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Analysis of Accident Chain and Consequences of Hazardous Chemical Logistics Warehouse Under Earthquake Coupled Disaster

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Abstract: To further clarify the development of earthquake-coupled disaster chains in hazardous chemical logistics warehouses and enhance emergency response capabilities for such scenarios, this study establishes an accident evolution analysis framework integrating Bayesian networks and failure probability models. First, based on disaster chain theory, we analyze the evolutionary patterns during the direct earthquake impact phase and domino effect phase, identifying key scenario elements and development pathways for earthquake-coupled disasters in hazardous chemical warehouses. Second, we propose a scenario simulation method combining Bayesian networks and probabilistic models to identify critical nodes and dominant pathways in disaster evolution. By integrating thermal radiation and overpressure consequence models, we quantify the disaster's impact scope and destructive severity. Finally, through case studies of earthquake-coupled disasters in hazardous chemical warehouses, we validate the model's feasibility and applicability, providing theoretical foundations and practical references for disaster scenario construction and emergency resource allocation.

Keywords: Hazardous Chemical Fire; Disaster Chain Analysis; Bayesian Network; Failure Probability

1. Introduction

China's vast territory is prone to frequent natural disasters, with various types of calamities causing varying degrees of damage across regions annually. As critical nodes for storing high-risk substances, chemical storage facilities face significant damage risks during natural disasters like earthquakes and lightning strikes. When such disasters strike these facilities, they may trigger chain reactions of hazardous materials, creating multi-hazard coupling effects that dramatically amplify accident consequences. These coupled disasters can easily lead to chain reactions including chemical leaks, fires, and even explosions, posing severe threats to the lives and property of surrounding residents and regional ecosystems. Regarding the evolution mechanisms of such coupled disasters and the assessment of accident chain consequences, scholars both domestically and internationally have conducted extensive research with phased progress. Current studies primarily focus on disaster chain modeling, identification of risk transmission pathways, and analysis of multi-hazard coupling mechanisms, providing crucial theoretical foundations for understanding risk evolution patterns in complex disaster scenarios involving chemical facilities.

Tan Hua[1] investigated the consequences of accidents caused by different natural disasters on various disaster-bearing entities, constructing a spatiotemporal matrix model for emergency disaster outcomes. Zhang Rong [2] developed an emergency evolution model using cellular automata and analyzed the chain reaction pathways of sudden disasters through Hopfield neural network methodology. In accident consequence studies, Cleaver [3] et al. proposed a steam cloud TNO model and an explosion hemispherical model centered on ignition points to determine the impact range of steam cloud explosions. Van den Bery [4] et al. further considered obstacle constraints and airflow effects, establishing a multi-energy explosion model. Stawczyk [5] et al. conducted experimental research on liquefied gas explosions, analyzing the entire BLEVE accident process and identifying relevant impact ranges and factors. Although existing studies have made significant progress in disaster consequence simulation and hazard assessment, there remain notable gaps in predicting consequences under coupled disaster scenarios. This research gap primarily stems from two constraints: First, coupled disaster systems inherently exhibit high complexity and multi-variable nonlinear characteristics, with their internal mechanisms remaining unclear. Second, current theoretical models and computational methods lack adaptability for such complex systems, making it difficult to support high-precision consequence simulations and predictions, thereby limiting the development and application of specialized analytical tools.

2. Analysis of Earthquake-Coupled Disaster Chain in Hazardous Chemical Logistics Warehouse

2.1 Hazardous Chemicals Logistics Warehouse Earthquake Disaster Accident Chain

The mechanism behind earthquake-induced chemical warehouse accidents fundamentally involves a catastrophic chain reaction triggered by seismic destructive effects. This process begins with structural damage to vulnerable facilities like warehouses caused by seismic waves, leading to hazardous material leaks that may subsequently trigger secondary disasters such as fires or explosions. The process typically exhibits three characteristic features: concurrent disaster occurrences, paralysis of lifeline systems, and collapse of safety protection systems—including loss of barrier functions like building structures, containment dikes, and automated control systems. The earthquake disaster chain in chemical logistics warehouses represents a "primary, secondary, and derivative" disaster transmission process formed through multi-system interactions following initial earthquake-induced damage, primarily categorized into three types. The structure-dominant type starts with earthquake-induced structural failure, where collapsing components impact chemical containers causing leaks. Flammable liquid spills ignite upon encountering fire sources, and high temperatures exacerbate structural collapse, forming a "earthquake→structural collapse→container damage → chemical leakage → ignition → secondary structural collapse" cycle. The chemical-leak-dominant type involves earthquake-induced ruptures in storage tanks and pipelines causing chemical spills, toxic gas dispersion leading to poisoning, flammable vapor explosions upon contact with open flames, and shockwaves damaging facilities triggering secondary chemical leaks, creating a "earthquake→tank/pipeline rupture→chemical leakage→toxic gas dispersion, combustible vapor cloud formation → poisoning, explosion → secondary chemical leakage" trajectory. The environmental coupling mechanism demonstrates the synergistic effects between earthquakes and extreme weather/geochemical conditions. Heavy rainfall erodes hazardous chemical leaks, generating toxic wastewater that contaminates soil and water bodies. Strong winds accelerate toxic gas dispersion or trigger external fires, while earthquakes in geologically sensitive zones induce landslides that further damage infrastructure. This creates a chain reaction: "earthquake→hazardous chemical leakage→environmental factors→ecological pollution→geological hazards→cross-regional risks." These three types of accident chains often intersect and interact. Clarifying their patterns and evolutionary mechanisms provides critical support for accident prevention and emergency response, which is vital for minimizing disaster losses.

2.2 Domino Effect Derivative Mechanism and Development Law

In hazardous chemical logistics warehouses, when an earthquake disaster chain transforms into coupled accidents triggering disasters, there is a high probability of subsequent disasters forming a domino effect. The triggering and propagation patterns of the domino effect primarily rely on three elements: thermal radiation, shock waves, and explosive fragments. Jiang Dai et al. [9] explained the causes of domino accidents using the principle of physical triggers, proposing three main propagation modes: simple propagation (where a single initial event triggers secondary accidents), chain propagation (where initial events cause damage to adjacent disaster-bearing entities, denoted as secondary accidents, which then lead to tertiary accidents, propagating sequentially until disaster termination), and multi-layer propagation (where initial events simultaneously trigger multiple parallel secondary accidents, resulting in higher-order disasters through network-like nonlinear coupling). This disaster chain evolution path exhibits a typical network distribution pattern, representing the most severe consequence propagation model.

2.3 Calculation Method of Coupling Disaster Accident Probability

The fundamental mechanism by which earthquake disasters trigger coupled disaster events lies in their physical destructive capacity to cause functional failures in industrial facilities or storage systems. Therefore, scientific risk assessment must prioritize analyzing the physical vulnerability of disaster-bearing components within chemical logistics warehouses and evaluating system resilience. Current research has developed multiple computational models and evaluation methods to quantify Na-Tech accident risks caused by natural disasters like earthquakes. The Cozzani method, as demonstrated in Equation 1, is employed to calculate equipment failure probabilities under natural disaster disturbances.

$$Y = k_1 + k_2\, ln(PGA) \tag{1}$$

Table 1: Comparison of Peak Seismic Acceleration and Seismic Intensity.

Peak acceleration g $()g$	< 0.05	0.1	0.15	0.2	0.25	0.3	0.4	≥ 0.5
Seismic intensity	< VI	VI	VII	VII	VIII	VIII	IX	$\geq X$

Here, Y represents the unit value of failure probability, and PGA denotes the peak ground acceleration. The relationship $k_1 k_2$ between peak ground acceleration and seismic intensity is shown in Table 1, with values listed in Table 2

Table 2: Failure Probability of Different Equipment Under Earthquake Action.

Device type	Damaged condition	k_1	k_2
Fixed roof tank	≥ 2	5.43	1.25
	3	3.36	1.25
Floating roof tanks	≥ 2	7.71	1.43
	3	5.51	1.34
Horizontal tank	≥ 1	5.36	1.01
	≥ 2	4.50	1.12
	3	3.39	1.12
Pipelines, pumps	≥ 2	5.31	0.77
	3	4.30	1.00

After determining the failure probability unit value, the actual probability P of different facilities being damaged by seismic action is calculated as shown in Formula 2.

$$P(x) = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{Y-5} e^{-x^2/2} \, dx \tag{2}$$

Here, P denotes the failure probability, Y represents the unit value of the failure probability, and the integral variable is denoted by.

Table 3 lists the calculation methods of unit values of failure probability and corresponding critical values under two scenarios: the destruction of the target device caused by shock wave and the damage of the container overpressure caused by thermal radiation.

Table 3: Units and Critical Values of Domino Failure Probability.

Physical effects of destruction	Target device	Unit value of failure probability	Critical value
Impact wave	Non-pressure vessel	$Y = -9.36 + 1.43\, ln(\Delta P)$	$5.17KPa$
	Pressure vessel	$Y = -14.44 + 1.82\, ln(\Delta P)$	$30KPa$
Heat radiation	Non-pressure vessel	$Y = 12.54 - 1.847\, ln(ttf)$	$30min$
		$ln(ttf) = -1.128\, ln(I) - 2.667 \times 10^{-5}V + 9.877$	$10kW/m^2$
	Pressure vessel	$Y = 12.54 - 1.847\, ln(ttf)$	$30min$
		$ln(ttf) = -0.947\, ln(I) + 8.835V^{0.032}$	$40kW/m^2$

Where Y , represents the unit ΔPvalue Pa $\Delta P$of ttf failure Paprobability I $sttf$; represents kW/m^2soverpressure I (kW/m^2); is the device failure time (); and is the thermal radiation flux (). Volume $V$of device (m³).V

To ensure the scientific validity of secondary accident probability calculations in earthquake-coupled disaster scenarios, it is crucial to consider the unique open effect and amplification effect inherent in hazardous chemical logistics warehouses. These effects can cause persistent or recurring damage to warehouse systems from natural disasters, leading to deviations in traditional probabilistic model calculations. To address this, this study introduces a correction mechanism for unit values of failure probability. The specific calculation method for the corrected probability values is detailed in Formula 3

$$Y = Y(V) + Y(u) \quad (3)$$

In the formula, Y represents the secondary accident $Y(V)$ failure probability unit value ≤ 5, $Y(u)$ the initial ≤ 5 accident $Y(u)$ failure probability unit value, and the domino destruction probability unit value.

3. Construction of Earthquake-Coupled Disaster Scenario for Hazardous Chemical Logistics Warehouse

Since Thomas Bayes proposed the Bayes Theorem in the 18th century, this theory has been widely applied across various disciplines. The core of the Bayesian approach lies in its probability updating mechanism, where prior and posterior probabilities are two key concepts. As a significant advancement in this field, Bayesian networks have become a common model for handling uncertain knowledge reasoning. Structurally, they manifest as directed acyclic graphs, where nodes and their directed edges represent probabilistic dependencies between variables.

3.1 Bayesian Network Generation for Earthquake-Coupled Hazard in Hazardous Chemical Logistics Warehouses

Through analyzing the earthquake-triggering mechanisms and domino effect patterns in hazardous chemical logistics warehouses, this study reveals that such earthquake-coupled disasters exhibit a characteristic chain propagation structure. By introducing a failure probability calculation method, we can effectively identify critical nodes in disaster evolution. In this chapter, using earthquake disasters as a typical scenario, we apply this computational approach to quantify the probability of secondary accidents such as fires and explosions. The resulting universal model for earthquake-triggered coupled disasters in hazardous chemical logistics warehouses is illustrated in Figure 1.

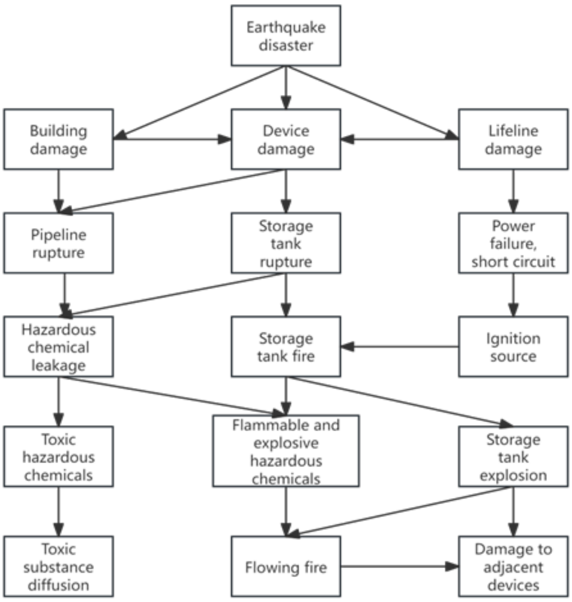

Figure 1: General Model of Disaster Evolution of Hazardous Chemical Logistics Warehouses Under Earthquake Disasters.

3.2 Conditional Probability Computation in Bayesian Networks

After constructing the Bayesian network model for disasters and accidents, it is necessary to assign corresponding conditional probabilities to the variables in each node of the network. The probability distribution mainly includes the following two cases:

(1) For root nodes without parent nodes, they are defined as initial event nodes, requiring the setting of prior probabilities. For example, the initial probability of Na-Tech events triggered by earthquake disasters. The determination of these prior probabilities serves as the foundation for calculating conditional probabilities of subsequent nodes.

(2) For non-root nodes with parent nodes, the determination of conditional probabilities primarily relies on empirical formulas and data obtained from historical research, supplemented by expert evaluations conducted through the Delphi method. Given the complex structure and numerous variables in hazardous chemical logistics warehouse systems, the relationships between network nodes under coupled disaster scenarios exhibit high complexity. Due to the scarcity of relevant accident sample data, it is challenging to obtain reliable probability parameters through statistical learning methods. Therefore, this study adopts the expert scoring method as the primary approach for calculating failure probabilities, supplemented by a pessimistic decision-making criterion to complete the conditional probability distribution of nodes.

4. Accident Consequence Analysis of Hazardous Chemical Logistics Warehouse

In this section, the possible consequences of fire and explosion in the disaster-bearing body in the logistics warehouse under the coupled scenario of earthquake disaster will be analyzed, and the quantitative calculation method adopted in this paper will be given.

4.1 Disaster Accident Consequence Analysis

Earthquake-coupled disasters in hazardous chemical logistics warehouses represent a typical category of major hazards. Given the complex internal structures and comprehensive functional systems of these warehouses, the industrial accidents triggered by seismic activities exhibit significant diversity. Table 4 details the typical accident types and their characteristics that may result from flammable materials in warehouse equipment.

Table 4: Types of Accidents Frequently Occurring in Different Equipment for Hazardous Materials.

Device	Explosion hazard gases	Liquefied gas	Flammable liquid	Flammable liquid
Storage tank	Cloud explosion	BLEVE	Fire	Fire
Storehouse	Cloud explosion	BLEVE	Fire	Fire
Pipeline	Cloud explosion	—	Fire	Fire

This study employs the TNT equivalent model to predict the consequences of typical vapor cloud explosions (VCE) in hazardous chemical warehouses. The method balances computational efficiency with accuracy by assessing the explosion overpressure to determine the damage extent and fatality radius, providing a quantitative basis for personnel and equipment deployment in emergency response.

4.2 Accident Consequence Calculation Method

(1) Fire consequence calculation model

1)Fire in the pool

Ideally, in the case of a fire dike around the tank, the maximum combustion area of the pool fire is based on the area of the fire dike. Taking the tank as an example, the calculation of the maximum pool fire radius is shown in Equation 4.

$$r = \sqrt{\frac{a \times b}{\pi}} = \frac{D}{2} \tag{4}$$

where r represents the maximum a combustion b radius, L and W are the length and width of the fire dike, and D is the diameter of the pool fire.

Surface thermal flux of a fire

Assuming that the thermal radiation is uniformly radiated to the surrounding area through the flame surface, the calculation method of the surface thermal radiation flux of the pool fire is shown in Equation 5.

$$E = \frac{0.25\pi D^2 \Delta H_f m_f f}{0.25\pi D^2 + \pi DL} \tag{5}$$

where represents ΔH_f the kJ/kg f combustion heat (m_f), the thermal radiation kg/m^2s coefficient is generally taken as 0.15, and the combustion rate is (m_f).

The formula for calculating the thermal flux received by the target device is as follows:

$$Q(r) = E(1 - 0.058\, ln\, r)F \tag{6}$$

The result E is calculated by formula 6 (kw/m^2); where r is the distance between the target device and the flame center, and F is the viewing angle coefficient.

2) Full liquid fire

Flame shape is considered to be a cylinder, and the flame height can be calculated by formula 7.

$$H_L = 42D(\frac{m_f}{\rho_{a\sqrt{gD}}})^{0.61} \tag{7}$$

Here, h H_L represents the m flame height (m); D denotes m the m_f combustion m m_f kg/m^2s diameter ρ_a (tank kg/m^2s diameter ρ_a, m); r indicates the combustion rate (m^3/s); ρ is the ambient air density (1.2 kg/m^3); and g is the gravitational acceleration (9.8 m/s^2).

At this time, it is assumed that the thermal radiation generated by the flame radiates out from the center of the tank to the surrounding area. The calculation formula of the thermal radiation flux generated by the fire is shown in 8.

$$E = \frac{(\pi r^2 + 2\pi r H_L) m_f \Delta H_f \eta}{72 {m_f}^{0.61} + 1} \tag{8}$$

Here, represents $\Delta H_f kJ/kg$ the $\eta kJ/kg$combustion heat (η); represents $H_L$the efficiency factor H_L, typically 0.3; r denotes the tank radius; and represents the flame height, calculated using Formula 7.

At this point, the target receives the following calculation method for the thermal radiation flux:

$$I_i = \frac{ER}{4\pi x^2} \tag{9}$$

where, I_i the thermal radiation x intensity from w/m^2E point Ei to w the distance R from R that point x is (w); the thermal radiation flux of the heat source is (x); the emissivity is (with a maximum value of 1); and the distance from the pool fire center to the target point is.

(2) Explosion consequence calculation model

1) VCE Explosion Overpressure Calculation Model

This study employs a simplified model approach, converting TNT equivalent values for computational purposes.

The calculation method for TNT equivalent is shown in Equation 10.

$$W_{TNT} = \frac{AW_fQ_f}{Q_{TNT}} \tag{10}$$

In Equation 10, the TNT equivalent coefficient 4% for Q_{TNT} the steam cloud is defined as [value W_{TNT}], with TNT W_{TNT}explosion heat output typically set at 4520 kJ/kg, and the TNT equivalent value of the explosive material is represented by [value].

The total energy of steam cloud explosion is calculated as follows:

Here, represents 1.8 the ∂ ground explosion coefficient 0.04; W_f denotes the equivalent coefficient kJ/kg Q_fkg of combustible kJ/kg gas vapor cloud, taken as; is the fuel quantity (); and is the fuel's combustion heat ().

VCE explosion's lethal radius.

$$R_{0.5} = 13.6\left(\frac{W_{TNT}}{1000}\right)^{0.37} \tag{11}$$

2) BLEVE Explosion Calculation Model

As previously noted, BLEVE explosions occur when prolonged baking disrupts the pressure equilibrium between a container's interior and exterior, causing stored materials to vaporize rapidly and ignite. Strictly speaking, this type of explosion is classified as a fire. The primary destructive mechanism of BLEVE explosions is thermal radiation, which will not be elaborated upon in this article.

5. Example Analysis

The storage complex spans approximately 21,000 m², comprising six warehouses and two workshops. Located about 23.75 meters east of the eastern boundary of Tank Area No.1, the facility includes three warehouses (Nos.1-3) and a powder grinding workshop. The production zone features both operational and reserved workshops. At around 3:00 AM on March 11, a magnitude 7 earthquake struck the hazardous chemical logistics warehouse, triggering a chain of disasters: Tank T5 in Tank Area No.1 caught fire due to structural damage, creating a large-scale flowing fire; Tank T7 in Tank Area No.2 exploded, causing chain damage to multiple tanks; gasoline leakage from Warehouse No.1 in the storage area ignited and spread to surrounding areas. The quake simultaneously paralyzed the park's water and power systems. Over 500 firefighters and more than 90 fire trucks were mobilized for emergency response. After 11 hours of rescue operations, the main firefighting and search-and-rescue missions were completed by 1:43 PM on the same day.

5.1 Disaster-Bearing Entity Failure Probability Calculation

According to the data in Tables 1 and 2, for the six internal floating roof tanks in Zone 1 of the storage tank area, the failure probability values are 7.71 and 1.43 when the damage level reaches Grade 2 or higher, and 5.51 and 1.34 when it reaches Grade 3. When the seismic intensity reaches IX degree (peak acceleration 0.4g) or X degree (peak acceleration 0.5g) or higher, corresponding damage levels may occur. For seismic intensity IX, the failure probability unit value when the floating roof tank damage reaches Grade 3 is calculated as follows: Substituting the above data into Formula 1 yields:

$$Y = 5.51 + 1.34\,ln(0.4g)$$

You can get Y=6.40.

Substituting the calculated failure probability unit value into Formula 2 yields the failure probability of the storage tank under IX-level earthquake damage, as expressed:

$$P(x) = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{2.34} e^{-x^2/2}\, dx$$

By comparing the probability $P(x)$ distribution table, we can get 83.9%.

Through full parameter substitution calculations, the failure probability distribution of the storage tank area was obtained (Table 5). This result quantifies the failure risks of various storage tanks and facilities under different seismic intensities. To meet the modeling requirements of the disaster evolution network, this study sets a 25% failure probability as the risk threshold. Nodes exceeding this critical value will be identified as key nodes in the accident evolution process.

Table 5: Failure Probability Table of Tank Area 1.

Type of storage tank	Seismic intensity	Damaged condition	Unit value of failure probability	Failure probability	Type of storage tank	Seismic intensity	Damaged condition	Unit value of failure probability	Failure probability
Covered floating roof tank	VIII	>2	8.96	40%	Fixed top tanks	VIII	>2	7.18	39.4%
		3	6.68	38.1%			3	5.11	21.6%
	VIII	>2	8.67	40%		VIII	>2	7.58	39.8%
		3	6.41	38.1%			3	5.50	27.7%
	IX	>2	9.66	40%		IX	>2	7.9	39.9%
		3	7.34	39.6%			3	5.83	31.9%
	≥ X	>2	9.98	40%		≥ X	>2	8.2	40%
		3	7.64	39.8%			3	6.13	34.8%

5.2 Construction of Disaster Scenario Network Based on Failure Probability

Given the structural damage to Tank T5, there is a high risk of fire incidents when exposed to ignition sources, sparks from physical impacts, or chemical exothermic reactions. By inputting the storage tank's parameters into $kg/m^2 \cdot s$ the MJ/kg formula, we refer to the maximum mass burn rate table for common substances. For $H_L = 19.57m$ toluene, the burn rate is 0 .09 with a combustion heat of $E = 14102.3Kw/s^2$. With Tank T5's radius of 3.25m, the diameter (D) is calculated as 6.5m. Substituting these values into formulas 3.4 to 3.5 yields the flame height and the thermal radiation flux released during Tank T5 combustion.

Subsequently, the calculated thermal radiation fluxes for the five storage tanks (T1 to T6) were obtained by substituting the aforementioned data and the distance between the T5 tank and adjacent storage tanks into Equation 9, as shown in Table 6

Table 6: Thermal Radiation Received by the Surrounding Storage Tank During T5 Combustion.

Disaster body (tank)	Distance from the accident tank (m)	Received thermal radiation flux (kW/m2)
T1	11.61	8.3
T2	9.4	12.71
T3	12.58	7.09
T4	6.16	29.59
T6	6.05	30.68

As shown in Table 7, the thermal radiation flux received by T2, T4, and T6 exceeds the critical value, and the burning time of the material in the storage tank is more than 30min, that is, the burning time exceeds the critical value of the target disaster-bearing body.

Table 7: Failure Probability of Storage Tanks Around T5.

Damaged structures (tanks)	ln(ttf)	Y	P
T2	7.01	5.59	28.9%
T4	6.05	6.36	36.5%
T6	6.02	6.4	36.8%

For risk zones lacking specific data or corresponding damage/failure probability calculation methods, the conventional approach involves inviting domain experts to conduct evaluations and scoring to ultimately identify disaster nodes. The resulting hazardous chemical logistics warehouse disaster evolution network is shown in Figure 2.

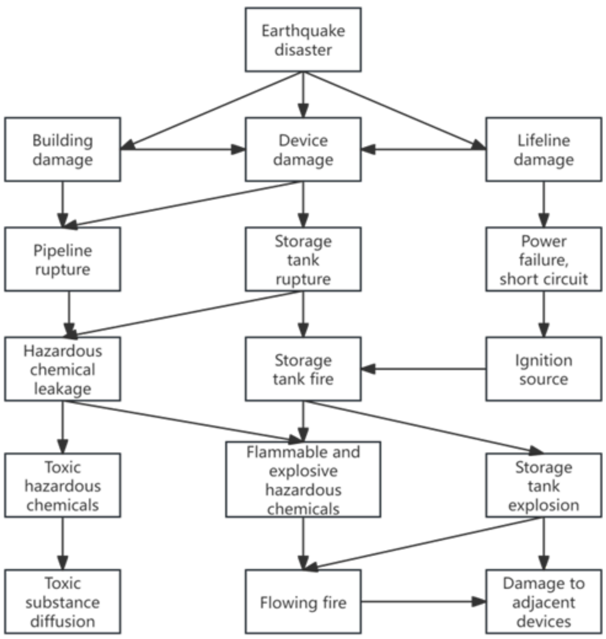

Figure 2: Disaster Scenario Evolution Network Diagram.

5.3 Warehouse Disaster Scenario Evolution Trend Map and Disaster Consequences

Based on the disaster scenario evolution network diagram obtained above, experts in the field were invited to score the conditional probability of each scenario node.

After obtaining the conditional probabilities of the nodes, the joint probability calculation formula is applied to compute the posterior probabilities of each node. In this study, the Netica software was used to obtain the posterior probabilities of the variables in each node, as shown in Figure 3.

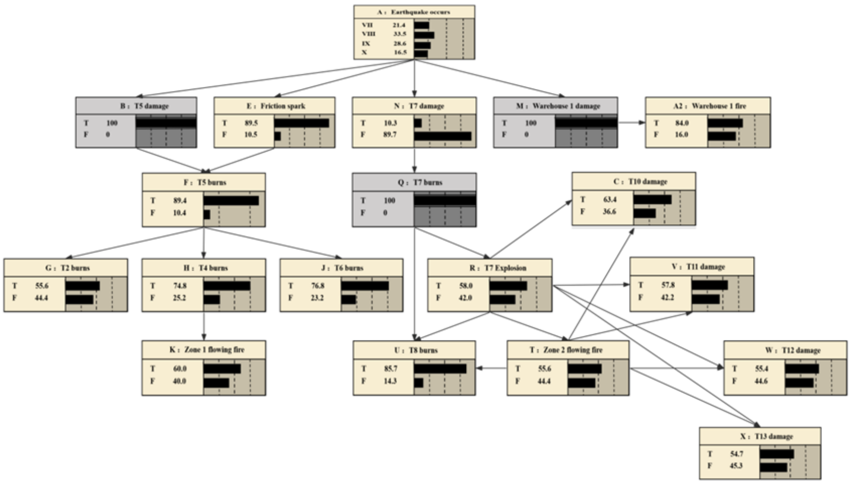

Figure 3: Bayesian Network Probability Diagram of Disaster Evolution.

The computational posterior probability of the accident scenario indicates that the earthquake intensity is most likely to reach VIII. The worst-case disaster scenario involves three tanks in the No.1 storage area being ignited, forming a flowing fire; an explosion at Tank T7 in the No.2 storage area igniting Tank T8 and creating a flowing fire; four tanks (T10, T11, T12, T13) leaking hazardous liquid chemicals; and a burning oil spill in the No.1 warehouse with potential large-scale spread.

6. Conclusion

By integrating Bayesian network with failure probability calculation model, this study systematically analyzes the evolution process of earthquake-coupled disasters in hazardous chemical logistics warehouses. The research content mainly includes the following four aspects:

First, in the analysis of disaster mechanisms, the disaster evolution process is deconstructed into two major modules: the earthquake event phase and the domino effect phase. By analyzing the triggering mechanisms of earthquake-induced accidents, a methodology system for calculating failure probabilities in hazardous chemical logistics warehouses has been established. Second, in scenario construction and model transformation, based on the typical structural characteristics of hazardous chemical logistics warehouses, an accident evolution sequence under earthquake disaster scenarios has been constructed. By converting the disaster accident chain into a Bayesian network topology, a probabilistic reasoning-capable accident evolution analysis framework has been developed. This framework enables quantitative calculation of accident evolution paths and identification of critical paths after obtaining node probability parameters. Regarding probability distribution methods, to address parameter determination in Bayesian networks and considering the scarcity of hazardous chemical accident samples, a strategy combining the Delphi method with pessimistic decision criteria was adopted, ensuring scientific rigor and conservatism in node conditional probability allocation. Finally, in accident consequence assessment, a consequence calculation model for typical accidents such as fires and explosions has been established. By quantifying key parameters like death radius and damage scope, this provides theoretical foundations and data support for emergency rescue force allocation and decision-making in disaster response.

The comprehensive analysis method established in this study provides a complete technical path for the risk assessment and emergency decision of earthquake coupled disaster in hazardous chemical logistics warehouse.

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