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ANALYSIS OF THE MARKET FOR A NEW FROZEN COAL RELEASE DEVICE

December 1981

Prepared for:

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
Technology Transfer Division
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NASA Technology Applications Team

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PREFACE

The contributions of the National Aeronautics and Space Administration (NASA) to the advancement of the U.S. technology base are broader, more complex, and in some cases more indirect than the public may realize. The NASA contributions to advances in aerospace technology have been numerous. The transfer of these technologies to other scientific fields is under way.

These transfers have been made possible, in part, by NASA's Technology Utilization Office. This office has been successful in expediting the transfer of aerospace-derived technology for the solution of important technological problems in the areas of public transportation materials, housing, the environment, and biomedicine. To aid NASA in achieving this transfer of knowledge, a Technology Applications Team (TATeam) has been established at SRI International. This team works actively in specified areas of public concern, helping to match problems and solutions and following through to ensure the most efficient utilization of the transferred technology.

The SRI TATeam is concerned with problems in transportation, public safety, environmental protection, biomedical engineering, and agriculture. Members of the team routinely work with representatives of industry, government, and private and public associations. In addition, the team maintains continuous contact with NASA's scientific community in its efforts to bridge the gap between the technological needs of the user and the available technology or expertise at NASA. This market study was conducted to examine the feasibility of the transfer and commercialization of an aerospace technology for the railroad and electric power industries.

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ACKNOWLEDGMENTS

The author thanks all those who contributed their time, knowledge, and suggestions to this market analysis. Particular thanks are extended to Mr. Melvin Lucy and Mr. Les Rose at Langley Research Center and Mr. Jim Wilhelm at SRI International for their comments and contributions.

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I INTRODUCTION

The demand for inexpensive, alternative forms of energy to lessen U.S. dependence on foreign oil imports has created a renewed emphasis on the development of domestic coal reserves. Low-sulfur coal fields in the West are being developed, oil is being deemphasized as a primary fuel for major power-generating companies, and the conversion to or construction of coal-burning power plants is occurring. New coal utilization technologies, such as fluidized bed combustion, coal gasification, and coal liquefaction, have also increased demand for coal. In view of this emphasis on coal as a major energy source, coal production has increased and is expected to reach 1,197 million tons by 1985,* with rail shipments of 753 million tons anticipated.+

These increases in the demand and production of coal have required new developments in handling. New railcar designs for rapid unloading, unit trains dedicated to shipping only coal to large-quantity users, and new lines to reduce the distance traveled between mines and new utility plants have all been implemented in the last decade. Yet one problem continues to hamper unloading during winter months: the freezing of coal during shipment. Almost all producers, haulers, and users of coal in the Northeast and Midwest have encountered this problem because ambient temperatures of 32°F or lower are prevalent in these areas during the winter; in addition, most of the coal they use originates from eastern mines and is hauled on northern routes.

Coal is used extensively in the Northeast and Midwest by utilities, industry, and residential customers who require regular deliveries of large quantities of coal. However, it is the electric power generation plants, which use 80% of all the coal produced, that are most affected by the coal freezing problem. This industry must pay the cost of increased labor for unloading frozen cars, maintenance costs for overworked equipment, and demurrage charges for holding cars longer than anticipated. If coal shipments are frozen, the utilities must also buy electricity from other sources or buy coal on the spot market (usually at higher rates). According to SRI figures, these costs amount to $15 million industrywide.**

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*National Transportation, June 1979.

+Predicasts Forecasts, 1981 Annual Cumulative Edition, Issue No. 84, July 27, 1981.

**Derivation of this figure is explained in Section III, Costs of Frozen Coal Handling.

Methods the industry currently uses to unload frozen cars include application of heat, vibration, chemical treatments, and specialized mechanical devices. No one method has gained overall industry acceptance, but there is an established trend toward the use of chemicals and heat. This combination is most effective when used with bathtub gondola cars and rotary dumping, which are not available at all user locations.

Industry research to solve the problem of coal freezing has been hampered by the fact that three independent industries--mines, railroads, and end users (i.e., utilities)--are affected by coal freezing in different ways. Uncoordinated research efforts are sponsored by each industry, resulting in solutions that require action and expenditure by the other two. In addition, because of the seasonal nature of the problem, it is considered of low priority by most managers so that funds for research or for implementation of solutions are often unavailable. As one railroad executive said, "When the weather is nice, no one thinks to try and repair the roof and when the rain comes, it's too wet to get up on the roof and fix it."

The problem of coal freezing during shipment was brought to the SRI TATeam's attention 3 years ago. Three railroads (the Bessemer and Lake Erie Railroad; the Duluth, Missabe and Iron Range Railway; and the Illinois Central Gulf Railroad), the Office of Mining/Coal Preparation of the Department of Energy, and the Electric Power Research Institute provided information on the scope and extent of the problem as well as technical background information. Using this information, the SRI TATeam prepared a problem statement and disseminated it to the 10 NASA field centers. The TATeam received 15 suggested solutions. The suggestion of a controlled gas detonation lance from a pyro/propulsion engineer at NASA Langley Research Center was viewed as the most practical by industry sources and has since been funded by NASA for a feasibility demonstration.

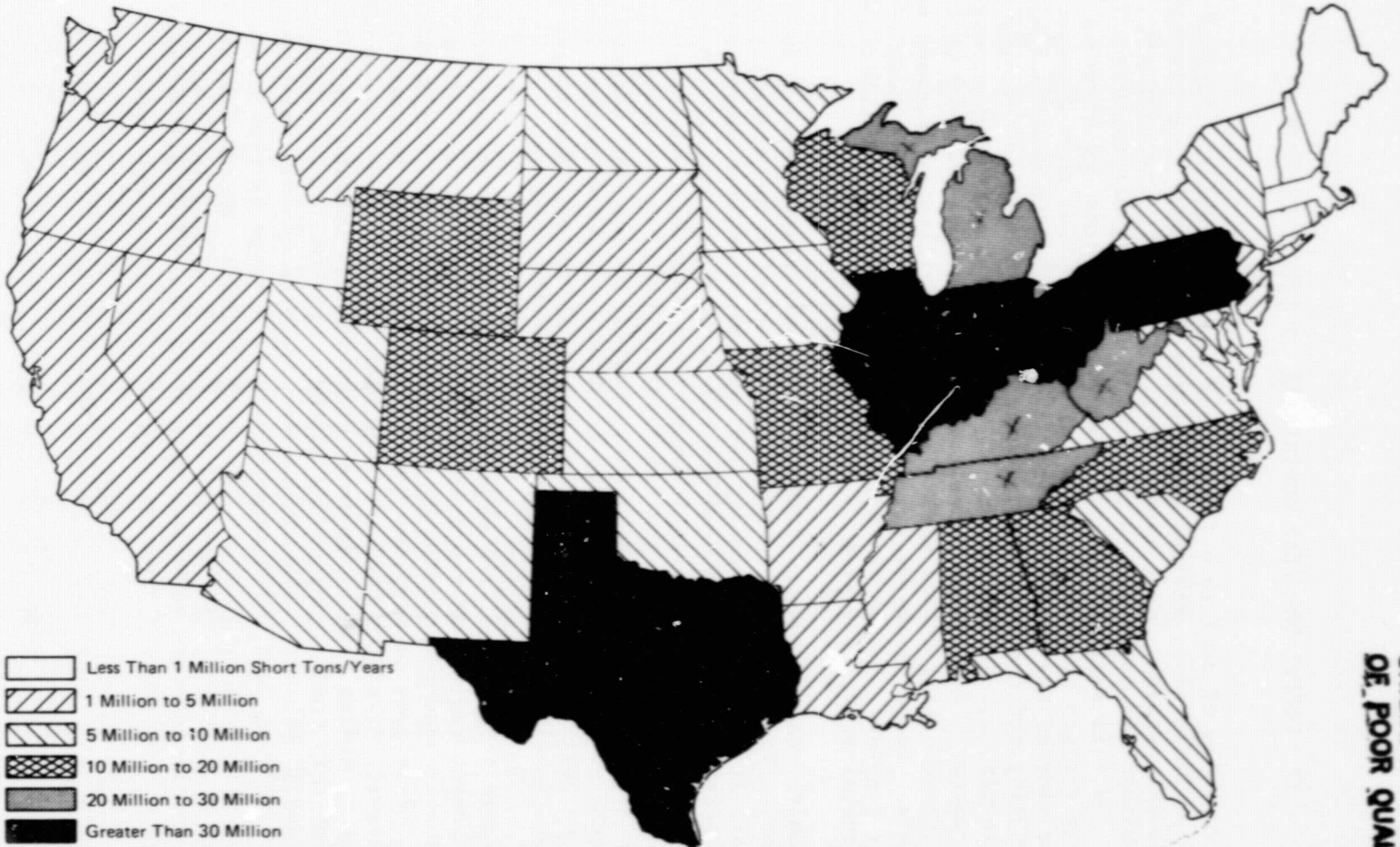
The purpose of this study was to explore the market demand for the NASA-designed controlled gas detonation lance and to identify competitive products or processes. Section II provides information on the conditions that cause coal to freeze. Costs to the industry are outlined in Section III, and current products or process used to handle the problem are discussed in Section IV. A description of NASA's controlled gas detonation lance, including the estimated cost of assembly, is presented in Section V. Section VI covers the market demand for the lance and comments about market penetration.

II CONDITIONS THAT CONTRIBUTE TO COAL FREEZING

The freezing of coal is a function of many conditions. Surface moisture, particle size, ambient temperature, and travel time all contribute to the problem. Coal itself does not freeze: The moisture retained within the pores on the surface of coal provides the water for freezing. As this surface moisture freezes, it creates ice crystals that bridge the gap between the coal particles and bind them together and to the side of the railcars. The washing of coal to control dust during handling and the moisture inherent in coal contribute to surface moisture levels, which average 5 to 7%. Particle size is another significant parameter. Coal fines present more surface area and tend to fill the voids between larger coal particles, which facilitates bridging by ice crystals. Large pieces--i.e., one-half inch or larger--cannot settle as closely together, making the distance between particles farther and the ice crystal bridging weaker.

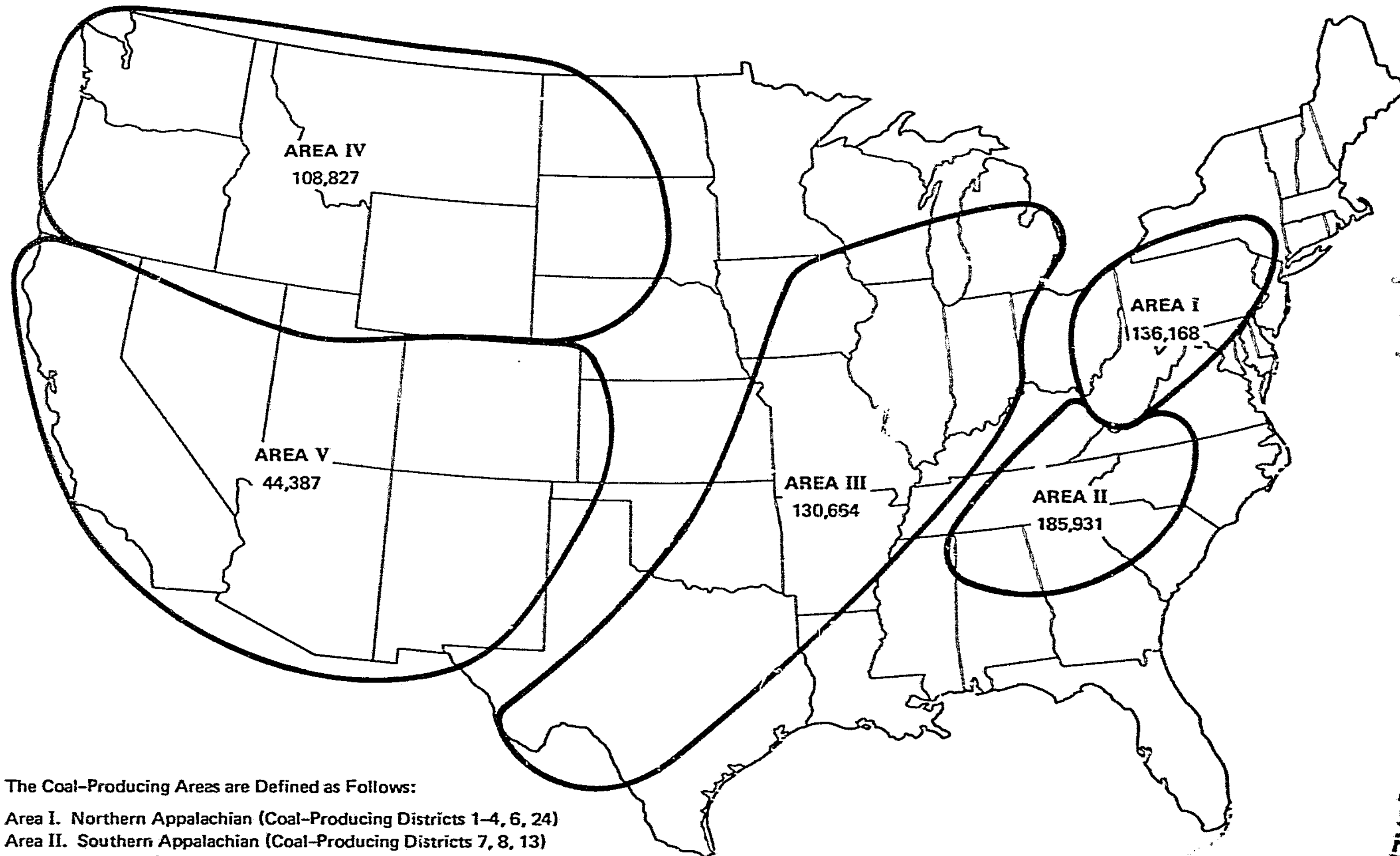
An ambient temperature of 32°F or lower will cause freezing in coal cargoes. The lower the temperature, the greater the probability of extensive freezing. Compounding the problem of ambient temperature is the temperature of the coal and the car at time of loading. As moist coal is loaded into cold cars in freezing temperatures, a heat-sink effect occurs. The energy of the warm coal (above 32°F) is drawn toward the cold steel of the car sides, creating an ice bond between coal and car. During shipment, these ice bonds penetrate farther into the cargo as coal is cooled by the ambient temperatures. The longer the shipping or travel time, the more extensive the ice bridging.

As Figure 1 indicates, the majority of coal is used in the Northeast and Midwest regions of the United States. Approximately 279 million short tons are consumed annually by utility, industry, and residential customers. This coal is supplied both by the established eastern mines in Pennsylvania, Virginia, Kentucky, and West Virginia and, increasingly, by the western mining area of Wyoming, Colorado, and Montana (see Figure 2). Most of this coal is shipped by northern railroad lines. During December through February, the minimum temperatures in the coal-producing regions are 32°F or less, with temperatures in a large section never rising above freezing (see Figure 3). Coal shipments during this period are approximately 230 million short tons, or 2.3 million car loads. According to northeastern and midwestern utilities, 4% of all shipments freeze. This represents a freezing rate of 92,000 cars per year.



SOURCE: Energy Data Report: Coal Distribution, U.S. Department of Energy

FIGURE 1 COAL USE IN THE UNITED STATES BY STATE

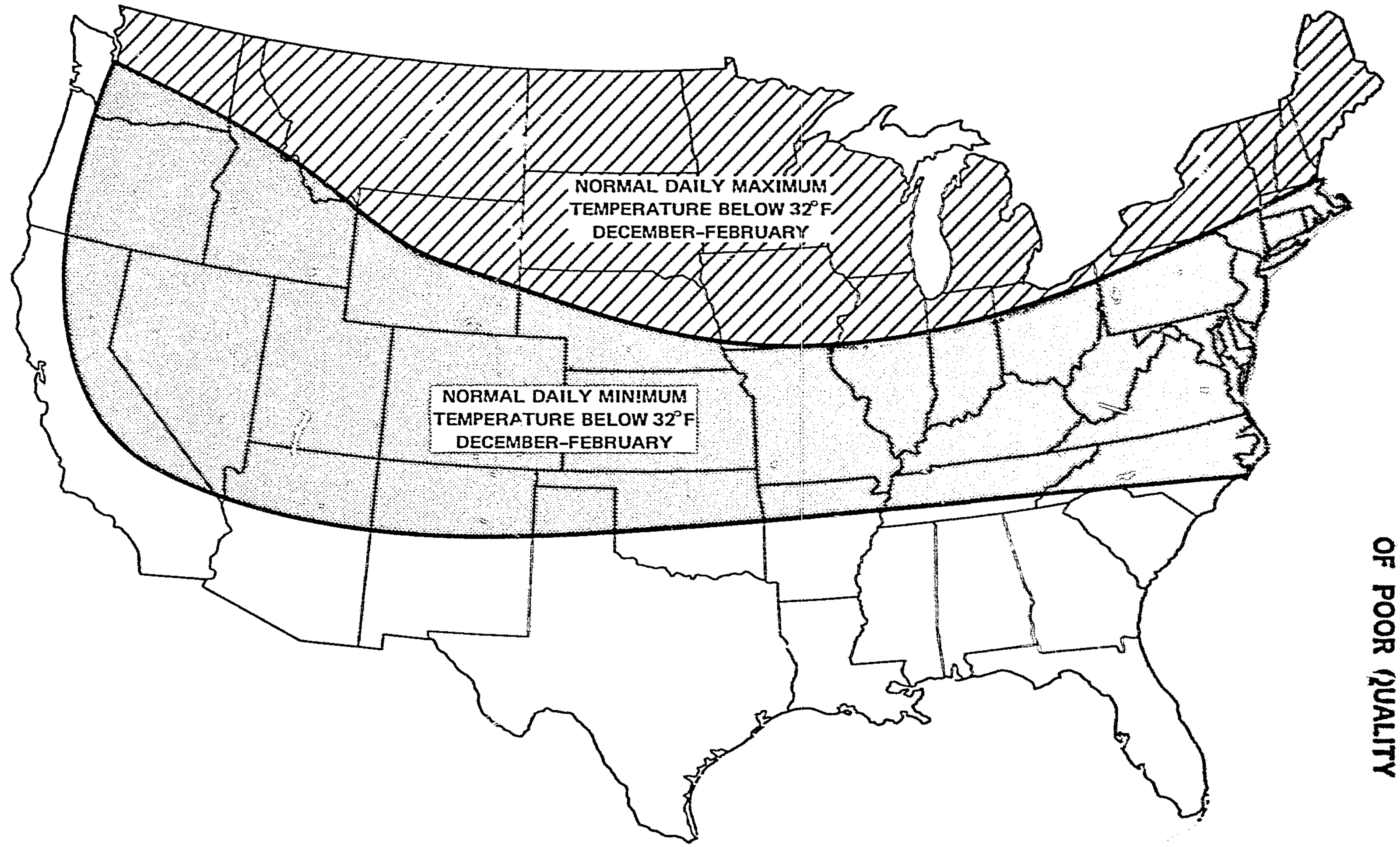


The Coal-Producing Areas are Defined as Follows:

Area I. Northern Appalachian (Coal-Producing Districts 1-4, 6, 24)
Area II. Southern Appalachian (Coal-Producing Districts 7, 8, 13)
Area III. Interior (Coal-Producing Districts 5, 9-12, 14, 15)
Area IV. Northern Great Plains and Pacific (Coal-Producing Districts 19, 21-23)
Area V. Rocky Mountains (Coal-Producing Districts 16-18, 20)

SOURCE: Energy Data Report: Coal Distribution, Department of Energy

FIGURE 2 COAL-PRODUCING AREAS (Thousands of Short Tons)



SOURCE: Comparative Climatic Data for the U.S. Through 1978; Governmental Data and Information

FIGURE 3 THIRTY-YEAR AVERAGES FOR MAXIMUM/MINIMUM TEMPERATURE DURING DECEMBER THROUGH FEBRUARY

III COSTS OF FROZEN COAL HANDLING

The principal costs associated with frozen coal handling are for labor, maintenance, demurrage, unit deratings, and coal replacement. At the 1980 National Conference and Workshop on Coal Freezing, Mr. Richard Voytas, fuel buyer for Union Electric Company, St. Louis, Missouri, discussed the effects and magnitude of these costs on operations at Union Electric during an extreme winter (1976-77). He stated that the records maintained on a Union Electric power plant consuming 20,000 tons of coal per day indicated that labor costs tripled during that winter because of coal-handling problems. The additional labor costs totaled tens of thousands of dollars per month.

Mr. Voytas indicated that increased maintenance costs also were in the range of tens of thousands of dollars per month. The costs rose because of increased use of mobile equipment to push coal from the stockpile into the storage area, increased wear on belts handling large frozen chunks of coal, and car damage caused by heating and shaking.

Demurrage charges increase when a train must be held in the yard longer than the unloading time stated in the applicable tariff. These charges vary depending on the tariff. Demurrage charges on frozen coal trains are assessed according to the general car demurrage rules as stated in Freight Tariff PHJ-6004. The demurrage charges quoted in that tariff, once the unloading time has expired, are: \$20 per car per day for each of the first 4 chargeable days; \$30 per car per day for each of the next 2 days; and \$60 per car per day for each subsequent day. Mr. Voytas said that Union Electric paid demurrage charges of about \$400,000 for a completely frozen western unit train that was stored for 69 days during the winter of 1976-77.

He believes, however, that unit deratings can constitute the major utility costs from frozen coal. According to Mr. Voytas, on a day when the average temperature was 4°F, a Union Electric generating station that was capable of producing 1,800 MWe had to reduce its capacity by 375 MWe because of frozen coal. The cost of replacing this power during the 24-hour period was \$155,000.

Mr. Voytas explains "coal replacement costs" as follows:

> Let us assume that a generating plant consumes X tons of coal per year and that all of that coal is under long-term contract with one source. Also, let us assume that the management of the utility desires to maintain a coal

inventory at a rather high level in anticipation of a summer-peaking season. If the mine cannot store coal and cannot ship any coal because all the railcars are in storage with frozen coal, the utility may be forced to go to the spot market to replenish their coal supplies. The spot market delivered price for coal probably may be much higher than the long-term contract price, depending on market conditions.

Assuming that 9.2 million short tons of coal is affected annually by freezing, an estimated $15 million is spent each year in handling frozen coal. This figure includes coal pretreatment, the cost of unloading a frozen car, and demurrage charges and is based on the SRI TATeam's survey of coal handlers and users.* The utilities the TATeam surveyed reported that their frozen coal shipments totaled 1.2 million short tons and that they spent $2 million a year on coal freezing problems, or $1.67 per ton. Multiplying that cost by the estimated industrywide figure of 9.2 million tons produces the $15 million figure. These costs are historical and are based on two relatively mild winters (1979-80 and 1980-81), during which frozen coal handling costs were low.

*The list of handlers and users contacted is appended.

IV METHODS USED FOR COAL HANDLING DURING FREEZING WEATHER

The methods that have been devised for handling frozen coal vary from rotary dumping (rotating a car 160°) to having workers manually chip frozen coal from the sides of hopper cars. In this section, the various methods currently used to handle frozen coal are described and assessed relative to costs, effectiveness, and advantages and disadvantages. Table 1 summarizes the information presented. For purposes of discussion, these methods have been divided into three categories: chemical, heat and vibration, and mechanical.

Chemical

The use of freeze-conditioning agents (FCAs) for prevention of coal freezing has been increasing. One railroad has instituted the policy that all coal shipped on its lines must be treated by some form of FCA from December through mid-March. The FCA must be added before shipment and mixed in thoroughly with the cargo to ensure effectiveness. Spraying occurs at the loading site, with nozzles being added around the conveyor belts that carry coal to the cars. The capital costs for application equipment vary with size and individual site requirements. The cost of building an application system with the minimum components is approximately $11,000. This includes storage tanks, spray nozzles, pumps, flow meters, and pressure gauges.*

Pressurized FCA is sprayed at different points, usually at places where the coal is tumbling or turning (such as where two conveyor belts intersect and as the coal is being dumped into a car). This allows for better total coverage with small amount of FCA. Application rates vary from 0.5 to 4 pints per ton of coal, with 2 pints per ton considered the most effective. The most common bases for FCAs are glycol, oil, and calcium chloride; glycol is the most widely used.

Glycol-based FCAs are water soluble and thus may dilute if exposed to rain or snow in shipment. An unusually high moisture content in a load of coal requires a heavier FCA application rate. The average cost ranges from $1 to $1.50 per ton, or $100 to $150 per 100-ton carload.

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*National Conference and Workshop on Coal Freezing, Electric Power Research Institute, 1980.

Table 1

SUMMARY OF STATE-OF-THE-ART SYSTEMS FOR TREATING FROZEN COAL

Method	Description	Capital Costs	Operating Costs per 100-Ton Car	Advantages	Disadvantages
Chemicals					
Glycol	Sprayed on prior to shipment	$11,000	$100-$150	Prevention of freezing; ease of application; use in rotary or hopper discharge.	Inability to accurately predict when needed leads to overuse and uncontrolled expenditures.
Calcium chloride					CaCl may cause corrosion.
Heaters and vibrators/shakers					
Infared radiant heaters	Electric or gas heaters	$35,000-$63,000 per car length plus shed	$14-$40	Thaws ice from car walls; used only when needed.	Heat may cause car damage; capital expenditure high.
Vibrator		$11,000	One operator and electricity	Breaks up internal ice bonds.	May cause car damage.
Car shaker	5 ton, 1,100 cycles/min	$35,000	One operator and electricity	Breaks up internal ice bonds.	May cause car damage.
Mechanical and other					
Backhoe	Conventional backhoe	$12,000	One operator and gasoline	Inexpensive, non-dedicated equipment available for use in other areas.	May cause car damage.
Carhoe	Mounted on tower above tracks, hydraulic arm breaks up coal	$11,250-$12,500	One operator and power		May cause car damage.
Hopper Popper	Three augers mounted on tower above the tracks; uses pressurized air to break up coal	$125,000	One operator and power	Good for emergency use.	Expensive; does not loosen coal from sides of cars.
Vibrating hammer	I-beam with vibrator, lowered into car	$100,000-$200,000	One operator, power, backhoe/crane	Emergency use.	May cause car damage; bulky and expensive.
Galloping Gertie	30 I-beams of varying lengths with vibrator lowered into car		One operator, power, backhoe/crane	Emergency use.	May cause car damage; bulky.

Source: Based on Ford, Bacon & Davis study.

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Oil-based FCAs are not widely used, but they do not dilute in rain. Their effectiveness, however, is limited to temperatures above 0°F, below which freezing will commonly occur. No shippers contacted were using an oil-based FCA, but the cost was considered to be similar to that for glycol.

Only one utility, Detroit Edison, is currently using products with a calcium chloride ($CaCl_2$) base. An unconfirmed industry belief is that $CaCl_2$ promotes corrosion in railcars and boilers. Detroit Edison maintains that the small amounts used have not presented a problem for its equipment. Should coal freeze to the sides of a car, Detroit Edison washes the car out with a $CaCl_2$ solution that has proven to be effective at removing residue from the sides. Once treated, cars have reportedly dumped clean as many as three loads later. Costs of $CaCl_2$ are similar to those for gycol.

An inherent problem with use of FCAs is predicting when they should be applied. With varying weather conditions and mild winters, not all loads need be treated. Some utilities use long-range weather services to predict need; some base their application decisions on the weather on the day of shipment; and others are required by their haulers to treat throughout the winter months.

Heat and Vibration

The traditional combination of heat and vibration to free frozen coal has evolved from the practice of lighting fires under cars and striking the sides with mallets to use of large electric or gas thawing systems and mechanical shakers/vibrators. The former system of thawing frozen cars by keeping them in large buildings (thaw sheds) overnight has given way to the skin thawing system, consisting of electric or gas-fired infrared radiant heaters that use high temperatures (1,400 to 1,600°F) for short periods (3 to 6 minutes). In skin thawing sheds, heat is used to melt the ice bonds between the car walls and the coal. Heat penetration of 5 to 12 inches is normal and is considered optimum because it is sufficient for dumping (especially rotary dumping) and because obtaining any further heat penetration is costly and time consuming. As the ice near the surface and walls of a car melts, the thermal conductivity drops, hampering further penetration. Temperatures at the car surface are limited to 300 to 350°F (higher temperatures will melt brake tubings and couplings), so further heat penetration would require longer heating times, which are not desired by industry.

Frozen cars are passed through a series of heaters positioned on the sides and below the car, as shown in Figure 4. This allows for the maximum transfer of heat in a minimum amount of time. The cost of electric heating units, the most commonly used, can range between

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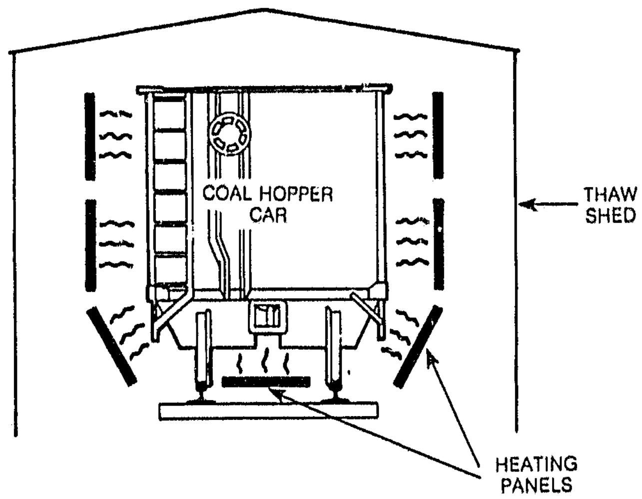
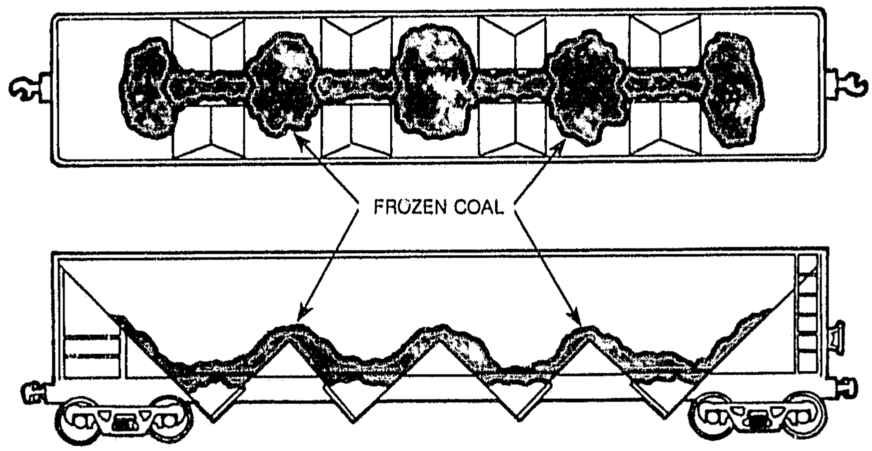


SOURCE: Ford, Bacon & Davis

FIGURE 4 THAW SHED HEATING ELEMENT CONFIGURATION



SOURCE: Ford, Bacon & Davis

FIGURE 5 AREAS COMMONLY LEFT UNTHAWED ON HOPPER CARS

$35,000 and $63,000* per car length, not including building costs. Depending on the type of car and dumping system, the energy used to thaw a car ranges from 2.5 to 7.0 kWh per ton.* This equates to a cost of $14.22 to $39.83 per 100-ton car load. (The utility rate used is based on an average of the northeastern area.) In hopper cars, which have interior structural supports and peaked floors, heat convection is not strong enough to melt the bonds between car surface and coal in all areas. Figure 5 shows the typical pattern of frozen coal left behind after thawing. Discharge vents remain blocked by frozen coal, which must be broken up, usually with vibrators, shakers, or in some cases manual labor.

Vibrators/shakers are electric or pneumatic devices (see Figure 6) that are lowered into or attached along the side of the car and physically jerk the car and its contents to enhance the flow of coal. Relatively inexpensive ($11,000 per vibrator) compared with the capital cost of thawing sheds, vibrators are often used year-round to speed the flow of coal from conventional hopper cars. Vibrators can structurally weaken cars, however, especially after heating, lowering the useful life expectancy of the cars. Other physical damage (e.g., dents) has been attributed to vibrators, but statistics of occurrence have not been kept.

Mechanical and Other

Mechanical unloading devices are commonly used to dislodge frozen coal from railcars. These devices range in sophistication from backhoes, temporarily mounted on tracks above the car, to pressurized devices that blast the coal loose. Many are one-of-a-kind, "homemade" remedies based on commercialized products or designed by the company engineer. Among those most commonly used are the backhoe, carhoe, Hopper Popper, vibrating hammers, and galloping gerties.

Backhoes and carhoes (see Figure 7) are commonly used by small coal consumers who do not have a significant freezing problem or considerable capital investment backing. The mechanial arm of the hoe scrapes frozen coal from the side of the car and forces it out the bottom doors. The risk of damage to the car is high with this method, but capital costs ($12,000) are low and the equipment can be used year-round. Low operating costs (one operator) also make this an attractive alternative to hand labor or demurrage charges.

Pressurized air exerting a localized force on the ice bonds, causing them to break, is the principle behind the Hopper Popper (shown in Figure 8). Using augers mounted on towers above the track, holes are drilled into the frozen coal. With remote controls, pressurized air

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*"Survey of the State of the Art of Coal Handling During Freezing Weather," Ford, Bacon & Davis, New York, New York, April 1981.

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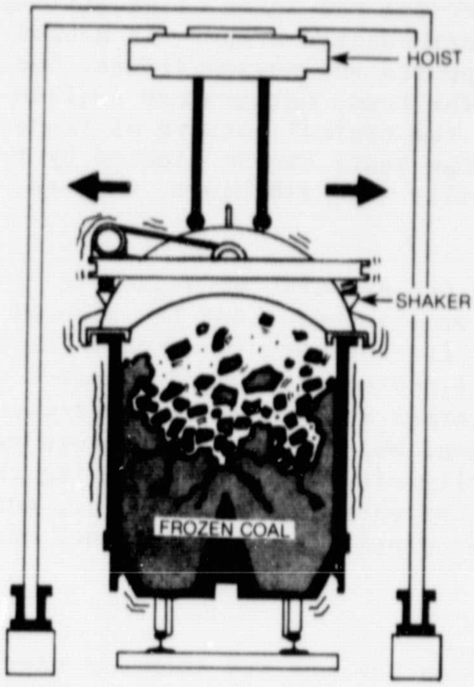
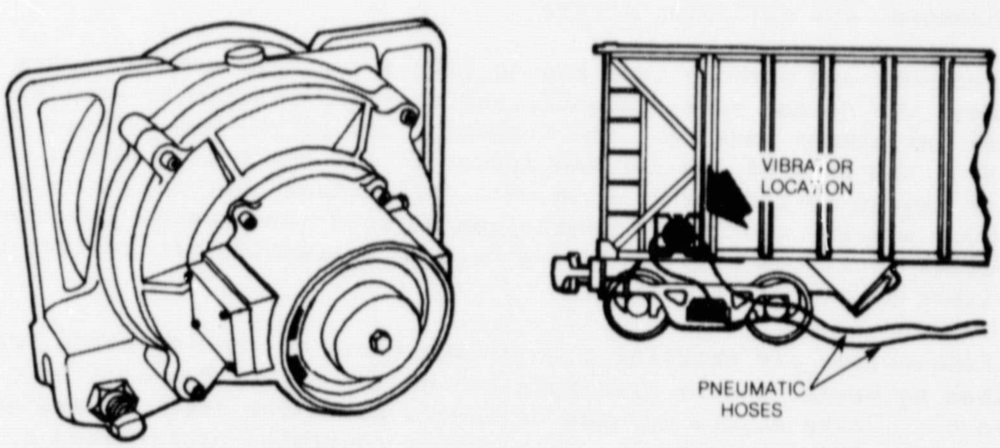


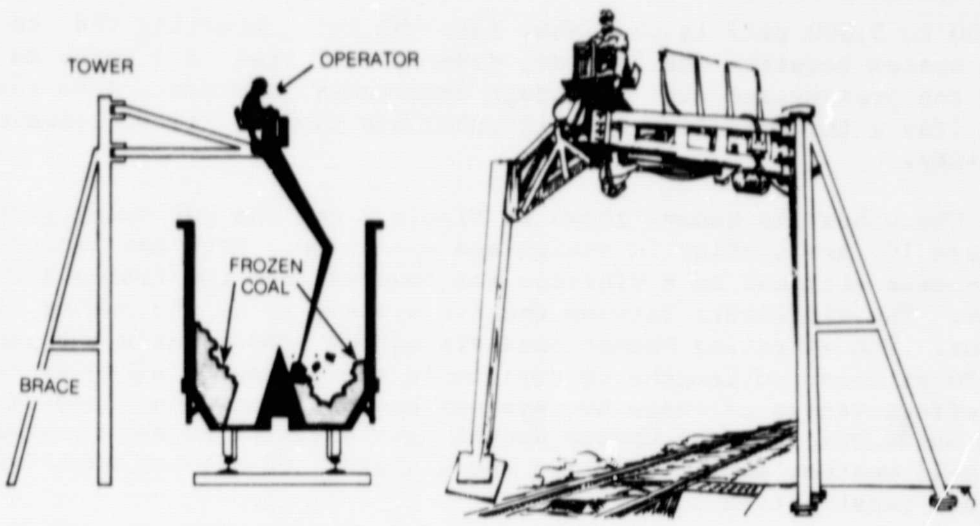
SOURCE: Ford, Bacon & Davis

FIGURE 6(a) SHAKER (Large Vibrator)



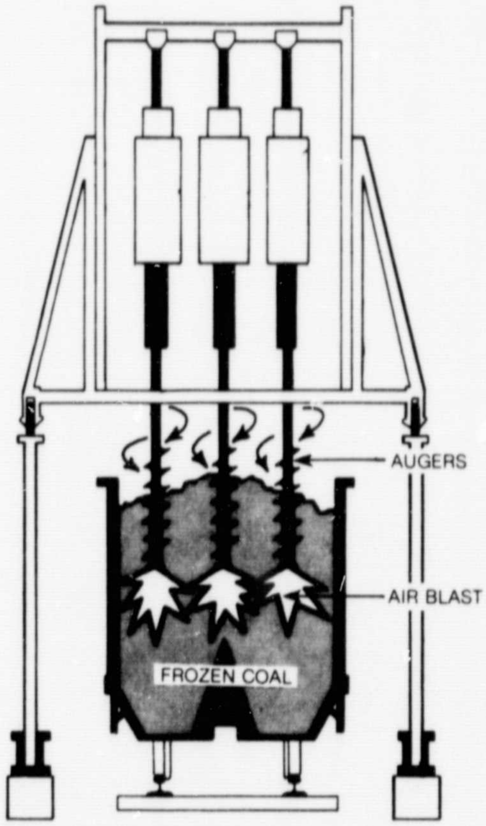
SOURCE: Ford, Bacon & Davis

FIGURE 6(b) VIBRATOR



SOURCE: Ford, Bacon & Davis

FIGURE 7 CAR HOE



SOURCE: Ford, Bacon & Davis

FIGURE 8 HOPPER POPPER

(1,000 to 5,000 psi) is then shot into the hole, breaking the ice bonds. This system requires one laborer, devoted full time, and power to maintain the pressurized air. Although reportedly effective, this system's cost (for a three-drill unit, $125,000) has limited its acceptance by industry.

The vibrating hammer shown in Figure 9 and the galloping gertie (Figure 10) are similar in design and operation. Both use probes made of I-beams attached to a vibrator and lowered into the frozen cars by crane. The difference between the two systems is in the number of probes. The vibrating hammer consists of one probe, while the gertie has 30 at measured lengths to conform to the bottom of a hopper car. The effectiveness of these two systems has not been documented, and the five units built by the Chesse System have never been used because of the mild weather during the last two winters. Chesse was unwilling to discuss construction costs.

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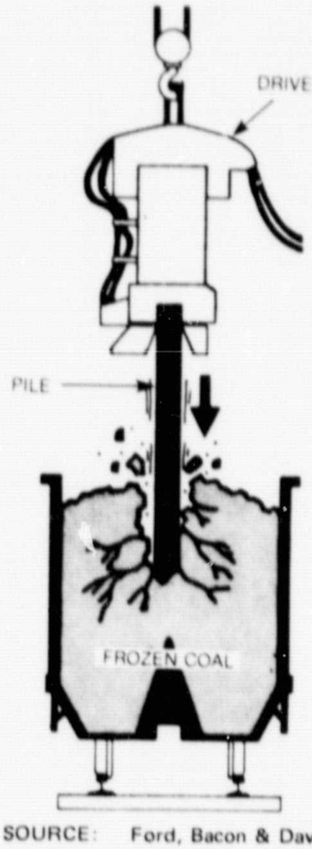


SOURCE: Ford, Bacon & Davis

FIGURE 9 VIBRATING HAMMER

SOURCE: Ford, Bacon & Davis

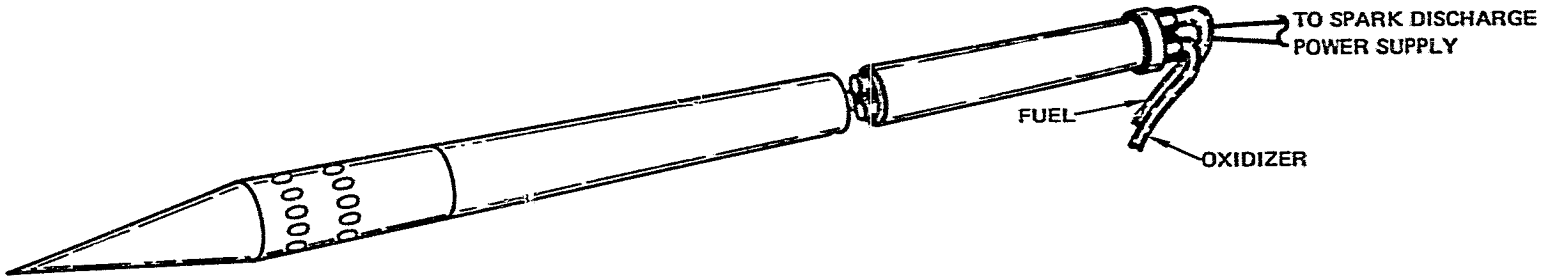
FIGURE 10 GALLOPING GERTIE

V NASA-DESIGNED GAS DETONATION LANCE

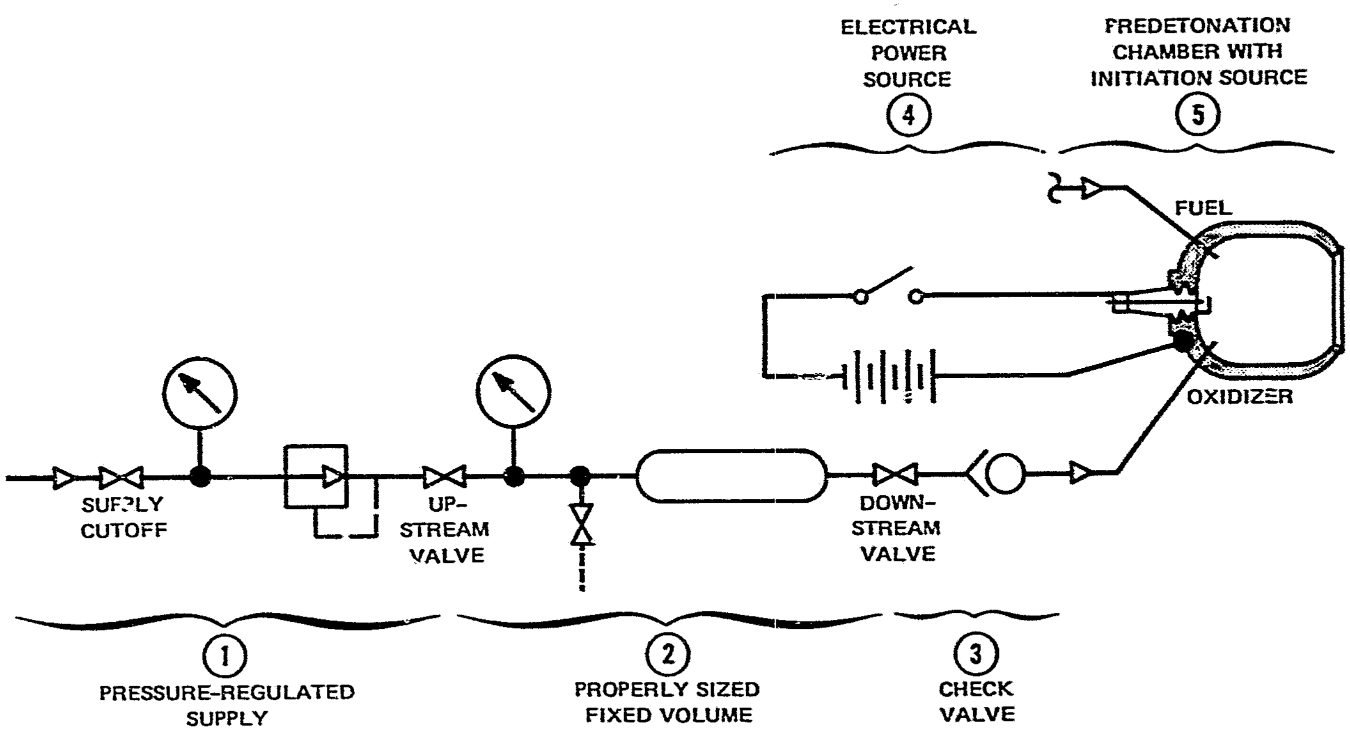
The principle underlying the NASA-designed gas detonation lance is that the shock waves created by the detonation of a small amount of a common fuel (e.g., acetylene, propane, butane, methane, hydrogen) that has been mixed with oxygen--or air--in a combustion lance, and in the aggregate, will break the ice bonds between frozen coal nuggets. With the incorporation of a series of valves, the fuel and oxidizer, initially contained in fixed volumes at known pressures, can be mixed safely in the combustion lance and introduced into the frozen aggregate. The mixture is then detonated, remotely, via an electric ignition circuit to create a series of small, localized shocks in and around the frozen coal.

Identical fuel and oxidizer supply systems are encased in a lance (or auger or drill) that is caused to penetrate the frozen aggregate to a predetermined depth. The control mechanism (see Figure 11) is placed in the first position, which closes the downstream valves and opens the upstream valves. This permits the gases to flow from the regulated supplies into the fixed volumes. When a preset pressure level is reached in the fixed volumes, the control mechanism is switched into the second position, which closes the upstream valves and opens the downstream valves. The gases flow past the one-way check valves into the predetonation chamber where they are mixed. The mixed gases then flow into the aggregate, displacing air. The control is then placed in the third position, which ignites the mixture via an electrical spark discharge creating a localized detonation that sympathetically detonates the small pockets of mixed gas in the aggregate. The latter shocks are expected to have the major effect in loosening the frozen coal. The lance is then removed, repositioned, and the process repeated until the cargo is sufficiently fragmented to permit dumping. An assembly drawing of a prototype lance appears in Figure 12.

The cost of fabrication of the demonstration system, including hardware and technician time for assembly and checkout, is projected to be $5,193 to $5,693 per unit. Table 2 lists the hardware components used in construction of the prototype at LRC and their prices. These costs are not to be considered typical of a commercially designed and manufactured system because most of the purchased parts are high-quality, R&D types of items that are intended to be used on other LRC projects; hence, their cost is higher than that of corresponding commercial parts. Labor cost estimates of $540 to $1,040 are based on an hourly rate of $9 to $13 for a senior technician working between 60 and 80 hours to complete assembly and checkout of the lance.



LANCE



FUEL OR OXIDIZER

SOURCE: Langley Research Center

FIGURE 11 NASA GAS DETONATION LANCE-SCHEMATIC

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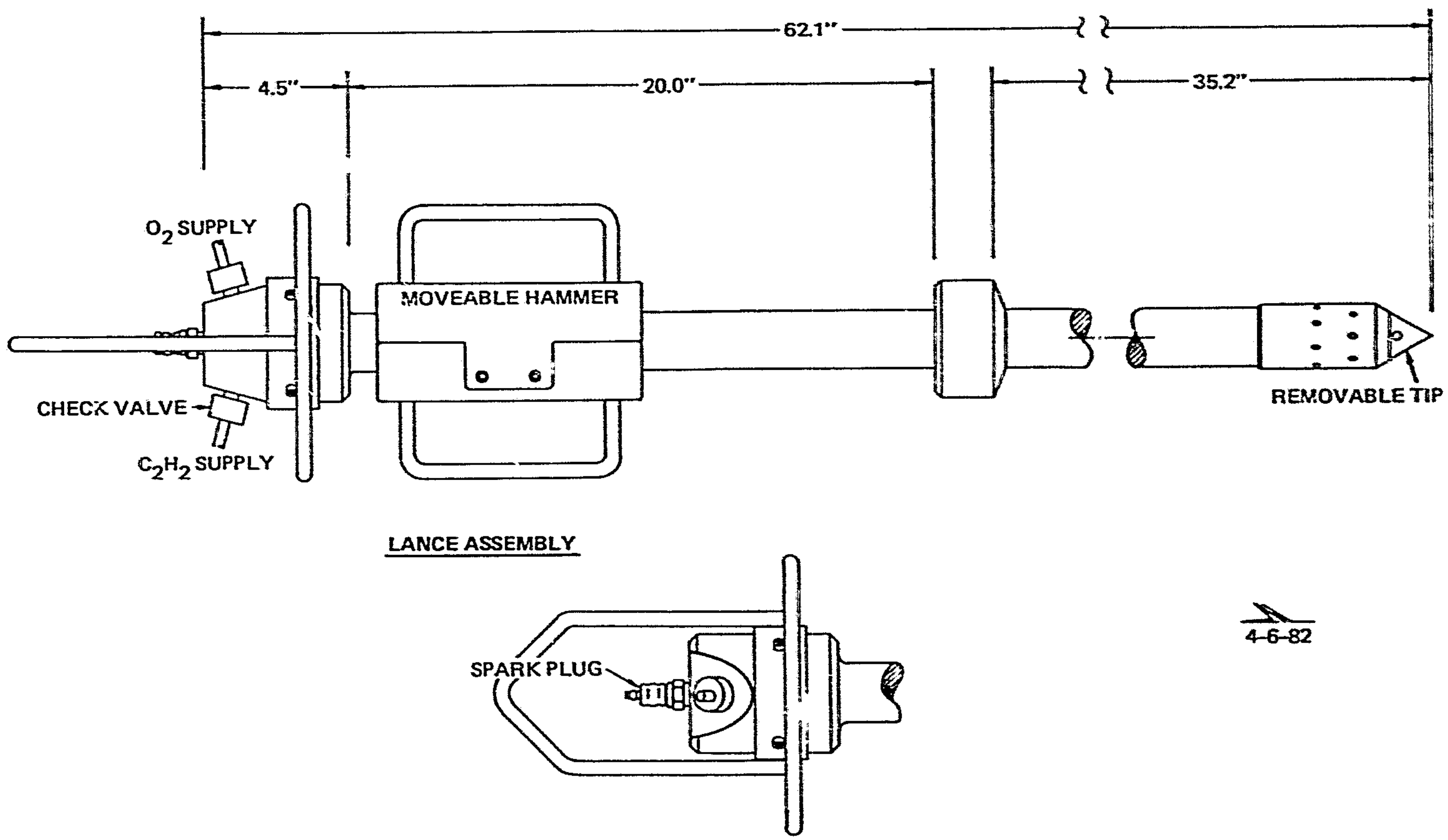

SOURCE: Langley Research Center

FIGURE 12 NASA GAS DETONATION LANCE-ASSEMBLY

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Table 2

HARDWARE FOR THE DEMONSTRATION NASA LANCE SYSTEM

Description	Unit Cost	Quantity Required	Total
Marotta 1/4-inch N.C., two-way, two-position, solenoid-actuated, 24 Vdc, 110 Vac, direct-acting magnetic, 3000-psi valves. Model NV100, Part 206003	$ 285	4	$1,140
Marotta 1/4-inch flow check valves, Model 3	1,250	2	2,500
Smith Flowmeters, Models H1230 and H1251A (not required for a commercial system)	50	2	100
Whitey Sample Cylinder Bottles, 3785 cc, Model 304-HDF8, 1 gal.	231	2	462
Victor Welding Cylinder Truck, Model CTR-514-1T	85	1	85
Victor Heavy Duty Deluxe Journeyman Gas Welder Outfit	299	1	299
Victor Model 12-T2 and Model 320 Straight Nozzle and Handle Extension (not required for a commercial system)	67	1	67
			$4,653

Source: Langley Research Center.

VI MARKET INFORMATION

The market demand for the controlled gas detonation lance is estimated to be at least 10 units. This estimate is based on the TATeam's survey of northeastern and midwestern utilities, which use a combined total of approximately 42.5 million short tons annually, 32.1 million short tons of which arrive by rail. Combined, these utilities' freezing problem amounted to about 4% of the total coal shipments received by rail, or 1.2 million short tons. Of the company representatives surveyed, three expressed possible interest in four lances as an emergency treatment, contingent on cost figures. This represents a market of 1.3 lances for every 1.2 million tons of coal that arrive frozen. Using the estimated industrywide figure of [illegible] million short tons, the estimated figure of 10 units is obtained.

Several factors limit further expected market penetration: the severity of previous winters, industry prejudice, and speed of operation. Should the severity of the winter of 1981-82 continue, coal handlers' interest in new methods of unloading frozen coal cars is expected to increase proportionately. Because the two previous winters were mild, coal freezing problems were slight. This caused industry concern to lessen, and interest in developing or acquiring new methods or products to deal with frozen coal cars also waned. When the TATeam contacted them in early fall 1981, coal users expressed little interest in the development of a new frozen coal loosener. Most of them had established a coal treatment program involving chemicals and heat that was effective for the relatively mild winter temperatures. The TATeam contacted 42% of the participants of the original survey after the winter began to determine whether the use of FCAs had helped limit freezing. In only one instance, when a heavy rain had been followed by a severe freeze, did any problems occur.

The systems adopted by the industry during this period are representative of industry attitudes toward coal freezing and innovation. Coal-using industries tend to be conservative and traditional in their approches to probleme. The heat and vibration method used today is a natural progression from the fires and manual labor of yesterday. Past devices using explosives or explosions to break up ice bonds were not widely accepted by the industry, a reflection on the lack of control over the size of detonation (more than one car had been blown apart).

In general, the industry seems willing to adopt any proven method of solving a problem that costs less than the problem. The proof required is successful use in the field by a major company for a year or longer. Even this, however, does not guarantee acceptance. The Hopper Popper, developed by a railroad as the answer to the frozen coal car problem, has never gained the industry acceptance expected. Capital and operating costs are cited by most as reasons. However, even companies whose coal freezing costs them more in bad years than the Hopper Popper have not accepted this innovation. Another reason sited for lack of acceptance has been the time involved. Large coal using operations require dumping a car every minute. The Hopper Popper and other mechanical devices have not been able to achieve and maintain this rate.

Several survey participants expressed the opinion that the largest market would be among small users who could not afford thaw sheds or rotary dumping equipment. Members of this market segment, however, tend to be highly conservative in their capital investments because their resources are limited. Offering a lease option plan would probably be the best means of introducing a new product into this market.

The increasing trend toward dedicated unit trains to ship coal will affect the treatment of frozen coal. Gondola cars, chemicals, heat, and rotary dumping are an effective combination that best serves this type of coal shipping. Demand for other methods probably will decrease, except for emergency service and small user applications. Introduction of the NASA controlled gas detonation lance thus will not greatly affect the current trend, and demand for it most likely will not be great.

Appendix

COMPANIES CONTACTED DURING TATeam SURVEY

Listed below are the companies contacted during the TATeam survey. At each, the respondent was a coal traffic manager or vice president.

Union Electric Company St. Louis, Missouri	Dayton Power & Light Dayton, Ohio
Pennsylvania Power & Light Shippingport, Pennsylvania	Philadelphia Electric Co. Philadelphia, Pennsylvania
Wisconsin Power & Light Madison, Wisconsin	Toledo Edison Company Toledo, Ohio
Buckeye Power, Inc. Columbus, Ohio	Ohio Edison Company Akron, Ohio
Duke Power Company Charlotte, North Carolina	Southern Railway System Washington, D.C.
DMI Range Railroad Co. Duluth, Minnesota	Burlington Northern, Inc. St. Paul, Minnesota
Old Ben Coal Company Chicago, Illinois	