

Explosion of Organic Peroxide caused due to Warehouse Fire

【July 14th, 1964 Shinagawa, Tokyo , Japan】

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At around 21:56 on July 14th, 1964, from the warehouse zone in the coastal reclaimed land that adjoins the Tokyo Metropolitan Expressway No.1, suddenly a pillar of flames rose like fireworks with an explosion sound up into the night sky. The explosion occurred at the Katsushima warehouse of Takaragumi Co., Ltd. There were many dangerous substances as well as non-dangerous materials in the warehouses and open freight storage. The dangerous substances consisted of self reactive materials such as nitrocellulose, organic peroxides like methyl-ethyl-ketone-peroxide (MEKPO), and inflammable fluids such as acetone.

The fire station still conducted fire tower observation at this time, and this fire was discovered by at least two fire stations almost simultaneously. Open freight materials, such as nitrocellulose, and organic solvents, such as acetone, caused small explosions incessantly and continued to burn. A large number of professional and voluntary firemen fought a fire. Many reporters gathered to collect information about the fire, since it occurred just near the Metropolitan Expressway Haneda, which is a major expressway between Tokyo and Yokohama. At 22:56, when it appeared that the fire would be extinguished at last, a large explosion happened inside the warehouse. Fragments of the roofs of three warehouses were scattered by the explosion, which produced a 100m high pillar of flames. As a result of this explosion, a total of 19 persons were killed including 18 professional firemen and one voluntary fireman, and a total of 117 persons were injured including 80 professional firemen, 12 voluntary firemen, and 25 policemen and journalists.

The first explosion and fire seemed to be caused by the spontaneous ignition of nitrocellulose in drum cans that had been stored in the open freight storage. Acetone and alcohol that were also stored there ignited, causing repeated explosions. MEKPO stored inside the warehouse was ignited by the fire and exploded. In addition, the fire spread to another warehouse which stored sundries, and thus the fire spread.

The reason why the fire became so large was the illegal storage of many substances that were designated as dangerous materials and controlled by the fire protection law

everywhere in the yard. Moreover, it was indicated that the management system had been very loose. Furthermore, the data that was given to the fire fighting team was old, and it showed different stored materials from the practice. In addition, the request that was made by the employees to the fire fighters was only to protect the acetone and nitrocellulose in the open freight storage. The fire fighters were only informed that the contents of the warehouse were canned food. Since most of the fire men did not know the actual conditions of the warehouse in which dangerous substances were stored, it became a large disaster.

In short, careless management and control of the warehouse operation by managers and supervisors caused the disaster.

Although the first ignition was caused by spontaneous ignition of nitrocellulose in the open freight storage, in the appealed court decision in the Tokyo High Court, the judge did not affirm clearly that the cause of the explosion was spontaneous ignition of the nitrocellulose based on the result of a certain experiment. However, nitrocellulose should be handled under the premise that spontaneous ignition may occur, because nitrocellulose is definitely unstable, and there have been many accidents related to spontaneous ignition of nitrocellulose before this accident.

1. Event

On the night of July 14th, 1964, an explosion and fire occurred at warehouse for dangerous materials and the open freight storage located along the Metropolitan Expressway No.1 near Shibaura. The fire fighters noticed the fire by fire tower observation and mobilized the second grade fire fighting team immediately, which consisted of 13 to 15 pump cars and one ambulance. At the site where the fire occurred, the employees who lived in the company houses at the site and voluntary firemen tried initial firefighting using a small pump, but they could not do anything at all, and the fire spread to engulf the whole open freight storage. The fire brigade judged that the fire was involved in dangerous materials from the observation of the flames on the way to the site, and they requested the mobilization of the chemical fire brigade, which consisted of six fire engines for chemical fire.

The initial target of the fire brigade was to put out the fire of nitrocellulose, oils and fats in the open freight storage. However, the force of the fire was strong and the fire spread from a warehouse to another warehouse one after another. Given this situation, the fire fighting crew was strengthened by the third grade and then the fourth grade mobilization. Finally 26 pump cars, 14 chemical fire fighting engines, 12 material transportation vehicles and seven fire boats turned out. The No.3 area where the fire

occurred and the No.5 area that was adjacent to the No.3 area on the north side were surrounded with firefighters, and the fire in other areas seemed to be extinguished at last. Until that moment, the firefighters knew only that the contents of buildings 6, 7, and 8 in the No.3 area were paper and cigarettes, the building of 5 in the same area contained miscellaneous articles and canned food, and the building 1 in the same area and the open freight storage contained nitrocellulose. In addition, the persons related to the warehouse requested the firefighters to protect area No.5 because there was a large amount of acetone, alcohol, and nitrocellulose in the open freight storage.

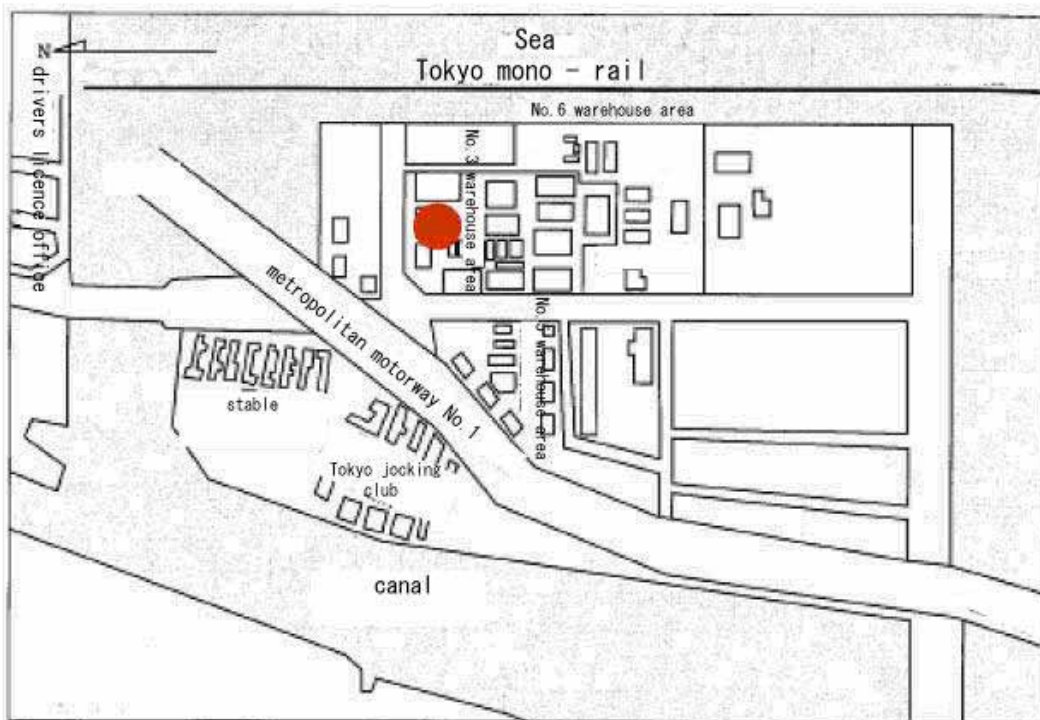


Fig.1 warehouse location

Under this situation, at 22:56, about an hour after the fire started, a large explosion occurred at the warehouse No.12 for general materials, which had been reported to contain canned food. The roofs of the warehouse No.12 and the other two warehouses adjoined the No.12 warehouse were scattered instantly, and an enormous pillar of flames with a large mushroom cloud rose from the site. The external walls were blown away, and many firemen were buried under the wall. A crater over one meter in depth was made at the center of the explosion.



There were 2,000 nitrocellulose at the open freighting area
The front was estimated as the fire occuring point

Fig. 2 photo after the fire

The trigger of this large explosion and fire seems to have been the spontaneous ignition of nitrocellulose at the open freight storage in the third area. Excessive storage of un-licensed dangerous materials was the reason of increase in damage. Many victims were sacrificed because the employees did not know that the warehouse contained organic peroxide MEKPO. However, the problem was not that the employees did not know what the warehouse contained. More serious cause of the disaster was that the managers and superintendents had stored a large amount of dangerous materials illegally, that they had not informed the employees about the stored material nor had they introduced countermeasures against the accident, and furthermore that they did not give sufficient information to the firefighting team.

The president of this warehouse company had started business with the management of a hotel, and he also carried on businesses such as a contractor of civil engineering and construction and sales and processing of seafood, warehousing and shipping. It was not known whether or not he had managed the warehouse business with sufficient knowledge of the danger caused by a large amount of dangerous materials stored in the warehouses and the dangers of nitrocellulose and MEKPO. However, at least the president should assign a qualified person for the manager of the warehouse, a required number of qualified persons for supervisors and operators for the actual operations, and make sure that laws are observed.

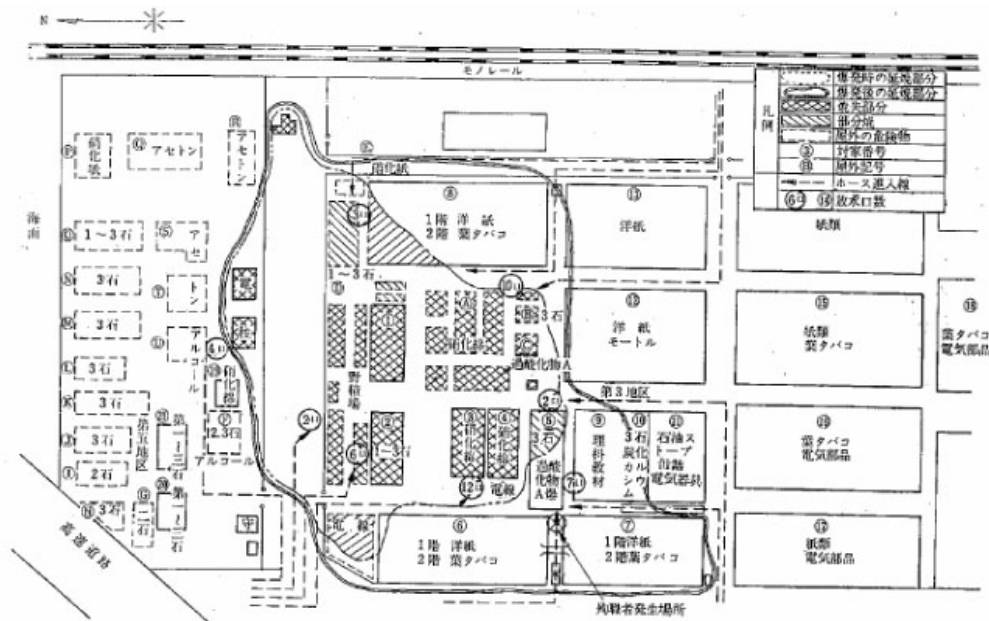


Fig. 3 fired area

2. Course

At around 21:56 on July 14th, a fire occurred. At 22:00, the public fire brigade turned out. Although this was the second grade order, soon after it was changed to the third grade, and then the fourth grade order were issued at 22:13.

At 20:56, a large explosion happened.

At 00:27 on July 15th, the spreading of fire was successfully prevented. At 01:38, the fire was extinguished, but the complete treatment of the embers was not completed until 14:00.

3. Cause

The true cause of this accident was the careless management. Dangerous materials that far exceeded the permitted quantity limits were stored without care. In addition, the superintendents who did not train and educate the operators on the contents of the stored materials, the methods of treating the materials and countermeasures against the fire should be blamed. Refusing the storage of materials over the permitted quantity is originally the responsibility of the manager. It is the duty of the managers and superintendents to grasp clearly the stored materials at that time, to establish correct methods to treat the material, and to give correct information to the authorities including the fire fighting team. The first spontaneous ignition might have been prevented, and a large number of victims sacrificed to the disaster could

have been avoided, if the correct information had been provided.

Nitrocellulose is well known as a substance that ignites spontaneously. There are many persons who estimate that the cause of this fire is spontaneous ignition of nitrocellulose.

Furthermore, considering the size of the explosion, it must be the explosion of 2500 kg of MEKPO that was stored.

4. Process of cause elucidation

At first the ignition point was determined. On the basis of twenty testimonies by observers who saw the first pillar of flames near the accident site, straight lines were obtained by connecting each observer's standing point and the reported direction of the flame, and the lines intersected at the open freight storage in front of the warehouse No.103. There were four layers of drum cans of nitrocellulose at this position. The conditions for spontaneous ignition of nitrocellulose are as follows (quoted from the literature of Professor Kitagawa) (1) Storage in a dry state. (2) Storage for a comparatively long period at a high temperature. (3) Storage of a comparatively large amount of material such that the heat of decomposition will be accumulated as the diffusion of the heat of decomposition is prevented. The weather was fine and the maximum temperature was also high for a few days before the day of the accident, and the temperature at the drum surface appeared to reach a maximum of 60-70 °C, so the condition (2) was satisfied. In addition, one drum contained 60 kg nitrocellulose in a dry state. This quantity is enough to satisfy the condition (3). The satisfaction of condition (1) is considered as follows. Although the nitrocellulose was in a wet state that contained 25% ethanol, it can be hypothesized that the inner bag made of polyethylene had split. This hypothesis is substantiated by the observation by other users that the polyethylene bags of all of the drum cans had almost split at the shoulder. If the polyethylene bag had split, the alcohol would have evaporated from the upper part, because it was heated to about 70 °C in the drum can upper surface upon which the sun shone. A part of the evaporated ethanol would have been pushed out from the opening of the lid of the drum can with hot expanded air. Fresh air would have been drawn into the can, when the drum can was cooled at the night. The upper part would dry as a result of the repetition of this process. An employee testified that he had observed this condition when he conducted sampling from the drum cans on June 10th. From the facts above, it was supposed that the following events occurred. Nitrocellulose decomposed spontaneously, the heat of decomposition was accumulated, the temperature reached ignition temperature at around 22:00, and the nitrocellulose

explosively decomposed. The lids of the drum cans came off from the piled up drum cans, and the drum cans scattered like rockets with jetting flames from the lid side. The nitrocellulose and alcohol were included in the material that spouted from the lid side, and these materials helped to spread fire.

However, as described in the "Outline" above, in the criminal trial, a different judgment was also given. In the hearing of intermediate appeal in the Tokyo High Court, the "spontaneous ignition theory" was not adopted as the fire accident cause, because the evidence supporting the "spontaneous ignition theory" was insufficient compared to that of the theory "the spontaneous ignition was not being generated" based on the different estimation results. It is considered that they did not regard the facts as denying the spontaneous ignition theory, but they chose to apply the principle of "giving a person the benefit of the doubt". Nitrocellulose should be regarded as a substance that ignites spontaneously if storage conditions are bad. In the warehouse where the large explosion occurred, a label for MEKPO was found during the investigation after the explosion, and after the firefighting authorities investigated the actual receiving and shipping records of the warehouse, they were certain that the warehouse had contained MEKPO. Therefore, they determined that the warehouse was the center of the explosion.

5. Immediate action

The employees who lived in the company house at the site tried to extinguish the initial fire with some voluntary firemen using a small pump right after the first explosion, but it was of no avail.

6. Countermeasure

There is a rule of handling dangerous materials. The amount, the distance, and methods of treating those materials etc. are prescribed in the fire protection law and other laws. The first countermeasure is at least to follow these laws.

More concretely, the following measures may be required: the quantity of storage must be kept under the permitted limit, the correct storage method must be taken with sufficient knowledge of the danger of nitrocellulose, the quantity and properties of the stored materials must be correctly understood, suitable countermeasures against emergencies should be prepared at any time, and suitable information must be provided to the firefighting authorities and police at need.

7. Knowledge

The laws that control dangerous materials, such as the fire protection law, show the minimum regulations. It is reasonable that the minimum regulations given by the laws must be kept.

Often chemical substances can undergo unexpected changes when storage and other handling methods are incorrectly applied, and the substances may be transformed into a dangerous state. Not only so-called dangerous materials are dangerous. It is important to remember that we are always surrounded with danger and that safety should be maintained by attention and action in our normal activities.

8. Influence of failure

As for the human damage, 19 persons died and 117 persons were injured. All of the fatalities and 92 of the injured were from the fire fighting brigades. Policemen and members of the press were also included among the injured. According to another report, 158 persons were injured.

As for the physical damage, fifteen buildings including the warehouse burned down, two buildings were half destroyed by fire, and eight buildings burned partially. The monetary damage was estimated to be 55 hundred million yen in the current price of 1964. In addition, regulation of traffic and other effects caused social damage.

9. On the side

The fire triggered a revision of the fire protection law. The revised contents included the following: extension of the authority of the firefighting, such as giving an authority to do on-the-spot inspection, to order the measures to be taken, to approve the temporary storage of dangerous materials, and to require the necessary information at the accident site.

An article of the special edition of "Modern Fire Fighting, July, 2000" which dealt with this explosion, says that "although it may seem that the most dangerous materials are explosives, the explosives that are used industrially are safe and mass production is possible, as long as the handling process is not mistaken. What are really dangerous are materials such as MEKPO and other organic peroxide that are used as catalysts. Therefore, these materials cannot be used as explosives."

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