Go Make the World a Safer Place

Essays on Workplace Safety

by

Mike Schmidt

Go Make the World a Safer Place: Essays on Workplace Safety

by Mike Schmidt

2026

Ethics International Press, UK

British Library Cataloguing in Publication Data

A catalogue record for this book is available from the British Library

ISBN (Hardback): 978-1-83711-601-0

ISBN (Ebook): 978-1-83711-602-7

Contents

List of Figures

List of Tables

Part One

Where We Come From

1.
The Good Old Days?

"Nostalgia is a file that removes the rough edges from the good old days."
— Doug Larson

It's hard to imagine the New York skyline without the Statue of Liberty. The Paris skyline without the Eiffel Tower. The San Francisco skyline without the Golden Gate Bridge. The Saint Louis skyline without the Gateway Arch. But before October 28, 1886, no completed Statue of Liberty adorned the New York skyline. Before March 31, 1889, no completed Eiffel Tower embellished the Paris skyline. Before April 19, 1937, no completed Golden Gate Bridge spanned the strait connecting San Francisco Bay to the Pacific Ocean. And before October 28, 1965, no completed Gateway Arch defined the St. Louis skyline.

They all beat the actuarial predictions for work-related fatalities. There were no work-related fatalities in France when the Statue of Liberty was first constructed and none when it was reassembled in New York. There was one work-related fatality during the construction of the Eiffel Tower. And there were no work-related fatalities associated with the construction of the Gateway Arch.

Of these four, the Golden Gate Bridge had the worst record: 11 workers died while building the bridge, but another 19 were saved by safety nets when they fell, becoming the only members of what they called the "Halfway to Hell Club." (GGB, n.d.)

All these projects pre-dated the creation of OSHA or the regulatory requirements that all modern nations have for fall protection when

working at elevation. As wondrous as these engineering marvels are, there is no reason to be nostalgic for workplace safety as it was "back in the good old days." Their safety records were exceptions to expectations of the time.

Expectations of the Time

A few years ago, I saw an exhibition of photographs about the construction of the Gateway Arch in St. Louis. One of the photographs stopped me in my tracks. It showed a man standing atop the arch with a water hose, washing down the stainless steel panels. He was not wearing any type of fall protection

When the Gateway Arch was constructed, the actuaries advised the insurers to budget for 13 fatalities. They were planning on 13 fatalities! At a 95% confidence level, that could have been anywhere between 6.9 and 22.3. So, keeping it to zero fatalities was an astonishing accomplishment.

The twin towers of the World Trade Center in New York were finished six years later. That project had 60 work-related fatalities. That was much more in keeping with the expectations of the time, a time that is thankfully past.

Expectations of Today

During the past decade, the fatality rate in the construction industry has held at about 10 fatalities per 100,000 full time equivalents (FTEs). (BLS, 2025) The project to build the Gateway Arch lasted for 2.5 years and at its peak had no more than 100 workers on the project. Conservatively, the project used 250 FTEs, meaning that if the project were to be repeated today, the expected number of fatalities would be 0.025 for the entire project. In whole numbers, zero.

What was an extraordinary accomplishment in the early 1960's would simply be the expectation today. That's progress.

What About Manufacturing?

Construction is not the most hazardous industry, at least on a per employee basis. At 13 to 14 fatalities per 100,000 FTEs since 1992, the transportation and warehousing industries are more dangerous than construction. At around 20 fatalities per 100,000 FTEs, agriculture, forestry, fishing, and hunting are even more dangerous than construction.

Manufacturing, on the other hand, is much less dangerous than construction. With a fatality rate of around 2.5 fatalities per 100,000 FTEs, manufacturing jobs are safer than the average job in the U.S. The overall fatality rate in U.S. workplaces, has been around 3.5 fatalities per 100,000 FTEs for over a decade. in 2020.

At a rate of 2.5 fatalities per 100,000 FTEs, a manufacturing employer with a workforce of 2,000 employees can expect about one fatality every two decades.

No Going Back

While sending someone up to work at elevation without a harness or other fall protection was accepted in the 1960s and before, it is simply not acceptable now. For every project from that era that was completed without serious injury or fatality, there were hundreds more that finished with tragedies as part of their legacy. We know better now and should not let nostalgia for the past cloud our vision for the future. There can be no going back. Our workplaces are safer now than they have ever been, but in the future, people will look back at some of what we do today with the same horror with which we look

at a worker washing down the top of the Gateway Arch with no fall protection. Regardless, we need to keep moving forward. The good old days will never be as good as what we can do in the future.

References

GGB. (n.d.). *Construction.* Golden Gate Bridge Highway & Transportation District. https://www.goldengate.org/bridge/history-research/bridge-construction/construction/

BLS. (2025). *Census of Fatal Occupational Injuries.* Bureau of Labor Statistics, United States Department of Labor. https://www.bls.gov/iif/

2.
Process Safety: How Far We've Come

"Life is a journey and not a destination." — Lynn H. Hough

When Richard Nixon signed the Occupational Safety and Health Act in 1970, the United States was looking at 14,000 work-related fatalities per year. (Eisenbrey, 2011) With a total civilian workforce of about 70 million (BLS, *Labor Force Statistics*, 2025) in all U.S. workplaces—private and public—the work-related fatality rate was about 18 fatalities per 100,000 workers.

By 2019, the size of the workforce had doubled to almost 140 million FTEs. The pandemic forced the size to drop to about 132 million FTEs. (FRED, 2025) Still, the fatality rate was down to around 3.5 fatalities per 100,000 FTEs in both of those years, where it has held for over a decade. (BLS, *Census of Fatal Occupational Injuries*, 2025)

The Occupational Safety and Health Administration (OSHA) celebrated its 50th anniversary in 2020, and with good cause. The overall work-related fatality rate fell over 5-fold in that half-century.

Wouldn't Fatality Rates Have Fallen, Even Without OSHA?

OSHA is an agency that many love to hate. "They have all these ridiculous rules." When told that the workplace in the United States has become much, much safer as a result of the efforts of OSHA, the response is sometimes, "Yeah, but wouldn't fatality rates in the U.S. workplace have fallen anyway? Isn't that what the market demands?"

Work-related fatality rates would have fallen, I'm sure. But 5-fold? Not likely. Consider the self-employed, which includes gig-workers. In the most recent data, the work-related fatality rate for wage and salary workers—employees who OSHA regulations are meant to protect—was 3.2 fatalities per 100,000 FTEs. (BLS, *Census of Fatal Occupational Injuries*, 2025) That's almost six times lower than the work-related fatality rate in 1970. On the other hand, the work-related fatality rate for the self-employed—workers to whom OSHA regulations do not apply—was 10.7 fatalities per 100,000 FTEs. (AFL-CIO, 2024) That is clearly less than the overall rate in 1970, but only by about half. It is hard to argue that OSHA regulations and OSHA's enforcement of those regulations are not making a difference.

Process Safety Management

The Process Safety Management (PSM) standard, 29 CFR 1910.119, was not among the first of OSHA's regulations. It hit the books in 1992, 22 years after Congress first established OSHA. It was largely a response to the disaster in Bhopal, India, where the December 3, 1984, release of methyl isocyanate from a Union Carbide pesticide plant resulted in the deaths of 3,928 according to official records, (Eckerman, 2001) although there are estimates that put the toll at over 22,000 deaths. (Dummett, 2024)

I remember as a young chemical engineer who had started his career working for Union Carbide being shocked and dismayed at the death toll and at the realization that I could be responsible for decisions that could result in the deaths of thousands.

I also remember at the time the rationalizing in our industry. Many argued that the chemical industry in the U.S. should not be judged by a disaster in a "third world country", insisting that nothing like that could ever happen here. That, despite an explosion at the Union Oil

refinery on July 23, 1984, in Romeoville, Illinois that killed 17. (McHenry, et al., 1986)

Fortunately, leaders from 17 companies in the process industries came together to form the Center for Chemical Process Safety, chartered less than four months after Bhopal on Mary 23, 1985, under the auspices of the American Institute of Chemical Engineers. (CCPS, 2024) That organization assisted OSHA in drafting the PSM standard.

If we needed reminders that something like the PSM standard was necessary, there were plenty. In the time between the Bhopal tragedy and the implementation of the PSM Standard, the U.S. experienced:

- August 12, 1985 – Institute, West Virginia (Franklin, 1985)
  Release of MIC from Union Carbide's Bhopal sister-plant in West Virginia
  No fatalities
- May 4, 1988 – Henderson, Nevada (Routley, 1988)
  Pepcon fire and explosion
  2 fatalities, 372 serious injuries
- May 5, 1988 – Norco, Louisiana (OSHA, 1988)
  Shell Oil refinery explosion
  7 fatalities, 19 serious injuries
- October 23, 1989 – Pasadena, Texas (Bond, 1991)
  Phillips refinery explosions and fire
  23 fatalities, 130 serious injuries
- July 5, 1990 – Channelview, Texas (OSHA, 1990)
  ARCO Chemical explosion and fire
  17 fatalities, no survivors, so no injuries
- May 1, 1991 – Sterlington, Louisiana (OSHA, 1991)
  Angus Chemicals/IMC Fertilizer explosions
  8 fatalities, 112 serious injuries

Have Things Gotten Better?

The pace of fatal process safety disasters has slowed. Wikipedia's list (List of industrial disasters, 2025) includes over a half dozen in the United States during the twenty-year period from 2005 through 2025:

- March 23, 2005 – Texas City, Texas
  BP Refinery explosion
  15 fatalities, 180 injured
- December 19, 2007 – Jacksonville, Florida
  T2 Laboratories explosion
  4 fatalities, 32 injured
- February 7, 2008 – Port Wentworth, Georgia
  Imperial Sugar dust explosions
  14 fatalities, 42 injuries
- April 17, 2013 – West, Texas
  West Fertilizer ammonium nitrate explosion
  15 fatalities, 160 injuries
- November 15, 2014 – LaPort, Texas
  Du Pont mercaptan release
  4 fatalities, 1 serious injury
- June 21, 2019 – Philadelphia, Pennsylvania
  Philadelphia Energy Solutions refinery explosion
  No fatalities, minor injuries
- January 24, 2020 – Houston Texas
  Watson Grinding propylene explosion
  3 fatalities, 18 "self-reported" minor injuries
- January 28, 2021 – Gainesville, Georgia
  Foundation Food Group liquid nitrogen leak
  6 fatalities by asphyxiation

- October 10, 2025 – Bucksnort, Tennessee
  Accurate Energetic Systems munitions explosion
  16 fatalities, 4 injuries

It is interesting to note that process safety catastrophes in the U.S. are increasingly rare, so that the Philadelphia Energy Solution explosion made the list despite there being no fatalities or serious injuries. The threat alone was sufficient. On the other hand, neither the Du Pont incident in LaPort, Texas nor the Watson Grinding incident in Houston, Texas made the lists; they are included here because they obviously should be.

It is also interesting to note that many of the disasters on the list above involved processes not covered by the PSM standard. And while the frequency of fatal process safety disasters in the U.S. is lower now than at the time the PSM standard was implemented, the frequency of process safety disasters globally has not diminished. The disasters are simply happening in parts of the world that are developing a chemical industry but have not yet implemented equivalent regulations.

Are We There Yet?

The PSM Standard was implemented in 1992. Except for some tweaks to correct clerical errors and to adjust language to make it consistent with the Globally Harmonized System of Classification and Labelling of Chemicals, the standard is unchanged since it was first implemented. Surely, with almost 30 years to comply, the need for this regulation would be behind us.

No.

OSHA still finds many opportunities to cite for violations of the PSM standard. In part, this is because while the standard has not changed,

enforcement has become more rigorous. Things OSHA would let slide in 1995 are no longer given a pass. But also, it's because some organizations still don't get it, and some organizations are new to industry and need to understand their responsibilities for process safety management.

We Have Come A Long Way…

In the U.S., with its increasingly sophisticated chemical process industry, process safety incidents are increasingly less frequent, and the consequences are increasingly less severe. The same is true of the chemical process industries in other developed industrial nations. In the rest of the world, where the chemical process industry is just emerging from its infancy, however, the industry is experiencing the growing pains we have already experienced.

For some, it may be tempting to believe that we have arrived. We haven't. We can do better.

…But There Is No "There" to Get To

Process safety, like life, is not a destination but a journey. It's a road we must continue to travel, no matter how far we've come. It's nice to look back and acknowledge that we have come a long way, because that confirms for us that our efforts truly make a difference. But our efforts only make a difference as long as we continue to make the effort. Let's keep up the good work. Even though we will never get there, it's still worth the journey.

References

AFL-CIO. (2024, April 23). *Death on the job: The toll of neglect, 2024*. American Federation of Labor and Congress of Industrial Organizations. https://aflcio.org/reports/dotj-2024

BLS. (2025). *Census of Fatal Occupational Injuries.* Bureau of Labor Statistics, United States Department of Labor. https://www.bls.gov/iif/

BLS. (2025). *Labor Force Statistics from the Current Population Survey.* Bureau of Labor Statistics, United States Department of Labor. https://www.bls.gov/cps/wlftable20.htm

Bond, J. (1991, February). Explosion at the Phillips' Houston chemical complex, Pasadena, 23 October 1989. *Loss Prevention Bulletin 097*. https://www.icheme.org/media/13605/lpb272_pg29.pdf

CCPS. (2024). *History*. Center for Chemical Process Safety, American Institute of Chemical Engineers. https://www.aiche.org/ccps/history

Dummett, M. (2024, December 2). Bhopal gas tragedy: 40 years of injustice. *The Diplomat*. https://thediplomat.com/2024/12/bhopal-gas-tragedy-40-years-of-injustice/

Eckerman, I. (2001). *Chemical industry and public health - Bhopal as an example.* Göteborg, Sweden: Nordic School of Public Health. https://www.researchgate.net/publication/237527071_Chemical_Industry_and_Public_Health_Bhopal_as_an_Example

Eisenbrey, R. (2011, May 31). *Government regulations save lives on the job*. Economic Policy Institute. https://www.epi.org/publication/government_regulations_save_lives_on_the_job/

Franklin, B. A. (1985, August 12). Toxic cloud leaks at Carbide plant in West Virginia. *The New York Times*.

https://www.nytimes.com/1985/08/12/us/toxic-cloud-leaks-at-carbide-plant-in-west-virginia.html

FRED. (2025). *Full-time equivalent employees*. Federal Reserve Bank of St. Louis. https://fred.stlouisfed.org/series/A4301C0A173NBEA

List of industrial disasters. (2025, November 13). Wikipedia-The Free Encyclopedia. https://en.wikipedia.org/wiki/List_of_industrial_disasters

McHenry, H. I., Shives, T. R., Read, D. T., McColskey, J. D., Brady, C. H., and Purtscher, P. T. (1986, January 1). *Examination of a pressure vessel that ruptured at the Chicago Refinery of the Union Oil Company on July 23, 1984.* (Report NBS IR 86-3049) National Bureau of Standards, United States Department of Commerce. https://www.govinfo.gov/content/pkg/GOVPUB-C13-26f56fc24b75d8023ab9899ee163ec6b/pdf/GOVPUB-C13-26f56fc24b75d8023ab9899ee163ec6b.pdf

OSHA. (1988, September 20). *Inspection detail: Shell Oil Company*. (Inspection Nr. 100478866) Occupational Safety and Health Administration, United States Department of Labor. https://www.osha.gov/ords/imis/establishment.inspection_detail?id=100478866

OSHA. (1990, December 20). *Inspection detail: Arco Chemical Co*. (Inspection Nr. 110318540) Occupational Safety and Health Administration, United States Department of Labor. https://www.osha.gov/ords/imis/establishment.inspection_detail?id=110318540

OSHA. (1991, October 31). *Inspection detail: Angus Chemical Co*. (Inspection Nr. 107526733) Occupational Safety and Health Administration, United States Department of Labor. https://www.osha.gov/ords/imis/establishment.inspection_detail?id=107526733

Routley, J. G. (1988, May). *Fire and explosions at rocket fuel plant, Henderson, Nevada.* (Report USFA-TR-021) United States Fire Administration, Federal Emergency Management Agency https://permanent.fdlp.gov/websites/www.nfa.usfa.fema.gov/2022/www.nfa.usfa.fema.gov/downloads/pdf/publications/tr-021.pdf

3.
Bhopal: Still the Worst

"You can't let your failures define you. You have to let your failures teach you." — Barack Obama

On December 3, 1984, the Union Carbide plant in Bhopal, India released 45 tons of methyl isocyanate. The official toll of immediate deaths is 2,259 people. (India Today, 2016) Estimates of the final death toll range but is generally thought to be between 15,000 and 25,000. (Santoshi, 2016) The incident led the United States to create the Process Safety Management (PSM) standard, which became effective in 1992. Union Carbide, one of the largest chemical companies in the world, no longer exists except as subsidiary of Dow Chemical.

Much was said about the Bhopal gas tragedy on its 40th anniversary. Much will be said about the Bhopal gas tragedy on its 50th anniversary, and again on its 60th anniversary. What is most important is that we continue to learn from that terrible disaster.

I Remember

I started my career in the chemical process industry with Union Carbide in 1977, as an intern at a cryogenic gas plant owned and operated by Linde, the industrial gases division of Union Carbide. I was very aware of the safety culture at the plant where I worked and throughout the division. I no longer worked for Union Carbide when the Bhopal gas tragedy occurred, but I had a hard time reconciling it with my own experience. So, it was easy for me to accept the common wisdom in the United States at the time, especially within the industry: "Bhopal is a plant in a third-world area. What do you

expect? This could never happen here." This despite the string of disasters that had occurred before—Texas City, 1947; Woodbine, 1971; Romeoville, 1984—and occurred soon after—Henderson, 1988; Norco, 1988; Pasadena, 1989; Channelview, 1990; Sterlington, 1991. It sobered me to realize that as a young engineer, I could find myself in a position where my decisions might result in the deaths of dozens, even thousands.

"The Worst in History"

Over the years, various authors have assembled "worst ten" lists about industrial disasters. Not "top ten"; it's not a competition anyone should want to win, and these are certainly not lists that any company or any town should want to be on. We considered ten of these lists. They go by names like "10 Worst Industrial Disasters of All Time" (Wion, 2023), "The World's Worst Industrial Disasters" (National Accident Helpline, 2023), and "15 Worst Industrial Disasters in the World" (Abbas, 2024). While no two lists are the same, the Bhopal gas tragedy is on all ten lists. It is the only industrial disaster on all ten lists. In terms of fatalities, it is the worst.

This is a composite of the ten lists, weighted for number of appearances and ranking on each list:

1. Bhopal Gas Tragedy; Bhopal, India; December 3, 1984; 2,259 killed immediately
2. Rana Plaza Collapse; Dhaka, Bangladesh; April 24, 2013; 1,134 killed
3. Chernobyl Nuclear Disaster; Pripyat, Ukraine, April 26, 1986; 30 killed immediately
4. Benxihu Colliery Coal Dust Explosion; Liaoning, China; April 26, 1942; 1,549 killed

5. Halifax Explosion; Nova Scotia, Canada; December 6, 1917; 1,782 killed
6. Fukushima Nuclear Accident; Fukushima, Japan; March 11, 2011; 1 killed
7. Courrières Mine Disaster; Pas-de-Calais, France; March 10, 1906; 1,099 killed
8. Seveso dioxin release; Seveso, Italy; July 10, 1976; 0 killed
9. Deepwater Horizon Explosion and Oil Spill; Gulf of Mexico; April 20, 2010; 11 killed
10. *Exxon Valdez* Oil Spill; Prince Williams Sound, Alaska, USA, March 24, 1989; 0 killed

Unfortunately, we all tend to take a short-sighted view of history. If we can't remember it ourselves, or know someone who can remember, we forget it or discount it entirely. For instance, the worst industrial incident in history didn't occur after the start of the Industrial Revolution. It occurred on May 30, 1626, in Beijing, China. The Wanggongchang Armory, one of several gunpowder factories in the city, exploded. Contemporary reports put the immediate death toll at around 20,000. (Liang and Deng, 2013)

The Wanggongchang Armory explosion of 1626 didn't make any of the lists. I learned about it from an engineering student.

Industrial Disasters

As the professor for a graduate class on manufacturing process risk assessment, I assigned each student to create a list of 10 industrial disasters. Not the worst 10 disasters, but 10 disasters that resulted in at least 10 fatalities. The assignment required them to identify a disaster from the previous year (industrial disasters are still happening), a disaster from the 19th century or earlier (industrial

disasters are as old as industry), and from at least four different continents (industrial disasters are a global phenomenon).

In fourteen years of teaching this class, I had 935 students. Of them, 386 listed the Bhopal disaster as one of their 10 disasters. No other disaster comes close in capturing the attention of today's engineering students. We should all take comfort in that. As the Spanish-born philosopher, George Santayana said in his 1905 book, *The Life of Reason*, "Those who cannot remember the past are condemned to repeat it." We need to continue to teach engineering students about the disasters that have plagued our industry. There is no need for every generation to learn only from its own experience.

Never Again

Four decades later, our focus needs to be on keeping the memory of the Bhopal gas tragedy alive. The incident changed those of us who were around when it happened. Increasingly, though, older engineers who remember Bhopal are leaving the work force, leaving it to younger engineers to discover for themselves. We should be able to say, "Never Again," but unless we consciously work to keep the memory of this disaster and its lessons alive, the memory will fade. The desire to keep this memory alive may be too optimistic. Nonetheless, we need to try.

References

Abbas, R. (2024, January 23). 15 worst industrial disasters in the world. Insider Monkey, Yahoo Finance. https://finance.yahoo.com/news/15-worst-industrial-disasters-world-231306491.html

India Today Web Desk. (2016, December 3). *Bhopal gas tragedy: 32 years on, world's worst industrial disaster continues to haunt*. India Today. https://www.indiatoday.in/fyi/story/bhopal-gas-tragedy-32-years-industrial-disaster-355431-2016-12-03

Liang, G. and Deng, L. (2013, April 29). *Solving a mystery of 400 years-An explanation to the "explosion" in downtown Beijing in the year of 1626*. AllBestEssays. https://www.allbestessays.com/essay/Solving-a-Mystery-of-400-Years-An-Explanation-to/47238.html

National Accident Helpline. (2023, October 10). *The world's worst industrial disasters*. National Accident Helpline. https://www.national-accident-helpline.co.uk/news/post/worlds-worst-industrial-disasters

Santayana, G. (1905-1906). *The life of reason: or, The phases of human progress*. Charles Scribner's Sons. p. 284.

Santoshi, N. (2016, December 3). *Bhopal disaster: So, how many died? 32 years on, no one sure*. Hindustan Times. https://www.hindustantimes.com/bhopal/bhopal-disaster-so-how-many-died-32-years-on-no-one-sure/story-luLN0QaTxHlu05RTGNHOoI.html

Wion Web Desk. (2023, March 28). *10 Worst Industrial Disasters of All Time*. Wion News. https://www.wionews.com/web-stories/trending/10-worst-industrial-disasters-of-all-time-1679921871337

4.
Process Safety: Addressing Risk or Dread?

> *"The risks that scare people and the risks that kill people are very different." — Peter Sandman*

I often wonder if work in process safety is a misallocation of resources.

The leading cause of work-related fatalities is transportation, at about 40%. The next three—of seven causes identified by the Bureau of Labor Statistics—all at about 15% each, are slips, trips, and falls, contact with objects, and workplace violence. (BLS, 2025)

The two BLS categories that are related to process safety—harmful exposures and fire and explosions—are perennially the lowest causes of work-related fatalities.

Given that, would our efforts be better directed at driver safety or more general issues of workplace safety?

What About the Chemical Industry?

The chemical enterprise is different from workplaces in general. One would expect the causes of fatalities to be different, and they are. Transportation and workplace violence are causes, but not leading causes. The leading causes of fatalities in the chemical enterprise (petroleum products, chemical manufacturing, and plastics manufacturing) are slips, trips, and falls, contact with object, and, no surprise, harmful exposures.

Fires and explosions? Not so much.

So, the need for process safety in the chemical industry is not driven by risk. What then?

Dread

People are afraid of hazards that are not likely to kill them. Gerd Gigerenzer tells us that psychology has an answer: the fear of dread risks. (Gigerenzer, 2015) A dread risk is a situation where many people die within a short time. It is not the fear of dying, but the fear of dying suddenly with many people in a brief period.

The causes of death that kill people one at a time don't provoke the kind of fear that mass fatalities do. That's why terrorism is so effective. It's not that people are killed suddenly and violently. That happens hundreds of times a year in the U.S. workplace. It's that so many die, all at once. Terrorists inflict their initial damage, and then for the survivors, there is secondary damage of living with the knowledge of that event.

What do we dread in the chemical industry? Not slips, trips, and falls, or contact with objects, even though those are the leading causes of death and injury in the chemical industry. No, we dread explosions and harmful exposures, the concerns of process safety.

Industrial Catastrophes

I define an industrial catastrophe as one that occurs in a manufacturing environment and results in at least 10 fatalities.

Why ten?

The fear of hazards that kill ten people is much more than ten times higher than the fear of hazards that kill one person. The fear of hazards that kill a hundred people is more than the fear of hazards

that kill ten people, but not an order of magnitude higher. Research shows that there is no difference in the fear of hazards that kill a thousand people and the fear of hazards that kill a hundred people. (Galesic and Garcia-Retamero, 2012)

What Causes Industrial Catastrophes?

I taught a graduate-level class on process risk management. The first assignment of the semester was for each student to do research on industrial catastrophes and create a list of 10 industrial catastrophes. Their list was required to include at least one industrial catastrophe from the previous year, at least one industrial catastrophe from the 19th century or earlier, and at least one industrial catastrophe from at least four different continents. They never had any trouble meeting those criteria. We have been suffering industrial catastrophes since the Industrial Revolution began in the late 18th century.

Every semester, despite a lot of duplication between lists, the students collectively identify around 150 unique catastrophes. The leading cause of the industrial catastrophes identified by these students is fire and explosions. Year after year, about three-quarters of the industrial catastrophes identified were the result of fires and explosions. The second cause, year after year, is harmful exposure, which accounts for about 15% of the listed industrial catastrophes. The remaining causes (contact with objects, transportation, slips, trips, and falls, and workplace violence) only made a few student's lists.

Process Safety Is About Risk

The leading causes of industrial catastrophes are fires and explosions, and harmful exposures. These are the concerns of process safety. They are not the sources of greatest risk, but the sources of greatest dread.

It is rare for a process hazard analysis or a layer of protection analysis to uncover a scenario that invokes dread – 10 or more fatalities. These tools tackle risk. When they are insufficient, we turn to other tools, like Quantitative Risk Assessment.

We do not have a tool for doing Quantitative Dread Assessment.

Dread Is Real

Morally and ethically, I am convinced that 10 fatalities are equally bad, whether they occur one at a time or all at once. That doesn't change the fact that most people are more afraid of a hazard that could kill 10 people at once than they are of a hazard that could kill 10 people one at a time. The fear is real, even if it is not rational. We should all keep that in mind as we lead or conduct process safety risk assessments.

References

Galesic, M. and Garcia-Retamero, R. (2012). *The Risks We Dread: A Social Circle Account*. PLoS ONE 7(4): e32837. https://doi.org/10.1371/journal.pone.0032837

Gigerenzer, G. (2015, December 23). *Fear of dread risks*. Edge https://www.edge.org/annual-question/2016/response/26645

BLS. (2025). *Census of Fatal Occupational Injuries.* Bureau of Labor Statistics, United States Department of Labor. https://www.bls.gov/iif/.

Part Two

The Power of Words