Fig. 1: Examples of High Energy Hazards[5]

ENERGY-BASED HAZARD RECOGNITION:
ENHANCING WORKPLACE SAFETY – CONTROLLING HIGH ENERGY HAZARDS

BY SCOTT GREENHAUS

Introduction

Effective hazard recognition and mitigation is a cornerstone of workplace safety. Traditional hazard identification focuses on recognizing physical dangers, but energy-based hazard recognition takes a more holistic approach by identifying sources of energy that can cause Serious Injuries or Fatalities (SIF). This methodology enhances risk assessment by linking hazards to their energy sources and applying controls systematically.

This article explores key concepts of energy-based hazard recognition, including the **Energy Wheel Theory,[1] Direct Controls,[2] Alternative Controls,[2] HECA® (High Energy Control Assessment),[3]** and how they integrate with **Construction Safety Research Alliance (CSRA)[4]** frameworks. Special attention is given to applications in the construction industry, particularly in concrete repair and new concrete construction.

Energy Wheel Theory: Understanding the Source of Hazards

The **Energy Wheel** is a visual tool designed to identify and categorize energy sources in the workplace.[1] It is based on the premise that hazards stem from uncontrolled energy. By recognizing and controlling these energy forms, organizations can work to prevent serious injuries and fatalities.

Energy Wheel Categories:[1]

In **concrete repair** and **new concrete construction**, several energy types can pose significant risks:

- **Motion Energy:** Movement of heavy equipment like concrete mixers, cranes, work zones and transport trucks
- **Gravity Energy:** Suspended concrete loads, formwork failures, working at heights, stored energy in concrete pump hoses, post-tension cables, unsecured materials, steep slopes, footing excavations and formwork under tension
- **Electrical Energy:** High voltage electrical lines, power supplies such as spider boxes,

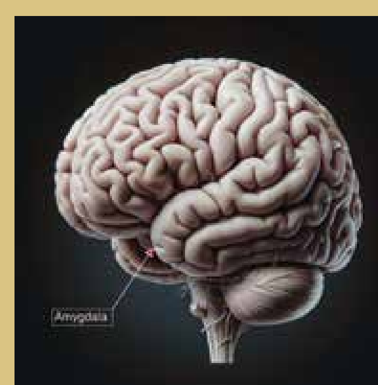


Fig. 2: Amygdala (Fight or Flight)[6]

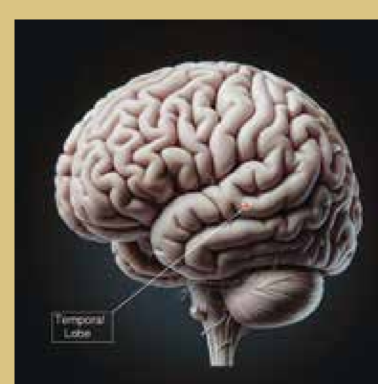


Fig. 3: Temporal Lobe (Information processing)[7]

power tools, generators and lightning strikes

- **Temperature Energy:** Heat from curing and temperature controls, engines, hot work and weather including extreme temperatures during reinforcement placement and concrete pours
- **Chemical Energy:** Handling of hazardous materials such as solvents, using concrete finishing equipment with combustible engines that generate CO indoors, and unexpected releases of hazardous gases while performing concrete repairs at a refinery.

The various types of energy sources are identified by the icons shown in Figure 1. By identifying these energy sources, construction teams can proactively address hazards during the planning process and apply controls before they result in life threatening, life altering or life ending events. It is critical to address high energy hazards because the hazards that hurt people are not the same hazards that will kill people.

Cognitive Effort in Hazard Recognition

Research reveals strong evidence that commonly identified hazards (e.g., gravity, motion) are recognized instinctually and require comparatively low mental effort. The amygdala (a small, almond-shaped brain structure involved in processing emotions, particularly fear and aggression) activates the "fight or flight" response, preparing the body for action when it perceives danger or stress (Fig. 2). It is part of the "primitive brain," which refers to the oldest, most basic part of the brain responsible for fundamental survival functions and instinctive responses. In contrast, hazards that are most commonly missed (e.g., mechanical, pressure, chemical) are processed in more advanced areas of the brain and require much greater cognitive effort. Cognitive function is centered on the temporal lobe (Fig. 3), which is a part of your brain that helps you use your senses to understand and respond to the world around you. It also plays a key role in how you communicate with other people, including your ability to access memories, use language and process emotions. This distinction underscores the importance of structured hazard recognition processes, such as the Energy Wheel, to capture hazards that may otherwise be overlooked.

Direct Controls: Mitigating Hazards at Their Source

Once energy sources are identified, the next step is applying **Direct Controls** and, if necessary, **Alternative Controls** to mitigate risks.[2] A Direct Control has three components:

1. It must specifically target the high energy.
2. It must effectively mitigate exposure to the high energy source when installed, verified and used properly.
3. It cannot be vulnerable to human error and remain effective, even if someone makes a mistake.

Direct controls are measures that either eliminate or reduce exposure to hazardous energy and exist in approximately 60 percent of high energy hazards. When a Direct Control is not present, Alternative Controls can be applied to reduce the high energy hazard risk.

These controls align with the **Hierarchy of Energy Controls** (Fig. 4), which prioritize the most effective methods for managing risks.[2] In **concrete repair** and **new construction**, examples of direct controls include:

- Installing a hard barricade around a full depth slab repair in a parking garage
- Planning and implementing a lockout/tagout procedure before entering a water pipeline to perform repairs and strengthening
- Deenergizing the electrical system when performing floor repairs with embedded conduit in an electrical distribution room in an apartment building
- Erecting a barrier system around high-pressure gas lines while performing repairs to a concrete wall in a gas pumping station.

Examples of alternative controls include dedicated human monitors, physical barriers and signage to reinforce existing direct controls and mitigate the potential for human error. Direct Controls and Alternative Controls are described in Figure 5.

HECA®: High Energy Control Assessments

HECA is an **assessment metric** used to capture mass observational data on high energy hazards and the presence of direct controls.[8]

It emphasizes four key components:

1. **Hazard:** Identify the specific energy hazard present.
2. **Energy:** Understand the type and magnitude of energy involved.
3. **Control:** Apply direct controls to mitigate or eliminate the hazard.
4. **Action:** Implement and monitor the effectiveness of the control measures.

Using **HECA** during **concrete repair** and **new construction** ensures that every energy hazard is systematically identified and controlled. For example:

- **Hazard:** Performing repairs to bridge pier on a highway (Fig. 6)
- **Energy:** Motor vehicles and semi-trucks moving at 60-plus miles per hour (96.5-plus km/h)
- **Control:** Jersey Barriers and truck attenuators
- **Action:** Install Jersey Barriers securely attached to the pavement and place the truck attenuator at the proper location. Monitor to ensure controls are in place.

Almost all contractors perform safety observations on a regular basis. This typically is performed by recording observations on a

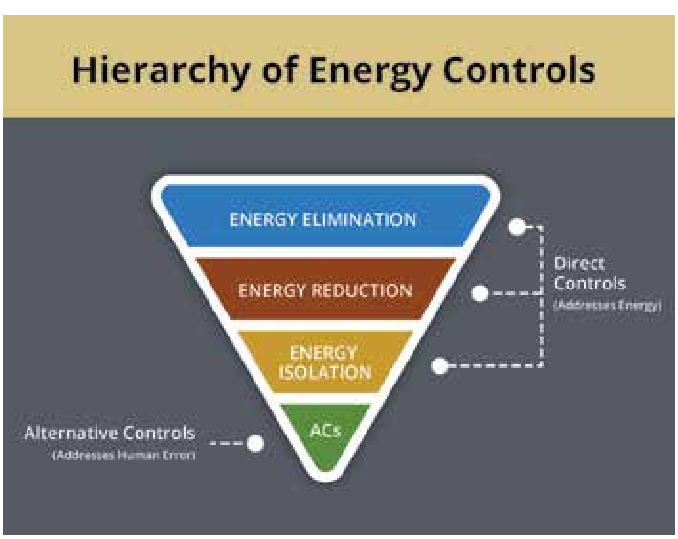


Fig. 4: Hierarchy of Controls[2]

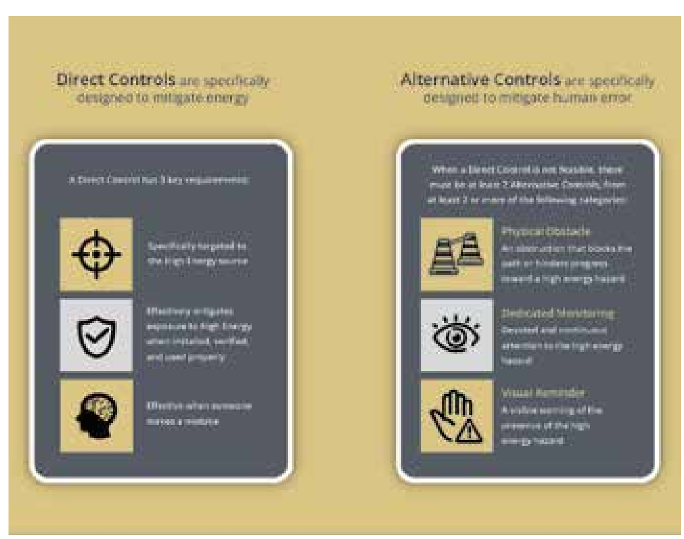


Fig. 5: Direct and Alternative Controls[2]

Fig. 6: Roadway repair project[9]

customized safety audit form. In addition to the ongoing hazard assessment process you have in place, the next step is to assess the high energy hazards (Fig. 1) that exist on the project and note the direct controls (Fig. 5) in place to mitigate those hazards. When there is a control in place, it is labeled a "success." When there is no control in place, it is labeled an "exposure." An HECA score can be calculated by comparing the controls in place to the total hazards present ("Success + Exposure").

HECA = Success / (Success + Exposure)[8]

By making many observations and calculating HECA scores, a contractor can begin to monitor how well they are observing and controlling hazards that can cause SIFs.

Construction Safety Research Alliance (CSRA)

CSRA has researched, developed and presented a systematic process for identifying, evaluating and mitigating high-risk activities. Integrating energy-based hazard recognition within a CSRA framework enhances its effectiveness by providing a structured method for analyzing energy hazards.

Steps to Integrate Energy-Based Hazard Recognition in CSRA:

1. **Identify Critical Tasks:** Pinpoint operations with significant risk potential.
2. **Analyze Energy Sources:** Use the Energy Wheel to identify all potential energy forms.
3. **Evaluate Risk Levels:** Assess the likelihood and severity of energy-related incidents.
4. **Apply Direct Controls:** Implement HECA principles to mitigate identified risks.
5. **Apply Alternative Controls:** When Direct Controls are not available or feasible.
6. **Monitor and Review:** Regularly review controls for effectiveness and adjust as needed.

The Tyranny of TRIR and the Injury Pyramid

Total Recordable Incident Rate (TRIR) is a commonly used safety metric to measure workplace safety performance. However, over-reliance on TRIR can lead to unintended consequences, often called the "Tyranny of TRIR." Organizations may focus on reducing minor incidents to improve TRIR rather than addressing high-impact, low-frequency risks that pose the most significant threat to worker safety. As shown in Figures 7 and 8, while the nonfatal injury and illness rates have significantly reduced in the past decade (Fig. 7), the fatal injuries have actually increased over the same period. (Fig. 8)

Similarly, the traditional **Safety Pyramid**, also known as the **Injury Pyramid**, (Fig. 9) suggests that reducing minor incidents will proportionately reduce serious injuries and fatalities.[12]

However, research by the **CSRA** indicates that the causal factors for serious injuries are often unrelated to minor incidents. This flawed assumption can divert resources toward minor hazards while neglecting the critical energy-based risks that lead to life-threatening outcomes.

In order for a metric like TRIR to be valid in measuring current safety performance and the likelihood of future performance, it must have the following attributes:[13]

1. **Objective:** Observations not subject to observer bias.
2. **Valid:** The data required for the metric can be generated in sufficient volume to produce statistically significant trends.
3. **Predictive:** Trends in the metric provide information on the probability of future trends.
4. **Clear:** The metric is easy to understand and practical to communicate.
5. **Actionable:** The metric provides information that may prompt interventions and strategic planning.
6. **Important:** The metric reports information related to an organization's strategic vision and goals.

Research has shown that TRIR does not meet these six criteria:

1. **Objective:** TRIR is objective because it is based on direct observation.
2. **Valid:** TRIR is not valid because it is not statistically significant (not enough man-hours to create a high confidence level in the repeatability of the measured results).

Nonfatal injury and illness incident rate per 100 equivalent full-time workers according to self-reported data by private U.S. employers.

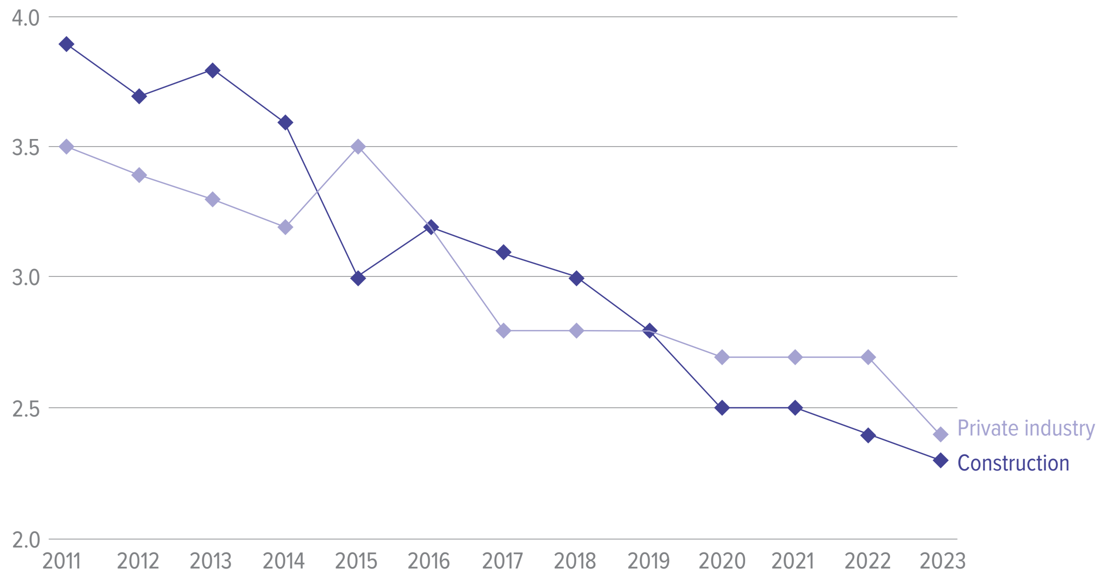
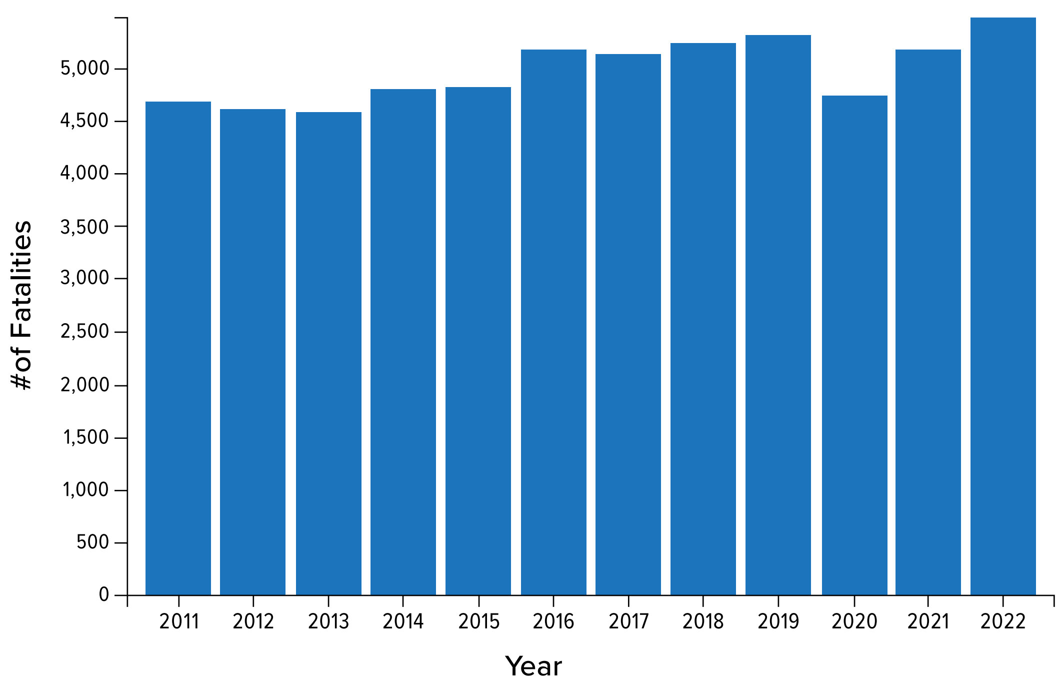


Chart: Zachary Phillips | Construction Dive • Source: BLS • Get the data • Created with Datawrapper

Fig. 7: Nonfatal injury and illness trends[10]

Count of Fatal Injuries by Year, All U.S., 2011-2022



Source: Bureau of Labor Statistics (BLS), Census of Fatal Occupational Injuries (CFOI)

Fig. 8: Fatal Injury Trends[11]

Fig. 9: Traditional Safety Pyramid[12]

3. **Predictive:** TRIR is not predictive because TRIR of the past is not indicative of TRIR (or fatalities) in the future.
4. **Clear:** TRIR is clear because it is easy to understand and communicate.
5. **Actionable:** TRIR is not actionable because it does not support proactive behavior or strategic decisions.
6. **Important:** TRIR is not important because it is not aligned with emergent safety principles or a focus on preventing serious injuries and fatalities.

Therefore, CSRA recommends TRIR should not be used as a predictor of serious injuries and fatalities given the lack of statistical association between TRIR and fatalities, which suggests that the assumption holds no scientific merit. TRIR should not be used to track internal performance or compare companies, business units, projects or teams. As a construction company requires tens of millions of worker-hours to return a confidence interval with one decimal point of precision, organizations should be very careful making any comparisons using TRIR.

Companies should not place much emphasis on short-term changes in TRIR and as observed in empirical analysis, changes that occur from month to month are mostly random and do not necessarily reflect any actual change in the safety system.

While TRIR is used by owners and general contractors to differentiate and select between various contractors based on their safety performance, research has shown that this is an incorrect use of this measure and TRIR is not the most valid tool for measuring safety performance. The HECA score, as mentioned above, may be a viable alternative in the process of monitoring the work site in real time and assessing whether controls are in place to mitigate high energy hazards.

Conclusion

Energy-based hazard recognition provides a robust framework for identifying and mitigating risks by focusing on the energy sources behind workplace hazards. When integrated with methodologies such as the Energy Wheel, Direct Controls and HECA, organizations can move beyond traditional safety metrics like TRIR and address the root causes of serious incidents. In the construction industry, particularly in concrete repair and new concrete construction, adopting these practices enhances worker safety and prevents life-threatening injuries. By recognizing and controlling energy, workplaces can foster a proactive safety culture that prioritizes the most significant risks.

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