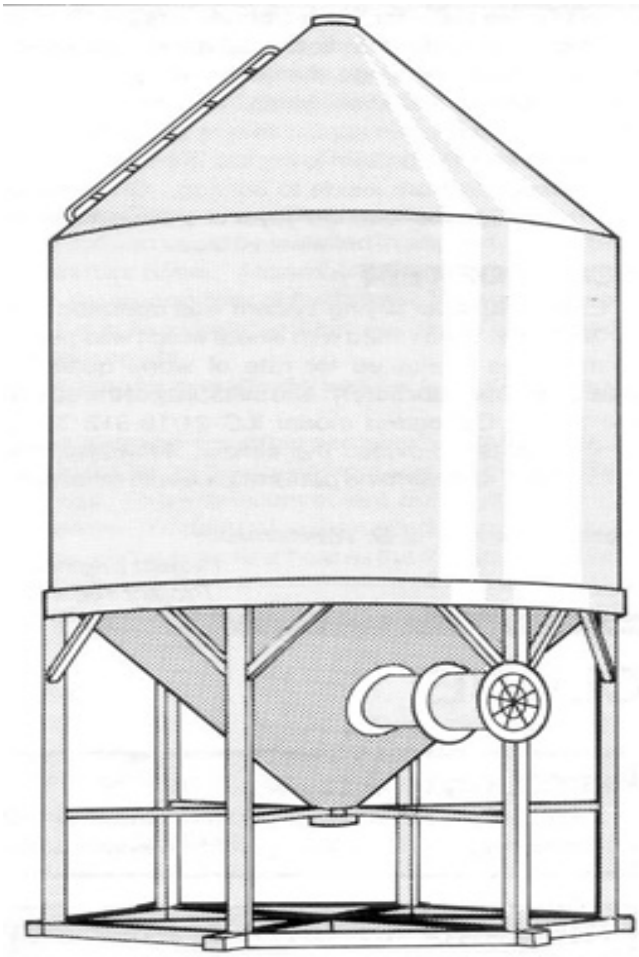
Printed: August, 1989
Tested at: Humboldt
ISSN 0383-3445
Group 1 b

Evaluation Report 578



Keho Cyclone
Grain Guard GG 7000
Naicam
Taylor
Univision Ultra-Dry
Series 2000

Hopper Bin Natural Air Drying Systems

A Co-operative Program Between

ALBERTA FARM MACHINERY RESEARCH CENTRE
PAMI
PRAIRIE AGRICULTURAL MACHINERY INSTITUTE

HOPPER BIN NATURAL AIR DRYING SYSTEMS

TERMINOLOGY

DRYINGTIME

Natural air drying time is dependent on many factors, including grain moisture content, airflow rate, drying uniformity, weather and the air distribution system shape and location. Because so many factors affect the drying time. it is unrealistic to directly compare the actual drying times of different systems tested at different times. For this reason, PAMI uses a reference bin to compare drying trmes. The reference bin is a flat bottom bin with a fully perforated drying floor and holding capacity equivalent to the test bins. The reference bin is operated along with each test bin under the same test conditions. Each test bin drying time can then be directly compared to the reference bm and a relative drying time can be obtained. This relative drying time can be used to compare drying times for different bins tested at different times.

Both average and through-drying times are stated in this report. Average-drying refers to drying until the average of all the grain is dry (14.5% moisture content for wheat). Some grain will still be wet while some will be overdried. However. if all the grain is unloaded and mixed, the overall average moisture content will be dry. Through-drying refers to drying until all of the grain in the bin is dry. Normally. some of the grain is overdried with this practice.

Two main factors of the natural air drying system that contribute to drying time are the airflow rate permitted by the system and the drying uniformity. These are each discussed in the following sections.

AIRFLOW

The airflow rate in a natural air drying system is a measure of how much air is moving through each unit of grain [(cfm/bu (L/s·m^3)]. The airflow rate is dependent on the air distribution system design, the power and efficiency of the fan being used, and other factors. For comparison purposes, the airflow rates in this report are based on "typical" fans, and not the fans used in the tests. The fan data is an average of the performance of all centrifugal and in-line centrifugal fans currently available in the particular power group. Actual system performance may vary. depending on the fan and on the grain being dried in a particular installation.

DRYING UNIFORMITY

Drying uniformity in a natural air drying system depends on the uniformity of the airflow through the bin. Ideally. the natural air drying system should provide uniform airflow through all parts of the bin. If the airflow is uniform throughoutthe bin. the top layer of grain through which the air passes will dry all at the same time. If the airflow is not uniform, parts of this top layer of grain will take longer to dry than other parts. While the last part is being dried, the air passing through already dried parts of the top layer is being wasted.

Drying uniformity, is important when through-drying but less important if the operator is average-drying the grain. When average-drying the grain, if the top layer is mixed before it starts to dry. none of the air passing through the grain is wasted.

PAMI measures the drying uniformity of natural air drying systems by comparing them to an ideal system. The time required for all the top layer of grain to dry for the system is compared to the time required for the top layer to dry if airflow was ideal. The smaller the difference between these two times, the better rating.

The above explanation, which rates the uniformity of airflow through the "top" layer of grain applies to bins in which the primary air direction is vertical from the bottom to the top. Some bins are designed to move air horizontally from reside to outside. On these bins. uniformity of airflow through the "outside" layer of grain is measured.

SCOPE OF TEST

Each natural air drying system was operated in a hopper bin until through-dry. It was filled with wheat which was peaked at the top. The system was evaluated for rate of work. quality of work. ease of operation, operator safety, and suitability of the operator's manual. For the test, a Denouden model ILC 21/18-312 3 hp (2.2 kW) in-line centrifugal fan provided the airflow. However, the report provides information to determine performance with other fans installed.

Senior Engineer: J. D. Wassermann

Project Engineer: D. E. Lischynski

Project Technologist: W. F. Stock

KEHO CYCLONE

MANUFACTURER AND DISTRIBUTOR:

Keho Alta Products Ltd.
P.O. Box 70
Barons. Alberta
T0L 0G0
(403) 757-2444

RETAIL PRICE:

$990.00 (June 1989, f.o.b. Humboldt, Saskatchewan)

SUMMARY AND CONCLUSIONS

Average-drying time was 0.95 times the reference bin. Through-drying time was greater than 1.75 times the reference bin.

Airflow rate was 1.05 cfm/bu (13.7 L/s•m^3) with a typical 3 hp (2.2 kW) fan. Drying uniformity results indicated that parts of the top layer of grain took greater than 35% longer to dry than if airflow uniformity was ideal.

The natural air drying system could be field installed in any bin. Ease of installing the fan was fair. Ease of cleaning was very good.

Installation instructions were provided and no mechanical problems were encountered. The system had to be removed for storing fertilizer.

RECOMMENDATIONS

It is recommended that the manufacturer consider:

1. Providing natural air drying guidelines with each system.

THE MANUFACTURER STATES THAT

With regard to recommendation number:

1. Natural air drying guidelines are available from any Keho dealer.

GENERAL DESCRIPTION

The Keho Cyclone hopper bin natural air drying system consists of eight cylindrical louvred screens arranged in an octagon ring positioned part-way up the hopper of the bin. Air from the fan passes through a rectangular transition in the side of the hopper to the air distribution system. The cylinders are joined by metal elbows and allow air to enter the grain. The configuration is shown in FIGURE 1.

RESULTS AND DISCUSSION

RATE OF WORK

Drying Time: The time for the Keho Cyclone hopper bm natural air drying system to average dry a 14 ft (4.3 m) diameter bin with 1780 bu (64.7 m^3) of wheat was 0.95 times the reference bin. In drying conditions that would take tile reference bin 14 days to reach average-dry, the Keho Cyclone would take 13 days

The time for the Keho Cyclone hopper bin natural air drying system to through-dry a bin of wheat was greater than 1.75 times the reference bin. In drying conditions that would take the reference bin 21 days to reach through-dry, the Keho Cyclone would take more than 37 days.

QUALITY OF WORK

Airflow: Expected airflow rates with three different typical fan sizes are given in TABLE 1. For example, a typical 3 hp (2.2 kW) fan would achieve an airflow rate of 1.05 cfm/bu (13.7 L/s•m^3). Note that these values will vary if the grain has a different airflow resistance.

TABLE 1. Keho Cyclone Airflow Rates in Wheat.

TYPICAL FAN SIZE hp (kW)	1 to 2 (0.75 to 1.5)	3 (2.2)	5 (3.7)
EXPECTED AIRFLOW RATE cfm/bu (L/s·m^3)	0.75 (9.8)	1.05 (13.7)	1.20 (15.6)

Drying Uniformity: Drying uniformity results with the Keho Cyclone hopper bin natural air drying system indicated that airflow was higher at the bin edges than in the center of the bin. This resulted in parts of the top layer taking greater than 35% longer to dry completely than if the airflow uniformity was ideal. The last grain to dry when through-dry was at the top centre of the bin.

EASE OF OPERATION

Installation: The Keho Cyclone was field installed in a Bader Model B1412045E bin. The system could be installed in any bin. Installation took three men about four hours. Assembling the components was easy, but working on the sloped floor of the hopper bin was awkward.

Ease of installing the in-line centrifugal fan was fair. The fan had to be lifted above shoulder height.

Monitoring: Monitoring for average-dry was fair and for the through-dry was good.

To determine when average-dry, grain samples had to be collected from many locations in the bin as the drying front was not level. Instead it was lower in the center. This was inconvenient, but is typical of many natural air drying systems. To determine through-dry, a grain sample could be collected through the grain filler hole as the last grain to dry was at the top centre of the bin

Cleaning: Ease of cleaning was very good. The natural air drying system did not affect bin unloading.

FAN REQUIREMENTS

Fan requirements in wheat for various airflow rates are given in TABLE 2. For example, to obtain an airflow rate of 1 cfm/bu (13 L/s•m^3), the fan must be able to deliver an airflow of 1780 cfm (840 L/s) at a static pressure of 5.3 in•wg (1330 Pa). Note that these values will vary if the grain has a different airflow resistance..

TABLE 2. Keho Cyclone Fan Requirements in Wheat.

DESIRED AIRFLOW RATE cfm/bu (L/s·m^3)		0.5 (6.5)	0.75 (9.8)	1.0 (13)	1.25 (16.3)	1.5 (19.5)
MINIMUM FAN PERFORMANCE	**STATIC PRESSURE** in·wg (Pa)	**1.7** (430)	3.3 (830)	5.3 (1330)	7.7 (1930)	10.4 (2610)
	AIRFLOW cfm (L/s)	890 (420)	1340 (630)	1780 (840)	2230 (1050)	2670 (1260)

OPERATOR SAFETY

No safety hazards were apparent when normal precautions were observed.

OPERATOR'S MANUAL

The operator's manual contained installation instructions. The installation instructions were well written and contained useful illustrations. Some operating tips were also included but more information would have been useful. It is recommended that the manufacturer provide natural air drying guidelines with each system.

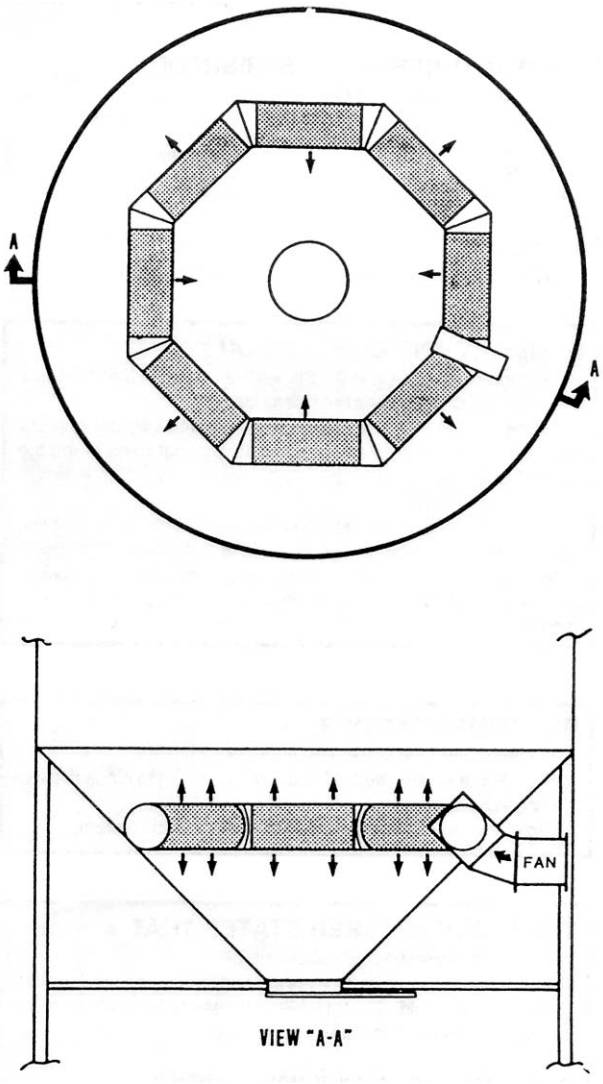


FIGURE 1. Keho Cyclone Natural Air Drying System.

MECHANICAL HISTORY

An extended durability test was not performed. No mechanical problems were encountered during testing. The air distribution system had to be removed for storing fertilizer.

SPECIFICATIONS

Make:	Keho
Model:	Cyclone
Air Distribution System:	
air transfer to grain	louvred screen
porosity	5.5 holes/in^2 (0.85 holes/cm^2)
hole shape	oval
hole size	0.276 x 0.078 in (7 x 2 mm)
surface area	34.6 ft^2 (3.2 m^2)
tube diameter	10.2 in (26 cm)
octagon ring inner diameter	6.5 ft (2.0 m)
Transition:	
- inlet size	13.8 x 8.9 in (35 x 23 cm)
outlet size	14.2 x 9.1 in (36 x 23 cm)
- length	2.6 ft (0.8 m)

GRAIN GUARD GG 7000

MANUFACTURER AND DISTRIBUTOR:

Grain Guard Mfg. & Sales Ltd.
9705 - 56th Avenue
Edmonton, Alberta
T6E 0B4
(403) 434-7111

RETAIL PRICE:

$795.00 (June 1989, f.o.b. Humboldt, *Saskatchewan)*

SUMMARY AND CONCLUSIONS

Average-drying time was 0.75 times the reference bin. Through-drying time was 1.05 times the reference bin.

Airflow rate was 1.20 cfm/bu (15.6 L/s•m^3) with a typical 3 hp (2.2 kW) fan. Drying uniformity results indicated that parts of the top layer of grain took greater than 35% longer to dry than if airflow uniformity was ideal.

The natural air drying system could be field installed in some bins. Ease of installing the fan was good. Ease of cleaning was very good.

No operator's manual was provided and no mechanical problems were encountered. The system could be epoxy coated for storing fertilizer.

RECOMMENDATIONS

It is recommended that the manufacturer consider:

1. Providing a simple method to determine when to close the wall wing exhaust ports.
2. Providing natural air drying guidelines with each system.

THE MANUFACTURER STATES THAT

With regard to recommendation number:

1&2. Natural air drying guidelines are available upon request, and with each fan sold. Drying tables are readily available from the Departments of Agriculture.

MANUFACTURER'S ADDITIONAL COMMENTS

1. Grain Guard recommends against the practice of overdrying as a result of through-drying because of the economic disadvantages:
   -higher power costs due to long-term fan operation
   -lower cash values for crops due to reduced weight from overdrying [for example, a 5000 bu (136 t) bin of wheat at $5.00/bu ($184/t) overdried to 11% represents a $975.00 loss].
2. The GG 7000-4 ft (1.2 m) Rocket Duct System utilized in this test is the smallest system of this type offered by the manufacturer. Five larger sizes are available. Drying rates can be greatly increased by use of these larger capacity systems.
3. When comparing drying rates, readers should note that drying will be faster in a 16 ft (4.9 m) diameter bin than in a 14 ft (4.3 m) bin with the same number of bushels, because of relative grain depth.

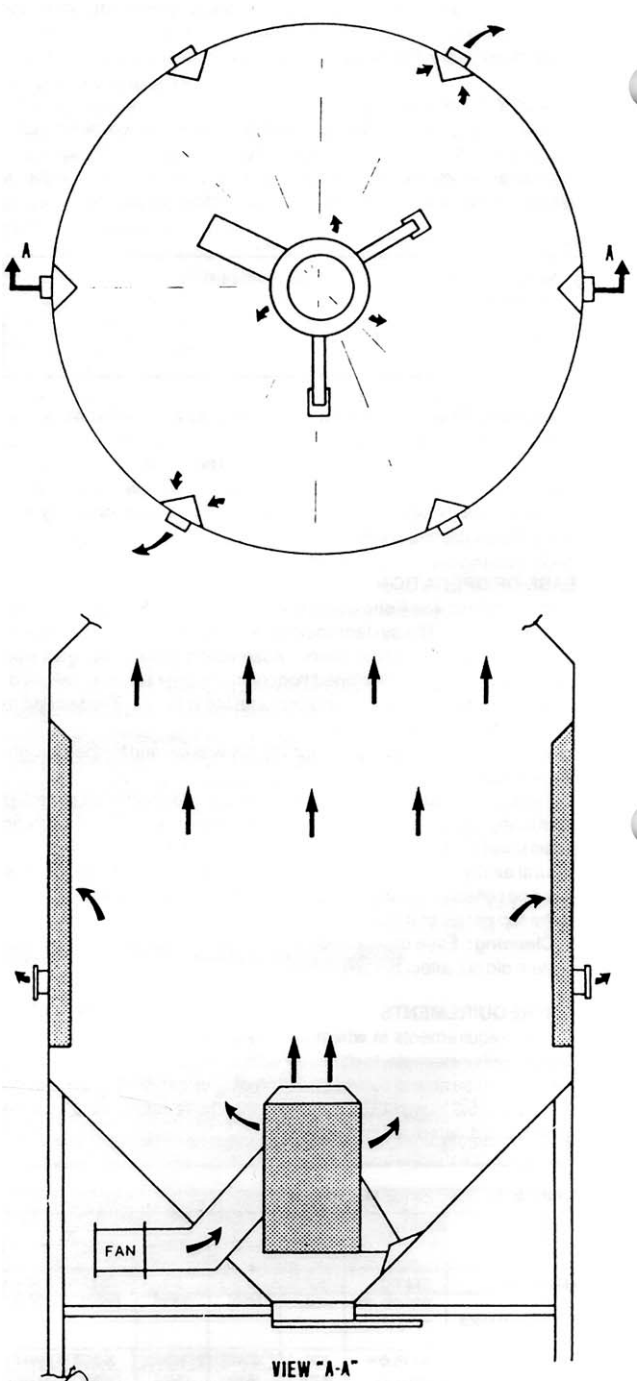


FIGURE 2. Gram Guard GG 7000 Natural Air Drying System.

GENERAL DESCRIPTION

The Grain GuardGG 7000 [4 ft (1.2 m) size] hopper bin natural air drying system consists of two concentric cylinders positioned vertically at the bottom centre of the bin. The cylinders are joined at the top and made of louvered screens, which allow air to enter the grain. Air from the fan passes through a rectangular transition in the side of the hopper to the air distribution system. Six triangular screens ("wall wings") are positioned vertically on the bin wall to allow some air to exhaust to the outside through ports in the side wall of the bin.

Air also passes out the top layer of grain. The configuration is shown in FIGURE 2.

RESULTS AND DISCUSSION

RATE OF WORK

Drying Time: The time for the Grain Guard GG 7000 hopper bin natural air drying system to average-dry a 14.5 ft (4.4 m) diameter bin with 1730 bu (62•9 m^3) of wheat was 0.75 times the reference bin. In drying conditions that would take the reference bin 14 days to reach average-dry, the Grain Guard GG 7000 would take 11 days.

The time for the Grain Guard GG 7000 hopper bin natural air drying system to throughdry a bin of wheat was 1.05 times the reference bin. In drying conditions that would take the reference bin 21 days to reach through-dry, the Grain Guard GG 7000 would take 22 days.

QUALITY OF WORK

Airflow: Expected airflow rates with three different typical fan sizes are given in TABLE 3. For example, a typical 3 hp (2.2 kW) fan would achieve an airflow rate of 1.20 cfm/bu (15.6 L/s•m^3). Note that these values will vary if the grain has a different airflow resistance.

TABLE 3. Grain Guard GG 7000 Airflow Rates in Wheat.

TYPICAL FAN SIZE hp (kW)	1 to 2 (0.75 to 1.5)	3 (2.2)	5 (3.7)
EXPECTED AIRFLOW RATE cfm/bu (L/s•m^3)	0.80 (10.4)	1.20 (15.6)	1.45 (18.8)

Drying Uniformity: Drying uniformity results with the Grain Guard GG 7000 hopper bin natural air drying system indicated that airflow was higher in the centre of the bin than at the bin edges. This resulted in parts of the top layer taking greater than 35% longer to dry completely than if the airflow uniformity was ideal. The last grain to dry when through-dry was at the top centre of the bin.

EASE OF OPERATION

Installation: The Grain Guard GG 7000 was factory installed in a Wheatland Model 1510 bin. The system could not be disassembled, but could be installed in any bin with an opening of 30 in (760 mm) or more. Alternatively, it could be installed during bin fabrication.

Ease of installing the in-line centrifugal fan was good. The fan had to be lifted to chest height.

Monitoring: Monitoring for average-dry was fair and for the through-dry was good.

To determine when average-dry, grain samples had to be collected from many locations in the bin as the drying front was not level. Instead it formed a hump above the screen. This was inconvenient, but is typical of many natural air drying systems. To determine through-dry, a grain sample could be collected through the grain filler hole as the last grain to dry was at the top centre of the bin.

The manufacturer suggests closing the wall wing exhaust ports when the grain near the bottom part of the bin wall is dry. This is difficult to determine, and the time will vary with weather, fan size and grain moisture content. It is recommended that the manufacturer consider providing a simpler method to determine operating procedures for the wall wing exhaust ports.

Cleaning: Ease of cleaning was very good. The natural air drying system did not affect bin unloading.

FAN REQUIREMENTS

Fan requirements in wheat for various airflow rates are given in TABLE 4. For example, to obtain an airflow rate of 1 cfm/bu (13 L/s•m^3), the fan must be able to deliver an airflow of 1730 cfm (810 L/s) at a static pressure of 4.1 in•wg (1030 Pa). Note that these values will vary if the grain has a different airflow resistance.

TABLE 4. Grain Guard GG 7000 Fan Requirements in Wheat.

DESIRED AIRFLOW RATE cfm/bu (L/s•m^3)		0.5 (6.5)	0.75 (9.8)	1.0 (13)	1.25 (16.3)	1.5 (19.5)
MINIMUM FAN PERFORMANCE	**STATIC PRESSURE** in•wg (Pa)	1.6 (400)	2.8 (690)	4.1 (1030)	5.6 (1400)	7.2 (1780)
	AIRFLOW cfm (L/s)	870 (410)	1300 (610)	1730 (810)	2160 (1020)	2600 (1220)

OPERATOR SAFETY

No safety hazards were apparent when normal precautions were observed.

OPERATOR'S MANUAL

No operator's manual was provided. It is recommended that the manufacturer consider providing natural air drying guidelines with each system.

MECHANICAL HISTORY

An extended durability test was not performed. No mechanical problems were encountered during testing. The bin and air distribution system could be epoxy coated for storing fertilizer.

SPECIFICATIONS

Make:	Grain Guard
Model:	GG 7000
Air Distribution System:	
- air transfer to grain	louvred screen
- porosity	5.7 holes/in^2 (0.88 holes/cm^2)
- hole shape	oval
- hole size	0.315 x 0.078 in (8 x 2 mm)
- surface area	45.8 ft^3 (4.3 m^3)
Transition:	
- inlet diameter	17.8 in (450 mm)
- outlet size	20.0 x 12.4 in (51 x 32 cm)
-length	4.4 ft (1.4 m)
Wall Wings:	
- number	6
- air transfer from grain	louvred screen
- porosity	5.7 holes/in^2 (0.88 holes/cm^2)
- hole shape	oval
- hole size	0.315 x 0.078 in (8 x 2 mm)
- total sudace area	60.5 ft^2 (5.6 m^2)

NAICAM

MANUFACTURER AND DISTRIBUTOR:

Naicam Industries Ltd.
P.O. Box 637
Naicam. Saskatchewan
S0K 2Z0
(306) 874-2262

RETAIL PRICE:

$570.00 (June 1989. f.o.b. Humboldt. Saskatchewan)

SUMMARY AND CONCLUSIONS

Average-drying time was 0.95 times the reference bin. Through-drying time was 1.10 times the reference bin.

Airflow rate was 1.05 cfm/bu (13.7 L/s•m^3) with a typical 3 hp (2.2 kW) fan. Drying uniformity results indicated that parts of the top layer of grain took greater than 35% longer to dry than if airflow uniformity was ideal.

The natural air drying system could be field installed in some bins. Ease of installing the fan was fair. Ease of cleaning was very good.

No operator's manual was provided and no mechanical problems were encountered. The system had to be removed for storing fertilizer.

RECOMMENDATIONS

It is recommended that the manufacturer consider:

1. Providing natural air drying guidelines with each system.

THE MANUFACTURER STATES THAT

With regard to recommendation number:

1. An installation manual is provided with field installed units. Also, operating procedures on natural air drying can be determined from pamphlets available from the Dept. of Agriculture in all three prairie provinces.

GENERAL DESCRIPTION

The Naicam hopper bin natural air drying system consists of a rectangular louvred screen mounted horizontally near the top of the hopper of the bin. A rectangular transition enters the side of the hopper to direct air from the fan to the air distribution system (FIGURE 3).

RESULTS AND DISCUSSION

RATE OF WORK

Drying Time: The time for the Naicam hopper bin natural air drying system to average-dry a 13.8 ft (4.2 m) diameter bin with 1870 bu (68.0 m^3) of wheat was 0.95 times the reference bin. In drying conditions that would take the reference bin 14 days to reach average-dry, the Naicam would take 13 days.

The time for the Naicam hopper bin natural air drying system to through-dry a bin of wheat was 1.10 times the reference bin. In drying conditions that would take the reference bin 21 days to reach through-dry, the Naicam would take 23 days.

QUALITY OF WORK

Airflow: Expected airflow rates with three different typical fan sizes are given in TABLE 5. For example, a typical 3 hp (2.2 kW) fan would achieve an airflow rate of 1.05 cfm/bu (13.7 L/s•m^3). Note that these values will vary if the grain has a different airflow resistance.

TABLE 5. Naicam Airflow Rates in Wheat.

TYPICAL FAN SIZE hp (kW)	1 to 2 (0.75 to 1.5)	3 (2.2)	5 (3.7)
EXPECTED AIRFLOW RATE cfm/bu (L/s.m3)	0.75 (9 8)	1.05 (13.7)	1.30 (16.9)

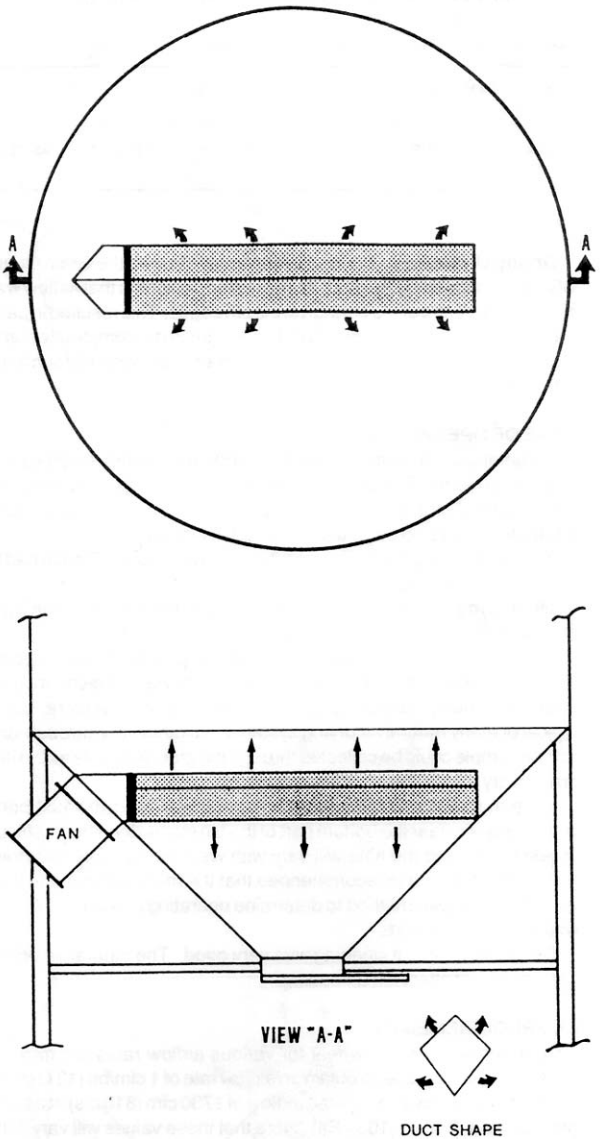


FIGURE 3. Naicam Natural Air Drying System.

Drying Uniformity: Drying uniformity results with the Naicam hopper bin natural air drying system indicated that airflow was higher above the duct than near the bin edges at a right angle to the duct. This resulted in parts of the top layer taking greater than 35% longer to dry completely than if the airflow uniformity was ideal. The last grain to dry when through-dry was at the top centre of the bin.

EASE OF OPERATION

Installation: The Naicam was factory installed in a Naicam Model 72T bin. The system could be field installed in Naicam bins.

Ease of installing the in-line centrifugal fan was fair. The fan's angled mounting position made installation awkward.

Monitoring: Monitoring for average-dry was fair and for the through-dry was good.

To determine when average-dry, grain samples had to be collected from many locations in the bin as the drying front was not level. Instead it formed a hump above the duct. This was inconvenient. but is typical of many natural air drying systems. To determine through-dry, a grain sample could be collected through the grain filler hole as the last grain to dry was at the top centre of the bin

Cleaning: Ease of cleaning was very good. The natural air drying system did not affect bin unloading.

FAN REQUIREMENTS

Fan requirements in wheat for various airflow rates are given in TABLE 6. For example, to obtain an airflow rate of 1 cfm/bu (13 L/s·m^3), the fan must be able to deliver an airflow of 1870 cfm (880 L/s) at a static pressure of 4.7 in.wg (1180 Pa). Note that these values will vary if the grain has a different airflow resistance.

TABLE 6. Naicam Fan Requirements in Wheat.

DESIRED AIRFLOW RATE cfm/bu (L/s•m^3)		0.5 (6.5)	0.75 (9.8)	1.0 (13)	1.25 (16.3)	1.5 (19.5)
MINIMUM FAN PERFORMANCE	**STATIC PRESSURE** in•wg (Pa)	1.9 (460)	3.2 (800)	4.7 (1180)	6.4 (1590)	8.1 (2040)
	AIRFLOW cfm (L/s)	940 (440)	1400 (660)	1870 (880)	2340 (1100)	2810 (1320)

OPERATOR SAFETY

No safety hazards were apparent when normal precautions were observed.

OPERATOR'S MANUAL

No operator's manual was provided. It is recommended that the manufacturer consider providing natural air drying guidelines with each system.

MECHANICAL HISTORY

An extended durability test was not performed. No mechanical problems were encountered during testing. The air distribution system had to be removed for storing fertilizer.

SPECIFICATIONS

Make:	**Naicam**
Air Distribution System:	
air transfer to grain	louvred screen
porosity	4.9 holes/in^2 (0.76 holes/cm^2)
hole shape	oval
hole size	0.472 x 0.059 in (12 x 1.5 mm)
surface area	50.6 ft^2 (4.7 m^2)
screen length	8.6 ft (2.6 m)
Transition:	
- inlet size	19.6 x 19.6 in (500 x 500 mm)

TAYLOR

MANUFACTURER AND DISTRIBUTOR:

Taylor Industries
P.O. Box 340
Melfort. Saskatchewan
S0E 1A0
(306)752-9212

RETAIL PRICE:

$470.00 (June 1989, f.o.b. Humboldt, Saskatchewan)

SUMMARY AND CONCLUSIONS

Average-drying time was 0.90 times the reference bin. Through-drying time was 0.80 times the reference bin.

Airflow rate was 1.15 cfm/bu (15.0 L/s•m^3) with a typical 3 hp (2.2 kW) fan. Drying uniformity results indicated that parts of the top layer of grain took 14% longer to dry than if airflow uniformity was ideal.

The natural air drying system could be field installed in any bin. Ease of installing the fan was poor. Ease of cleaning was very good.

No operator's manual was provided and no mechanical problems were encountered. The system could be epoxy coated for storing fertilizer.

RECOMMENDATIONS

It is recommended that the manufacturer consider:

1. Providing natural air drying guidelines with each system.

THE MANUFACTURER STATES THAT

With regard to recommendation number:

1. Operating procedures on natural air drying can be determined from pamphlets available from the Departments of Agriculture in both Saskatchewan and Manitoba.

MANUFACTURER'S ADDITIONAL COMMENTS

We are considering providing a probe port or inspection hole in future bins to improve ease of through-dry sampling.

GENERAL DESCRIPTION

The Taylor hopper bin natural air drying system consists of an inverted "V" duct positioned horizontally at the bottom of the bin side wall. A round transition enters the side wall to direct air from the fan to the air distribution system (FIGURE 4).

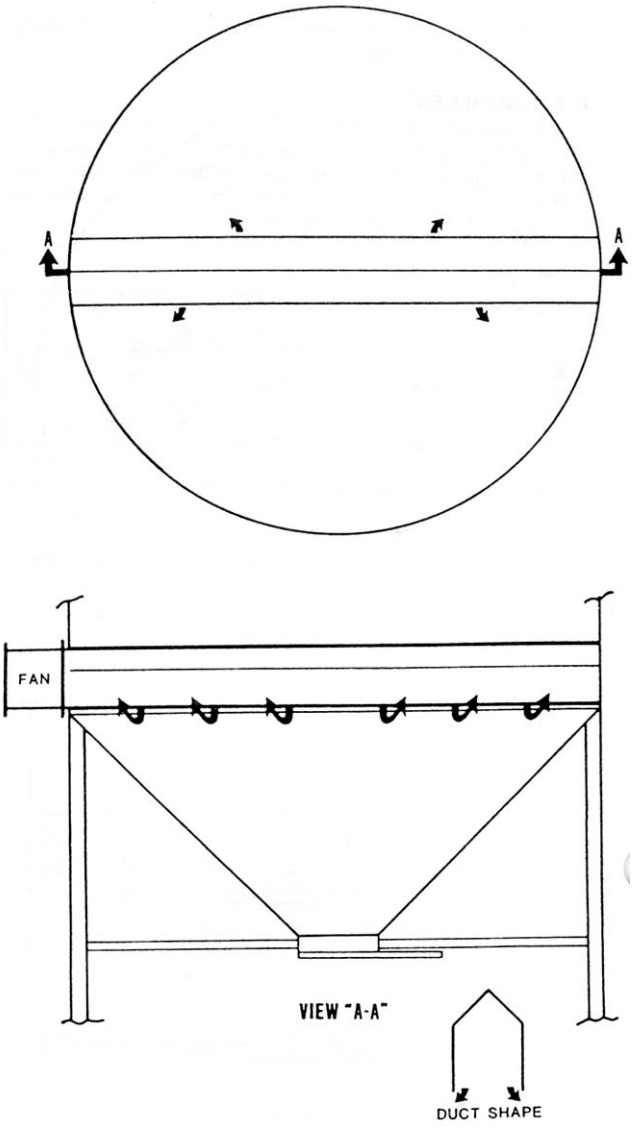


FIGURE 4. Taylor Natural Air Drying System.

RESULTS AND DISCUSSION

RATE OF WORK

Drying Time: The time for the Taylor hopper bin natural air drying system to average-dry a 13.6 ft (4.2 m) diameter bin with 1710 bu (62.2 m^3) of wheat was 0.90 times the reference bin. In drying conditions that would take the reference bin 14 days to reach average-dry, the Taylor would take 13 days.

The time for the Taylor hopper bin natural air drying system to through-dry a bin of wheat was 0.80 times the reference bin. In drying conditions that would take the reference bin 21 days to reach through-dry, the Taylor would take 17 days.

QUALITY OF WORK

Airflow: Expected airflow rates with three different typical fan sizes are given in TABLE 7. For example, a typical 3 hp (2.2 kW) fan would achieve an airflow rate of 1.15 cfm/bu (15.0 L/s•m^3). Note that these values will vary if the grain has a different airflow resistance.

Drying Uniformity: Drying uniformity results with the Taylor hopper bJn natural air dryJng system indicated that airflow was higher above the duct than near the bin edge at a right angle to the duct. This resulted in parts of the top layer taking 14% longer to dry completely than if the airflow uniformity was ideal. The last grain to dry when through-dry was at the bin eave, at a right angle to the duct.

EASE OF OPERATION

Installation: The Taylor natural air drying system was factory installed in a Taylor Model TI75-14FC bin. The system could be field installed in any bin.

Ease of installing the in-line centrifugal fan was poor. A mechanical lifting device, such as a front-end loader, was required to lift the fan as the fan mount was 8.0 ft (2.5 m) above ground level.

Monitoring: Monitoring for average-dry was fair and for the through-dry was fair.

TABLE 7. Taylor Airflow Rates in Wheat.

TYPICAL FAN SIZE hp (kW)	1 to 2 (0.75 to 1.5)	3 (2.2)	5 (3.7)
EXPECTED AIRFLOW RATE cfm/bu (L/s•m^3)	0.80 (10.4)	1.15 (15.0)	1.40 (18.2)

To determine when average-dry, grain samples had to be collected from many locations in the bin as the drying front was not level. Instead it formed a hump above the duct. This was inconvenient, but is typical of many natural air drying systems. To determine when through-dry, a grain sample had to be collected from the bin eave, at a right angle to the duct. This was inconvenient to do through the grain filler hole in the center of the bin.

Cleaning: Ease of cleaning was very good. The natural air drying system did not affect bin unloading.

FAN REQUIREMENTS

Fan requirements in wheat for various airflow rates are given in TABLE 8. For example, to obtain an airflow rate of 1 cfm/bu (13 L/s•m^3), the fan must be ableto deliver an airflow of 1710 cfm (810 L/s) at a static pressure of 4.2 in•wg (1060 Pa). Note that these values will vary if the grain has a different airflow resistance.

TABLE 8. Taylor Fan Requirements in Wheat.

DESIRED AIRFLOW RATE cfm/bu (L/s•m^3)		0.5 (6.5)	0.75 (9.8)	1.0 (13)	1.25 (16.3)	1.5 (19.5)
MINIMUM FAN PERFORMANCE	**STATIC PRESSURE** in•wg (Pa)	1.6 (410)	2.8 (710)	4.2 (1060)	5.7 (1430)	7.4 (1840)
	AIRFLOW cfm (L/s)	860 (400)	1290 (600)	1710 (810)	2140 (1010)	2570 (1210)

OPERATOR SAFETY

No safety hazards were apparent when normal precautions were observed.

OPERATOR'S MANUAL

No operator's manual was provided. It is recommended that the manufacturer consider providing natural air drying guidelines with each system.

MECHANICAL HISTORY

An extended durability test was not performed. No mechanical problems were encountered during testing. The bin and air distribution system could be epoxy coated for storing fertilizer.

SPECIFICATIONS

Make:	Taylor
Air Distribution System:	
- duct length	13.2 ft (4.0 m)
- air/grain interface area	21.2 ft^2 (1.97 m^2)
Transition:	
- inlet diameter	17.7 in (450 mm)
- length	3.9 in (100 mm)

UNIVISION ULTRA-DRY
(SERIES 2000)

MANUFACTURER AND DISTRIBUTOR:

Univision industries
P.O. Box 2139
Humboldt. Saskatchewan
S0K 2A0
(306) 682-3372

RETAIL PRICE:

$1250.00 (June 1989. f.o.b. Humboldt, Saskatchewan)

SUMMARY AND CONCLUSIONS

Average-drying time was 0.70 times the reference bin. Through-drying time was 0.75 times the reference bin.

Airflow rate was 1.40 cfm/bu (18.2 L/s•m^3) with a typical 3 hp (2.2 kW) fan. Drying uniformity results indicated that parts of the outside layer of grain took greater than 35% longer to dry than if airflow uniformity was ideal.

The natural air drying system could be factory installed in Univision bins, but could not be field installed. Ease of installing the fan was good. Ease of cleaning was very good.

No operator's manual was provided and no mechanical problems were encountered. The system could be epoxy coated for storing fertilizer.

RECOMMENDATIONS

It is recommended that the manufacturer consider:

1. Providing natural air drying guidelines with each system.

THE MANUFACTURER STATES THAT

With regard to recommendation number:

1. Manuals will be provided now that final testing is complete and will include guidelines for natural air drying and recommended probe locations for through-dry testing.

MANUFACTURER'S ADDITIONAL COMMENTS

The bin used for these tests was not equipped with any probe ports as it was understood that PAMI would be installing their own sampling equipment. Univision has probe ports and inspection hatches available to permit easy grain sampling du ring drying. This would improve ease of monitoring and may improve the ratings given in this report.

The Univision Ultra-Dry (Series 2000) is an updated version of the Ultra-Dry tested for PAMI report 588, and therefore this report should be used for all future reference. The Ultra-Dry (series 2000) includes refinements to both centre duct and eave ring designs.

GENERAL DESCRIPTION

The Univision Ultra-Dry hopper bin natural air drying system consists of a cylindrical louvered screen positioned vertically at the bottom centre of me bin. Afr from the fan passes through a rectangular transition in the side of the hopper and into the air distribution system. Five welded eave rings made of louvred screen, on the intenor of the bin wall allow air to move from the grain to vertical ducts which exhaust to the outsside above each bin leg. A small amount of air is exhausted through the bin lid vent,as the lid is closed durlng operation. The configuration is shown in FIGURE 5

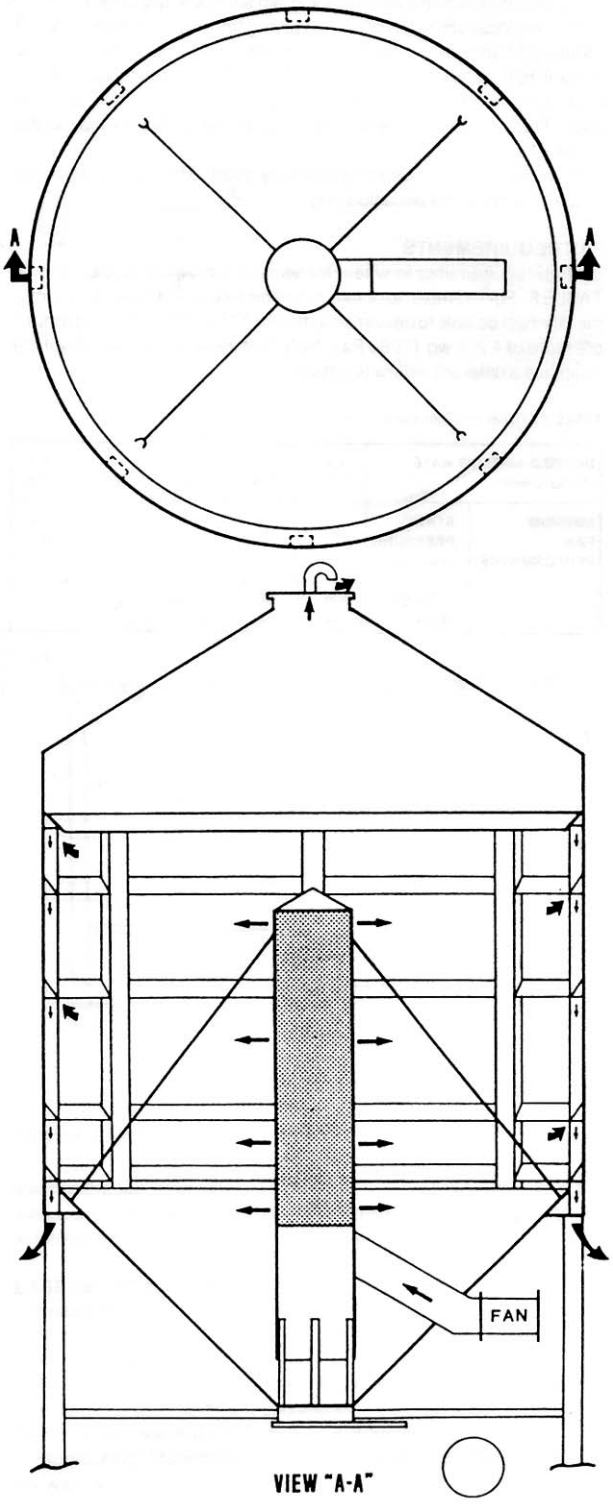


FIGURE 5. Univision Ultra-Dry Natural Air Drying System.

RESULTS AND DISCUSSION

RATE OF WORK

Drying Time: The time for the Univision Ultra-Dry hopper bin natural air drying system to average dry a 16 ft (4.4 m) diameter bin with 1780 bu (647 m) of wheat was 0.70 tines the reference bin. In drying conditions that would take the reference bin 14 days to reach average-dry, the Univision Ultra-Dry would take 10 day.

The time for the Univision Ultra-Dry hopper bin natural air drying system to through-dry a bin of wheat was 0.75 times the reference bin. In drying conditions that would take the reference bin 21 days to reach through-dry, the Univision Ultra-Dry would take 16 days.

QUALITY OF WORK

Airflow: Expected airflow rates with three different typical fan sizes are given in TABLE 9. For example, a typical 3 hp (2.2 kW) fan would achieve an airflow rate of 1.40 cfm/bu (18.2 L/s•m^3). Note that these values will vary if the grain has a different airflow resistance.

TABLE 9. Univision Ultra-Dry Airlow Rates in Wheat.

TYPICAL FAN SIZE hp (kW)	1 to 2 (0.75 to 15)	3 (2.2)	5 (3.7)
EXPECTED AIRFLOW RATE cfm/bu (L/s•m^3)	0.95 (12.4)	1.40 (18.2)	1.70 (22.1)

Drying Uniformity: Drying uniformity results with the Univision Ultra-Dry hopper bin natural air drying system indicated that airflow was higher at the bottom of the bin walls and the top centre of the bin than at the top of the bin near the eave. This resulted in parts of the outside layer taking greater than 35% longer to dry completely than if the airflow uniformity was ideal. The last grain to dry when through-dry was at the top edge of the bin near the eave.

EASE OF OPERATION

Installation: The Univision Ultra-Dry was factory installed in a Univision Model UB1608 bin. The system could not be field installed in other bins. Ease of installing the in-line centrifugal fan was good. The fan had to be lifted about 4 ft (1.2 m) above ground level.

Monitoring: Monitoring for average-dry was fair and for the through-dry was good.

To determine when average-dry, grain samples had to be collected from many locations in the bin as the drying front was not level. Instead it formed a hump above the duct. This was inconvenient, but is typical of many natural air drying systems. To determine through-dry, a grain sample could be collected through the inspection hole near the roof ladder as the last grain to dry was near the eave of the bin. Optional probe ports were not tested but will improve ease of monitoring.

The Univision Ultra-Dry operated with the bin lid closed which could be an advantage if rain occurs during drying.

Cleaning: Ease of cleaning was very good. The natural air drying system did not affect bin unloading.

FAN REQUIREMENTS

Fan requirements in wheat for various airflow rates are given in TABLE 10. For example, to obtain an airflow rate of 1 cfm/bu (13 L/s•m^3), the fan must be able to deliver an airflow of 1780 cfm (840 L/s) at a static pressure of 2.5 in.wg (620 Pa). Note that these values will vary if the grain has a different airflow resistance.

TABLE 10. Univision Ultra-Dry Fan Requirements in Wheat.

DESIRED AIRFLOW RATE cfm/bu (L/s•m^3)		0.5 (6.5)	0.75 (9.8)	1.0 (13)	1.25 (16.3)	1.5 (19.5)
MINIMUM FAN PERFORMANCE	**STATIC PRESSURE** in•wg (Pa)	0.8 (210)	1.6 (390)	2.5 (620)	3.6 (890)	4.8 (1190)
	AIRFLOW cfm (L/s)	890 (420)	1340 (630)	1780 (840)	2230 (1050)	2670 (1260)

OPERATOR SAFETY

No safety hazards were apparent when normal precautions were observed.

OPERATOR'S MANUAL

No operator's manual was provided. It is recommended that the manufacturer consider providing natural air drying guidelines with each system.

MECHANICAL HISTORY

An extended durability test was not performed. No mechanical problems were encountered during testing. The bin and air distribution system could be epoxy coated for storing fertilizer.

SPECIFICATIONS

Make:	Univision
Model	Ultra-Dry (Series 2000)
Air Distribution System:	
air transfer to grain	louvred screen
height	11.2 ft (3.42 m)
diameter	20.3 in (516 mm)
porosity	5.5 holes/in^2 (0.85 holes/cm^2)
hole size	0.039 x 0.27 in (1 x 7 mm)
hole shape	oval
air/grain interface area	40.3 ft^2 (3.74 m^2)
Air Exhaust System:	
- number of rings	5
- ring bottom open width	3 in (76 mm)
- air/grain interface area	139 ft^2 (12.9 m^2)
Transition:	
- inlet diameter	18 in (460 mm)
- outlet size	9 x 13.8 in (230 x 350 mm)
- length	4.6 ft (1.39 m)

APPENDIX I

MACHINE RATINGS

The following rating scale is used in PAMI Evaluation Reports:

Excellent	Fair
Very Good	Poor
Good	Unsatisfactory

SUMMARY CHART

Keho Cyclone

RETAIL PRICE	$990.00 (June 1989, f.o.b. Humboldt, Sask.)
RATE OF WORK	
Drying Time	Average-Dry: 0.95 times Reference bin Through-Dry: greater than 1.75 times Reference bin
QUALITY OF WORK	
Airflow	1.05 cfm/bu (13.7 L/s.m³) with typical 3 hp (2.2 kW) centrifugal fan
Drying Uniformity	Top layer takes greater than 35% longer than if uniformity ideal
EASE OF OPERATION	
Installation	Air distribution system - could be field installed in any bin Fan - **Fair;** above shoulder height
Monitoring	**Fair** for average-dry; **Good** for through-dry
Cleaning	**Very Good;** did not affect bin unloading
FAN REQUIREMENTS	Must deliver 1780 cfm (840 L/s) @ 5.3 in.wg (1330 Pa) to achieve 1 cfm/bu (13 L/s.m³)
OPERATOR SAFETY	No safety hazards apparent
OPERATOR'S MANUAL	Installation instructions were provided
MECHANICAL HISTORY	No mechanical problems; had to be removed for storing fertilizer

Grain Guard GG 7000

RETAIL PRICE	$795.00 (June 1989, f.o.b. Humboldt, Sask.)
RATE OF WORK	
Drying Time	Average-Dry: 0.75 times Reference bin Through-Dry: 1.05 times Reference bin
QUALITY OF WORK	
Airflow	1.20 cfm/bu (15.6 L/s.m³) with typical 3 hp (2.2 kW) centrifugal fan
Drying Uniformity	Top layer takes greater than 35% longer than if uniformity ideal
EASE OF OPERATION	
Installation	Air distribution system - could be field installed in some bins Fan - **Good**; chest height
Monitoring	**Fair** for average-dry; **Good** for through-dry, difficult to determine when to close wall wings
Cleaning	**Very Good**; did not affect bin unloading
FAN REQUIREMENTS	Must deliver 1730 cfm (810 L/s) @ 4.1 in.wg (1030 Pa) to achieve 1 cfm/bu (13 L/s.m³)
OPERATOR SAFETY	No safety hazards apparent
OPERATOR'S MANUAL	None provided
MECHANICAL HISTORY	No mechanical problems; could be epoxy coated for storing fertilizer

Naicam

RETAIL PRICE	$570.00 (June 1989, f.o.b Humboldt, Sask.)
RATE OF WORK	
Drying Time	Average-Dry: 095 times *Reference bin* Through-Dry: 1.10 times Reference bin
QUALITY OF WORK	
Airflow	1.05 cfm/bu (13.7 L/s.m³) with typical 3 hp (2.2 kW) centrifugal fan
Drying Uniformity	Top layer takes greater than 35% longer than if uniformity ideal
EASE OF OPERATION	
Installation	Air distribution system - could be field installed in some bins Fan **-Fair;** mounting position awkward
Monitoring	**Fair** for average-dry; **Good** for through-dry
Cleaning	**Very Good;** did not affect bin unloading
FAN REQUIREMENTS	Must deliver 1870 cfm (880 L/s) @ 4.7 in.wg (1180 Pa) to achieve 1 cfm/bu (13 L/s•m³)
OPERATOR SAFETY	No safety hazards apparent
OPERATOR'S MANUAL	None provided
MECHANICAL HISTORY	No mechanical problems: had to be removed for storing fertilizer

Taylor

RETAIL PRICE	$470.00 (June 1989, f.o.b. Humboldt, Sask.)
RATE OF WORK	
Drying Time	Average-Dry: 0.90 times Reference bin Through-Dry: 0.80 times Reference bin
QUALITY OF WORK	
Airflow	1.15 cfm/bu (15.0 L/s.m³) with typical 3 hp (2.2 kW) centrifugal fan
Drying Uniformity	Top layer takes 14% longer than if uniformity ideal
EASE OF OPERATION	
installation	Air distribution system - could be field installed in any bin Fan - **Poor**; 8.0 ft (2.5 m) above ground
Monitoring	**Fair** for average-dry; Fair for through-dry
Cleaning	Very Good; did not affect bin unloading
FAN REQUIREMENTS	Must deliver 1710 cfm (810 L/s) @ 4.2 in.wg (1060 Pa) to achieve 1 cfm/bu (13 L/s.m³)
OPERATOR SAFETY	No safety hazards apparent
OPERATOR'S MANUAL	None provided
MECHANICAL HISTORY	No mechanical problems; could be epoxy coated for storing fertilizer

Univision Ultra-Dry (Series 2000)

RETAIL PRICE	$1250.00 (June 1989, f.o.b. Humboldt, Sask.)
RATE OF WORK	
Drying Time	Average-Dry: 0.70 times Reference bin Through-Dry: 0.75 times *Reference* bin
QUALITY OF WORK	
Airflow	1.40 cfm/bu (18.2 L/s.m³) with typical 3 hp (2.2 kW) centrifugal fan
Drying Uniformity	Top layer takes greater than 35% longer than if uniformity ideal
EASE OF OPERATION	
Installation	Air distribution system - factory installed in Univision bins Fan - **Good;** 4 ft (1.2 m) above ground level
Monitoring	**Fair for** average-dry; Good for through-dry; optional probe ports were not tested, but will ease monitoring
Cleaning	**Very Good;** did not affect bin unloading
FAN REQUIREMENTS	Must deliver 1780 cfm (840 L/s) @ 2.5 in.wg (620 Pa) to achieve 1 cfm/bu (13 L/s.m³)
OPERATOR SAFETY	No safety hazards apparent
OPERATOR'S MANUAL	None provided
MECHANICAL HISTORY	No mechanical problems; could be epoxy coated for storing fertilizer

ALBERTA FARM MACHINERY RESEARCH CENTRE

3000 College Drive South
Lethbridge, Alberta, Canada T1K 1L6
Telephone: (403) 329-1212
Fax: (403) 328- 5562
http://www.agric.gov.ab.ca/navigation/engineering/afmrc/index.html

Prairie Agricultural Machinery Institute
Head Office: P.O. Box 1900, Humboldt, Saskatchewan, Canada S0K 2A0
Telephone: (306) 682-2555

Test Stations:
P.O. Box 1060
Portage la Prairie, Manitoba, Canada R1N 3C5
Telephone: (204) 239-5445
Fax: (204) 239-7124

P.O. Box 1150
Humboldt, Saskatchewan, Canada S0K 2A0
Telephone: (306) 682-5033
Fax: (306) 682-5080