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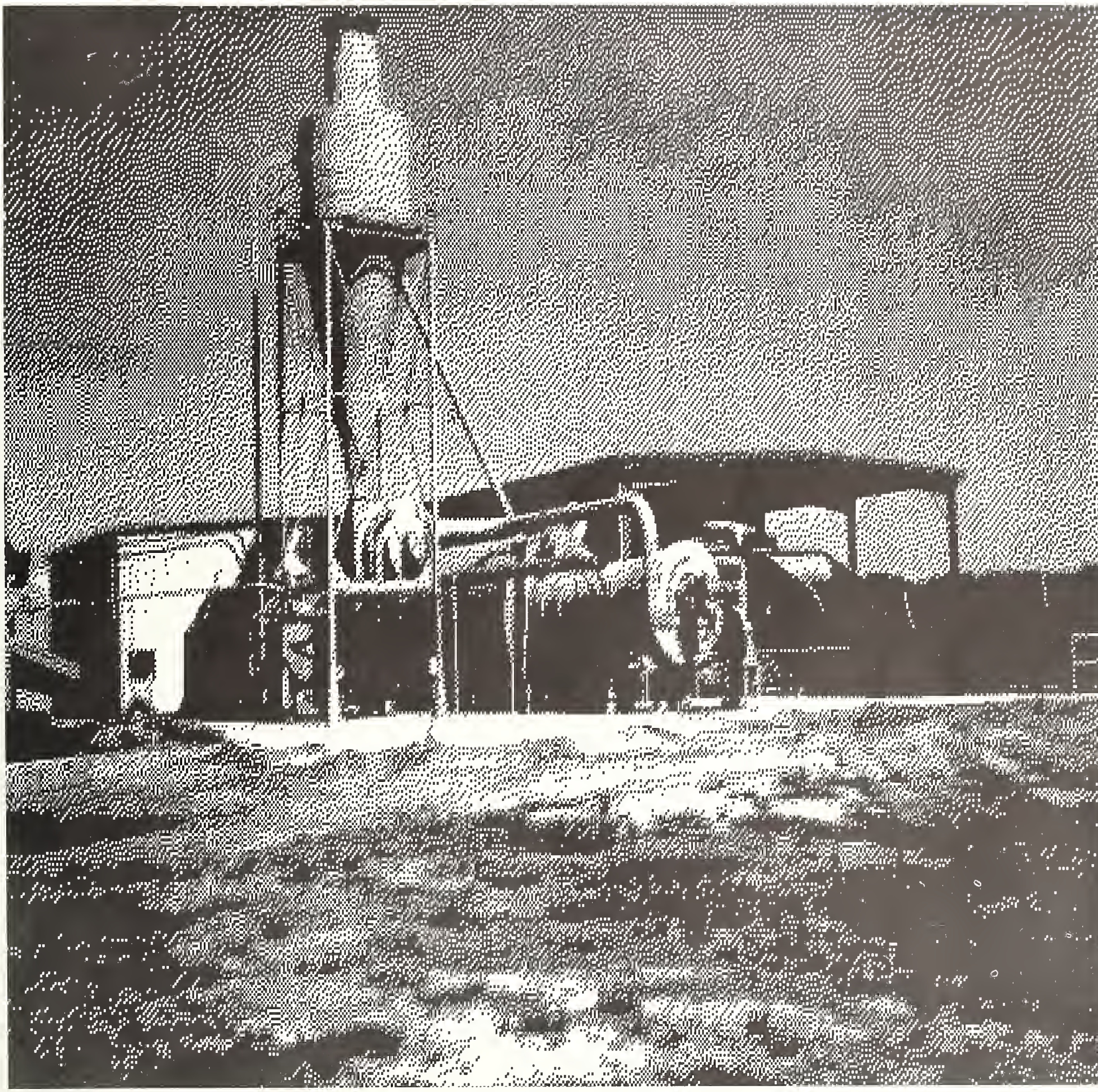
Cubing Alfalfa Hay

Systems, Facilities and Costs

Gerald E. Berney



Acknowledgment

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Summary

The facilities, equipment and labor requirements needed to cube alfalfa hay were determined. The investigation was primarily concerned with stationary cubing operations, located in humid areas of the country that used dehydrators. Operations in Colorado, Illinois, Indiana, California, Utah and Arizona were analyzed.

Cubing is a process that compacts small amounts of hay into small rectangular solids, usually 1.25 in. x 1.25 in. by 6 in.. There are several reasons for doing this. The compacted hay has a higher bulk density and thus more hay can be stored in a given volume of space. Feed handling, mixing and storing are simplified. Waste of feed by livestock is reduced, and leaf loss that normally occurs during handling of baled hay is minimized.

It was determined that a single cuber dehydration/cubing plant would cost about $1.7 million. The annual fixed costs for such a plant would be slightly in excess of $200,000 and the variable costs would be approximately $64 per-ton.

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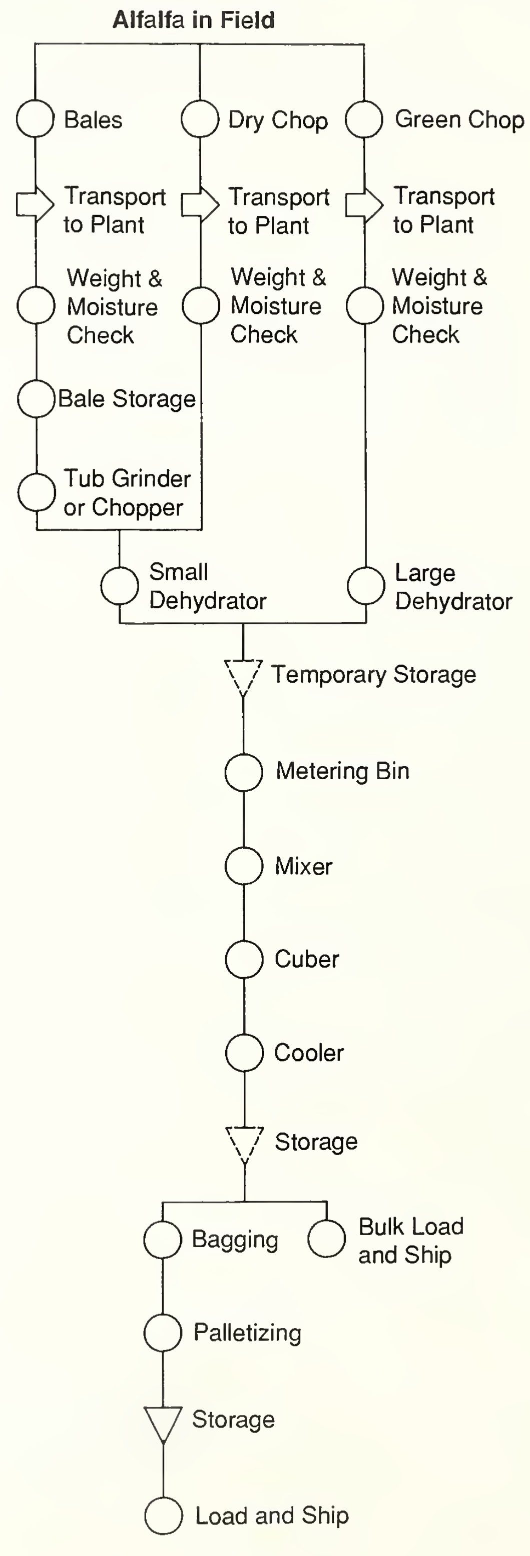
Introduction

Making the decision to begin an enterprise, public or private, with one's own funds or with borrowed funds, alone or with others, is fraught with excitement, danger and risk. One important factor, often overlooked, is that the small decisions made at the beginning of an enterprise often affect the final result as much as the so-called "major" decisions. This is one reason why much study and thought are necessary before the enterprise is undertaken.

In order to understand what facilities, equipment and labor are required to produce alfalfa cubes, one must understand the process itself. Figure 1 is a flowchart showing the various ways that cubes can be produced. This flowchart, and the methods of production noted, are the results of visiting a number of commercial alfalfa cubers in the western, midwestern, and eastern parts of the United States. The alfalfa must be (1) harvested, (2) transported, (3) inspected, (4) stored, (5) dried, (6) cubed, (7) cooled/cured, (8) packaged, (9) stored and (10) transported to customer. This report attempts to outline what's needed to perform these functions.

Figure 1. Flowchart of Alfalfa Cubing Operation



Land

The amount of farmland (figure 2) required for an alfalfa cubing operation depends on the level of output of the cubing plant, and the expected yield from that land. Dry land farmers in Colorado harvest as little as 1 ton per-acre, while some carefully managed land in Indiana produces 8 tons of quality alfalfa per-acre per-season. Average production for western Iowa is approximately 3 tons per-acre. It is expected that this figure would increase over time to 5 tons per-acre or more as experience is gained by the farmers participating in a cubing operation. Over time this would lead to a decrease in the number of acres required to service a plant of fixed capacity. Table 1 gives the approximate amount of land needed to produce alfalfa for a cubing operation at various levels of production.

Figure 2. Sufficient Cropland Must Be Available Close to a Cubing Operation.

Table 1. Acreage Requirements For Cubing Operation

	Annual Production Levels (tons per-year through plant)			
Yield tons/acre	5,000 tons	10,000 tons	15,000 tons	20,000 tons
3	1,700 ac.	3,300 ac.	5,000 ac.	6,700 ac.
5	1,000 ac.	2,000 ac.	3,000 ac.	4,000 ac.
8	625 ac.	1,250 ac.	1,875 ac.	2,500 ac.

The type of hay harvesting system (figures 3 and 4) that is chosen dictates in large part the types of drying, material handling and cubing equipment that are needed later in the operation. It will also strongly affect the quality of the cubes that are produced, as well as the price paid by customers.

The choices for systems are: (1) conventional bales (large or small, round or square), (2) direct chopping or "green chopping" of high moisture hay and (3) "dry chopping" of alfalfa that has been cut, raked, and conditioned before being chopped. The tables were calculated by assuming a production level of 5,000 tons per-year from 1,000 acres. It was thought that 5,000 or 6,000 tons annual production was the maximum production from the chosen equipment. Additional production would have to come from additional equipment purchases rather than more intense usage of the existing equipment. Estimates of the cost for harvesting 10,000; 15,000; and 20,000 tons of alfalfa could thus be made by simply using whole-number multiples of the values from the tables. Table 2 gives approximate labor requirements for each method.

Figure 3. A Self-Propelled Windrower.

Figure 4. A Self-Propelled Forage Harvester.

Table 2. Estimated Labor Requirements for Hay Harvesting
(man-hours per-ton, for each harvesting system)

Function	Square Bale	Large Bale	Green Chop	Dry Chop
Cut	0.15	0.15		0.15
Rake	0.10	0.10		0.10
Bale	0.16	0.13		
Chop			0.45	0.30
Load	1.00	0.30		
Transport	0.10	0.10	0.10	0.10
Unload	0.10	0.05	0.25	0.25
Totals	1.61	0.83	0.80	0.95

Table 3 gives the estimated machinery requirements for harvesting alfalfa using a conventional square bale system at a 5,000 ton annual production level. The cost of labor is included in the per-ton cost figure.

Table 3. Estimated Machinery Requirements for a Square Bale Harvesting System

Machine	Initial cost($)	Expected life(yr)	Capacity(ton/hr)	Usage(hrs/yr)	Usage(tons/yr)	Total cost($/ton)
14 ft self-propelled						
Mower-conditioner	$45,000	8	7	714	5,000	$8.43
Hay rakes(tandem)	$6,000	5	10	500	5,000	$0.20
w/Tractor (50-hp)	$16,000	10	10	500	5,000	$2.00
Square baler	$14,000	5	6.25	800	5,000	$0.82
w/Tractor(50-hp)	$16,000	10	6.25	800	5,000	$2.36
Bale wagon	$20,000	5	6.25	800	5,000	$0.90
w/Tractor(50-hp)	$16,000	10	6.25	800	5,000	$2.36
Totals	$133,000					$17.07 per-ton

Table 4 shows the machinery and cost requirements for a large round bale harvesting system. Labor costs are included in the cost per-ton figures.

Table 4. Estimated Machinery Requirements for a Large Round Bale Harvesting System

Machine	Initial cost($)	Expected life(yr)	Capacity(ton/hr)	Usage(hrs/yr)	Usage(tons/yr)	Total cost($/ton)
14 ft self-propelled						
Mower-conditioner	$45,000	8	7	714	5,000	$8.43
Hay rakes(tandem)	$6,000	5	10	500	5,000	$0.20
w/Tractor (50-hp)	$16,000	10	10	500	5,000	$2.00
Large round baler	$14,000	5	7.7	650	5,000	$0.85
w/Tractor(50-hp)	$16,000	10	7.7	650	5,000	$2.18
Bale mover	$6,000	10	6.25	800	5,000	$0.30
w/Tractor(50-hp)	$16,000	10	6.25	800	5,000	$2.36
Totals	$119,000					$16.22 per-ton

Table 5 shows the machinery and cost requirements for green chopping alfalfa for cubes. Costs for labor are included.

Table 5. Estimated Machinery Requirements for a Green-Chop Harvesting System

Machine	Initial cost($)	Expected life(yr)	Capacity(ton/hr)	Usage(hrs/yr)	Usage(tons/yr)	Total cost($/ton)
Large self-propelled						
Forage chopper	$110,000	5	6.25	800	5,000	$11.81
(3)Forage wagons	$36,000	10	6.25	800	5,000	$1.80
Truck	$16,000	10	6.25	800	5,000	$2.44
Totals	$162,000					$16.05 per-ton

Table 6 gives estimated machinery needs and costs for harvesting alfalfa with a dry chop system. Costs for labor, fuel, repairs, taxes and insurance are included in the cost per-ton figures.

Table 6. Estimated Machinery Requirements for a Dry-Chop Harvesting System

Machine	Initial cost($)	Expected life(yr)	Capacity(ton/hr)	Usage(hrs/yr)	Usage(tons/yr)	Total cost($/ton)
14 ft self-propelled						
Mower-conditioner	$45,000	8	7	714	5,000	$8.43
Hay rakes(tandem)	$6,000	5	10	500	5,000	$0.20
w/Tractor (50-hp)	$16,000	10	10	500	5,000	$2.00
Large self-propelled						
Forage chopper	$110,000	5	6.25	800	5,000	$11.81
(3)Forage wagons	$36,000	10	6.25	800	5,000	$1.80
Truck	$16,000	10	6.25	800	5,000	$2.44
Totals	$229,000					$26.68 per-ton

Examining the cost data in these tables shows that machinery ownership and operating costs for square bales, large round bales, and green chopping are approximately equal, while costs for dry chopping appear to be higher. Table 7 summarizes these findings.

Table 7. Comparison of Harvesting Costs (cost per-ton)

Square Bales	Lg. Round Bales	Green Chop	Dry Chop
$17.07	$16.22	$16.05	$26.68

Transportation to Cubing Plant

Transportation costs are often an important element of feasibility studies. Transportation costs for moving alfalfa from fields within 2 miles of the cubing plant are included in harvesting costs in tables 2 through 7. For distances greater than this the figures will have to be adjusted upward. Long distance movement of hay to a cubing plant is not generally economical because hay is a low density material. Also, wet hay is prone to spoilage and this limits the amount of time it could be kept in transit before drying. Ten tons of hay on a tractor trailer could have an incremental cost of $.10-$.20 per-ton per-mile. Baled hay can be transported on farm wagons, bale transporters, truck or tractor trailer. Chopped hay may be transported in forage wagons, specially built trailers or trucks (figures 5 and 6). All chopped hay transportation should have built in unloaders.

Figure 5. A Truck Designed to Haul Chopped Hay.

Figure 6. Incoming Chopped Hay Is Weighed and Inspected.

Inspection

Before unloading, all incoming loads must be inspected, weighed and sampled (figure 6). This is a crucial step in the cube production process. The price paid to the grower is determined by the results of the tests. Also, defective, moldy, or contaminated alfalfa can be identified and rejected. Typically, a load will be pulled onto a large truck scale in front of the office/testing lab. Samples from several parts of the load will be taken and brought into the lab for analysis, or stored before being sent to an outside laboratory. Simple moisture tests may be performed with a precision scale and a microwave oven. The larger commercial cubers perform a detailed in-house analysis of the incoming load with a specially calibrated Near Infrared Reflectance Spectrophotometer (NIRS). Samples for the NIRS instrument are ground with a sample mill, placed in specially made vials and then put into the NIRS machine. The analysis is performed in a few moments and is printed out from the attached PC-type computer. A sample output from this type of device is included in the appendix. Table 8 contains the equipment and costs associated with the inspection function. Labor costs are not included in this table.

Table 9. Equipment Requirements for Inspection of Incoming Alfalfa

Equipment item	Initial cost($)	Expected life(yr)	Annual fixed cost($/yr)
Pacific model 4250 NIRS* feed ingredient and forage tester	$32,000	10	$5,000
Computer, pc w/printer etc.	$6,000	10	$1,000
Sample grinder	$1,400	10	$250
70 foot electronic truck scale, w/printer, installation and lightening protection	$40,000	20	$5,000
Totals	$79,400		$11,250 per-year

* Mention of brand names is for informational purposes only and does not imply an endorsement of any kind.

Storage Requirements

Storage is required for alfalfa (1) prior to processing, (2) after drying and (3) after cubing. Additional storage is required for pallets, bags, material handling equipment and harvesting equipment if stored at the cubing facility.

Before Processing

Typical cubing installations have approximately 30,000 square feet of heavy duty paved area for chopped hay to be dumped on and stored prior to drying (figure 7). Baled hay at many cubing plants is stored outside, on the ground and often covered with plastic. In areas of frequent rainfall, covered hay storage is preferred (figure 8). Damage from rain and discoloration of baled hay due to exposure to sunlight reduces both its feeding and its market values. Table 10 contains estimated costs and requirements for storage of hay before processing. Paving costs are based on 6 inches of high strength reinforced concrete. Baled hay storage costs are based on a pole-type structure, paving, wooden trusses and corrugated metal roof. The amount of baled hay storage a cubing plant needs should be based on knowledgeable estimates of the maximum amount of baled hay accumulated at the end of the harvesting season. 30,000 square feet, with large round bales stacked 3 high, should hold 1,800 tons.

Figure 7. A Large Paved Area for Dumping Hay.

Table 10. Facility Costs for Chopped and Baled Hay Storage

Item	Size(sq ft)	x	Cost($/sq ft)	=	Initial cost($)	Expected life(yr)	Annual ownership and operating costs($/yr)
Paved dump area	30,000	x	$5.00	=	$150,000	20	$18,000
Bale storage	30,000	x	$11.00	=	$330,000	20	$37,800
Totals					$480,000		$55,000

Figure 8. Baled Hay Stored Under Plastic.

After Drying

Storage of alfalfa after drying would seem an unnecessary expense, since it is ready to be cubed. However, if the arrival of a load of high moisture chopped alfalfa coincides with a cuber breakdown, the dried hay will need to be stored somewhere while the cuber is being repaired. The capacity to store the output from several days of dryer operation is probably required for dried chopped alfalfa storage. The amount of dryer output depends on the dryer's capacity and the number of hours of operation.

Bulk Cube Storage

Storage of cubed alfalfa in bulk is necessary unless all cubes are bagged or shipped from the plant as soon as they are produced. This is unlikely because the demand for dried forage is probably not at its greatest in the middle of haying season. Some long-term observers of the cubing scene consider half of the annual production as a minimum storage capacity for bulk storage of cubed alfalfa.

Cubed alfalfa requires a cool dark environment in order to be optimally stored. Molding, heating and other problems have been associated with bulk cube storage. It is not certain whether these problems were caused by storing cubes at moisture contents above 10 percent or failure to properly aerate the alfalfa. The basic idea of aeration is to force air through the cubes and keep the hay temperature between 40°F and 60°F. This temperature should inhibit molding and heating. Storage at lower temperatures promotes moisture migration and condensation on the cubes when warm weather returns. A good aeration system distributes air evenly through the mass of cubes. The proper airflow rate for aeration of cubes is not known. It will depend on local environmental conditions and the temperature and moisture content of cubes in storage. If better information is not available, a minimum airflow rate of 5 cubic feet per-minute per-ton of cubes being stored (5 cfm-per-ton) should probably be maintained. This is approximately equal to the 0.10 cfm-per-bushel airflows recommended for aeration of stored corn. It **is highly recommended that aeration systems for bulk storage of alfalfa cubes be made an integral part of the storage structure, and not added as an after-thought at a later time.**

It is also recommended that cube storage facilities be kept completely free from roof leaks, surface water, backed up drains or any other source of moisture. Also, long-term cube storage structures should be monitored for temperature with a thermocouple monitoring system, preferably attached to an alarm.

Material handling in a flat bulk storage structure consists of one or more flat conveyor belts or chain and flight conveyors, with a built-in distributor, that convey the cubes into the flat storage. Conveyors, especially those without distributors, should be checked for the accumulation of fine material that often occurs at the end of the conveyor. Loading out of this type of storage structure is by small front end loader filling a hopper that feeds a flight and chain conveyor.

Alternatively, hopper bottom grain bins (figure 9) work very well as cube storage structures. Material handling with hopper bottomed storage is simplified, and labor is much less. However, there is some chance that bridging and flow restrictions may occur with hopper bottomed bins. Table 10 shows equipment and cost requirements for flat storage and hopper bottom storage. Labor costs are not included, since they depend too heavily on the turnover rate of the facility. Costs of the flat storage were estimated at $14.32 per-square foot for a standard grain storage structure, with 240 feet of conveyor, heavy duty concrete floor, lights and a built-in aeration system capable of delivering 25,000 cfm. Costs for the hopper bins were estimated at $1.61 per-cubic foot of storage capacity for a 45° hopper bottomed grain storage bin, 21 feet in diameter, 28 feet high. The capacity of a single bin of this type is estimated to be 121 tons.

Figure 9. Bulk Storage of Cubes in Hopper Bottom Bins.

Table 11. Costs for Two Alternative Types of Bulk Storage of Alfalfa Cubes

Storage type	Size	Capacity(tons)	Initial cost(yr)	Expected life(yr)	Annual ownership and operating cost ($/yr)
Flat indoor	80'x240'x16'	5,000	$275,000	20	$35,478
Hopper bottom bins	21'diameter	5,000	$537,000	20	$83,000

Bagged cube storage

Many alfalfa cubing operations bag at least a portion of their annual production. 40-lb., 50-lb. or 70-lb. bags are filled, palletized and stored before shipment. Palletized bags of cubes require considerably more room for storage than bulk. Efficient use of space will require pallet racks in any area designated as exclusively for bag storage. Multipurpose storage areas and parts of the bulk storage area shifted to pallet storage will obviously be underutilized. Additional storage areas are required for bags, empty pallets, pallet wrapping materials and the like. Typical installed **price for a single-story warehouse** with some office space, lights, truck docks, etc., is **$35 per-square foot.** The annual ownership and operating costs for this type of area are about **$3 per-square foot per-year.**

Alfalfa for cubing should ideally be cut into uniform lengths of about 2 inches. There are probably several reasons for this: one is that the cube is only 1.25 inches x 1.25 inches and long pieces would not work well, and another is that animal health people have become concerned about the health of ruminants who only consume finely ground grains and forages. The animals do not get the benefit of long stem fiber in their diets. This was a criticism of pelleted feeds that cubing is supposed to address.

Cutting the alfalfa can be accomplished in several ways: (1) using a forage chopper in the field or windrow, (2) grinding with a tub grinder at the plant or (3) feeding small bales into a bale shredder at the plant. Each method has its advantages and difficulties.

Forage Chopping

The forage chopper, when operated properly, produces a nice uniform cut, with a high proportion of the pieces the desired length. Losses of leaf and protein are minimized. Forage chopping equipment is probably not standard equipment on the cash grain farms likely to be growing alfalfa, however.

Tub Ginding

Tub grinders (figure 10) are very convenient because they readily grind large bales, small bales, loose hay or just about anything else. However, they also tend to create a larger percentage of very small length pieces. These small pieces may be lost in subsequent material handling operations. The cubes produced are crumbly, easily broken, and of inferior quality. There may be an increase of customer concern about the loss of long stem fiber. Tub grinders are available in various capacities, both portable, power-take-off (pto) powered models and stationary, electrically powered units.

Figure 10. A Pto Powered Tub Grinder.

Stationary Chopping

Stationary bale shredders (figure 11) use a cylinder type cutter as found in forage harvesters and probably produce a more uniform cut than tub grinders. The difficulty noted in operations using this method is the large amount of hand labor feeding the machine. Three men loading and partial use of one man running a fork lift were needed to feed the shredder.

Table 12. Estimated Costs for Tub Grinding

Grinder type	Power(hp)	Capacity(ton/hr)	Initial cost($)	Expected life(yr)	Annual fixed cost($)	Hourly variable cost($)
P-T-O	60	10	$10,000	10	$1,650	$12
P-T-O	80	15	$13,500	10	$2,228	$17
P-T-O	100	18	$18,000	10	$2,970	$21
Stationary*	150	20	$30,000	15	$4,050	$15
Stationary**	200	30	$44,000	15	$5,940	$20
Stationary	300	40	$60,000	15	$8,100	$30

Fixed costs are based on depreciation, interest, taxes and insurance. Variable costs are based on use of a tractor for pto models, fuel, electricity for stationary models, repair and maintenance costs. Costs are listed on an annual and hourly basis instead of a per-ton basis because the level of production is not known and the listed hourly capacities come from manufacturers' brochures and may be somewhat overstated. The 150-hp grinder(*) is usually listed as sufficient for a single cuber installation, while the 200-hp model(**) is used in 2 cubing head plants.

Drying Alfalfa

Alfalfa, whether it comes from the field as bales, dry chop, or green chop, will usually be too wet to cube properly as is. (In some dry western areas of the country cubes can be produced without artificially drying the hay.) Experts disagree about exactly what moisture content the alfalfa should be before cubing, but most plant operators want it between 8 percent and 10 percent (wet basis). Alfalfa dryers tend to be of the rotary drum, multiple pass design (figure 12). Size and cost of the dryers depend very heavily on the moisture content of the hay coming into the dryer. This in turn depends on the harvesting method and weather conditions. Green chopped alfalfa will have about a 70 percent moisture content, while well managed dry chopped hay will have about 30 percent moisture content. Hay is usually baled between 25 percent and 30 percent moisture content.

It is possible to fuel alfalfa dryers with fuel oil, liquified petroleum gas, natural gas, coal, biogas, electricity, biomass or waste heat from industrial sources. Coal is the cheapest energy source on a per-unit basis, but has material handling and pollution control problems.

Figure 11. Stationary Bale Shredder.

Figure 12. Rotary Drum Alfalfa Dryer.

Biomass is also a material handling problem, but biomass, biogas and waste industrial heat should be investigated if cheap local supplies are available. In the end most dryers are fueled by liquefied petroleum gas (LP) or natural gas. Energy costs are an extremely important aspect of determining drying cost, and those prices are not easy to estimate because of the complex rate structures used by most gas and electric utilities. Unless there are unusual local conditions, the cost of alternative fuels (such as oil instead of gas) tends to be very competitive. The price of electricity is normally the highest of all energy sources and is the most difficult to predict because of rate structures, demand charges and the like.

Table 13. U.S. Natural Gas Prices (Oct. 1987)

User	Price (per-million btu's)
Industrial	$3.22
Commercial	$4.50
Residential	$5.10

Another important energy question that must be asked is what about the future availability of natural gas? Predictions of the nation's reserve supply of natural gas took a drop in media reports of March 1988.

Table 14 contains equipment and cost data for alfalfa drying installations. Two example installations are represented. The 30 percent moisture content column assumes baled or dry chopped material and the 70 percent column assumes high-moisture green chopped material.

Table 14. Costs for Two Sizes of Alfalfa Drying Equipment

Moisture level of incoming hay	30 percent	70 percent
Model(s)	[1]Heil* SD-90-30'	[2]Heil* SD-125-48'
Total fan horsepower	120-hp	600-hp
Heat input	12.8 million btu/hr	90 million btu/hr)
Capacity(incoming)	19.9 tons/hr in at 30% m.c.	90 tons/hr in at 70%)
Capacity(outgoing)	15 tons/hr out at 10% m.c.	15 tons/hr out at 10%)
Cost	$165,000	2 @ $342,000 = $684,000
Installation	$16,000	$102,000
Concrete pad	$10,000	$30,000
Wiring	$5,000	$10,000
Total cost	$196,000	$826,000
Annual fixed cost	$25,000	$105,000
Variable cost	$4.50 per-ton output	$30.20 per-ton output

* Brand names are mentioned for informational purposes only, no endorsement is implied.

Examination of the cost figures in table 14 make it clear that controlling the moisture content of incoming hay is very important in controlling production costs.

Mixing

After the chopped hay is dried to 8 percent to 10 percent moisture content it is almost ready for cubing. The hay is placed in a metering bin (figure 13) which controls the flow of material into the mixer and then into the cuber. In the mixer (figure 14), water and other assorted additives are combined with the alfalfa. Water acts as a lubricant in the cuber and helps the alfalfa stick together in the cube shape. It is used as such in all cubing/mixing systems. Other common additives, along with their uses, are shown in table 15.

Figure 13. Industrial Type Loader Places Dry Chopped Alfalfa into a Metering Bin.

Figure 14. Mixer, Where Water and Other Additives Are Added to Alfalfa Prior to Cubing.

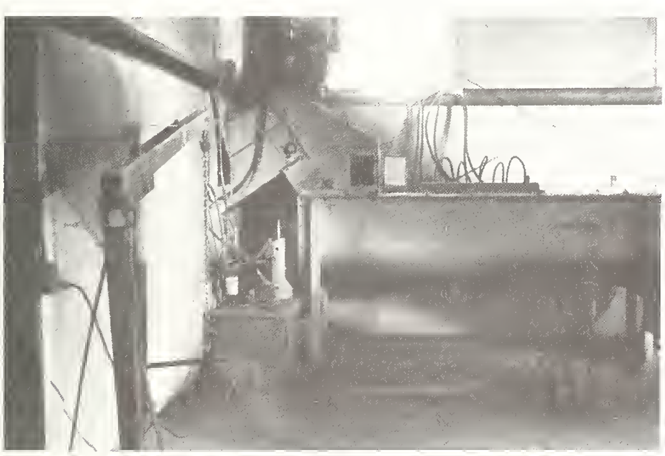


Table 15. Common Additives for Cubes

Additive	Function
Propionic acid	Preservative
Bentonite	Binder
Starches	Binder
Molasses	Binder/energy
Minerals	Supplement
Distillers' grains	Total ration concept

Propionic acid is the preservative most often used with cubes. It is mixed with chopped hay in various proportions of the weight of the final product to insure against molding. Feed grade Propionic acid is delivered in 40,000 lb. loads for about $0.30 per-pound. If 0.5 percent Propionic acid is added to a ton of cubes, $3 per-ton is added to the cost of production.

Bentonite is a clay used to bind cubes together and to prevent crumbling and the production of small bits and pieces of hay, usually referred to as fines. It also makes the cube difficult for animals to chew. There has been some evidence that animals fed bentonite-treated cubes may develop sore mouths. It is often necessary to use a binder like bentonite if poor-quality alfalfa, grass hay or "total ration" cubes are made. These other ingredients, like grass hay and grain, do not contain the natural binders found in alfalfa.

Total ration cubes are cubes that contain a complete diet designed for a specific species of animal. It would then not be necessary to handle, measure and mix other feeds with the cubes in order to satisfy the dietary requirements of the animal. Distillers' grains are a byproduct of alcohol production that are available in many areas that could possibly be mixed with alfalfa and other ingredients to produce a "total ration" cube.

Cubing

Cubers for alfalfa fall into two main categories, stationary and field. One manufacturer makes a stationary cuber on a flat bed trailer to make it a "portable". The field cubers (figure 15) are primarily used in the dry areas of the West where weather conditions are favorable for their use.

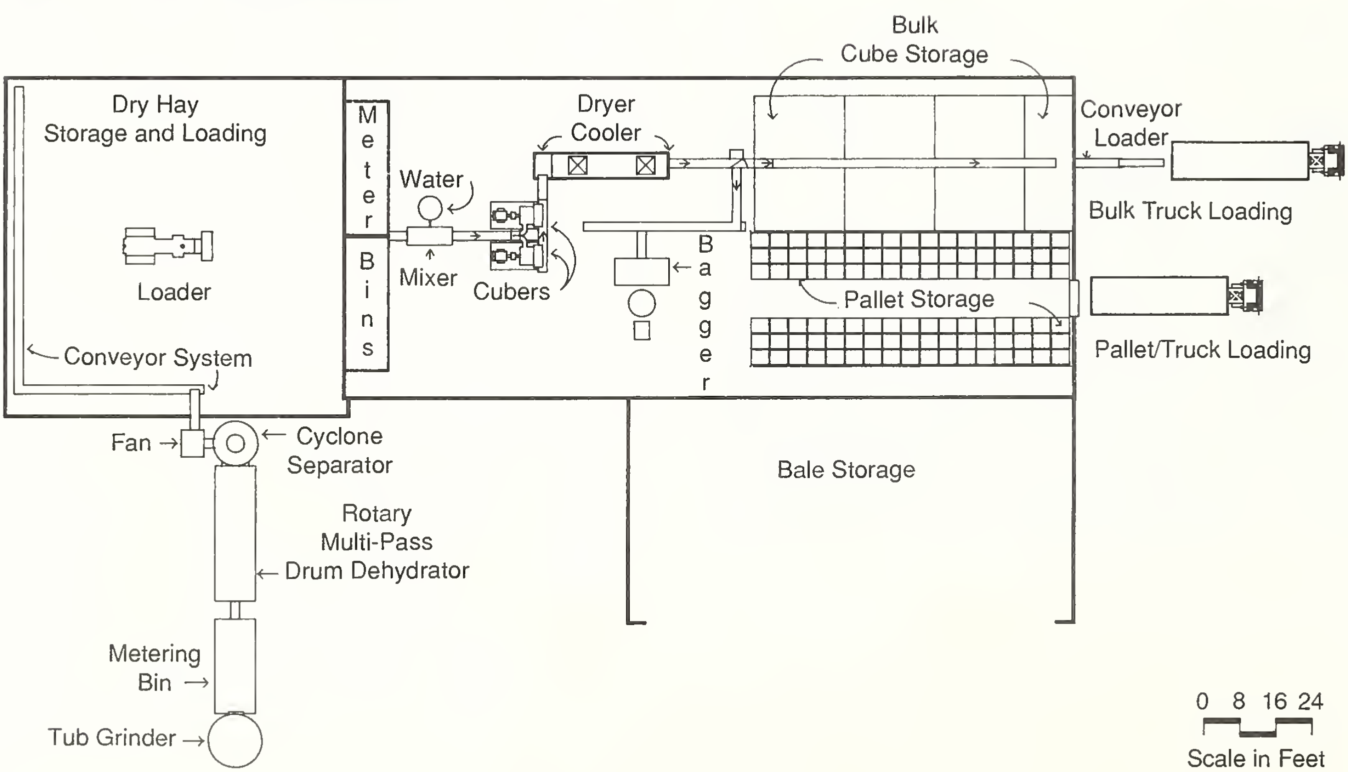
Stationary cubers (figure 16) for alfalfa are manufactured by two or three domestic companies. A basic cubing plant layout is shown in figure 17. Some sample ownership and operating costs are given in table 16. Some manufacturers offer more than one model of cuber, with capacities generally in the order of 7-9 tons of alfalfa cubed per-hour.

Cubers work by feeding cut hay into a central auger inside the cuber, which in turn feeds the hay to a press wheel that

Figure 15. A Field Cuber.

Figure 16. A Twin Head Alfalfa Cuber.

Figure 17. A Basic Alfalfa Cubing Operation



forces it through a die ring. The die dimensions determine the cube dimensions. By changing die sets it is possible to produce a variety of cube sizes. The most popular size is the 1.25 inch by 1.25 inch cube, but both smaller and larger, circular and square "cubes" may be produced, depending on market requirements. Some cube manufacturers suggest that two cubers and two metering bins be purchased because downtime for repairs can be devastating if it occurs in the middle of harvest season. Most cubing firms, however, own only one cubing head and one metering bin.

Table 16. Cubing Equipment and Costs

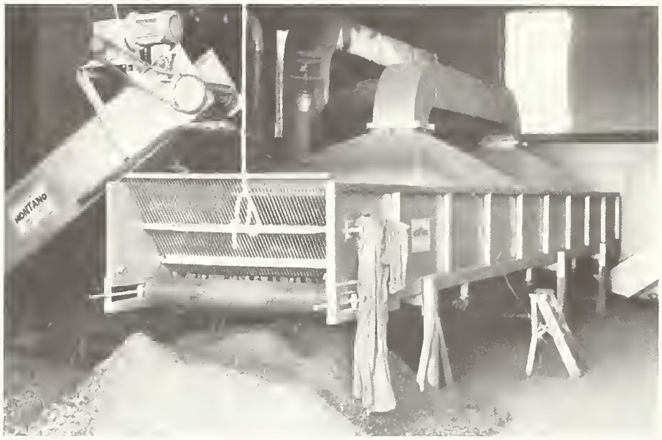
Item	Cost
8-ton-per-hour cuber	$50,000
200-hp electric motor	$6,000
Starter	$4,000
Mixer	$7,000
Metering bin	$42,000
Feed conveyor	$5,500
Output conveyor	$2,500
Fines return system	$1,000
Cube cooler/dryer	$38,000
Installation	$16,000
Total	$172,000
Useable life	10 years
Annual fixed costs	$28,380
Annual variable costs	$5.68 (per-ton)

Cooling and "Curing"

The cube cooling and drying equipment (figure 18) listed in table 16 is used to cool and dry the cubes back to 8 percent-10 percent moisture content after cubing. This is because the cubes emerging from the cubing head are between 14 percent and 18 percent moisture content and about 140o F. Some firms in the industry are using 20-to 40-horsepower fans to draw ambient, unheated air through a thin layer of cubes as they move on a wire mesh conveyor. Some firms use heated air in order to remove moisture as well as to cool the cubes. If a major deficiency exists in the design of cubing plants it probably comes in this area of drying, cooling and storing cubes. Plants that add Propionic acid to their cubes and have massive coolers to cool them down still have moldy cubes in their storage rooms. More research and development on the drying and cooling characteristics of alfalfa cubes is needed.

The term curing is used in the West to denote the time that cubes are left outside in the sun to dry and cool. This procedure is not recommended in the humid East and Midwest, as spoilage is likely to occur.

Figure 18. A Small Cube Cooling Apparatus.



Bagging

A portion of most cube production will likely be bagged, depending on the desires of the market. Bags are usually 40, 50 or 70 pounds each. The quality of the hay in them is usually the highest in an attempt to get a premium price for the product. Bags are colorful, with green being the predominant color. Typical four layer bags cost about $0.57 each in minimum orders of 10,000. A list of ingredients including a minimum crude protein percentage is prominently displayed.

Bagging equipment (figure 19) may be relatively simple or marvels of the computer age. The basic bagging operation consists of a stream of cubes from a conveyor feeding the hopper of a bag filling device. A scale reads the weight in the sack and manually or automatically stops filling the bag when the set weight is achieved. The filled bag travels upright on a conveyor to a sewing head that closes the bag. Typical bagging stations employ two people filling bags at a rate of five to seven per minute. Some plants employ metal detection equipment at this point as a final safeguard against "hardware disease." (Hardware disease is a condition caused by the animal ingesting metal.) Table 17 lists some bagging costs, estimated using 40-pound bags, 1,000 lb. per-pallet and $2.00 each for disposable pallets.

Figure 19. Bag Filling Equipment.

Table 17. Bagging Cost Estimates, 6 tons/hr

Item	Cost	Life	Annual fixed cost	Variable cost/ton
Bag filler with scale, conveyor and sewing head	$15,000	10	$2,400	$24.50
Goring-Kerr* metal detector	$8,000	10	$1,300	$0.10
Totals	$23,000		$2,700	$4.60

* mention of brand names is for informational purposes only,no endorsement is implied.

Material Handling Costs

Most of the costs of moving, storing and packaging has been included in the tables presented earlier. The exception to this is powered vehicles used for moving hay (1) to the metering bin (or tub grinder), (2) within cube storage and (3) loading out. Filling the metering bin at a rate of 8 tons or more per-hour requires a large industrial front end loader (figure 13) with an oversized (5 cubic yard or so) scoop. Moving large bales requires a tractor equipped with bale spear device. Moving cubes within storage can be accomplished with the large loader noted in (1); however, this large type of loader may be unwieldy for use indoors. A smaller skid loader might be more appropriate. Palletized bags of cubes are moved with a fork lift (figure 20). Table 18 is a summary of material handling equipment needs and costs.

Depending on the market being served, some additional, specialized loading machinery may be required. Figure 21 shows a small pickup truck loading conveyer for direct sale of small quantities of cubes. Figure 22 shows a portable conveyer for loading containers for overseas shipment.

Figure 20. Typical Material Handling for Palletized Bags.

Figure 21. A Small Conveyer Used to Load Pickup Truck Loads.

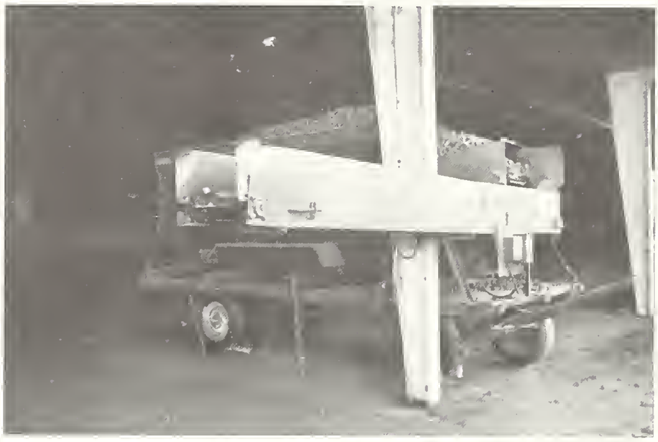


Figure 22. A Special Conveyer to Bulk Load Containers for Export.

Table 18. Estimated Material Handling Costs

Item	Cost	Expected Life(yrs)	Annual fixed cost	Variable cost($ per-ton)
Industrial loader	$80,000	10	$12,800	$3.20
Skid Loader 50-hp.	$19,000	10	$3,040	$2.50
Fork lift 4,000 lb.	$32,000	10	$5,120	$2.70
Totals	$131,000		$20,960	$8.40

Summary of Costs

The purpose of generating all these tables and data is to get an understanding of what the total cost of cubing might be, so as to decide whether it is worth further investigation. Table 19 is a summary of the costs shown in previous tables. Tables 19 and 20 assume a single cubing plant that produces between 5,000 and 15,000 tons of cubes annually from 30 percent moisture content hay delivered to the plant in large bales.

Table 19. Summary of Estimated Costs(for a single cuber plant)

Item	Price	Annual fixed cost	Variable cost($ per-ton output)
Testing & weighing	$80,000	$11,250	
Dump area	$150,000	$18,000	
Bale storage	$330,000	$37,800	
Bulk cube storage	$275,000	$35,478	
Bag storage, cubing room and office	$350,000	$30,000	
Grinding	$30,000	$4,050	$2.00
Drying	$196,000	$25,000	$4.50
Propionic acid			$3.00
Cubing	$172,000	$28,380	$5.68
Bagging	$23,000	$2,700	$24.60
Material handling	$131,000	$20,960	$24.60
Totals	$1,737,000	$213,618	$64.38

Table 20. Estimated Unit Costs of a Single Cuber Plant

Production level (tons output per-year)	5,000	10,000	15,000
Cost per-ton	$105.90	$84.54	$77.42

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Appendix I. Example of an NIRS Analysis Report

NIRS Analysis Report

Sample Number	1
Sample Type	Legume Hay
Sample ID	Smith Farms
Date Processed	08-31-1991
Name	Doniphan Alfalfa Coop
Address	PO Box 1 Bendena, KS
Association	

Analysis	As Sampled	Dry Matter
Moisture, %	8.0	8.7
Dry Matter, %	92.0	100.0
Crude Protein, %	18.9	20.6
Dig. Protein Est., %	14.2	15.4
Acid Det. Fiber, %	25.0	27.2
Neut. Det. Fiber, %	49.2	53.5
TDN Est., %	59.9	65.1
NE/LACT,MCAL/LB	0.63	0.69
NE/MAINT,MCAL/LB	0.62	0.67
NE/GAIN,MCAL/LB	0.37	0.40
Relative Feed Value (WI)		126.3
Minerals		
Calcium, %	0.98	1.07
Phosphorus, %	0.34	0.37
Potasium, %	2.36	2.56
Magnesium, %	0.28	0.31