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UNLOADING BOXCARS of GRAIN at TERMINAL ELEVATORS

in the Hard Winter Wheat Area

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UNLOADING BOXCARS OF GRAIN AT TERMINAL ELEVATORS IN THE HARD WINTER WHEAT AREA

by

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SUMMARY

At terminal grain elevators, prompt unloading of grain from boxcars is especially important during and after the harvest. Of the five methods of unloading hard winter wheat studied, the fastest was a mechanical car dumper, used with a car puller to position the boxcar. The time required to unload a 1,900-bushel boxcar of grain was 6.1 minutes. The slowest method, a power shovel (1 unit) used with a car puller to position the boxcar, required 26.8 minutes.

Based on labor and equipment cost and unloading rate, the power shovel is recommended when annual receipts of grain are 1 million bushels. Either the 2-unit power shovel or the car shaker is recommended when annual receipts are 3 million bushels and the car shaker when annual receipts are 5 million bushels. The mechanical or hydraulic car dumper would be best for annual receipts of 10 million bushels.

BACKGROUND

Generally, terminal elevators in the Hard Winter Wheat Area receive all grain by rail. After the country elevators are filled at harvesttime, the rush of receiving grain begins at terminal elevators, where receipts may vary from 10 to 100 carloads each day. Efficiency and speed of unloading are important because boxcars must have a minimum "turn-around" time. To insure this, railroad companies apply a demurrage charge to each consigned boxcar detained beyond 2 days. Although the use of special bulk grain rail cars designed for gravity unloading is increasing, most of the grain is still shipped in standard side-loading boxcars.

The purpose of this study was to provide basic information for selecting the most practical equipment for unloading various volumes of grain at terminal elevators.

The study was conducted at terminal elevators ranging in storage capacity from 8 to 40 million bushels. Although not all boxcar loads were checked, the 2-year average at a terminal of 15-million bushel capacity was 1,900 bushels per car.

Equipment and methods used to unload grain were studied and data on five of the most common types of unloading equipment were collected. The labor

requirements for the unloading operation were obtained by time studies. Data were also obtained on the number of boxcars unloaded per day and on equipment ownership and operating costs.

THE UNLOADING OPERATION

Three- or four-man crews are used to unload boxcars at most terminal elevators. The operation consists of: (1) Positioning the boxcar for unloading; (2) opening the grain door; (3) unloading the car; and (4) moving the empty car away from the dump pit.

The type of equipment used to unload cars is the most important factor both in speed of unloading and in cost. This equipment and its operation is therefore described first, followed by the same information on equipment used to position and move cars. Details on labor requirements are given in the appendix.

Five types of unloading equipment and two types of equipment to move cars were studied. The unloading equipment was: (1) Mechanical car dumper; (2) hydraulic car dumper; (3) car shaker; (4) self-propelled auger supplemented by a power shovel; and (5) power shovel. The Trackmobile and the car puller were the two types of car-moving equipment studied.

The unloading and car-moving equipment were considered the limiting factors in the unloading operation. Pits, elevating equipment, and holding bins were considered to have sufficient capacity to handle the grain at the highest unloading rate.

EQUIPMENT FOR UNLOADING BOXCARS

Mechanical Car Dumper

The mechanical car dumper (fig. 1) consists of: (1) Two rail sections each 60 feet long, supported on a semicircular frame to tilt the car endwise; (2) a mechanism to tilt the car sidewise toward the pit; (3) two end clamps to hold the car secure during unloading; and (4) a hydraulic or pneumatic door breaker.

The electric motors normally used are one 40-horsepower motor to tilt the car endwise, one 10-horsepower motor to tilt it sidewise, and one 15-horsepower motor to operate the clamps. A concrete-walled pit about 15 feet wide, 70 feet long, and 20 feet deep is required to house the underground portion of the mechanical dumper.

To unload a boxcar of grain, the operator raises and closes the end clamps after the loaded car has been positioned on the car dumper. Upon a signal that the dump pit is empty, he starts the door breaker, which pushes in the grain door, and then tilts the car sidewise 13 to 15 degrees. Next, he tilts the car endwise, first one end down and then the opposite, three or four times. Before

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Figure 1.--Mechanical car dumper with boxcar at the maximum tilt. Grain dump pit is at far side of dumper.

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Figure 2.--Hydraulic car dumper has tilted boxcar towards dump pit and is starting to tilt car endwise.

or during the last tilt endwise to 40 degrees, a deflector is inserted to divert the last portion of grain into the pit. A crew member sometimes enters the car to remove loose boards or paper left from the grain door so that the deflector rests properly on the floor. After the empty car is returned to a level position, the clamps are loosened and lowered and the car is ready to be moved from the dumping area.

Hydraulic Car Dumper

The hydraulic car dumper (fig. 2) consists of: (1) Two rail sections positioned on a frame equipped with trunnion devices to hold either end of the car while the opposite end is being raised; (2) a hydraulic piston located at the center of the rail section to tilt the car endwise; (3) a mechanism to tilt the car sidewise toward the dump pit; and (4) a hydraulic door breaker.

The electric motors normally used are one 100-horsepower motor to operate the hydraulic lift, one 20-horsepower motor to operate the end clamps, and one 10-horsepower motor to operate the control system.

A machinery pit, about 15 feet wide, 70 feet long, and 7 feet deep, and a deep caisson for the main hydraulic cylinder are required for the hydraulic dumper.

After the loaded car is positioned on the car dumper, the operator raises and closes the end clamps. Upon a signal that the dump pit is empty, he starts the door breaker and tilts the car sidewise 18 degrees. He then engages the trunnion to secure one end of the car while the hydraulic piston raises the opposite end and tilts the car endwise. The car is then lowered to horizontal and the trunnion released. The opposite trunnion is secured and the car is tilted in the opposite direction.

Before or during the last endwise tilt to 37 degrees, a deflector is inserted into the car to divert the last portion of grain. A crew member sometimes enters the car to remove loose boards or paper so the deflector will rest on the floor properly.

After the empty car is returned to the horizontal position, the clamps are loosened and lowered and the trunnion device is released. The car is then ready to be moved from the dumper.

Car Shaker

The car shaker (fig. 3) consists of: (1) A section of rail track attached to a platform with one rail permanently raised to tilt the car sidewise 8 degrees toward the grain dump pit; (2) two clamps, one at each end of the platform; (3) a motor-activated (40-horsepower) spring mechanism for oscillating the car endwise, thus moving the grain to the center of the car and out the door; (4) a hydraulically operated door breaker; and (5) a combination 25- and 15-horsepower hydraulic power system to activate the clamps and door breaker.

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Figure 3.--Car shaker unloading boxcar of grain. A hydraulic door breaker has pushed in the grain door.

A machinery pit about 10 feet deep, 70 feet long, and 15 feet wide is required to house the car shaker.

After the loaded car is positioned on the platform, the operator raises and closes the end clamps. Upon a signal that the pit is empty, he starts the door breaker, and then the shaker motor. The shaker oscillates the car until it is empty. The clamps are then loosened and lowered and the empty car is ready to be moved from the shaker platform.

Self-Propelled Auger with Power Shovel

The self-propelled auger unloader (fig. 4) consists of twin 9-inch diameter augers, 30 feet long, on a movable carriage. The augers, rotating in opposite directions, are powered by a 10-horsepower motor. The carriage, hydraulically operated, moves the auger assembly up and down, sidewise, and into and out of the car. The carriage is supported by rails, one above and one below the carriage. These 30-foot-long rails are permanently installed parallel to the track.

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Figure 4.--A self-propelled auger unloader.

After the loaded car is positioned over the dump pit, the grain doors on both sides are opened manually. Then a worker moves the auger into the car, turns it on, and manipulates it in various directions to remove the grain from one end of the car. Meanwhile, another crew member operates a second auger on the opposite side of the car and unloads the other end of the car. Grain from the floor and corners of the car is removed by power shovel and by sweeping. When the car is empty, the door boards from the broken grain door are thrown into the car. The car is then ready to be moved out.

When two parallel tracks are available, boxcars are positioned opposite each other and three auger unloaders are used. The auger located between the two tracks is used to help unload first one car and then the other.

Power Shovel

A power shovel unit consists of two wood or aluminum shovels connected by chain to a cable winch line. The winch line is threaded through anchored sheaves near the car door. The winch (powered by a 10-horsepower motor) is outside the car.

After a loaded car is positioned at the dump pit, the grain door is opened manually and two men enter the car, each with a power shovel. The men go to opposite ends of the car, insert the shovels in the grain, and engage the cable. They alternate in moving loaded shovels of grain out the door (fig. 5). This procedure is repeated until the car is empty.

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Figure 5.--Unloading a boxcar of grain by the power shovel method. The second worker and shovel are out of view.

Because it is generally hot and dusty inside the car, shoveling is rotated among four men. All four men sweep grain, move cars, and open grain doors.

Trackmobile

The Trackmobile (fig. 6) is a four-wheel vehicle with steel wheels for moving on railroad tracks and rubber-tired wheels for off-track travel. Either a gasoline or diesel engine furnishes the power. Standard couplers at the front and rear are used to push or pull railcars.

BN-27878

Figure 6.--A Trackmobile moving boxcars. Road wheels are in the retracted position.

When the derail[1/] opens or a signal is given by the unloading foreman, the Trackmobile operator pulls a loaded car into position for unloading and at the same time pushes an empty car away from the pit. The Trackmobile is then disengaged from the loaded car and continues to move the empty car onto a rail siding.

Car Puller

The car puller is a permanently installed winch driven by an electric motor. The motor size varies from 10 to 60 hp., depending upon the winch capacity.

Two men drag the winch cable to the line of loaded boxcars and attach the end hook to one of the cars. One man starts the winch, which rewinds the cable and pulls the loaded cars to the unloading position. The empty cars are pushed away from the unloading position by the movement of the loaded cars.

1/ A derail is a hinged device on one rail of the track that can be closed to stop movement of cars toward the dump pit or opened to allow movement of cars.

COST OF UNLOADING

Table 1 shows the time needed to unload a boxcar of grain, with normal crew sizes, for the car unloading equipment, using either the car puller or Trackmobile to move cars. Whether a Trackmobile or car puller is used has little effect on the labor cost. The lowest labor cost occurs with a mechanical car dumper and the highest with a power shovel.

Table 2 shows the ownership and operating costs of the car unloading and moving equipment for annual volumes of 1, 3, 5, and 10 million bushels of grain. The method of determining these costs is described in the appendix. Note that not only do the annual ownership costs increase as more grain is handled, because of a reduction in expected life, but the annual operating costs also increase. The cost per boxcar, however, is reduced as the annual volume of grain unloaded increases. For example, when only 1 million bushels per year is unloaded by a mechanical car dumper, the equipment ownership and operating cost (excluding labor) per boxcar is $24.77. This cost is reduced to $2.87 when 10 million bushels are unloaded annually.

Tables 3 to 6 show the labor and equipment cost per boxcar unloaded and per year for unloading 1, 3, 5, and 10 million bushels of grain. The tables also show the time required to unload maximum daily receipts. Only power shovels are listed for an annual volume of 1 million bushels because the cost of other equipment would be excessive at this volume (table 3). When 3 million bushels are unloaded (table 4), the cost of either of the two car dumpers would be excessive. The car dumpers are the least costly when 10 million bushels a year are unloaded (table 6).

The mechanical and hydraulic car dumpers differ slightly in unloading cost. In the study, the elapsed time for the hydraulic car dumper was longer and the electrical power cost greater.

The unloading cost using the self-propelled auger, when 3 units are used to unload 2 boxcars opposite each other on parallel tracks, is less than when 2 units are used to unload a single boxcar. The added savings gained by reducing the elapsed time more than offset the total cost of the third unit.

As shown in table 3, the 2-unit power shovel required 3.5 hours to unload the maximum receipts of 10 carloads in a day. However, when 3 million bushels are received annually and 30 carloads received in a day, from 10 to 13 hours is required to unload by power shovels (table 4). For higher daily receipts, not enough time would be available to unload by power shovels the maximum number of boxcars received in a day.

Table 1.--Crew sizes, elapsed time and labor cost per boxcar, and hourly unloading rates for equipment used to unload and move cars at terminal grain elevators

Car unloading and car moving equipment	Crew 1/	Unloading rate per hour	Per boxcar	
			Elapsed time	Labor cost 2/
	Number	Boxcars	Minutes	Dollars
Mechanical car dumper with:				
Car puller	3	9.8	6.1	0.76
Trackmobile	3	9.5	6.3	.79
Hydraulic car dumper with:				
Car puller	3	8.6	7.0	.88
Trackmobile	3	8.3	7.2	.91
Shaker with:				
Car puller	3	4.0	14.9	1.86
Trackmobile	3	4.0	15.1	1.89
Self-propelled auger (2 units) with:				
Car puller	4	2.3	25.6	4.27
Trackmobile	4	2.5	23.5	3.92
Self-propelled auger (3 units) with:				
Car puller	4	3.2	18.7	3.12
Trackmobile	4	3.2	18.7	3.12
Power shovel (1 unit) with:				
Car puller	4	2.2	26.8	4.46
Trackmobile	4	2.3	26.4	4.40
Power shovel (2 units) with:				
Car puller	4	2.8	21.2	3.53
Trackmobile	4	2.8	21.2	3.53

1/ See appendix tables 10 to 16 for details of labor performed by the crews.

2/ Based on a wage rate of $2.50 per hour.

Table 2.--Estimated annual costs of ownership and operation of selected items of equipment for unloading grain from boxcars at terminal elevators, by annual volume

Annual volume of grain and type of equipment	Replacement cost 1/	Expected life	Annual costs					
			Ownership 2/	Operating			Total	Per boxcar unloaded
				Power	Maintenance	Total		
	Thousand dollars	Years	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars
1 MILLION BUSHELS (526 BOXCARS)								
Mechanical car dumper.....	200	39	12,968	10	50	60	13,028	24.77
Hydraulic car dumper.....	200	39	12,968	65	50	115	13,083	24.87
Shaker.....	100	38	6,652	40	100	140	6,792	12.91
Self-propelled auger (2 units)	40	33	2,780	25	70	95	2,875	5.47
Self-propelled auger (3 units)	60	36	4,019	25	70	95	4,114	7.82
Power shovel (1 unit).....	5	33	348	20	55	75	423	.80
Power shovel (2 units).....	10	36	670	20	55	75	745	1.42
Trackmobile.....	21	26	1,218	57	38	95	1,313	2.50
Car puller.....	5	38	328	23	43	66	394	.75
3 MILLION BUSHELS (1,579 BOXCARS)								
Mechanical car dumper.....	200	37	13,245	30	150	180	13,425	8.50
Hydraulic car dumper.....	200	37	13,245	200	150	350	13,595	8.61
Shaker.....	100	34	6,861	120	300	420	7,281	4.61
Self-propelled auger (2 units)	40	20	3,568	75	200	275	3,843	2.43
Self-propelled auger (3 units)	60	30	4,352	75	200	275	4,627	2.93
Power shovel (1 unit).....	5	20	446	60	170	230	676	.43
Power shovel (2 units).....	10	30	725	60	170	230	955	.60
Trackmobile.....	21	23	1,264	173	112	285	1,549	.98
Car puller.....	5	34	343	69	128	197	540	.34

5 MILLION BUSHELS (2,632 BOXCARS)								
Mechanical car dumper.....	200	35	13,554	50	250	300	13,854	5.26
Hydraulic car dumper.....	200	35	13,554	330	250	580	14,134	5.37
Shaker.....	100	30	7,253	200	500	700	7,953	3.02
Self-propelled auger (2 units)	40	12	4,901	125	335	460	5,361	2.04
Self-propelled auger (3 units)	60	18	5,685	125	335	460	6,165	2.33
Power shovel (1 unit).....	5	12	613	100	285	385	998	.38
Power shovel (2 units).....	10	18	948	100	285	385	1,333	.51
Trackmobile.....	21	20	1,323	287	188	475	1,798	.68
Car puller.....	5	30	363	115	212	327	690	.26
10 MILLION BUSHELS (5,263 BOXCARS)								
Mechanical car dumper.....	200	30	14,507	100	500	600	15,107	2.87
Hydraulic car dumper.....	200	30	14,507	660	550	1,160	15,667	2.98
Shaker.....	100	15	10,587	400	1,000	1,400	11,987	2.28
Self-propelled auger (2 units)	40	6	8,235	250	670	920	9,155	1.74
Self-propelled auger (3 units)	60	10	8,352	250	670	920	9,272	1.76
Power shovel (1 unit).....	5	6	1,029	200	570	770	1,799	.34
Power shovel (2 units).....	10	10	1,392	200	570	770	2,162	.41
Trackmobile.....	21	10	1,823	575	375	950	2,773	.53
Car puller.....	5	15	529	230	425	655	1,184	.22

1/ Replacement cost includes installation when necessary.

2/ Allowance for depreciation; insurance--0.1 percent, taxes--1.32 percent, and interest--2.5 percent of replacement cost.

Table 3.--Annual volume, 1 million bushels and maximum daily receipts, 10 carloads: Elapsed time per day for maximum receipts and labor and equipment cost per car and per year to unload grain at terminal elevators

Type of equipment	Elapsed time per car	Elapsed time per day for maximum receipts	Cost per car	Annual cost
	Minutes	Hours	Dollars	Dollars
Mechanical car dumper 1/..	--	--	--	--
Hydraulic car dumper 1/...	--	--	--	--
Shaker 1/.....	--	--	--	--
Self-propelled auger 1/...	--	--	--	--
Power shovel (1 unit) 2/:				
Car puller	26.4	4.4	6.01	3,161
Trackmobile	26.8	4.5	7.70	4,050
Power shovel (2 units) 2/:				
Car puller	21.2	3.5	5.70	2,998
Trackmobile	21.2	3.5	7.45	3,918

1/ Equipment cost is excessive.

2/ One power shovel unit (two shovels) may be used for unloading from either one or two tracks; two units are more often used with two tracks.

Table 4.--Annual volume, 3 million bushels and maximum daily receipts, 30 carloads: Elapsed time per day for maximum receipts and labor and equipment cost per car and per year to unload grain at terminal elevators

Type of equipment	Elapsed time per car	Elapsed time per day for maximum receipts	Cost per car	Annual cost
	Minutes	Hours	Dollars	Dollars
Mechanical car dumper[1/]	--	--	--	--
Hydraulic car dumper[1/]	--	--	--	--
Shaker with:				
Car puller	15.1	7.6	6.81	10,752
Trackmobile	14.9	7.5	7.48	11,810
Self-propelled auger (2)[2/]:				
Car puller	23.5	11.8	7.47	11,795
Trackmobile	25.6	12.8	7.76	12,248
Self-propelled auger (3)[2/]:				
Car puller	18.7	9.4	6.99	11,037
Trackmobile	18.7	9.4	7.63	12,048
Power shovel (1 unit)[3/]:				
Car puller	26.4	13.2	5.23	8,258
Trackmobile	26.8	13.4	5.81	9,173
Power shovel (2 units)[3/]:				
Car puller	21.2	10.6	4.47	7,058
Trackmobile	21.2	10.6	5.11	8,068

1/ Equipment cost is excessive.

2/ Two augers are required for unloading from one track and three for unloading from two tracks.

3/ One power shovel unit (two shovels) may be used for unloading from either one or two tracks; two units are more often used with two tracks.

Table 5.--Annual volume, 5 million bushels and maximum daily receipts, 50 carloads: Elapsed time per day for maximum receipts and labor and equipment cost per car and per year to unload grain at terminal elevators

Type of equipment	Elapsed time per car	Elapsed time per day for maximum receipts	Cost per car	Annual cost
	Minutes	Hours	Dollars	Dollars
Mechanical car dumper with:				
Car puller	6.3	5.3	6.28	16,528
Trackmobile	6.1	5.1	6.73	17,040
Hydraulic car dumper with:				
Car puller	7.0	5.8	6.51	17,134
Trackmobile	7.2	6.0	6.96	18,319
Shaker with:				
Car puller	15.1	12.5	5.14	13,528
Trackmobile	14.9	12.4	5.59	14,712
Three self-propelled augers 1/:				
Car puller	18.7	15.6	6.22	16,371
Trackmobile	18.7	15.6	6.64	17,476
Power shovel 2/	--	--	--	--

1/ Two augers are required for unloading from one track and three for unloading from two tracks.

2/ Not enough time available to unload maximum daily receipts.

Table 6.--Annual volume, 10 million bushels and maximum daily receipts, 100 carloads: Elapsed time per day for maximum receipts and labor and equipment cost per car and per year to unload grain at terminal elevators

Type of equipment	Elapsed time per car	Elapsed time per day for maximum receipts	Cost per car	Annual cost
	Minutes	Hours	Dollars	Dollars
Mechanical car dumper with:				
Car puller	6.1	10.2	3.85	20,262
Trackmobile	6.3	10.5	4.19	22,052
Hydraulic car dumper with:				
Car puller	7.0	11.7	4.08	21,473
Trackmobile	7.2	12.0	4.42	23,240
Shaker 1/	--	--	--	--
Self-propelled auger 1/	--	--	--	--
Power shovel 1/	--	--	--	--

1/ Not enough time available to unload maximum daily receipts.

MOST PRACTICAL METHOD OF UNLOADING

Unloading Cost and Time

Based on unloading costs, an elevator manager who plans to unload about 1 million bushels of grain per year will find power shovels to be the most practical equipment. The power shovel (2 units), used with a car puller to position cars, costs $5.70 per boxcar (see table 3). The maximum 10 carloads per day can be unloaded in 3.5 hours.

If 3 million bushels are to be unloaded annually, the manager has a choice of various unloading methods. When the unloading cost is the controlling factor, two power shovel units unloading cars from two tracks, used with a car puller, result in a cost of $4.47 per car, the lowest cost for this volume (table 4). When unloading time is the controlling factor, the shaker method of unloading, with a Trackmobile positioning the cars, results in the maximum daily receipts of grain being unloaded in the least time--7.5 hours.

If 5 million bushels of grain are to be unloaded annually, the car shaker method, with a car puller positioning cars, probably should be the first choice. The cost per boxcar unloaded is the lowest, and the estimated maximum 50 carloads per day can be unloaded in 12.5 hours (table 5).

The elevator manager who plans to unload 10 million bushels of grain per year and expects to receive as many as 100 carloads each day should use a car dumper. The mechanical car dumper method is slightly faster than the hydraulic car dumper, although the unloading cost per car is nearly the same (see table 6).

The time needed to unload a boxcar when the cars were moved by a Trackmobile was only slightly more than the time needed when a car puller was used. However, the unloading cost was always higher for the Trackmobile. For example, when 10 million bushels are unloaded annually, using either type of car dumper (table 6), the cost per car was 34 cents more for the Trackmobile than for the car puller. This added cost may be justified because of other uses of the Trackmobile, such as assisting in loading out cars. Loading out often occurs simultaneously with unloading. The Trackmobile also is advantageous at locations where a long railroad siding sloping away from the elevator often prohibits the use of a car puller.

Other Factors

Factors other than cost and speed of unloading often influence the choice of unloading methods. Although these factors were not included in the study, they are offered as added guides for the selection of equipment.

1. Improved Working Conditions.--Several elevator managers reported they changed from using power shovels to the self-propelled auger method mainly because working conditions--and therefore labor efficiency--could be improved.

2. Existing Layout.--Modification of an existing installation is kept to a minimum when a change is made from the power shovel method to the self-propelled auger. For example, the existing dump pit and elevator leg still will have sufficient capacity. However, changing to one of the car dumper methods requires not only increased capacity of dump pit and elevator leg, but the elevator boot also must be 30 feet below grade level. The capacity of the elevating leg and other handling equipment may need to be as high as 30,000 bushels per hour to eliminate waiting for the dump pit to empty. A large dump pit is needed because most of the carload of grain flows into the pit in about 2 minutes.

3. Space Requirements.--A car shaker needing only a shallow pit can be installed where poor soil conditions or lack of space prohibits the installation of a car dumper. If space is available for two unloading tracks, efficiency of both the self-propelled auger and the power shovel methods can be improved by adding more units, without modifying existing handling equipment.

APPENDIX

Equipment Ownership and Operating Costs

The replacement cost is the initial cost of the equipment delivered plus the installation cost at the elevator. The installation cost includes labor,

electrical wiring, and other costs necessary to prepare the equipment for operation. Sources of cost information were manufacturers, elevator construction contractors, elevator managers, and owners.

The expected life is based on information obtained from the cooperating elevator managers. Although some equipment now in use was observed to be older than the expected life shown, obsolescence is also considered.

Depreciation was calculated using the straight-line method, permitting management to charge off the same decrease in value each year during the life of the equipment.

Interest charges were based on a rate of 5 percent per year. Although the rate paid by the elevators at the time of the study was less than 5 percent, after discussions with bank officials, the 5 percent rate seemed a reasonable figure for a long-range plan. The annual interest charge was determined by applying this rate to one-half of the replacement cost, thus obtaining an average interest charge over the life of the equipment.

An insurance rate of 0.1 percent of the replacement cost is used. This rate was obtained from premiums paid by cooperating elevator managers and from discussions with insurance companies.

A tax rate of 1.32 percent of the replacement cost is based on rates obtained from managers located in various sections of the Hard Winter Wheat Area.

Electric power consumption at the various elevators was measured while the unloading equipment was operating. Electric power costs were obtained from managers of four terminal elevators and from schedules of three power companies. Elevators using a car dumper consume sufficient electric power to place their energy charge in a schedule where the rate is slightly less than 2 cents per kilowatt hour. Terminals equipped with power shovels usually use less total kilowatt hours per month and are charged a higher energy rate (slightly over 2 cents per kilowatt hour). This report uses 2 cents per kilowatt hour.

Maintenance costs include routine maintenance and repairs, labor and material.

An annual operating schedule was developed for each size of elevator as a basis for establishing equipment use and equipment life, and for prorating equipment costs.

Labor Requirements

Labor requirements for the various methods of unloading were prepared from data obtained through time studies at terminal elevators. Tables 7 to 13 show the man-minutes of labor for each part of the unloading operation together with the time necessary to unload.

Table 7.--Labor required for a three-man crew to unload a 1,900-bushel boxcar of grain by using a mechanical car dumper with a Trackmobile or car puller to position the loaded boxcar

Operation element	Labor required per boxcar by using a mechanical car dumper with -			
	Trackmobile		Car puller	
	Man-minutes		Man-minutes	
Productive labor:				
No. 1 man dumps boxcar.....	4.91		4.91	
No. 2 and No. 3 men move boxcars.	2.86		5.90	
Total productive labor.....		7.77		10.81
Unproductive labor:				
No. 1 man waits while No. 2 and No. 3 men move boxcars.....	1.43		1.19	
No. 2 man waits during dumping 1/.....	4.91		3.15	
Total unproductive labor...		6.34		4.34
Available for other assignment:				
No. 3 man to boxcar loading or other operation.....	4.91	4.91	3.15	3.15
Total labor.....		19.02		18.30

Elapsed time: Trackmobile--6.34 minutes
Car puller --6.10 minutes

1/ Available to assist in removing door boards.

Table 8.--Labor required for a three-man crew to unload a 1,900-bushel boxcar of grain by using a hydraulic car dumper with Trackmobile or car puller to position the loaded boxcar

Operation element	Labor required per boxcar by using a hydraulic car dumper with -			
	Trackmobile		Car puller	
	Man-minutes		Man-minutes	
Productive labor:				
No. 1 man dumps boxcar.....	5.82		5.82	
No. 2 and No. 3 men move boxcars	2.86		5.90	
Total productive labor....		8.68		11.72
Unproductive labor:				
No. 1 man waits while No. 2 and No. 3 men move boxcars.....	1.43		1.19	
No. 3 man waits during dumping 1/.....	5.82		4.06	
Total unproductive labor..		7.25		5.25
Available for other assignment:				
No. 3 man to boxcar loading or other operation.....	5.82	5.82	4.06	4.06
Total labor.....		21.75		21.03

Elapsed time: Trackmobile--7.25 minutes
Car puller --7.01 minutes

1/ Available to assist in removing door boards.

Table 9.--Labor required for a three-man crew to unload a 1,900-bushel boxcar of grain by using a car shaker with a Trackmobile or car puller to position the loaded boxcar

Operation element	Labor required per boxcar by using a car shaker with -			
	Trackmobile		Car puller	
	Man-minutes		Man-minutes	
Productive labor:				
No. 1 man empties boxcar.....	13.19		13.19	
No. 1 and No. 2 men throw in boards.....	1.00		1.00	
No. 2 and No. 3 men move boxcars.....	2.86		6.40	
Total productive labor.....		17.05		20.59
Unproductive labor:				
No. 1 man waits while No. 2 and No. 3 men move boxcars.....	1.43		1.19	
No. 2 man waits while boxcar empties 1/.....	13.19		11.43	
Total unproductive labor...		14.62		12.62
Available for other assignment:				
No. 3 man to boxcar loading or other operation.....	13.69	13.69	11.43	11.43
Total labor.....		45.36		44.64

Elapsed time: Trackmobile--15.12 minutes
Car puller --14.88 minutes

1/ Available to assist No. 1 man in removing grain doors.

Table 10.--Labor required for a four man crew to unload a 1,900-bushel boxcar of grain when cars are positioned side-by-side on two tracks by using three self-propelled augers with a Trackmobile or car puller to position the loaded boxcars

Operation element	Labor required per boxcar by using three self-propelled augers with -			
	Trackmobile		Car puller	
	Man-minutes		Man-minutes	
Productive labor:				
No. 1 and 2 or No. 2 and 3 men operate augers	14.96		14.96	
No. 1, 2, 3 and 4 men sweep	40.96		40.96	
No. 1, 2, 3 and 4 men throw in door boards	4.00		4.00	
No. 1 and No. 4 men move boxcars	2.86		7.04	
No. 1 and No. 4 men open grain doors	6.76		6.76	
Total productive labor		69.54		73.72
Unproductive labor:				
No. 3 and 4 men wait while augers are operated	5.34		1.16	
Total unproductive labor		5.34		1.16
Total labor		74.88		74.88

Elapsed time: Trackmobile--18.72 minutes
Car puller --18.72 minutes

Table 11.--Labor required for a four-man crew to unload a 1,900-bushel boxcar of grain by using power shovel (2 units) with a Trackmobile or car puller to position the loaded boxcars side-by-side on two tracks

Operation element	Labor required per boxcar by using power shovels (2 units) with -			
	Trackmobile		Car puller	
	Man-minutes		Man-minutes	
Productive labor:				
No. 1 and No. 2 men shovel 1/	39.74		39.74	
No. 3 and No. 4 men sweep 1/	14.06		14.06	
No. 3 and No. 4 men throw door boards in empty car	2.00		2.00	
No. 3 and No. 4 men move boxcars	2.86		7.04	
No. 3 and No. 4 men open boxcar door	6.76		6.76	
Total productive labor		65.42		69.60
Unproductive labor:				
No. 3 and No. 4 men wait while No. 1 and No. 2 men shovel	16.68		15.12	
No. 1 and No. 2 men wait while No. 3 and No. 4 men sweep boxcar	2.62		--	
Total unproductive labor		19.30		15.12
Total labor		84.72		84.72

Elapsed time: Trackmobile--21.18 minutes
Car puller --21.18 minutes

1/ Men rotate between shoveling and sweeping.

Table 12.--Labor required for a four-man crew to unload a 1,900-bushel boxcar of grain by using power shovel (1 unit) with Trackmobile or car puller to position the loaded boxcar

Operation element	Labor required per boxcar by using power shovel (1 unit) with -			
	Trackmobile		Car puller	
	Man-minutes		Man-minutes	
Productive labor:				
No. 1 and No. 2 men shovel 1/	39.74		39.74	
No. 3 and No. 4 men sweep 1/	14.06		14.06	
No. 3 and No. 4 men throw door boards in empty car	2.00		2.00	
No. 1 and No. 2 men move boxcar	2.86		2.86	
No. 3 and No. 4 men open boxcar door	6.76		6.76	
Total productive labor		65.42		65.42
Unproductive labor:				
Two men wait while two shovel 1/	28.30		28.30	
No. 1 and No. 2 men wait while No. 3 and No. 4 men sweep car	3.46		--	
No. 3 and No. 4 men wait while No. 1 and No. 2 men move boxcar	8.46		9.18	
Total unproductive labor		40.22		37.48
Total labor		105.64		107.08

Elapsed time: Trackmobile--26.41 minutes
Car puller --26.77 minutes

1/ Men rotate between shoveling and sweeping.

Table 13.--Labor required for a four-man crew to unload a 1,900-bushel boxcar of grain on one track by using two self-propelled augers and a Trackmobile or car puller to position the loaded boxcar

Operation element	Labor required per boxcar by using two self-propelled augers with -			
	Trackmobile		Car puller	
	Man-minutes		Man-minutes	
Productive labor:				
No. 1 and No. 2 men operate augers	14.96		14.96	
No. 1, 2, 3 and No. 4 men shovel and sweep boxcars	40.96		40.96	
No. 1, 2, 3 and 4 men put loose door boards in empty boxcar	4.00		4.00	
No. 3 and No. 4 men move boxcars	2.86		7.04	
No. 3 and No. 4 men open grain doors	6.76		6.76	
Total productive labor		69.54		73.72
Unproductive labor:				
No. 1 and No. 2 men wait while grain doors are opened	6.76		6.76	
No. 3 and No. 4 men wait while augers are operated	14.96		14.96	
No. 1 and No. 2 men wait while boxcars are moved	2.86		7.04	
Total unproductive labor		24.58		28.76
Total labor		94.12		102.48

Elapsed time: Trackmobile--23.53 minutes
Car puller --25.62 minutes

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