Load-Haul-Dump Concept in Salt Mining

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ABSTRACT

This paper compares previous conventional Loader-Truck and Stationary Crusher Mining System to new Load-Haul-Dump (L-H-D) with Portable crusher/Feeder System presently now in use. A brief history of operation is included along with maps, charts and graphs of production results achieved through new L-H-D system.

INTRODUCTION

The Cleveland Mine of the International Salt Company (ISCO) is located within the City limits of Cleveland, Ohio, on Whiskey Island adjacent to the Cleveland waterfront and less than 1-1/2 miles from Public Square. The mine, which went into production in 1961, has a present capacity of approximately 2,000,000 short tons annually based on a 2-shift production operation. Shipments are made by rail, truck and boat.

Except for an initial unsuccessful start-up trial of a continuous mining system, the operation has been of conventional design. A basic room and pillar method of mining is used to remove rock salt of 98% average quality from a 35-ft. thick bedded deposit located 1,765 ft. below the surface. Rooms are 45 ft. wide by 18 to 20 ft. high with at least 2-1/2 ft. of salt being left in the roof. This results in an extraction ratio of 50%. The present mining operation is totally under Lake Erie.

Undercutting is done by Joy 15RU Cutting Machines with 13 foot bars using conventional Tungsten Carbide Insert bits. Drilling is done by Twin Boom Fletcher Hydraulic Face Drills using 2" diameter Tungsten Carbide bits. Drills can drill to a depth of 15 ft. Blasting is by prilled Ammonium Nitrate (AN/FO) using electric millisecond delay blasting caps and DuPont Detaprime primers. AN/FO is placed in the drill holes pneumatically. A blasted room yields roughly 700 tons of fragmented salt. Roof bolting is performed in all permanent haulageways and roadways along with random bolting at all permanent equipment locations. Bolting is done with a one man diesel powered Fletcher Roof Bolter equipped with dust collection. Normal bolts are 6-ft. X 5/8" diameter on 4-ft. centers and one man can install up to 100 per shift. Electric power is taken into the mine and distributed at 4160 volts AC and all Face and Mainline Haulage equipment is 440 volt AC and ground fault protection equipped.

All of the equipment and systems mentioned have operated satisfactorily over the years and existing available equipment has been adapted to production requirements in a sound and economic fashion. However, with salt loading, gathering transportation, and primary crushing, this has not always been so. Up until two years ago, ISCO handled its blasted salt differently: A small 1-1/2 yd. Wagner Mine Scoop pushed up blasted fly rock salt in each shot room. A Jeffrey 97B Loading Machine picked up the salt and loaded it into articulated trucks (6 Wagner MTT26 units and 6 Long Ejecto-Haul units) for the trip to the Primary Crusher. The Primary Crusher was a McLanahan 36" X 48" single roll crusher which was fed by a variable rate controlled hydraulic Feeder-Grizzly unit. This equipment was mounted beneath a 70-Ton feed hopper into which the haulage trucks dumped. The complete complex was constructed in an excavation in the mine floor that was 26-ft. deep X 14-ft. wide with a 200-ft. long X 14-ft. wide ramp for the mainline haulage belt to handle the minus 8" crushed product. This large primary crusher installation and positioning the trucks at the surge hopper required a crusher attendant at all times.

Maximum truck haulage distance was 4,400-ft. one way and minimum distance was never less than 450-ft. It took at least three months to complete an installation and its cost ran between $20,000 and $35,000. Within six months of start up, the haulage distance started to become

excessive and our truck availability curve would begin to slide in direct proportion to the length of haul. For years ISCO knew that the key to improved gathering-transportation was to keep the haul to a minimum, but the only crushers that were available required massive installations that did not allow constant moving.

NEW OPERATIONS

The breakthrough came for ISCO when we visited the Trona mines of Southwest Wyoming in 1970 and saw how effective the new Stamler Feeder-Breakers, recently placed in service, were operating. ISCO's Retsof Mine ordered one of these units for service with shuttle cars and it was an instant success. Simultaneously the Load-Haul-Dump industry had introduced a new "large size" machine with a 7 cu. yd. bucket and it appeared that these machines, compared to the Stamler, were a natural for our conditions. After much investigation, two 7 cu. yd. Duetz powered Eimco 915 L-H-D units along with a large Stamler Feeder-Breaker were ordered. These units went into service in January of 1971 and were an immediate success. As many readers know, ISCO's Cleveland Mine contains a displacement fault that cuts completely across the property. This barrier has forced development of a completely new mine operation on the north side of the fault, once the necessary access openings were pushed through it. The new L-H-D system was chosen for this development work because of the desire to open up the new area as rapidly as possible. In performance, the system has exceeded expectations. Surprisingly, soon after purchasing the two 7 cu. yd. machines, the industry introduced a 14 cu. yd. model. Based on the results obtained from the two smaller machines, in June of 1972 an order was placed for two Eimco 920 L-H-D units with 14 cu. yd. buckets. These machines went into service in the summer of 1972 and were an immediate success. The 7 yd. 915 machine is powered by an 8 cyl. Duetz and averages 7–1/2 tons of salt per trip. The larger 920 uses a 12 cyl. Duetz and averages 15 tons of salt per trip. Since August of 1972, 100% of production has been from the L-H-D system. Normally two 920's and one 915 are operated with the other 915 unit as a spare. These three units dump into two Stamlers. Each Stamler has one Eicmo 920 feeding it with the single 915 Eimco working the Stamler that has the longest haul. A total average of 500 tons/shift hour is expected from these three machines. Recently there was delivery of a third Stamler which is much bigger than No. 1 or No. 2. The original No. 1 machine is presently being rebuilt the same as No. 3 after having handled 1,400,000 tons of salt. These machines have 2 - 100 HP motors. One drives the feeder chain and the other drives the breaker shaft. Each machine is capable of crushing 600 tons per hour.

The most economical distance for ISCO at Cleveland to operate is a maximum haul of 600 ft. one way in the development section and 750-ft. one way in the mining section. The Development Section is purposely kept as narrow as practical to keep the forward advance as rapid as possible for two reasons: (1) There is exploration ahead for possible other faults or major disturbances and (2) Because of the desire to develop the area for full scale mining as rapidly as possible.

The Belt Haulage system presently consists of a 48" Mainline belt and 36" Section panel belts which feed directly onto the Mainline belt at intermediate transfer stations. All belts are wire rope suspended from floor stands. In the future, plans are to replace the mainline haulage belt with a rigid frame type. The rope type suspension is not being considered for long range service due to the mine atmosphere. The presence of small quantities of hydrogen sulfide combined with moisture and salt dust requires that the ropes be changed approximately every three years. This is costly, especially if a premature failure occurs. Total mine production is weighed on a Thayer electronic load cell belt scale located in the 48" Mainline belt system.

In the recent past, both the mainline and panel belts were advanced a number of times so that the final shutdown advance routine is down to three shifts. With the recent purchase of the Third Stamler, all of the belt advancing will be on a straight time basis at minimum cost and maximum system flexibility. (Any temporary Stamler or Panel Belt failure can be supplemented by the third Stamler-Belt unit, provided it is not being advanced.) One of the significant factors of a belt line advance, is the mine power advance that must accompany it. With the ground fault protection electrical system, it has been decided that all cables should be hung and heavy rubber tired equipment should not run over trailing cables at all. All Belt line advances are actually complete section moves and in this type of system, advanced planning coordination of all elements has positive results. In addition, the elimination of the Jeffrey Loading machine has greatly simplified the electrical requirements, for the undercutter and the drill are the only electrified face equipment within the section. The belt lines and the Stamler are handled as another separate power system. The Stamler Breaker-Feeders are presently set for a maximum 8" product to the belt lines, although sometimes a longer slab type piece will go through.

The Load-Haul-Dump system has produced the following results at the Cleveland Mine:

Man power

Significant improvements were realized on a Tons per manhour basis comparing labor for the old system (loading, gathering transportation and primary crushing) with labor for the new L-H-D–Feeder Breaker System. An

improvement of 238% for operating labor, 388% for maintenance labor and 308% for total labor was realized. (Figs. 1 & 2)

Investment

Based on a present day equivalent replacement value, for both systems, the Old Loading Machine Truck fixed crusher system costs $175,000/million tons of production per year, or $.175/ton, whereas the new L-H-D Stamler Feeder-Breaker System costs $87,000/million tons of production per year or $.087/ton. (Fig. 3)

Costs

1. The Jeffrey Loading costs are completely eliminated.

2. If the L-H-D units are compared to the haulage trucks, operating labor is reduced by 50.3%, maintenance labor by 39.1% and maintenance materials by 57.9%.

3. The crusher operator has been eliminated and it is felt that the moving of the Stamler every 3 months approximately equals the moving of the large crusher with pit and dumping system every 2–3 years. The maintenance of the Stamler may be a little more than the large single roll unit, but the hydraulic crusher feeder unit is eliminated with resulting savings and it must be remembered, that the Stamler Feeder-Breaker is a new concept and improvements are being made daily that result in lower maintenance costs.

4. Belt line costs are up a little due to the increased number of belt lines, but this is easily offset by the versatility of the system. Under the old method, any belt line failure resulted in the total system being down. In the L-H-D system, any Panel Section Belt failure means only a 50% loss of Production and in many cases, this is only temporary until the mobil equipment can move to the spare section.

5. Availability—Discounting the debugging and modification work performed on the L-H-D units, ISCO has experienced an availability figure in excess of 90% for this equipment. This is compared to an average of 65% for trucks and 75% for loading machines. The Stamler Breaker-Feeder has had an availability in excess of 95% which is equal to the old Stationary Crusher-Hydraulic Feeder system.

MAN POWER

	OPERATING LABOR	MAINTENANCE LABOR	TOTAL LABOR
OLD SYSTEM	Loading, Truck Haulage & Primary Crushing	Loading, Truck Haulage & Primary Crushing	Loading, Truck Haulage & Primary Crushing
	46.8	36.4	20.5
LHD SYSTEM	L-H-D & Stamlers	L-H-D & Stamlers	L-H-D & Stamlers
	158.3	177.4	83.7

(All figures shown are Tons per man hour.)

Figure 1.

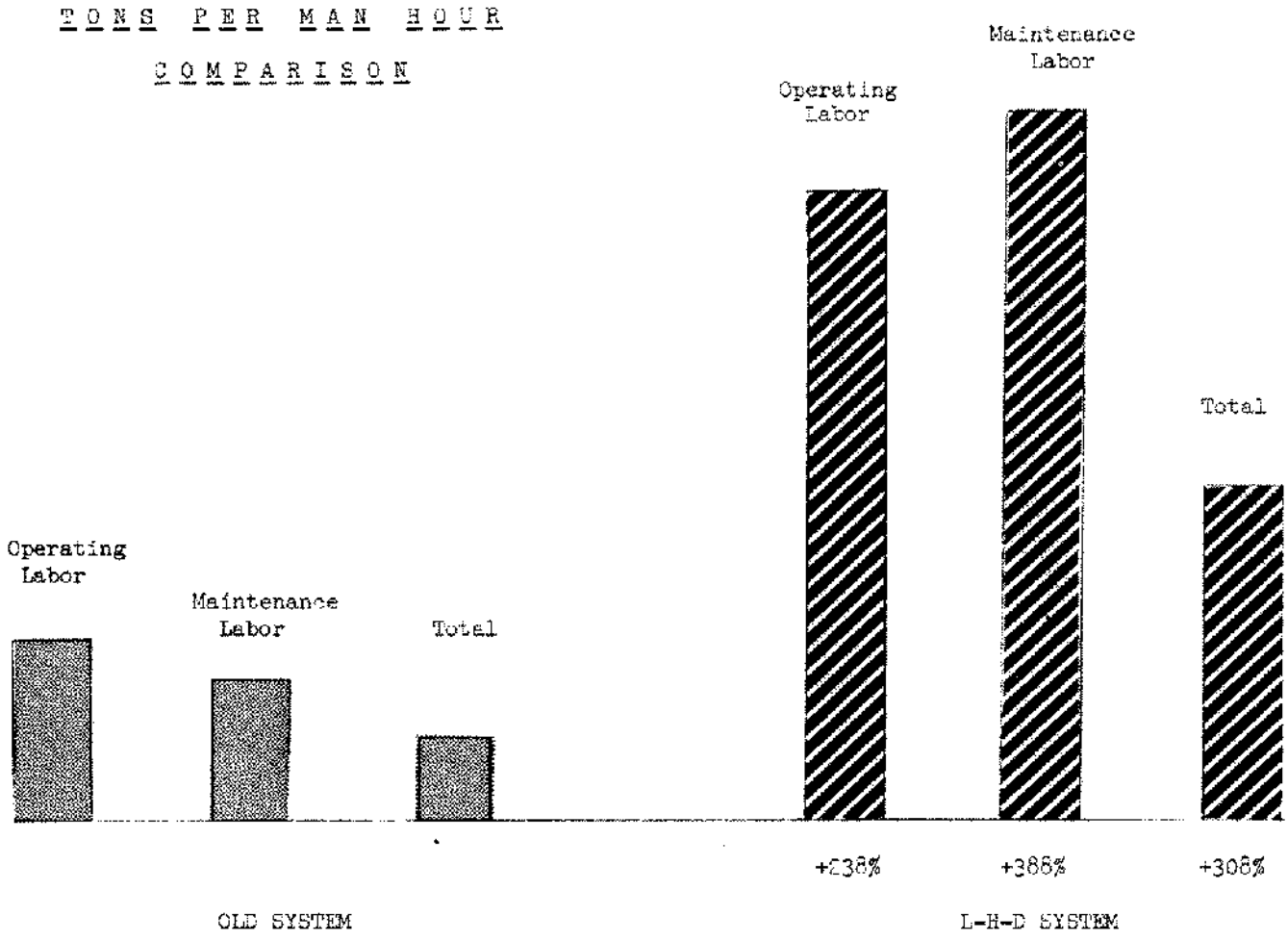

Figure 2.

INVESTMENT ANALYSIS

	EQUIPMENT	UNIT COST	TOTAL INVESTMENT	LIFE	INVESTMENT PER YEAR
OLD SYSTEM	4 Jeffrey Loaders	$ 100,000	$400,000	8 Yrs.	$ 50,000
	8 Trucks	100,000	800,000	5 Yrs.	160,000
	1 Crusher, Feeder w/truck Dump	85,000	85,000	15 Yrs.	5,700
	Crusher Moving				15,000
	Belt Line		400,000	10 Yrs.	40,000
	Power		150,000	15 Yrs.	10,000
	Total				280,700

At Production Rate of 400TPH and 4000 hrs./yr = $280,700 per 1,600,000 tons = $.175/ton

Figure 3.

NEW LHD SYSTEM

2 EIMCO 920's	$150,000	$ 300,000	5 Yrs.	$ 60,000
2 EIMCO 915's	65,000	130,000	5 Yrs.	26,000
3 Stamlers	60,000	180,000	6 Yrs.	30,000
Belt Lines		200,000	10 Yrs.	20,000
Moving (Belts)				30,000
Power		120,000	15 Yrs.	8,000
Total				174,000

At Production rate of 500TPH and 4000 hrs.yr = $174,000 per 2,000,000 tons = $.087/ton

Figure 3. (Continued)

C O S T S

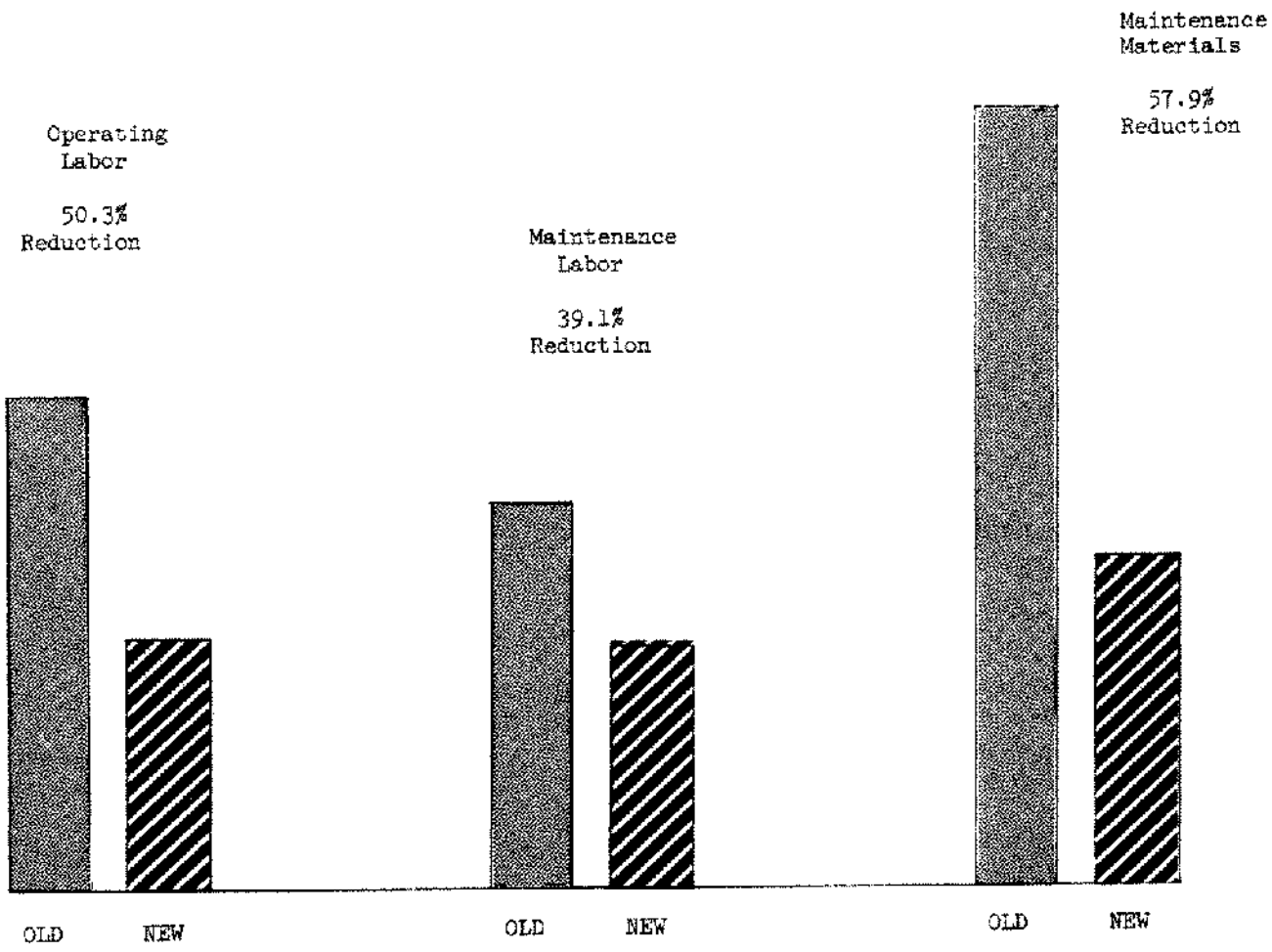

Figure 4.

6. Tires—Many people are concerned over the tire costs of L-H-D systems, for under some operating conditions, tire wear can be horrendous. ISCO's greatest tire wear comes in breaking in new operators and it is found that the wear on the larger 920 machines is less than that of the smaller 915 units.

Tire Type	Wear
EIMCO 915 Front (18.00 x 25—24 Ply)	660-1200 hrs. before capping
EIMCO 915 Rear	2500-3000 hrs. before capping
EIMCO 920 Front (29.50 x 29—34 Ply)	1500-2000 hrs. before capping
EIMCO 920 Rear	?***

(*** Oldest 920 has 1800 hours with 90% tread remaining)

Tire cost of the 915 is approximately $1,000 complete and that of the 920 is approximately $2,000. With the 920 carrying just twice the load of the 915, and with wear approximately half, simple arithmetic shows tire cost of the larger machines about half that of the smaller on a per ton basis.

Recently, a front 915 tire that has been capped for the second time, was received from the factory. The original tire had 950 hours, and the first cap had 1,155 hours. A tire recapping costs approximately one-third the cost of a new one.

In addition, it is noteworthy that our debugging problems with both the Eimco and Stamler equipment have been about what was expected and service and help from Eimco has been quite good and from Stamler, excellent.

SUMMARY

The L-H-D system has been applied successfully to the ISCO operation, because:

1. A piece of equipment—the Loading machine—is eliminated. This is an expensive, high maintenance unit.
2. Belt lines have replaced the long haulage distance of the trucks, which involved very high maintenance costs.

Of course, none of the L-H-D system would work in the case of the Cleveland Mine if it were not for the Stamler Feeder-Breaker and the system should really be called the L-H-D Feeder-Breaker System.

To complete the mining picture, the mainline haulage system feeds a 300 ton surge hopper and then from there, salt is fed to an underground secondary crushing station. Tertiary crushing is next followed by screening, and more screening, and finally the finished product goes into underground storage.