Global Cost of Corrosion and CP Impacts

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Global Cost of Corrosion and CP Impacts Bio's

An Introductory Presentation prepared by

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Global Cost of Corrosion and CP Impacts Abstract

- Some of the content of this presentation was previously presented by **Izabela Gajewska** to the UK Parliamentary and Science Committee in October 2024.

- Additional material has been provided by **Eilidh MacDonald** who has a particular experience of some the costs and practical difficulties of Subsea CP installation.

Global Cost of Corrosion and CP Impacts

1. Safety Impact of Corrosion
2. Financial Impact of Corrosion on Society
3. Environmental Impact of Corrosion
4. Solutions to Corrosion Problems
5. Role of Corrosion Professionals
6. Role of Education, Mentoring, Knowledge Transfer
7. CP Cost Considerations
8. Summary

Figure 1: Close up of shiny and rusted metal chains (source: www.alamy.com)

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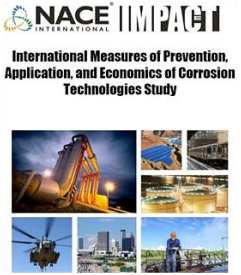
What Can Happen?

1985 – Swimming Pool Roof Collapse in Switzerland
12 people died,
cause – Chloride Stress Corrosion Cracking of stainless-steel rods
(source: HSE)

Financial Impacts of Corrosion

- Global cost of corrosion is **~$2.5 trillion annually** (source: NACE 2016 Study)
- ~3.4% of the global Gross Domestic Product
- 2023 – UK GDP was £2,690 Billion (source: House of Commons Library on-line)
  - If 3.4% of GDP is the UK's cost of corrosion, **corrosion costs UK Plc ~£90 billion per year**
- **~15 to 35% of annual corrosion costs could be saved** (source: NACE 2016 Study)



Annual cost of corrosion in UK ≈ **Annual budget for UK education**

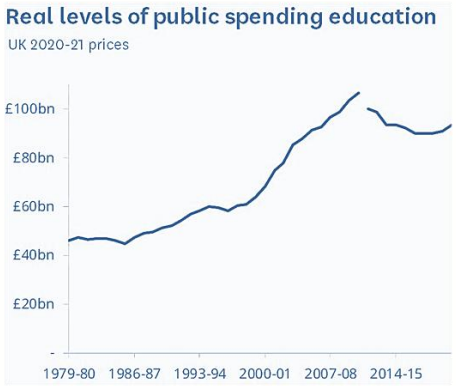


Figure 3: UK education costs over the years (source: House of Commons Library on-line)

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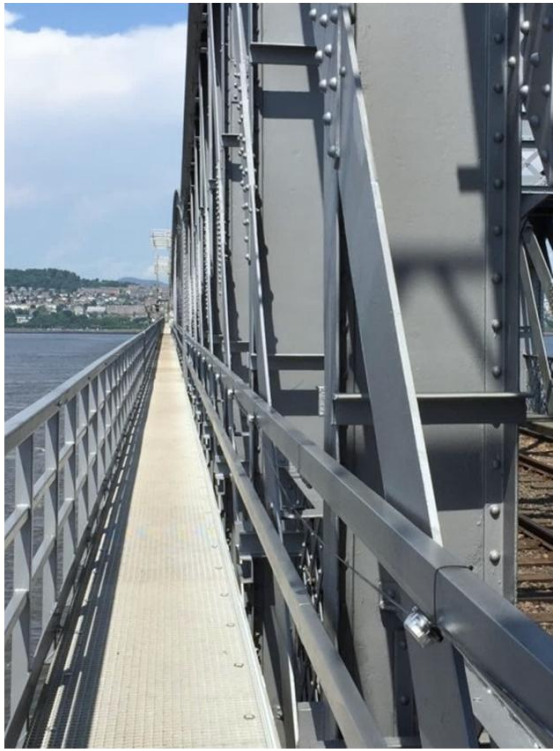
Environmentsl Impacts of Corrosion

Corrosion can cause leaks and spills, leading to environmental pollution. Global CO_2 emissions from steelmaking for replacement of corroded steel are forecasted to be ~4–9% of total CO_2 emissions by 2030 if no appropriate mitigation actions are taken.

(source: Iannuzzi M. and Frankel G. S., 2022)

- Corrosion and associated costs **cannot be eliminated completely**
- **~£10 to £30 billion / year could be saved in the UK**
- **Optimised** corrosion prevention practices can:
  - Improve safety
  - Protect the environment
  - Save a lot of money
  - Reduce inconvenience to the Public, i.e.:
    - **Prevent or reduce water and gas leaks**
    - **Enable more reliable journeys** by preventing corrosion of roadside and trackside infrastructure
    - **Extend life of public infrastructure**
      - e.g., Forth Road Bridge (FRB) cable corrosion led to wires failure. Partial mitigation by dehumidification. FRB replacement could have cost even ~£2.4 billion. A new bridge was built due to weight limits on the damaged FRB."



Refurbished Tay Bridge (Dundee, Scotland), UK's longest rail structure – restoration cost: £75 million (source: www.networkrail.co.uk)

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Solutions to Corrosion Problems

Cost-effective materials selection to match asset life cycle and improve safety & reliability

Effective corrosion risk management

Enabling effective contact between Materials and Corrosion Specialists and Government bodies and communities to facilitate the provision of corrosion control expertise

Appropriate education, training and mentoring to increase competency and corrosion awareness

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Role of Corrosion Professionals

- Fundamental Research
- Development of Products (alloys, coatings, inhibitors)
- Design
- Engineering
- HSE Compliance – COMAH and Safety Cases
- Asset Integrity Management
- Plant & Equipment Engineering
- Plant & Equipment Inspection
- Plant & Equipment Safety

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Role of Education, Mentoring, Knowledge Transfer

Knowledge – one of the most powerful competitive advantages in today's markets

Insufficient competent * Engineers in the UK – up to 59,000 core engineering roles unfilled annually
* Competency = Qualifications + Training + Experience

Knowledge transfer (KT) is particularly important when more senior and experienced personnel is approaching retirement

- Losing expertise due to ageing population in the UK
- Our universities are training students from around the world, many supported by their governments
- **The need to enable and encourage home-grown students into Corrosion Science & Engineering**
  - e.g., ICorr 5 Year Funding for 6 Student Scholarships annually at the University of Manchester

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Approaches to Knowledge Transfer

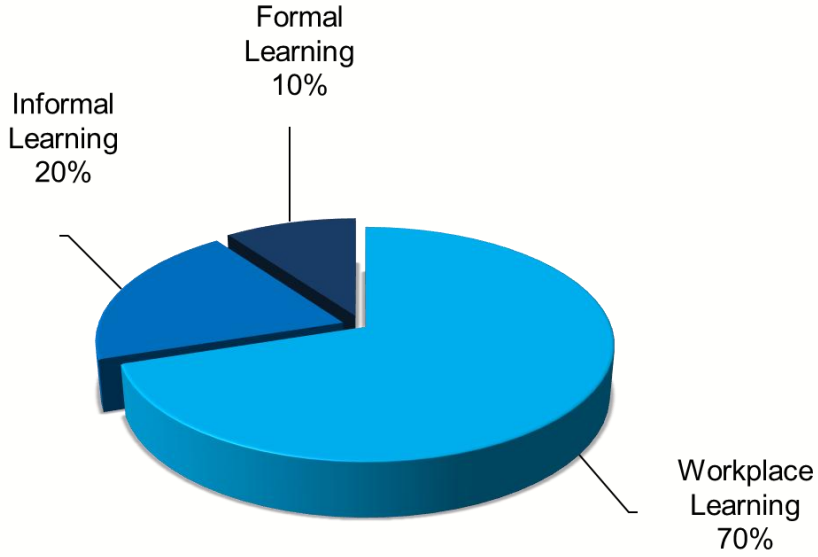

Figure 5: 70:20:10 Model for Learning and Development (Eichinger, R. and Lombardo, M.,1990s)

- Projects
- Work meetings
- Taking notes
- Site visits

- Mentoring
- Appraisals
- Feedback

- Technical books
- Codes & standards
- Training courses
- E-learning
- Conferences

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Mentoring Future Generations of Corrosion Professionals

- **Mentoring – one of the solutions** to corrosion issues
  - Mentors matched with development needs of mentees
  - Clearly defined schedule, regular meetings
  - Technical presentations + talks about corrosion problems and solutions using sketches, images, videos + site-based learning
  - Customised subject-based curriculum – mentoring tool
- **Sharing experience-based knowledge is critical**
  - Mentor's support to be assured, including discussions about issues related to ongoing projects
- **Evaluation of KT**, e.g., presentations, tests, exams

	A	B	C	D
1	SUBJECTS			
2	Downhole & reservoirs	Oil&gas processing facilities	Soft issues: HF, MoC, Creeping Chge, NoD	Internal Corr Mon.
3	Flow lines, gathering lines, trunk lines	Water injection systems	Subsea systems	NDT
4	Main oil lines	Legislation	Corrosion Threats Assessments	
5	Main gas lines	Corrosion mechanisms	Barriers to failure	
6				
7				
8	DOWNHOLE AND RESERVOIRS	% COMPLETION OF BASIC INTRODUCTION	TOPIC	TOPIC
9	Oil & gas reservoirs	90	sandstone / carbonaceous	lifecycle stages of production
10	Offshore production	90	types of installation:	fixed jacket
11	Onshore production	90	types of installation:	single well
12	Production types	90	primary	secondary
13	Tubing	90	purpose	Material grades
14	Well casing	90	purpose	Material grades
15	Xmas trees	90	purpose	types

Figure 6: Customised subject-based curriculum (source: personal collection)

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Societal Impacts

- Advances by Corrosion Engineers / Scientists / Chemists mean that your **car no longer looks like this after a few years**

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Cathodic Protection Cost Considerations

- Cathodic Protection is not a standalone mitigation measure. It is part of a system.
- We need to consider the intended coating system.
- For example, FBE (fusion bonded epoxy) coating vs. 3LPP (3-layer polypropylene)
- FBE coating is a cheaper product but has higher coating breakdown factors and will require more CP protection.
- This will also increase installation costs, as pipeline anodes are installed offshore.

Figure 7: FBE coated pipe

Figure 8: 3LPP coated pipe

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Cathodic Protection considerations electrical isolation

- Consequences of failing to ensure electrical continuity.
- Accelerated corrosion of components
- Electrical continuity checks should be performed for all components not connected by welding.

Figure 9: Umbilical connection showing severe corrosion(source: EEMUA Publication 194)

Figure 10: PTFE coated subsea fastener (source: EEMUA Publication 194)

Cathodic Protection considerations

- Retro-fitting of anodes may need to be considered if:
    - Life extension is required.
    - Design did not consider all components.
    - Current drain occurs to existing infrastructure.
- Anode skids can be connected in this case. Skids are relatively inexpensive, but offshore installation of this can be costly.

(source: forcetechnology.com)

Summary

- Corrosion degradation:
  - Is potentially significant safety and environmental threat
  - Adds significant costs to people and society
  - Indirectly adds to the tax burden
- **Chance to save ~£10-30 billion / year corrosion costs**
- **Shortage of home-grown Corrosion Professionals** in the UK – relatively few universities and colleges offer this training
- **Corrosion & degradation can only be managed by competent Corrosion Engineers & Scientists**
  - Fundamental academic R&D and knowledge transfer are key to managing corrosion, thus enhancing safety, cutting costs, and promoting sustainability.
- **Cathodic Protection (CP) is one widely-used Corrosion Prevention Option for our Infrastructure**
  - Requires Certified Designers/Installers/Inspectors

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Thank you for your attention.
Any Questions?

Advancing Corrosion Science & Engineering

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Aberdeen CAD Event - 2025