

Explosion and Fire of Dibenzoyl Peroxide Factory

【May 26th, 1990 Itabashi, Tokyo, Japan】

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At around 10:40 on May 26th, 1990, a large explosion occurred at the chemical plant of Daiichi Chemical Industry Co., Ltd. The plant was located in the area where factories and houses exist together in the north of the 23 wards of Tokyo. Eight persons were killed, 18 persons were injured, nine of the twenty factory buildings burned down, and 33 buildings in the surrounding area were damaged.

The large explosion started with a small explosion of dibenzoyl peroxide (BPO), which the company manufactured, in the subdivision room. The explosion spread to each workshop at different buildings. Several explosions occurred at intervals of one or two minutes after the first explosion. BPO that caused the first explosion was a high-density product that exceeded 98% purity. This high-density product was manufactured at only this factory in Japan (there were six manufacturers of this product in Japan). Since manufacturing of this high-density product is very dangerous, the U.S.A. and Japan were the only countries where this product was manufactured. BPO is known as a dangerous material, and it is designated as a self-reactive material, dangerous material type 5, in the fire protection law. The company that caused the accident had recognized sufficiently the danger and the regulations of the fire protection law. However, at site inspections by the fire fighting authorities, in order to hide the fact that the stock of BPO had extensively exceeded the permitted quantity, the company repeatedly conducted the illegal actions, such as covering the fiber cans containing BPO with a sheet or putting empty fiber cans on the upper part of the multistage pile. Furthermore, the company had caused accidents three times in the past.

As a result of this accident, the problems related to the location of a factory that handled dangerous materials, where existed adjacent to private residences in the area where factories and houses exist together, were recognized.

BPO: abbreviation of dibenzoyl peroxide. The chemical formula is $C_6H_5-CO-O-O-CO-C_6H_5$. It is organic peroxide where two benzoyl groups are combined at the O-O. The O-O bond is easy to break, and the dried product can

explode by friction, impact, or heating. For a long time, it has been used for the bleaching of fats, oils and flour. More recently, with the rise of the petrochemical industry, it is used as a catalyst for manufacturing resin.

1. Event

In the area where factories and houses exist together of Itabashi Ward in Tokyo, an explosion occurred at a chemical plant at around 10:40 on May 26th, 1990. The material causing the explosion was organic peroxide BPO. BPO has been used for many years for bleaching of fats, oils and flour. With the rise of the petrochemical industry, it is now used as a catalyst for manufacturing resin. For chemical use, three grades of BPO products are produced: 100%, 75% and 50%. The 100% grade product, which means the product with over 98% purity, was manufactured at only this factory among six BPO manufacturing companies in Japan, and only the USA and Japan were the countries manufacturing the 100% grade product in the world. The 100% grade product is designated as a self-reactive substance by the Fire Protection Law.

The factory at which the explosion occurred manufactured each of the three grades of product: 100%, 75% and 50%. The product forms were also varied, including crystal, granular, wetted, and powder. Various processes were placed in a complicated manner within a small area of the factory in Tokyo, and each stage of work was frequently changed in proportion to the fluctuation of the demand for the product. Furthermore, manufacturing and handling operations were often different from those permitted under the fire protection law, and it was repeatedly concealed during site inspections by the fire fighting authorities and so on.

The accident occurred when the operators were subdividing 100% grade products into 5 kg polyethylene bags from a fiber can that contained 40 kg using a polyvinyl chloride scoop and an electronic balance on a dolly. The 100% grade products are produced by refining the 75% grade products and finally by drying using methanol. The explosion happened during the subdivision work in the subdivision room by some causes. An operator, who was passing by the subdivision room, saw flames spouting out before the explosion from under the part of the east door of the subdivision room. Some buildings where low-density products were manufactured or stored exploded one after another, because the flames scattered with fragments of a slate roof and so on.

This explosion and fire resulted in a large disaster. Eight persons were killed, 18 persons were injured, and nine of the buildings in the factory burned down. Furthermore, 33 private houses adjacent to the factory were damaged, including broken windowpanes and so on.

According to the newspaper, the illegal situation of the factory was as follows: the daily output was six times larger than the permitted quantity, and the stockpile also greatly exceeded the permitted quantity. The methods of illegalities and the cover-up were reported in newspapers and other mass media after the accident. For example, they hid the cans containing BPO by piling empty cans above and beside the filled cans, and they prepared the countermessure manual which indicated the roles of the employees in hiding the illegality at the site inspections, etc.

2. Course

The work on May 26th, 1990 started at 8:30. The subdivision staff removed dust and other materials manually from the dried product, and then they carried dried BPO from the drying room to the subdivision room. The subdivision work started at 9:30. The floor was wetted with water before the work to prevent static electricity.

At 10:40, a fire occurred in the subdivision room with spouting a small scale flame from the room, and a large explosion followed in the room soon after. The course of events was guessed as follows, regarding the start of the fire as 0 seconds.

0 second: A small fire occurred.

A few seconds later: An explosion occurred in the room, and a funnel state hole was generated in the room.

12-15 seconds later: The subdivision room burned down, and block fences and so on, fell down. The fire spread to the adjacent buildings. BPO in the drying process at the adjacent building exploded twice.

After this, explosions occurred one after another, causing the fire to expand.

3. Cause

3.1. First small fire and explosion in the subdivision room

A combustible gas-air mixture was generated by evaporation of methanol that remained in the BPO product contained in the fiber drum. The combustible gas-air mixture was thought to have been ignited by electrostatic discharge of subdividing operators. Then the fire spread to BPO powder that was in a floating state in the fiber drum, and next, it was estimated that the BPO powder exploded. In addition, the explosion spread to other BPO in the subdivision room. An operator saw the first fire.

Another possible cause of the explosion was that BPO dust or BPO decomposed gas that was generated by friction filled the room and was ignited by an electrical spark due to breakage of a fluorescent lamp. There is a possibility that some BPO spilled while being transported to the subdivision room and that the BPO got into the bearings

of the dolly, where it was decomposed by friction. However, the damage of fluorescent lamps that was observed after the accident might have been a result of the explosion.

Although matters mentioned above were triggers that directly caused the explosion, the true cause of the explosion was the company's characteristics itself that had caused many accidents, had stored BPO extremely exceeding the permitted quantity and had hidden the illegality for a long period.

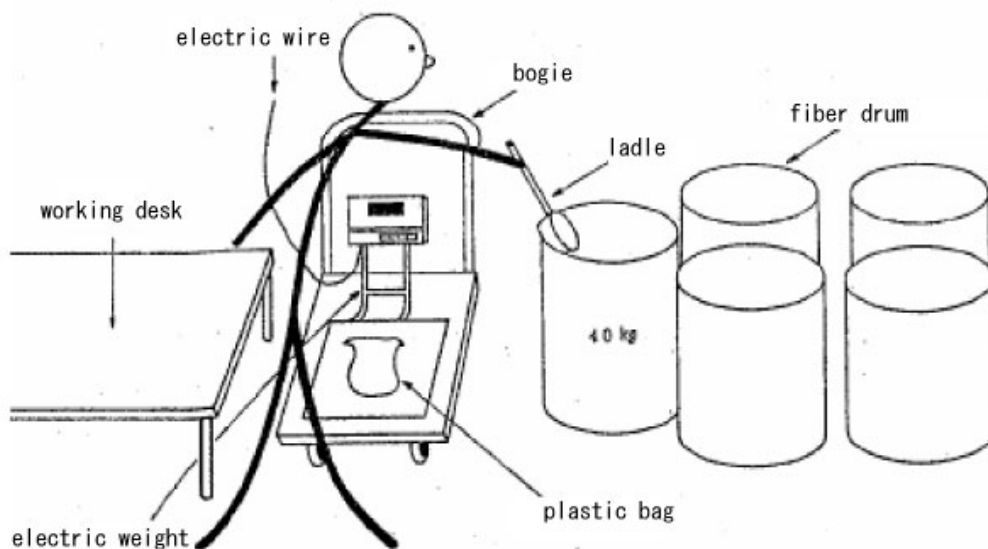


Fig.1 explanation of sub - division work

3.2 . Cause of the spread of the damage extension

- 1) The burning speed of the 100% BPO product is very high, and it is a material that burns intensely. Therefore, the explosion spread to the adjacent building and the fire occurred in an instant.
- 2) There was a lot of BPO stored in the places where the explosions spread.
- 3) The fire that was caused by the explosion in the subdivision room spread rapidly and caused explosions one after another because the buildings where BPO was handled were close each other.
- 4) The distance from the factory gate to the area of the subdivision room was far, and evacuation was not easy.
- 5) Storage and production that exceeded the permitted quantity had been done.

The causes mentioned above are not the true causes, just as the causes of the explosion in the subdivision room. Although it might have been an inevitable result of

the economic situation, the main problem was that the operation was continued at a site without room for expansion, which was located in an area crowded with private residences.

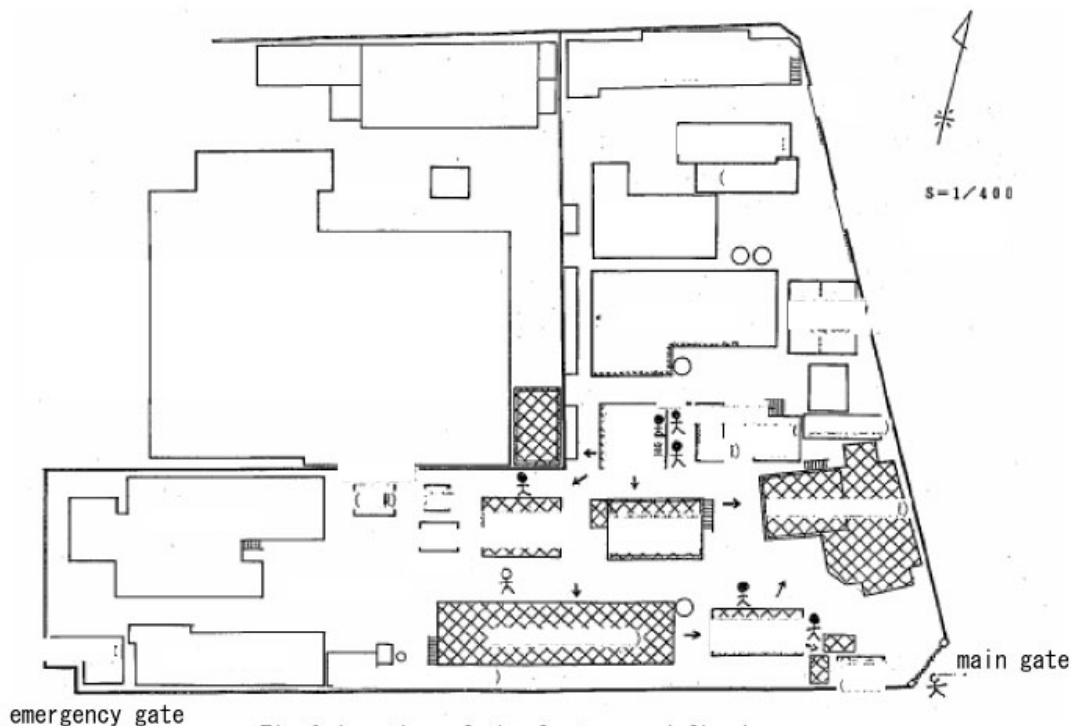


Fig.3 location of the factory and fired area

4. Process of cause elucidation

Since all four persons who were working in the subdivision room died and the subdivision room was destroyed without leaving any traces by the explosion, the cause of the explosion was confirmed through various experiments designed to test the conceivable hypotheses based on interviews with the persons concerned and slight traces that remained at the site.

- 1) It was shown that the explosion was a condensed phase explosion caused by some explosives, not a gas explosion, because a funnel hole remained in the subdivision room was in a typical shape of a condensed phase explosion. The explosion was therefore determined to have been generated by BPO in the subdivision room.
- 2) The four persons working in the subdivision room died outside the room, which means they escaped from the room and died. From this fact, it was shown that the fire occurred first, and then the explosion followed.
- 3) The hypothesis that the fire had occurred as a result of the contamination of BPO itself was rejected based on the examination of the National Institute of Fire and Disaster.

- 4) The possibility that the explosion was caused by a cigarette or direct sunlight was also examined. The cigarette hypothesis was rejected by the testimony of other employees, and the possibility of direct sunlight was also rejected based on the consideration of the building structure and working condition.
- 5) The existence of methanol was sufficiently possible after drying for obtaining the 100% grade BPO product. It was also possible that static electricity was generated in the subdivision work. If the electrostatic charge prevention method was insufficient, for instance only wetting of floor by water spraying was done, and then the prevention effect would be lost when ventilation was carried out. Incidentally, the BPO product may not have been dried perfectly during drying operation. Also, it is certain that static electricity is generated when work is done.

5. Immediate action

The factory staff tried to extinguish the fire by using the fire pump at the site in the initial stage of the explosion. However the power line of the pump was cut by the influence of the explosion.

6. Countermeasure

After receiving the survey result of the investigation committee, the Ministry of Labor demanded the concerning group as take countermeasures as follows;

- 1) Change to a safe BPO product, for example, a conversion to a lower purity grade.
- 2) Ensuring the safety of BPO handling facilities.
- 3) Paying more attention to the time and ventilation conditions for the drying of BPO.
- 4) Ensuring the safety of the subdivision room (four items).
- 5) Ensuring the safety of the subdivision work; wearing the anti-static electricity clothes and decreasing of BPO quantity in the subdivision room, and so on (five items).
- 6) Providing complete safety education, preparation of work standards, and so on.

The guidance and advice mentioned above are reasonable. However, the essential problem remains unsolved if the safety consciousness of the managers and executives is not improved. Furthermore, no solution was given for the location problem of the factory where factories and houses exist together.

7. Knowledge

This case is an example of an accident in which the largest problems lies in the

attitude and consciousness of the management staff. Any difficult techniques were required for operating the facilities in safety. This accident would not have occurred if the company had operated the factory with common care about safety that is required for normal chemical plants. If they were aware of the danger of the work they were doing, they should have taken the basic safety measures such as static electricity countermeasures and confirmation of drying.

8. Influence of failure

As the human damage, eight persons were killed and 18 persons were injured. Furthermore, some of the nearby residents were treated temporarily for eye pains and other minor problems. As for the physical damage, nine buildings with a floor area of 970m² burned down in the factory, windowpanes of 38 private residences in the neighborhood broke, and 19 cars were damaged. The monetary damage was estimated to be about 150 million yen, and 700 million yen was paid as indemnities to the bereaved family members.

The biggest damage would be a loss of the social confidence in the enterprise.

9. On the side

Many accidents had occurred at the factory before this accident. The list of previous accidents is as follows.

- 1) In September 1975, a small explosion of a piece of metal adherent to BPO occurred when a small piece of a metal was thrown from the second floor of the factory and hit the metal adherent to BPO on the first floor.
- 2) In July 1978, 170 kg of BPO, which was stopped shipping, was ignited by the heat of sunlight, and the fire spread to the warehouse. Twelve persons were injured.
- 3) In March 1990, a batch of BPO product, in which alkalinity of sodium hydroxide remained as a result of insufficient water washing during the manufacturing process, exploded under storage due to a spontaneous chemical reaction, and the external wall and glass of the factory were damaged.

In this accident, the damage to the neighborhood was small, because the explosions had occurred at a time when children were not playing outside. The damage would have been much greater if the time of the explosions had been different.

Although the factory was surrounded by houses at that time of the accident, it is likely that there had been only a few residences nearby when this factory was established. It appears that houses were constructed around the factory some time after the factory had been built. Considering such a time course, it can be seen that the

problem here is equivalent to the problem that "an old building that fulfilled the laws and rules in that days becomes illegal in today's laws and rules" which is mentioned related to the earthquakes. The idea of the management should be changed according to the environment changes, or danger will be generated.



Fig.3 fired area

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