Statens haverikommission

Fire at Liseberg Oceana Waterworld in Gothenburg

The Swedish Accident Investigation Authority has investigated a fire at the construction work site Liseberg Oceana Waterworld in Gothenburg, Västra Götaland County on 12 February 2024

20 March 2025

Final report

SHK 2025:05e

Information about the Swedish Accident Investigation Authority

The Swedish Accident Investigation Authority (SHK) investigates accidents and serious incidents from a safety perspective, regardless of whether they took place on land, at sea or in the air. SHK's accident investigations shall disseminate knowledge and provide evidence that authorities, companies, organisations and individuals can use to implement measures to improve safety and reduce the risk of accidents. SHK's operations are also to contribute to people having a sense of security and trust in societal institutions and confidence in transportation systems. SHK's assignment also includes assessing the contributions made by public rescue services in connection with an accident. However, the investigations are not to address issues of guilt, blame or liability for damages.

SHK accident investigations thus aim at answering three questions:

- What happened?
- Why did it happen?
- How can a similar event be avoided in the future?

The report is also available on SHK's web site: www.shk.se

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Contents

Summary

On the morning of 12 February 2024, a fire broke out in one of the waterslides at the future waterworld Oceana. The fire spread rapidly through the water attraction and a fire gasexplosion took place that resulted in major damage to the building. One person was fatally injured in conjunction with the fire.

The constructions were in their final stages ahead of completion of the waterworld. A number of work tasks were ongoing on the day of the accident. One of these work tasks was electrofusion of diversion pipes connected to one of the waterslides.

The fire probably started as a result of deficiencies in the fitting of the diversion pipes, which resulted in the pipes overheating and then catching fire during electrofusion.

Causes/contributing factors

Deficiencies in the systematic work environment management at the construction site resulted in the work on the diversion pipes being carried out without adequate conditions. There were shortcomings in knowledge about the risks associated with the work, its execution, and its planning. Consequently, the fire risks linked to the work were neither identified nor addressed.

Safety recommendations

The Swedish Work Environment Authority is recommended to

- Investigate the feasibility of increasing, within the scope of construction sites, the focus on systematic work environment management and other matters relating to a good safety culture (see Section 2.4.1). *(SHK 2025:05e R1)*
- Implement measures within the scope of its work with product safety and market surveillance to enhance safety when using electrofusion machines. Such measures can encompass, for example, market surveillance, regulatory changes or standardisation work (see Section 2.4.2). *(SHK 2025:05e R2)*

Liseberg is recommended to

- As a developer, continue to develop its systematic work environment management with the aim of enhancing the safety culture. This work should encompass, among other things, clearer imposition of requirements on contractors and continual follow-up of their systematic work environment management (see Section 2.3.2). *(SHK 2025:05e R3)*

NCC Sverige AB is recommended to

- Take action in its role as general contractor to enhance monitoring and follow-up of compliance with established rules and procedures relating to safety. This action should include the promotion and maintenance of a good safety culture (see Section 2.3.2). *(SHK 2025:05e R4)*

WhiteWater West is recommended to

- Take action to enhance compliance with established rules and procedures relating to safety. This action should include the promotion and maintenance of a good safety culture (see Section 2.3.2). *(SHK 2025:05e R5)*

The investigation

SHK was informed on 12 February 2024 that a fire had occurred on the construction site Liseberg Oceana Waterworld in Gothenburg, Västra Götaland County, on the morning of that same day.

On 21 February SHK decided to investigate the occurrence in light of the fact that the fire had extensive consequences and because an investigation by SHK was deemed to have the potential to lead to safety improvements.

The accident has been investigated by SHK, which has been represented by Kristina Börjevik Kovaniemi, chairperson, Håkan Josefsson, investigator in charge, Lars Dahlin and Eva-Lotta Högberg, operations investigators, and Tomas Ojala, investigator emergency response up to and including 31 December 2024.

Research Institutes of Sweden AB (RISE) has assisted SHK with technical fire investigations.

The investigation has been monitored by the Swedish Work Environment Authority through Bengt Andreasson, the Swedish Civil Contingencies Agency (MSB) through Stefan Särdqvist and the Swedish National Board of Housing, Building and Planning through Anders Johansson.

Investigation material

SHK visited the accident site on 26 February 2024. A fire investigation has been conducted in order to identify the location where the fire broke out and to assess the cause of the fire and its initial course.

SHK has interviewed people including witnesses of the occurrence, representatives of the developer, the general contractor, subcontractors and other contractors. However, SHK has not been given the opportunity to conduct interviews with all relevant staff and has therefore been limited to using interview material from other parties as a basis.

SHK has also interviewed representatives of the Greater Gothenburg Fire and Rescue Service.

In addition to this, SHK has held meetings with organisations including the Swedish Work Environment Authority, the Swedish Welding Commission, the Swedish Fire Protection Association, the association Swedish Construction Clients, the association Swedish Fire Safety Companies (SVEBRA) and GPA Flowsystem AB.

Data from the interviews conducted has been incorporated into this report.

SHK has studied material including photographs, films, relevant documentation and logs from the aforementioned parties.

One fact finding presentation meeting with relatives and one with other interested parties were held in Gothenburg on 26 September 2024. At these meetings SHK presented the facts discovered during the investigation, available at that time.

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Occurrence	Fire
Developer	AB Liseberg Skår 40:17, subsidiary of Liseberg AB
General contractor	NCC Sverige AB
Other contractor	WhiteWater West Industries Ltd
Time of occurrence	In the morning of 12 February 2024
Location	Construction site Liseberg Oceana Waterworld, Gothenburg, Västra Götaland County
Weather	Temperature -1˚C, north-easterly wind 3–5 m/s. Freezing rain or drizzle.
Personal injuries	One person was fatally injured. A number of people suffered minor smoke-related injuries.
Damage to the building	Extensive
Other damage (environment)	Emissions of environmentally hazardous substances in the smoke from the fire

1. Factual information

1.1 Circumstances

Liseberg Oceana was a planned waterworld with an associated hotel just south of the Liseberg amusement park in Gothenburg (see Figure 1). The area where the hotel and waterworld were to be built was acquired in 2013 by a newly started subsidiary of Liseberg AB, AB Liseberg Skår 40:17. The subsidiary was the developer and was to be converted to a property company once the project was complete. Liseberg AB provided staff for the project and additional resources were brought in as consultants under the subsidiary. Liseberg AB is a limited liability company that is wholly owned by the City of Gothenburg. The name Liseberg is used in this report collectively for the parent company and the subsidiary.

A feasibility study about building the waterworld on a carpark alongside the road Mölndalsvägen was initiated in 2014. The construction of the facility began following a decision by Liseberg's board of directors at the end of November 2020. Liseberg had engaged a general contractor, NCC Sverige AB, subsequently referred to as NCC, for the works. Liseberg had also engaged a number of other contractors in order to accomplish the works associated with the water attractions. This included, Liseberg entered into an agreement with a Canadian company, WhiteWater West Industries Ltd, hereinafter referred to as WhiteWater, for the purchase and installation of waterslides.

The hotel was completed in spring 2023. A final inspection of the waterworld was planned for 8 April and the plan was to open the waterworld on 1 June 2024.

Figure 1. Architect's image of Liseberg Oceana Waterworld. The entrance is shown in the foreground and the pool building with associated tower with waterslides is in the background. The hotel and the amusement park Liseberg are to the left, outside of the picture. Source: Liseberg.

The waterworld Liseberg Oceana had a theme inspired by the history of Gothenburg and the Swedish East India Company. The facility was to have 14 water attractions, including four large waterslides: Family Boomerango (light yellow), Masterblaster (red), Abyss (turquoise) and Rattler (green). The large waterslides started in a 40-metre-high tower, continued mainly outside of the tower and ended inside a 6,000 m² pool building on level two (see Figure 2). Under level two there was a basement level with technical spaces for the water attractions.

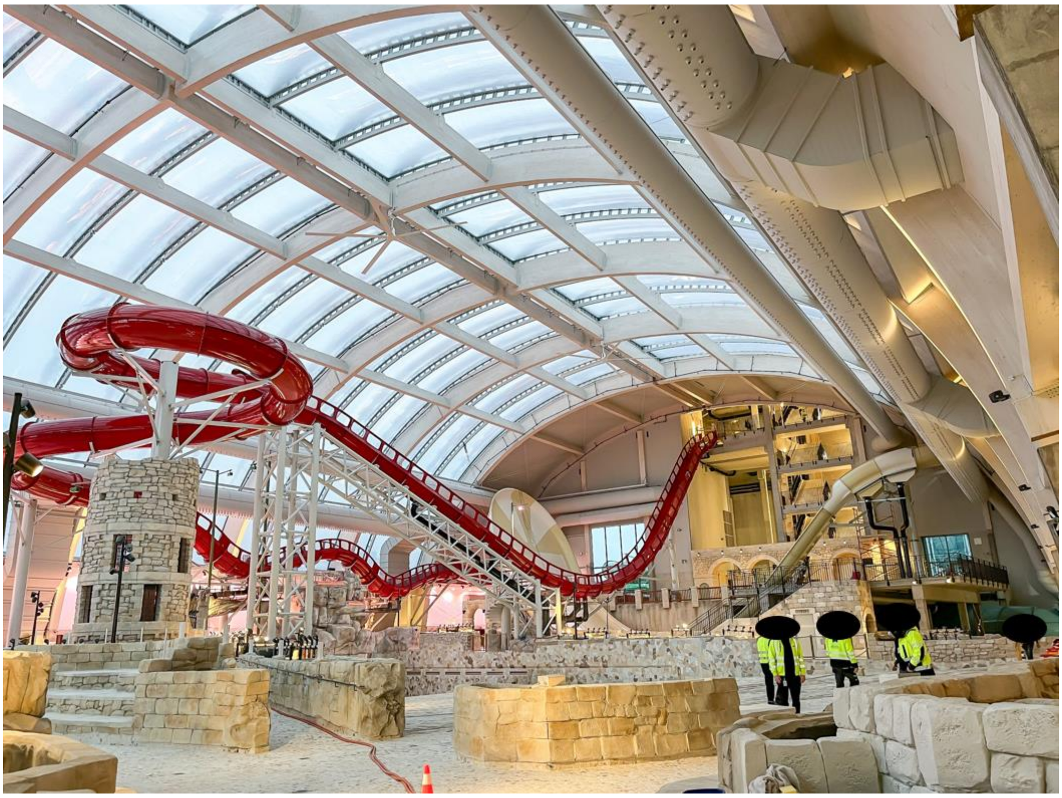

Figure 2. The hall containing the pool on level two. Level three and the stairwell that leads up to the start of the waterslides are visible in the background. The image has been edited by SHK to anonymise the people in the picture. Photo: NCC.

The waterslides Rattler and Masterblaster started on level four and Family Boomerango and Abyss started on level five. These levels were reached via stairs on level three. The top level (level six) in the tower consisted of a technical space for the ventilation and could only be accessed via an exterior spiral staircase (see Figure 3).

Figure 3. The image shows the waterslides under construction. The four waterslides started in the tower and ended in the pool building. The waterslide Rattler, which is coloured green, is visible in the foreground of the image. The spiral staircase that was the only way to and from the technical space on the top level (level six) is also visible. Photo: Enviro-Process Sweden AB.

The waterslides were built of fibreglass reinforced plastic and were held in place with steel structures. The water for the slides was transported from pumping stations in the basement of the main building via pipes up to the start of the slide. The water in some of the slides was controlled through water being added or removed through 'diversion pipes'.

The construction site was protected by a fence with a number of gates through which only authorised personnel with authorisation cards had access.

In February 2024 construction of the waterworld was in its final stages and the waterslides had been test run for a few weeks. Installation of a fire alarm was underway, but this was not yet operational.

According to the SMHI (Swedish Meteorological and Hydrological Institute), there was freezing rain or drizzle over the area on 12 February. During the day the precipitation turned into light snowfall from around eleven o'clock. The wind was north-easterly with a speed of 3–5 metres per second. The outside temperature was -1°C and the indoor temperature was 30–33°C.

1.2 Sequence of events

On 12 February 2024 work started on the construction site at around seven in the morning. Approximately 140 people from just over 40 different companies were present on the construction site at that time. Several different work activities were taking place during the morning.

Outside, close to the tower, two people were working on lamination in the upper waterslides Abyss and Boomerango. Two people were standing on a boom lift and working on tightening of fasteners, and two other people were standing on another boom lift and working with the fitting of diversion pipes under the waterslide Rattler. Tarmacking work was being started in the area at the same time.

Between 08:45 and 09:15 hrs the inside of the lower part of Rattler was cleaned with water and liquid soap following previous work on the waterslide over the weekend. The waterslide was to be test run later in the afternoon. There were people working with, tiling and cleaning, on levels 4 and 5, of the tower.

An inspection was taking place in the pool building. At 09:30 hrs the inspection team had reached the part of the pool building where the waterslides Masterblaster and Rattler terminated. Several of the people who were conducting the inspection noticed a smell of burnt plastic at that time. Some also thought they smelled wax.

At 09:40 hrs two technicians began a manual test of the fire alarm. One of the technicians went up to level six in the tower and the other technician was at the central unit in the basement. The alarm was in test mode at this time. The final test of the alarm was recorded at 09:55 hrs.

Just before 10:00 hrs a construction supervisor went up to level five in the tower in order to check the cleaning after the work that had been performed at the weekend.

At approx. 10:00 hrs the people who were working on the diversion pipes under the waterslide Rattler heard ‘a strange hissing sound’ that they through was water that had been releaseed. They stopped working and went down in the boom lift.

The staff who were in the tower noticed that smoke was coming from the start of the waterslide Rattler and started to evacuate.

At 10:03 hrs white smoke can be seen coming from Rattler on video from a security camera located in a carpark to the east of the construction site (see Figure 4).

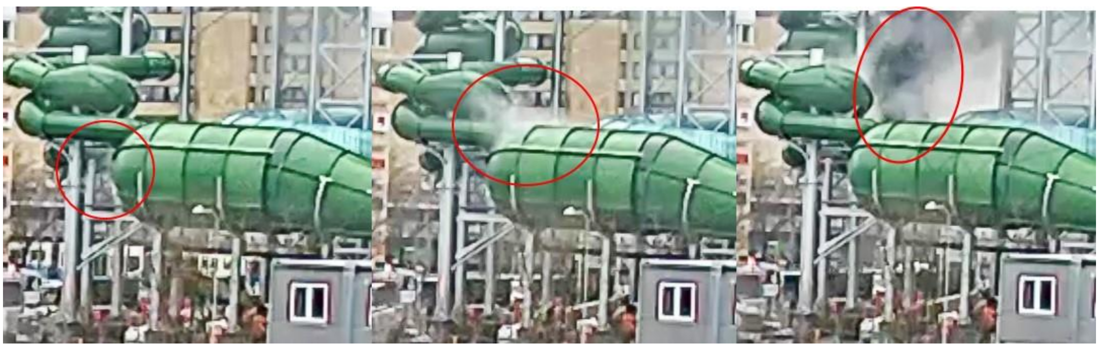

Figure 4. Series of images from a security camera video. Light-coloured smoke can be seen coming from the waterslide Rattler at 10:03 hrs. At 10:04 hrs the intensity of the smoke has increased and at 10:05 hrs it has become darker. Source: Liseberg. The red circles that mark the smoke have been added by SHK.

Approximately two minutes later, flames emerged from two places on Rattler (see Figure 5).

Figure 5. Flames emerged from two places on Rattler at approximately 10:05 hrs. People in the picture have been anonymised by SHK. Photo: Tingstad Måleri AB.

The fire alarm system gave the first indication of a fire at 10:05 hrs. The indication came from sensors in the tower on levels 4 and 5. Since the fire alarm was in test mode, no evacuation alarm sounded.

Black smoke is seen entering the pool building in a picture taken at 10:06 hrs (see Figure 6). The first emergency call was received by SOS Alarm at this time.

Figure 6. At 10:06 hrs the tower was filled with smoke and smoke began spreading to the pool building. Photo: EnviroProcess Sweden AB.

The fire spread rapidly in Rattler. The picture in Figure 7 was taken at 10:11 hrs, six minutes after the first flames emerged from the waterslide. The fire and rescue service was en route at this time.

Figure 7. Picture taken at 10:11 hrs, six minutes after the first flames emerged from Rattler. Photo: Sweco AB.

1.3 Emergency response

Several calls about the fire were received by SOS Alarm from 10:06 hrs. The fire and rescue service's control centre, which was listening in to the calls, called out several rescue units. SOS Alarm called out several ambulances and informed the police. The fire and rescue service also established staffs in order to manage the extensive operation.

When the first rescue unit was en route to the construction site they saw a thick column of smoke, and received information that there was a fire in a waterslide. It arrived at 10:13 hrs and was met by staff from the construction site. The incident commander was informed that one person, who had gone up to level five in the tower just before the fire, was missing. This information was based on a colleague having had telephone contact with the person about the fire, but that the telephone call had been interrupted/disconnected shortly thereafter.

The incident commander decided to initiate a life-saving operation with smoke divers through a stairwell in the tower and to start external firefighting.

A group of firefighters consisting of one supervisor and two firefighters, guided by two people from the construction site, entered the stairwell in order to assess whether this was a possible route to enter the tower. Because the stairwell was free of smoke, the firefighters made the assessment that it was possible for the individuals from the construction site to enter the stairwell without breathing apparatus with the mask on. Furthermore, the firefighters made the assessment that firehoses connected to a water supply were not required.

The firefighters went up and opened a door on level three and noticed motionless black smoke. The firefighters put on the masks of their breathing apparatus and searched the area closest to the inside of the door without finding anyone. They then went back down half a flight of stairs where the others had stopped in order to discuss the situation with the supervisor. The door to level three had not been closed and thick black smoke was forced out into the stairwell shortly thereafter. Everyone went quickly down the stairwell and out of the tower without being injured.

In parallel with the life-saving operation, the firefighting was taking place outside (see Figure 8).

Figure 8. Firefighting taking place. Photo from 10:16 hrs. Photo: EnviroProcess Sweden AB.

Following proposals from operations technicians on site, a decision was made to start the pumps for the flow of water in the waterslides. The water was released at 10:17 hrs. Around 3 minutes later, 10:20 hrs, a fire gas explosion explosion occurred high up in the tower (see Figure 9).

Figure 9. The fire gasexplosion at 10:20 hrs. Source: Liseberg.

Windows were shattered and sections of the building were forced out and fell to the ground. The gables of the pool building were forced outwards. All fire and rescue service personnel got out of the buildings and continued external firefighting.

The fire and the smoke increased in strength after the fire gas explosion. The fire spread rapidly to the other waterslides and into the pool building. A decision was made that no operations were to take place in the tower and that firefighting would be done from safe places. It was decided that the objective of the operation was to delay the fire, limit its spread towards the hotel and then to attempt to extinguish it.

Consequently, it was not possible for the life-saving operation in the tower to continue, but the search for the missing person continued where this was possible. Staff from NCC assisted by providing information about the construction of the buildings in order to assess which places were safe. Aside from external firefighting, it was possible to conduct firefighting in towards the pool building from inside the adjoining building.

The heavy smoke development meant that thick smoke was spread by the wind over a large area (see Figure 10). The fire and rescue service therefore decided to issue a VMA[1] to stay indoors and close the ventilation. The VMA was active from 10:50 to 19:55 hrs. The smoke had an impact on, e.g. Sahlgrenska Hospital, which had to close its fresh-air intake.

[1] VMA – Important public announcement.

Figure 10. The smoke had an impact on, among other things, Sahlgrenska Hospital. Photo: EnviroProcess Sweden AB.

While the firefighting efforts were ongoing, the emergency services removed gas cylinders and protected a chemical storage from the fire and from being filled with extinguishing water. Other adjacent buildings were also evacuated and monitored for potential fire spread. Prepa-rations were made to demolish a connecting walkway between the water world and the hotel to prevent fire spread. This did not need to be carried out.

Later in the day, the assessment was made that the fire and rescue service would be able to temporarily enter the pool building and level two of the tower. The search for the missing person continued there, but without success. Nor was the person found when searching using drones in parts of the building where it was not possible for firefighters to enter.

In the evening it was possible to reduce the extent of the emergency response but it continued for a further four days. Certain parts of the building partially collapsed over the following days, making several fire hotspots difficult to access for firefighting efforts. A mobile crane was used in parts of the pool building in order to enable access to the fires for fire-fighting. Substantial quantities of water were required during the entire operation. So as not to contaminate the adjacent river Mölndalsån, some of the firewater was collected in pools and the water was pumped from there.

On Friday 16 February, four days after the fire started, the assessment was made that the tower could be entered in order to search for the missing person. The person was found deceased on level five at 12:00 hrs. The emergency response was then terminated at 19:00 hrs.

1.4 Personal injuries

One person was fatally injured in conjunction with the fire. The results from the post-mortem examination strongly suggest that the person died as a result of carbon monoxide poisoning in conjunction with the spread of the fire.

A number of people suffered minor smoke-related injuries.

1.5 Material damage

The facility sustained extensive damage from the fire. All external waterslides were destroyed. The tower and sections of wall and roof of the pool building sustained extensive damage.

The Environment Department of the City of Gothenburg has measured the emissions of environmentally hazardous substances in the air and water and made the assessment that the smoke from the fire has largely only affected the immediate surroundings. In the longer term, the contributions from the fire are not deemed to have affected the air quality to any decisive extent. The fact that it was raining during the initial days contributed to keeping down the quantity of soot and particles in the air.

With regard to the water, it was assessed early in the firefighting operation that all foam that was used had remained inside the building and that the contaminated firewater had been dealt with. The drinking water is not judged to have been affected by the occurrence.

Investigation of ongoing work tasks. The initial observations that can be linked to the fire were made in connection to the waterslide Rattler. A number of investigations have been conducted in order to establish the site where the fire started and the cause of the fire. In addition, the works taking place in connection to Rattler have been analysed in more detail.

1.6 Ongoing works in the area where the fire was detected

The heat-generating work that was conducted closest to Rattler was welding of diversion pipes made of plastic polyethylene (PE). This work was being done using a method called electrofusion[2].

Other works taking place in the vicinity of Rattler were tarmacking and minor lamination works. Tarmacking and lamination were being done at such a distance from Rattler that these works are not deemed to have had any relevance to the fire. No works during which sparks are formed have been identified in the area where the fire was detected.

Nor have any technical installations, for example lighting or heating plant, been identified that may have started a fire.

In light of this, SHK has investigated the works involving the diversion pipes in more detail.

1.6.1 The work with the diversion pipes

The works with the diversion pipes were being conducted by WhiteWater on behalf of Liseberg. The work encompassed fitting of diversion pipes under the waterslides on the outside of the tower and had begun at the beginning of November 2023. The fitting would involve, among other things, a number of PE pipes being joined together.

The PE pipes were prepared by another contractor that cut and buttwelded[3] the pipes on the ground on the basis of measurements from WhiteWater. The PE pipes were then lifted up and fastened under the waterslides using straps. When the pipes were in place, they were

[2] The method is described in more detail in section 1.7.

[3] Butt welding is a procedure where the end surfaces of the pipe are joined through the surfaces being melted and then pressed together under pressure.

joined together using electrofusion by WhiteWater's fitters. Up until the day before the fire, WhiteWater had completed approximately 30 electrofusions.

The diversion pipe under Rattler started at two drainage boxes that were located under Rattler, just before the waterslide's final bend. After the bend the diversion pipe was reconnected to Rattler and the waterslide then continued into the pool building (see Figure 11).

Figure 11. The yellow boxes added by SHK show, on the left, a PE pipe connected to the drainage boxes and, on the right, a PE pipe that connects back to Rattler. A suspended pipe in the strap that has been prepared for being fused together with other pipes is visible between the markings. Photo: NCC.

The works under Rattler were delayed and were to have been completed prior to the day of the accident. The works continued over the weekend prior to the accident but it was noticed that there was a missing electrofusion coupler that was needed in order to complete the work. Consequently, final fitting would be completed on Monday 12 February, once the electrofusion coupler had been delivered. Because this was the only fitting left to be competed, the contractor that was working with the diversion pipes on the ground had wound up their activities on site and had also removed left-over pipe material.

The final installation

The final installation consisted of a pipe being welded at both ends to pipes that had already been fitted. The two fitters that performed the work have, in evidence SHK has studied, stated that the pipe was prepared the week before through the pipe being cut to the correct dimensions.

Preparations ahead of the final installation can be observed in the picture above, taken at 08:00 hrs on the day of the accident. One electrofusion coupler was already prepared on the pipe and the final electrofusion coupler was delivered that morning. The first electrofusion began after 09:00 hrs at the pipe joint closest to the outflow from the drainage boxes under Rattler. Once the first electrofusion was complete, the second began shortly thereafter.

According to the fitters who performed the work, they scanned the codes for the electrofusion couplers and used the scanned values for the electrofusions. They have previously stated that an electrofusion took around 20 minutes[4] and that both of the electrofusions were completed just before 10:00 hrs.

Observations of the final installation

The two joints that were to be electrofused in conjunction with the final installation have been marked (see the markings in Figure 12). It is evident from the picture that there was a gap between the ends of the pipes that were to be joined together. See marking no. 1 in Figure 12.

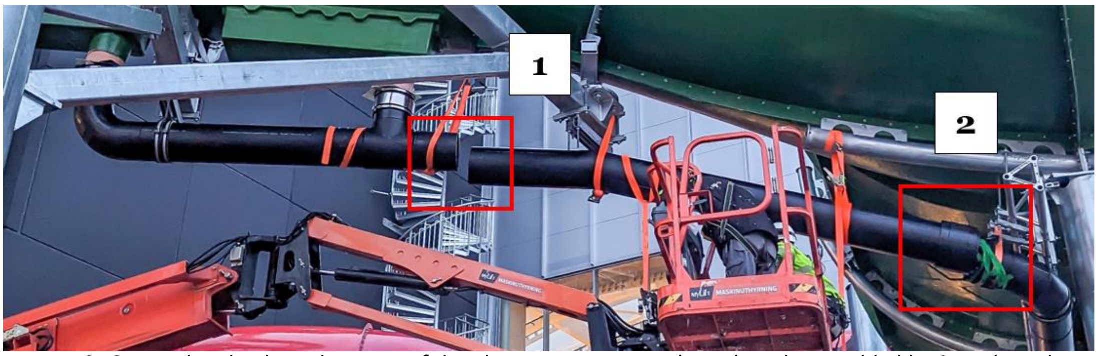

Figure 12. Cropped and enlarged version of the photo in Figure 11. The red markings added by SHK show the locations of the electrofusion joints. The figures show the order in which the electrofusions were performed. Photo: NCC.

Following measurement of the picture and with the information that the diameter of the pipe is 315 mm as a reference, SHK has estimated that the distance between the ends of the pipes is 10 cm. The length of the pipe that is hanging in the straps in the picture is approximately 4.5 metres. The pipe with an electrofusion coupler weighs approximately 85 kg[5].

The two fitters who performed the work have, in an interview with an insurance company that SHK has studied, stated that the pipes had the correct measurements at the time of electrofusion and that by and large there was no gap between the ends of the pipes.

1.7 General information about electrofusion and fire risks

Electrofusion is a welding method that has been in use since the 1990s for PE pipes. Electrofusion is performed by two PE pipes being inserted into an electrofusion coupler made of the same material and jointed together through the pipes and the electrofusion coupler being melted together. The plastic material is melted through a coiled metal wire in the electrofusion coupler being heated electrically by an electrofusion machine.

The electrofusion machine controls the voltage and the fusion time for the electrofusion. Factors that affect these are what type of electrofusion coupler is being used and the ambient temperature. The values for voltage and fusion time are set automatically by scanning a barcode on the electrofusion coupler or manually. When the barcode is read the ambient temperature is registered by a sensor in the electrofusion control unit. A low ambient temperature means a longer fusion time and a higher temperature.

[4] The fitters have provided two estimated times, c. 17 and c. 20 minutes, respectively.

[5] The pipe with two electrofusion couplers fitted weighs 92 kg.

The electrofusion machine that was used for the work was of the type Ritmo Elektra 500. The electrofusion machine was CE marked and was encompassed by the requirements in the Machinery Directive[6]. The machine had a memory function where it was possible to connect a USB stick in order to store data about fusions that had been performed. The electrofusion machine was found after the accident, completely destroyed in the boom lift. Consequently, it has not been possible to obtain any data from the memory function of the electrofusion machine.

There are certified training programmes in electrofusion that adhere to a standard[7]. The instruction manuals for various types of pipe and electrofusion machines contain directions for how these are to be assembled and used and they also cover the risks associated with incorrect assembly. The training materials[8] that SHK has studied also cover quality risks and fire risks. However, there is no requirement for a fitter to have completed such a training programme in order to be permitted to work with electrofusion[9].

According to the guidelines for plastic welding[10], the distance between the ends of the pipes must not be more than 5% of the external diameter of the pipes when the pipes are inserted into the electrofusion coupler prior to electrofusion. This means that the maximum distance from the middle of the electrofusion coupler to the end of each pipe during electrofusion of a 315 mm pipe must be no more than 16 mm.

The guidelines state that, in order to ensure that the distance between the ends of the pipes is correct and that the pipes are placed in the middle of the electrofusion coupler, the insertion depth should be measured and marked on the pipes. Examples of how marking is to be done are shown in Figure 13.

[6] Directive 2006/42/EC of the European Parliament and of the Council of 17 May 2006 on machinery, and amending Directive 95/16/EC (recast). The directive sets out the fundamental health and safety requirements that apply to all machinery that is released onto the market within the EU.

[7] The Swedish Welding Commission is responsible for Swedish implementation of the European system for training and certification of plastic welders, European Plastic Welder (EPW). Trainers that have been approved by the Swedish Welding Commission provide training in accordance with guidelines produced by the European Welding Federation (EWF). Examination takes place in accordance with the EN 13067 standard.

[8] The training materials refer, among other things, to German guidelines for plastic welding DVS 2202 and DVS 2207-1. DVS Deutscher Verband für Schweissen und Verwandte Verfahren. DVS provides indicative guidelines for plastic welding.

[9] For certain applications such as welding of gas pipes and for applications within water and sewerage there are specific requirements in the reference material AMA (General Description of Materials and Work) Construction.

[10] Guidelines for plastic welding DVS 2202 and DVS 2207-1.

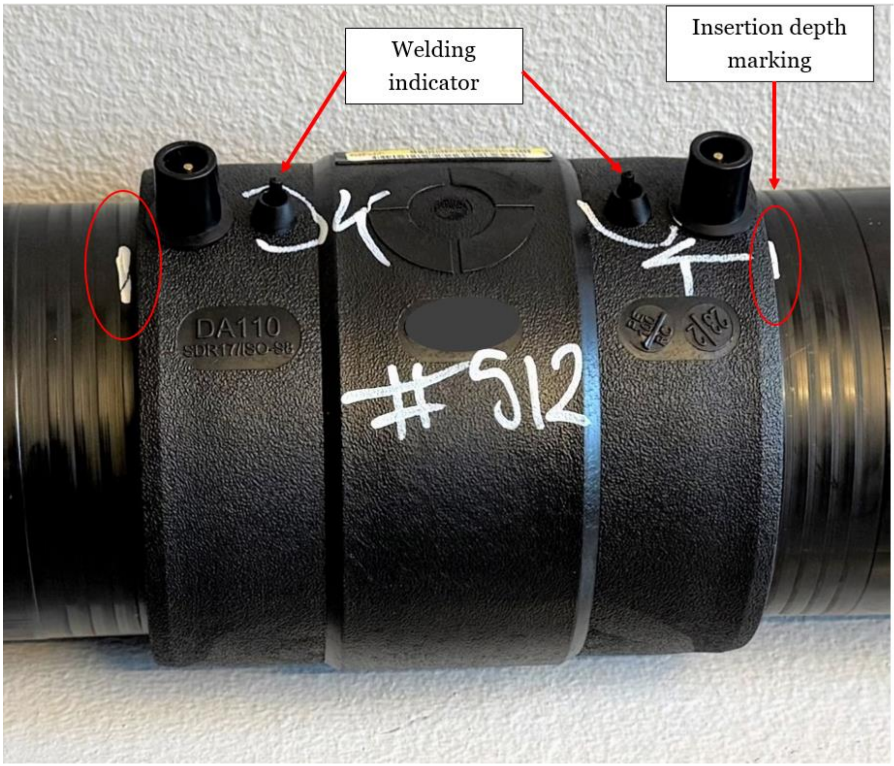

Figure 13. Example showing markings of insertion depth. The weld indicators that indicate that the material has melted in the weld joint is also shown in the picture.

During electrofusion the whole electrofusion coupler is not heated, rather there are fusion zones and cool zones[11]. In the fusion zone the temperature rises to between 230°C and 250°C, which makes the plastic material in the coupler and the pipe melt together (see Figure 14).

[11] The cool zone is an area on both sides of the fusion zone. When a small quantity of the material that melts and expands is forced out into the cool zone it hardens and encloses the fusion area. Fusion pressure builds up in the fusion zone and contributes to the fusion result.

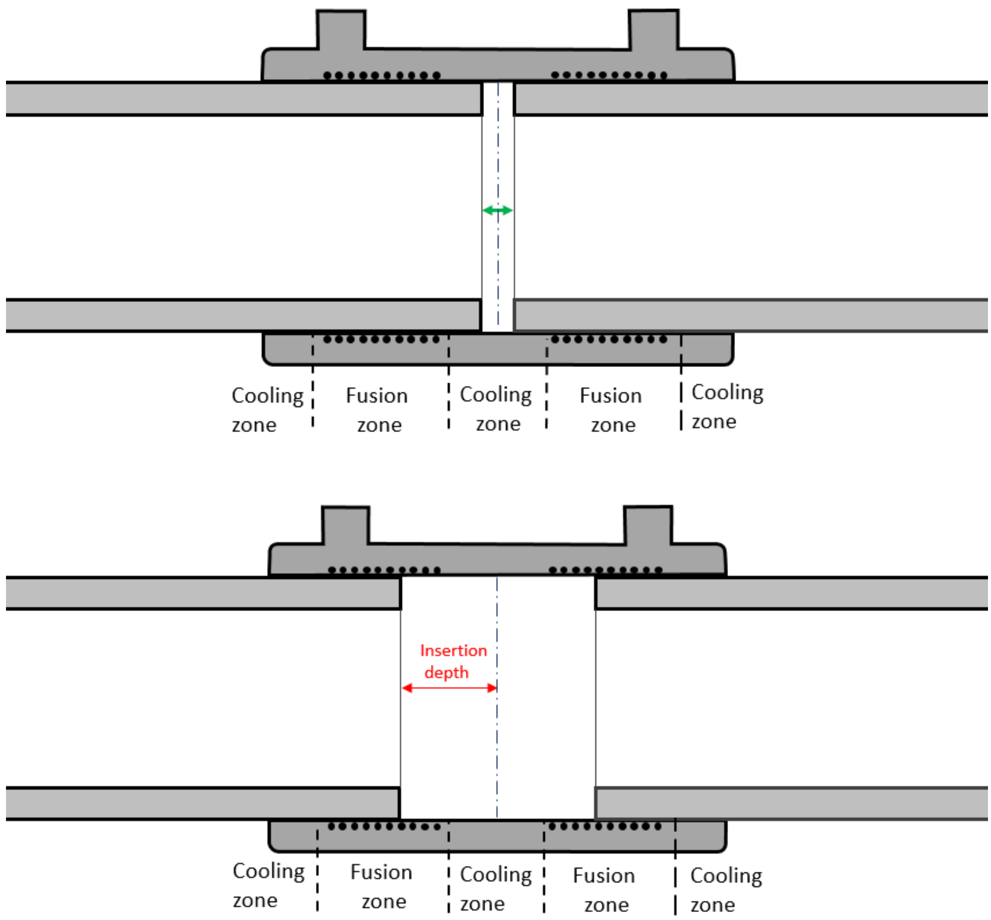

Figure 14. The sketch above shows a correctly fitted electrofusion coupler where the ends of the two pipes that are to be joined are in the inner cool zone. The green arrow shows the maximum permitted distance between the ends of the pipes. The red arrow in the lower sketch shows an incorrect insertion depth. The ends of the pipes lie in the fusion zones and metal wires are exposed without meeting pipe material. Source: GPA Flowsystem AB. Markings made by SHK.

Fixtures can be used to ensure that the pipes are fitted correctly and that the fitting remains straight over the period in which the fusion is taking place. There are also special scrapers to use to prepare the surface of the pipe before fusion[12]. These tools will increase the conditions of the fusion being of a good quality.

According to the instruction manual for the type of pipe that was being used, a fire can break out if the pipes are not fitted into the electrofusion coupler correctly. If the pipes do not cover the fusion zone in the electrofusion coupler where the metal wires heat up the plastic, the material may overheat. This can happen if the pipes are not cut straight or if the distance between the ends of the pipes inside the coupler is too large.

Airflow through the pipes should be avoided during fusion because supplying oxygen increases the risk of fire. If air cannot flow freely inside the pipe, a potential fire in the pipe can extinguish itself due to lack of oxygen.

[12] It is stipulated that at least 0.2 mm shall be scraped off before fusion.

1.8 Technical fire investigations

This section describes the technical fire investigations that have been conducted with the aim of understanding how a fire can start in conjunction with electrofusion.

1.8.1 Fire tests

With the support of Research Institutes of Sweden AB (RISE), SHK has performed a number of tests in order investigate in more detail how a fire can start during electrofusion.

The tests were performed using the same type of electrofusion machine, pipe and electrofusion coupler used in the work with the diversion pipes under Rattler. The dimension of the pipes was 315 mm[13] and they weighed 17.6 kg per metre. The electrofusion coupler[14] was from AGRU and had a weight of 6.36 kg (see Figure 15).

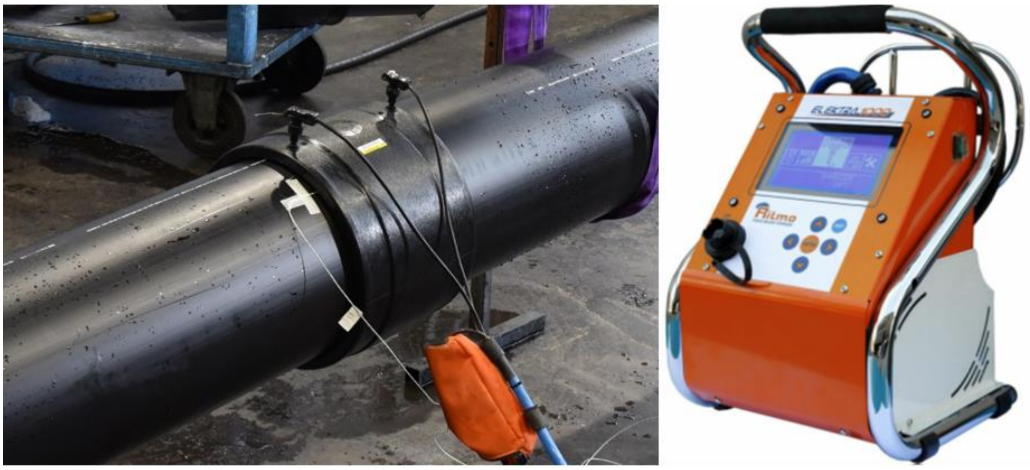

Figure 15. The picture on the left was taken in conjunction with SHK's fire tests and shows a fitted electrofusion coupler with connected power cables. The picture on the right shows an electrofusion machine of the type Ritmo Elektra 500. Source: GPA Flowsystem AB.

Each test was performed with two pipes and an electrofusion coupler[15] that were hung up at an inclination of approximately three degrees from the horizontal plane. This was equivalent to the inclination of the pipes under Rattler during the final installation (see Figure 16).

[13] Pipe with a diameter of 315 mm, PE100-RC17-0315 SDR17.

[14] Pipe fitting PE100-RC-electrofusion coupler d315mm SDR33-17.

[15] New pipes and electrofusion couplers were assembled for each test.

Figure 16. The picture shows the testing arrangement of pipes with the fitted electrofusion coupler. The temperature indicator that was used to register the temperature during the tests are marked in white with the designation TC1-TC4. Source: RISE.

A total of seven tests were performed, one of which was performed in two parts. The outcome of the tests is reported in Table 1.

Tests one to four were performed with a material temperature of 20°C. Tests five to seven were performed with a material temperature of -1°C, which corresponded to the temperature on the day of the accident.

The first test was performed in accordance with the instructions from the pipe manufacturer and the values for voltage and fusion time were set automatically by reading the barcode on the electrofusion coupler. Six tests were then performed where the distance between the pipes in the joint, known as the insertion depth, was greater than the stipulated maximum distance of 16 mm from the centre of the electrofusion coupler. If the insertion depth is too large, the metal wires become exposed and end up outside of the fusion zone. Test two was performed in two parts using scanned values.

To investigate whether a fire can break out and if so when, the fusion time was increased in the remaining tests. The barcode on the electrofusion coupler was scanned in order to get the correct values for each test. The fusion time was then increased manually.

Table 1. The outcome of the fire tests.

Test	Distance between pipes in the joint	Number of exposed metal wires	Scanned time	Outcome	Additional information
1	4 mm	0	15 min. 40 sec.	Neither smoke development nor fire	The fitting was done up to the heel[16] inside the electrofusion coupler
2a	The fitting was done with asymmetrical errors where there was a distance of 40 and 60 mm on either side of the centre of the electrofusion coupler.	2 and 6, respectively	16 min. 30 sec.	Smoke development after 16 min.	The test was performed in two parts, 2a and 2b
2b	40 and 60 mm	2 and 6, respectively	New scan 16 min. 30 sec.	Fire after 6.5 min. 30 sec.	After test 2a the test continued after 6 min. cooling. The barcode was read again ahead of test 2b.
3	60 and 60 mm	6 and 6, respectively	16 min. 30 sec.	Fire after 24 min.	
4	40 and 40 mm	2 and 2, respectively	16 min. 30 sec.	Fire after 18 min. 30 sec.	
5	40 and 40 mm	2 and 2, respectively	18 min. 27 sec.	Smoke development	Circuit breaker was actuated in the electrofusion machine
6	40 and 40 mm	2 and 2, respectively	18 min. 27 sec.	Fire after 18 min. and 18 sec.	Fire development is visible in Figure 17
7	30 and 30 mm	1 and 1, respectively	18 min. 27 sec.	Neither smoke development nor fire	

Fire broke out in the pipes in four of the seven tests performed. The fire development varied in terms of time between the different tests. No visible signs of fire could be established on the outside of the electrofusion couplers or pipes during the tests.

In one of the tests, fire broke out within the specified scanned fusion time (test 6). The fire smouldered for more than 14 minutes and melted burning plastic dripped down from the upper edge of the pipe and formed a small pool fire on the bottom of the pipe. A powerful increase in the fire then took place and flames emerged from the upper end of the pipe (see Figure 17).

[16] Inside the electrofusion coupler there is a heel that marks the middle of the electrofusion coupler. The heel can be removed if needed in order to shift the electrofusion coupler sideways. The width of the heel for a 315 mm pipe is approximately 4 mm.

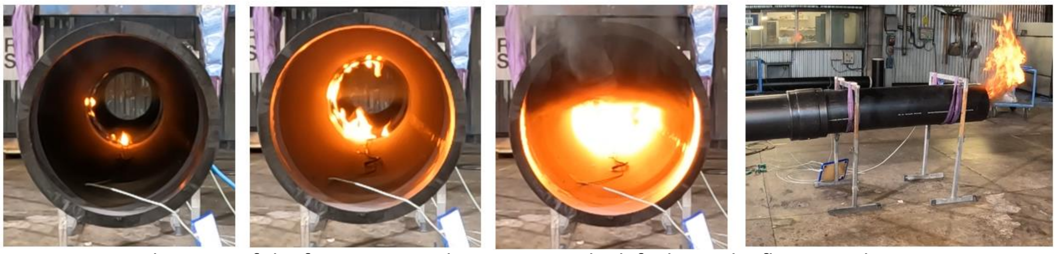

Figure 17. Development of the fire in test 6. The picture on the left shows the flames in the joint 7 minutes after the pipe caught fire. There is then a picture that shows the fire 11 minutes after the fire started when a pool fire has emerged. In the third picture, the fire gases are seen in the upper edge of the pipe when the fire increased rapidly in extent. The fourth picture was taken 14 minutes and 20 seconds after ignition when the flames emerge from the upper end of the pipe.

In the pipes, where fire has broken out, there were clear signs that cratering of the plastic had taken place in the area where the metal wires were exposed. It was also possible to establish that the metal wires that were exposed had been displaced from their original location and ended up closer to each other (see Figure 18).

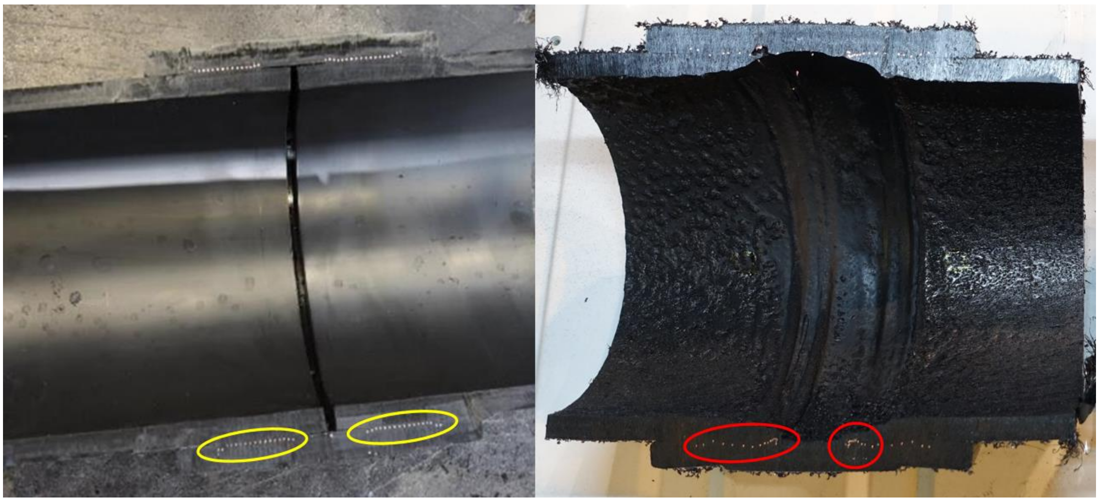

Figure 18. Sawn apart electrofusion couplers following completed tests. On the left after test 1 where no fire broke out and on the right after test 6 where fire broke out. The picture on the left shows how the metal wires are evenly distributed. This is marked by the yellow circles. The picture on the right shows how the metal wires have been concentrated closer to the middle of the electrofusion coupler. This is marked by the red circles.

1.8.2 Examination of other electrofusion couplers from the accident site

The remains of burnt electrofusion couplers that were located under Rattler had extensive damage. Consequently, SHK has not conducted any further assessment of these.

In order to gain an impression of how other electrofusions have been performed on the construction site, five sections of pipe with fused on electrofusion couplers that were damaged in the fire have been examined. The pipes had the same diameter as the diversion pipes under Rattler and had been located outdoors in connection to the waterslides. It was possible to note the following as a result of the examinations.

Three sections of pipe had a correct or almost correct distance between the ends of the pipes inside the electrofusion couplers. No signs of fire or melt damage were visible in these electrofusion couplers.

In two of the sections of pipe there was a gap between the ends of the pipes in the joint inside the electrofusion coupler. In one of the sections of pipe the gap was approximately 45 mm and melted plastic had emerged in the joint but there were no visible signs of fire having broken out. The gap between the ends of the pipes was not evenly distributed across the middle of the electrofusion coupler. One pipe was up against the heel in the middle of the electrofusion coupler which meant that the end of the other pipe was closer to the fusion zone on that side (see Figure 19).

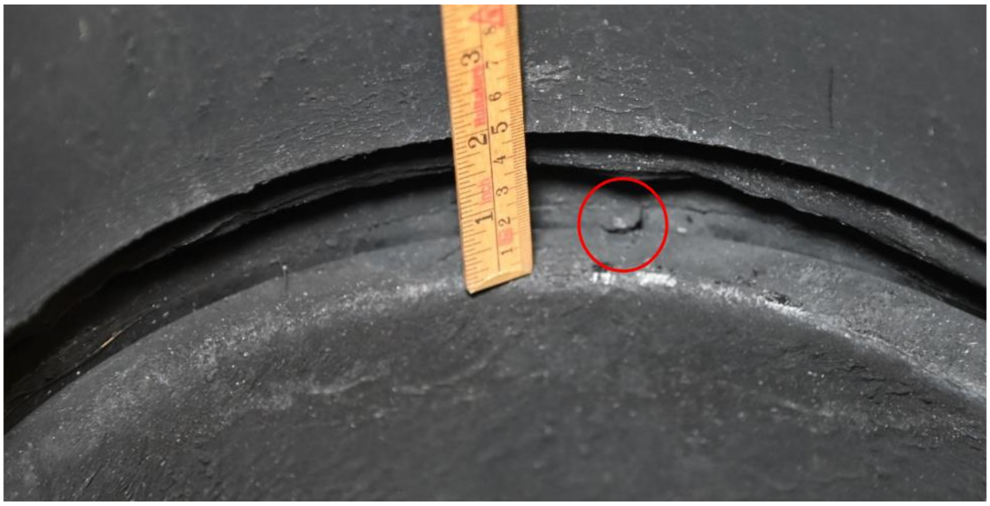

Figure 19. The joint on the inside of the electrofusion coupler with a gap of c. 45 mm between the pipes. The red marking indicates the heel. Melted plastic that is being forced out is visible at the upper edge of the joint.

In the second pipe section, the distance between the pipes was closer to 50 mm at the joint in the electrofusion coupler. Here, there were deformations after the plastic in the pipe ends and the electrofusion coupler had melted, and there were signs that it had burned at the joint. There were also droplet formations that can be interpreted as plastic having dripped from that side inside the joint. This indicates that that part of the pipe was positioned upwards and that the electrofusion coupler was placed horizontally. There were also charring on the opposite side of the droplet formations, indicating that the plastic had burned there in a small pool fire that subsequently self-extinguished (see Figure 20).

Figure 20. The picture on the left shows the upper side of the joint in the section of pipe where there were drop formations. The red marking shows the drop shape after melted plastic has run down. The picture on the right shows the opposite side from the drop formations in the joint. The carbonised remains where the plastic has probably burned is visible in the red marking.

The sections of pipe did not have markings on the pipes for the insertion depth in the electrofusion coupler. It is not been possible to establish whether no marking has been done when performing fusion or if the markings have disappeared in conjunction with the fire-fighting.

1.8.3 Modelling of the initial fire development

At an early stage of the course of the fire, flames could be observed from two different places in connection to Rattler. Flames were seen in the place where the diversion pipes connected to the waterslide and also on the upper side of the waterslide. The distance between these locations is approximately nine metres (see Figure 21).

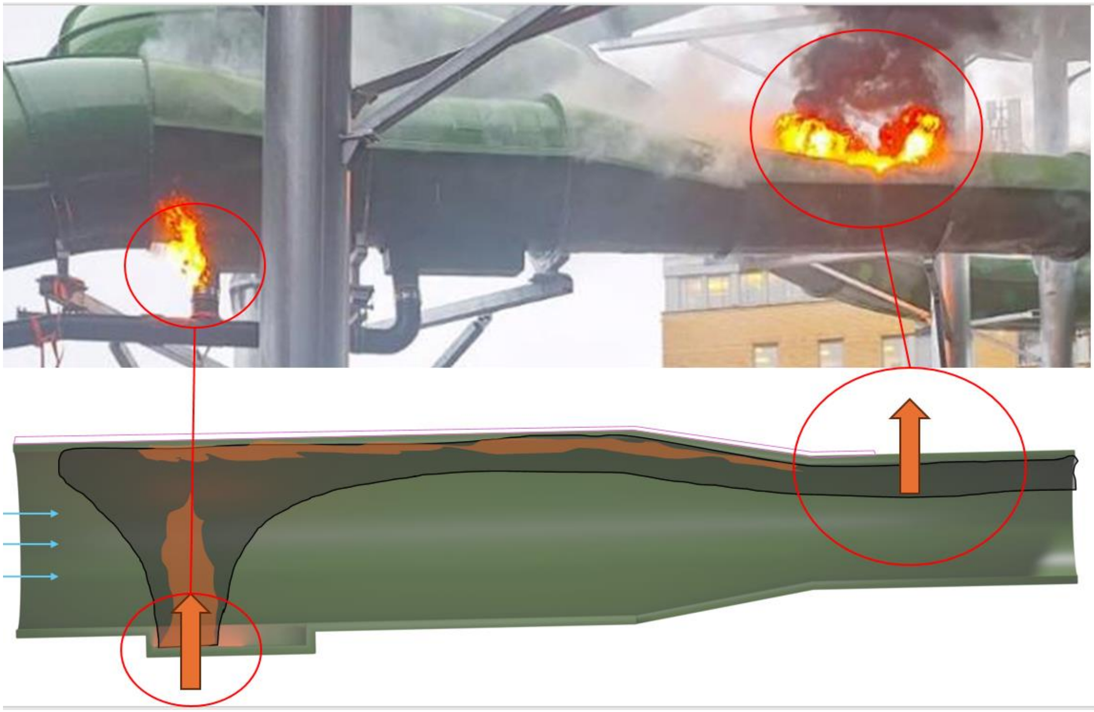

Figure 21. The upper picture shows where the first flames emerged from Rattler. The sketch below shows a cross-section of Rattler. The orange arrows on the sketch show where the flames emerged. The blue arrows show the airflow. The dark-green field shows the spread of the fire. Source: Tingstad Måleri AB and RISE.

RISE has modelled the initial course of the fire on behalf of SHK. The modelling shows that the inclination, design and varied thickness of the waterslide, combined with the cooling effect of the weather can result in an initial fire development with flames in two different places.

1.9 Management of safety and risks on the construction site

1.9.1 The developer

As developer, Liseberg had an overarching responsibility for the work environment both in the construction phase and in the use phase (Ch. 3, Section 6 of the Work Environment Act). This responsibility included appointing appropriate construction work environment coordinators for planning and design (BAS-P) and for the execution of the work (BAS-U). The construction work environment coordinators were to coordinate the parties involved in the construction project throughout the entire construction process, from the start of the project's planning and design to the completion of construction (Ch. 3, Section 6, first paragraph of the Work Environment Act).

During each phase of the planning and design, Liseberg was also to ensure that the time allocated to the sub-stages was ample enough that work could be executed at such a pace that the risk of ill health and accidents was avoided (Section 5a, AFS 1999:3)[17].

Liseberg had engaged NCC as general contractor. There was a partnership agreement between them that was consistent in some respects with ABT 06[18]. The agreement appointed NCC as construction work environment coordinator for design/planning (BAS-P) and for execution (BAS-U). The aim of coordination during the design and construction phase was for the parties involved to take into consideration each other's work so that work environment risks did not arise.

Procurement of and setting requirements in other contracts

In order to allow for Liseberg to control the work with the water attractions in more detail, Liseberg procured these as other contracts to NCC's turnkey contract. An other contractor, performs work alongside the other contractors within the same project. One of these contracts encompassed the manufacture and delivery of waterslides and was awarded to WhiteWater. In the original procurement, WhiteWater, in addition to manufacture and delivery, was also to supply technical expertise on site and Liseberg was to provide the labour. In the specification of requirements set by Liseberg in the procurement, WhiteWater was to have the necessary technical ability and capacity to enable it to execute the assignment. The assignment for WhiteWater was expanded to also encompass installation of the water attractions. Liseberg's organisation included resources that were allocated in order to manage other contracts, including project managers and construction managers.

During installation of the waterslides a discussion arose concerning forthcoming work on the diversion pipes. Liseberg and WhiteWater investigated the feasibility of using the company that had performed similar pipework inside the pool building on behalf of NCC and was familiar with fitting plastic parts. The company offered to supply materials and to help on the ground but made the assessment that they were unable to take on the work of fitting the pipes in a safe manner because of factors including its complexity and working at height. Another company that had experience with fitting plastic parts was asked and gave the same response. The solution was that this company assisted WhiteWater by supplying and preparing the pipes on the ground. The company also lent WhiteWater an electrofusion machine and a scraper for preparing the pipes. WhiteWater then performed the fitting under the waterslides from a boom lift.

Follow-up of contractors

Liseberg had an organisation that followed up the work of the general contractor and the other contractors. This follow-up took place through staff from Liseberg participating in various meetings, e.g. construction meetings, morning debriefings and various forums. Liseberg had also allocated a construction manager to be the person who handled coordination between the developer and the general contractor and the other contractor WhiteWater.

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[17] This regulation applied at the time of the accident and was replaced on 1 January 2025 with AFS 2023:3.

[18] *ABT 06 General provisions concerning general contracts with respect to construction, civil engineering and installation works* is intended for use in procurement processes and agreements in respect of contracts that are to be executed as turnkey contracts.

1.9.2 The general contractor

NCC was the general contractor and had entered into a contract with Liseberg. NCC provided administrators for the accomplishment of the duties incumbent on NCC as BAS-P and BAS-U. NCC had responsibility for coordination of the work involved in preventing risks relating to health and workplace accidents. The people who NCC had appointed as administrators had undergone training and had the experience that was demanded by Liseberg.

The agreement between Liseberg and NCC stipulated that all contractors were required to follow NCC's rules at the construction site and the instructions of the construction work environment coordinator. Documentation from NCC directed at subcontractors and other contractors indicates that subcontractors and other contractors were, among other things, responsible for providing the BAS-U with risk assessments and work preparations prior to commencing tasks. Liseberg had informed WhiteWater about NCC's Rules on Order and Safety.

Among other things, NCC had produced a work environment plan (cf. Section 8 of AFS 1999:3). The work environment plan had been revised a number of times, most recently on 21 September 2023. The work environment plan included descriptions of the organisation and the rules that were applied on the construction site. Alongside the work environment plan, NCC had produced a list of work environment risks and mitigation measures (cf. Section 12a of AFS 1999:3).

Follow-up of the work environment

The action taken to follow up the work environment included regular safety inspections and ongoing meetings with all contractors in order to regularly follow up work tasks. The safety inspections were conducted every Wednesday at 14:30 hrs. The safety organisation, various contractors and sometimes a representative of the developer participated in the safety inspections, which were led by BAS-U, or their appointee. The safety inspections involved checking a number of predetermined points, including fire protection, work at height, organisational and social work environment and contractors' risk assessments and work preparations. Deviations were documented in a 'project portal'.

No deviations concerning electrofusion or deficiencies in risk assessments/work preparations are evident from the completed safety inspections. However, details have emerged that the safety inspections have not always included other contractors.

In addition to safety inspections, management of deviations on the construction site has been handled by NCC through the deviation management system Synergi. Follow-up of incidents and remedial measures were documented in the system. SHK has not found any deviations of relevance to the fire in the system.

Companies were fined in the event of repeated violations of the work and safety regulations. Deviations that led to fines were not documented in Synergi because these were deemed rectified.

A number of deviations have come to light that pertained primarily to WhiteWater's compliance with work environment rules during work at height. However, it is reported that deviations continued to occur.

Introduction and training

Before a contractor begins its work for the first time, an introduction was to be conducted by NCC. The introduction encompassed a verbal safety briefing, the Swedish Construction Federation's safety training course 'Safe Construction Training'[19] and a workplace introduction that contained, as a minimum, the work and safety regulations. After the introduction was complete the contractor was to answer control questions that were then acknowledged on a form. Other authorisations/training courses were also to be specified on the form.

After the introduction and training had been completed and confirmed, the authorisation was registered on an authorisation card (ID06 card) and the contractor was given access to the construction site. According to NCC's work and safety regulations, it was mandatory foreverybody on the construction site to, at all times, be able to present a valid ID card and to visibly carry their ID06 card. It was also intended that recorded attendance was to be used when taking rollcall after any evacuation. Before the start of each workday each contractor was to begin recording its attendance by registering its ID06 card at a construction booth and then using the card for passage into the construction site.

Fire protection work on the construction site

According to the contract with Liseberg, NCC was responsible for the fire protection work on the construction site (Section 19 of AFS 1999:3[20]). NCC had chosen, among other things, to adhere to the Swedish Fire Protection Association's safety rules for hot work[21] on the construction site. This was mentioned in, among other things, the work and safety regulations, in which NCC described the procedures for assessing fire risks and conducting risk assessments ahead of work tasks. The work and safety regulations also described how those works that were deemed to be hot work were to be reported to NCC's authorisation supervisor. NCC's subcontractor performed electrofusion inside the pool building. Ahead of this work, the subcontractor assessed that the electrofusion procedure did not constitute hot work, and that therefore, no authorisation from NCC was required.

There was no functioning evacuation alarm or fire alarm on the day of the accident. For the construction phase, NCC had installed a temporary evacuation alarm. The temporary evacuation alarm was removed the week before the accident because the construction of the waterworld was nearing completion. No work that was deemed to be 'hot work' was to be performed before the regular fire and evacuation alarm was operational. SHK has not seen any risk assessment concerning this change.

NCC had a procedure for evacuation in the event of fire (cf. Sections 27–30 of AFS 1999:3). This document described who the evacuation coordinator was and the responsibility and procedure for evacuation. The procedure also encompassed evacuation plans.

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[19] The Swedish Construction Federation is a trade and employers' association that brings together approximately 4,000 construction, civil engineering and specialised companies. The training course Safe Construction Training is obligatory for the members of the Swedish Construction Federation.

[20] When planning construction and civil engineering work all factors that are of significance to the work environment shall be taken into account. The risks of ill health and accidents at work shall be assessed as early as possible. The risk of fire breaking out and spreading shall be noted in particular.

[21] The Swedish Fire Protection Association, in cooperation with representatives from various industries, fire associations and insurance companies, has produced the damage prevention concept 'Hot Work'. Hot work is defined in this concept as work involving tools and equipment that give off heat or sparks. The concept describes the importance of risk assessment before starting work.

The document also described the procedure for head counting, involving counting all persons on the site and comparing this with lists of logged-in staff (ID06 registration). An evacuation exercise had been conducted in May 2023.

Following the evacuation during the fire, NCC conducted a double-check of the number of people on the work site. A total of 144 people could be counted in. Of these, 110 were logged in in accordance with the procedures in the work and safety regulations. Twenty people had only used their ID06 card at the gate in order to gain access to the construction site. Fourteen were neither logged in nor had used a card reader at a gate. It has emerged during this investigation that additional people were present on the construction site but not observed by NCC in conjunction with the double check.

1.9.3 WhiteWater

WhiteWater was directly awarded a contract by Liseberg and was thereby an other contractor to NCC. The supervisor was from Canada and the fitters who were to perform the work and were included in the workforce came primarily from Poland.

Under the Work Environment Act, WhiteWater was responsible as employer for its staff and for reporting posted workers to the posted workers registry[22]. In addition, it was under an obligation to comply with NCC's work and safety regulations on the construction site. These included obligations for subcontractors to conduct risk assessments and produce work preparations for the work that was to be performed.

In advance of assembling the waterslides WhiteWater produced a risk assessment. The risk assessment only covered the work tasks that were specified in the Swedish Work Environment Authority's regulations (Section 12a of AFS 1999:3). This risk assessment was coordinated with NCC. NCC has stated that assembly instructions from WhiteWater and discussion about the work were regarded as a work plan.

With regard to the work with the diversion pipes, no detailed documentation that describes the work, choice of materials[23] and implementation of the work was produced by WhiteWater. Nor were any detailed drawings produced. SHK has asked for, but not been given, any written risk assessment or work plan in respect of the work with the diversion pipes.

NCC has stated that continual coordination has taken place ahead of the work with the diversion pipes. NCC has also stated that they have received a verbal briefing on the fitting instructtions, which has been considered as constituting a work plan.

WhiteWater has stated that they did not know that electrofusion could entail a risk of fire. The other parties on the construction site had also not identified electrofusion as work that potentially entailed a fire risk.

According to the work and safety regulations, all workers were to undergo NCC's introduction and training in order to be granted access to the construction site. Ten out of WhiteWater's 20 members of staff had done this. Of the seven people who were working on the day of the accident, only two had undergone introduction and training. All people who were

[22] See section 1.10.3.

[23] WhiteWater normally used PVC pipes to divert water from waterslides. PE pipes were used in this case. PE pipes are joined together using plastic welding, while PVC pipes are glued together.

working on the construction site were also to be logged in and registered in ID06. Data from NCC's log-in system reveals that none of the staff from WhiteWater were logged in or registered in ID06 on the day of the accident or during the period in which the work with the diversion pipes was being performed.

The following can be noted with regard to WhiteWater's knowledge and experience of similar work. The supervisor for the fitters did not have previous experience of PE pipes or electrofusion because the company normally used PVC material for diversion pipes. The fitters did not have any training in electrofusion but one of them had told the supervisor that he had experience of this. In advance of the work with the diversion pipes the contractor that supplied the electrofusion machine to WhiteWater had provided instruction to the fitters about how it worked. They were also instructed to protect the electrofusion machine and the electrofusion couplers from water. It is reported that the fitters did not study any other safety instructions concerning PE pipes or electrofusion.

1.10 Rules and supervision of construction sites

1.10.1 Work Environment Act

The aim of the Work Environment Act is to prevent ill health and accidents at work (Ch. 1, Section 1). The Work Environment Act applies to all employers and employees. The Work Environment Act governs, among other things, the employer's responsibility for ensuring that all employees have the knowledge and expertise required to perform their duties in a safe and effective manner (Ch. 3, Section 3). The employer also has an obligation to create the prerequisites for safe work by providing appropriate protective equipment and by ensuring that the workplace is designed so as to minimise risks that are associated with the work. Furthermore, the employer has an obligation to organise the work in such a way that it does not lead to accidents, for example by avoiding time pressure and work overload.

In addition to the requirements in the Work Environment Act, the Swedish Work Environment Authority has issued regulations concerning systematic work environment management (AFS 2001:1)[24]. These regulations apply to all employers and entail an obligation to investigate, implement measures and follow up activities in order to prevent accidents and ill health (Sections 8–11). When changes to activities are planned, the employer must assess whether the changes entail risks of ill health or accidents that may need to be dealt with. The regulations describe the importance of, ahead of risk assessments, gathering knowledge, experiences and sometimes research in advance of assessments concerning changes to activities. The regulations also describe that, employers and employees, should have the correct prerequisites, training and knowledge concerning the work tasks that are to be performed.

Furthermore, the Swedish Work Environment Authority has issued regulations concerning specific requirements that the employer ensure that those who use a piece of equipment have the requisite knowledge and that the work is organised in a safe manner (Use of Work Equipment, AFS 2006:4)[25].

[24] This regulation applied at the time of the accident and was replaced on 1 January 2025 with AFS 2023:1.

[25] This regulation applied at the time of the accident and was replaced on 1 January 2025 with AFS 2023:11.

1.10.2 Role of the Swedish Work Environment Authority

The Swedish Work Environment Authority exercises supervision in accordance with the Work Environment Act. The Swedish Work Environment Authority plans which workplaces will be subject to supervision ahead of each new year. The plans can also include various projects or focus areas, for example work at height on construction sites. For example, the Swedish Work Environment Authority also conducts supervision following accidents, reports from safety representatives or tip-offs that are received. Normally, no overarching supervision of the systematic work environment on construction sites is conducted during supervision.

The Swedish Work Environment Authority had conducted supervision of the construction site Liseberg Oceana Waterworld on two occasions in 2023 together with the Swedish Tax Agency, with a focus on the Posting of Workers Act (see section 1.10.3). The Swedish Work Environment Authority has not conducted any other supervision of, for example, systematic work environment management or the construction site's work environment in general.

The Swedish Work Environment Authority also conducts market surveillance of products within the product areas for which the authority is responsible in Sweden. Market surveillance is a form of supervision in which the Swedish Work Environment Authority checks that manufacturers, distributors and importers of products have complied with their obligations before the product is supplied to others. This includes the Swedish Work Environment Authority checking that products which must be CE marked are marked and that they comply with fundamental safety requirements, documentation requirements etc. If this is not the case, the Swedish Work Environment Authority implements measures such as banning sales. In addition to this, the Swedish Work Environment Authority works with regulation and participates in standardisation. Market surveillance in a broad sense also means dissemination of information and educational initiatives that enhance regulatory compliance within the area.

1.10.3 Posting of workers

The Posting of Workers Act (1999:678) governs the posting of an employee from an employer in another country, to perform a service in Sweden for a limited period, and where there is a recipient in Sweden of the services the employee is to provide.

The employer must report the posted worker to the Swedish Work Environment Authority's register of posted workers. The employer must also ensure that the Swedish regulations and collective bargaining agreements concerning work environment, discrimination, working hours, annual leave, parental leave, pay and tax are complied with.

If the Swedish Work Environment Authority is to obtain information about foreign employers who are operating in Sweden, it is a prerequisite that the employer and its employees are registered in the register of posted workers. As mentioned previously, the Swedish Work Environment Authority conducted supervision of the construction site together with the Swedish Tax Agency with a focus on the Posting of Workers Act. The supervision took place on 28 February 2023 and 17 October 2023. After the inspection on 17 October, it was concluded in an official note that no discrepancies were found during the inspection.

Other checks on, among other things, posted workers were conducted on the construction site. The City of Gothenburg conducted an unannounced workplace inspection on behalf of Liseberg on 26 April 2023[26]. On-site checks were made of, among other things, which companies were present on the construction site. Employees' identification and ID06 cards were also checked.

The results showed that 15% of the employees were not logged in to the staff register. The recommendations to Liseberg from the City of Gothenburg following the inspection included:

- Implementing requisite measures to ensure that logging in and out of the staff register takes place in accordance with the law.
- Denying people without an ID06 card and identification access to the workplace.
- Ensuring that the general contractor rectifies deficiencies in ID06 cards so that these show the correct nationality.

The City of Gothenburg passed on its observations to the Swedish Work Environment Authority.

SHK has scrutinised which members of staff have worked on the waterslides since the beginning of 2023. According to the register of posted workers, eleven people were registered on 16 January 2023. The end date for these people's postings had passed at the time of the accident. On the day of the accident, no members of staff from WhiteWater who were working on the waterslides were registered in the register of posted workers. Six people from WhiteWater were registered on the day after the accident.

1.10.4 Supervision in accordance with the Planning and Building Act

The Planning and Building Act (2010:900) contains provisions concerning planning with respect to land and water and construction. The purpose of the Planning and Building Act is to, taking into consideration the freedom of the individual, promote societal development with equal and good social living conditions and a good and sustainable living environment for people both today and for future generations.

Requirements concerning construction sites are set out in the regulations that accompany the Planning and Building Act: the Swedish National Board of Housing, Building and Planning's construction rules (2011:6) – regulations and general advice, BBR (BFS 2011:6 as amended up to and including BFS 2020:4). Fire safety requirements of relevance to this investigation are included in section 2:3, General rules concerning construction, of the regulations. Measures shall be put in place to prevent fire from breaking out and spreading. If it is not possible to use the regular evacuation routes, temporary routes should be arranged.

Supervision by the building committee

It is the municipality's building committee that supervises the developer's compliance with its obligations under the Planning and Building Act and its regulations. SHK has studied both the minutes of a technical consultation on 30 August 2021 concerning the construction of a building and the minutes of a workplace visit on 19 April 2023 where no deviations were noted.

[26] Report – inspection of sound competition, Liseberg's Jubilee project (JP2) Gothenburg 25/05/2023.

1.10.5 The role of the fire and rescue service in the construction phase

The Planning and Building Act sets out requirements in respect of structural fire protection. The Civil Protection Act sets out requirements for reasonable fire protection in the individual case and encompasses requirements in respect of structural and organisational fire protection. The act contains requirements for the owner and tenant that relate to fire protection. The requirements pertain both to buildings and other structures (Ch. 2, Section 2) and are applied in parallel to the Planning and Building Act.

Under the Civil Protection Act it is the municipality that is responsible for supervision. Normally, the supervision is tasked to the municipality's fire and rescue service or the municipal fire and rescue service federation. The Swedish Civil Contingencies Agency, in partnership with the Swedish National Board of Housing, Building and Planning, has produced a guide concerning the role of the fire and rescue service in the planning permission and construction process[27]. Among other things, this guide highlights how collaboration between the building committee and the fire and rescue service can facilitate the handling of fire protection matters in a construction process.

In light of the requirements in the Civil Protection Act, the Swedish Civil Contingencies Agency has produced a guide for systematic fire protection work. Systematic fire protection work is a structured working method for preventing fires and ensuring functional fire protection. This involves organisations identifying fire risks, conducting risk assessments, drawing up procedures for inspections, conducting training and documenting fire protection work. Systematic fire protection work is not a term that is defined by law. However, it is an established working method for complying with the legal requirements in the Civil Protection Act and the Work Environment Act.

As a supplement to the requirements in the Planning and Building Act and the Civil Protection Act, the Work Environment Act and accompanying regulations contain requirements pertaining to fire protection. With regard to the role of the fire and rescue service in these matters, it is stated that, during extensive and complicated construction or civil engineering works, it is appropriate to contact the fire and rescue service for consultation regarding evacuation questions (cf. the commentary to Section 27 of AFS 1999:3).

1.11 Additional information

1.11.1 Government commission concerning safety culture

In October 2024 the Swedish Agency for Work Environment Expertise was commissioned by the Swedish Government to produce and disseminate knowledge about the safety culture within the construction industry. The government commission described the construction industry as the industry that has the highest number of fatal accidents. The Government has tasked the working group with producing and disseminating knowledge about the safety culture and safety behaviour in workplaces.

[27] The role of the fire and rescue service in the planning permission and construction process, Swedish Civil Contingencies Agency (MSB), MSB1143 – January 2018.

1.11.2 The Swedish Work Environment Authority's work on renewal of regulations

The Swedish Work Environment Authority has conducted a renewal of regulations that entered into force on 1 January 2025. Over 60 regulations have been reviewed and sorted into 15 new regulations.

The new regulations mainly entail editorial changes. However, new requirements that clarify responsibilities and duties, primarily in the early stages of the construction process, have been drafted.

According to the new requirements, the developer must follow up the work environment management by ensuring that BAS-P/U have the correct prerequisites for performing work environment duties and that they actually do this (Ch. 2, Section 18 of AFS 2023:3). One additional new requirement is that employers must provide information to BAS-U about work environment risks that can be mitigated through coordination (Ch. 5, Section 5 of AFS 2023:13). The same regulation also describes the importance of producing a work plan in advance of the work, and of information and instructions (Ch. 5, Sections 7 and 8 of AFS 2023:13).

1.11.3 Specific focus on the causes of fatal accidents

Over the years 2024–2025, the Swedish Work Environment Authority is carrying out a special project that, among other things, will produce data about the causes of fatal accidents at work and communicate these to relevant organisations. The aim is to contribute to employers' ability to prevent fatal accidents at work.

1.12 Similar occurrences

1.12.1 Fire in Landskrona 2019

A fire broke out in conjunction with electrofusion in industrial premises belonging to Boliden Bergsöe AB in Landskrona. A large amount of smoke was produced and the public close to the industrial premises were encouraged by a VMA to remain indoors and close windows, doors and ventilation.

According to the investigation into the cause of the fire, the fire broke out due to incorrect fitting of the pipes when conducting electrofusion.

1.12.2 Fire in Karlshamn 2022

A fire broke out in conjunction with electrofusion in a biogas plant in Karlshamn on 28 January 2022.

The report following the fire listed two possible hypotheses about the cause of the fire[28]. One of the possible causes of the fire was incorrect fitting or movement during fusion, which led toexplosion of PE pipes. Furthermore, it was stated that the chimney effect may have accelerated the development of the fire.

[28] Fire in biogas plant produced by the Western Blekinge Fire and Rescue Service. File number 2022-000 433.

The other possible cause of the fire was a potential product defect. However, this was deemed less likely.

1.13 Actions taken following the accident

1.13.1 Liseberg

Liseberg has stated that work is ongoing to, in its role as developer, strengthen and improve the safety culture. This work includes revising relevant governing documents. Work is also underway to establish structures for monitoring and following up set requirements in a systematic way.

Ahead of the reconstruction of Liseberg Oceana Waterworld, Liseberg has planned a number of measures to improve fire safety and the work environment. Liseberg has announced that the actions they have taken include the following.

- Engaging an external consultancy for the purpose of developing, together with NCC, a common view with regard to the work environment responsibilities incumbent on the developer and the general contractor with BAS-P and BAS-U, respectively.
- Arranging external checks for the purpose of scrutinising the responsibility of the developer in the workplace, including the responsibility of the general contractor.
- Engaging an external consultancy for extra support with expertise and expert know-how in the field of fire.
- Reconsidering its participation in safety inspections, construction meetings and production meetings.
- The fire rating of the attractions (fibreglass) has been given the fire rating C (previously E).
- Supplement the attraction tower with emergency evacuation stairs from both level 4 and level 5.
- Additional sprinklers on the façade of the southern part of the building.

1.13.2 NCC

NCC has announced that, ahead of future reconstruction work on Liseberg Oceana Waterworld, the actions they have taken include the following.

- Clarification of existing procedures for safety inspections in respect of ID06.
- Updated procedures for targeted safety inspections.
- Ensured monitoring of and compliance with access security to the workplace.
- Decided to increase the number of fire safety inspections during the construction period.
- Clarified the responsibilities of all parties by producing the document ‘Guidelines for Coordination of Work and Installation’.
- Ensured that NCC has been able to comment on the list of the responsibilities of WhiteWater and Liseberg, respectively, when procuring new attractions.

During the reconstruction of Liseberg Oceana Waterworld and in other projects, NCC will also clarify the importance of adhering to all work and safety regulations for all parties in the workplace. This includes risk assessments, work preparations, measures that are implemented and applications for permits to perform hot work that entails a fire risk. As an additional action, NCC will consider electrofusion as hot work that entails a risk of fire during the reconstruction of Liseberg Oceana Waterworld.

1.13.3 WhiteWater

WhiteWater has announced that actions they have taken include the following.

- Electrofusion will not be included in WhiteWater's undertakings until further notice.
- Enhanced awareness of the risk of fire when hot work such as welding close to fibreglass pipes is being performed.
- Instructions to project managers and technical advisers before a project starts in another country, obtaining the requisite knowledge through local experts about the rules that apply with regard to safety and administration in that country.
- When planning future projects, WhiteWater will not perform any work where a client or principal contractor requests that their staff perform work tasks for which they lack the established training and cannot assess the risks.
- In the future project with the reconstruction of Liseberg Oceana Waterworld, work tasks involving diversion pipes will not be performed by WhiteWater.

2. Analysis

The construction site for Liseberg Oceana Water World was a large workplace. A significant number of companies had worked for several years to complete the project, which was in its final stages at the time of the accident. At the time of the accident, the developer, the general contractor, subcontractors, and other contractors were all active on the construction site. The analysis does not cover all activities at the construction site but focuses specifically on the work related to the diversion pipes.

In those cases where it is deemed relevant to the sequence of events, the analysis also addresses organisational circumstances at the developer and relevant contractors. Accordingly, the analysis also encompasses questions regarding systematic work environment management, coordination and the safety culture on the construction site.

2.1 The fire

2.1.1 Start and cause of the fire

The investigation demonstrates that electrofusion of PE pipes was the heat generating work that was being performed closest to the waterslide Rattler on the day of the accident. SHK has conducted a number of investigations in order to establish whether the fire may have started in conjunction with this work.

Fire tests were performed with the equivalent temperature, inclination, pipe dimensions and fusion time to the work performed on the day of the accident. The results show that a fire can break out within the scanned fusion time if there is too large a gap between the ends of the pipes that results in at least two metal wires in the electrofusion coupler's fusion zone being exposed.

SHK's fire tests also show that, under similar circumstances as in the current incident, a fire can burn to a limited extent before it develops and spreads further. In other words, there can be a delay before the fire becomes noticeable outside of the pipe.

The first pictures of the fire show flames emerging from two locations in the waterslide. SHK's modelling indicates that such an initial fire development could occur under the conditions present on the day of the accident.

Accordingly, the probable cause of the fire is deemed to be that the PE pipes have been overheated and then caught fire in conjunction with electrofusion. The reason for the overheating is deemed to be that the PE pipes were not covering the fusion zone in the electrofusion coupler to a sufficient extent. There have probably been deficiencies in the fitting.

2.1.2 The fire was initially difficult to detect

The first indication that can be linked to the fire was the smell of burning in the pool building. However, the people who noticed the smell did not perceive any immediate danger. There was, initially, no indications on the outside of the pipes for the fitters who were working on the diversion pipe, that a fire had broken out, with the exception of a bubbling sound, which they perceived to be water that had been released. As a result, the fire was able to continue. There was also no active fire or evacuation alarm in place to provide an early warning of the fire.

Once the fire had developed, it spread rapidly in the pipe system. The pipes were connected to a closed system that can be compared to a chimney. Because there were no physical barriers inside the pipes to prevent the fire spreading or access to air (oxygen), the fire developed rapidly, at which point it spread upwards within the waterslide Rattler to level four and onwards out into the tower. Since the fire smoke was hot and rose upwards, it likely became denser more quickly higher up in the tower, resulting in a short evacuation window from the moment the smoke was first detected.

Smoke from fires generally contains various substances that are hazardous to health. In this case, the smoke came from various burning plastics, which led to a high concentration of hazardous substances. The smoke was also dark and dense, which probably contributed to it quickly becoming difficult to orient oneself. Just a few inhalations of the smoke could rapidly impair the ability to navigate or even cause unconsciousness.

A decisive factor for survival and for the ability to evacuate in conjunction with a fire is an early warning. A fire alarm is one way to contribute to an early warning. The investigation shows that there was no active fire or evacuation alarm as it is reported that no more hot work was to be performed before the regular fire and evacuation alarm was operational. Consequently, it had not been recognized that work with a potential fire risk was being carried out. Knowledge of the tasks being performed and an understanding of the risks associated with these tasks are crucial for making appropriate adjustments to fire protection measures.

Liseberg and NCC have stated that they intend to take action within the field of fire protection during the reconstruction of Liseberg Oceana Waterworld. Consequently, SHK is not issuing any recommendation in this respect.

2.1.3 Emergency response

Once the fire and rescue service had arrived on site the fire development escalated quickly. The incident commander made the decision to begin a life-saving operation in a complex and hard-to-assess situation. The risks that emerged for fire and rescue service personnel and the individuals from the construction site when the fire gas explosion occurred were therefore difficult to predict. The decision to discontinue the life-saving operation following the fire gas explosion appears necessary in order to prevent further serious risks to the fire and rescue service personnel from arising.

2.2 The correct conditions were not in place

WhiteWater was performing the work with the diversion pipes within the scope of its undertaking to install the water attractions for Liseberg and the following section addresses the prerequisites for the performance of this work.

The investigation shows that the conditions for carrying out the work safely were not in place due to shortcomings in planning and a lack of knowledge about the risks associated with electrofusion welding. These shortcomings likely contributed to a faulty assembly.

2.2.1 There were shortcomings in planning

Ahead of the work with the diversion pipes enquiries were made to two companies that specialised in plastic assembly. Taking into account the complexity of the work and limited opportunities to accomplish fitting in a safe manner the companies said no to the enquiries but were able to assist with preparations. So as to complete the work without further delay, Liseberg and WhiteWater agreed that WhiteWater would perform the work with the diversion pipes with the support of one of the companies.

Liseberg did not impose any specific requirements concerning training in conjunction with the work with the diversion pipes. Neither Liseberg nor WhiteWater developed any documentation regarding the design and specifications of the diversion pipes. Furthermore, no detailed risk assessment or work preparation was conducted for the tasks related to the diversion pipes, and as a result, the risks were not identified during coordination. There was also a lack of detailed documentation on how the work was to be carried out.

The shortcomings in the planning of the work with the diversion pipes has affected the prerequisites for the implementation of this work.

2.2.2 The risk of fire associated with electrofusion was unknown

As established previously, deficient fitting of PE pipes when conducting electrofusion can entail a risk of fire, something which was also mentioned in, among other places, training materials.

Two contractors had performed work with electrofusion during the construction period. WhiteWater and Liseberg have stated that they did not know that there was a fire risk associated with electrofusion. Nor has it emerged that NCC or its subcontractor that also performed electrofusion on the construction site were aware of this risk. This is evident from sources including the risk assessment pertaining to electrofusion that has been documented on the construction site.

The fire risk associated with electrofusion welding was therefore not sufficiently understood at the construction site. As a result, no specific risk-reducing measures were implemented.

2.2.3 Prerequisites for the fitters

Neither the fitters nor the supervisor had any training in electrofusion although one of the fitters had stated that he had previous experience of electrofusion. Before starting work on the diversion pipes, the fitters were instructed on how the electrofusion machine operated but did not receive any specific instructions regarding the assembly process or the risks associated with improper assembly. It has also not been established that the fitters received any other information about the fire risks associated with electrofusion welding or how these risks could be mitigated.

The work in question involved large and heavy pipes that were to be joined together with millimetre precision ahead of the electrofusions. Correct fitting was dependent on the insertion depth being measured carefully and marked on the pipes. The conditions for performing a correct installation were hampered by the length of the pipe, angle and inclination, and that the pipe was to be fitted with millimetre precision at two ends ahead of the electrofusions. The possibility for the fitters to ensure that the pipe did not change position in conjunction with the fitting or during fusion was also limited due to the work having been performed at height and without fitting aids. Although the fitters having stated that the fitting was done correctly, there may therefore have been a gap between the pipes that has not been noticed by the fitters. Such a gap is also difficult to detect once all parts of the fitting are in place because the joints are covered by the electrofusion couplers.

The distance between the PE pipes was too large in two other electrofusion couplers that were connected to the waterslides outdoors. In one of these electrofusion couplers that was examined there were also traces of a small pool fire. This suggests that other fitting had also been deficient.

It has also emerged that the work was delayed and was performed under time preassure, which may have contributed to prioritizing the completion of the work. Even if a non-conformity with regard to the PE pipes were to have been detected, there were also limited opportunities to quickly obtain replacement parts because the contractor that prepared the PE pipes had discontinued its activities on site.

2.3 There were deficiencies on the construction site

The systematic work environment management by the developer and contractors is essential for identifying and managing risks, as well as ensuring effective coordination. On a construction site it is the developer that has principal responsibility for creating the right conditions and ensuring compliance with established processes, rules and procedures. A safe construction site requires a good safety culture in which shared values and behaviours permeate the activities. A good safety culture is built on everyone on the construction site working together in order to prevent accidents.

The investigation shows that there have been deficiencies in compliance, monitoring and follow-up of established processes, rules and procedures.

2.3.1 Deficiencies have not been identified

Liseberg had the overall responsibility for the work environment and safety. Through agreements, Liseberg had imposed requirements on NCC, including with regard to the work environment and fire safety, which has established rules for the construction site that were to be adhered to by all contractors. Liseberg had also informed WhiteWater about the work and safety regulations. Nevertheless, a number of deficiencies with regard to the work with the diversion pipes and compliance with established rules and procedures have emerged during the investigation.

NCC maintained ongoing contact with WhiteWater during their assignments in the workplace to an extent that NCC had deemed sufficient. NCC has also stated that they have been aware about the work with the diversion pipes and that they had discussed the work, which NCC considered equivalent to a relevant work plan. However, the task of electrofusion is not documented in any written work preparation. Nor is there any documented risk assessment that encompasses this task. Despite NCC and Liseberg having continual insight into the work that WhiteWater was performing, these deficiencies have not been dealt with before the work began. The consequences of this include that the risks associated with the work with the diversion pipes were not identified and managed within the scope of systematic work environment management.

There have also been other deficiencies that, in and of themselves, cannot been said to have had a direct impact on the conditions for the work but which indicate that the systematic work environment management has not been fully functional. Only a few of the fitters from WhiteWater had undergone NCC’s introduction, which was a requirement to be permitted to work on the construction site. Nor were WhiteWater’s staff using the workplace’s log-in system while performing the work. Neither Liseberg nor NCC took sufficient action to ensure that staff from WhiteWater had undergone introduction and had the correct authorisation.

Deficiencies, including in logging in to the construction site, also emerged during a workplace inspection conducted by the City of Gothenburg. Consequently, Liseberg had been recommended to take action. In spite of this, none of WhiteWater's staff were logged in on the day of the accident or during the period in which the work with the diversion pipes was taking place. Deficiencies in introduction and authorisation were also not detected during safety inspections that was conducted on the construction site each week. This suggests that there have also been deficiencies in the follow-up of the work environment.

These deficiencies have resulted in one of the contractors on the construction site, in practice, having worked for a long period without adhering to the established rules and procedures. Which is something that has also been known about on the construction site. The parties lack of ability to ensure compliance with the rules and follow-up of safety suggests that there was a weak safety culture. A weak safety culture may have contributed to shifting norms and diminished compliance with the rules.

2.3.2 The companies concerned should take action

A safety culture reflects how a construction site, as a unit, works with its systematic work environment management. Ensuring that safety is prioritised and integrated into all aspects is a decisive factor in order to prevent accidents and create a safe work environment. An important part of prioritising safety is ensuring there is the right expertise and knowledge about the work tasks that are to be performed and the equipment that is to be used. Contractors following up activities in a structured and systematic manner is a prerequisite for assessing and managing safety within their activities. The companies concerned have implemented a number of measures to enhance safety but further action is required.

Liseberg has implemented a number of measures in its role as developer to enhance monitoring and follow-up of compliance with established rules and procedures relating to safety. As developer, Liseberg had overarching responsibility for the work environment and safety. Liseberg should therefore continue developing its systematic work environment management in order to further improve the safety culture of its activities. In light of the central role the developer has in setting requirements, the requirements imposed on outsourced contractors should be clarified. Such measures can, for example, encompass imposing clearer requirements with respect to the outsourced contractors' systematic work environment management and continual follow-up of these matters.

NCC has implemented a number of measures pertaining to the contractor's systematic work environment management and has clarified parties' responsibilities by clarifying the importance of coordination. As general contractor, NCC had a specifically delegated responsibility for the work environment and thus plays an important role in building a good safety culture in the workplace. Consequently, NCC should take action in its role as general contractor to enhance monitoring and follow-up of compliance with established rules and procedures relating to safety. This action should include the promotion and maintenance of a good safety culture.

WhiteWater has implemented a number of measures to ensure that all of its staff have the correct prerequisites in future projects. For example, WhiteWater's staff will not be carrying out work tasks for which they lack the customary training and are unable to conduct a risk assessment. As contractor, WhiteWater was responsible for ensuring compliance with rules and procedures on the construction site. Consequently, WhiteWater should take action to enhance compliance with established rules and procedures relating to safety. This action should include the promotion and maintenance of a good safety culture.

2.4 The public oversight of fire safety at construction sites is limited

The requirements relating to fire protection during the construction period are not regulated in detail in the Planning and Building Act or the Civil Protection Act. Responsibility for the detailed design of fire protection falls to the developer.

According to information from the Swedish National Board of Housing, Building and Planning, building committees conduct supervision of fire protection during the construction phase to a very limited extent. Nor is any supervision of constructions sites in accordance with the Civil Protection Act conducted regularly. Consequently, official monitoring of fire protection during ongoing works on construction sites is limited.

In light of how the requirements concerning fire protection during the construction period are structured and how supervision is conducted, the deficiencies identified in this investigation would probably not have been detected during supervision in accordance with the Planning and Building Act or the Civil Protection Act.

2.4.1 The Swedish Work Environment Authority should enhance its supervision of systematic work environment management

The Swedish Work Environment Authority has identified construction sites as a high-risk industry for workplace accidents. The authority has an important function with regard to the work environment in workplaces by using its supervision to monitor compliance with the rules. The Swedish Work Environment Authority's inspections contribute to strengthening the ability of the workplace to mitigate risks, including those linked to fire protection and evacuation. The Swedish Work Environment Authority does not have the opportunity to inspect all construction sites and instead conducts random inspections on the basis of need, e.g. after a serious accident.

Systematic work environment management is the foundation of the ability of the employer to manage risks and thus prevent accidents and maintain a good safety culture. This is especially the case on a construction site where a large number of contractors are working and where there is a great need for coordination. During inspections at construction sites, a comprehensive review of the systematic work environment management is not routinely conducted. This type of supervision could potentially support operators' systematic work environment management and also include matters relating to the safety culture on construction sites. However, this requires an enhanced focus on supervision of the systematic work environment management on construction sites. As the authority responsible, the Swedish Work Environment Authority should investigate the feasibility of, within the scope of construction sites, increasing the focus on systematic work environment management and other matters relating to a good safety culture.

2.4.2 Action may be required in order to enhance product safety

There are training courses in electrofusion welding but there is no general requirement to be trained in order to be permitted to perform electrofusion. Those who are to perform this work can obtain knowledge about the risks through the instruction manual for the electrofusion machine and other instructions. However, the description of fire risks in the instruction manual for the electrofusion machine is brief and does not describe in any detail how a fire can break out. The fitting instructions for the PE pipes that were used are somewhat more exhaustive with regard to the risk of fire in the event of, for example, incorrect fitting, but the focus is primarily on ensuring the quality of the fusion.

The investigation also indicates that there is insufficient awareness of the risk of fire in conjunction with electrofusion, despite accidents having also occurred in other facilities. This highlights the importance of disseminating knowledge about how electrofusion should be performed and what safety measures are to be used.

The investigation also shows that there may be a need to ensure that the information relating to the risks associated with electrofusion machines, pipes and their use is sufficient in order to use these products safely. The Swedish Work Environment Authority deals with product safety issues, including within the scope of market surveillance, but also through other actions. The Swedish Work Environment Authority should therefore investigate whether there is a need to implement measures to enhance product safety. Such measures can encompass, for example, market surveillance, regulatory changes or standardisation work.

3. Conclusions

3.1 Findings

a) Liseberg Oceana Waterworld was under construction.
b) The work on the construction site was in its final stages.
c) Work including fitting of diversion pipes was taking place under the waterslide Rattler.
d) The diversion pipes were being joined together using electrofusion.
e) The fire probably started as a result of deficiencies in the fitting of the diversion pipes that resulted in the pipes overheating and then catching fire during electrofusion.
f) The start of the fire inside the diversion pipes was difficult to detect from the outside.
g) The fire spread further in the water attraction and to the tower.
h) It was not known on the construction site that there was a risk of fire associated with electrofusion.
i) There was no active fire alarm.
j) One person was fatally injured in conjunction with the fire.
k) A number of people suffered minor injuries.
l) The facility sustained extensive damage.

3.2 Causes/contributing factors

Deficiencies in the systematic work environment management at the construction site resulted in the work on the diversion pipes being carried out without adequate conditions. There were shortcomings in knowledge about the risks associated with the work, its execution, and its planning. Consequently, the fire risks linked to the work were neither identified nor addressed.

4. Safety recommendations

The parties concerned have implemented a number of measures that aim to enhance safety and decrease the risk of similar accidents. In addition, the Swedish Work Environment Authority has clarified the rules pertaining to, among other things, the responsibilities of the developer. SHK is not issuing any recommendations in those respects where these measures already relate to the deficiencies that have been observed in this investigation. In light of this, the following recommendations are being made.

The Swedish Work Environment Authority is recommended to

- Investigate the feasibility of increasing, within the scope of construction sites, the focus on systematic work environment management and other matters relating to a good safety culture (see Section 2.4.1). *(SHK 2025:05e R1)*
- Implement measures within the scope of its work with product safety and market surveillance to enhance safety when using electrofusion machines. Such measures can encompass, for example, market surveillance, regulatory changes or standardisation work (see Section 2.4.2). *(SHK 2025:05e R2)*

Liseberg is recommended to

- As a developer, continue to develop its systematic work environment management with the aim of enhancing the safety culture. This work should encompass, among other things, clearer imposition of requirements on contractors and continual follow-up of their systematic work environment management (see Section 2.3.2). *(SHK 2025:05e R3)*

NCC Sverige AB is recommended to

- Take action in its role as general contractor to enhance monitoring and follow-up of compliance with established rules and procedures relating to safety. This action should include the promotion and maintenance of a good safety culture (see Section 2.3.2). *(SHK 2025:05e R4)*

WhiteWater West is recommended to

- Take action to enhance compliance with established rules and procedures relating to safety. This action should include the promotion and maintenance of a good safety culture (see Section 2.3.2). *(SHK 2025:05e R5)*

The Swedish Accident Investigation Authority respectfully requests to receive, **no later than 23 June 2025**, information regarding actions taken in response to the safety recommendations included in this report.

On behalf of the Swedish Accident Investigation Authority

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