C. A. Herbert

REPORT OF EXPLOSION IN LIQUID OXYGEN EXPLOSIVE PLANT, FIDELITY STRIP MINE, UNITED ELECTRIC COAL COMPANY DUQUOIN, PERRY COUNTY, ILLINOIS.

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Supervising Engineer

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF MINES

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IN
LIQUID OXYGEN EXPLOSIVE PLANT,
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DUQUOIN, PERRY COUNTY, ILLINOIS.

About 9:00 a.m. February 14, 1941, an explosion occurred in the liquid oxygen explosive plant of the United Electric Coal Company, located at their Fidelity Mine about 5 miles west of DuQuoin, Perry County, Illinois, resulting in the instant death of the seven men who were at the plant at the time.

The liquid oxygen explosive manufactured at this plant was being used in blasting the overburden preparatory to stripping, or uncovering, the coal by means of electrically-operated shovels.

Liquid oxygen explosive, usually referred to as "L.O.X." is a high explosive of about the same strength as 40% nitroglycerine dynamite and consists of a combustible absorbent saturated with liquid oxygen. Usually, some form of carbon in canvas sacks is used as an absorbent to form the explosive cartridge. It is a highly inflammable explosive and is more sensitive to impact than 40% nitroglycerine dynamite.

On February 15, the day following the explosion, an investigation was made by the following representatives of the Bureau of Mines: C. A. Herbert, Supervising Engineer and A. U. Miller, Mining Engineer, Vincennes, Ind., and A. R. T. Dennes, Explosives Engineer, Pittsburgh, Penna.

It was evident that this disaster was due to the accidental detonation of approximately 650 pounds of explosives contained in a soaking box in which the carbon filled cartridge sacks were being saturated with liquid oxygen.

It was impossible to determine the cause of the detonation of the explosives as all evidence was destroyed by the blast and all of the employees at the plant were killed. A number of possible causes for the detonation may be conjectured; a most likely one being the accidental ignition of the explosives by a match or cigarette, as smoking materials were found on the bodies of several of the victims.

Location and Ownership

The Fidelity mine is located about 5 miles west of DuQuoin, Perry County, Illinois, and is served by the Illinois Central and Missouri-Pacific railroads.

The mine is owned and operated by the United Electric Coal Company, with main offices at 307 N. Michigan Avenue, Chicago, Illinois. The officials of the Company are as follows:

Louis Ware.....	Chairman of the Board.....	Chicago, Ill.
Frank Kolbe.....	President.....	Chicago, Ill.
Wm. Moser.....	Vice President, in charge of operations....	Chicago, Ill.
Eric Laurell.....	Mine Superintendent.....	DuQuoin, Ill.

Employees and Tonnage

There are approximately 290 men employed at this mine and an average daily output of 7000 tons is produced.

Coal Bed

The Fidelity mine is operating in the Number 6 Bed of the Illinois Series which is approximately 6 ft. in thickness and lies at an average depth of 55 ft.

The overburden consists of approximately 30 feet of surface clay, 14 feet of limestone, and 11 feet of shale.

The coal is underlain with fire clay.

Method of Mining

The coal at the Fidelity mine is recovered by stripping methods. The overburden is removed after blasting by means of electrically-operated shovels that have dippers of 26 cubic yards' capacity. The coal is loaded by means of electrically-operated shovels of a capacity of about 5 cubic yards. Two strip pits are in operation. About half the daily coal tonnage comes from each pit.

Both the stripping and coal shovels are mounted on caterpillar tractors and are operated with 440-volt alternating current. Electric current for the shovels and other equipment is conveyed to the pit by rubber sheathed 3-conductor trailing cables.

Haulage

The coal from one pit is hauled to the preparation plant in drop bottom, standard gauge cars, by steam locomotive. From the other pit it is hauled to the preparation plant in trailer-type auto trucks of 25 tons capacity.

Explosives and Blasting

The coal before loading is blasted with black pellet powder fired electrically.

Prior to this disaster, the overburden was shot with liquid oxygen explosive (L.O.X.) manufactured at the Company's own plant.

Vertical, well-drilled holes 8" in diameter were shot singly with No. 8 electrical detonators. Shot holes were stemmed with surface clay, shoveled into the holes.

The L.O.X. cartridges used consisted of a canvas sack 7-1/2" in diameter and 24" long, containing 8 pounds of carbon, and when saturated with liquid oxygen weighed from 28 to 30 pounds.

The carbon used as an absorbent was a gas black manufactured in the gas fields of Texas by the United Carbon Company, Union Building, Charleston, West Virginia, and sold under the trade name of "Explo".

The explosive was transported by truck from explosive plant to the pit, in the soaking boxes in which the cartridges were saturated with liquid oxygen. These soaking boxes held 24 cartridges, or a total of about 650 pounds of explosives, and served as temporary magazines from which the cartridges were carried to the shot holes as needed. The boxes are square with tight-fitting lids and are lined with copper and insulated with balsa wood.

The Liquid Oxygen Explosive Plant

The liquid oxygen explosive (L.O.X.) plant is located in the mine yard at the Fidelity mine, in close proximity to a number of buildings some of which are regularly occupied. The roadway leading to the mine office and to other surface buildings is only about 50 feet distant on one side, and on the other side and about the same distance away is a railway passing track over which there is a considerable amount of switching.

Fifty feet south of the plant is a storehouse used for the storing of electrical supplies. Within 500 feet there is a large garage for the mine trucks, and about the same distance away is a residence occupied by an employee of the mine. The mine office and the preparation plant are about eight or nine hundred feet distant.

The explosive plant is a steel structure covered with corrugated iron, about 125 feet long and 50 feet wide. It is divided into two sections by a 12-inch brick partition. The larger of the two sections houses the compressors and other equipment necessary to the manufacture of liquid oxygen, while the smaller section is where the cartridges are packed in the soaking boxes and where the soaking or saturating of the cartridges is done.

The plant has a capacity of 300 pounds of liquid oxygen per hour and is known as a Messer type plant, the equipment having been manufactured in Germany.

In the soaking room end of the plant the soaking boxes are handled on a four-wheel rubber-tired hand truck. From this hand truck they are loaded on the auto trucks for transportation to the pit, by means of a mono-rail traveling-crane.

After the 24 carbon cartridges have been placed in the soaking box the box is moved onto a platform scale adjacent to the brick partition and opposite the liquid oxygen storage tank in the main part of the plant. A weighed amount of liquid oxygen equivalent to four pounds of liquid oxygen per pound of carbon is then run into the box through a bronze pipe. During the time the liquid is being run into the box the lid is slid back about two inches to make room for the pipe, thus leaving a crack about 2" wide the length of the box. About forty-five minutes are required for saturating the cartridges.

The carbon (gas black), was purchased in the cartridge sacks ready for soaking and received at the plant in carload lots. The supply of carbon-filled sacks was stored in a loft above the soaking room. When unloading and storing a car of carbon sacks it was necessary to carry them into the soaking room from the railroad car and toss them up through a hole in the loft floor.

There are two regular employees at the plant; the engineer in charge and one who packs the carbon cartridges in the soaking boxes and attends to the soaking or saturating of the cartridges.

The Explosion

At the time of the explosion there was a soaking box on the scales and the soaking time was about completed as the truck driver was on his way to the plant to pick up the box and was only about 600 feet distant when the explosion occurred.

In addition to the box on the scales there was another in the soaking room which had been packed with cartridges ready to be soaked.

On the morning of the explosion a supply of carbon cartridges was being unloaded from a box car, which had been placed on the siding adjacent to the plant, and stored in the overhead loft. This was being done by three laborers who were not ordinarily employed at the plant. In addition, there were two carpenters working at the loading entrance to the soaking room, making preparations to build a canopy above this entrance. One of the carpenters was on a ladder and the other was standing on the ground at its foot, holding it.

For some days prior to the explosion a painter had been engaged in painting the plant building and equipment. Shortly before the explosion he had left the plant to get a new paint brush.

Unquestionably, the soaking box of explosives on the platform scales exploded. All that could be found of the box, hand truck, or platform scales, was one of the rubber-tired wheels of the truck. A crater marked the location of the scales. All of the steel members of the structure at the soaking room end were blown away. Some bent and twisted beams had been blown some distance.

The bodies of the six victims at the soaking room end were all mutilated; that of the carpenter who had been on the ladder was blown about 500 feet and was mutilated the worst.

The brick partition wall and the 1000-gallon liquid oxygen tank were blown towards the N or opposite end. The body of the plant engineer was also blown towards this end.

Smoking materials were found in the clothing of several of the victims.

Considerable damage was done to the residence south of the plant and the doors of the garage were blown off.

The box car from which the carbon sacks were being unloaded was demolished. Some carbon in sacks and a considerable amount of loose carbon was scattered around on the ground for a radius of about 100 feet.

The soaking box with the unsoaked cartridges had been blown about 50 feet.

Several automobiles belonging to employees at the plant and parked nearby were destroyed, partly by violence but mostly by the intense heat of the explosives and the burning carbon which was thrown into the air and ignited by the explosives.

Ordinarily, only two men are employed at this plant - the engineer and the man who soaks the cartridges - but on the day of the explosion there were in addition, the three laborers unloading the cartridges and the two carpenters. Had the explosion occurred a few

minutes later it would probably have included the truck driver and the painter.

A chemist at the coal analysis laboratory several hundred feet distant was looking out the window and saw the explosion and observed the mass of reddish flame of the burning carbon and the flying debris.

An employee at the coal preparation plant was dropping some empty railroad cars down to be loaded and was just about opposite the LOX plant when the explosion occurred. He either jumped or was blown off the car - he was not certain which - and escaped injury from flying debris.

With the plant destroyed and the employees all killed it is difficult to say, with any degree of certainty, just what caused the explosion. However, a likely cause was the ignition of the explosives followed by detonation, due to smoking on the part of one of the men. Smoking materials were found on the bodies of several of the victims and, in addition, five of them were not regularly employed at the plant and probably did not realize the extreme hazard of smoking in close proximity to liquid oxygen explosive.

On the morning of the explosion there was a strong wind blowing from the west, and with the doors to the soaking room open as they were the wind would sweep through this room. Had the carpenter standing on the ground at the west door dropped a lighted cigarette, it would very likely have been carried in towards the soaking box.

Some persons discount this possibility, claiming that the engineer in charge of the plant was very strict about not permitting smoking at the plant, and that, in addition, the men handling the carbon sacks would be unlikely to smoke because of the fact that their hands and possibly their respiratory passages were covered with carbon black. In unloading and storing the carbon sacks it was necessary for these men to walk into the soaking room and toss them up through an opening in the floor of the loft to a man who was stacking them away. Had one of these men attempted to smoke he would have been in close proximity to the soaking box.

As a further reason for discounting the possibility of smoking having caused the explosion it is claimed that the lid to the soaking box covered over the box except for a crack at one side to make room for the liquid oxygen pipe. However, a crack two inches wide would be large enough for a cigarette to fall through.

While it may be true that the engineer was strict about smoking, yet, he was in another part of the plant and could not watch employees at the soaking room end. In addition, when visiting an LOX plant at another mine about two years ago it was noticed that smoking was permitted in the compressor end of the plant and the same conditions may have existed here and the regulations not very rigidly enforced.

Several other possibilities which might have been responsible for this explosion have been suggested. Lubricants getting into the

liquid oxygen might increase greatly, the sensitivity of the explosive. One producer of liquid oxygen now re-distills the oxygen to prevent just such an occurrence. Paint getting on any of the cartridges before soaking might have a similar effect, and as they were painting at the time, this is, of course, a possibility. Also, an accumulation of fine carbon in the bottom of the soaking box might become extremely sensitive. It is the practice to clean the soaking boxes at the end of the week and as the explosion occurred on the last working day of the week, there may have been a considerable amount of this fine carbon in the bottom of the box. When the liquid oxygen is run into the box there is sometimes a tendency for some of the cartridges to float up out of the liquid and when this occurs they are pushed back down with a wooden paddle. The explosive in the box may have been rendered extremely sensitive because of some extraneous hydrocarbon, or by an accumulation of fines in the bottom of the box, and when the floating cartridges were struck with the wooden paddle to force them down they may have detonated. The suggestion was made that the explosion might have been due to the accidental ignition of a cloud of carbon black from a broken cartridge sack. This appears extremely remote as tests by the Bureau of Mines indicate that carbon blacks are not easily ignited and will not propagate an explosion.

In visiting LOX plants one cannot help being amazed at the lack of control over the materials going into the manufacture of the explosive, and the lack of safeguards. The carbon is often purchased

from some manufacturer on the basis of price only, without specifications and without any checks or tests at the plant to find out whether it is suited to the purpose, and apparently with a total lack of knowledge on the part of either the carbon manufacturer or the coal company of the hazards that might be created by contamination of either the carbon or the sacks. Similarly, there are often no adequate control tests made of the liquid oxygen to disclose contamination with oils or other foreign substances which might increase the sensitivity of the explosive; and the liquid oxygen at these small plants is never re-distilled.

Further, the LOX plant at this mine is located in the mine yard close to occupied buildings and within fifty feet of the highway on one side and about the same distance from a railroad passing track on the other. In the warm weather when both doors to the soaking room are open there is nothing to prevent hot cinders from a passing locomotive blowing in on the soaking box. The plant is not enclosed by a fence and there is nothing to prevent anyone, whether an employee or not, from walking into either the soaking room or the main part of the plant, and there is no assurance that any such unauthorized visitor will not be smoking or will not attempt to smoke.

The LOX plants at these mines manufacture a highly sensitive and highly inflammable explosive and it would seem especially important

to execute a rigid control to assure a reasonable constancy in the properties of the product. It would appear also, in the interest of safety, that these plants should be in an isolated location, away from other buildings, railroad tracks or other activities, and should be protected from unauthorized visitors by a tight fence on which suitable warning signs should be placed. It would also appear desirable to separate the soaking room from the main part of the plant and to protect the latter by means of a barricade.

The names, ages, and addresses of the seven victims of this disaster are as follows:

Lou W. Barker...	age 69...	Engineer in charge of plant..	DuQuoin, Ill.
James Thornton..	" 72...	Employed in soaking room.....	do
John Bailey.....	" 25...	Unloading carbon sacks.....	do
Lyle Cook.....	" 35...	Carpenter.....	do
Russell Cook....	" 31...	Carpenter.....	do
John Rapuzzi....	" 30...	Unloading carbon sacks.....	do
Nelson Todd.....	" 24...	Unloading carbon sacks.....	do

Mr. Barker and Mr. Thornton were the two regular employees at the plant and had been so employed since the plant was installed in 1929.

RECOMMENDATIONS

In the interest of safety the following recommendations are offered regarding the location and operation of liquid oxygen explosives plants:

1. Liquid oxygen explosives plants should be in an isolated location, away from other buildings, railroad tracks, or highways, and should be protected from unauthorized visitors by a tight fence on which suitable warning signs should be posted.

2. The soaking room should be separated from the main part of the plant and there should be a protecting barricade between the two sections of the plant.

3. The supply of unsaturated cartridges should be stored in a room adjoining the soaking room and not above it. This storage room should be so arranged that it will be unnecessary to pass through the soaking room when delivery of unsaturated cartridges is being made. Such delivery should preferably be made during hours when cartridges are not being soaked.

4. The loading point at which soaking boxes are loaded and unloaded from the trucks should be so situated that it will be impossible for sparks from the engine exhaust to enter the soaking room. No loading or unloading of soaking boxes should be permitted while the truck engine is running.

5. No smoking should be permitted inside the fence which surrounds the explosive plant and no one should be permitted to enter the fenced enclosure with either matches or smoking materials on his person. Preferably, the employees of the plant should be non-smokers.

6. All electric wiring, light fixtures, and switches in the soaking room should be such as to reduce the danger of electric arcs or sparks to a minimum.

7. The absorbent used should be one which will give a resultant explosive with a minimum of sensitivity and tests should be made of each shipment of absorbent to insure the uniformity and purity of the product.

8. Extreme care must be exercised to prevent cartridge sacks from coming in contact with oil, grease, paint, or any other inflammable substance which may tend to increase the sensitivity of the explosive.

9. Tests should be made of the liquid oxygen at regular intervals to insure that it is not being contaminated with lubricating oils or any substance which might increase the sensitivity of the explosive. Preferably, the liquid oxygen should be re-distilled to insure its purity.

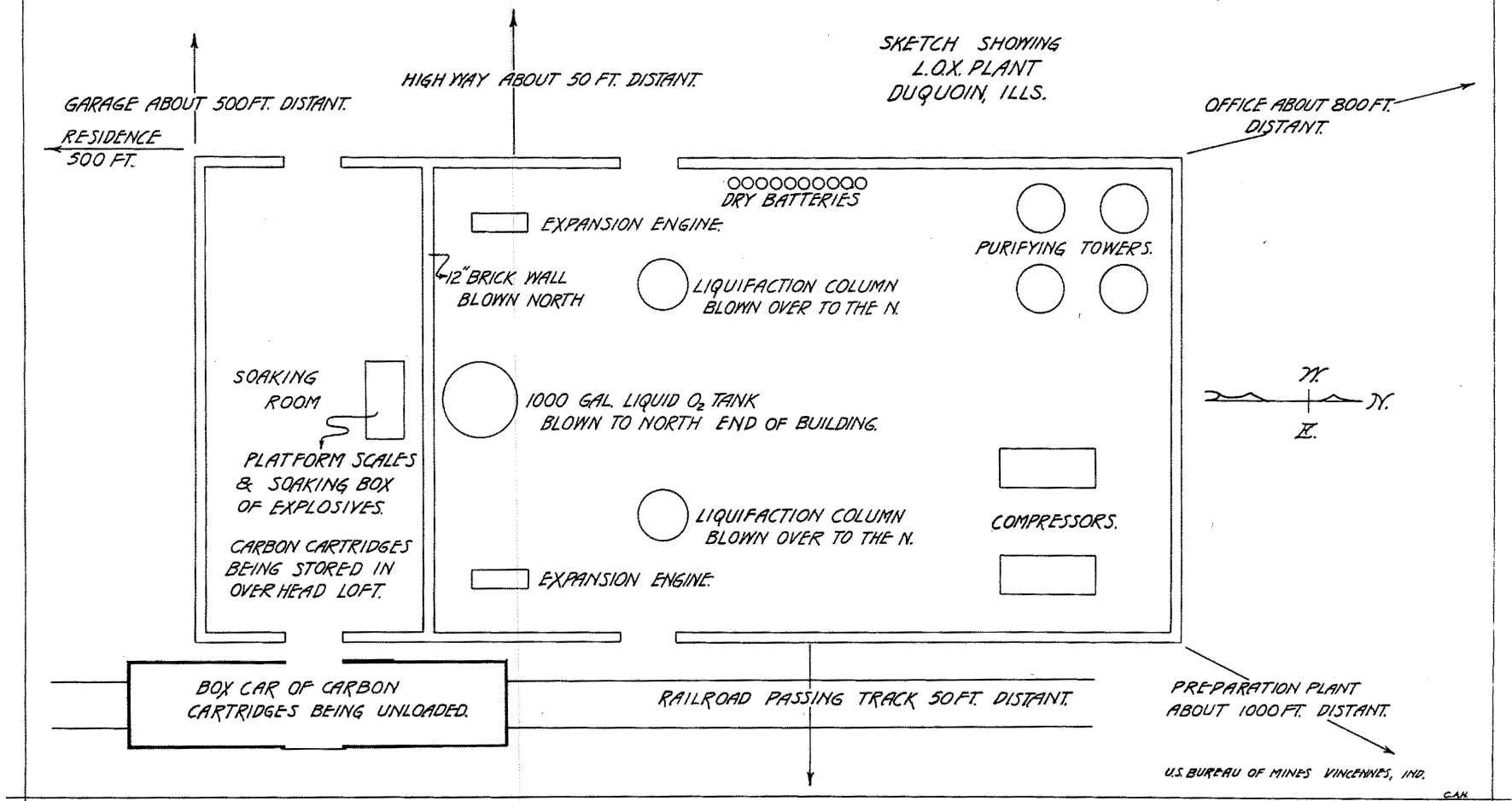
10. Soaking boxes should be frequently inspected and kept clean and free of loose carbon or other sediment.

Following this disaster there was considerable talk of the possibility of sabotage, just as there was following other recent fatal accidents due to L.O.X., but there were too many opportunities for this disaster, as well as the other recent fatal accidents, to have occurred because of dangerous practices, to give very much credence to any such theory.

The attached sketch shows the layout of the plant and approximate location with respect to other plant buildings.

Respectfully submitted,

C. A. Herbert,
Supervising Engineer


SKETCH SHOWING
L.O.X. PLANT
DUQUOIN, ILLS.
GARAGE ABOUT 500FT. DISTANT.
RESIDENCE
500 FT.
HIGHWAY ABOUT 50 FT. DISTANT.
OFFICE ABOUT 800 FT.
DISTANT.
DRY BATTERIES
EXPANSION ENGINE.
PURIFYING TOWERS.
12" BRICK WALL
BLOWN NORTH
LIQUIFACTION COLUMN
BLOWN OVER TO THE N.
SOAKING
ROOM
1000 GAL. LIQUID O_2 TANK
BLOWN TO NORTH END OF BUILDING.
N.
N.
E.
PLATFORM SCALES
& SOAKING BOX
OF EXPLOSIVES.
CARBON CARTRIDGES
BEING STORED IN
OVER HEAD LOFT.
LIQUIFACTION COLUMN
BLOWN OVER TO THE N.
COMPRESSORS.
EXPANSION ENGINE.
BOX CAR OF CARBON
CARTRIDGES BEING UNLOADED.
RAILROAD PASSING TRACK 50FT. DISTANT.
PRE-PARATION PLANT
ABOUT 1000 FT. DISTANT.
U.S. BUREAU OF MINES VINCENNES, IND.
C.A.H.