

# Error-proofing Chemical Safety for Fatigue and Other Cognitive Impairments

How New Developments in Brain Science Can  
Help Your Safety Program be “Smarter”

Part of the “Lean EHS in the Real World” Series

When I originally wrote the abstract for this poster, I was thinking about cool BI (Business Intelligence) things you could do with SDS data to make it more cognitively understandable to users of the chemicals.

But after attending the Michigan Safety Conference mid-April, I realized that a huge problem at the moment is Safety Culture. No tool works if the worker doesn't pick it up and use it.

So I changed the emphasis of the poster to focus on new “technologies” of brain science, and how to “connect the dots” on those to improve the safety culture of your organization.

Posters 2 of this series will go more into depth on Error-Proofing vs Mistake-Proofing, and Poster 3 of this series will delve into the original topic, using Data Visualization tools for error-proofing and mistake-proofing chemical safety.

If you would like parts 2 and 3 of this series, email me at [manguardehs@gmail.com](mailto:manguardehs@gmail.com) or [kathyimalone@gmail.com](mailto:kathyimalone@gmail.com), or text or call me at 810-515-0115.

I hope this poster will get your inquisitive brain “playing the game” of improving Safety both for you and your organization!

# OSHA Info on Fatigue (Exerpt)

<https://www.osha.gov/SLTC/workerfatigue/hazards.html>

## What Are the Effects of Worker Fatigue?

Worker fatigue increases the risk for illnesses and injuries. Accidents and injury rates are 18% greater during evening shifts and 30% greater during night shifts when compared to day shifts. Research indicates that working 12 hours per day is associated with a 37% increased risk of injury<sup>1</sup>. In a 2005 study reporting on a survey of 2737 healthcare workers, every extended shift scheduled in a month increased by 16.2 % monthly risk of a motor vehicle crash during their commute home from work.

- Decreased alertness from worker fatigue has been a contributing factor in:
  - Industrial disasters such as the 2005 Texas City BP oil refinery explosion, the 2009 Colgan Air Crash, the explosion of the space shuttle Challenger and the nuclear accidents at Chernobyl and Three Mile Island
  - Increased sleep problems and risk for injury<sup>2</sup> among full-time employees in relation to the number of hours worked per week.
  - Errors in patient care, increased needlesticks and exposure to blood and other body fluids and increased occupational injuries among healthcare workers.
  - Direct or indirect links to increased costs<sup>3</sup> from lost productivity, increased injury and illness costs, increased time off the job due to illness and increased workers' compensation costs
  - An estimated annual cost of \$136.4 billion from fatigue-related, health-related lost productive work time to employers<sup>4</sup>.



Fatigue is arguably worse than drinking on the job, or at least comparable.

The difference is that the effect of fatigue is cumulative, increasing the risk of injury as the number of days over which fatigue is accumulating increases.

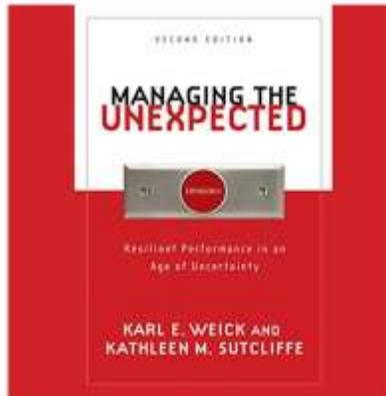
This is especially true of fatigue induced by disruptions in people's circadian rhythms such as by night work and changing shifts.

And just as with alcoholic impairment, people are very poor judges of their degree of impairment.

Many good resources are on the OSHA website if you search for "fatigue"

## Did You Know that High Reliability Organizations (HRO's) are a Model?

- 5 traits of HRO's
  - Prevention
    - Preoccupation with Failure
    - Reluctance to Simplify
    - Sensitivity to Operations
  - Mitigation
    - Commitment to Resilience
    - Defer to Expertise
- “Managing the Unexpected” book



A good model for protecting your organization and your workers against the negative effects of fatigue and other cognitive impairments is that used by High Reliability Organizations (HRO's).

Think aircraft carriers, firefighters, nuclear power plants, etc. Examples of both successes and breakdowns in managing HRO's are featured in the book.

HRO's have 3 traits that differentiate them from less “mindful” organizations. 3 are preventative and 2 are for mitigation.

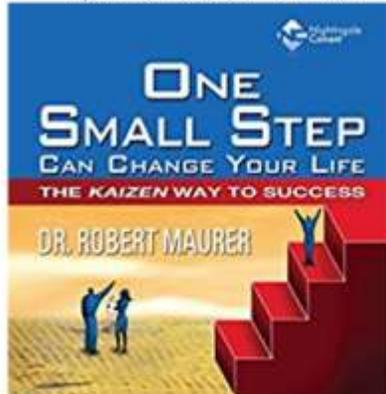
With respect to preventing unwanted outcomes, HRO's pay disproportionate attention to all of the potential failure modes they can think of, plan for them, and watch for weak signals that indicate that one is developing.

HRO's are unwilling to simplify, since easy categorization can cause a corresponding dismissal of the significance of events that may be shaping up in ways that can result in big impact. And they pay attention to the details of operations that influence how the first 2 factors impact operations.

Once an event has occurred, HRO's are relentless on building resilience into response systems so that the situation can be returned to as close to its pre-incident state, and they defer to expertise rather than hierarchy.

## Did You Know that the Mind Cannot Refuse A Question?

- That big change (innovation) sets off the brain's amygdala and shuts down creativity?
- But that good micro-change (kaizen) engages the brain's love of a puzzle?
- "One Small Step Can Change Your Life" and "Spirit of Kaizen" books



Dr. Rob Maurer's original version of this book is in audio format, since it is recordings of his presentations at Canyon Ranch. I highly recommend the audio version since you are likely to get more of the richness of his presentation.

There are 2 models for change, Innovation (with a big I) and Kaizen (good micro-change). Humans are neurologically hard wired to resist big change. The brain's amygdala instinctively responds to too big a change with fear and a shut-down of creativity,

Kaizen in the "Lean" world (think Toyota Production System or Rosie the Riveter and the Training Within Industry program during WWII), or good micro-change, flies under the amygdala's radar screen.

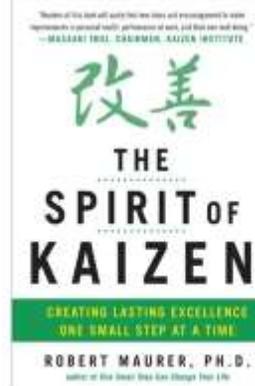
Furthermore, the brain cannot refuse a question. Repeatedly asking questions like "what is the smallest change I could make to make this job or process safer or to error-proof it" cause the subconscious to pay attention to the question and to start creatively "playing the game" to come up with answers.

You don't even need to try to come up with answers, the brain will surface them (why we get some of our best ideas in the shower).

Examples of how small the changes can be and how big the results are huge here!

## What Questions Can You Ask and Have Your Workers Ask?

- What's the smallest change/one small change I could make to:
  - Improve safety?
  - Error-proof the process?
- What could go wrong unexpectedly with this process?
  - How could we prevent it?
  - How would we mitigate?
- “One Small Step Can Change Your Life” and “Spirit of Kaizen” books



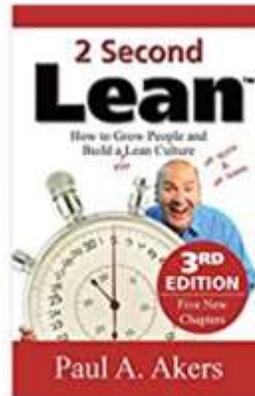
One Small Step Can Change Your Life is about Kaizen (good micro change) in your personal life, which makes it immediately relatable to your team members. (Want to start an exercise program? Stand on the treadmill and drink your coffee and read the newspaper each morning for a month to start. Want to lose weight? Throw away the first bite of food (the last bite is way too hard).

The Spirit of Kaizen takes the same principles applied to a business setting.

Back to the HRO topic, since a big theme of this talk will be the importance of training your mind and the minds of your team to inculcate safe behaviors and thinking processes, HRO's additionally ask their brains the question “what could go wrong with this process that we haven't anticipated yet? And if that happened, how could we respond to minimize and to mitigate the effect ?”

## Did You Know that According to Paul Akers, Money Kills Creativity?

- Setting the criteria for questions that the changes are free or cheap
  - Lowers the amygdala's perceived risk
  - Keeps it a game
- "2 Second Lean" by Paul A. Akers



In his quick read, brash book 2 Second Lean, author Paul A. Akers contends that “Money kills creativity”.

Just as too big a change sets off the amygdala's alarm system, having a lot of money to throw at a problem may have a similar effect because the risk of spending the money unsuccessfully in an attempt so solve a problem or improve things may trigger the amygdala's fear response. It makes the stakes too high

Research has shown that intrinsic rewards keep the brain engaged, creative and playful, while rewards, no matter how well meaning, typically cause the brain to be less creative and less effective at solving problems.

This can result in the other negative effect of having a lot of money to spend on the solution, the brain goes into “tunnel vision” thinking (we must spend money to solve the problem).

The average Toyota worker submits 100 to 600 suggestions for improvement per year, with an average of 90+ percent being adopted and an average award value of about \$3. The average American auto worker submits 1-2 suggestions per year with an average value of \$100+.

The lower award builds teamwork and is about recognition.

# Have You Built a Culture Where Everyone Is Working on Their Habits?

- When the chips are down, people revert to their habits
- SafeStart's "4x3+1 for Safety"

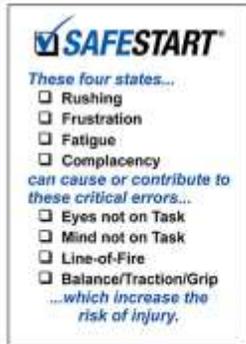


Figure 2a



Figure 2b

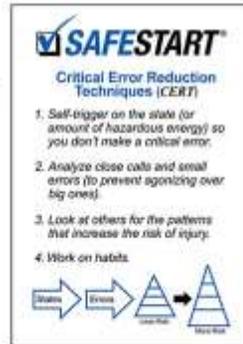


Figure 2c

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Safestart, a Canadian company that consults in safety, has this "Cliff Notes" way of describing risk factors for safety and how to mitigate them, which you will see goes back to building safety habits.

I call this 4x3+1 for safety, and present it as a 3 minute opener for every training program I conduct.

4 things that make it more likely that a Near Miss (rebranded Good Catch) will become an incident: Rushing, Frustration, Fatigue (back to that again), and Complacency.

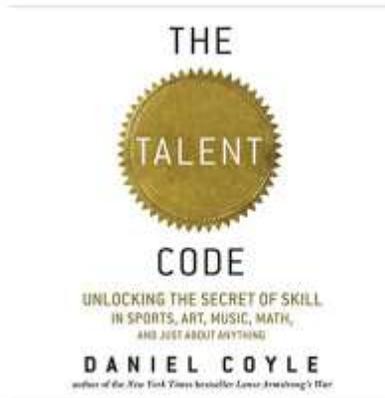
Next to the word Complacency they say "write the word "kills", and show a short video clip of a person working the cash register in a party store getting ready to step back into the open trap door where they stored liquor in the basement. "You think she didn't know about it?" She was the owner of 18 years".

4 more things that make an incident more likely: Eyes not on task (can you say "cell phone), Mind not on task, Line of fire (getting in the), Balance/traction/grip

To fix it, 1. Call it on yourself, 2. Analyze near misses, 3. Look at unsafe behaviors around you, and 4. Work on your habits.

## Did You Know that the Conscious Mind Processes 20k bps, Subconscious 20M?

- Talent Code: Creating disproportionate centers of excellence
- Neurologically, how habits are built, and how to build the right ones
- And let the wrong ones atrophy, although they don't go away



When you first start on a behavior, you have to think about it, then it becomes a habit, then a reflex.

Safety needs to be at the habit level at least, if not the reflex level.

The Talent Code goes into the neurology of disproportionate excellence, no matter what the skill, whether piano playing or safety.

When I was learning to rope, the cowboy teaching us had already figured this out (probably without reading the book). “When you get a good throw, stop, savor the muscle memory, then go do something else.”

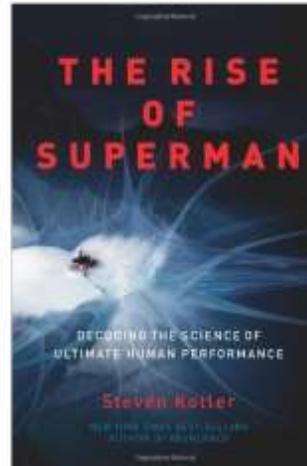
“Most people train to failure.” he then said,. “When they get a good throw, they try it again. The next try is not as good. They keep trying as it gets worse until they quit frustrated.”

Turns out quitting on a good note myelinates the neural circuit of success, versus myelinating the unsuccessful circuit. Myelin is the insulation on nerves, the more myelination the faster and more reliable the circuit. Disused circuits gradually demyelinate but don't actually go away.

The book covers individual as well as how to coach and build a culture for excellence.

## Did You Know that in Times of Stress, Your Thinking Brain Goes Off-line?

- And that that is good?
- It lets you take advantage of the faster processing speed of the subconscious
- Let's you "hack" Anders Ericksen's 10,000 hours of mindful practice
- Why good safety needs to be a habit (HRO's)
- When you don't get to practice before the event



You may have heard of Anders Ericksen's "10,000 hours of mindful practice to achieve excellence."

In *The Rise of Superman*, we get the brain neurology of excellence outside of previous experiences. The first example contrasts the Olympic gymnast who lands the vault on her bad ankle to win the gold medal for the American team. "She had made that vault 1000 times before".

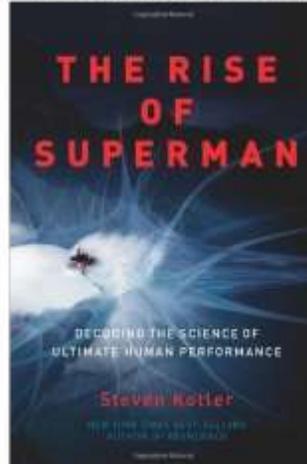
Contrast that with Danny Wei, who goes to skateboard the Great Wall of China on a half million dollar mega-ramp that a sponsor built. On the first practice run, they discover that the measurements were wrong and Danny crashes, damaging both his knee and ankle. They rebuild the ramp to the correct specifications, he walks the 5 flights of stairs up to the top, and he nails the jump. And then does it a few more times, because how many times do you get a half million dollar mega-ramp?

We used to think that excellence was when your thinking brain (pre-frontal cortex) got smarter. Turns out in times of stress, the pre-frontal cortex of the brain goes off-line, deferring to the subconscious.. And this is a good thing, because the thinking brain only processed thousands of bits per second while the unconscious processes millions.

Back to the need to build safety as a habit.

## Preserving Your Cognitive Attention for When You Need It (Chunking)

- Back to the building habits
- To reduce the energy required for commonly repeated task, the brain “chunks” them into a series of steps
- Why good safety needs to be a habit (HRO’s)
- When you don’t get to practice before the event



To be efficient, the brain “chunks” the steps together and stores the “chunk” as a unit.

This lets routine activities be conducted without the need for a lot of “cognitive awareness”, which is energy intensive. The brain would rather save its cognitive awareness for when it is really needed, such as when things start to go wrong.

The key to having this be successful is to build more and more of the HRO “what if” questions into scenarios that the brain already has a trained answer and behavior for., and to have a trigger to identify when “none of the above” is the answer and customized response is needed, preferably with consultation with experts.

HRO’s sensitivity to weak signals that the default answer stored in the subconscious is not unfolding true to pattern and that the situation needs cognitive awareness and a more thoughtful approach is what makes their processes so successful.

Smart checklists that indicate key points at which to ask “is this doing what I think it should be doing”, SOPs that delineate what could go wrong, and what would indicate a new way of something going wrong that hasn’t been planned for yet, are 2 ways to help error proof processes.

## Did You Know You Can Learn About Organizational Culture From A Deli?

- What if your team members knew that for every \$1000 in Worker's Compensation cost they needed to bring in \$50,000 in sales to offset the cost?
- And what if they knew that took away from their profit sharing?

- [www.zingtrain.com](http://www.zingtrain.com)



When you look for an organizational framework that supports employee engagement, Zingerman's is a great model. The Zingerman's Community of Businesses (ZCoB) went from a deli that everyone said would fail 35 years ago to 11 separate food related businesses, and \$65 million in gross revenues, a \$2 million a year business of which is ZingTrain, which trains how they have done it (go to [www.zingtrain.com](http://www.zingtrain.com), lower right hand side is Free Stuff and Webinars where you can learn a lot).

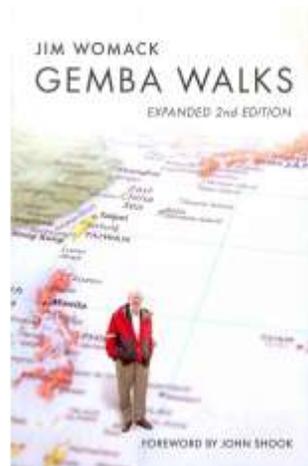
The company is open book, so employees know that for every \$1000 in work comp costs, at the typical 2% food-related profit margin, they need to sell \$50,000 worth more Reubens to make that profit back. And since profit-sharing is transparent, they know that cost decreases the funds for profit sharing (they call it gain sharing).

The Business Perspective Chart shows the Zingerman's Experience around everything,. They Vision extensively, from the 15 year vision for the ZCoB as a whole (they're on their 3<sup>rd</sup> 15 year vision, the first one in which the original founders and managing partners are transitioning out), to Mail Order that does a daily vision. Have a problem? "Vision the solution then lets talk about it" might be what you hear.

Principles are what they do when it's difficult, systems are how they implement it all, culture is what they actually do, you try to have the gap be as close to 0 as possible. Which feeds their triple bottom line, great food, great service, great finance.

## What's the Difference Between Error-Proofing and Mistake-Proofing?

- Error proofing: cannot be done wrong
  - Mistake proofing: making it more difficult to do it wrong
  - Any time you say “be careful” you have a process with the opportunity to be error proofed
- “Gemba Walks” by Jim Womack



So with all this talk of safety culture, what's the difference between error-proofing and mistake-proofing?

I have heard it described as error proofing is when it can't be done wrong. Mistake proofing is when you implement controls to try to keep something from being done wrong.

Easy example, I don't want to disturb the meeting with my cell phone going off. If I leave it in my vehicle, I have error-proofed against that happening. To mistake proof it, I might remind myself to put it on silent, turn off all alarms, etc.

Gemba Walks, while not specifically about Error Proofing, is a book with extensive practical information about improving your processes and culture in order to create excellence.

Any time you hear the words “be careful” or you say “you have to be careful about this”, you are looking at a process that is not optimally error-proofed. A small question you could ask yourself is “how could I improve this so it is automatically safer?”

SafeStart contends that the statement “be careful” is pretty useless culturally for safety, since it gives the hearer no help in understanding how to act more safely.

## Are You Ready to Explore Error Proofing and Mistake Proofing?

- Espresso making
  - Traffic
  - Process of your choice
  - 3 levels of SOP
    - First time, never seen the process before
    - Index card reminders
    - Visual checklist
- What can you learn about Error Proofing and Fatigue when making coffee?



So back to the original topic, error-proofing for fatigue, with my espresso maker sand SOP story.

I have been doing some work where I have been “shift hopping”, sometimes going until 4 in the morning, sometimes trying to maintain a normal daytime schedule. I didn’t think I was that tired or affected. ..

Remember how people who are cognitively impaired by fatigue are poor judges of the extent of their impairment.?

Then I started the espresso maker with everything done properly. Except that I didn’t have a cup under the spout. Wish I had thought to take a picture of that actual mess, but you get the point.

Mistake proofing change to the order of the steps in the SOP: I don’t put the coffee in the espresso maker basket until the cup is under the spout.

Another time, I turned it on with no water in it (no harm done, let it cool down). SOP change, add water before plugging it back in and turning it on.

Further improvements? Checklist laminated on the espresso maker? Takes my need for cognitive attention away, I can mindlessly follow the steps.

Or buy a coffee....error-proofed!

# Thanks for Participating!

Kathy J. Malone, CHMM  
ManGuard Systems, Inc.  
[manguardEHS@gmail.com](mailto:manguardEHS@gmail.com)  
810-515-0115

Thank you for your interest in this topic!

Please send me your error-proofing and mistake-proofing examples and stories, I would love to hear them.

If you would like help setting up processes or training your employees or management in a number of “Lean in the Real World” safety topics, please reach out to me.

Kathy Malone, CHMM

About me: 37+ years, Purdue environmental engineer Automotive, Aerospace, Hazardous Waste Transfer Facilities, now food-related manufacturing and service as well.

Interesting projects: end to end integration from chemical request, through receipt into EHS inventory for regulatory and other reporting, integrated through to waste disposal, integration of safety all the way through. Templating of Chemical Safe Use Instruction, equipment Safe Operating Procedures, and Job Hazard Assessments.

Error-proofing and mistake-proofing of environmental, health and safety activities.