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# Evaluation Report 307

## Moridge 8440 Grain Dryer

A Co-operative Program Between

ALBERTA FARM MACHINERY RESEARCH CENTRE

PAMI
PRAIRIE AGRICULTURAL MACHINERY INSTITUTE

# MORIDGE 8440 GRAIN DRYER

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## SUMMARY AND CONCLUSIONS

**Functional Performance:** The Moridge 8440 recirculating batch grain dryer was *very good* in wheat, barley, rapeseed and Hybrid 3996 com.

**Drying Capacity:** The rated drying capacity of the Moridge 8440 was 127 bu/h (3.5 t/h) in wheat, 134 bu/h (2.9 t/h) in barley, 124 bu/h (2.8 t/h) in rapeseed and 87 bu/h (2.2 t/h) in com.

**Fuel Consumption:** At rated drying capacity, the specific fuel consumption or the amount of propane required to dry a quantity of grain was 5.4 gal/100 bu (9.1 L/t) in wheat, 5.1 gal/100 bu (10.6 L/t) in barley, 4.2 gal/100 bu (8.4 L/t) in rapeseed and 11.4 gal/100 bu (20.4 L/t) in com. This corresponds to a fuel consumption of 7.0 gal/h (32 L/h) in wheat, 6.6 gal/h (30 L/h) in barley, 5.3 gal/h (24 L/h) in rapeseed and 9.9 gal/h (45 L/h) in com.

**Energy Consumption:** At rated capacity, the specific energy consumption or the total energy required to remove a quantity of water from the grain, was 1500 Btu/lb (3600 kJ/kg) in wheat, 1800 Btu/lb (4200 kJ/kg) in barley, 1500 Btu/lb (3600 kJ/kg) in rapeseed and 1600 Btu/lb (3700 kJ/kg) in com.

**Grain Quality:** A grade loss occurred in commercial red spring wheat when operating at the manufacturer's recommended temperature settings. At temperature settings, that did not reduce the grade of commercial red spring wheat, the rated drying capacity decreased 30 to 40% while specific fuel and energy consumption increased by 10 to 20%.

**Ease of Operation and Adjustment:** The Moridge 8440 was easy to transport and set up. Burner performance was *very good* and provided a steady and uniform drying air temperature in most conditions. Adequate drying air temperatures could not be obtained when drying com at outside temperatures below 20°F (-7°C). The drying air temperature was easy to set. Grain cooling *was very good.* Ease of filling and unloading was *good.* Grain recirculation was adequate for most conditions. Ease of cleaning the Moridge 8440 was *fair.* Lubrication points were accessible and fairly easy to service.

**Safety:** The Moridge 8440 was safe to operate as long as the manufacturer's safety instructions were followed. The sound level at the operator's station was 102 dBA. It is recommended that an operator wear ear protection when working near the Moridge 8440.

**Operator Manual:** The operator manual was well illustrated, clearly written and contained much useful information.

**Mechanical History:** Seven minor mechanical problems occurred during the tests.

**RETAIL PRICE:**
$14,602.00 (March, 1983, f.o.b. Humboldt, complete with power take-off drive, 0.05 in (1.3 mm) rapeseed screens and optional operator's platform, foldaway loading auger, and grain cleaner attachment.)

## RECOMMENDATIONS

It is recommended that the manufacturer consider:

1. Supplying a hitch jack.
2. Lengthening the control circuit power supply cord.
3. Supplying holding brackets to prevent the unloading chute from turning in the wind.
4. Modifications to prevent plugging of the unloading chute in wet conditions.
5. Reducing the recommended temperature settings to prevent grade loss when drying commercial red spring wheat.
6. Providing a warning of caution when using the ladder during drying.
7. Modifications to keep the airflow sensor from freezing shut and preventing burner startup in cold weather.
8. Providing a waming system on the dryer to indicate a safety shutdown.
9. Including information on transporting in the operator manual.

*Senior Engineer-- G.E. Frehlich*

*Project Technologist-- R.M. Bartel*

## THE MANUFACTURER STATES THAT

With regard to recommendation number:

1. Customer demand for an optional hitch jack has not been sufficient to justify the added cost to the dryer.
2. On 1983 machines, the control circuit power cable has been lengthened to accommodate tractors with batteries set further forward.
3. Stops for the unloading spout are currently on 1983 machines.
4. An optional kit is available for grain conditions which require a steeper slope of the unloading chute to prevent bridging.
5. We will make a new listing in our recommended air and grain drying temperature chart to include commercial spring wheat.
6. A warning decal cautioning the operator about using the ladder during drying is being considered.
7. Due to CSA requirements, it is almost impossible to modify the air differential flow switch. Nuisance safety shutdowns caused by frosting of the air switch during cooling of grain in abnormally cold weather have not been reported from the field.
8. An optional warning system to indicate safety shutdown is being considered.
9. Instructions on transportation information will be reviewed.

**MANUFACTURER'S ADDITIONAL COMMENTS**

1. The recommended drying temperatures included in the manual for wheat will not cause grade damage to hard red winter wheat or most straight-cut spring wheats. Spring wheat windrowed and damaged by rainy weather is very difficult to dry without causing additional grade loss.
2. The model 8440 has been designed to operate at a power take-off speed of 400 to 420 rprn to allow the tractor engine to operate at its maximum fuel efficiency. When using a 1000 rpm power take-off, the operator must check with a tachometer to ensure that he does not overspeed the fan.
3. Current model 8440 dryers have increased loading capacity over the 8440 tested.

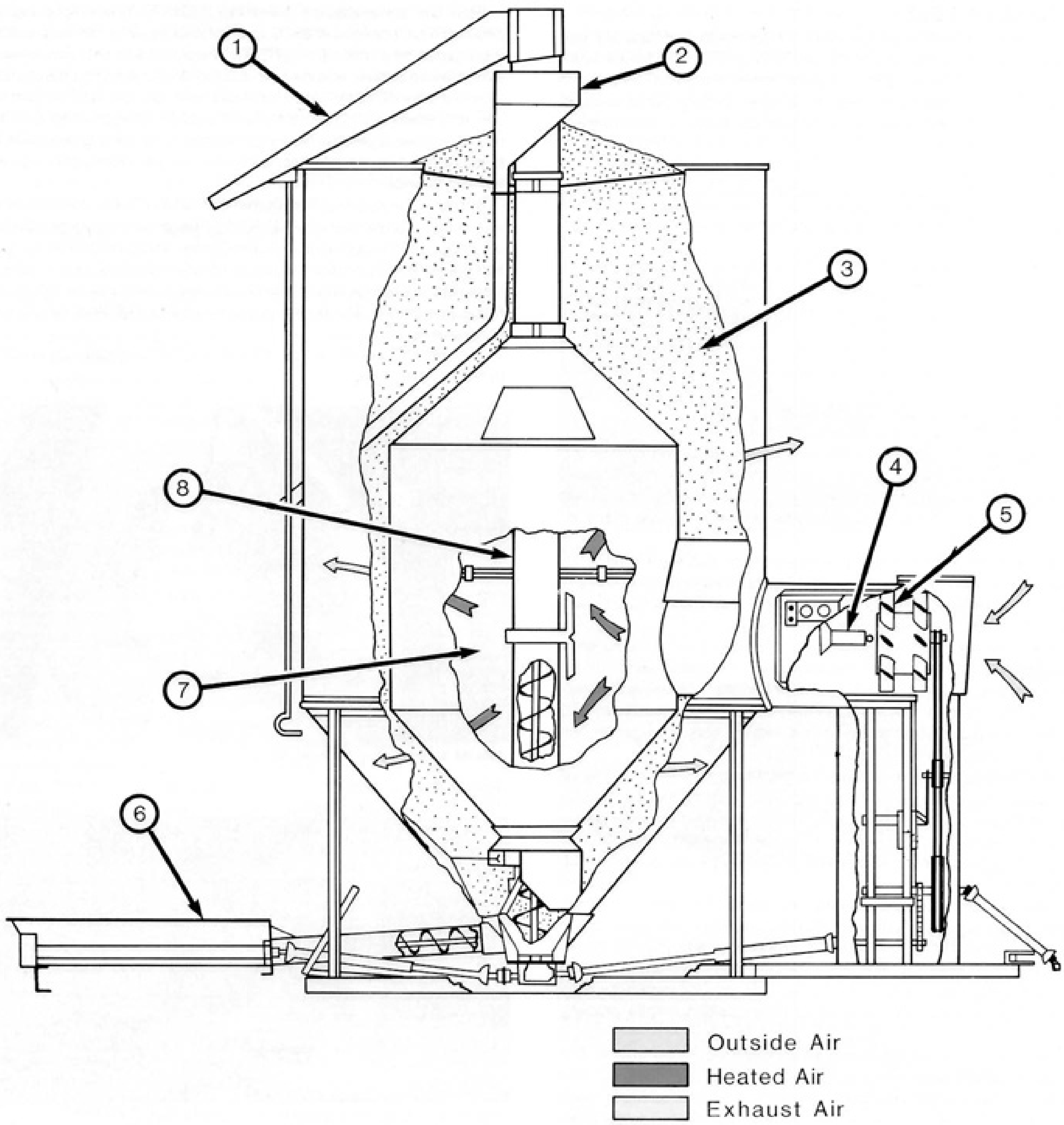



**FIGURE 1.** Mondge 8440 Grain Dryer: (1) Unloading Chute, (2) Grain Cleaner, (3) Grain Chamber, (4) Bumer, (5) Fan, (6) Loading Auger, (7) Air Plenum, (8) Vertical Auger.

## GENERAL DESCRIPTION

The Moridge 8440 is a recirculating batch, cross-flow grain dryer with an axial fan, propane burner and cylindrical grain chamber enclosing the air plenum. Grain is loaded into a loading auger at ground level or into the top of the dryer. The grain is fed into the bottom of a vertical auger by the grain regulator and continuously recirculated from the bottom to the top of the dryer. An optional grain cleaner attachment removes fines and small weed seeds as the grain is recirculated. Outside air is forced by the fan past the burner into the air plenum and through the grain chamber, to dry or cool the grain. Dry grain is discharged at the top of the dryer.

Drying air temperature is controlled by a pressure regulator while drying grain temperature is controlled by a modulating valve. Both temperatures are monitored at the control panel. The length of the drying cycle is set on a timer which automatically shuts off the burner to start the cooling cycle.

The test machine was power take-off driven. The control circuit required a 12 V DC supply. An optional three speed electric drive and 110 V AC control circuit were available.

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 exceeds the high limit setting.

Detailed specifications are given in APPENDIX I.

## SCOPE OF TEST

The Moridge 8440 was operated with artificially and naturally wet grain under the conditions shown in TABLE 1 for 133 hours while drying about 12,100 bu (295 t) of grain. It was evaluated[1] for ease of operation and adjustment, rate of work, power requirements, fuel and energy consumption, quality of work, 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 | 3 | 17.0 to 24.5 | 37 | 3300 | (90) |
| Barley | 1 Feed | 1 | 17.0 to 23.6 | 33 | 2850 | (62) |
| Rapeseed | 1CW | 7 | 11.6 to 16.7 | 24 | 2900 | (65) |
| Corn (Hybrid 3996) | 4CW | 2 | 17.7 to 26.6 | 39 | 3050 | (78) |
| | | | TOTAL | 133 | 12100 | (295) |

## RESULTS AND DISCUSSION

### EASE OF OPERATION AND ADJUSTMENT

**Assembly:** The Moridge 8440 required some assembly. The top screen and vertical auger section were installed by three men in about 3-1/2 hours. The grain cleaner attachment was installed by one man in about 1-1/2 hours. Assembly instructions were unclear and made installation difficult.

**Transporting:** The Moridge 8440 was quite stable when hitching, allowing easy one man hookup. No hitch jack was provided and it is recommended that the manufacturer supply one. The hitch clevis was not adjustable to suit varying tow bar heights.

Transport width of the test machine was 9 ft (2.8 m) while transport height was 18.8 ft (5.7 m). Extreme care was needed when transporting on public roads, through gates, over bridges, and beneath power and telephone lines. The transport height could be decreased to 12.6 ft (3.8 m), by removing the top screen section, vertical auger section and grain cleaner attachment.

The Moridge 8440 towed well at normal transport speeds. Care had to be taken to use a towing vehicle with adequate brakes and weight to permit safe stopping in emergency situations, and to reduce front-to-rear rocking while transporting. Caution had to be used when travelling over uneven terrain because of minimal ground clearance (FIGURE 2).

Rear visibility when transporting was good. The rear lights of the towing truck were partially obscurred by the dryer. Adequate signal devices were required for travelling on public roads.

**Setup:** The Moridge 8440 was set up by one man in about 1/2 hour. The base required blocking on uneven surfaces. The dryer was unstable when jacking into transport or field position unless properly anchored.

The power take-off drive was easily attached to the tractor. The propane supply was easily connected to the dryer plumbing. The power supply cord for the control circuit required lengthening to reach the tractor. It is recommended that the manufacturer consider lengthening the power supply cord.

The Moridge 8440 did not require additional grain conveyors to load from or into trucks.

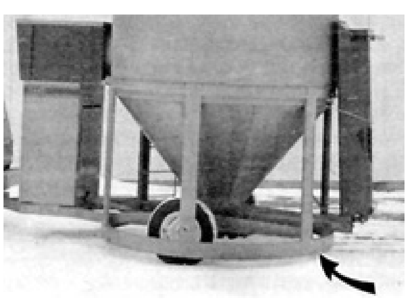


**FIGURE 2.** Minimal Ground Clearance on Uneven Terrain.

*[1]Tests were conducted as outlined in the Machinery Institute Detailed Test Procedures for Grain Dryers.*

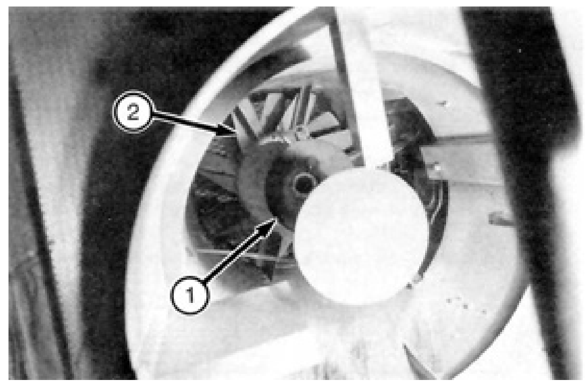


**Fan:** The power take-off driven fan (FIGURE 3) was operated at 2400 rpm for drying and 2850 rpm for cooling. The fan was easily disengaged by a clutch (FIGURE 4). The clutch was very convenient as it allowed quieter and cleaner loading and unloading operations.

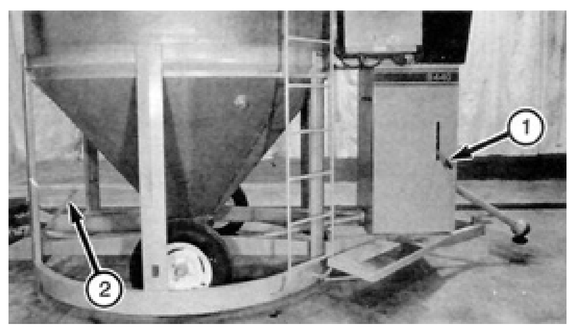
Power take-off speed was increased from 420 rpm when drying to 500 rpm when cooling. A tractor with a 1000 rpm power take-off is recommended to permit operating the tractor at a low engine speed. It is important that the operator does not exceed permissible power take-off speeds.

**Burner:** The spark-ignited burner (FIGURE 3) was started with a switch at the control panel (FIGURE 5). Fuel pressure was monitored on gauges in the control panel. The burner would not ignite, on low flame setting with the burner gauge pressure below 2 psi (14 kPa). However, the burner would operate at lower fuel pressures once the flame was ignited. The burner performed well for all other conditions encountered.

The optional operator's platform was required to obtain easy access to the control panel.




**RGURE 3.** Fan Housing: (1) Bumer, (2) Fan.




**RGURE 4.** Controls: (1) Fan Clutch Lever, (2) Loading Auger Clutch Lever.

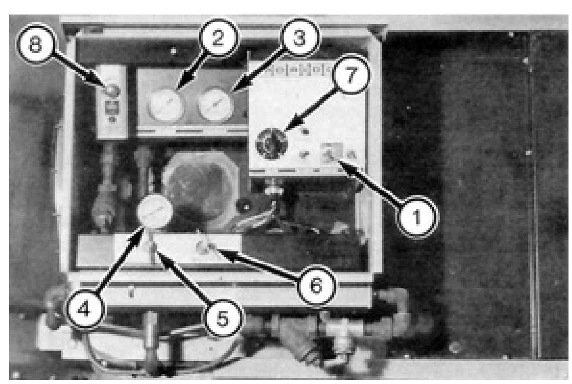



**FIGURE 5.** Controls and Instruments: (1) Power Switch, (2) Drying Air Temperature Gauge, (3) Grain Temperature Gauge, (4) Fuel Pressure Gauge, (5) Pressure Regulator Valve, (6) Modulating Valve, (7) Timer, (8) High Limit Switch.

**Grain Filling:** The Moridge 8440 could be filled using the optional foldaway loading auger (FIGURE 6) or a portable auger with a discharge height of 16 ft (4.9 m). The loading auger was heavy, making it difficult for one man to lower it to the ground. The loading auger extended 7.2 ft (2.2 m) from the dryer providing fairly easy access when filling from a truck. Supervision was required during filling. The loading auger was easily engaged or disengaged.

The holding capacity of the Moridge 8440 was about 392 bu (14.3 $m^3$). Batches smaller than the holding capacity could be dried, but at least 200 bu (7.3 $m^3$) of grain was required.

**Grain Drying:** The drying air temperature was set by adjusting a screw on the pressure regulator. The grain temperature was set by adjusting a screw on the modulating valve. The maximum drying air temperature limit was adjusted on a high limit temperature switch in the control panel. If this setting was exceeded, the fuel to the burner was automatically shut off. The length of the drying cycle was set on a timer in the control panel.

The drying air temperature was controlled by the pressure regulator until the set grain temperature was achieved. The modulating valve then regulated the drying air temperature to maintain the grain temperature. Drying air temperature was monitored at the control panel and was adequate except when drying corn at temperatures below 20°F (-7°C).

The dryer was equipped with a timer that would automatically control the length of the drying cycle. The length of the drying cycle was initially determined by monitoring grain moisture content. Grain samples were obtained from the sampling tube at ground level or from the vertical auger discharge as recommended by the manufacturer. The grain samples from the vertical auger discharge were very representative if the sampling time was more than 15 minutes. Once set, the timer automatically shut off the burner. Drying time had to be adjusted when grain or outside air conditions changed.

The Moridge 8440 required minimal supervision while drying. However, 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.

Grain flow through the dryer was adequate and uniform except when drying high moisture trashy corn. Bridging occurred once over the opening to the bottom of the vertical auger. Uniform grain flow was restored by cooling the grain for a short time.

**Grain Cooling:** Grain cooling occurred after the timer automatically shut off the burner. For faster cooling, the power take-off speed was increased from 420 to 500 rpm. Grain temperature was monitored on a gauge in the control panel.

**Grain Discharge:** Grain was discharged at the top of the dryer. A chute was manually swung around to direct the grain from the vertical auger to a truck on either side of the dryer (FIGURE 7).

On windy days, the chute was occasionally blown from the recirculating position into a partial unloading position, spilling grain onto the ground. It is recommended that the manufacturer consider supplying holding brackets for the chute.

When the unloading chute became wet or when emptying wet grain, the unloading chute plugged, causing grain to spill over the sides. It is recommended that the manufacturer consider modifications to prevent plugging of the unloading chute in wet conditions.

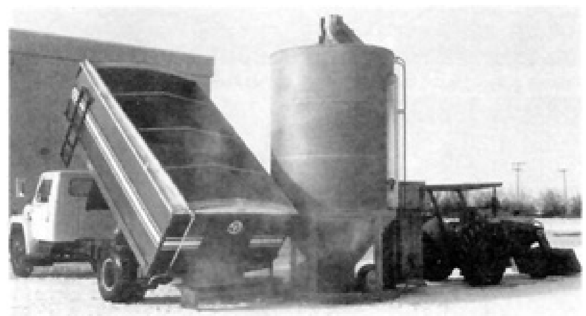
**Grain Cleaner:** The Moridge 8440 was equipped with an optional grain cleaner attachment (FIGURE 8). Fines and small weed seeds were separated and discharged from the dryer as the grain flowed from the vertical auger outlet across two screens. The screens had to be periodically cleaned with a wire brush. One man could clean or change the screens in about 5 minutes. Screens were available for wheat and corn.

The grain cleaner removed about 20 to 40% of the total dockage in wheat and about 60 to 80% in corn. The grain cleaner attachment was useful since it reduced dockage and allowed more efficient grain drying.

**Cleaning:** Ease of cleaning the Moridge 8440 was fair. The screens, especially those in the lower grain chamber, partially plugged during operation. The screens could be adequately cleaned with a high pressure washer.

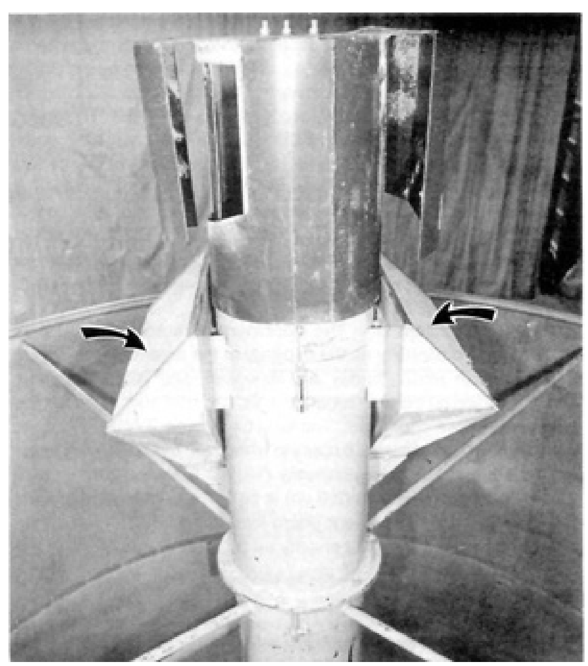
Fines did not collect in the air plenum since the bottom of the plenum had an opening. A small cleanout door (FIGURE 9) was provided for the vertical auger sump. Cleaning the vertical auger sump was difficult. Fines accumulated under the dryer and had to be cleaned up daily to prevent buildup and excessive driveline wear (FIGURE 10).

**Servicing:** The Moridge 8440 had 13 pressure grease fittings. One required greasing every 6 hours, two required greasing every 8 hours and ten required greasing every 40 hours. The oil level in the grain regulator gear box and the auger drive gear box had to be checked every 8 hours. The oil in the auger drive gear box had to be changed each season. Checking and changing the oil was difficult (FIGURE 9).



**RGURE 6.** Grain Filling.

**FIGURE 7.** Grain Discharge.



**RGURE 8.** Grain Cleaner Attachment.

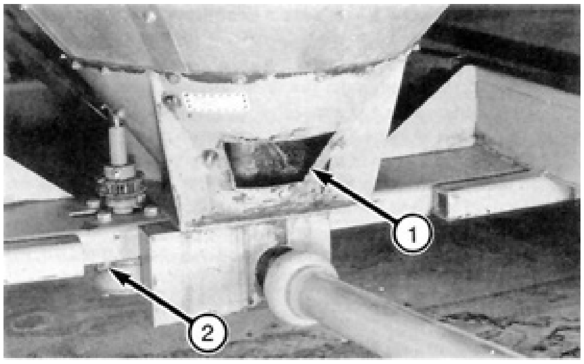



**FIGURE 9.** Servicing: (1) Cleanout Door, (2) Umited Access for Servicing Gear Boxes.

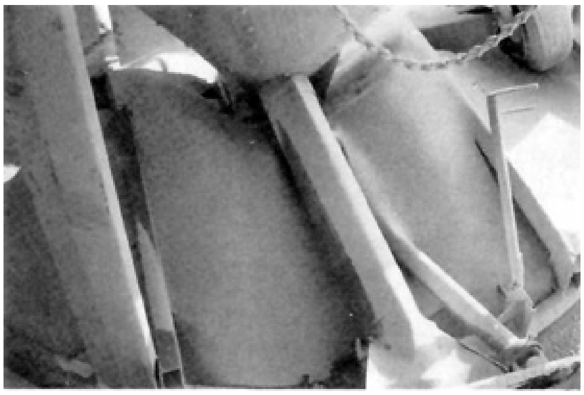


**FIGURE 10.** Fines Accumulated Under the Dryer.

## RATE OF WORK

**Standard Conditions:** To provide a meaningful comparison of grain dryer performance, the 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 11 to 14 present capacity curves for the Moridge 8440 while drying wheat, barley, rapeseed and Hybrid 3996 corn.

Grade loss occurred when drying red spring wheat at the manufacturer's recommended temperatures. The drying capacities shown for wheat would be 30 to 40% less if the dryer was operated at lower temperatures to prevent grade loss.

**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 com. 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 Moridge 8440 varied from 2.6 hours in wheat and barley to 3.4 hours in corn, while the rated drying capacity (TABLE 3) varied from 87 bu/h (2.2 t/h) in corn to 134 bu/h (2.9 t/h) in barley. Operating the dryer at lower temperatures to prevent grade loss in commercial red spring wheat decreased the rated capacity by 30 to 40%.

*[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 grain 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.*

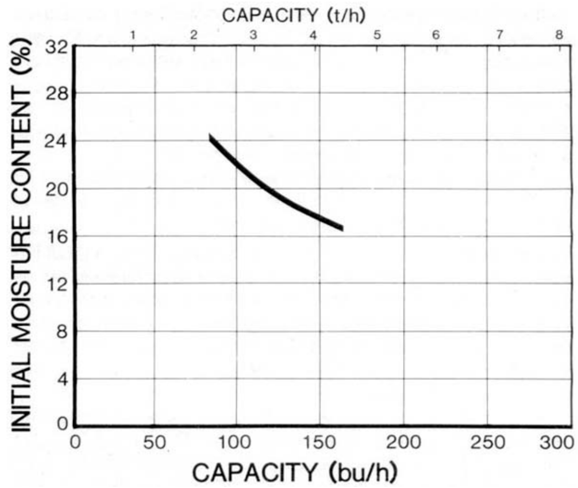



**FIGURE 11.** Drying Capacity in Wheat.

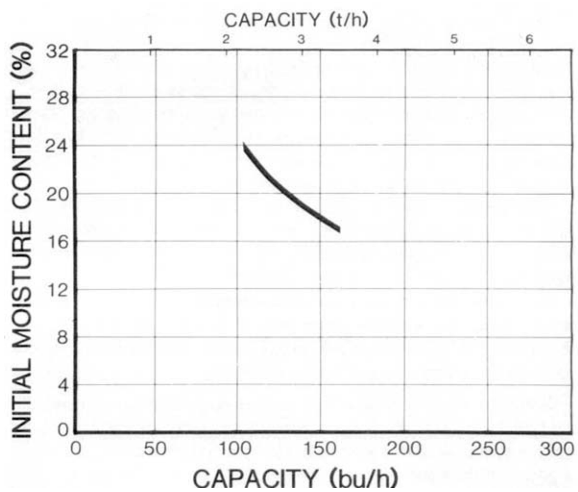



**FIGURE 12.** Drying Capacity in Barley.

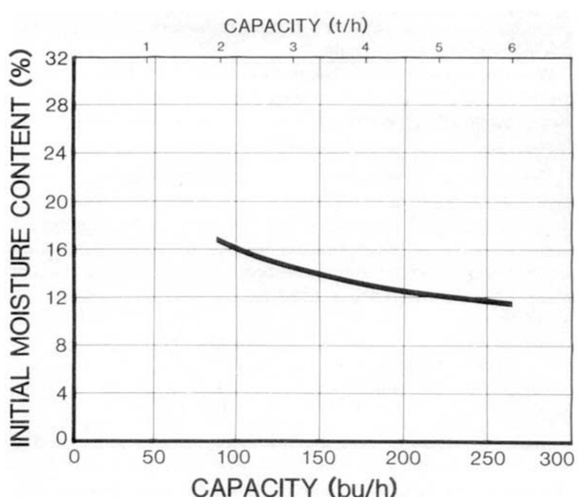



**FIGURE 13.** Drying Capacity in Rapeseed.

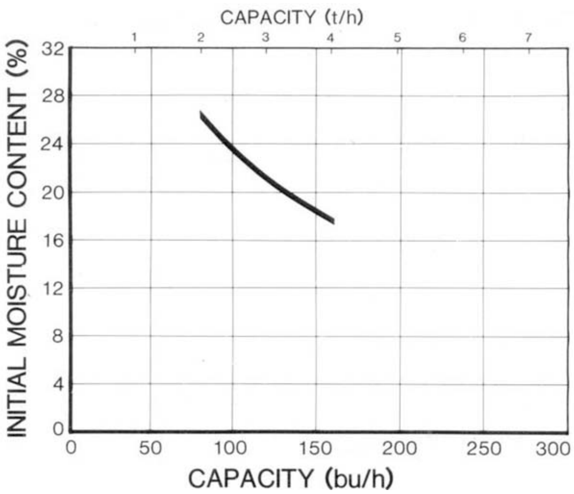



**FIGURE 14.** Drying Capacity in Corn (Hybrid 3996).

**TABLE 2.** Batch Times.

| GRAIN | FILLING (Hours) | DRYING (Hours) | COOLING (Hours) | DISCHARGE (Hours) | TOTAL (Hours) |
|---|---|---|---|---|---|
| Wheat[4] | 0.3 | 1.3 | 0.8 | 0.2 | 2.6 |
| Barley | 0.3 | 1.1 | 1.0 | 0.2 | 2.6 |
| Rapeseed | 0.2 | 2.1 | 0.3 | 0.2 | 2.8 |
| Corn (Hybrid 3996) | 0.3 | 2.1 | 0.8 | 0.2 | 3.4 |

**TABLE 3.** Rated Drying Capacities

| GRAIN | INITIAL MOISTURE CONTENT (%) | MOISTURE REMOVED (%) | DRYING AIR TEMPERATURE SETTING | | DRYING GRAIN TEMPERATURE SETTING | | RATED DRYING CAPACITY | | FIG. NO. |
|---|---|---|---|---|---|---|---|---|---|
| | | | °F | (°C) | °F | (°C) | bu/h | (t/h) | |
| Wheat[4] | 19.5 | 5 | 290 | (143) | 130 | (54) | 127 | (3.5) | 11 |
| Barley | 19.8 | 5 | 290 | (143) | 130 | (54) | 134 | (2.9) | 12 |
| Rapeseed | 15.0 | 5 | 180 | (82) | 110 | (43) | 124 | (2.8) | 13 |
| Corn (Hybrid 3996) | 25.5 | 10 | 300 | (150) | 140 | (60) | 87 | (2.2) | 14 |

## 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, 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[4] occurred when drying commercial rapeseed or feed barley and corn. A grade loss did occur when drying commercial red spring wheat at the recommended drying temperature settings. However, reducing the drying air temperature to 180°F (82°C) and the drying grain temperature to 110°F (43°C) prevented grade loss when drying commercial wheat. It is recommended that the manufacturer consider reducing the recommended temperature settings for drying commercial red spring wheat.

**Drying Air Temperature:** A uniform drying air temperature minimizes grain damage and provides uniform and efficient grain drying. The uniformity of the drying air temperature for the Moridge 8440 was fair. The drying air temperature gauge accurately indicated the average drying air temperature. See APPENDIX IV for further details.

## POWER REQUIREMENTS

A 12 V DC electrical supply was required to operate the control circuit. Power take-off power requirements varied from 13 hp (9.8 kW) in rapeseed to 16 hp (11.9 kW) in wheat. An optional electric drive and a 110 V AC control panel were available. A 20 hp (15 kW) tractor should have sufficient power to operate the Moridge 8440.

[4]*Grade loss occurred when drying commercial red spring wheat at the recommended setting.*

## 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.

The specific fuel consumption for the Moridge 8440 at rated drying capacity (TABLE 4) varied from 4.2 gal/100 bu (8.4 L/t) in rapeseed to 11.4 gal/100 bu (20.4 L/t) in corn. Operating the dryer at lower temperatures to prevent grade loss in commercial red spring wheat, increased specific fuel consumption by 10 to 20%. Fuel consumptions ranged from 5.3 gal/h (24 L/h) in rapeseed to 9.9 gal/h (45 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 the 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 electricial, mechanical and fuel, required to remove a quantity of water. It is expressed in British thermal units (Btu) of energy per pound (Ib) 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 Moridge 8440 (TABLE 4) at rated drying capacity varied from 1500 Btu/lb (3600 kJ/kg) in wheat and rapeseed to 1800 Btu/Ib (4200 kJ/kg) in barley. Operating the dryer at lower temperatures to prevent grade loss in commercial red spring wheat, increased specific energy consumption by 10 to 20%.

**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) |
| Wheat[4] | 5 | 7.0 | (32) | 5.4 | (9.1) | 1500 | (3 600) |
| Barley | 5 | 6.6 | (30) | 5.1 | (10.6) | 1800 | (4 200) |
| Rapeseed | 5 | 5.3 | (24) | 4.2 | (8.4) | 1500 | (3 600) |
| Corn (Hybrid 3996) | 10 | 9.9 | (45) | 11.4 | (20.4) | 1600 | (3 700) |

## OPERATOR SAFETY

The Moridge 8440 operator manual emphasized safety, and warning decals adequately indicated most dangerous areas. Caution was required when using the ladder which became slippery during drying. No warning was provided and it is recommended that a warning be provided. Drives were well shielded and machine adjustments could be safely made.

Extreme care was needed when transporting on public roads, through gates, over bridges, and beneath power and telephone lines. Transport height of the 9 ft (2.8 m) wide test machine was 18.8 ft (5.7 m) when fully assembled which is high enough to contact many prairie power and telephone lines. Operators must contact the authorities when transporting machines that exceed allowable transport widths or heights.

The Moridge 8440 towed well at normal transport speeds. Care had to be taken to use a towing vehicle with adequate brakes and weight to permit safe stopping in emergency situations and to reduce front-to-rear rocking while transporting. A hitch safety chain for transporting was not provided.

Since the rear lights of a towing truck are partially obscured by the dryer, the operator should ensure that adequate signal devices are installed before transporting on public roads. A slow moving vehicle sign was not provided since the tires are rated for normal road speeds.

Sound level at the operator's station was about 102 dBA when the Moridge 8440 was powered with a 60 hp (45 kW) tractor. It is recommended that an operator wear ear protection when working near the Moridge 8440.

[5]*Fuel consumption for batch dryers is the fuel consumed dunng the drying cycle averaged over the total batch time.*

The Moridge 8440 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. While drying corn at temperatures below 5°F (-15°C), the airflow sensor occasionally froze shut during the cooling cycle and had to be defrosted before the burner could be started for the next batch. It is recommended that the manufacturer consider modifications to the airflow sensor for operating under these conditions. There was no warning system to indicate a safety shutdown and it is recommended that the manufacturer consider providing one.

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

### OPERATOR MANUAL

The operator manual was clearly written and well illustrated. It contained useful information on safe operation, adjustments, service and lubrication. However, it did not include complete lubrication and assembly instructions. Also, information on transporting was not included and it is recommended that it be included.

## DURABILITY RESULTS

TABLE 5 outlines the mechanical history of the Moridge 8440 during 133 hours of operation while drying 12,100 bu (295 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

**Screen Buckling:** The bottom of the outside dryer screen buckled slightly in several places. The cause of the buckling was not determined and no problems occurred because of it.

**Shearbolt Failure:** The shearbolt broke when quickly engaging the power take-off with the dryer loaded. The shearbolt was easily replaced.

**TABLE 5.** Mechanical History.

| ITEM | OPERATING HOURS | GRAIN DRIED bu | (t) |
|---|---|---|---|
| - A weld on the lower screen support arm broke and was repaired at | Beginning of test | | |
| - The bottom of the outside screen buckled at | 6 | 700 | (16) |
| - A grain leak, between the grain cleaner discharge pipe and the outer screen, was sealed at | 43 | 3900 | (90) |
| - Rapeseed leaked from the vertical auger sump cleanout door. It was sealed at | 72 | 6200 | (154) |
| - The shearbolt in the auger drive broke and was replaced at | 85, 90 | 8000<br>8700 | (193)<br>(209) |
| - The upper screen support arm pulled through the screen. The screen was repaired at | 94 | 9000 | (217) |
| - The airflow sensor plugged at | 125 | 11700 | (284) |

### APPENDIX I

**SPECIFICATIONS**

| | | |
|---|---|---|
| **MAKE:** | Moridge | |
| **MODEL (1981):** | 8440 | |
| **SERIAL NUMBER:** | 0261 | |
| **MANUFACTURER:** | Moridge Manufacturing Inc.<br>Moundridge, Kansas<br>U.S.A. | |
| **GRAIN FILLING:** | | |
| - position | | ground level loading auger or top loading |
| - height | | |
| - loading auger | | 16 in (410 mm) |
| - top loading | | 15.3 lt (4.7 mm) |
| - loading hopper | | |
| - length | | 6.5 ft (2.0 m) |
| - width | | 22 in (578 mm) |
| - reach from dryer body | | 7.2 ft (2.2 m) |
| - loading auger | | |
| - diameter | | 6 in (150 mm) |
| - speed | | 560 rpm |
| - drive | | chain |
| - control | | spiral jaw clutch |
| **GRAIN CHAMBER:** | | |
| - type | | cylindrical and cone-shaped grain column |
| - diameter | | |
| - outer | | 8 ft (2.4 m) |
| - inner | | 5 ft (1.5 m) |
| - height | | 15.4 lt (4.7 m) |
| - grain column thickness | | 18 in (452 mm) |
| - grain recirculation | | |
| - type | | vertical auger |
| - diameter | | 10 in (254 mm) |
| - length | | 17.8 ft (5.4 m) |
| - speed | | 290 rpm |
| - drive | | gear box |
| - grain regulator | | |
| - type | | one stirring arm with vertical auger feed control |
| - speed | | 1.8 rpm |
| - drive | | chain |
| - grain cleaner attachment | | |
| - separation device | | wheat or corn screens |
| - location | | vertical auger discharge |
| - number of screens | | 2 |
| - screen area | | 116 in² (746 cm²) each |
| **GRAIN DISCHARGE:** | | |
| - type | | inclined chute |
| - height | | 15 ft (4.6 m) |
| - positions | | either side of machine |

**AIR PLENUM:**

| | |
|---|---|
| - shape | cylindrical with cone-shaped bottom |
| - air transfer to grain | screen |
| - screen porosity | |
| - plenum | 48 holes/in² (7.5 holes/cm²) |
| - outer | 148 holes/in² (23 holes/cm²) |
| - screen hole size | |
| - plenum | 0.09 in (2.36 mm) |
| - outer | 0.05 in (1.30 mm) |
| - screen area | |
| - plenum | 100 ft² (9.3 m²) |
| - outer | 322 ft² (29.9 m²) |

**FAN:**

| | |
|---|---|
| - type | dual axial |
| - diameter | 22 in (555 mm) |
| - number of blades | 8 |
| - speed | 2400 to 2850 rpm |
| - drive | belt from pto |
| - control | belt tightener clutch |

**BURNER:**

| | |
|---|---|
| - maximum rating | 2.0 MBtu/h (2.1 GJ/h) |
| - type | gun |
| - fuel | propane |
| - ignition | spark |
| - temperature adjustment | fuel pressure regulator and grain temperature modulating value |

**ELECTRICAL SYSTEM:**

| | |
|---|---|
| - control circuit | 10 amp, 12 V DC |

**NO. OF CHAIN DRIVES:** 3

**NO. OF BELT DRIVES:** 1

**NO. OF PRELUBRICATED BEARINGS:** 9

**LUBRICATION POINTS:**

| | |
|---|---|
| - 6h | 1 |
| - 8h | 4 |
| - 40h | 10 |
| seasonal | 1 |

**TIRES:** 2, 7.75 x 15ST, 4 ply

**OVERALL DIMENSIONS:**

| | FIELD POSITION | | TRANSPORT POSITION |
|---|---|---|---|
| - wheel tread | | | 6.811 (2.1 m) |
| - height | 18.3 ft | (5.6 m) | 18.8 I1 (5.7 m) |
| - length | 19.9 ft | (6.1 m) | 14.1 ft (4.3 m) |
| - width | | | |
| - with grain cleaner) | 10.8 ft | (3.3 m) | 9.1 ft (2.8 m) |
| - (without grain cleaner) | 10.1 ft | (3.1 m) | 8.3 ft (2.5 m) |
| - ground clearance | 0 in | (0 mm) | 5 in (127 mm) |
| - hitch height | | | 15 in (387 mm) |
| - clevis gap | | | 1.9 in (47 mm) |
| - body metal thickness | 19 ga (1.14 mm) | | |

**WEIGHT:** (Dryer Empty)

| | | |
|---|---|---|
| - hitch | 545 lb | (247 kg) |
| - transport wheels | 2730 lb | (1239 kg) |
| TOTAL | 3275 lb | (1486 kg) |

**SOUND LEVEL:** (At Operator's Station) 102 dBA

**HOLDING CAPACITY.** 392 bu (14.3 m³)

**INSTRUMENTS:** fuel pressure gauges, drying air temperature gauge, grain temperature gauge

**OPTIONS:** 12 V DC or 110 V AC control panel kits, electric motor drive

liquid propane or natural gas fuel systems

grain cleaner attachment, 0.05 or 0.09 in (1.30 or 2.36 mm) dryer screens, sunflower kit, toldaway loading auger, three speed auger drive, operator's platform, power takeoff drive, automatic moisture controller

## 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) |
| 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 11 to 14 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 11 to 14 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 | 11 | $\ln B = 10.10 - 1.77 \ln M$<br>$\ln C = 6.50 - 1.77 \ln M$ | .99 | 200[1] | 8 |
| Barley | 12 | $\ln B = 8.80 - 1.3 \ln M$<br>$= 4.97 - 1.3 \ln M$ | .99 | 397[1] | 6 |
| Rapeseed | 13 | $\ln B = 12.29 - 2.76 \ln M$<br>$\ln C = 8.50 - 2.76 \ln M$ | .99 | 211[1] | 8 |
| Corn (Hybrid 3996) | 14 | $\ln B = 6.46 - 0.08M$<br>$\ln C = 2.78 - 0.08M$ | .97 | 88[1] | 8 |

[1] Significant at $P \leq .01$.

## 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 Moridge 8440 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 | 290 | (143) | 284 | (140) | 11 |
| Barley | 290 | (143) | 284 | (140) | 12 |
| Rapeseed | 180 | (82) | 180 | (82) | 13 |
| Corn | 300 | (150) | 288 | (142) | 11 |

*[6]The coefficient of variation is the standard deviahon 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**

| | |
|---|---|
| 1 inch (in) | = 25.4 millimetres (mm) |
| 1 pound (lb) | = 0.45 kilograms (kg) |
| 1 gallon (gal) | = 4.5 litres (L) |
| 100 bushels (bu) | = 3.6 cubic metres (m³) |
| 1 British thermal unit/pound (Btu/lb) | = 2.3 kiloioule kilogram (kJ/kg) |
| 100 bushels (bu) | = 2.7 tonne (t) wheat |
| | = 2.2 tonne (t) barley |
| | = 2.3 tonne (t) rapeseed |
| | = 2.5 tonne (t) corn |

$$\text{dry grain weight (ton)}\ \text{wet grain weight (ton)} \times \frac{(100 - \text{wet moisture content (\%)})}{(100 - \text{dry moisture content (\%)})}$$

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