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Evaluation Report 596

Cereal Implements 9850 Pull Type Combine- Series 64005

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

CEREAL IMPLEMENTS 9850 PULL-TYPE COMBINE - SERIES 64005

MANUFACTURER:
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RETAIL PRICE:
$92,500 (March, 1989, f.o.b. Humboldt, with “Super 8” Victory pickup and straw chopper).

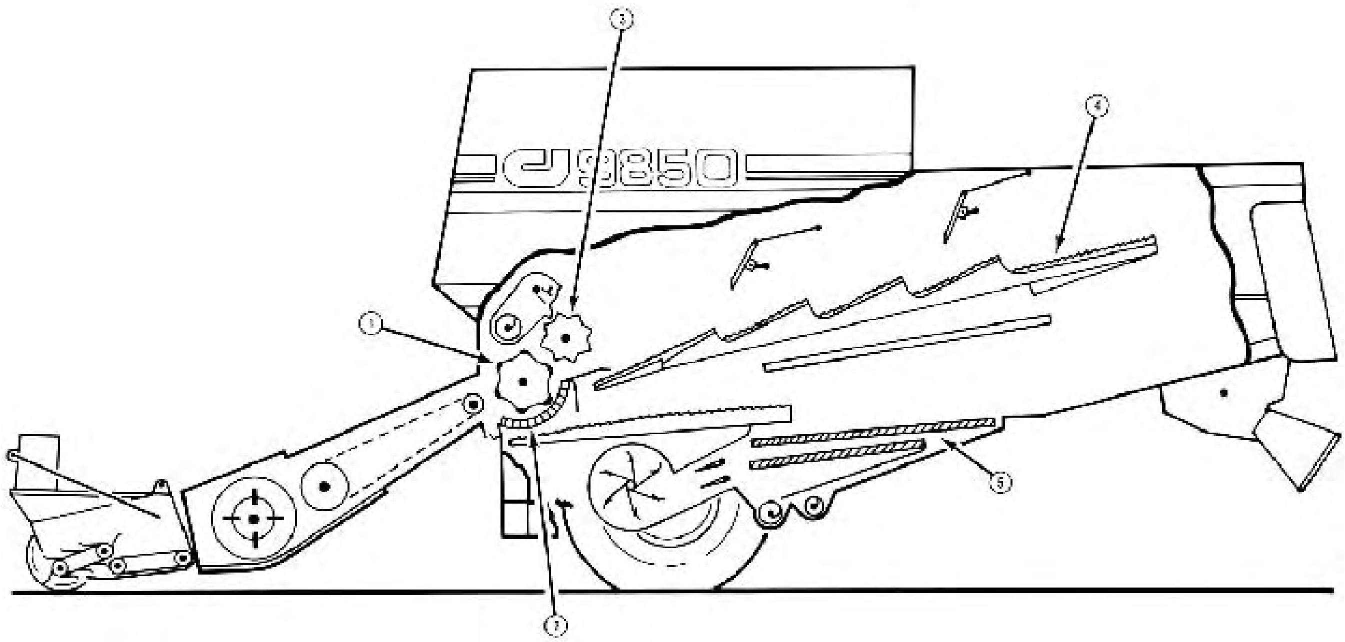

FIGURE 1. Cereal Implements 9850: (1) Cylinder, (2) Concave, (3) Rear Beater, (4) Straw Walkers, (5) Cleaning Shoe.

SUMMARY AND CONCLUSIONS

Capacity: In the capacity tests, the MOG feedrate* at 3% total grain loss was 490 lb/min (13.3 t/h) in Argyle barley and 345 lb/min (9.4 t/h) in Harrington barley. In Katepwa wheat, combine capacity was 445 and 610 lb/in (12.2 and 16.6 t/h) at 3% total grain loss.

The capacity of the Cereal Implements 9850 at 3% loss was about 1.2 times the capacity of the Reference II combine in Argyle barley, about 0.9 times its capacity in Harrington barley, and 0.9 and 1.1 times its capacity in the two Katepwa wheat crops.

Quality of Work: Pickup performance was very good in all crops. It picked cleanly at speeds up to 6 mph (9.6 km/h) and moved material smoothly to the table auger. Feeding was very good in most crops and conditions. The table auger was aggressive and seldom plugged. However, in tough flax, the table auger frequently wrapped.

The stone trap provided good stone protection. Objects up to 3 in (75 mm) in diameter were emptied from the trap. A few small stones went through the combine and caused minor concave damage.

Threshing was good. Unthreshed loss was very low in easy-to-thresh crops, but very aggressive cylinder and concave settings were required to minimize unthreshed loss in hard-to-thresh crops. The concave blanks helped reduce unthreshed loss and “white caps” in the clean grain sample. Grain damage was low in all crops.

Separation of grain from straw was good, although, in both barley and wheat, grain loss over the straw walkers limited capacity.

*MOG feedrate (Material-Other-than-Grain Feedrate) is the mass of straw and chaff passing through the combine per unit of time.

Cleaning shoe performance was very good. In barley and wheat, shoe loss was usually very low over the entire operating range. The chaffer and cleaning sieves tended to “spear” with straw. In all crops, the grain tank sample was very clean.

Grain handling was good. The 225 Imp bu (8.2 m³) grain tank filled evenly in most crops. Unloading a full tank of dry wheat took about 130 seconds. The unloading auger had ample clearance for unloading into all trucks and trailers encountered. The high discharge resulted in some loss when unloading in windy conditions.

Straw spreading was good. Straw was spread up to 25 ft (7.6 m) in a fairly uniform pattern. Converting the chopper to drop-straw was very quick and convenient.

Ease of Operation and Adjustment: Ease of hitching was fair. Initial hook-up took one person about one day. A three-point hitch adapter had to be attached to the tractor drawbar and the combine PTO shaft had to be cut to fit. Operator comfort and visibility depended on the tractor used.

Instrumentation was good. The digital display indicated cylinder and fan speed. Warning to indicate a slowdown of critical shafts was clearly shown on the control console. The controls were fair. The control switches were difficult to identify and operate while harvesting. The optional remote header control kit greatly improved the ease of operating the header controls.

The loss monitor was fair. Full width loss sensors were located under the end of the straw walkers and at the back of the chaffer sieve. Like most loss monitors, the reading was meaningful only if compared to actual loss. However, in some conditions, the monitor adjustment did not provide an adequate response for normal loss levels.

Lighting supplied by the combine for nighttime harvesting was good. Additional light from the tractor was required for proper lighting.

Handling was very good. The unique hitch of the Cereal Implements 9850 enabled very sharp cornering without PTO vibration. The hydraulic hitch-pole positioning made it very easy to switch to field or transport position.

Ease of adjusting the combine components was very good. All components were easy to adjust. Ease of setting to suit crop conditions was very good. After initial adjustments, some fine-tuning was usually required. This was easy as the effect of adjustments was easy to see and check.

Ease of unplugging was good. The feeder reverser backed out most table auger and feeder obstructions. Severe feeder plugging had to be cleared by hand. A plugged cylinder could usually be cleared by lowering the concave fully and powering the slug through. The tailings return plugged frequently when operating in weedy conditions or damp flax. Ease of complete cleaning was good. The grain tank retained very little grain; however, the sump door was difficult to open. Cleanout doors were provided for the clean grain and return elevator cross augers.

Ease of lubrication was very good. The few daily grease points made lubrication quick and easy. Ease of performing routine maintenance was good. Most drives were easily accessed for checking and adjusting. Main power belt tension was easily checked, but adjustment took about 10 minutes and required large wrenches.

Power Requirements: The manufacturer's recommended optimum tractor size of 165 PTO hp (123 kW) was suitable. Measured input power in Katepwa wheat was 105 hp (78 kW) at capacity. Extra power was required to pull the combine and for auxiliary functions.

Operator Safety: The operator's manual emphasized operator safety. No safety hazards were apparent on the Cereal Implements 9850. However, normal safety precautions were required and warnings had to be heeded.

Operator's Manual: The operator's manual was fair. Information was vague and often incomplete. Different names were used for the same component from one reference to another, and some information was incorrect.

Mechanical History: Several mechanical problems occurred throughout the test.

RECOMMENDATIONS

It is recommended that the manufacturer consider:

1. Modifications to improve the ease of identifying and operating the combine controls.
2. Modifications to provide a more regulated pickup speed and cylinder speed control response.
3. Modifications to provide a greater adjustment range on the grain loss monitor.
4. Modifications to the grain tank sump door to enable easier more convenient opening.
5. Modifications to improve the ease of disconnecting the header hydraulic lines to permit quicker, more convenient feeder removal.
6. Revising and reorganizing the operator's manual to provide complete and correct information in a logical format.
7. Modifications to eliminate repeated failure of the secondary power belt idler arm tensioning springs.
8. Modifications to prevent hydraulic oil leakage in the control bay.

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Project Manager: L.G. Hill
Project Engineer: C.A. Hanson

THE MANUFACTURER STATES THAT

With regard to recommendation number:

1. Alternate combine control designs are being considered for future production.
2. A service bulletin has been issued to Cereal Implements dealers describing simple, inexpensive solutions, which can be implemented where required.
3. Modifications to provide greater grain loss monitor adjustment will be an inherent part of the control redesign mentioned in Reply 1.
4. A service bulletin has been issued to Cereal Implements dealers describing a technique to ease opening the grain tank sump door, which can be implemented when required.
5. Cereal Implements feels that this is not a serious problem since feeder house removal is usually infrequent; however, the recommendation will be considered for future production.
6. The operator's manual will be revised for future production.
7. Cereal Implements will monitor secondary power belt idler springs and will take corrective action if necessary.
8. Leakage past blind plugged ports in the hydraulic filter base will be sealed. Leakage in the valve block area can occur from hairline cracks in the fittings. These cracks are caused by overtightening. Replacement and correct torquing of the fitting will eliminate this.

GENERAL DESCRIPTION

The Cereal Implements 9850 is a power-take-off driven, pull-type combine. It has a transverse-mounted, tangential threshing cylinder, concave, rear beater, straw walkers with stirring tines, and a cleaning shoe. The open design cylinder has six rasp bars with the ribs on alternate bars having the opposite angle. A bar and wire concave is matched to the cylinder. The eight wing beater has a finger-bar grate. There are five, multi-step, open bottom straw walkers. The cleaning fan is a six blade paddle fan, and the adjustable lip chaffer, tailings and cleaning sieves move in unison.

Crop is fed from the feeder to the cylinder where, upon contact, threshing begins. The crop is pulled between the cylinder and concave where further threshing takes place and grain separation begins. The crop is stripped away from the cylinder by the beater and directed onto the straw walkers for further separation. The separated material is carried to the shoe by reciprocating grain pans. The grain is cleaned by a combination of pneumatic and sieving action. Tailings are returned to the front of the cylinder.

The test combine was equipped with a 13 ft (3.9 m) header, 12 ft (3.7 m) Victory "Super 8" four roller belt pickup, straw chopper, and optional accessories as listed on page 2.

The Cereal Implements 9850 has a unique hitch which permits turning while keeping the PTO drive in line. Power is transferred from the front mounted gearbox to the combine through a multi-vee belt enclosed in the hitch tube.

The combine has a self-contained hydraulic system, with most functions controlled electronically from a cab-mounted console. Separator, header and unloader drives, header height, hitch and unloader swing, cylinder speed and pickup speed are all actuated electrohydraulically. Fan speed, header reverser and combine lights are controlled electrically. Front and rear concave clearance, concave blank engagement, windboard position, and sieve settings are adjusted externally on the machine. Tailings may be sampled from a spring loaded door in the bottom of the tailings elevator. Important component speeds and harvest functions are displayed electronically on the console.

Detailed specifications are given in APPENDIX I.

SCOPE OF TEST

The main purpose of the test was to determine the functional performance of the Cereal Implements 9850. Measurements and observations were made to evaluate the Cereal Implements 9850 for rate of work, quality of work, ease of operation and adjustment, power requirements, operator safety and the suitability of the operator's manual. Although extended durability testing was not conducted, mechanical failures, which occurred during the test were recorded.

The Cereal Implements 9850 was originally evaluated during the harvest of 1987, and Evaluation Report #575 was subsequently published in the spring of 1988. The manufacturer has since made several modifications and updates which will be applied to all machines. To provide a current report, these changes were evaluated during the 1988 harvest. This report covers the performance with the changes and replaces the original report.

The Cereal Implements 9850 was operated for a total of

123 hours while harvesting about 1090 ac (443 ha) of various crops. In addition, capacity tests were conducted in two wheat crops and two barley crops.

The operating conditions for the season are shown in TABLES 1 and 2.

TABLE 1. Operating Conditions

Crop	Variety	Yield Range		Width of Cut		Sep. Hours	Field Area		Crop Harvested	
		bu/ac	t/ha	ft	m		ac	ha	bu	t
Barley	Argyle Herrington	25-50 55-80	1.4-2.7 2.9-4.3	24 20, 50	7.3 6.1,15.2	16 20	120 135	49 55	4400 7700	96.0 168.0
Canola	Tobin Westar	15-20 20-35	0.8-1.0 1.1-2.0	20,21 20,25	6.1,6.4 6.1,7.6	11 17	135 140	55 57	2200 3300	50.0 75.0
Flax	Norlin	10-25	0.7-1.5	18,30, 50	5.5,9.1 15.2	16	105	42	1600	41.5
Lentils	Laird	11	0.7	25	7.6	2	20	8	200	6.0
Rye	Musketeer	25-40	1.6-2.6	20,25 30,40	6.1,7.6 9.1,12.2	12	70	29	2000	50.0
Wheat	Katepwa	15-30	1.1-2.0	25,50 60	7.6,15.2 18.3	29	365	148	9400	256.5
Total						123	1000	443	30800	743.0

TABLE 2. Operation in Stony Conditions

Field Conditions	Hours	Field Area	
		ac	ha
Stone Free	85	785	318
Occasional Stones	38	305	125
Total	123	1090	443

RESULTS AND DISCUSSION

TERMINOLOGY

MOG, MOG Feedrate, Grain Feedrate, MOG/G Ratio and Total Feedrate: A combine's performance is affected mainly by the amount of straw and chaff it is processing and the amount of grain or seed it is processing. The straw, chaff, and plant material other than the grain or seed is called MOG, which is an abbreviation for "Material-Other-than-Grain". The quantity of MOG being processed per unit of time is called "MOG Feedrate". Similarly, the amount of grain being processed per unit of time is the "Grain Feedrate".

The MOG/G ratio, which is the MOG Feedrate divided by the Grain Feedrate, indicates how difficult a crop is to separate. For example, MOG/G ratios for prairie wheat crops may vary from 0.5 to 1.5. In a crop with a 0.5 MOG/G ratio, the combine has to handle 50 lbs (22.7 kg) of straw for every 100 lbs (45.4 kg) of grain harvested. However, in a crop with a 1.5 MOG/G ratio for a similar 100 lbs (45.4 kg) of grain harvested the combine now has to handle 150 lbs (68.1 kg) of straw -- 3 times as much. Therefore, the higher the MOG/G ratio, the more difficult it is to separate the grain.

Total feedrate is the sum of MOG and grain feedrates. This gives an indication of the total amount of material being processed. This total feedrate is often useful to confirm the effects of extreme MOG/G ratios on combine performance.

Grain Loss, Grain Damage, Dockage and Foreign Material: Grain loss from a combine can be of two main types: Unthreshed Loss, consisting of grain left in the head and discharged with the straw and chaff, or Separator Loss which is free (threshed) grain discharged with the straw and chaff. Separator Loss can be further defined as Shoe Loss and Walker (or Rotor) Loss depending where it came from. Loss is expressed as a percentage of the total amount of grain being processed.

Damaged or cracked grain is also a form of grain loss. In this report the cracked grain is determined by comparing the weight of the actual damaged kernels to the entire weight of a sample taken from the grain tank.

Dockage is determined by standard Canadian Grain Commission methods. Dockage consists of large foreign particles and of smaller particles that pass through a screen specified for that crop. It is expressed as a percentage of the weight of the total sample taken.

Foreign material consists of the large particles in the sample, which will not pass through the dockage screens.

Capacity: Combine capacity is the maximum rate at which a combine, adjusted for optimum performance, can process crop at a certain total loss level. PAMI expresses capacity in terms of MOG Feedrate at 3% total loss. Although MOG Feedrate is not as easily visualized as Grain Feedrate, it provides a much more consistent basis for comparison. A combine's ability to process MOG is relatively consistent even if MOG/G ratios vary widely. Three percent total loss is widely accepted in North America as an average loss rate that provides an optimum trade-off between work accomplished and grain loss. This may not be true for all combines nor does it mean that they cannot be compared at other loss levels.

Reference Combine: It is well recognized that a combine's capacity may vary greatly due to differences in crop and weather conditions. These differences make it impossible to directly compare combines not tested in the same conditions. For this reason, PAMI uses a reference combine. The reference combine is simply one combine that is tested along with each combine being evaluated. Since the test conditions are similar, each test combine can be compared directly to the reference combine to determine a relative capacity or "capacity ratio". This capacity ratio can be used to indirectly compare combines tested in different years and under different conditions. As well, the reference combine is useful for showing how crop conditions affect capacity. For example, if the reference combine's capacity is higher than usual, then the capacity of the combine being evaluated will also be higher than normally expected.

For 10 years PAMI had used the same reference combine. However, capacity differences between the reference combine and some of the combines tested became so great that it was difficult to test the reference combine in the conditions suitable for the evaluation combines. PAMI changed its reference combine to better handle these conditions. The new reference combine is a larger conventional combine that was tested in 1984 (see PAMI report #426). To distinguish between the reference combines, the new reference will be referred to as Reference II and the old reference as Reference I.

RATE OF WORK

Capacity Test Results: The capacity test results for the Cereal Implements 9850 are summarized in TABLE 3.

The performance curves for the capacity tests are presented in FIGURES 2 to 5. The curves in each figure indicate the effect of increased feedrate on walker loss, shoe loss, unthreshed loss and total loss. From the graphs, combine capacity can be determined for loss levels other than 3%. The rate at which loss changes with respect to feedrate shows where the combine can be operated effectively. Portions of loss curves, which are "flat" or slope gradually indicate stable performance. Where the curves hook upward sharply, small increases in feedrate cause loss to increase greatly. It would be difficult to operate in this range of feedrates without having widely varying loss.

Both of the barley crops used for the test were from uniform stands and were laid in well formed single windrows. The Argyle barley windrow was nearly as wide as the feeder of the Cereal Implements 9850, while the Harrington barley windrow was slightly wider than the feeder. Heads were evenly distributed across the windrow in both crops. The crops were mature, the grain dry and the straw tough. In the Argyle barley, straw break-up was relatively low, and the lower MOG/G ratio meant that high grain feedrates accompanied relatively low MOG feedrates. The Harrington barley had average straw break-up and a somewhat higher MOG/G ratio. In both crops the grain threshed easily and the awns broke off readily.

Capacity in barley, at 3% loss, was 345 and 490 lb/min (9.4 and 13.4 t/h) MOG, respectively, for the Harrington and Argyle crops. Total loss was very low at MOG feedrates up to 350 to 400 lb/min (9.6 to 10.9 t/h) in the Argyle barley and 250 to 300 lb/min (6.8 to 8.1 t/h) in the Harrington barley (FIGURES 2 and 3). At higher feedrates walker loss increased rapidly, limiting capacity.

Both Katepwa wheat crops were from uniform stands, and were laid in well formed side-by-side double windrows. The heads were uniformly distributed over each windrow, and together the windrows were much wider than the feeder on the Cereal Implements 9850. Both crops were mature and the straw dry. The grain was dry for the first crop but tough for the second. The straw was short and the yield

TABLE 3. Capacity of the Cereal Implements 9850

Crop Conditions									Results									
		Width of Cut		Crop Yield		Moisture Content			MOG Feedrate		Grain Feedrate		Total Feedrate		Grain Cracks	Dockage	Foreign	Loss
Crop	Variety	ft	m	bu/ac	t/ha	Straw %	Grain %	MOG/G	lb/min	t/h	bu/h	t/h	lb/min	t/h	%	%	Material	Curve
Barley	Argyle	24	7.2	69	3.7	12.9	13.1	0.72	490	13.3	850	18.5	1170	31.8	0.3	1.7	0.4	2
Barley	Harrington	20	6.0	78	4.2	12.4	10.2	0.85	345	9.4	505	11.0	750	20.4	1.8	1.3	0.2	3
Wheat	Katepwa"A"	40	12.2	30	2.0	7.4	12.4	0.59	445	12.1	755	20.5	1200	32.6	0.8	1.6	0.5	4
Wheat	Katepwa"B"	60	18.3	37	2.5	8.4	14.8	0.63	610	16.6	970	26.4	1580	43.0	1.1	1.4	0.2	5

about average, which resulted in low MOG/G ratios, thus, the MOG feedrates were accompanied by high grain feedrates.

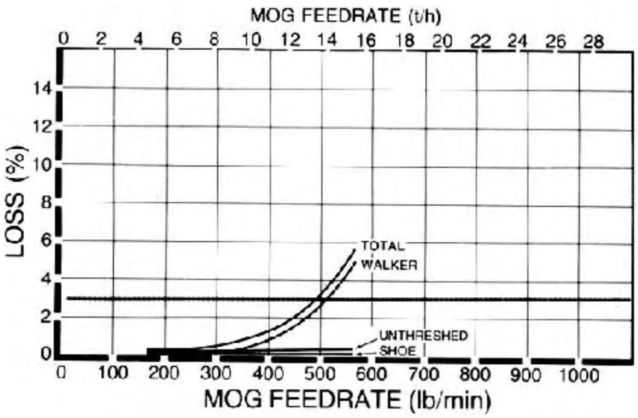

FIGURE 2. Grain Loss in Argyle Barley.

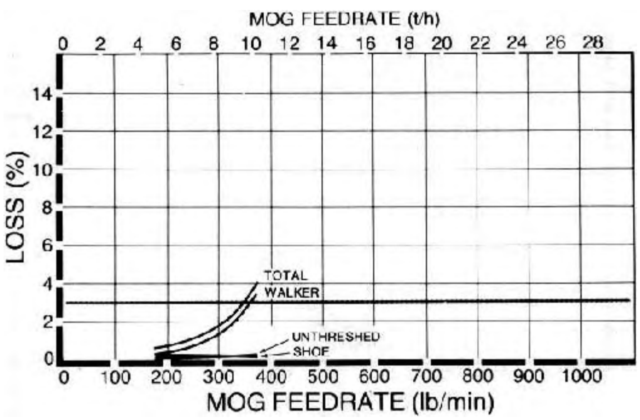

FIGURE 3. Grain Loss in Harrington Barley.

In wheat, the capacity at 3% loss was 445 and 610 lb/min (12.2 and 16.7 t/h) MOG. The higher feedrate in the second crop was most likely the result of the wider windrow and the more weathered condition of the crop.

Loss was very low for MOG feedrates up to 350 to 400 lb/min (9.6 to 10.9 t/h) in the first wheat crop and 500 to 550 lb/min (13.6 to 15.0 t/h) in the second wheat crop (FIGURES 4 and 5).

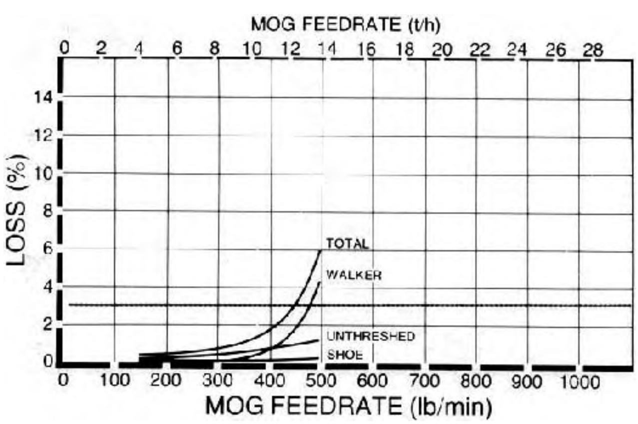

FIGURE 4. Grain Loss in Katepwa Wheat "A".

In both barley and wheat, total loss increased gradually with feedrate up to about 1.5%. At higher MOG feedrates, straw walker loss increased rapidly. This meant that once the practical separating limit had been reached increasing ground speed or encountering heavier crop caused a disproportionate increase in loss. This is typical of many conventional combines and suggests that operating at higher loss may be impractical.

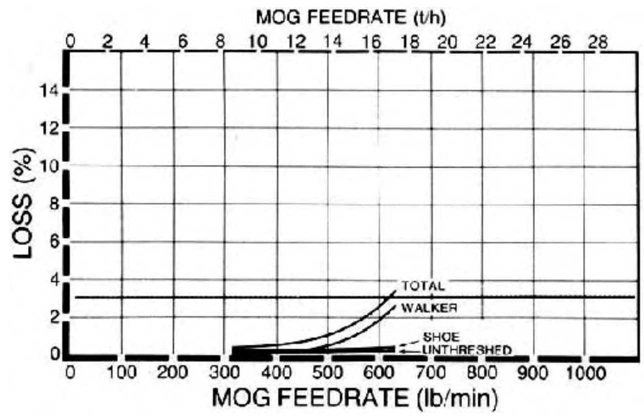

FIGURE 5. Grain Loss in Katepwa Wheat "B".

Average Workrates: TABLE 4 shows the range of average workrates achieved during day-to-day operation in the various crops encountered. The table is intended to give a reasonable indication of the average rates most operators could expect to obtain, while acknowledging the effects of crop and field variables. For any given crop, the average workrates may vary considerably. Although a few common variables such as yield and width of cut are included in TABLE 4, they are by no means the only or most important ones. There are many other crop and field conditions which affect workrate; as well, operating at different loss levels, availability of grain handling equipment and differences in operating habits can have an important effect.

TABLE 4. Field Workrates

Crop	Range	Grain Feedrate		Area Rate		Width of Cut		Yield		Variety
		bu/h	t/h	ac/h	ha/h	ft	m	bu/ac	t/ha	
Barley	High	540	11.7	10.0	4.0	50	15.2	53	2.9	Harrington
	Low	180	4.0	6.5	2.7	24	7.3	27	1.5	Argyle
	Avg.	335	7.3	7.0	2.7			48	2.6	
Canola	High	345	7.8	10.0	3.9	25	7.6	35	2.0	Westar
	Low	95	2.2	5.5	2.2	20	6.1	18	1.0	Westar
	Avg.	195	4.4	10.0	4.0			20	1.1	
Flax	High	155	4.0	8.0	3.3	18	5.5	19	1.2	Norlin
	Low	80	2.0	5.0	2.2	50	15.2	15	0.9	Norlin
	Avg.	105	2.7	6.5	2.7			16	1.0	
Lentils	Avg	100	2.5	9.0	3.6			11	0.8	Laird
Rye	High	230	5.8	7.0	2.8	20	6.1	32	2.1	Musketeer
	Low	80	2.1	2.0	0.8	25	7.6	40	2.6	Musketeer
	Avg.	160	4.0	5.5	2.2			28	1.8	
Wheat	High	490	13.4	17.0	7.1	60	18.3	29	1.9	Katepwa
	Low	175	4.8	10.5	4.4	25	7.6	17	1.1	Katepwa
	Avg.	325	8.9	12.5	5.1			26	1.8	

The effect of the variables, as indicated in TABLE 4, explains why even the maximum average workrates may be considerably lower than the capacity results, which are instantaneous workrates.

Clearly, TABLE 4 should not be used to compare performance of combines. The factors affecting average workrates are simply too numerous and too variable to be duplicated for each combine tested.

Comparing Combine Capacities: The capacity of combines tested in different years or in different crop conditions should be compared only by using the PAMI reference combines. Capacity ratios comparing the test combine to the reference combine are given in the following section. For older reports where the ratio is not given, a ratio can be calculated by dividing the MOG feedrate listed in the capacity table by the corresponding MOG feedrate of the reference combine listed in APPENDIX II for that particular crop.

Once capacity ratios for different evaluation combines have been determined for comparable crops, they can be used to approximate capacity differences. For example, if one combine has a capacity ratio of 1.2 times the reference combine and another combine has a capacity ratio of 2.0 times the reference combine, then the second combine is about 67% larger [(2.0 - 1.2) / 1.2 x 100 = 67%]. An evaluation combine can also be compared to the reference combine at losses other than 3%. The total loss curves for the test combine and reference combine are shown in the graphs in the following section. The shaded bands around the curves represent 95% confidence belts. Where the bands overlap, very little difference in capacity exists, where the bands do not overlap a significant difference can be noticed.

PAMI recognizes that the change to the Reference II combine may make it difficult to compare test machines, which were compared to Reference I. To determine a relative size it is necessary to use a ratio of the two reference combines. Tests indicated that Reference II had about 1.50 to 1.60 times the capacity of Reference I in wheat and about 1.40 to 1.50 times Reference I's capacity in barley.

Capacity Compared to Reference Combine: The capacity of the Cereal Implements 9850 was comparable to that of the PAMI Reference II combine. At 3% total loss, the Cereal Implements 9850 had about 1.2 times the capacity of the Reference II combine in Argyle barley, about 0.9 times its capacity in Harrington barley, and 0.9 and 1.1 times its capacity in the two Katepwa wheat crops.

FIGURES 6 to 9 compare the total losses of both combines in wheat and barley.

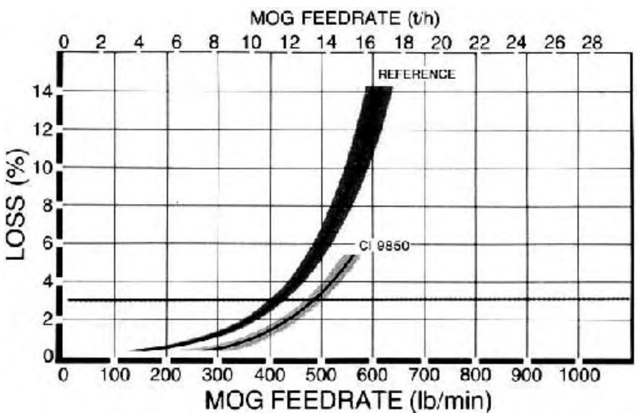

FIGURE 6. Total Grain Loss in Argyle Barley.

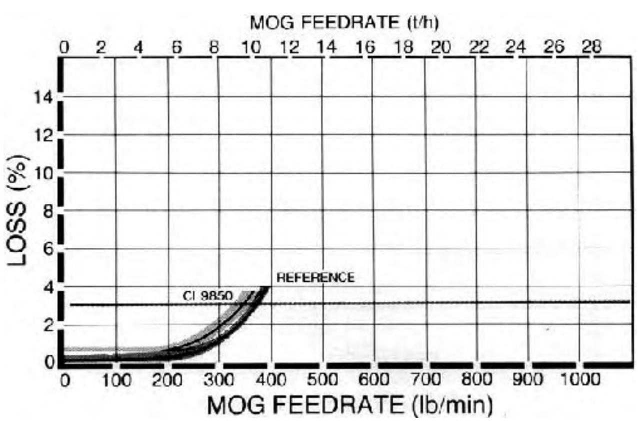

FIGURE 7. Total Grain Loss in Harrington Barley.

QUALITY OF WORK

Picking: Pickup performance was very good.

The pickup was normally operated at about a 30° angle to the ground with the gauge wheels adjusted so the teeth just touched the ground. The draper speed was set slightly faster than ground speed. With these settings, a well supported windrow was picked cleanly at speeds up to 6 mph (9.6 km/h). Picking aggressiveness was increased in poorly supported windrows by increasing pickup speed and reducing pickup angle. The pickup occasionally picked a few smaller stones when operating in stony conditions.

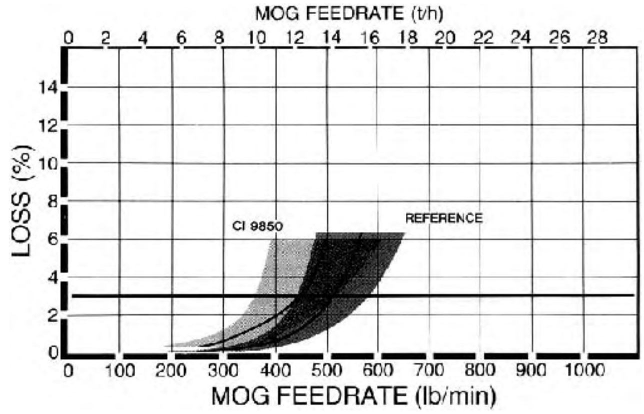

FIGURE 8. Total Grain Loss in Katepwa Wheat "A".

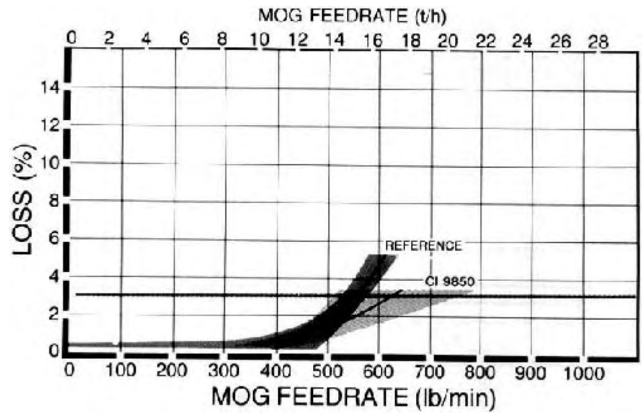

FIGURE 9. Total Grain Loss in Katepwa Wheat "B".

The transfer draper behind the picking drapers moved material smoothly to the table auger. The windguard was effective in directing material under the table auger, and could be easily positioned to provide adequate clearance for bushy canola windrows.

The pickup was wide enough to pick around most corners.

Feeding: Feeding was very good.

As with all conventional combines, to fully utilize the threshing and separating ability at the cylinder and concave it was necessary to feed windrows that were at least as wide as the width of the cylinder and concave and that had the heads evenly distributed across the width. In narrower windrows and windrows with the heads concentrated in one area, it was best to center the windrow or heads on the feeder opening.

The table auger, which used a smaller tube and deeper flighting than most North American combines, fed crop smoothly to the feeder even when the crop was fed slightly above the centerline. The table auger was aggressive and seldom plugged but did wrap frequently in tough flax. No adjustment stopped the wrapping.

The feeder conveyor was aggressive and plugged only occasionally. Backfeeding down the feeder occurred only when large wads were taken in.

Stone Protection: Stone protection was good.

The stone trap, located directly in front of the concave, was effective, stopping most stones. Hard objects were driven into the pocket when contacted by the rasp bars. Objects up to 3 in (75 mm) in diameter were emptied from the trap. The stone trap was most effective if emptied regularly to prevent grain and dirt from hardening in the trap. Some small stones did go through the combine, and caused minor damage to some concave wires (FIGURE 10).

Threshing: Threshing was good.

In all crops and conditions crop fed smoothly into the cylinder and concave area. There was no evidence of backfeeding around the cylinder.

In most crops, the cylinder speeds used were much faster than those for many conventional combines. Even though the cylinder diameter of the Cereal Implements 9850 was smaller, the speed of the rasp bars was still considerably higher. Concave clearances

TABLE 5. Crop Settings

Crop	Cylinder	Concave Clearance				Sieve Openings						Fan Speed	Windboard Setting	
		Front		Rear		Chaffer		Tailings		Cleaning				
	rpm	in	mm	in	mm	in	mm	in	mm	in	mm	rpm	Top	Bottom
Barley	1200 - 1500	9/16	15	3/16	5	5/8	18	3/4	20	7/16	11	700 - 950	1	2
Canola	700 - 800	23/32	18	7/16	11	1/2	13	5/8	19	3/16	5	530 - 700	1	2
Flax	1500 - 1600	13/32	10	1/32	1	3/8	10	9/16	15	1/8	3	550 - 600	1	2
Rye	1000 - 1200	1/2	13	7/32	5	3/8	10	9/16	15	1/4	6	750 - 850	3	4
Wheat	1300 - 1500	13/32	10	1/32	1	5/8	18	3/4	20	5/16	8	850 - 950	2 - 3	3

*Refers to the Hole Number from the Top.

used were usually slightly wider than those for other conventional combines.

FIGURE 10. Concave Damage.

In barley and other easy-to-thresh crops unthreshed loss was usually very low. In hard-to-thresh crops such as wheat or damp cereal crops, it was necessary to use very aggressive settings to minimize unthreshed loss. In some wheat crops, engaging the concave blanks (disawning plates) helped reduce unthreshed loss and "white caps" in the clean grain sample.

Grain damage was quite low even though aggressive threshing settings were used. Grain damage was primarily affected by the cylinder speed and the concave blanks. Concave clearance had little effect.

TABLE 5 shows the settings PAMI found to be suitable for different crops.

Separating: Separation was good.

In all crops, material flowed smoothly over the concave and straw walkers. No plugging or bridging occurred.

In both barley and wheat, grain loss over the straw walkers limited capacity. This occurred even though the combine was equipped with "stirring tines" to aid separation on the straw walkers and aggressive cylinder and concave settings were used. Typical of many conventional combines, the straw walker loss was very low until the separating capacity was reached, then loss increased very rapidly.

The minimum front concave clearances on the Cereal Implements 9850 were relatively wide compared to other conventional combines. It is possible that reducing the front concave clearance from the original linkage adjustment may have slightly increased separation at the concave.

In canola and flax, loss over the straw walkers was low and did not limit capacity. In flax, even with the concave blanks engaged, loss over the straw walkers was low. However, in clamp flax with the concave blanks in, material hardened in the section of the concave over the blanks. This made it important that an operator check for concave plugging after using the concave blanks, as concave blanks or a plugged concave greatly reduced separation in cereal crops.

Settings used in the different crops are shown in TABLE 5.

Cleaning: Cleaning shoe performance was very good.

Shoe loading was usually even except when harvesting narrow windrows or feeding off-center.

Straw tended to "spear" through the chaffer and cleaning sieves (FIGURE 11). A moderate amount of spearing had little effect on shoe loss but could eventually cause increased shoe loss. Although the unison movement of the chaffer and cleaning sieves may not have been responsible for the "spearing", it did not "work" the straws through. Slight reductions in chaffer sieve openings decreased "spearing" but also increased shoe loss.

FIGURE 11. Straw "Spearing" on Chaffer.

In barley and wheat, shoe loss was usually very low over the entire operating range even at high grain feedrates. In canola and flax where total loss over 1 to 1.5% is often considered unacceptable, reasonable feedrates were attained when shoe loss was between 0.5 and 1%.

In all crops the Cereal Implements 9850 produced a very clean sample when set for minimal shoe loss. TABLE 5 shows the settings PAMI found suitable for the crops encountered.

Clean Grain Handling: Grain handling was good.

The open grain tank filled evenly in most crops however, in some crops the front of the grain tank did not fill completely. The four adjustable flighting segments on the leveling auger helped distribute the grain, but were too small to provide uniform distribution.

A full grain tank held about 225 bu (8.2 m³) of dry wheat. Adjustable sensors in the tank warned the operator when the grain level reached "near full" and "full". In addition, a window in the front of the grain tank allowed the operator to visually monitor grain flow and tank level while operating. If overfilled, grain spilled over the back and the right side of the tank.

The unloading auger was hydraulically positioned which helped when "topping" loads. However, the steep slope of the unloading auger meant that as the auger was swung back the clearance height was reduced and caution was required.

The unloading auger had ample clearance for unloading into all trucks and trailers encountered (FIGURE 12). Although unloading auger reach was adequate for trucks to drive under from behind, it was difficult for the operator to drive into position for unloading into a stationary truck, especially if the tractor was equipped with dual wheels. The combine did have the advantage that it could be easily swung into transport position which enabled driving past the truck to unload rather than backing in.

The auger discharged grain in a compact stream and unloaded a full tank of dry wheat in about 130 seconds. In windy conditions the unloading auger had to be swung back to reduce the discharge height to minimize grain loss.

Straw Spreading: Straw spreading was good.

The straw chopper on the Cereal Implements 9850 had adjustable stationary knives and sharpened hammers. Even with the stationary knives completely retracted, the straw was very finely cut.

FIGURE 12. Unloading.

The chopper tail plate adjustment was suitable for all conditions. Under ideal conditions, a spread width of up to 25 ft (7.6 m) was achieved. Straw distribution was usually fairly uniform over the entire spread width.

Converting the chopper to drop straw was very quick and convenient. No tools were required and the conversion took one person only about 3 minutes. Windrow forming tines concentrated the straw into a narrow windrow, which was ideal for baling.

The chaff was not spread with the straw.

EASE OF OPERATION AND ADJUSTMENT

Hitching: Ease of hitching was fair.

Initial hook-up took one person about one day. The control console was mounted in the tractor cab and electrical wires routed. An adapter to substitute for a three-point hitch was installed on the tractor drawbar and the combine PTO shaft was cut to fit.

Initial hitching would have been easier if the tractor had been equipped with a three-point hitch. Unhitching was easy, however, the adapter had to be removed to use the drawbar. Switching from one tractor to another may be inconvenient since different makes and models may require the purchase and fitting of a new PTO shaft.

A tractor with either a standard 1.38 or 1.75 in (35 or 44 mm) spline, 1000 rpm PTO and a 12 V negative ground electrical system was required. No remote hydraulic circuits were required as the combine was equipped with its own hydraulic system.

Operator Comfort: Operator comfort and visibility depended on the tractor used.

The most practical location for the control console was in the right rear corner of the tractor cab (FIGURE 13). Arm room was restricted for operating the controls and the operator had to sit in a turned position. This was awkward and made prolonged operation uncomfortable.

The optional remote header control kit (FIGURE 14) was positioned further forward. This provided convenient control of the frequently used header functions, and permitted the operator to sit in a more comfortable position most of the time.

FIGURE 13. Control Console in Tractor Cab.

The windrow was clearly visible as it entered the pickup and feeder while both the grain and truck were easy to see while unloading.

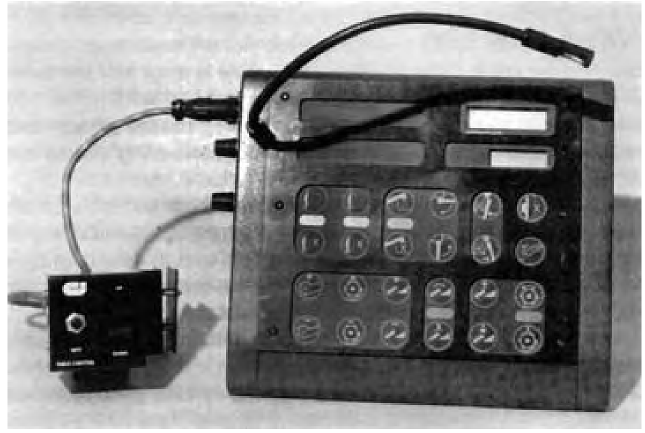

FIGURE 14. Console with Remote Header Control.

The noise from the gearbox did not raise the noise level in the cab appreciably.

The tractor's power shift transmission was well suited to the Cereal Implements 9850's capacity. The working speeds were well spaced and on-the-go shifts maximized the combine's harvesting ability.

Instrumentation: Instrumentation was good.

The instruments were located in the control console. A digital display indicated cylinder or fan speed while an audible alarm and indicator lights signalled slowdown of important shafts.

The instruments worked well. There were no false alarms and the shaft speed alarm would cancel once a shaft had returned to its proper speed. The digital display was easy to see; however, the shaft speed indicators were small and hard to quickly distinguish.

Controls: The controls were fair.

The combine controls were located on the cab-mounted console. The 24 switches controlling combine function were located under the touch sensitive membrane keypad. These control switches were difficult to identify and operate while harvesting. The number of controls hampered quick identification, and the similarity of many of the symbols made them hard to distinguish at a glance. As well, activating the switches required precise finger placement, which was difficult when harvesting. The membrane type switches provided little indication that contact had been made, thus the operator had to visually confirm the reaction. It is recommended that the manufacturer consider modifications to improve the ease of identifying and operating the combine controls.

The optional remote header control kit contained mechanical switches for header height and header clutch disengagement. This kit provided much more convenient and positive control for the header functions.

The response of the cylinder speed and pickup controls was too fast which made fine adjustment difficult. The valve that controlled cylinder speed was adjusted for the slowest response, but the speed still changed too fast. Several attempts were required to achieve a desired speed and best results usually occurred when slowing the cylinder to the desired speed rather than when increasing it. Similarly, the pickup speed was also difficult to set as it also changed too quickly within the normal operating range. It is recommended that the manufacturer consider modifications to provide more regulated cylinder speed and pickup speed control response.

Loss Monitor: The loss monitor was fair.

Full width loss sensors were located under the end of the straw walkers and at the back of the chaffer sieve. A bar graph display for each sensor was located on the control console. The display was easy to see in all light conditions.

Individual display range adjustments were provided for both the straw walker and cleaning shoe loss. Like most loss monitors, these adjustments were intended to calibrate the meter display to the actual loss from the combine. Normally, calibration adjustments must provide a wide enough range to accommodate the range of loss levels normally accepted by different operators. In some crops, the meter could be calibrated for acceptable response at 2 or 3 % loss, but often, the adjustment did not provide an adequate response for higher or lower losses. It is recommended that the manufacturer consider modifications to provide a greater adjustment range on the grain loss monitor.

As with all grain loss monitors, loss readings were useful only if compared to actual losses behind the machine.

Lighting: Lighting supplied by the combine for nighttime harvesting was good.

Two combine lights shone forward to provide lighting for the windrow and header. This forward lighting was marginally adequate and additional lighting from the tractor was essential for proper forward and rearward lighting.

Lights were supplied for the grain tank and for the unloading auger. The auger light was originally mounted on the rear side of the unloader discharge spout, which provided poor illumination of the discharge stream and truck box. The light was moved to the front side of the unloader discharge spout, which improved its effectiveness.

The control console was equipped with a work lamp. The light was located at the end of a flexible arm, and could be adjusted to shine on the face of the console. This was essential for viewing.

Four warning flashers and a single taillight were provided to aid in safe road transport.

Handling: Handling was very good.

The unique hitch of the Cereal Implements 9850 (FIGURE 15) enabled very sharp cornering without PTO vibration.

FIGURE 15. Hitch and Drive.

This was possible since the PTO shaft remained in-line with the front gearbox even while turning. During the turn, the hitch pivoted about the vertical output shaft of the gearbox. Since the output of the gearbox was a belt drive the rotation had an insignificant effect.

The unique hitch enabled picking around 90° corners with ease. However, the hitch adapter lengthened the drawbar and since the hitch pole was quite heavy, it was necessary to add front weights to the tractor to maintain suitable handling characteristics. Without the front weights, the wheel brakes were often required for turning.

A width of cut of about 24 ft (7.3 m) was required to enable a tractor with dual wheels to drive between windrows and feed the windrow centered on the feeder.

As with most pull-type combines, caution was required when crossing ditches or washouts. The straw chopper could easily contact the ground. The danger of ground contact and damage was even greater when the tailplate and windrow forming tines were in position for dropping straw.

The hydraulic hitch-pole positioning made it very easy to switch to field or transport position. In transport position the Cereal Implements 9850 transported well at speeds up to 20 mph (32 km/h).

Adjustment: Ease of adjusting the combine components was very good.

Pickup, cylinder and fan speeds were adjusted from the control console in the tractor cab, while concave spacing, sieve openings, and windboard settings were adjusted externally on the combine.

Auger finger timing and auger clearance were easily set and didn't need to be changed once properly adjusted. Both front and rear concave clearances were easy to access and quick and convenient to adjust. Five concave blanks could be easily engaged with levers on the side of the combine. The shoe was split down the center with left and right chaffer sieves and cleaning sieves, which had to be set independently. Chaffer and cleaning sieve adjustment was easy. Both could be adjusted from outside the combine without opening access panels. Changing the windboard settings by shifting levers in index holes was quick and easy.

Field Setting: Ease of setting to suit crop conditions was very good.

Some fine tuning was usually required after initial adjustments but ease of access for checking performance made this relatively easy. The large number of adjustment combinations meant that some experimenting was required to determine the effects in various crops.

Threshing and separation were easy to set for. The straw chopper was easily converted to drop straw for checking loss and the convenient adjustment of front and rear concave clearance enabled flexibility of adjustment for fine tuning.

Setting the shoe was very easy. Chaff was discharged in a slow “lofting” pattern. The effects of changing the fan blast, sieve openings or windboard position were easy to see. Clear access to the rear of the shoe made catching effluent easy, thus determining the amount and pattern of shoe loss was straightforward.

Returned tailings were easily and safely sampled (FIGURE 16) using the spring loaded chute at the bottom of the tailings elevator.

FIGURE 16. Tailings Sampling Chute.

Unplugging: Ease of unplugging was good.

An electric feeder reverser was supplied for unplugging the table auger and feeder. Nearly all table auger obstructions were easily backed out with the reverser. Only severe feeder plugging had to be cleared by hand.

A plugged cylinder could usually be cleared by lowering the concave fully and powering the obstruction through. For severe cylinder plugging, a breaker bar was supplied for reversing the cylinder. The bar was easy to use and effectively cleared a severely plugged cylinder.

Operation in weedy conditions and damp flax often resulted in tailings elevator plugging. Tailings elevator plugging was usually easy to clear if the operator responded promptly to the alarm.

Machine Cleaning: Ease of complete cleaning was good. Cleaning the grain tank was easy, as there were few ledges to hold grain. The sump retained only about 2 quarts (2 L) of grain; however, removing the sliding sump cleanout door was difficult and required a hammer and drift (FIGURE 17). It is recommended that the manufacturer consider modifications to the grain tank sump door to enable easier more convenient opening.

The sieves were easy to remove, and the tailings and clean grain auger troughs could be easily accessed through doors on the bottom of the auger troughs. The front of the grain pan under the concave was accessible through the large side panels, but the rear portion of the pan was difficult to reach for cleaning. Some chaff and dust built up on ledges on the combine and inside shields (FIGURE 18) but was not difficult to remove. The outside of the combine was easily cleaned. Dust and chaff stuck to oil that leaked from hydraulic fittings in the control bay, resulting in an accumulation that could only be properly removed with a high pressure washer.

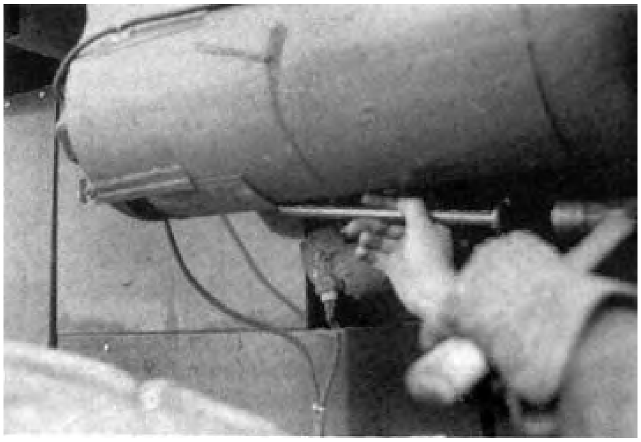

FIGURE 17. Sliding Sump Door.

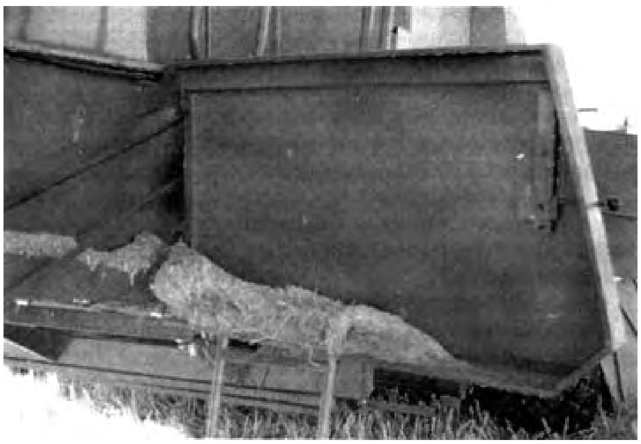

FIGURE 18. Chaff Inside Shields.

Lubrication: Ease of lubrication was very good.

Daily lubrication was quick and easy. There were only a few lubrication points and most were easily accessible. The combine had 46 pressure grease fittings. Thirteen required greasing at 10 hours, seventeen at 50 hours, an additional thirteen at 100 hours, and three more at 500 hours. Gearbox and hydraulic oil levels required regular checking.

Maintenance: Ease of performing routine maintenance was good.

The Cereal Implements 9850 was assembled with metric hardware.

Most drives on the combine had hinged shields, which enabled quick, easy access for checking and adjusting. However, a few shields were bolted or latched which made access inconvenient.

A tension gauge on the main drive belt idler provided a quick method for checking belt tension. Adjusting the tension on the main drive belt required a 24 mm and a 30 mm metric wrench. Adjustment took about ten minutes.

Slip clutches protected the PTO, table auger and feeder drives.

The table was easy to remove but complete table and feeder assembly removal was inconvenient. To detach the feeder, the steel pickup drive hydraulic lines had to be disconnected at the control bay. This necessitated draining the hydraulic reservoir. Once the lines were disconnected, feeder removal was easy. It is recommended that the manufacturer consider modifications to improve the ease of disconnecting the pickup hydraulic lines to permit quicker and more convenient feeder removal. With the feeder removed, the cylinder and concave were accessible and easy to remove and install.

POWER REQUIREMENTS

The manufacturer recommended a minimum tractor size of 130 PTO hp (97 kW) and suggests an optimum size of 165 PTO hp (123 kW). These recommendations are appropriate.

Input power measured in Katepwa wheat was 105 hp (78 kW) (FIGURE 19) at 610 lb/min (16.6 t/h) MOG, which was the combine's capacity for that crop.

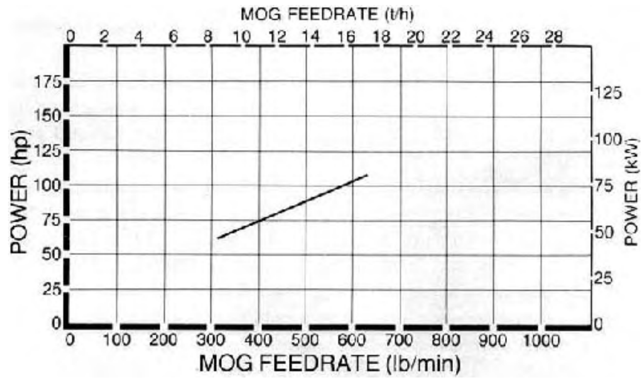

FIGURE 19. Power Requirement in Katepwa Wheat.

Additional tractor power was required to pull the combine with a full grain tank, especially in hills or soft ground. As well, extra power was required for hydraulic functions, harvesting tough crop, and unloading on-the-go. PAMI suggests that a tractor with at least 150 PTO hp (112 kW) is needed to adequately power the Cereal Implements 9850 in typical harvest conditions.

During the tests, the combine was powered with a two-wheel drive tractor rated at 165 PTO hp (123 kW). This tractor had adequate power for all conditions.

OPERATOR SAFETY

No safety hazards were apparent on the Cereal Implements 9850. However, normal safety precautions were required and warnings had to be heeded.

The operator's manual emphasized operator safety. The Cereal Implements 9850 had warning decals to indicate dangerous areas. All moving parts were well shielded.

A header lift cylinder safety stop was provided and should be used when working near the header or when the combine is left unattended.

The combine was equipped with hitch safety chains, a slow moving vehicle sign, warning lights, and a taillight to aid in safe road transport. However, care had to be taken when transporting as rear visibility was restricted.

If the operator must make adjustments or work in dangerous areas, all clutches should be disengaged and the tractor engine shut off. A fire extinguisher, class ABC, should be carried on the combine at all times.

OPERATOR'S MANUAL

The operator's manual was fair.

The manual was fairly well organized, but contained many vague, incomplete, and incorrect references. Several major components were referred to by different names. This often occurred from one statement to another, even on the same page. Some information was needlessly repeated, both within specific sections, and from one section to another. It is recommended that the manufacturer consider revising the operator's manual to provide complete and correct information in a logical format.

MECHANICAL HISTORY

The intent of the test was evaluation of functional performance. Extended durability testing was not conducted. However, TABLE 6 outlines the mechanical history of the Cereal Implements 9850 combine for the 123 hours of field operation during which about 1090 ac (443 ha) of crop were harvested.

Tensioning Spring Failures: Two springs maintained idler tension on the secondary power belt idler arm. Usually, a failure of one of these springs had little adverse effect on belt tension, but failure of both made continued operation impossible. No apparent cause for the repeated failures was found, and it is recommended that the manufacturer consider modifications to eliminate repeated failure of the secondary power belt idler arm tensioning springs.

Solenoid Failure: The solenoid, which controlled the separator clutch failed and caused a subsequent failure of the corresponding electronics. To be able to continue harvesting the solenoid valve was manually activated by turning a screw on the back of the valve block. The separator stayed engaged and was controlled by the PTO clutch. This procedure was not in the Operator's Manual.

Hydraulic Leaks: Oil leaked from several fittings and around the hydraulic oil filter mount. Despite several attempts to stop the leaks, they continued. It is recommended that the manufacturer consider modifications to prevent hydraulic oil leaks in the control bay.

TABLE 6. Mechanical History

Item	Operating Hours	Field Area ac	(ha)
Drives			
-The secondary power belt idler arm tensioning spring failed and was replaced at	47, 95, 101	480, 860, 910	(194, 347, 368)
-A gib key on the header drive shaft sheared off and damaged the shaft and pulley hub. It was replaced at	88	819	(331)
Electrical			
-The unloading auger light wiring contacted some moving belts under the grain tank and was damaged. The wiring was repaired and rerouted at	16	110	(44)
-The cylinder speed sensor loosened in its bracket causing erratic cylinder speed indication. The sensor was retightened at	50	505	(204)
-Dirt or corrosion caused the contacts in one of the grain tank level sensors to become intermittent. Repeated manual activation of the sensor restored contact continuity at	70	695	(281)
-The solenoid and associated electronics which engaged the separator failed and was replaced at	115	1020	(413)
Hydraulic			
-The hydraulic oil filter housing and valve stacks leaked oil from various points into the control bay	Throughout the Test		
-The reworked unloading auger drive cylinder, which was installed at 102 hours, initially failed to activate the drive unless another hydraulic function was momentarily activated at the same time. After a few hours of operation, it functioned properly	For the remainder of the Test		
Miscellaneous			
-The spot welds on the straw chopper drive shield hinges failed and were rewelded at	30	254	(103)
-The table auger finger crank roll pin sheared and was replaced at	56	545	(221)
-The set screw that keyed the hydraulic pickup speed control valve to its activating motor loosened causing loss of pickup speed control. The setscrew was secured in place at	59	564	(228)
-One side of the feeder chain "jumped" one tooth on its drive sprocket and was realigned at	75	750	(304)
-A loose bolt and weld failure allowed the end of one rasp bar to contact the concave, damaging both at	89	823	(333)

APPENDIX I
SPECIFICATIONS

MAKE:	Cereal Implements Pull-Type Combine
MODEL:	9850 - Series 64005
SERIAL NUMBER:	Header - 263478 Body - 64005-00010
MANUFACTURER:	Cereal Implements Box 3200, 1000 - 6th Avenue N.E. Portage la Prairie, Manitoba R1N 3R3

WINDROW PICKUP:

-- make	Victory “super 8”
-- type	rubber draper and transfer belts
-- pickup width	12 ft (3.7 m)
-- number of belts	8
-- type of teeth	plastic
-- number of rollers	4
-- height control	castoring gauge wheels
-- speed control	electric over hydraulic
-- speed range	0 to 600 ft/min (0 to 3.05 m/s)

HEADER:

-- type	centre feed
-- width	
- table	12.8 ft (3.9 m)
- feeder house	50.4 in (1280 mm)
-- auger diameter	22.6 in (574 mm)
-- feeder conveyor	3 roller chains with undershot slatted conveyor
-- conveyor speed	590 ft/min (3.0 m/s)
-- picking height range	+64 to -27 in (+1626 to -686 mm)
-- number of lift cylinders	2
-- raising time	4.7 s
-- lowering time	4.2 s
-- options	non-retracting auger fingers, flighting extensions

STONE PROTECTION:

-- type	sump
-- cleaning	manually operated access door

CYLINDER:

-- type	rasp bar
-- number of bars	6
-- diameter	17.8 in (451 mm)
-- width	51.3 in (1303 mm)
-- drive	variable pitch belt, torque sensitive tensioning
-- speed range	630 to 1490 rpm

CONCAVE:

-- type	bar and wire
-- number of parallel bars	12
-- number of wires	103
-- width	51.7 in (1313 mm)
-- radial length	19.2 in (487 mm)
-- wrap	106°
-- total area	991 in² (0.64 m²)
-- open area	558 in² (0.36 m²) (56%)
-- grain delivery to shoe	reciprocating grain pan

BEATER:

-- type	drum with 8 triangle bats
-- diameter	15 in (383 mm)
-- speed	1105 rpm
-- grate	
- type	finger bar, 0.3 x 9.9 in (8.2 x 252 mm)
- area total	- 643 in² (0.41 m²) open - 354 in² (0.23 m²) (55%)

STRAW WALKERS:

-- type	formed steel, multi-step, oblong openings
-- number	5
-- length	14.3 ft (4.4 m)
-- walker housing width	52 in (1320 mm)
-- separating area	8944 in² (5.77 m²)
-- crank throw (radius)	1.8 in (45 mm)
-- speed	220 rpm
-- grain delivery to shoe	closed bottom under last step of each walker and reciprocating grain pan
-- straw curtain	1, adjustable

SHOE:

-- type	sieves move in unison
-- speed	302 rpm
-- chaffer sieve and tailings sieve	
- type	adjustable louvre, regular tooth
- louvre spacing	1.15 in (29 mm) hinge, 0.87 in (22mm) teeth total 2542 in² (1.64 m²), tailings 868 in² (56 m²)
-travel	0.63 in (16 mm) vertical, 1.42 in (36 mm) horizontal
-- cleaning sieve	
- type	adjustable louvre, regular tooth
- louvre spacing	1.15 in (29 mm) hinge, 0.4 in (10 mm) teeth
-- area	2480 in² (1.6 m²)
-- travel	0.63 in (16 mm) vertical, 1.42 in (36 mm) horizontal

CLEANING FAN:

-- type	6 blade undershot
-- diameter	24 in (610 mm)
-- width	49.4 in (1255 mm)
-- drive	variable pitch belt
-- speed range	450 to 980 rpm

ELEVATORS:

-- type	roller chain with rubber paddles
-- clean grain (bottom drive)	6.4 x 9.3 in (163 x 236 mm)
-- tailings (bottom drive)	4.6 x 8.9 in (117 x 224 mm)

GRAIN TANK:

-- capacity	225 Imp bu (8.1 m³)
-- unloading time	130 s
-- unloading auger diameter	11.5 in (292 mm)
-- unloading auger length	189 in (4.8 mm)

STRAW CHOPPER:

-- type	hammer and knife
-- width	52.4 in (1330 mm)
-- speed	3125 rpm
-- option	straw spreader

CLUTCHES:

-- header	hydraulic belt tightener
-- separator	hydraulic belt tightener
-- unloading auger	hydraulic belt tightener

NUMBER OF CHAIN DRIVES:	5
NUMBER OF BELT DRIVES:	17
NUMBER OF GEARBOXES:	3

LUBRICATION POINTS:

-- annual 10 h	13
-- annual 50 h	17
-- annual 100 h	13
-- annual 500 h	3

TIRES:	two, 23.1 x 26, R3

OVERALL DIMENSIONS:

-- wheel tread	11.8 ft (3.6 m)
-- transport height	12.1 ft (3.7 m)
-- transport length	41.3 ft (12.6 m)
-- transport width	16.7 ft (5.1 m)
-- field height	12.1 ft (37 m)
-- field length	40.3 ft (12.3 m)
-- field width	20.2 ft (6.2 m)
-- unloader discharge height	12.0 ft (3.7 m)
-- unloader reach (in line with hitch pin)	5.5 ft (1.7 m)
-- unloader clearance	10.9 ft (3.3 m)

WEIGHT:

-- right wheel	7,650 lb (3,470 kg)
-- left wheel	8,228 lb (3,732 kg)
-- hitch	1,265 lb (574 kg)
TOTAL	17,143 lb (7,776 kg)

APPENDIX II

PAMI REFERENCE COMBINE CAPACITY RESULTS

TABLE 7 and FIGURES 20 and 21 present the capacity results for the PAMI reference combines in barley and wheat crops harvested from 1984 to 1987.

FIGURE 20 shows capacity differences in barley crops for 1984, 1986 and 1987. The 1987 Argyle barley crop shown in TABLE 7 had average grain and straw yield and average straw and grain moisture.

FIGURE 21 shows capacity differences in wheat crops for the three years. In 1987, the Katepwa wheat crops had below average straw yield, and average grain yield. They also had average grain moisture and slightly below average straw moisture content.

Results show that the reference combine is important in determining the effect of crop variables and in comparing capacity results of combines evaluated in different years.

TABLE 7. Capacity of the PAMI Reference Combines at a Total Grain Loss of 3% Yield

				Crop Conditions							Capacity Results									
				Width of Cut		Crop Yield		Moisture Content		MOG/G Ratio	MOG Feedrate		Grain Feedrate		Total Feedrate		Grain Cracks %	Dock-age %	Foreign Material %
		Crop	Variety	ft	m	bu/ac	t/ha	Straw %	Grain %		lb/min	t/h	bu/h	t/h	lb/min	t/h			
REF II	1987	Barley	Argyle	24	7.2	69	3.5	12.6	13.0	0.82	395	10.8	600	13.1	876	23.8	0.5	1.5	1.2
		Barley	Harrington	20	6.4	79	4.3	7.7	10.8	0.81	370	10.1	570	12.4	825	22.5	1.5	3.0	0.1
		Wheat	Columbus	25	7.6	43	2.9	5.0	13.4	1.16	540	14.7	465	12.7	1005	27.4	1.5	3.5	0.1
		Wheat	Katepwa"A"	40	12.2	31	2.2	6.9	12.9	0.65	520	14.2	800	21.8	1320	35.9	1.5	2.5	0.2
		Wheat	Katepwa"B"	60	18.3	37	2.6	8.3	14.5	0.64	580	15.8	905	24.6	1485	40.4	2.0	2.0	0.1
		Wheat	Katepwa"C"	60	18.3	31	2.1	12.8	16.0	1.07	630	17.2	590	16.1	1220	33.2	1.5	1.5	0.1
	1986	Barley	Harrington	56	17.0	62	3.3	10.5	10.8	0.64	424	11.6	828	18.1	1090	29.7	0.4	0.3	0.2
		Wheat	Columbus	56	17.0	51	3.4	8.8	16.7	1.14	647	17.7	568	15.5	1210	33.0	1.5	4.6	3.5
		Wheat	Katepwa	29	8.9	49	3.3	6.5	14.0	1.32	644	17.6	488	13.3	1135	31.0	1.8	1.7	1.0
	1984	Barley	Bonanza	42	12.8	52	2.8	15.0	11.2	0.70	363	9.9	648	14.1	875	23.8	0.5	1.0	
		Barley	Bonanza	24	7.3	77	4.1	11.3	11.6	0.66	352	9.6	687	14.6	880	24.0	0.5	1.0	
		Wheat	Neepawa	44	13.4	36	2.4	6.3	10.9	1.32	539	14.7	408	11.1	950	25.9	1.1	5.5	
		Wheat	Neepawa	22	12.8	44	3.0	8.7	10.2	1.18	601	16.4	509	13.9	1110	30.3	4.5	7.0	
REF I	1986	Barley	Harrington	28	8.5	59	3.7	10.5	9.2	0.56	294	8.0	656	14.3	820	22.3	0.8	0.5	0.2
		Wheat	Columbus[1]	42	12.8	32	2.2	11.8	14.7	1.09	438	12.0	402	11.0	835	22.8	1.2	4.9	3.0
		Wheat	Katepwa	29	8.9	50	3.4	7.5	14.1	1.33	420	11.5	316	8.6	735	20.1	1.3	1.5	0.7
	1985	Barley	Argyle	60	18.0	75	4.0	25.5	11.4	0.94	293	8.0	390	8.5	600	16.4	2.0	1.0	0.4
		Barley	Bonanza	55	16.8	83	4.5	21.0	15.0	0.76	285	7.7	469	10.2	660	18.0	1.0	1.7	1.2
		Wheat	Neepawa	42	12.8	42	2.8	23.7	18.0	1.43	391	10.7	273	7.5	660	18.0	4.9	2.3	0.2
		Wheat	Katepwa	41	12.5	82	4.2	24.8	18.5	0.95	435	11.9	458	12.5	890	24.3	2.5	1.3	0.2
	1984	Barley	Bonanza	42	12.8	68	3.7	18.5	12.9	0.74	275	7.5	464	10.1	645	17.6			
		Barley	Bonanza	24	7.3	85	4.8	12.0	12.1	0.62	213	5.8	429	9.4	550	15.0			
		Wheat	Neepawa	44	13.4	42	2.8	6.7	11.8	1.47	308	8.4	209	5.7	510	13.9			
		Wheat	Neepawa	42	12.8	41	2.8	8.5	10.3	1.17	356	9.7	304	8.3	655	17.9			
		Wheat	Neepawa	42	12.8	23	1.8	7.2	12.5	0.99	345	9.4	348	9.5	695	19.0			

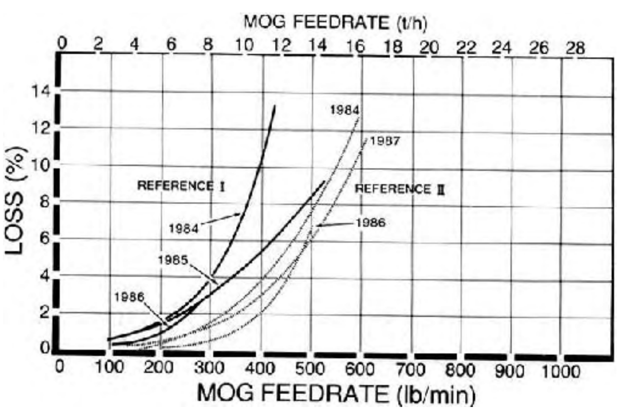

FIGURE 20. Total Grain Loss for the PAMI Reference Combines in Barley.

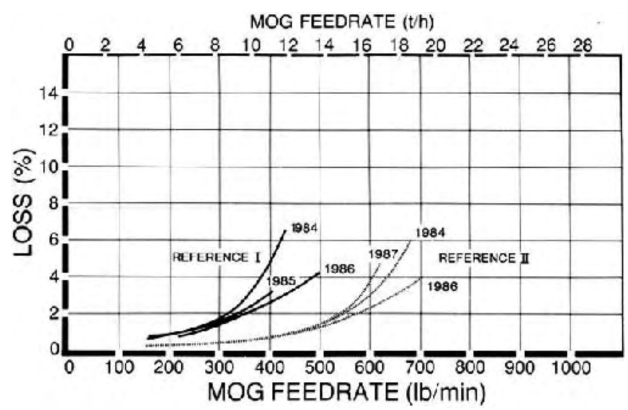

FIGURE 21. Total Grain Loss for the PAMI Reference Combines in Wheat.

APPENDIX III

REGRESSION EQUATIONS FOR CAPACITY RESULTS

Regression equations for the capacity results shown in FIGURES 2 to 5 are presented in TABLE 8. In the regressions, U = unthreshed loss in percent of yield, S = shoe loss in percent of yield, W = walker loss in percent of yield, F = the MOG feedrate in lb/min, while $\ln$ is the natural logarithm. Sample size refers to the number of loss collections. Limits of the regressions may be obtained from FIGURES 2 to 5 while crop conditions are presented in TABLE 3.

TABLE 8. Regression Equations

Crop - Variety	Figure Number	Regression Equations	Simple Correlation Coefficient	Variance Ratio	Sample Size
Barley - Argyle	2	$U = 0.11 + 5.55 \times 10^{-4}F^{1}$ $S = 0.10 + 1.84 \times 10^{-15}F^{5}$ $W = -0.02 + 8.77 \times 10^{-14}F^{5}$	0.36 0.93 0.99	3.41 75.69[2] 481.70[2]	8
Barley - Harrington	3	$U = 0.12 + 2.58 \times 10^{-14}F^{5}$ $S = 0.26 - 8.61 \times 10^{-10}F^{3}$ $\ln W = -3.43 + 1.25 \times 10^{-2}F$	0.88 0.15 0.95	35.34[2] 0.85 95.83[2]	8
Wheat - Columbus	4	$\ln U = -2.01 + 4.57 \times 10^{-3}F$ $S = 0.17 + 5.16 \times 10^{-15}F^{5}$ $\ln W = -7.62 + 1.83 \times 10^{-2}F$	0.67 0.92 0.85	10.14[1] 56.79[2] 27.41[2]	8
Wheat - Katepwa	5	$\ln U = -7.37 + 9.54 \times 10^{-1}\ln F$ $S = 0.23 + 2.63 \times 10^{-15}F^{5}$ $\ln W = -41.56 + 6.60\ln F$	0.34 0.71 0.89	2.57 12.05[1] 41.63[2]	8

[1]Significant at $P \leq 0.05$
[2]Significant at $P \leq 0.01$

APPENDIX IV
MACHINE RATINGS

The following rating scale is used in PAMI Evaluation Reports:

Excellent	Fair
Very Good	Poor
Good	Unsatisfactory

SUMMARY CHART
CEREAL IMPLEMENTS 9850 PULL-TYPE COMBINE - Series 64005

RETAIL PRICE	$92,500.00 (March, 1989, f.o.b. Humboldt, Sask.)
CAPACITY	
Compared to Reference Combine	
- barley	0.90 to 1.20 x Reference II, 1.30 to 1.70 x Reference I
- wheat	0.90 to 1.10 x Reference II, 1.40 to 1.70 x Reference I
MOG Feedrates	
- barley - Argyle	490 lb/min (13.3 t/h) at 3% total loss, FIGURE 2
- Harrington	345 lb/min (9.4 t/h) at 3% total loss, FIGURE 3
- wheat - Katepwa “A”	445 lb/min (12.1 t/h) at 3% total loss, FIGURE 4
- Katepwa “B”	610 lb/min (16.6 t/h) at 3% total loss, FIGURE 5
QUALITY OF WORK	
Picking	**Very Good;** picked cleanly, moved material smoothly to table auger
Feeding	**Very Good;** feeding was aggressive, some wrapping in tough flax
Stone Protection	**Good;** stone trap stopped most stones
Threshing	**Good;** aggressive settings required for some conditions, low unthreshed loss
Separating	**Good;** walker loss limited capacity
Cleaning	**Very Good;** low loss, clean tank sample
Grain Handling	**Good;** tank filled unevenly in some crops
Straw Spreading	**Good;** spread up to 25 ft (7.6 m)
EASE OF OPERATION AND ADJUSTMENT	
Hitching	**Fair;** required three-point hitch adapter
Operator Comfort	Depends on tractor
Instruments	**Good;** indicated slowdowns of critical shafts
Controls	**Fair;** difficult to identify and operate, some controls respond erratically
Loss Monitor	**Fair;** useful when calibrated to combine loss, lacks adequate adjustment range
Lighting	**Good;** forward, grain tank and unloader lighting provided
Handling	**Very Good;** unique hitch enabled sharp turns
Adjustment	**Very Good;** all adjustments convenient
Field Setting	**Very Good;** fine tuning easily performed
Unplugging	**Good;** reverser effective
Cleaning	**Good;** grain tank unobstructed and most areas accessible
Lubrication	**Very Good;** all lubrication points accessible
Maintenance	**Fair;** components accessible but feeder inconvenient to remove
POWER REQUIREMENTS	The manufacturer recommends a 165 PTO hp (123 kW) tractor as optimum
OPERATOR SAFETY	All moving parts were shielded
OPERATOR’S MANUAL	**Fair;** inconsistent and incomplete, some incorrect references
MECHANICAL HISTORY	A few mechanical problems

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