EMERGENCY MANAGEMENT USE CASE

Research Title:	**Hazard Index for Emergency Response in Chemical Facilities**
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Description:	With the rapid development of chemical process plants worldwide, the safe storage of hazardous chemicals continues to be an important topic. Chemical warehouse incidents related to fire and explosion are reported constantly (i.e., the 2013 West Fertilizer Plant explosion). These incidents not only cause direct economic loss but also harm the local environment. Therefore, an accurate hazard identification method for chemical facilities is valuable before any emergency response actions. This type of index can help emergency responders recognize potential hazards in the chemical storage or chemical facility areas and to have a better emergency management.
When Applied:	This hazard index could be applied to any hazardous chemicals before a disaster happens.
Who Applies:	Any individual working in chemical facilities (*i.e.*, the facility manager), any first responders (*i.e.*, firefighters), and any public living near the chemical facilities.
Disaster Type:	Fire, explosion, chemical release, *etc*.
Infrastructure Affected:	Chemical-related facilities, *i.e.*, chemical warehouses
Industry Affected:	Chemical, petrochemical, oil & gas industries, and fire service industry
Where Applied:	Chemical-related facilities, *i.e.*, chemical warehouses Chemical warehouse safety incidents happen worldwide. In the U.S., a fire and explosion occurred at the West Fertilizer Company in Texas in 2013. The violent detonation fatally caused 15 fatalities, and the local hospitals treated more than 200 injured victims. This incident is a failure of regulation, where the storage facilities may lack awareness of the potential hazard. Moreover, the corporation should be responsible for this catastrophic incident due to a lack of safety knowledge and insufficient hazard identification. This example indicate that the chemical warehouse is a potential weak point in chemical safety. It usually stores numerous hazardous chemicals in a considerable amount and may cause incidents due to the lack of hazard identification. Moreover, even if the consequence does not lead to a chemical incident, sufficient hazard identification is still needed to prevent or mitigate the potential hazard. To improve the current situation, the identification of vulnerability in the chemical process and the specific hazard becomes an essential topic in chemical safety.
Agency Affected:	US Chemical Safety Board, OSHA, FEMA
VOAD Affected:	No

Who/What Affected:	Any individual working in chemical facilities (*i.e.*, the facility manager), any first responders (*i.e.*, firefighters), and any public living near the chemical facilities.
How Affected:	For any individual working in chemical facilities (*i.e.*, the facility manager), the hazard index is helpful for hazard identification and preparing for emergency management. For any first responders (*i.e.*, firefighters), the hazard index could provide some basic hazard information about the chemical facility, reducing the risk of entering an unknown chemical facility. For any public living near the chemical facilities, the residents could have an effective hazard communication with the facilities. Furthermore, the government can better allocate the resources for first responders to make fire protection strategies, and the stakeholders can achieve improved risk management for the facility.
Timing of Application:	Before any disaster, when the chemicals are stored in the facility.
Critical Points:	**Overall:** In order to rank facilities based on the potential to cause harm to the surrounding public, this study proposes a simple functionality which takes into account four factors. The four factors are the material inherent property represented by storage hazard index (SHF), quantity of the material stored in the facility (S_1), population around the facility (S_2), and the distance to the nearest fire station (S_3). Thus, the hazard could be mathematically represented as follows: $$Hazard\ Index = SHF \times S_1 \times S_2 \times S_3$$ **Critical Points 1**: Different chemicals have different inherent properties, which represent the inherent hazard of the chemicals. Material inherent properties include flammability (NF), which may lead to fires or explosions, reactivity (NR), which represents the instability of the chemicals in certain conditions, and toxicity (NH), which will cause harm to human health and environment. Thus, the formula for calculating the SHF proposed in this study is as follows: $$SHF = 2^{Modified\ NF} + 2^{Modified\ NR} + 2^{Modified\ NH}$$ Where original NF, NR and NH are National Fire Protection Association (NFPA) ratings, and the modification rule is discussed in our original research work in details. **Critical Points 2**: Besides of the inherent hazard the chemical possess, the quantity of the material stored in the facility (S_1), population around the facility (S_2), and the distance to the nearest fire station (S_3) also factors into the calculation for the potential to cause harm to the public. Those GIS-related information could be found in the public available database, and the penalty value determination guide is listed in our original research work.
What Benefit:	Our hazard index can be used to engage in a dialog for better risk management, emergency response planning, and sharing information with the public and emergency responders.

Where Used:	Chemical facilities, chemical warehouses, chemical/petrochemical plants
Additional Research:	Original research is based on the urban and suburban areas around the Greater Houston area, and it can be expanded if more data is available.
Additional Information:	In our original paper listed below, the details about the hazard index development are described.
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Original Research:	Zhang, Z., Yuan, S., Yu, M., Mannan, M. S., & Wang, Q. (2020). A hazard index for chemical logistic warehouses with modified flammability rating by machine learning methods. ACS Chemical Health & Safety, 27(3), 190-197. https://doi.org/10.1021/acs.chas.9b00026
What Risks:	There is no risk of using this hazard index to help the emergency management.
Partner Agencies/Jurisdictions:	Texas A&M Engineering Extension Service (TEEX) Testing and Innovation Center
New Question:	[Add a description of the information to enter.]
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Research with a Technology Component Should Respond to the Following Questions

Research Requested:	This proposed technology is not in response to a specific request from emergency managers.
Why Better:	Hazard identification is typically the starting point for risk assessment. The scope of hazard identification is to identify hazards and risk factors that have the potential to cause harm. In the past century, several methods have been developed to identify hazards in the workplace. NFPA 704 is a standard developed by the NFPA, which is also known as the “hazard diamond”, and it offers hazard information for degrees of instability, toxicity, and flammability. The NFPA diamond is a rating system that provides useful hazard information for emergency responders. However, the NFPA diamond only represents the inherent hazard of a chemical without taking the quantity into account, which is also an essential factor for the storage hazard. Moreover, this standard is intended to be used by designated engineers and safety professionals, as well as emergency responders, which its purpose might limit its applicability to the public. In order to design an index system specifically used for chemical facilities, we will modify the penalty factor used in our index, as well as the method to calculate the inherent hazard of a chemical.

Reliability:	The reliability of this hazard index is high. Some potential problem might be the accuracy of the raw hazard information. However, most of the used information are standard values, so the potential problem is minimized.
Support Needed:	An accurate database about what chemical is storage in the facility and its hazard information (*i.e.*, NFPA rating, Protective Action Criteria (PAC) value)
Citizen Impact:	No
Training Required:	The hazard index itself is intuitive and easy to understand. For people who will use this index (*i.e.*, first responders, and public living near the facility), there is no training required. For people who develop this index (*i.e.*, facility managers), they need some time to collect hazard information (*i.e.*, NFPA rating, PAC value).
Public Accountability:	All used information is publicly available information and most of them are required by the standard (easy to collect).

Please Note: Questions or suggestions regarding the Use Case Template may be directed to Dr. MacGregor Stephenson at the Texas Division of Emergency Management at macgregor.stephenson@tdem.texas.gov.