Major accident
Fire
Agrochemistry
Pesticides
Fire-fighting water
Confinement
Fauna
Alert
Catchpit
Regulations

The Rhine polluted by pesticides

November 1st, 1986

Schweizerhalle

Switzerland

THE INSTALLATIONS IN QUESTION

Geographic location

The warehouse is located south of Bâle in Schweizerhalle, Switzerland, and administratively attached to Muttenz near the Rhine River which forms the physical border between France and Switzerland. The river is a key element in terms of the industrial economy, waterway transport and fish farming. The site is bounded to the south by the motorway and the merchandise warehouse, and to the north by the Rhine. The Bâle-Rheinfelden byroad cuts the site into 2 zones: the North and South sectors, connected by an underground passage, the eastern side used for a chemical industry, and the western fence adjacent to a vast silvicultural plot.

Installation concerned

This former industrial plant facility, transformed into a warehouse, is used to store 1,250 tons of miscellaneous chemical products used in the plants production operations (additives, colorants, agro-pharmaceutical products, and substances used in the textile industry). On the day of the accident, among the 1,250 tonnes of products stored there were 859 tonnes of organophosphate insecticides, 2 tonnes of organochlorine pesticides, 71 tonnes of herbicides, 40 tonnes of fungicides (including 12 t of mercury ethoxyethyl-hydroxyde) and 200 tonnes of solvents and colorants. Warehouse 956, located in the operation's south-western peripheral zone and just 50 m from the edge of the forest, contained liquid agrochemical products: fungicides, herbicides, and insecticides... The neighbouring warehouses (947 and 955) also contained highly flammable or water-reactive chemical products (metallic sodium...).

SUBSTANCES STORED IN THE WAREHOUSE

Organosphophate insecticides
323 t of disulfuron
121 t of etrimphos (N)
285 t of thiometon (T)
60 t of propetamphos (T)
25 t of ethyl parathion (T^+)
10 t of fenitrothion (N)
0.6 t of quinalphos (T)
0.3 t of formathion

Organochlorine insecticides
2 t of endosulfan (T)

Rotendicide
0.45 t of zinc phosphide (T^+)

Sulphur acaricide
2.32 t of tedlon-tetradifon

Fungicides
12 t of mercury ethoxyethyl-hydroxyde
27 t of oxadixyl
0.7 t of zinebe (Xi)
0.15 t of captafol (N)

Herbicides
60 t of DNOC (dinitro-o-cresol) (T^+)
11 t of metoxuron (N)

Emulsifying solvents, intermediary and manufacturing aid products
numerous specialties: detergents, alcohols urea, amines

Colorants
rhodamine B
Berlin (or Prussian) blue

THE ACCIDENT, ITS BEHAVIOUR, EFFECTS AND CONSEQUENCES

The accident

A fire started suddenly in a pesticide warehouse. At 0.19 am, a mobile police patrol reported seeing flames above a storage building in a large chemical complex. The plants emergency services sounded the alarm simultaneously. In just three minutes following the alarm, the plant's firefighters had set up the first nozzles. The flames had consumed a third of the 4,500 m² hangar in just a few minutes.

Figure 1 – Firemen fought the blaze for several hours

http://www.spiegel.de/sptv/special/0,1518,grossbild-227356-231227,00.html

The firemen sprayed the heart of the fire abundantly although, despite their efforts, were unable to bring the blaze under control. It became impossible to combat the flames in the hangar as the temperature had reached several thousand degrees. They decided to drown the fire by spraying down the exterior then initiating the "water curtain" which should dowse the flames from the ceiling. However, the roof structure to which the system came crashing down. The building's metal structure collapsed under the thermal radiation generated by the fire, bringing down the fire walls with it. Attacking the fire with foam proved difficult: the heart of the fire was confined under the rubble and was not accessible. The use of extinguishing foam proved to be difficult, and considerable quantities of water were used (25 m³/min.) to put out the fire. After the emergency services had been fighting the blaze for 20 minutes, firefighters from neighbouring industries came to assist. The flames reached heights of 80 meters and were visible in a radius of 10 km. The emergency services were occasionally "bombarded" by flaming canisters thrown out by the fire. In addition to extinguishing the primary fire, they also had to deal with numerous outbreaks caused by the incendiary bombs. An hour after the fire began, 200 to 300 firemen, 15 water canons and a fireboat were mobilised. In addition to the pandemonium created by the fire, a characteristic rotten egg smell (mercaptans) was detected and the flames reached the stocks of phosphate ester. Five-hundred tonnes of colorants and agro-pharmaceutical products were consumed in the fire. The firemen attempted to control the fire so that it would not spread to the plant's other buildings. A thick cloud of smoke headed in the direction of town centre and towards France.

At around 4 am, the township authorities initiated the chemical alert, which had been set up following an accident in 1982 in another establishment. The night time alert, the first since the Second World War, caused psychological trauma among numerous people. The instructions issued by the authorities were relayed via vehicles equipped with loudspeakers and via the local radio stations: the population of Bâle was instructed to confine themselves in their homes. The sirens continued to blare throughout the night. Tramway service and vehicle traffic was suspended and schools remained closed. The Bâle-Liestal motorway, which runs past the warehouse, was closed down. Passers-by searching for shelter were seen with handkerchiefs or scarves blocking their faces. On the French-Swiss border, Swiss customs agents wore gas masks. The streets of Bâle were nearly deserted even though November 1st is an ordinary work day in the Switzerland.

The firemen were able to bring the fire under control around 5 o'clock. The light wind was unable to dissipate the greyish cloud stinking of mercaptans. Three French policemen at the Bâle rail station experienced slight respiratory difficulties and went to the hospital in Mulhouse as a precautionary measure: one of them experienced nose bleeding (epitaxis). At the French border, 10 hours after the accident began, analyses detect the presence of 0.005 g/l of mercaptan in the atmosphere. The toxic cloud dissipates for the most part throughout the Upper-Rhine as the meteorological conditions were favourable (significant rainfall and SW winds).

At around 5.30, the authorities of the township of Bâle alerted the Colmar Prefecture. The French authorities were unable to warn the public at the instant when the Swiss announced the end of the alert at 7 o'clock. According to the international alert procedure for the protection of the Rhine, the Rhine navigation department was informed of the accident only at 9 o'clock on November 3.

The Rhine river and the atmosphere were seriously polluted. According to certain sources, the 50 m³ catchpit built on the site was unable to contain the 10,000 to 15,000 m³ of firefighting water resulting from the millions of litres of water sprayed to put out the fire flowed for 28 hours via the rainwater drainage system into the river which took on a pinkish tint. According to certain sources, this water transported approximately 30 tonnes of toxic products (decomposition products produced in the fire, agro-pharmaceutical products…), including 150 kg to 2.6 tonnes of mercury incorporated in organic mercury compounds. The cocktail of substances which made its way down the river at 4 kph completely wiped out all aquatic life over more than 250 km, then reached Rotterdam more than 1,000 km downstream and slightly contaminated a few water tables. Upon seeing the river's pinkish-red colour, the guard of the Huningue canal's water inlet decided to close the valve and inform a civil employee of the Departmental Agriculture Department who decided to lock the outlets of the Hardt, from the Rhône to the Rhine, Blodelsheim and Chalampé canals. A few days later, the Rhine's ecosystem, including fauna and flora, was destroyed despite the high level of dilution (approximately 1:2,000,000). Thousands of dead fish were collected: 190 tonnes of eels died in a few hours. The destruction of the major part of the invertebrate fauna significantly disturbed the aquatic food chain. On November 19th, analyses of the surface waters did not reveal the presence of disulfoton, etrimphos and mercury. Despite this, the Rhine was chronically polluted: the river transports 27 tonnes of toxic substances per day that flow into the Dutch delta and the North Sea.

Figure 2 – Overall view: burned warehouse and pink firefighting water http://www.wissen.swr.de/sf/begleit/bg0016/nn15h.htm

As a precautionary measure, a water collection station for the City of Bâle was closed. The French Ministry of the Environment ordered the closure of all water inlets and a certain number of locks for a period of 6 months, and all fishing was prohibited in the river. Several German communities prohibited the consumption of tap water produced by drinking water treatment stations on the Rhine. For several days, firemen delivered water to the inhabitants of Hoenningen or Unkel. Breweries in Düsseldorf had to stop their production operations due to a lack of water. All German fountains along the river were stopped. Fishing in the Rhine was prohibited for 6 months.

A week after the accident, according to certain sources, a poorly closed pipe or the rupture of a temporary firefighting water according to others, released 2,000 litres of mercury-containing compounds into the river. The consequences of this second release of pollution were less considering the rapid alert and the low amount of substances spilled.

The company was unable to establish a complete list of substances stored until 17 days after the accident.

Consequences

The smoke and other releases caused headaches, ocular and respiratory irritations, although no one was hospitalised for serious symptoms. The company's medical service examined more than 300 people (including firemen, police, employees…).

According to the sources, the underdimensioning or total lack of catchpits directly led to the spillage of polluted water into the Rhine and the destruction of its ecosystem. Several tons of dead fish were collected over the following days.

According to the manufacturer, the river's natural ability to purify itself was not completely destroyed. The Swiss Federal Institute of Environmental Science and Technology (EAWAG) stipulates that, à priori, in the spring of 1987, the population of small invertebrates had been replenished and the fish would repopulate their habitat within the Rhine.

Figure 3- Thousands of dead fish in the Rhine
http://www.ethlife.ethz.ch/articles/tages/EAWAGInfotag.html

The fire caused 221 MF (34 M€) in damages and civil liability damages 154 MF (24 M€).
The evaluation of the amount of compensation is based on requests submitted by the French government and an association (Alsarhin) including territorial communities, certain public establishments, private citizens, the associative sector, except for the fishermen's federation…. It does not take into account requests made by third parties, and the differed effects of the contaminants released. In September 1987, the temporary amount of damages was broken down as follows [5]:

❖ ***damage endured by the government***	
- costs borne by the government (additional personnel and equipment costs, loss of earnings, analysis costs, expert assessment costs)	2,609,577 F
- study and measurement programme	13,639,000 F
- the Rhine ecosystem restoration programme	14,300,000 F
	30,548,577 F
❖ ***damage endured by territorial communities***	
- costs borne by the Alsace region, the Lower and Upper Rhine departments, businesses and their groups (additional costs, analysis costs, costs relative to the Rhine ecosystem restoration measurements)	***6,351,820 F***
❖ ***damage endured by public establishments***	
- analysis costs, additional expenses (personnel and equipment costs), expert assessment costs	***9,344,043 F***
❖ ***damages caused to private individuals***	
- associations: conservation of nature, professional fishermen, uncertified sport fishermen, tourism promotion	6,920,269 F
- individuals: manufacturers and retailers of fishing tackle, tourism and resort establishments, market gardeners, industrial users of water, micro-hydroelectric station operators….	686,437 F
	7,606,706 F
Overall amount	**53,851,146 F**

According to other sources, an agreement reached between France and the manufacturer awarded 46 MF in compensation, of which 11 MF was allocated to the Alsarhin association.

The damage caused by this pollution is outlined in the table below:

Fish clean-up operations	0.1 MF.
Analyses of Rhine River water and sediments	0.15 MF.
Drinking water analysis	0.1 MF.
Ecological monitoring	1 MF/year - 5 years at least
Monitoring of the Rhine	0.2 MF.
Monitoring of the Alsace water table (40 water storage basins, and complementary on the water table for 5 years)	1.4 MF.

The decontamination of the site and treatment of 25,000 t of polluted soil cost 250 MF.

European scale of industrial accidents

By applying the rating rules of the 18 parameters of the scale made official in February 1994 by the Committee of Competent Authorities of the Member States which oversees the application of the 'SEVESO' directive, the accident can be characterised by the following 4 indices.

The parameters that comprise these indices and the corresponding rating method are available at the following address: http://www.aria.ecologie.gouv.fr.

The risk and safety phrases of the substances involved in this fire range from irritant (Xi) to very toxic (T^+). Overall, the chemical cocktail released was considered toxic. The 30 tonnes of dangerous materials released during the accident represent 15% of the corresponding Seveso threshold (200 t - toxic), i.e. to level 4 for the "dangerous materials released" rating according to parameter Q1 (10% < Q1 < 100%). According to the sources, the 150 kg to 2.6 t of mercury spilled represent 0.075% to 1.3% of the corresponding Seveso threshold (200 t - toxic), which equals level 1 of the "quantities of dangerous materials" rating according to parameter Q1 (Q1 < 0.1%)
The overall "dangerous materials" rating is thus 4.

Three parameters are involved in determining the level of the "Human and social consequences" rating: H5, H7 and H8.

- Parameter H5 reaches level 1 by default: the number of people injured is not precisely known.
- Parameter H7 reaches level 5 by default: several tens of thousands of people were confined during the accident (50,000 ≤ N < 500,000, with N = number of residents confined x number of hours)
- Parameter H8 is set to level 2 by default: the number of people without drinking water is not known (N < 1,000).

As a result, the overall "Human and social consequences" rating is 5.

Photo: picture alliance/dpa. http://www.munichre.com/publications/302-04262_fr.pdf

Figure 4 - Swiss firemen recovering tons of dead eels

Five parameters are involved in determining the level of the "environmental consequences" rating: Env10, Env11, Env12, Env13 and Env14.

- Level 5 of parameter Env10 characterises the 190 t dead eels (50 t ≤ Env10 < 200 t).
- Parameter Env11 reached level 1 by default: no quantitative information is available regarding the animal or rare or protected vegetal species that were destroyed.
- Parameter Env12 is 1 by default: the volume of water polluted is unknown.
- Level 1 of parameter Env13 is reached: a few water tables were contaminated.
- Level 6 of parameter Env14 is reached: the Rhine was polluted over more than 1,000 km.

As a result, overall "Environmental consequences" rating is 6.

The €18 of the "economic consequences" rating is 6: the cost of environmental clean-up, decontamination or rehabilitation measures was at least 257 MF, i.e. 39 M€ (€18 > 20 M€).

ORIGIN, CAUSES AND CIRCUMSTANCES OF THE ACCIDENT

In a report established in 1981, an insurance company concluded that it was unable provide the site with civil liability insurance due to the low number of fixed firefighting installations and the insufficient capacity of firefighting water catchpits. The insurers felt that the Rhine had a strong chance of being polluted in the event of a fire. The manufacturer was thus oriented toward a different insurance company.

The firefighting authorities who had inspected the warehouse had granted approval 4 days prior to the catastrophe. Safety measures were in place: thermal probe monitoring system, a sufficient number of portable fire extinguishers, strict safety rules, and the presence of internal firemen.

On December 16th, the Bâle police discovered the debris of a homemade bomb in the rubble.

On June 5th, 1987, the scientific department of the Arlesheim prefecture issued the verdict based on the conclusion of the Swiss experts: the fire may have started by the accidental ignition of a pallet of Prussian blue since the pallets had just been welded; combustion may have taken place for several hours without flame, smell or smoke.

ACTIONS TAKEN

THE RHINE

The Rhine originates from several sources located in the Swiss Grisons and extends 1,320 km between Reichenau and the North Sea. One of them supplies the anterior Rhine (Vorderrhein), and another the posterior Rhine (Hinterrhein): they come together at the Swiss village of Reichenau forming the Alpine Rhine, the natural border between Switzerland and Austria. It then crosses the Lake Constance. Following the famous 25-meter Schaffhouse falls, the High Rhine (Hochrhein) flows to the west and forms the border between Germany and Switzerland. Downstream from Bâle, it turns northward: the Upper Rhine (Oberrhein) flows more than 300 km. It then forms the border between the Switzerland and France, then that between France and Germany along 180 km. It then limits several German Länder. At Mayence, the river again flows west but at Bingen, it turns northward. The Middle Rhine (Mittelrhein) crosses the Rhine Schist Massif over 110 km. From Bonn, it is called the Low Rhine (Niederrhein). Arriving at the Dutch border near Emmerich, is subdivides to form the Rhine Delta, where it meets the Meuse. The Rhine hydrographic basin covers roughly 250,000 km².

http://www.unesco.org/courier/2000_06/fr/planet.htm#top

http://www.rivernet.org/rhin/welcomef.htm

Initially, in order to limit chronic pollution, a specialised company cleaned the sediments over several hundred square meter around the plant. The authorities concerned required that the waste and rubble from the hangar be decontaminated and insulated. The site was protected from the rain by an immense tent, then cleaned. The water used for this operation was recovered and processed in the complex's treatment plant. The highly toxic wastes were loaded into : 20 rail cars, 200 bins and 6,000 hermetically closed drums.

One week after the fire, a safety audit was conducted on all the storage locations, under lease or not, throughout all subsidiaries worldwide with the goal of abandoning all buildings which did not meet minimum safety requirements. Of the 16 facilities in France, this examination lead to the immediate closure of 2 storage warehouses and 3 in the following months.

In late 1986, the production of insecticides was reduced 60% at the site and storage areas by one third. The manufacturer discontinued producing all phosgene-based substances in Schweizerhalle, and all mercury-based products in all the group's plants as of 01/01/1987. All the agro-pharmaceuticals produced and/or stored shall be subject to re-evaluation according to their usefulness for agriculture, their profitability, toxicity and flammability. In the 8 months following the accident, more than 108 potentially-dangerous molecules were no longer used by the group's chemical and agricultural divisions. According to a Bâle manager, the storage of toxic products, explosives and asphyxiants was rethought and the risk reduced at the source. The productions at risk, such as chlorine, were transferred to the USA where it is easier to implement a safety perimeter of 30 km.

The monitoring measures were reinforced at night and over the weekends. The group equipped all its warehouses with automatic fire control installations.

In 1989 and 1990, 17% of group investments were dedicated to the construction of catchpits at all of its sites throughout the world. At Schweizerhalle, one of the measures announced was the construction of 2 water catchpits of 15,000 and 2,500 m³ for a cost of 15 M Swiss francs.

The company which recognised its moral blameworthiness one month after the fire, participated with the partners concerned in the creation of a negotiation structure (Alsarhin) and initiated joint action with the resident associations…. One third of the 350 requests relative to the repair of property damage were paid. In all, 240 MF (60 M Swiss francs) were paid out.

The Swiss group spent 250 MF in decontaminating the site and treating 25,000 tonnes of polluted soil and released 40 MF (10 M Swiss francs) to finance 36 European scientific research projects concerning the Rhine: atlas of the fauna of the Rhine,

the role of the river's marsh zones, breeding rivers for reintroducing fry production, highlighting pesticides in the water, transport of micropollutants from a waterway to its water table….

Swiss, French and German fishing associations were contacted to implement repopulation programs along the Rhine, financed by the manufacturer.

The International Commission for the Protection of the Rhine and the EC's Council of Ministers for the Environment demonstrate the civil liability of the Swiss pharmaceutical industry.

This accident, with its serious ecological consequences, occurred slightly after the Chernobyl catastrophe of 04/26/1986, and was given significant media attention.

Figure 5 – Burned drums of pesticides and pink-coloured firefighting water
http://www.alsapresse.com/dossiers_classes/60ans/pdfs/alsace_1986.pdf

LESSONS LEARNED

The accident raised the awareness of industrial entrepreneurs, the population and authorities regarding the importance of the "environmental" dimension in primarily chemical and industrial activities. This event shows that the safety of storage installations was not afforded the same attention as that of production units, which was the core of the group's concerns. It highlights 3 problems: inappropriate preventive measures, insufficient control measures and malfunctioning regarding the transmission of information.

Transmission of the alert

The period of time between the start of the fire and when the population of Bâle and border countries appears to be inappropriate. In 1986, no alert system was in place between France and Switzerland in event of a chemical accident; on the other hand, the 2 countries must inform one another in the event of a nuclear accident. The delay in the transmittal of information to the French authorities caused a high-degree of indignation among the Alsatian communities near the accident. Since the accident, local operational centres (Saint-Louis civil protection department, Bâle police) have implemented a local procedure.

Public opinion has directed its concern to the distribution of information and preventive measures which could be taken in similar situations.

The group's new safety / environmental organisation

The new safety / environment organisation foreseen relies on human and equipment reinforcements at the operational division level. As such, a team of roughly one hundred people at the central international group level update the "directives" relative to their activities from the safety and environmental protection perspective. They are equipped with laboratories to analyse a substance's inherent risks and to develop analytical methods to determine the amount of pollutants in the water, air or soil. Two crisis management systems were created: the "local emergency management system" to facilitate the relationship between the public relations department and the employees in charge of solving the problem identified at the local level and the "emergency response and communications system" which handles emergencies in the pharmaceutical division. Once per year, these teams conduct an exercise to demonstrate their ability to react to a given accident scenario. Audits are performed in the various units on a yearly basis.

The group passed an internal directive (Guideline 28 or GL 28) which establishes the rules to be respected henceforth for the design and operation of storage warehouses:

- a new classification broken down into 15 substance categories according to various characteristics: combustibility, reactivity, toxic and ecotoxic properties for water and air…,
- separation of stocks by category, with very little co-storage authorised,
- limitation of tonnages stored per fire compartment,
- installation of fire detection and extinguishing equipment,
- construction of a firefighting water catchpit of 5 m³/t of products stored.

This document has become a reference and is considered as state of the art for the industry.

Figure 6 - Elimination of wastes

The strict application of these requirements may lead to major modifications in existing warehouses, sometimes requiring the operation to be abandoned as the cost of rebuilding a new facility is less than backfitting the existing structure.

A warehouse must thus meet several criteria:

- fire stability by using a concrete structure,
- roof made of concrete or inert material and equipped with smoke vents,
- light-duty outside walls to allow the fire to be reached easily,
- building volume broken down into cells with fire walls and doors,
- natural or forced ventilation avoiding vapour concentrations,
- ground rendered hermetic to prevent infiltrations,
- external rainwater downspouts on the warehouse to prevent accidental pollution of this network.

As a complete list of the substances stored became available only 17 days after the accident, the company agreed to provide the inventory of the chemical products stored in its warehouses on a weekly basis.

The industrial group agreed to extensive efforts to pour convert its wastes and sub-products: regeneration of sulphuric acid, recycling of organic solvents, development of a dryer enabling 99.5% of the solvent to be retained during the production of pharmaceutical substances, development of a process enabling the recovery of copper when producing colorants, for example… .

Through its major cleanup efforts, the group created an environmental technology unit to share knowledge in this field and to propose its services.

Rhine action program

On October 1, 1987, the International Commission for the Protection of the Rhine (CIPR) adopted the ambitious plan to restore the quality of the Rhine; the Rhine Action Program (PAR) 2000 was evaluated at 91 billion francs:

- reimplantation of superior fish species (salmon, sea trout…)
- the use of Rhine water to the drinking water supply,
- notable reduction in the contamination of sediments released to the sea or likely to be spread in fields [10],
- improvement in the quality of the water in the North Sea.

In 1996, the majority of the PAR's 4 objectives were reached well ahead of the 2000 forecast. Salmon appeared in the Rhine and spawning grounds were observed. The CIPR now operates 8 alert centres which monitor a section of the Rhine and the Moselle. When pollution is detected, information or a warning is released to all neighbouring countries depending on the extent of the problem. Despite the improvement in the ecological quality of the Rhine, eels were not edible for 10 years after the accident.

INTERNATIONAL WARNING AND ALERT CENTRES ON THE RHINE AND MOSELLE

The **International Commission for the Protection of the Rhine (CIPR)** operates a warning and alert system for the Rhine: 6 international warning centres located between Bâle and the German-Dutch border share river monitoring operations and 2 others are installed on the Moselle. Each of these centres supervise a specific section of the Rhine or several tributaries. In the event of an accident, the centre concerned transmits an initial message to all the centres downstream and the secretariat of the CIPR in Coblence. Most often it is just an informative bulletin. In the event of serious pollution, a warning is sent. The residents located downstream may intervene to ward off or limit possible damages.
Currently, the services linked with the alert model can monitor changes in the pollution wave and rapidly forecast concentrations in the substances transported.

http://www.iksr.org/index.php?id=195

Regulations

On November 12, the Ministers of the Environment of the surrounding countries met in Zurich to convince Switzerland to adopt legislation similar to the Seveso Directive and finance the restoration of the river. The French Minister created a board of inquiry to evaluate the financial damage and the damage caused to the French side of the Rhine River. This commission of independent experts requested 257 MF to provide long-term monitoring of the pollution, to secure the procurement of drinking water, restore the fauna, improve alert procedures in the event of an accident and reimburse the costs incurred by the French authorities.

The French Minister of the Environment drew inspiration from this accident to write the "Water Law" in 1992 by taking the productive river environments into account. This environmental catastrophe also resulted in the creation of land-use and water management plans (SDAGE) and water management and development plans (SAGE).

Switzerland will adopt legislation similar to the European Seveso Directive (major hazards ordinance – OPAM – which came into effect April 1st, 1991), thus reinforcing the safety of industrial sites and improving the exchange of information between neighbouring countries in the event of an accident.

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