

MINING ENGINEERING

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Maintenance at Henderson



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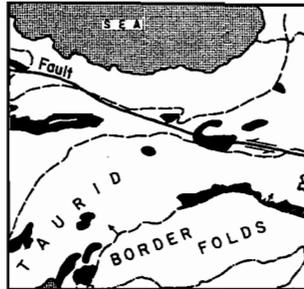
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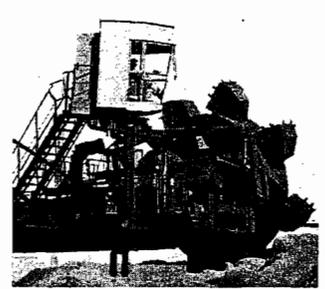
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Preventive maintenance is economic. It aids productivity. Find out about Henderson's maintenance program, beginning on page 1091.

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Novel design for a thin seam shuttle car featuring an ergonomic operator compartment

A. G. Mayton, J. R. Bartels, and W. D. Mayercheck

Abstract—Since 1982, the US Bureau of Mines has investigated improvements in protection for operators of thin seam shuttle cars. Due to working height restrictions in thin seam mines (≤ 1.22 m or 48 in.). Federal mine regulations require that canopy protection on shuttle cars be provided only in mines ≥ 1.07 m (42 in.). However, court obtained variances are granted to mines ≤ 1.22 m (48 in.). This paper presents ongoing research to design and evaluate a uniquely positioned, ergonomic compartment for a shuttle car that provides the operator with full canopy protection in working heights of 1.02 m (40 in.).

Introduction

The importance of cabs and canopies for mining machinery is shown by the 260 lives saved during roof falls in underground coal mines from January 1974 through April 1988 (Pascoe, 1988). In thin seam mines, the availability of these

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protective structures is low, while the need is great. This is true especially for shuttle cars that travel quickly and frequently throughout the face area of a mining section.

Recognizing the serious technical problems encountered in protecting operators of thin seam shuttle cars, as well as the shortcomings of traditional shuttle car designs, Bureau of Mines research has been focusing on an innovative approach to resolve these problems ergonomically.

Development of novel, ergonomically designed operator compartment

The traditional approach to shuttle car design emphasizes performance criteria - maximum coal carrying capacity and tramping clearance as opposed to the needs (safety, adequate visibility, comfort) of the shuttle car operator. In contrast, the Bureau's approach emphasizes ergonomic criteria and has developed a novel operator compartment that gives the needs of the operator equal priority with traditional design criteria.

Cab-shuttle car concepts

To provide a forum for generating cab-shuttle car concepts and to guide this research effort, a project advisory committee, comprising Bureau of Mines and Mine Safety and Health Administration (MSHA) personnel, was established. The committee reviewed both mandatory and desirable evaluation criteria. It selected 1.02 m (40 in.) as the working height for the new design and conceived the following basic configurations that were then evaluated:

- transverse, center-driven;
- parallel, end-driven;
- parallel, center-driven;
- transverse, end-driven; and
- cross-car, end-mounted.

Of these, the cross-car, end-mounted configuration was selected as the most promising design for enhanced protection of the thin seam shuttle car operator. This design (Fig. 1) positions the operator at the end of the vehicle, perpendicular to its long axis, and gives the operator excellent visibility when tramping to and from

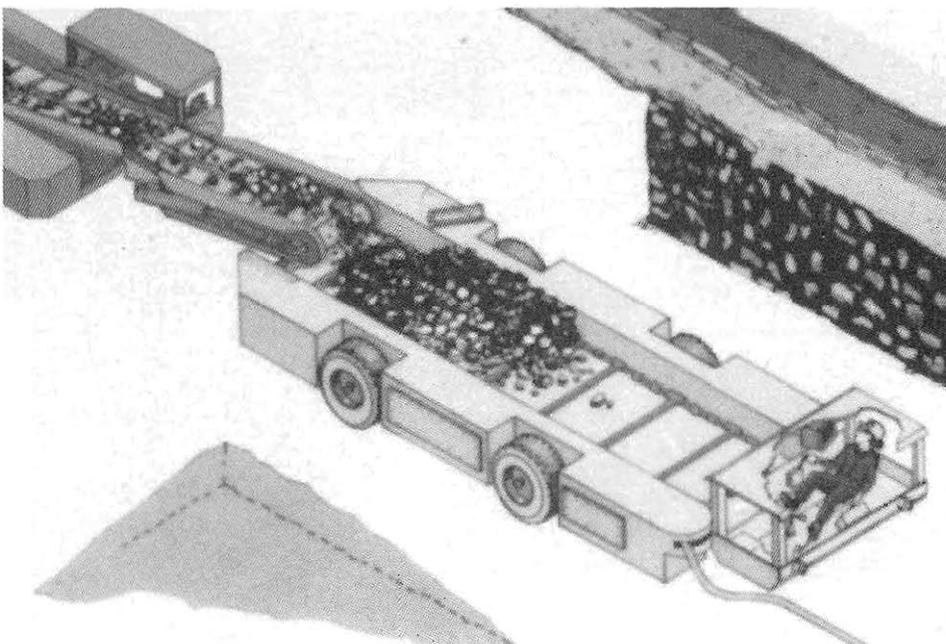
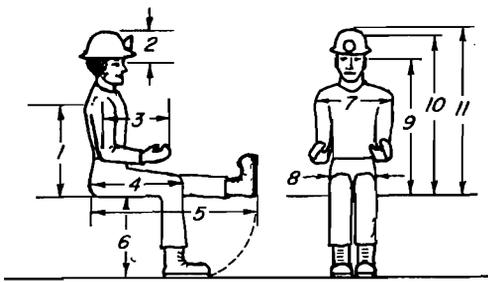


Fig. 1—Artist's illustration of cross-car, end-mounted cab-shuttle car.



Dimension, in	5th-percentile 95th-percentile	
	female	male
1 Shoulder height	19.7	25.7
2 Eye-to-helmet top	6.0	6.5
3 Forearm-hand length	15.3	20.2
4 Buttock-knee length	20.5	25.9
5 Buttock-leg length	38.0	46.1
6 Back-of-knee height	14.8	18.2
7 Shoulder breadth	14.1	20.1
8 Hip breadth	12.9	15.4
9 Eye height	26.9	33.9
10 Sitting height	30.9	38.4
11 Sitting height with helmet	32.9	40.4

Fig. 2—Coal miner anthropometric data.

the face. The main drawback is extra maneuvering of the machine when unloading coal.

In general, turning a corner to the dump site should be no problem. The shuttle car is only about 0.3 m (1 ft) longer than a standard car as a result of modifying the operator end (the original load end) of the car. Further, any decrease in production because of the maneuvering at the dump area appears minimal and should be a small tradeoff for the increased safety and comfort of the shuttle car operator.

Compartment design

Design details of the compartment and related components were based on anthropometric criteria for the 5th percentile female and 95th percentile male operators (Fig. 2) using two computer modeling programs. The main program was the crew-station analysis program (CAP) developed by the Bureau of Mines (Rider and Unger, 1989). It aided in analyzing the anthropometric parameters for the cab and checked operator visibility at required visual attention locations (VALs).

The second program, crew-station assessment of reach (CAR), was developed by Boeing Aerospace (Harris et al., 1980). It was adapted for use within the framework of CAR. CAR ensured that all the shuttle car controls were at optimum reach locations.

The basic dimensions of the compartment structure were set at 0.9 m (3 ft) wide by 1.8 m (6 ft) long by 0.9 m (3 ft) high (Fig. 3). The width provides the operator with sufficient hip room and freedom of movement while not interfering with the capability of the shuttle car to tram around corners. (The unused load end of the vehicle can be shortened without altering the standard chain conveyor or decreasing haulage capacity.)

The length of the compartment allows more leg room and comfort for the operator in a reclined seating position. Considering the compartment is designed as a full-floating cab, the 0.9 m (3 ft) height permits enough clearance to prevent roofing in a 1.02-m (40-in.) coal seam.

Moreover, support posts for the canopy have been placed

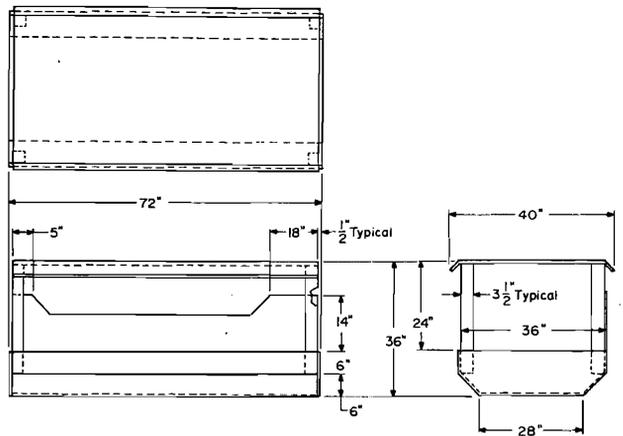


Fig. 3—Dimensions of the operator compartment.

as far as possible out of the operator's field of view. Further, all corners and edges of the operator compartment and canopy are beveled or sloped so the compartment can float over or deflect off, rather than jam on, any roadway obstacles.

Loading capacity and ease of loading are accommodated by modifications to the loading end (the original discharge end) of the shuttle car. This end will be reinforced for additional strength and stability. The width will be increased to allow for side loading by the continuous miner. Side boards, higher than those available on current thin seam shuttle cars, will also be added.

When loading, the operator is protected from coal spilling into the compartment by a steel blocking plate operated by a hydraulic ram. In this situation, the operator still has good visibility looking directly down the side of the car. Additionally, the operator can view the tail boom conveyor of the continuous miner (obscured by the loaded coal) through the closed-circuit video system. This system consists of a remotely operated video camera protected by an explosion-proof enclosure on the right boom end of the shuttle car and a black-and-white monitor located inside the operator compartment.

The video system allows the operator to view important areas in the working environment. A two-position rotary actuator pans the camera 90° to allow viewing coal from the tail conveyor of the continuous miner and the area around the dump site when tramping to unload coal. The accumulation of dust on the camera window is minimized with a pneumatic lens cleaner developed by the Bureau (Kwitowski et al., 1988).

Seating for the compartment is designed to enable the shuttle car operator to perform for an eight-hour shift or longer without unnecessary discomfort or fatigue. Notable features of the seat include:

- an adjustable back with lumbar support to permit smaller operators to sit in a more upright position;
- a seat pad, with adjustable tilt, short enough to prevent cutting off circulation in the legs and wide enough to provide adequate hip room;
- an adjustable, pre-shaped headrest to hold the head and neck in a comfortable, upright position for prolonged periods of operation;
- contoured, foam cushioned padding with vinyl covering;
- the means for minimizing shock and vibration to the operator; and
- an optional seat belt with a Velcro hook-and-loop fastener to help secure the operator during conditions of rough bottom.

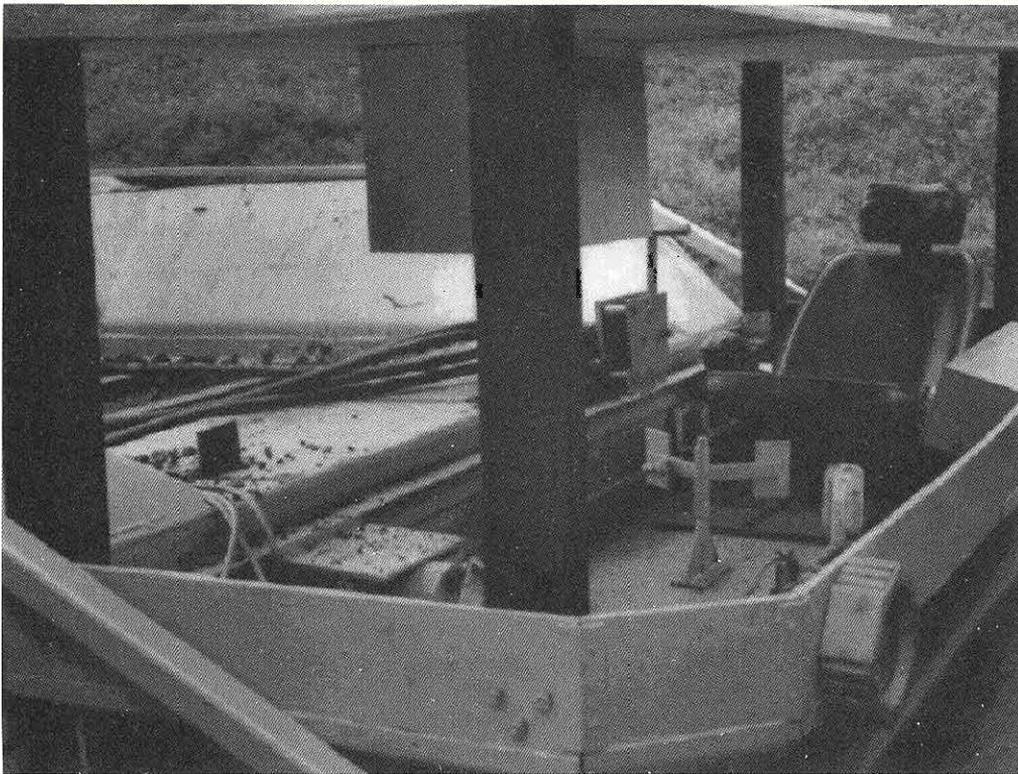


Fig. 4—Mockup of cross-car, end-mounted operator compartment.

Mockup and evaluation

A mockup of the operator compartment was built and mounted on a shuttle car to identify deficiencies and permit improvements in the design before constructing a full-scale prototype. It underwent a surface evaluation with several personnel operating the shuttle car through a predetermined course. Favorable comments from operators included the dramatic increase in operator visibility, the comparative roominess inside the compartment, the ease of entering and exiting the compartment, and the ease in adjusting the seat to accommodate all operators.

Two improvements involving the control layout and the steering unit resulted from the mockup (Fig. 4). Changing the control layout from the swing-away style in front of the operator to a more traditional side mounted style better accommodated very large operators who tended to hit their legs on the swing away controls. The standard orbital steering unit was replaced with lever-type steering using a gearing mechanism. This change should minimize operator confusion and error by enabling the operator to turn the vehicle in the same direction the lever is pushed or pulled, regardless of the direction of travel.

Summary and conclusions

The Bureau of Mines ergonomically designed compartment appears to offer a workable and safer solution to the problems of protecting operators of thin-seam shuttle cars. The novel design provides effective operator protection from roof/rib falls and pinching-squeezing accidents that are responsible for 90% of all shuttle car accidents. Operator visibility, when tramming to and from the working face, is dramatically improved by the unique location of the operator compartment. The cross-car, end mounted design also gives ample space for operator comfort and permits designing wider shuttle cars, thereby increasing coal transport capacity.

With a full-scale prototype of the compartment now built, effort in the program continues toward these primary goals:

- surface testing of the prototype with operational control and video systems on a modified thin seam shuttle car; and
- an underground evaluation of the cab-shuttle car under actual operating conditions.

The ultimate goal of this effort is a new shuttle car design featuring an ergonomic operator compartment. At this stage of work, it is difficult to project the impact of costs for a new shuttle car/compartment design. However, the Bureau believes the cost of such a design should be competitive with existing equipment. ♦

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