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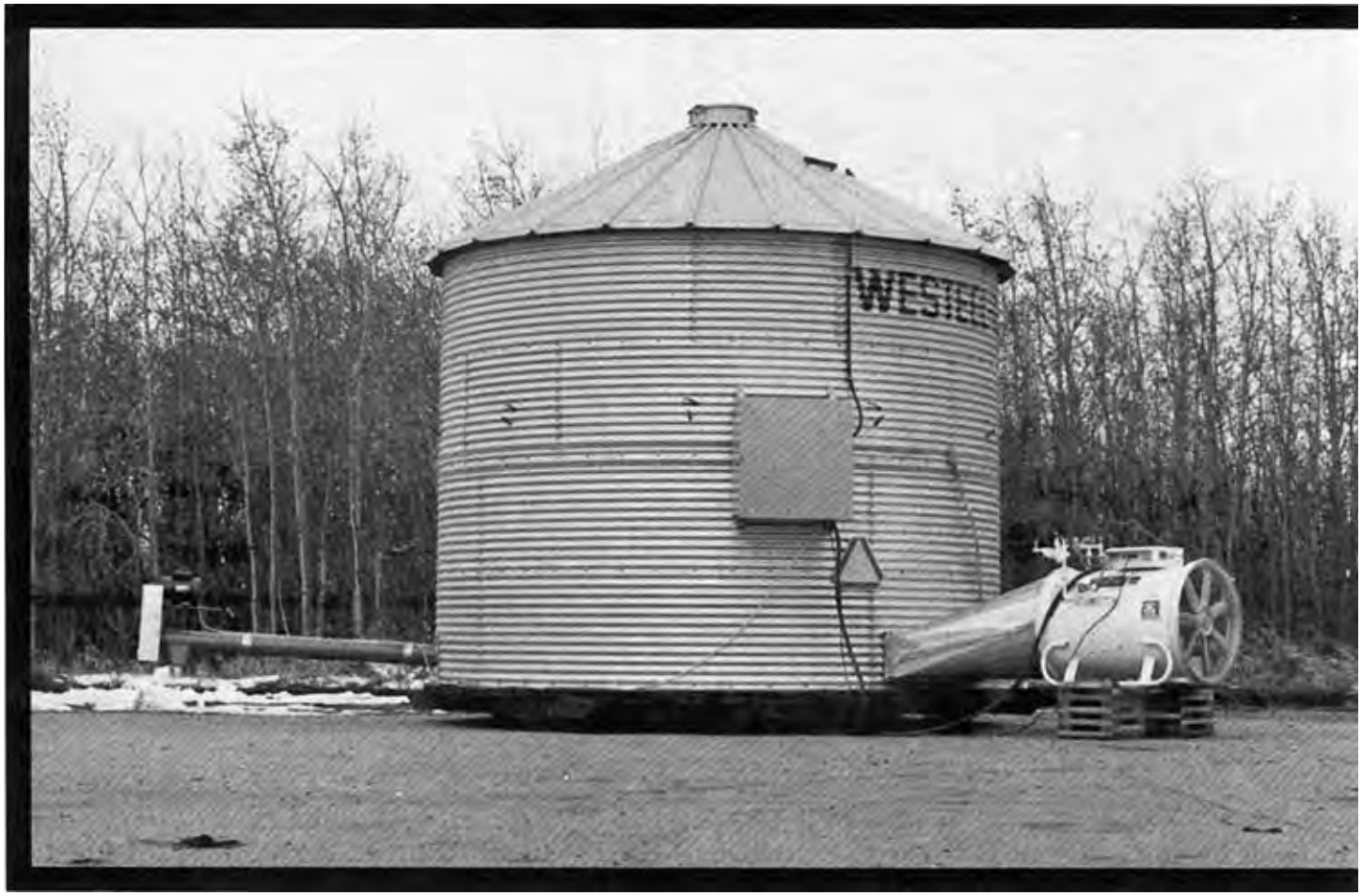

Adams Grain Dryer

A Co-operative Program Between
ALBERTA FARM MACHINERY RESEARCH CENTRE
PAMI
PRAIRIE AGRICULTURAL MACHINERY INSTITUTE

ADAMS GRAIN DRYER

MANUFACTURER AND DISTRIBUTOR:

Adams Grain Dryer Co. Ltd.
1944 St. George Avenue
Saskatoon, Saskatchewan
S7M 0K5

RETAIL PRICE:

$12,450.00 (March, 1984, f.o.b. Humboldt, complete with optional discharge auger).

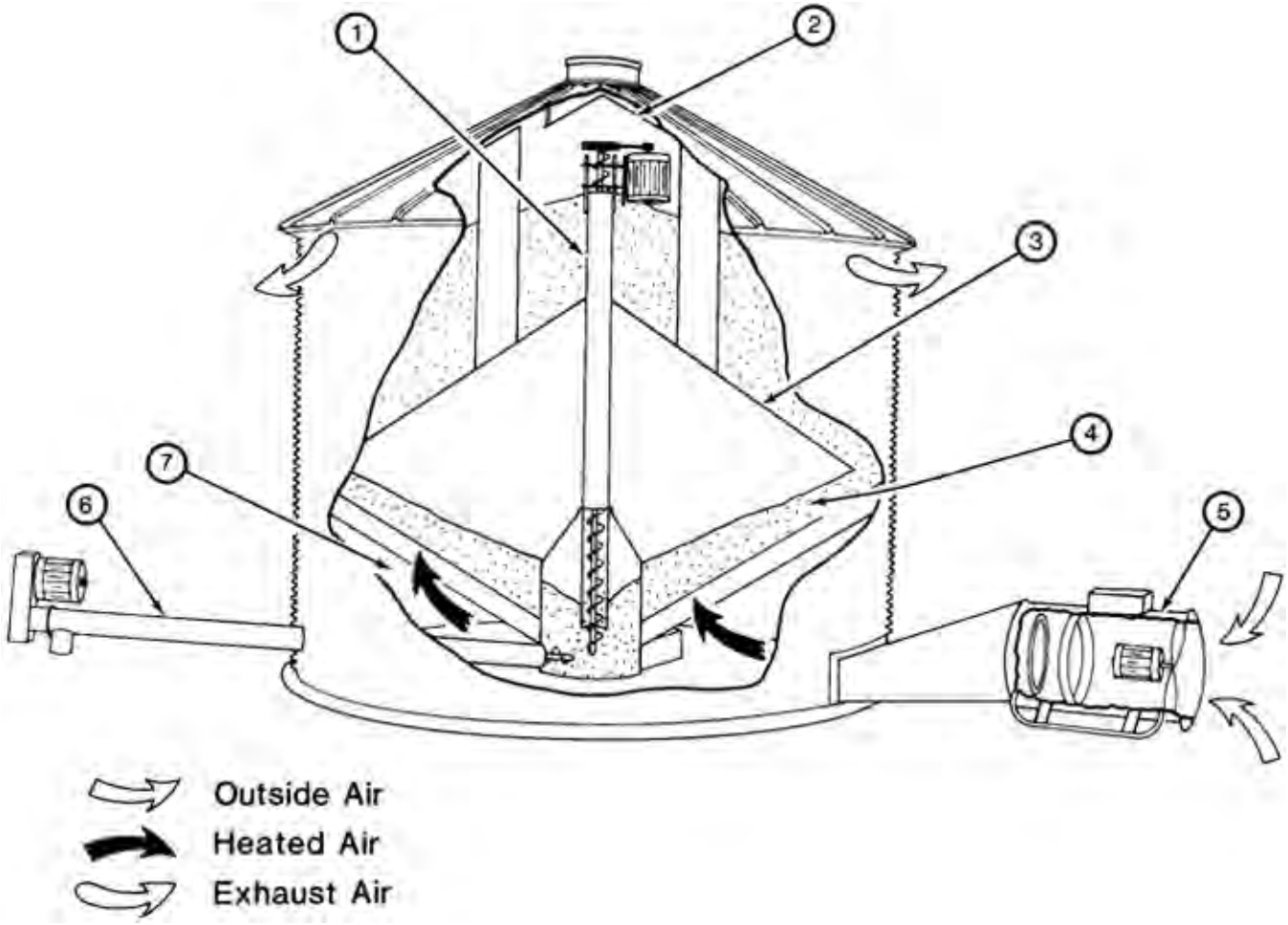

FIGURE 1. Adams Grain Dryer (1) Vertical Auger, (2) Spreader Cone, (3) Upper Grain Holding Cone, (4) Grain Drying Section, (5) Fan/Burner Unit, (6) Discharge Auger, (7) Air Plenum.

SUMMARY AND CONCLUSIONS

Drying Capacity: The rated drying capacity of the Adams Grain Dryer was 82 bu/h (2.2 t/h) in wheat, 98 bu/h (2.1 t/h) in barley, 82 bu/h (1.9 t/h) in rapeseed and 61 bu/h (1.6 t/h) in Hybrid 3996 corn.

Fuel Consumption: At the rated drying capacity, the specific fuel consumption or the amount of propane required to dry a quantity of grain was 7.0 gal/100 bu (11.7 L/t) in wheat, 5.5 gal/100 bu (11.5 L/t) in barley, 5.5 gal/100 bu (11.0 L/t) in rapeseed and 13.3 gal/100 bu (23.8 L/t) in corn. This corresponds to a fuel consumption of 5.7 gal/h (26 L/h) in wheat, 5.4 gal/h (25 L/h) in barley, 4.5 gal/h (20 L/h) in rapeseed and 8.1 gal/h (37 L/h) in corn.

Energy Consumption: At rated drying capacity, the specific energy consumption or the total energy required to remove a quantity of water from the grain, was 2000 Btu/lb (4700 kJ/kg) in wheat, barley and rapeseed and 1900 Btu/lb (4400 kJ/kg) in corn.

Quality of Work: No grade loss occurred in the grains tested when operating at the manufacturer's recommended drying air temperature settings. The drying air temperature was very uniform and adequate for all drying conditions encountered, but was slightly lower than the temperature setting.

Ease of Operation and Adjustment: Ease of assembly and installation was very good. The Adams Grain Dryer was mounted on skids for transporting short distances. Ease of filling and discharge was fair. Ease of drying was fair as regular supervision was required. The drying air temperature was difficult to set. Ease of cooling was good. Ease of cleaning the Adams Grain Dryer was good as the air plenum and auger sump required cleaning weekly. Only seasonal lubrication was required making the ease of servicing excellent.

Power Requirements: The Adams Grain Dryer required 10.4 hp (7.8 kW) when operated on 230 V AC electrical power.

Safety: The Adams Grain Dryer was safe to operate as long as the manufacturer's limited safety instructions and common safety practices were followed. The sound level at the operator's station was 107 dBA. It is recommended that the operator wear ear protection when working near the Adams Grain Dryer.

Operator Manual: The operator manual was incomplete and poorly written, providing limited useful information on operation, adjustments and safety.

Mechanical History: Seven mechanical problems occurred during the test.

RECOMMENDATIONS

It is recommended that the manufacturer consider:

1. Including discharge auger installation instructions in the operator manual.
2. Modifications to support the propane pipe connected to the supply.
3. Providing either a procedure to prevent dryer overfilling or modifications to prevent grain from entering the vertical auger motor.

4. Labelling the vertical and discharge auger switches.
5. Modifications to the vertical auger feed control lever to provide easier access while drying,
6. Modifications to the discharge auger to prevent motor overload.
7. Modifications to the discharge auger sump to permit easier cleaning.
8. Emphasizing safety and installing the appropriate warning decals on the dryer.
9. Modifications to the discharge auger drive shield to completely enclose the drive.
10. Providing a warning to indicate a safety shutdown.
11. Providing guidelines on drying air temperature settings that will ensure that wood components do not exceed maximum allowable temperatures.
12. Revising the operator manual to contain complete information on safe operation and adjustments.
13. Revising instructions in the operator manual on drying air temperature sensor location to permit proper operation.
14. Increasing quality control to prevent air leakage.
15. Strengthening the upper grain cone to prevent buckling.
16. Providing a better bonding of the canvas strip to the inside of the dryer wall to prevent grain from leaking into the air plenum.

Senior Engineer: G.E. Frehlich
Project Engineer: J.D. Wassermann
Project Technologist: W.F. Stock

THE MANUFACTURER STATES THAT

With regard to recommendation number:

1. The operator manual will include instructions and diagrams for installation of the discharge auger.
2. A support for the propane line will be standard equipment on new dryers.
3. Consideration is being given to installing an electronic sensor to prevent overfilling. A perforated metal shroud will be installed on new dryers to prevent grain from entering the vertical auger motor if the dryer is overfilled,
4. The auger switches will be labelled for easy identification.
5. The vertical auger feed control lever will be extended above the grain level, for easy access when the dryer is loaded.
6. The intake end of the discharge auger will be equipped with a control gate to prevent motor overload.
7. A cleanout door will be added to the auger sump to facilitate easier cleaning.
8. Warning decals will be attached to appropriate locations.
9. The discharge auger shield will be modified to totally enclose the drive.
10. The addition of an optional warning light on the heater control panel to indicate a safety shut down will be considered.
11. The operator manual will indicate the maximum allowable drying air temperature of 194°F (90°C).
12. A revised operator manual shall be printed containing complete information on safe operation and adjustment of the dryer.
13. Instructions and the diagrams in the operator manual will be improved to clearly indicate the location of the temperature sensor.
14. New procedures will be adopted to reduce air leakage.
15. A strengthened cone, that is presently being load tested, will be included on new dryers. This cone may also be retrofitted to dryers in the field.
16. Canvas webbing will be preshrunk before installation to eliminate bonding problems. A better bonding adhesive is being investigated.

Manufacturer's Additional Comments

Due to the-highly uniform drying air temperature and the recirculating gram design, we feel the drying air temperature could be increased to 194°F (90°C). This will increase drying capacity, improve the efficiency and decrease grain drying costs.

Consideration is being given to adding a drying air temperature gauge. This would reduce time in setting the pressure regulator.

GENERAL DESCRIPTION

The Adams Grain Dryer is a recirculating batch, cross-flow grain dryer with an axial fan, propane burner, and a funnel-shaped grain drying section above the air plenum. Grain fills through the top centre of the dryer and gravity feeds, from the upper grain holding section, through the grain drying section in a layer. A vertical auger continuously recirculates the grain from the bottom of the grain drying section to the top of the upper grain holding section. Outside air is forced by the fan past the burner into the air plenum and through the grain drying section, to dry or cool the grain. Dry grain is discharged by an auger from the bottom of the dryer.

Drying air temperature is controlled by a thermostat and pressure regulator. No temperature gauge is available. All dryer cycles are controlled manually.

The fan is driven by a 7.2 hp (5.4 kW) 230 V AC, single phase electric motor. The vertical and discharge augers are each driven by 1.5 hp (1.1 kW) electric motors.

A safety control circuit shuts off fuel to the burner if the burner flame is extinguished, the fan shuts down, or if the drying air temperature high limit setting is exceeded.

Detailed specifications are given in APPENDIX I.

SCOPE OF TEST

The Adams Grain Dryer was operated with artificially and naturally wet grain under the conditions shown in TABLE 1 for 194 hours while drying about 13425 bu (325 t) of grain. It was evaluated[1] for rate of work, fuel and energy consumption, quality of work, ease of operation and adjustment, power requirements, operator safety and suitability of the operator manual.

TABLE 1. Operating Conditions

Grain	Grade	Dockage	Moisture Content	Hours	Grain Dried	
		%	%		bu	t
Wheat	2CW RS	2	17.9 to 23.8	53	3530	96
Barley	1 Feed	1	16.6 to 24.5	56	3535	77
Rapeseed	2CW	3	12.8 to 21.1	43	3390	77
Corn (Hybrid 3996)	2CW	3	19.0 to 29.8	42	2970	75
Total				194	13425	325

RESULTS AND DISCUSSION

RATE OF WORK

Standard Conditions: To provide a meaningful comparison of grain dryer performance, the drying capacity, and fuel and energy consumption of the dryers should be determined for identical drying conditions. Because it is impossible to obtain the same air and grain conditions in the field when testing each machine, the dryer capacities and fuel and energy consumptions included in this report have been mathematically adjusted to standard drying conditions[2]. These adjusted results can be compared to the adjusted results of other dryers, even though they were tested under different conditions or in different years.

Drying Capacity: The drying capacity[3] of a dryer is the rate at which grain can be dried to the dry moisture content specified by the Canadian Grain Commission, while operating the dryer at standard conditions and the settings recommended by the manufacturer. The drying capacity is based on the time to fill, dry, cool and discharge the grain. Drying capacity varies with the grain type and the amount of moisture removed. FIGURES 2 to 5 present capacity curves for the Adams Grain Dryer while drying wheat, barley, rapeseed and Hybrid 3996 corn.

Rated Drying Capacity: The Machinery Institute has designated the rated drying capacity as the capacity of the dryer while removing 5% moisture in wheat, barley and rapeseed, and 10% moisture in corn. It is based on the time required to fill, dry, cool and discharge the grain under these conditions.

The total batch time (TABLE 2) for the Adams Grain Dryer varied from 5.1 hours in wheat to 6.6 hours in corn, while the rated

[1]Tests were conducted as outlined in the Machinery Institute Detailed Test Procedures for Grain Dryers
[2]The standard drying conditions used by the Machinery Institute for the presentation of grain dryer results are given in APPENDIX II.
[3]The Machinery Institute determines the drying capacity using the weight of the dried gram discharged from the dryer. Some manufacturers state their drying capacity using the weight of the wet grain entering the dryer. See APPENDIX VI for the wet grain to dry grain conversion.

drying capacity (TABLE 3) varied from 61 bu/h (1.6 t/h) in corn to 98 bu/h (2.1 t/h) in barley.

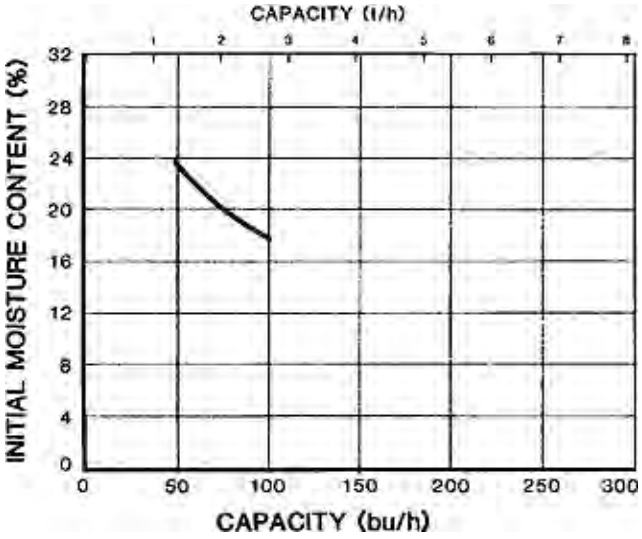

FIGURE 2. Drying Capacity in Wheat.

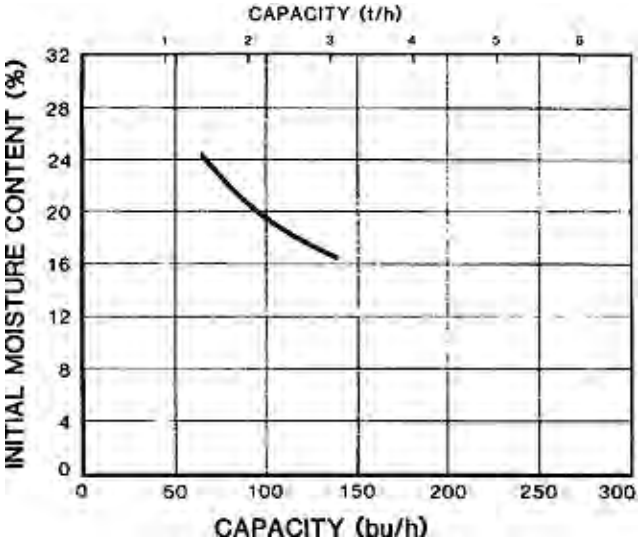

FIGURE 3. Drying Capacity in Barley.

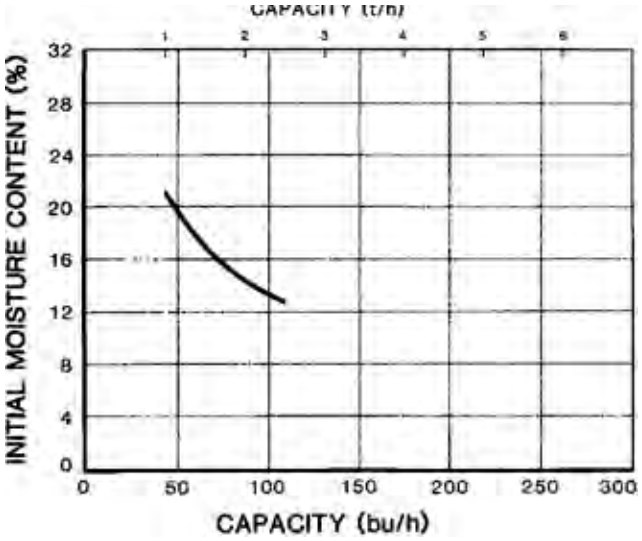

FIGURE 4. Drying Capacity in Rapeseed.

FUEL AND ENERGY CONSUMPTION

Specific Fuel Consumption: Fuel consumption of a grain dryer varies considerably with the temperature and moisture content of the grain and ambient air, the drying air temperature, airflow and burner efficiency. To permit comparison of fuel used in different dryers, fuel consumption must be adjusted to standard conditions and must be related to the quantity of grain dried. Specific fuel consumption is a measure of the fuel used to dry a quantity of grain. It is expressed in gallons (gal) of propane per 100 bushels (bu) of grain dried [litres (L) of propane per tonne (t) of grain dried]. A low specific fuel consumption indicates efficient fuel use.

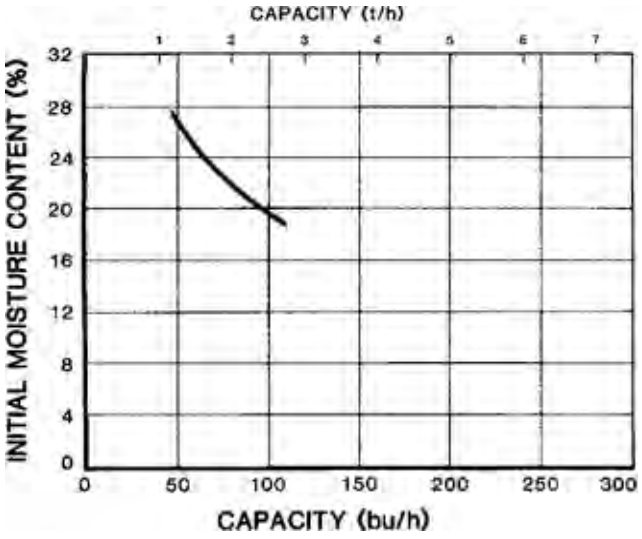

FIGURE 5. Drying Capacity in Corn (Hybrid 3996).

TABLE 2. Batch Times

Grain	Filling	Drying	Cooling	Discharge	Total
	Hours	Hours	Hours	Hours	Hours
Wheat	0.4	3.3	1.0	0.4	5.1
Barley	0.5	3.3	1.1	0.5	5.4
Rapeseed	0.4	4.5	0.7	0.4	6.0
Corn (Hybrid 3996)	0.4	5.0	0.8	0.4	6.6

TABLE 3. Rated Drying Capacities

Grain	Initial Moisture Content	Moisture Removed	Drying Air Temperature Setting		Rated Drying Capacity		Fig. No.
	%	%	°F	°C	bu/h	t/h	
Wheat	19.5	5	180	82	82	2.2	2
Barley	19.8	5	180	82	98	2.1	3
Rapeseed	15.0	5	170	77	82	1.9	4
Corn (Hybrid 3996)	25.5	10	185	85	61	1.6	5

The specific fuel consumption for the Adams Grain Dryer at rated drying capacity (TABLE 4) varied from 5.5 gal/100 bu (11.0 L/t) in rapeseed to 13.3 gal/100 bu (23.8 L/t) in corn. Fuel consumption[4] ranged from 4.5 gal/h (20 L/h) in rapeseed to 8.1 gal/h (37 L/h) in corn.

Specific Energy Consumption: Energy consumption of a dryer also varies with drying conditions and grain dryer design. To permit comparison of energy used in different dryers, energy consumption must be adjusted to standard conditions and related to the quantity of water removed from the grain. Specific energy consumption is a measure of overall dryer efficiency. It is the total energy, including electrical, mechanical and fuel, required to remove a quantity of water. It is expressed in British thermal units (Btu) of energy per pound (lb) of water removed (kilojoules (kJ) of energy per kilogram (kg) of water removed). A low specific energy consumption indicates efficient grain drying.

The specific energy consumption for the Adams Grain Dryer (TABLE 4) at rated drying capacity varied from 1900 Btu/lb (4400 kJ/kg) in corn to 2000 Btu/lb (4700 kJ/kg) in wheat, barley, and rapeseed.

QUALITY OF WORK

Grain Quality: Grain can be damaged in the dryer, if it is dried too long at excessively high temperatures. The grain damage that can occur before there is a loss in the grade and a corresponding reduction in the grain price depends on whether the grain is seed,

[4]Fuel consumption for batch dryers is the fuel consumed during the drying cycle averaged over the total batch time.

commercial or feed. Feed grain is permitted the greatest damage and seed grain the least damage before a grade loss occurs. It is very important for the operator to occasionally have the grain tested for damage especially when drying unfamiliar grains or operating at new dryer settings.

No grade loss occurred when drying commercial wheat and rapeseed or feed barley and corn with the Adams Grain Dryer.

TABLE 4. Fuel and Energy Consumption

Grain	Moisture Removed	Fuel Consumption		Specific Fuel Consumption		Specific Energy Consumption	
	%	gal/h	L/h	gal/100 bu	L/t	Btu/lb	kJ/kg
Wheat4	5	5.7	26	7.0	11.7	2000	4700
Barley	5	5.4	25	5.5	11.5	2000	4700
Rapeseed	5	4.5	20	5.5	11.0	2000	4700
Corn (Hybrid 3996)	10	8.1	37	13.3	23.8	1900	4400

Drying Air Temperature: A uniform drying air temperature minimizes grain damage and provides uniform and efficient grain drying. The drying air temperature for the Adams Grain Dryer was very uniform. The cycling burner controls resulted in an average drying air temperature that was slightly lower than the setting. See APPENDIX IV for further details.

EASE OF OPERATION AND ADJUSTMENT

Transporting: The Adams Grain Dryer was not equipped with transport wheels. However, the main body was a grain bin constructed on 5 permanently mounted wooden skids for transporting short distances. Bin dollies and a hitch could be installed for longer hauls.

Assembly: The Adams Grain Dryer required some assembly. The discharge auger was installed by two men in about 1 hour. No instructions were included in the operator manual. It is recommended that the manufacturer include assembly instructions for the discharge auger in the operator manual.

Installation: The Adams Grain Dryer was installed by two men in about 2 hours. A level surface was required to locate the dryer and blocking was required under the fan. The dryer was easily connected to the propane and electrical supplies. The propane pipe connected to the supply was dangerously unsupported for about 2 ft (0.6 m). It is recommended that the manufacturer consider modifications to support the propane pipe connected to the supply.

Grain Filling: The Adams Grain Dryer could be filled (FIGURE 6) from a grain conveyor with a discharge height of 15 ft (4.6 m). Supervision was required for even filling and to prevent overfilling which caused grain to enter the vertical auger electric motor. Overfilling easily occurred because it was difficult to see the grain level in the dust, and the grain level after filling became higher in the centre of the bin as the grain was recirculated. It is recommended that the manufacturer consider providing either a procedure to prevent dryer overfilling or modifications to prevent grain from entering the vertical auger motor.

The holding capacity[5] of the Adams Grain Dryer was about 485 bu (17.7 m³). The volume of the dried grain was less and varied considerably with grain type and initial moisture content. Batches smaller than the holding capacity could be dried, but at least 250 bu (9.1 m³) of grain was required.

FIGURE 6. Grain Filling.

[5]The holding capacity is the volume of wheat held at 19.5% moisture content.

Grain Drying: The fan (FIGURE 7) and burner were started with switches at the control panel (FIGURE 8). The drying air temperature was set with a calibrated dial on the thermostat and a screw on the pressure regulator. Fuel pressure was monitored on a gauge at the control panel. The maximum drying air temperature was determined by the factory set high limit temperature switch. If this setting was exceeded, fuel to the burner was automatically shut off. The vertical auger was started with a switch at the main panel (FIGURE 9). The switch was unlabelled and located directly beside an unlabelled discharge auger switch. It is recommended that the manufacturer consider labelling the auger switches. The length of the drying cycle was controlled manually.

FIGURE 7. Fan Housing: (1) Burner, (2) Fan.

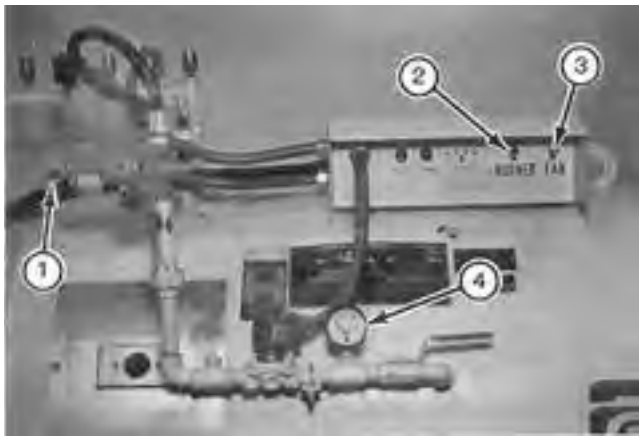

FIGURE 8. Control Panel: (1) Pressure Regulator Adjustment, (2) Burner Switch, (3) Fan Switch, (4) Fuel Pressure Gauge.

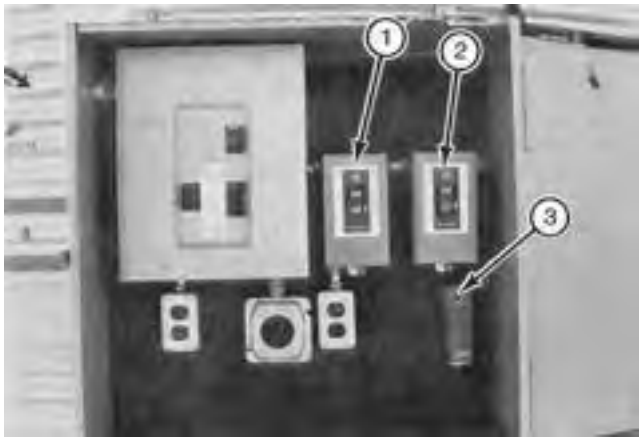

FIGURE 9. Main Panel: (1) Vertical Auger Switch, (2) Unloading Auger Switch, (3) Drying Air Temperature Thermostat.

The thermostat controlled the burner by cycling the burner off when drying air temperature reached the dial setting and on when the drying air temperature dropped. To maintain the average drying air temperature as near the thermostat settings as possible, the fuel

pressure regulator had to be adjusted such that the burner cycled every 1 to 5 minutes. Setting the pressure regulator was very time consuming and difficult as there was no gauge to monitor drying air temperature. However, once set, drying air temperatures were adequate for all conditions encountered.

The drying cycle was determined by measuring the moisture content of samples collected from the vertical auger. Drying time varied when grain type, moisture content, or temperature changed. Although some grain around the perimeter of the bin and in front of the exhaust stacks did not appear to circulate, grain flow through the dryer was adequate to provide a uniform discharge moisture content.

The Adams Grain Dryer required supervision while drying. If the dryer was to be operated at the optimum drying air temperature for maximum capacity, the pressure regulator had to be frequently adjusted for changing conditions. Occasionally at the beginning of the drying cycle with the dryer completely filled, the electric motor on the vertical auger exceeded the full load current and tripped the motor's thermal breaker. The lever that controlled grain flow to the vertical auger was covered with grain during operation and could not be adjusted to prevent motor overload. It is recommended that the manufacturer consider modifications to provide access to the vertical auger feed control lever while drying.

Grain Cooling: Grain cooling occurred after the operator shut off the burner. Samples had to be collected from the vertical auger to determine grain temperature.

Grain Discharge: Grain was discharged from an auger at the bottom of the dryer (FIGURE 10). The optional discharge auger could be located during assembly to discharge from any point around the dryer at discharge heights ranging from 0.9 to 8.0 ft (0.3 to 2.4 m). However, once the auger was installed, its position was fixed. The electric motor did not have sufficient power to operate the discharge auger unless some of the exposed flighting on the auger inlet was covered. It is recommended that the manufacturer consider modifications to the discharge auger to prevent motor overload.

FIGURE 10. Grain Discharge.

Cleaning: Ease of cleaning the Adams Grain Dryer was good. The screens did not plug during the test, however, several locations on the dryer required regular cleanup. Fines sifted through the screens into the air plenum and also collected around the vertical auger just above the grain drying section. Damp grain and fines also built up on the inside of the grain drying section outer wall. About 2 bu (0.1 m^3) of grain remained in the discharge auger sump. Access into the discharge auger sump for cleaning was difficult. It is recommended that the manufacturer consider modifications to the discharge auger sump to permit easier cleaning. The dryer had to be cleaned weekly or when changing grains and took one man about 1 hour.

Servicing: Daily servicing was not required on the Adams Grain Dryer. The fan motor bearings should be lubricated each season.

POWER REQUIREMENTS

The Adams Grain Dryer was equipped with a 200 ampere main panel. It drew a current of 40 amperes when operating on 230 V AC single phase power. Power requirement with the fan and vertical auger running was 10.4 hp (7.8 kW).

OPERATOR SAFETY

The Adams Grain Dryer operator manual did not emphasize safety. Warning decals were only present on the fan and discharge auger to indicate dangerous areas of operation. It is recommended that the manufacturer consider emphasizing safety in the operator manual and installing the appropriate warning decals on the dryer.

The discharge auger drive shield did not adequately cover the auger motor pulley (FIGURE 11). It is recommended that the manufacturer consider modifications to the discharge auger drive shield to completely enclose the drive.

FIGURE 11. Exposed Discharge Auger Drive.

Sound level at the control panel was 107 dBA. The dryer was very noisy and it is recommended that an operator wear ear protection when working near the Adams Grain Dryer.

The Aerovent fan/burner unit is CSA (Canadian Standards Association) certified as meeting the requirements of Gas Fired Equipment for Drying Farm Crops. The safety controls were effective in automatically shutting off the fuel to the burner if the burner flame went out, if the drying air temperature exceeded the set maximum, or if the fan shut down. There was no warning system to indicate a safety shutdown and it is recommended that the manufacturer consider providing one. It was possible to operate the dryer at temperatures that exceeded the maximum allowable material temperature of 194°F (90°C) for wooden components on a grain dryer. It is recommended that the manufacturer consider providing guidelines on drying air temperature settings that will ensure that wood components do not exceed maximum allowable temperatures.

A ULC multi-purpose fire extinguisher with a 2A 10BC rating should be kept with the dryer at all times.

OPERATOR MANUAL

The operator manual was incomplete and poorly written. It is recommended that the manufacturer consider revising the operator manual to contain complete information on safe operation and adjustments.

The operator manual recommended the drying air temperature sensor be located in front of the burner. This caused the burner control to cycle constantly. When properly relocated away from the burner, the control functioned properly. It is recommended that the manufacturer consider revising instructions in the operator manual on drying air temperature sensor location to permit proper operation.

DURABILITY RESULTS

TABLE 5 outlines the mechanical history of the Adams Grain Dryer during 194 hours of operation while drying 13,425 bu (325 t) of grain. The intent of the test was to evaluate the functional performance of the machine. An extended durability test was not conducted.

DISCUSSION OF MECHANICAL PROBLEMS

Discharge Auger: The discharge auger twisted during initial operation and had to be braced to prevent further twisting. It is recommended that the manufacturer consider modifications to prevent the discharge auger from twisting during operation.

Air Leaks: Air leaks, that were present when the dryer was

received, had to be sealed. Fan and transition connections also required slight modification to form a complete seal. The foam seal on the plenum door quickly deteriorated under normal use. Air leakage will reduce drying capacity and efficiency. It is recommended that the manufacturer consider increasing quality control to prevent air leakage.

Prototype Upper Grain Holding Cone: The Adams Grain Dryer had recently been redesigned and contained a prototype upper grain cone. The cone functioned adequately throughout the tests, but buckled from the weight of the grain. It is recommended that the manufacturer consider strengthening the upper grain cone to prevent buckling.

Canvas Seal: The canvas strip glued to the inside wall of the dryer, to prevent grain from leaking into the air plenum, came loose several times. It is recommended that the manufacturer consider providing a better bonding of the canvas strip to the inside of the dryer wall.

TABLE 5. Mechanical History

Item	Operating Hours	Grain bu	Dried (t)
-The discharge auger twisted during operation and required modification at	The beginning of test		
-Several air leaks in the dryer were sealed at	The beginning of test		
-The prototype upper grain holding cone buckled	During the test		
-The canvas seal on the inner bin wall, that prevents grain from leaking into the air plenum, came loose and was reglued several times	During the test		
-The airflow safety switch on the burner malfunctioned and was replaced at	53	3500	(95)
-A propane hose swivel leaked and was replaced at	151	10500	(250)
-The pressure regulator failed and was replaced at	158	11000	(260)

APPENDIX I
SPECIFICATIONS

MAKE:	Adams Grain Dryer
MODEL (YEAR):	1984
SERIAL NUMBER:	403
MANUFACTURER:	Adams Grain Dryer Co. Ltd. 1944 St. George Avenue Saskatoon, Saskatchewan S7M 0K5
GRAIN FILLING:	
-- position	top centre
-- height	14.2 ft (4.3 m)
-- spreading device	cone at grain inlet
GRAIN DRYING SECTION:	
-- type	funnel-shaped
-- diameter	14 ft (4.3 m)
-- effective grain depth	12 to 24 in (305 to 710 mm)
-- grain recirculation	
-type	vertical auger
-diameter	6 in (152 mm)
-length	12.3 ft (3.8 m)
-speed	587 rpm
-drive	belt
-feed	controlslide gate on inlet
GRAIN DISCHARGE	
-- type	auger
-- number	1
-- diameter	6 in (152 mm)
-- length	12.9 ft (3.9 m)
-- drive	belt
-- speed	501 rpm
-- discharge height	14 in (356 mm)
-- discharge position	right side
AIR PLENUM:	
-- shape	cylindrical with a funnel-shaped top
-- air transfer to grain	expanded metal
-- porosity	56 holes/in^2 (8.7 holes/cm^2)
-- hole size	0.04 x 0.12 in (1.0 x 3.0 mm)
-- area	183 ft^2 (17 m^2)
FAN:	
-- make	Aerovent
-- type	vane-axial
-- outer diameter	27 in (686 mm)
-- number of blades	7
-- speed	3500 rpm
-- drive	direct from motor
-- control	switch
BURNER:	
-- make	Aerovent
-- maximum rating	2.1 MBtu/h (2.2 G J/h)
-- type	1.25 in (32 mm) diameter pipe in a 20 in (508 mm) diameter circle
-- fuel	propane
-- ignition	spark
-- temperature adjustment	fuel pressure regulator and air temperature thermostat
ELECTRICAL SYSTEM:	
-- main circuit	200 amps, 230 V AC, single phase
-- electric motors	
-number	3
-size	
-fan	7.2 hp (5.4 kW), 230 V AC, single phase
-vertical auger	1.5 hp (1.1 kW), 230 V AC, single phase
-discharge auger	1.5 hp (1.1 kW), 230 V AC, single phase
NO. OF BELT DRIVES:	2
NO. OF PRE-LUBRICATED BEARINGS:	2
LUBRICATION POINTS:	seasonally lubricate fan motor bearings
OVERALL DIMENSIONS:	
-- field length	22.9 ft (7.0 m)
-- field height	14.2 ft (4.3 m)
-- field width	14.9 ft (4.5 m)
-- body metal thickness	22 gauge (0.9 mm)
WEIGHT: (Dryer Empty)	5250 lbs (2390 kg)
SOUND LEVEL: (At Operator's Station)	107 dBA
HOLDING CAPACITY:	485 bu (17.7 m^3)
INSTRUMENTS:	fuel pressure gauge
OPTIONS:	discharge auger

APPENDIX II
MACHINERY INSTITUTE STANDARD DRYING CONDITIONS

The Machinery Institute has chosen to state the performance of grain dryers at the following air and grain conditions:

Ambient temperature	50°F (10°C)	
Initial grain temperature	50°F (10°C)	
Initial grain temperature	50°F (10°C)	
Barometric pressure	13.8 psia (95 kPa)	
Final grain moisture content	-wheat	14.5%
(Canadian Grain Commission)	-barley	14.8%
	-rapeseed	10.0%
	-corn	15.5%

APPENDIX III
REGRESSION EQUATIONS FOR DRYING CAPACITY RESULTS

Regression equations for the drying capacity results shown in FIGURES 2 to 5 are presented in TABLE 6. In the regressions, B= drying capacity in bu/h, C= drying capacity in t/h and M= initial grain moisture content in percent of total weight, while ℓn is the natural logarithm. Sample size refers to the number of tests conducted. Limits of the regression may be obtained from FIGURES 2 to 5 while the grain conditions are presented in TABLE 1.

TABLE 6. Regression Equations

Grain	Fig. No.	Regression Equation	Simple Correlation Coefficient	Variance Ratio	Sample Size
Wheat	2	$\ell n B = 11.84\text{-}2.50\ \ell n M$	0.99	353[1]	9
		$\ell n C = 8.24\text{-}2.50\ \ell n M$			
Barley	12	$\ell n B = 10.50\text{-}1.98\ \ell n M$	0.99	239[1]	8
		$\ell n C = 6.68\text{-}1.98\ \ell n M$			
Rapeseed	13	$\ell n B = 9.39\text{-}1.84\ \ell n M$	0.97	69[1]	8
		$\ell n C = 5.61\text{-}1.84\ \ell n M$			
Corn (Hybrid 3996)	14	$\ell n B = 11.46\text{-}2.27\ \ell n M$	0.98	86[1]	7
		$\ell n C = 7.79\text{-}2.27\ \ell n M$			

[1]*Significant at P ≦ .01*

APPENDIX IV
DRYING AIR TEMPERATURE VARIATION

The coefficient of variation[6] (CV) is used to describe the variation in the temperature within the air plenum during drying. The lower the CV, the more uniform is the drying air temperature.

TABLE 7 presents the coefficients of variation for the Adams Grain Dryer when drying wheat, barley, rapeseed and corn.

TABLE 7. Drying Air Temperatures

Grain	Gauge Setting		Average Drying Air Temperature		CV
	°F	°C	°F	°C	%
Wheat	180	82	171	77	2
Barley	180	82	171	77	2
Rapeseed	160	71	149	65	3
Corn	185	85	172	78	3

[6]*The coefficient of variation is the standard deviation of the measured drying air temperatures expressed as a percent of the average drying air temperature.*

APPENDIX V
MACHINE RATINGS

The following rating scale is used in Machinery Institute Evaluation Reports:

excellent	fair
very good	poor
good	unsatisfactory

APPENDIX VI
CONVERSION TABLE

Imperial Units	Multiply By	SI Units
British Thermal Units/Pound (Btu/lb)	2.33	Kilojoules/Kilogram (kJ/kg)
Bushels (bu) - volume	0.0364	Cubic Metres (m^3)
-weight	0.0272	Tonnes (t) wheat
	0.0218	Tonnes (t) barley
	0.0227	Tonnes (t) rapeseed
	0.0254	Tonnes (t) corn
Feet (ft)	0.305	Metres (m)
Gallons (gal)	4.55	Litres (L)
Horsepower (hp)	0.746	Kilowatts (kW)
Inches (in)	25.4	Millimetres (mm)
Pounds (lb)	0.455	Kilograms (kg)
Pounds/Square Inch (psi)	6.89	Kilopascals (kPa)

$$\text{Dry Grain Weight} = \text{Wet Grain Weight} \times \frac{(100 - \text{wet moisture content (\%)})}{(100 - \text{dry moisture content (\%)})}$$

SUMMARY CHART

ADAMS GRAIN DRYER

Retail Price $12,450.00 (March, 1984, f.o.b. Humboldt, complete with optional discharge auger).

	Evaluation		Comments
RATED DRYING CAPACITY	bu/h	(t/h)	
Wheat	82	(2.2)	
Barley	98	(2.1)	
Rapeseed	82	(1.9)	
Hybrid 3996 Corn	61	(1.6)	
SPECIFIC FUEL CONSUMPTION	gal/100 bu	(L/t)	
Wheat	7.0	(11.7)	
Barley	5.5	(11.5)	
Rapeseed	5.5	(11.0)	
Hybrid 3996 Corn	13.3	(23.8)	
QUALITY OF WORK			
Grain Quality			- no grade loss in grains tested
Drying Air Temperature			- very uniform and adequate for all drying conditions - slightly lower than temperature setting
EASE OF OPERATION AND ADJUSTMENT			
Dryer Preparation	**very good**		- very little assembly
Filling and Discharge	**fair**		- supervision required
Drying	**fair**		- some supervision required - drying air temperature was difficult to set
Cooling	**good**		- minor supervision required
Cleaning	**good**		- air plenum and auger sump required cleaning weekly
Servicing	**excellent**		- no daily servicing
POWER REQUIREMENTS	10.4 hp (7.8 kW)		- 230 V AC electric drive
OPERATOR SAFETY	**good**		- CSA certified, few decals or warnings, noisy fan
OPERATOR MANUAL	**poor**		- very incomplete

CAUTION:
This summary chart is not intended to represent the final conclusions of the evaluation report. The relevance of the ratings is secondary to the information provided in the full text of the report. It is not recommended that a purchase decision be based only on the summary chart.

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