



## Pipe assembly blows off, strikes operator

At a well stimulation site, an operator needed to release excess carbon dioxide (CO<sub>2</sub>) from a mobile tanker unit, known as a queen. The queen was parked between two other queens, so the excess gas could not be released directly out to the side. To redirect the venting gas to the front of the queen, the CO<sub>2</sub> operator constructed a pipe assembly using available piping components. When the CO<sub>2</sub> operator opened the discharge valve to release the excess CO<sub>2</sub>, the pressure of the venting gas unthreaded the pipe assembly and it spun counterclockwise. The pipe assembly struck the CO<sub>2</sub> operator, causing fatal injuries.



### Purpose of this report

The purpose of this online incident investigation report is to identify the causes and contributing factors of this incident to help prevent similar incidents and to support preventive actions by industry and WorkSafeBC. This online version is not the official WorkSafeBC report. It has been edited to remove personal identifying information and to focus on the main causes and underlying factors contributing to this incident.

### Notice of Incident information

Number: 2005144250175

Outcome: Fatal

Core activity: Well stimulation

Region: Northern BC

Date of incident: August 2005

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# 1 Factual Information

## 1.1 Work site and employer

The incident occurred at a well site north of Fort St. John, British Columbia. The site is typical of most well locations after the drilling rigs have moved out. The area is a large open field that has been cleared of all vegetation and levelled using heavy equipment.

The work site was a multiple-employer work site consisting of several companies carrying out various aspects of the well servicing. One employee of the oil and gas licensee was working on-site. The company involved in the incident was a well-servicing company that operated the mobile tanker units, known as queens, that contain refrigerated liquid carbon dioxide (CO<sub>2</sub>). Testing operations, transport of queens, and first aid were provided by various other companies.

This site was set up for the stimulation of two gas wells. Four queens were set up and parked parallel to each other to supply carbon dioxide (CO<sub>2</sub>), which is pumped down the well under pressure to stimulate the well back into activity. The CO<sub>2</sub> is pumped through a network of pipes to access the wellhead. Setting up queens in this manner is a common practice in the oil and gas industry when more than one queen is needed (see Photo 1). The work site was organized according to the instructions for setting up multiple queen units found in the well-servicing company's manual for CO<sub>2</sub> operators. The manual states that if multiple queens are used, the operator must leave 5–7 feet of space between the units whenever possible to allow the product and vapour hoses to easily hook up between the units.



Photo 1: Rear view of the four mobile tanker units (called queens). The incident occurred between two queens, near the position of the workers in the photograph.

## 1.2 Sequence of events

After the stimulation of the wells had been completed, the CO<sub>2</sub> remaining in the queens needed to be released (vented) into the atmosphere because the queens are used only for stationary storage and are not designed to transport liquid CO<sub>2</sub>. The outlet for venting was on the side of the queen, directly facing the queen beside it. To direct the venting gas away from the adjacent queen, the CO<sub>2</sub> operator put together on-site a pipe assembly made up of pieces of available straight pipe, 45° elbows, and connectors (see Photos 2 and 3).

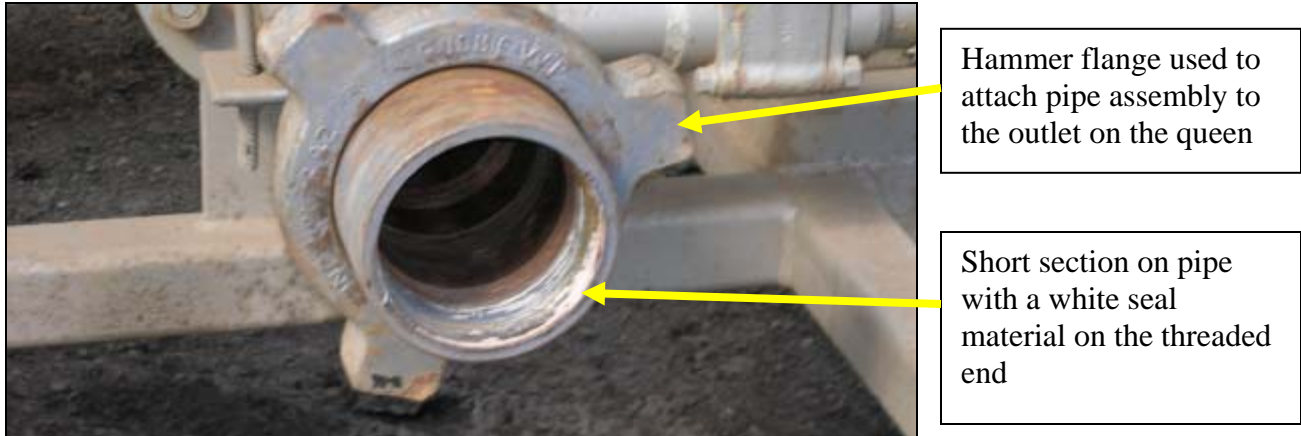


Photo 2: The first connection of the pipe assembly. A short (8-inch) section of pipe was attached to the outlet on the queen with a hammer flange.

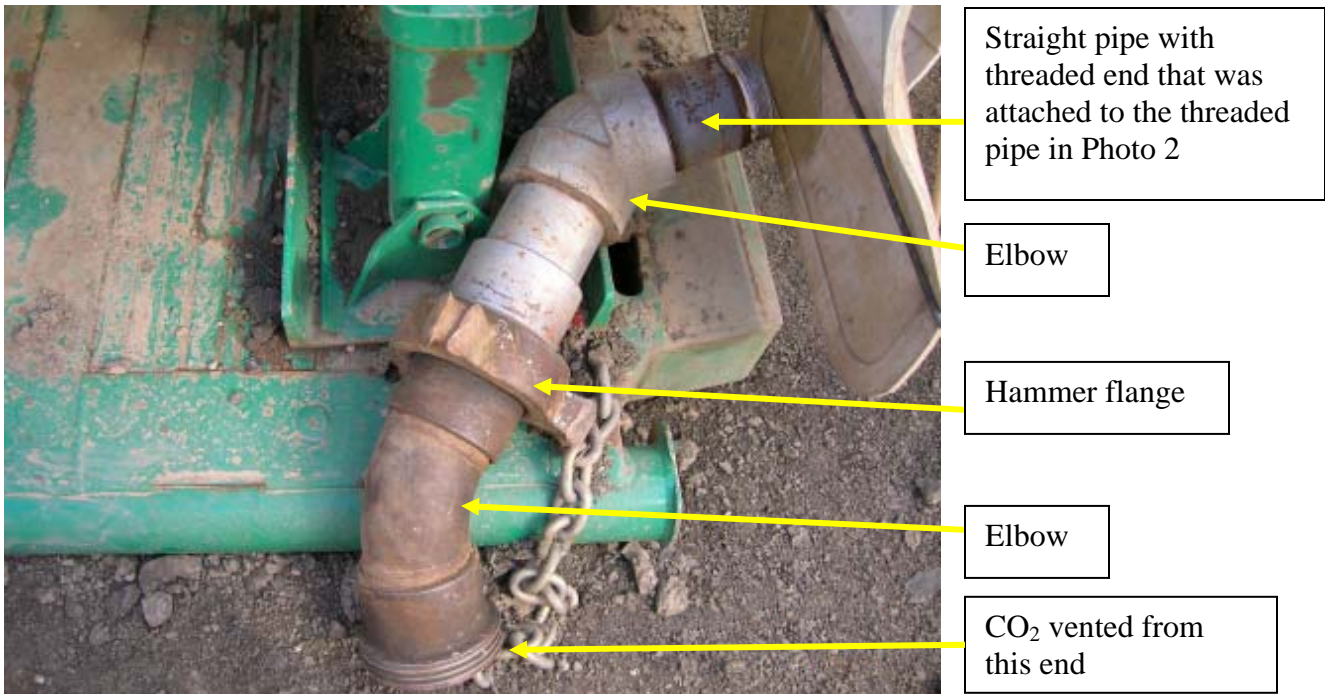


Photo 3: The vent pipe was assembled on-site and used to direct the venting CO<sub>2</sub> gas away from the adjacent queen.



The CO<sub>2</sub> operator successfully released the remaining CO<sub>2</sub> from the two queens on the left in Photo 4. After the second queen had been vented, two co-workers joined the CO<sub>2</sub> operator. They removed the vent pipe assembly from the second queen and installed it onto the next queen. The co-workers installed the pipe so it would vent straight up into the air. The CO<sub>2</sub> operator then came over and repositioned the pipe to vent the gas to the front of the queen (see Photo 5).



Photo 4: This view shows the front of the queens. The circle shows where the CO<sub>2</sub> operator was standing at the time of the incident.



Photo 5: After the incident, workers indicate the position of the vent pipe assembly when the CO<sub>2</sub> operator attached it to the queen.

The CO<sub>2</sub> operator advised the two co-workers to take a break, as the venting noise would be loud. He then opened the discharge valve (see Photo 6). As the venting gas passed through the pipe assembly, a section of the pipe assembly started to spin in a counterclockwise direction. The spinning section struck and fatally injured the CO<sub>2</sub> operator as it spun around before coming off completely.

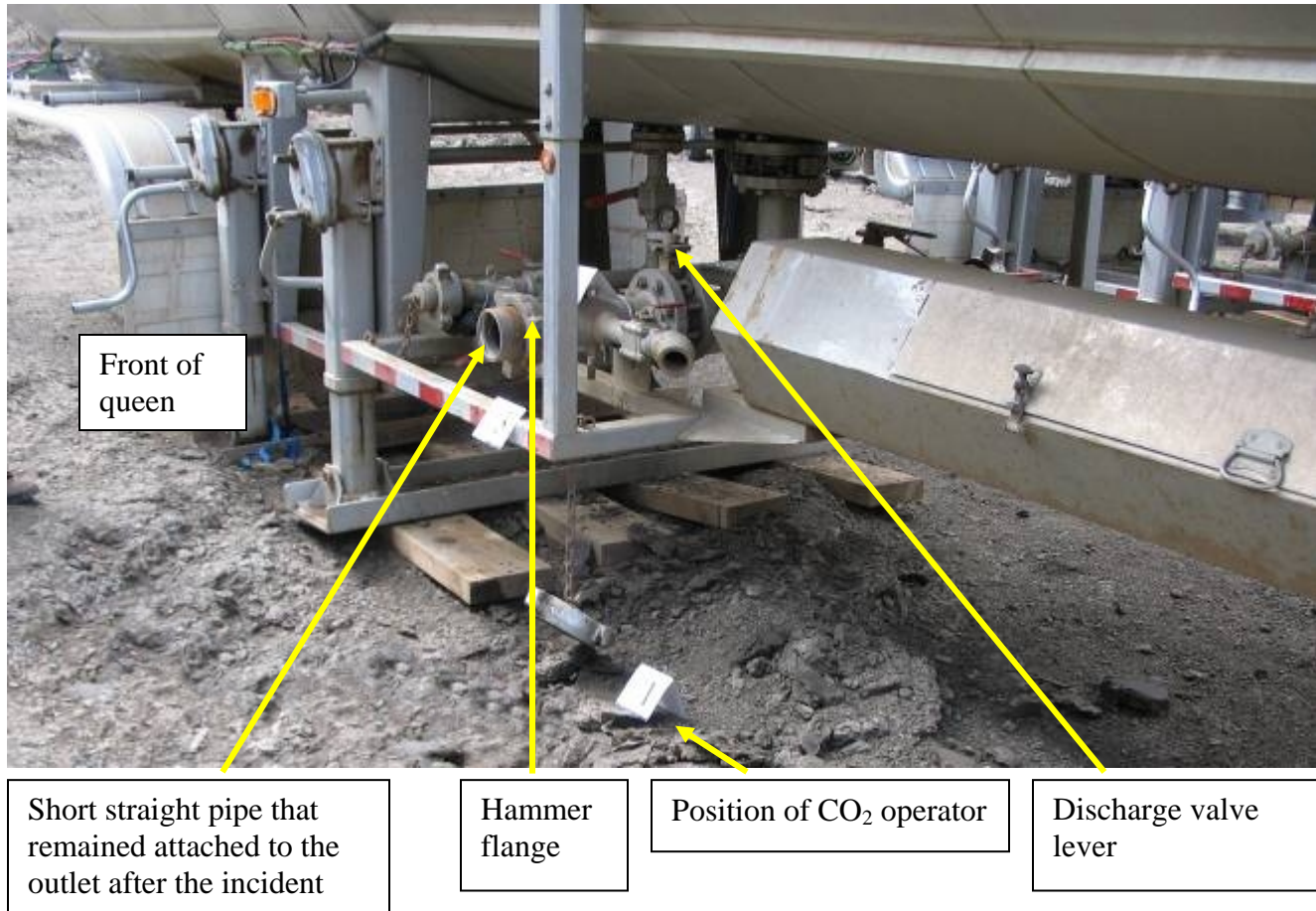


Photo 6: The pipe assembly shown in Photo 5 was positioned to vent the gas towards the front of the queen. It turned counterclockwise as it unthreaded. One piece of straight pipe remained attached to the outlet; the rest of the pipe assembly spun off.

### 1.3 Vent pipe assembly

The pipe assembly that was used to vent the excess CO<sub>2</sub> from the queens was assembled on-site using different pieces of available pipe, elbows, and connectors. The straight pipe (approximately 8 inches long) was connected to the outlet using a hammer flange mounted on the queen (see Photo 2). The combined length of this pipe assembly was approximately 30–36 inches. The white substance on the threaded portion of the pipe in Photos 2 and 3 is an unidentified thread seal material. Photo 5 shows the approximate position of the vent pipe assembly when the gas was vented.

The company's manual for CO<sub>2</sub> operators states that all plumbing materials are rated as schedule 80 (SKD 80) as the minimum wall thickness for pipes. The elbows and connecting flanges of the pipe

assembly involved in the incident were SKD 80, but the straight pipe used to connect the pipe assembly to the outlet was SKD 40 and therefore had a thinner wall.

## 1.4 Work procedures

A procedure for discharging the excess gas from queens is located in the company's manual for CO<sub>2</sub> operators. The procedure states that the operator should slowly open the product valve (using the discharge lever) to release the gas into the atmosphere and ensure that nothing is within 300 feet of the direction the valve is facing. Photo 7 shows the force with which CO<sub>2</sub> is vented, approximately 300 psi through a 4-inch-diameter vent pipe. The procedure does not indicate where the CO<sub>2</sub> operator should stand when opening the valve.



Photo 7: CO<sub>2</sub> is vented at a pressure of approximately 300 psi through a 4-inch-diameter pipe.

## 1.5 Supervision

There was no evidence of supervision of the workers employed by the company involved in the incident. The company's supervisor on the site was focused primarily on the successful stimulation of the gas well and on the subcontractors whose operations overlapped his own company's work. The supervisor did not have a copy of the safe work procedures in the CO<sub>2</sub> operators' manual. He was not aware of the requirement that nothing be within 300 feet of a venting queen, as specified in that manual.

## 2 Analysis

This analysis focuses on the lack of clarity in the position of the queens in the CO<sub>2</sub> operators' manual, the mechanical aspects of the pipe assembly and its connection, the effects of venting gas on the vent pipe, and supervision as factors in the incident.

### 2.1 Position of the queens

The work site was organized according to the instructions for set-up of multiple queens found in the CO<sub>2</sub> operators' manual, with 5–7 feet of space between the queens. This configuration for the queens is a common practice in the industry, and it facilitates the supply of gas to the well in order to stimulate the well into production. In this incident, the arrangement of the four queens in a row for venting was a violation of another procedure in the same manual, which states that nothing must be within 300 feet of the direction the valve is facing. (Note, however, that in situations where only one well is stimulated, two queens can usually be placed side by side and vented from the side away from the other queen.)

The fact that the four queens were lined up only 5–7 feet apart made it impossible to vent the CO<sub>2</sub> from the centre two units safely. However, nowhere in the CO<sub>2</sub> operators' manual is there any instruction to move any of the queens during the venting process (for example, venting the end queen and then moving the empty queen out of the way so the next queen can be vented). This led the CO<sub>2</sub> operator to improvise a method (a site-assembled vent pipe unit) to vent the remaining gas away from the adjacent queen.

In addition, the procedure for venting queens does not indicate where the CO<sub>2</sub> operator should stand when opening the valve. The CO<sub>2</sub> operator was close to the vent pipe assembly as it began to spin, because the discharge lever that the CO<sub>2</sub> operator had to turn was behind and above the outlet (see Photo 6). However, the operator could stand on the opposite side of the queen and reach in to turn the discharge lever.

### 2.2 Vent pipe construction and use

The vent pipe constructed at the work site was assembled from elbows and connecting flanges of SKD 80 pipe and one straight piece of SKD 40 pipe approximately 8 inches long. The entire pipe assembly had a nominal inside dimension of 4 inches.

The individual pieces of pipe were kept in several storage cabinets of the queens. The vent pipe assembly was configured on-site to vent the excess gas away from the adjacent queen, which was located 5–7 feet away. The fitting together of the two elbows and one straight piece of pipe resulted in an assembled vent pipe that was 30–36 inches long and that would enable the gas to flow parallel to the queen, thereby preventing the adjacent queen from being exposed to the venting gas.

This pipe assembly was used twice on two queens before being used on the third queen, when the incident occurred. Each time, the straight piece of pipe was attached to the queen and tightened with the hammer flange. On the third queen, the pipe assembly was initially installed in a vertical fashion, in the 12 o'clock position, with the opening facing straight up and then repositioned towards the front of the trailer by the CO<sub>2</sub> operator just prior to venting. It is not known whether the repositioning of the pipe caused the threads on the straight piece of pipe to loosen where it was connected to the outlet.



## **2.3 Effects of venting gas on the vent pipe**

WorkSafeBC engineering calculated that the forces of the venting gas acting on the 4-inch pipe were significant and led to the unthreading of the pipe, causing it to spin and strike the CO<sub>2</sub> operator (see Photo 6). A WorkSafeBC engineer examined the pipe assembly and reported on the possible reason that the pipe disconnected while the gas was venting. The engineering report states that there could have been a torque of 2,200 foot-pounds tending to unthread the pipe. The engineering report states:

It is likely that the torque required to make or break this threaded fitting was in the order of 200 foot-pounds, which is equivalent to a 100-pound pull on the end of a 2-foot long wrench. Therefore, the nozzle created by the end of the pipe where the carbon dioxide exited only had to be 10 percent efficient in converting the tank pressure into thrust in order to rotate off a tight pipe fitting. This could reasonably have been achieved.

The engineering report concludes that the most likely cause of the incident is that compressed gas escaping from the end of a 45-degree pipe elbow created a thrust. The relative orientation of the thrust and distance of the 45-degree elbow from the axis of rotation of a threaded pipe joint caused the pipe to unthread. The threaded connection was not tight enough to resist the torque created by the escaping jet of gas. The engineering report also concluded that the white substance on the pipe threads may have acted as a lubricant, allowing the pipe to unthread at a lower torque.

## **2.4 Supervision**

Supervision of the company's employees at the work site was not evident. The supervisor of the CO<sub>2</sub> operator did not have a copy of any work procedures at the site and was not aware of the requirement in the company's manual that said that nothing should be within 300 feet of the direction the valve is facing. The lack of supervision led to a situation where the workers were left to direct themselves and to come up with solutions to the problems they encountered.

# **3 Conclusions**

## **3.1 Findings as to causes**

### ***3.1.1 Venting pipe assembly***

A CO<sub>2</sub> operator improperly vented CO<sub>2</sub> gas from a queen by using a vent pipe assembly constructed of on-site components. When the pipe assembly unthreaded at the outlet, the pipe assembly started to turn counterclockwise and struck the CO<sub>2</sub> operator, causing fatal injuries.

### ***3.1.2 Pressure of the gas being vented***

The pressure of the CO<sub>2</sub> gas where it impacted on the angled pipe assembly caused it to spin off the thread mount of the outlet.

## 3.2 Findings as to underlying factors

### 3.2.1 *Inadequate safe work procedures*

Work procedures required that there be nothing within 300 feet of the direction the discharge valve was facing before venting CO<sub>2</sub> into the atmosphere. However, the queens were positioned side-by-side with minimal room between them, so the 300-foot requirement could not be adhered to. No alternative safe work procedure was offered, such as moving the end queen after venting it or initially placing the queens in a different position to eliminate the need to redirect the CO<sub>2</sub> away from the adjacent queen.

No worker direction or procedures were provided on where to stand when opening the discharge valve.

### 3.2.2 *Supervision*

Failure to provide for adequate supervision led to a situation where the workers were left to direct themselves and to improvise solutions to the problems they encountered.

## 4 Orders Issued after the Investigation

WorkSafeBC issued one order after the investigation. An order requires an employer to take steps to comply with the *Workers Compensation Act* or Occupational Health and Safety Regulation, to take measures to protect worker health and safety, or to fix a hazardous condition. An order is not intended to identify fault on the part of the employer but to ensure that unsafe conditions are identified and corrected and that the employer complies with the Act and the Regulation. An employer may ask the Review Division to review an order; the Review Division may confirm, vary, or cancel an order.

In addition to issuing orders, WorkSafeBC may recommend proceeding with an administrative penalty against an employer. In order to protect the privacy of individuals, this report does not give details of any penalty proceeding arising from this incident as that would identify the employer. Penalties are fines for health and safety violations of the *Workers Compensation Act* and/or the Occupational Health and Safety Regulation. For information on when penalties are considered and how the amount of the penalty is calculated, see the [penalty FAQs](#) on WorkSafeBC.com. [Companies that have been penalized](#) are also listed on the web site.

### 4.1 Order to the employer

This section summarizes an order to the employer of the CO<sub>2</sub> operator. The investigation found that this employer was in contravention of the *Workers Compensation Act*, [section 115\(2\)\(e\)](#), which states that an employer must provide to the employer's workers the information, instruction, training, and supervision necessary to ensure the health and safety of those workers in carrying out their work and to ensure the health and safety of other workers at the workplace.

## 5 Health and Safety Action Taken

In addition to the specific actions below, employers, workers, or others in industry may have taken measures to prevent a recurrence of this type of incident. Employers are expected to comply with any orders issued. At WorkSafeBC, the Lessons Learned committee examines recommendations from incident investigations to see what can be done to prevent similar incidents.

### 5.1 Employer

The employer issued a Safety Alert and had the manufacturer make modifications to the queens by changing the 4-inch blow-down line to vent at the rear of the queen, well above the ground and out of the way of workers (see Photo 8).

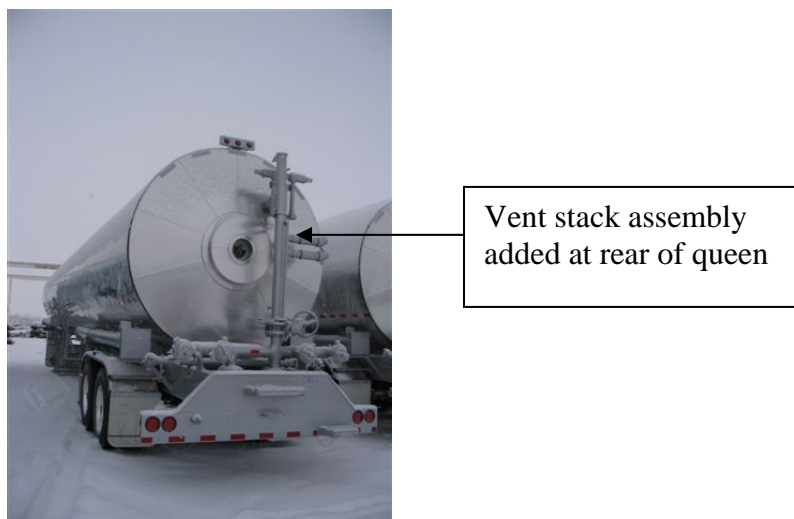


Photo 8: The manufacturer added a vent stack assembly, with a cap and valve, at the rear of the queen.

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