

Occupational Safety & Process Safety: Sisters, Cousins or Unrelated?

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The previous work undertaken as part of the *Discovering Safety* programme to deliver a Loss of Containment Insights project was described in a paper to Hazards 29 in Birmingham. This new paper builds upon the work previously described and discusses the value, challenges and scientific rigour needed to extract process safety insights from a dataset which is dominated by apparently occupational safety focused incidents. Findings from process safety incident investigations strongly suggest that process safety and occupational safety have different features and need to be managed in different ways; however it is clear from manual analysis that many minor injury incident records from events occurring in the process industries provide wider intelligence around process plant design, hazard identification and risk assessment. There are several personal injury events which resulted in minor injuries which could have escalated to result in off-site harm. At the same time there are many occupational safety incidents which have no process safety learning associated with them.

This paper describes how natural language processing could be used to extract valuable process safety insights from a wider dataset and explores in particular:

• How wide the crossover between occupational safety and process safety is, by providing examples;

• What biases could be introduced by adopting this novel approach; for example, does the presence of injury over or underrepresent process safety risk and the potential for escalation;

• The proposals to validate the approach using process safety specific datasets and to address biases.

The paper is written with the strong desire to consult again with experienced process safety specialists and subject the proposed approach to rigorous challenge given the novelty and potential limitations of the approach.

KEYWORDS: DATA, LOSS OF CONTAINMENT, HSE, PROCESS SAFETY, OCCUPATIONAL SAFETY

Background

Process safety management is focused upon the prevention and mitigation of high consequence outcomes such as fires, explosions and toxic releases; such events can affect off site public as well as workers within the site boundary. In contrast, occupational safety refers to the prevention and mitigation of events which tend to affect individual workers, such as falls from height and workplace vehicle collisions. For these reasons it is important to manage both occupational safety and process safety issues since both can result in significant and ongoing harm to people.

The Baker Panel review (Baker, Erwin et al. 2007) into the 2005 Texas City refinery explosion stated that '…the panel believes that the presence of an effective [occupational] safety management system does not ensure the presence of an effective process safety management system'. Furthermore, it is also clear that occupational safety metrics associated with a process plant, such as lost time incident rate, are not helpful in assessing the effectiveness of process safety management. This has led to widely published and ongoing work to establish leading performance indicators (HSE 2006) within the process industries which provide better alignment with measures that prevent and mitigate major accidents.

The direction of travel since the Baker Panel report has been to acknowledge the key differences in features between occupational safety and process safety and manage them accordingly. At the same time it has also been observed that poorly managed organisations tend to manage a whole range of topics poorly – quality, customer service, environment, safety etc. In addition, decisions made by leadership such as allocating resources (financial and people) may well have an impact both on occupational safety and process safety.

The work previously presented at Hazards 29 (Clay, Kidd et al. 2019) describes the *Discovering Safety* programme[1] which is an initiative funded by the Lloyd's Register Foundation and delivered through the Thomas Ashton Institute[2]. The Institute is a collaboration between the Health & Safety Executive (HSE) and the University of Manchester. The programme aims to improve plateaued safety performance through better use of data, particularly flawed, chaotic and unstructured data. Within the programme the Loss of Containment Insights project is focused upon onshore process safety issues. The project team are applying Natural Language Processing (NLP) techniques to unstructured text, i.e. 'free text', within HSE's regulatory datasets to extract insights which would not be extractable from coded data. The aspiration is that this will help developing a model which can also be applied to additional unstructured and anonymised industry data with the aim of extracting insights from incomplete, chaotic and repurposed data without imposing further data collection or analysis burdens on 'time poor' end users.

As part of the project, which is led by the need to improve process safety intelligence, the team have also reviewed the available data within HSE, including HSE's main regulatory database, the Corporate Operational Intelligence System (COIN). This database contains approximately 1.5 Terabytes of data, much of which is text occurring in document attachments such as investigation and inspection reports.

[1] www.discoveringsafety.com
[2] https://www.ashtoninstitute.ac.uk/

The limited manual review of the available data shows that there is a large volume of data containing valuable insights. A key finding is that data can exist within unexpected places. It became apparent, for example, that process safety insights may be contained within records which appear at first sight to be occupational safety entries. Noting the lessons learnt about the dangers of using occupational safety as a surrogate measure for process safety performance, it was decided to cautiously explore this issue further.

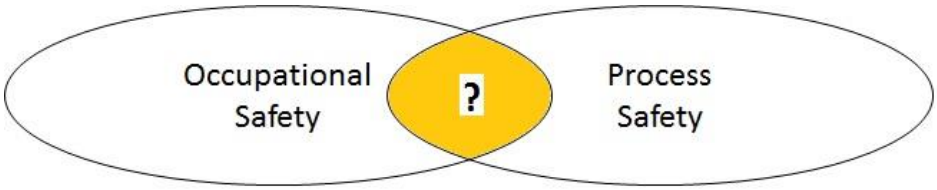

Figure 1 - A valid relationship?

As Figure 1 shows, it is important to consider whether there is a valid relationship between process safety and occupational safety, how significant this overlap is, and whether there are any features of the overlap which are important to consider in relation to data analysis to glean process safety insights.

Prior to exploring this issue further it is useful to briefly review the sources of process safety and occupational safety data within the UK as a starting point.

Process Safety Incident Reporting

Within the UK there are duties placed upon process industry organisations to report some process safety incidents to the regulator. Those sites subject to the Control of Major Accident Hazards Regulations (COMAH) 2015 (HSE 2015) which applies onshore are required to report major accidents to the COMAH competent authority in accordance with Regulation 26(2) of COMAH. Major accidents are defined within COMAH as being an event where the following three criteria apply:

a) It results from uncontrolled developments at an establishment to which the Regulations apply; and

b) It leads to serious danger to human health or to the environment, inside or outside the establishment; and

c) It involves one or more dangerous substances defined in the Regulations, irrespective of the quantity involved.

Such events will include fires, explosions and toxic releases giving rise to serious danger, but the criteria will exclude many untoward process safety events. For example, the guidance to the regulations describes an unplanned toxic release safely contained within the design basis of a scrubber system as being excluded from this definition and therefore the need to report. It is important to note that even in such cases there will still be a need internally within organisations to understand and address the causes of such issues.

More broadly, the Reporting of Injuries, Diseases and Dangerous Occurrences Regulations 2013 (RIDDOR) (2013) requires the reporting of ‘dangerous occurrences’ across a wide spectrum of industries. These are events which result in no harm to humans but could have had the potential to do so under different circumstances. RIDDOR applies to harm to persons only, not the environment. Many of these dangerous occurrences are relevant to occupational safety, however a non-exhaustive list of examples which may be relevant to process safety is provided below:

- Any unintentional explosion or fire in any plant or premises which results in the stoppage of that plant, or the suspension of normal work in those premises, for more than 24 hours;
- The unintentional release or escape of any substance which could cause personal injury to any person other than through the combustion of flammable liquids or gases;
- The sudden, unintentional and uncontrolled release—

  (a) inside a building—

  (i) of 100 kilograms or more of a flammable liquid;

  (ii) of 10 kilograms or more of a flammable liquid at a temperature above its normal boiling point;

  (iii) of 10 kilograms or more of a flammable gas; or

  (b) in the open air, of 500 kilograms or more of a flammable liquid or gas.

In addition to these statutory safety requirements, there are requirements under environmental law together with data collection arrangements led by trade bodies and insurers. The effectiveness of organisation’s own performance management arrangements, including performance indicators, may also be subject to scrutiny during proactive inspection by the COMAH competent authority. There are also well established arrangements in place for employees, contractors, the public and others to raise concerns with the regulator about process safety management or events not meeting reporting requirements. It is important to note that there is no ‘blanket’ reporting of all adverse process safety issues to the regulator in the UK.

Collection of Occupational Safety Data in the UK

Within the UK there has been a long-standing requirement for employers and others to report accidents and cases of ill health to the regulator. The criteria have slightly changed over time, but the current position is that the following are examples of the sort of events which harm that need to be reported in accordance with the RIDDOR Regulations.

- Fatal work-related accidents involving either workers or the public;
- Specified injuries to workers, for example fractures, amputations, etc;
- Accidents to workers resulting in them being absent or incapacitated from performing normal work duties for over seven days;
- Specified occupational diseases, e.g. occupational asthma.

These events are reported electronically via a website and are directed to the relevant regulator (e.g. HSE, Local Authorities and others). The reporting requirement is based on the outcome, not the cause of the event and does not take into account whether the event could have been prevented. If the outcome meets the relevant criteria, it must be reported.

Volume of Data

Within the UK system there are several routes by which both process safety and occupational safety data is reported or recorded by the regulator. A challenge highlighted in the previous Hazards paper is that the number of RIDDOR dangerous occurrences received which were identified as loss of containment events and coded as such is relatively small; around 450 records over a seven year retention period.

Many more records exist in the COIN system than the relatively small number of loss of containment dangerous occurrences in the onshore process industry. These include investigations into what appear to be relatively minor occupational safety accidents as well as outcomes from proactive inspections and inspection ratings on process safety topics such as management of change and ageing plant integrity.

Early and ongoing work to review the available data revealed that there may well be useful data in unexpected places and that the bulk of data held is unstructured and would initially appear to be occupational safety related from a cursory examination.

In addition to the data in COIN, other HSE datasets exist which can be text mined. Only a proportion of RIDDOR accidents are investigated by HSE with detailed findings existing in COIN. The RIDDOR reports which are not investigated remain available for searching and there are approximately 70 000 non-fatal employee injuries reported via RIDDOR each year across all industries.

It is also important to note that some process industry sites are classed as ‘sub-COMAH’ in that they do not hold the inventory of substances necessary to come within scope of COMAH but still have significant inventories with the associated process safety issues. In these cases, the COMAH major accident reporting requirements would not apply although RIDDOR would.

It is apparent that being able to use the widest possible data sources available would increase the amount of data and therefore the amount of valuable detail which could be extracted, however, doing this also presents challenges to ensure that biases are understood and addressed.

Examples

Three edited, shortened and anonymised examples of unstructured text associated with records in the COIN database are provided below.

Example 1 – Occupational Safety Event

A fall from height occurred at a consumer products chemical manufacturing site. The injured person (IP) was found standing on a floor way adjacent to a process unit roof and is believed to have fallen from the roof having accessed it via an unlocked access hatch. The IP was found by a work colleague, bleeding from a head wound and in a confused state. The IP landed on pipework and subsequently was found to have a fractured rib, head lacerations, and a shoulder and back injury. The IP had no recollection of the incident and there were no witnesses. The IP was originally tasked with removing redundant ducting from below the roof in another area. A risk assessment for the task was carried out prior to starting which stipulated access from an internal mobile scaffold platform at a height of approx. 1.5m. The site operator stated that there was no requirement to access the roof from the outside in order to complete the task.

This is an example of an occupational safety accident occurring within the process industry, involving conventional hazards. It was reported under RIDDOR and has no obvious direct lessons for process safety. There are implications for 'control of work' which may have wider process safety implications, but this example could occur in any industry and the progression of the incident is likely to have been similar in other settings.

Example 2 – Process Safety Event

Approximately 2000 litres of spirit (high concentration ethanol) were lost from primary containment within a whisky distillery subject to the COMAH Regulations. The loss occurred from a smashed sight glass used for observing product flow and colour during manufacturing operations. The failure of the sight glass is believed to have been a latent failure which was revealed when product transfer was initiated. The loss of liquid was successfully captured in a bund which also activated a liquid level sensor which ceased product transfer operations, although it could not prevent the loss of remaining inventory in the system downstream of an isolation valve. The loss of spirit was directed in the area of electrical lighting, although this was ATEX rated equipment and no ignition occurred. The lost inventory was recovered from the bund into IBCs and no damage to people or the environment occurred. The cause of the broken sight glass is unknown, but it is believed to have resulted from either accidental impact damage which went unnoticed or the over-torqueing of flange fittings on the sight glass. This event was reported as a RIDDOR Dangerous Occurrence.

Clearly this is a process safety incident with useful lessons (including the effectiveness of mitigation) for the process industry. This was correctly reported as a dangerous occurrence and would prompt coding in the COIN database as described in the previous Hazards paper. It could not be picked up by occupational safety reporting since no harm to personnel occurred.

Example 3 – Occupational Safety Event with Process Safety Implications

Two employees sustained acute respiratory problems following exposure to chlorine gas which resulted in time off work, and in one case, short-term hospitalisation; both were expected to sustain a full recovery. The incident was reported as two separate RIDDOR accidents by the employer, the site operator. The incident commenced when a chlorine alarm sounded at the site and the two employees went to investigate without wearing respiratory protective equipment; subsequent investigations revealed that the release site was a water tank overflow pipe. This followed the failure of duty and standby water pumps and seal failures, which provided a reverse flow pathway for chlorine gas in a process unit to flow back along the water piping system and into the water header tank. The water header tank was open to the surrounding area via the overflow pipe and this provided the final path for the loss of containment. The operator had conducted several hazard analysis exercises on the plant but none had identified the possibility of the reverse flow deviation for chlorine.

This injury accident, whilst only briefly outlined here, clearly provides process safety insights in respect of hazard identification, risk assessment and emergency response. The receipt of these RIDDOR accidents prompted a full HSE investigation at site. The operator made the argument that had injury not occurred, the incident would not have met the criteria for reporting as a RIDDOR dangerous occurrence. Whilst this argument was not accepted by HSE, it illustrates that it is possible this event would not have come to the regulator's attention by any other means.

Potential Biases

The few manually reviewed data seem to indicate that there could be value arising from extracting insights from occupational safety data such as personal injury accidents. It should be noted that biases could be introduced when doing this, which could skew findings and direct a focus on issues which place too much or too little emphasis on specific factors. Some examples are provided below, although many others will need to be considered:

- Occupational safety accidents may tend to involve a human proximate to the point of release and therefore suggest that operational issues such as 'control of work' (e.g. control of contractors, isolation, permit-to-work) are more causative of process safety problems than latent design issues (e.g. insufficient pressure relief sizing) within a process plant;
- Occupational safety accidents may appear to overstate the effectiveness of mitigation measures which are provided for workers but are not effective or available for the off-site public, such as toxic gas refuges;
- Incidents involving harm to a worker may arise from human intervention to prevent escalation; such incidents may overreport the viability of such interventions to provide mitigation in other slightly different circumstances; in other words there may not always be an operator present to take avoiding action, reducing immediate danger to that operator but allowing the incident to progress to much bigger consequences;
- The effects of human failures issues may be skewed, for example giving greater emphasis to errors in maintenance which result in immediate harm, e.g. failure to isolate prior to breaking containment, rather than latent defects being introduced during maintenance which lead to a loss of containment later, such as the inadvertent disabling of safety systems leading to a later tank overfill;
- Occupational accidents may be more likely to occur in proximity to some plant items but not others, for example those requiring regular human intervention and/or inspection (e.g. filter units); this may misrepresent the potential for other plant items (e.g. remote pipework elbows) to give rise to major accidents;
- Occupational accidents could be more prevalent at installations with a significant workforce present (e.g. batch chemical production) and underplay the off-site risks created by normally unattended installations (e.g. gas compressor station).

In November 2019 the project team held a workshop with representatives of the onshore process industries. A large proportion of this engagement was around ensuring that the NLP work would extract relevant intelligence from unstructured data which would be actionable by industry; Discussions were also held around the proposal to potentially mine occupational safety datasets for process safety purposes. Delegates were cautiously supportive of examining the feasibility of this approach and made the following observations:

- There may be other ways to split data analysis, such as separating out process safety from operational safety, with a focus on asset integrity, e.g. plant design, maintenance inspection, etc. in the former and operational safety in the latter, e.g. control of work, breaking containment, etc;
- Terminology can act as a barrier to cross sector sharing as different sectors use different terms for the same thing and the distinction between occupational safety and process safety may also have such terminology;
- The ability to utilise occupational safety data should not be at the expense of better sharing of specific process safety data sets owned by companies. Better accessibility of such data, suitably anonymised would be powerful.
- Loss of containment events are not just about safety and include environmental and asset protection; it is possible this is another source of bias;
- There was support to trial the approach using the UK and the RIDDOR dataset but whilst remembering that this is very different to regulation in other parts of the world.

Conclusions & Next Steps

The proposal to move the project forwards is to continue to develop NLP models overseen by subject matter experts to extract process safety intelligence from unstructured text. This includes extracting information relevant to the progression of a loss event such as:

- Initiating events;
- Enabling events, e.g. activity prior to an event such as tank filling;
- Presence and effectiveness of prevention and mitigation barriers;
- Loss event type, e.g. runaway reaction, tank overfill, etc;
- Consequences/severity, e.g. harm to people, assets and the environment.

It is proposed to firstly apply this model to process safety specific unstructured text in COIN and then to repeat this work with occupational safety data. The comparison of findings by subject matter experts in consultation with the industry will then enable the feasibility of occupational safety datasets as a resource to be assessed. The resulting models can then be applied to

wider datasets and the project team are particularly keen to hear from organisations holding relevant unstructured data who would be willing to collaborate to analyse this using the new techniques. The wider programme team are currently developing tools, techniques and collaborations to address concerns and suitably anonymise data prior to sharing to address concerns around personal and commercial data and reputational concerns. The focus of this work is expanded to include global datasets as well as UK ones. Given the inclusion of environmental impacts within process safety it would also be useful to encompass datasets established to record environmental events and their precursors as well as safety and asset protection sources.

The work done to date demonstrates that process safety and occupational safety are cousins, linked by key features but also with important differences between them. Further work is needed to understand just how much commonality exists between them.

Disclaimer

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