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NFPA 704 Safety Diamond – CISA Chemical SRMA Informational Webinar

Slide 1 "CISA Logo"

The following webinar is part of CISA's work as the Chemical Sector Risk Management Agency. We strive to provide resources, information, and training related to the chemical sector to enhance the resilience of the sector and cross sector coordination. Enjoy the webinar, provided by two of our HS-Power Interns, and take what you learn to enhance critical infrastructure security!

Slide 2 "NFPA 704 Safety Diamond"

Welcome, and thank you for attending our presentation today. We appreciate you allowing us the opportunity to speak to you today regarding the National Fire Protection Association's safety diamond. My name is Derek, and I will be presenting the first two diamonds and then I will pass it off to Daniel to finish the presentation.

Slide 2 "What is the NFPA 704 Safety Diamond?"

So, what is the NFPA 704 safety diamond? The NFPA stands for the National Fire Protection Association. Their mission statement is to help save lives and reduce loss with information knowledge and passion. The NFPA 704 is a standard system used to identify chemical health, fire, and instability hazards. This system was created in 1960 and has been amended over the last 60 years. It was created to be used by first responders so they can immediately identify what type of situation they are dealing with. When seen in literature the diamonds properties are read from left to right. This means you would say the number within the blue diamond first, the red diamond second, the yellow diamond next, and anything present within the white diamond last.

Slide 3 "Blue Diamond- Health Hazards"

The first diamond is the blue diamond, which is located in the left quadrant of the larger diamond. What is the blue diamond and what does it stand for? The blue diamond signifies a chemical that presents a health hazard. Within the blue diamond there will be a number from zero to four. This number tells us the intensity of the health hazard. This risk level ranges from minimal at ZERO to extreme at FOUR. If an asterisk is shown next to the number, it signifies a chemical that presents a chronic health risk. The health hazard levels signify how serious of an injury can be caused, based on short- or long-term exposure via breathing vapors or contact with the skin. The levels are defined by the LD50. The LD50 is the dosage of a chemical that is lethal to 50 % of the population exposed to it. This dosage is measured in milligrams of a chemical per kilogram of body weight. The health hazard levels also will define when and what type of Personal Protective Equipment needs to be used. Many of the chemicals that will be mentioned are precursors for making other chemicals. A precursor is a chemical that is reacted, sometimes with another chemical, to then form a new chemical that is a final end-use product or useful in the synthesis of a final product.

Slide 4 "Health— Level 0 to 2"

Blue level ZERO chemicals pose no risk to human health, as the oral LD50 threshold is high, at above 2000 milligrams per kilogram of body weight. To give you a visual, a 200 lb. person would have to eat an amount similar to or greater than the weight of a large apple, or in terms of volume, around

¾ cup. Igniting these materials would present no hazard beyond that of other commonly combustible items. These chemicals require no Personal Protective Equipment when handling. Some commonly used examples of Health Hazard Level ZERO compounds are water, wood, paper and cooking oils.

Blue level 1 chemicals pose a minor risk of irritation or residual injury. A residual injury would be like scarring or disfigurement. The LD50 for level 1 chemicals is above 500, but less than 2000 milligrams per kilogram of body weight. For a 200 lb. person this ranges from a volume of a little less than ¼ cup to ¾ cup, or from about the size of 7 blackberries to the size of a nectarine. Prolonged contact poses a risk of skin, eye, and lung irritation, with treatment the effects will subside. A breathing apparatus MAY be worn, but it is not required. Some commonly used Health Hazard level 1 chemicals are turpentine which is used as a paint thinner, and acetone which in a diluted form is also used as nail polish remover. Other Health Hazard Level 1 compounds that people may come in contact with are gasoline and ammonium nitrate which is used in fertilizer.

Blue level 2 chemicals can cause injury with a large exposure over a minimal amount of time, or a lesser exposure over a longer period of time. The LD50 for level 2 compounds is between 50 and 500 milligrams per kilogram of body weight. This is around a teaspoon to a little less than ¼ cup for a 200 lb. person, or about the size of 1 to 6 grapes. Chronic exposure could lead to temporary incapacitation and possible residual injury and WILL require immediate treatment. A breathing apparatus and face mask are required to handle these chemicals. Level 2 Health Hazard compounds are not commonly used outside of specialized processes with specific uses. Some commonly used compounds in industry are ammonia gas, concentrated hydrogen peroxide, glacial acetic acid, and phosphorus. These chemicals are often used in manufacturing processes as precursors for other chemicals, as well as being commonly used in fertilizers.

Slide 5: "Health— Level 3 and 4"

Blue level 3 compounds even with short term exposure can cause serious temporary or residual injuries. The LD50 for level 3 compounds is between five and fifty milligrams per kilogram of body weight. This lethal dose range for a 200 lb. person is around the volume of 20 drops of water to about a teaspoon, or the size of 2 currants or gooseberries to the size of a grape. Breathing the vapor of these compounds or contact with skin can cause serious short- and long-term injury even with medical treatment. Handling these chemicals will require a full protective suit, a breathing apparatus and a full-face mask. Common level 3 compounds are chlorine, liquid hydrogen, and carbon monoxide. Chlorine and hydrogen are two of the most widely used chemicals in the creation of fertilizers, medications, plastics, and many other commonly used items. Carbon monoxide is used in industry as a precursor for making aldehydes which are then used to make other materials like plastics, coatings, adhesives.

Blue level 4 compounds are highly toxic and can be fatal with short term exposure. The LD50 exposure for level 4 compounds is less than five milligrams per kilograms of body weight. This means dosages smaller than the volume of 20 water droplets can be fatal for a 200 lb. person, depending on the compound this amount can even be less than the tip of a pin. Exposure to minimal doses of these compounds can cause death or major long term injury. Handling of these chemicals requires a full protective suit, breathing apparatus and a face mask. Commonly used compounds in manufacturing applications are hydrogen cyanide, hydrogen fluoride, and phosgene gas. Sarin would also fall under a Health Hazard Level 4. These chemicals are commonly used as precursors for creating other chemicals to create a wide range of products like plastics, dyes, and pesticides.

Slide 6: "Red Diamond— Flammability Hazard"

The next diamond is red which is located in the top quadrant of the larger diamond. What is the red diamond and what does it stand for? The red diamond in the NFPA color code represents chemicals that are a flammability hazard. Within the red diamond there will be a number from zero to four. This number tells us how flammable a chemical is. The risk level ranges from not normally flammable at ZERO to extremely flammable at FOUR. The flammability ratings are defined by the temperatures of the flash and boiling points of the chemical. A chemicals flash point is the lowest temperature that it's vapor will ignite in air when provided with an ignition source. While the boiling point has a specific definition related to the temperature and pressure, it is essentially the temperature at which a liquid changes to a gas.

Slide 7: "Flammability — Level 0 to 2"

Red Level 0 compounds will not burn under normal conditions. Commonly encountered level zero compounds are concrete, stone, and sand. Within industry carbon tetrachloride is a chemical precursor used in many processes to make plastics. It is an extremely stable molecule. Red Level 1 chemicals are at only slight risk of combustion. For these chemicals to ignite it will require a constant heat to be applied over a period of time to raise the overall temperature above the flashpoint of 200 degrees Fahrenheit. For reference this is a little below the temperature of boiling water. Commonly used Flammability Level 1 compounds are cooking oils. More commonly used in industry are chemicals like nitrochlorobenzene and nitrophenol which are used in the manufacture of pharmaceutical and agricultural products. A less common level 1 chemical that was banned in 1979, but still may be found in old equipment are polychlorinated biphenyls, typically called PCB's.

Red Level 2 compounds are at a moderate risk of igniting. These chemicals have a flashpoint above 100 but below 200 degrees Fahrenheit. They require preheating of the overall volume or a sufficiently high ambient temperature before ignition can occur. Ambient temperature is the scientific way to say "the temperature of the surroundings", for example the ambient temperature in this room is about 70 degrees Fahrenheit. A commonly used example of a level 2 chemical would be diesel fuel used for vehicles or generators. In manufacturing, compounds like acrylic acid are used to make adhesives and coatings. Cresol is another compound with a Red Level 2, it is often used to make or dissolve other compounds, as well as being a by-product of burning wood. You may have heard of it in the form of creosote which builds up in a fireplace and becomes a fire hazard.

Slide 8: "Flammability — Level 3 and 4"

Red Level 3 chemicals have a serious flammability risk. These compounds have flashpoints below 73 degrees Fahrenheit AND a boiling point greater than or equal to 100 degrees Fahrenheit, OR a flashpoint above 73 degrees Fahrenheit AND a boiling point below 100 degrees Fahrenheit. This category includes solids, liquids and gases that can be ignited under almost all ambient temperature conditions. Which you may remember means roughly 70 degrees Fahrenheit. The most commonly used level 3 chemicals are gasoline used in vehicles, methane with uses for energy production, and acetone with properties that make it useful as a paint or nail polish remover. Another Red Level 3 would be benzene, it is one of the most common chemicals used in the production of chemicals like gasoline, as well as being a precursor for making many other chemicals for various industries.

Red level 4 compounds are extremely flammable. These chemicals have flashpoints below 73 degrees Fahrenheit AND a boiling point above 100 degrees Fahrenheit. Which means below 73 degrees Fahrenheit, at their specific flashpoint they would ignite. Typically, these chemicals will completely vaporize at atmospheric pressure and normal ambient temperatures. Vaporize means

the chemical changes from a liquid to a gas, so an open bottle on this table would evaporate and fill the room with vapors. Level 4 compounds will ignite in air at room temperature. This means that if a bottle of a Red Level 4 chemical evaporated in this room it could ignite with any spark. A commonly used level 4 chemical is acetylene which is used in welding applications. Others are propane and liquid hydrogen which are both used as fuels. Think of those large white propane tanks in rural communities or the small propane tanks used for gas grills. That concludes the first two quadrants for the NFPA 704 Safety Diamond. Daniel is now going to explain the yellow and white safety diamonds.

Slide 9: "Yellow Diamond – Instability Hazards"

Yellow Diamond Introduction. Following both the Blue and Red diamonds, the next one is the yellow diamond. This depicts the measure of somethings instability. Something is unstable when it is not "comfortable" in its current form, and therefore it has increased potential to react in unwanted ways. These interactions can be dangerous, and the substance can be at risk of reacting violently either with itself or something else.

Slide 10: "Instability — Level 0 to 2"

Similar to both Blue and Red, Yellow also works on a 0 to 4 scale, 0 being the least dangerous and 4 being the most dangerous. When the yellow diamond has a 0 on it, it means that whatever substance it is pertaining to is very stable, and hard to make unstable. A good thing to look for when determining instability is to look at how it reacts with certain things like water and fire, and how intensely they react if at all. Some examples at this level are Helium which you can find in balloons and cryogenic cooling. Carbon dioxide which you can find in a small percentage of our breathing air, in food, and in beverage. And nitrogen gas which you can also find in 78% our atmosphere, and cryogenic preservation.

Moving up a notch from zero, an instability level of 1 means that the substance is usually stable, but there is a chance that it can become unstable in the right conditions. These situations where it becomes unstable are usually when the substance is exposed to conditions of increased temperature and/or pressure. When this happens, and instability increases, so does the reactivity. Some examples at this level are red phosphorus which you can find on the outside of matches. Propene which is produced from fossil fuels and coal. And carbonic acid which can be found in soda, the ocean, and heartburn medication.

Something with an instability level of 2 can easily become unstable from its standard form. When a substance with a level 2 instability is heated or pressurized, it can produce a chemical change that could be violent, depending on the chemical and the intensity of the conditions. The more unstable something gets, the more likely it will be to react extremely with water. Some examples at this level are white phosphorus which is used to manufacture fertilizers, food additives, and cleaning compounds. Potassium which maintains normal fluid levels inside our cells and reacts extremely with water because it is an alkali metal. And Sodium which maintains normal fluid levels outside our cells.

Slide 11: "Instability — Level 3 to 4"

Things with an instability level of 3 are naturally very unstable. Because they are so unstable, they can explode or decompose if influenced to do so. The substance can either be shocked or heated in confinement to cause said reactions. Level three substances are extremely reactive and would likely

explode upon contact with water. Some examples at this level are hydrogen peroxide which is used in cleaning supplies, bleach hair, etc. Ammonium nitrate which is part of making matches and some explosives. And perchloric acid which is a basic precursor for ammonium perchlorate which is used in rocket fuel.

Substances that have an instability level 4 are some of the most dangerous things there are. They are extremely unstable, explosive, and reactive. At this point, the detonation or explosive decomposition can happen at any point in normal conditions. Some examples to put it into context are TNT which is used in bombs. Nitroglycerin which is a component of dynamite. Chlorine dioxide which is used to disinfect drinking water and bleaching of wood pulp.

Slide 12: "White Diamond — Special Hazards"

This last diamond is the white diamond which is used to identify substances which meet certain criteria to classify them as dangerous in specific ways, separate from what the first 3 diamonds show. If none of these criteria apply to the substance, it will be blank. If this information was not known, something could be mistaken as safe and then put in a dangerous environment, which is why it is necessary.

Slide 13: "Special Hazards — Asphyxiant Gas"

The first white diamond symbol represents the presence of an asphyxiant gas. An asphyxiant gas is non-reactive and will displace the normal amount of oxygen in breathing air. Asphyxiation refers to suffocating due to a lack of oxygen. Thus these gases decrease the concentration of oxygen in the air below the concentration we need to breath. A reason these gases are so dangerous is because they are hard to detect when released because they are inert, so they don't exactly announce their presence in the air. For this reason, some companies have built sensors to monitor the oxygen concentration in the air and alert it if it dips below a certain percentage, indicating the potential leak of an asphyxiant. Some examples asphyxiant gases are helium which is used in balloons and cryogenic cooling. Carbon dioxide which is present in a small percentage of our breathing air, and used in food and beverage. Nitrogen Gas which is present in 78% of our atmosphere, and is also used in cryogenic preservation and chip manufacturing. And argon, which is used in fluorescent tubes, low-energy light bulbs, and in the welding and casting industry.

Slide 14: "Special Hazards — Oxidizer"

The second white diamond symbol represents an oxidizer which can get complicated. Oxygen takes up 21% of our atmosphere. It is what we breathe, and what we need to live. However, it is also what is needed to be present for most things to burn. Oxidizers are generally substances that contain enough oxygen within them, allowing for burning reactions to take place without air present. It will usually happen when an oxidizer is put into contact with something that is combustible. The reason this information needs to be specified is so that oxidizers are not stored in a place where they can react with things around them, flammable things specifically. Some examples of oxidizers are potassium permanganate which is used in water treatment and battery production. Potassium perchlorate which is used in flares, rocket propellants, car air bags, and photography. And chlorine which is used to disinfect water as part of the sanitation process, also used as bleach for paper and cloth, in pharmaceuticals, and in cleaning products.

Slide 15: "Special Hazards — Use No Water"

The third and final white diamond symbol represents a substance that should be place nowhere water, due to the fact that it is likely very reactive with water. The reason it is necessary is because there are things that are almost non-reactive, generally with the exception of water. But there are also things that are reactive, but so much so with water that it warrants the warning. Some examples are cesium which is used in drilling fluid, and as an example cesium explodes violently upon direct contact with water. Another example is sodium you can find this in salt in the ion form as sodium chloride. And sulfuric acid which is used to refine petroleum and is found in explosives and glue.

Slide 16: "Guessing Game"

So, after hearing all of this information on the four safety diamonds, how about we play a little game? In front of you, you have 3 very well-known substances, and 3 hazard safety diamonds. Take a guess at which substance corresponds to which safety diamond. In fifteen seconds I will give you the answer. (15 second pause). If you got it correct, congratulations! Water corresponds to the second safety diamond. Methane corresponds to the first. And Bleach, also known as sodium hypochlorite, corresponds to the third.

Slide 17: "Why is this information Important?"

So why is all this information important? I'm sure there are plenty of you watching this presentation who will not see this diamond on a day-to-day basis. However, if you do, it is better to know what you are looking at then to not. Safety is a number 1 priority, so it is crucial to be aware of warnings when they are shown. Also, now that you know what this is and what it means, you may find it easier to spot them where you might have overlooked them.

Slide 18: "Why is this information Important?"

Thank you for listening to the Chemical Sector Risk Management Agency's informational webinar on the NFPA 704 Safety Diamond. This slide leaves you with some examples of where you could see the safety diamond in public places from storefronts and storage areas to public pools and others. As the Chemical Sector Risk Management Agency, CISA aims to lead the national effort to understand, manage, and reduce risk to the chemical sector. By participating in webinars like these one you are a valued partner in enhancing knowledge and understanding across the sector which in turn aids to reduce and mitigate risk while enhancing resilience.

Slide 20 "Helpful Information"

This slide provides some helpful links, feel free to pause here and obtain these URLs for further detailed study for the NFPA 704 safety diamond

Slide 21: "For more information?"

For more information visit the URL on the screen which takes you to CISA's Chemical Sector page. If you have questions, please email us at ChemicalSector@CISA.DHS.GOV

Slide 22: "CISA Seal"

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