University of Nottingham
UK | CHINA | MALAYSIA

MMME2049
- *Safety, Health*

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Who am I?

EHO

EH & Safety Consultant

PhD Ergonomics
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Environmental Science
U. of Salford

Work activities
Workplaces
Work systems
Work Organisation



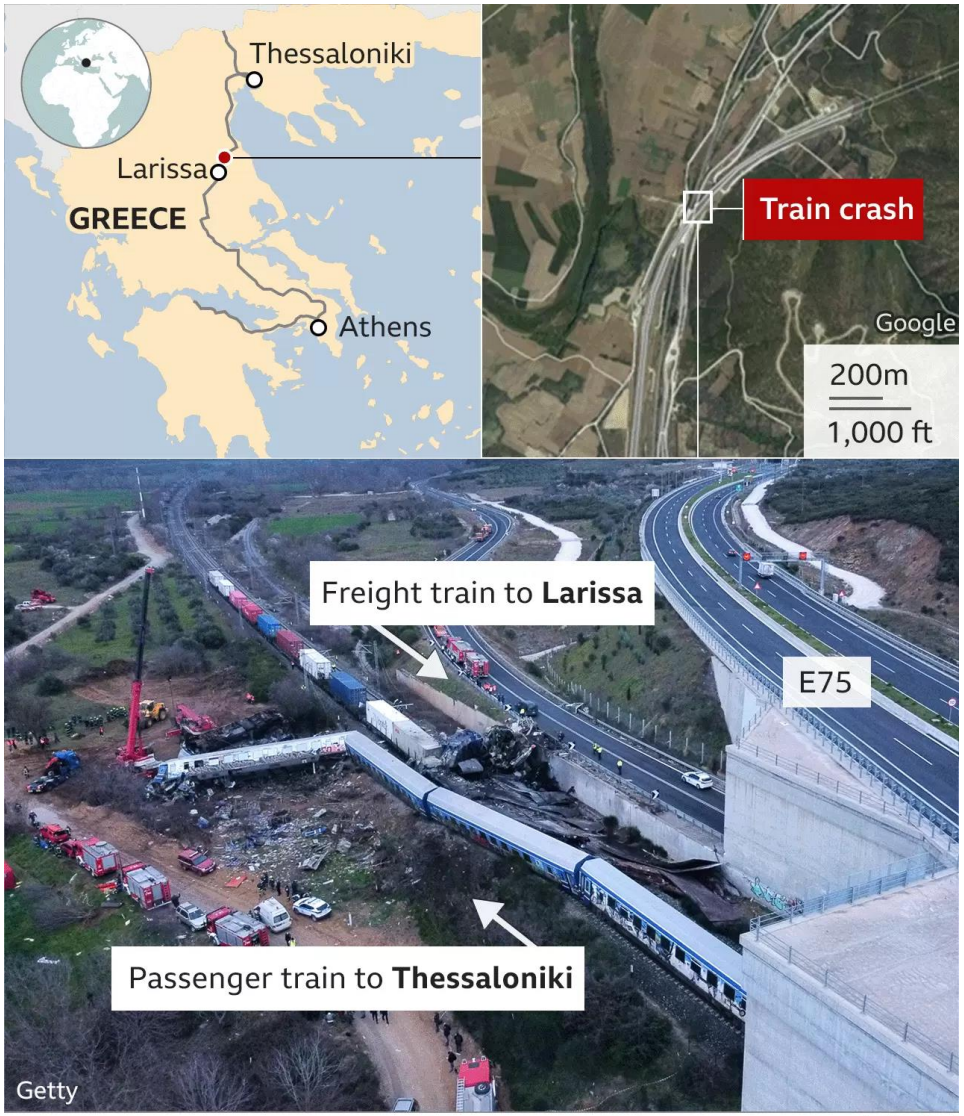


Aims of the lecture

- Provide an introductory overview of safety for engineering students.
- Explain the relevance of safety for engineers, taking account of some different contexts in which engineers may operate.
- Present examples of events when things go wrong, including an opportunity to consider short case studies of safety incidents.

Tempi - Greece

- 28 Feb 2023 Passenger service carrying 350 people collided head on with a freight train
- First four carriages of the passenger train derailed and first two caught fire
- At least 57 died
- Earlier incident in the day leading to delays in trains
- Station manager allowed the train to pass red signals
- Claims of problems with a switch (points), which should have put trains on different lines
- ETCS system intended for implementation in 2020, but put back to late 2023



East Palestine, Ohio

- 3 Feb 2023 1.7 mile freight train carrying various dangerous chemicals partly derailed and caught fire
- Still burning several days later
- Controlled burn to reduce the risk of explosion
- Toxic cloud engulfing a local rural community with 1800 people
- Dioxins and PFAS (Polyfluoroalkyl Substances-”forever chemicals”) leaking into the soil and water supplies
- Potential health effects on first responders

Some general points to be discussed

- Safety is not a matter of common sense
- Safety is not the only goal .. but of course it is a really import at one.
- Predicting problems is not always possible
- Safety can be viewed as a science .. there are many methods to study this… and these are not always quantitative
- Solving problems is also not straightforward

Accidents, errors

- Has anyone had an accident that they would like to share with us?


Diesel
Diesel
DIESEL ONLY
ULTRA
LOW-SULFUR
DIESEL FUEL ONLY
DIESEL ONLY
Gasoline

Some influencing factors

Influencing factors
- Distraction
- Rushing / urgency
- Incorrect decision (wrong question in this case)
- Wrong mental model / schema
- Design of the equipment and warnings

Outcomes
- Cost, embarrassment

Potential solutions
- Redesign of equipment
- Warning signs?
- Re-training?
- Take more care?

https
mista

What can we learn from this?

- Things go wrong, even in circumstances where things appear to be quite simple
- People can make mistakes (human error)
- Things are not always what they seem – we can be led into making some mistakes
- It can be hard to react and recover from a mistake / error e.g. pressure
- Can we design a better system, more error tolerant?

Faye Dunaway, Warren Beatty
Moonlight and La La land

What is safety?

What is ***Safety***?

- The condition of being protected from or unlikely to cause danger, risk, or injury. *Oxford Dictionary*

- A condition where the number of adverse outcomes was as low as possible *(Hollnagel – describing the traditional view)*

- The ability to succeed under varying conditions, so that the number of intended and acceptable outcomes is as high as possible *(Hollnagel – a new interpretation, changing the definition of safety from 'avoiding that something goes wrong' to 'ensuring that everything goes right'.)*

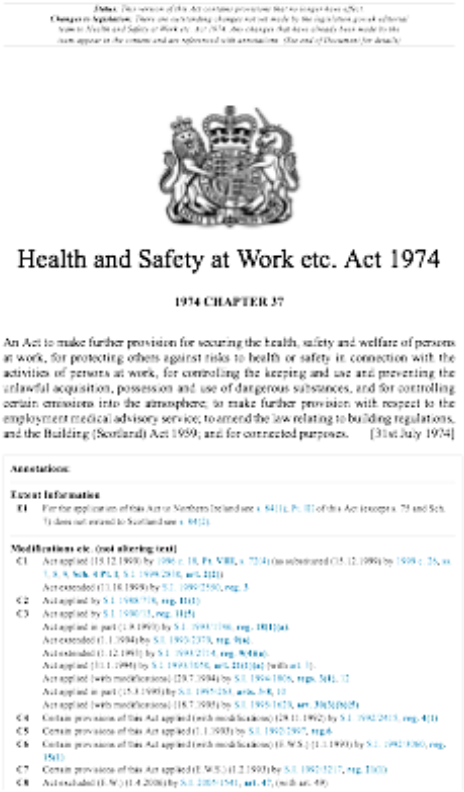
Why do we focus so much on safety?

Why do we focus so much on safety?

- **We have to** – legislation, Codes of Practice, Standards, company rules, processes, procedures
- **We want to** – It is the right thing to do, we are keeping people from harm, Corporate Social Responsibility
- **It makes good business sense**

We have to

- **Legislation, Codes of Practice, Standards, company rules, processes, procedures**
  - The Health and Safety at Work etc. Act 1974
    - Places general duties on: Employers, Employees, Self Employed, Designers, Manufacturers, Importers, Suppliers, etc.
    - "It shall be the duty of every employer to ensure, so far as is reasonably practicable, the health, safety and welfare at work of all his employees". Extends to "persons not in his employment who may be affected by the way he conducts his undertakings"
  - The Management of Health and Safety at Work Regulations 1999
  - The Manual Handling Operations Regulations 1992
  - The Health and Safety (Display Screen Equipment) Regulations 1992
  - The Workplace (Health, Safety and Welfare) Regulations 1992
  - The Provision and Use of Work Equipment Regulations 1992
  - The Personal Protective Equipment at Work Regulations 1992
  - The Control of Noise at Work Regulations 2005
  - Control of Substances Hazardous to Health Regulations 2002 (COSHH)
  - Environmental Protection Act 1990



Health and Safety at Work etc. Act 1974

1974 CHAPTER 37

An Act to make further provision for securing the health, safety and welfare of persons at work, for protecting others against risks to health or safety in connection with the activities of persons at work, for controlling the keeping and use and preventing the unlawful acquisition, possession and use of dangerous substances, and for controlling certain emissions into the atmosphere; to make further provision with respect to the employment medical advisory service; to amend the law relating to building regulations, and the Building (Scotland) Act 1959; and for connected purposes. [31st July 1974]

Annotations:

Extent Information

Modifications etc. (not altering text)

- These are often prescriptive – we must do certain things
- Commonly use principles of *Risk assessment*
- Applies the test of what is *"Reasonably practicable"*

We want to

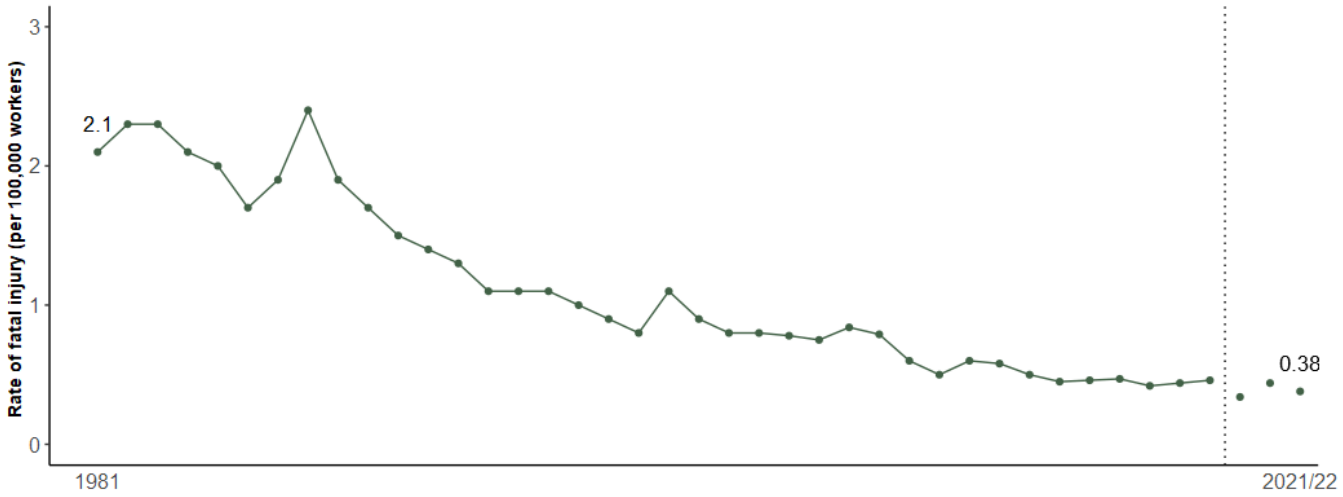
How many people are killed in the UK at work each year? e.g. In 2022?

How many in the year you were born?
Is there a trend?
If so, what could influence this?
Which work sectors are affected and what type of incidents lead to fatalities?
How do we compare with other countries?
Are there any particular problems we need to consider?

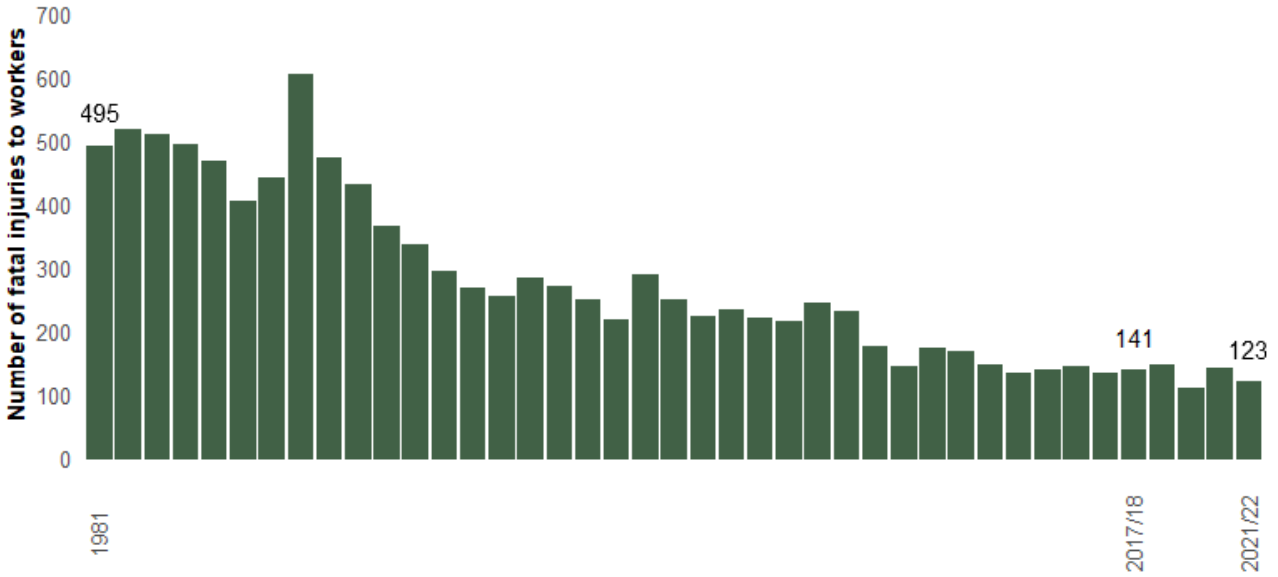
Try to write down answer to these

Fatalities – from HSE, 2022

Rate of fatal injury per 100,000 workers

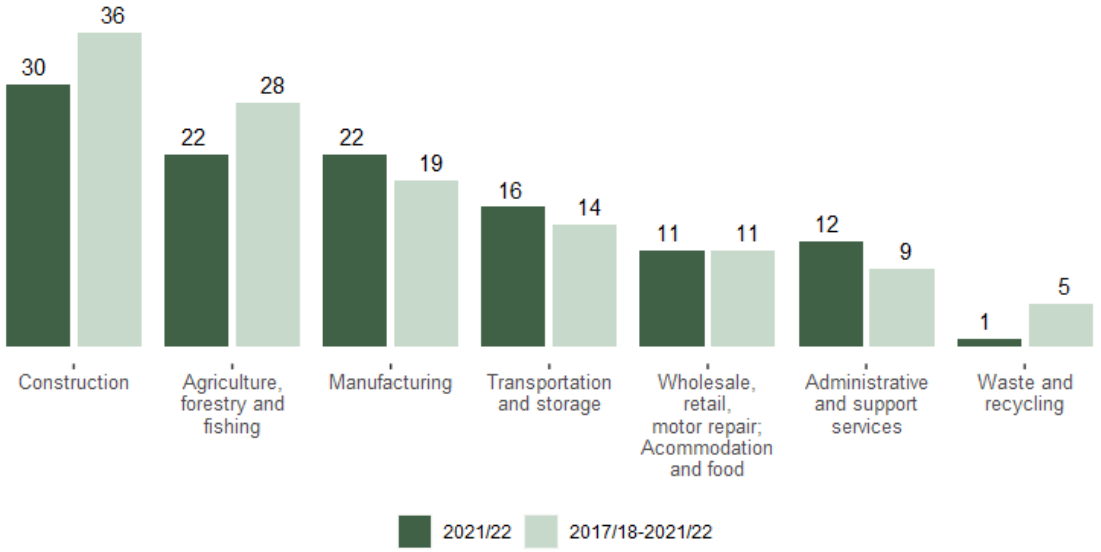


Number of fatal injuries to workers in Great Britain Fatal injuries to workers: GB 1981-2021/22p.

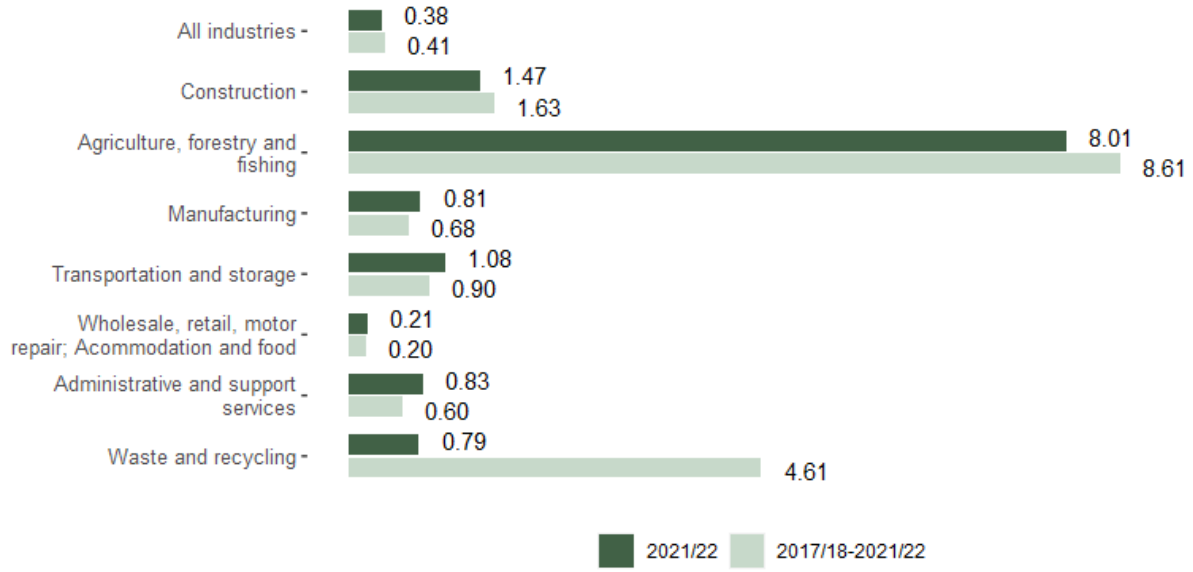


Which industries have the greatest problems?

Number of fatal injuries by main industry group for 2021/22p and annual average for 2017/18-2021/22p.

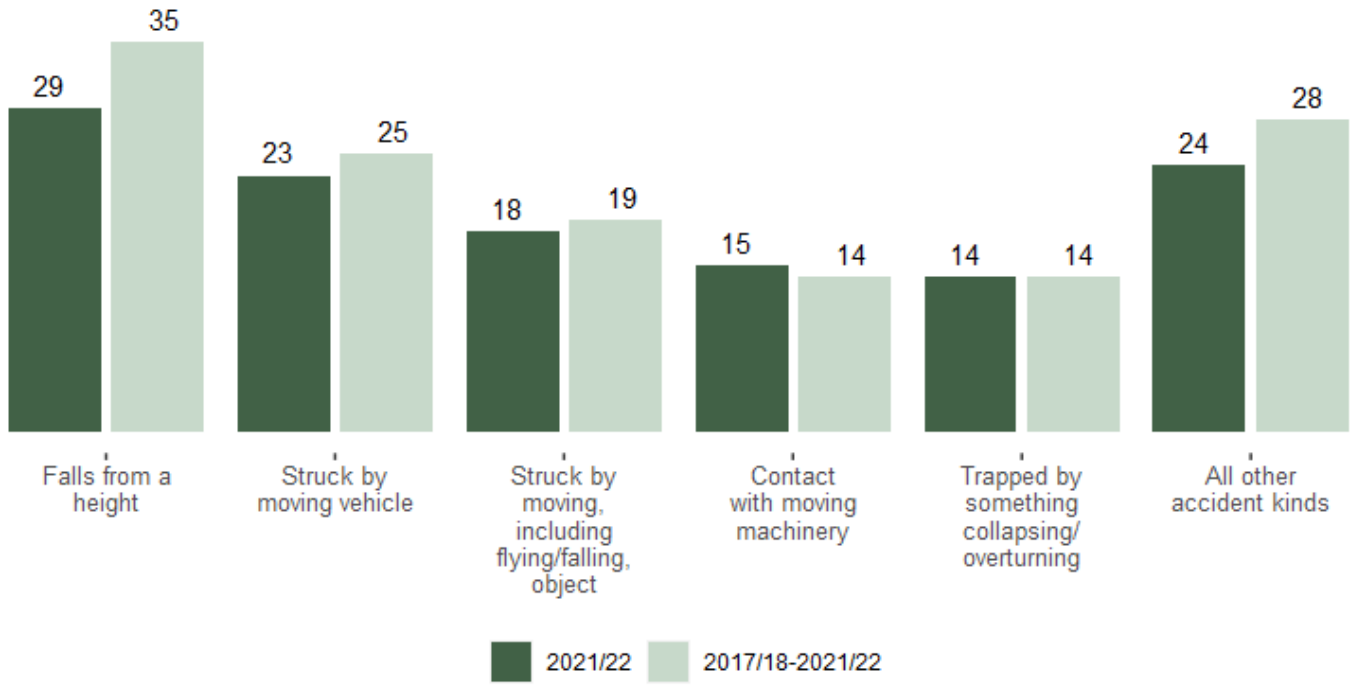


Rate of fatal injuries by selected main industry group (per 100,000 workers), 2021/22p and annual average for 2017/18-2021/22p.



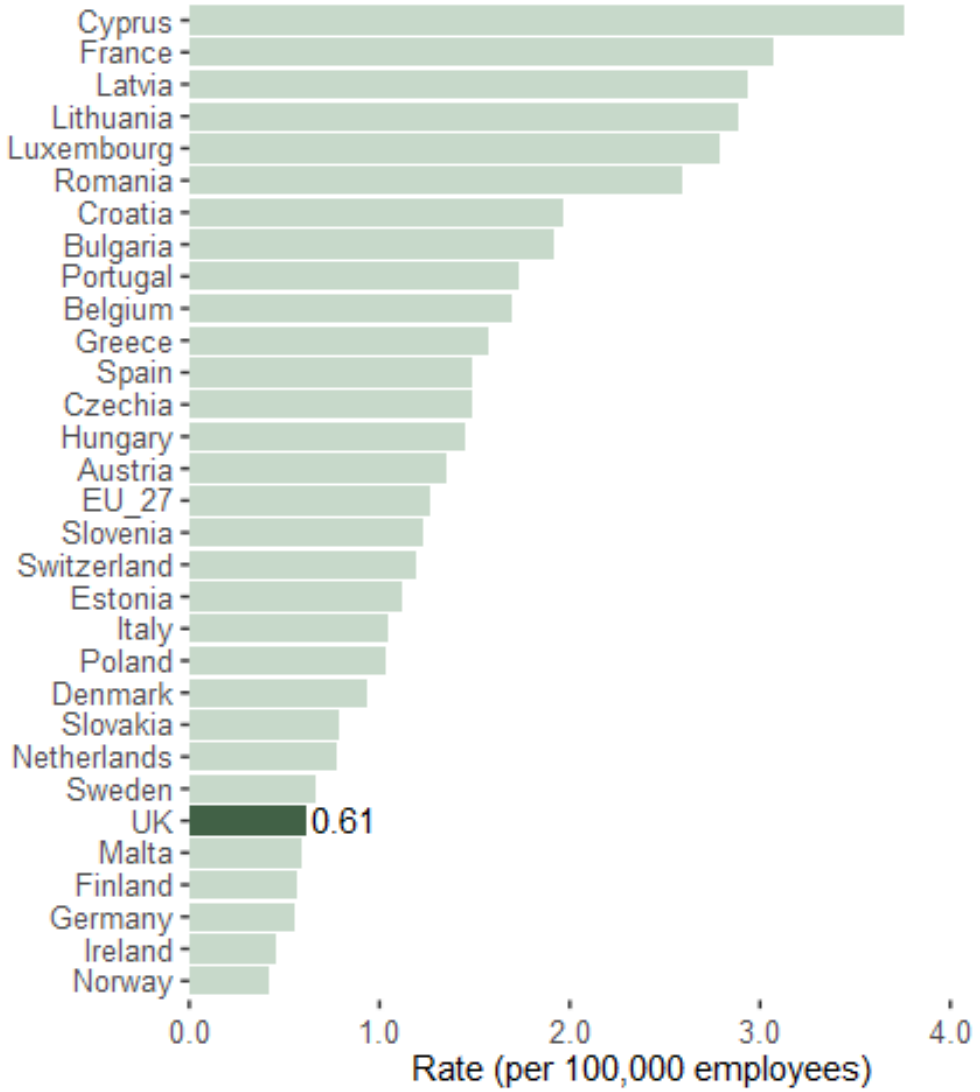
What types of events or activities lead to fatalities?

Number of fatal injuries to workers by accident kind, 2021/22p and annual average for 2017/18-2021/22p.



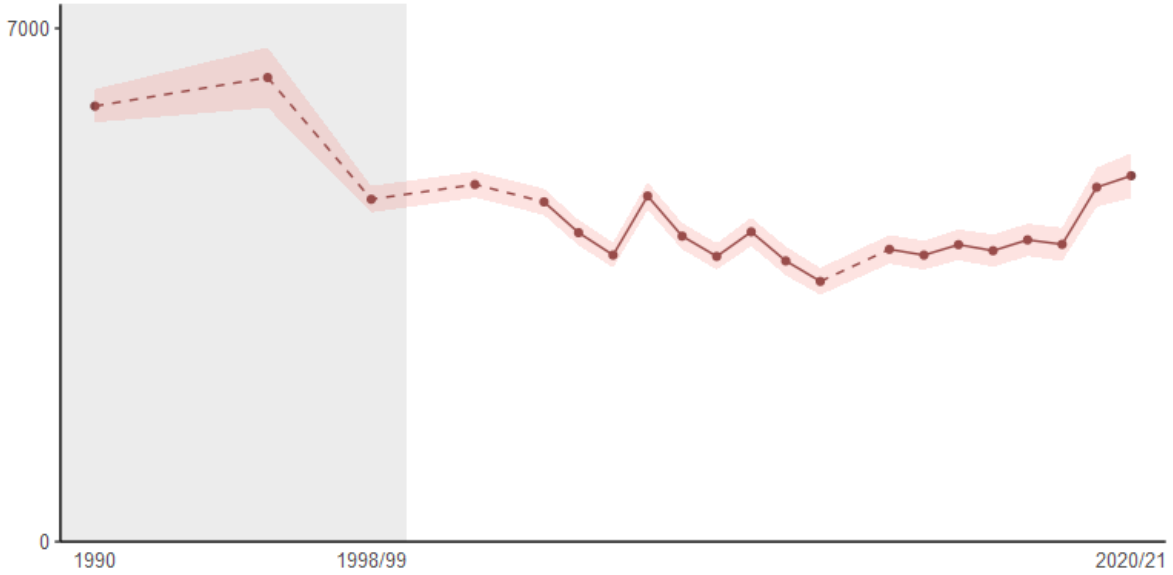
How do we compare with other countries?

Standardised incidence rates (per 100,000 employees) of fatal injuries at work for 2018



Non-fatal work related injuries

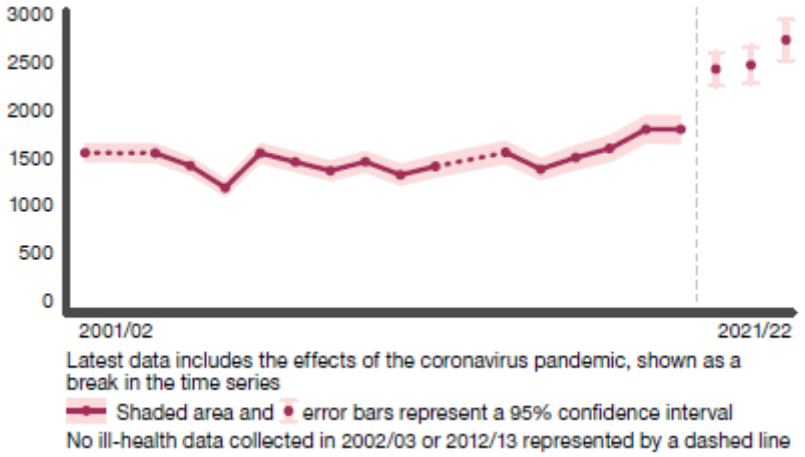
Estimated rate of self-reported work-related musculoskeletal disorders per 100,000 workers, Great Britain (new and long-standing cases)



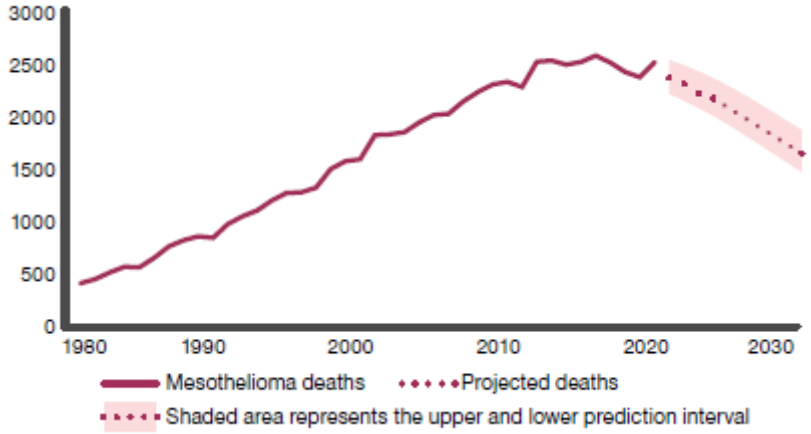
There is generally a downward trend, apart from recently, but where do you think there could still be problems (e.g. upward trend)?

Not all trends are in the right direction

Rate of self-reported stress, depression or anxiety (LFS, Great Britain; estimated rate per 100,000 workers)



Annual mesothelioma deaths and future projections 2030



Transport and airline fatality statistics

- https://www.icao.int/safety/iStars/Pages/Accident-Statistics.aspx

European Transport Safety Council, 2003. Transport Safety Performance in the EU – A Statistical Overview

Tables 1 and 2 show the death risk for the different travel modes in the EU (over distance and time) for the period 2001/2002.

Road (Total)		0.95
Motorcycle/moped	13.8	
Foot	6.4	
Cycle	5.4	
Car	0.7	
Bus and coach	0.07	
Ferry		0.25
Air (civil aviation)		0.035
Rail		0.035

Table 1: Deaths per 100 million person kilometres

Road (Total)		28
Motorcycle/moped	440	
Cycle	75	
Foot	25	
Car	25	
Bus and coach	2	
Air (civil aviation)		16
Ferry		8
Rail		2

Table 2: Deaths per 100 million person travel hours

Interpreting accident statistics

Sidney Dekker & Corrie Pitzer (2016) Examining the asymptote in safety progress: a literature review, International Journal of Occupational Safety and Ergonomics, 22:1, 57-65

- Reports on the plateau in accident numbers
- Industries where incident numbers are low can give a sense of security / safety that is misplaced, with the organisation surprised when the large event occurs.
- Provides commentary on a number of misconceptions around safety practices, including
  - linear causation and complexity,
  - compliance and consistency,
  - risk control,
  - human error,
  - quantification,
  - invulnerability.

- Interesting points around monitoring of safety monitoring – meta-monitoring. Awareness of the models of risk embodied in safety strategies and countermeasures.

Sidney Dekker

We want to

”At its height in the 1920s, 1.2m men were employed and approximately 2,000 died accidentally in pits every year. Today there are just 4,000 miners and each death is national news”

The Guardian - Reality check: how dangerous is mining?

https://www.buzzfeed.com/lauragallant/historical-photos-that-will-make-you-nostalgic-for-the-br?utm_term=.ewAZ5EVJg#.rwgXgPmYj

Stillingfleet Colliery, York, for the last time as the mine closes

But we still have problems

- Part time working
- Self-employment
- Agency work
- Temporary work
- Multi-jobs
- Gig economy work

See the Taylor report – “Good Work”

- It is the right thing to do
- We are keeping people from harm - see the reductions in accident statistics
- Corporate Social Responsibility - more in the lecture on Ethics

It makes good business sense

- This can be demonstrated using techniques such as cost benefit analysis

From http://www.hse.gov.uk/business/business-benefits.htm

"Good practice in health and safety makes sound business sense. You can:

- Protect your workers from the suffering caused by accidents and ill health
- Reduce absences and sick leave
- Retain staff
- Maintain your organisation's reputation
- Boost productivity and profits
- Reduce your insurance premiums and legal costs"

Isn’t safety obvious … common sense?


THOMPSON-STARRETT
COMPANY, INC.
BUILDING CONSTRUCTION
© Getty Images


© Getty Images

Some incidents waiting to happen….

http://www.slideshare.net/jamestl2/top-10-unsafety-awards

It is often trivialised –

Health and safety myths

http://www.hse.gov.uk/myth/myth-busting/index.htm

The myth

Stepladders have been banned!

The reality

Stepladders have not been banned

Different viewpoints, perspectives, contexts

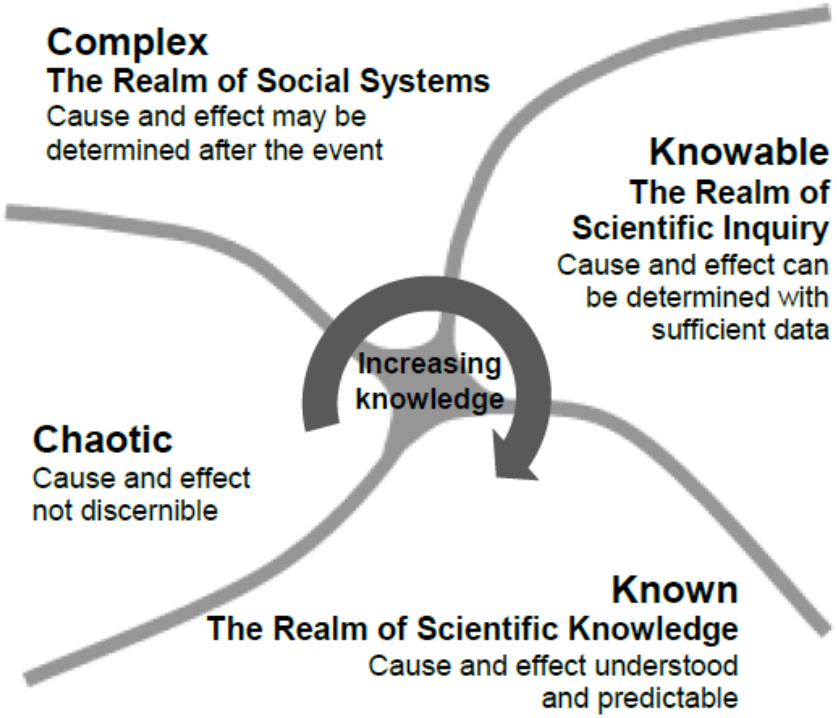
- Safety in the past and present
- Safety in different stages of a project lifecycle?
  - Feasibility, Design, Construction, Operation, Maintenance, Decommissioning, Recycling
- Safety in the future?

What are the things that will affect the safety of people in society in the next 10 to 20 years?

Different viewpoints, perspectives, contexts – safety in the future?

- Risks for older workers,
- New technologies, nano technologies
- New materials and processes,
- Impacts of “big data”,
- New ways of working / living / travelling?
- Driverless cars, flying cars!

Some theory – what do we know about our work systems?



See French

Figure 2: The Cynefin Model (Snowden, 2002)

Where do engineers work, in relation to this model?

Resilience engineering

- What is resilience?

Resilience engineering

- Focus on successes – collect information on what goes right – study work and performance adjustments
- Environments are not stable
- Recognise performance variability – monitor, control, dampen or amplify, anticipate, absorb, adapt to and/or rapidly recover
- Four cornerstones from Hollnagel, (anticipating, monitoring, responding, learning)
- We not be able to observe transient phenomena – unexpected combinations of performance variability – need to be constructed or inferred
- Need – (see Wreathall)
  - The right culture (top level commitment, just culture, learning culture)
  - Good communications throughout the organisation,
  - Preparedness to anticipate problems and respond,
  - Flexibility to adapt,
  - Awareness of proximity to the boundary of safety

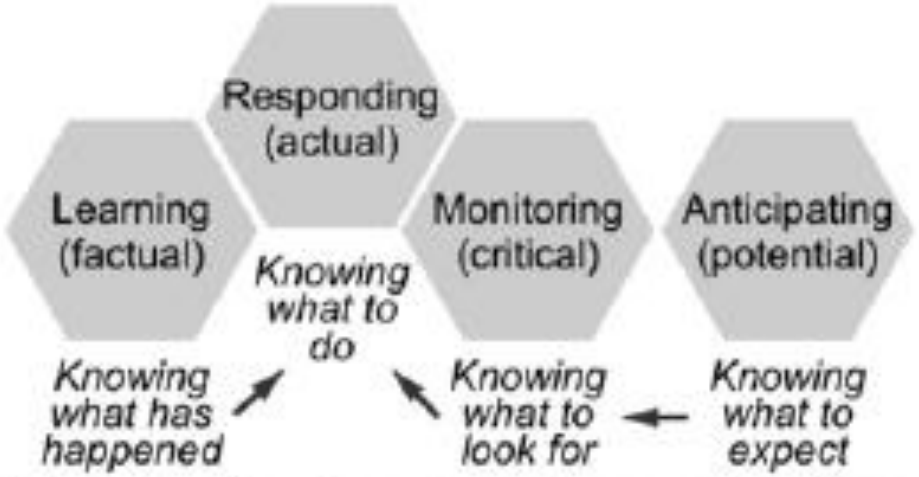


Figure 1. The four cornerstones of resilience (Hollnagel, 2011a, p. xxxvii).

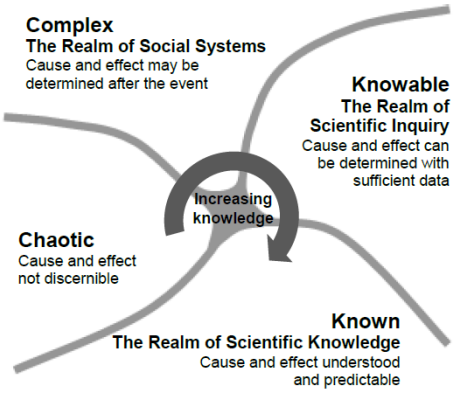


Figure 2: The Cynefin Model (Snowden, 2002)

Besnard and Hollnagel

Myths of safety 1
See Besnard, D., Hollnagel, E. 2014, I want to believe: some myths about the management of
industrial safety. Cognition, Technology and Work, 16 (1), pp.13-23.

- Human error is the largest single cause of accidents and incidents.
- Systems will be safe if people comply with the procedures they have been given
- Safety can be improved by barriers and protection; increasing the layers of protection leads to higher safety
- Root cause analysis can identify why mishaps happen in complex socio-technical systems.
- Accident investigation is the logical and rational identification of causes based on facts.
- Safety always has the highest priority and will never be compromised.

Besnard and Hollnagel

Revisions to the myths
See Besnard, D., Hollnagel, E. 2014, I want to believe: some myths about the management of industrial safety. Cognition, Technology and Work, 16 (1), pp.13-23.

- 'Human error' is an artefact of a traditional engineering view, which treats humans as if they were (fallible) machines and overlooks how performance adjustments are used to match the working conditions.
- Actual working situations usually differ from what the procedures assume and strict compliance may be detrimental to both safety and efficiency. Procedures should be used carefully and intelligently.
- Technology is not value neutral. Additional protection changes behaviour so that the intended safety improvements might not be obtained.
- Human performance cannot be described as if it was bimodal. In socio-technical systems, things that go wrong happen in the same way as things that go right.
- Accident investigation is a social process, where causes are constructed rather than found.
- Safety will be as high as affordable—from a financial and ethical perspective.

Air Canada Boeing 767

- 23 July 1983 – Montreal to Edmonton – Boeing 767-200, 61 passngers and 8 crew
- At 41000ft low fuel pressure warning in left fuel pump – assumed pump failure and alarm switched off
- Moments later, right fuel pump alarm – decide to diver to Winnipeg 120 miles away
- Commenced decent, left engine failed, planned for one engine landing
- All engines out alarm, no power, all instruments went dark, Ram air turbine could power the emergency flight instruments and provide hydraulic support to manoeuvre the aircraft
- But no vertical speed indicator, calculations to determine how far the plane could glide
- Not trained for this

Air Canada Boeing 767 the Gimli glider

- Captain Bob Pearson, 48, 15000 hours flying time – established glider pilot. First officer Maurice Quintal, 36, 7000 hours flying, trained at Gimli (old air force base – now drag racing track – 12-20 miles away) while in the army
- Decommissioned based, no emergency services, but deemed safer option – major race later that day, unknown to pilots
- Gravity drop of heavy landing gear, though light nose gear only partly extended
- Realised that coming in too quickly, too high towards the runway
- No time for 360 degree turn
- Side slip / Forward slip (“crossed the controls”) to increase drag and lose height and speed - employed as a gliding or light aircraft manoeuvre (not known or commonly used in 767)
- Everyone survived, ten minor injuries during evacuation

Air Canada Boeing 767 - cause

- Combination of **technical** (Fuel Quantity Indication system malfunction), **organisational** (communication error in logbook entry, poorly assigned responsibilities for calculating fuel levels) and **human error** (manual fuel calculation– and metric system (767 was the first metric plane in Canada – 5000 litres rather than 20000 litres required
- Pilot initially suspended and demoted, later awarded warded the first ever Fédération Aéronautique Internationale Diploma for Outstanding Airmanship – similar effort to do this by other crews in simulators resulted in crashes

Revisiting the general points to be discussed

- Safety is not a matter of common sense
- Safety is not the only goal .. but of course it is a really import at one.
- Predicting problems is not always possible
- Safety can be viewed as a science .. there are many methods to study this… and these are not always quantitative
- Solving problems is also not straightforward

Summary

- We have looked at some definitions of safety and reasons why an engineer needs to have a good understanding of safety principles, to minimise risk in a range of contexts *(e.g. including all stages of a project lifecycle in the world today, but also consider safety in the development of new concepts and ideas).*

- Accidents / incidents occur in a wide variety of circumstances and involve a wide range of contributing factors. There are methods that can be used to describe and analyse the complexity within systems.

- Examples of a recent accident and a review of recommendations after accident investigations have been presented.

An exercise

- Read about the incident ("ejection seat failure" in the handout)
- Highlight some parts of the text that catch your attention, or write some brief notes on these details.
- Use the checklist to help you do this

- Description of the incident
  - what happened
  - sequence of events
  - injuries / outcomes
- Some contributing factors
  - Multiple people / organisations
  - Physical layout / environment / equipment design
  - Maintenance activities / issues
  - Planning
  - Briefing / instructions
  - Communication
  - Unexpected circumstances
  - Time available, rushing, deviations from usual
  - Safety procedures
  - Changes in plans / decisions
- Safety concepts
  - Rules and regulations, safety instructions
  - Culture
  - Behaviour
  - Risk assessment and control
  - Failsafe design
  - Accident / incident investigation
  - Organisational learning
  - Others?

Some points of interest

- Description of the incident
  - **what happened**
  - **sequence of events**
  - **injuries / outcomes**
- Some contributing factors
  - **Multiple people / organisations**
  - **Physical layout / environment / equipment design**
  - **Maintenance activities / issues**
  - Planning
  - **Briefing / instructions**
  - **Communication**
  - Unexpected circumstances
  - Time available, rushing, deviations from usual
  - Safety procedures
  - Changes in plans / decisions
- Safety concepts
  - Rules and regulations, **safety instructions**
  - Culture
  - Behaviour
  - **Risk assessment and control**
  - **Failsafe design**
  - Accident / incident investigation
  - **Organisational learning**
  - Others?

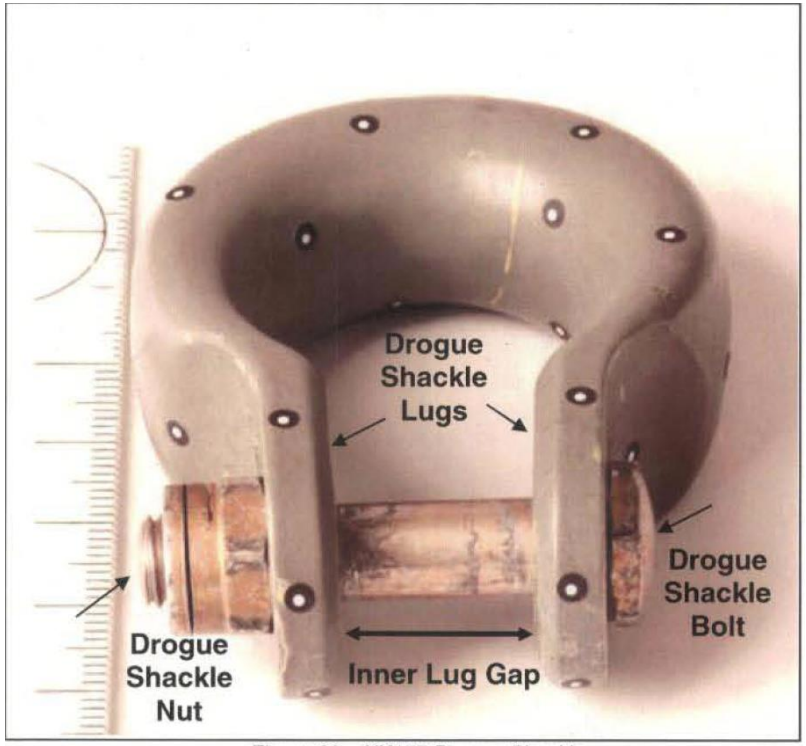


Figure 39 – XX177 Drogue Shackle.

https://www.gov.uk/government/publications/service-inquiry-into-the-accident-involving-hawk-tmk1-xx177

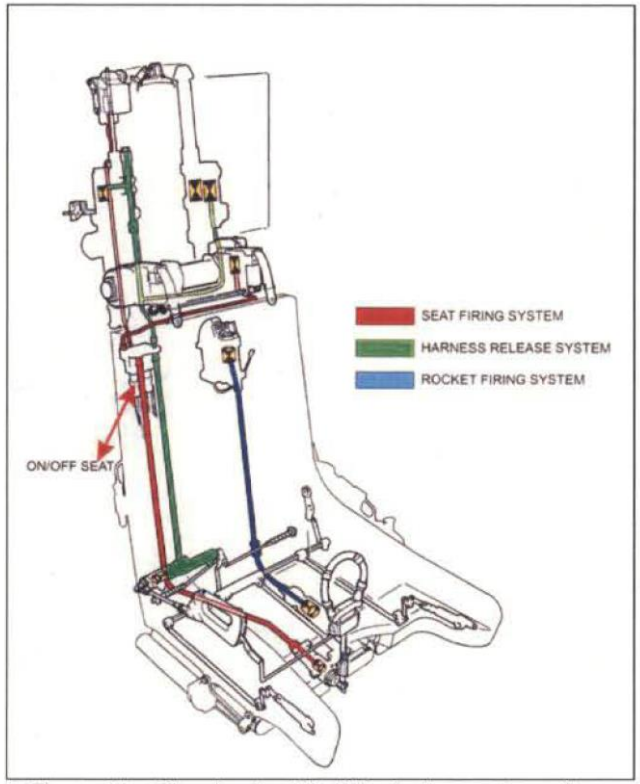


Figure 31 – Showing the Mk 10B ejection seat gas flow.

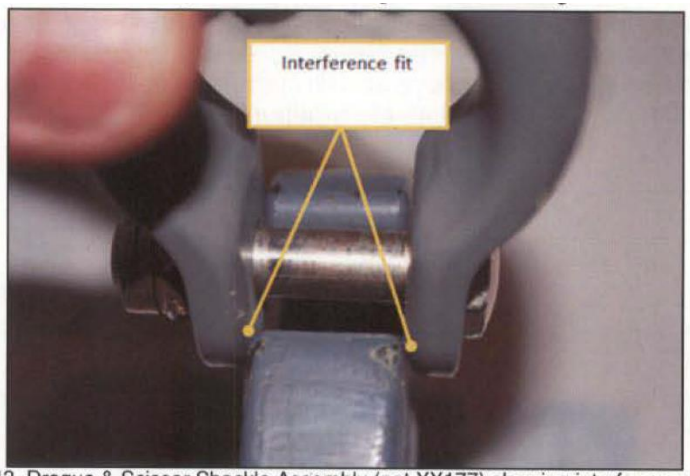


Figure 43–Drogue & Scissor Shackle Assembly (not XX177) showing interference fit.

Figure 46 – Drogue and scissor shackle test rig

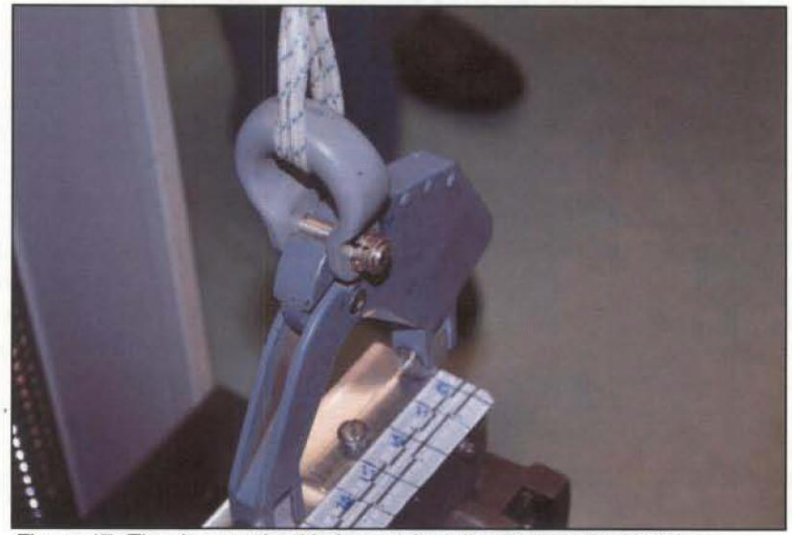


Figure 47- The drogue shackle jammed on the scissor shackle jaws.

Any Questions?

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