dry lubes are best in environments that are prone to dust. Dry lubes won’t attract dirt or grime and can be reapplied without cleaning. On the flip side, dry lubes don’t last as long as wet lubes, requiring more-frequent applications. Wet lubricants are longer lasting but can attract gunk and grime and need regular cleaning. Wet lubes also provide superior performance in keeping rust and corrosion off equipment.

APPLY WITH PRECISION

While lubrication is a must, over spray or over lubrication can get messy, wastes product, and requires extra time and effort in clean up. To avoid over lubrication, apply lubricants with precision. Consider using products such as gel lubricants, which go on thick and stay where sprayed. Gels are particularly good for use on vertical surfaces.

SET UP A REGULAR SCHEDULE FOR CLEANING AND LUBRICATION

Stay ahead of potential issues by setting up a regular cleaning, lubricating, and maintenance schedule for chains and equipment. A good way to begin is to create a log of all equipment in use, including key points in need of inspection, lubrication, and cleaning. The log should track when maintenance is done, who performed it, and what was done. When choosing a cleaner and degreaser, look for one that doesn’t contain harsh solvents and make sure to rinse away cleaners thoroughly to avoid degrading any new lubricants that may be applied following cleaning. Finally, check with equipment manufacturers on recommended frequency for cleaning and lubrication, and for any specific guidance unique to your equipment.
Every area of manufacturing requires different technologies to make Industry 4.0 a reality. For process heating applications, data logging is the key, says Austin Johannes who is a controls specialist at industrial technology company Watlow.

Survey data from Deloitte suggests that businesses with a comprehensive Industry 4.0 strategy will become more profitable. Every area of manufacturing requires different technologies to make ‘the Fourth Industrial Revolution’ easier to realise. In process heating applications, one of the most important technologies manufacturers must be aware of is data logging.

Industry 4.0 has caused numerous changes to factory automation and data exchange. Machines have become increasingly connected, with information created, calculated and shared across various communication points in real-time. With the right tools and experience, Industry 4.0 can optimise a facility’s production, making it smarter, more efficient and more profitable. In sectors that use process heating, such as medical equipment, semiconductor processing and food manufacturing, one of the most useful technologies to implement is data logging.

A data logging transition

In the past, facilities were manned by technicians with clipboards who would manually monitor equipment and processes. For obvious reasons, this method was inefficient compared with the technology available today.

Advancements in analogue electronics brought strip recorders into the industry. Using strip recorders, technicians relied on small pens and rolling paper to record vital processes. While this freed them from continuously monitoring a single machine, the machines were bulky and expensive to implement.

Today, the average smart factory generates millions of gigabytes (GB) of data per week. With that in mind, it’s vital that facilities collect and understand their data so that it can be used to benefit the entire production line. Digital data loggers avoid the time and expense of sending a technician to take measurements in a remote location, and they enable much higher data recording density than is achievable through manual recording, providing higher quality data.

Today’s equipment is dynamic, offering solutions that enable multiple zones and varying signal types at affordable costs. Multi-channel data loggers support numerous inputs and can be compatible with different types of temperature sensors such as thermocouples, thermistors and resistance temperature detectors (RTDs). Users can download and share recorded information via built-in communication channels, such as USB, WiFi and Ethernet, enabling cloud-based storage and access to big-data analysis — supporting Industry 4.0 transformation.

The benefits of digital data logging

So why should data logging be an essential part of any manufacturing facility that wants to advance with Industry 4.0? Greater insight into areas for improvement allows design engineers to optimise systems and understand which steps in their process are most critical to achieve the desired outcome. Digital data logs also make it easier for information to be distributed and shared, which improves communication among team members working on a system. When the inevitable gremlins emerge, having a historical log of what caused the incident ensures the problem can be identified and addressed, preventing future downtime from overlooked issues.
Perhaps the most significant benefit of data logging, however, is that it supports efficient preventative maintenance. Having access to real-time data, engineers and technicians can act before issues spiral into downtime. It’s estimated that the average factory loses at least 5% of its productivity because of downtime. Eventually, this adds up to extreme revenue loss.

The data collected can highlight variations or anomalies, suggesting that something has changed in the system. Take for example, a foam sheet manufacturer who used a Watlow controller with built-in data-logging to quickly react to a quality issue indicated by specific temperature variations in their curing process. This information allowed engineers to identify and resolve the cause of the problem, saving costs and minimising waste.

Instead of issuing alarms for staff to react to, temperature data monitored over a period of time can demonstrate that implementing better thermal uniformity at a key stage in the production process can reduce, or even eliminate, issues. Because they are receiving data in real time, engineers can resolve problems before equipment failure occurs — minimising downtime, saving costs and increasing productivity.

Logging options

Depending on the application, data loggers can be incorporated as one integrated solution or as an extra to a system. Watlow – which is continuously piloting and implementing Industry 4.0 technology programmes – manufactures advanced heating products, including sensors, controllers and data logging equipment.

Manufacturers looking to implement digital data logging can choose an integrated system such as the F4T® temperature controller, with built-in data logging, or the D4T™, a dedicated data logging device. With these solutions, customers can log parameters that are preconfigured, saving setup time and complexity. Watlow’s solutions also feature a list of popular setup configurations to help manufacturers optimize data logging that’s tailored to their specific needs.

For demanding applications, the RMA PLUS™ module dynamically connects with other devices providing measurement capability and can record data with onboard SD cards and also push data to the cloud.

Leveraging these technologies, Watlow is automating data-gathering and analysis to anticipate issues earlier and speed up implementation of solutions. Our experience of Industry 4.0 has increased the efficiency and productivity of our operations, equipping us with the knowledge that helps us provide support to our customers who are implementing Industry 4.0 solutions.

Industry 4.0 is significantly transforming the way that data is exchanged. The increasingly rapid rate of digital transformation may well lead to mainstream integration of artificial intelligence (AI) data logging capabilities. This would give manufacturers the advantages of advanced algorithms that calculate and rectify value discrepancies, without the need for routine manual intervention.

With the incorporation of wireless and cloud-based technology, data loggers of the future may be able to broadcast real-time data to the cloud and may also present themselves as smartphones, tablets and web applications, offering greater remote control of data.

Data loggers will eliminate hourly inspections on an autoclave and free engineers’ schedules from periodic logging. The future will see these devices become smarter and more reliable. This will enable workforces to focus on more value-added tasks, such as product development and system improvements, to promote growth and scalability across industries.

While data collection is crucial in any facility, it is understanding how to act on that data that is key to realising the benefits of Industry 4.0. Gone are the days of engineers with clipboards in hand. Data loggers do the work so that engineers don’t have too, freeing up schedules to improve performance and streamline operational efficiency. By providing engineers with information in real-time, systems can be improved, and errors can be resolved before equipment failure occurs — minimising downtime, saving costs and increasing productivity.

F4T is a registered trademark® and D4T and RMA PLUS are trademarks™.
A PROTECTIVE BUBBLE AGAINST ARC FLASHES

By Pauline Weisser
Application development specialist at DuPont Personal Protection.

Arc flash-resistant clothing is critical to protect against industrial accidents, but selecting the correct level of protection for the application can be challenging.

An arc flash, also referred to as electric arc, can be defined as a non-contact short circuit taking place between two conductors such as busbars or cables. These conditions can lead to a plasma fireball that can reach extremely high temperatures of up to 20,000°C. This is enough heat to cause a worker’s clothes to catch fire, even at a distance.

Faulty electrical equipment due to incorrect installation, dust, corrosion, surface impurities, or wear and tear is a common cause of electric arcs. However, in most cases, short circuits are a result of human errors.

An arc flash can have severe consequences for workers that can range from external and internal burns to fatal injuries. There is also a risk of exposure to toxic hot gases and vaporised metal that can lead to eye injuries due to the ultraviolet light that is generated in the process.

HOW WIDESPREAD IS THE RISK OF EXPOSURE TO ARC FLASHES?

Arc flashes continue to represent a common risk to workers across industries. The latest Eurostat data shows that over 76,000 workers in Europe suffered injuries due to “contact with electrical voltage” in 2018. These workplace accidents can have far-reaching consequences, not only for the employees involved but also for their employers. For example, in May 2021, Network Rail was fined nearly £700,000 after a worker suffered third-degree and mixed depth burns due to an electrical arc.

Arguably, the growth that the renewable energy sector is set to experience in the coming years may indirectly lead to an increase in arc flash-related incidents. The installation and maintenance of renewable energy generators such as solar panels and wind turbines inevitably present arc flash hazards, just like any other electrical application. Similarly, battery energy storage systems, the backbone of the expanding low-carbon power grid may expose workers to electric arcs.

THE “4 PS” OF ARC FLASH PROTECTION

A thorough workplace risk assessment, which is a legal requirement in the UK and other countries, is key to putting in place measures to protect workers against arc flashes. This is known as the 4P Methodology, which involves four key steps: PREDICTING the severity of the arc flash, PREVENTING damage through hazard mitigation, PROTECTING workers from any residual hazard and PUBLISHING the results.

Personal protective equipment (PPE) such as protective clothing is the last line of defence against arc flash injuries and, therefore, plays a critical role in the 4P Methodology. But not all PPE is created equal. Employers must take steps to ensure that the equipment is compliant with the latest standards is paramount.
THE IMPORTANCE OF ARC FLASH PROTECTION STANDARDS

When it comes to specifying arc flash-protective clothing, there are different standards to consider, which vary from region to region. A fabric that complies with these minimum requirements must be flame-resistant and ensure protection against electric arcs by preventing ignition.

In Europe, there are two main standards to take into account: "IEC 61482-1-1:2019: Live working – Protective clothing against the thermal hazards of an electric arc – Part 1-1: Test methods – Method 1: Determination of the arc rating of clothing materials and protective clothing using an open arc" and "IEC 61482-2:2018: Live working – Protective clothing against the thermal hazards of an electric arc – Part 2: Requirements". "EN ISO 11612: 2015 (Protective clothing — Clothing to protect against heat and flame — Minimum performance requirements") is another important standard to consider.

Additional tests may be conducted by some manufacturers of protective clothing to guarantee an even higher level of protection. These tests are based on an instrumented manikin (as specified by ISO 13506-1:2017) and measure the amount of transferred energy. This way, the performance of protective clothing during exposure to short-duration flame engulfment can be assessed with great accuracy.

CONSIDERATION WHEN SPECIFYING PROTECTIVE CLOTHING

The single most important feature to consider when selecting arc flash protection garments is the fabric’s ability to carbonise and thicken when exposed to intense heat. This is how the fabric prevents ignition, acting as a protective barrier between the heat source and the wearer’s skin.

But there are also other important factors to bear in mind. Built-in inherent thermal protection: durable fabrics that maintain their heat resistance over time – even after having been washed repeatedly – are an essential feature, especially if the clothing is used in dirty environments. Multi-hazard protection: fabrics that integrate multiple layers of protection, including resistance to heat, flame, and molten metal splashes, are the optimal choice for environments that may present multiple hazards. Comfort: selecting arc flash-protective clothing made using lightweight and highly breathable fabrics is key to ensuring a good level of comfort and preventing fatigue, which is a common cause of injuries. This is especially important in applications where workers must wear protective clothing for extended periods. Durability: some of the latest arc flash-resistant fabrics provide greater breaking strength than traditional flame-resistant-treated cotton.

THE BUBBLE EFFECT EXPLAINED

Double-faced fabrics, also known as "bubble-effect" technology, constitute one of the most recent advancements in arc flash protection. These innovative materials are designed in a way that, when they are exposed to heat, air bubbles form inside the internal layer, insulating the wearer against electric arcs. This way, it is possible to achieve best-in-class heat resistance without having to increase the weight of the material. Tests conducted by DuPont show that double-faced fabrics exhibit a higher level of electric arc flash protection than conventional fabrics with the same material composition and weight.

When tested according to IEC 61482-1-1, a double-faced fabric displays an ATPV (Arc Thermal Performance Value) between 16 and 19 cal/cm², which is more than double the ATPV of an equivalent conventional fabric (7.2 cal/cm²).

Arc flashes continue to represent a serious risk to workers across many industries. The seemingly unstoppable trend towards electrification means that more workers than ever before will be dealing with electrical applications where they may be exposed to electric arcs.

Protective clothing is key to keeping workers safe from the risks associated with electric arcs. Double-faced fabrics are proving the optimal choice for arc flash protection. They deliver enhanced heat and flame resistance without compromising on comfort.
Regular Checks
Keep Compressed Air Efficient

Poorly maintained compressed-air systems can be the source of significant energy waste and reduced production efficiency.

If your system was properly specified and the compressor seems to be running more than normal and/or workers are constantly asking for more air, it’s likely that your maintenance program needs some adjustment. A first step is to establish a regular, preferably daily, check of basic compressed-air-system components. The larger the system, the more critical the checks become. These tips and tricks, compiled by Brad Taylor of Fluid Aire Dynamics, Schaumburg, IL, provide a good starting point for a program aimed at optimizing your compressed-air system performance.

Follow instructions
It may seem obvious but reading the manual for your air compressor is a brief time investment with big payoff. You’ll learn the recommended maintenance schedule and operating guidelines for your unit. With this information, you can extend equipment life and minimize downtime.

Check oil levels daily
Operating with insufficient oil is a quick way to seriously damage a compressor.

Clean intake vents
Keep air intakes clean, especially if the environment is dirty or dusty. Buildup on intake vents forces the compressor to work harder and robs it of pressure.

Replace the separator element
The separator element needs to be replaced every 2,000 to 8,000 hr. of use (depending upon make and model of the compressor) and prevents excessive oil usage. Analysis has shown that compressor energy costs rise by 1% for every 2 psi of separator pressure drop.

Keep things tight
Vibration from compressor operation can loosen screws, nuts, and bolts. Check them periodically and tighten the loose ones.

Keep an eye on hoses
Inspect all of your compressor’s hoses regularly because any cracks can lead to leaks, which in turn strain the compressor’s other components. Replace any hoses that are cracked or damaged.

Drain moisture and contaminants
The receiver tank collects moisture from the air that it’s compressing. Empty this regularly to prevent water build up in the system. Also, check systems such as filters and separators that remove oil and other contaminants. Watch for condensate stuck upstream of the drain.

Monitor temperature
The manufacturer will specify acceptable operating ranges. Excessive heat will cause extraordinary wear and shorten your compressor’s life. To help with this, the compressor may have a built-in safety shutdown system if it gets too hot. Test this feature to make sure it’s functioning properly.

Patrol for leaks
Leaks can originate from lines, gaskets, fittings, valves, clamps, and connections. They can divert an estimated 25% of compressed air, so check the entire system regularly. Ultrasonic leak detectors can be helpful.

Look and listen
Keep your ears tuned for strange noises and watch for things such as excessive vibration or belts that slip. Know what your compressor’s gauges should read when it’s operating normally. If you monitor your machine closely, you can prevent major damage.
Heat pump heating technology has been growing in popularity for a number of years, boosted recently by the increased pressure to decarbonise heating in line with the aim for the UK to reach net zero by 2050 and the government’s established target to phase out the installation of new gas boilers.

The role heat pumps can play in reducing carbon emissions from homes is clear. However, a heat pump alone may not be the right option for some customers and properties. For example, heat pumps may not be suitable for older homes with poor levels of insulation that cannot be improved. Much of the UK housing stock is more than a century old with 4.9 million homes that are currently occupied built before 1919. Also, some customers may want to reduce their carbon footprint and energy usage but are reluctant to switch to a fully renewable heating system. In these situations, hybrid heating can provide the solution.

A hybrid heat pump combines air-to-water heat pump technology with a gas condensing boiler to achieve high levels of efficiency and performance. These hybrid systems can operate in heat pump only, gas boiler only or hybrid modes depending on the conditions. To make it simple for homeowners, the system can automatically switch between the operating modes as required to ensure efficiency and deliver guaranteed comfort. Furthermore, some products, such as Daikin Altherma hybrid heat pumps, can also factor in electricity and gas prices for to utilise the optimum combination of technologies.

Could heat pump hybrid heating systems provide an option for a greater number of properties in the UK? Hamid Salimi, product specialist – heating and renewables at Daikin, looks at the factors that could drive their increased uptake and the opportunities for installers.

Typically, the system will operate primarily in heat pump mode during the warmer months to deliver high levels of energy efficiency, with the gas boiler used to boost the system output when the temperature drops. When in heat pump mode, a hybrid system can achieve up to A++ energy rating and deliver 160% efficiency – it outputs 60% more energy than the input energy source. In practice, hybrid heat solutions have been proven to deliver up to a 50% reduction in energy bills for homeowners.

BEST OF BOTH WORLDS
In addition to a ‘true’ hybrid system, there is also the option to install a heat pump alongside an existing gas boiler in a ‘bi-valent’ system. This allows switching between the heat-pump and boiler but does not offer the option of running the two simultaneously. However, this may suit customers who do not want to replace a relatively new boiler but still want to benefit from renewable energy.

For installers, heat pumps offer a significant business opportunity to expand the services they can offer to customers. Hybrid systems increase these opportunities still further by providing a renewable heating option that meets the needs of more customers and can be installed in a wider range of properties.

Heat pumps will have a key role in delivering renewable energy for domestic heating and hot water and therefore reducing carbon emissions. For many properties and customers, a hybrid system that combines the advantages of renewable heating and traditional gas boilers is the most suitable. With the right training, installers can benefit from the increased interest in this technology and prepare for future changes in the market.
Using Vibration to Advance Reliability

By Frederic Baudart, Fluke Corp.

An effective reliability strategy optimizes operations by increasing predictability across the board, i.e., maximizing safety and production while reducing downtime, waste, and spending. Accurate, up-to-date vibration data is an important factor in a successful strategy.

When maintenance and reliability (M&R) teams understand which assets are most critical and know when they need attention, they can plan effectively and extend peak performance. Reliability also depends on other aspects, such as core-team training, strong support from leadership, and knowledge of asset criticality.

Vibration sensors capture asset condition data, detecting potential wear and tear or abnormalities. Paired with software, vibration sensors can let M&R teams know when assets require attention.

Selecting vibration sensors
Measuring vibration patterns to spot when and how they change offers a useful view into a machine’s health. Vibration, in and of itself, is normal, but excessive vibration can cause premature wear and tear, and changes in vibration can signal problems.

Sensors placed on machinery capture vibration frequencies, which are then transmitted to software to alert teams and enable analysis. When an asset’s vibration data indicates a fault, teams can decide how to proceed after considering asset criticality, history, and fault severity.

The correct action may be gathering more data, performing testing, or scheduling a repair. When M&R teams can focus their time and efforts on the assets that need it most, they can extend asset lifecycles while reducing overall downtime and costs.

There are sensors available to fit every need and budget. The most critical assets may require sensors that collect detailed vibration data around the clock. For less production-critical assets, sensors can capture snapshots of data. Assets in dangerous or difficult-to-reach areas can benefit from “set it and forget it” battery-less sensors.

Vibration as a practice
With training and experience, maintenance professionals can use vibration data to identify and diagnose faults. Most machine faults fall into four categories:

- misalignment
- looseness
- imbalance
- bearing wear.
Changes in vibration patterns can indicate that assets are not operating in peak condition. Increased vibration can shorten the life of equipment and components. Replacing a bearing is treating a symptom, not getting to the root cause. Asking what happened in a specific instance helps teams not just solve that problem, but also refine their outlook and better understand what could happen in the future.

By collecting vibration data over time, M&R teams can compare and learn from patterns. When teams can identify abnormalities and diagnose faults in advance, they can plan and prioritize their actions, improving availability and reliability.

Technological advances have made it easier than ever for sensors to make and communicate accurate measurements. Advanced technology also makes it easier for teams to analyze asset data, share it, and act on it.

Condition-monitoring sensors available today are accurate and reliable, as well as easy to install and set up. Whether they are wired or wireless makes little difference. Rather, the variety of sensors available on the market simply reflects the wide range of possible applications. Different areas within a plant, machine types, and varying levels of criticality can all be factors that determine the appropriate type of sensor.

Driving reliability forward
In ways large and small, an effective reliability strategy helps organizations achieve efficiency, realize the optimum asset ROI, and maximize asset availability and longevity. The improved efficiencies come from minimizing unplanned down time and making the most of resources.

For example, assets near the end of their lifecycles may not need the intensive time and attention that other assets require. Machines that are operating in peak condition don’t consume as much energy as inefficient assets.

In today’s ever-changing manufacturing environment, asset availability for production is more important than ever. Hitting production targets requires maximizing asset availability. M&R teams can’t achieve that if they’re constantly responding and reacting to breakdowns.

Ensuring that assets are operating at their designed level of capacity requires a clear strategy, a prioritized workflow, and actionable data. Having real-time data on asset health and knowing how to put that data to use helps organizations learn from every response and move toward continuous improvement. Reliability is a journey, not a destination. Fuel it by measuring, learning, and doing. EP

Use either wired or wireless sensors to properly monitor asset vibration and improve overall uptime. Photo: Fluke Corp.

Remote monitoring and reliability
Route-based maintenance is time consuming—even risky in some settings and situations. Reducing dependence on physical routes also helps teams align their work with organizational needs. M&R teams can use PCs or mobile devices to remotely view vibration data. Having access to asset-health data in real time, from anywhere, enhances data-driven decision making and helps teams collaborate across sites or confer with off-site specialists.

Remote monitoring bolsters a reliability strategy by providing:

- alarm notifications that make it possible to respond quickly to potential failures
- real-time knowledge of asset health
- trending asset-health data to find patterns and insights
- integrated data to perform in-depth analysis or generate reports.

Driving reliability forward
In ways large and small, an effective reliability strategy helps organizations achieve efficiency, realize the optimum asset ROI, and maximize asset availability and longevity. The improved efficiencies come from minimizing unplanned down time and making the most of resources.

For example, assets near the end of their lifecycles may not need the intensive time and attention that other assets require. Machines that are operating in peak condition don’t consume as much energy as inefficient assets.

In today’s ever-changing manufacturing environment, asset availability for production is more important than ever. Hitting production targets requires maximizing asset availability. M&R teams can’t achieve that if they’re constantly responding and reacting to breakdowns.

Ensuring that assets are operating at their designed level of capacity requires a clear strategy, a prioritized workflow, and actionable data. Having real-time data on asset health and knowing how to put that data to use helps organizations learn from every response and move toward continuous improvement. Reliability is a journey, not a destination. Fuel it by measuring, learning, and doing. EP

About the author
Frederic Baudart is Lead SME Manager for Fluke Corp., Everett, WA, focusing on the company’s reliability and condition-monitoring product lines within the Fluke Reliability Solutions business. He has more than 20 years of experience in field-service engineering work and preventive/predictive maintenance industries.
Computerised Maintenance Management Software (CMMS) is a relatively mature product category. CMMS has existed for nearly 60 years and while there have been innovations along the way, the core functionality offered is relatively common across all vendors. Products evolve and the agreed and accepted workflows become the norm. Usability issues are addressed with customer feedback while functionality is added to resolve business challenges. In general, CMMS vendors now over-deliver on system functionality. So why do some implementations not live up to expectations while others are career changers, delivering value to their business far exceeding the initial investment?

There are lots of statistics out there to support the view that a large percentage of software projects fail. The numbers range from 50 - 70% and can be higher if there is significant software development required. Because the CMMS space is mature, you should never find yourself customising a chosen solution. Software products, like all products, are built with an end user in mind. Most companies have an ideal customer profile they are trying to address when they build their product. That buyer will have certain problems they are trying to address, and the functionality is built with them at the centre. So, it’s important to establish if you are the correct buyer for that company’s offering. One way to establish this is to find out what other companies are using the offered CMMS or if they are wrestling with similar problems to you?

John Kotter is widely regarded as the world’s foremost authority on leadership and change. According to Kotter, change is achieved through an eight-stage process, and he argues that skipping one step either causes the change project to fail or for it to peter out prematurely. These eight steps distill down to having a ‘sense of urgency’ or a key set of problems that people want to address. In a food company, this could be an audit recommendation from one of their key customers, or in a pharmaceutical company, a regulatory requirement in order to manufacture. Without either, the business might close. It’s then necessary to develop a vision to direct the efforts involved in resolving the problem and then communicating this to those involved or impacted.

Human beings have a strong sense of inertia, a natural resistance to push back on something they don’t understand, fear or don’t want. It’s important to show why staying in the current state isn’t possible or is worse than the future state. This is an incredibly
important step. Another related aspect to be on the guard for, is calling the end of the change process too early. It’s important to have mapped out the phases and the associated signs that this phase has been effective. The next step is to consolidate this win and ensure it becomes the accepted work practice. For example, on one site a system upgrade of the CMMS coincided with a new engineering stores building. The new system required engineers to go to a screen to search electronically for the spare rather than walk the aisles to find it. The CMMS told them where the spare was, and if one wasn’t available here, what was available in the satellite store. There was an improvement in spare search time and the only additional thing the engineer had to do was scan the spare on the way out to ensure it was logged. The real benefit was better stock control and improvements in spare carrying facilitated by using the CMMS upgrade as a justification for the work process change.

It isn’t possible to implement a CMMS on your own and it’s definitely not desirable to do so either. Apart from the workload involved, you tend to see adoption issues later when the system is rolled out. A better approach is to create a ‘guiding coalition’ or group of people who have enough power to lead that change. People also tend to trust people who are similar to themselves, so setting up a cross functional team with a representative from each affected department helps to ensure that each end user’s fears are addressed. It also shares the work, shortens the implementation timelines, and prevents adoption issues. Each representative can be used to manage the communication to their department, provide feedback and help remove obstacles.

Anything new is scrutinised but there is also an initial goodwill period. Offering to roll the CMMS out for a period and invite end user feedback helps to address objections while also showing that the end user is an important component in your overall project. Microsoft routinely released their products in the Japanese marketplace because Japanese end users like reporting problems or finding faults, but it also didn’t negatively affect the brand. The same is true in your CMMS project. Identifying key users to field test the system helps create a feedback loop and also a level of interest in the wider user population. If the end users are also key personnel that others watch to take their cue from, then they become even more important. Being selected to field test the new system is seen as a reward or a vote of confidence. It’s a little like Tom Sawyer asking his friends to paint the wall. The work gets done and you gain valuable allies for the system rollout.

Every project needs a win. A quick win helps to establish credibility, ensures senior management support doesn’t waver and might release capital for the next phase. Establishing what improvements are required and focusing initial efforts on those, helps to create some visible gains. That increased credibility can be useful if the next phase is more difficult or if there is a considerable lag in crystallising a win. A good example is looking at paperless maintenance. While paper is a low-tech approach it’s dependable and simple. However, it’s administratively intensive, expensive to store and ever more expensive to retrieve and analyse.

Deploying your maintenance system with an App allows you to free up administration time for individual engineers, access equipment history at the machine and also create real time reporting outcomes. You also see dramatic improvements in data quality and quantity recorded. Moving from a 16-step paper process to a 4-step electronic process frees up a lot of time.

With the data now going directly into the CMMS, you create the reporting benefits and an analysis capability. There is improved accuracy which affects metrics like Mean Time To Repair (MTTR) and Mean Time Between Failure (MTBF) which can be used to adjust the preventative maintenance intervals for your equipment.

This leads us to one final element. Your CMMS system needs some feedback loop once it’s up and running in order to ensure there is always a drive towards efficiency. The DMAIC (Define, Measure, Analyse, Improve and Control) wheel is a useful way to view your CMMS. One simple example is taking the breakdown information reported on your CMMS to inform your MTBF measure and to then compare this to the preventative maintenance intervals on the related asset. Your CMMS can then identify over- and undermaintained assets based on this metric allowing you to free up resources and save money. Identifying value added and non-value-added activities has become more important and over time it’s possible for your CMMS to have duplicate tasks appearing in weekly, monthly and yearly PMs that are wasted effort. In one example 80% of the tasks inside the CMMS were duplicates or overlapping. Getting your CMMS to warn you that this is happening creates additional wins over time and more credibility for your initiatives.
Oil and gas pipeline leakage is a huge problem for the industry. Major oil spills such as the very recent one off the coast of Orange County, California which sent at least 126,000 gallons of oil into the Pacific, rightly get global news coverage, but the constant ongoing leakage of oil and gas worldwide is a serious issue.

Clearly, early detection of escaping hydrocarbons is urgently needed, and one innovative solution developed by Canadian company, Direct-C, is now using flexible printed circuits - 26 metres in length - produced in the UK by Trackwise Designs to facilitate detection systems that are able to operate continuously and remain in situ for 20 years.

Based in Edmonton, Alberta, Direct-C develops leak detection products that utilize a proprietary nanocomposite which is specifically designed only to react to liquid hydrocarbons (typically C4-C20). The system comprises of a sensing element consisting of a silicone-based polymer embedded with conductive nanoparticles. The silicone-based polymer swells in the presence of hydrocarbon molecules, causing increases in the distances between nanoparticulates, thereby increasing the resistance of the sensing element.

The nanocomposite is applied as a coating to a substrate which also contains electronic circuitry that can capture this change in resistance and feed the information back, identifying the presence of a leak. The addition of nanoparticulates into the polymer matrix increases electrical conductivity and reduces material costs. Moreover, the geometry of the nanoparticulates results in improvements in the robustness and stability of the coating over time.

Direct-C offers several products that use this technology, including WrapSense, which is provided as strips that can be positioned along a pipe, delivering - the company claims - "previously unachievable certainty in 24/7 leak detection monitoring for the oil and gas industry...(that is)...completely free of false-positive alarms".

When a leak is detected, a signal is sent back instantly to a control centre using a low power cellular wireless connection with precise location information, enabling swift action to be taken to minimise the impact of the leak. WrapSense is typically placed on the underside of the pipe where any leaks will gather, at critical locations - such as over a river, marsh or...
other sensitive area. Less vulnerable lengths of pipe may be monitored using less accurate but cheaper flow meters. WrapSense can remain in place for many years with no maintenance, except for the periodic changing of the IoT wireless transmission units every five years when the batteries run out of charge - in remote areas there is rarely mains power.

ADDRESSING RELIABILITY

Direct-C’s challenge when implementing WrapSense was producing long lengths of the sensing strip. Initial products rely on 50cm lengths daisy-chained together. Using this method, the company has produced WrapSense installations of many metres, but reliability was a concern because of the number of connectors required. Installation was also an issue, as handling long lengths of WrapSense held together with connectors proved problematic, requiring the addition of a stiffening element to make a robust system.

Enter Trackwise, a UK company that specialises in long, single- and multi-layer flexible printed circuits (FPC). FPC manufacturing techniques have traditionally limited their length to less than one metre, but a patented innovation in the manufacturing process by Trackwise called Improved Harness Technology (IHT) has removed these restrictions, opening up many new applications.

Unlike conventional FPC manufacturing techniques that are based on static process steps, IHT uses dynamic processes based on reel-to-reel techniques to enable the cost-effective production of length-unlimited multi-layer FPCs. Recently, Trackwise broke its own record by producing a 72m long FPC for an energy generation company that contains 434,652 through holes and 434,636, all plated, with a total routed path length of 4785m.

FPCs, of course, deliver many advantages over traditional harness interconnect systems. FPCs take up considerably less space and weigh much less than wiring harnesses. Very thin dielectric substrates, some down to 40µm or less, coupled with their planarity, also make it possible to bond the circuits to, or within, the structure of a product, enabling multi-functional structures. Total system weight savings also result because fewer connectors and fixings are required. Smaller conductors and reduced copper content make an additional contribution.

FPCs are very versatile, as they are custom-designed to fold, bend and fit into virtually any shape of housing. They are also more reliable since they have fewer interface connections. Physically, FPCs are more resistant to vibration and shock than rigid PCBs.

In terms of electrical performance, crosstalk, noise and electromagnetic compatibility (EMC) are all tightly controlled by the FPC manufacturing process. FPC layer build constructions can provide lower inductance and lower radiated emissions than conventional wiring, and impedance control is more easily achieved. Flat foil conductors within the FPC can dissipate heat better and carry more current than equivalent round wires.

Significantly, FPCs lead to cost reduction thanks to a number of factors: simplified assembly; elimination of wiring errors; reduced component count; higher levels of automation resulting in greater repeatability and precision; and lower installation costs.

WRAPSENSE

Direct-C approached Trackwise, because of the company’s proven ability to produce long FPCs, and together with test house TWI, the three companies have successfully built and trialled one-piece, 26m-long strips of WrapSense.

According to Direct-C’s Chief Science Officer, Stephen Edmondson, “Our main concern was ruggedness and reliability. A 10m long WrapSense produced using separate smaller 50cm lengths might contain 300 solder joints - and each one is a potential failure point. With a continuous strip, you have, perhaps, only eight solder joints, so the unit is much more reliable and easier to manufacture. We do make very long lengths of WrapSense: we just completed a 350m run for a European refinery using 50cm piece parts as a pilot. It works very well but using Trackwise’s IHT FPC will significantly improve robustness and reduce installation time.”

Scaling up is another key issue. Edmondson: “If someone ever orders 20km of WrapSense, we certainly don’t want to be making that using 50cm lengths!”

Direct-C and Trackwise worked very closely on materials selection to ensure that the substrate did not contaminate the nano-composite coating, and also on the choice of protective mesh. Another challenge that Trackwise has had to address is the solder masking of such long lengths of FPC required to place the electronic components that complete the WrapSense sensor circuitry on the opposite side of the FPC to the coating. Trackwise is working to implement reel-to-reel component assembly on the IHT FPCs which will further streamline the manufacturing process.

Finally, Trackwise’s experience in the aerospace industry where the highest quality and reliability levels are routinely demanded was invaluable for Direct-C.

Amongst the many benefits of FPCs that have been mentioned, one stands out: FPCs are simply printed according to the spec as one machined item, so the risks of errors creeping in are minimized and each part will be the same as the other, time after time. As well as being used in aerospace and the oil and gas industries, FPCs are finding applications in many sectors, including automotive, consumer, medical, entertainment, IT and industrial equipment.

Currently the biggest number of layers that Trackwise has incorporated into an IHT length-unlimited FPC is eight, but the company’s mantra is ‘never say no to anything, it can be done’.
Purpose-built solution AI and machine vision solution on Intel® edge processors are helping manufacturers successfully adapt the defect detection technology and expand it to address broader Industry 4.0 use-cases.

Welding, be it manual or automated, is a complex manufacturing process that is prone to defects. Such defects can prove to be crucial in getting the final product rejected or in making them go through costly repairs.

Here comes the role of AI and Machine Vision in building a solution that can prove to be a game-changer for the factory automation era. Right from detecting defects in the early stage to reducing costs and optimizing operations, the solution can have a far-reaching impact in minimizing the overall scraps and meeting the required quality standards.

What are welding flaws?

Welding flaws are something that manufacturers want to avoid at all costs. When a robotic welder generate defects during the welding process, it might compromise the weld’s integrity, lowering the product’s quality.

Factors causing weld porosity

Porosity is one of the most common welding defects, it is the presence of cavities in the weld metal caused by the absorption of atmospheric gases (excessive hydrogen, nitrogen and oxygen) in the molten weld pool that escapes and leaves cavities upon cooling, resulting in potentially detrimental weld metal corrosion and fatigue performance, less ductile welds that cannot pass inspection.

However, welding processes are typically prone to defects and anomalies. These defects affect the strength of the weld, thus impacting the quality of the final product.

What is robotic arc welding (GMAW)?

Robotic arc welding is a critical component of heavy machinery manufacturing plants. The primary benefit of it is the production of high-quality welds in a shorter cycle time.

Gas Metal Arc Welding (GMAW) process uses heat created from a DC electric arc between a consumable metal electrode and a workpiece which melts together to create a weld pool that fuses to form a join.

Traditional methods vs. AI-based machine vision solution

Traditional manual inspection is a tedious process that is insufficient to detect defects and relies on highly skilled inspectors causing production delays, material wastage, and lower efficiency.
With advances in AI technology, manufacturers look to integrate machine vision solutions to overcome their challenges, operational efficiency, and improve quality. This machine vision-based automated defect detection solution allows manufacturers to find defects early in the production process and aims to solve a costly, age-old problem of manual defect detection in the robotic welding process.

**Key Solution Ingredients – Rugged Hardware + Software**

Heavy industries nowadays rely on precision and high-quality goods, which could benefit from machine vision as part of their manufacturing process. AI and machine vision-powered robots allow machines to see, detect and analyze images automatically on the production line and spot any imperfections. The setup includes:

- **Ruggedized Cameras** – AI cameras with integrated AI capabilities, combining hardware with a pre-installed software environment capture input streams with ruggedized cameras mounted on a robotic arm.

- **Industrial PC** – Industrial PC runs on Intel Edge AI processors with support for USB/GigE/Modbus/OPC, where multiple cameras can be connected to the industrial PC to enable cost optimizations.

- **Intel® Distribution of OpenVINO™ toolkit** – Toolkit to quickly develop applications and solutions that emulate human vision. Based on Convolutional Neural Networks (CNNs), it accelerates applications with high-performance, AI and deep learning inference deployed from edge to cloud.

- **Artificial Intelligence (AI)** – AI adds a new dimension to weld defect detection. AI-powered machine vision solution; built on neural-network-based inference engine, detects welding defects and sends commands to pause the robotic arm immediately in case an anomaly is identified.

**Challenges: Weld Porosity Defects**

Welding is the heart of any manufacturing industry. Traditionally, quality checks are conducted in a separate cell after the welding is complete. Any defects found in the QC stage would mean that the assembly is taken back to the welding cell and corrected for defects. Also, a lot of QC processes are manual lending themselves to manual errors facing an acute shortage of skilled resources – both for welding and for QC – which means higher costs and timelines for corrections. Early detection of any defects during the arc welding process is crucial to reduce delays, avoid material wastage and reduce costs. The figure below summarizes the challenges in traditional defect detection.

**Low latency machine vision solution and how it works?**

Machine vision-based arc welding defect detection solution leverages the power of machine vision to generate insights for the Gas Metal Arc Welding (GMAW) process. The solution is powered by Intel® Core™ i7 processors and uses Intel® Movidius™ VPUs and the Intel® Distribution of OpenVINO™ toolkit.

The robotic arm is mounted with a ruggedized camera that determines where the problems are being introduced in a weld pool so that corrective action can be taken. The camera captures input stream and captured data is ingested into industrial PC based on Intel Edge AI processors. Built on a neural network-based inference engine, this solution detects welding defects and sends commands to pause the robotic arm immediately in case an anomaly is identified.

**Conclusion**

Major global manufactures have started experimenting with artificial intelligence and there is the enormous potential of AI use cases in manufacturing to transform performance across the depth and breadth of operations. However, this new industrial era will realize AI is a game-changer only if manufacturers focus their efforts on adding the most value and then drive the solutions to scale.
The intelligent monitoring and diagnosis of steel defects plays an important role in improving steel quality, production efficiency, and associated smart manufacturing. The application of the bio-inspired algorithms to mechanical engineering problems is of great significance. The split attention network is an improvement of the residual network, and it is an improvement of the visual attention mechanism in the bionic algorithm. In this paper, based on the feature pyramid network and split attention network, the network is improved and optimised in terms of data enhancement, multi-scale feature fusion and network structure optimisation. The DF-ResNeSt50 network model is proposed, which introduces a simple modularized split attention block, which can improve the attention mechanism of cross-feature graph groups. Finally, experimental validation proves that the proposed network model has good performance and application prospects in the intelligent detection of steel defects.

**Introduction**

The application of Bio-inspired computation and artificial intelligence technology is gradually taking an important position in the field of mechanical engineering. More specifically, bio-inspired algorithms can replace humans to a certain extent, through training and learning to complete the tedious task of detecting steel surface defects. Research on steel plate defect detection based on visual attention mechanisms and bionic algorithms will help the steel industry move towards intelligence and information.

Currently, the detection of steel plate defects is still dominated by manual inspection, i.e., manual visual inspection or random sampling of products. However, manual inspection has problems such as strong subjectivity, limited vision and low efficiency, which to a certain extent restrict the intelligent and efficient production in the steel industry. Meanwhile, eddy current inspection, infrared inspection, leakage magnetic inspection, laser scanning, and machine vision have facilitated the equipment-based inspection of steel, but there are still problems such as low speed and accuracy of defect detection.

For steel plate defects, the types of defects are complex and diverse, and there are many influencing factors, and the shape of defects will continue to change with factors such as process and environment, which adds many challenges to steel defect detection. Figure 1 shows the four typical steel plate defects: (a) Pit defect, (b) Edge crack, (c) Scratches, (d) Rolled-in scale.
The key contributions of this work are:

1) The steel plate defect dataset is masked using Run-Length encoding, and the defect detection model is segmented using multi-scale feature fusion.

2) Based on the visual attention mechanism in the bio-inspired algorithms, combined with the feature pyramid network, on the basis of the residual network, a simple modular split-attention block is added, and the DF-ResNeSt50 network is proposed.

3) DF-ResNeSt50 network adopts radix-major to realize the block, the block is set to Cardinality = 2, Radix = 4, Width of bottleneck = 40. The proposed DF-ResNeSt50 algorithm is analyzed and compared with other classical algorithms. After experimental comparison, the network has better steel defect detection performance and detection efficiency.

The rest of this paper is organized as follows:

Section 2 discusses the related work of steel plate surface defect detection in recent years.

Section 3 briefly analyzes the data set and proposes to use Run-Length encoding to compress the data and perform data pre-processing. In addition, an improved split-attention network based on the visual attention mechanism in bionic computing is proposed for residual networks and feature pyramid networks. Before network training, use mIoU, Dice and other related indicators to monitor, and use Adam to dynamically adjust and optimize the learning rate.

Section 4 compares and trains the proposed DF-ResNeSt50 network model after setting up the experimental environment and hyperparameters, and compared with other network models. Section 5 concludes the paper with summary and future research directions.

To read the full paper, go to: https://www.frontiersin.org/articles/10.3389/fbioe.2021.810876/full

Research source and information:
1 Key Laboratory of Metallurgical Equipment and Control Technology of Ministry of Education, Wuhan University of Science and Technology, Wuhan, China
2 Hubei Key Laboratory of Mechanical Transmission and Manufacturing Engineering, Wuhan University of Science and Technology, Wuhan, China
3 Precision Manufacturing Research Institute, Wuhan University of Science and Technology, Wuhan, China
4 Research Center for Biomimetic Robot and Intelligent Measurement and Control, Wuhan University of Science and Technology, Wuhan, China
5 Hubei Key Laboratory of Hydroelectric Machinery Design and Maintenance, Three Gorges University, Yichang, China
Zhiqiang Hao 1,2,3
Zhigang Wang 1,2
Dongxu Bai1 1,4
Bo Tao 1,2,3
Xiliang Tong 3,4
Baojia Chen 5
Paper published at frontiers in Bioengineering and Biotechnology - https://www.frontiersin.org
Does the vehicle industry need to change its approach to electrification?

By Paul McNamara, Technical Director, Williams Advanced Engineering

Paul McNamara is Technical Director at Williams Advanced Engineering. He was previously UK Engineering Director at Ricardo, and has worked on high-profile projects with Ford, Volvo and McLaren.

Williams Advanced Engineering’s Technical Director, Paul McNamara, considers whether there should be more to an electrified future than just replacing combustion-engined vehicles with electrified versions.

Over the last decade there has been a rapid shift from owning vehicles outright to hire purchase or leasing. More ready access to credit is a key driver, but so too is the high investment required for automotive technology, which means the industry needs to recover costs across car sales.

The pressure to sell high volumes of new cars contrasts with the reliability and durability of new cars. In a world that’s focused on becoming more environmentally aware, it doesn’t feel like a particularly sustainable approach. But as we shift toward an electrified future and innovation drives improved performance, we’re in danger of the ‘throwaway culture’ becoming an even greater feature.

From a customer perspective, an EV’s practicality is dominated by its battery, the amount of energy it can store and how fast it can be recharged. The pace of technology evolution means that evermore advanced systems are coming to market all the time.

For example, after an initial three-year contract hire or PCP deal is up, a buyer will be presented with a whole range of new models to choose from, all of which are likely to have better performance. There is no incentive to hang on to what they have. This rate of turnover will flow down into the whole market, with the potential to create early obsolescence, and reverse the longevity trend for vehicles.

And that’s before even considering that batteries degrade over time. At the point that the battery can’t sustain an acceptable charge, the whole vehicle may have to be recycled, because its market value and usefulness have reduced.

But what if you could upgrade an EV’s onboard hardware, extending life and helping deliver improved performance? The ability to change batteries as a service action would go a long way to futureproofing vehicles and maintaining them in the market. This will also create the opportunity to upgrade an EV.

You can see from the development paths of the first mass-produced EVs how far battery technology has come. But imagine if you could upgrade your existing car? Having this option would assist consumers in making the switch to electric and provide confidence in vehicle resale value.
Once the ability to upgrade is established, then the same thinking can provide consumers with the ability to adapt their vehicles to better suit their needs. This could even extend to offering different battery options after they have made a first purchase of a vehicle and in doing so, enable sales of vehicles at different price points. However, for the car industry to deliver this type of flexibility, it will need to build in maintainability and upgradeability of hardware in the aftermarket as a key design feature.

The automotive industry has spoken extensively about platforms as the building block of an EV architecture. These rolling chassis can integrate a fully structural battery pack that enables subpacks to be added (or subtracted), giving consumers flexibility – and the vehicle a longer life. It’s an approach that is highly suited to EVs, as the core components of the powertrain – the electric motor and inverter – have long lifespans, and it addresses the primary life-limiting factor: the battery.

Investment in the products, facilities and business systems that can support a consumer’s desire to upgrade a battery’s performance during the car’s life will require further collaboration and a change to the way we have been used to dealing with ICE vehicles; a change that will unlock new possibilities for electric vehicle manufacturing, use and value creation in the aftermarket.

The industry talks a great deal about sustainability but moving to an electrified future is more than just replacing combustion-engined vehicles with electrified versions. It requires a more holistic approach to how those vehicles are maintained after they leave the production line – and a culture shift in how cars are offered to consumers.

About Williams Advanced Engineering Limited

Williams Advanced Engineering Limited is a world-leading technology and engineering business, born out of Williams F1 in 2010.

Based on the Williams technical campus in Grove, Oxfordshire, UK they successfully deliver projects for a global customer base. With over 300 employees, the company prides itself in solving the most difficult applied engineering challenges for clients across a wide range of sectors, combining cutting edge technology and the industry’s best engineers with precision and speed to market.

Their unique knowledge of high-performance lightweight batteries has been honed in the highly-competitive and demanding motorsport arena and the company now provides battery systems for the majority of the global electric racing series including Extreme E and ETCR.
BMW’s fifth generation electric motor is a magnet-free masterpiece

The electric vehicle industry is looking to solve the problem of rare earth metals, which are increasingly hard to source ethically, without sacrificing motor efficiency.

BMW’s fifth-generation electric motor, which will power its new BMW iX M60, provides a solution that combines an old-school sensibility with high-tech EV technology to actually improve efficiency without the use of rare earth minerals, a report from MotorTrends explains.

Old tech boosts EV sustainability
BMW recently announced that the standard combined output of the front and rear motor of its new iX M60 will be 532 hp and 749 lb-ft of torque. The front motor will output 255 hp while the rear motor in normal operation will have an output of 483 hp. Other modes such as Sport Boost mode would see the combined output jump up to 610 hp.

To achieve these impressive numbers, BMW developed its magnet-free fifth-gen motor, which operates as a three-phase AC synchronous motor and, in a retro twist, utilizes brushes and a commutator to power its rotor windings. Typically, brushes and commutators generate dust and cause wear that requires them to be replaced periodically. That’s why most electric vehicle makers have opted not to use them.

However, BMW hopes that its use of modern materials and its high-tech sealing technology will mean a longer lifespan for its brushed motor than is traditionally the case. According to MotorTrend, a BMW representative told them that the new motor’s brush modules are placed “in an enclosed and sealed compartment, eliminating dust contamination inside the stator/rotor wiring.”

Turning away from rare earth metals
Rare-earth metals used in permanent magnet motors are increasingly difficult to source in an ethical fashion and China controls over 90 percent of the world’s reserves of the materials. Companies such as German firm MAHLE and even Bentley are developing highly efficient magnet-free induction motors in a bid to reduce this great reliance on China as well as to improve the sustainability record of an industry that’s built largely on the promise of reducing fossil fuel consumption.

BMW has followed suit with its new magnet-free electric motor. According to the automaker, its fifth-gen motor has more energy density, better heat management, and faster switching frequency. All of this, the company says, “translates to higher RPM, more torque, and even more power.”

In other words, BMW is helping the electric vehicle industry to address one of the issues spurring detractors to claim it’s not as good for the planet as advertised. And it’s doing this while enabling the impressive spec exhibited by its new iX M60.

Article first published at Interesting Engineering https://interestingengineering.com/ and reprinted here with thanks.
Digitalization is expediting and maximizing the safety and economics of structural stress and fatigue measurement technologies. Yet to be mandated by the IMO or included in any SOLAS regulations, structural stress and fatigue monitoring systems have in fact been used for providing real-time safety warnings on large and specialist vessels for more than two decades. They are used to measure the impact of dynamic forces on a ship’s hull and structure to provide data that captains, and navigators can act on to ensure safe operations in practically any conditions.

There are two competing approaches to hull stress monitoring, setting ship managers and owners up with a choice between electro-mechanical systems or fiber optic technology. The latter is the basis for the SENSFIB Hull measuring system developed by Light Structures, which uses an accurate, high-level multi point monitoring technique called Fiber Bragg Grating (FBG) to deliver more precise data covering diverse local loads and global loads such as deflection, slamming, whipping and springing.

Light Structures was responsible for commercializing FBG-based hull stress sensors as a spin-off from a Norwegian Defense Association project around the turn of the century. The ambition was to provide commercial customers with access to stress and fatigue measurement data that was not only more resilient and granular than that provided by electro-mechanical systems but was also more cost-effective due to being easier to install and having no requirements for annual recalibration.

By Terje Sannerud, Chief Commercial Officer at Norwegian fiber optic condition monitoring system developer Light Structures.
Specialist vessels

The puzzling lack of a regulatory focus on either electro-mechanical or fiber optic stress monitoring systems has meant that only vessels with very specific requirements have so far adopted the technology. Still, despite the lack of pressure from authorities, there are now more than 300 customized SENSFIB installations currently active on the largest commercial ships, oil and gas platforms, FPSOs and naval or coast guard vessels.

The hull stress data acquired via SENSFIB has undoubtedly contributed to reducing maritime casualty statistics, but as the technology and its use as an early warning system on board matures, new avenues for unlocking insight from the data are opening up, especially as maritime digitalization takes hold. Improved fatigue measurements, calculated as a result of monitored deflection and vibrations is perhaps the most advantageous of the emerging uses for structural stress data, especially when applied to verify the design numbers of expensive, one-of-a-kind vessels or to improve asset management across a large fleet of identical, or similar ships.

Comparison of actual fatigue life with design fatigue life is a standard function in SENSFIB systems. Results are normally presented based on the latest half hour of data (single point in time) with a bar graph, and the time history of the comparison implemented as an onshore function. A graphical representation of the timeline can be implemented onboard as a custom function in the SENSFIB operator station and in case there is a significant difference between the actual fatigue life and the design life, the system can provide the user with advice on the cause of this difference.

The standard function is to present the overall fatigue life calculation together with the contribution due to wave loading (included in design life) and contributions due to vibrations (not included in design life). With access to a full set of design parameters and environmental data, including wave data, it is possible to extend the advisory function to include a comparison of the actual loading conditions with the loading conditions used for design life calculations, as well as a comparison of the actual wave scatter with the design wave scatter.
Unlocking Data

To date, fatigue calculations from stress monitoring measurements have been somewhat constrained because the raw data would normally have to be hand delivered on back-up media to the shore office, and then analyzed or applied in what is essentially, an operational silo. Lower cost satellite connectivity and the deeper integration possibilities of digitalization and the Internet of Things are bringing new life to stress and fatigue monitoring data though, and nowhere is this more important than efforts to maximize operational lifetimes of multi-million-dollar maritime assets.

With online access to SENSFIB data uploaded direct from ocean-going assets, Light Structures can help to verify or refute complex vessel designs on an on-going basis. Over time, this will contribute to building even safer, more effective and less costly ships and maritime assets. Further, through digitalization of SENSFIB data, it’s possible to measure fatigue across entire fleets of identical vessels in order to ascertain how certain maritime environments affect the condition of ships.

As part of a Condition Monitoring System for instance, this data could allow for preventative maintenance on stress and fatigue hotspots as well as providing a platform for improved fleet management. With the ability to measure the impact of dynamic forces in any particular region, the lifespan of vessels across an entire fleet could be improved by minimizing exposure to environments that have been measured to cause more damage to vessels. By ‘swapping out’ vessels, there is potential to spread the financial and asset life expectancy cost of operating areas with high fatigue rates, therefore reducing damage or downtime caused by fatigue across an entire fleet.

The optional SENSFIB Active Fatigue Management (AFM) system is a service that adds advanced fatigue analysis functionality to the core system, including; a rainflow counting algorithm and miner’s sum calculations for calculating actual fatigue damage at sensor locations; hotspot monitoring by sensors in coldspots, by scaling measurements with Stress Concentration Factors (SCFs preferably provided by yard based on structural analyses); virtual sensors, i.e. each actual sensor is scaled with different SCFs for several nearby hotspots; life-time usage based on comparison over time between the actual fatigue life consumption and the nominal consumption for design life; separate calculations of fatigue damage due to wave-driven stresses and fatigue damage due to vibration phenomena and; low-cycle fatigue calculations to include the contribution from loading and offloading cycles.

Long-term Fatigue

Light Structures has already developed methodologies and workflows to apply SENSFIB data for long-term fatigue measurement. The US Coast Guard’s Service Life Extension Program (SLEP) is an ideal example, where fatigue data has helped to signpost specific maintenance requirements. With data collected manually however, the complexity has made it the preserve of the particular dedicated owner or operator. It’s no surprise that an organization that is duty bound to maximize the lifespan of its assets will carry out such an undertaking then. For the rest, digitalization is making lifetime fatigue monitoring more viable due to instant access to data and the ability to analyze seemingly disparate data in a single platform, which ultimately, can provide more connected insight and even more value.

Light Structures is leveraging more connectivity with the SENSFIB Integrated Marine Monitoring System (IMMS), which combines comprehensive stress monitoring with environment monitoring parameters and advanced processing for real-time analysis of live data and theoretical models. Third party data from environmental monitoring systems, loading computers, DGPS and mooring tension measurements can be combined with data from the FBG sensors for stress and strain monitoring, as well as the motion sensors and wave spectrum analysis that make up a standard SENSFIB installation.

This is also just the start. Light Structures’ stress and fatigue data will be used as an essential component in Digital Twins and CBM systems, and through this, the combinations of data types are practically endless. And so too is the insight that can be gained. Regulations or not, the savings enabled by extending the useable lifespan of a vessel or an entire fleet are an attractive proposition for ship owners and managers counting on digitalization to deliver operational efficiency.
The force of waves slamming into offshore rigs, wind turbine pillars, ships or other offshore structures can do an enormous amount of damage.

One of the fundamental – and unresolved – problems with designing these kinds of large structures is being able to predict exactly how they will react to extreme stresses. What exactly is the load from the force of powerful waves slamming into structures?

Solving these challenges will be a major step towards safer and more cost-effective marine operations.

The overall goal is to increase the safety at sea.

**Building bridges and better design**

It’s important to expand what’s known about these challenges, but that will require systematic experimental studies of wave-impact scenarios. The project will do exactly that, which should allow researchers to figure out how a structure’s behaviour interacts with the loads that are applied to it.

The researchers are developing experimental methods to measure this interaction. Better calculation methods can help the industry when new offshore structures are designed.

---

**Interaction between load and load effect**

“It’s crucial to understand the mutual interaction between the impacting wave and the response of the structure,” says Rene Kaufmann.

Kaufmann is a postdoctoral fellow at the NTNU SIMLab (Structural Impact Laboratory) and one of the researchers in the SLADE KPN project. This is a Knowledge-building Project for Industry (KPN) funded by the Research Council of Norway, in which researchers from SINTEF Ocean and NTNU are collaborating on basic research.
Kaufmann’s focus is measuring the impact of local surface deformations from massive loads.

One important aspect of Kaufmann’s research is to make sure the measuring equipment itself doesn’t affect the structure’s properties. Researchers at SIMLab have used their experience with camera-based techniques to measure the structural response to loads from impacts and explosions.

But more on that later. First we’re heading out on a trip out into the Norwegian Sea.

“Huge wave on its way”
The monster horizontal waves that can slam violently against ships and other structures at sea originate from what are called 100-year storms.

In 1995, the offshore platform “Draugen” was put to a serious test at the Halten Bank area, on the Norwegian Continental Shelf. On 12 March, a hurricane swept through the Norwegian Sea, and platform manager Magne Gundersen received an unexpected phone call from the Aberdeen Weather Center.

The Center warned of a massive wave on its way to the platform. The crew had only 30 minutes to prepare. Production was immediately stopped. Gundersen gathered the crew of 134 people into the gymnasium in the interior of the platform. There he reassured everyone by expressing his unconditional trust in the engineers who had designed the Draugen platform.

Platform shook under crew
“Just after I said those words, the loudest, most shivery and violent ’BANG’ I have ever heard rang out,” Gundersen said in an interview after the incident.

“We started to feel an increasingly large amount of movement under our feet. (…) [T]he room kept pitching. I couldn’t tell exactly how long it lasted but my guess would be more than a minute,” he said.

First the huge wave had hit the shaft, before it lifted itself up under the deck with tremendous force. The distance between the still water level to cellar deck of the platform is 30 metres.

Into the physics of wave slamming
A key question for SLADE is: What is the effective stress of these kinds of loads?

“We have to understand the load before we can study the details of a structure’s behaviour,” says Vegard Aune, an associate professor at SIMLab.

Another incident that contributed to the motivation for SLADE occurred in the North Sea in December 2015, when a large, steep wave thundered into the COSL Innovator drilling rig. The platform was designed in accordance with regulations, but still failed to withstand the load.

The incident took one human life and four people were injured. The rig was also extensively damaged.

Understanding load to predict load response
“Accidents like the COSL Innovator event raise the question of whether we fully understand the underlying physics of loading during violent wave slamming. It’s crucial to provide construction engineers with detailed knowledge about loads, the underlying physics and the materials. All this is key to understanding and predicting how structures respond during extreme stress,” says Aune.

Controlled model tests
Kaufmann, along with fellow researchers Bjørn Christian Abrahamsen from SINTEF Ocean Transport & Energy and project engineers Trond Auestad (SIMLab) and Jens Åge Havmo (SINTEF Ocean), recently spent several days in the Ocean Basin Laboratory at Tyholt in Trondheim, where they conducted wave slamming tests on small-scale models.

The researchers tested the measurement technique they had worked out, which involves measuring the load as the wave strikes the structure.

Today, this is measured with point meters that rely on wires. The SLADE team has been exploring the use of lasers and camera techniques that not only provide measurements at a given point, but can potentially determine in time and space how the entire incoming wave field evolves as it approaches the structure.

This development is leading to another goal for SLADE, that of bridging the gap between physical tests and reliable computer simulations.

The researchers recreated breaking waves in the basin, causing them to slam into a flat steel plate. The plate was integrated into a steel pillar representing a scaled-down steel structure at sea.

Measurements at the micro level
Kaufmann has a background in flow mechanics. He is an expert in deflectometry, which he describes as a “full-field surface slope measurement technique.” The technique has high sensitivity and enables deformations to be measured down to the micrometre level.

Kaufmann received his doctorate from the University of Southampton, UK in 2019. The technique he uses in SLADE is related to his dissertation.

Scientists who complement each other
SLADE’s project manager, Dr. Øyvind Hellan, describes the project as an “inspiring collaboration between research environments that complement each other.”

Hellan is Vice President for Research at SINTEF Ocean. He says that when SLADE was launched, they wanted to focus on gathering a top team of Norwegian researchers. SINTEF Ocean, a world leader in marine technology and marine bioresearch, teamed up with NTNU’s Department of Marine Technology and SIMLab at the Department of Structural Engineering.

IMT is a world leader in education, research and innovation for technical systems in the marine environment. SIMLab carries the same status within the field of load-bearing structures subjected to extreme loads.

The Factories of the Future
By Debajyoti Chakraborty, Associate Partner, IBM Global Business Services, Skip Snyder, Senior Partner and Global Intelligent Connected Operations Leader and Euan Pirie, Industry Business Development Technical Leader.

As the volume of data generation is increasing at an exponential pace, factories today are struggling to make real use of the incredibly important insights hidden in data. With the arrival of 5G, hybrid cloud and powerful asset management solutions, now that became simpler. IBM is working in the UK’s prestigious ‘5G Factories of the Future’ project to define the new paradigm for how the future factories will operate, how connected assets will improve operational agility and make the supply chain smarter. This article explains top five use cases that are core deliverables of the project, technology behind those and how these will transform the manufacturing industry in the future.

Introduction
Efficiency, productivity, and sustainability are vital considerations in the manufacturing industry. And, as we look to the Factory of the Future, manufacturers are integrating new technologies, including the Internet of things (IoT), cloud computing and analytics, and AI and machine learning into their production facilities and throughout their operations. These changes will revolutionize the way that companies manufacture, improve, and distribute their products.

Consider for a moment the amount of data on a single factory floor – from the sensors that track heat and occupancy to the cameras collecting visual data and monitoring workplace safety.

Then, expand that across a larger organisation with several different kinds of facilities and the demand for data processing grows exponentially and the artificial intelligence (AI) models needed to sort through this data get significantly more complex. With extra data sorting comes the issue of time: an AI model that can tell you a month from now that employees are crowding in a passageway isn’t particularly useful.

Today, different technologies are being used to solve these issues, such as Edge Computing for making decisions on the manufacturing floor, connectivity technologies such as 4G, or existing plant networking technologies.
However, they can often be cumbersome to retrofit into a factory and can be challenged by IT departments or security teams. Additionally, many companies today also struggle to justify investments in Industry 4.0 technologies and find business cases hard to develop.

So unsurprisingly, another approach that is gaining a lot of attention is 5G. Much has already been written about how 5G will help, how it will transform manufacturing, increase efficiency and productivity.

5G may still feel a long way off but it does offer something different by providing increased bandwidth, increased connectivity in terms of the numbers of devices, reduced latency, and in-built security. In addition, it offers the possibility of deploying a private network – which in a manufacturing facility eases the implementation headaches associated with retrofitting a physical network.

Reduced latency will allow real-time remote control of manufacturing systems while increased bandwidth will allow line side support through augmented and virtual reality devices. In short, the potential of Industry 4.0 for a ‘smart shop floor’ at scale starts to become a reality.

To help test how 5G can help in manufacturing, IBM is working with several partners to develop 5G testbeds across the world to help prove practical use cases and ease its adoption. One such example, here in the UK, is the 5G Factory of the Future programme, an open access two-year project aiming to demystify 5G for the manufacturing sector and work towards developing the smart factory of the future.

**5G Factory of the Future**

The project is primarily based at the University of Sheffield Advanced Manufacturing Research Centre’s new site in Samlesbury; with a significant additional footprint in both BAE Wharton and AMRC’s site in Sheffield.

It brings together industrial and academic leaders from the manufacturing and telecommunications sectors to establish a 5G manufacturing testbed. It is the largest of all the investments made by the UK Government Department of Culture, Media, and Sport as part of its £200m 5G Testbed and Trials programme.

5G Factory of the Future is being led by AMRC North West and includes BAE Systems; IBM; telecoms and private 5G network provider, aql; along with Burnley-based MTT, an SME developer of digitalisation technologies for machine tools; and the Lancashire-based data-driven logistics specialist, Miralis. Digital Catapult is the technical authority lead and is coordinating 5G integration, working closely with aql and use-case developers, and developing the ecosystem of partners required to deliver end-to-end industrial 5G solutions.

Engineers are asking for faster IOT adoption to improve asset performance
Use cases designed to deliver

There are five key use cases that will be investigated in the programme:

1. Real-time Monitoring and Adaptive Closed-Loop Control (RTM)
2. Digital Twin Track and Trace (DTT)
3. Factory Ecosystem Monitoring (FEM)
4. Chain of Custody System (CCS)
5. Distributed and Shared Hybrid Reality Spaces (HRS)

The first that we are looking at is real-time process monitoring and control. By using the ultra-low latency of the 5G network we can start to process even more information from factory floor operations into remote AI models (both in a separate on-premise facility and on cloud) to improve process precision and predictive maintenance solutions.

One of the key aims here is to demonstrate a 15-25% reduction in the number of defects, amount of waste generated and machine downtime arising from improved process precision and predictive maintenance strategies and error reduction.

The second use case is focused on digital twins – the virtual representation of a physical asset. We’re investigating how they can be used for tracking the performance and health of manufacturing assets given the increased number of sensors we can connect over a 5G network.

We’re aiming to see 15-20% machine utilisation improvement (reduction in idle time, improved scheduling) and general improvements in factory efficiency. They can arise from data-driven decision-making, real-time asset location, efficient machine scheduling, asset performance optimisation or improved predictive maintenance.

The next use case will examine how environmental information such as temperature, humidity, vibration and energy can be combined with real-time asset data to improve machine utilisation, and a reduction in both energy usage and maintenance time.

The fourth use case looks at how we track assets across different manufacturing and production sites through the supply chain. This aims to increase asset visibility to improve schedule accuracy and generate a 30% decrease in lost or damaged assets. Again, 5G enables us to connect a lot of sensors and ingest in real-time, something that is difficult to achieve currently.

The final use case is focused on augmented and virtual reality technologies and uses the ultra-low latency, high bandwidth capabilities in 5G to enable mixed realities across multiple sites. For example, if an engineer is in one site can he collaborate across another site to provide support for maintenance or training. This could see a reduction in downtime on the plant floor.

The Role Of Technology

The programme uses an IBM IT backbone which is deployed both on-premise at each of the sites and with an identical environment deployed on IBM Cloud to facilitate data aggregation.

A variety of other IBM technologies are deployed which allow us to integrate the IT systems and sensors together and consume the data on a platform where we can
organise and analyse it in a variety of ways – and which allows engineers and specialists across the consortium to collaborate on the use cases.

IBM Maximo Application Suite is at the centre of monitoring, managing, and maintaining the factory assets. It provides transparent visibility of assets across their lifecycles. There are numerous indicators that can signal slow and steady deterioration of asset health long before the often-invisible asset performance impacts production continuity or product quality.

A powerful asset management tool is thereby extremely important to translate the data driven predictive analytics into actionable work items.

Maximo’s ISO 14224 aligned process automation capability does that translation. It helps automatically generate executable work orders with corrective maintenance tasks, required spares, and suggests recommended safety gears.

Such automation on top of the predictive capabilities helps factory managers take the most optimised decisions to improve operational efficiency, reduce cost and enhance health, safety, and environmental compliance. Not only that, but advance visibility of the maintenance needs helps also plan for the required production stoppage by choosing the right operating windows when the impact is minimum.

One example being the Maximo Application Suite which is used to manage the remote assets and explore how Visual Inspection can operate over a 5G network.

While AI technologies such as visual inspection are not necessarily new in manufacturing, 5G can change the way we approach it. Cameras arrayed throughout a factory floor could gather image data which a model uses to scan for problems, so that inspectors spend more time going where they’re needed.

In industries like apparel manufacturing, visual inspection can be used for such precise tasks as spotting flaws in stitching or fabric. In automotive manufacturing, it can spot paint chips, part defects, or even safety flaws.

In all these scenarios, 5G would provide access to more images, in higher resolution and as such it could help reduce overall costs, both by preventing defective products from getting to market and streamlining the processes for maintenance and repairs of critical equipment.

However, as sensor and camera deployments grow in scale and sophistication, a key challenge is identifying ways to combine all the visual and sensor data in a way that makes sense and can be analysed. A large manufacturer might have millions of inputs at a given moment.

Without tools that are powerful enough to help humans analyse it, all that data easily becomes overwhelming, meaning the potential insights within that data are ignored or worse, misunderstood.

So, while collecting the data is one important aspect, the project is looking at how to maximise the value of that data, particularly in how manufacturers can make real-time remote-control decisions. To do that, we’re using IBM Cloud Pak for Data.
The Hybrid Cloud Advantage

While AI and Internet of Things (IoT) are two of the key building blocks and are integral to large-scale industrial automation, to achieve this at scale requires a third building block: Hybrid Cloud.

Manufacturers have been reluctant to move operational data to the cloud, but at the same time have wanted to exploit the benefits of AI and advanced analytics.

Hybrid Cloud allows manufacturers to do just that, keeping the confidential operational data on premise at the manufacturing site, while sharing fewer sensitive data in a private cloud environment where it can be used to facilitate collaboration across multiple production facilities, help improve AI models, or for advanced reporting.

For this reason, the IT backbone has RedHat OpenShift at its core.

A Lesson Learnt

One interesting aspect to the project is that it has been worked on primarily during Covid lockdowns. From the initial definition, through the project submission, award and now in delivery, the team have worked remotely throughout.

Bringing together a consortium remotely is not without its challenges but using online tools and an adaptable approach from all the parties, we have been able to collaborate and work effectively and still maintain the project timelines.

What’s Next

With the private 5G network now live, we’re feeding data from the different sites into the platform and beginning to ingest even more – in terms of both quantity and variety of data types – into the platform. This is a key step to enable us to start to benchmark the performance characteristics of the overall solution. The need for industry collaboration has never been clearer, with specialists coming together to demonstrate the benefits of 5G in digital manufacturing.

With the impact of the pandemic and Brexit, combined with often low productivity rates found in the UK manufacturing sector, the need to innovate to remain competitive has never been greater. This programme is a key step in helping us understand how 5G can help play a part in developing a sustainable and smart Industry 4.0 vision in the UK.

Next generation factory assets are also going to be more sophisticated and thereby costlier. They need an AI-enabled enterprise asset management (EAM) solution that is easy to use and provides enterprise scale execution for maintenance, operations, and reliability teams.

IBM’s Maximo Application Suite provides remote asset monitoring, maintenance and reliability applications in a single platform that enables factory owners to increase uptime, improve productivity, reduce maintenance costs, and build more resilient operations.

Application of advanced robotics is increasing in smart factories. Robots are being used to augment human inspectors by spotting defects in areas that are difficult and risky to approach. Inbuilt data analytics capabilities area helping fast transfer of insights to the decision makers to take quick actions.

As the modern factory assets are digitally connected, besides maintaining their physical links, it is now feasible to improve performance of the connected asset system instead of a single asset.

Insights from intelligent, connected assets and untapped data sources are critical to understanding the preventive, predictive and prescriptive actions needed to drive efficiency, reduce operating costs, and consistently meet quality targets.

Increased predictability of asset performance will enhance certainty of production planning. Improved accuracy of the production planning will drive future factories to optimise raw material and MRO materials and services demand and finished product supply to the market more accurately.

As a result, smarter factories of the future will lead huge supply chain efficiency gain in the ecosystem of partners.
“What”, I hear you ask, “have two sword fencing terms got to do with an investigation into a failed engine - if that is what we are going to have to read about, yet again, this time?”

Patience, please, dear reader, as I have hardly put computer to paper!

All of us in our chosen professions have tasks that are really basic to our work, and could be considered to be so routine, that we scarcely need to think about them.

Alas, sometimes these tasks are so routine that very occasionally we find that we miss them out or get them wrong.

I have not forgotten investigating a fatal collision where it was important to know the speed of the motorcycle prior to the collision. We knew exactly where the body of the motorcyclist ended up and thought it would be a relatively simple matter to calculate the speed from the distance the body had travelled. Our efforts were somewhat confounded when we discovered that the pathologist who carried out the post-mortem had failed to weigh the body or to measure its height!

This is rather like me forgetting to record the make, model and registration number of a vehicle prior to examining it, and I am sure all of you can think of tasks that you carry out on a regular basis that fall into that category.
So, let us now consider the case in point. Ellis Calthorpe was the proud owner of a Japanese go-faster hatchback. I am sure you know and can guess to which model I am referring and it was his pride and joy.

At some point, he decided that it should go even faster and had various modifications carried out, including a competition clutch.

He also felt that the engine would benefit from a bit of “tweaking”, and so it was dismantled, and the component parts sent to the Albury Engineering Company, his local specialist machinist, for attention.

This included, amongst other things:

1. Reboring the cylinders and honing them to size;
2. Balancing the crankshaft;
3. Pressure testing the cooling system;
4. Fitting new valve guides and re-cutting the seats;
5. Machining the cylinder head;
6. Assembling the “short” engine.

After the crankshaft had been balanced, the journals were polished, and the short engine was re-assembled with new bearings and thrust washers - all standard size. The customer collected the engine, paid the bill and went off to assemble the rest of the engine and fit it back in to the car. All well and good so far!

A year later, almost to the day, the customer contacted Albury Engineering to say that all was not well with the engine, and that one of the crankshaft thrust washers had failed because it had been fitted back to front!

As Albury Engineering was a family-owned company and had been in business for more than sixty years, and as they had probably lost count of the number of engines they had machined and rebuilt over that time, they found this accusation rather hard to swallow, not surprisingly, as the fitting of thrust washers is a very routine task, and it is hardly rocket science!

Naturally, they asked Mr. Calthorpe to return the engine, and in particular, the thrust washers. Unfortunately, he refused both requests on the grounds that “they would destroy the evidence, and therefore he was going to hang on to them.”

Oh, dear, this looks like trouble is brewing.

Albury Engineering were in a bit of a quandary as to the best way forward; however, after receiving a sharply worded letter from Mr. Calthorpe’s solicitors, they contacted me.

After a somewhat protracted correspondence, Mr. Calthorpe reluctantly agreed that I could inspect the engine and the thrust washers at his house, as they were stored in his garage. Accordingly, I turned up bright-eyed and bushy-tailed at the appointed time to see what had happened to the engine and the thrust washers. When you look at the photograph of the damaged washer, you will appreciate just how badly it had been damaged, as it had spun in its housing, thus damaging the engine block as well as itself; but the burning question was, what had caused it to spin?

Part of the thrust washer has started to “creep” towards the main bearing shell, which in turn had started to overheat, and the top coating of the shell had disappeared.
The really odd thing was that it was the front thrust washer that had been damaged, not the rear one, which I would have expected to be the case. Is it possible that if the thrust washer had been fitted back to front that this much damage could have occurred as a result, or was there another factor to consider?

The answer to part (a) of that question, I am reliably informed by my learned mentor, is “decidedly so!”

This now raises the fundamental question. Did Albury Engineering fit the thrust washer the wrong way round, or is there something else that I need to know about or discover?

I think that Mr. Calthorpe by this time had accepted that I was only there to establish the facts in an impartial manner, and I was not trying to destroy the evidence, as he very kindly provided a mug of tea whilst I was busy inspecting the engine. I also discovered, joy of joys, that he was a fellow member of the Fresh Air Society, so smoking whilst at work was not an issue!

It was whilst we were chatting that I asked Mr. Calthorpe what, if any modifications he had made to the vehicle, just out of idle curiosity, I suppose. When he told me about the competition clutch, my ears pricked up, and very gently I started probing to get as much information as possible.

Did this clutch “push” on the crankshaft, like most of them do, or did it “pull”? It did indeed pull rather than push, and it was an up-rated competition clutch made by a firm who specialised in manufacturing parts for “go-faster” vehicles! Ho, hum, we now have to sort out whether the clutch was the contributory factor to the failure, or whether the thrust washers had been fitted back to front, or could it be a case of both?

The only way to do this forensically is to have the thrust washer examined by a metallurgical laboratory, but the question is, will Mr. Calthorpe agree to this? Rather to my surprise, he did agree, and so the remains of the thrust washers were sent to my preferred metallurgists to see whether they could determine which way round the thrust washers had been fitted. Their reply, when it came back, was certainly going to be music to the ears of one of the parties in this dispute. They stated that the material that had been worn away was non-ferrous, so the thrust washers had been fitted correctly after all.

What a huge relief for Albury Engineering, and something of a big disappointment for Mr. Calthorpe.

The claim in the court was withdrawn, and the case was closed.

I have a sneaking suspicion, that in future, fitting thrust washers to crankshafts will no longer be a routine matter for Albury Engineering.
Managing an industrial facility means dealing with several hazards. While some of these risks, like repetitive motion strains and machine collisions, may be obvious, some are less evident. Noise control, for example, often goes overlooked in the grand scheme of industrial safety.

The manufacturing industry saw more than 373,000 workplace injuries and illnesses in 2020, more than any other sector but healthcare. With such a large body of incidents, subtler hazards like noise can fly under the radar.

Why Industrial Noise Control Matters

While it may not take center stage, industrial noise control is a critical safety consideration. Roughly 22 million U.S. workers encounter hazardous noise levels at work, and industrial sectors account for many of those instances. Industrial machines and utility systems are often loud, reverberating throughout metal warehouses and factories.

Authorities recommend that employees avoid exposure to sounds louder than 85 decibels for eight hours. However, sounds at just 70 decibels can cause hearing damage after prolonged exposure. As workers’ hearing declines, they may not be able to sense other hazards, such as approaching vehicles.

Hearing damage can also cause a ringing in employees’ ears, distracting them from their work. This distraction could cause them to miss other hazards as well, further endangering them.

Industrial noise is a troubling concern, but solutions are improving. Here are six emerging technologies and strategies for mitigating noise hazards.

1. Constrained Layer Damping

The best way to address any risk is to remove it in the first place. For many industrial noise sources, that means reducing vibrations to let machines run quietly. Damping, which dissipates vibrations, is one of the most popular approaches to this issue, and constrained layer damping takes it further.

Traditional damping techniques stick a high-damping material to metal surfaces. Constrained layer damping, on the other hand, places the dampening material between two metal sheets. This approach is 30% more efficient than conventional methods, as it prevents the damping layer from deforming as the panel bends and vibrates.

While constrained layer damping works well for many machines, it’s less effective with thicker sheets. Systems that require wider panels may need another solution.

2. Noise-Canceling Windows

If removing the source of the industrial noise isn’t possible, facilities can try to counteract it. One emerging solution takes inspiration from noise-canceling headphones. Devices like Apple AirPods drown out surrounding sounds disrupt sound waves with sensors and speakers, and the same principle can work with windows.

Researchers in Singapore found they could reduce incoming sounds by 50% by mounting such a system to window grilles. The technology uses sensors to detect incoming noise, then plays a sound with a similar but inverted waveform. These out-of-phase sound waves counteract the incoming waves, dissipating them before they go through the window.
Since this specific instance applies to windows, it only works for blocking outside noise coming in. Similar systems could apply the same idea to other areas, though.

3 IoT Noise Cancellation

Another approach to this active noise cancellation concept uses the internet of things (IoT). One of the shortcomings of most noise-canceling systems is that there’s not enough time between sensing and emitting. By the time the speakers emit their disruptive waves, some of the incoming waves have already reached people’s ears.

Some researchers have suggested using an IoT-based system instead. IoT sound sensors throughout a property detect incoming waves before they reach an area where people are. They then trigger the sound emitters to start playing counteractive noise, canceling incoming waves earlier.

The downside to this system is that it works best with headphones. Blocking sound in an open area is much harder, especially if the noise is coming from within that area.

4 Intelligent Active Noise Suppression

A newer and more widely applicable approach to active noise cancelation uses intelligent panels. The panels resemble traditional soundproofing materials, but instead of blocking sound, they counteract it. The central idea works the same as other active noise suppression, but these are more condensed and adaptable.

The system analyzes sound data to produce equal but opposing waves. This closer data analysis lets the panels achieve a 92% sound reduction, as far as the human ear perceives. That places it far above similar but more rudimentary sound-canceling systems.

Since this system uses panels instead of headphones or other small form-factor devices, it’s a better fit for open industrial facilities. However, being so new, it may not yet be a viable or even available solution for every facility.

5 Acoustic Metamaterial Rings

Active noise cancellation isn’t the only novel approach to industrial noise control that shows promise. In 2019, researchers at Boston University discovered a passive method that has a unique advantage over traditional sound blocking. Their device allows air to pass through but not noise.

The solution is a 3D-printed ring containing a spiral pattern to redirect sound waves while allowing air to pass through the center. This design effectively uses acoustic waves against themselves, as soundwaves’ vibrations cause the ring to generate equal but counteractive vibrations. This ring provides an affordable and surprisingly effective tool for silencing loud exhausts, like industrial fans or HVAC units. With more development, companies could create custom rings to match and eliminate specific frequencies, making them more widely applicable.

6 Nanotechnology Soundproofing Foam

Soundproofing foam is one of the oldest approaches to noise reduction. However, recent advances have made it far more effective. One of the most promising uses nanotechnology to turn soundwaves into heat.

This foam uses readily available off-the-shelf soundproofing foam as its base. Manufacturers then inject it with a nanopowder that then forms microscopic channels. These tubes convert acoustic vibrations into heat, dissipating the sound, and using readily available materials keeps costs low. Compared to the off-the-shelf foam, the injected version absorbs sound 60 to 100% more effectively, greatly reducing the sound that gets through. While it may not be a perfect solution, it provides a substantial improvement without high costs.

Remaining Obstacles in Industrial Noise Control

Many emerging solutions hold promise for industrial noise control. Still, many of these either have limited applications or exist only as proofs of concept. More development will be necessary before some of these innovations are ready for widespread industrial use.

No one solution will be ideal for every situation. Industrial facilities will have to review their needs to find the best possible solution for their specific situation. In most cases, they’ll need a mix of several approaches.

Minimize Industrial Noise

Industrial noise may not be the most recognizable hazard, but it’s a concerning one. Thankfully, there are many possible solutions, with new ones showing particular promise. Manufacturers and other industrial organizations should keep an eye on how these technologies develop. Employing these innovations could save employees from potentially life-altering injuries.

Article by Martin Banks, Managing Editor at Modded
As several aircraft systems are now computerised, it is becoming more common for the professional development of aircraft engineers to revolve more around computerised troubleshooting rather than manual skills.

Brett Levanto, vice president of operations at the Aeronautical Repair Station Association (ARSA), believes that industry entities always have to keep up with technology and properly utilise new tools and associated methods, techniques and practices in order to perform work.

"As a result, the use of computers and other assessment tools are often needed in maintenance organisation training programmes. Of course, the repair station/approved maintenance organisation community is very 'bottom heavy', i.e. there are many small businesses that adopt new technologies with careful planning whilst bigger companies, with more capital resources, can be more exploratory with new technology," he says.

"As a result, the kinds of training and skill required will vary by organisation, size and type of work. However, there will always be skill requirements related to the hands-on performance of work (regardless of the systems available to troubleshoot) and to report and assess the status of the system."

**Digital vs hands-on work**

Air France Industries KLM Engineering & Maintenance (AFI KLM E&M) believes that the traditional line between mechanical engineers and avionics engineers is becoming vaguer.

"This trend has for a certain part already been incorporated in the regulatory framework when introducing EASA Part 66 whereby the mechanical B1 engineer also deals with more avionics types of problems. Then all traditional mechanical items are having computers and software linked to them.

"In our training programmes, we have shifted to incorporate these new skills. We are helped of course by the fact that all our existing personnel, as well as the new generations of people we hire in their daily life are more and more exposed to using digital tools. So, we do not face major challenges based upon this trend," says Vincent Metz, head of strategy, marketing & communication at AFI KLM E&M
These new requirements create a new sort of hands-on competence that is of a different nature compared to the old one, but the basis is the same, i.e. experience in troubleshooting and solving problems will provide the experience one can use for future needs.”

At a cultural level, there has been a trend for a long time away from hands-on/technical work.

“In the United States, skills training, shop classes and other skills-based learning opportunities are nowhere near as prevalent as they were 30 years ago. We have lost that foundational level of skill that every potential job applicant used to have,” says Levanto.

“That is not because of new technology or computer assessment, it is because of how we culturally approach learning pathways and career development. Perhaps there is a positive in the increase of new technology in aviation maintenance as it may attract applicants who would have thought the work to be too ‘blue collar’ otherwise.”

According to Iavor Konarov, head of production at Lufthansa Technik Sofia, despite the significant digitalisation in the MRO business as well as the fast steps in the automation of aircraft systems, the skilled aircraft engineer is irreplaceable due to his/her wide understanding of the aircraft systems.

“The maintenance tasks are getting more complex and in certain cases are requiring more reading, understanding and analysing of the results and measurements. However, the skilled hands and years of experience are more crucial. In addition, the aging of the aircraft and system components is always revealing new challenges that are not that easy to catch with automated systems,” he says.

“Nowadays training development is even more crucial to maintain a stable bridge between the new complex aircraft systems and human perception and comprehension. We constantly need to find new ways to provide training content in an easy way to understand in the environment of increasing complexity of aircraft systems and management system requirements.”

Levanto points out that in the United States, aviation maintenance training schools operate under a rule that has not been substantively updated since the early 1970s.

“The rule’s curriculum requirements are very prescriptive, so schools have extremely limited leeway to introduce new technologies that are not directly related to aircraft systems”, he says.

“In aviation, our focus is and should always be on necessary competency to perform work. Tools and technologies have been changing since the day the Wright Brothers first flew in Kill Devil Hills. Competency focus, procedural awareness and system safety should be the guiding principles of performing work no matter what resources are in use. From that perspective, it is not worth panicking about impacts on proficiency.”
Human Factors Training

Human factors training is an integral part of the professional development of maintenance personnel. Developments are being witnessed whereby maintenance organisations are being more about this training aspect.

"Human factors awareness, like competency, will always be fundamental. In aviation, just about every failure tracks back to the human element in some form. Since we are in a period of unprecedented public fervour about aviation safety, managing the 'human element' is incredibly important," says Levanto.

"The perception that human factors is a familiarisation in the Dirty dozen principles and a simple explanation of human physics and psychology is long gone," says Konarov.

"We are constantly searching for new ways on how to reach and work on the level of personal mindset and affect daily behaviours, which directly correspond to the organisational culture. There is a need that the core of the safety management system, leadership training and practices, and training systems get into an aggregated flow clearly shaping the organisational culture."

AFI KLM E&M’s training programmes have a dedicated part on human factors.

"On top, we have safety programmes in our maintenance organisation that are focused on creating awareness of all safety-related matters and creating a safety culture built on learning and improving openness with no fear to ask for help or for speaking out on mistakes," says Metz.

At the very top, it is the International Civil Aviation Organization (ICAO) that encourages national aviation authorities to include human factors training in their regulatory requirements.

"EASA and Transport Canada both have explicit requirements in their rules, including suggested topics, for human factors training. These requirements are included in the special conditions of the US-EU MAG, so American repair stations performing work under the bilateral must have training.

"The FAA does not have explicit regulatory requirements but strongly encourages its inclusion, even using the word 'must' in its guidance related to repair station training programs, even though the use of the word in an advisory circular does not create a requirement under the rules," says Levanto.
Maintainability Developments

Aircraft have experienced several developments with regard to their maintainability and certainly, the digitisation of the elements onboard has had an important impact.

“At AFI KLM E&M we are very active in the development of predictive maintenance techniques. Our Prognos suite is one of the industry-leading tools. Prognos changes radically the way of working. We can monitor the aircraft status and the tool is predicting much earlier, around 30 cycles, that certain problems will arise.

“This window allows to make all necessary preparation and really plan the maintenance activities. This drastically improves aircraft availability and reduces delays and cancellations for technical reasons. Further digitization is having a sizeable impact on troubleshooting processes around the aircraft," says Metz.

There are still many possibilities in front of the OEMs to provide easier and quicker access not only to maintainers but also to other parts of the maintenance organisations, such as better direct possibility for planning purposes, according to Konarov.

“The easy possibility to use the maintenance data for easy transfer into customised job cards, as well as quick links to the proper corresponding other manuals would be a great step forward," he says.

“In the development phases of the latest aircraft generations the large aircraft manufacturers have established mixed working groups in which MRO experts have been involved also to support them. For example, Lufthansa Technik's engineers participated in the so-called A350 customer focus group and supported the manufacturer in the design and development phase of the aircraft with respect to maintainability and maturation.”

Specific Initiatives at MRO Companies

AFI KLM E&M's training programmes are linked to fulfilling all required training and to enable the personnel to fulfill their technical duties.

“More and more we use new techniques to bring our training material to life. Nice example is the augmented reality (AR) technology we use in our technical training department that we developed in in conjunction with NLR, the Dutch Aerospace laboratory,” says Metz.

“On top, we try to familiarise our personnel also with the latest technologies. An interesting development is the Fablab factory we started at Paris Charles De Gaulle airport where we have all new technologies like 3d-printing. And these tools can be used by all our personnel to develop work-related items but also items for private use.

“The reason for this is that we want to expose our personnel to the use of these new technologies so that they get the feeling for it. Once they understand how the technology works and what it can bring they will link these solutions to their day to day working problems and it will stimulate innovation.”

To support the continuous professional development of personnel ARSA is pressing for a focus on career path development that is less concerned with airman certification and more focused on having the right body of knowledge to perform work.

“For too long, the industry has over-focussed on certificated mechanics (who will always be important and are required under the rules) at the expense of flexibility. As systems become more and more advanced – both in terms of necessary flight operations and ‘amenities’ like passenger entertainment and connectivity – we need the biggest possible net for collecting potential technicians, engineers and support staff," says Levanto.

“The most successful examples are organisations that have stopped hiring A&P mechanics and instead hire non-certificated personnel that enter ‘helper’ training programmes through which they gain the necessary experience for their certificate. By doing so, companies can tailor the experience exactly to the work being performed, hire for ‘character’ and willingness to work/learn rather than credential and make a much bigger impact on the lives of the people they employ.”

Lufthansa Technik is increasingly looking at developing its team members not only on technical topics but also at supporting their personal development, such as interacting with colleagues, customers and peers.

“Risk assessment and management in daily life is not only an upcoming requirement but already part of our maintainers’ daily operations around the aircraft in a much more structured way and through understanding,” says Konarov.

“Parts of the classical leadership training and development are more and more provided not only to leaders and potentials but also to team members. Empowerment and self-managed teams are getting more common and not anymore just HR buzzwords.”

institutiondiagnosticengineers.org
If you are reading this page and wondering why you might consider subscribing to the Institution, here are a few compelling reasons.

One of the key benefits of subscribing is that you may use the following postnominal letters to prove your dedication to your profession.

SIDiagE. (Student Member)
MIDiagE. (Member)
AMIDiagE. (Associate Member)
FIDiagE. (Fellow)

Diagnostic Engineers Community Network

At the heart of DIAGS is the obvious but vital benefit of being part of a group of like-minded people, thinkers and people who resolve through knowledge.

It's not only a community to build your professional network, get in touch with other diagnostic engineers and find support when you need it, but as your career develops and you grow personally you will be able to use your experience and enthusiasm to inspire the next generation of diagnostic engineers.

Diagnostic Engineers Communications for Subscribers

Be the first to know about what’s happening at the Institution and to find out about your industry news, features, events and developments.

The new and occasional DIAGS What’s the Buzz newsletter will be circulated electronically in pdf and eReader formats to subscribers. The newsletters aim to keep members up to date in the diagnostic engineering world.

The DIAGS magazine: ‘Diagnostic Engineering’ has been completely remodelled and restyled. As a subscriber, you will receive notification when a new edition is published. The publication is available to read electronically in pdf or eReader formats. Each issue of the publication is varied in content, with industry news, supported by topical articles and features. Subscribers are invited to submit articles to the magazine for publication.

The DIAGS Website

Unlimited access to the new and ever-growing website. Not only a space where we’re developing an invaluable online resource to help you in your day-to-day work and research, but it’s also a library of news, events, training courses, links to magazine back issues, articles and helpful links to other interesting resources.

E-mail: info@institutiondiagnosticengineers.org Web: institutiondiagnosticengineers.org
3D Scanning and Fusion 360 in Traditional Boat Building

Using modern day technology in traditional craftsmanship

The Cotswolds, a region of outstanding natural beauty located in the heart of the UK, is not where one might expect to find a boat builder. For Daniel Lee, building a boat is the ultimate woodworking project. Lines on a boat are very rarely straight. This adds a whole new dimension, challenge and beauty to the way of forming a boat, he says.

At the Intersection of Craftsmanship and Technology

Boats and wood have both been Daniel’s passions since a very young age. He loves the combination where the two meet. His favourite are vintage race boats and runabouts from the pre-war era. He believes the ‘golden age’ of boating dates back to a time when quality and style in wooden boat building were at their peak. The advancement of technology, modern construction methods, design and how this brings constant change to boat building fascinate Daniel.

His father and grandfather have always ‘played with boats’ and wood, so wooden boat building was a natural path of interest for Daniel to end up following. For many years he wanted to get into boat building full time. He has now taken the step into this adventure at the intersection of handcrafting and high-tech equipment.
From Scanning to Manufacturing: Authentic Digital Restoration and Replication with the EinScan H and Fusion 360

1 3D scanning with the EinScan H

Currently, Daniel is working on the restoration of a Stapley ski race boat. He is using the EinScan H Hybrid Light 3D Scanner to digitally capture the entire hull.

As the EinScan H is a very efficient, user friendly and at the same time accessible device, it is the perfect tool for Daniel’s boat-building business. Getting started 3D scanning with the EinScan H is smooth and easy, also in technically demanding environments. It is light and flexible, so even getting it set up in a workshop and manoeuvring it around huge objects for surface capturing is a simple task.

3D scanning with the EinScan H creates an authentic digital image of the boat hull in the EXScan software. The boat was scanned on a medium detail level to an accuracy of 1mm.

2 Reverse Engineering in Fusion 360

In the further process, alongside the restoration of the boat, Daniel is using Fusion 360 to reverse engineer
the scanning data to create mould sets. With this information, he is able to roughly calculate the costs of replicating the Stapley ski race boat with modern construction technologies and materials.

Placement of some equally spaced cross sections or “stations” in order to create the new hull. Combined with a cross-section of the keel, these are used to loft new skins for the boat.

Rough drawing of the new hull, deck and transom components. At this point, the hull isn't faired but the shape is close enough to be able to obtain material quantities for producing a new boat.

Drawing of an approximate layout of the mould. The original boats contain 6 layers of mahogany veneer, laid in opposing diagonal directions over a mould to form a rigid shell. This mould can be made from CNC cut sheets of MDF that will slot together in an egg crate style assembly.

The mould is then skinned with wood battens which would be faired and used to build up the layers of veneer. The outer surface of this mould needs to match the inner shape of the hull.

The last step is the comparison of the scan data to the newly lofted hull skin and transom.

Daniel drew the data up in around 2 hours for the purposes of working out some rough pricing for what a replica of the boat might cost to build. If prices seem feasible Daniel can start to draw the boat up in more detail and do some refinements.

All images in this article are courtesy of Daniel Lee at Dan Lee Boatbuilding.

For more information on Daniel and his work with the EinScan H visit www.danleeboatbuilding.co.uk

BOATBUILDING
New solutions for automation networking and wiring

Not so many years ago, sensors and actuators in automation systems were invariably connected individually to a central control panel, sometimes directly and sometimes via local terminal boxes. As a result, there was a lot field wiring using a lot of expensive cable and terminals. Not only were systems of this type difficult and time consuming to install, but sorting out the wiring errors that inevitably occurred often extended the commissioning time for new plant by days or even weeks.

Small wonder then that the automation sector gave such a warm welcome to fieldbus systems when they first appeared on the market around 30 years ago. Although they all dramatically reduced the amount of field wiring needed, the early fieldbus systems often had technical limitations and many quickly disappeared. The survivors and their direct descendants, however, continue to give good service today.

This shouldn’t be taken to mean that evolution in wiring and networking solutions for automation applications has ceased. In particular, there are some niggling issues with fieldbus solutions that have been around for so long that they’re almost taken for granted, but which have been successfully addressed by recent developments.

The key to many of these developments is the emergence of the IO-Link protocol which is easily integrated into sensors, actuators, and other devices. It is vendor neutral and is supported by most of the leading suppliers of sensors and other field-mounted devices. Put simply, the IO-Link protocol enables point-to-point two-way communication between what would previously have been simple sensors, actuators or I/O blocks.

Several key benefits that are immediately apparent to the user result from the use of IO-Link. The first is the ability to add an IO-Link device to a new or existing system and parameterise it without the complexities that are usually
associated with adding intelligent or smart devices. The second is that an IO-Link device can automatically give the user additional diagnostics down to sensor level without the need for extensive coding in the PLC. Finally, the replacement of a faulty device is simplified as the new device is recognised and its parameters loaded automatically. This eliminates errors and makes it unnecessary for replacement work to be carried out by skilled technicians.

If you have an existing plant that uses fieldbus or network systems, it would be entirely understandable if you were now thinking that, much as you like the idea of IO-Link, you don’t like the thought of having to make extensive modifications to accommodate it. The good news is that you don’t need to. Fieldbus modules are available with “IO-Link master ports”, which let you connect up to eight IO-Link devices to an existing fieldbus installation. There are versions to suit all of the most popular fieldbus systems. So, if you are using EtherCat for example, you can use one of these modules to make a direct connection between your IO-Link devices and your EtherCat fieldbus.

An interesting recent development is the appearance of configurable IO-Link I/O modules, which solves a longstanding fieldbus system design problem. In the past, if the I/O modules in a particular system had eight channels – which is fairly typical – that was fine if you needed, say, eight digital inputs or eight analogue inputs in a given location. But what would you do if you needed four digital inputs and four analogue inputs? Usually the answer was that you had to buy an eight-channel digital input module and also an eight-channel analogue input module then leave half the channels on each unused. Clearly this increases costs.

With a configurable IO-Link I/O module however, any of the eight channels can be set to operate as a digital input, an analogue input or a digital output. So, if you want four digital and four analogue inputs, or three digital inputs, two analogue inputs and three digital outputs, or any other combination of eight channels, one module is all you need. As this module is an IO-Link device you can connect up to eight of them to the new generation of fieldbus modules discussed earlier, which means that a large amount of I/O can be connected to a single fieldbus module.

If you need to send data from your sensors to an ERP system or similar as well as to your control system, there are IO-Link modules that will help with this. They have two network interfaces, one of which can be used for a link to the control system while the other is connected directly to the ERP system. With this so-called Y configuration, data for the ERP system doesn’t have to pass through the control system, which decreases the load on it as well as simplifying the programming required.

Because IO-Link was developed from the outset for automation applications, IO-Link I/O modules support the connection of up to eight IO-Link devices. The devices are connected to the module using standard pre-configured sensor cables, which cuts wiring time dramatically. In addition, the modules are available in versions with high IP ratings which can be mounted directly on the plant without the need for further protection. Modules manufactured from materials suitable for use in the food industry are also available, and these are unaffected by washdown cleaning methods.

In today’s industrial environment, fieldbus and network systems are in many cases the most satisfactory and most economical choice for connecting field-mounted devices. But there are exceptions to this rule. Very simple standalone systems and machines may not benefit from the features offered by fieldbus connections; ordinary wired connections directly to the control system may be all that’s needed.

Even in these cases, however, there are developments that can save money and make life easier. For example, splitter boxes with high IP ratings are available that make provision for the connection of multiple field-mounted devices – typically up to eight – using standard premanufactured cables with plug-in connectors. The splitter box is then connected to the control panel with a single multicore cable.

For small, simple systems, this arrangement is both convenient and cost effective. The splitter boxes take up very little room on the plant and need no additional protection, yet they greatly simplify wiring and make maintenance easier as, if it is ever necessary to replace a field-mounted device or its connecting cable, all of the connections simply plug in – no screws, no terminals! And even for these simple systems, useful accessories are available such as T-splitters which allow a connection that would normally serve just one field device to serve two.

As we have seen, wiring systems for field-mounted devices have come a long way in the last two or three decades, but to get the best from them it’s important to stay on top of recent developments, even in simple systems where a fieldbus implementation isn’t appropriate.

With thanks to Industrial, Plant and Maintenance where this article was first published.
There is a big difference between preventive and predictive strategies. To predict or to prevent? That is the question.

It’s a well-known fact that prevention is better than cure. When it comes to industrial equipment, emergency repairs are notorious for causing extended unplanned downtime, so tackling problems before they occur is generally seen as the best approach. However, there is a big difference between preventive and predictive strategies.

According to a new report published by maintenance specialist Senseye, manufacturers experience an average of 27 hours of downtime a month because of equipment failure, resulting in multi-million revenue losses by the end of the year.

With manufacturers striving to cope with rising competition, rapidly changing consumer trends and an unprecedented pressure to deliver high-quality products quickly, these losses can seriously compromise business’ bottom lines.

Taking care of existing equipment is one of the most effective ways for manufacturers to minimise costs while delivering on customers’ expectations. As Darren Halford writes in EU Automation’s BoOM – The Book of Obsolescence Management, which can be downloaded from our website: “There is an old adage in Britain that goes if it ain’t broke, don’t fix it. It means you shouldn’t tamper with things if they are running smoothly. If we want innovation to prevail, this proverb shouldn’t be taken literally. Although it might seem counterintuitive, sometimes the best option is to maintain the status quo. This is often also the most cost-effective solution.”
Historical vs real-time data

Preventive — or preventative — and predictive maintenance are often used interchangeably to refer to maintenance strategies that allow manufacturers to act before equipment fails. Both methods are vastly superior to reactive maintenance, where equipment is run to failure until emergency repairs are needed.

However, preventive and predictive are not the same thing. Preventive maintenance involves carrying out checks at regular intervals, regardless of the equipment’s condition. It relies on best practice guidelines and historical data to give plant managers the best chances to keep machines in good repair, but requires cyclical planned downtime. Moreover, planned checks might be scheduled too infrequently or too late to react to sudden changes in the equipment’s condition, meaning that this method might not always succeed in spotting problems in a timely manner.

On the other hand, predictive maintenance occurs only when needed, relying on real-time data from IIoT-connected equipment to identify potential threats before it’s too late. In this way, repairs address an actual problem and are more targeted, meaning that downtime, when required, will be generally shorter compared to other maintenance methods. The use of real-time data also means that manufacturers can react almost instantly to potential threats.

As competition increases and manufacturers struggle to keep up with rapidly changing trends, predictive maintenance can be a blessing. As Jim Davison, region director of the South of England at Make UK, recently commented: “predictive maintenance can play a crucial role in not only reducing costs, but also boosting productivity at a time when manufacturers need to be using every tool at their disposal to meet the demands of an ever-changing industry.”

The problem with big data

Predictive maintenance has clear advantages, but relies on technologies for continuously monitoring equipment and gather valuable data — an approach also known as condition-based maintenance. While the devices to collect data can be relatively inexpensive and easy to set up, processing that data to draw relevant information on the machines’ health is the challenging part.

IBM estimates that about 90% of all data generated by sensors never get used. This means that manufacturers miss opportunities to make informed decisions about their equipment, while still paying to collect and store unused data. Data that are collected but not processed or used in any way are known as dark data and represent a huge challenge for the industry.

Dark data can offer manufacturers an untapped resource for potential insight, or may be a costly waste of space, which is why enforcing data policies and training staff on the handling and analysis of data is the first step to manage this information more effectively.

Another issue with big data is the presence of data silos, where data is processed and relevant patterns are discovered, but the resulting insights are not shared among the different departments of an organisation. This can happen because the business doesn’t have the necessary technology in place for data visibility, for example it might lack a unified integrated data management (IDM) tool, and every team might rely on different platforms.

For example, data suggesting that an electric motor is overheating might be available, but if the C-suite don’t share it with the maintenance team on the production floor in a timely manner, the motor might be doomed to failure.
Technology that helps

Having sensors to gather significant information on your equipment is the first step to incorporate predictive technique into your maintenance strategy. Recent machines normally come with a variety of options for real-time data acquisition, but legacy equipment can also be retrofitted with inexpensive add-on sensors.

As a matter of facts, predictive maintenance can be a huge help when dealing with aging assets, which require careful planning when sourcing obsolete spare parts. Retrofitting older assets offers the possibility to not only keep machinery in operation for longer, but also to improve operations by collecting data that could be used for process optimisation.

However, the impressive amount of dark data in the industry, coupled with the pervasive issue of data silos, shows that gathering data is not enough. To predict equipment failure effectively, manufacturers should implement technologies that facilitate real-time data processing and that allow all relevant personnel to have access to the resulting insights.

In this sense, edge computing can be a valuable solution. One of the problems with data from industrial equipment is that the older it gets, the less relevant and accurate it becomes. By analysing data as close as possible to the source, rather than sending it all to the cloud, edge computing minimises latency and supports real-time decision making.

Edge computing can also help deal with another issue that comes with connecting more equipment to the IIoT — cybersecurity. When data travels back and forth from the cloud, there is an increased risk that it might be compromised. Processing data closer to the source reduces this risk, offering the advantages of increased digitalisation without opening up more potential attack surfaces. This doesn't mean that processing or storing data in the cloud should be avoided at all costs, but simply that the two options can go hand in hand to maximise results.

Another priority should be the convergence of information technology (IT) and operational technology (OT). These used to be managed by separate teams with different skillsets, but the increased digitalisation of manufacturing processes, including maintenance, means that there is now the need to bring these areas together. OT collects raw data from PLCs, motors, sensors and other key equipment, while IT gives the data meaning by uncovering relevant patterns. However, for this to work, both equipment and teams must communicate and collaborate proactively.

Implementing technology for data acquisition and processing can require a sizable initial investment and, most importantly, a radical cultural shift in manufacturing plants. However, the results in term of reduced downtime and increased efficiency will give manufacturers the competitive edge they need to prosper in an increasingly digitalised world.
Pure Innovation is a new section in the Diagnostic Engineering Journal. Each edition, we showcase some far reaching concepts and innovative thinking at various stages of development. In some cases the concepts already are, but in others, may shape our future engineering processes and procedures in years to come.

Clawed Robot Mimics Bird Landing and Perching

Stanford University have biomimetic clawed robot land and perch on branches different shapes and sizes.

SNAG (stereotyped nature-inspired aerial grasper) is based on the legs of a peregrine falcon. 3D printed structures mimic bones, while motors and fishing line replicate the bird’s muscles and tendons. Each of the robot’s legs has a motor for moving back and forth and a second motor for grasping. A tendon-like mechanism in the legs converts the energy from impact with the branch into grasping force, triggering a high-speed clutch in around 20 milliseconds. Once the claws are locked on to the branch, an accelerometer confirms the landing and initiates a balancing algorithm to stabilise the robot.

“It’s not easy to mimic how birds fly and perch,” said William Roderick, a graduate student from the labs of Stanford University engineers Mark Cutkosky and David Lentink. “After millions of years of evolution, they make take-off and landing look so easy, even among all of the complexity and variability of the tree branches you would find in a forest.” The researchers attached SNAG to a quadcopter drone to test how the grasping platform could catch and carry objects, as well as perch on various surfaces. During COVID-19, Roderick moved equipment from Lentink’s lab at Stanford to rural Oregon where he set up a basement lab for controlled testing. He sent SNAG along a rail system that launched the robot at different surfaces and at different speeds to see how it performed in various scenarios. Roderick also confirmed the robot’s ability to catch objects thrown by hand, including a prey dummy, a small bean bag and a tennis ball.

Solution for Next-Gen Bionic Eyes Developed

Researchers in the UK and China have developed a new technology solution to provide low-power systems for use in bionic eyes. The solution has been jointly developed by academics from the Harbin Institute of Technology and Northumbria University.

Bionic eye implants work inside the existing eye structures or in the brain. They are designed to achieve functional vision goals as opposed to physical, cosmetic ones. Several bionic eye implants are in development but currently very few are available and are
suitable only for blindness caused by specific eye diseases. However, as research continues, more people may soon benefit from high-tech bionic eyes.

Working in partnership with a research group led by Professor PingAn Hu from the Harbin Institute, Northumbria’s Professor Richard Fu described the newly developed method for controlling the artificial synaptic devices used in bionic retinas, robots and visual prostheses as a ‘significant breakthrough’.

Researchers discovered that injecting elements of the soft metal, indium, into a 2D material called molybdenum disulphide (MoS2) could improve electrical conductivity and reduce power consumption of the optical synapses used in the development of bionic eyes.

According to the team, the technology was then tested within the structure of an electronic retina and found to produce the high-quality image sensing functions required.

“The current visual systems are based on physically separated sensors, memories and processing units,” said Professor Fu, an expert in shape memory, piezoelectric thin films, nano-materials and nanodevices.

Avnet Silica has announced details of its work with a German startup company that is using advanced IoT networking to help prevent the spread of forest fires across the world. Dryad is a Berlin-based company that has developed advanced sensing nodes and highly distributed networking technology. Designed to overcome constraints such as the lack of power and connectivity in forests, its Silvanet solution consists of three pieces of hardware; proprietary RF networking that extends the reach of the low-power and low-data-rate LoRaWAN communications protocol; and a cloud analytics platform.

The first element is the solar-powered Silvanet Wildfire Sensor node, which measures standard environmental conditions including concentrations of various gases. It uses a low-power microcontroller that integrates LoRaWAN support and machine-learning processing. These devices connect to solar-powered Silvanet Mesh Gateways. Dryad has been able to extend the typical LoRaWAN network via proprietary technology to link the gateways and form a mesh of star networks, which together can reach deep into a forest.

These two elements create an ‘Internet of Trees’ that reaches the internet via the Silvanet Border Gateway, which can be placed at the edge of forest and acts as a LoRa gateway and implements 4G, or 2G/GPRS connectivity if necessary. The final element is the Silvanet Cloud Platform, which provides a complete solution for wildfire detection and monitoring. The platform can group sensor devices and gateways either by geographical area or by characteristics.

The forest environment presents an enormous challenge for implementation. For example, the system must use supercapacitors to power the sensors rather than using potentially toxic and flammable rechargeable batteries. And, in addition to the hardware, which must be produced at the lowest possible cost to enable wide deployment while also being rugged enough to ensure long operating lifetimes, also necessary is firmware development for energy-constrained data analytics, over-the-air update support, IoT security and LoRaWAN standards compliance. All this must be achieved with equipment working at low power with solar panels that are often in shade. Additionally, RF communications is a challenge as every tree is an obstruction that absorbs radio waves.
SUPERABSORPTION UNLOCKS KEY TO NEXT GENERATION QUANTUM BATTERIES

Researchers at the University of Adelaide and their overseas partners have taken a key step in making quantum batteries a reality. They have successfully proved the concept of superabsorption, a crucial idea underpinning quantum batteries.

“Quantum batteries, which use quantum mechanical principles to enhance their capabilities, require less charging time the bigger they get,” said Dr James Q. Quach, who is a Ramsay Fellow in the School of Physical Sciences and the Institute for Photonics and Advanced Sensing (IPAS), at the University of Adelaide.

“It is theoretically possible that the charging power of quantum batteries increases faster than the size of the battery which could allow new ways to speed charging.”

To prove the concept of superabsorption, the team – who published their findings in the journal Science Advances – built several wafer-like microcavities of different sizes which contained different numbers of organic molecules. Each was charged using a laser.

“The active layer of the microcavity contains organic semiconductor materials that store the energy. Underlying the superabsorbing effect of the quantum batteries is the idea that all the molecules act collectively through a property known as quantum superposition,” said Dr Quach.

“It is theoretically possible that the charging power of quantum batteries increases faster than the size of the battery which could allow new ways to speed charging,” said Dr Quach.

“As the microcavity size increased and the number of molecules increased, the charging time decreased.

“This is a significant breakthrough, and marks a major milestone in the development of the quantum battery.”

The idea of the quantum battery has the potential to significantly impact energy capture and storage in renewable energy and in miniature electronic devices.

By 2040, energy consumed by people is expected to have increased by 28 per cent from 2015 levels. The majority of energy will still come from fossil fuels at great cost to the environment. A battery that is capable of harvesting and storing light energy simultaneously would provide significant cost reduction while reducing the unpredictability of energy from solar technologies.

The next step is to develop a fully functioning quantum battery prototype.

WASTE GLASS IMPROVES INSULATING PROPERTIES OF CONCRETE

Waste glass could find use in 3D-printed buildings after researchers demonstrated that concrete made with ground-up glass has better insulating properties than more traditional concrete mixes.

The researchers found that when they gradually replaced a conventional aggregate traditionally found in concrete with waste glass, the thermal conductivity of the concrete went down. The results could prove timely to those interested in 3D printing in construction and aiming to prove the technology with better insulated, more environmentally-friendly buildings.

“Although much of our waste glass can be recycled to produce new glass products, a big quantity is still being sent to landfill,” said Dr Seyed Ghaffar, lead of the Additive Manufacturing Technology in Construction Research Group at Brunel University London. “So, to reduce the waste glass that is sent to landfill, different recycling strategies need to be investigated.”

Dr Ghaffar believes the construction industry could be one potential destination for the unrecycled glass, a partial substitute for the vast
quantities of natural sand that is currently being used to meet
global demand for concrete.

The team estimate that around 2000 recycled beer bottles
could be used per square meter, if used in the 3D printing of
a building.

Published in the Journal of Building Engineering, the research
showed that when used as a substitute for basalt aggregate, a
substance that already provides good insulation, glass waste
had a thermal conductivity almost a fifth lower.

“To be specific, the samples with 50 per cent and 100 per
cent waste glass volume substitution had lower thermal
conductivity by 11 per cent and 17 per cent, respectively,”
said Dr Mehdi Chougan, a Marie Curie Research Fellow in
Brunel’s Department of Civil and Environmental Engineering.
“But it’s also worth noting that the thermal conductivity of
soda-lime glass – the most common type of glass, that you’d
find in windows and bottles – is more than three times lower
than that of quartz aggregate.”

According to Brunel, the team also discovered that the
addition of ‘expanded thermoplastic microspheres’ – spheres
of polymer filled with gas – provided an additional boost to
its thermal properties whilst also increasing the viscosity of
the poured concrete.

“Simply, they can be explained as a micro ‘balloons,’ which
upon heating exhibit tremendous volume expansion,” said
co-author Dr Pawel Sikora, an associate professor in civil
engineering at Poland’s West Pomeranian University of
Technology in Szczecin.

“The team will now begin scaling-up the project and 3D
printing demonstration walls to get a better understanding
of their thermal and mechanical performance.”

NEW IMAGING TECHNIQUES CAN REVEAL
EARLY SIGNS OF CONCRETE DAMAGE

Small cracks in a painted cement block are barely visible under ambient lighting (left)
but show up clearly in the near-infrared image (right) (Credit: Weisman Research
Group/ Nagarajaiah Group/ Rice University)

The method, which potentially provides a new way of
monitoring cement and concrete structures, such as bridges
or nuclear power plants, was discovered by chance at Rice
University in Houston, Texas. A collaboration between research
groups at Rice and the Kuwait Institute for Scientific Research
found that common Portland cement contains microscopic
 crystals of silicon, which emit near-infrared fluorescence when
illuminated with visible light.

The finding led to two realisations:
1) that the exact wavelength can be used to identify the type of
cement in a structure;
2) that, perhaps more importantly, the near-infrared emission can
reveal tiny ‘microcracks’ which are invisible to the naked eye.

The process is enabled by applying a thin coat of opaque
paint to the concrete when it is new. In near-infrared scans,
intact concrete appears black and glowing light reveals the
tiny fractures.

First author of the new research, Wei Meng, found the
phenomenon while working on optical strain sensing with
carbon nanotubes.

“This arose from a project in which we were trying to apply
our strain measurement technique to cement and concrete,
but we ran into an unexpected problem when we illuminated a
specimen coated with a nanotube film,” said fellow researcher
Bruce Weisman, a pioneer in nanotube spectroscopy. “We
found that one of the peaks in our film spectrum was obscured
by much stronger emission coming from somewhere. We never
expected it would be from the cement itself.”

The emission’s unusual spectral signature led to the
realisation that the source was pure silicon crystals.

“Silicates are major components of cement, and we
hypothesised that during the high-temperature production
process very small amounts decompose to form microscopic
silicon crystals,” Weisman said. “Their emission wavelength
tells us that they’re larger than about 10 nanometres, but
they can’t be much bigger or people would have noticed
them long ago.”

Meng experimented on small concrete blocks painted
black, with holes drilled in the middle. The holes served as
focal points for the formation of microcracks, which would
propagate outwards when the blocks were compressed, also
cracking the paint. Meng found the fluorescent signal came
through the tiny cracks and could easily be mapped with a
raster-scanning laser.

He said the benefits of better crack detection could extend
beyond bridges and buildings to containment structures at
nuclear power plants, or on ships or the insides of wells and
pipelines that are difficult to access.

“Cement cracking can be an early symptom of failure, so
people who are concerned with the structural integrity and
safety of concrete structures want to detect microcracks
before they grow,” Weisman said.

The research was first published in Scientific Reports.
A bright and shiny new website
https://institutiondiagnosticengineers.org

If you have the old website address saved in your browser, it will now automatically redirect when clicked to the new one.

New look and feel

All the relevant links and contacts

Easy menu navigation

Clear content pages

This website is for you - use it and be informed

New logo

Developing valuable online resources to help you in your day to day work and research

Read relevant feature articles

See upcoming events

Back issues

If you have the old website address saved in your browser, it will now automatically redirect when clicked to the new one.
How many ‘thinkers’ can you find?

Answers in edition #202