FINAL REPORT ON MAJOR MINE-FIRE DISASTER
BELLE ISLE SALT MINE
CARGILL, INCORPORATED
ST. MARY PARISH, LOUISIANA

March 5, 1968

by

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INTRODUCTION

This report is based upon an investigation made in accordance with the provisions of Public Law 89-577, the Federal Metal and Nonmetallic Mine Safety Act, approved September 16, 1966, and at the request of the mine operator.

A fire occurred on Tuesday, March 5, 1968, at about 11:30 p.m. in the Belle Isle Salt Mine, while 21 men were working underground. There were no survivors; 20 died of carbon monoxide poisoning, and one as result of massive skull fracture. Although every piece of available evidence was examined in detail during an investigation that required nearly 6 months, neither the cause of the fire nor the point of origin could be definitely established. It appears that the fire originated in the lower part of the shaft at about, or below, the mining level. The cause could have been an electrical fault, use of an oxyacetylene torch, or frictional ignition of a belt conveyor, and the evidence does not clearly favor any one of the three possibilities. Direct property damage was confined to the mine shaft and its equipment.

GENERAL INFORMATION

The mine is located on the Belle Isle salt dome, along the Gulf Coast, in St. Mary Parish, 19 miles southeast of Franklin, Louisiana. It is one of a group of underground salt mines in similar domes in the area, each of which is operated by a separate company. The domes are known as Jefferson Island, Avery Island, Weeks Island, Cote Blanche Island, and Belle Isle. Their surface elevations are not high, but as they were mound-shaped and rose abruptly above the flat marshland, they came to be known as the Five Islands. The location is shown in a sketch of the area, Appendix C. Salt shipments from Belle Isle were handled by an affiliated barge line. Personnel and supplies were transported to the mine by water. The landside base of operations is known as Calumet Landing, along U. S. Highway 90, on Wax Lake Outlet, about 13 miles due north of the mine.

The mine, which went into production late in 1962, is owned and operated by Cargill, Incorporated. The principal officers associated with the company salt activities, with headquarters in the Cargill Building, Minneapolis, Minnesota, are:

E. E. Kelm	President
Clifford M. Roberts, Jr.	Vice President, Commodities Division
F. Clayton Tonnemaker	Assistant Vice President and Manager of Salt Department
C. Robert Burge	Manager, Terminal Operations, and Staff Engineer
Calvin J. Anderson	General Counsel
John F. McGrory	Assistant General Counsel
L. H. Gretzer	Safety and Loss Control

The mine and these operating officials have as Post Office address, Franklin, Louisiana:

Nicholas J. Nicola	Mine Superintendent
Joe Neal Pinkham	Assistant Mine Superintendent
James W. Gustafson	Mining Engineer
Clarence Dartez	Maintenance Supervisor
Eugene F. Geist	Office Manager

The total number of employees was 60, of whom 32 were classified as regular underground employees; some surface employees worked underground intermittently, and staff officials spent much time below. The mine was operated two shifts a day, and produced an average of 6,400 tons of salt (sodium chloride) daily. Ordinary maintenance work was done on production shifts.

The mine was opened by a single shaft, with inside diameter of 16 feet, and approximately 1,250 feet deep, into the Belle Isle salt dome. It was divided into two compartments for ventilation purposes. The larger compartment (upcast) was divided by timbering into two skipways and a service compartment for electric power cables. The smaller compartment was the downcast-air compartment, and it was equipped with a self-service auxiliary cage for personnel travel. The shaft was concrete-lined to the depth of 369 feet. Below that point, the salt was self-supporting, but conventional timbering was installed to support skip and auxiliary-cage guides, with sets at 7-foot centers. All shaft timbering was of wood, and a plywood curtain wall separated intake- and return-air currents. At shift-changing times, men were transported in a man cage beneath one of the skips. The man cages were built integrally into the steel skip frames, beneath the aluminum skip buckets. They were provided with solid metal bonnets and, originally, enclosed with expanded metal. The salt corroded this relatively light screening severely, and it had been replaced on one unit, referred to as the "north" skip, with plywood; on three sides, the lower 4 feet was solid plywood sheet, and the upper part was enclosed by strips of plywood, 3 inches wide, spaced 1 inch apart. The fourth side was provided with a wooden gate. Use of the other man cage had been discontinued.

According to the company management, planning and budgeting called for a second shaft to be sunk in the not-too-distant future, but, while it was intended to equip it with a man cage, as a second escapeway, the shaft was proposed primarily to augment ventilation. As of the present, it is planned to locate it 900 feet from the present shaft and equip it for a production shaft.

Although a complete Federal inspection of this mine has never been made, it had been visited by Bureau of Mines representatives at the request of the mine management on several separate occasions between 1963 and the end of 1967 to examine particular phases of the operation. The most recent of these visits was made by Bureau mining engineer Arthur M. Evans on August 9, 1967, nearly 7 months before the fire. His memorandum report, copies of which were mailed to the company on September 13, 1967, included recommendations pertinent to the disaster, that: (a) fire protection should be provided for (among other facilities) shaft stations; and (b) a second shaft should be sunk and connected to the workings.

MINING METHODS, CONDITIONS, AND EQUIPMENT

Geology of the Salt Deposit

Some description of the Gulf Coast salt domes should be helpful in understanding the selection of the location for the shaft, the general plan of mining, and other factors of the Belle Isle operation. Many salt domes in the Gulf Coast area, including the Belle Isle dome and its neighbors, though all somewhat different in shape, size, and depth below the present surface, when viewed in plan, have a generally either cylindrical or elliptical cross section, the axis (or axes) increasing from top to bottom. The origin of the Gulf Coast domes is from a deep mother bed of salt, thought to be more-or-less continuous over the area. The weight of overlying sediments is thought to be the force which causes the salt to extrude upward through the overlying sediments, and some salt domes on the continental shelf are said by geologists to be still pushing upward at a rate of perhaps 1 foot every 100 years.

A Bureau of Mines publication 1/ provides this graphic description: "If it were possible to remove the overlying and surrounding sediments from the salt domes, these massive intrusions would stand like giant mesas or buttes rising to 20,000 feet or more above the source bed." A sketch showing a generalized vertical section of Belle Isle dome is included in Appendix D.

Salt domes formed as described above are classified as "piercement" domes. They are generally topped with a mantle of sedimentary cap rock, frequently anhydrite and limestone. The term "cap" is particularly apt here, since the rocks envelop the salt domes like a sheath or cap. Domes in marsh and tideland country frequently are overlain above the cap rock by unconsolidated sediments, which create a major problem in sinking mine shafts; at Belle Isle, the job was accomplished by freezing the highly water-bearing sediments until the shaft had been deepened into solid salt for approximately 180 feet and the concrete lining poured.

Mining Methods

The top of the Belle Isle dome, like most salt domes, is quite irregular, as determined from drill holes. At some locations salt was not encountered above 700 feet, total depth; at other points it lies much closer to the surface. In Appendixes E and F, the section X-Y, across the Cargill lease

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1/ Bureau of Mines, Information Circular 8313. Salt Domes in Texas, Louisiana, Mississippi, Alabama, and Offshore Tidelands: A Survey, by M. E. Hawkins and C. J. Jirik, 1966.

in a generally southwest to northeast direction and through the shaft area, shows how the shaft was so located as to get into massive, self-supporting strata at about 200 feet depth.

By reference to Appendix E, it will be seen that the original subsurface lease was an irregular polygon of limited extent. Even with later lateral extensions east and south, the horizontal area for which mining rights are held is considerably less than 1 square mile. The depth of the salt deposit, however, as indicated by the vertical section, Appendix D, is practically unlimited, future downward development being restricted only by whatever natural and economic factors greater depth may produce.

A room-and-pillar system of mining was employed. Since the terrain of Belle Isle is barely above sea level (elevation at shaft collar 25 feet, 6 inches above mean tide), prevention of surface subsidence is essential, and, therefore, pillars were not extracted.

To avoid approaching the irregular boundaries at the top of the salt core and possibly bringing about inflow of water, or total inundation, it was decided to start development from the shaft at sufficient depth to eliminate the boundary problem. The first level, termed the "mining level," was developed at elevation -1,138.25 feet, at the floor. All production thus far has been from this one level, which actually includes a sublevel, as described later, not connected directly to the shaft. By reference to the mine map, Appendix G, it will be seen that the development plan at the first level is following the configuration of the subsurface lease generally.

Some definition of terms is in order. The adopted spoken and map nomenclature for the Belle Isle mine is, as follows:

- Entry -- a horizontal development tunnel (drift)
- Room -- a principal production excavation turned from an entry (a flat stope)
- Crosscut -- an excavation between entries, and between rooms, for ventilation, and for haulage
- Ribs -- vertical sidewalls of excavations
- Top -- the back in excavations
- Floor -- sill, bottom
- Scales -- loose pieces of salt on roof or ribs (the loose)
- Slope -- inclined excavation between the mining level and the sublevel, for movement of self-propelled equipment, and to transport salt to the upper level
- Bulkhead -- a stopping in a crosscut to direct ventilation; also used to fence off abandoned workings from entrance of persons and air currents

The shaft is near the north end of the lease, and the first level was developed from the shaft area by three main entries trending about south-southwest. As the map indicates, early development of the northerly area followed a block pattern. Corners of pillars were found to be highly susceptible to hazardous scaling (sloughing) of the salt, and the plan was changed to typical room-and-entry system with longer rooms, which obviously create fewer corners. In this massive salt deposit, excavations can be projected to any desired dimensions. Currently, rooms were projected 60 feet wide, and pillars 70 feet wide. Rooms were projected to be driven 380 feet deep and to connect to the next cross entry. The rooms were driven about 25 feet high. They were undercut 11 feet with an electric cutting machine, drilled with an electric drill, blasted, then loaded with a diesel front-end loader into diesel trucks. A sub-level, not indicated on the map, was developed by slopes from the mining level. Lower-level excavations and pillars were alined with those on the working level and mined similarly. As the next step, the floor pillar was drilled with an electrically powered vertical drill from the upper level, blasted, and then loaded out from the lower level. Completely mined-out excavations were 85 feet high. A typical room plan, with vertical section, is shown in Appendix H. See also Appendix K.

Scaling of top and ribs was accomplished with a gasoline-truck-mounted rig with telescoping boom. The top (salt) is generally self-supporting; however, planes of separation sometimes occur at horizons above the exposed top. A study made in March 1967 by a Bureau of Mines roof-control representative resulted in a recommendation that suspected areas be probed by means of a stratascope and roof-bolted as found advisable; this procedure had been adopted. Corners of pillars were rounded off, as this had been found to reduce scales.

Explosives

Blasting was done with bulk AN-FO prills, primed with dynamite; when wet holes were encountered, they were blasted with gelatin dynamite. Rounds were fired electrically from a remote station. The high explosives, AN-FO, and other blasting supplies were stored underground in separate magazines. There was no surface storage. The magazines were about 500 feet from the shaft in an area remote from active workings. The holes being charged at the time of the fire were still farther from the shaft and in a different direction, and there was no involvement of explosives or blasting agent in the fire.

Ventilation and Gases

Flammable, toxic, or noxious gas has not been the determining factor in providing ventilation for this mine. The mission of ventilation has been to improve the personal comfort and efficiency of employees exposed to a year-round environment of 85-90 degrees F., and high relative humidity. Ventilation was induced by a Jeffrey 8H-72 Aerodyne fan, operated blowing, installed underground 20 feet from the shaft on the (upper) mining level, in a wooden bulkhead in the Air Entry. (See Appendix I.) It was belt driven by a 480-volt, 100-horsepower motor, and it was said to circulate 130,000 cubic feet of air a minute. The fan was operated continuously when men were in the mine; it was shut down for blasting when all men were at the bottom being hoisted at the end of the second shift, because the hoisting compartment was the return airway. The blasting rounds were all initiated from firing lines, controlled by a master switch near the shaft bottom. After those in charge of blasting reached the surface, the fan was restarted by remote control from the surface to clear the products of the explosives before the shift entered next morning.

The shaft was divided by a plywood curtain wall. The fan drew air down one compartment and directed it into the Air Entry, but the crosscuts were roughly 25 by 25 feet in area and, consequently, difficult to block off. Bulkheads were built of fine salt, piled as high as feasible, then topped for the last few feet with plywood or plastic brattice material, but the concussion from blasting knocked out these brattices. As the workings progressed, the effect of concussion near the fan was reduced somewhat, but, up to the time of the fire, effort had been made to close only two crosscuts on each side of the Air Entry. Beyond that, the air meandered through the workings on both levels until it found its way back to the shaft.

It was said that air movement was perceptible in active workings of the mine, which, in view of no positive directing, other than bulkheading, or at least partial bulkheading, of openings to abandoned areas, was probably because there was negligible mine resistance except in the shaft compartments. Based upon 130,000 cubic feet a minute, the velocity in the upcast compartment was estimated as possibly over 1,000 feet a minute, and there must have been appreciable turbulence caused by shaft timbering. Thus, the upcast shaft would probably act as a regulator, causing the intake-air current to disperse rather than to short-circuit directly to the upcast. In the producing areas, large portable blowers were used as boosters, and, though operated free, that is, without tubing or ducts of any sort, it was reported that the air movement noticeably added to comfort.

Examinations for methane were not made during normal mine operation. Gas has been ignited in the kerf on occasion, while undercutting in areas where a shale streak appeared in the salt. From the characteristic odor and instrument tests, the flammable gas has been taken to be hydrogen sulfide. Since, however, a flammable concentration of hydrogen sulfide is a highly lethal mixture, whereas mine workers have not experienced even slight hydrogen-sulfide symptoms, and since methane and hydrogen sulfide have been found in association in salt mines, and usually in the vicinity of a shale occurrence, it appears that the principal constituent of the gas ignited in the Belle Isle mine was probably methane. Analysis of samples collected during recovery operations in the absence of positive ventilation indicated presence of 0.09 percent methane.

General Conditions

The downcast compartment was usually wet as result of condensation, decidedly so in the summer months; however, any moisture present was apparently little deterrent to the fire.

Transportation

Diesel trucks hauled the salt to the underground crushing and screening plant. A program to replace gasoline engines of other units of equipment with diesel engines had not been completed, and several gasoline units were still in use. Only one such unit, a Jeep used by mechanics servicing the skips, was in the vicinity of the shaft; it was found intact after the fire some distance from the shaft. None of the automotive equipment was involved in the fire.

Gasoline, fuel oil, and lubricants were stored more than 1,000 feet from the shaft; none of these materials was involved in the fire.

Rubber-belt conveyors transported the salt from storage chambers near the screening plant to a surge bin on the mining level 50 feet from the shaft. Wood was used extensively in the construction of the screening plant, and to support the conveyor belts, because of the corrosive action of salt on metal. However, not even the main belt and its wooden understructure, nor the wooden flooring about the surge bin, was ignited. These installations were inby in the return air with respect to the fire in the shaft, for such time as the air continued to circulate.

From beneath the surge bin, a rubber-belt conveyor fed salt through a tunnel to the skip loaders suspended down one side of the shaft from the tunnel level to the skip-loading level. (See Appendix J.) This belt and its wooden supporting structure were partially burned.

Electricity

Electric power, at 34,500 volts, was taken from the mainland to the island mine site by overhead lines and submarine cables. The high voltage was transformed at the Cleco (public utility) substation to a metered 4,160 volts for mine surface and underground use by three 833 kv.-a., air-cooled transformers, which were connected delta/wye. The wye secondary midpoint was solidly connected to the station ground with no ground-fault relay or impedance. All metallic frames were grounded to the station ground. The incoming 34,500-volt line was provided with fuse-type disconnecting switches and lightning arresters at the substation. Overload and short-circuit protection for the 4,160-volt circuit was provided by a manual-reclose type oil circuit breaker, and peak power consumption was recorded by a demand meter.

The 4,160-volt circuit was conducted to a mine-owned switching station located some 500 feet away, near the shaft collar, by a three-conductor-plus-ground pole line. The incoming circuit was provided with lightning arresters, power-factor correction in the form of banks of capacitors, and overload or short-circuit protection by a master circuit breaker and two branch circuit breakers. The two branch circuits consisted of a surface-and-hoist circuit and the underground circuit. Switching-station breakers were of the "Magne Blast" type, rated at 1,200 amperes, and were provided with ground-fault protection by a conventional relay and current transformer arrangement. Breakers were provided with flags, to indicate prolonged overcurrent or short circuit, but with no such flags for ground faults. The main underground electric-power system did not out due to any overcurrent or ground fault at the time of the fire, but the underground power circuit was manually opened shortly after surface employees became aware of the fire.

The main hoist was of a double-drum type, driven by a single, reduction-geared, 1,000-horsepower, slip-ring induction motor, with primary potential 4,160 volts. Each 14-foot drum was equipped with an air-operated brake; overwind, overspeed, automatic-stop controls, a position indicator, and an adequate signal system were provided.

An auxiliary hoist was also provided near the shaft collar for the auxiliary man cage. It was driven by a variable-horsepower, variable-speed, 440-volt, 3-phase electric motor. The hoist was provided with automatic electric and hydraulic brakes. Emergency power for the hoist motor was provided by a 100-kilowatt generator, driven by a manually started diesel engine, located in the main hoist house. The auxiliary cage was controlled by pistol-grip-type controls at top and bottom of the shaft, and on the cage, and was equipped with limit switches (overwind). The hoist was in operating condition 1 hour prior to the fire, when it had been used by two surface employees to descend to mining level. When the fire occurred, the cage was on the bottom, and the control cables of the hoist were short-circuited by the effects of the heat on their insulation, causing erratic operation of the hoist, which finally resulted in the burning out of a small control transformer and the eventual outing of hoist-control circuit breakers.

Main electric power at 4,160 volts, 3-phase, was taken underground by two, 4/0-sized, 3-conductor cables, with galvanized-steel-wire armor and plastic-over-armor coating, commonly known as borehole cable, with both cables commonly connected to a single circuit breaker at the shaft-collar switching station. The borehole cables carried ground-fault current through the metallic armor, which was tied into the surface grounding network. The two cables were anchored properly at the shaft collar and clamped to shaft timbers at intervals down to the mining level.

One borehole provided power to a wye/wye connected, inert-oil-cooled transformer, 4,160/4,160 volts, rated at 1,500 kv.-a. The transformer served as a buffer against steep overloads, and the wye secondary midtap was utilized as a frame-grounding medium, with a grounding resistor, a current-transformer, and a relay arranged to protect against ground-fault transients. The 4,160-volt secondary provided power through a 4/0, type PCG cable to an inside transformer, which was rated at 600 kv.-a., 4,160/480 volts, connected delta/wye, with the wye secondary midpoint utilized as a grounding medium through a grounding-resistor-and-relay arrangement. The latter transformer provided 480-volt power to all electrical face equipment and to some of the underground salt-preparation plant equipment. All underground metallic switchgear, transformers, motors, and motor control stations were frame-grounded.

The other 4,160-volt borehole cable provided power to a 500 kv.-a., inert-oil-cooled transformer, 4,160/480 volt, connected delta/wye, with the secondary midpoint solidly connected to the transformer frame as a secondary grounding medium, and the transformer frame connected to the incoming 4,160-volt system ground. The transformer provided power to some of the salt-preparation plant, vibrators, skip-loader equipment, and the conveyor belts.

Other wiring in the shaft consisted of control and signal circuits and communication lines, utilizing cables of the SO (silicon rubber, oil-resistant) type. Circuits consisted of auxiliary man-cage controls, knocker signals, main ventilation fan control, and control and indicating circuits governing the skip travel and skip loading. Voltages ranged from 120 to 480 volts, and all circuits were provided with overcurrent protection. The cables were suspended in the shaft and clamped at intervals to shaft timbers.

Communication in the mine and to the surface was by sound-powered telephones, none of which depended upon mine electric power. Telephone cables in the shaft and underground consisted of 16-pair, shielded-type cable, which was suspended in the shaft and clamped to shaft timbers.

Underground lighting near the shaft bottom consisted of gasketed-and-enclosed, 220-volt light fixtures, with 100-watt globes. Wiring was of the MCC type (mineral insulation or metal sheathed, cotton covered conductors); the metal bases of the light fixtures were frame-grounded, and overload protection was provided.

The main fan, located underground, was driven by a 100-horsepower, 480-volt, induction motor, equipped with a magnetically operated across-the-line starter. The fan could be started and stopped remotely underground, and also started from the surface, by pushbuttons. It could not be stopped from the surface except by outing the main underground power circuits. The fan was provided with electrical overload protection, and with thermal protection on each of the two main fan-shaft bearings. The fan was coupled to the motor by a multiple-V-belt drive (10 belts) and provided with an audible alarm at the bottom, in event the fan stopped. A visible signal (lamp) was provided at the shaft collar. The fan received power through a 2/0-sized, type G cable from a transformer underground, and all metallic frames were grounded. Other electrical equipment in and near the shaft bottom consisted of a skip-loader belt conveyor, apron feeder, bucket conveyor and a screw conveyor. Motors of these units were provided with adequate start and stop controls, overload protection, and frame-grounded.

After the fire, it was discovered that the circuit breakers in circuits serving the sump bucket elevator, the sump screw conveyor, the skip apron feeder, and the skip-loader conveyor belt were all in a tripped position. The heat of the fire probably caused the cables to short-circuit, and, under this condition, the breakers would trip regardless of whether the equipment was running or stopped.

Electric face equipment, of the 480-volt, 3-phase type, consisted of a Goodman Universal rubber-tire mounted cutting machine, a Fletcher rubber-tire mounted face drill, a Fletcher AN-FO loading machine (jumbo), and a Fletcher roof-bolting machine on a telescoping platform arrangement, all mounted on a gasoline truck, the latter rig also used to scale roof and ribs. Trailing cables were protected from short circuits by safety circuit centers, and ground-fault protection for face equipment was provided by window-type (balanced flux) current transformers and tripping arrangement at the safety circuit centers, and additional ground-fault protection at the aforementioned 600 kv.-a. transformer. The frames of all electrical face equipment were checked daily for frame-to-salt-bottom potential.

Illumination and Smoking

Incandescent lighting was provided generally, but some of the men also used permissible electric cap lamps. Smoking was prohibited in certain designated areas but was otherwise permitted and practiced.

Fire Hazards and Fire Protection

It has been a not uncommon practice for salt mines to employ a great deal of wood for many purposes, some mines having even the headframe and contiguous buildings of all-wood construction. Basically, wood is used because salt is highly corrosive to common metals. There is also, however, a belief rather widespread among salt-mine people, that when the wood becomes coated and to some extent impregnated with salt, it will not burn. Apparently, serious fires have not previously occurred in any salt mine in the area, and remnants of timber removed from the Belle Isle shaft proved very difficult to ignite and burn in an ordinary bonfire. However, many materials considered normally fireproof or fire-resistant will, after preheating, and particularly in the presence of forced-draft air supply, be rapidly and entirely consumed by fire. Obviously, that is what happened on March 5 at the Belle Isle mine.

A safety inspection was made monthly, surface and underground, by a designated employee. The latest "Safety/Fire Prevention Check List" had been completed, signed, and dated March 5, 1968, the date of the fire. This was a form report covering many details at numerous locations; it gave evidence that the inspection and report had been made with diligence, as the report included several notations of varied hazards at specified locations, including absence of a fire extinguisher at each of two locations (of no seeming moment with regard to the shaft fire).

Waterlines on the surface were inadequate for protection at the shaft, and none was provided in the shaft or underground. The firefighting facilities underground were confined to fire extinguishers of several types at numerous locations.

Mine Rescue

Mine rescue teams were not maintained by any of the salt-mining companies in the area. Since the fire, arrangements have been started by Cargill, Incorporated, and the Bureau of Mines to provide a mine rescue station at Belle Isle Salt Mine, and to train at least two mine rescue teams in recovery and firefighting procedures, as well as to interest neighboring salt-mining companies in doing the same.

STORY OF FIRE AND RECOVERY OPERATIONS

Participating Organizations

Many organizations participated directly in the recovery operations or provided vital support services; because there were so many, it is not possible to give adequate recognition here to their individual contributions. It can only be said, that without their competent, experienced all-out performances, the job could not have been done. The Bureau of Mines herewith expresses its deep appreciation for the assistance from these other organizations. The list below, according them honorable mention, is but small thanks for what they did.

The American Red Cross
Berry Brothers Industries, Inc.
Berwick Fire Department
Cargo Carriers, Inc.
Commonwealth of Kentucky:
  Dept. of Mines and Minerals
Diamond Crystal Salt Company
Franklin Fire Department
Halliburton Oil Well Service
Humble Oil Company
Island Creek Coal Company
Mine Safety Appliances Company
State of Louisiana: State Police;
  Wildlife and Fisheries
Morgan City Fire Department
Morton Salt Company
Patterson Fire Department
Petroleum Helicopters, Inc.
The Pittsburg & Midway Coal Mining Company
St. Mary Parish Sheriff's Department
The Sun Oil Company
United States Coast Guard
Winston Brothers Company

The Governor of Louisiana, Hon. John J. McKeithen, visited the mine to offer use of any facilities which might be of help, in addition to the personnel of the State agencies named above, who were already assisting.

Activities of Bureau of Mines Personnel

Mr. Eugene F. Geist, office manager, Belle Isle Salt Mine, Cargill, Incorporated, contacted Mr. H. F. Browne, subdistrict manager, U. S. Bureau of Mines, Dallas, Texas, by telephone at 8 a.m., Wednesday, March 6, 1968, and informed him that 21 men were trapped underground as a result of a fire that occurred in the shaft, and that the last time that anyone had been able to communicate with the men underground was at 11:30 p.m. on March 5, 1968. Mr. Browne notified Mr. H. A. Schrecengost, district manager, Health and Safety District D, Vincennes, Indiana, of the occurrence, who, in turn, immediately relayed the information to the office of the Bureau of Mines at Washington, D. C. Upon instructions from Mr. Schrecengost, Mr. Browne, accompanied by Messrs. Roy Capps and M. G. Moore, safety representatives, proceeded by chartered plane to the mine. After some delay occasioned by fog at Dallas, they arrived at the mine about 3:30 p.m., Wednesday, March 6, 1968. Mr. A. M. Evans, mining health and safety engineer, who was on an assignment at El Paso, Texas, was advised by Mr. Browne to report to the mine by the quickest available means, and he arrived by airline through New Orleans at 10:30 p.m., Wednesday, March 6, 1968.

Mr. Schrecengost contacted other District D personnel, most of whom were working away from headquarters, and arranged for their transportation to the mine. The first group to be dispatched from District D headquarters at Vincennes, Indiana, included Messrs. J. A. O'Connor, supervisory mining engineer, R. W. Whittaker, coal-mine inspector (roof control), and J. R. Harvey, Federal coal-mine inspector from Benton, Illinois, and they arrived at the mine about 7:30 p.m., Wednesday, March 6, 1968. Messrs. C. M. Dovidas and D. E. Martin, Federal coal-mine inspectors, also dispatched from Vincennes, Indiana, were joined by Mr. Louis Zaverl, safety representative, Duluth, Minnesota, at New Orleans, and they traveled together in a company-chartered plane, arriving at Calumet, Louisiana, at the mainland office of the mine about 11:30 a.m., Thursday, March 7, 1968. Upon their arrival, they were informed by Mr. Browne that they would not be needed for duty until 11 p.m., when a shift change was to be made. This group reported at the mine at 10 p.m., on Thursday, March 7, 1968.

Since trained mine rescue teams were not available in the area, the company requested Mr. Schrecengost to secure the services of rescue teams, if possible. Officials of Island Creek Coal Company, West Kentucky Division, Madisonville, Kentucky, and the Pittsburg & Midway Coal Mining Company, Sturgis, Kentucky, were informed of the company's plight. They readily agreed to offer assistance, and each company sent a fully-equipped mine rescue team, and their respective safety directors, Messrs. Raymond Ashby and William Meadows. Mr. Lawrence Risley, District Supervisor of the Madisonville office, Kentucky Department of Mines and Minerals, informed Mr. A. H. Mandt, Commissioner of the Department at Lexington, Kentucky, of the decision of the coal-mining companies to send mine rescue teams and was directed to accompany the teams, and to render the Department's assistance in whatever capacity he felt necessary. The team members had to be summoned from different mines where they were working; the group left Madisonville, Kentucky, at 6:30 p.m. in a chartered plane, and they arrived at the mine at 10:30 p.m., Wednesday, March 6, 1968.

Mr. F. C. Memmott, Associate Director--Health and Safety, was notified at the Bureau's Washington, D. C., headquarters and arrived at the mine at 9 p.m., on Thursday, March 7, 1968. Mr. James Westfield, Assistant Director--Coal Mine Safety, arrived at the mine about 5:30 a.m., on March 7, 1968.

Bureau of Mines personnel, as well as the mine rescue personnel from Kentucky, traveled by commercial or company-chartered plane, or a combination of both, to Patterson Airport, located approximately 7 miles west of Morgan City, Louisiana. From Patterson, they were either airlifted to the mine by helicopter or driven 6 miles to the company's Calumet landing, chiefly by the Louisiana State Police and the Sheriff's Department of St. Mary Parish, and then ferried 13 miles by boat to the mine.

When Dallas personnel reached the mine and learned that mine rescue teams would be arriving, Roy Capps advised company personnel on clearing a building, setting up work tables, providing cylinders of oxygen, and otherwise improvising a highly suitable rescue station for a base of operation for the teams, and for servicing their equipment. Next day, when it was seen that the recovery operations were moving slowly, it was suggested that cots be provided. The company had reserved motel accommodations at Franklin, but because of the time involved in travel, the team members were reluctant to leave to obtain rest, lest they be needed. Cots were then obtained from the National Guard.

The Bureau was able to supply supplemental mine rescue equipment and supplies from Vincennes and Birmingham. Bureau representatives Capps, Dovidas, Harvey, Martin, Moore, and Zaverl assisted with design, prefabrication, and underground erection of a structure to serve as a fresh-air base, accompanied rescue team members on exploratory trips and recovery of victims, and serviced gas masks and oxygen-breathing apparatus at the underground fresh-air base to expedite the exploration. Capps also trained company personnel to wear respiratory protective equipment, so that they might operate diesel equipment underground when it was found safe and expedient to do so. A company truck on the surface was used in the training, to familiarize the men with wearing the protective equipment while operating vehicles.

In addition to advising with all concerned parties, other Bureau personnel made continuing tests of the shaft atmosphere at the collar, which kept slightly upcast, and later also made continuing tests for CO and NO_2 in the compressed-air lines supplying the fresh-air base. In addition, they helped to service instruments and rescue equipment on the surface.

Evidence of Activities and Story of Fire

The day's activities on March 5, 1968, were reconstructed from brief entries in the hoist operator's log, supplemented by statements of the second-shift hoistmen and other mine personnel. The day shift went down at 7:40 a.m. There were no barges available for loading. Salt preparation and maintenance work were carried on underground, and dynamite in conventional cartons was lowered in the north cage and placed in the magazine from 11 a.m. to 3 p.m. At 3:11 p.m., hoisting and barge-loading of salt was started. The night shift relieved the day shift underground at about 3:30 p.m., and the day-shift crew was hoisted. Hoisting of salt was resumed and continued for about 6 hours. For the period 9-10 p.m., the log showed 39 skips hoisted, followed by the remark: "Stop hoist 9:49 No barge." Nothing unusual had occurred up to this time on this date, and no maintenance work had been done in or about the shaft on either shift up to this time.

When out of barges, it was customary to continue mining and processing, and to divert the crushed salt into the underground storage chambers. The night shift had been working overtime regularly, and on this day it was scheduled to continue crushing until 1:45 a.m. In the early part of the shift, 18 men were underground, and seven on the surface; the latter, locally called "topside" employees, included a hoist operator and a relief hoist operator, a skipper who piloted the company crew boat between Belle Isle and the Calumet landing, a loading-dock operator, a barge loader, a topside foreman, and a watchman (who actually worked the third shift). After the available barges had been loaded, the loading-dock crew went underground to complete their shift, bringing the number underground to 21 men. These last men went below in the auxiliary cage about 10:25 p.m.

A maintenance crew on this shift was scheduled to lubricate the skips and the skip loader, and to make any needed repairs. This routine was performed at least once a week, and, so far as feasible, when there were no barges to be loaded. The usual procedure was for the maintenance men to bring their equipment, lubricant, compressed-air grease gun, compressor, and arc welder from the underground shop area, using a military-type Jeep. Oxyacetylene equipment was kept on a hand cart at a safe distance from, but convenient to, the shaft. Thus, all necessary equipment was at hand at the mining level shaft station.

It is not known definitely what, if anything, besides lubrication, was required to be performed this night, but, after the fire, all the named equipment was found not far from the shaft, and the indications were that all had been used, except, possibly, the arc welder.

The lubrication routine was, of course, known to the hoistmen. All signals for movement of the skips were given by a conventional shaft pull-switch electrical system, still commonly called a "knocker." At approximately 10:15 p.m., the maintenance men signalled for the north skip. It was lowered to about 4 feet of the mining level floor. The skip units were approximately 32 feet overall, including the man cages. At the bottom of the frame on each side were three solid-rubber-tired stabilizing rollers, which ran on three faces of the respective wooden guides. About midpoint was a shaft, on which the unloading chute at the bottom of the skip bucket rotated, when dumping in the headframe. At the top of the frame were three rollers on each side, identical with those at the bottom, and, just below them, the mechanism of a common type of spring-loaded, toothed-cam safety catches. By signals, the hoistman moved the cage to permit reaching bottom, middle, and top grease fittings. The next step was to tie off the skip at mining level and call for slack in the rope, to test operation of safety catches. The usual time for the full procedure for one skip was about 15 minutes, and, although the hoistman did not record the exact time, all went as usual, and he judged that the elapsed time was about 15 minutes.

Next, the mechanics called for the south skip, and went through the same routine. The time worked on the south skip was estimated as also about 15 minutes.

Then they called for the north skip again. After the north skip was sent down, there was a slight delay at the mining level, while, as the hoistman assumed, the mechanics "put whatever stuff they needed on the cage to work down below." As explained before, the cage of the north skip was the only one kept in condition to handle men and materials. They then belled to be lowered to the skip loader, stayed there about

10 minutes, and were hoisted to mining level. Shortly, they went back down to the skip loader, stayed longer this time, came back to the mining level, and gave the signal releasing the north skip at 11:20 p.m.

This would ordinarily signal completion of the lubrication-repair work, and someone would then telephone the hoistman and report the job finished. This time, however, they immediately signalled for the south skip again, a most unusual occurrence. After the south skip had been landed at the mining level station for something like 5 minutes, someone released it by the knocker, and the hoistman received a call by telephone: "Come down with the north side; the shaft is on fire."

The hoistman lowered the north skip, which required about 1 minute. In his haste, he overshot the landing slightly, but quickly recovered position. After 2 or 3 minutes, someone gave six or seven rapid signals; then the same man who had called before telephoned again: "The skip is on fire; we can't get on it." By now, it would appear to have been close to 11:30 p.m.

The hoistman recognized the voice of the caller as that of Roy Byron, a topside man. While the hoist operator was still on the phone, Paul Granger, the underground foreman, cut in and said: "Go to the radio, get some help, get a lot of help." He repeated the exhortation three times. Immediately another voice, unrecognized, repeated three or four times, "Pour some water down the shaft." This was the last communication from the men underground to the surface, and later attempts to call from the surface were fruitless. There was thus no indication of how the fire started, nor exactly which part of the shaft was aflame.

The hoistman, Clomere LeBouef, raised the north skip about 30 feet. He could not recall exactly why, but it is customary for hoistmen to take cages away from landings, so that no person may get on a cage without calling for it and thus making it known to the hoistman that some person will be riding it. He was thus probably acting from habit. He then called the relief hoistman, Larry Granger, by telephone, told him of the fire, and instructed him to start running water down the shaft.

For some time prior to being summoned to the telephone, Granger had been shoveling salt spillage from atop the steel enclosure housing the intake-air compartment above the shaft collar. He had been loading it into the south skip, which was positioned above the collar while the mechanics were at the skip loader with the north skip. After LeBouef moved the skips in response to signals from below, both skips were below the shaft collar. Granger then went down to the roof of the air lock to the intake-air compartment, which was 5 feet below where he had been working, and also farther from the skip (upcast) compartment, and started shoveling salt from this lower level to the higher level. While so engaged, he became aware of salt particles dropping on and around him, and, as he looked upward, he observed smoke. The upcast air, discharged at high velocity from the shaft, escaped near the top of the headhouse, and, presumably, the now-heated upcast air was drying out the normally moist salt fines adhering to the upper structure, which then started to rain down on Granger.

At about the same time that he observed the smoke, Granger got the signal from LeBouef and went to a telephone. He then went back, as directed, to the shaft area and set about getting water down the shaft. There was a 1-1/4-inch pipeline for fire protection in the gallery housing the surface belt conveyor from the shaft to the loading dock. The line ended a short distance from the shaft, and was used on occasion to wash down the collar area. It was supplied by a pump at the loading dock. Granger found that the hose, usually kept near the end of the line, was missing.

LeBouef had gone to the office and had tried to raise the mainland marine-mobile operator on the radio-telephone. Failing to make immediate contact, he asked the watchman to take over, while he went to help Granger. Together, the hoistmen got a gravity-flow hose line to the shaft from the nearby 20,000-gallon-capacity, fresh-water tank.

Then LeBouef instructed Granger to center the two skips in the shaft, hoping, he thought, to save at least one. The reasoning is not clear, but, as events transpired, it is of no moment. Sometime after midnight, the hoistmen observed that both hoisting ropes (cables) were sagging between the head sheaves and the hoist, indicating that the heat had severed both, and the skips were lost.

The hoistman remembered an admonition from safety meetings, that if there should be trouble below, the underground electrical circuits should be deenergized at the surface. He also observed that the fan was no longer circulating air in the shaft, and he reasoned, that if the men underground had not stopped the fan, then the curtain wall had burned through, and the fan would be circulating carbon monoxide throughout the mine. Therefore, he killed the underground power at a time he estimated as 25-30 minutes after the reporting of the fire, and his estimate appears close. An electric clock at the screening plant underground was later observed to have stopped at 11:58. The public service company provided a copy of the demand chart from the metering point; it was calibrated in 4-hour increments, and, as nearly as it could be interpolated, the load had dropped abruptly to minimum at very close to midnight, March 5, 1968.

At about 11:45 p.m., the watchman was in contact with the mine superintendent in Franklin, Louisiana, but the transmission was garbled. The crew-boat skipper took over the radio-telephone, and the watchman went to help the two hoistmen at the shaft. At about 11:55 p.m., the skipper got through to the mine superintendent, and was directed to bring the crew boat in to the landing.

The superintendent notified key mine officials and made arrangements for notification of the Coast Guard, Minneapolis company officials, Bureau of Mines, and anyone else who might render assistance.

The skipper of the crew boat and another man from a nearby operation of the Sun Oil Company, while en route to their dock at 12:10 a.m., March 6, 1968, saw the smoke billowing from the headhouse, and they put in to the mine dock to offer their help. Learning of the missing hose, they went back to their operation and procured a hose, but, when it had been attached to the gallery pipeline, it was found that the fire pump at the loading dock had lost its priming, although it had, reportedly, been operating normally at about 8 p.m. The mine crew boat returned at 1:40 a.m., March 6, 1968, bringing the staff officials. The fire pump was quickly put into operation, but more than 2 hours' time had been lost.

In the absence of forced ventilation, the shaft was breathing periodically, and, on the downdraft of the cycle, the smoke would clear, and it could be observed that the upper 200 feet, at least, was not afire. Nothing further could be done, however, until more firefighting equipment should arrive. Within the next 2 hours, Sun Oil, Halliburton, and U. S. Coast Guard vessels, as well as barges carrying fire engines from Patterson, Berwick, Franklin, and Morgan City, were lying to in the bayou, and six hose lines, varying in diameter from 1-1/4 to 6 inches, were playing water down the mine shaft. Pumping was continued until about 3 p.m., Wednesday, March 6, 1968, when it appeared that the fire had been extinguished.

While water was still being directed down the shaft, and thereafter, repeated attempts to communicate with the men underground by telephone proved futile.

Mr. Eugene F. Geist, office manager, placed calls to various contractors and to nearby salt and oil companies for supplies, equipment, and workmen. He also obtained the services of various agencies, such as Sheriff's officers, village police, and the Louisiana State Police, and, as mentioned previously, he arranged for the services and transportation of the two Kentucky mine rescue teams.

Recovery Operations

Messrs. F. Clayton Tonnemaker and C. Robert Burge were in New Orleans, Louisiana, when they were notified of the fire. As soon as they reached the mine, Mr. Tonnemaker assumed charge of the firefighting and rescue and recovery operations, and remained in charge throughout the entire emergency. He formed a strategy committee consisting of Cargill, Incorporated officials, representatives of the Bureau of Mines, and oil-field contractors; the safety engineers of both rescue teams later became part of the committee, and next day, Washington officials of the Bureau, also. The decisions and recovery procedures adopted by this committee were strictly adhered to during the 7 days spent in recovery work.

When the heat and smoke had died off, an inspection was made of the soot-covered headhouse, including the entire headframe, sheaves, and wire hoisting ropes; with the exception of the ropes, no damage was found above the collar of the shaft which might endanger persons attempting to travel in the shaft. However, upon prior advice from Mr. Schrecengost, company officials decided that no person would be lowered into the mine until the arrival of the two mine rescue teams from Kentucky, with sufficient competent personnel and adequate, proper equipment.

An oil well survey line, known as a "wire line," which is a small diesel-powered hoist, equipped with 20,000 feet of No. 12 gage, very-high-strength steel line, and a footage indicator, was brought to the shaft collar. A sheave was rigged over the south skip compartment, and a 2-inch by 4-foot barrel was attached to the line; probing disclosed a number of obstructions. Shifting to the north compartment, the barrel was successfully lowered to mining level at several locations across the area, indicating that the north compartment was reasonably clear of obstructions.

The damaged north hoist rope was removed, and a 1-inch nonspinning rope, provided by a neighboring salt company, was secured to the north drum of the hoist. A 3- by 5-foot cage had also been sent in from a neighboring mine. It was suggested that it needed some modification. A team of oil-field welders set about providing side panels from the waist-high handrail to the floor, and a gate to permit men wearing apparatus to enter and exit. The gate evolved into a tall dropgate, which could serve as a gangplank from cage to landings. The cage was attached to the rope, and bags of salt were placed in the cage to simulate more than the weight of several men, and to stabilize it for a trial run.

Planners of recovery procedures were confronted by a situation where a shaft approximately 1,200 feet deep, damaged to extent unknown, must be traversed before mine rescue teams could begin to explore the mine workings. This situation involved departure from mine rescue procedures established from long years of experience, whereby a complete mine rescue team advances not over 1,000 feet, maximum, on level ground, under the best conditions, and then only when backed up by another complete team at the fresh-air base. Some of the difficulties encountered and overcome are related, for what such details may be worth in any future similar situation. For brevity, the events are recorded in the form of a log, where feasible; however, it has been necessary to include some narrative where explanation of procedures seems desirable.

March 7, 1968, Thursday

1:10 a.m. Trial run, cage. As the cage was lowered slowly, it kept turning to a diagonal position and fouling on the sound timber sets below the collar of the shaft. In view of the nonspinning rope, this was puzzling, until it was observed that its bail was welded solidly to two diagonally opposite corners of the frame. The clevis was thus alined at 45 degrees, also, and so, the rectangular cage could not possibly be kept oriented with the rectangular skip compartment. (Someone then remembered that it was normally used for inspection of a circular untimbered shaft.)

The rescue teams had been briefed and were standing by and ready, but it was obvious that the rectangular cage was unsuitable. It was then decided that a cylindrical shape would reduce the chance of snagging on timbers. The team of oilfield welders immediately set about to fabricate a cylindrical cage from scratch, while calls were being made to try to locate a large sinking bucket in the vicinity. At about the same time, one of the rescue men pointed out the possibilities of using the casing of a spare fan on hand. While some of the welders continued working on their original design, others cut the vanes, spider, and rotor out of the fan and welded in a floor. This made a bucket 42 inches in diameter and 48 inches deep. To help guide the cage through possible obstructions in the shaft, four pieces of 3-inch pipe, each about 10 feet long, were welded to the outer side, lengthwise, and equidistant around the periphery. The projecting ends were then bent and tapered inward above and below the bucket, so as to act like sled runners and glide off obstructions.

3 a.m. Test oxygen at mine level. A lighted flame safety lamp, a pencil, and a notebook were secured to the barrel of the wire line. The line was paid out to just below calculated mining level, but, when retrieved, it was evident that the barrel had been immersed in water, and the lamp had been drowned out. This indicated that the shaft was filled up to mining level with water used to extinguish the fire.

3:35 a.m. Second oxygen test. After recalculation of desired footage, the lamp was lowered and retrieved burning, indicating adequate oxygen to support life; the pencil and notebook and walkie-talkie radio, which had also been attached to the barrel on this try, were undisturbed indicating no person at the mining level.

4:55 a.m. Trial run with bucket improvised from fan casing, loaded with bags of salt. Round trip to mine level and return without hang-up.

5:35 a.m. Prepare to lower men. One member of each mine rescue team had volunteered for the first trip. When they took positions back-to-back, so as to be able to observe, and also to stabilize bucket against oscillation, clearance between the two units of oxygen-breathing apparatus was not sufficient to allow freedom of movement. Since the oxygen content of the atmosphere had been found adequate, and carbon monoxide was indicated as 0.02-0.04 percent, they switched to universal gas masks. Walkie-talkie radio was used to maintain constant communication between bucket and shaft collar. On all subsequent trips, at least one man stayed at the shaft station below, while others moved about. By telephone between the shaft collar and a second man at the hoist, the position of the bucket was constantly logged.

6 a.m. Drop No. 1. Holmes and Holeman.
Objective: Determine general conditions in shaft; if feasible to reach mining level, do not leave bucket; determine effectiveness of walkie-talkie communication.
To -369 feet, end of concrete lining, shaft timbering relatively unaffected; concrete spalled in places.
Below this point, fire damage increasing progressively.
At -455 feet, center guide burned out.
At -677 feet, all timber burned out.
Not familiar with normal conditions, but slabs of salt on shaft walls at a number of places apparently loose.
At -1,163 feet, stopped bucket. Shaft below station floor here is full of water. Active fire of limited extent near fan. Diesel engine idling, not far away. CO during descent and at bottom 0.02 percent. Safety lamp burning with flame about normal. Atmosphere in lower shaft and at bottom very hot and smoky. All timber at station burned out.

As the bucket was ascending, one of the rescue men suffered a bruised left shoulder, when struck by salt falling from shaft wall. A steel bonnet was then fabricated and installed.

11:05 a.m. Drop No. 2. Holmes, Gregory, and Pinkham, assistant superintendent.
Objective: Extinguish fire, and try to establish contact with men.
Additional equipment carried: grappling hooks, pressurized water fire extinguishers, pails to bail water, rope, and a bull horn.
Grappling hook thrown into debris at shaft station holds well; bucket pulled over to station and secured.
Expended extinguisher contents, and bailed water from shaft. Water in sump very hot. Fire in remains of fan bulkhead apparently extinguished.
Oxygen and carbon monoxide as before. Atmosphere very hot and smoky.
After efforts in extinguishing fire in the hot and humid environment, they felt physically unable to try to reach diesel engine to shut it down.
Calling with bull horn; no response.
12:10 p.m. Crew landed at surface.

This second recovery group recommended that a fresh-air base must be established at the mining level to expedite recovery. To avoid entanglement of the bucket with snags of timber and protruding bolts in the midsection of the shaft, possibly causing dislodgment, and precipitating serious injury to rescue workers, or at least obstructing travel completely, it was required to keep rope speed to a crawl, and to make frequent stops to damp oscillations of the bucket. Each one-way trip required 20 minutes, so that preparation to descend, and the round trip wasted away nearly half the usual life of a canister or an apparatus charge. Men were exposed to the heat during travel, as well as below, which sapped vitality and limited their effectiveness. If fresh air could be conducted at least to the mine level station, it being obvious that it could not be conducted farther, the rescue workers could have occasional respite, and they could be working from the station, while others came down to relieve them. Since it was not feasible to install ventilation tubing, it was decided to run compressed-air lines down the shaft.

Berry Brothers Industries, Inc., an oilfield construction company, had brought in a barge, carrying a crane, clam shell, bulldozer, air compressors, pipe, tools, and an oilfield crew. A substantial platform was constructed over the south skip compartment to serve as a work deck, and to support tongs and several strings of 2-7/8-inch I.D. oil well tubing. The deck was placed and the first string of pipe, approximately 1,200 feet, was run in total time of 2-1/2 hours. It was estimated that the line should deliver 750 cubic feet of air a minute, not enough to be considered ventilation, but the air movement was expected to provide some relief for rescue men.

4:55 p.m. Drop No. 3. Blair, Reynolds, and Gustafson, mine engineer.
Objective: Couple hose to steel air line, to conduct air to shaft station.
Clear debris at landing. Explore if time permits.
On bottom 5:12 p.m. No fire observed near fan.
At 5:30 p.m., hose coupled; turn on the air.
Clearing some debris, to facilitate getting in and out of bucket.
Environmental conditions unchanged.
The telephone line, with phone and blinking battery-powered light, lowered down the south side, is at mine level and functioning.
Up to 50 feet from shaft can still communicate by walkie-talkie to the collar.
Farther away the signal is lost.
6:35 p.m. Returned to surface.

Three men with gear were quite crowded in the improvised fan-casing bucket, and, when the rescue men advised that a bucket of larger diameter would clear, the welders completed building a bucket which accommodated four men and their gear. More air was needed at the station below.

11:30 p.m. Second air line in. Calls for more oil tubing brought delivery in record time, under the circumstances of water transportation, and a second string had been run down the shaft in about 1-1/2 hours. The second compressor was started; this was a 500 c.f.m. unit.

March 8, 1968, Friday

12:45 a.m. Drop No. 4. Holmes, Gregory, Holeman, Dovidas.
Objective: Explore.
The larger bucket is riding much better. (The hoistman now knowing locations where timber snags required slow speed, the drop time was reduced to 13 minutes.)
Less smoke now. Oxygen O.K. CO - 0.04 percent. Temperature 90-94 degrees F., at different points.
Three men checking fan area. Found glowing embers.
Found 10 or more extinguishers around corner of pillar at room 1. Some empty.
Taking two water extinguishers to fan.
(It was obvious to mine officials on the surface that the group of extinguishers had been collected from other points and used in a futile attempt to extinguish the fire in the shaft.)
1:23 a.m. All four at shaft and fire at fan is out.
Three men went toward diesel sound. Found a front-end loader around the corner in room 1, about 150 feet from shaft; shut engine down. Another similar unit ahead of it. No sign of men; no footprints in soot.
One man stopped at intersection, and two explored magazine area 500 feet from shaft; found nothing.
CO, oxygen, temperature, no change.

All came back to shaft and rested briefly in front of air line; moving air gave considerable relief; also cooled canisters, which were hotter than they should be, according to detector readings.
Two men staying at shaft; other two will explore in 1st main entry south.
Located Jeep and compressor about 350 feet from shaft with compressor still coupled to Jeep. (This could indicate that the Jeep was taken away hurriedly from the shaft, because of its gasoline tank. Ordinarily, maintenance men would park compressor here and take Jeep to shop area.) Found another front-end loader and a haulage truck, 30 feet inby Jeep. (All the heavy equipment should be far inby; why was it brought to shaft area?)
No signs of men; no footprints on soot-covered floor.
Explored farther same entry; crossed to 2nd main entry south, between 1st and 2nd main entries west; searched office, shop, and supply house.
No men; no notes left. Returned to shaft.
2:04 a.m. Four above men on surface.

3:15 a.m. Start third air line. Drilling crew started third 1,200-foot string of oil well tubing. Finished at 4:30 a.m., 1-1/4 hours. Third compressor started.

5:10 a.m. Drop No. 5. Henderson, Steele, Martin, Dovidas.
Conditions unchanged. Two men stayed at shaft. Two went around the corner into 1st main entry south and searched around the screening plant between blocks 36 and 28. Going down to the sublevel, they encountered water of unknown depth, and the heat was intolerable; it was apparent that there could be no survivors there.
After a short rest and refresher at the air lines near the shaft, they walked to the raw-salt dumping station, beyond the screening plant. No sign of survivors.
They explored 2nd main entry east and entrances to rooms 1 through 6.
Again, no sign of the men.
Flame safety lamp burned with near normal flame, and CO was 0.04 percent at the mouth of room 6. Thermometer reading at shaft and several inby points was 92 degrees F.
Returned to shaft.
6:48 a.m. Four men returned to the surface.

9 a.m. Drop No. 6. Holmes, Blair, Patterson, Gustafson, mine engineer.
Objective: Continue exploration.
The mine engineer was familiar with the workings, and the potential pitfalls in active and abandoned areas where there were drop-offs to the lower level, and it was intended to use the Jeep.
Uncoupled compressor, but then found Jeep battery discharged.
Two stayed at shaft; two proceeded afoot, systematically exploring the east side, where men would have been working.

After combing the entire area east, they found 16 men huddled at the farthest point of development southward on the east side, at the intersection of room 2 and 4th main entry east. All were unmistakably dead. Oxygen and CO conditions were about the same throughout the east area and at the shaft.
10:40 a.m. Four men reached the surface.

12:15 p.m. Drop No. 7. Lee, Dupree, Reynolds, Dovidas.
Objective: Account for five other miners.
Two stayed at shaft; two others picked up where group No. 6 had stopped, and working westward, found five men, all lifeless, at and in room 1, 3rd main entry west, about 1,100 feet from the first group found.
Oxygen unchanged; CO at room 1 the highest yet indicated, 0.10 percent.
1:40 p.m. Four men reached the surface.

At this point a conference was held to discuss future needs and procedures. It was decided that the primary need was something resembling a true fresh-air base. The compressed-air lines were beneficial, but, discharging into the contaminated air, they were only a weak palliative. It was decided to build a chamber at the mining level station, where self-contained oxygen-breathing equipment could be kept and serviced. Gas masks were still suitable for shaft travel, and the apparatus could be used by most of the workers underground while recovering the victims, hoping that the stimulating effect of the oxygen might help counteract the debilitating effect of the heat.

Since it had been determined that there were no survivors, and that recovery of victims would be a slow proceeding because of the mine temperature and humidity, recovery operations were suspended to give everyone involved a much-needed rest. This applied to company employees and officials, the contractor, contract welders, Sheriff's officers, State Police officers, the Coroner and other physicians, as well as actual mine rescue workers, most of whom had been working for several days practically continuously.

March 9, 1968, Saturday

Materials were procured from the mainland, and the frame for a 14- by 16- by 8-foot structure was fabricated of 2- by 4-inch lumber and erected on the surface. Framing members were cut to facilitate transportation, then overlap-spliced and bolted. Pieces were numbered and disassembled, and, with transparent plastic sheeting, were taken underground. The frame was reassembled by a rotating crew, using one man to pilot the "empty" bucket up and to radio signals to control hoisting, as the damaged shaft timbering was still a hazard, more so with men working below. The sheeting was applied inside the frame to withstand the pressure from the compressed-air line.

1:44 p.m. Drop No. 8. Gregory, Holeman, Patterson, Dovidas.
Prepare place for fresh-air chamber, about 50 feet straight ahead from shaft, in room 1, at the surge bin. (Appendix G)
2:18 p.m. Gregory back at collar.

3:05 p.m. Drop No. 9. Gregory and materials lowered.
Materials unloaded and taken to erection site.
3:49 p.m. Gregory, Holeman, Patterson, Dovidas at surface.

4:02 p.m. Drop No. 10. Henderson, Steele, Gregory, Martin.
Start erection of fresh-air chamber.
4:32 p.m. Gregory at surface and relieved.

4:45 p.m. Drop No. 11. Reynolds, Simpson, and materials.
Unload materials, carry to site.
5:26 p.m. Reynolds returned to collar.

5:42 p.m. Drop No. 12. Reynolds, Dovidas, Harvey, Aucoin, Cargill mechanic.
Procured truck at raw-salt dumping station at intersection of 1st main entry south and 2nd main entry east. Drove it outby and started front-end loader in 1st main entry south with jumper, and brought it to shaft area.
6:56 p.m. Steele, Henderson, Simpson, Martin reached surface.

7:30 p.m. Drop No. 13. Reynolds, Blair, Lee.
Continue work on fresh-air chamber.
8:06 p.m. Aucoin, Harvey, Dovidas reached surface.

8:13 p.m. Drop No. 14. Patterson.
Continue work on fresh-air chamber.
9:24 p.m. Reynolds, Blair, Lee, Simpson, and Patterson reached surface.
Operations suspended for the night.

March 10, 1968, Sunday

10:59 a.m. Drop No. 15. Steele, Reynolds, Aucoin, Martin.
Started front-end loader and ran it briefly.
Attached manifold to compressed-air line in chamber to diffuse air, also to dissipate pressure. Then, for door, hung drop sheet, to allow pressure relief and airflow. Fresh-air chamber ready for equipment.
11:40 a.m. Reynolds, Aucoin returned to surface.

11:50 a.m. Drop No. 16. Reynolds, Henderson, Harvey, Zaverl.
Took down oxygen-breathing apparatus and supplies.
12:52 p.m. Reynolds, Steele, Martin returned to surface.

1:05 p.m. Drop No. 17. Blair with more apparatus.
Henderson, Zaverl still below readying equipment.
1:49 p.m. Blair on surface.

2 p.m. Drop No. 18. Holeman and materials to handle bodies.
2:35 p.m. Holeman, Henderson, Zaverl on surface; all out at this time, and preparations on bottom completed.

3:07 p.m. Drop No. 19. Holmes, Dupree, Patterson, Gregory.
3:49 p.m. Patterson on surface.

3:54 p.m. Drop No. 20. Patterson, Aucoin, Harvey, Martin.
Aucoin, Harvey, wearing gas masks, handling front-end loader; others using breathing apparatus; start inside. Radio contact man at fresh-air chamber.
Brought five victims to bottom. Changed to gas masks for ascent.
6:30 p.m. Four rescue men on surface.

7:30 p.m. Drop No. 21 completed, bringing last of seven rescue workers to surface; shortly thereafter operations secured for the night.

March 11, 1968, Monday

7:36 a.m. Drop No. 22. Aucoin, Moore, Capps, Zaverl.
Start front-end loader, service apparatus and instruments.
9:29 a.m. Returned to surface.

10:10 a.m. Drop No. 23. Holmes, Dupree, Lee, Dovidas, Aucoin.
Remove victims from front-end loader, and change to oxygen apparatus.
Went back into mine workings and prepared some of victims for transportation.
Returned to fresh-air base, switched back to gas masks.
12:58 p.m. Above five men on surface.

2:10 p.m. Drop No. 24. Gregory, Reynolds, Patterson, Henderson.
Naul Vice of Cargill to operate equipment.
Continued work of group in previous drop.
4:56 p.m. Above five men on surface.

Heavy weather warnings had been out most of this day, and, while this last group was still in the mine, the warnings became more urgent, and the helicopter and light amphibian planes were ordered to the mainland to tie down. Departure of the aircraft left no fast means of transportation in event of an injury requiring hospitalization, or for other emergency. In addition, heavy fog was rolling in fast, threatening to make water navigation dangerous, and it was decided that all personnel should evacuate the mine area. The fog continued to thicken, but the expert pilots navigated the bayous on radar and landed all personnel safely.

March 12, 1968, Tuesday

7:27 a.m. Drop No. 25. Zaverl, Moore, Capps, Aucoin.
Unload supplies, start front-end loader, prepare apparatus for team use. With compressors down overnight, the CO indication in the fresh-air chamber was 0.04, same as mine atmosphere. In a short time the compressed air purged the base.
9:42 a.m. Above four men on surface.

10:11 a.m. Drop No. 26. Holmes, Lee, Dupree, Aucoin, Dovidas.
Completed work started previous day, bringing the last of victims to the bottom.
12:34 p.m. Above five men on surface.

1:15 p.m. Drop No. 27. Gregory, Steele, Patterson, Martin.
The welding team was fabricating a large compartmented steel chest to be slung below the bucket. Travel in the shaft in the free-swinging bucket was still touchy, and it was thought that all victims might be brought up in one trip, rather than one at a time. The above group went down to size up the feasibility of landing the chest with the help of a line to the front-end loader.
2:14 p.m. Above four men at surface. Reported handling feasible at bottom; however, the large unit later proved too cumbersome to be handled at the headframe, without changes which would consume considerable time, and the idea was abandoned.

4:10 p.m. Bring up victims. Starting here, a series of drops was made, rotating rescue men and "pilots" in the bucket.
10:15 p.m. All victims at shaft collar.
All company and mine rescue men on the surface.
10:52 p.m. All Bureau personnel returned to surface; recovery operation complete. Operations secured for the night.

March 13, 1968, Wednesday

9:28 a.m. Recover rescue equipment. Bureau employees Capps, Zaverl, Moore, and Dovidas made two drops to recover oxygen-breathing apparatus and other equipment.
11:17 a.m. Above men returned to surface; all men and equipment secure.

Much of the foregoing detail, and the comments following, are intended for the information of those who have been, or continue to be, involved in rescue and recovery operations after mine disasters. Nearly every such instance is a case in itself, with its own particular hazards and complications. In this instance, the temperature and humidity, with no air movement, created an atmosphere which was unique in the experience of the rescue team members and Bureau personnel involved. To say that conditions were debilitating, is to state the case mildly. As the appended mine map indicates, the extent of the horizontal workings was limited, yet the recovery required a full week, only part of which was attributable to the limitations of shaft transportation by bucket.

It was utterly impraticable to try to reestablish ventilation before searching for possible survivors. The compressed-air lines were helpful in providing some air movement, and the opportunity for an occasional breather and cooling off at the mining-level shaft station, and the rescue workers are grateful to the oilfield crew who strung these lines, as described previously, in what must be some sort of record for time.

The air chamber provided means by which five men could ride the bucket wearing gas masks, as against three or four with oxygen-breathing apparatus. Since it was necessary to leave one man always at the shaft station for radio communication, at least one more man was thus made available for recovery work. By sending down a team to service the apparatus in advance, the rescue men could descend with gas masks, switch quickly to apparatus, and switch conversely on their return, thereby, having available the nominal 2-hour capacity of the oxygen apparatus for exploration and recovery work at mine level.

In fact, however, it was seldom that the rescue men could endure the environment for a full 2 hours. At one stage, the apparatus oxygen bottles were immersed in an ice-water bath before use; however, the bottles assumed mine temperature in a short time, so that the relief to the wearers was short-lived, and the stratagem was abandoned.

After the one air line had been extended into the fresh-air chamber, a complaint was received that the air was hot, and that the line was suffusing the chamber with petroleum fumes. Some of the oil well tubing was of the "used" classification; apparently, the heated air delivered by the compressor was vaporizing residual oil coating the tubing. The welding team then devised a refrigeration coil, or heat exchanger, by cutting and welding the tubing into a flat labyrinth, which was interposed into the line between the compressor and the shaft. Helicopters, meanwhile, flew in several tons of ice, which, with salt added, was packed over the coil, and, in a matter of minutes, the line was visibly frosted at the shaft collar, the vaporization was overcome, and the air below was refreshing. Again, the competence of the welders merits commendation; no time record was kept, but from conception to completion, the refrigeration unit was in service in not over 2 hours.

Company employees were apparently not affected by the underground atmosphere to the same extent as were the others; they modestly claimed that they were accustomed to the temperature, and that they merely operated mobile equipment, while others did the work. Nevertheless, their courage in joining in the recovery work, without previous experience, and their competence under fire must be highly commended. Without the use of the mobile equipment, it is difficult to conceive how the recovery could have been effected.

Another item of interest was the behavior of carbon-monoxide detectors. Three different instruments, one colorimetric, and two different makes of length-of-stain detectors, consistently indicated carbon monoxide present, but in concentration not over 0.04 percent. In one isolated instance, an indication of 0.10 percent carbon monoxide was obtained. As mentioned previously, canisters of universal gas masks became much hotter than warranted by such low concentrations. Bottle samples collected in the mine workings, and analyzed at the Bureau of Mines laboratory, Pittsburgh, Pennsylvania, indicated carbon monoxide ranging from 0.32 to 0.34 percent. (See table 1.) The volatilization at high temperature of sodium chloride and associated salts, natural organic compounds in shaft timber, and organic compounds used in timber treatment, might explain the discrepancy. Later, at intervals during the investigation, the results obtained by instrument tests agreed with results obtained by analysis of bottle samples. Universal gas masks, of course, provided adequate respiratory protection for the recovery workers, but the low detector indications, coupled with the adequate-oxygen indication by the continued burning of flame safety lamps, raised and sustained the hope that the mine workers might still be alive.

The salt air seemed to accelerate the build-up of resistance to breathing through gas masks, so that canisters required replacement more frequently than would usually be necessary. Salty moisture fouled detecting instruments mechanically, and also affected walkie-talkie circuits, so that equipment required service far more frequently than usual. After early experience with faulty communications, two of these radio units were carried below on all subsequent drops, with one wrapped in plastic material. The need for the standby unit added to the complication of keeping units top and below matched for frequency.

To minimize mechanical fouling of oxygen-breathing apparatus, it was necessary that each unit be wrapped in plastic sheeting before being sent down, and kept wrapped when not being worn or serviced. With this precaution, no trouble was experienced.

Only a few of the men engaged in the actual recovery work had any appreciable shaft-mining experience, particularly in riding a free bucket, but, in short order, all were performing like experienced shaft sinkers.

The short-wave radio-telephone from the mine office to the Calumet landing office was at first the only means of communication with the mainland, and the traffic was beyond its capacity. Within the next couple days, Cargo Carriers, Inc., a subsidiary of Cargill, Incorporated, installed another radio system, and Sun Oil Company arranged for installation of a line from the mine to their refinery on Belle Isle, connecting through their microwave system directly to landside local and long-distance lines, without going through the Cargill transceiver at the landing. Later Southern Bell Telephone Company provided two more marine-mobile units, which were used chiefly by news media representatives.

The salt-mining area is in the midst of an oilfield where drilling and production are carried on in bayous, swamps, and offshore. Every conceivable sort of heavy equipment and supplies was available in the area, and the populace is water- and air-transport oriented. Cooperation from all sides to provide prompt delivery of anything requested was amazing to those from other areas, and the seeming handicap of the isolated location of the mine was thus overcome.

The people of Berry Brothers Industries, directed by Messrs. Doyle and Everett Berry, along with Mr. Paul O'Neal of Winston Brothers Company, provided the ingenuity and expertise for devising and rigging improvised facilities; and the speed, competence, and endurance of Mr. C. C. Box and his crew of welders deserve the highest commendation. The recovery operation required a week, but without people like these to overcome some of the obstacles presented by the shaft, the lack of ventilation, and the underground temperature, the task could scarcely have been finished in a month.

INVESTIGATION OF CAUSE OF FIRE

Investigation Committee

The investigation of the cause of the fire was begun by Bureau personnel on March 6, 1968, and continued concurrently with the recovery work. The condition of the shaft to the mining level, and the fact that the lower part (loading pocket and sump) was filled with water and debris precluded completing the investigation immediately following the recovery operation. The investigation was continued intermittently as progress in shaft rehabilitation permitted, and was completed on August 29, 1968. Because of the circumstances, an investigating committee, as such, was not formed, but many persons contributed to the findings by reporting piecemeal evidence observed during recovery efforts, and as such was uncovered during rehabilitation of the shaft. These persons are listed in Appendix L.

An informal hearing was held at Franklin, Louisiana, March 19-20, 1968. The following persons represented the several parties during the hearing:

State of Louisiana

Curtis C. Luttrell	Commissioner of Labor Representing Governor McKeithen

St. Mary Parish

Chester C. Baudoin	Sheriff

Cargill, Incorporated

John F. McGrory	Assistant General Counsel

Employees of Cargill, Incorporated

Jeffrey D. Aucoin	Maintenance Leadman
Murphy Olivier	Undercutter Operator

United States Bureau of Mines

Frank C. Memmott	Associate Director--Health and Safety
James Westfield	Assistant Director--Coal Mine Safety

Several members of the official staff of the mine and 20 other employees volunteered to appear at the hearing, and they freely divulged information pertinent to conditions and practices at the mine prior to and on March 5. The composite information thus obtained from many individuals has been most helpful in compiling this report.

Probable Point of Origin

Since the ignition agency could not be established, the point of origin could not be established definitely, and vice versa. The evidence seems to point to that part of the shaft below mining level as the most probable point of origin, and several potential sources of ignition were either actually or possibly present in that area.

Summary of Evidence

Although pertinent mine records were made available, and all requested information was provided by company officials and workmen, some of the essential facts are unknown, and, therefore, some of the evidence summarized herewith was arrived at by deduction or conjecture, as will be evident.

1. The hoistman on duty had heard no telephone calls between stations underground indicating any trouble prior to the report to him that the shaft was afire.

2. The two telephone calls reporting the fire were terse, but the hoistman quite properly took action as requested, without delaying to ask for details.

3. Of 21 men underground, none survived, and the telephoned reports did not indicate cause of the fire, or point of origin. It, therefore, becomes necessary to try to determine such by deduction.

4. Dynamite and other supplies had been delivered underground during the shift preceding the shift on which the fire occurred, but they had been removed promptly from the cage, and thence from the shaft area to remote storage points. No supplies had been taken underground during the second shift.

5. Explosives and blasting agent being used to charge holes at working faces were far from the shaft.

6. Neither high explosives nor the blasting agent was involved in the fire.

7. Fuel oil had been delivered underground on Saturday, March 2, 1968, 3 days before the fire. The fuel-oil supply line was installed in the shaft in a compartment separate from the skip compartments. It was open at both top and bottom to avoid build-up of static-pressure head when delivering oil to the portable underground tank, or between deliveries,

and the quantity to be delivered was controlled from the surface. The oil supply line was drained after each delivery of oil. Although the installation in proximity to shaft timbering was a potential hazard, no evidence implicated the fuel-oil line as a factor in the fire.

8. Gasoline was taken underground promptly upon receipt by boat, in 55-gallon drums, which were removed promptly from the cage and the shaft area. It was said that two to three drums was the quantity kept on hand underground. Lubricants were also taken underground in closed containers in the cage. There had been no delivery of gasoline or lubricants for some days before the fire.

9. The fuel-oil storage tank, after refilling, was taken to the haulage area, well over 1,000 feet from the shaft, where it was accessible for refueling equipment. Gasoline and lubricants were also kept at points a similar distance inby. None of these stores of flammable materials was involved in the fire.

10. Mining equipment was not ordinarily used near the shaft, and none of the electrical, gasoline-powered, or diesel-powered mining and haulage equipment was involved in the fire.

11. A gasoline-powered Jeep, used by maintenance men to bring equipment to the shaft for lubrication and repair work, was found parked about 350 feet from the shaft, with the air compressor coupled behind it. These units had not been harmed by the fire.

12. Customary procedure was to park the compressor where it was found, after completing the lubrication routine, and to take the Jeep inby to the shop area. Since the compressor was still coupled to the Jeep, the indication is that this equipment was hurriedly removed from the shaft area to get the fuel tanks away from the fire.

13. The main belt, which terminated 50 feet from the shaft, did not ignite, and there was nothing flammable between the shaft and the belt, so that, in summary, the fire was confined to the shaft timbering and equipment.

14. It is necessary first to try to establish the probable point of origin, in order to try to determine the probable cause of the fire.

15. It appears certain that the fire started in the production side of the shaft. Had it started in the auxiliary-cage compartment, which was the downcast-air compartment, men working in the shop area in the main intake-air current would have been aware of smoke in a short time, and

before men at the shaft landing, who were in return air. However, the shop men would not have known the exact location of the fire, whereas, each of the telephone calls was immediately preceded by knocker signals, and the caller, who was the same man each time, said definitely: "----- the shaft is on fire," and later: "----- the skip is on fire." Obviously, he was at the telephone on the mining level near the shaft.

16. The shaft was timbered with pine from collar to sump, and a plywood curtain wall was secured to the timbers from collar to just below mining level. In the service compartment, which extended from the sump to just above mining level, were the ladderway, with landings and handrails at intervals, all of wood construction, and, also, a bucket-elevator, with buckets riveted to a rubber belt, and boxed in with plywood, all being supported by timber sets.

17. The timber in the upper part of the shaft, from the collar to the end of the concrete lining, -369 feet, showed the least burning. Sets near the collar appeared only scorched; farther down the timber was deeply charred but still in place, to about the end of the concrete. The curtain wall had burned out to about 250 feet from the collar, and partially above that point.

18. The fire damage increased progressively downward, from about -369 feet, the end of the concrete lining, until from -677 feet, roughly midpoint, to mining level, the timber was totally consumed, except for stubs of beams, or plates, protruding from the shaft wall. (Every set had been hitched into the wall when the shaft was being timbered.) From mining level to the skip loader, the timbering in the north skip compartment was partially burned but still in place; from the skip loader to the sump screw it was only slightly charred; in the south skip compartment, and in the service compartment adjacent to the south skip compartment, the timbering was almost completely consumed.

19. The telephone and signal systems were both operative when the fire was reported, at which time it is evident that the fire was making rapid headway at about mining level. Had the fire started above mining level, it would have made still greater headway above by that time, and the relatively small communication cables would, seemingly, have been sufficiently affected to have rendered communication impossible.

20. The maintenance of communications up to that time is an implication that the fire started at, or below, mining level, and there are other such implications.

21. Turning to work in progress before the fire: the hoisting of salt was discontinued at 9:49 p.m., when all barges had been loaded; production and maintenance work were scheduled to continue until 1:45 a.m., the crushed and screened salt to go into storage chambers underground.

22. No maintenance or repair work had been done in or about the shaft on the day of the fire prior to 10:15 p.m., when the mechanics called for the north skip to be brought to mine level.

23. According to testimony from company personnel, fine salt worked into and "gummed up" the grease around the sleeve bearings used on skip and skip-loader mechanisms, so that it was sometimes impossible to force fresh grease through the bearings. When this occurred, company employees said, it was the practice to heat the bearing housings with an oxyacetylene flame until the pressure from the grease gun could force out the old grease and salt.

24. Reportedly, it was sometimes necessary to heat the metal to cherry red color, and, on occasion, the thinned-out grease had ignited. There was a possibility, too, of igniting nearby wood. Company policy required mechanics to have fire-extinguishing facilities at hand at all times. According to testimony, however, a handful of fine salt usually extinguished the blaze. It was said by a number of persons who had done this work that a fire watch was kept after such heating.

25. On occasion, the mechanics were said to have used the oxyacetylene torch or the arc welder to make repairs to shaft equipment.

26. The north and south skips had been serviced from 10:15 to 10:45 p.m., which was about average time, and which seems to indicate no repair work was done, though it does not entirely preclude heating with the torch.

27. The mechanics next went down to the skip loaders for about 10 minutes, came back to mining level, shortly took the skip back to the skip loaders, stayed about 20 minutes, came back up and released the skip to the hoistman. This was longer than the usual time for lubrication, if no complication were encountered, but not longer than usual when it became necessary to heat bearings, or to work on the arms which tripped the skip loader chutes.

28. This trip up may have been to get the torch. This is conjectural, but the torch and tank cart were found about 50 feet from the shaft, with the hoses just doubled back, and not reeled as usual, which seems to indicate that the equipment had been used and was hurriedly removed from proximity to the fire. However, there was no indication of where the torch might have been used.

29. If it be assumed that a fire got beyond the usual "handful of salt" treatment during the first 10-minute work period at the skip loaders, it might be assumed that the trip up to mine level was to get extinguishers. But then, it must be assumed further that the mechanics fought the fire for about 20 minutes, failed to get it under control, and retreated to mining level, and still further, assumed that the fire spread 45 feet upward to the mining level in another 10 minutes, to the extent that they were unable to board the cage, and with no positive ventilation in that part of the shaft.

30. The foregoing assumptions are scarcely tenable, because:

a. Extinguishing equipment available in the immediate area was not sufficient to continue fighting a fire for 20 minutes; and,

b. If the fire had been threatening to get out of control, it appears logical to believe that the mechanics would have called the shop for more extinguishers; and,

c. If the fire were spreading as assumed, the men could scarcely have endured the heat and smoke for 20 minutes in that portion of the shaft, where air movement was practically nil.

31. When the mechanics came up to mining level the second time and released the north skip to the hoistman, this would ordinarily signal completion of the round of maintenance work, and the engineer would also be notified by telephone. Instead, the south cage was called for again.

32. If it be assumed that a fire was started at the skip loaders during the second, or 20-minute, work period and could not be extinguished, it seems logical to believe that when the mechanics were hoisted to mining level, they would have held the north skip and telephoned the alarm to others in the underground workings, since only the north skip had a usable man cage.

33. It might be assumed that the fire then existed in the south side of the skip-loader pocket, where burning was later found to have been more intense, and that it was intended to use the south skip to get at the fire, but the extinguishers found nearby, some emptied, could not have been collected from inby points in so short a time, and it thus appears that they were collected after the fire was reported.

34. The next presumption is that the mechanics meant to have a second go at servicing something on the south skip, since they had previously serviced it. If it be assumed that a fire was started by use of the torch during this period of 5 minutes, then it had to spread to the north skip compartment so rapidly, that when the north skip was sent down in answer to the telephone call, a matter of 1 minute from collar to mining level, the north skip could not be approached.

41. The fan was installed underground near the shaft and operated blowing. It could be started and stopped from a control in the shaft area which was readily accessible for at least some time after the fire occurred. The hoistman observed that the upcast air current had ceased to flow before midnight, possibly by about 11:45 p.m., but it is not known whether the fan had been stopped by those underground, or whether the curtain wall had burned through. The fact that carbon monoxide was diffused throughout all mine workings explored during recovery operations implies that the fan operated for some time after the curtain wall burned through.

42. The near end of the fan installation was 20 feet from the downcast compartment of the shaft. A wooden bulkhead surrounded the discharge end of the duct, 50 feet from the downcast. The existence of some flame and glowing embers at this point, extinguished by the rescue workers some 40 hours after the fire started, indicates that the fan installation was not involved in starting the fire, for, had it been so involved, the bulkhead would have been burned out in much shorter time. Further, had the fire started at the fan, men in the shop just inby would have been aware of it practically immediately. Moreover, a fire at this bulkhead would be isolated by solid salt in all directions from any other wood installations. Thus, it appears certain that this wood structure was ignited sometime later by radiant heat. The fan and motor appeared to have suffered no appreciable damage, and the V-belts had not burned away.

43. The plywood curtain wall undoubtedly helped to spread the flame from mining level upward; however, it could scarcely have been a factor in the incipient stage of the fire. None of the potential sources of ignition on the production side of the shaft was close to the curtain wall. Those which were close, electrical cables and controls mounted on or near the curtain wall in the intake-compartment side, are eliminated as sources of ignition, because the evidence is clear that the fire did not originate in the downcast, or so-called "air" side, of the shaft.

44. Restriction of fire to the shaft confines possible causes to smoking, an electrical fault, use of torch or arc welder, or frictional ignition involving skip-loader belt or bucket-elevator belt.

45. Smoking was prohibited in the shaft. It was said that men, on occasion, smoked in the sump, while cleaning up the salt spillage at "the screw." No such work had been performed on this day.

46. It appears unlikely that mechanics would smoke while engaged in work that was apparently carried on in 1-2-3 fashion, and, in any case, though perhaps not impossible, it appears unlikely that a discarded lighted cigarette or match would ignite wood of the dimensions involved.

47. Electrical cables, motors, and switchgear serving the belt feeder and the conveyor belt were installed in a tunnel below mining level, and to, and at, the screw conveyor in the sump area. The motor and supply cable for the bucket elevator were located just above mining level. The lighting circuit extended about the mining level and from top to bottom of the ladderway. Some of this equipment was destroyed by the fire. The four circuit breakers in these four motor circuits and one in the lighting circuit were remote from the shaft and were not damaged by the fire.

48. These five circuit breakers were normally in "on" position, leaving the circuits energized up to the individual motor starters or switches. All were later found in tripped position, indicating that each had been tripped by a fault in its circuit before the primary circuit was opened at the surface about midnight.

49. Had the primary circuit been manually opened at the surface before a fault of low-resistance value occurred in any of the five circuits in question, all five circuit breakers should have remained in normal "on" position, whether the particular unit served by each was operating or idle. This is inherent in the design of the breakers.

50. Had a fault of low-resistance value occurred in only one of the same five circuits before the primary circuit breaker on the surface was manually opened, the circuit breaker in the faulted circuit should have tripped, but the other four circuit breakers should have remained in the normally "on" position, which could then have been taken to indicate that the fire possibly originated from the faulted circuit.

51. By the usual procedure, the apron feeder and the skip-loader belt would have been stopped when hoisting was suspended, but the sump screw and the bucket-elevating conveyor were usually left running to carry off salt spillage, even when not hoisting, until the end of the second shift. The incandescent lamps should have been burning. A fault could, of course, have occurred in an energized circuit before the fire, although the unit served was not operating. It is, however, not reasonable to believe that a fault occurred in each of the five circuits before the fire occurred.

52. It is possible that an electrical fault in one circuit was the source of ignition, or all five faults which tripped the breakers could have resulted from the effect of the heat from the fire. Since only about one-half hour elapsed from the report of fire until the surface circuit breaker was deliberately opened, the tripping of all five circuit breakers under discussion appears to be further indication that the fire originated at or below mining level.

53. Of all the circuit breakers on the surface, protecting power and signal lines in the shaft, only one had opened as result of a fault. This was the circuit breaker in the control circuit of the auxiliary cage. The heat of the fire presumably created a fault, which caused the hoist to raise the auxiliary cage to within about 300 feet of the collar, when, apparently the fault resulted in the burning out of a transformer in the control circuit, which actuated the circuit breaker. Engaged otherwise, no one observed this fault-induced activation of the auxiliary hoist, and so, this occurrence sheds no light on when the fire got to the control circuit. It could have been in the early stages of the fire, or much later, since the auxiliary hoist and its controls were supplied by a surface circuit and were still energized after the underground power supply had been purposely interrupted.

54. Even when power circuits are provided with all conventional protective devices, there is, unfortunately, still the possibility of the occurrence of a high-resistance electrical fault which will not cause the circuit breaker to open, and which, therefore, is the sort of fault which is capable of causing a fire. For that reason, the possibility of an electrical source of ignition cannot be flatly ruled out, even when, as in this case, no positive evidence of electrical failure is observed.

55. In a tunnel below mining level was the 53-foot belt which carried salt from the surge bin to the top of the skip loader. The top part of this belt and part of its wooden supporting structure, for about 40 feet from the shaft end, was burned. Since the back end, including woodwork around the surge bin above did not burn, it appears that the fire could not have started in this tunnel, but that it spread to here from the shaft proper.

56. The torch presents itself as the ready-made culprit. The indications were that it had been used, but, even so, there was no indication of where, or when, during the hour-long servicing routine. Granted, that use of the torch to heat grease in proximity to shaft timbers was a decidedly unsafe practice, it is difficult to conceive how a fire started by the torch could have gotten out of hand so quickly.

57. One other possible source of ignition was the bucket elevator. This unit operated at very slow speed, practically a crawl, which is not highly conducive to frictional heating. However, assuming a frictional ignition, it would appear that smoke and odor could have been carried up the natural chimney formed by the plywood enclosure, and the fire could have progressed unknown to the mechanics working in the area. Airflow through the enclosure could have been augmented by the velocity of the mine air current at the head of the enclosure above mining level, a sort of Venturi effect.

Such a fire could have spread very rapidly after it burst out of the enclosure, considering the relatively light lumber used in construction of the facilities in the service compartment. The extent of destruction in the south skip compartment and in the service compartment, in contrast to the north skip compartment, could be taken as substantiation of this theory. On the other hand, if the fire first became intense in the south skip compartment, it could have spread more readily to the relatively light wooden installations in the service compartment than to the heavy timber sets in the north compartment. So, again, the evidence is far from conclusive, but a fire originating in the bucket-elevator installation might explain the apparently sudden outburst of fire enveloping the shaft at mining level.

Cause of Fire

The cause of the fire could not be determined with certainty. An electrical source is a possibility, but no positive evidence to sustain such source was observed. The open flame of the oxyacetylene torch is a distinct possibility; grease fires, though extinguished promptly, reportedly had occurred on occasion, when using the torch to assist lubrication. Frictional ignition of the rubber belt of the bucket-elevating conveyor cannot be ignored, particularly in view of its plywood enclosure and the contiguous ladderways and timbers.

Conclusions

Although the cause of the fire could not be determined, the investigation following the disaster revealed three factors that must, in the Bureau's opinion, be considered as contributing in a major degree to the loss of the miners' lives. Those factors are:

(1) The absence of adequate fire prevention measures in a shaft that incorporated a great deal of flammable light timber and plywood in its structure and its facilities.

(2) The inadequacy of firefighting facilities at and in the shaft.

(3) The lack of a separate shaft, which could have provided the trapped men with another way out of the mine.

It must be noted that these inadequacies had been called to the attention of the company management nearly 6 months before the disastrous fire occurred. Had a second shaft been begun then, it could not have been completed in time to have had any effect on the outcome of the fire. The shaft had not, however, been started at the time the disaster occurred.

RECOMMENDATIONS

The following recommendations are made for prevention of a similar occurrence:

1. Use of combustible materials for construction in and about mine shafts should be avoided, wherever practicable. (The shaft is being reconstructed with structural-steel sets, steel guide rails, and steel curtain wall.)

2. When not practicable to avoid use of wood or wood products, the material should be treated with an effective fire-retardant treatment or coating, and a sprinkler system, or other adequate fire-protection facilities should be provided, commensurate with the character and extent of the installations to be protected.

3. When necessary to use a torch or arc welder for maintenance or repair work in the vicinity of combustible materials, the area should be wet down before and after the work is done. A suitable fire extinguisher should be instantly available, and a person other than the one occupied with the cutting or welding should keep a fire watch. Diligent search should be made for indication of fire after completion of the work, and a fire patrol should be maintained for at least 8 hours when any men are in the mine, unless the area is under relatively continuous ordinary surveillance.

4. All belt conveyors not attended when in operation should be equipped with slippage controls, or with a heat-sensing device arranged to disconnect power and give an alarm if temperature rises to a predetermined value.

5. Adequate suitable firefighting facilities should be provided for equipment installed in the lower part of the shaft, below mining level.

6. Though no evidence indicated involvement of the fuel-oil line in the fire, it should be taken underground through a borehole at a safe distance from the present shaft, the proposed second shaft, and electrical installations.

7. Though it appears improbable that the fire resulted from smoking, nevertheless, the company safety rule prohibiting smoking in the shaft should apply to the entire shaft, including the skip-loading and sump section, and the vicinity of the shaft, and it should be rigorously enforced.

8. The proposed new main fan should be installed on the surface so as to be accessible to a competent person at all times when men are underground, and such person should be thoroughly instructed in measures to be taken in an emergency. Until such time as the fan can be relocated, an air lock should be provided through the fan bulkhead, to permit traveling in intake air to the auxiliary cage, in event of a fire at the screening plant or along the belt conveyors.

9. A second shaft should be provided as soon as practicable, readily accessible from every working area, and it should be fitted with facilities to permit ready escape from the mine, which should be operable by persons underground, without dependence upon anyone on the surface, unless a qualified hoistman is on duty at each shaft at all times when any person is underground. No mining operations should take place below ground prior to the construction of such second shaft unless there is provided a refuge room of sufficient size to accommodate the maximum number of men that might be underground at any one time, with independent ventilation and communications, and with stores of water and food sufficient to support such number of men for 30 days.

10. While only one way of escape to the surface is available, and if a refuge chamber as described above is not fully operable, not more than 10 men should be underground at any one time, and their work should be devoted to providing a separate escapeway or a fully operable rescue chamber.

11. Man cages should be built entirely of noncombustible material.

12. A mine rescue station, with adequate equipment and supplies, should be maintained, or this mine should be affiliated with a central mine rescue station. Not fewer than six men should be trained in the use of mine rescue equipment, and in proper and effective firefighting procedures.

Note: Responsible company officials have assured representatives of the Bureau of Mines that all of the foregoing recommendations will be adopted.

ACKNOWLEDGMENT

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Effort has been made previously to acknowledge the selfless help of the Kentucky rescue teams and their sponsoring companies, as well as many other individuals and organizations. To those nameless ones who carried on for many of the named organizations, our deepest thanks.

The kind hospitality of the people of Franklin, and of St. Mary and neighboring Parishes will be long remembered.

In summary, the contribution of all concerned can be expressed by only one word, magnificent.

Respectfully submitted,

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