Honeywell

UNDERSTANDING THE RISKS OF WORKING IN CONFINED SPACES

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Introduction

Working in a confined space is riskier than working in other workplaces as there are many variable and unpredictable factors to be evaluated when looking for hazards. Also, conditions can change very quickly and unexpectedly for the worse. This combination of factors poses a serious health risk to workers, at worst resulting in fatality or serious injury[1]. It also complicates emergency response for rescuers who subsequently put their lives in danger too.

This whitepaper explains how to identify a confined space, giving examples and characteristics. It also warns about the specific conditions that confluence together to create a confined space, which under normal circumstances would not be considered as such. Thereafter it provides examples of key industries at high risk of exposure to confined space accidents.

Confined space fatalities can be prevented by establishing an effective safe system of work and following procedures. It is very important for companies to develop a culture of safety where they can carry out their responsibilities with greater confidence. To do this, they must be aware of and understand everything about confined spaces, why they are dangerous, the associated risks of working in them and the general principles of safety precaution.

By being educated, companies can make safe choices and will know what proper personal protective equipment (PPE) and training to provide, thus mitigating and preventing fatalities or serious injuries.

1. https://iffmag.mdmpublishing.com/hazards-of-confined-space/

Confined spaces

How to identify a confined space

A confined space is generally defined as a place that presents specific risks to workers because of its enclosed nature. Contrary to popular belief, it doesn't have to be physically small and many confined spaces can in fact be very large.

According to the French National Research and Safety Institute (INRS)[2] , a confined space has the following characteristics that are all pointing to a clear and present danger.

- Not primarily designed or intended for a human to work in
- Has restricted entry and exit, making access, rescue, evacuation, or emergency response activities complicated
- Has a hazardous atmosphere, e.g. lack of oxygen or contains toxic gas
- Contains substances or material that could trap or engulf someone e.g. liquid
- Presents a risk to the health and safety of anyone who enters because of work activities being carried out in it or because there are mechanical, electrical, process and safety hazards

Although some confined spaces are easy to identify, such as a storage tank, silo, sewer or well, others are less obvious. An open-topped chamber or vat, ductwork and even a poorly ventilated room can temporarily become confined spaces if conditions inside change. This may be during their construction, fabrication or subsequent modification, or while cleaning or maintenance work is carried out. Within the context of this whitepaper there are two conditions to fulfil for an area to be classified as a confined space. A confined space is not only, as the name suggests, an area that is partially, substantially or fully enclosed but one where there also exists a certain risk of death or serious injury to the personnel working in it and those who may be called upon in case of an emergency.

2. http://www.inrs.fr/dms/inrs/PDF/r447/r447.pdf

What are the dangers?

Dangers can arise in confined spaces, or change an area into a confined space, because of the following conditions:

- High and low oxygen level
- Toxic gas, fume or vapour
- Presence of free-flowing solids or liquids
- Fire or explosions from high concentrations of flammable gas, vapour or dust
- Residues which, if disturbed, can give off toxic gas, fume or vapour
- High temperature conditions

Under normal circumstances a poorly ventilated room is not a confined space as it is free of toxic substances and has a safe level of oxygen. However, activities such as welding, which can lower the concentration of oxygen in the air to a dangerous level, or chemical cleaning, which can introduce toxic substances into the air, are just some examples where circumstances may change. In such cases, the room may become a confined space while that work is ongoing and will continue to be until the level of oxygen recovers or the contaminants have dispersed.

Additionally, whenever a certain area is used to store toxic/combustible items that if discharged/ignited will be a health risk, it will be considered a confined space. It is important, therefore, for all related personnel, from workers to safety managers, to fully understand the principles behind the definition of a confined space and take into consideration the working conditions.

Even in workplaces that, under all circumstances, are classed as confined spaces, new, temporary dangers may arise as a result of specific conditions. For example, a sewer after heavy rain may put workers at risk of drowning.

It is also worthwhile noting that, according to recent statistics, the majority of confined space fatalities occur among would-be rescuers.[3] This is because confined spaces are, by definition, difficult to access and dangerous, which makes any rescue operation especially risky. Incidents often occur when workers who have not received appropriate training and are not wearing the correct PPE precipitously enter a confined space to come to a colleague's rescue. The consequences of such interventions can be severe and range from falls from height to asphyxiation.

It is also important to remember that a confined space can not only pose a threat to the workers entering it, but also to their colleagues or members of the public near the entrance. The latter may be exposed to several risks including exhaust fumes and explosions. Therefore, a risk assessment should always account for any workers or members of the public in the vicinity of a confined space.

It is also important to take into consideration any external event that may indirectly affect the air quality within a confined space. For example, a power cut affecting ventilation may suddenly put workers inside a confined space at risk.

3. https://www.cdc.gov/niosh/docs/86-110/default.html

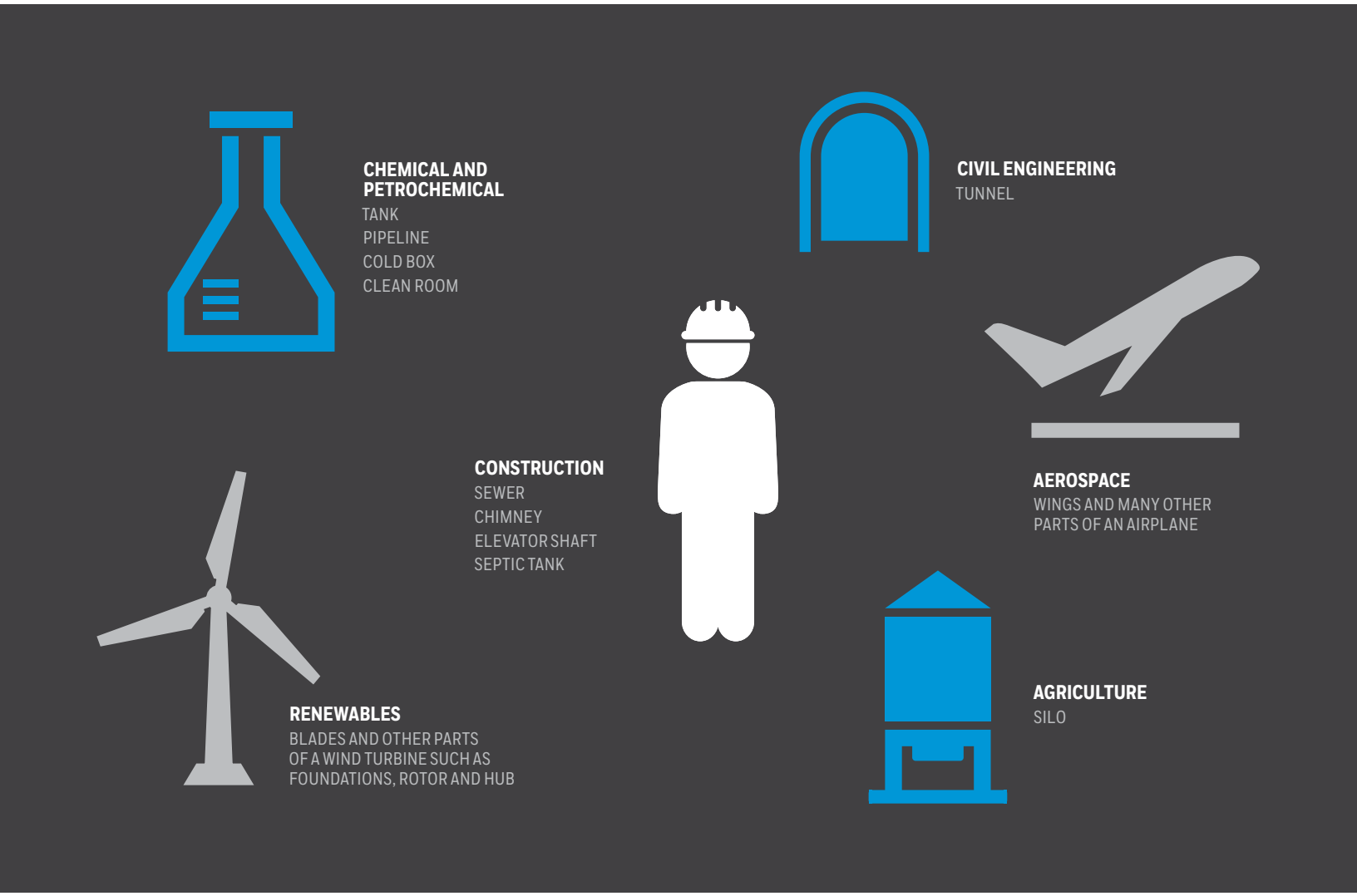
Key industries associated with confined spaces

A confined space can be above or below ground and is found in almost any industry. The French government, for example, recently identified the following industries where confined space accidents were prevalent.[4]

- In the food manufacturing industry, there were a large number of intoxications from the ammonia used in refrigeration installations, accidental mixes of incompatible chemical substances (e.g. acid and bleach) and gases released from fermentation
- In chemical processing and refining, there were accidents involving nitrogen and other toxic gases used or released during the various processes
- The collection and treatment of industrial or agricultural waste, including water and wastewater treatment, with accidents involving the production of hazardous gases effluent by means of physicochemical reactions or fermentation

However, there are many other industries and applications where work in confined spaces is commonplace, including:

4. https://www.aria.developpement-durable.gouv.fr/wp-content/files_mf/ACCIDENTSCONFINED_SPACES.pdf



Why is a confined space dangerous?

There are two main types of danger, namely atmospheric hazards and physical hazards. Hazards can already exist or be introduced and arise when the presence of substances and the change in conditions, mixed together, increase the risk to health and safety. All hazards found in a regular workspace can also be found in a confined space. However, the presence of multiple risks combined with difficult rescue operations often aggravate the situation.

The types of injuries sustained from confined space accidents include: burns and damages from fire and explosion; poisoning and anoxia (which are often the main cause of injuries in confined spaces); loss of consciousness or asphyxia drowning; heat-related disorders; electrocution; cuts by tools/ machinery moving or rotating parts; and fractures resulting from slips, trips and falls.

Dangers from atmospheric hazards

Asphyxia

The air in our natural environment contains 20.9 percent oxygen. Asphyxia starts when the concentration of oxygen is approximately less than 17 percent. Low oxygen levels cannot be detected by sight or smell. To illustrate this, let us take a look at the case where a worker was performing welding inside a storage tank. Argon gas, which displaces the oxygen, acts as an inert shielding blanket to obtain a very high quality weld. The worker was found unconscious in the tank and later died from suffocation. By monitoring the oxygen level in the air and using suitable breathing apparatus, this incident could have been avoided.

As this example illustrates, oxygen depletion is always dangerous, but what determines the severity of the risk is the gas or substance that oxygen gives way to. For example, hydrogen sulphide (H2S) can be immediately deadly even at low concentrations: as soon as it reaches 1000 ppm (parts per million) – the equivalent of 0.1 percent of the air in a confined space – it can kill a worker.

Other common reasons for oxygen deficiency include oxidation, i.e. when a metal rusts, combustion during welding or cutting, and bacterial growth that uses up oxygen. Reduced oxygen levels can also arise in poorly ventilated enclosed spaces, such as process plant vessels, silos, ship decks etc. Oxygen can also be displaced by other gases, for example where inert gases are forced into the space to prevent corrosion. On the other hand, too much oxygen can create other issues.

Fire and explosion

Three elements are necessary for a fire or explosion to occur: oxygen, flammable material, and an ignition source. Materials that would not normally catch fire or burn in normal air may do so extremely quickly and easily where there is a high level of oxygen. The risk is extremely high whenever there is a build-up of any flammable gas or vapour. As with oxygen, if the gas or vapour is colourless and odourless, the build-up cannot be detected unless a gas detection instrument is used.

Substances that can cause explosions or fires include:

- Acetylene gas from leaking welding equipment
- Methane and hydrogen sulphide gases produced by rotting organic waste in tanks or sewers
- Hydrogen gas produced by contact between aluminium or galvanised metals and corrosive liquids
- High concentrations of flour or coal dust
- Solvents such as acetone, ethanol, toluene, and xylene, which may have been introduced into the space through spills or by improper use or disposal

Toxic air

Chemical asphyxiants prevent the delivery of oxygen from the bloodstream to cells. The most common gases are hydrogen sulphide (H2S) and carbon monoxide (CO).

Other instances when toxic air can occur include:

- Evaporation of a liquid in a tank, such as chemicals, producing noxious vapours
- When pockets of toxic gas in waste materials are disturbed during cleaning
- Biological hazards, including viruses, bacteria from faecal matter in sludge or slurry, spore from fungi and moulds
- Work activities like grinding, descaling, insulation removal, metal spray applications, etc. that release harmful substances into the air
- Leaks from a neighbouring toxic site, through porous walls or openings that are difficult to seal

Dangers from physical hazards

The risks associated with physical hazards are widely known within the industry and are certainly avoidable in the context of working in a confined space. The close proximity of the walls can amplify the noise level of a tool by up to 10 times in comparison to it being used in an open space.

For example, a boilermaker removing tubes inside a heat exchanger with the aid of a pneumatic tool may be exposed to up to 120 decibels of noise. This will be sufficient to cause major temporary hearing loss after a few minutes of exposure. Here, adequate hearing protection must be worn.

An important point to consider, however, is that a noisy environment in a confined space can potentially cause accidents as it impedes communication with support personnel.

Falls are another major risk in confined spaces and generally occur as a result of workers losing their grip, for example when climbing a wet or greasy ladder or due to unstable structures (e.g. a worn-out ladder). They are one of the main sources of severe injuries and, according to the CNAMTS (the French occupational health insurance body) a sick leave due to a fall from height is, on average, twice as long as a sick leave due to other types of injury.

What makes confined spaces particularly dangerous is that workers typically operate at relatively low heights. The higher the workplace the more likely a worker is to adopt all the necessary safety measures, but – when heights don't seem particularly daunting – they might underestimate the risk and be tempted to cut corners. The truth is that a worker falling from a height of 4 metres would hit the ground in less than one second and suffer life-changing or even fatal injuries. Perhaps unsurprisingly, according to the CNAMTS, most injuries in confined spaces result from falls from heights below 5 metres.

Slips and trips are also common and can be caused by slippery surfaces and awkward ergonomics.

OTHER PHYSICAL HAZARDS INCLUDE:


EXCESSIVE HEAT


POOR LIGHTING AND VISIBILITY

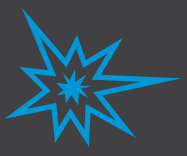

CHEMICAL BURNS


ELECTRICAL OR MECHANICAL RISKS


FLOODING


FALLING OBJECTS


MOVING PARTS OF EQUIPMENT AND MACHINERY


RISKS OF COLLISION WITH PLANT (E.G. IN TUNNELS)


BIOLOGICAL OR BACTERIOLOGICAL RISKS


FALLS FROM HEIGHT

Variable and unpredictable risk factors

There are many variable and unpredictable factors to be evaluated when looking for hazards in a confined space. Thus, conditions can change very quickly and unexpectedly for the worse. Also, there is a smaller margin for error in identifying or evaluating potential hazards, which can have more serious consequences. In some cases, the conditions are always extremely hazardous. In others, conditions become more dangerous under an unusual combination of circumstances.

The following are some examples of how risk factors can change in a confined space:

- The opening might not allow the worker to get out in time should there be a flood or collapse of free-flowing solid
- The interior configuration often does not allow easy movement, thereby escape by the worker or rescue by emergency responder is more difficult
- Air does not circulate freely or there is no mechanical ventilation. Hence natural ventilation alone is often not enough to maintain breathable quality air
- Work activities may introduce hazards not present initially
- Fall protection system is not installed or not used correctly
- The space outside the confined space can impact on the conditions inside and vice versa. For example, if the confined space contains toxic gases, workers who are near the opening may be at risk. This is because the toxic gases, under pressure due to heat inside, are being pushed out. As a result, the concentration of toxic gases near the opening can be high enough to cause death
- Lack of communication between the workers and the emergency response team

Overview of European and national legislation

The European Union has not introduced any legislation specifically relating to work in confined spaces. However, the Framework Council Directive 89/391/EEC of June 12, 1989 covers all aspects of safety and health at a workplace. The Directive places a duty on employers to take into account the specific characteristics of every workplace (e.g. including confined spaces).[5]

Legislation differs by country. However, countries with extensive, well-regulated industries all have legislation that is similar in principle to that in force in the UK, which is the Confined Spaces Regulations (CSR), 1997.[6] The regulations cover a wide range of subject matter and guidance for employers to follow, including the definition of a confined space, preventing the need for entry, safe working and emergency arrangements.

In France, CATEC® – the national standard regulating work in confined spaces – was originally created in 2012 to provide obligatory guidelines for all businesses and local authorities in the water treatment and sanitation industries, but it is now used across industries.[7]

It is important to remember that there are also other regulations that apply to work in confined spaces. They cover a broad range of areas including working in mines, lifting operations, exposure to noise and vibration, electrical safety and asbestos. It is the responsibility of safety managers to ensure compliance with all the relevant legislation.

5. https://www.hsimagazine.com/article/confined-spaces-59
6. http://www.legislation.gov.uk/uksi/1997/1713/contents/made
7. http://www.inrs.fr/risques/espaces-confines/formation-personnel.html

Safety precautions to manage and reduce risks

Work in confined spaces is inherently dangerous and must only be conducted by workers who are suitably trained. Besides conducting a risk assessment, there are three basic guidelines of safety precautions for working in confined spaces: ventilation, gas detection and communication.

In the first instance, avoid entering the area if the worker is not fully prepared or sufficiently trained. If entry is unavoidable, for example when maintenance, repair, cleaning, inspection, construction work or emergency response is necessary, then develop and implement a safe system of work. Prior to entry, ensure that suitable ventilation is in place to ensure an adequate supply of fresh air. Depending on the circumstances, it might be enough to increase the number of openings while in other cases mechanical ventilation may be needed.

Effective gas detection and communication are also paramount and some of the latest PPE on offer can provide both. For example, wireless portable gas monitors worn by workers will automatically alert them of an impending risk, and the specialised software also alerts their safety managers of the danger in real time so they can then raise the alarm. This connected PPE offers transparency to personnel working in confined spaces and reduces the risk to rescuers too.

Finally, devise an appropriate emergency plan before the work starts, including an entry and exit plan for rescuers. However noble it is to want to help co-workers in distress, it is essential not to go in unprepared and risk exposure to the same hazards.

No one should enter or work in a confined space unless there are emergency arrangements in place that are appropriate for the risk level. These should include a procedure to extract injured workers from the confined space and first-aid equipment (including resuscitation equipment). Those who are likely to be involved in emergency rescue operations should be trained accordingly.

Worst case scenario – when it can all go wrong

Deaths or injuries while working in confined spaces are happening all around the world. The victims are not only the people working in the confined space but the ones who try to rescue them. The negative impacts are huge. Besides the tragic loss of human lives, the negligent companies also face the full weight of the law, and may suffer lower brand value and financial losses.

In recent research by the European Agency for Safety and Health at Work in 2017, it was found that work-related accidents and injuries cost the European Union €476 billion a year.[8] In the UK alone, there are 15 confined space fatalities every year,[9] and, according to the United States Department of Labour, oxygen deprivation is the leading cause of death in a confined space.[10]

Explosion causes a death and serious injury

Here a worker was killed in an explosion while welding a pipe inside a methane gas tank, a designated confined space. A co-worker, who was standing on top of a ladder at an opening to the tank, suffered burns. The authority found that their employers failed to ensure safeguards and did not train them on the risks associated with working in a confined space. A worker lost a life and their colleague sustained life-changing injuries, as a result, the employers were prosecuted.[11]

Lack of risk assessment results in toxic gas exposure

In 2016, a UK food waste and animal rendering firm was fined £250,000 after it failed to perform a risk assessment before three of its workers entered a trailer filled with pig carcasses because it did not consider it to be a confined space. The three employees were subsequently overcome by toxic gases from the decomposing pig carcasses. The court concluded that this preventable incident could have resulted in fatalities.[12]

8. https://osha.europa.eu/en/about-eu-osha/press-room/eu-osha-presents-new-figures-costs-poor-workplace-safety-and-health-world
9. https://iffmag.mdmpublishing.com/hazards-of-confined-space/
10. https://webapps.dol.gov/elaws/osha/confined/PRCSGEN.asp
11. https://www.ishn.com/articles/97951-worker-in-ny-fatally-burned-in-confined-space-accident
12. https://www.healthandsafetyatwork.com/confined-spaces/john-pointon-trailer-inspector-interview

Fall from height in a confined space

A large food retailer was recently fined £2.5m following the death of a contractor working at height in a confined space. The worker was tasked with replacing filters within an air conditioning unit, which was located on a plant platform above a suspended ceiling in a warehouse. He fell almost 3 metres from the platform and through the suspended ceiling, sustaining fatal injuries. An investigation revealed that there were no barriers in place to prevent falls from the platform. In addition, the area of the platform immediately in front of the access ladder was restricted, measuring just 45cm in width, and there were several tripping hazards in this area, including cabling and the fixing points for the ladder itself.[13]

Toxic fumes kill two

Two workers were cleaning a food reactor in the thermal processing room after the production of a food flavour. The vessel, which was about 1.8 metres tall, required a raised platform for the workers to gain access. After finding some stubborn residue at the bottom of the reactor, one of the workers climbed inside to get a better look and, soon after, complained of a strong smell and fainted. In a bid to rescue, the other worker immediately climbed into the reactor, but soon suffered similar breathing difficulties and also faint. It was later found that, under the high temperature reactions during the manufacturing of the food flavours, a concentration of hydrogen sulphide had formed.[15]

Another example of fall from height in a confined space

An employee fell from a ladder while descending into a well cellar to remove tie rods on the cellar wall. The initial report stated that the injured person removed his safety harness hook from the ladder rung above in order to hook onto the rung below, at this point he lost balance and fell 2.5 metres onto the concrete cellar floor. It was defined, that restricted and congested workplace with inappropriate protective methods and insufficient skills were the reason of the accident.[14]

13. https://www.healthandsafetyatwork.com/work-at-height/iceland-rotherham-tony-hopkins
14. https://www.imca-int.com/alert/947/fall-from-height-in-a-confined-space/
15. https://www.wshc.sg/files/wshc/upload/cms/file/2014/cs2.pdf

Conclusion

Workers operating in a confined space are at risk from a number of atmospheric and physical hazards. Key types of injuries include asphyxia, burns, hearing loss, electrocution, cuts and broken bones. Serious accidents can result in a fatality, which are translated into significant financial costs for a business. With this in mind, understanding the definitions of a confined space and the risks that workers may be exposed to is vital to provide them with the level of protection they need. Legislations are in place to both inform and regulate this protection. Specifically, these stipulate that where it is unavoidable to work in a confined space and that the risks cannot be eliminated or mitigated, then it is the responsibility of the employers to provide the most appropriate PPE. This is a major responsibility and can only be fulfilled by choosing PPE that is fully certified for specific tasks and obtained from a reliable and trusted supplier.

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