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Evaluation Report 649

Ford New Holland TR96

A Co-operative Program Between

ALBERTA FARM MACHINERY RESEARCH CENTRE

PAMI PRAIRIE AGRICULTURAL MACHINERY INSTITUTE

NEW HOLLAND TR96 SELF-PROPELLED COMBINE

MANUFACTURER:
Ford New Holland, Inc.
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DISTRIBUTORS:
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RETAIL PRICE:
$168,940.00 [March, 1991, f.o.b. Humboldt, Sask., with a 13 ft (4.0 m) header, 11.7 ft (3.6 m) Victory pickup, variable speed feeder, feeder jack stand, electronic stone detection, hydraulic feeder reverser, rotor separating agitating kit, Petersen chaffer, slow speed fan kit, 30.5 L x 32, R1 drive tires, 14.9 x 24, R3 steering tires, grain loss monitor, starting fluid injector kit, AM-FM radio, heater, air conditioner, large windshield wiper, and portable service light].

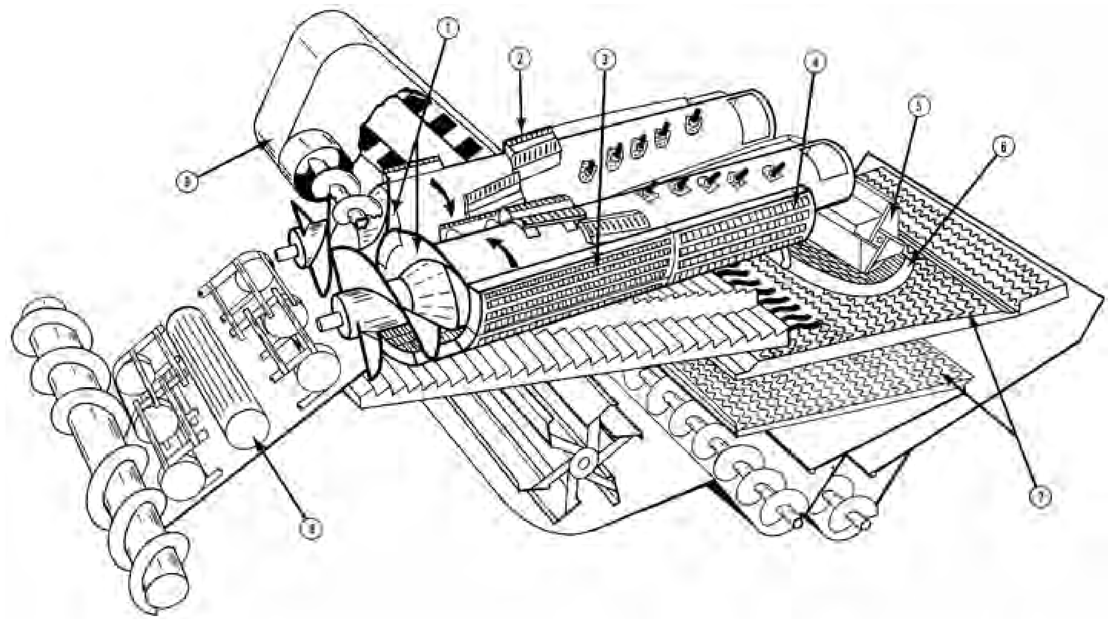

FIGURE 1. New Holland TR96: (1) Rotors, (2) Rasp Bars, (3) Threshing Concave, (4) Separating Concave, (5) Discharge Beater, (6) Beater Grate, (7) Cleaning Shoe, (8) Stone Ejection Roller, (9) Tailings Return.

SUMMARY AND CONCLUSIONS

Capacity: In the capacity tests, the MOG Feedrate* at 3% total grain loss in Harrington and Heartland barley was 755 lb/min (20.5 t/h) and 865 lb/min (23.5 t/h), respectively. Combine capacity was 910 lb/min (24.8 t/h) and 1440 lb/min (39.2 t/h) in Katepwa and Biggar wheat.

In the barley tests the New Holland TR96 had about 2.4 times the capacity of the PAMI Reference II combine when compared at 3% total grain loss. In the wheat tests, the capacity of the New Holland TR96 was about 1.7 times that of the Reference II in the Katepwa crop and 2.5 times in the Biggar crop.

Quality of Work: Picking performance was good. The pickup picked cleanly in all reasonably well supported windrows and no plugging occurred.

Feeding was good. Although critical settings were required the table auger and feeder were aggressive, feeding crop smoothly and seldom plugging. The stone trap provided good stone protection and often prevented dense wads of crop from entering the rotors. Objects up to 6 in (152 mm) in diameter were ejected from the feeder. No rasp bar or concave damage was noticed.

Threshing was very good. The rotors and concaves were aggressive resulting in low unthreshed losses in all crops encountered. Crop fed smoothly into and through the rotor cages in nearly all conditions encountered. The rotors did not plug at any time during the test.

Separating was very good. Free grain loss from the rotors constituted the majority of total grain loss but was usually 1.5% or less when engine power limit was reached.

Cleaning shoe performance was excellent. Shoe loss was very low in all crops when the material was distributed uniformly onto the grain pan.

Clean grain handling was good. The 240 bu (8.7 m³) grain tank filled evenly in all crops. The unloading auger had adequate reach but excessive clearance for most trucks and trailers encountered. The auger discharged the grain in a compact stream and unloaded a full tank of dry wheat in about 130 seconds. Unloading without loss in windy conditions was difficult when using only the standard discharge spout.

Straw spreading was good. Straw was spread evenly up to a maximum of 22 ft (6.7 m). Only a small portion of the chaff was spread with the straw.

Ease of Operation and Adjustment: Operator comfort was very good. The cab was clean, quiet and was well suited for one person. The air conditioner and heater provided comfortable cab temperatures. The seat and steering column were adjustable to suit most operators. The operator had a clear view forward and to the sides and large convex mirrors were provided for rear visibility. View of the incoming swath was only blocked slightly by the steering wheel.

Instrumentation was very good. All important machine and engine functions were monitored with a combination of gauges, digital displays, warning lights and audio alarm. The vertical console to the right of the operator contained most routinely checked operating information and was convenient to view. The horizontal console, to the right of the operator contained mainly engine instrumentation. It was slightly less convenient to view. The controls were very good. Most of the controls were located to the right of the operator with only a few to the left, on the floor, in the steering console and above the operator. The frequently used controls were conveniently located close to the operator while the

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

less frequently used controls were placed out of the way. Mechanical controls were used for the engagement of combine functions while electrical controls were used for some hydraulics and for adjusting component speeds. The floor mounted unloading auger position control was very convenient to use.

The loss monitor was fair. The combine loss monitor could be operated in either a time or an area base mode. The loss monitor gave accurate indication of shoe toss. However, the loss monitor did not give accurate indications of total combine performance since rotor loss was not monitored.

Lighting was very good. Short, medium and long range lighting was very good for the pickup header and could be adjusted to suit wider headers. The portable service light was very handy.

Handling was excellent. The quick steering response and short turning radius allowed the New Holland TR96 to pick around sharp windrow corners without the aid of wheel brakes. The hydrostatic control was smooth and responsive and the gear ratios were appropriate for suitable harvest speeds. The combine was stable in the field and while transporting.

Ease of adjustments was good. Most components were very easy to adjust from the cab. However, the tailing sieve was inconvenient to adjust when it was set at the lower slope. Accurately gauging the clearance between the rotors and concaves was difficult. Ease of setting the components to suit crop conditions was very good. Once familiar with the combine's performance setting was quick and little fine tuning was required. Ease of unplugging was very good. The header reverser backed material from the header and also enabled feeding material slowly into the combine. The rotors did not plug at any time during the test. Opening the lower access door usually allowed the tailings return to clear when reengaged. Occasionally material between the auger flighting and elevator paddles had to be removed by hand. Ease of cleaning the combine was good. The open grain tank was unrestricted which made cleaning easy. Restricted access to the bubble-up auger sump and tailings return auger made cleaning inconvenient.

Ease of lubrication was good. Daily lubrication was quick and easy. Ease of performing routine maintenance was good although changing oil in the final drives and rotor gear cases was difficult. Most belts had spring loaded idlers and the chain drives had draw bolt tighteners for simplified maintenance.

Engine and Fuel Consumption: The engine started quickly and ran well. It had adequate power for conditions encountered with sufficient torque reserve to recover from overloading. Average fuel consumption was 7.5 gal/h (34.2 L/h) and oil consumption was insignificant.

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

Operator's Manual: The operator's manual was very good. The manual was clearly written and the table of contents and index made finding material easy. A separate engine manual and 971 header operator's manual were supplied.

Mechanical History: A few mechanical problems occurred during the test.

RECOMMENDATIONS:

It is recommended that the manufacturer consider:

1. Modifications to prevent the tailings return from plugging.
2. Providing a header tilt switch that is less prone to snagging or relocate it to a more protected position.
3. Providing an indicator for feeder speed or to show relative feeder speed adjustment.
4. Adding the capability to monitor grain loss from the rotors.
5. Modifications to provide adequate clearance between the front feeder drum and face plates to allow the drum to be operated in the most forward position.
6. Modifications to improve the ease of adjusting the distribution plates and to prevent interference between the right front distribution plate adjusting rod and the header drive belt.
7. Modifications to prevent the tailings return door from extending beyond its guides.
8. Providing a safe convenient method for sampling the return tailings.
9. Modifications to provide easy access to the tank loading auger sump door.
10. Modifications to provide easier adjustment of the tailings return elevator chain.

Senior Engineer: J.D. Wassermann
Harvesting Manager: L.G. Hill
Project Engineer: S.J. Grywacheski

THE MANUFACTURER STATES THAT

With regard to recommendation number:

1. Changes have been made for 1991 production to reduce tailings return plugging. Further changes will continue to be investigated.
2. A new heavier switch with rounded edges has been released for 1991 production and Service Parts.
3. The feeder speed indicator is available in Service Parts as an option.
4. There are no current plans to add a sensor for rotor loss.
5. This is under design consideration.
6. This will be investigated for future design changes.
7. This will be investigated for future design changes.
8. There are no plans for change in this area.
9. This will be investigated for future design changes.
10. A new tailings return elevator chain adjustment is under test.

GENERAL DESCRIPTION

The New Holland TR96 is a self-propelled combine with two axial mounted rotors, threshing and separating concaves, a discharge beater, and a cleaning shoe. The closed tube rotors are mounted beside each other. The front of the rotors have auger flighting followed by six sets of spiralled, segmented and staggered rasp bars. Behind the rasp bars are two rows of five agitator pins located between the two spiralled separating blades. The threshing and separating concaves and discharge beater grates are a bar and wire design. The cleaning fan is a six-blade paddle fan. The grain pan and chaffer are a single unit that moves in opposed motion to the cleaning sieve.

As crop travels up the feeder, it passes over a stone sensor, which can open the stone ejection door. Also located in the feeder house is a powered stone roller which can also trip the stone ejection door located directly below it.

The spiralled auger flighting on the front of the rotors divide the crop and pull it into the threshing section of the rotors (FIGURE 2).

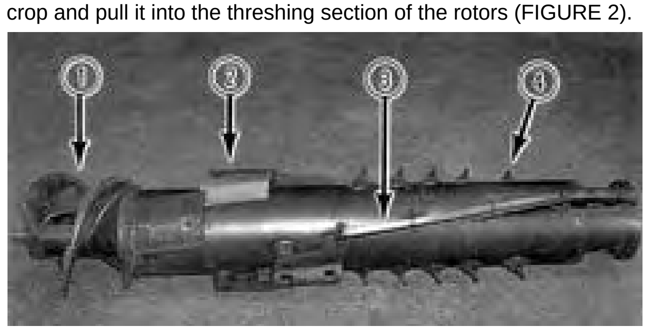

FIGURE 2. "S" Cubed Rotor: (1) Intake Flighting and Wear Plate, (2) Rasp Bars, (3) Separating Blades, (4) Agitating Pins.

The rotors and guide vanes in the rotor cages (FIGURE 3) spiral the crop rearward. Most of the threshing takes place at the front of the rotors while grain separation occurs along the full length of the threshing and separating concaves. The straw is discharged at the end of the rotors into a discharge beater, which sweeps the straw over a grate for final separation and propels the crop out of the combine or into the spreaders. Separated material is directed onto an oscillating grain pan by the adjustable distribution plate beneath the concaves. The material is delivered to the cleaning shoe where air and mechanical sieving action provide final cleaning. The tailings are returned to the front of the rotors.

The test machine was equipped with a 240 hp (179 kW) Ford inline, six cylinder, turbocharged diesel engine; a 13 ft

(4 m) header; an 11.7 ft (3.6 m) Victory pickup; and other optional equipment (FIGURE 1). The New Holland TR96 has a pressurized operator’s cab, power steering, hydraulic wheel brakes, four-speed transmission and a hydrostatic traction drive.

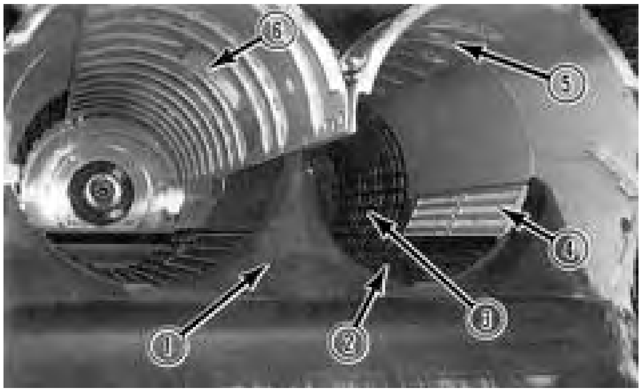

FIGURE 3. Rotor Cage: (1) Dividing Plate, (2) Threshing Concave, (3) Separating Grates, (4) Concave Extensions, (5) Guide Vanes, (6) Return Inlet.

The separator, header, and unloading auger drives are manually engaged. Header height and unloading auger swing are hydraulically controlled. Rotor RPM, pickup speed, cleaning fan RPM, feeder RPM, feeder reverser, and concave clearance are adjusted within the cab. Cleaning shoe adjustments are performed at the rear of the machine. There is no provision to safely and conveniently inspect the return tailings while operating. Important component speed and alarms are displayed by electronic monitors in the cab.

Detailed specifications are given in APPENDIX I.

SCOPE OF TEST

The machine evaluated by PAMI was configured as described in the General Description, FIGURE 1 and Specifications section of this report. The manufacturer may have built different configurations of this machine before or after PAMI tests. Therefore, when using this report, check that the machine under consideration is the same as the one reported here. If differences exist, assistance can be obtained from PAMI or the manufacturer to determine changes in performance.

The main purpose of the test was to determine the functional performance of the New Holland TR96. Measurements and observations were made to evaluate the New Holland TR96 for rate of work, quality of work, ease of operation and adjustment, operator safety, and the suitability of the operator’s manual. Although extended durability testing was not conducted, the mechanical failures were recorded.

The New Holland TR96 was operated for 119 hours while harvesting approximately 1125 ac (455 ha) of various crops. The crops and conditions are shown in TABLES 1 and 2. Capacity tests were conducted in two barley crops and two wheat crops, and a comparison between the Petersen and standard chaffers was performed in barley.

TABLE 1. Operating Conditions

Crop	Variety	Yield Range		Cut Width		Sep.	Field Area		Crop Harvested	
		bu/ac	t/ha	ft	m	hrs	ac	ha	bu	t
Barley	Bonanza	50-79	2.7-4.3	30	9.1	3.5	30	12	1910	42
	Harrington	56-67	3.0-3.6	21,30	6.4,9.1	9.0	90	36	5415	118
	Heartland	90-110	4.8-5.9	21	6.4	8.5	75	30	7200	157
	Virden	67-91	3.6-4.9	25	7.6	7.0	45	18	3935	86
Canola	Tobin	20-30	1.1-1.7	30	9.1	5.5	50	20	1325	30
	Westar	25-40	1.4-2.2	25	7.6	25.0	220	89	6925	157
Flax	Norlin	25-28	1.4-1.5	18,24, 30	5.5,7.3, 9.1	13.0	135	65	4135	105
Rye	Gazelle	35-52	2.2-3.3	22	6.7	6.0	55	22	2340	59
	Musketeer	20-35	1.3-2.2	21, 24	6.4, 7.3	6.5	85	35	2635	67
Wheat	Biggar	60-90	4.0-6.1	24	7.3	1.0	10	4	665	18
	Katepwa	35-60	2.4-4.0	18, 22, 25, 30	15.5, 6.7, 7.6, 9.1	31.0	290	118	14575	397
	Norstar	20-28	1.3-2.0	30	9.1	3.0	40	16	920	25
Total						119.0	1125	455	51980	1261

TABLE 2. Operation in Stony Conditions

Field Conditions	Hours	Field Area	
		ac	ha
Stone Free	86	815	330
Occasional Stones	21	200	81
Moderately Stony	12	110	44
Total	119	1125	455

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 the “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 lb (22.7 kg) of straw for every 100 lb (45.4 kg) of grain harvested. However, in a crop with a 1.5 MOG/G ratio for a similar 100 lb (45.4 kg) of grain harvested the combine now has to handle 150 lb (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. For this reason, PAMI is now including a comparison at 1.5% total loss, which may reflect a more realistic operating loss as machines and crops have been improved.

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 conditions suitable for the evaluation combines. PAMI changed its reference combine to better handle these conditions. The new reference combine is a John Deere 7720 Titan II 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. Combines appearing in reports printed in 1986 or earlier have been compared to Reference I (Old Reference) and combines appearing in reports printed in 1987 or later are compared to Reference II.

RATE OF WORK

Capacity Test Results: The capacity test results for the New Holland TR96 are summarized in TABLE 3.

TABLE 3. Capacity of TR96 at a Total Loss of 1.5 and 3% of Yield

CROP CONDITIONS									
Crop	Variety	Cut Width		Crop Yield		Moisture Content		MOG/G Ratio	Figure Number
		ft	m	bu/ac	t/ha	Straw %	Grain %		
Barley	Harrington	30	9.2	50	2.7	6.1	10.8	0.83	4
Barley	Heartland	25	7.7	107	5.8	8.8	12.5	0.71	5
Wheat	Biggar	24	7.4	82	4.4	11.6	15.5	0.96	6
Wheat	Katepwa	24	7.4	34	1.8	4.1	13.0	1.40	7

CAPACITY AT 3%										
Crop	Variety	Feedrates						Grain Cracks	Dock-age	Foreign Material
		MOG		Grain		Total				
		lb/min	t/h	bu/h	t/h	lb/min	t/h	%	%	
Barley	Harrington	755	20.5	1134	24.7	1660	45.2	0.4	1.2	0.8
Barley	Heartland	865	23.5	1519	33.1	2080	56.6	0.3	3.0	2.7
Wheat	Biggar	1440[1]	39.2	1500	40.8	2940	80.0	0.3	3.4	2.2
Wheat	Katepwa	910[2]	24.8	650	17.7	1560	42.5	1.0	4.3	0.6

CAPACITY AT 1.5%										
Crop	Variety	Feedrates						Grain Cracks	Dock-age	Foreign Material
		MOG		Grain		Total				
		lb/min	t/h	bu/h	t/h	lb/min	t/h	%	%	
Barley	Harrington	630	17.1	950	20.7	1390	37.8	0.4	1.2	0.5
Barley	Heartland	800	21.8	1410	30.7	1925	52.4	0.3	3.0	2.7
Wheat	Biggar	1440[1]	39.2	1500	40.8	2940	80.1	0.3	3.4	1.5
Wheat	Katepwa	785	21.4	560	15.2	1720	46.8	1.2	4.3	0.6

[1]Capacity at Power Limit and 0.9% Total Loss
[2]Capacity at Power Limit and 2.4% Total Loss

The performance curves for the capacity tests are presented in FIGURES 4 to 7. The performance curves are plots of rotor, shoe, unthreshed and total grain loss for a range of MOG feedrates. From the graphs, combine capacity can be determined at various loss levels. The rate at which loss changes with respect to feedrate shows where the combine can be operated effectively. Portions of the curves which are "flat" or slope gradually indicates stable performance. Where the curves hook up 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.

The Harrington barley crop used for the test came from a uniform stand on a slightly sloping field. The crop was cut a day before the test was performed. The windrow was fluffy and exceeded the width of the feeder house. Both the straw and grain were very dry. The grain yield was slightly below average and the MOG/G ratio was typical. The 30 ft (9.1 m) windrows enabled high MOG feedrates without travelling at high ground speeds. In areas where the crop was extremely fluffy maximum feedrate was limited by the feeder. The grain was easy to thresh and the awns were easily removed.

For this capacity test the concave wires were not removed and the Petersen chaffer was installed. MOG feedrate at 3% loss was 755 lb/min (20.5 t/h). Higher feedrates could easily be reached without experiencing power or feeding limit, but loss levels were unacceptable. This indicated that in these conditions typical harvesting rates would likely be in the 500 to 600 lb/min (13.6 to 16.4 t/h) range. Rotor loss became the largest component of loss at MOG feedrates higher than 400 lb/min (10.9 t/h) and increased sharply with an increase in MOG feedrate. Shoe loss was stable and remained low through the entire range of MOG feedrates. Unthreshed loss was insignificant staying below 0.1% throughout the test. The rotor loss may have been lowered if concave wires were removed, but the break-up of dry straw would have increased the cleaning shoe load, which may have reduced shoe performance.

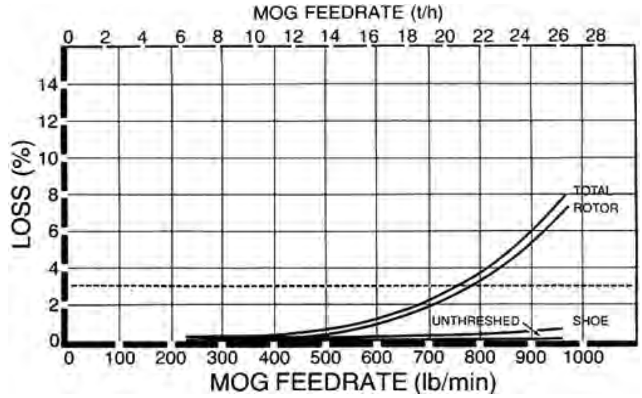

FIGURE 4. Grain Loss in Harrington Barley.

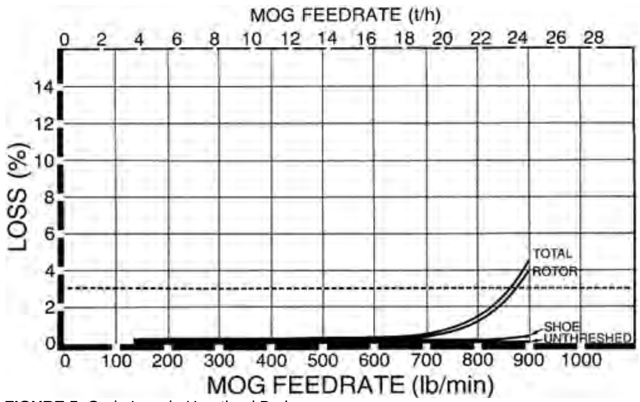

FIGURE 5. Grain Loss in Heartland Barley.

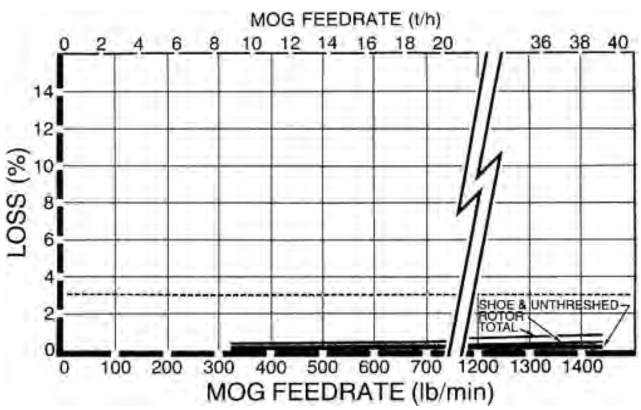

FIGURE 6. Grain Loss in Biggar Wheat.

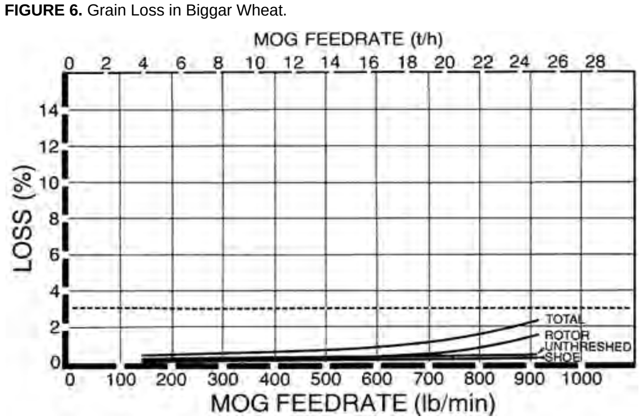

FIGURE 7. Grain Loss in Katepwa Wheat.

The Heartland barley crop chosen for the test came from a uniform, heavy stand. The crop was cut some time before the test but had not been rained on prior to testing. The windrow was slightly wider than the feeder and very uniform, with the straw lying parallel to the direction of travel. The crop yield was well above average with an average MOG/G ratio. Straw and grain moisture contents were average. The grain threshed easily and the awns broke off readily.

During this capacity test, every third concave wire was removed in the middle section of the threshing concaves, every second wire was removed in the rear section of the threshing concaves, and the Petersen chaffer was installed. The MOG feedrate at 3% total loss was 863 lb/min (23.5 t/h). Rotor loss was the greatest component of total loss but was low and stable at MOG feedrates up to 750 lb/min (20.5 t/h). Rotor loss increased significantly at higher feedrates and limited capacity. Shoe loss was low over the entire operating range. Un-threshed loss was also very low and insignificant. With the concave wires removed more awns remained on the kernels, which made up about 2% of the foreign material in the clean grain sample.

The MOG feedrate at 3% total loss was 865 lb/min (23.5 t/h). However, this was near the power limit and would likely trigger the low speed alarms. To prevent alarm triggering, a more practical operating MOG feedrate would be about 800 lb/min (21.8 t/h) with a corresponding total loss of 1.5%.

The Katepwa wheat was from a mature, light to average stand. The windrow was uniform with the straw lying at a slight angle to the direction of travel. The windrows were about the same width as the feeder. The crop was cut approximately one week before testing and had not been rained upon. The crop yield was slightly below average while the MOG/G ratio was much higher than typical. Straw and grain moisture were low. The dry straw condition contributed to high straw break-up but threshing difficultly was typical for Katepwa wheat.

No concave blanks were used. The Petersen chaffer was installed. The maximum feedrate attainable was limited by engine power. This occurred at a MOG feedrate of 910 lb/min (24.8 t/h) with a total grain loss of 2.4%. Rotor, shoe and unthreshed loss were equal up to a MOG feedrate of 600 lb/min (16.3 t/h), beyond this, rotor loss became the major loss but was stable while shoe and unthreshed loss remained low. Typical operation would be in the 600 to 800 lb/min (16.4 to 21.8 t/h) MOG range, which would be at generally accepted loss.

A second wheat test was performed in Biggar wheat, which is a semi dwarf, red Canada Prairie Spring wheat. The grain yield was high with an average MOG/G ratio. The windrow was uniform and of a similar width as the feeder. Straw and grain moisture contents were average. The straw break-up was average and the grain easy-to-thresh.

The Petersen chaffer sieve was used in this test. The maximum feedrate was limited by engine power, which occurred at a MOG feedrate of 1440 lb/min (39.2 t/h) with a total grain loss of 0.9%. Rotor, shoe and unthreshed loss contributed almost equally to the total loss over the full range of feedrates. In these conditions, most operators would probably operate most comfortably at about 1100 to 1200 lb/ min (30 to 33 t/h) MOG. Losses would be minimal.

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 workrate 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 factors. There are many other crop and field conditions, which affect workrates. As well, operating at different loss levels, availability of grain handling equipment, and differences in operating habits can have an important effect.

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. Note that 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.

TABLE 4. Field Workrates

Crop	Average Workrate	Grain Feedrate		Area Rate		Associated Conditions				
						Width of Cut		Yield		Variety
		bu/h	t/h	ac/h	ha/h	ft	m	bu/ac	t/ha	
Barley	High	970	21.1	10.1	4.1	20	6.1	96	5.5	Heartland
	Low	520	11.3	8.9	3.6	21	6.4	59	3.4	Harrington
	Season	680	14.8	8.6	3.5			77	4.4	
Canola	High	330	7.2	10.9	4.4	24	7.3	30	1.7	Westar
	Low	190	4.1	7.5	3.0	24	7.3	25	1.4	Westar
	Season	270	5.9	9.0	3.6			30	1.7	
Flax	High	370	8.1	10.5	4.3	30	9.1	36	2.1	Norlin
	Low	285	6.2	9.8	4.0	24	7.3	30	1.7	Norlin
	Season	320	7.0	10.5	4.3			30	1.7	
Rye	High	535	11.6	15.3	6.2	22	6.7	40	2.5	Musketeer
	Low	320	7.0	8.6	3.5	22	6.7	32	1.8	Musketeer
	Season	390	8.5	11.4	4.6			35	2.0	
Wheat	High	740	16.1	10.3	4.2	24	7.3	71	4.1	Biggar
	Low	280	6.1	11.7	4.7	30	9.1	24	1.4	Norstar
	Season	485	10.6	9.6	3.9			48	2.8	

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 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 1.5 to 1.6 times the capacity of Reference I in wheat and about 1.4 to 1.5 times Reference I's capacity in barley.

Capacity Compared to Reference Combine: The capacity of the New Holland TR96 was much greater than the PAMI Reference II combine in the wheat and barley crops. The New Holland TR96 had 2.4 times the capacity of the Reference II combine in Harrington and Heartland barley at 3% total loss. For the Katepwa and Biggar wheat crops the capacity of the New Holland TR96, at power limit, was respectively 1.7 and 2.5 times that of the Reference II at 3% total loss.

Compared at 1.5% total loss, the capacity of the New Holland TR96 was 2.3 and 2.7 times that of the Reference II in the Harrington and Heartland barley tests. The New Holland TR96 had 1.7 times the capacity of the Reference II in Katepwa wheat and 3.0 times in Biggar wheat when compared at 1.5% total loss.

FIGURES 8 to 11 compare the total losses of both combines over the range of feedrates tested. The graphs show that at total losses greater than 1% the New Holland TR96 usually had much higher capacity than the Reference II combine. This difference in capacity would usually be easily noticed when harvesting. At losses less than 1%, the confidence belts in the graphs overlap, indicating that the difference in capacity may not be statistically significant. However, even when operating at low losses the difference in capacity would usually be quite noticeable.

QUALITY OF WORK

Picking: Picking performance was good.

The picking drapers were usually operated at an angle of 20 to 30 degrees to the ground. The gauge wheels were adjusted so the teeth cleared the ground by about 0.5 in (13 mm). The draper speed was normally adjusted slightly faster than ground speed.

The pickup picked most well supported windrows cleanly at speeds up to 8.0 mph (12.9 km/h). In windrows that had settled to the ground, tooth clearance had to be reduced to zero, pickup angle reduced to about 10 degrees and the pickup speed increased. With these aggressive settings caution was needed to prevent picking stones, dirt and other objects.

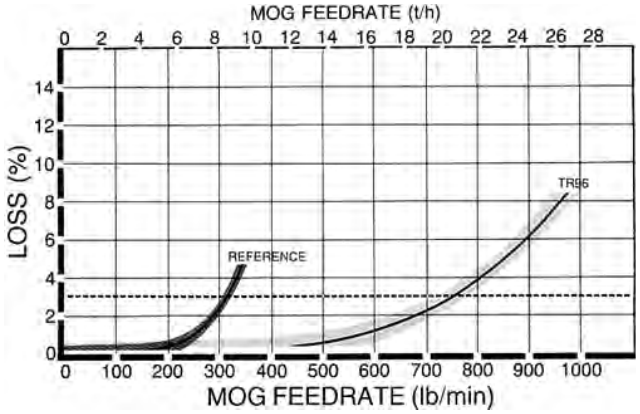

FIGURE 8. Total Grain Loss in Harrington Barley.

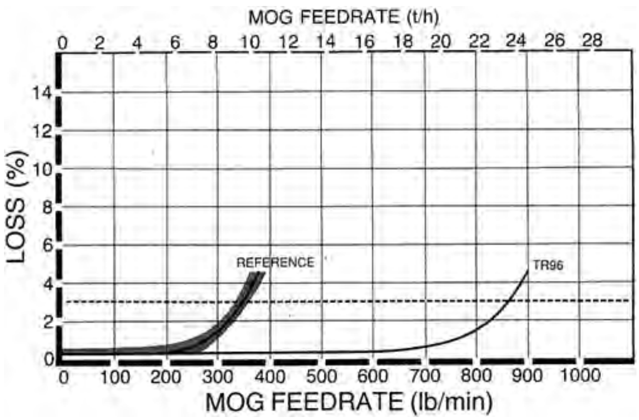

FIGURE 9. Total Grain Loss In Heartland Barley.

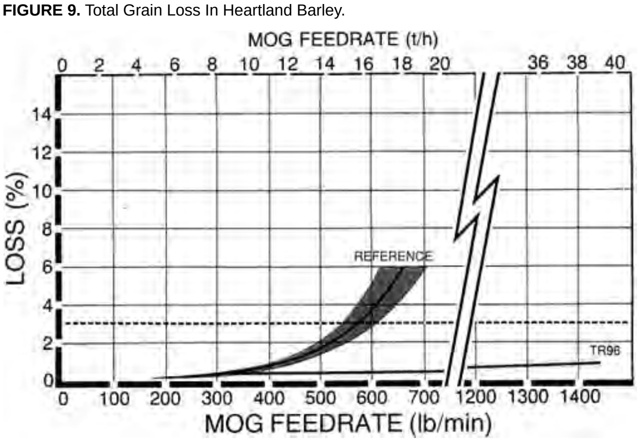

FIGURE 10. Total Grain Loss in Biggar Wheat.

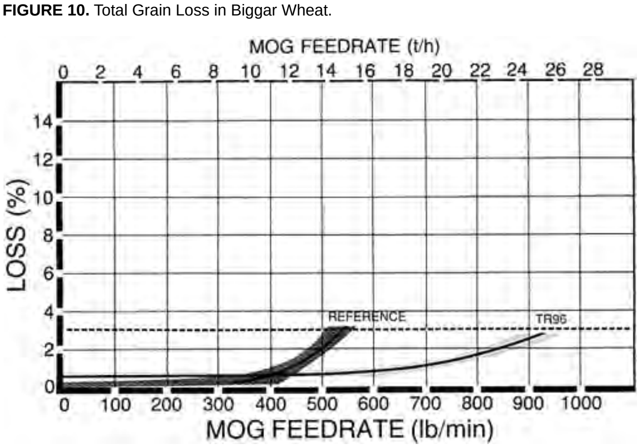

FIGURE 11. Total Grain Loss In Katepwa Wheat.

In windy conditions the wind guard assisted in guiding material into the table. In fluffy barley and canola windrows the wind guard had to be raised. The wind guard was easily raised, in about one minute. A 9/16 in wrench was required.

The pickup was wide enough to pick around most windrow corners.

Feeding: Feeding was good.

The relatively high capacity of this combine necessitated smooth and aggressive feeding. To achieve this, several key adjustments were necessary. To keep the windrow feeding under the table auger, the pivot mounts on this pickup were lowered 1.5 in (38 mm). As well, the header table was tilted fully forward. To handle the crop flow, the table auger speed was increased from 180 to 210 rpm by installing an optional sprocket on the auger drive. It was also essential to have the lower table auger strippers set in furthest inward position. The variable speed feeder was run at its fastest speed. The stone roller was usually set about 3/4 of the way up the adjustment range. Care was also required to ensure the stone trap door was adjusted so that the trailing edge was slightly above the feeder floor. This helped provide smooth crop flow and also reduced feeder chain noise. The front feeder drum also had to be set as far forward as possible.

Once properly adjusted, feeding was aggressive from the table into the rotors. Occasionally the feeder plugged in bunchy windrows or when feeding bulky windrows at high feedrates. Feeding off centre did in some conditions feed one rotor more than the other, but this did not cause any noticeable problems. However, in most conditions the relatively narrow feeder provided uniform distribution to the rotors.

Stone Protection: Stone protection was good.

The stone trap was effective in ejecting hard objects up to 6 in (151 mm) in diameter. Objects less than 2 in (50 mm) diameter were heard going through machine, although on final inspection no damage was found.

The stone trap on the New Holland TR96 was dually operated by a mechanical and/or electronic system. The mechanical system consisted of the trap door and adjustable stone roller. Large stones which passed under the stone roller were forced against the trap door which tripped the locking linkage and opened the door. The electronic stone detecting device consisted of a sensing plate, control unit and electric solenoid (FIGURE 12). On entering the feeder, hard objects struck a sounding board. The signal from the sounding board energized a solenoid and tripped the door linkage opening the stone trap door. Once the trap door was open, the object was ejected and no material could enter the rotors.

An open stone trap door was detected by a mercury switch that activated an alarm in the cab. The trap door was reset by raising the header fully or by manually operating a lever at the side of the feeder. Triggering sensitivity was adjustable. On some occasions a loose feeder chain activated the system. The stone roller position was usually set at mid to 3/4 raised position to prevent the door from opening during high MOG feedrates.

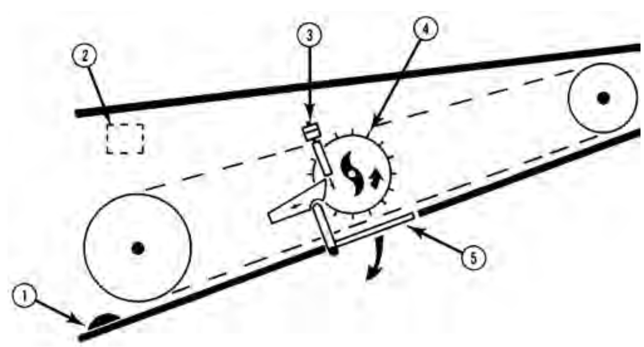

FIGURE 12. Electronic Detection Components: (1) Sounding Board, (2) Electric control Unit, (3) Solenoid, (4) Stone Roller, (5) Door.

Threshing: Threshing was very good.

Crop fed smoothly into and through rotor cages in nearly all conditions encountered. A momentary rotor vibration or "rumble" was noticed only when a dense wad of crop passed through the machine or when feeding windrows off centre. The rotor drive was very positive and the rotors were not plugged during the test.

PAMI found that in most crops, using the average to more aggressive settings recommended by the manufacturer resulted in adequate threshing.

The adjustments range available provided suitable concave and rotor settings for the crops encountered. In hard threshing crops such as Katepwa wheat, the rotors were set near maximum RPM and the concave near minimum clearance. In easier threshing crops like canola and barley, rotor speed was reduced and the concaves opened. Awning plates (blanks) were supplied but were not required in wheat. They were used to assist in threshing flax.

Unthreshed loss was usually very low even in hard-to-thresh crops. Grain damage from the New Holland TR96 was lower than the Reference II machine in the same crops.

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

Separation: Separation was very good.

In all crops material flowed smoothly through the separating section. No plugging occurred.

In barley, rotor loss limited capacity. Separation was increased by removing 18 wires from the concaves on each side. This increased open area from 44% to 49% and allowed more material to pass through. Even with concave wires removed, rotor loss eventually became prohibitive before the engine power limit was reached.

Although rotor loss was the largest part of total loss, it did not typically limit capacity in wheat. Rotor loss was usually 1.5% or less when the engine power limit was reached.

In flax and canola when awning plates were installed to reduce the amount of material passing through the concaves, rotor loss was increased slightly. However, the loss was generally very small and did not limit capacity. The settings used by PAMI are shown in TABLE 5.

Cleaning: Cleaning shoe performance was excellent.

The uniformity of material delivered to the shoe was adjusted by 10 distribution plates (5 each side). By observing the chaff load under the concaves after a "kill stall" the distribution plates were easily adjusted to distribute a uniform layer of material onto the shoe.

The wind boards did not have to be adjusted from factory settings. The angle of the chaffer and cleaning sieve did not greatly affect the shoe performance and were operated mainly in the lowest position.

In barley, wheat and rye, shoe loss was very low and the grain samples generally had less than 2% dockage.

In flax and canola, the chaffer and tailing sieve openings had to be set to balance loss, sample quality and return tailings volume. In these crops, cleaning shoe loss usually limited the harvesting rate, although on occasion it was limited by the return plugging. Plugging occurred when chaff wedged between the return elevator paddles and return auger flighting. This problem was more a result of the crop not making the transition from the auger into the elevator rather than the volume being conveyed. It is recommended that the manufacturer consider modifications to prevent the tailings return from plugging. In canola, cover plates were installed on the discharge beater grate to reduce straws spearing in the chaffer sieve.

The New Holland TR96 came equipped with the Petersen airfoil chaffer and was tested with it for most of the season. A standard lip-type chaffer was installed and tested on the same day as the test in Heartland barley. It gave similar loss characteristics over nearly all of the feedrate range but had lower loss at the highest feedrates. It was also used in canola and gave similar loss characteristics as the Petersen chaffer.

Clean Grain Handling: Clean grain handling was good.

The open grain tank filled evenly and completely in all crops. It held approximately 240 Imp. bu (8.7 m³) of dry wheat. The full bin sensor triggered when the bin was 90% full. The audible alarm lasted about 5 seconds and a light remained on while the sensor was covered. Windows between the cab and grain tank allowed the operator to watch the grain entering the tank.

Fully extended, the unloading auger had ample reach for unloading into most farm trucks. Clearance was high (FIGURE 13). To prevent loss when unloading in windy conditions, using the original unloading auger spout required swinging the auger rearward to reduce clearance. This also reduced the reach and made it difficult for the operator to view the auger. A 4 ft (1.2 m) flexible spout, (not the New Holland Option), was installed by PAMI (FIGURE 14), which allowed the grain tank to be unloaded with the auger in the forward position with minimal loss due to wind.

FIGURE 13. Unloading.

FIGURE 14. PAMI Installed Loading Spout.

The unloading auger was hydraulically positioned for unloading to the left and would unload in any position. The grain stream was compact and uniform, and a full tank unloaded in about 130 seconds.

If the unloading auger was stopped while full and then retracted to the transport position, about 0.25 bu (9 L) of grain trickled from the end of auger.

Caution was required if the combine was transported with a full grain tank when the separator was disengaged. Grain ran back into the clean grain elevator causing the clean grain slip clutch to slip when the separator was engaged.

Straw Spreading: Straw spread was good.

Straw was spread from the New Holland TR96 by two angled rotating discs with 3 rubber bats on each disc. The straw from the rotors was usually well broken and further chopping was not necessary. However, when using less aggressive threshing settings or if the straw was green or damp, the discharged straw was nearly full length. Some light airborne chaff was spread with the straw. Typically the straw was spread in a range from 15 to 22 ft (4.6 to 6.7 m) (FIGURE 15).

The spreaders were easily removed to allow checking losses or for dropping straw in a windrow. Dry and/or low straw yields produced straw that would generally be very difficult to bale with most balers.

TABLE 5. Crop Settings

Crop	Rotor Speed rpm	Concave Setting Position #	Sieve Openings						Fan Speed
			Chaffer		Tailings		Cleaning		
			in	mm	in	mm	in	mm	rpm
Barley	1400 - 1570	1 - 2	5/8 - 3/4	14 - 19	3/4	19	5/16 - 1/2	8 - 13	680 - 800
Canola	900 - 1100	2 - 5	1/2 - 3/4	13 - 19	1/2 - 3/4	13 - 19	1/8 - 3/16	3 - 13	570 - 620
Flax	1400	3	7/16	11	5/16	8	1/4	6	570
Rye	1500 - 1550	4 - 5	9/16	14	1/2	13	5/16	8	670 - 800
Wheat	1400 - 1750	1 - 2	9/16 - 3/4	14 - 19	3/4	19	1/4 - 3/8	6 - 10	750 - 850

FIGURE 15. Typical Straw Spread Pattern.

EASE OF OPERATION AND ADJUSTMENT

Operator Comfort: Operator comfort was very good.

The New Holland TR96 was equipped with an operator's cab positioned ahead of the grain tank and centred on the combine body.

Cab access was safe and easy. Cab space was suitable for the operator but was limited for a passenger. The cab was quiet and pressurized with well filtered air. Airflow could be directed to suit the operator, and the heater and air conditioner provided comfortable cab temperatures. The seat and steering wheel could be adjusted to fit most operators.

The operator had a clear view forward and to the side. Rear visibility was provided by two convex mirrors, which gave a good view but distorted the distances of objects.

Most operators had a clear view of the incoming windrow with only a small section of the table auger being obstructed by the steering wheel (FIGURE 16). Leaning slightly left or right improved visibility of the auger but became uncomfortable after several hours of operating. Grain entering the tank was easily viewed through windows between the cab and grain tank.

FIGURE 16. View of Incoming Windrow.

Instruments: Instrumentation was very good. The instruments were located to the right of the operator in a vertical and a horizontal console (FIGURE 17).

FIGURE 17. Instrument and Control Console.

The vertical console contained indicator lights for normal operation, full grain bin, straw spreaders, unloading auger, stone trap door, discharge beater, clean grain elevator, straw chopper, rotors, and cleaning fan, slow down of major harvest components as well as two displays, one for engine speed and the other which selectively displayed ground speed, fan speed or rotor speed. The horizontal console contained warning lights for low engine oil pressure, high coolant temperature, low coolant level, parking brake engagement, high hydrostatic/hydraulic temperature, engine air filter restriction, low battery, and drives engaged. It also had an engine hour meter, and gauges for electrical system voltage and fuel level. A separator hour gauge was located in a compartment in front of the throttle.

The instrument location was convenient to view while harvesting and all instruments worked well. A simple touch automatically reset the rotor and fan alarm once operating speed was selected. A test button provided a diagnostic check to see if all functions were operating. When activated, the appropriate warning light illuminated and a five second audible alarm was sounded. A switch behind the vertical console enabled the operator to select the ground speed display in either mph or km/h.

Controls: The New Holland TR96 controls were very good.

Some of the machine function controls were located to the right of the operator (FIGURE 17), some to the left beside the seat (FIGURE 18) and some on the cab floor. Accessory controls were located in the overhead panel and steering column. The controls were conveniently placed and easy to identify and use.

FIGURE 18. Lower Left Controls.

A neutral safety switch prevented the engine from cranking unless the hydrostatic control lever was placed in neutral. Fuel shut off was electrically controlled from the ignition key. The mechanical lever throttle control was located to the right of the operator. The gear shift was also located to the right of the operator. Although gear shift action was smooth and easy, it was somewhat inconvenient to select 2nd and 4th gears. Pulling upward and back did not follow natural arm motion and the operator often had to change position in the seat to select these gears.

The mechanical park brake was located on the floor and to the right of the seat. The hydrostatic control was located to the right of the operator. This location allowed the operator's arm to rest on the armrest of the seat while controlling forward speed. An adjustable friction disc could be set to provide desired hydrostatic control action.

The mechanical linkage for engaging the separator, feeder and unloading auger provided feedback to the operator for smooth engagement. The levers were convenient to use and required average force to operate. The feeder could be engaged separately or with the separator. The header reverser was controlled with the header engagement lever or a rocker switch. All hydraulic controls, except the unloading auger position, were controlled with electric switches. The header height, header level (Terrain Tracer), and reel position switches were located on the hydrostatic lever handle. These switches were conveniently placed. However, the header tilt switch was often snagged by the operator and was easily broken. It is recommended that the manufacturer consider providing a header tilt switch that is less prone to snagging or consider relocating the switch to a more protected position.

Pickup speed was controlled either automatically or manually with a toggle switch. For automatic control, minimum speed and the index to ground speed was set using a two tier dial. The top knob set the ground speed to pickup speed ratio and the bottom knob set minimum pickup speed for low or zero ground speed. The top knob was occasionally bumped when setting the minimum speed but did not greatly affect performance. Once set for a particular field, pickup speed did not have to be readjusted. The minimum speed adjustment was effective in preventing pickup stall when travelling at slow ground speeds.

A rocker switch, located on the horizontal console, controlled feeder speed. Although this switch was convenient to use, feeder speed was difficult to determine. To determine feeder speed, the relative position of the variable speed drive had to be observed. It is recommended that the manufacturer consider providing an indicator for feeder speed or to show relative feed speed adjustments.

The unloading auger was positioned hydraulically with a foot pedal located to the left of the steering column. The foot pedal control was very handy and useful for positioning the auger. Fan and rotor speed were controlled with switches located to the right of the hydrostatic lever permitting the operator to make changes while harvesting.

Loss Monitor: The loss monitor was fair.

Grain loss was monitored only for the cleaning shoe. Three sensors were positioned across the back of the shoe. Loss level was indicated by a series of 10 coloured lights in the right vertical console in the cab along with the monitor adjustments. Green lights indicated low loss, yellow indicated average loss and red indicated high loss. The lights were easy to read. The loss monitor could be operated in either an area base or time base mode.

Rotor loss was not monitored. Caution was required especially when operating in barley since excessive loss could come from the rotors. It is recommended that the manufacturer consider adding the capability to monitor grain loss from the rotors.

Lighting: Lighting was very good.

Lighting for nighttime harvesting was provided by eight forward lights, one rear light, an unloading auger light, and a grain tank light. The forward lights illuminated the header well and provided suitable short, medium and long range lighting. The lights were adjusted to suit the pickup header but could be adjusted for wide straight cut headers as well. The unloading auger light was placed approximately 4 ft (1.2 m) from the end of the unloading auger. This illuminated unloading stream of grain and the level of grain in the truck box. The grain tank light enabled easy viewing into the grain tank from the cab.

A portable service light could be plugged into the left lower cab panel or into the panel near the radiator screen. With these locations and available cord length, all areas of the combine could be reached. This was convenient for night service.

The controls and instrumentation panel were lit by a movable dome light. By changing the intensity and direction of the light, the operator could easily set cab lighting to suit operator preference. The back lighting on the gauges provided good lighting for easy night viewing. The gauge back lighting intensity was also adjustable by turning the light switch dial. Two ceiling mounted interior lights, on either side of the seat, brightened the cab, making it easy for the operator to see all areas.

Two tail lights and four flashing warning lights aided in safe road transport.

Handling: Handling was excellent.

The New Holland TR96 was easy to drive and very maneuverable. The steering and hydrostatic ground drive were smooth and responsive. The quick steering and short turning radius allowed the New Holland TR96 to pick around sharp windrow corners. The wheel brakes assisted in cornering but were rarely needed. The hydrostatic ground drive was very convenient for matching ground speed to crop conditions and made backing up quick and easy on hard-to-pick corners. The speed ranges in the various gears were appropriate with most harvesting being done in third gear.

The combine was very stable in the field even with a full grain tank. Normal caution was needed when operating on hillsides and when travelling at transport speeds. The combine transported well at speeds up to its maximum of 16 mph (26 km/h).

Adjustment: Ease of adjustment was good.

Pickup, feeder, fan, rotor speeds and concave clearance were adjusted from the cab. Sieve openings and wind board position were adjusted on the machine.

Table angle, table auger clearance, table auger finger timing, table auger stripper position, front feeder drum height, stone roller height, stone trap door position, wind board position, discharge beater plate angle, and sieve angle were easily adjusted with the aid of hand tools. Although there were many adjustments, once adjusted for suitable performance, they seldom had to be readjusted.

The front feeder drum could not be adjusted fully forward without contacting the feeder face plate. It would have been beneficial to operate with the drum fully forward for optimum feeding. It is recommended that the manufacturer consider modifications to provide adequate clearance between the feeder drum and face plates to allow the drum to be operated in the most forward position.

Initial centring and proportioning of the concaves under the rotors were simplified by the use of adjusting bolts rather than shims on previously evaluated TR combines. Accurately gauging the clearance between the rotors and concaves at the centre of the machine could not be done with the feeder assembly attached and was even difficult to measure with the feeder assembly removed. The ratchet lever and position indicator scale in the cab made it convenient to adjust concave clearance for crop conditions. Installing concave blanking plates or removing concave wires was easily done with the concave extension modules removed. The module removal was fairly quick and easy since they were pinned in place.

Adjusting the distribution plates below the concaves was at times frustrating. If the adjustment rod was pushed all the way in, it usually stuck in that position. The concave extension module had to be removed to move it back out. As well, on the right side one of these adjustment rods when set out interfered with the header drive belt. It is recommended that the manufacturer consider modifications to improve the ease of adjusting the distribution plates and to prevent interference between the right front adjustment rod and the header drive belt.

The feeder speed, although easy to adjust from within the cab, provided no indication of the change in speed or linkage position. A feeder speed indicator would have been convenient.

The Terrain Tracer provides a header lateral tilt option. On the pickup table this was not beneficial but could be on wider straight cut headers. No indicator was provided to show when the table was level which would be desirable.

The indexed adjustment levers on the sieves made it easy to position the adjustment precisely but the access to the chaffer and cleaning sieve adjustments was inconvenient. If tailing sieve angle was low, access to the adjustment lever was inconvenient.

Adjusting the distribution door which directed the tailings into the rotors was inconvenient. When opening the door fully, it extended beyond the guides and was difficult to realign. It is recommended that the manufacturer consider modifications to prevent the tailings return door from extending beyond its guides.

Field Setting: Ease of setting components to suit crop conditions was very good. Once familiar with the combine's performance, setting was usually quick and little fine tuning was required.

Threshing was easy to set for in all crops. The spreaders were quick and easy to remove and provided an easy means to check rotor effluent. The small rotor diameter meant that relatively high rotor speed was required to produce threshing bar speeds typically used by other combines. Maximum rotor RPM and minimum concave clearance provided the most aggressive threshing. These settings were often used in hard-to-thresh crops such as Katepwa wheat. In flax, awning plates were used to assist threshing.

Separation was also easy to set for, since the settings, which provided suitable threshing usually also provided acceptable separation. Removal of concave wires appeared to assist separation in barley, while covering the discharge beater grate did not seem to affect separation in any crops.

The shoe was easily set once the material was uniformly distributed to the shoe. In wheat and barley, both the standard and Petersen chaffers were usually set wide open and then the wind adjusted accordingly. However, in flax and canola the chaffer and tailing sieve openings had to be decreased to reduce the amount of MOG passing to the cleaning sieve and into the return. Care was required when catching shoe discharge since it was usually very close to the rotor discharge. No provision was made to easily check tailings return, which would have been useful. It is recommended that the manufacturer consider providing a safe, convenient method for sampling the tailings return. The wind boards did not require adjustments from factory settings. The clean grain sample was easy to see in the tank but hard to sample. The sample cleanliness was usually easily adjusted for with the clean grain sieve. Fan speed was used to minimize loss.

Unplugging: Ease of unplugging was very good. The header, clean grain elevator and tailings auger were the only components that plugged during the test.

The table auger plugged occasionally when dense wads of crop wedged under the table auger. The feeder also plugged occasionally with these wads or at extremely high feedrates. The header reverser easily backed out these obstructions. The slow operation option on the reverser made it very convenient for clearing obstructions and refeeding them.

If the machine was transported with a full grain tank when the separator was disengaged, grain leaked down the grain tank loading auger and packed in the clean grain elevator. Engaging the separator quickly caused the clean grain slip clutch to slip. Engaging the separator slowly prevented slipping.

Chaff wedged between the elevator paddle and flighting at the end of the return auger. This occurred when the returns consisted mainly of chaff and could happen with either high or low amounts of returns. The return system was unplugged by opening the elevator door, removing some of the material and engaging the separator slowly. Often, return plugging was prevented by increasing fan speed and reducing the chaffer and tailing sieve openings.

Machine Cleaning: Ease of cleaning the New Holland TR96 completely was good.

Cleaning the grain tank was easy. The tank was open and accessible. Only about 0.3 bu (11 L) of grain remained in the tank. The majority of this grain was left in the unloading auger and loading auger sumps. The sumps were easily cleaned when the sump doors were removed. However, a chain safety shield and the elevators made access to the grain tank loading auger sump door difficult. It is recommended that the manufacturer consider modifications to provide easy access to the tank loading auger sump door.

The sieves were fairly easy to remove and when removed provided access to the clean grain auger. A pan over the tailing auger made cleaning the tailings auger difficult.

Chaff and straw were easily cleaned from internal machine components with the aid of a blower. Access to the rotor cage and grain pan was provided by removing the concave extension modules.

The small amount of chaff on the exterior of the machine was easily removed with the aid of a blower. The straw spreaders had to be removed to clean material from the shields surrounding the drive shafts on the spreaders. Large amounts of chaff also collected in the bracing above the straw spreaders and would dislodge during transport.

Lubrication: Ease of lubrication was good.

Daily lubrication was quick and easy requiring only 10 to 15 minutes. Of the 65 pressure grease fittings, fourteen required 10 hour service, twenty-three at 50 hours, twenty-five at 100 hours, two at 250 hours and one at 500 hours. In difficult to reach places, more than one fitting was provided so that the most accessible one could be used. A grease bank was provided for the unloading auger pivot. The manufacturer also suggested lubricating six roller chains at 10 hour intervals. The 50 and 100 hour service took considerably longer than daily service.

Engine, hydraulic and gear base oil levels required regular checking. Access to the rotor gearbox dip sticks was difficult. Changing engine oil was easy, however, changing the hydraulic reel drive filters and oil in final drives was very inconvenient.

The fuel inlet was approximately 8 ft (2.4 m) above the ground and was difficult to fill from some gravity fuel tanks.

No service decal was provided on the machine or in the operator's manual. Service decals would have reduced the time required to lubricate.

Maintenance: Ease of performing routine maintenance was good.

Most shields or panels were hinged or easily removed to provide convenient access to the drives for lubrication and adjustment. Most belts had spring loaded idlers and the chain drives had draw bolt tighteners for simplified maintenance. One exception to the otherwise easy maintenance was tensioning the tailings return elevator chain. The inside draw bolt and lock nut on the tailings return elevator chain was difficult to reach, and there was little room to turn a wrench. It is recommended that the manufacturer consider modifications to provide easier adjustment of the tailings return elevator.

The spring tensioned feeder chain reduced the frequency of adjustment needed. Slip clutches protected the table auger, feeder, tailings, and clean grain drives.

The engine compartment was accessible from the back, the top and through a large door in the grain tank. The large radiator screen swung up and out of the way for easy access to the radiator. Cab and engine air filters were easily removed for servicing.

The concave extension modules were easily removed which then provided convenient access to the main threshing concaves and front of the grain pan.

The table and feeder assembly could be removed quickly with the aid of only a few hand tools. Detaching the feeder assembly and removing the rotor drive chain couplers allowed rotor removal. The rotors were heavy and required a hoist to support them as they were removed.

ENGINE AND FUEL CONSUMPTION

The Ford 474 diesel engine started quickly and ran well. The engine had adequate power to achieve reasonable feedrates in most conditions. It also had sufficient torque reserve to recover from overloading. One annoying characteristic was a surge in engine speed when loaded to about 2530 RPM. This was attributed to the governor response. It did not cause any performance problems.

Average fuel consumption was 7.5 gal/h (34.2 L/h). Oil consumption was insignificant.

OPERATOR SAFETY

No safety hazards on the New Holland TR96 were apparent. However, normal safety precautions were required and warnings had to be heeded.

The operator's manual emphasized safety. The New Holland TR96 had warning decals to indicate dangerous areas. All moving parts were well shielded and the shields were easily removed and replaced.

The neutral safety switch was incorporated in the hydrostatic lever ensuring the combine would not move when started. The combine came equipped with a horn to provide the operator with a means to warn individuals outside the machine. A "drives engaged" warning alarm and light came on when the operator left the seat if separator or unloading auger were engaged. These drives were not automatically disengaged. This made it vitally important that the operator disengage all drives and shut off the engine before making adjustments or working on the combine. A header 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 a slow moving vehicle sign, warning lights, signal lights, road lights and rear view mirrors to aid in safe road transport.

While these safety features were effective, PAMI still emphasizes the importance of conscientious maintenance and operating practices to prevent accidents or injury.

A fire extinguisher, Class ABC, should be carried on the combine at all times.

OPERATOR'S MANUAL

The operator's manual was very good.

The operator's manual was well organized and well written. A table of contents and index made finding specific material quick and easy. Some inaccurate referencing was found in the Combine Operator's Manual.

The manual contained sections on safety, general information, operation, lubrication, maintenance, troubleshooting, standard and optional equipment and specifications. Although some engine information was supplied in the Combine Operator's Manual, the separate and more comprehensive Engine Operator's Manual was more useful. A separate manual provided information on the 971 header.

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 New Holland TR96 for the 119 hours of operation during which about 1125 ac (455 ha) of crop were harvested.

TABLE 6. Mechanical History

Item	Operating Hours	Equivalent Field Area ac	(ha)
-Header table floor was misaligned and was reshaped and welded at	The start of test.		
-An O-ring on the hydraulic pump leaked and was replaced at	7	65	(26)
-The header drive shaft bearings failed and were replaced at	20	200	(81)
-A quick coupler for the pickup hydraulic drive leaked. The O-ring was replaced at	23	225	(91)
-The work lights circuit breaker tripped intermittently. A larger breaker was installed at	27	285	(115)
-The header tilt switch was damaged and replaced at	30	300	(121)
-The stone trap door mercury switch falsely indicated an open door and was replaced at	115	1090	(441)

Header Table Floor Misalignment: The header table floor was misaligned during manufacturing. This misalignment prevented the table auger from being adjusted to specifications. The weld between the table floor and brace was removed, and the table floor sheet metal was realigned to the brace and rewelded.

Header Drive Shaft Bearing: A broken lock collar allowed the shaft to turn in the bearing. This caused the shaft to wear. The shaft was rebuilt and the bearings were replaced.

Work Lights Circuit Breaker: The 20 amp work lights circuit breaker was not adequate to operate the field work lights. After a short time of operating, the circuit breaker would open. The 20 amp circuit breaker was replaced with a 25 amp breaker and no further problems were experienced.

APPENDIX I
SPECIFICATIONS

MAKE:	New Holland
MODEL:	TR96
SERIAL NUMBER:	header-551347 body-530526 engine-VZ072407
MANUFACTURER:	Ford New Holland, Inc 500 Dillar Avenue New Holland, Pennsylvania 17557 USA
WINDROW PICKUP:	
-- make	Victory
-- model	Super 8
-- type	rubberized, double draper
-- pickup width	11.7 ft (3.6 m)
-- number of belts	
-pickup belts	8
-transfer belts	8
-- type of teeth	plastic (single)
-- number of rollers	
-pickup	2
-transfer	2
-- height control	castoring gauge wheels
-- speed control	electro-hydraulic
-- speed range	0 to 678 ft/min (0 to 3.4 m/s)
HEADER:	
-- model	New Holland 971
-- type	centre feed
-- width	
-table	12.5 ft (3.8 m)
-feeder house	39.5 in (1000 mm)
-- auger diameter	24.2 in (615 mm)
-- feeder conveyor	3 roller chains with staggered “U” slats
-- conveyor speed	438 to 546 ft/min (2.2 to 2.8 m/s)
-- range of picking height	-42.1 to +43.8 in (-1.1 to +1.1 m)
-- number of lift cylinders	2
-- raising time	adjustable (49 sec minimum)
-- lowering time	adjustable
-- options	variable speed feeder, terrain tracer, feeder stand and auger speed up sprocket (23 tooth)
STONE PROTECTION:	
-- type	trap door in floor of feeder house with stone roller
-- ejection	reset by raising header
-- option	electronic stone detection
ROTOR:	
-- number of rotors	2
-- type	closed tube, 3 stage: inlet, thresh and separate; 6 pairs of rasp bars staggered around threshing tube; 2 spiralling blades and 2 rows of 5 agitating pins mounted in separating section
-- diameter	
-tube	11.9 in (302 mm)
-feeding	19.0 in (484 mm)
-threshing	17.0 in (432 mm)
-separating	17.0 in (432 mm)
-- length	
-feeding	152 in (385 mm)
-threshing	289 in (735 mm)
-separating	427 in (1085 mm)
-total	868 in (2205 mm)
-- drive	electro-hydraulic controlled variable pitch belt through two 90 degree gearboxes
-- speed	730 to 1790 RPM
CONCAVE (THRESHING):	
-- number	
-concave	2
-concave extension	4 (2 each side)
-- type	bar & wire
-- number of bars	
-concave	11
-concave extension	5
-- configuration	
-concave	10 intervals with 0.15 in (3.6 mm) diameter wires and 0.25 in (6 mm) spaces
-concave extension	4 intervals with 0.15 in (3.6 mm) diameter wires and 0.25 in (6 mm) spaces
-- area	
-concave total	837 in² (0.54 m²)
-concave open	372 in² (0.24 m²) - 44%
-concave extensions total	297 in² (0.19 m²)
-concave extension open	116 in² (0.07 m²) - 38%
-- wrap	
-concave	98 degrees (maximum)
-concave plus extensions	134 degrees
-grain delivery to shoe	grain pan
-- options	awning plates

CONCAVE (SEPARATING):	
-- number	2
-- type	bar and wire
-- number of bars	22
-- configuration	21 interval with 0.25 in (6.4 mm) diameter wire and 2.1 in (52 mm) spaces
-- area total	2062 in² (1.33 m²)
-- open area	1361 in² (0.887 m²) - 67%
-- wrap	215 degrees
-- grain delivery to shoe	grain pan
THRESHING AND SEPARATING CHAMBER:	
-- number of spirals	10
-- pitch of spirals	12 degrees
DISCHARGE BEATER:	
-- type	4 wing box
-- speed	850 rpm
DISCHARGE BEATER GRATE:	
-- type	bar and wire
-- configuration	6 interval with 0.25 in (6.4 mm) diameter wires and 0.75 in (19 mm) spaces
-- area total	744 in² (0.48 rn²)
-- area open	507 in² (0.33 m²) - 68%
-- grain delivery to shoe	gravity
-- options	covers
SHOE:	
-- type	opposed motion
-- speed	350 CPM
-- type	Petersen (adjustable)
-- type	regular tooth - adjustable
-- tooth depth	0.9 in (22 mm)
-- louvre spacing	1.3 in (29 mm)
-- total area	2582 in² (1.67 m²)
-- effective area	2230 in² (1.44 m²)
-- travel	0.8 in (20 mm) vertical 1.3 in (32 mm) horizontal
-- tailing sieve	
-type	regular tooth - adjustable
-tooth depth	0.9 in (23 mm)
-louvre spacing	1.2 in (30 mm)
-total area	845 in² (0.54 m²)
-effective area	637 in² (0.4 m²)
-- tailings extension	wire rake
-- cleaning sieve	
-type	regular tooth - adjustable
-tooth depth	0. 4 in (9 mm)
-louvre spacing	0.9 in (22 mm)
-total area	2980 in² (1.66 m²)
-effective area	2257 in² (1.46 m²)
-travel	0.3 in (8 mm) vertical 1.2 in (30 mm) horizontal
CLEANING FAN:	
-- type	6 blade undershot
-- diameter	24.6 in (624 mm)
-- width	55 in (1400 mm)
-- drive	electrically controlled variable pitch belt
-- speed range	420 to 1030 RPM
-- wind boards	2 (adjustable)
-- options	slow speed fan kit
ELEVATORS:	
-- type	roller chain with rubber paddles
-- clean grain (top drive)	7.6 x 11.4 in (194 x 290 mm)
-- railings (bottom drive)	4.8 x 11.4 in (121 x 290 mm)
GRAIN TANK:	
-- capacity	240 Imp. bu (87 m³)
-- unloading time	130 sec
-- unloading auger diameter	12.2 in (310 mm)
-- unloading auger length	13.6 ft (4.2 m)
-- options	flexible auger down spout
STRAW SPREADERS:	
-- number of spreaders	2
-- type	bat and disc
-- speed	275 RPM
ENGINE:	
-- make	Ford
-- model	474
-- type	Diesel
-- number of cylinders	6 (in-line)
-- displacement	474 in³ (7. 8 L)
-- governed speed (full throttle)	2600 RPM
-- manufacturer's rating	240 hp (179 kW)
-- fuel tank capacity	82 gal (375 L)
CLUTCHES:	
-- header	mechanical (belt tightener)
-- separator	mechanical (dry friction disc)
-- unloading auger	mechanical (belt tightener)
NUMBER OF CHAINS:	6
NUMBER OF BELT DRIVES:	14

NUMBER OF GEAR BOXES:	4
LUBRICATION POINTS:	
-- 10h	15
-- 50h	23
-- 100h	25
-- 250h	2
-- 500 h	1
TIRES:	
-- front	30.5L - 32 R1
-- rear	14.9 - 24 R3
TRACTION DRIVE:	
-- type	hydrostatic, 4 speed transmission
-- speed range	
-1st gear	0 - 1.9 mph (0 - 3.1 km/h)
-2nd gear	0 - 4.3 mph (0 - 6.9 km/h)
-3rd gear	0 - 7.5 mph (0 - 12.0 km/h)
-4th gear	0 - 16.1 mph (0 - 26.0 km/h)
OVERALL DIMENSIONS:	
-- wheel tread (front)	10.2 ft (3.11 m)
-- wheel tread (rear)	8.9 ft (2.72 m)
-- wheel base	10. 8 ft (3.28 m)
-- transport height	13.7 ft (4.16 m)
-- transport length	30.4 ft (9.28 m)
-- transport width	16.6 ft (5.04 m)
-- field height	14.9 ft (4.54 m)
-- unloader discharge height	12.8 ft (3.92 m)
-- unloader reach	10.2 ft (3.11 m)
-- unloader clearance	12.9 ft (3.94 m)
-- turning radius	
-left	21.0 ft (6.4 m)
-right	20.7 ft (6.31 m)
WEIGHT: (grain tank empty)	
-- right front wheel	9190 lb (41 70 kg)
-- left front wheel	9500 lb (4310 kg)
-- right rear wheel	4080 lb (1850 kg)
-- left rear wheel	4080 lb (1850 kg)
Total	26,850 lb (12,180 kg)

APPENDIX II

PAMI REFERENCE II COMBINE CAPACITY RESULTS

The tables below and FIGURES 19 and 20 present the capacity results for the PAMI Reference II Combine in barley and wheat crops for 1987 to 1990.

FIGURE 19 shows capacity differences in barley crops for the different years, The Heartland barley crop shown in FIGURE 19 had slightly above average grain and straw yields and slightly below average straw moisture and average grain moisture. Capacity was near average in this barley crop.

FIGURE 20 shows capacity differences in wheat crops, In 1990, the Katepwa wheat crop selected had average grain and straw yield with average grain moisture and below average straw moisture, Wheat capacity in 1990 ranged near average for the Reference II.

The average capacity of the Reference II Combine in the 1990 season indicates that the test combines tested alongside the Reference II would also likely have had a similar average capacity. Results show that the Reference II combine is important in determining the effect of crop variable and in comparing capacity results of combines evaluated in different years.

Reference Combine Capacity Results for 1990

Crop	Variety	Cut Width ft	Cut Width m	Crop Yield bu/ac	Crop Yield t/ha	Moisture Content Straw %	Moisture Content Grain %	MOG/G Ratio
Barley	Harrington	30	9.2	56	3.0	5.9	11.2	0.71
Barley	Heartland	25	7.7	92	4.9	8.2	12.4	0.63
Barley	Virden	24	7.4	89	0.0	13.0	9.6	0.78
Wheat	Biggar	24	7.4	91	4.9	9.4	15.1	0.78
Wheat	Katepwa	24	7.4	45	2.4	4.2	12.7	0.99

CAPACITY AT 3%

Crop	Variety	Feedrates MOG lb/min	MOG t/h	Grain bu/h	Grain t/h	Total lb/min	Total t/h	Grain Cracks %	Dockage %	Foreign Material
Barley	Harrington	315	8.6	555	12.1	760	20.7	2.5	0.8	0.4
Barley	Heartland	355	9.7	700	15.2	920	25.0	1.6	4.0	3.6
Barley	Virden	405	0.0	650	0.0	925	0.0	1.2	1.8	0.8
Wheat	Biggar	575	15.6	735	20.0	1310	35.7	3.0	3.7	0.5
Wheat	Katepwa	550	15.0	555	15.1	1105	30.1	2.8	4.0	0.5

CAPACITY AT 1.5%

Crop	Variety	Feedrates MOG lb/min	MOG t/h	Grain bu/h	Grain t/h	Total lb/min	Total t/h	Grain Cracks %	Dockage %	Foreign Material %
Barley	Harrington	270	7.3	475	12.1	650	17.7	2.5	0.8	0.4
Barley	Heartland	300	8.2	600	15.2	755	21.1	1.6	4.0	3.6
Barley	Virden	325	0.0	520	0.0	730	0.0	1.2	1.8	0.8
Wheat	Biggar	485	13.2	620	16.9	1105	30.1	4.6	4.0	0.5
Wheat	Katepwa	475	12.9	480	15.1	955	26.0	2.8	4.0	0.5

Reference Combine Capacity Results for 1988

Crop	Variety	Cut Width ft	Cut Width m	Crop Yield bu/ac	Crop Yield t/ha	Moisture Content Straw %	Moisture Content Grain %	MOG/G Ratio
Barley	Ellice	30	9.1	68	3.7	12.9	11.4	0.75
Wheat	Katepwa A	30	9.1	35	2.4	4.7	12.4	0.93
Wheat	Katepwa B	30	9.1	43	2.9	9.5	13.7	1.20

CAPACITY AT 3%

Crop	Variety	Feedrates MOG lb/min	MOG t/h	Grain bu/h	Grain t/h	Total lb/min	Total t/h	Grain Cracks %	Dockage %	Foreign Material
Barley	Ellice	400	10.9	665	14.5	930	25.4	1.3	0.6	0.1
Wheat	Katepwa A	540	14.7	580	15.8	1120	30.5	1.7	2.0	0.3
Wheat	Katepwa B	570	15.5	475	12.9	1045	28.4	2.3	3.3	1.3

CAPACITY AT 1.5%

Crop	Variety	Feedrates MOG lb/min	MOG t/h	Grain bu/h	Grain t/h	Total lb/min	Total t/h	Grain Cracks %	Dockage %	Foreign Material %
Barley	Ellice	325	8.8	541	24.7	760	19.5	1.0	0.5	0.1
Wheat	Katepwa A	465	7.5	500	9.3	965	16.7	2.1	2.0	0.2
Wheat	Katepwa B	485	12.5	400	8.6	890	23.3	2.2	3.1	1.5

Reference Combine Capacity Results for 1989

Crop	Variety	Cut Width ft	Cut Width m	Crop Yield bu/ac	Crop Yield t/ha	Moisture Content Straw %	Moisture Content Grain %	MOG/G Ratio
Barley	Harrington	30	9.1	64	3.4	10.8	10.5	0.60
Barley	Heartland	30	9.1	70	3.8	10.0	13.4	0.64
Wheat	Katepwa A	20	6.1	55	3.7	8.8	16.2	1.00
Wheat	Katepwa B	30	9.1	57	3.9	11.5	15.4	1.10
Wheat	Katepwa C	30	9.1	66	4.4	14.8	15.8	1.13

CAPACITY AT 3%

Crop	Variety	Feedrates MOG lb/min	MOG t/h	Grain bu/h	Grain t/h	Total lb/min	Total t/h	Grain Cracks %	Dockage %	Foreign Material
Barley	Harrington	330	9.0	690	15.0	880	24.0	0.8	0.7	0.4
Barley	Heartland	320	8.7	625	13.6	820	22.3	1.7	0.1	0.1
Wheat	Katepwa A	490	13.4	490	13.4	980	26.8	3.1	0.7	0.4
Wheat	Katepwa B	405	11.0	370	10.1	775	21.1	2.8	0.5	0.3
Wheat	Katepwa C	470	12.8	415	11.3	885	24.1	3.1	0.5	0.3

CAPACITY AT 1.5%

Crop	Variety	Feedrates MOG lb/min	MOG t/h	Grain bu/h	Grain t/h	Total lb/min	Total t/h	Grain Cracks %	Dockage %	Foreign Material %
Barley	Harrington	285	8.8	595	24.7	760	19.5	0.8	0.6	0.4
Barley	Heartland	255	7.5	500	9.3	655	16.7	1.9	0.2	0.1
Wheat	Katepwa A	420	12.5	420	15.5	840	31.8	3.1	0.9	0.7
Wheat	Katepwa B	335	13.2	305	16.5	640	33.7	3.5	0.5	0.4
Wheat	Katepwa C	375	14.3	330	10.7	705	27.6	3.0	0.6	0.5

Reference Combine Capacity Results for 1987

Crop	Variety	Cut Width ft	Cut Width m	Crop Yield bu/ac	Crop Yield t/ha	Moisture Content Straw %	Moisture Content Grain %	MOG/G Ratio
Barley	Argyle	24	7.2	69	3.5	12.6	13.0	0.82
Barley	Columbus	25	7.6	43	2.9	5.0	13.4	1.16
Barley	Harrington	20	6.4	79	4.3	7.7	10.8	0.81
Wheat	Katepwa A	40	12.2	31	2.2	6.9	12.9	0.65
Wheat	Katepwa B	60	18.3	37	2.6	8.3	14.5	0.64
Wheat	Katepwa C	60	18.3	31	2.1	12.8	16.0	1.07

CAPACITY AT 3%

Crop	Variety	Feedrates MOG lb/min	MOG t/h	Grain bu/h	Grain t/h	Total lb/min	Total t/h	Grain Cracks %	Dockage %	Foreign Material
Barley	Argyle	315	10.8	600	13.1	875	23.8	0.5	1.5	1.2
Barley	Columbus	540	14.7	465	12.7	1005	27.4	1.5	3.5	0.1
Barley	Harrington	370	10.1	570	12.4	825	22.5	1.5	3.0	0.1
Wheat	Katepwa A	520	14.2	800	21.8	1320	35.9	1.5	2.5	0.2
Wheat	Katepwa B	580	15.8	905	24.6	1485	40.4	2.0	2.0	0.1
Wheat	Katepwa C	630	17.2	590	16.1	1220	33.2	1.5	1.5	0.1

CAPACITY AT 1.5%

Crop	Variety	Feedrates MOG lb/min	MOG t/h	Grain bu/h	Grain t/h	Total lb/min	Total t/h	Grain Cracks %	Dockage %	Foreign Material %
Barley	Argyle	323	8.8	490	24.7	715	19.5	0.5	1.5	1.2
Barley	Columbus	460	12.5	395	8.6	855	23.3	1.7	3.5	0.2
Barley	Harrington	275	7.5	425	9.3	615	16.7	1.5	3.0	0.1
Wheat	Katepwa A	460	12.5	710	15.5	1170	31.8	1.7	2.7	0.2
Wheat	Katepwa B	485	13.2	760	16.5	1240	33.7	2.0	2.3	0.1
Wheat	Katepwa C	525	14.3	490	10.7	1015	27.6	1.7	1.6	0.1

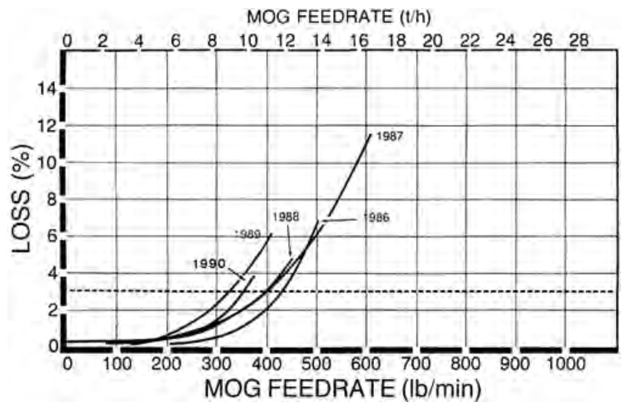

FIGURE 19. Total Grain Loss for the PAMI Reference II Combine in Barley.

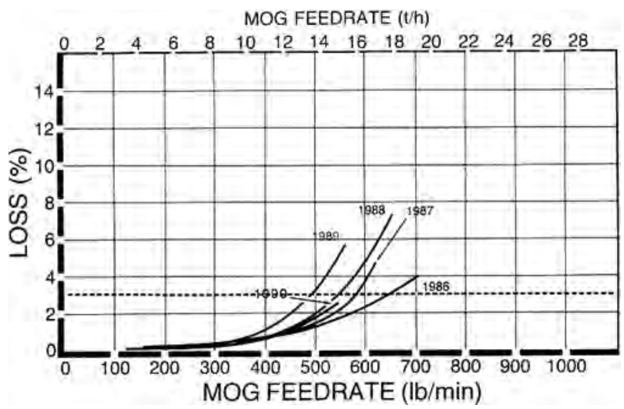

FIGURE 20. Total Grain Loss for the PAMI Reference II Combine in Wheat.

APPENDIX III
REGRESSION EQUATIONS FOR NEW HOLLAND TR96 CAPACITY RESULTS

Regression equations for the capacity results shown in FIGURES 4 to 7 are presented in TABLE 8. In the regressions, U = unthreshed loss in percentage of yield, S = shoe loss in percentage of yield, R = rotor loss in percentage of yield, F = the MOG feedrate in lb/min, while ln is the natural logarithm. Sample size refers to the number of toss collections. Limits of the regressions may be obtained from FIGURES 4 to 7 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 Harrington	4	$U = 0.02 + 7.00 \times 10^{-15} \times F^5$ $S = 0.22 + 6.00 \times 10^{-16} \times F^5$ $R = -0.13 + 8.46 \times 10^{-12} \times F^4$	0.72 0.74 0.99	12.92 14.12 20.15[2]	7
Barley Heartland	5	$U = 0.05 + 6.50 \times 10^{-17} \times F^5$ $S = 0.10 + 1.07 \times 10^{-33} \times F^{11}$ $R = 0.17 + 1.23 \times 10^{-32} \times F^{11}$	0.51 0.64 1.00	5.28 25.52 39.14[2]	7
Wheat Biggar	6	$U = 0.17 + 3.03 \times 10^{-8} \times F^2$ $S = 0.08 + 5.55 \times 10^{-8} \times F^2$ $R = 0.03 + 1.92 \times 10^{-7} \times F^2$	0.13 0.19 0.64	0.87 1.39 30.57	8
Wheat Katepwa	7	$U = 0.05 + 4.44 \times 10^{-4} \times F$ $S = 0.20 + 1.55 \times 10^{-4} \times F$ $R = 0.14 + 2.24 \times 10^{-15} \times F^5$	0.19 0.40 0.92	1.18 3.33 58.60	7

APPENDIX IV
MACHINE RATINGS

The following rating scale is used in PAMI Evaluation Reports:

Excellent	Fair
Very Good	Poor
Good	Unsatisfactory

SUMMARY CHART
FORD NEW HOLLAND TR96

RETAIL PRICE	$168,940.00 (March, 1991, f.o.b. Humboldt, Saskatchewan)
CAPACITY	
Compared to Reference II	
-barley	2.4 x Reference II
-wheat	1.7 and 2.5 x Reference II
MOG Feedrates	
-barley - Harrington	755 lb/min (20.5 t/h) at 3.0% total loss, FIGURE 4
-barley - Heartland	865 lb/min (23.5 t/h) at 3.0% total loss, FIGURE 5
-wheat - Biggar	1440 lb/min (39.2 t/h) at 0.9% total loss, FIGURE 6
-wheat - Katepwa	910 lb/min (24.8 t/h) at 2.4% total loss, FIGURE 7
QUALITY OF WORK	
Picking	**Good;** picked well in all crops
Feeding	**Good;** aggressive table auger, seldom plugged
Stone Protection	**Good;** ejected most stones
Threshing	**Very Good;** aggressive threshing, concave blanking in some flax and canola
Separating	**Very Good;** rotor loss usually low
Cleaning	**Excellent;** very low shoe loss in all crops
Grain Handling	**Good;** difficult unloading in windy conditions without spout extension
Straw Spreading	**Good;** spread evenly up to 22 ft (6.7 m)
EASE OF OPERATION AND ADJUSTMENT	
Comfort	**Very Good;** quiet cab, extra passenger seat
Instruments	**Very Good;** all functions monitored, instruments easy to observe
Controls	**Very Good;** well placed, easy to use
Loss Monitor	**Fair;** rotor loss not indicated
Lighting	**Very Good;** all areas well lit
Handling	**Excellent;** small turning radius, wheel brakes seldom required
Adjustment	**Good;** most convenient but some were inconvenient
Field Setting	**Very Good;** little fine tuning required
Unplugging	**Very Good;** feeder reverser worked well, rotors did not plug
Machine Cleaning	**Good;** most areas accessible
Lubrication	**Good;** no decals in manual or on the machine
Maintenance	**Good;** most areas easily accessible
ENGINE AND FUEL CONSUMPTION	
Engine	Started quickly ran well, good torque reserve, surge occurred near power limit
Fuel Consumption	7.5 gal/h (34.2 L/h)
OPERATOR SAFETY	Well shielded and many safety features
OPERATOR'S MANUAL	**Very Good;** well organized and easy to find information
MECHANICAL HISTORY	A few mechanical problems occurred

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